New England Wind

AVANGRID RENEWABLES

Construction and Operations Plan

Lease Area OCS-A 0534

Volume III Appendices

June 2022

Submitted by
Park City Wind LLC

Submitted to
Bureau of Ocean Energy Management
45600 Woodland Rd
Sterling, VA 20166

Prepared by
Epsilon Associates, Inc.

New England Wind Construction and Operations Plan for Lease Area OCS-A 0534

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Submitted to:
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45600 Woodland Rd
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Submitted by:
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Prepared by:
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June 2022

On April 29, 2022, modifications were made to the Envelope that involved changing the maximum wind turbine generator (WTG) and electrical service platform (ESP) topside parameters for Phase 1 (Park City Wind) to match those of Phase 2 (Commonwealth Wind) (see Table 1). As a result of this change, the potential minimum footprint of Phase 1 decreased, and correspondingly the potential maximum footprint of Phase 2 increased (see Table 2). Additionally, the maximum capacity in megawatts for both phases was eliminated to accommodate the rapid advancement in commercially available wind turbine generator size and technology.

Table 1 Modifications to the Phase 1 WTG and ESP Parameters[1]

Maximum WTG Parameters	Previous Dimension	New Dimension[2]
Tip Height	319 m (1,047 ft)	357 (1,171 ft)
Top of the Nacelle Height	199 m (653 ft)	221 m (725 ft)
Hub Height	192 m (630 ft)	214 m (702 ft)
Rotor Diameter	255 m (837 ft)	285 m (935 ft)
Minimum Tip Clearance[3]	27 m (89 ft)	27 m (89 ft)
Blade Chord	8 m (26 ft)	9 m (30 ft)
Tower Diameter	9 m (30 ft)	10 m (33 ft)[4]
Maximum ESP Parameters	**Previous Dimension**	**New Dimension[2]**
Width	45 m (148 ft)	60 m (197 ft)
Length	70 m (230 ft)	100 m (328 ft)
Height	38 m (125 ft)	No change
Height of Topside (above MLLW[5])	70 m (230 ft)	No change

1. Maximum WTG dimensions are included in Table 3.2-1 and maximum ESP dimensions are included in Table 3.2-3 of COP Volume I
2. The new Phase 1 WTG and ESP maximum parameters were revised to match those of Phase 2
3. All parameters are maximum values except tip clearance, where the minimum tip clearance represents the maximum potential impact
4. To accommodate the slight increase in tower diameter, the maximum transition piece diameter/width for Phase 1 monopile foundations was also increased from 9 m (30 ft) to 10 m (33 ft) (see Table 3.2-2 of COP Volume I)
5. MLLW: Mean Lower Low Water

To accommodate the larger Phase 1 WTG dimensions and greater capacity range, the minimum footprint of Phase 1 decreased and the maximum footprint of Phase 2 increased, thus also adjusting the potential number of WTG/ESP positions within each Phase (see Table 2).

Table 2 Modifications to the Phase 1 and Phase 2 Layout and Size

		Previous Layout and Size	New Layout and Size
Phase 1	Number of WTGs	50-62	41-62
	Area	182-231 km^2 (44,973-57,081 acres)	150-231 km^2 (37,066-57,081 acres)
Phase 2	Number of WTGs	64-79	64-88
	Area	222-271 km^2 (54,857-66,966 acres)	222–303 km^2 (54,857–74,873 acres)

These revisions remain within the maximum design scenario considered for this report and the maximum potential impacts are still representative considering these modifications. Therefore, this report was not updated to reflect these minor modifications, as the findings are not affected.

The Proponent has also identified two variations of the Phase 2 Offshore Export Cable Corridor (OECC)— the Western Muskeget Variant and the South Coast Variant—in the event that technical, logistical, grid interconnection, or other unforeseen issues arise during the engineering and permitting processes that preclude one or more Phase 2 offshore export cables from being installed within all or a portion of the OECC (see Section 4.1.3 of COP Volume I). This Appendix considers the potential impacts associated with the Western Muskeget Variant; an assessment of the South Coast Variant in federal waters is provided separately in the COP Addendum.

FINAL TECHNICAL REPORT
SEDIMENT TRANSPORT MODELING

New England Wind Offshore Cable Installation

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Contents

List of Acronyms

BOEM	Bureau of Ocean Energy Management
COP	Construction and Operations Plan
ENC	Electronic Navigational Chart
ESP	Electrical Service Platform
GIS	Geographic Information System
NDBC	National Data Buoy Center
NOAA	National Oceanic and Atmospheric Administration
O&M	Operations and Maintenance
OECC	Offshore Export Cable Corridor
OSAMP	Ocean Special Area Management Plan
SSFATE	Suspended Sediment FATE
SWDA	Southern Wind Development Area
TSHD	Trailing Suction Hopper Dredge
TSS	Total Suspended Solids
WTG	Wind Turbine Generator

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EXECUTIVE SUMMARY

New England Wind is the proposal to develop offshore renewable wind energy facilities in Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A 0534 along with associated offshore and onshore cabling, onshore substations, and onshore operations and maintenance (O&M) facilities. New England Wind will be developed in two Phases with a maximum of 130 wind turbine generator (WTG) and electrical service platform (ESP) positions. Four or five offshore export cables will transmit electricity from the Southern Wind Development Area (SWDA) to an onshore transmission system in the Town of Barnstable, Massachusetts. Park City Wind LLC, a wholly owned subsidiary of Avangrid Renewables, LLC, is the Proponent and will be responsible for the construction, operation, and decommissioning of New England Wind.

New England Wind's offshore renewable wind energy facilities are located immediately southwest of Vineyard Wind 1, which is located in Lease Area OCS-A 0501. New England Wind will occupy all of Lease Area OCS-A 0534 and potentially a portion of Lease Area OCS-A 0501 in the event that Vineyard Wind 1 does not develop "spare" or extra positions included in Lease Area OCS-A 0501 and Vineyard Wind 1 assigns those positions to Lease Area OCS-A 0534. For the purposes of the Construction and Operations Plan (COP), the SWDA is defined as all of Lease Area OCS-A 0534 and the southwest portion of Lease Area OCS-A 0501, as shown in Figure 1.1-1 of COP Volume I. The SWDA may be 411-453 square kilometers (km^2) (101,590-111,939 acres) in size depending upon the final footprint of Vineyard Wind 1. At this time, the Proponent does not intend to develop the two positions in the separate aliquots located along the northeastern boundary of Lease Area OCS-A 0501 as part of New England Wind. The SWDA (excluding the two separate aliquots that are closer to shore) is just over 32 kilometers (km) (20 miles [mi]) from the southwest corner of Martha's Vineyard and approximately 38 km (24 mi) from Nantucket.[1] The WTGs and ESPs in the SWDA will be oriented in an east-west, north-south grid pattern with one nautical mile (NM) (1.85 km) spacing between positions.

Each Phase of New England Wind will be developed and permitted using a Project Design Envelope (the "Envelope"). This allows the Proponent to properly define and bracket the characteristics of each Phase for the purposes of environmental review while maintaining a reasonable degree of flexibility with respect to the selection of key components, such as the WTGs, foundations, submarine cables, and ESPs. To assess potential impacts and benefits to various resources, a "maximum design scenario," or the design scenario with the maximum impacts anticipated for that resource, is established considering the Envelope parameters for each Phase that have the potential to cause the greatest effect. For some resources, the approach overestimates potential environmental impacts as the maximum design scenario is not the scenario the Proponent is likely to employ.

This appendix to the New England Wind COP documents the sediment dispersion modeling assessment of the sediment-disturbing offshore cable installation activities associated with the development of New England Wind. The cable installation methods may vary along the route depending on subsurface conditions; the installation methods are described in detail in the COP and the details of the assumed modeling parameters are documented within this report. Consistent with the Envelope, this study simulated multiple scenarios to capture the maximum design scenario and range of effects associated with the installation of inter-array cables in the SWDA and offshore export cables in the Offshore Export Cable Corridor (OECC), including dredging to clear sand waves and various cable installation methods.

Following is a brief overview of the terminology used to describe the methodologies modeled in this study:

- **Trailing Suction Hopper Dredge (TSHD):** Suction dredging through a drag arm near the seabed, overflow of sediment laden waters from a hopper and disposal of sediments from the hopper. In this report it refers to the methodology as applied to all sand wave sizes where dredging is needed.
- **Limited TSHD:** This method is the same as TSHD; the TSHD, however, is "Limited" in that it is only applied to larger (greater than 2 meters [m]) sand waves where dredging is needed.

[1] Within the SWDA, the closest WTG is approximately 34 km (21 mi) from Martha's Vineyard and 40 km (25 mi) from Nantucket.

- **Cable Installation:** Cable installation is accomplished by jetting techniques (e.g., jet plow, jet trenching, or similar) in areas where sand waves do not exist or have been cleared.
- **Cable Installation Aided by Jetting:** Cable installation is accomplished as described above; however, this method includes additional jetting by controlled flow excavation in areas of small sand waves.
- **Cable Installation using Vertical Injector:** Cable installation is achieved in areas with or without sand waves through the use of the 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 scenarios that were modeled include a representative offshore export cable route for the full length of the OECC, a representative inter-array cable route within the SWDA, and representative sections of cable routes within the OECC. The scenarios include:

- Inter-array cable installation with typical burial installation parameters
- Inter-array cable installation with maximum impact burial installation parameters
- OECC sand wave clearing by TSHD
- OECC sand wave clearing by Limited TSHD
- OECC cable installation with typical burial installation parameters
- OECC cable installation aided by jetting with typical burial installation parameters
- OECC cable installation in the lease area with typical burial installation parameters
- OECC section of cable installation with vertical injector with typical burial installation parameters
- OECC section of cable installation along the landfall approach with typical burial installation parameters

The sediment dispersion modeling assessment was carried out through two interconnected modeling tasks:

1. Development of a three-dimensional hydrodynamic model application of a domain encompassing New England Wind activities using the HYDROMAP modeling system; and
2. Simulations of the suspended sediment fate and transport, including evaluation of seabed deposition and suspended sediment plumes, using the SSFATE (Suspended Sediment FATE) modeling system to simulate installation activities. Velocity fields developed using the HYDROMAP model are used as the primary forcing for SSFATE.

The modeling was performed to characterize the effects associated with the offshore cable installation activities. The effects were quantified in terms of the above-ambient total suspended solids (TSS) concentrations as well as seabed deposition of sediments suspended in the water column during cable installation activities, including sand wave dredging. Results are presented with respect to thresholds listed below.

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

Simulations of sand wave dredging using a TSHD and associated disposal activities along the OECC show that above-ambient TSS originating from the source is intermittent along the route, matching the intermittent need for dredging. Above-ambient TSS concentrations may be present throughout the entire water column since sediments are released at or near the water surface. Above-ambient TSS concentrations of 10 mg/L extend up to 16 and 8.5 km from the area of activity for the TSHD and limited TSHD model scenarios, respectively; however, these concentrations only persist for a matter of hours. Concentrations greater than 10 mg/L persist less than six hours for TSHD activities and less than four hours for limited TSHD activities.

Deposition greater than 1 mm associated with the TSHD drag arm is mainly constrained to within 150 m of the area of activity, whereas the same deposition thickness associated with overflow and dredged material release extends greater distances from the source, resulting in deposition mainly within 1 km but extending up to 2.3 km in isolated patches when subject to swift currents through Muskeget Channel. Due to the hopper disposal, which releases the entire hopper of sediment in one location, the TSHD scenarios result in areas with deposition of 100 mm or greater, which is substantially greater than the cable installation scenarios.

Simulations of several possible inter-array or offshore export cable installation methods using either typical installation parameters (for inter-array and offshore export cable installation) or maximum impact parameters (for inter-array cable installation only) predict a plume that is localized to the seabed. The plume may be located in the bottom approximate 6 m of the water column, which is typically a fraction of the water column; however, in shallow waters, the plume may occupy the entire water column. Simulations of cable installation found that above-ambient TSS greater than 10 mg/L and deposition over 1 mm stayed closer to the cable alignment as compared to the dredging footprints; this is due to the fact that sediments are introduced to the water column closer to the seabed. Above-ambient TSS concentrations greater than 10 mg/L typically stayed within 200 m of the alignment, though did extend up to a maximum distance of approximately 2.1 km for typical installation parameters and up to 2.2 km for maximum impact installation parameters (for inter-array cable installation only). The extent of above-ambient TSS concentrations decreases at higher concentration thresholds. Above-ambient TSS concentrations stemming from cable installation for the various model scenarios remain relatively close to the cable alignment, are constrained to the bottom of the water column, and are short-lived. Above-ambient TSS concentrations substantially dissipate within one to two hours and fully dissipate in less than four hours for most of the model scenarios. For the vertical injector model scenario, above-ambient TSS concentrations similarly substantially dissipated within one to two hours but required up to six hours to fully dissipate, likely due to the relatively slower installation rate and deeper trench (greater volume disturbed per unit length). Deposition greater than 1 mm was limited to within 100 m of the cable alignment for typical installation parameters and to within less than 150 m of the cable alignment for maximum impact installation parameters (for inter-array cable installation only). The maximum deposition associated with inter-array or offshore export cable installation was typically less than 5 mm, though there was a small isolated area associated with the vertical injector model scenario with deposition between 5-10 mm. The results of the extent and persistence of the plume and the extent and thickness of deposition for inter-array or offshore export cable installation scenarios are generally similar regardless of the route location (SWDA versus OECC).

1 INTRODUCTION

New England Wind is the proposal to develop offshore renewable wind energy facilities in Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A 0534 along with associated offshore and onshore cabling, onshore substations, and onshore operations and maintenance (O&M) facilities. New England Wind will be developed in two Phases with a maximum of 130 wind turbine generator (WTG) and electrical service platform (ESP) positions. Four or five offshore export cables will transmit electricity generated by WTGs to onshore transmission systems in the Town of Barnstable, Massachusetts. Park City Wind LLC, a wholly owned subsidiary of Avangrid Renewables, LLC, is the Proponent and will be responsible for the construction, operation, and decommissioning of New England Wind.

New England Wind's offshore renewable wind energy facilities are located immediately southwest of Vineyard Wind 1, which is located in Lease Area OCS-A 0501. New England Wind will occupy all of Lease Area OCS-A 0534 and potentially a portion of Lease Area OCS-A 0501 in the event that Vineyard Wind 1 does not develop "spare" or extra positions included in Lease Area OCS-A 0501 and Vineyard Wind 1 assigns those positions to Lease Area OCS-A 0534. For the purposes of the Construction and Operations Plan (COP), the SWDA is defined as all of Lease Area OCS-A 0534 and the southwest portion of Lease Area OCS-A 0501, as shown in Figure 1.1-1 of COP Volume I. The SWDA may be 411-453 square kilometers (km^2) (101,590-111,939 acres) in size depending upon the final footprint of Vineyard Wind 1. At this time, the Proponent does not intend to develop the two positions in the separate aliquots located along the northeastern boundary of Lease Area OCS-A 0501 as part of New England Wind. The SWDA (excluding the two separate aliquots that are closer to shore) is just over 32 kilometers (km) (20 miles [mi]) from the southwest corner of Martha's Vineyard and approximately 38 km (24 mi) from Nantucket.[2] The WTGs and ESPs in the SWDA will be oriented in an east-west, north-south grid pattern with one nautical mile (NM) (1.85 km) spacing between positions.

Each Phase of New England Wind will be developed and permitted using a Project Design Envelope (the "Envelope"). This allows the Proponent to properly define and bracket the characteristics of each Phase for the purposes of environmental review while maintaining a reasonable degree of flexibility with respect to the selection of key components, such as the WTGs, foundations, offshore cables, and ESPs. To assess potential impacts and benefits to various resources, a "maximum design scenario," or the design scenario with the maximum impacts anticipated for that resource, is established considering the Envelope parameters for each Phase that have the potential to cause the greatest effect. For some resources, the approach overestimates potential environmental impacts as the maximum design scenario is not the scenario the Proponent is likely to employ.

Four or five offshore export cables-two for Phase 1, also known as Park City Wind, and two or three for Phase 2, also known as Commonwealth Wind-will transmit electricity from the SWDA to shore (See Figure 1). Unless technical, logistical, grid interconnection, or other unforeseen issues arise, all New England Wind offshore export cables will be installed within a shared Offshore Export Cable Corridor (OECC) that will travel from the northwestern corner of the SWDA along the northwestern edge of Lease Area OCS-A 0501 (through Vineyard Wind 1) and then head northward along the eastern side of Muskeget Channel toward landfall sites in the Town of Barnstable. At approximately 2 - 3 km from shore, the OECC will diverge for each Phase towards their landfall sites. The OECC for New England Wind is largely the same OECC proposed in the approved Vineyard Wind 1 COP, but it has been widened to the west along the entire corridor and to the east in portions of Muskeget Channel.

While the Proponent intends to install all New England Wind offshore export cables within the OECC that travels from the SWDA northward through the eastern side of Muskeget Channel towards landfall sites in the Town of Barnstable, the Proponent is reserving the fallback option to install one or two Phase 2 cables along

[2] Within the SWDA, the closest WTG is approximately 34 km (21 mi) from Martha's Vineyard and 40 km (25 mi) from Nantucket.

the western side of Muskeget Channel, referred to as the Phase 2 OECC Western Muskeget Variant[3] (see Section 4.1.3.2 of COP Volume I). The sediment transport modeling results for the Western Muskeget Variant to the Covell's Beach Landfall Site are summarized in Appendix B of this document.

This appendix to the New England Wind COP documents the sediment dispersion modeling assessment of the sediment-disturbing offshore cable installation activities associated with the development of New England Wind. The cable installation methods may vary along the route depending on subsurface conditions; the installation methods are described in detail in the COP and the details of the assumed modeling parameters are documented within this report. Consistent with the Envelope, this study has been designed to simulate physical impacts from installation of a representative inter-array cable, a representative offshore export cable within the OECC from the northern edge of Lease Area OCS-A 0501 to the landfall site, and a representative offshore export cable within the portion of the OECC that occurs within Lease Area OCS-A 0501. In addition, the study included sensitivity simulations including installation of the representative inter-array cable, a representative section of the OECC with sand waves, and a representative section of the OECC local to the nearshore landfall site. An illustration of the location of New England Wind and relevant study components is presented in Figure 1.

[3] The Western Muskeget Variant is the same exact corridor as the western Muskeget option included in the Vineyard Wind 1 COP and has already been thoroughly reviewed and approved by BOEM as part of that COP.

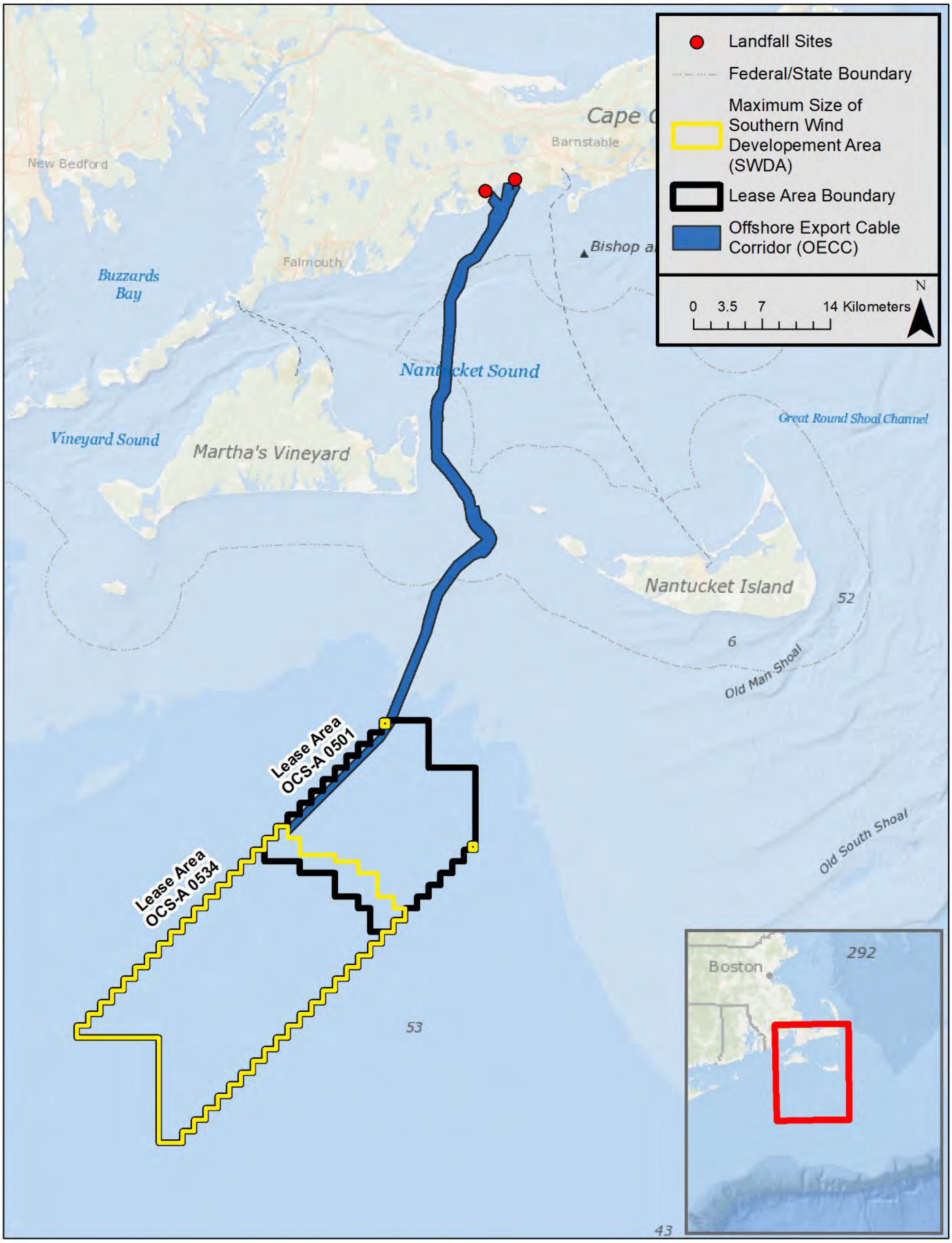

Figure 1. Map of Study Area with Indicative Locations for New England Wind's Offshore Components

1.1 Study Scope and Objectives

RPS applied customized hydrodynamic and sediment transport and dispersion models to assess potential effects from sediment suspension during cable installation activities. This approach is consistent to the modeling approach used for Vineyard Wind 1 and many similar studies that have been accepted by state and federal regulatory agencies for pipeline and cable installation (including the Block Island Wind Farm) as well as harbor dredging and land reclamation activities. Specifically, the analysis includes two interconnected modeling tasks:

1. Development of a three-dimensional hydrodynamic model application of a domain encompassing New England Wind activities using the HYDROMAP modeling system; and
2. Simulations of the suspended sediment fate and transport (including evaluation of seabed deposition and suspended sediment plumes) using the SSFATE modeling system to simulate installation activities. Velocity fields developed using the HYDROMAP model are used as the primary forcing for SSFATE.

This study assessed multiple scenarios representing the range of activities associated with New England Wind cable installation. While it is proposed that four or five cables will be installed within the OECC—two cables for Phase 1 and two or three cables for Phase 2—each cable will be installed in a separate trench; therefore, the simulations run were for a single representative cable. Also, since both Vineyard Wind 1 and New England Wind will share substantially the same OECC and will utilize similar cable installation technologies, the model results presented in this report are the same as those presented for the “Eastern Muskeget to Covell’s Beach” in the report for the Vineyard Wind 1 COP. This study provides new additional simulations including those associated with a representative portion of the OECC in the Lease Area, a representative New England Wind Phase 1 inter-array cable installation, a section of the OECC simulated with cable burial parameters associated with the use of a vertical injector, and a section of the OECC of the landfall approach that extends closer to shore.

This study was carried out to characterize the effects associated with the offshore cable installation activities. The effects were quantified in terms of the above-ambient TSS concentrations as well as seabed deposition of sediments suspended in the water column during cable installation activities (including sand wave dredging). Results are presented with respect to thresholds listed below, which were selected either because they are thresholds of biological significance or because they provide an effective means of demonstrating the physical effects. Thresholds associated with biological significance are documented in Sections 6.5 and 6.6 of the COP Volume III, which are the finfish and invertebrate and benthic sections, respectively.

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

This report describes the models, modeling approach, inputs, and outputs used to assess cable installation activities. A description of environmental data sources used is provided in Section 2. The HYDROMAP hydrodynamic model and its application to the study area are presented in Section 3. Section 4 provides an overview of the SSFATE sediment dispersion model and results from the application of SSFATE for range of scenarios. References are provided in Section 5.

2 STUDY ENVIRONMENTAL DATA

This study for New England Wind used environmental data gathered from public sources or through the OECC survey work completed as part of Vineyard Wind 1. By the end of 2019, more than 4,272 km (2,307 NM) of geophysical trackline data, 123 vibracores, 83 cone penetrometer tests (CPTs), 82 benthic grab samples with still photographs, and 50 underwater video transects were gathered to support the characterization of the OECC. Gathered environmental data were used to develop modeling inputs or for hydrodynamic model validation. An overview of the data types and sources is provided below while more detailed discussions of the data are presented in the hydrodynamic and sediment transport modeling sections. A map illustrating the locations of the discrete data sources is presented in Figure 2.

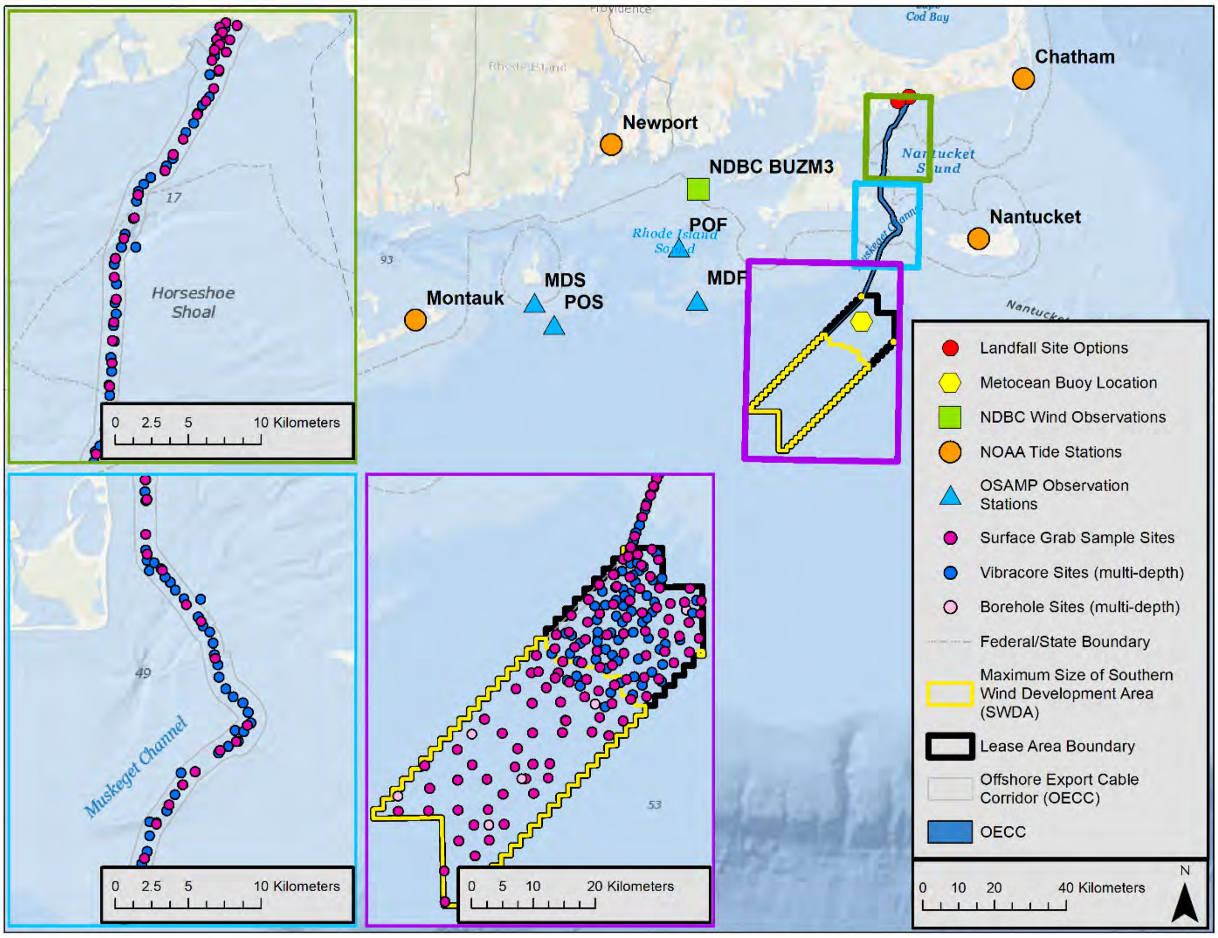

Figure 2. Locations of Environmental Data Sources

2.1 Shoreline Data

New England Wind footprint; the extent was chosen to best locate and define open boundary conditions. The shoreline for the domain was developed based on merging shoreline data from Massachusetts, Rhode Island, Connecticut, and New York, which was obtained from their respective Geographic Information System (GIS) clearinghouses per the links below. Each shoreline was projected from its native state plane coordinate system to the geographic coordinate system GCS_WGS_1984, which is the coordinate system used in the hydrodynamic and sediment transport modeling systems.

- Massachusetts: https://www.mass.gov/get-massgis-data
- Rhode Island: http://www.rigis.org/
- Connecticut: http://www.ct.gov/deep/gisdata/ (superseded by https://portal.ct.gov/DEEP/GIS-and-Maps/)
- New York: http://gis.ny.gov/gisdata/inventories/details.cfm?DSID=927

The shoreline data were used as a guide for developing the hydrodynamic model grid and to develop the land/water boundaries in the concentration and deposition grid used in the sediment transport modeling.

2.2 Bathymetry Data

Bathymetric data were gathered both from National Oceanic and Atmospheric Administration (NOAA) datasets for coastal and offshore waters as well as from detailed marine surveys that were performed in the New England Wind area. NOAA soundings were downloaded from the NOAA ENC (Electronic Navigational Chart) Direct to GIS portal (https://encdirect.noaa.gov/), where data were obtained for the harbor, coastal, and approach Electronic Navigational Chart band levels. Soundings were available from their native positioning, which is irregular in spacing. In addition, detailed marine surveys of the OECC and SWDA were performed to provide high-resolution bathymetric data at a 0.5-m resolution. These data were interpolated to create a grid at a 50-m resolution from which grid centroids were then merged with the NOAA data for a complete dataset of the study area waters. The combined bathymetric dataset was used to develop depths for the hydrodynamic model grid as well as the depth grid used for sediment transport modeling.

2.3 Meteorological Observations

Meteorological (i.e., wind) data used as inputs to the hydrodynamic model were obtained from the National Data Buoy Center (NDBC) BUZ3M Buzzards Bay station, the location of which is shown on Figure 2. Wind speed and direction at this location were obtained from an anemometer located approximately 24.8 m above mean sea level, where measurements were recorded hourly. The currents are dominated by the tides which repeat periodically, and therefore wind speed does not have a major influence on the currents, particularly near the seabed. While any time period would capture the variability of tidal currents, the month of March was selected to run the model since construction in early spring may be possible and the average wind speeds in March are broadly representative of the wind conditions at the site.

Monthly average wind speeds from 2006 to 2016 are presented in Table 1 along with annual averages; a wind rose of the same period is provided in Figure 3. While the monthly average wind speed ranged from 3.83 to 10.29 meters per second (m/s), it stayed primarily between 5.78 and 9.38 m/s (5^{th} and 95^{th} percentile, respectively). The average annual speed was 7.6 m/s, and the average wind speed for the month of March was 8.10 m/s which is also close to the average annual windspeed. Reviewing the monthly averages throughout the record, March 2016 was identified as having a monthly average (8.14 m/s) close to the record March average monthly windspeed and close to the average annual wind speed.

Table 1. Monthly Average Wind Speeds, 2006–2016

Timeframe	Monthly Average Wind Speed (m/s)											Average
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Jan	9.13	7.19	8.86	8.68	8.63	7.84	9.15	8.61	9.40	10.05	9.59	8.83
Feb	9.84	7.30	8.50	8.87	8.80	8.93	7.88	9.11	8.30	9.33	9.37	8.75
Mar	7.94	7.25	8.67	7.68	8.72	8.32	7.77	8.54	8.23	7.87	8.14	8.10
Apr	7.62	8.02	6.78	8.19	6.56	8.02	7.29	7.59	7.63	7.64	7.89	7.57
May	7.75	6.83	7.83	6.87	6.89	6.84	5.99	6.81	7.03	6.73	7.01	6.96
Jun	7.35	7.29	5.92	5.95	6.27	5.84	6.79	7.24	5.96	6.66	6.20	6.50
Jul	6.94	5.90	5.79	6.22	5.65	5.97	3.83	6.50	6.78	5.78	6.15	5.96
Aug	5.80	5.78	5.04	5.72	6.54	6.24	5.27	5.84	5.40	5.82	6.14	5.78
Sep	6.81	6.63	6.53	6.79	7.65	6.54	6.58	6.55	6.34	6.34	7.13	6.72
Oct	9.36	7.62	8.14	8.64	9.59	8.16	7.82	6.99	8.66	9.09	8.00	8.37
Nov	7.46	9.09	8.24	8.67	9.04	8.45	8.79	9.21	9.30	8.10	8.43	8.62
Dec	8.78	8.90	10.07	10.29	10.17	7.96	8.65	8.35	8.63	8.12	9.13	9.00
Annual	7.90	7.32	7.53	7.71	7.88	7.43	7.15	7.61	7.64	7.63	7.76	**7.60**

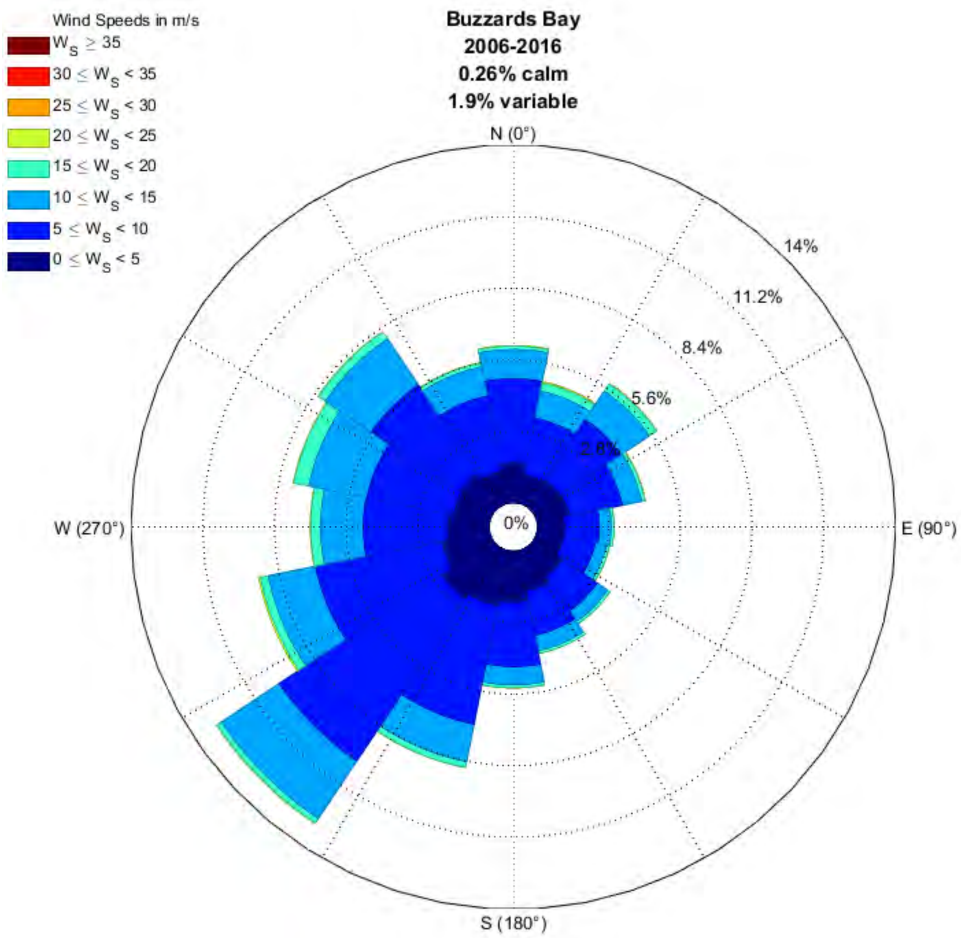

Figure 3. Wind Rose for 2006–2016 at NDBC BUZ3M Buzzards Bay Station

2.4 Sea Surface Height (Tides) Observations

Sea surface height characteristics were used to develop model forcing and verify hydrodynamic model predictions. Four data sources were used for this study, with data available either as time histories of observed water surface elevations or in the form of tidal harmonic constituents from a global model. Tidal harmonic constituents are the amplitude and phase of known periodic constituents of the tidal signal, where the tidal signal is the sum of all constituents added together by superposition. The amplitude describes the difference between a mean sea level datum and the peak water level for a constituent, and the phase describes the timing of the signal relative to a time datum. The constituent period determines the time for one full oscillation of the signal. The names of tidal harmonic constituents indicate the approximate period (e.g., M2 is twice daily and O1 is once daily).

The publicly available output from the TPXO7 global tidal model developed by Oregon State University was used to characterize the tides in the hydrodynamic model boundary forcing. This model output contains tidal harmonic constituent data on a one-quarter degree resolution across the globe. The model was based on data from the TOPEX/Poseidon and Jason satellites and the model methodology is documented in Egbert et al. (1994) and Egbert and Erofeeva (2002). The constituents obtained and their periods are provided in Table 2. Details on the spatially-varying amplitude and phase used to force the hydrodynamic model are provided in Section 3.2.2.

Table 2. Tidal Harmonic Constituents used as Hydrodynamic Model Boundary Forcing

Name	Constituent	Speed (degrees/hour)	Period (hours)
M2	Principal lunar semidiurnal constituent	28.98	12.42
S2	Principal solar semidiurnal constituent	30.00	12.00
N2	Larger lunar elliptic semidiurnal constituent	28.44	12.66
K1	Lunar diurnal constituent	15.04	23.93
O1	Lunar diurnal constituent	13.94	25.82

Observation-based tidal harmonic data were obtained from NOAA Tides and Currents for stations within the study area (see Figure 2). NOAA-published amplitudes and phases for M2, N2, S2, K1, and O1 constituents are provided in Table 3 and Table 4, respectively. These constituents were used to develop time histories of sea surface height at each location for different periods of time using the publicly available T_Tide Matlab Toolbox with methodologies of the toolbox described in Pawlowicsz et al. (2002). These time histories were used to validate model predictions.

Time histories of observational water column data (pressure) and published harmonic constituents from Grilli et al. (2010) characterizing the tides at two of the Rhode Island Ocean Special Area Management Plan (OSAMP) offshore buoys (POF and POS) were used in this study. Locations of the buoys are shown in Figure 2; note that the OSAMP had four buoys, but only two collected pressure which was converted to water depth to capture the tides. Data were available from October 2009 through June 2010 at a two-hour time step. Amplitudes and phases for the M2, N2, S2, K1, and O1 constituents at the OSAMP stations are provided in Table 3 and Table 4, respectively.

Table 3. Amplitudes of Tidal Harmonic Constituents at Points in the Study Area

Summary of Harmonic Constituent Amplitude (m)						
Location	**Source**	**M2**	**S2**	**N2**	**K1**	**O1**
Sandy Point	NOAA	0.688	0.134	0.158	0.103	0.054
Montauk	NOAA	0.302	0.065	0.079	0.074	0.054
Newport	NOAA	0.505	0.108	0.124	0.062	0.047
Nantucket	NOAA	0.439	0.047	0.113	0.092	0.084
Chatham	NOAA	0.713	0.089	0.139	0.103	0.088
POS	Grilli et al.	0.443	0.095	0.104	0.073	0.022
POF	Grilli et al.	0.452	0.098	0.111	0.068	0.034

Table 4. Phases of Tidal Harmonic Constituents at Points in the Vicinity of the Study Area

Summary of Harmonic Constituent Phase (degrees)						
Location	**Source**	**M2**	**S2**	**N2**	**K1**	**O1**
Sandy Point	NOAA	6.0	32.6	348.6	175.7	172.5
Montauk	NOAA	46.8	56.6	22.2	178.7	209.8
Newport	NOAA	2.3	25.0	345.8	166.1	202.0
Nantucket	NOAA	134.7	166.7	102.5	221.6	215.9
Chatham	NOAA	140.0	182.1	108.5	237.6	223.4
POS	Grilli et al.	3.9	18.7	350.5	166.8	16.3
POF	Grilli et al.	0.9	18.2	344.7	167.2	7.4

2.5 Ocean Current Observations

This study used observations of ocean currents from two different programs: the OSAMP and a field program carried out by the Proponent. Observations of currents were obtained from four OSAMP stations (MDF, MDS, POF, POS) (See Figure 2). At each station, currents were obtained at multiple depths through the water column through a number of different vertical bins. A summary of metrics for each station is provided in Table 5. The current observations were used to verify model predictions directly through comparison of the observed data to model predictions for times within the OSAMP deployment period.

Table 5. OSAMP Station Metrics and Current Observations

Source	Station Name	Time Step (hr)	Start Day Obtained	End Day Obtained	Bin Resolution (m)
OSAMP	POS	2	9/15/2009	1/15/2010	0.75
OSAMP	POF	2	9/15/2009	1/15/2010	0.75
OSAMP	MDF	1	10/9/2009	6/10/2010	1
OSAMP	MDS	1	10/9/2009	5/21/2010	1

Additionally, a metocean buoy was deployed within Lease Area OCS-A 0501 at the location shown in Figure 2. The buoy has been collecting metocean data, including observed current speeds and directions, since May 2018 at multiple ‘bins’ in the water column to provide observations of the currents as a function of depth. A record of some of the observed data was provided to RPS to be used for a qualitative comparison of the model predications at the buoy location. The comparison was qualitative in the sense that it was not based on model predictions from the deployment period but rather a general comparison of the observed characteristics versus the model predicted characteristics.

2.6 Sediment Grain Size Distribution Data

This study utilized sediment data from multiple field campaigns focused on the SWDA and the OECC. Sample sites and detailed grain size results are documented in Volume II of the COP. These field campaigns produced a combination of grab samples, vibracores, and borehole samples. The samples underwent varying degrees of analysis including sieve analysis, hydrometer analysis, and moisture testing. The sample locations sites used in this study are shown in Figure 2. Detailed information about samples, as they were used to develop inputs to the sediment transport model, is provided in Section 4.

3 HYDRODYNAMIC MODELING

The first modeling task was the development, validation, and application of a three-dimensional hydrodynamic model application of a domain that included all New England Wind activities. RPS' HYDROMAP hydrodynamic model was used to model the circulation pattern and water volume flux through the study area and to provide hydrodynamic conditions (spatially and temporally varying currents) for input to the sediment dispersion model. The hydrodynamic modeling task included gathering and analyzing environmental data, developing a hydrodynamic model grid and boundary conditions, validating model performance for a period with observations, and developing currents for a timeframe characterized by typical wind conditions to be used in sediment transport simulations.

Circulation (currents) in the study area is tidally dominated (Spaulding & Gordon 1982), with wind and density variations playing a smaller role. Tidal currents in the study area are a combination of rectilinear reversing currents and rotary currents (Haight 1936) and are predominately semidiurnal (two nearly equal high tides and low tides every day) and diurnal (one high and one low tide every lunar day). Notably strong tidal currents (peaks greater than 1.5 m/s) exist in the area surrounding Muskeget Channel, which is located between the islands of Nantucket and Martha's Vineyard, with Nantucket Sound to the north and the Atlantic Ocean to the south (NOAA 2017).

Tidal currents are present throughout the water column, and their predominance is clear when evaluating observed current data, particularly near the seafloor. Depending on wind speed and water depth, wind can also influence surface currents and, at times, bottom currents, and therefore plays a minor role in sediment transport through most of the study area. Therefore, since tidal currents exhibit cyclical, repeating patterns and are not characterized by season, wind was chosen as the metric for identifying an environmental timeframe for use in sediment transport and dispersion modeling.

3.1 HYDROMAP Model Description

The RPS-developed HYDROMAP (Isaji et al. 2001) is a globally re-locatable hydrodynamic model capable of simulating complex circulation patterns due to tidal forcing, wind stress, and freshwater flows anywhere on the globe. HYDROMAP employs a novel step-wise-continuous-variable rectangular gridding strategy with up to six levels of resolution. The term "step-wise-continuous" implies that boundaries between successively smaller and larger grids are managed in a consistent integer step. The advantage of this approach is that large areas of widely differing spatial scales can be addressed within one consistent model application. Grids constructed by the step-wise-continuous-variable rectangular are still "structured" so arbitrary locations can be easily located to corresponding computational cells. This mapping facility is particularly advantageous when outputs of the hydrodynamic model are used in subsequent application programs (e.g., Lagrangian particle transport model) that use another grid or grid structure.

The hydrodynamic model solves three-dimensional conservation equations in spherical coordinates for water mass, density, and momentum with the Boussinesq and hydrostatic assumptions applied. These equations are solved subject to the following boundary conditions:

1. At land boundaries, the normal component of velocity is set to zero.
2. At the open boundaries, the sea surface elevation is specified by the dominant tidal constituents, each with its own amplitude and phase from a reference time zone, or as a time series of total surface elevation defined relative to the local surface elevation.
3. At the sea surface, the applied stress due to the wind is matched to the local stress in the water column and the kinematic boundary condition is satisfied.
4. At the seafloor, a quadratic stress law, based on the local bottom velocity, is used to represent frictional dissipation and a friction coefficient parameterizes the loss rate.

The numerical solution methodology follows that of Davies (1977) and Owen (1980). Vertical variations in horizontal velocity are described by an expansion of Legendre polynomials. Resulting equations are then solved by a Galerkin-weighted residual method in the vertical and by an explicit finite difference algorithm in the horizontal. A space-staggered grid scheme in the horizontal plane is used to define the study area, and sea surface elevation and vertical velocity are specified in the center of each cell while the horizontal velocities are given on the cell face. To increase computational efficiency, a "split-mode" or "two mode" formulation is used (Gordon 1982; Owen 1980). In the split-mode, the free-surface elevation is treated separately from the internal, three-dimensional flow variables. The free-surface elevation and vertically integrated equations of motion (external mode), for which the Courant-Friedrichs-Lewis limit must be met, is solved first. The vertical structure of the horizontal components of the current may then be calculated such that effects of surface gravity waves are separated from the three-dimensional equations of motion (internal mode). Therefore, surface gravity waves no longer limit the internal mode calculations and much longer time steps are possible. The interested reader is directed to Isaji et al. (2001) and Isaji and Spaulding (1984) for a detailed description of the model physics and numerical implementation.

3.2 HYDROMAP Model Application

The model application was developed for simulations in the three-dimensional mode. First, an application was developed for a period with available in-situ current observations to verify model performance. Subsequent to model verification, an additional scenario application was developed for a period that reflected typical wind conditions, and the output was used in the sediment dispersion modeling. The main model application features are the model grid, bathymetry, and boundary forcing. These features are described in more detail below.

3.2.1 Model Grid

As described in Section 2.1, the shoreline for the model domain was developed based on merging shoreline data from each of the relevant states: Massachusetts, Rhode Island, Connecticut, and New York. The grid was mapped to the shoreline, with a coarse resolution at distances farther away from the immediate study area and fine resolution in areas closest to New England Wind components or where necessary to capture the physical characteristics of the study area.

Figure 4 shows the computational model grid cells for the entire domain, which consists of 24,313 active water cells. At the open eastern and southern boundaries and in the outer regions, a maximum cell size of approximately 1 km was assigned. Cell resolution was increased as needed to capture finer features and adequately resolve coastal features within the study area. The finest resolution of approximately 125 m was applied closer to shore to capture changes in shoreline and bathymetry. The model allows for three-dimensional simulations, which were utilized for this study. The vertical grid is represented by six Legendre polynomials to represent vertical variability in currents from tidal and wind forcing.

Model grid bathymetry was assigned by interpolating from a set of individual data points (developed as described in Section 2.2) onto the model grid. For grid cells with multiple soundings, values were averaged; for grid cells without soundings, the values were interpolated based on the closest soundings. The final gridded bathymetry in the study area is shown in Figure 5. Figure 5 is focused on the Offshore Development Area, which is the area where the Proponent’s offshore facilities are physically located and includes the SWDA and OECC.

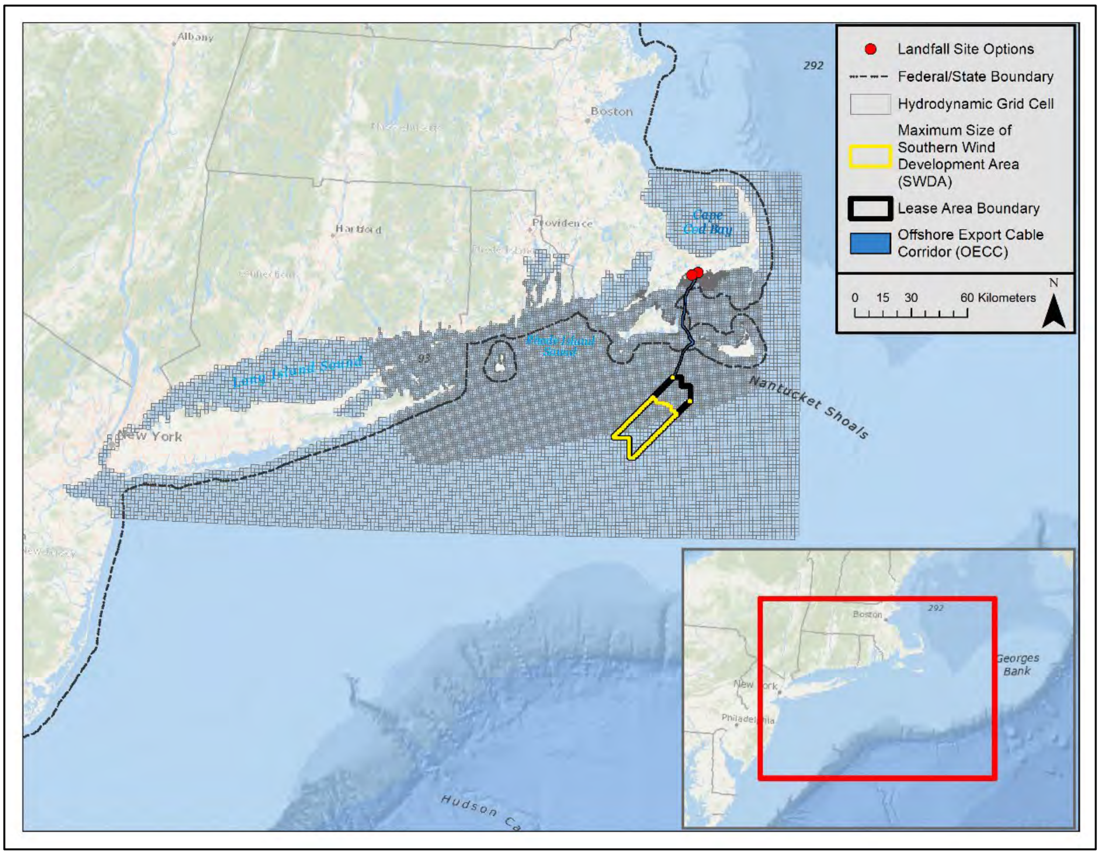

Figure 4. Hydrodynamic Model Grid

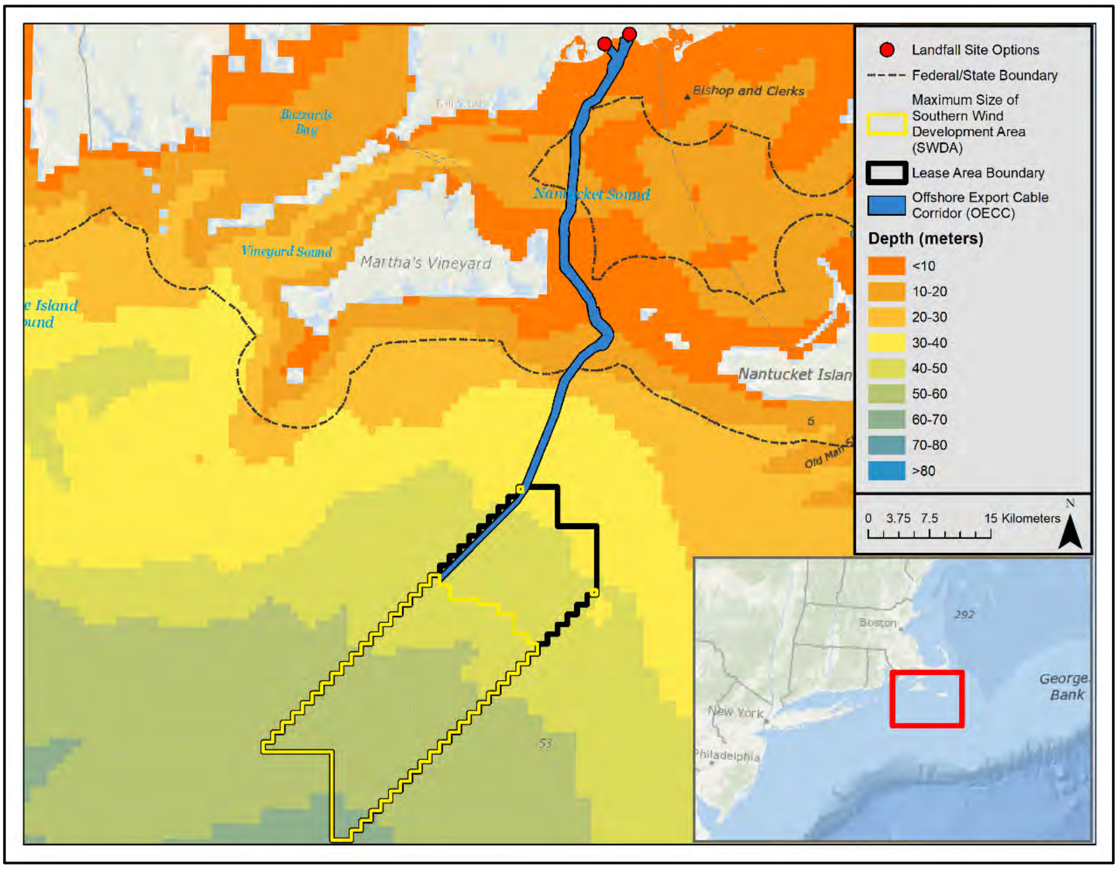

Figure 5. Model Grid Bathymetry Focused on the New England Wind Offshore Development Area

3.2.2 Model Boundary Conditions

Model boundary conditions included specification of tidal harmonic characteristics at open boundary water cells at the edge of the domain and surface winds that were applied to all cell surfaces.

<u>Tidal Boundary Conditions</u>

As previously noted, water circulation in the study area is tidally dominated (Spaulding and Gordon 1982) and is the key boundary forcing. Tidal harmonic constituent data extracted from the TPXO global tidal model were used at the model open boundaries. Each boundary cell was assigned a unique set of the tidal harmonic constituent amplitudes and phases. In total, the open boundary was specified for the predominant five tidal constituents in the area: three semidiurnal (M2, N2, and S2) and two diurnal (K1 and O1). HYDROMAP (Isaji et al. 2001) employs a strategy that uses the harmonic construction of astronomic tidal currents where each harmonic constituent is simulated individually and then the real-time tide is assembled using the harmonic summation of these simulated constituents. The dominant tidal constituent in this region is the M2-principal lunar semidiurnal (twice daily) constituent. The M2 causes the sea level to rise and fall approximately twice daily. This creates currents that peak and change direction approximately twice daily in the areas of reversing currents and rotary currents that complete their rotation approximately twice daily. Illustrations of amplitude and phase along the model grid open boundaries are shown in Figure 6 and Figure 7, respectively. Figure 6 illustrates that the M2 amplitude is greater than 0.4 m in most places with the exception of the southeast region of the domain. Figure 7 illustrates how the M2 phase is generally similar parallel to Long Island and Narragansett Bay, while a sharp change in phase is present southeast of Nantucket; north of this transition, the phase is again relatively similar. These notable features create the predominately semidiurnal surface elevation and current patterns; the sharp phase change southeast of Nantucket contributes to relatively fast-moving rotary currents within this domain.

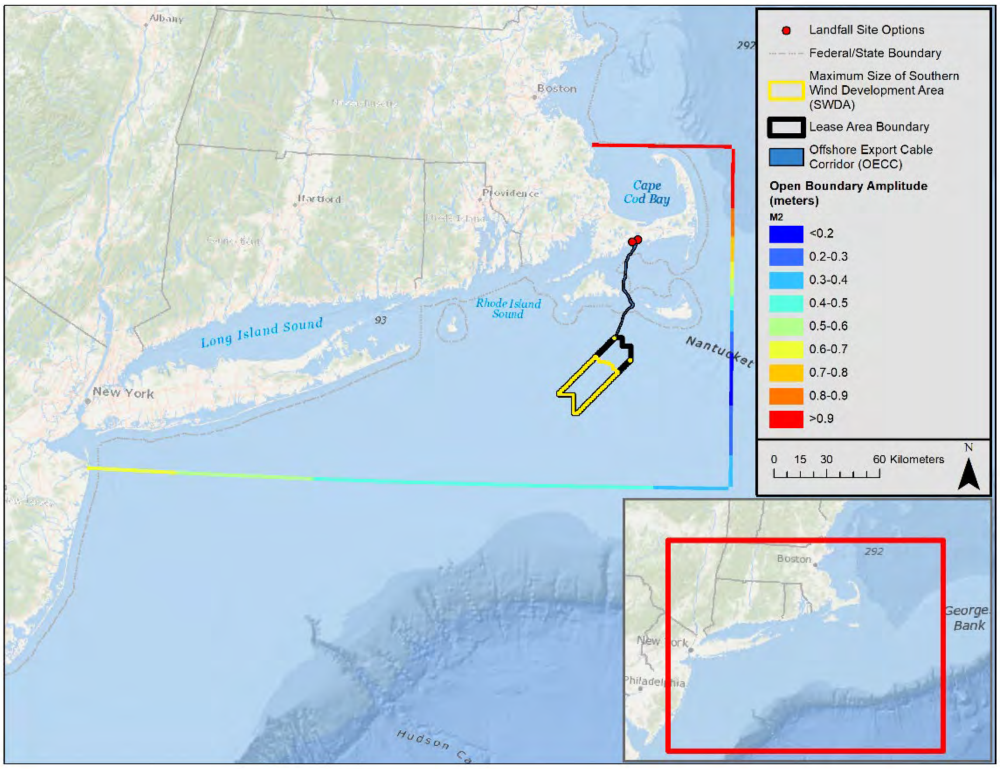

Figure 6. Tidal Boundary Forcing M2 Amplitude

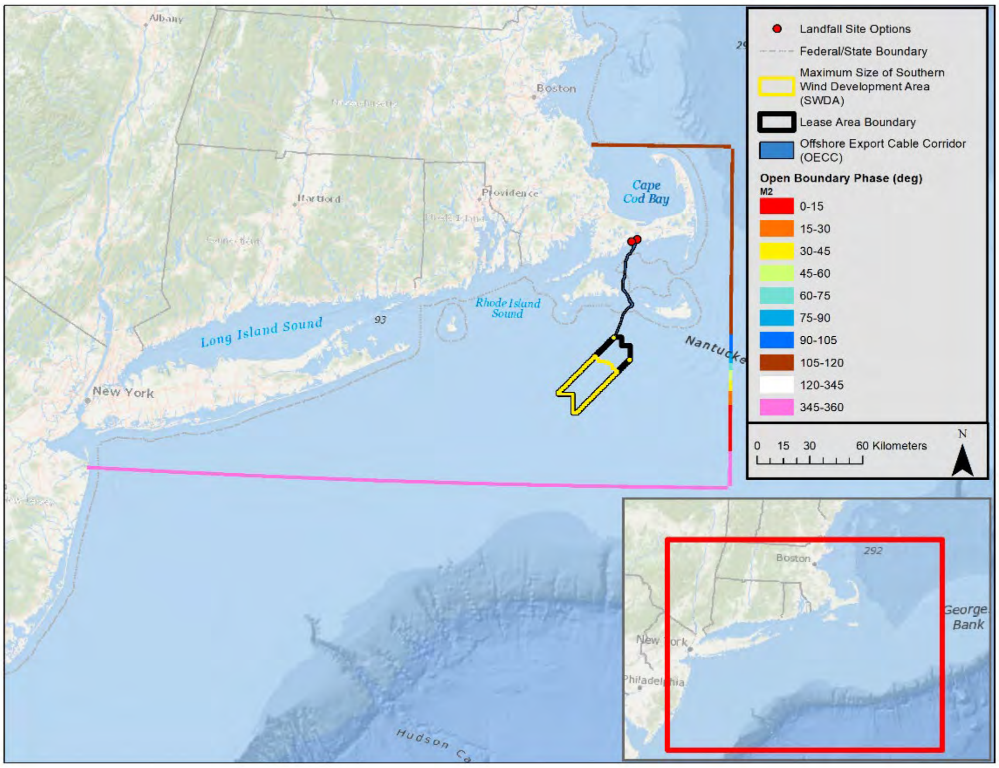

Figure 7. Tidal Boundary Forcing M2 Phase[1]

Notes:

1. Phase is defined between 0–360 degrees (and 360 degrees also equals 0 degrees) and there are no phases between 120–345 degrees which is why there are no white cells per the legend above.

Meteorological (Water Surface) Boundary Condition

The water surface boundary covers the entire gridded area and is influenced by wind speed and direction. Meteorological data were obtained from the NDBC Buzzards Bay Station, as described in Section 2.3, and was applied to the entire grid surface.

3.2.3 Model Results

The model was run for two different periods, the verification period and a scenario period. The verification period is a period with available observations such that the model predictions can be verified and the scenario period is the period of time simulated to produce a data set for the sediment transport modeling.

3.2.3.1 Model Application for Verification Period

Model-predicted surface elevations and current speeds at multiple water depths were compared to available observations to ensure the modeling was adequately reproducing tidal amplitude, current velocity, current direction, and vertical structure of the water column. The period used for model verification was October 15 to November 14, 2009. This date range was chosen because it had oceanographic (current) observations available from the OSAMP. Model predictions of water surface elevations at stations with tide data (pink) are compared with observed signals or with those reconstructed based on harmonics (blue) in Figure 8 (note the figure depicts a shorter period to facilitate viewing). This figure shows that the model was able to recreate the amplitude and phase throughout the domain.

A comparison of model predicted currents speeds and directions was also performed and presented as a comparison of current roses. Current roses show the frequency and intensity of current speed and direction. The rose petals reflect the direction the current flows towards and the color of the petals reflects the frequency of different speed intervals in each respective direction. A comparison of currents at the middle of the water column for the OSAMP locations are presented in Figure 9 (POS and POF) and Figure 10 (MDF and MDS) with observed roses shown on the left and modeled roses shown on the right. The model was able to recreate the range of speeds and general trends of directions. Both the observed and modeled show that speeds at the locations with observations are between approximately 0.15–0.25 m/s on average. The ability of the model to recreate the water surface elevations across the large domain and to recreate the predominate circulation features at these discrete points within the domain provides confidence that the model can be used to simulate actual conditions.

In addition to the comparison of model to observational data for a period of time with observations available, an additional qualitative comparison of current speeds at the location of a metocean buoy in the northern portion of Lease Area OCS-A 0501 was performed. The comparison was made based on observations for a period that was different from the model runs; however, it is expected that both records were long enough to capture the general trends of the currents at the buoy location. The observed and modeled current rose is presented in Figure 11. Figure 11 shows that both the observed data and model predictions result in the same trend of current directions and the same range of current speeds. It also shows that the speeds are typically less than 0.2 m/s and move in eastward or westward directions. The modeled record does have higher speeds; however, they are not frequent and may be due to anomalous wind forcing and not the predominate tidal circulation. Given that the model can capture the trends of the observed data, it is concluded that model predictions are representative of actual conditions.

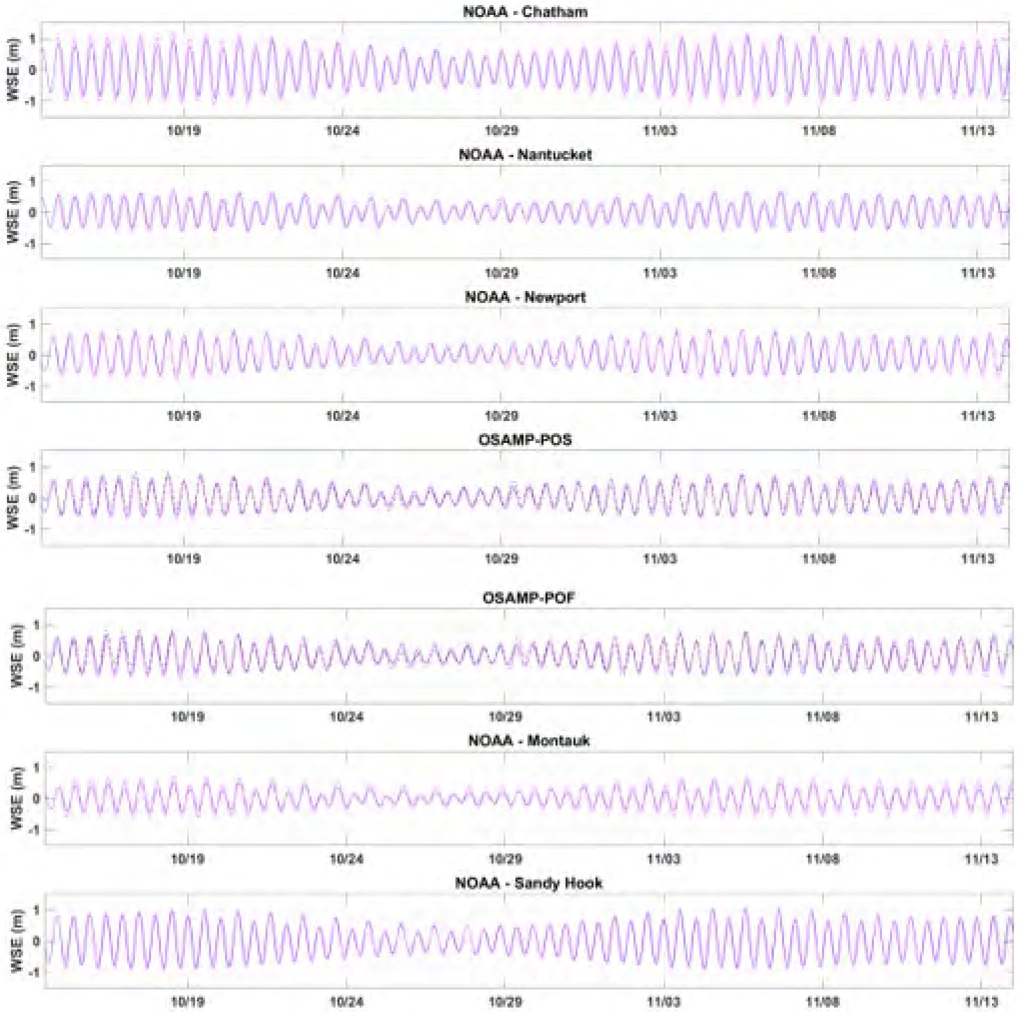

Figure 8. Comparison of Model Predicted to Constructed Tidal Elevations from Station Harmonics at Stations within the Model Domain[1]

Notes:

1. Modeled data is shown in pink and reconstructed data in blue. Y-axis for each sub plot ranges from -1.5 m to 1.5 m

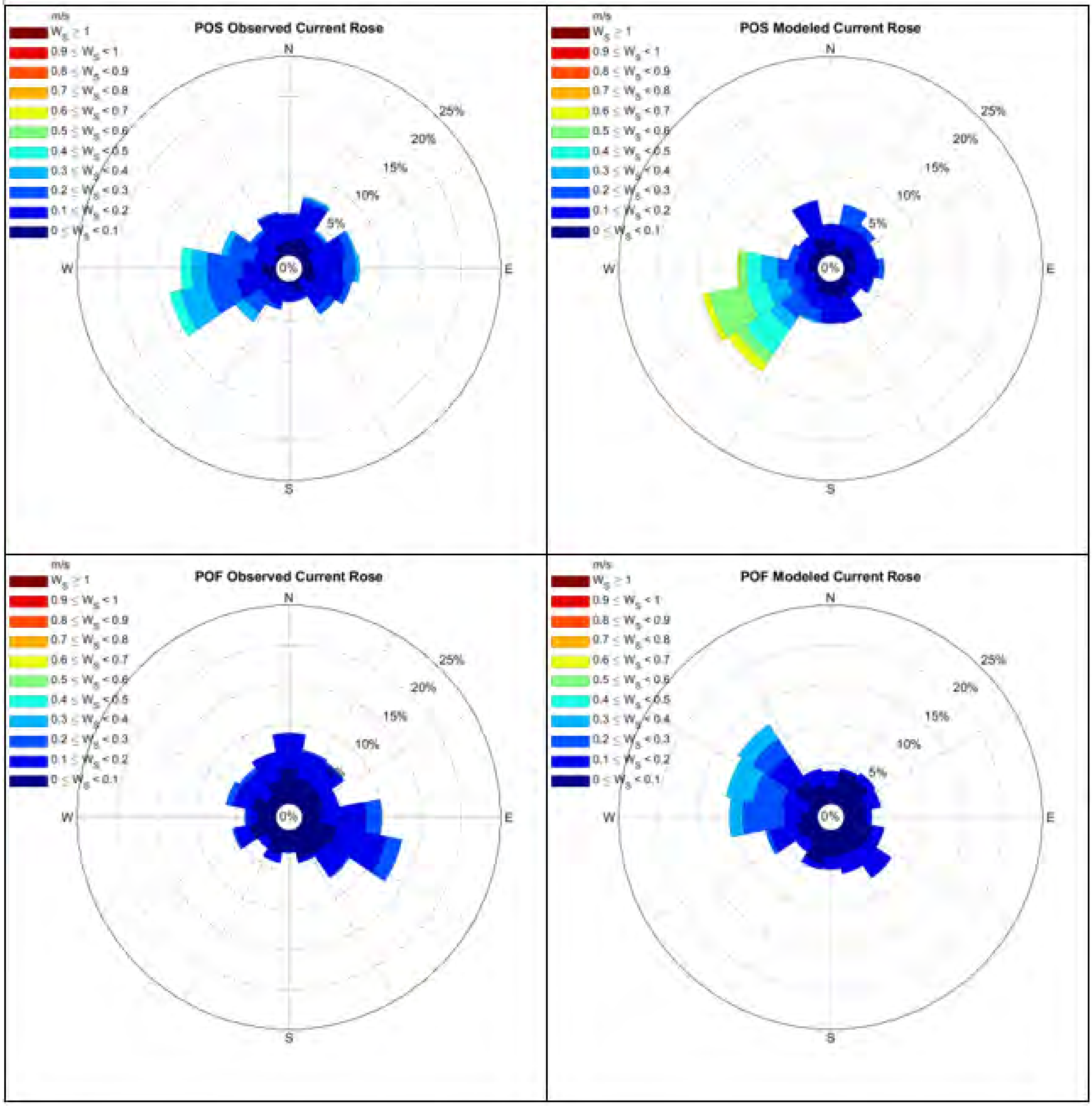

Figure 9. Comparison of observed (left) to modeled (right) currents at stations POS (top) and POF (bottom) presented as current roses from model verification period

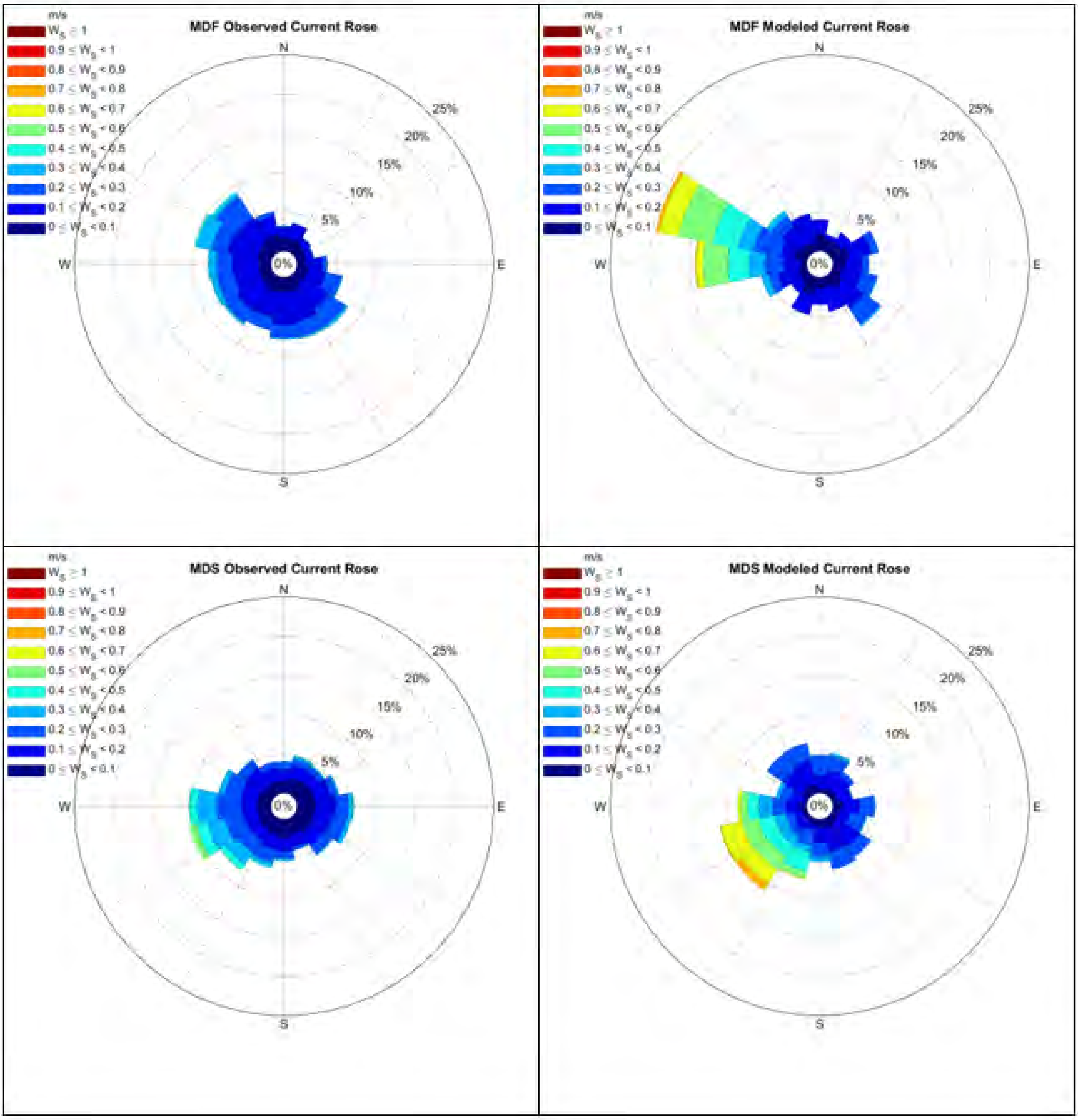

Figure 10. Comparison of observed (left) to modeled (right) currents at stations MDF (top) and MDS (bottom) presented as current roses from model verification period

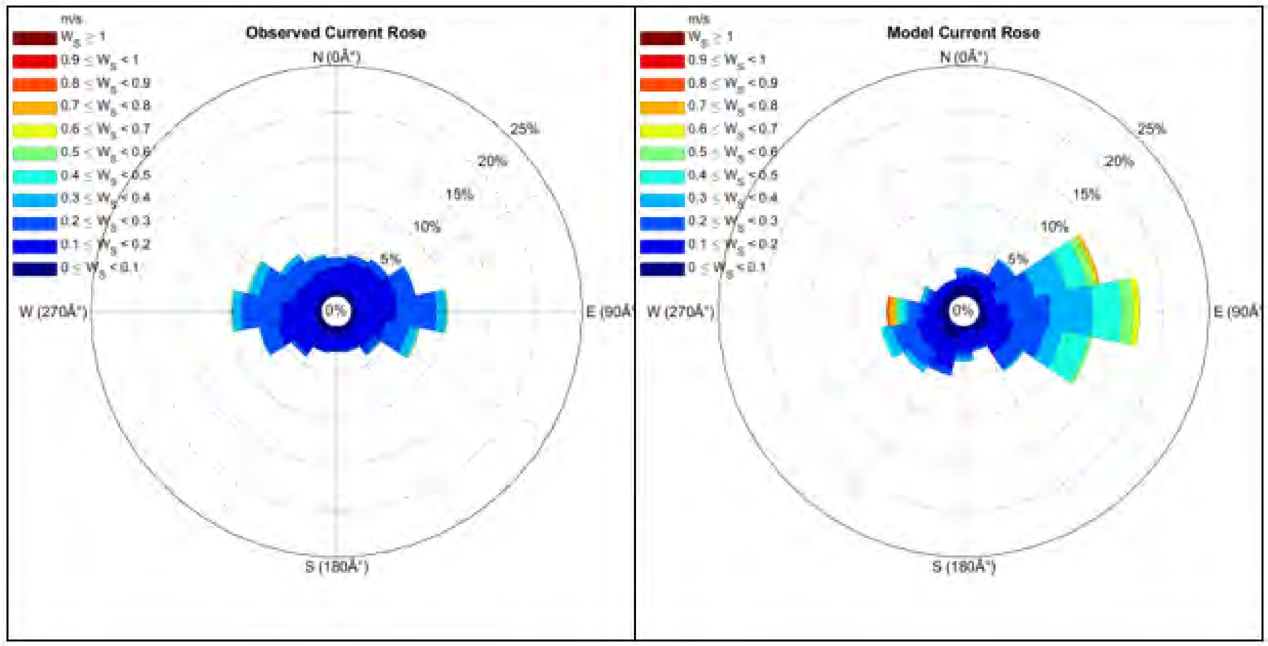

Figure 11. Qualitative comparison of observed (left) to modeled (right) currents at the metocean buoy location from a period within its deployment versus model predictions for the period used in the sediment transport modeling (detailed in Section 3.2.3.2)

3.2.3.2 Model Application for Scenario Period

Once the model performance was verified, a second application for a period with typical winds was modeled from March 1 to April 3, 2016. Snapshots of typical flood and ebb bottom current speeds and patterns are shown in Figure 12 and Figure 13, respectively; surface speeds are of a similar pattern but slightly stronger magnitude. Currents are variable throughout the New England Wind Offshore Development Area and relatively weak within the SWDA, though they increase sharply through Muskeget Channel. Within Vineyard Sound, currents are moderate, decreasing towards the coast.

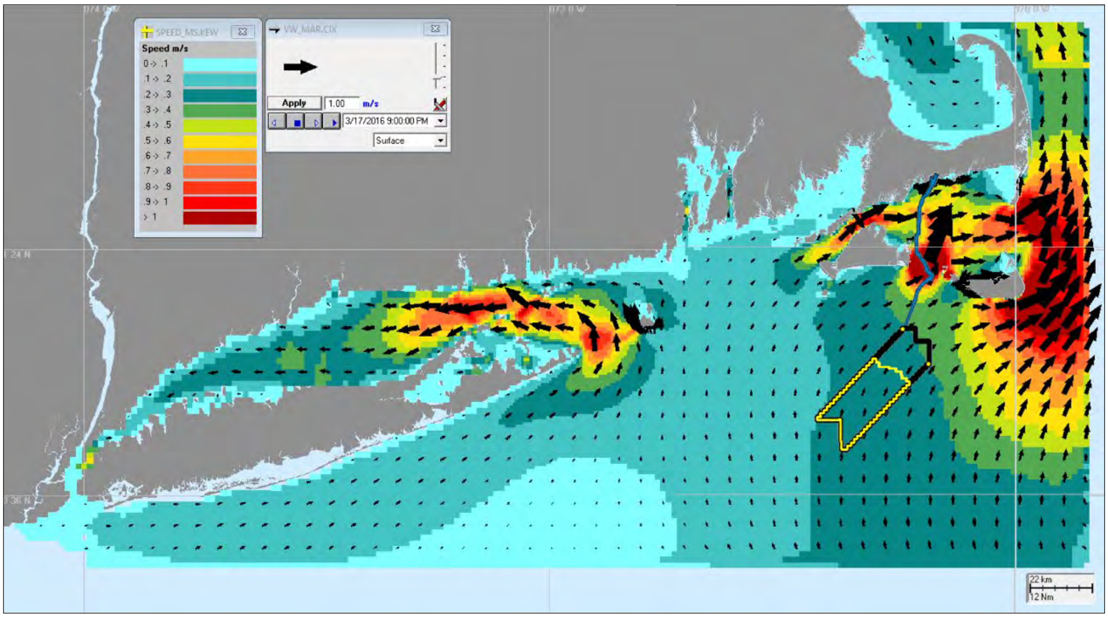

Figure 12. Snapshot Showing Peak Flood Current[1]

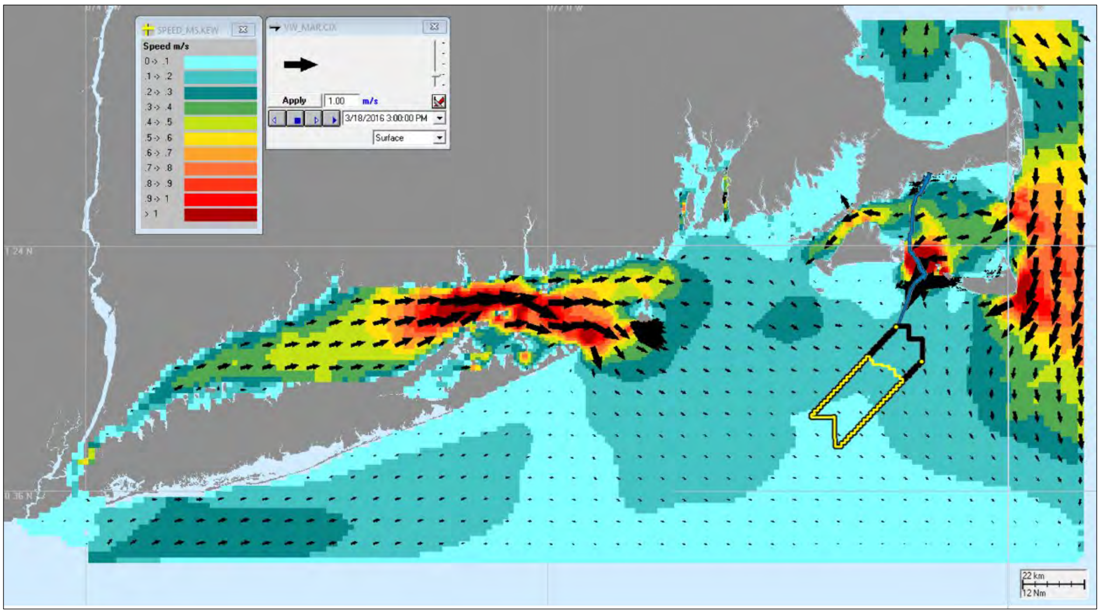

Figure 13. Snapshot Showing Peak Ebb Current[1]

Notes:

1. Cells are contoured by speed magnitude and vectors (sub-sampled for every 4th cell for clarity) show direction.

4 SEDIMENT MODELING

The sediment modeling was carried out using RPS in house model SSFATE. A description of the model, model application and the modeling results are presented in the following sections.

4.1 SSFATE Model Description

SSFATE is a three-dimensional Lagrangian (particle) model developed jointly by the United States (US) Army Corps of Engineers' Environmental Research and Development Center and Applied Science Associates (now part of RPS) to simulate sediment resuspension and deposition originally from marine dredging operations. Model development was documented in a series of US Army Corps of Engineers' 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. 2006; Swanson and Isaji 2004). 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 et al. 2006) and mechanical ploughs as well as sediment dumping and dewatering operations. The current modeling system includes a GIS-based interface for visualization and analysis of model output.

SSFATE computes TSS 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 with these studies receiving acceptance from federal and state regulatory agencies.

4.1.1 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 utilizes 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 (See Table 6.). 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 6. 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
	4	Fine sand	75-130
Coarse	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 density 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 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 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, the interested reader is directed to Swanson et al. (2007).

4.1.2 General Description of SSFATE Model Set-Up

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:

- The geographic extent of the activity (point release versus line source [route]);
- Grain size distribution along the 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 also requires characterization of the environment, including a definition of the study area's spatially and time-varying currents (HYDROMAP output) and water body bathymetry. Model setup also requires 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 hydrodynamic or bathymetric data used as inputs; this allows finer resolution which better captures water column concentrations without being biased by numerical diffusion. The concentration and deposition gridding is 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.

4.2 Study Model Application

A number of SSFATE model scenarios were run to encompass the potential cable routes and construction approaches included in the New England Wind Envelope. The following sections describe the routes and associated sediment-suspending activities as they pertain to defining modeling inputs.

4.2.1 Scenario Components: Routes

The model scenarios have been separated into two components: (1) the inter-array cables located within the SWDA; and (2) the offshore export cables located within the OECC.

The modeled inter-array cable route was selected from a representative layout of the New England Wind Phase 1 and Phase 2 inter-array cables. Grain size characteristics were reviewed for the entire SWDA. The individual inter-array cable route that passed through relatively larger regions of finer sediment was selected to model a conservative assessment of potential impacts from cable installation within the SWDA for either Phase 1 or Phase 2. Fine sediments (e.g., clays, silts) tend to last longer in the water column, whereas coarse sediment (e.g., fine sand, coarse sand) will settle at a faster rate. The route selected for modeling was a Phase 1 inter-array cable route, but it provides representative results for either Phase 1 or Phase 2. Similarly, short lengths of offshore export cable will need to be installed within the SWDA to reach the Phase 1 and Phase 2 ESPs, and inter-link cables may be used to connect ESPs. Due to the similarities in installation methods, the modeled results for inter-array cable installation are representative of potential impacts of inter-link and offshore export cable installation within the SWDA. Both the potential layout and the individual component modeled are shown in Figure 14. No sand wave dredging is proposed for either phase of inter-array cable installation.

The modeled offshore export cable route was selected along an approximate centerline within the OECC. As described in Section 1.1, the OECC is the same for both Phases of New England Wind until approximately 2–3 km from shore, at which point the OECC will diverge for each Phase to reach separate landfall sites in Barnstable. For Phase 1, the OECC includes two possible landfall sites located nearby to one another along the same stretch of shoreline in Barnstable: Craigville Public Beach Landfall Site and Covell’s Beach Landfall Site. Due to the proximity and similar sediment grain size results of the two landfall sites, the Craigville Public Beach Landfall Site route was modeled and serves as a proxy of results for the Covell’s Beach Landfall Site. The Phase 2 Landfall Site will be located to the west of Craigville Public Beach at the Dowses Beach Landfall Site and/or Wianno Avenue Landfall Site. Additionally, modeling of the Phase 1 Landfall Site was considered as a conservative representation of a worst-case plume for the Phase 2 Landfall Site because this location has a relatively high fraction of fine sediments compared with those of Phase 2.

The offshore export cable scenarios that were modeled include a representative offshore export cable route for a section of the OECC from the northern edge of Lease Area OCS-A 0501 to the Craigville Public Beach Landfall Site. A representative shorter offshore export cable route within Lease Area OCS-A 0501 (referred to as “Representative OECC in Lease Area OCS-A 0501”) was also modeled. The model scenarios also include several representative sections of the OECC, including a representative section of the OECC with sand waves, where cable installation is accomplished using a vertical injector, and a representative section of the OECC local to the nearshore Craigville Public Beach Landfall Site.

The representative cable installation within the OECC and detailed views of the various sections that were simulated are shown in Figure 15 through Figure 18.

A key component of the modeling is the delineated geographical extent of the source. The New England Wind cable routes assessed as part of this study are presented in Table 7. A further breakdown of the route length modeled for various installation methodologies simulated is presented in Table 8.

Table 7. Offshore Cable Routes Modeled and Assessed

New England Wind Functional Component	Total Route Length (km)
SWDA Representative Inter-array	19.9
OECC Lease Area OCS-A 0501 to Nearshore	61.2

Table 8. Route Length Modeled for Different Technologies and OECC Sections

OECC Methodology	Total Possible Route Length
Offshore Cable Installation	
TSHD	Intermittent along 61.2 km of route (Approximately 10% of route)
Limited TSHD	Intermittent along 61.2 km of route (Approximately 1 % of route)
Cable Installation	61.2 km (Representative OECC)
Cable Installation Aided by Jetting	61.2 km (Representative OECC)
Cable Installation along OECC in Lease Area OCS-A 0501	11.9 km (Representative Section of OECC)
Vertical Injector Section	1.7 km (Representative Section of OECC)
Landfall Approach Section	2.5 km (Representative Section of OECC)

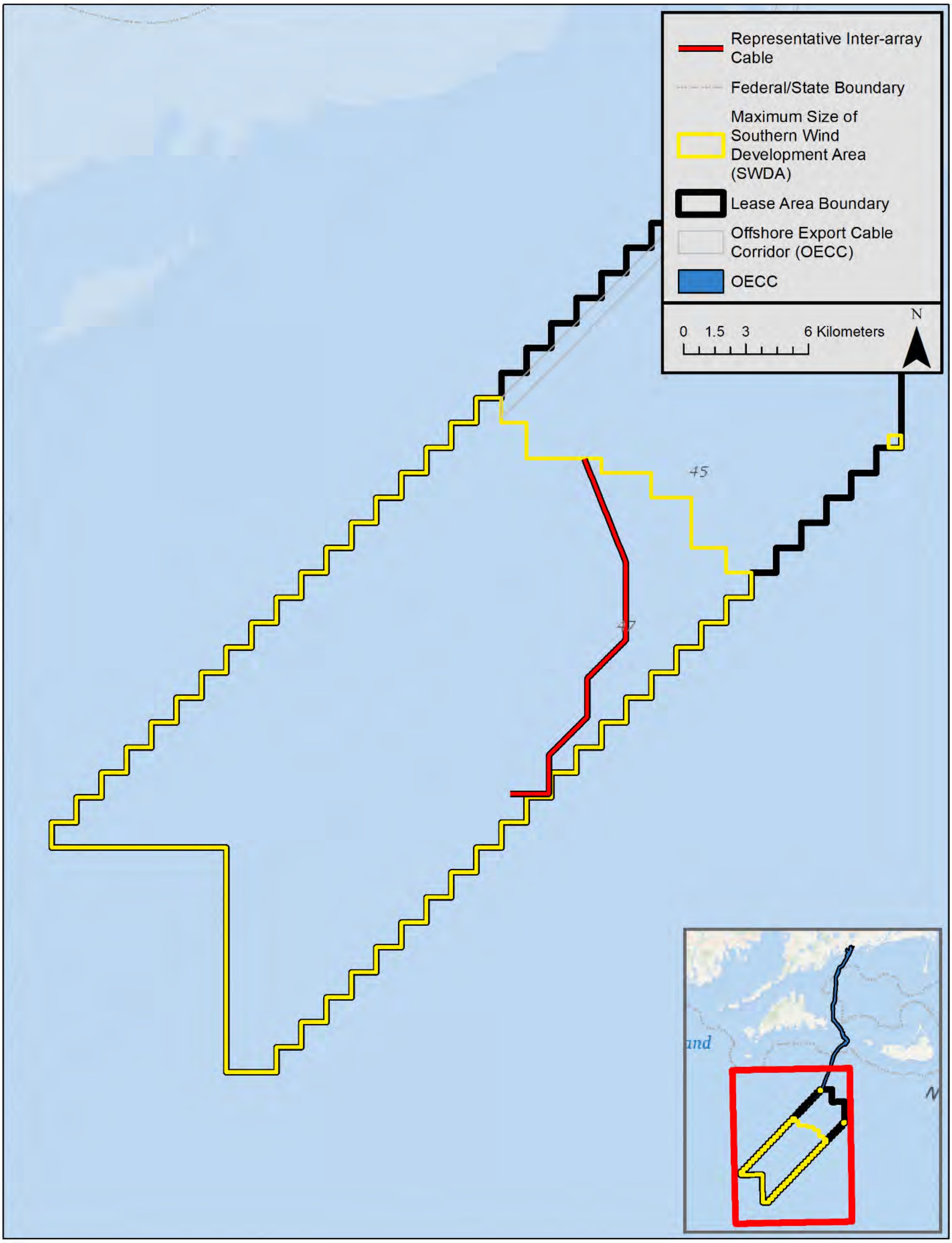

Figure 14. Representative Inter-array Cable Route

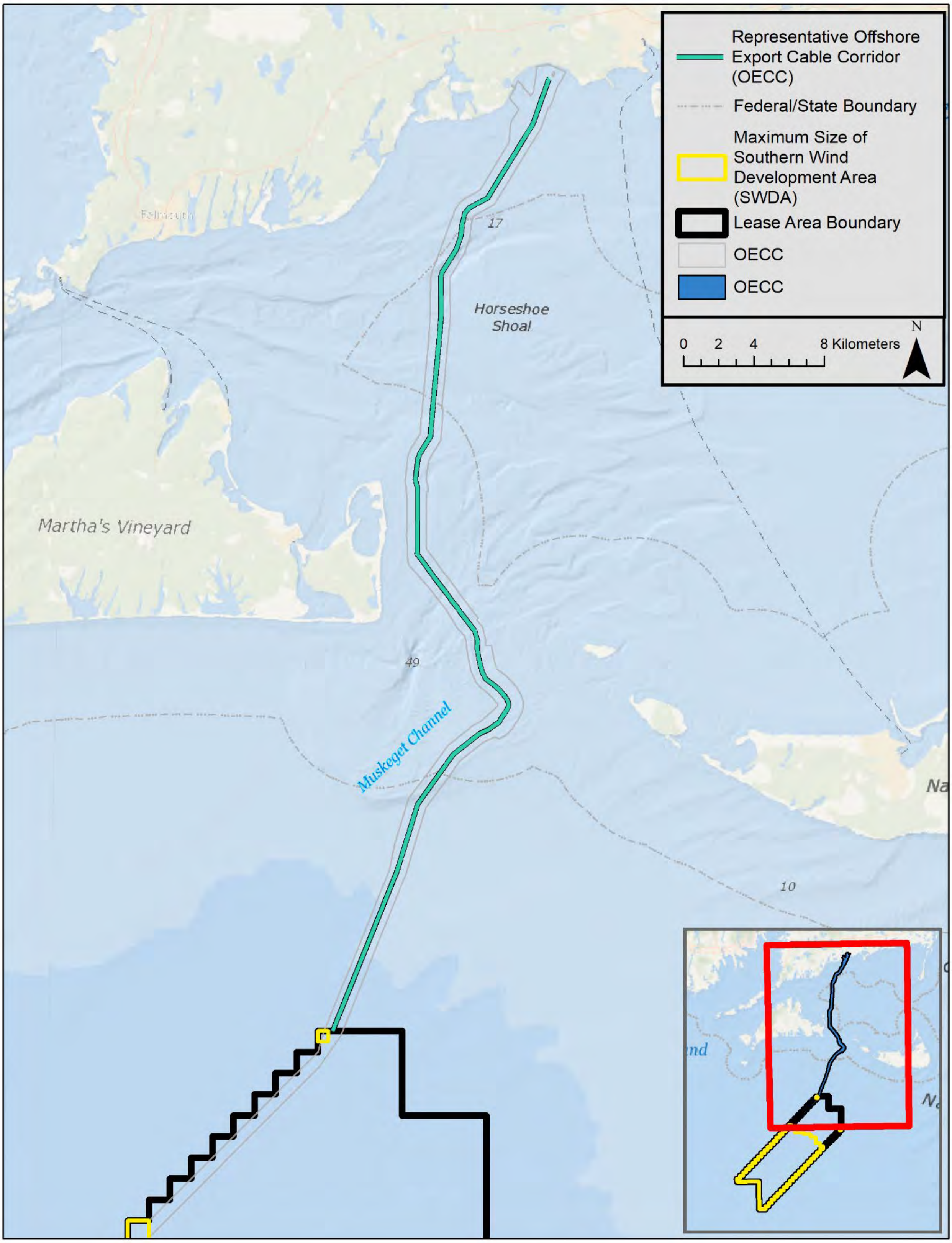

Figure 15. Representative OECC from the Northern Edge of Lease Area OCS-A 0501 to Phase 1 Landfall Sites

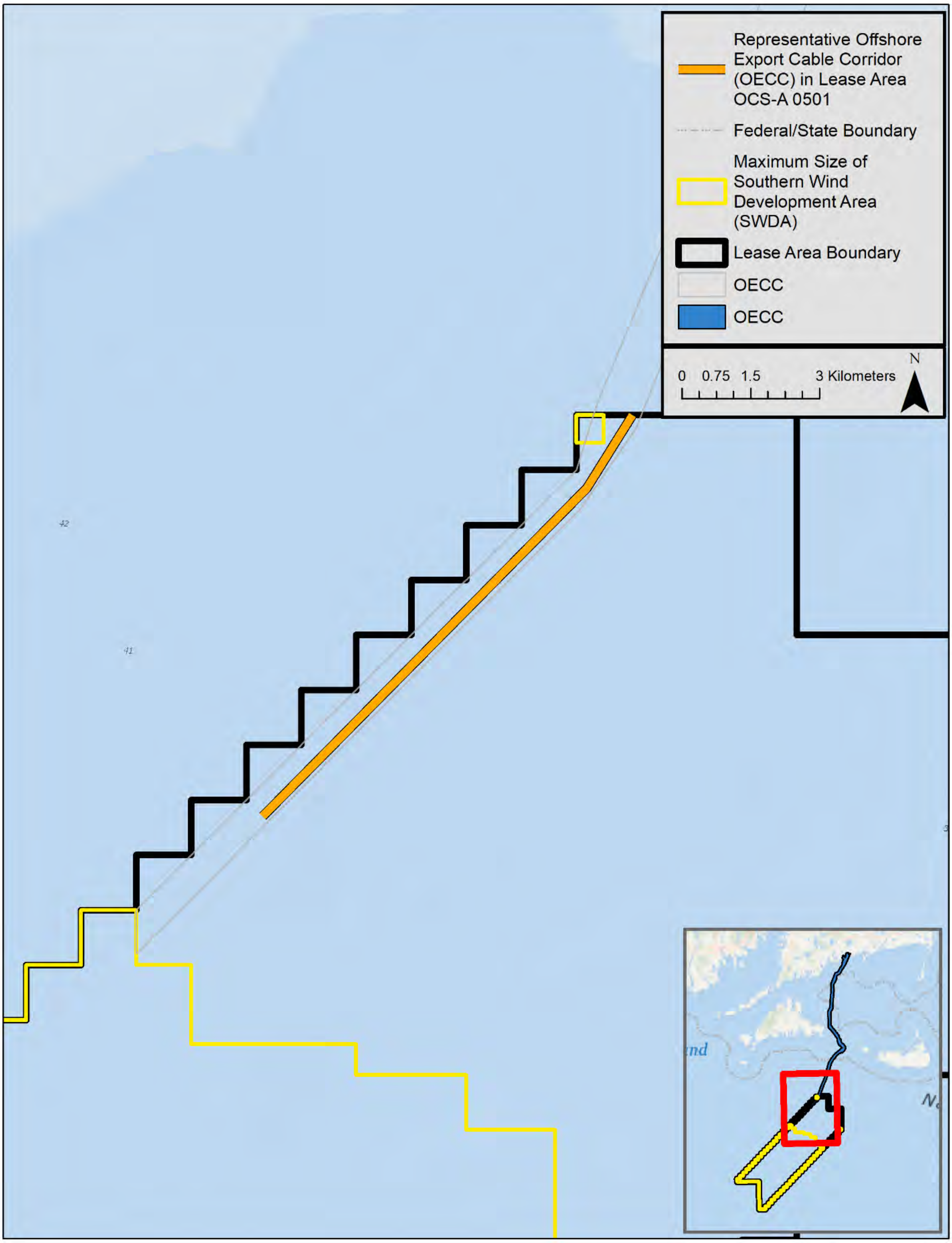

Figure 16. Representative Section of the OECC Located in Lease Area OCS-A 0501

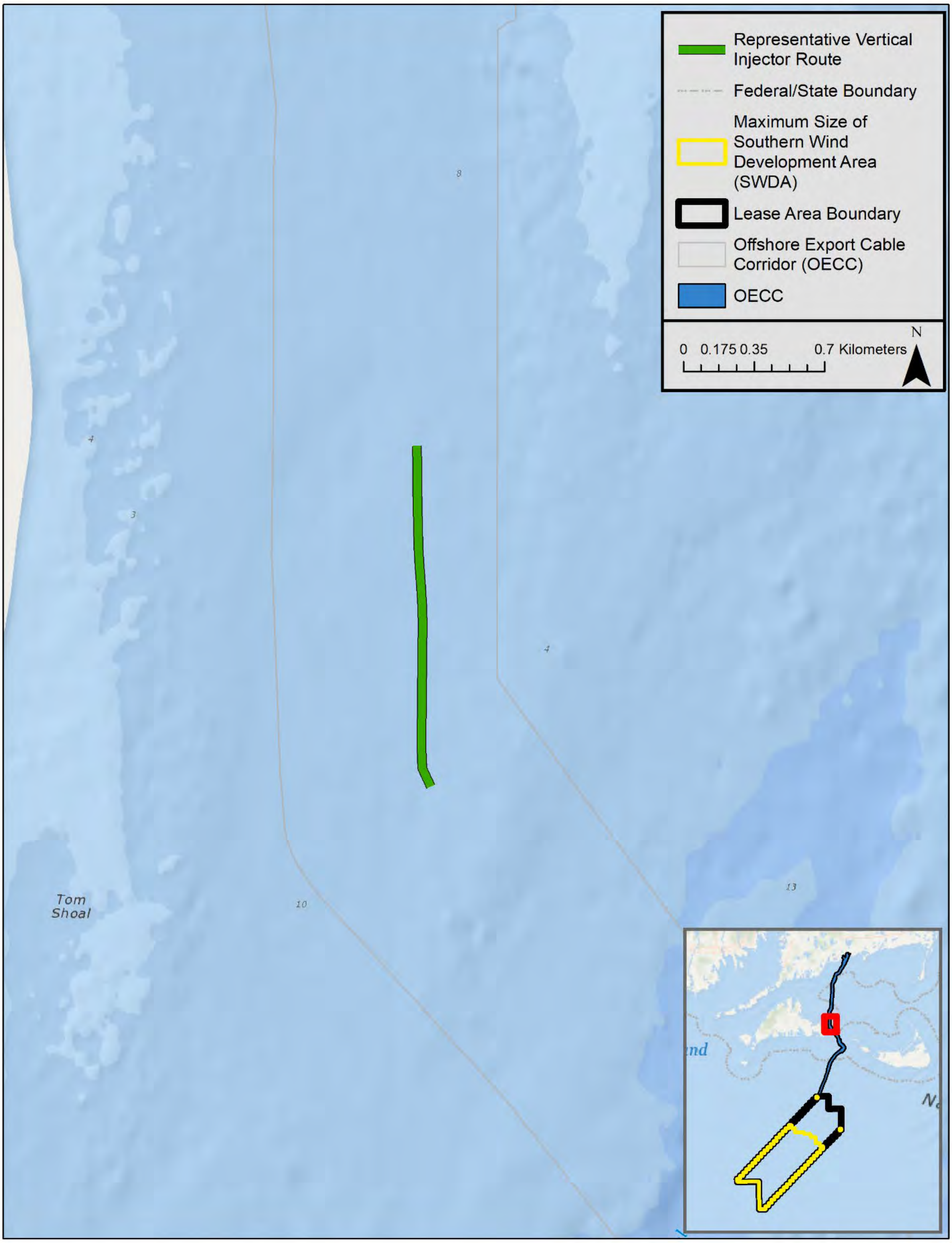

Figure 17. Representative OECC Vertical Injector Route

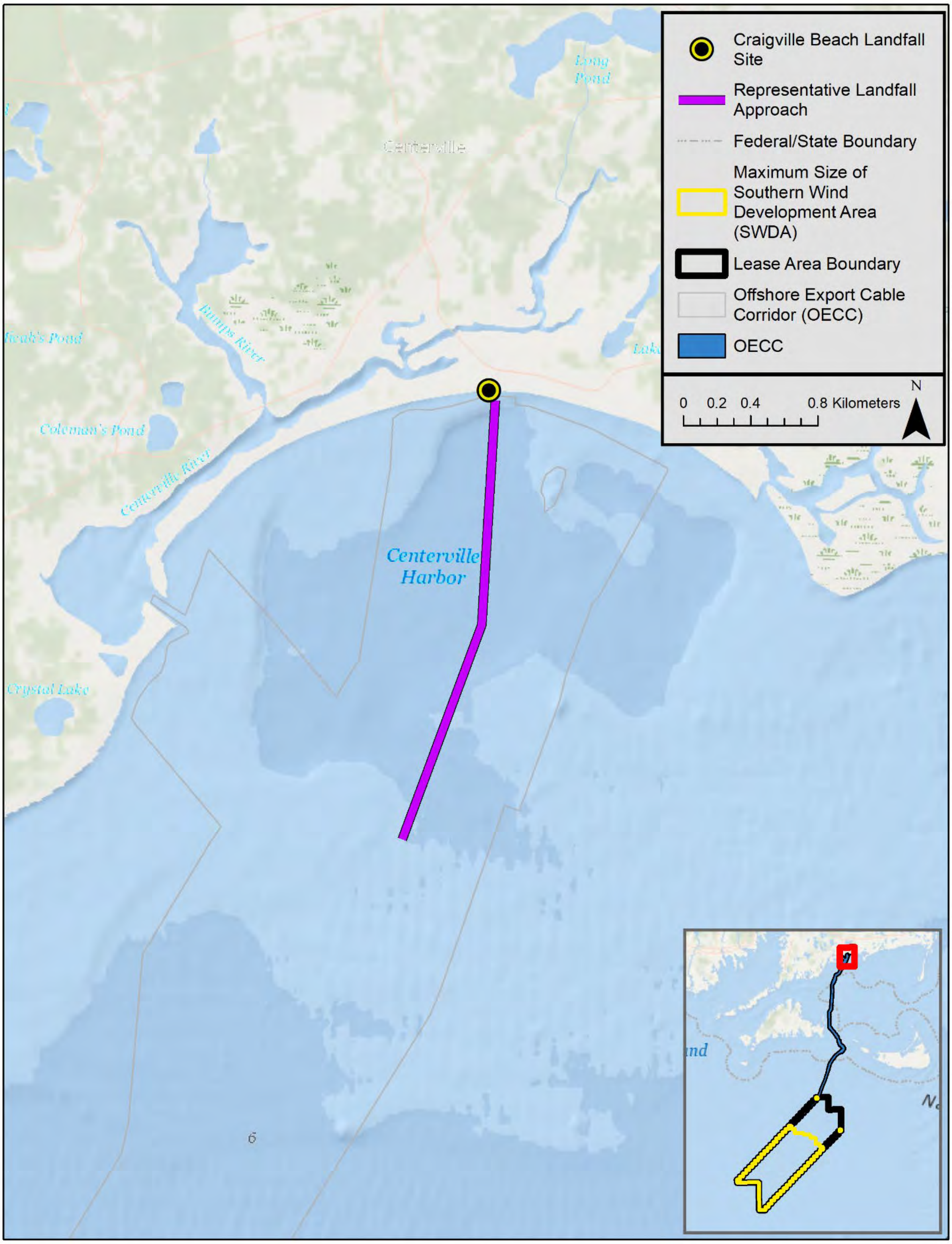

Figure 18. Representative OECC Landfall Approach Route

4.2.2 New England Wind Components: Construction Activities

Cable installation activities that will suspend sediments in the water column include cable burial within the SWDA (inter-array cables) and along the OECC (offshore export cables) and, for cable installation along the OECC, could also include either pre-cable installation sand wave dredging or installation within sand waves using a vertical injector. No sand wave dredging will be required within the SWDA for inter-array or inter-link cable installation.

Along the OECC, sand waves are mobile features. Removing the upper portions of the sand waves will facilitate cable installation within the stable seabed beneath thereby ensuring that sand wave migration will not leave a cable exposed on the seafloor. The amount of required sand wave dredging will vary based on the size of the sand waves and the achievable burial depth of the cable installation equipment employed. Once any needed sand wave removal occurs, installation and burial of the cable will occur.

Various approaches are being considered to remove the upper portions of the sand waves above the stable seabed where necessary along the OECC. The first technique is TSHD. Dredgers of this type are typically used for European offshore wind projects and are also commonly used in the US for channel maintenance, beach nourishment projects, and other uses. A TSHD would be used to remove an approximately 15 to 20 m wide[4] section of a sand wave (for each of the offshore export cables) that is deep enough to allow subsequent installation of the cable within the stable seabed.

The second approach involves jetting by controlled flow excavation (referred to as “jetting” herein), which uses a pressurized stream of water to push sand to the side. Jetting is a post-lay burial technique that removes the tops of sand waves while burying a section of cable that was previously laid on the surface of the seafloor. Accordingly, jetting both removes the tops of sand waves where required and buries the cable. Jetting is a viable technique where excavation less than approximately 2 m is required; if excavation greater than approximately 2 m is required, use of the TSHD or vertical injector would be required.

The third approach is to use a vertical injector. 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 waves without the need for any separate sand wave clearing.

Inter-array and offshore export cable installation may be achieved through various methods, which may be combined interchangeably. The methods captured through modeling are listed below along with a description of relevant operational parameters. The cable installation method was simulated using typical installation parameters that reflect a conservative estimate of typical installation speed and trench depth. For the inter-array cables, two scenarios were modeled: one with typical parameters and one with “maximum impact” parameters involving deeper penetration and faster installation.

<u>Inter-array Cable Installation</u>

- **Cable Installation:** Cable installation is accomplished by jetting techniques (e.g. jet plow, jet trenching, or similar).
    - **Typical Installation:** 1-m-wide x 2-m-deep trench, production rate (i.e., installation rate) of 200 meters per hour (m/hr), and sediment mobilization fraction of 0.25 (25% of total trench volume).
    - **Maximum Impact Installation:** 1-m-wide x 3-m-deep trench, production rate of 300 m/hr, and sediment mobilization fraction of 0.35 (35% of total trench volume).

[4] To be conservative, the model uses a 20-m wide section.

Offshore Export Cable Installation

- **TSHD:** For all sand wave sizes where dredging is needed, dredging is accomplished by TSHD to prepare the OECC for cable installation.
    - **Typical Operation:** Used for variable cross-section depending on sand wave height, production rate of 1,875 cubic meters per hour (m^3/hr). Assumes a drag arm sediment mobilization fraction of 0.01 (1%) and overflow sedimentation mobilization of 0.05 (5%) coarse sediments and 0.30 (30%) fine sediments from hopper. Once the hopper fills, it moves to dump. Upon dumping, the entire hopper load of sediment is mobilized.
- **Limited TSHD:** For larger (greater than 2 m) sand waves only where dredging is needed. Dredging is accomplished by TSHD to prepare the OECC for cable installation.
    - **Typical Operation:** Used for variable cross-section depending on sand wave height, production rate of 1,875 m^3/hr. Assumes a drag arm sediment mobilization fraction of 0.01 (1%) and overflow sedimentation mobilization of 0.05 (5%) coarse sediments and 0.30 (30%) fine sediments from hopper. Once the hopper fills, it moves to dump. Upon dumping, the entire hopper load of sediment is mobilized.

A summary of the intermittent length and modeled volume for TSHD and limited TSHD are summarized in Table 9 and assumptions relative to hopper size and operations are provided in Table 10.

Table 9. Approximate Dredging Lengths and Volumes for TSHD and Limited TSHD Pre-dredge

New England Wind Component with Sand Waves	TSHD		Limited TSHD	
	Length where TSHD may Occur	Per-Cable Volume of TSHD dredging[1]	Length with Sand Waves > 2m where TSHD may Occur	Per-Cable Volume of Sand Waves > 2m where Limited TSHD may Occur
	km	m^3	km	m^3
OECC	6.64	44,569	0.34	10,595

Notes:

1. These volumes are a conservative estimate based on the assumption that cable installation equipment would have an achievable burial depth of 1.5 m. In reality, cable installation equipment may be able to reach a greater burial depth of 2.5 m, which would require less sand wave removal to ensure burial within the stable seabed.

Table 10. Assumed Dredging Parameters

Sediment Characteristics		Depth weighted to 2 m[1] Average percent solid ~73%
Total Dredging Production (sediment + water)	**m^3/hr**	9,175
Sediment Production	**m^3/hr**	1,835
Hopper Volume	**m^3**	2,294
Sediment Suspended at Drag Head (as % of total dredged, both fines and coarse)	**%**	1
Target Fines in Overflow	**%**	29.7
Target Coarse in Overflow	**%**	4.95
Target Fines in Hopper Release	**%**	70.3
Target Coarse in Hopper Release	**%**	94.05
Operations	**hrs/day**	24
Time to Fill Hopper	**hrs**	1
Time to Transit, Release, Transit Back	**hrs**	0.5

Notes:

1. See Section 4.2.4. for details of the procedure to develop depth weighted grain size distributions.

- **Cable Installation:** Cable installation is accomplished by jetting techniques (e.g., jet plow, jet trenching, similar).
  - **Typical Installation:** 1-m-wide by 2-m-deep trench, production rate (i.e., installation rate) of 200 m/hr, and sediment mobilization fraction of 0.25 (25% of total trench volume).
- **Cable Installation Aided by Jetting:** Cable installation is accomplished by jetting in areas of small sand waves and by jetting techniques (e.g., jet plow, jet trenching, or similar) where sand wave dredging is not necessary.
  - **Typical Installation:** 2-m-wide by 2-m-deep trench, production rate (i.e., installation rate) of 100 m/hr, and sediment mobilization fraction of 0.25 (25% of total trench volume).
- **Cable Installation Using Vertical Injector:** Cable installation is achieved to the necessary target depth through use of a vertical injector. 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 tool is lowered to a depth such that seabed sediment fluidization is achieved and the cable ends is installed at the desired depth.
  - **Typical Installation:** 1-m-wide by up to 7.5-m-deep trench, production rate (i.e., installation rate) of 120 m/hr, and sediment mobilization fraction of 1.0 (25%) of the upper 3 m of the trench.

A summary of the inter-array and offshore export cable installation parameters is provided in Table 11. The individual SSFATE modeling scenarios is presented in Table 12 along with the method simulated and the total duration of the active loading.

Table 11. Inter-array and Offshore Export Cable Installation Parameters

Scenario Description	Inter-array or Offshore Export Cable	Sediment Characteristics[1]	Trench Width (m)	Trench Depth (m)	Trench Volume per meter (m^3)	Advance Rate (m/hr)	Percent Mobilized (%)
Typical cable burial	Inter-array, Offshore Export Cable	Depth weighted to 2m	1	2	2	200	25
Typical cable burial aided by jetting	Offshore Export Cable	Depth weighted to 2m	2	2	4	100	25
Maximum impact cable burial	Inter-array	Depth weighted to 3m	1	3	3	300	35
Vertical injector	Offshore Export Cable	Depth weighted upper 3m	1	3	3	120	25

Notes:

1. Details of the procedure to develop depth weighted grain size distributions are provided in Section 4.2.4.

Table 12. Summary of Modeling Scenarios

Location	Method	TYP or MAX	Duration of Sediment Loading for Scenario (days)
Inter-array Cable Installation			
SWDA Inter-array	Cable Installation	TYP	3.83
SWDA Inter-array	Cable Installation	MAX	2.87
Offshore Cable Installation[1] – Representative Sections			
OECC	TSHD	TYP	2.31
OECC	Limited TSHD	TYP	0.77
OECC	Cable Installation	TYP	12.80
OECC	Cable Installation Aided by Jetting	TYP	12.82
OECC in Lease Area OCS-A 0501	Cable Installation	TYP	2.31
OECC Vertical Injector Section	Vertical Injector Cable Installation	TYP	0.66
OECC Landfall Approach Section	Cable Installation	TYP	0.47

Notes:

1. Within this section of the table, the term "OECC" refers to the portion of the OECC from the northern edge of Lease Area OCS-A 0501 to the landfall site.

4.2.3 Sediment Loading Vertical Initialization

In addition to the sediment loading rate, the model requires specification of the vertical location of the sediment resuspension. The vertical initialization from the TSHD and limited TSHD operations of dredging, overflow, and dumping is summarized in Table 13 and the vertical initialization from the different cable installation methods is presented in Table 14.

Table 13. Vertical Distribution of Suspended Sediment Mass Associated with Dredging, Overflow, and Dredged Material Release

Dredging			Overflow			Dredged Material Release		
Individual Bin Percent	Cumulative Percent	Meters Above Bottom	Individual Bin Percent	Cumulative Percent	Meters Below Surface	Individual Bin Percent	Cumulative Percent	Meters Below Surface
5	100	3	100	100	0	100	100	6.1
10	95	2						
28	85	1						
28	57	0.66						
29	29	0.33						

Table 14. Vertical Initial Distribution of Mass Associated with Cable Installation and Cable Installation Aided by Jetting and Vertical Injection

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

4.2.4 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 is documented in Volume II of the COP though an overview of the RPS analysis of the sediment data follows since it pertains to the sediment characterization used in the modeling. The objective of the RPS analysis of the sediment data was to develop the sediment characteristics that represent either the upper two or three meters of the seabed, since those are the target depths of cable installation and represent the depth of sediments that may get resuspended during installation activities. Specifically, the objective was to determine the distribution within the five delineated classes used in SSFATE (Table 6) 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 included a combination of grab samples that sample the upper few centimeters of the seabed, as well as vibracores and boreholes, which both provide a vertical profile of sediments that are then analyzed at multiple depths from the profile. All samples were analyzed by a sieve, which is similar to a filter and screens out sediments smaller than the specific sieve size. Sieve analysis is performed on multiple sizes in order to build a curve of the percent finer than various grain sizes, though it can only resolve the fraction of sands relative to the classes in SSFATE. Some samples also included hydrometer analysis which is a laboratory test that can further resolve the fractions in the finer grain size classes. For all stations without hydrometer data, the remaining fraction (percent finer than fine sand) was split evenly between the three classes of coarse silt, fine silt, and clay. Additionally, the majority of samples had a measure of the water content.

The grab samples were typically staggered relative to the locations of vibracore or boreholes. Therefore, to develop a vertical profile of sediment characteristics, the samples taken at depth from a vibracore or borehole were paired with the nearest grab sample to develop a composite depth weighted average sediment distribution at each sample location.

The resulting sediment grain size distributions and percent solids are shown in Figure 19 and Figure 20. Figure 19 shows the two and three meter sediment characteristics in the SWDA and Figure 20 shows the two and three meter sediment characteristics in the OECC.

Most of the sediments are primarily coarse sand however there are isolated samples with noticeable fractions of fine sediments (clay, fine silt, and coarse silt). The SWDA has more fine material in the sediments relative to the OECC and the OECC is primarily coarse except near the landfall where most sediments have a larger amount of fine sediments. Comparing the two- to three-meter sediments in the SWDA, the three-meter sediments have relatively more fine material along the modeled route.

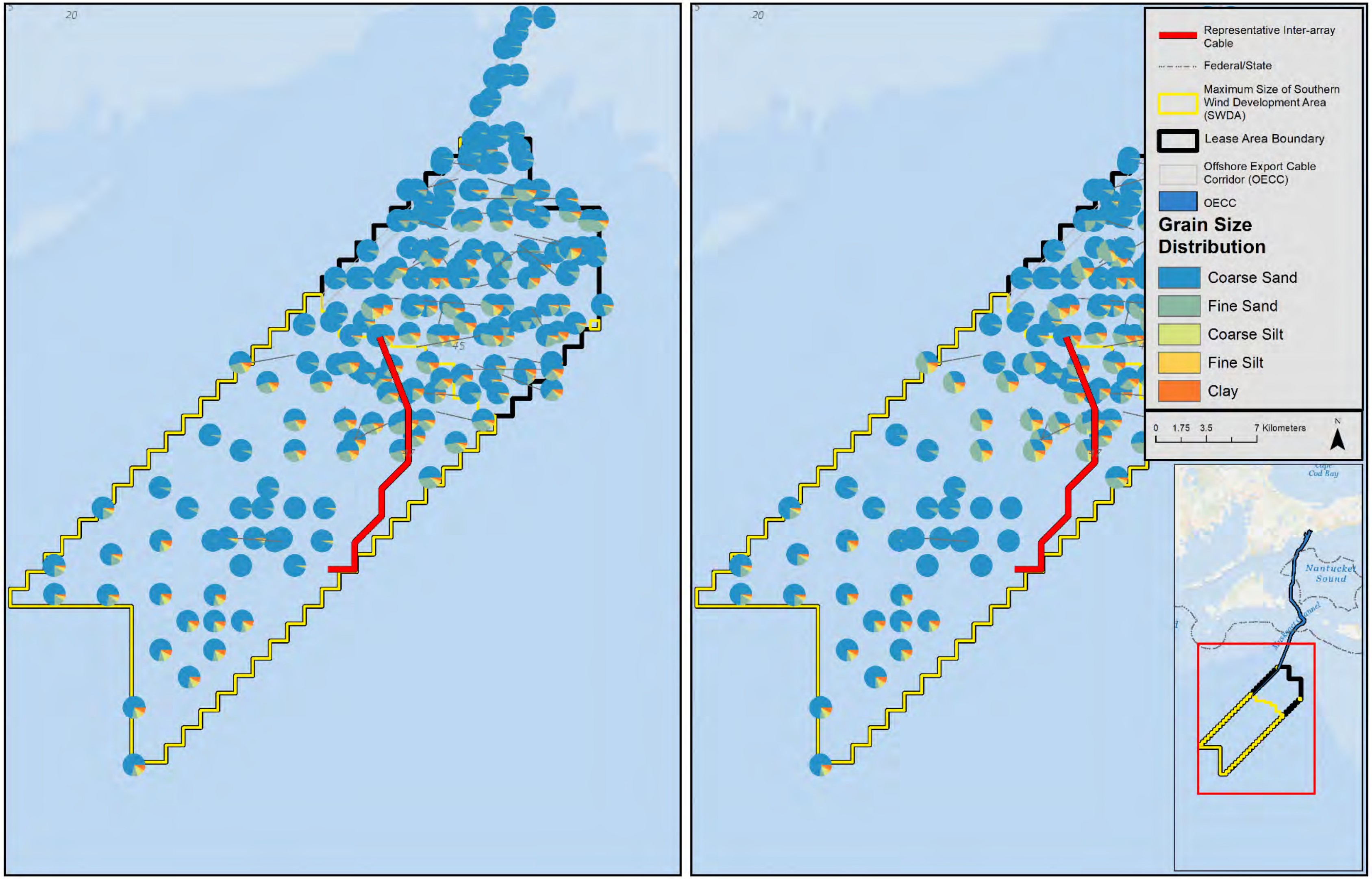

Figure 19. Sediment Grain Size Distributions for the Upper 2 m (left) and Upper 3 m (right) of the Seabed in the SWDA

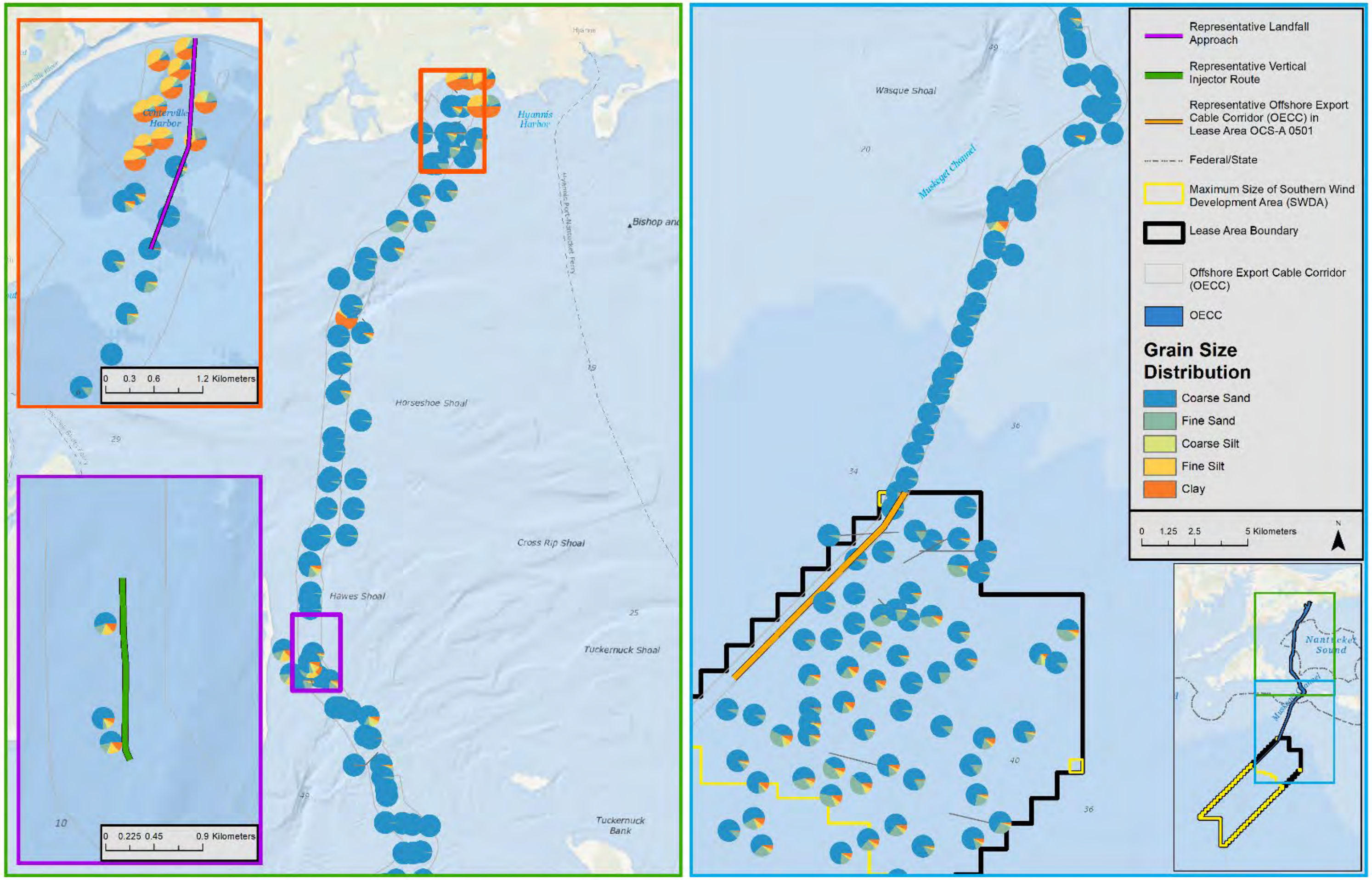

Figure 20. Sediment Grain size Distributions for OECC Scenarios[1]

Notes:

1. Left and right large panels show the northern and southern halves of the OECC, respectively. The insets on the left panel provide zoomed in views of the landfall (red outline) and the vertical injector section (purple outline); note that all views reflect characteristics depth weighted to two meters with the exception of the vertical injector which is showing the three meter depth weighted characteristics.

4.3 Sediment Modeling Results

SSFATE simulations were performed for each sediment disturbance activity. Sediment concentrations were computed on a grid with resolution of 50 m x 50 m in the horizontal dimension and 0.5 m in the vertical dimension. The model time step and output results-saving interval was five minutes for the cable installation scenarios and two minutes for the dredging/overflow/disposal simulations; a smaller time step was necessary for the dredging due to the faster production rate of those operations. 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. Maps of maximum above-ambient TSS concentrations, duration of above-ambient TSS of 10 mg/L or greater, and seabed deposition are provided for each modeled scenario. Tables quantifying the area exceeding TSS thresholds for specific durations as well as areas of seabed deposition exceeding thickness thresholds are presented for the representative inter-array and offshore export cables. Further, examples of instantaneous concentration snapshots are presented to provide further detail.

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

- **Maps of Instantaneous TSS Concentrations:** These figures show the instantaneous TSS concentrations at a moment in time. The plan view shows the maximum concentration throughout the water column and the vertical cross-section shows the cross-sectional variability of concentrations along a transect. An example of instantaneous concentrations is shown for an example time step from the SWDA inter-array simulation of typical burial parameters, the OECC TSHD simulation, and the OECC cable installation simulation. Additionally, hourly snapshots of instantaneous TSS concentrations over six consecutive hours for each scenario are presented in Appendix A.
- **Maps of Time-integrated Maximum TSS Concentrations:** These figures show the maximum time-integrated water column concentration from the entire water column in scaled plan view. Most figures also include 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 that: (1) these concentrations do not persist throughout the entire simulation and may be just one time step (30 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.
- **Maps of Duration of TSS Concentrations Greater than 10 mg/L:** These figures 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 figures show the 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 (1 mm and 20 mm) or to facilitate viewing the results.

4.3.1 Inter-array Cable

SSFATE modeling and results associated with TSS generation as well as sediment deposition from the installation of a representative inter-array cable are described below. A snapshot of the instantaneous concentrations from the cable installation using typical parameters is presented in Figure 21. This figure shows the plan view concentrations as well as the vertical cross-section. This figure illustrates that higher concentrations are contained around the centerline, with lower concentrations biased towards the west due to bottom currents. The vertical cross-section shows that all concentrations are constrained to the bottom of the water column, with the highest concentrations closest to the bottom (i.e., localized to the source).

Side-by-side comparisons of the results of the inter-array cable installation from typical and maximum impact cable burial parameters are presented in Figure 22 through Figure 24. The map of time-integrated maximum concentrations is presented in Figure 22. In this figure, the cross-sectional view, presented as an inset, runs along the route centerline and shows that the plume is localized to the bottom of the water column. For both cases, the overall footprint shows how the plume oscillates with the tides, which is reflective in the oscillatory pattern of the 10–25 mg/L (yellow) concentrations relative to the route centerline. Concentrations greater than 10 mg/L contour have a maximum excursion of approximately 1 km and 2.2 km from the centerline for typical and maximum cable burial parameters, respectively.

A map of hours with TSS concentrations greater than 10 mg/L is presented in Figure 23. The results for both the typical and maximum impact parameters show that in any given location, the total exposure is typically one to two hours or two to three hours with some small isolated patches of exposure between three to four hours for the maximum impact scenario.

The map of deposition thickness for the inter-array scenarios is presented in Figure 24. This figure shows that deposition is mainly centered around the installation alignment with deposition of 1 mm or greater limited to within approximately 100 - 150 m for typical and maximum impact, respectively. Deposition does not reach 5 mm in the simulation of typical parameters and has small isolated patches greater than 5 mm in the simulation of maximum impact parameters.

Figure 22 through Figure 24 indicate that most of the sediments settle out quickly and not transported for long by the currents. Relative to one another the maximum impact simulation has a larger footprint for each threshold and has more area of longer exposures to concentrations greater than 10 mg/L. Elevated TSS is confined to the bottom few meters of the water column, which is only a small fraction of the water column in the SWDA. Deposition greater than 1 mm is confined within 100 - 150 m of the installation alignment for the typical and maximum parameter simulations, respectively, and maximum deposition in both simulations is usually less than 5 mm. Water quality impacts from inter-array cable installation are therefore short-term and localized.

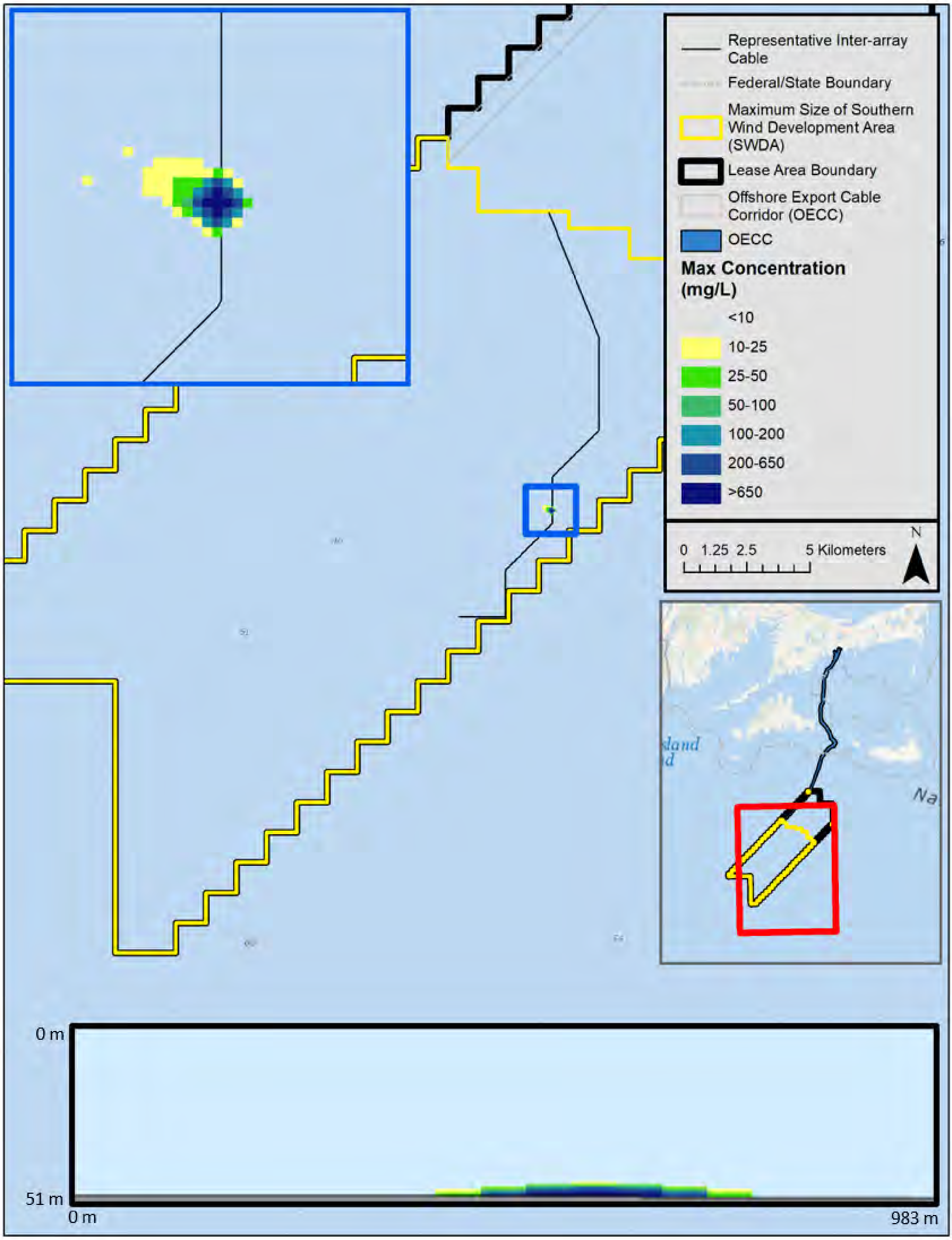

Figure 21. Snapshot of Instantaneous TSS Concentrations[1]

Notes:

1. The above depicts a time step from the simulation of inter-array cable installation using typical cable burial parameters. Inset at bottom shows the vertical cross-section across the plume.

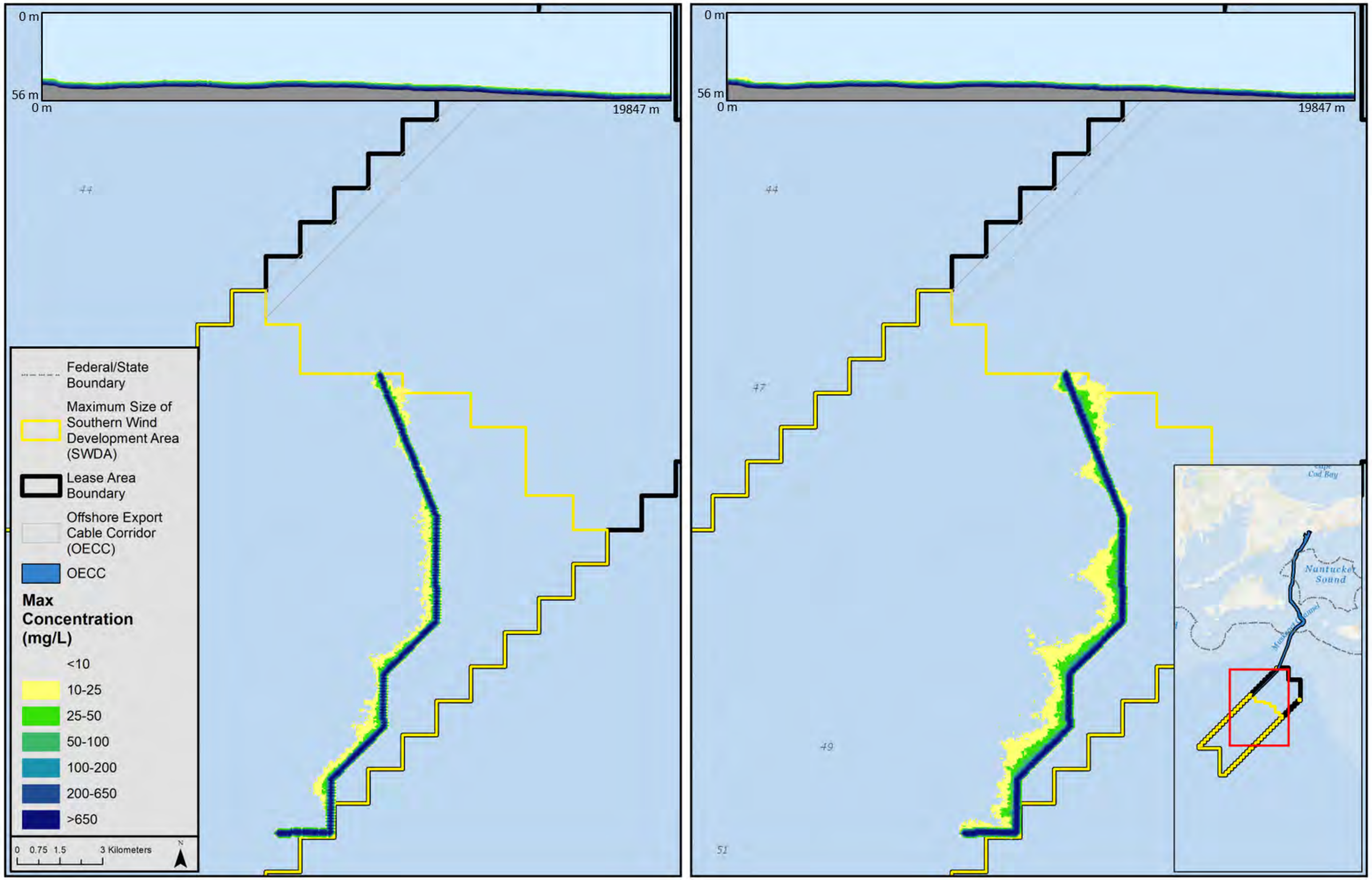

Figure 22. Map of time-integrated maximum concentrations associated with a representative inter-array cable installation using typical (left) and maximum impact (right) cable burial parameters[1]

Notes:

1. Inset shows a vertical cross-section along the route centerline.

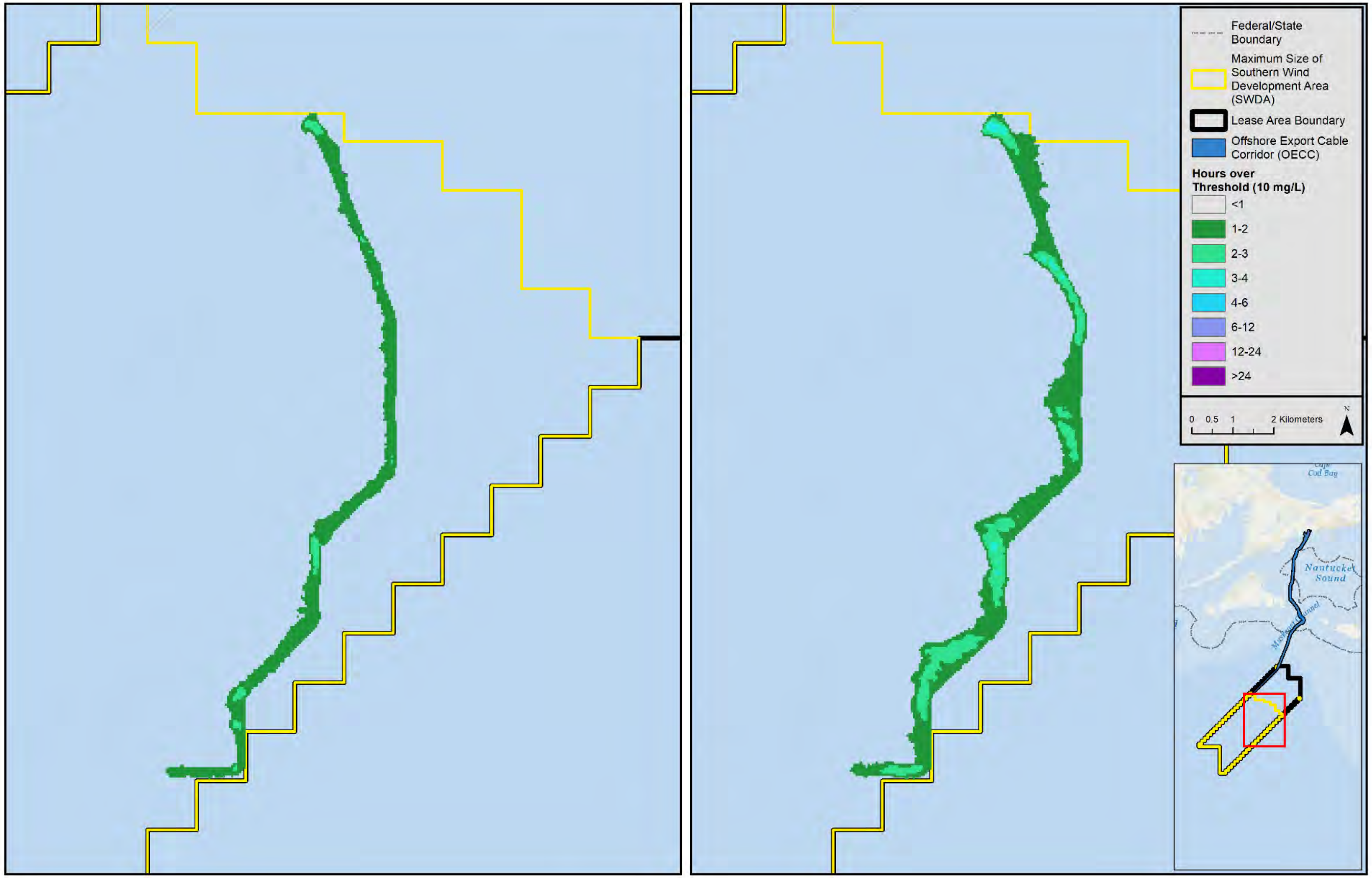

Figure 23. Map of duration of TSS ≥ 10 mg/L associated with a representative inter-array cable installation using typical (left) and maximum impact (right) cable burial parameters

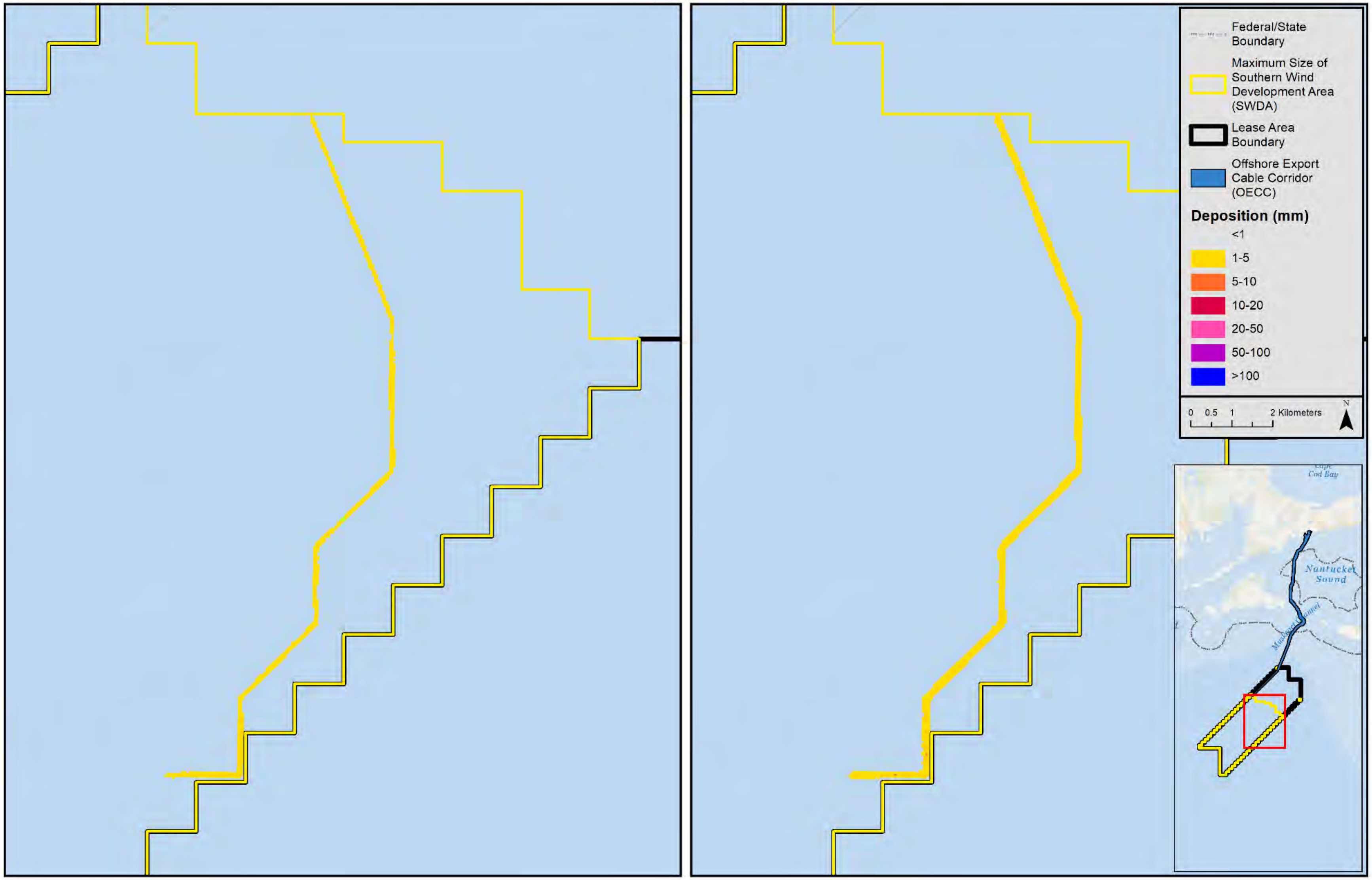

Figure 24. Map of deposition thickness associated with a representative inter-array cable installation simulation using typical (left) and maximum impact (right) cable burial parameters

4.3.2 OECC

This section presents results from the simulations of cable installation activities in the OECC. These activities include sand wave dredging and cable installation methods. Results are presented separately for each of the seven model scenarios:

- TSHD
- Limited TSHD
- OECC cable installation
- OECC cable installation aided by jetting
- OECC cable installation in the lease area
- OECC section of cable installation with vertical injector
- OECC section of cable installation along the landfall approach

Since both Vineyard Wind 1 and New England Wind occupy the same OECC and will utilize similar cable installation technologies, the model results presented in this report for TSHD, limited TSHD, OECC cable installation and OECC cable installation by jetting are the same as those presented for the “Eastern Muskeget to Covell’s Beach” in the report for the Vineyard Wind 1 project.

TSHD Model Scenario

A snapshot of the instantaneous concentrations from the TSHD scenario is presented in Figure 25, the inset contains the vertical cross-section across the plume. This figure shows that at this instance, TSS concentrations above ambient are occurring throughout most of the vertical extent of the water column due to disposal activity releasing sediments in the upper water column.

For the TSHD scenario, the map of maximum time-integrated concentrations is presented in Figure 26, the duration of exposure to TSS above ambient greater than 10 mg/L above ambient is presented in Figure 27, and the seabed deposition is shown in Figure 28. Figure 26 illustrates that the simulation predicted that the affected areas are discontinuous in response to the intermittent nature of dredging. The 10 mg/L footprint extends up to 16 km from the activity and may be present throughout the majority of the water column. The map of exposure of the water column to TSS concentrations greater than 10 mg/L shows a much smaller footprint as compared to the map of maximum concentrations, indicating that at 10 mg/L the plume is very transient (i.e., present for less than one hour) in most locations. Most locations have exposures of less than one hour, though there are some areas with exposure of up to six hours. The deposition greater than 1 mm is discontinuous and tends to stay central to the route centerline.

Limited TSHD Model Scenario

For the limited TSHD scenario, the map of maximum time-integrated concentrations is presented in Figure 29, the duration of exposure to TSS above ambient greater than 10 mg/L is presented in Figure 30, and the seabed deposition is shown in Figure 31. The results for the limited TSHD scenario are similar in trend to those of the TSHD, but are reduced in size and intensity due to the fact that this scenario is dredging less sediments.

OECC Cable Installation

A snapshot of the instantaneous concentrations from the representative OECC cable installation scenario is presented in Figure 32, the inset contains the vertical cross-section across the plume. This figure shows that at this instance, TSS concentrations are local to the bottom of the water column. The results of the representative cable installation scenario for the OECC is provided in Figure 33 through Figure 35. The map of maximum time-integrated concentrations is presented in Figure 33, the duration of exposure to TSS above ambient greater than 10 mg/L is presented in Figure 34, and the seabed deposition is shown in Figure 35. TSS greater than 10 mg/L typically remains within less than 200 m from the route alignment; however, may extend up to 1.9 km in the region of Muskeget Channel, which is expected due to the relatively higher current speeds.

Concentrations greater than 10 mg/L persist for less than two hours in most locations with small isolated areas that persist between two to three hours. Seabed deposition for this scenario between 1–5 mm is predicted to remain within 100 m from the route alignment and the footprint is uniform along the route.

OECC Cable Installation Aided by Jetting

The results of the OECC cable installation aided by jetting scenario for the OECC are provided in Figure 36 through Figure 38. The map of maximum time-integrated concentrations is presented in Figure 36, the duration of exposure to TSS above ambient greater than 10 mg/L is presented in Figure 37, and the seabed deposition is shown in Figure 38. These results are nearly identical to those from the cable installation scenario with small localized differences.

OECC Section of Cable Installation within the Lease Area

The results of the representative cable installation for the OECC in the Lease Area are provided in Figure 39 through Figure 41. The map of maximum time-integrated concentrations is presented in Figure 39, the duration of exposure to TSS above ambient greater than 10 mg/L is presented in Figure 40, and the seabed deposition is shown in Figure 41. The concentrations greater than 10 mg/L primarily stay within a few hundred meters from the route alignment with a few localized areas with greater excursion (up to 600 m). The map of duration shows that the plume typically persists between one to two hours in most locations with a few localized patches where it persists between two to three hours. The seabed deposition associated with this scenario shows that deposition between 1–5 mm remains within approximate 100 m from the route alignment and is a uniform footprint along the route.

OECC Section of Cable Installation with Vertical Injector

The results of the cable installation for the section of OECC with installation by vertical injector are provided in Figure 42 through Figure 44. The map of maximum time-integrated concentrations is presented in Figure 42, the duration of exposure to TSS above ambient greater than 10 mg/L is presented in Figure 43, and the seabed deposition is shown in Figure 44. TSS concentrations greater than 10 mg/L extend approximately 1.2 km from the route alignment in response to the fast currents in this area. The concentrations are localized to the bottom of the water column. Concentrations greater than 10 mg/L persist primarily for three to four hours or less though there are a couple of isolated patches that are exposed between four to six hours. Seabed deposition is between 1–5 mm extends up to 627 m from the route alignment with a small isolated patch close to the route alignment with thickness between 5–10 mm.

OECC Section of Cable Installation along Landfall Approach

The results of the cable installation for the section of OECC representing the landfall approach are provided in Figure 45 through Figure 47. The map of maximum time-integrated concentrations is presented in Figure 45, the duration of exposure to TSS above ambient greater than 10 mg/L is presented in Figure 46, and the seabed deposition is shown in Figure 47. Concentrations of TSS greater than 10 mg/L mainly stay within approximately 200 m from the route alignment; however, may extend up to 764 m. Concentrations occupy less than the bottom 6 m of the water column; however, since the water depths are shallower in this area, it may occupy nearly the entire water column. Concentrations of TSS greater than 10 mg/L persist typically less than one to two hours; however, there are two isolated patches with exposure between two to three hours and there is one small patch (~100 m x 50 m) that the concentrations persist between four to six hours. The seabed deposition is limited to 1–5 mm within approximately 100 m from the route alignment.

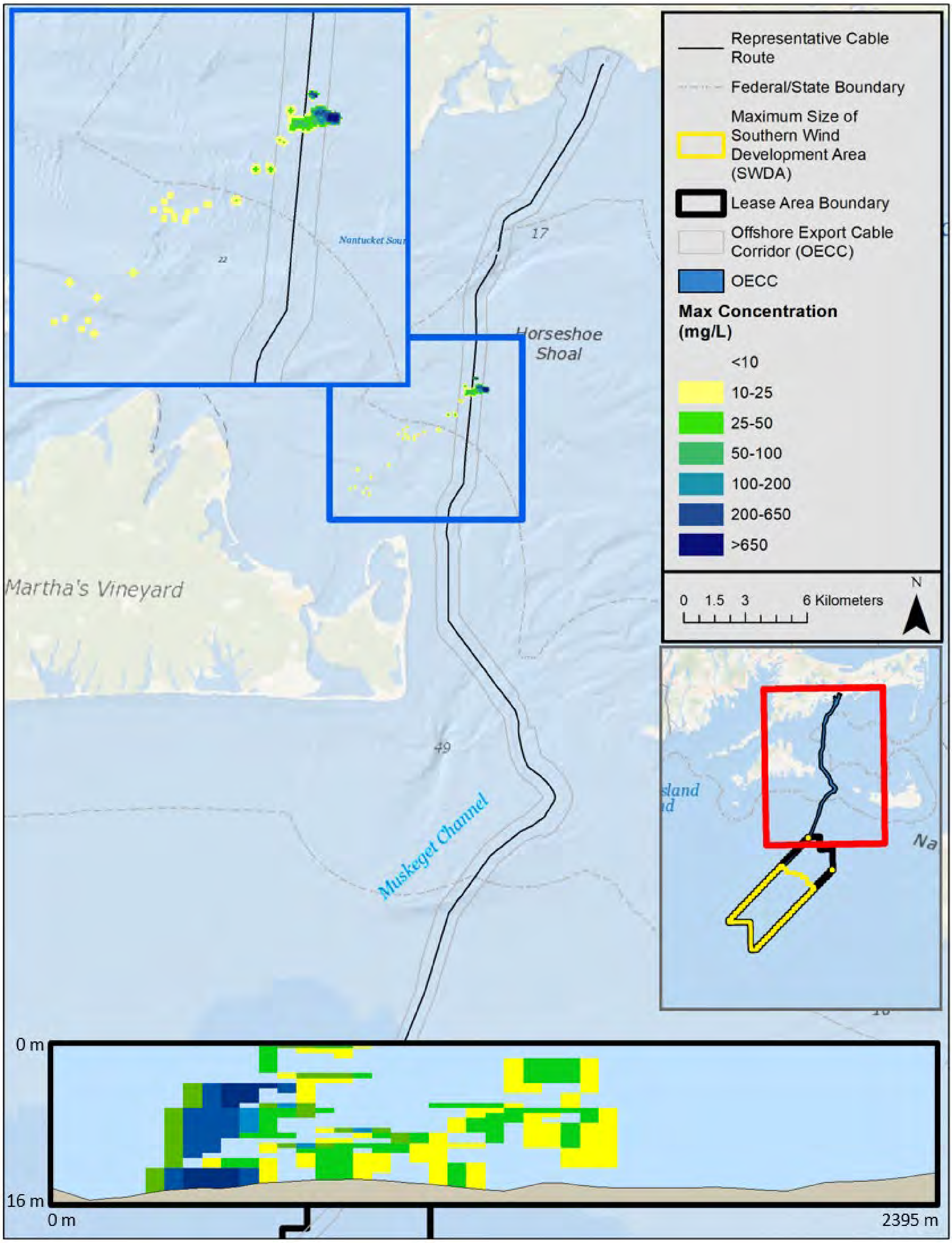

Figure 25. Snapshot of instantaneous TSS concentrations for a time step during simulation of TSHD dredging, overflow, and dredged material release operations for a representative cable route within the OECC[1]

Notes:

1. Inset at bottom shows the vertical cross-section across the plume east (left) to west (right).

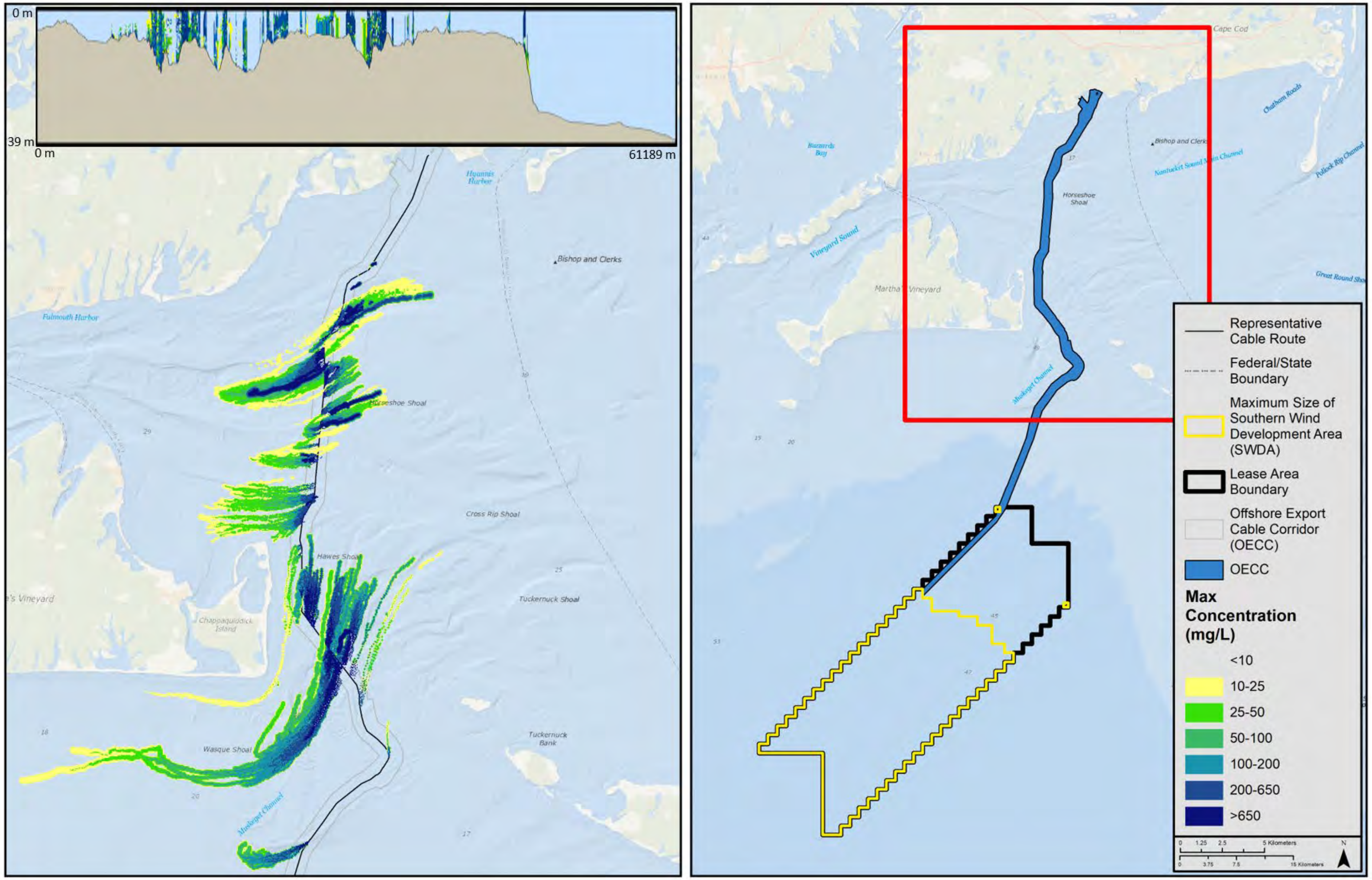

Figure 26. Map of time-integrated maximum concentrations associated with TSHD dredging, overflow, and dredged material release operations for a representative cable route within the OECC[1]

Notes:

1. Inset shows a vertical cross-section.

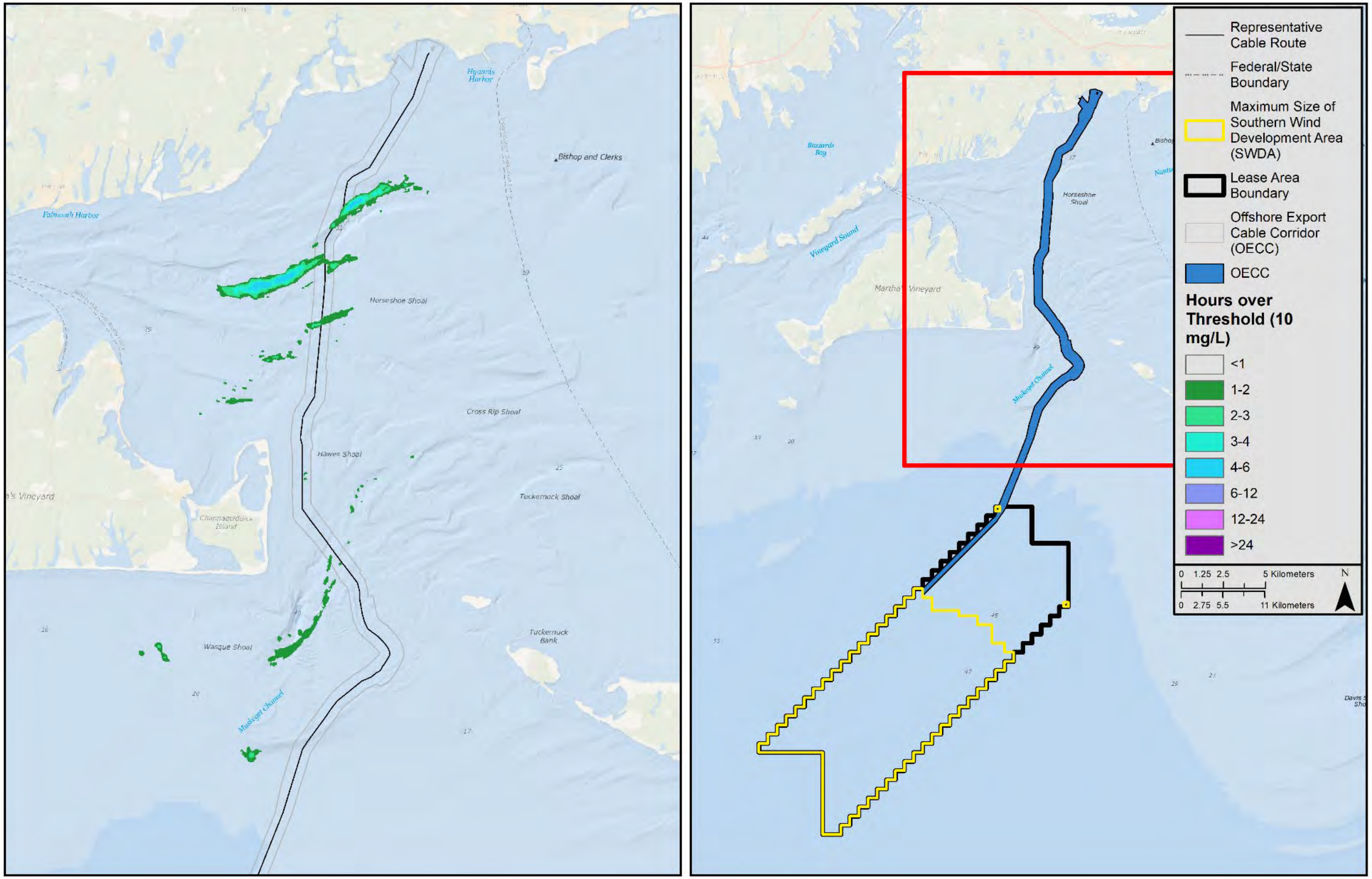

Figure 27. Map of duration of TSS ≥ 10 mg/L associated with TSHD dredging, overflow, and dredged material release operations for a representative cable route within the OECC

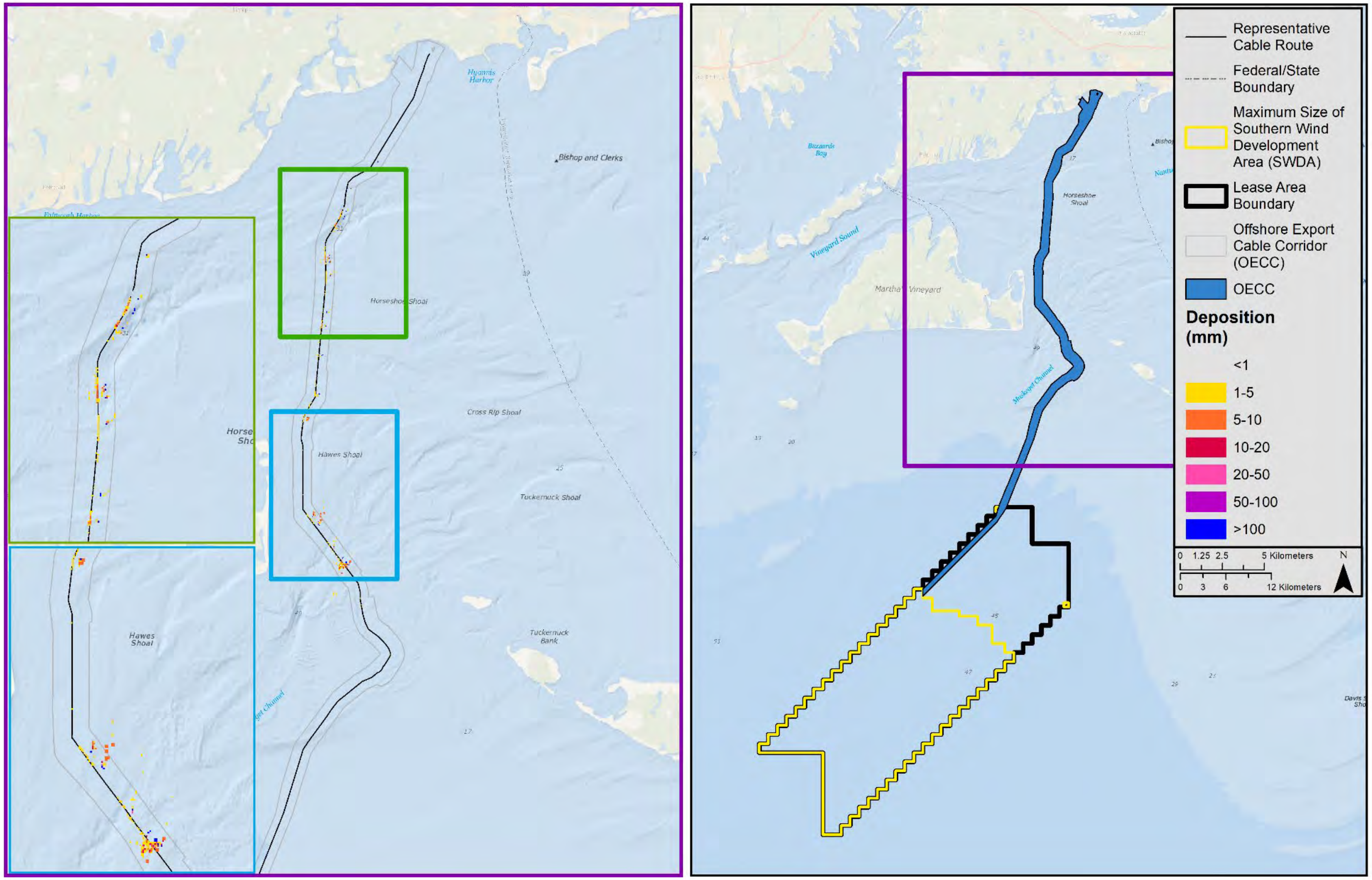

Figure 28. Map of deposition thickness associated with TSHD dredging, overflow, and dredged material release operations for a representative cable route within the OECC

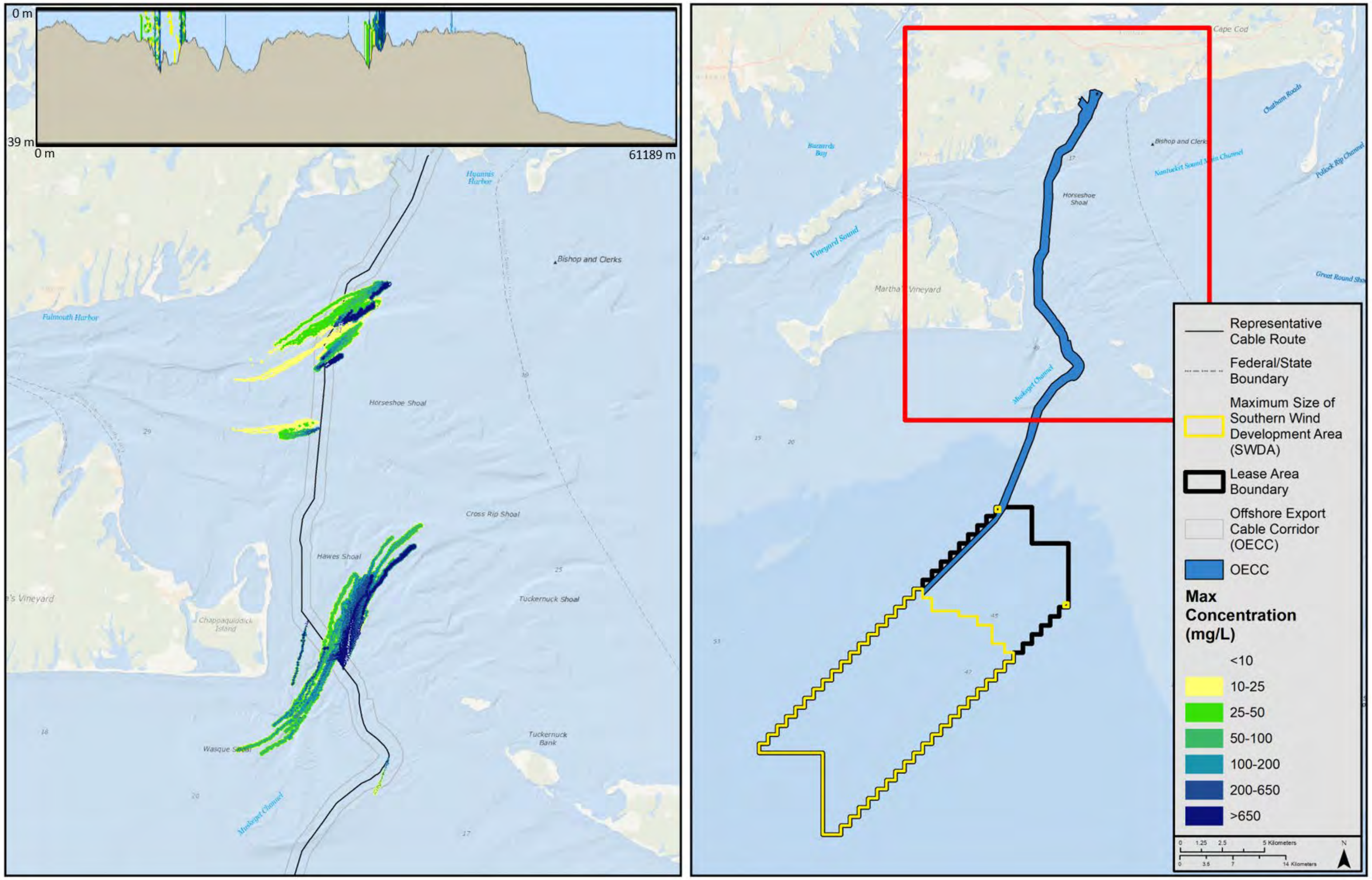

Figure 29. Map of time-integrated maximum concentrations associated with limited TSHD dredging, overflow, and dredged material release operations for a representative cable route within the OECC[1]

Notes:

1. Inset shows a vertical cross-section along the route centerline.

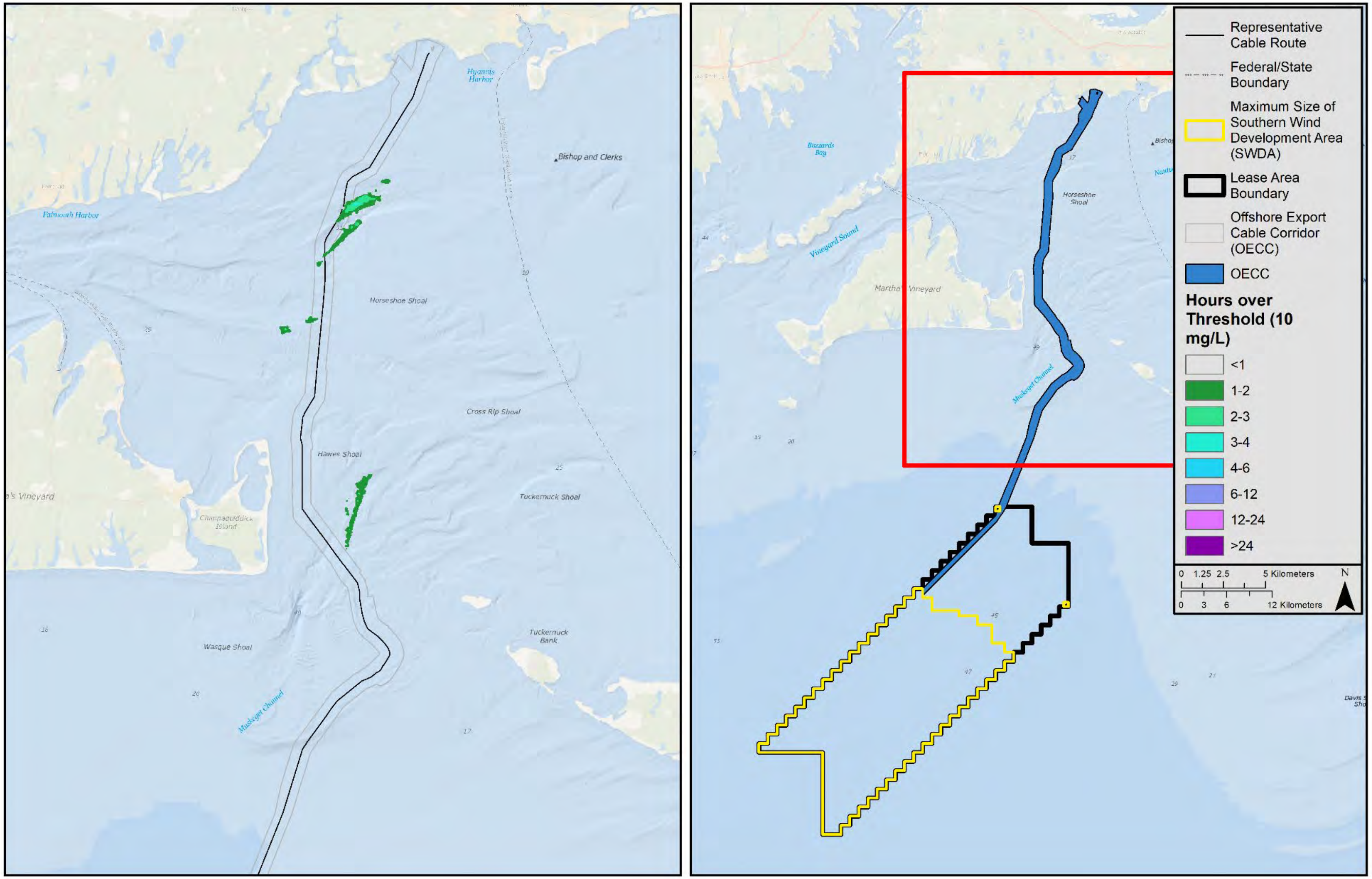

Figure 30. Map of duration of TSS ≥ 10 mg/L associated with limited TSHD dredging, overflow, and dredged material release operations for a representative cable route within the OECC

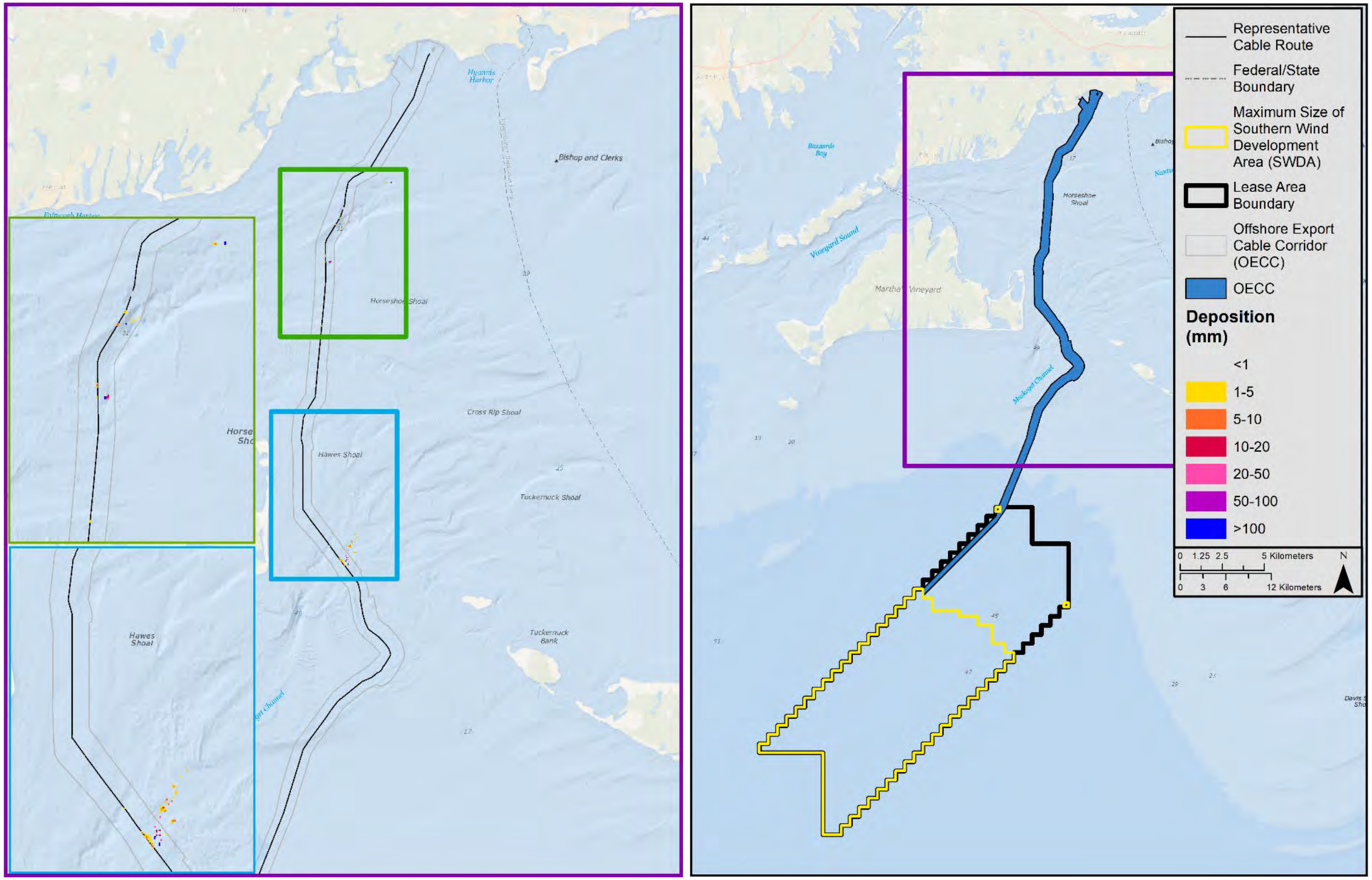

Figure 31. Map of deposition thickness associated with limited TSHD dredging, overflow, and dredged material release operations for a representative cable route within the OECC

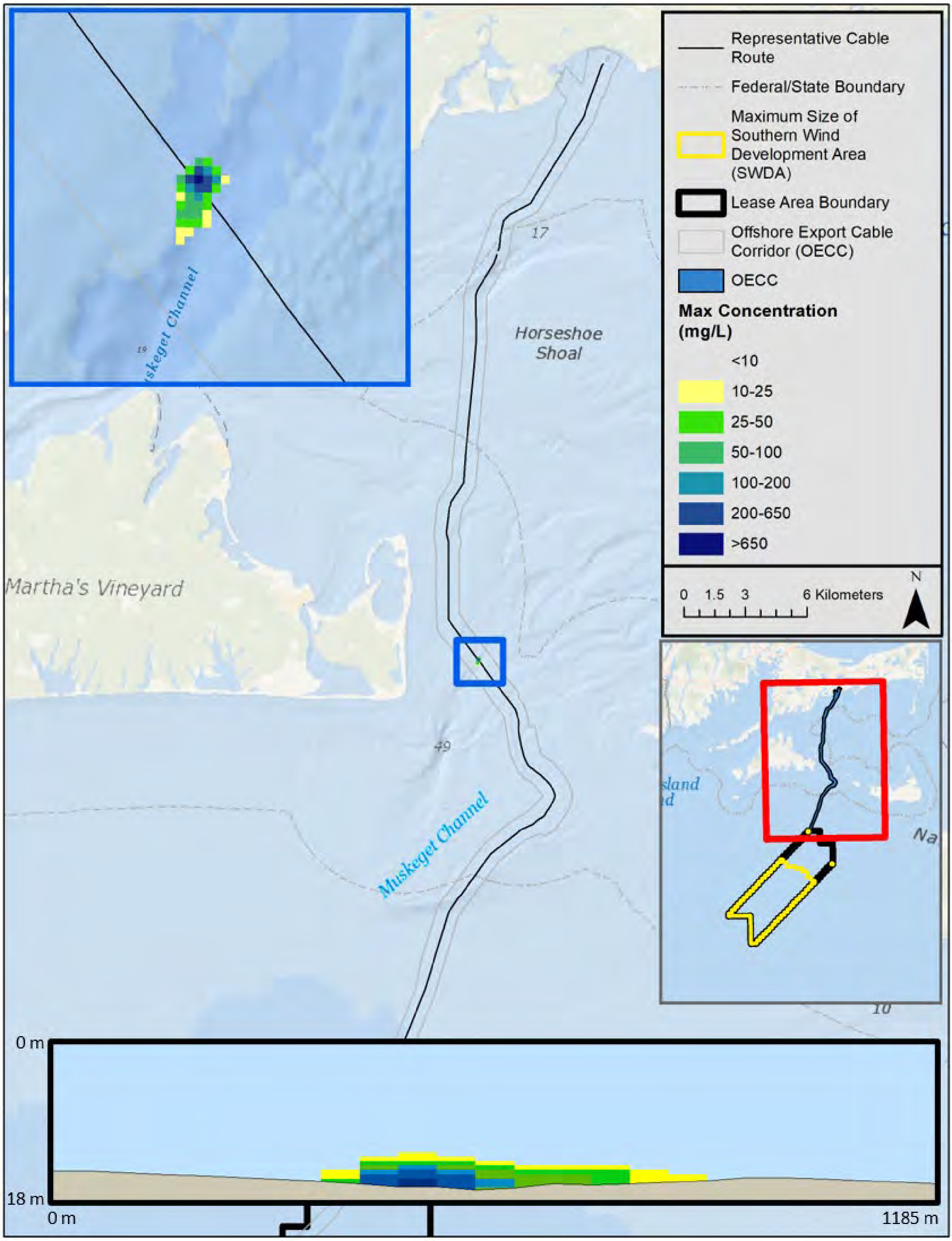

Figure 32. Snapshot of instantaneous TSS concentrations for a time step during simulation of representative cable installation within the OECC[1]

Notes:

1. Inset at bottom shows the vertical cross-section across the plume.

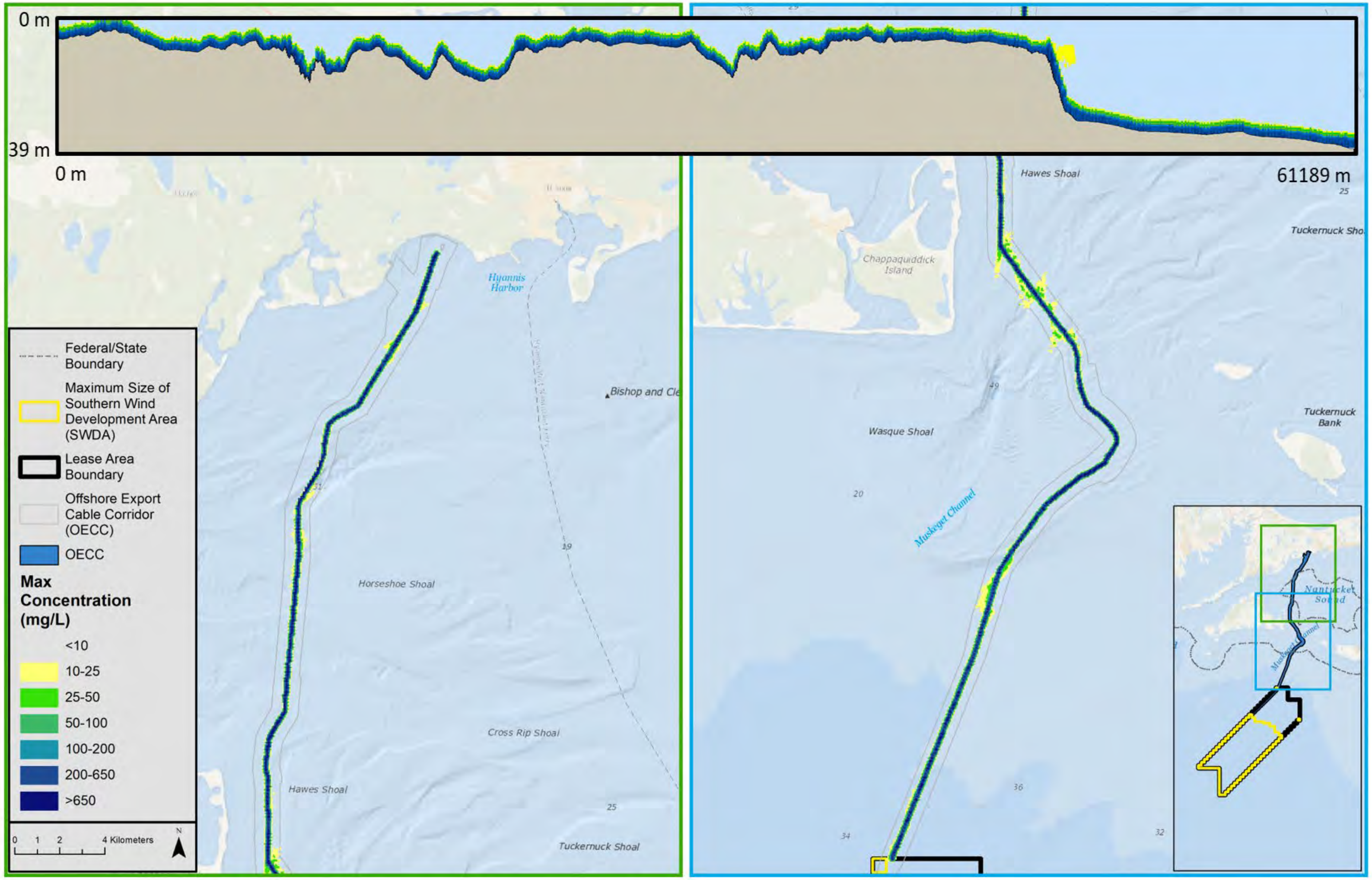

Figure 33. Map of time-integrated maximum concentrations associated with representative cable installation within the OECC[1]

Notes:

1. Inset shows a vertical cross-section along entire representative centerline.

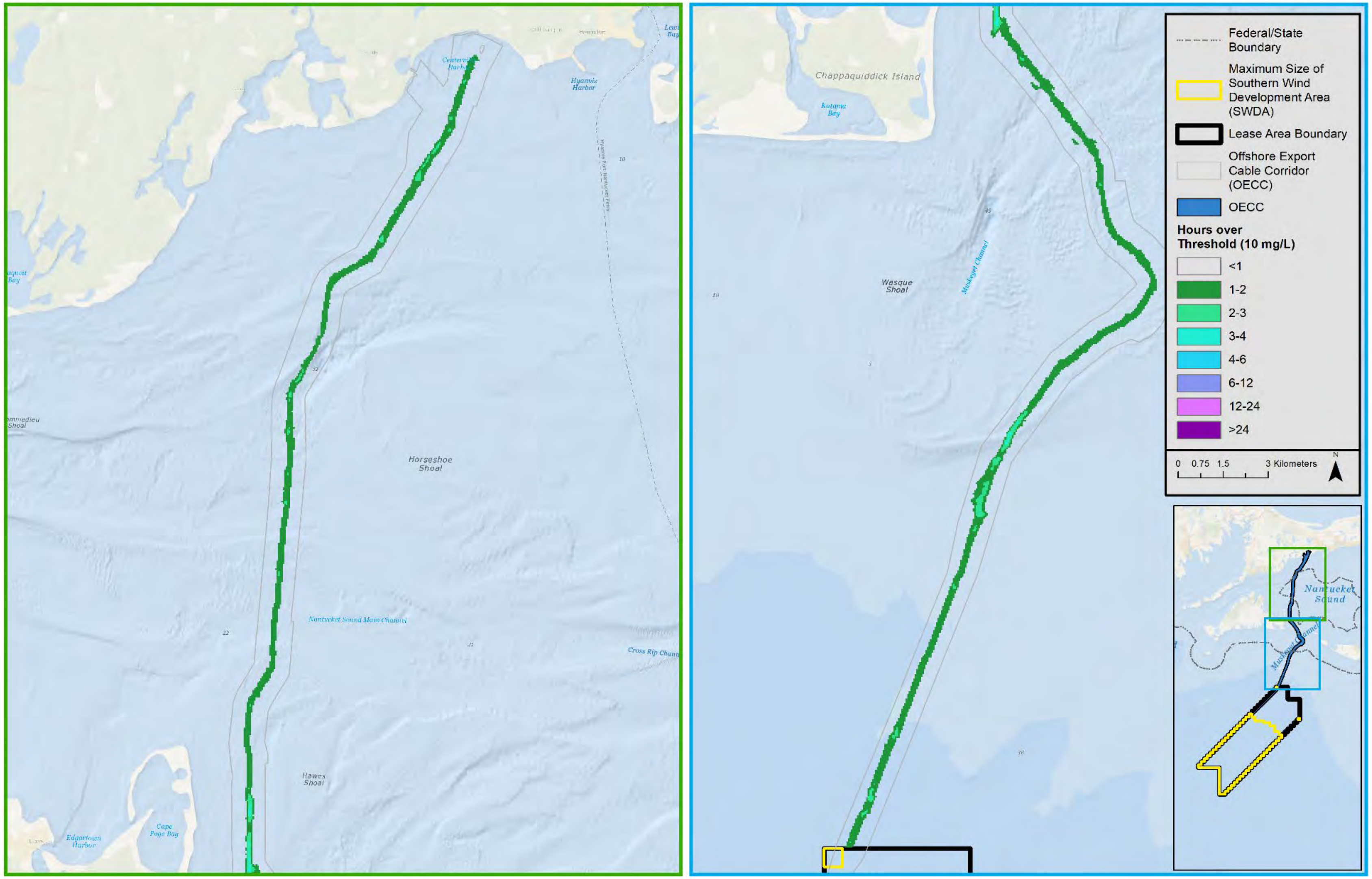

Figure 34. Map of duration of TSS ≥ 10 mg/L associated with representative cable installation within the OECC

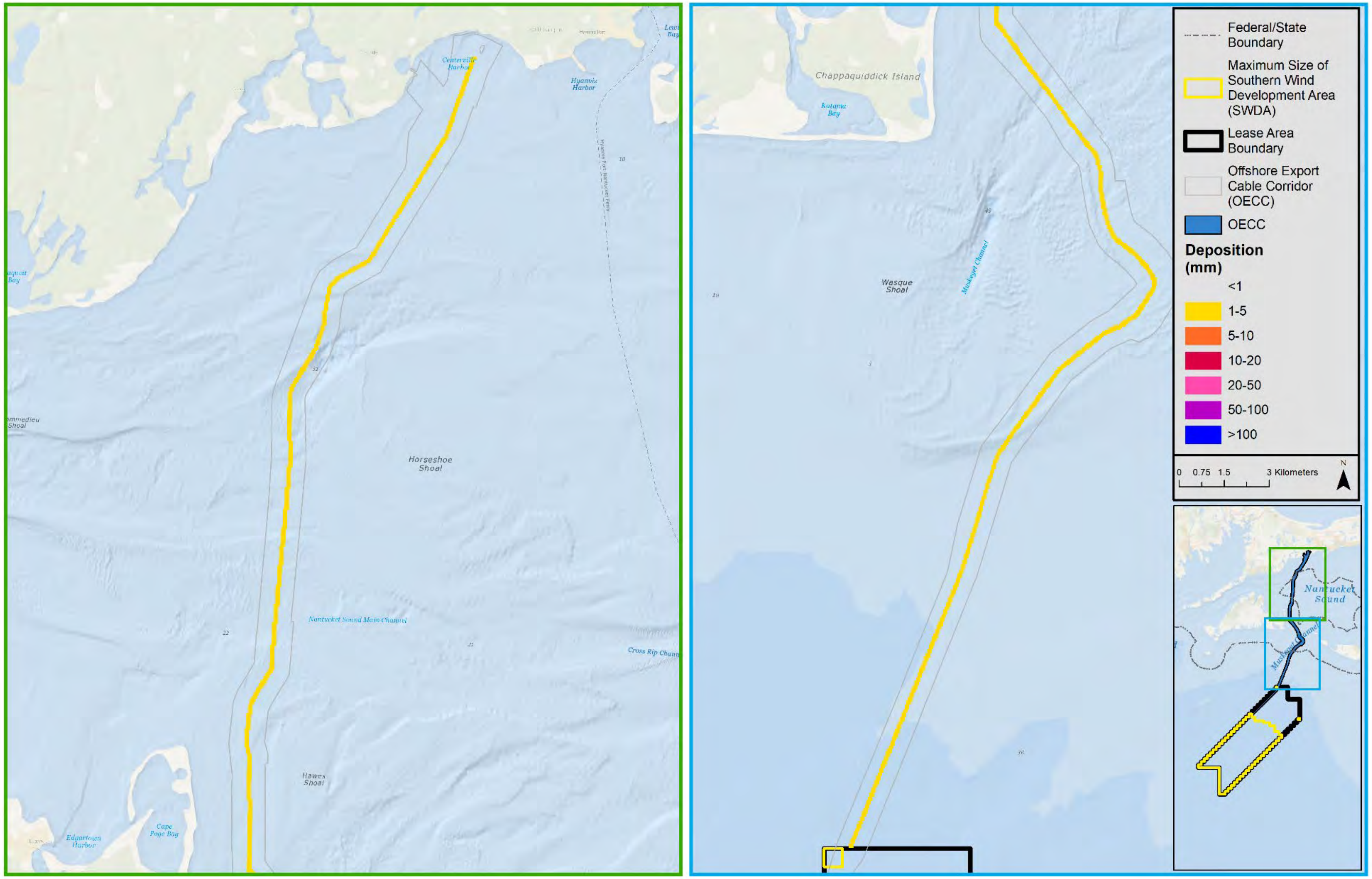

Figure 35. Map of deposition thickness associated with representative cable installation within the OECC

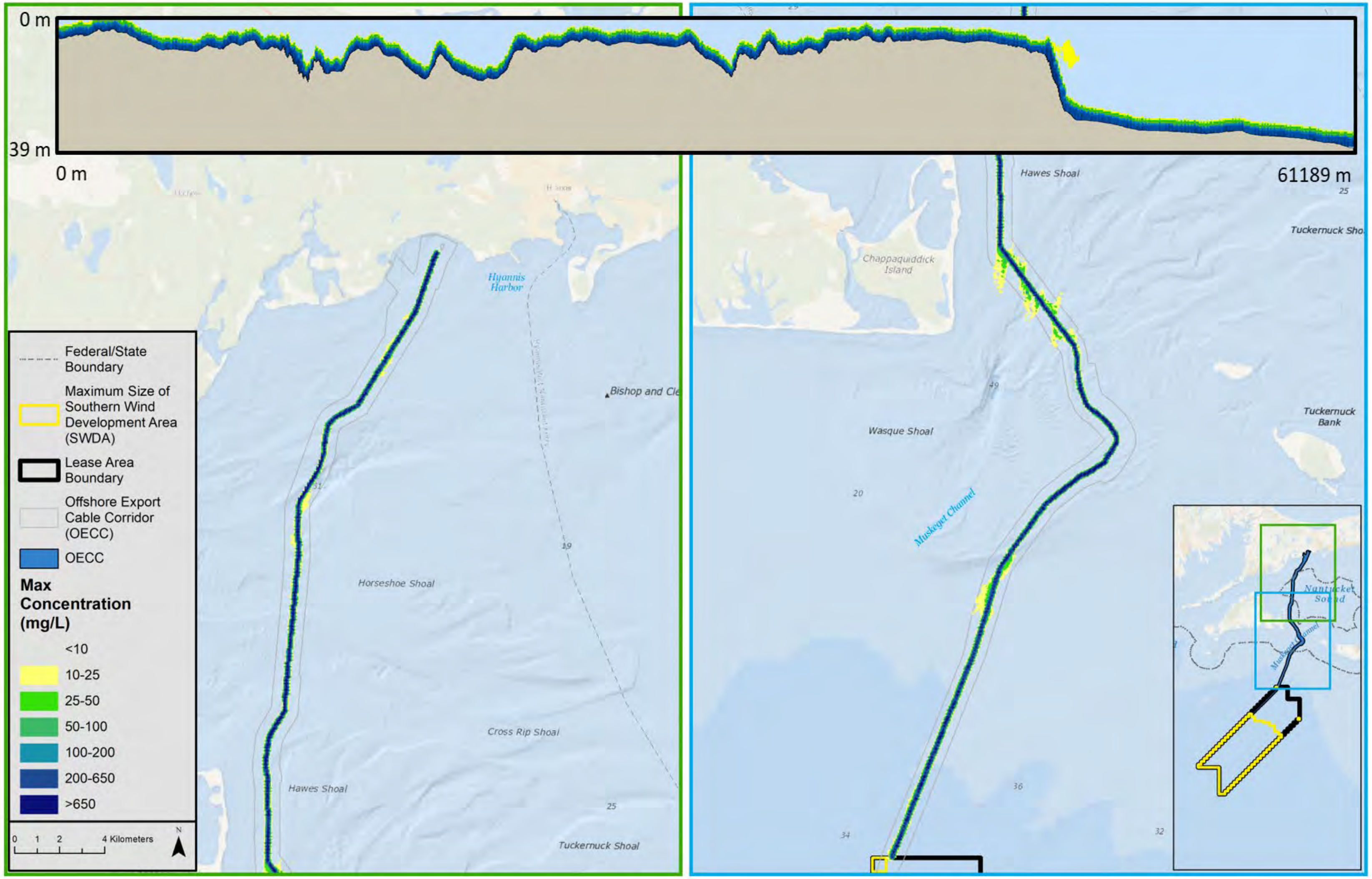

Figure 36. Map of time-integrated maximum concentrations associated with cable installation aided by jetting for a representative cable route within the OECC[1]

Notes:

1. Inset shows a vertical cross-section of entire representative route centerline.

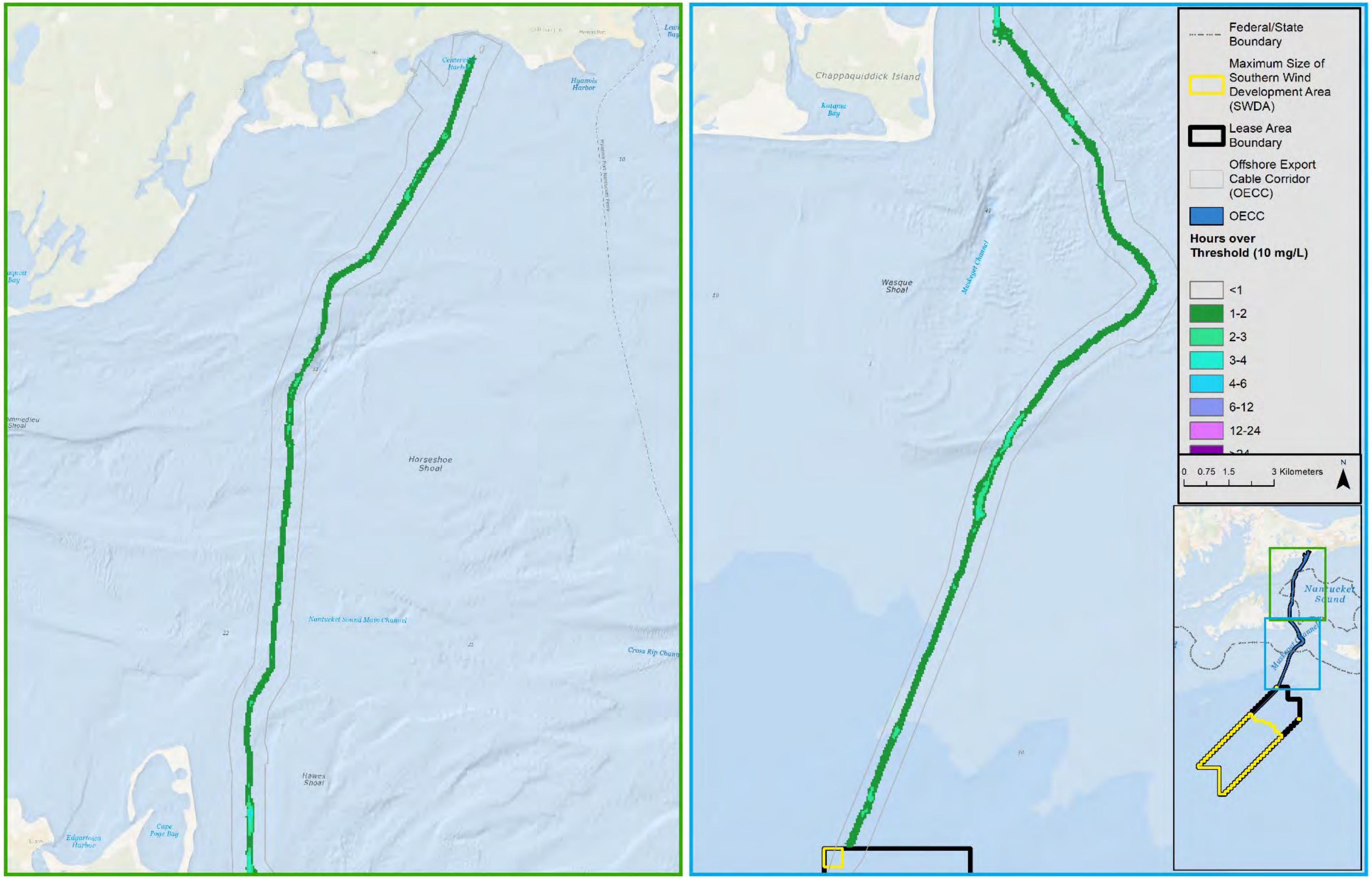

Figure 37. Map of duration of TSS ≥ 10 mg/L associated with cable installation aided by jetting for a representative cable route within the OECC

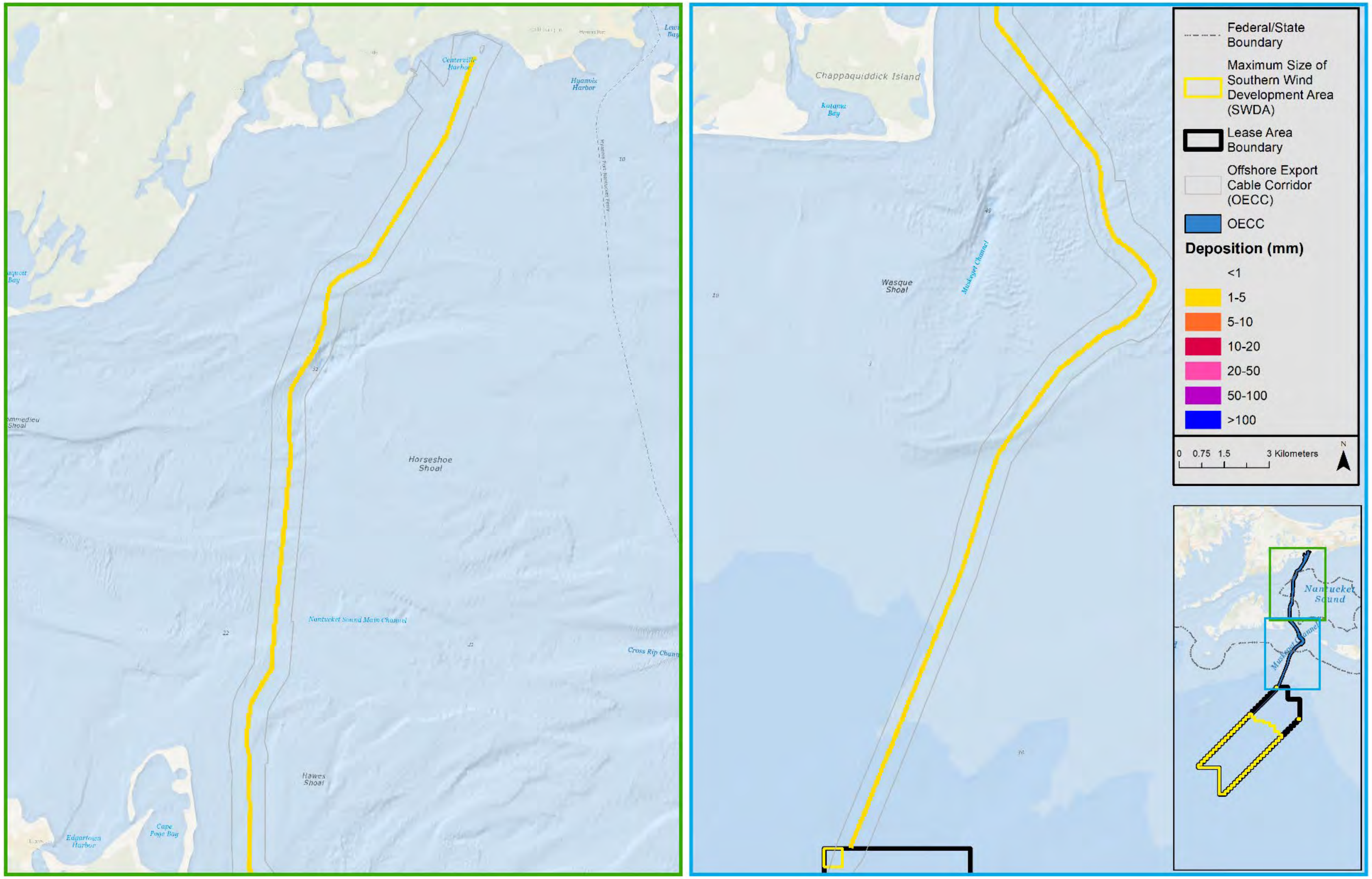

Figure 38. Map of deposition thickness associated with cable installation aided by jetting for a representative cable route within the OECC

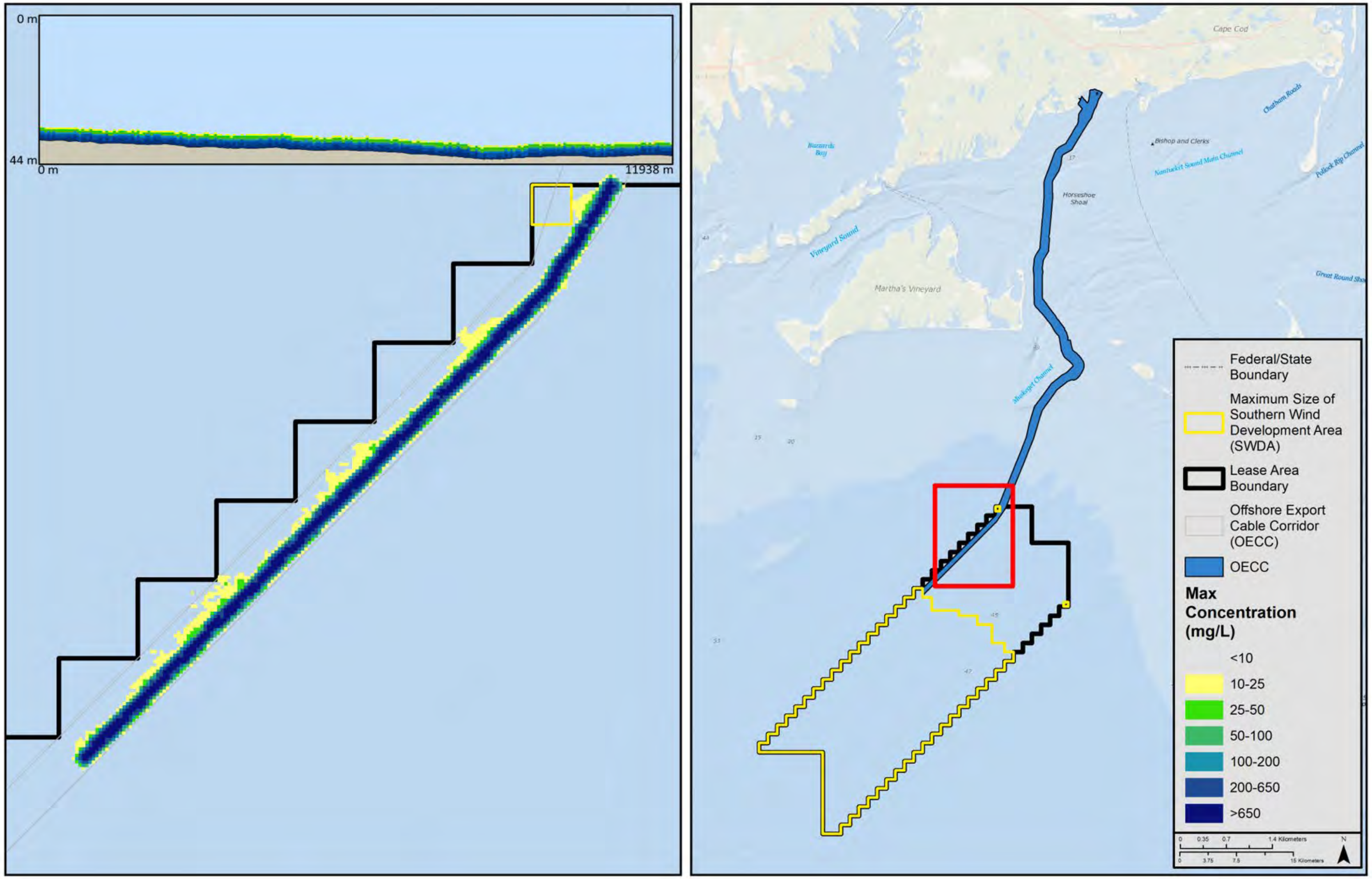

Figure 39. Map of time-integrated maximum concentrations associated with representative cable installation within the OECC in Lease Area OCS-A 0501[1]

Notes:

1. Inset shows a vertical cross-section.

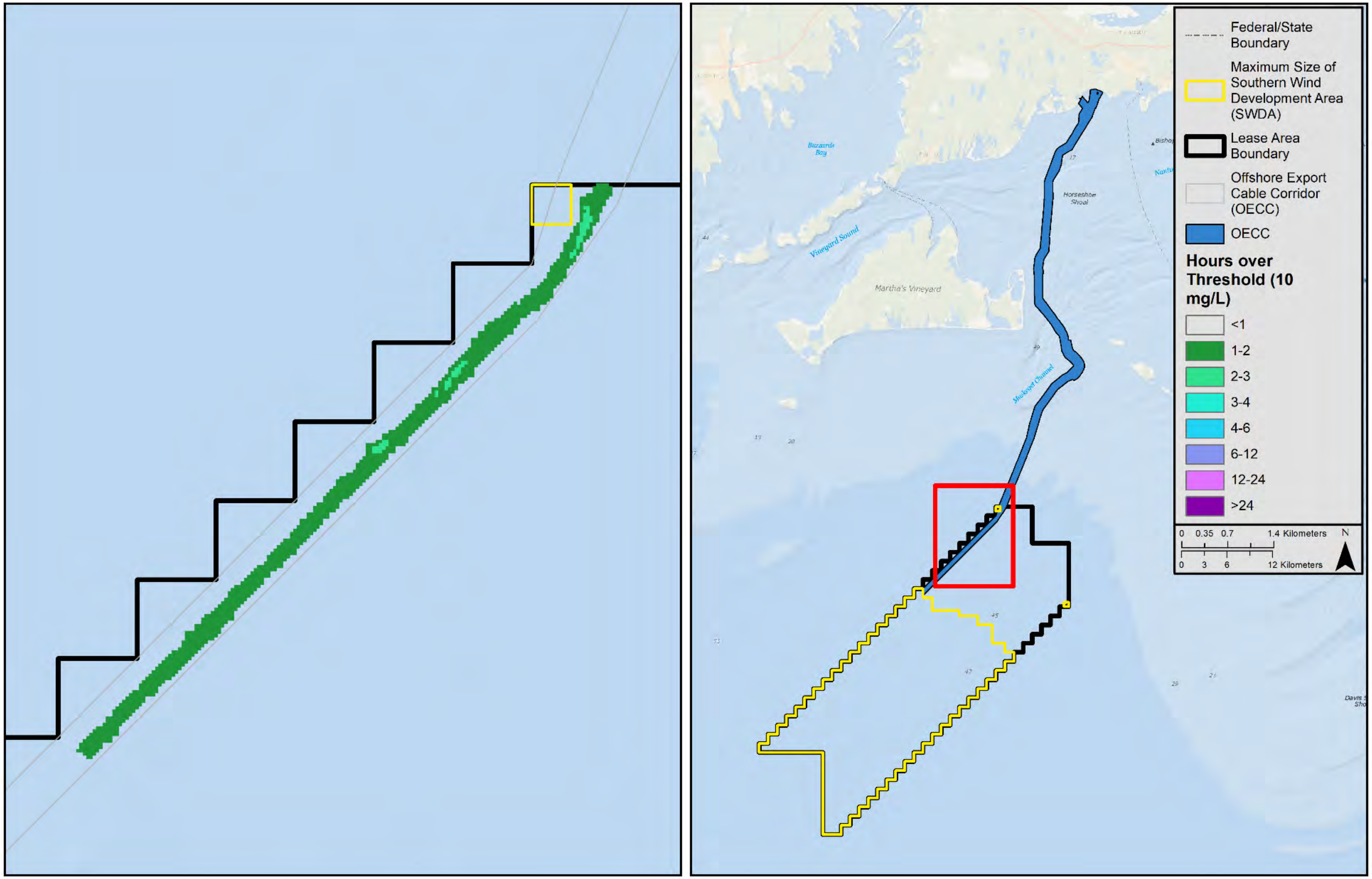

Figure 40. Map of duration of TSS ≥ 10 mg/L associated with representative cable installation within the OECC in Lease Area OCS-A 0501

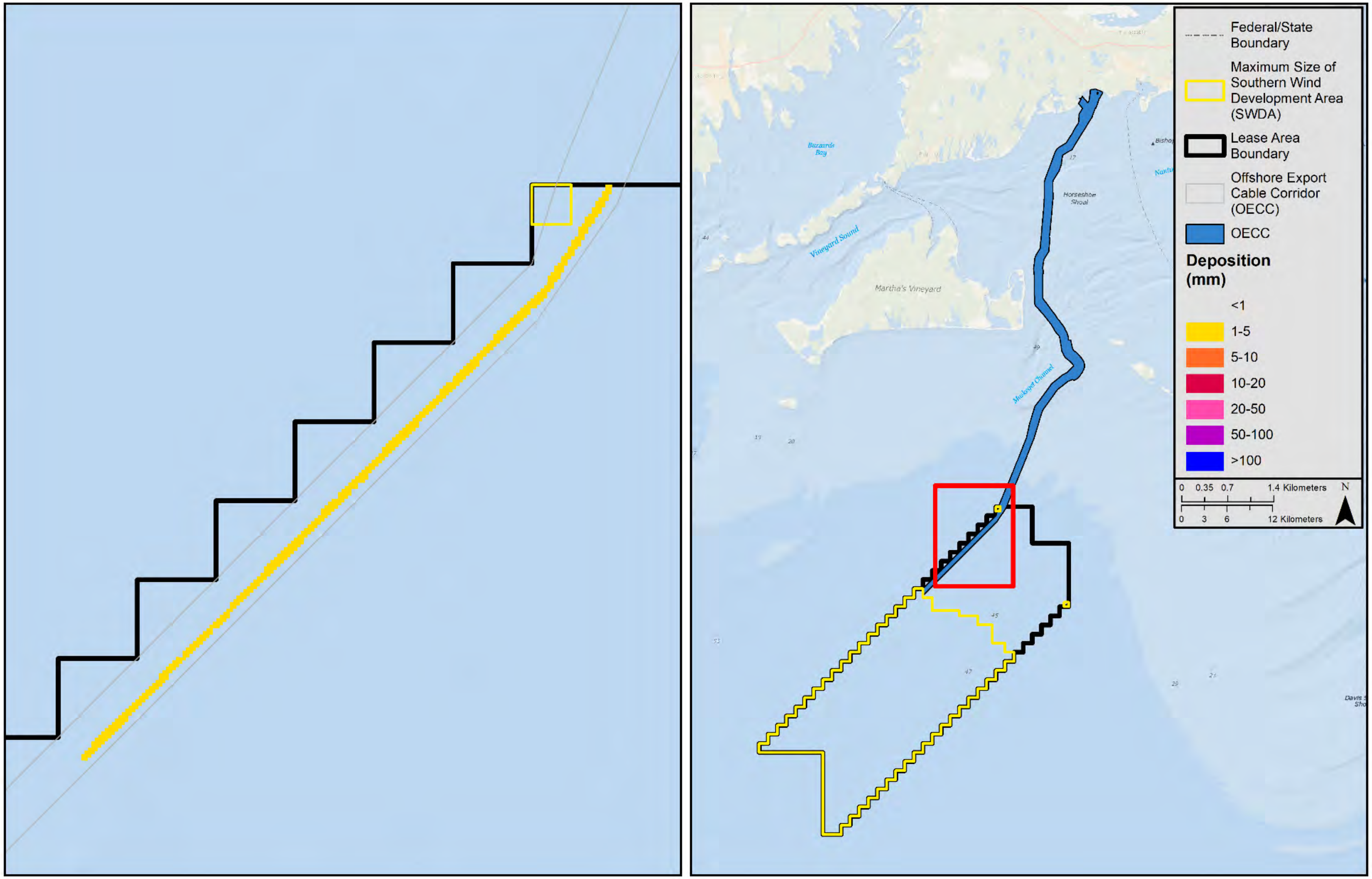

Figure 41. Map of deposition thickness associated with representative cable installation within the OECC in Lease Area OCS-A 0501

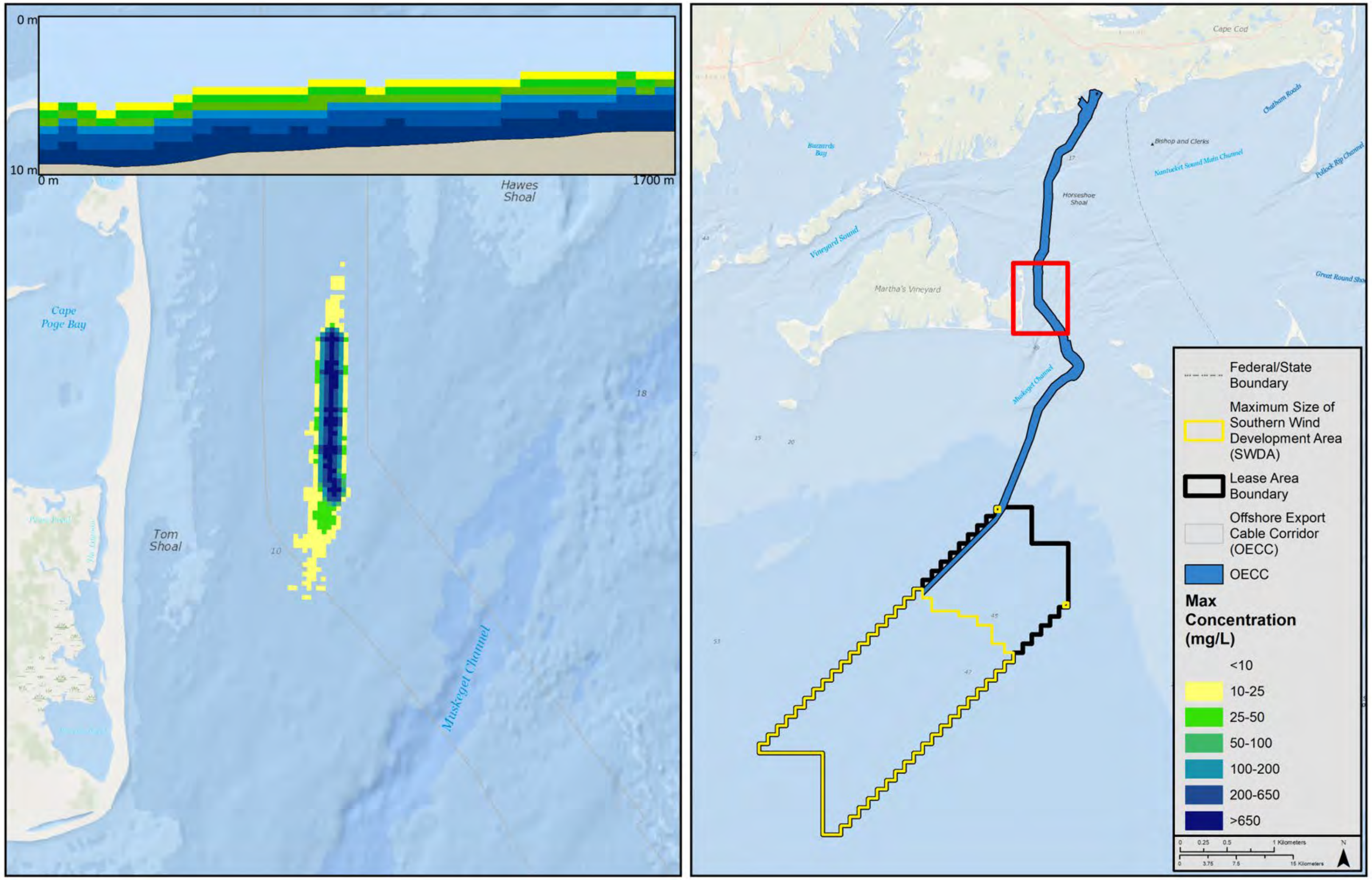

Figure 42. Map of time-integrated maximum concentrations associated with cable installation installed with a vertical injector for a representative section of the OECC[1]

Notes:

1. Inset shows a vertical cross-section.

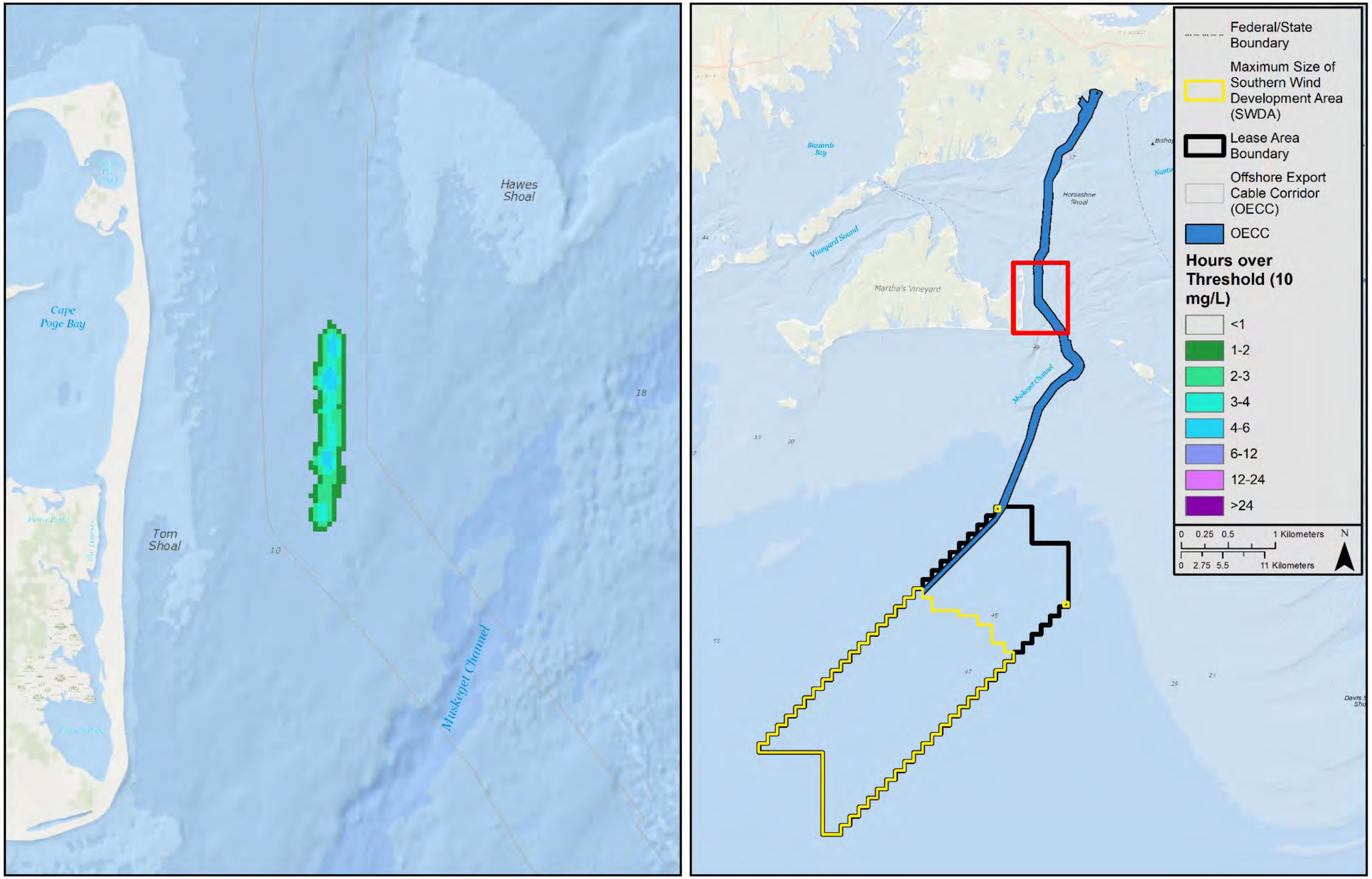

Figure 43. Map of duration of TSS ≥ 10 mg/L associated with cable installation installed with a vertical injector for a representative section of the OECC

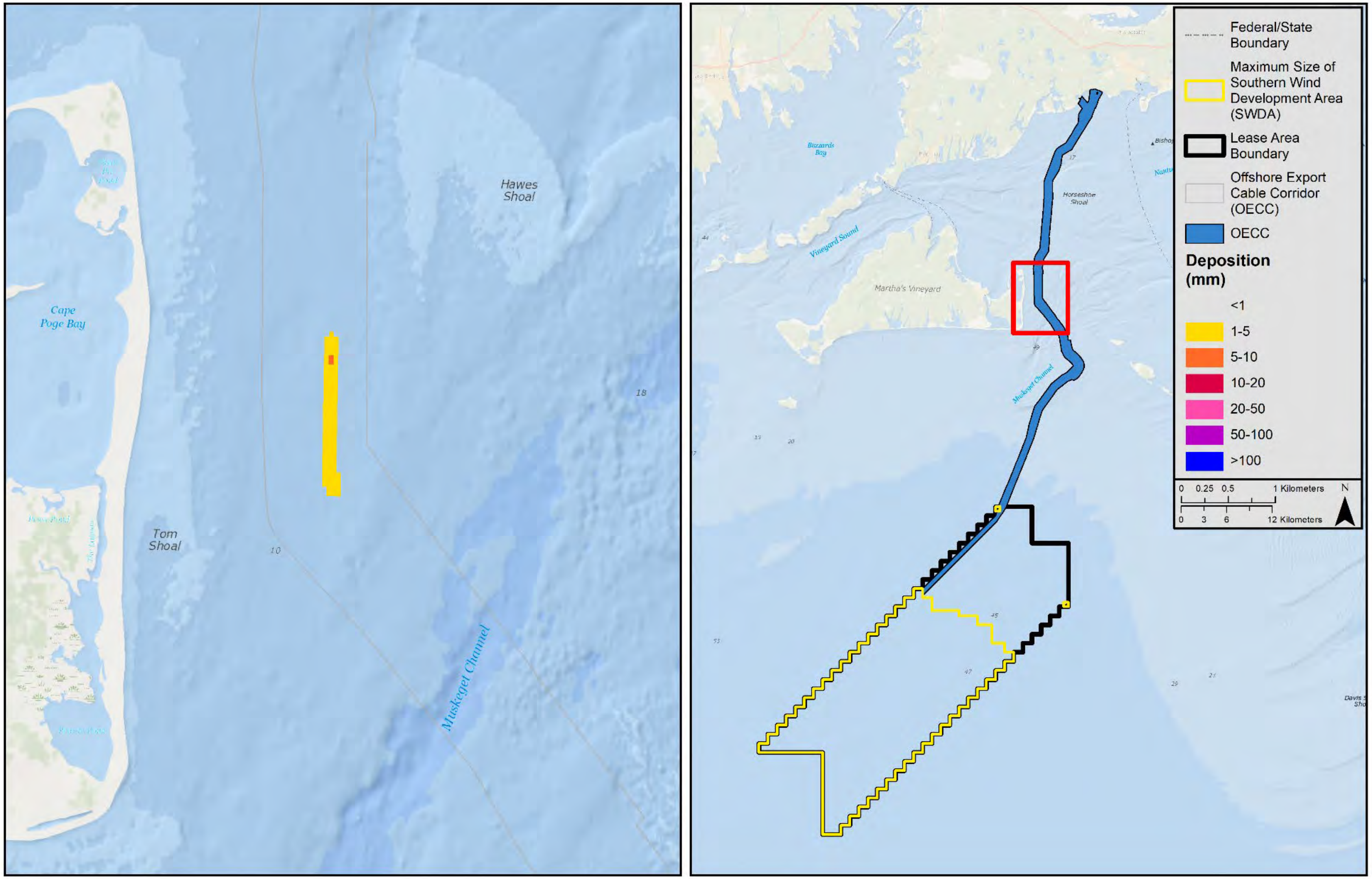

Figure 44. Map of deposition thickness associated with cable installation installed with a vertical injector for a representative section of the OECC

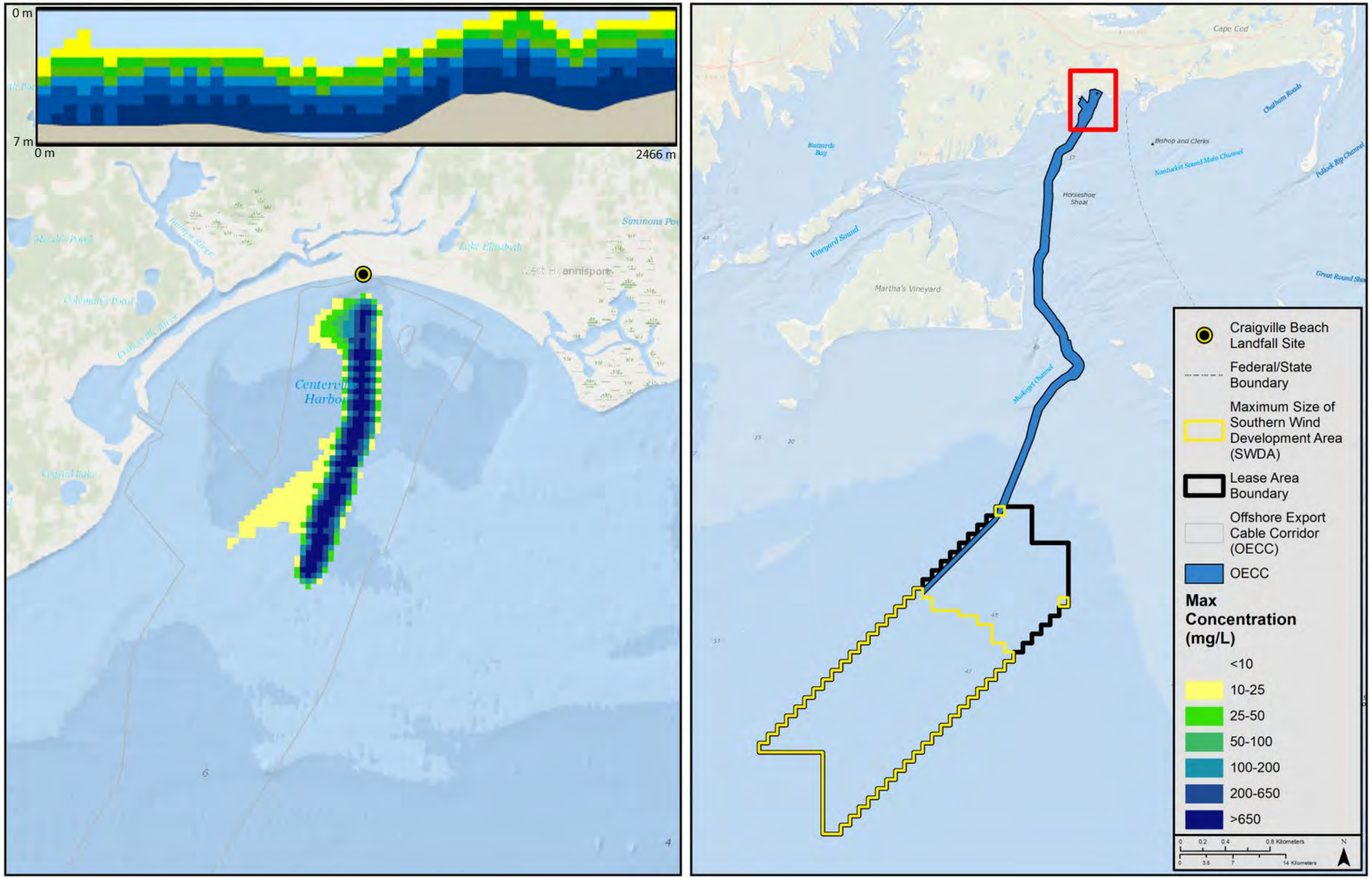

Figure 45. Map of time-integrated maximum concentrations associated with cable installation for a representative section of the OECC approaching the landfall site[1]

Notes:

1. Inset shows a vertical cross-section.

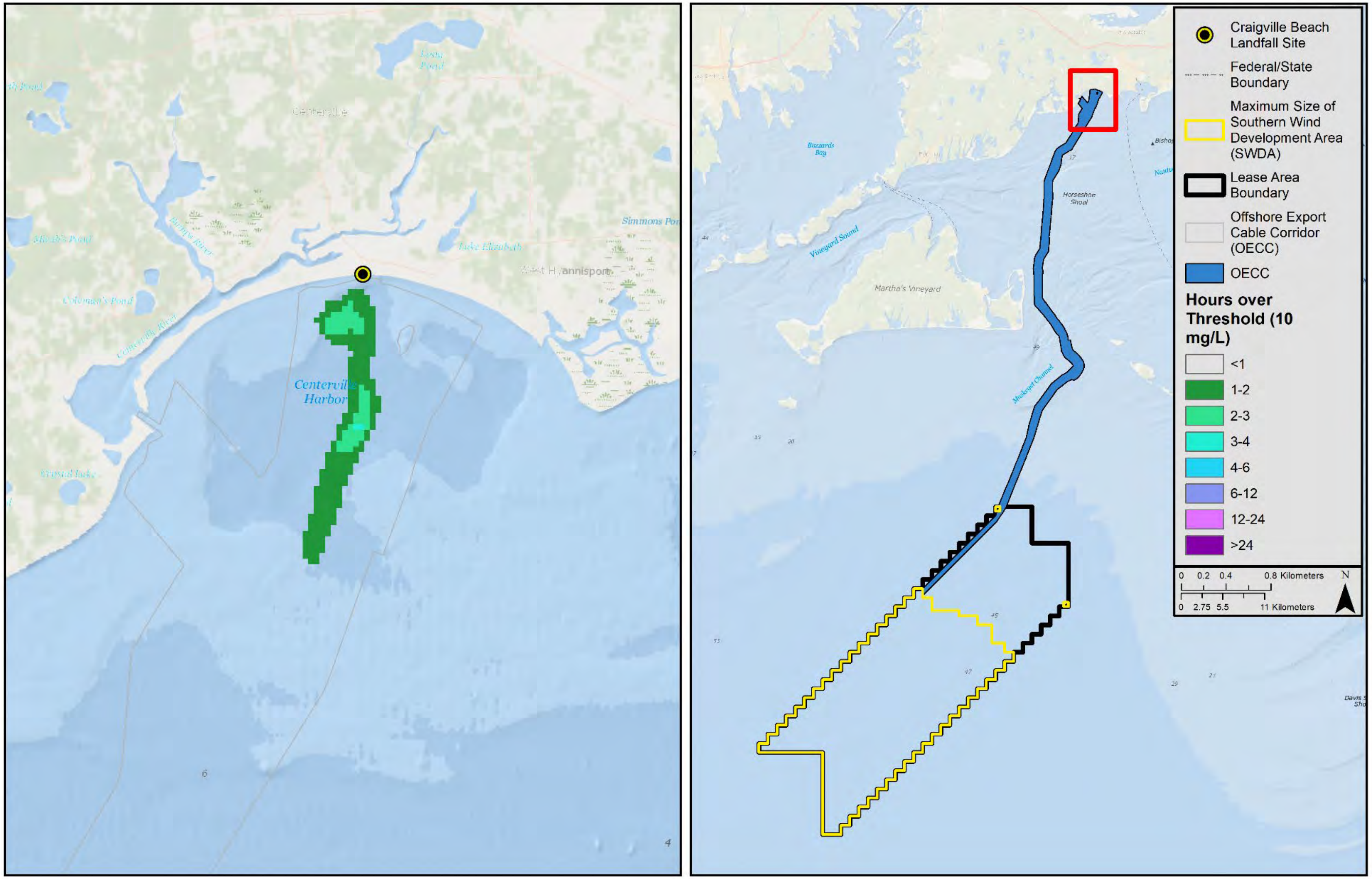

Figure 46. Map of duration of TSS ≥ 10 mg/L associated with cable installation for a representative section of the OECC approaching the landfall site

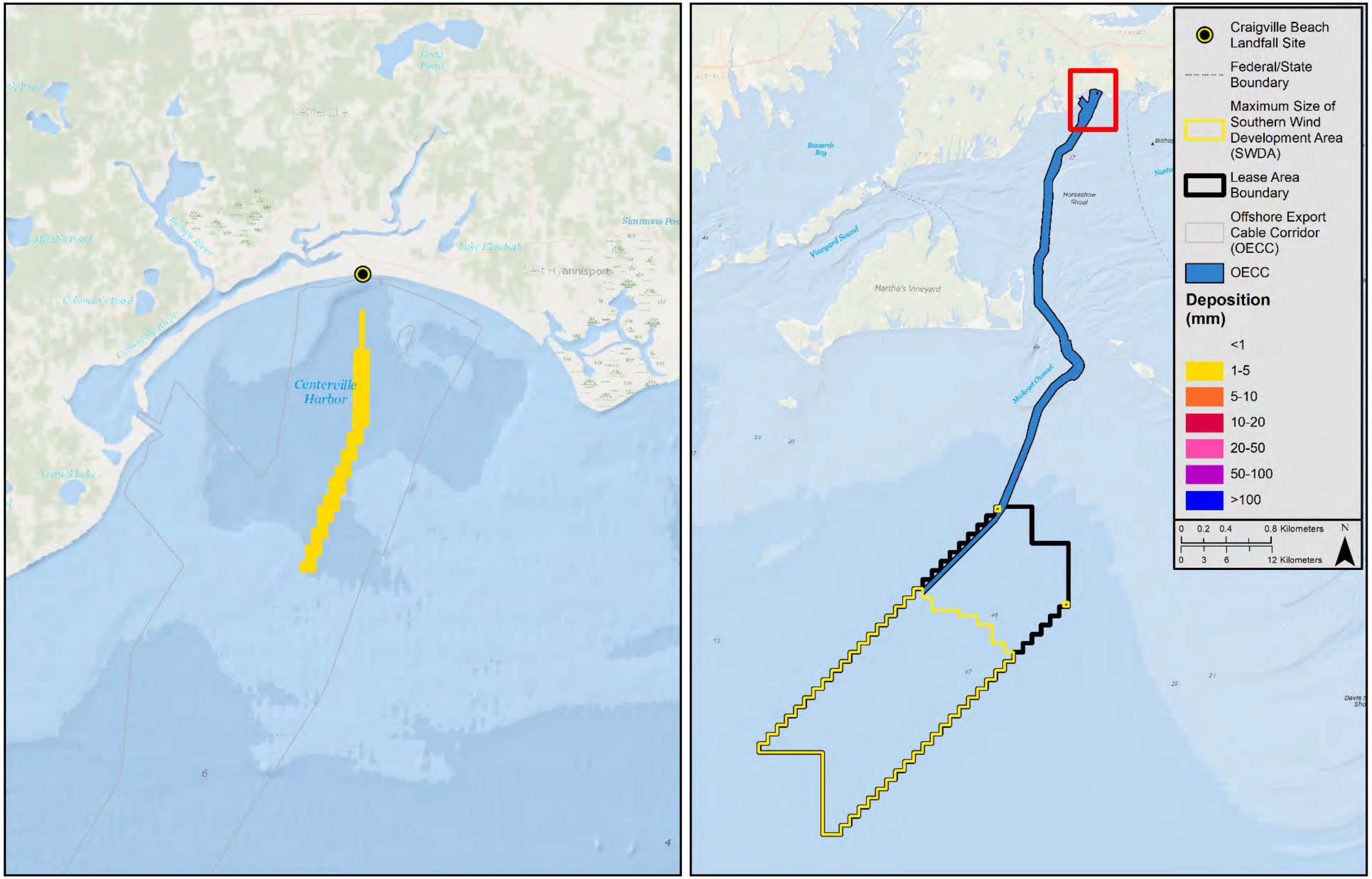

Figure 47. Map of deposition thickness associated with cable installation for a representative section of the OECC approaching the landfall site

4.3.3 Results Summary Tables

Results from all modeled scenarios were analyzed to determine the spatial area exposed to above-ambient TSS concentrations exceeding specific thresholds for various durations. 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. Post-processing included calculations with respect to duration threshold of one, two, three, four, six, 12, 24, and 48 hours; however, there were no areas over thresholds for the six-, 12-, 24-, or 48-hour durations. Table 15 through Table 18 show the results for durations of one, two, three, and four hours, respectively. In reviewing these tables, it is helpful to keep in mind that the concentration grid resolution is 50 m in the horizontal plane. For a route 60 km long, the area covered by the grid cells along the route is therefore 3 km^2 (60,000 m x 50 m = 3 km^2). The dredge source is introduced in a smaller footprint since dredging is intermittent and does not occur along the entire cable alignment. Similarly, the representative OECC in the Lease Area and the representative OECC sections (vertical injector and landfall approach) have a smaller direct footprint because their linear extent is smaller.

Table 15 through Table 18 illustrate that areas exposed to above-ambient TSS concentrations are largest when assessing concentrations above 10 mg/L, and that the areas rapidly decrease in size with increasing concentration threshold and increasing duration. For example, as shown in Table 15, the cable installation aided by jetting model scenario has a total area throughout the entire OECC of 13.3 km^2 over 10 mg/L for more than 60 minutes, but only 0.01 km^2 of this area is over 200 mg/L for more than 60 minutes. (Note the listed areas are a summation of impacts throughout the entire OECC, such that all the listed areas are not impacted simultaneously). Above-ambient TSS concentrations similarly decrease quickly with time: for the same example scenario (OECC cable installation aided by jetting) concentrations over 10 mg/L decrease from 13.3 km^2 for one hour (Table 15) to 0.7 km^2 for two hours (Table 16), to 0.1 km^2 for three hours (Table 17) to zero for four hours (Table 18). In addition, for this route TSS concentrations greater than 50 mg/L do not endure for periods of two hours or greater. Similar trends of rapid decrease of area with increasing time and/or increasing threshold are noted for all other routes presented.

Table 19 summarizes the maximum extent of the 10 mg/L concentration as measured perpendicular to the route centerline for each scenario. This table shows how the TSHD activities will have a 10 mg/L plume that reaches a farther extent as compared to the cable installation activities. This is because the TSHD activities have sediments introduced much higher in the water column during disposal, which means they take longer to settle so the 10 mg/L contour therefore extends farther from the activity. The plume is not expected to be of that size contiguously from the release, but the extent reflects the trajectory that sediments may follow away from source activities. As described in the preceding paragraphs, the plume is temporary and dissipates rapidly.

Table 20 summarizes the areas affected by sediment deposition over various thickness thresholds. The inter-array cable installation had deposition of up to 1–5 mm for the typical installation and a small patch of deposition of 5–10 mm for the maximum impact simulation. Comparing the two scenarios, the max distance to the 1 mm thickness contour is greater for the maximum impact simulation (150 m versus 100 m, approximately one additional grid cell) and thickness thresholds are greater for the maximum impact burial parameters as compared to the simulation with typical parameters. The OECC cable installation scenarios primarily result in a maximum thickness less than 5 mm with a small exception of the OECC section installed with vertical injector which has a small area (0.01 km^2) of thickness between 5–10 mm. The TSHD scenarios result in deposition thicknesses greater than the cable installation scenarios, with some areas of 100 mm or greater. These areas are associated with the hopper disposal which disposes of the entire hopper of sediment in one location.

Table 15. Summary of Areas Over Above-Ambient TSS Threshold Concentrations for One Hour or Longer for Each Scenario[1,2]

Location	Method	TYP or MAX	Concentration Thresholds in mg/L					
			10	25	50	100	200	650
			Areas Above Concentration Threshold (km²)					
Inter-array Cable Installation – Representative Section								
SWDA Inter-array	Cable Installation	TYP	6.7	4.4	3.6	2.5	1.3	N/A
SWDA Inter-array	Cable Installation	MAX	9.5	4.4	2.3	0.9	0.1	N/A
Offshore Cable Installation – Representative Sections								
OECC	TSHD	TYP	17.2	7.9	3.6	1.0	0.2	N/A
OECC	Limited TSHD	TYP	5.3	2.0	0.8	0.2	0.1	N/A
OECC	Cable Installation	TYP	13.3	10.8	6.2	2.4	0.1	N/A
OECC	Cable Installation Aided by Jetting	TYP	13.3	10.9	6.4	2.5	0.1	N/A
OECC in Lease Area OCS-A 0501	Cable Installation	TYP	3.4	2.7	2.2	1.7	0.6	N/A
OECC Vertical Injector Section	Cable Installation	TYP	0.6	0.5	0.4	0.3	0.3	N/A
OECC Landfall Approach Section	Cable Installation	TYP	0.7	0.5	0.4	0.3	0.1	N/A

Notes:

1. Typical (“Typ”) and maximum impact (“Max”) parameters are presented where applicable.
2. The areas in this table are the total areas from the entire simulation, and therefore reflect the sum of different instances of smaller areas and do not occur simultaneously.

Table 16. Summary of Areas Over Above-ambient TSS Threshold Concentrations for Two Hours or Longer for Each Scenario[1,2]

Location	Method	TYP or MAX	Concentration Thresholds in mg/L					
			10	25	50	100	200	650
			Areas Above Concentration Threshold (km^2)					
Inter-array Cable Installation – Representative Section								
SWDA Inter-array	Cable Installation	TYP	0.7	N/A	N/A	N/A	N/A	N/A
SWDA Inter-array	Cable Installation	MAX	1.5	N/A	N/A	N/A	N/A	N/A
Offshore Cable Installation – Representative Sections								
OECC	TSHD	TYP	5.7	2.4	0.7	N/A	N/A	N/A
OECC	Limited TSHD	TYP	0.9	N/A	N/A	N/A	N/A	N/A
OECC	Cable Installation	TYP	0.7	N/A	N/A	N/A	N/A	N/A
OECC	Cable Installation Aided by Jetting	TYP	0.7	0.1	N/A	N/A	N/A	N/A
OECC in Lease Area OCS-A 0501	Cable Installation	TYP	0.3	N/A	N/A	N/A	N/A	N/A
OECC Vertical Injector Section	Cable Installation	TYP	0.5	0.3	0.2	0.1	N/A	N/A
OECC Landfall Approach Section	Cable Installation	TYP	0.2	N/A	N/A	N/A	N/A	N/A

Notes:

1. Typical (“Typ”) and maximum impact (“Max”) parameters are presented where applicable.
2. The areas in this table are the total areas from the entire simulation, and therefore reflect the sum of different instances of smaller areas and do not occur simultaneously.

Table 17. Summary of Areas Over Above-ambient TSS Threshold Concentrations for Three Hours or Longer for Each Scenario[1,2]

Location	Method	TYP or MAX	Concentration Thresholds in mg/L					
			10	25	50	100	200	650
			Areas Above Concentration Threshold (km²)					
Inter-array Cable Installation – Representative Section								
SWDA Inter-array	Cable Installation	TYP	N/A	N/A	N/A	N/A	N/A	N/A
SWDA Inter-array	Cable Installation	MAX	0.1	N/A	N/A	N/A	N/A	N/A
Offshore Cable Installation – Representative Sections								
OECC	TSHD	TYP	2.8	0.8	N/A	N/A	N/A	N/A
OECC	Limited TSHD	TYP	0.1	N/A	N/A	N/A	N/A	N/A
OECC	Cable Installation	TYP	0.1	N/A	N/A	N/A	N/A	N/A
OECC	Cable Installation Aided by Jetting	TYP	0.1	N/A	N/A	N/A	N/A	N/A
OECC in Lease Area OCS-A 0501	Cable Installation	TYP	N/A	N/A	N/A	N/A	N/A	N/A
OECC Vertical Injector Section	Cable Installation	TYP	0.2	0.1	N/A	N/A	N/A	N/A
OECC Landfall Approach Section	Cable Installation	TYP	N/A	N/A	N/A	N/A	N/A	N/A

Notes:

1. Typical ("Typ") and maximum impact ("Max") parameters are presented where applicable.
2. The areas in this table are the total areas from the entire simulation, and therefore reflect the sum of different instances of smaller areas and do not occur simultaneously.

Table 18. Summary of Areas Over Above-ambient TSS Threshold Concentrations for Four Hours or Longer for Each Scenario[1,2]

Location	Method	TYP or MAX	Concentration Thresholds in mg/L					
			10	25	50	100	200	650
			Areas Above Concentration Threshold (km^2)					
Inter-array Cable Installation – Representative Section								
SWDA Inter-array	Cable Installation	TYP	N/A	N/A	N/A	N/A	N/A	N/A
SWDA Inter-array	Cable Installation	MAX	N/A	N/A	N/A	N/A	N/A	N/A
Offshore Cable Installation – Representative Sections								
OECC	TSHD	TYP	1.2	0.1	N/A	N/A	N/A	N/A
OECC	Limited TSHD	TYP	N/A	N/A	N/A	N/A	N/A	N/A
OECC	Cable Installation	TYP	N/A	N/A	N/A	N/A	N/A	N/A
OECC	Cable Installation Aided by Jetting	TYP	N/A	N/A	N/A	N/A	N/A	N/A
OECC in Lease Area OCS-A 0501	Cable Installation	TYP	N/A	N/A	N/A	N/A	N/A	N/A
OECC Vertical Injector Section	Cable Installation	TYP	0.1	N/A	N/A	N/A	N/A	N/A
OECC Landfall Approach Section	Cable Installation	TYP	N/A	N/A	N/A	N/A	N/A	N/A

Notes:

1. Typical ("Typ") and maximum impact ("Max") parameters are presented where applicable.
2. The areas in this table are the total areas from the entire simulation, and therefore reflect the sum of different instances of smaller areas and do not occur simultaneously.

Table 19. Summary of Maximum Extent to the 10 mg/L TSS Contour from the Route Centerline for Each Scenario[1]

Location	Method	TYP or MAX	Maximum (Max) Distance (km) to 10 mg/L Contour
Inter-array Cable Installation – Representative Section			
SWDA Inter-array	Cable Installation	TYP	1.0
SWDA Inter-array	Cable Installation	MAX	2.2
Offshore Cable Installation – Representative Sections			
OECC	TSHD	TYP	16.0
OECC	Limited TSHD	TYP	8.5
OECC	Cable Installation	TYP	1.9
OECC	Cable Installation Aided by Jetting	TYP	2.1
OECC in Lease Area OCS-A 0501	Cable Installation	TYP	0.6
OECC Vertical Injector Section	Cable Installation	TYP	1.2
OECC Landfall Approach Section	Cable Installation	TYP	0.8

Notes:

1. Typical (“Typ”) and maximum impact (“Max”) parameters are presented where applicable.

Table 20. Summary of Deposition Over Thresholds for Each Scenario[1]

Location	Method	TYP or MAX	Max Extent (km) of Deposition > 1 mm	Max Extent (km) of Deposition > 20 mm	Area (km^2) over Deposition threshold in mm					
					1 mm	5 mm	10 mm	20 mm	50 mm	100 mm
Inter-array Cable Installation – Representative Section										
SWDA Inter-array	Cable Installation	TYP	0.10	N/A	2.41	N/A	N/A	N/A	N/A	N/A
SWDA Inter-array	Cable Installation	MAX	0.15	N/A	3.48	0.01	N/A	N/A	N/A	N/A
Offshore Cable Installation – Representative Sections										
OECC	TSHD	TYP	2.3	0.4	1.06	0.37	0.14	0.10	0.08	0.08
OECC	Limited TSHD	TYP	2.3	0.9	0.26	0.10	0.06	0.03	0.02	0.02
OECC	Cable Installation	TYP	0.12	N/A	9.08	N/A	N/A	N/A	N/A	N/A
OECC	Cable Installation Aided by Jetting	TYP	0.10	N/A	9.08	N/A	N/A	N/A	N/A	N/A
OECC in Lease Area OCS-A 0501	Cable Installation	TYP	0.10	N/A	1.44	N/A	N/A	N/A	N/A	N/A
OECC Vertical Injector Section	Cable Installation	TYP	0.10	N/A	0.27	0.01	N/A	N/A	N/A	N/A
OECC Landfall Approach Section	Cable Installation	TYP	0.10	N/A	0.30	N/A	N/A	N/A	N/A	N/A

Notes:

1. Typical (“Typ”) and maximum impact (“Max”) parameters are presented where applicable.

4.3.4 Results Discussion

Simulations of sand wave dredging and associated disposal activities using a TSHD along the OECC show that above-ambient TSS originating from the source is intermittent along the route, matching the intermittent need for dredging. Above-ambient TSS concentrations may be present throughout the entire water column since sediments are released at or near the water surface. Above-ambient TSS concentrations of 10 mg/L extend up to 16 km and 8.5 km from the area of activity for the TSHD and limited TSHD model scenarios, respectively; however, these concentrations only persist for a matter of hours. Concentrations greater than 10 mg/L persist less than six hours for TSHD activities and less than four hours for limited TSHD activities. Deposition greater than 1 mm associated with the TSHD drag arm is mainly constrained to within 150 m of the area of activity, whereas the same deposition thickness associated with overflow and dredged material release extends greater distances from the source, resulting in deposition mainly within 1 km but extending up to 2.3 km in isolated patches when subject to swift currents through Muskeget Channel. Due to the hopper disposal, which releases the entire hopper of sediment in one location, the TSHD scenarios result in limited areas with deposition of 100 mm or greater, which is substantially greater than the cable installation scenarios.

Simulations of several possible inter-array or offshore export cable installation methods using either typical installation parameters (for inter-array and offshore export cable installation) or maximum impact parameters (for inter-array cable installation only) predict a plume that is localized to the seabed. The plume may be located in the bottom approximate 6 m of the water column, which is typically a fraction of the water column; however, in shallow waters, the plume may occupy the entire water column; these represent only a small fraction of the cable routes. Simulations of cable installation found that above-ambient TSS greater than 10 mg/L and deposition over 1 mm stayed closer to the cable alignment as compared to the dredging footprints; this is due to the fact that sediments are introduced to the water column closer to the seabed. TSS concentrations greater than 10 mg/L typically stayed within 200 m of the alignment, though travelled a maximum distance of approximately 2.1 km for typical installation parameters and up to 2.2 km for maximum impact installation parameters (for inter-array cable installation only).

Above-ambient TSS concentrations stemming from cable installation for the various model scenarios remain relatively close to the cable alignment, are constrained to the bottom of the water column, and are short-lived. Above-ambient TSS concentrations substantially dissipate within one to two hours and fully dissipate in less than four hours for most of the model scenarios. For the vertical injector model scenario, above-ambient TSS concentrations similarly substantially dissipated within one to two hours but required up to six hours to fully dissipate, likely due to the relatively slower installation rate and deeper trench (greater volume disturbed per unit length). Deposition greater than 1 mm was limited to within 100 m of the cable alignment for typical installation parameters and to within less than 150 m of the cable alignment for maximum impact installation parameters (for inter-array cable installation only). The maximum deposition associated with inter-array or offshore export cable installation was typically less than 5 mm, though there was a small isolated area associated with the vertical injector model scenario with deposition between 5–10 mm.

The results of the extent and persistence of the plume and the extent and thickness of deposition for inter-array or offshore export cable installation scenarios are generally similar regardless of the route location (SWDA versus OECC).

5 REFERENCES

Anderson, E., Johnson, B., Isaji, T., & Howlett, E. 2001. SSFATE (Suspended Sediment FATE), a model of sediment movement from dredging operations. In WODCON XVI World Dredging Congress (pp. 2-5).

Anchor QEA. 2003. Literature Review of Effects of Resuspended Sediments Due to Dredging Operations. Prepared for the Los Angeles Contaminated Sediments Task Force.

Connecticut Department of Energy & Environmental Protection. Accessed 2017. CT_TOWN.shp [Shapefile]. Retrieved from http://www.ct.gov/deep/gisdata/

Davies, A. M. 1977. The numerical solution of the three-dimensional hydrodynamic equations, using a B-spline representation of the vertical current profile. Elsevier Oceanography Series, 19, 1-25.

Egbert, G. D., Bennett, A. F., & Foreman, M. G. 1994. TOPEX/POSEIDON tides estimated using a global inverse model. Journal of Geophysical Research: Oceans, 99(C12), 24821-24852.

Egbert, G. D., & Erofeeva, S. Y. 2002. Efficient inverse modeling of barotropic ocean tides. Journal of Atmospheric and Oceanic Technology, 19(2), 183-204.

Foreman, J. 2002. Resuspension of sediment by the jet plow during submarine cable installation. Submitted to GenPower, LLC, Needham, MA. Submitted by Engineering Technology Applications, Ltd, Romsey, Great Britain.

Gordon, R. B. 1982. Wind-driven circulation in Narragansett Bay (Doctoral dissertation, University of Rhode Island).

Grilli, S., Harris, J., Sharma, R., Decker, L., Stuebe, D., Mendelsohn, D., Crowley, D., & Decker, S. 2010. High resolution modeling of meteorological, hydrodynamic, wave and sediment processes in the Rhode Island Ocean SAMP study area (p. 119). Technical Report 6.

Haight, F. J. 1936. Currents in Narragansett Bay, Buzzards Bay, and Nantucket and Vineyard Sounds (Vol. 4). US Government Printing Office.

Isaji, T., Howlett, E., Dalton, C., & Anderson, E. 2002. Stepwise-Continuous-Variable-Rectangular Grid. In Estuarine and Coastal Modeling (2001) (pp. 519-534).

Isaji, T. H., & Howlett, C. 2001. E. Dalton C. and Anderson E.(2001).,Stepwise-Continuous-Variable-Rectangular Grid.'. In Proc. 24th Arctic and Marine Oil Spill Program Technical Seminar (pp. 597-610).

Isaji, T., & Spaulding, M. L. 1984. A model of the tidally induced residual circulation in the Gulf of Maine and Georges Bank. Journal of physical oceanography, 14(6), 1119-1126.

Johnson, B. H., Andersen, E., Isaji, T., Teeter, A. M., & Clarke, D. G. 2000. Description of the SSFATE numerical modeling system (No. ERDC-TN-DOER-E10). Army Engineer Waterways Experiment Station Vicksburg MS Engineer Research And Development Center.

Kemps, H., & Masini, R. 2017. Estimating dredge source terms–a review of contemporary practice in the context of Environmental Impact Assessment in Western Australia. Report of Theme.

Lin, J., Wang, H. V., Oh, J. H., Park, K., Kim, S. C., Shen, J., & Kuo, A. Y. 2003. A new approach to model sediment resuspension in tidal estuaries. Journal of coastal research, 76-88.

MassGIS. Accessed 2017. OUTLINE25K_POLY.shp [Shapefile]. Retrieved from https://www.mass.gov/get-massgis-data

NDBC. Accessed 2017. Historic Meteorological Observations [ASCII Text Files]. Retrieved from http://www.ndbc.noaa.gov/station_page.php?station=buzm3

NOAA. Accessed 2017.ENC Data [Multiple geodatabase files]. Retrieved from https://encdirect.noaa.gov/

NOAA. Accessed 2017. Harmonic Constituents for Multiple Locations [ASCII Data]. Retrieved from https://tidesandcurrents.noaa.gov/

NOAA. Accessed 2017. Products Current Station Locations and Ranges [ASCII Data]. Retrieved from https://tidesandcurrents.noaa.gov/currents12/tab2ac2.html

NY GIS Clearinghouse. Accessed 2017. Counties_Shoreline.shp [Shapefile]. Retrieved from http://gis.ny.gov/gisdata/inventories/details.cfm?DSID=927

Owen, A. 1980. A three-dimensional model of the Bristol Channel. Journal of Physical Oceanography, 10(8), 1290-1302.

Pawlowicz, R., Beardsley, B., & Lentz, S. 2002. Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE. Computers & Geosciences, 28(8), 929-937.

RIGIS. Accessed 2010. Towns.shp [Shapefile]. Retrieved from http://www.rigis.org/

Soulsby, R.L. 1998. Dynamics of Marine Sands. Thomas Telford, England.

Spaulding, M. L., & Gordon, R. B. 1982. A nested NUMERICAL tidal model of the Southern New England Bight. Ocean Engineering, 9(2), 107-126.

Swanson, J. C., Isaji, T., Ward, M., Johnson, B. H., Teeter, A., & Clarke, D. G. 2000. Demonstration of the SSFATE numerical modeling system. DOER Technical Notes Collection (TN DOER-E12). US Army Engineer Research and Development Center, Vicksburg, MS. http://www.wes.army.mil/el/dots/doer/pdf/doere12. pdf.

Swanson, J. C., & Isaji, T. 2006. Modeling dredge-induced suspended sediment transport and deposition in the Taunton River and Mt. Hope Bay, Massachusetts. In WEDA XXVI/38th TAMU Dredging Seminar, June (pp. 25-28).

Swanson, J. C., Isaji, T., Clarke, D., & Dickerson, C. 2004. Simulations of dredging and dredged material disposal operations in Chesapeake Bay, Maryland and Saint Andrew Bay, Florida. In WEDA XXIV/36th TAMU Dredging Seminar (pp. 7-9).

Swanson, J. C., Isaji, T., & Galagan, C. 2007. Modeling the ultimate transport and fate of dredge-induced suspended sediment transport and deposition. Proceedings of the WODCON XVIII, 27.

Teeter, A. M. 1998.Cohesive sediment modeling using multiple grain classes, Part I: settling and deposition. Proceedings of INTERCOH

Van Rijn, L. C. 1989. Handbook sediment transport by currents and waves. Delft Hydraulics Laboratory.

FINAL TECHNICAL REPORT

SEDIMENT TRANSPORT MODELING: APPENDIX A

New England Wind Offshore Cable Installation

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January 5, 2022

Contents

Figures

1 INTRODUCTION

This appendix serves to supplement sediment modeling results presented in the technical report, "Sediment Transport Modeling: New England Wind Offshore Cable Installation". The purpose of this appendix is to provide hourly snapshots to represent a 'typical' day of each installation technology. A general figure is presented first for each scenario which shows the extent of the snapshots and then hourly snapshots for a day for each scenario are presented in a grid of the zoomed in extent.

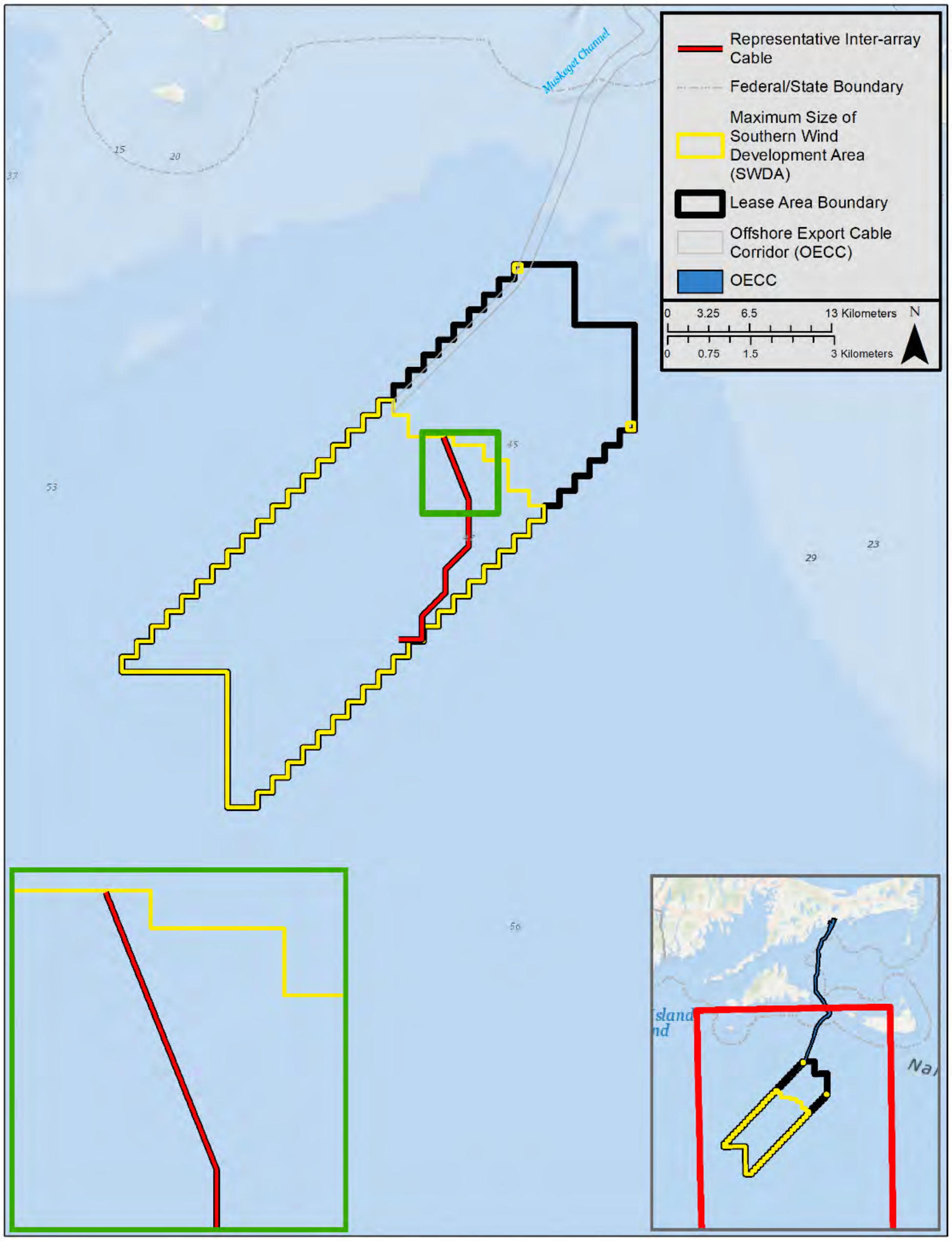

Figure 1. Representative inter-array cable installation, extent of hourly snapshots

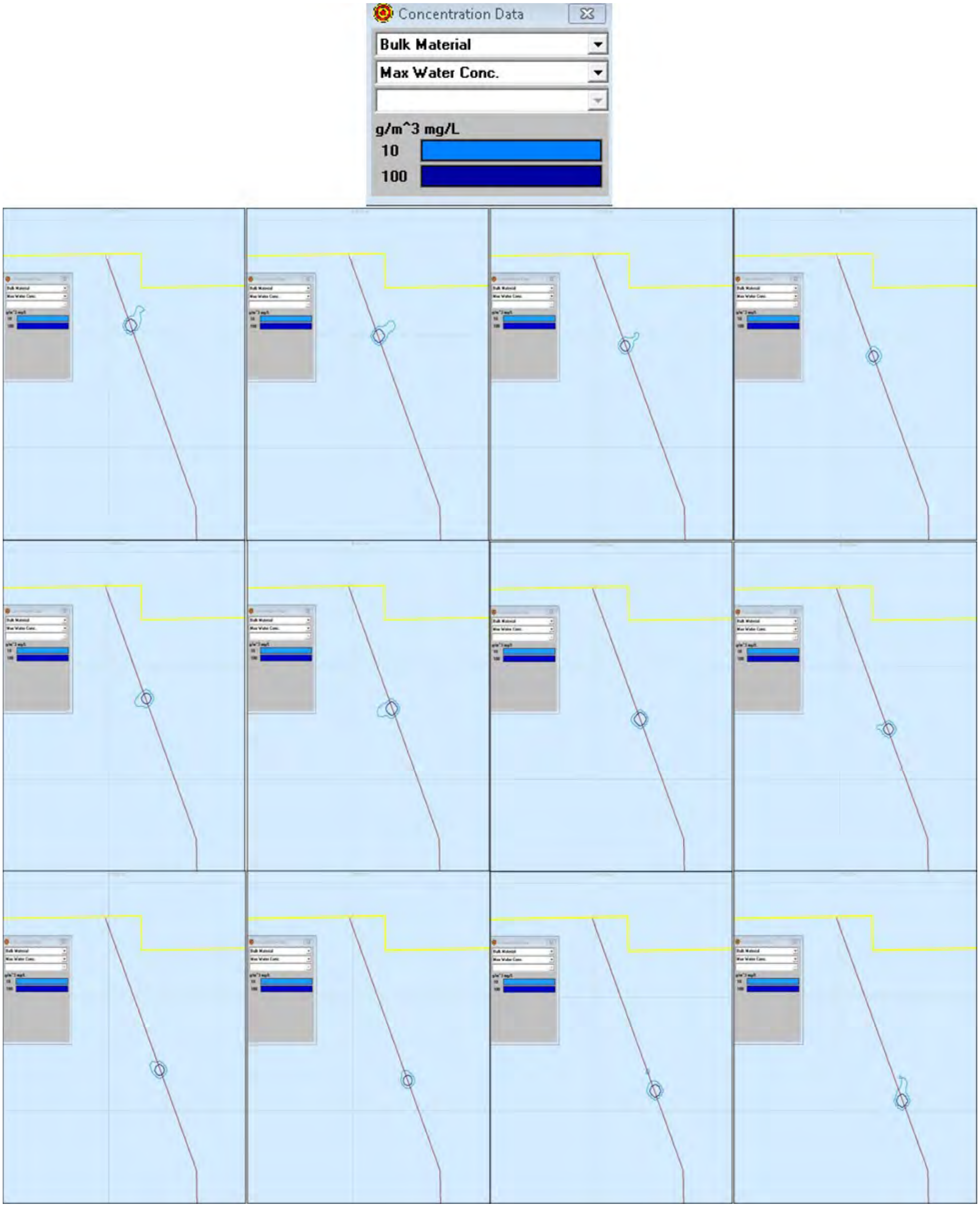

Figure 2. Representative inter-array cable installation (typical) hourly snapshots

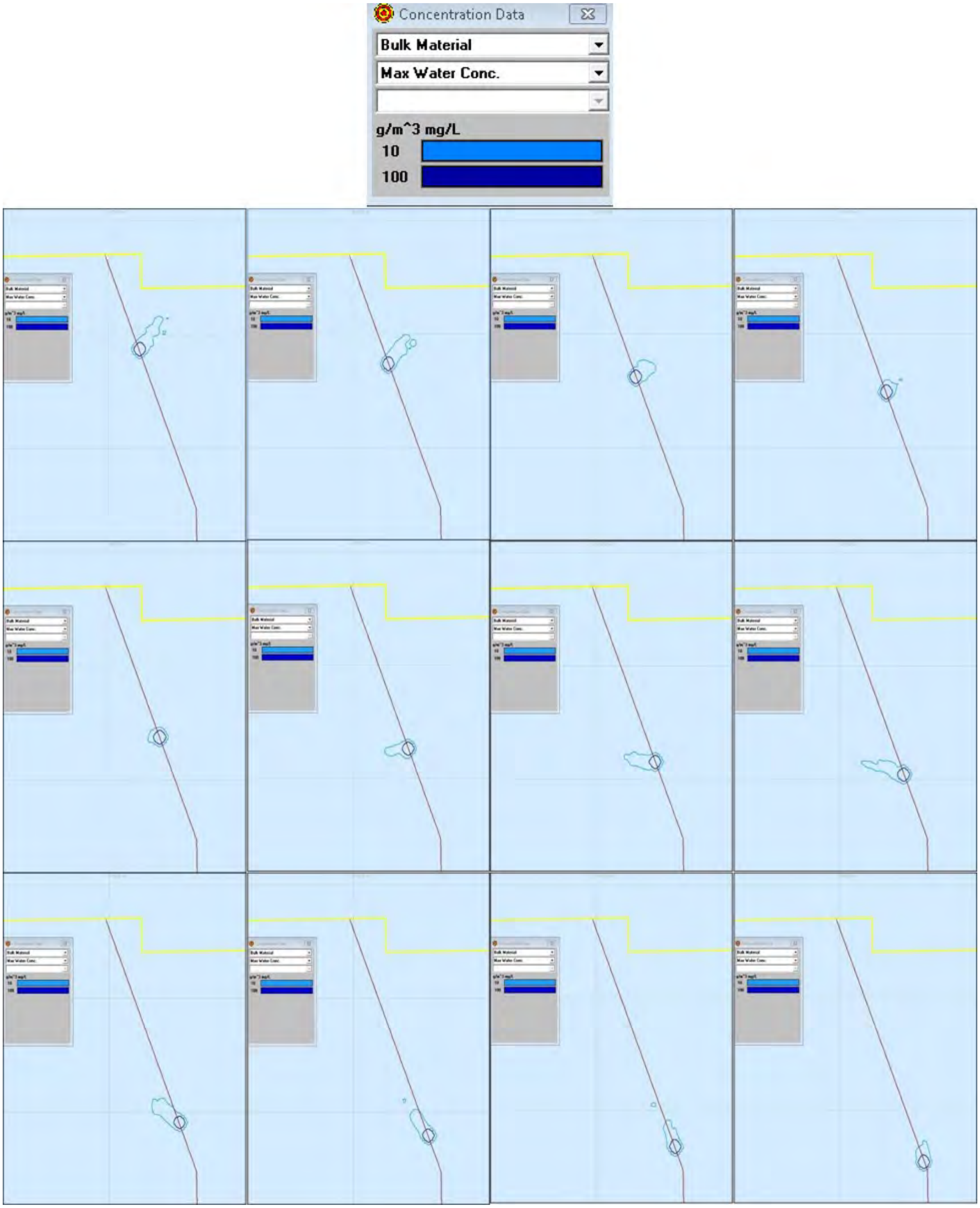

Figure 3. Representative inter-array cable installation (maximum) hourly snapshots

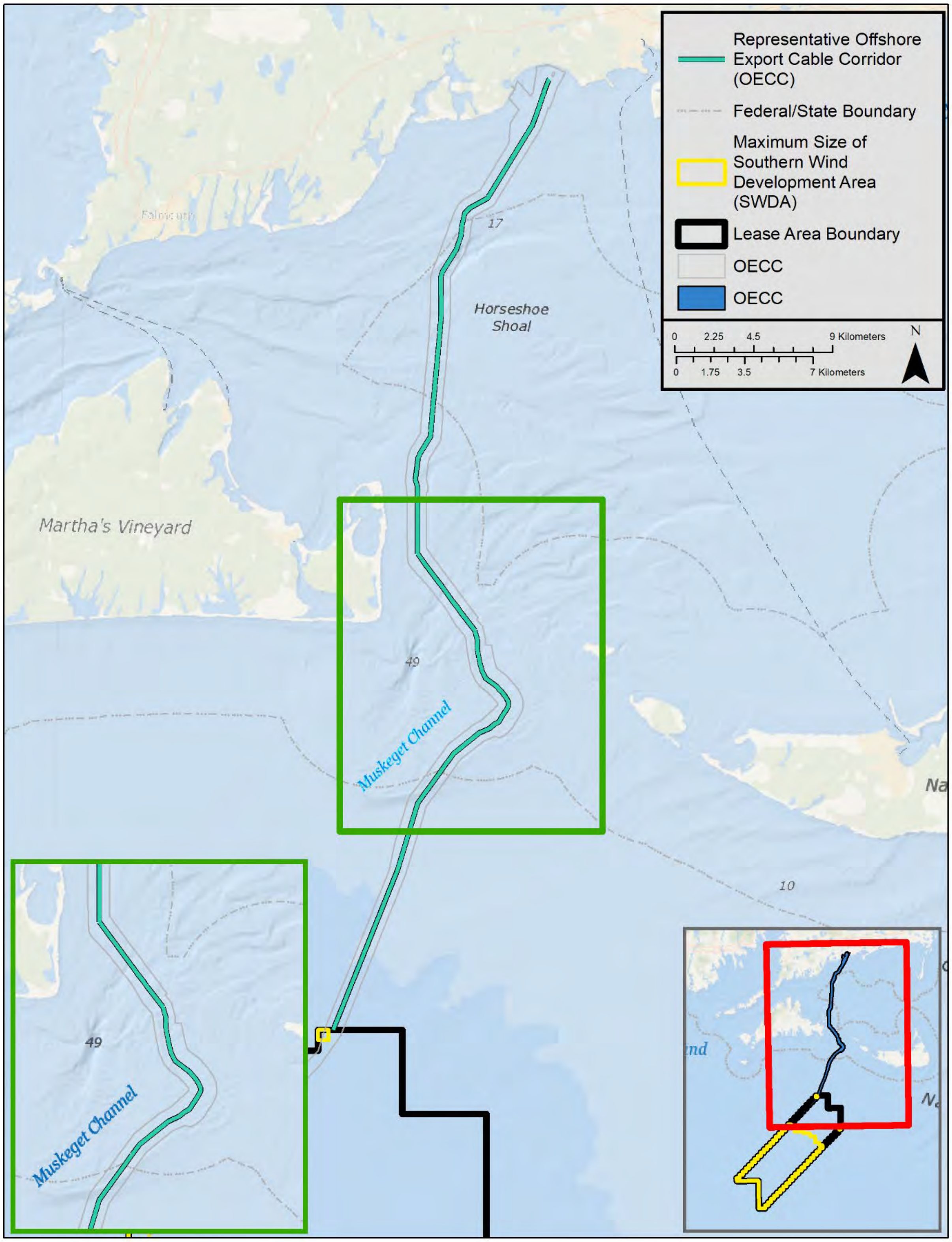

Figure 4. Representative TSHD and limited TSHD installation, extent of hourly snapshots

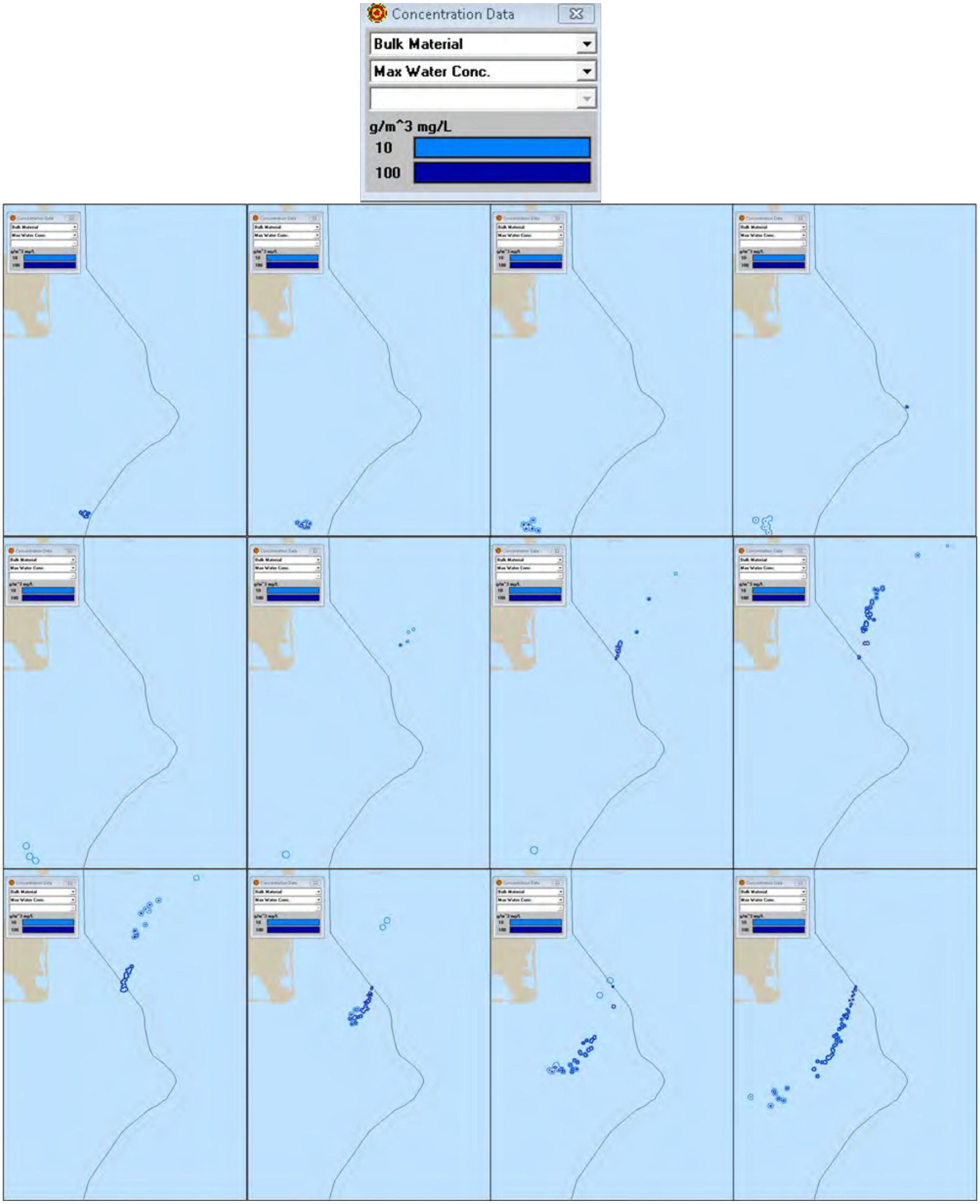

Figure 5. Representative TSHD installation hourly snapshots

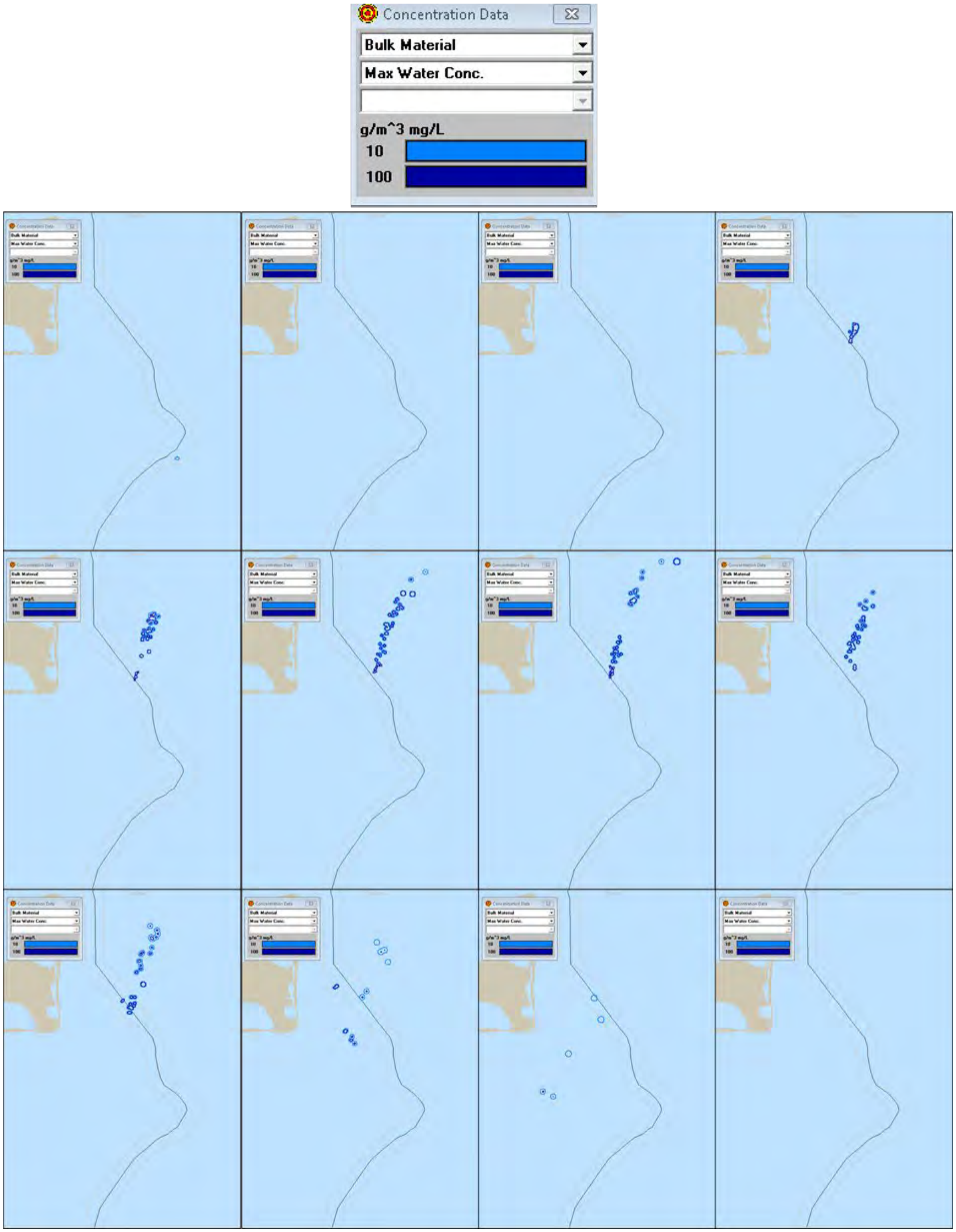

Figure 6. Representative limited TSHD installation hourly snapshots

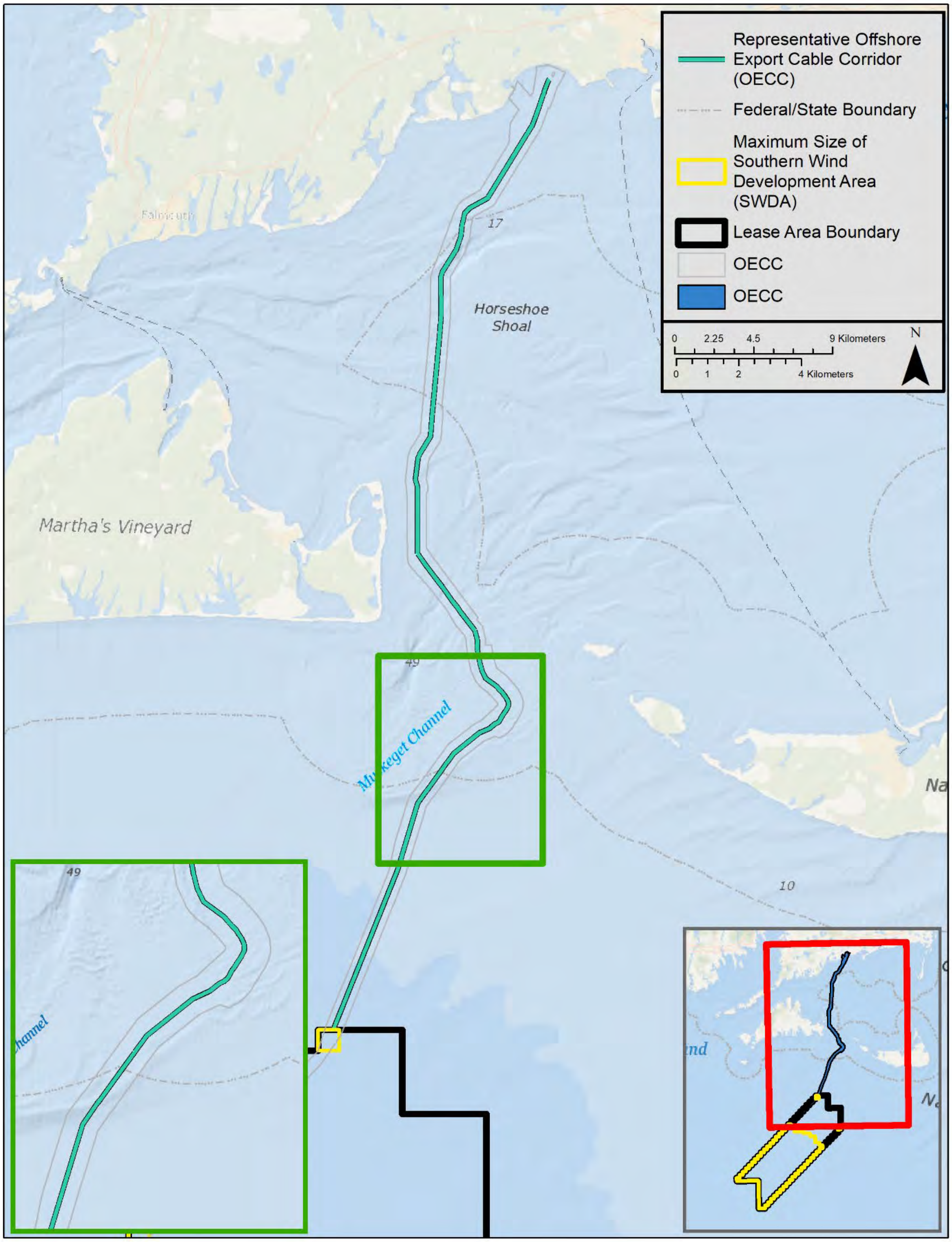

Figure 7. Representative cable installation with and without jetting aid, extent of hourly snapshots

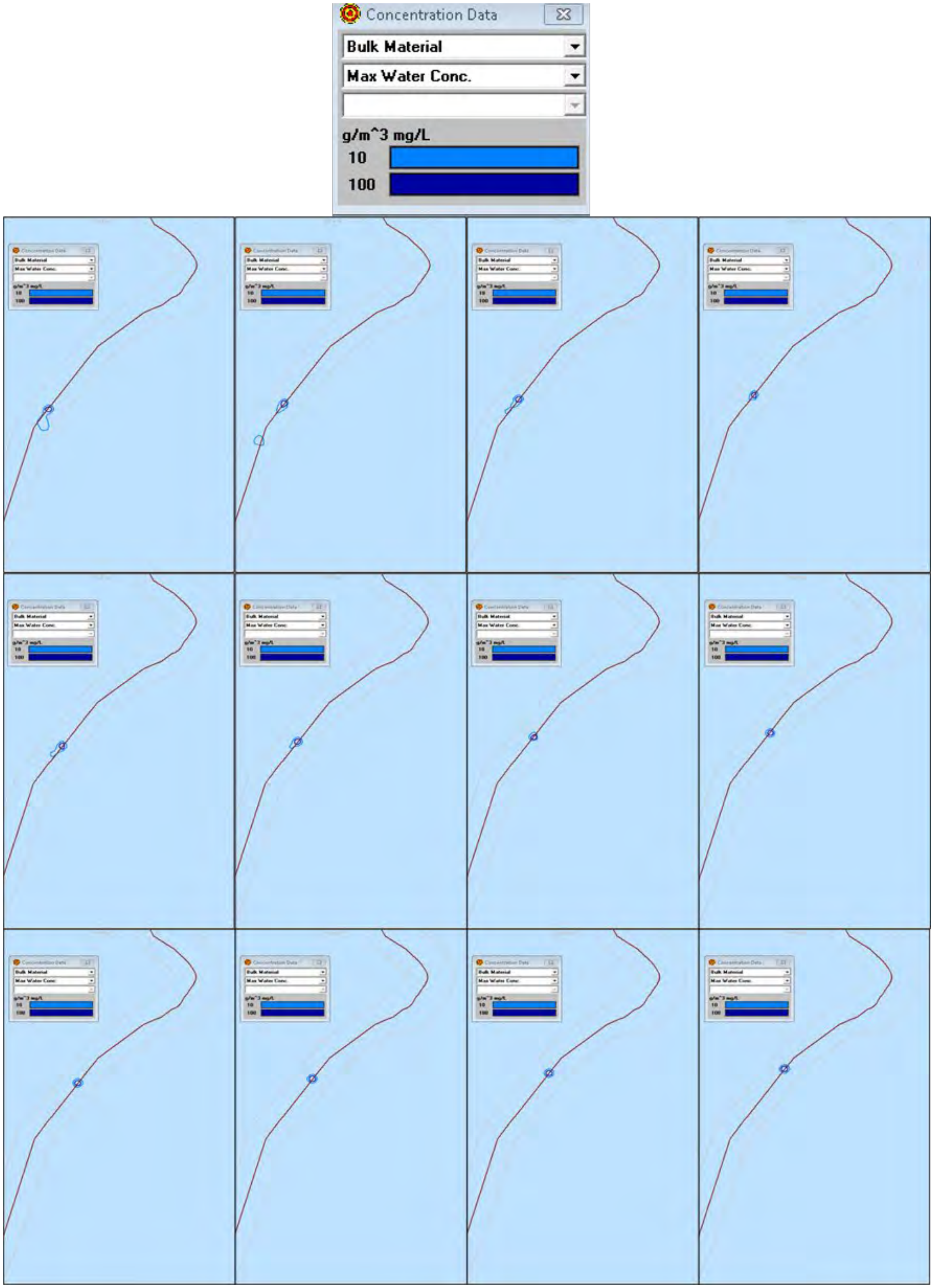

Figure 8. Representative cable installation without jetting aid hourly snapshots

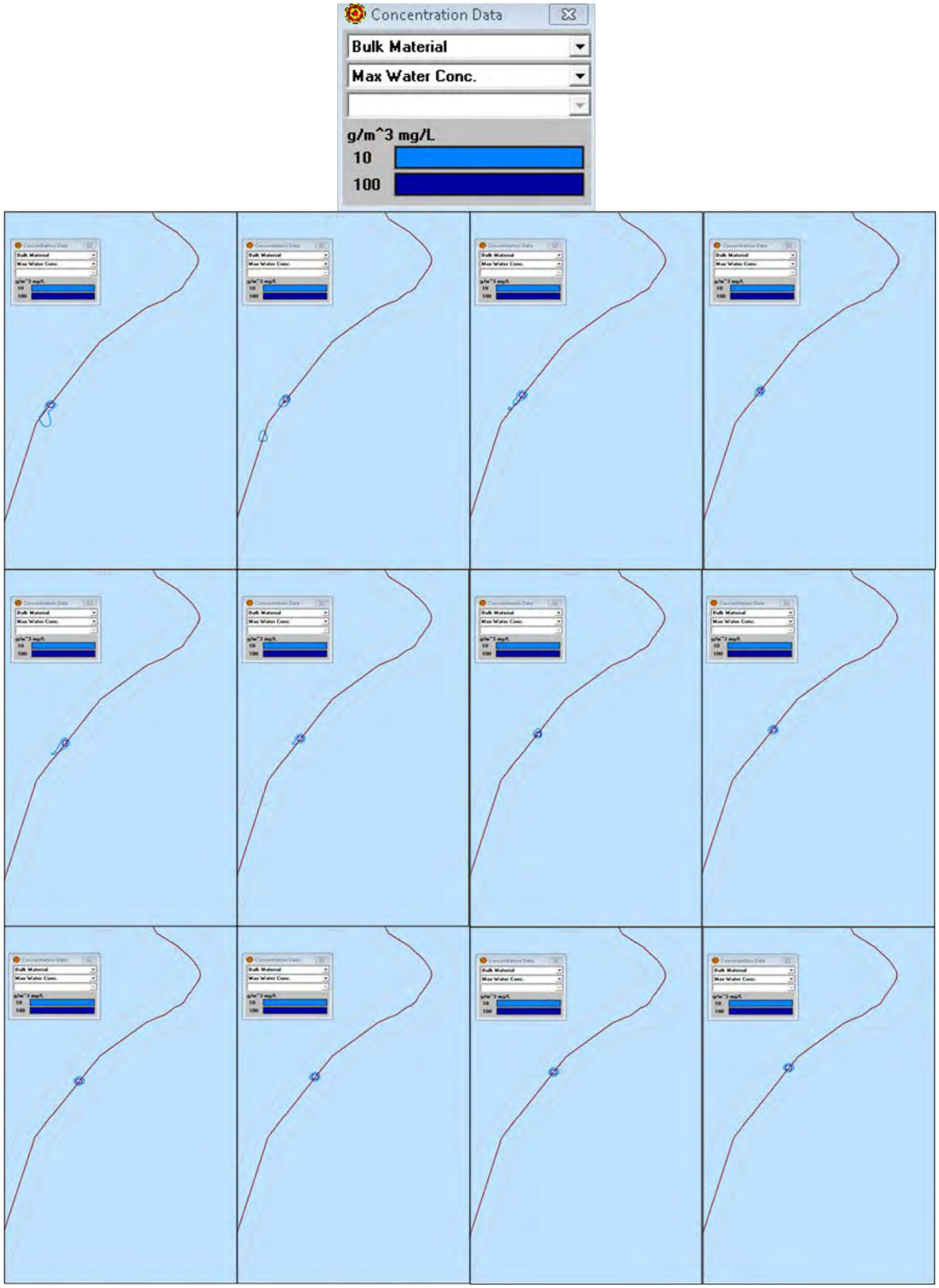

Figure 9. Representative cable installation aided by jetting hourly snapshots

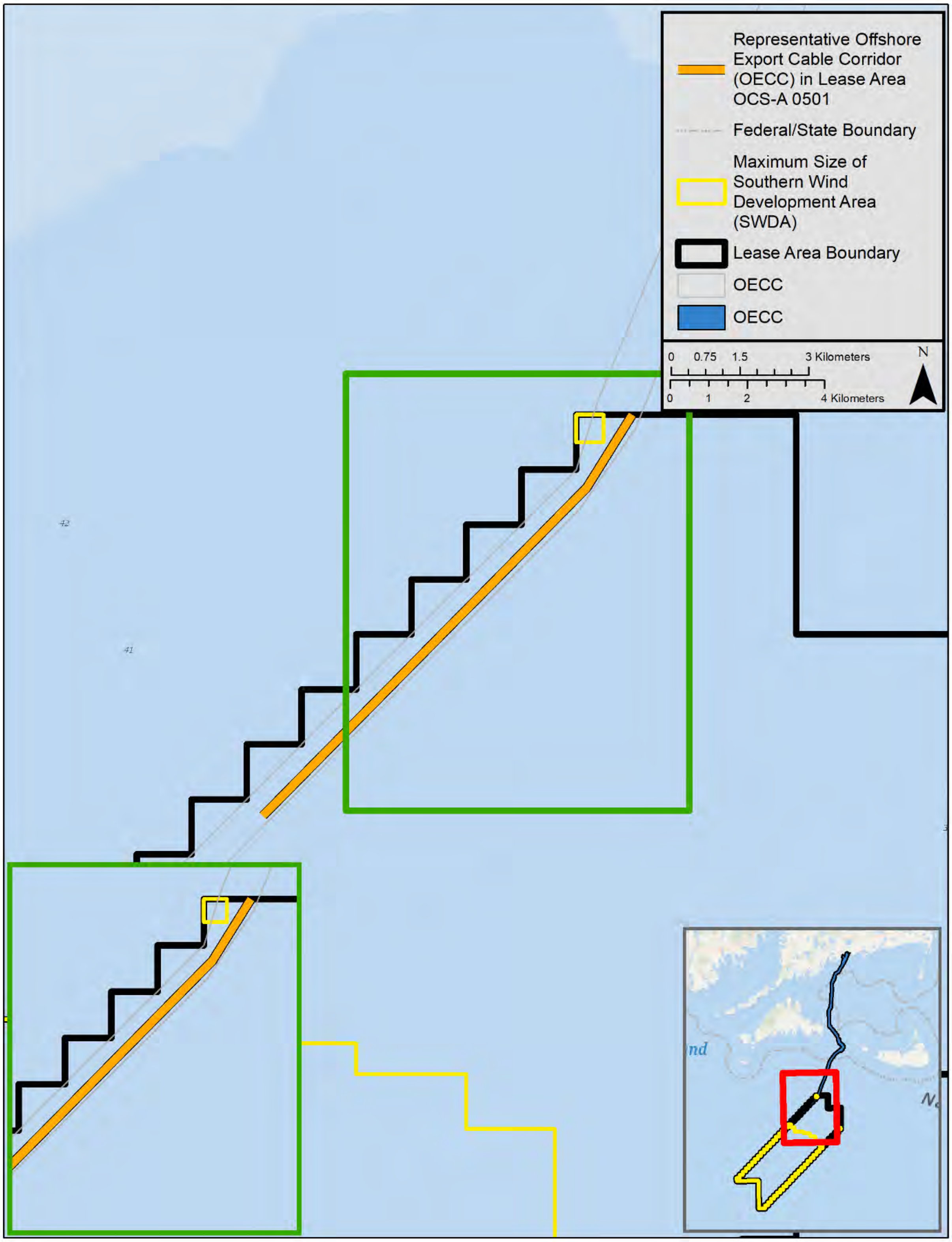

Figure 10. Representative OECC in Lease Area OCS-A 0501 installation, extent of hourly snapshots

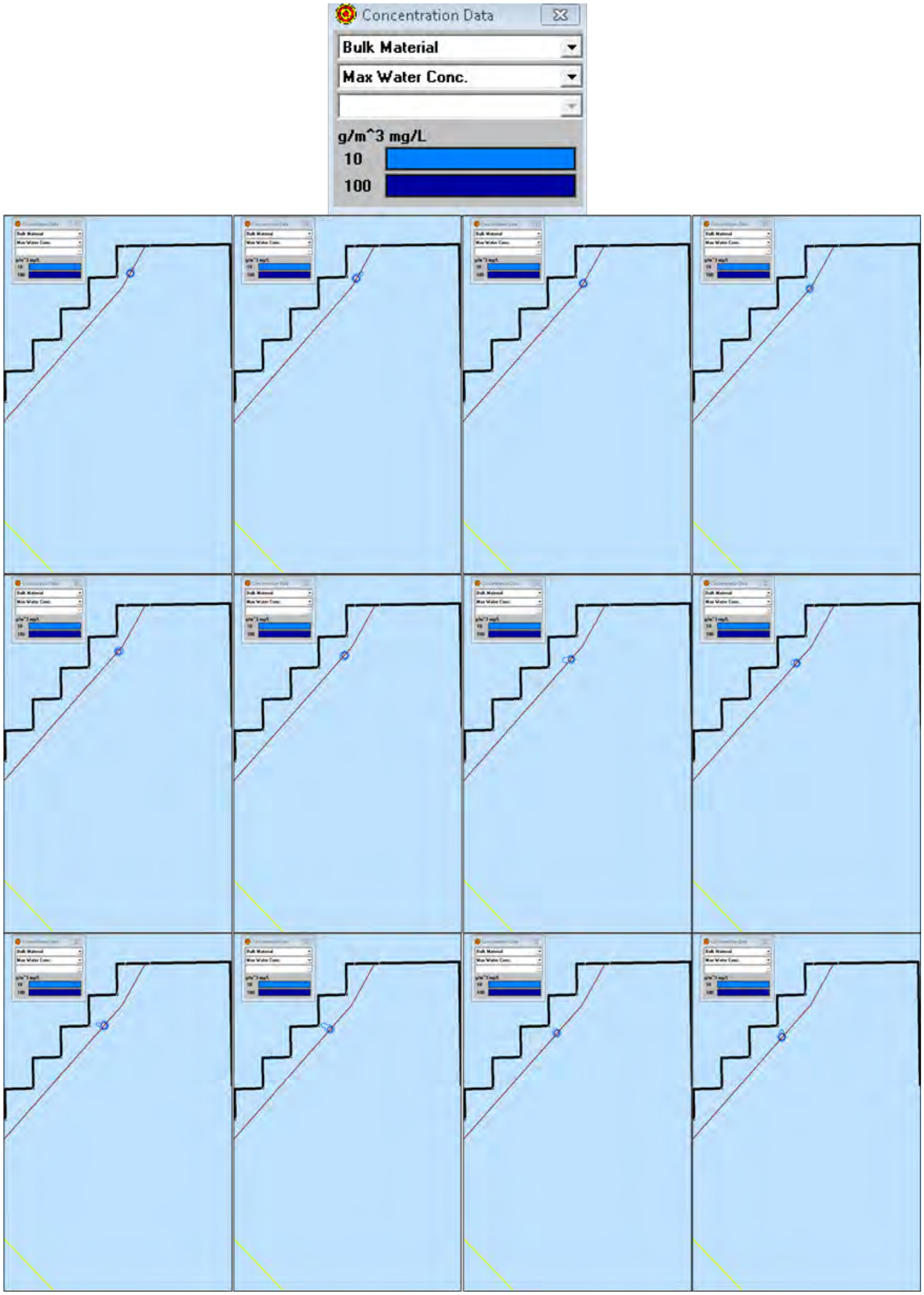

Figure 11. Representative OECC in Lease Area OCS-A 0501 installation hourly snapshots

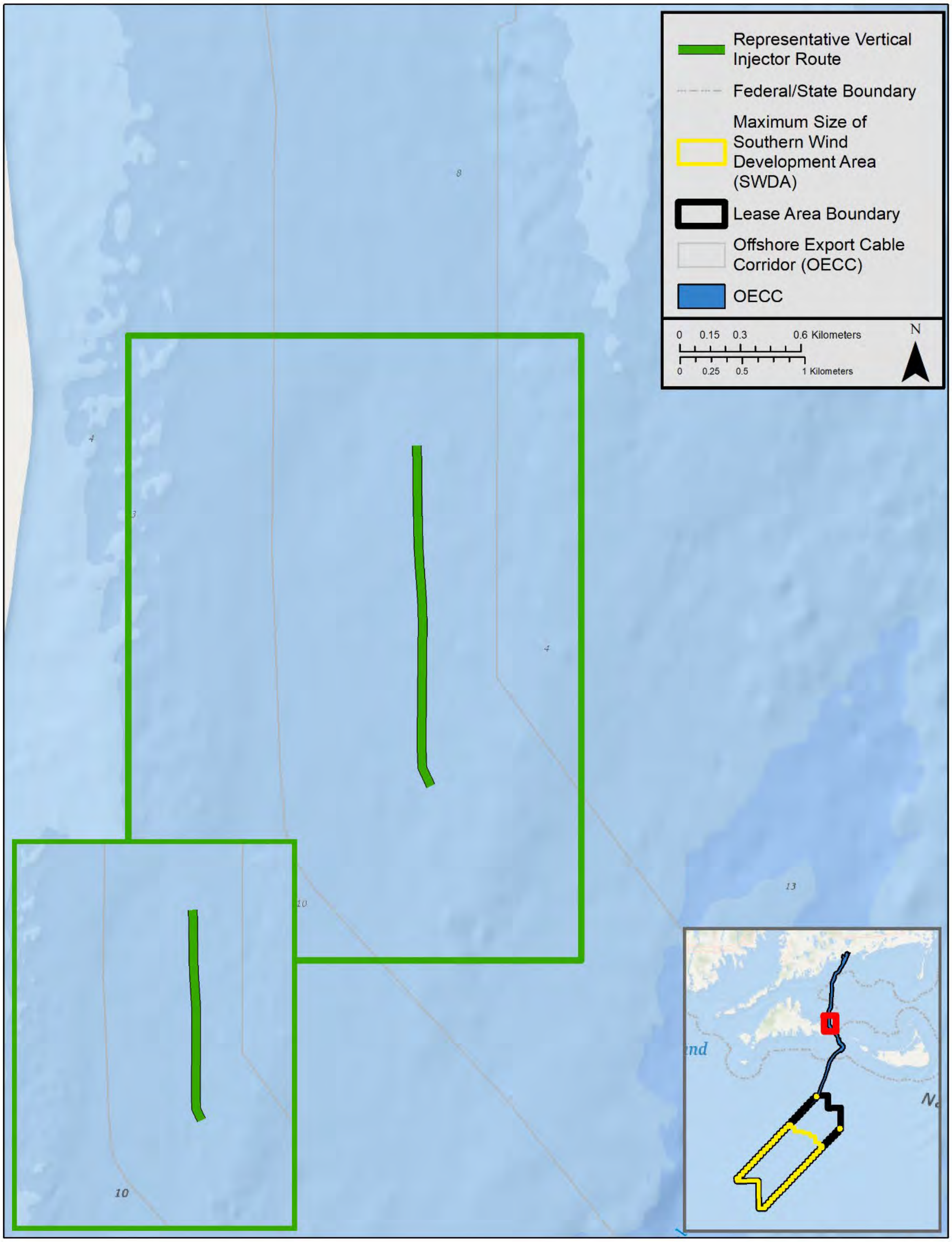

Figure 12. Representative OECC vertical injector installation, extent of hourly snapshots

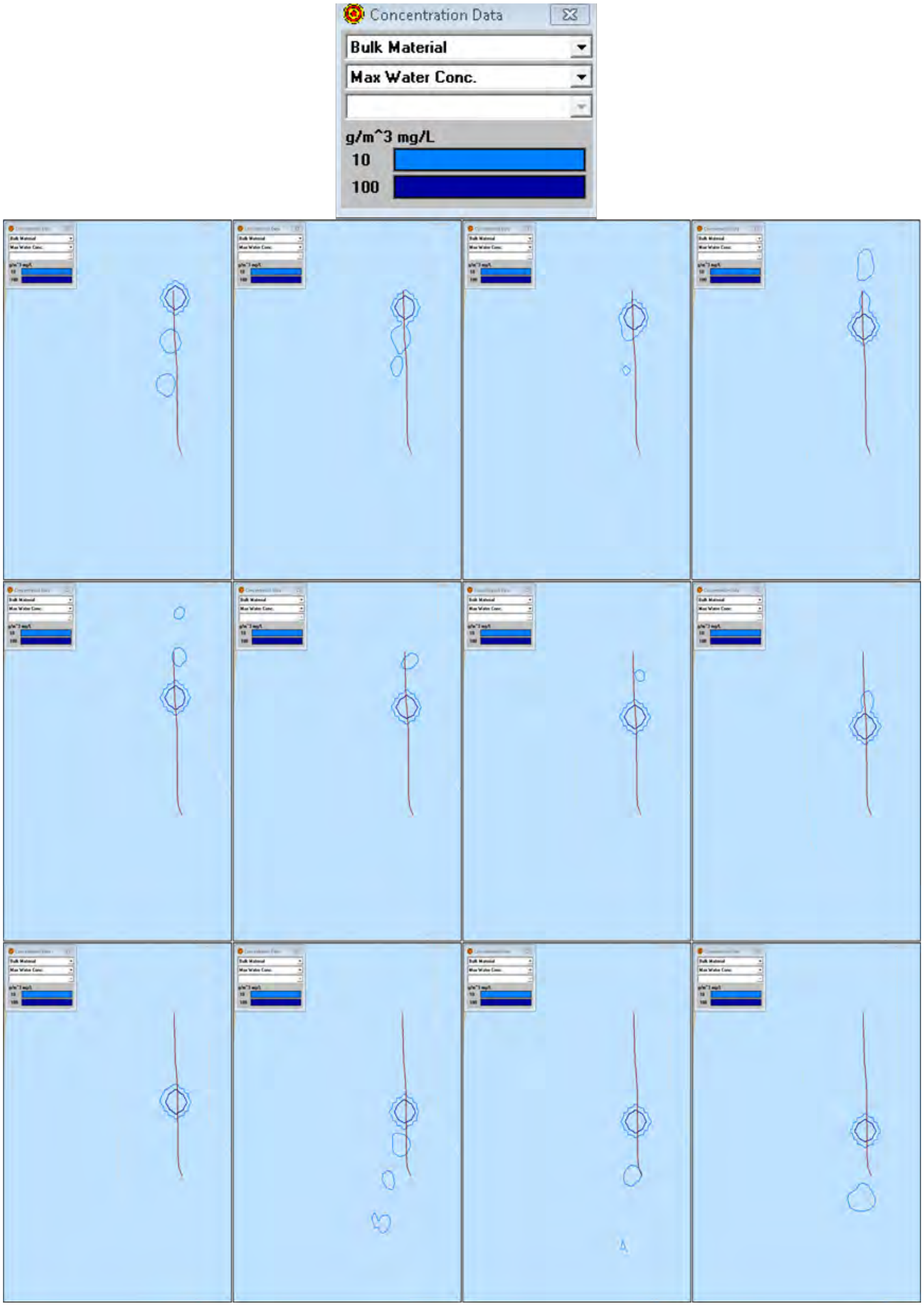

Figure 13. Representative OECC vertical injector installation hourly snapshots

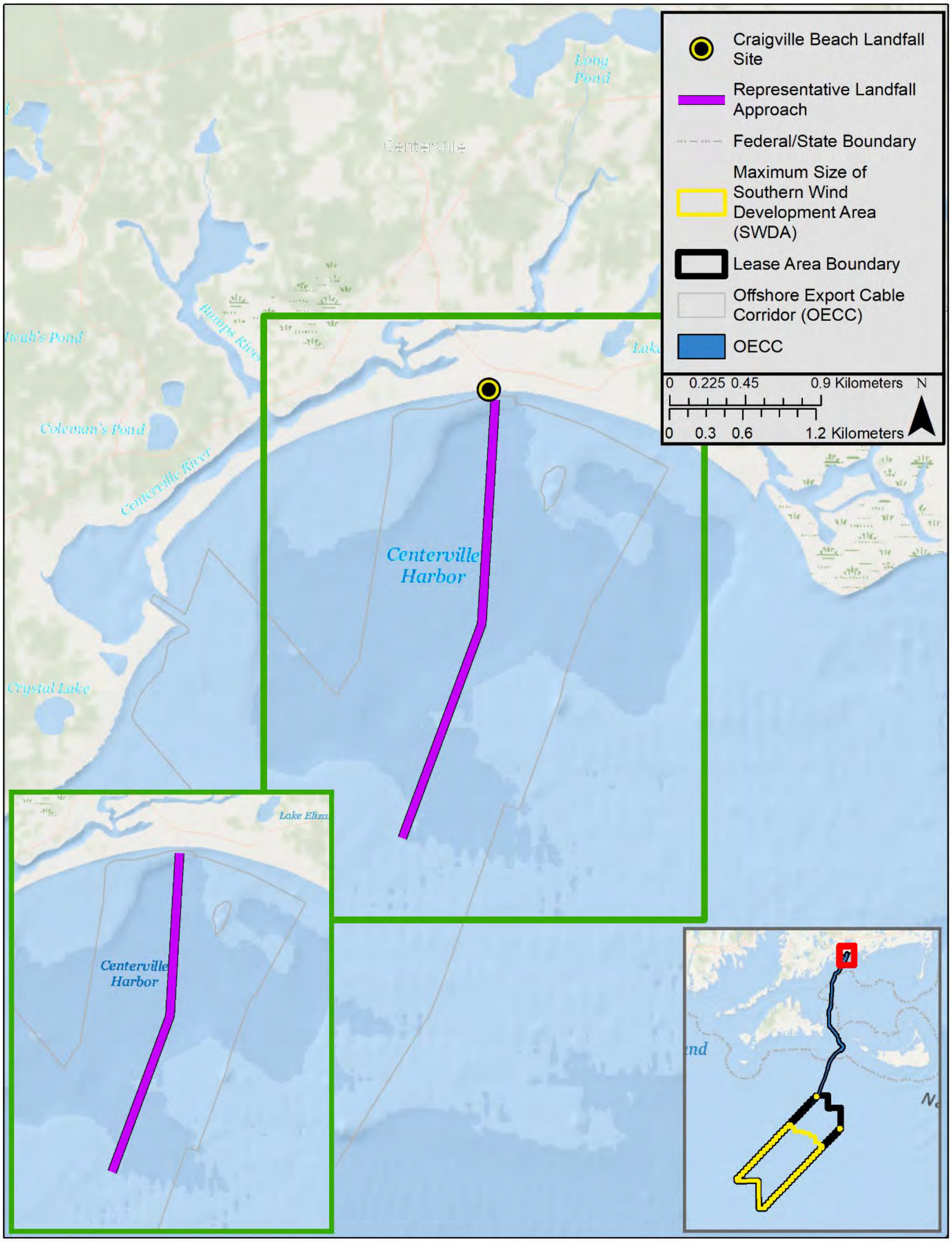

Figure 14. Representative OECC landfall approach installation, extent of hourly snapshots

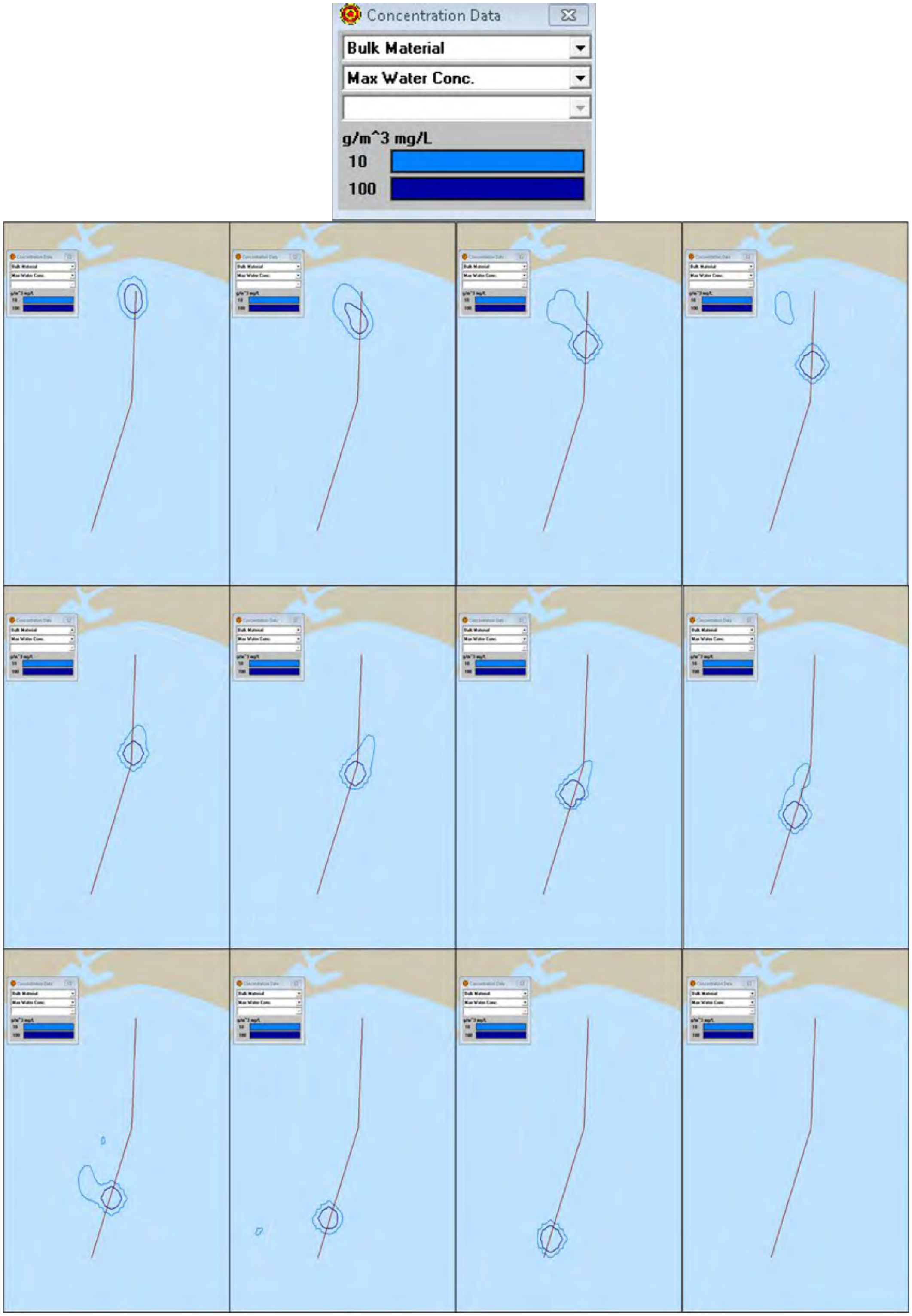

Figure 15. Representative OECC landfall approach installation hourly snapshots

FINAL TECHNICAL REPORT

APPENDIX B: WESTERN MUSKEGET VARIANT SEDIMENT TRANSPORT MODELING

New England Wind Offshore Cable Installation

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Contents

List of Acronyms

BOEM	Bureau of Ocean Energy Management
COP	Construction and Operations Plan
ESP	Electrical Service Platform
NOAA	National Oceanic and Atmospheric Administration
O&M	Operations and Maintenance
OECC	Offshore Export Cable Corridor
SSFATE	Suspended Sediment FATE
SWDA	Southern Wind Development Area
TSHD	Trailing Suction Hopper Dredge
TSS	Total Suspended Solids
WTG	Wind Turbine Generator
TSHD	Trailing Suction Hopper Dredge

Tables

Figures

EXECUTIVE SUMMARY

New England Wind is the proposal to develop offshore renewable wind energy facilities in Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A 0534 along with associated offshore and onshore cabling, onshore substations, and onshore operations and maintenance (O&M) facilities. New England Wind will be developed in two phases with a maximum of 130 wind turbine generator (WTG) and electrical service platform (ESP) positions. Four or five offshore export cables will transmit electricity generated by WTGs to onshore transmission systems in the Town of Barnstable, Massachusetts. Park City Wind LLC, a wholly owned subsidiary of Avangrid Renewables, LLC, is the Proponent and will be responsible for the construction, operation, and decommissioning of New England Wind.

New England Wind's offshore renewable wind energy facilities are located immediately southwest of Vineyard Wind 1, which is located in Lease Area OCS-A 0501. New England Wind will occupy all of Lease Area OCS-A 0534 and potentially a portion of Lease Area OCS-A 0501 in the event that Vineyard Wind 1 does not develop "spare" or extra positions included in Lease Area OCS-A 0501 and Vineyard Wind 1 assigns those positions to Lease Area OCS-A 0534. For the purposes of the Construction and Operations Plan (COP), the Southern Wind Development Area (SWDA) is defined as all of Lease Area OCS-A 0534 and the southwest portion of Lease Area OCS-A 0501, as shown in Figure 1.1-1 of COP Volume I. The SWDA may be 411-453 square kilometers (km^2) (101,590-111,939 acres) in size depending upon the final footprint of Vineyard Wind 1. At this time, the Proponent does not intend to develop the two positions in the separate aliquots located along the northeastern boundary of Lease Area OCS-A 0501 as part of New England Wind. The SWDA (excluding the two separate aliquots that are closer to shore) is just over 32 kilometers (km) (20 miles [mi]) from the southwest corner of Martha's Vineyard and approximately 38 km (24 mi) from Nantucket.[1] The WTGs and ESPs in the SWDA will be oriented in an east-west, north-south grid pattern with one nautical mile (NM) (1.85 km) spacing between positions.

Each Phase of New England Wind will be developed and permitted using a Project Design Envelope (the "Envelope"). This allows the Proponent to properly define and bracket the characteristics of each Phase for the purposes of environmental review while maintaining a reasonable degree of flexibility with respect to the selection of key components, such as the WTGs, foundations, offshore cables, and ESPs. To assess potential impacts and benefits to various resources, a "maximum design scenario," or the design scenario with the maximum impacts anticipated for that resource, is established considering the Envelope parameters for each Phase that have the potential to cause the greatest effect. For some resources, the approach overestimates potential environmental impacts as the maximum design scenario is not the scenario the Proponent is likely to employ.

While the Proponent intends to install all New England Wind offshore export cables within the OECC that travels from the SWDA northward through the eastern side of Muskeget Channel towards landfall sites in the Town of Barnstable, the Proponent is reserving the fallback option to install one or two Phase 2 cables along the western side of Muskeget Channel, referred to as the Phase 2 OECC Western Muskeget Variant[[2]] (see Section 4.1.3.2 of COP Volume I and Figure 1). This attachment describes the modeling approach, inputs, and results used to assess cable installation activities for four model scenarios along the Western Muskeget Variant. These representative sediment dispersion model scenarios were conducted to simulate the construction and installation of an approximately 58.3 km (36.2 mi) offshore export cable along the Western Muskeget Variant, spanning from the Covell's Beach Landfall Site to the northern edge of Lease Area OCS-A 0501.

[1] Within the SWDA, the closest WTG is approximately 34 km (21 mi) from Martha's Vineyard and 40 km (25 mi) from Nantucket.

[2] The Western Muskeget Variant is the same exact corridor as the western Muskeget option included in the Vineyard Wind 1 COP and has already been thoroughly reviewed and approved by BOEM as part of that COP.

The following is a brief overview of the terminology used to describe the methodologies modeled in this study:

- **Trailing Suction Hopper Dredge (TSHD):** Suction dredging through a drag arm near the seabed, overflow of sediment laden waters from a hopper and disposal of sediments from the hopper. In this report it refers to the methodology as applied to all sand wave sizes where dredging is needed.
- **Cable Installation:** Cable installation is accomplished by jetting techniques (e.g., jet plow, jet trenching, or similar) in areas where sand waves do not exist or have been cleared.
- **Limited TSHD:** This method is the same as TSHD; the TSHD, however, is “Limited” in that it is only applied to larger (greater than 2 meters [m]) sand waves where dredging is needed.
- **Cable Installation aided by Jetting:** Cable installation is accomplished as described above; however, this method includes additional jetting by controlled flow excavation in areas of small sand waves.

The scenarios that were modeled include a representative offshore export cable route along the Western Muskeget Variant from the northern edge of Lease Area OCS-A 0501 to the Covell’s Beach Landfall Site. The scenarios include:

- TSHD Pre-Dredge
- Cable Installation
- Limited TSHD Pre-Dredge
- Cable Installation aided by Jetting

The sediment dispersion modeling assessment was carried out through two interconnected modeling tasks:

1. Development of a three-dimensional hydrodynamic model application of a domain encompassing New England Wind activities using the HYDROMAP modeling system; and
2. Simulations of the suspended sediment fate and transport, including evaluation of seabed deposition and suspended sediment plumes, using the SSFATE (Suspended Sediment FATE) modeling system to simulate installation activities. Velocity fields developed using the HYDROMAP model are used as the primary forcing for SSFATE.

The modeling was performed to characterize the effects associated with the offshore cable installation activities. The effects were quantified in terms of the above-ambient total suspended solids (TSS) concentrations as well as seabed deposition of sediments suspended in the water column during cable installation activities, including sand wave dredging. Maps of instantaneous TSS concentrations, time-integrated maximum TSS concentrations, duration of TSS ≥ 10 mg/L, and seabed deposition are provided for each modeled scenario. Tables quantifying the area exceeding TSS thresholds for specific durations as well as areas of seabed deposition exceeding thickness thresholds are presented for each modeled scenario. Results are presented with respect to thresholds listed below.

- Water column concentrations thresholds: 10, 50, 100, 150, 200, 300, 650, 750, and 1,000 mg/L
- Water column exposure durations: 1, 2, 3, 4, 6, 12, 24, and 48 hours
- Seabed deposition thresholds: 1, 5, 10, 20, 50, and 100 mm

Simulations of sand wave dredging using a TSHD along the Western Muskeget Variant show that plumes originating from the source are intermittent along the route because of the intermittent need for dredging. Above ambient TSS concentrations may be present throughout the entire water column as sediments were released at or near the water surface. Above ambient TSS ≥10 mg/L extend up to 16 km from the area of activity for both TSHD scenarios, with the plume’s maximum extent occurring in different locations, due to the timing of the currents, as these simulations were modeled at slightly different times. Concentrations ≥10 mg/L persist less than six hours for TSHD Pre-Dredge activities and less than three hours for the Limited TSHD Pre-Dredge activities. For both TSHD scenarios, the deposition ≥1 mm was discontinuous and tended to stay close to the route centerline with small areas reaching thicknesses >100 mm. The deposition ≥1.0 mm associated with the TSHD drag arm is mainly constrained to within 80 m from the route centerline whereas the deposition greater than 1.0 mm associated with overflow and disposal extends to greater distances from the source, mainly within 1 km though such deposition can extend up to 2.3 km in isolated patches when subject to swift currents through Muskeget Channel (located within MA state waters).

The simulations of the cable installation showed that both the footprint of the 10 mg/L excess concentration plume and the footprint of deposition over 1.0 mm stayed close to the route centerline. The maximum excursion of the 10 mg/L excess plume extended up to ~2 km, though typically less than 200 m from the route centerline. The excess concentrations stemming from cable installation, both with and without jetting for sand wave clearance, remain relatively close to the route centerline, are constrained to the bottom of the water column, and are also short-lived (typically dissipating within four to six hours). Deposition greater than 1.0 mm was limited to within 100 m from the route centerline for typical installation parameters; this trend holds true in both federal and state waters.

These results illustrate that areas impacted by the plume follow similar trends regardless of the scenario. In general, trends of rapid decrease of area with increasing time and/or increasing concentration threshold are noted for all scenarios. While the plume patterns for the Cable Installation and Cable Installation aided by Jetting were similar, and TSHD Pre-Dredge and Limited TSHD Pre-dredge were similar, differences in the extent and persistence of the plumes and the extent and thickness of deposition may be attributed to route orientation relative to currents, timing of currents, installation parameters, volume suspended, and sediment grain size distribution.

1 INTRODUCTION

New England Wind is the proposal to develop offshore renewable wind energy facilities in Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A 0534 along with associated offshore and onshore cabling, onshore substations, and onshore operations and maintenance (O&M) facilities. New England Wind will be developed in two Phases with a maximum of 130 wind turbine generator (WTG) and electrical service platform (ESP) positions. Four or five offshore export cables will transmit electricity generated by WTGs to onshore transmission systems in the Town of Barnstable, Massachusetts. Park City Wind LLC, a wholly owned subsidiary of Avangrid Renewables, LLC, is the Proponent and will be responsible for the construction, operation, and decommissioning of New England Wind.

New England Wind's offshore renewable wind energy facilities are located immediately southwest of Vineyard Wind 1, which is located in Lease Area OCS-A 0501. New England Wind will occupy all of Lease Area OCS-A 0534 and potentially a portion of Lease Area OCS-A 0501 in the event that Vineyard Wind 1 does not develop "spare" or extra positions included in Lease Area OCS-A 0501 and Vineyard Wind 1 assigns those positions to Lease Area OCS-A 0534. For the purposes of the Construction and Operations Plan (COP), the SWDA is defined as all of Lease Area OCS-A 0534 and the southwest portion of Lease Area OCS-A 0501, as shown in Figure 1.1-1 of COP Volume I. The SWDA may be 411-453 square kilometers (km^2) (101,590-111,939 acres) in size depending upon the final footprint of Vineyard Wind 1. At this time, the Proponent does not intend to develop the two positions in the separate aliquots located along the northeastern boundary of Lease Area OCS-A 0501 as part of New England Wind. The SWDA (excluding the two separate aliquots that are closer to shore) is just over 32 kilometers (km) (20 miles [mi]) from the southwest corner of Martha's Vineyard and approximately 38 km (24 mi) from Nantucket.[3] The WTGs and ESPs in the SWDA will be oriented in an east-west, north-south grid pattern with one nautical mile (NM) (1.85 km) spacing between positions.

Each Phase of New England Wind will be developed and permitted using a Project Design Envelope (the "Envelope"). This allows the Proponent to properly define and bracket the characteristics of each Phase for the purposes of environmental review while maintaining a reasonable degree of flexibility with respect to the selection of key components, such as the WTGs, foundations, submarine cables, and ESPs. To assess potential impacts and benefits to various resources, a "maximum design scenario," or the design scenario with the maximum impacts anticipated for that resource, is established considering the Envelope parameters for each Phase that have the potential to cause the greatest effect. For some resources, the approach overestimates potential environmental impacts as the maximum design scenario is not the scenario the Proponent is likely to employ.

While the Proponent intends to install all New England Wind offshore export cables within the OECC that travels from the SWDA northward through the eastern side of Muskeget Channel towards landfall sites in the Town of Barnstable, the Proponent is reserving the fallback option to install one or two Phase 2 cables along the western side of Muskeget Channel, referred to as the Phase 2 OECC Western Muskeget Variant[2] (see Section 4.1.3.2 of COP Volume I and Figure 1). This appendix describes the modeling approach, inputs, and results used to assess cable installation activities for four model scenarios along the Western Muskeget Variant. These representative sediment dispersion model scenarios were conducted to simulate the construction and installation of an approximately 58.3 km (36.2 mi) offshore export cable along the Western Muskeget Variant, spanning from the Covell's Beach Landfall Site to the northern edge of the Lease Area OCS-A 0501.

The sediment modeling was carried out using an RPS in house model Suspended Sediment FATE (SSFATE). SSFATE computes TSS 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 (created using RPS' hydrodynamic model output from HYDROMAP), definition of the water body bathymetry, and parameterization of the sediment disturbance (source), which includes sediment grain size data and

[3] Within the SWDA, the closest WTG is approximately 34 km (21 mi) from Martha's Vineyard and 40 km (25 mi) from Nantucket.

sediment flux description. A description of the environmental data used in the modeling (e.g., bathymetry, meteorological observations), the descriptions and theory behind the models (HYDROMAP and SSFATE), and validation of the hydrodynamic forcing used in the sediment dispersion modeling is presented in the main sediment transport modeling report entitled “Sediment Transport Modeling for New England Wind COP.”

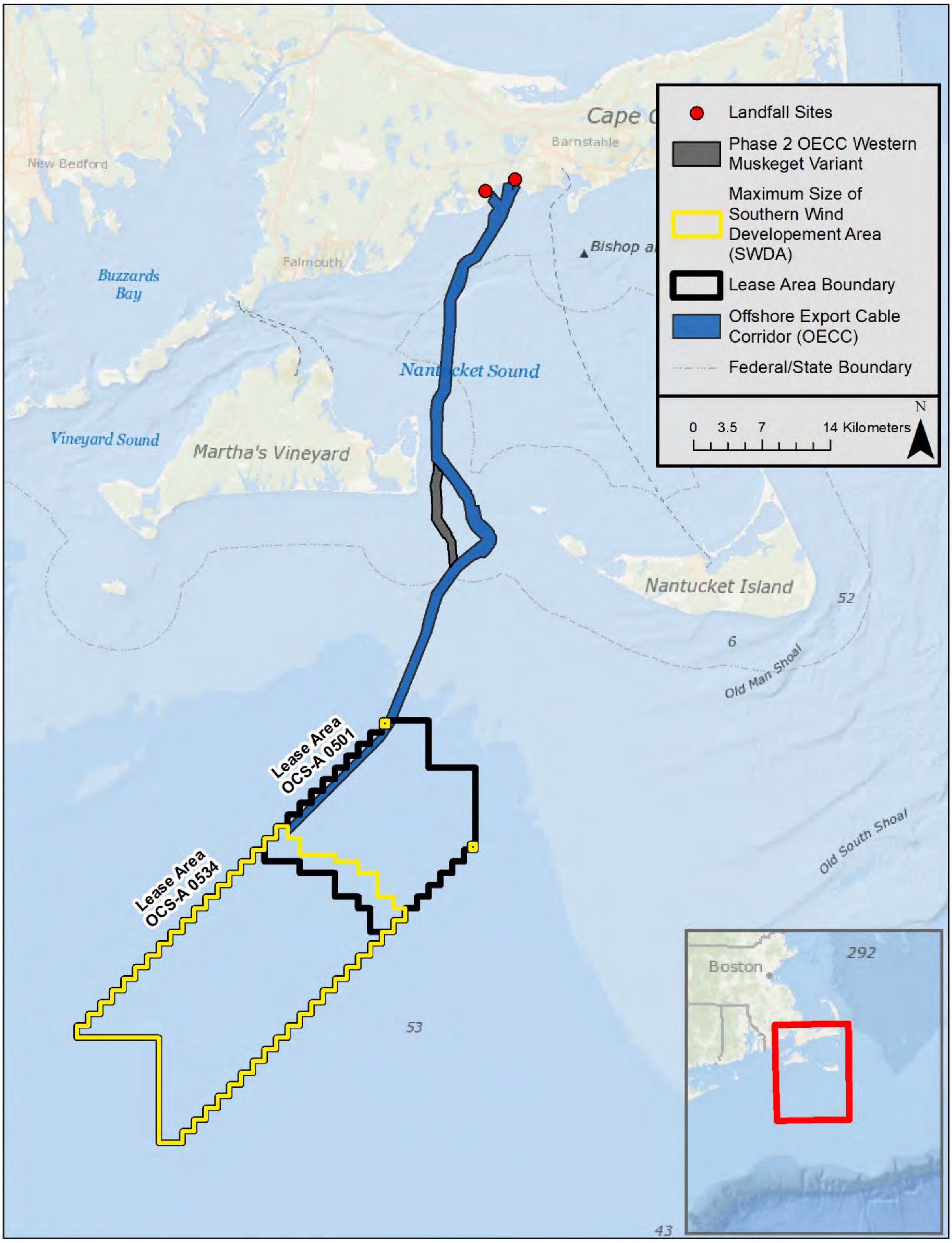


Figure 1. Map of Study Area with Indicative Locations for New England Wind's Offshore Components

1.1 Study Scope and Objectives

RPS applied customized hydrodynamic and sediment transport and dispersion models to assess potential effects from sediment suspension during cable installation activities. This approach has been accepted by state and federal regulatory agencies for pipeline and cable installation (including the Block Island Wind Farm) as well as harbor dredging and land reclamation activities. Specifically, the analysis includes two interconnected modeling tasks:

1. Development of a three-dimensional hydrodynamic model application of a domain encompassing New England Wind activities using the HYDROMAP modeling system; and
2. Simulations of the suspended sediment fate and transport (including evaluation of seabed deposition and suspended sediment plumes) using the SSFATE modeling system to simulate installation activities. Velocity fields developed using the HYDROMAP model are used as the primary forcing for SSFATE.

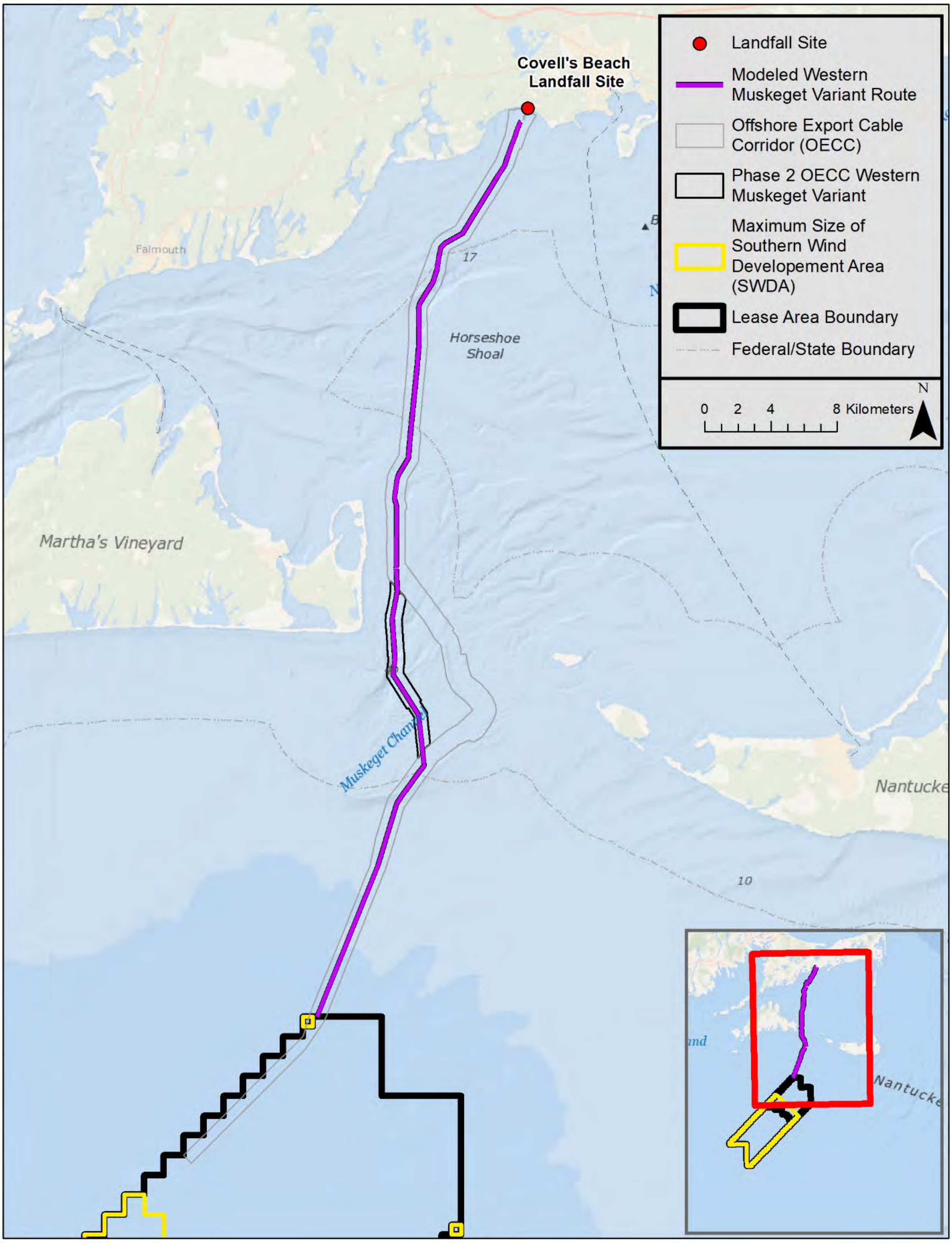
SSFATE predicts the transport, dispersion, and settling of suspended sediment released to the water column. The focus of the model is on the far-field processes (i.e., beyond the initial disturbance) affecting the dispersion of suspended sediment. The model uses specifications for the suspended sediment 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. For a detailed description of the SSFATE model equations governing sediment transport, settling, deposition, and resuspension, the interested reader is directed to Swanson et al. (2007).

The effects were quantified in terms of the above-ambient TSS concentrations as well as seabed deposition of sediments suspended in the water column during seabed preparation and cable installation activities. Results are presented with respect to the thresholds listed below, which were selected either because they are thresholds of biological significance or because they provide an effective means of demonstrating the physical effects. Thresholds associated with biological significance are documented in Sections 6.5 and 6.6 of the COP Volume III, which are the finfish and invertebrate and benthic sections, respectively.

- Water column concentrations thresholds: 10, 50, 100, 150, 200, 300, 650, 750, and 1,000 mg/L
- Water column exposure durations: 1, 2, 3, 4, 6, 12, 24, and 48 hours
- Seabed deposition thresholds: 1, 5, 10, 20, 50, and 100 mm

1.2 Scenario Components: Routes and Approaches

This study assessed multiple scenarios representing a range of activities associated with cable installation along the Western Muskeget Variant (Figure 2). This appendix was developed to summarize results from the COP Vol I Section 2.3.1 and Appendix I-G which was carried out to characterize the effects associated with the offshore cable installation activities. The construction activities that will resuspend sediments in the water column include cable burial along the offshore export cables and dredging along some of the offshore export cables prior to cable installation to remove sand waves. Portions of the sand waves may be mobile over time; therefore, the upper portions of the sand waves may need to be removed by dredging so that the cable laying equipment can achieve the proper burial depth below the sand waves and into the stable sea bottom. The sand waves are not uniform in presence or size (volume) and therefore the required dredging varies depending on the specific route and techniques used.


Covell's Beach Landfall Site
Falmouth
Martha's Vineyard
Horseshoe Shoal
Muskeget Channel
Nantucket
17
10
Landfall Site
Modeled Western Muskeget Variant Route
Offshore Export Cable Corridor (OECC)
Phase 2 OECC Western Muskeget Variant
Maximum Size of Southern Wind Developement Area (SWDA)
Lease Area Boundary
Federal/State Boundary
0 2 4 8 Kilometers
N

Two distinct approaches were considered to remove the upper portions of the sand waves above the stable seabed along the offshore export cables:

1. The first technique is a trailing suction hopper dredge ("TSHD"). Dredgers of this type are typically used for European offshore wind projects and are also commonly used in the US for channel maintenance, beach nourishment projects, and other uses. For this study, a TSHD would be used to remove a 20 m (65.6 ft) wide section of a sand wave (for each of the up to two cables) that is deep enough to allow subsequent installation of the cable within the stable seabed (referred to as "TSHD Pre-Dredge"). After the dredging was complete, cable installation would occur using one of the methods (e.g., jet plow) described in Sections 3.3.1.3.6 and 4.3.1.3.6 of Volume I of the COP. For the "TSHD Pre-Dredge" approach, cable installation is a separate activity that occurs after dredging is complete (referred to as "Cable Installation"). Therefore, the model first simulates the TSHD dredging, then separately simulates the cable installation. This combined approach of TSHD dredging followed by cable installation is referred to as "**TSHD Pre-Dredge + Cable Installation**".
2. The second approach involves jetting (also known as mass flow excavation), which uses a pressurized stream of water to push sand to the side. Jetting is a post-lay burial technique that removes the tops of sand waves while burying a section of cable that has previously been placed on the sand waves. Jetting removes the tops of sand waves where required and subsequently buries the cable. Jetting is a viable technique for excavation less than approximately 2 m through sand waves and into the stable seabed. If excavation greater than approximately 2 m is required, additional dredging by the TSHD would be required. Accordingly, the dredging could be accomplished entirely by the TSHD on its own (the "TSHD Pre-Dredge" described above) or the dredging could be accomplished by a combination of jetting and TSHD. In this scenario, jetting would be used in smaller sand waves and the TSHD would be used to remove the larger sand waves.
3. The jetting activity both removes the tops of sand waves where required and buries the cable (such jetting occurs only for very limited portions of the cable corridor). Therefore, the model accounts for cable installation both through jetting (in smaller sand waves) and through one of the other potential cable burial methods listed in the COP (such as a jet plow) in areas where sand wave removal is not required. This approach is referred to as "Cable Installation aided by Jetting". Accordingly, the model first simulates the limited TSHD dredging, then separately simulates the cable installation (which consists of jetting in limited segments for sand wave clearance and cable burial, plus jet plow or one of the other cable installation techniques listed in the COP for the remainder of the route). This combined approach of limited TSHD dredging (in larger sand waves) followed by cable installation via either jetting (in smaller sand waves) or one of the other potential cable burial methods (such as a jet plow) is referred to as "**Limited TSHD Pre-Dredge + Cable Installation aided by Jetting**."

The four independently modeled scenarios include: 1) TSHD Pre-Dredge, 2) Cable Installation, 3) Limited TSHD Pre-Dredge, and 4) Cable Installation aided by Jetting. The four scenarios can be grouped based on two distinct approaches defined in the text above: 1) TSHD Pre-Dredge + Cable Installation, and 2) Limited TSHD Pre-Dredge + Cable Installation aided by Jetting. However, the results are presented independently for each scenario because it is expected that there will be sufficient time between pre-dredging activities and cable installation such that the effects from sand wave clearance do not compound or influence effects from cable installation activities.

2 SEDIMENT MODELING

The following sections describe the construction methods and associated sediment-suspending activities as they pertain to defining modeling inputs.

2.1 Input Parameters: Construction Activities

In both options where the TSHD is used, a 20 m wide swath is required to be dredged for each cable (up to two cables are possible). The TSHD method includes a vessel with a drag arm that extends below the vessel to the seabed. The drag arm has an opening through which vessel-housed pumps suction the sediments (and water) from the seabed to the vessel hopper. The drag arm will induce some suspended sediments in the water column. It is assumed that it will resuspend 1% of the target sediments; this loss rate was based on a study (Anchor QEA, 2003) which established the average loss rate to be 0.77%, therefore the 1% is slightly conservative rounded up to the nearest integer. The suction process typically results in acquisition of 80% water and 20% sediment and therefore the vessel allows for overflow. The overflow will occur at the water surface and the overflow waters will contain some of the dredge sediments, preferentially the fine material. It is assumed that the overflow waters will contain 5% of the coarse material (fine sand and coarse sand as defined by the modeled binning of sediments) and 30% of the fine material (clay, fine silt and coarse silt as defined by the model binning of sediments); these values are based on a review of quantification of dredge related resuspension source terms. Given that the hopper will contain 99% of the target volume (since 1% is lost near the drag arm) this means that the overflow of coarse and fine sediments is equivalent to 4.95% and 29.7 % of the target volumes, respectively. Further it is assumed that the hopper will retain some of the water and the hopper will have a ratio of 20% water to 80% sediments on average.

Based on the parameters of this project it is anticipated that a 2,294 m^3 (3,000 cy) hopper will be employed and that the total (sediment plus water with a higher water content in the drag arm than in the hopper) production rate is 9,175 m^3/hr (12,000 cy/hr). Using the assumptions presented above, after 1 hour the hopper will contain approximately 1,835 m^3 (2,400 cy) of sediment and therefore the sediment production rate is 1,835 m^3/hour. This is approximate since, for the ease of discussion, it neglects the losses at the seabed or from overflow. Note that while ~30% of fines will overflow, fine material typically represents less than 5% of the sediment grain size distribution. Once the hopper is filled, the drag arm will stop suctioning and the vessel will sail offsite (but within the OECC) to dump the hopper contents (sediments and water). The hopper was assumed to open 6.09 m (20 ft) below the water surface. For the purposes of defining modeling inputs, it was assumed that the suction dredging would occur for approximately an hour, then the TSHD would sail to a location approximately 250 m east of the route and dump the hopper load and then sail back to the position along the route. The entire cycle of stopping the dredge, sailing to dump and sailing back is estimated to take approximately a half hour. Further, since the sand waves and associated dredging are intermittent, there are intermittent stoppages along the route and an average sail speed of 5.6 km/hr (3 knots) was assumed.

The actual volume of dredging is dependent on the cable installation method and achievable burial depth (Table 1). The volumes associated with dredged material were conservatively estimated, specifically for the jetting scenario, as jetting may be limited to even smaller sand waves than 2 m to ensure appropriate cable burial. In this case, less jetting will occur and more sand wave removal will occur by TSHD. As noted above, the Project Envelope includes both the “TSHD Pre-Dredge + Cable Installation” and the “Limited TSHD Pre-Dredge + Cable Installation aided by Jetting” approaches or various combinations of the jetting and TSHD amounts listed in these approaches.

The actual installation parameters could be one of these approaches on its own or some combination of these approaches. Components that are considered part of the Project Envelope were modeled based on established “typical” installation parameters which are described in more detail below. The dredging parameters (Table 2) and the vertical initialization of sediment mass associated with each of these activities (Table 3) were used as model input parameters.

Table 1. Approximate Dredging Lengths and Volumes for TSHD and Limited TSHD Pre-Dredge

OECC Route	TSHD Pre-Dredge Option		Limited TSHD Pre-Dredge + Jetting Option		Average Percent Solid
	Approx. Length with Sand Waves > 0 m where TSHD may Occur	Per Cable Volume of Sand Waves > 0 m where TSHD may Occur[1]	Approx. Length with Sand Waves >2 m where Limited TSHD may Occur[1]	Per Cable Volume of Sand Waves > 2 m where Limited TSHD may Occur	
	km	m^3	km	m^3	%
OECC – Western Muskeget Variant	7.65	60,080	0.63	19,634	72.85

Notes:

1. These volumes are a conservative estimate based on the assumption that cable installation equipment would have an achievable burial depth of 1.5 m. In reality, cable installation equipment may be able to reach a greater burial depth of 2.5 m, which would require less sand wave removal to ensure burial within the stable seabed

Table 2. Assumed Dredging Parameters

Sediment Characteristics		Depth weighted to 2 m[1]
Total Dredging Production (sediment + water)	m^3/hr	9,175
Sediment Production	m^3/hr	1,835
Hopper Volume	m^3	2,294
Sediment Suspended at Drag Head (as % of total dredged, both fines and coarse)	%	1
Target Fines in Overflow	%	29.7
Target Coarse in Overflow	%	4.95
Target Fines in Hopper Release	%	70.3
Target Coarse in Hopper Release	%	94.05
Operations	hrs/day	24
Time to Fill Hopper	hrs	1
Time to Transit, Release, Transit Back	hrs	0.5

Notes:

1. See COP Vol I Section 2.3.1 and Appendix I-G for details of the procedure to develop depth weighted grain size distributions.

Table 3. Summary of vertical initial distribution of mass associated with dredging, overflow and dumping.

Dredging			Overflow			Dumping		
Individual Bin Percent	Cumulative Percent	Meters Above Bottom	Individual Bin Percent	Cumulative Percent	Meters Below Surface	Individual Bin Percent	Cumulative Percent	Meters Below Surface
5	100	3	100	100	0	100	100	6.1
10	95	2	-	-	-	-	-	-
28	85	1	-	-	-	-	-	-
28	57	0.66	-	-	-	-	-	-
29	29	0.33	-	-	-	-	-	-

The impact cable installation parameters (Table 4) were developed based on typical modeling assumptions and discussions with the Proponent. The typical installation will have a one-meter-wide trench that is two meters deep, and the installation will advance at a rate of 200 m/hr. These parameters are considered applicable for a jet plow and are conservative for a mechanical plow.

For cable installation aided by jetting, sections requiring jetting will have a trench that is two meters wide and two meters deep and the excavation along those portions will advance at a rate of 100 m/hr. Mobilization fraction or percentage (often referred to as the loss rate or resuspension rate) during installation for the envelope of installation methods typically range from 10-35% (Foreman, 2002).

The typical sediment mobilization fraction for cable burial including sections where jetting was used was assumed to be 25%. The mass was assumed to be initialized in the bottom three meters (or less when depths are shallower than three meters) of the water column (Table 5). Additionally, operations were assumed to be continuous (i.e., 24 hrs/ day).

Table 4. Summary of typical and maximum cable installation impact parameters

Scenario Description	Grain Size Distribution	Trench Width (m)	Trench Depth (m)	Trench Volume per Meter (m^3)	Advance Rate (m/hr)	Percent Mobilized (%)
Typical – Cable Installation	Depth weighted to 2 m*	1	2	2	200	25
Typical – Cable Installation aided by Jetting	Depth weighted to 2 m*	2	2	4	100	25

Table 5. Summary of vertical initial distribution of mass associated with cable installation and jetting.

Individual Percent Mass (%)	Cumulative Percent Mass (%)	Height Above Bottom (m)
29	29	0.33
28	57	0.66
28	85	1
10	95	2
5	100	3

2.2 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. A combination of surface grab samples and sediment cores were available at locations along the Western Muskeget Variant offshore export cable. The grab samples, obtained from the upper half meter of the seabed, contained both sieve and hydrometer analysis as well as moisture content. The vibracore stations all yielded sieve data and a few stations also contained hydrometer analysis. Sediment analysis at multiple depths (typically two) within the upper three meters of the seabed were available at most vibracore stations, however they did not include analysis of the surface sediments; therefore, this information was obtained from the grab samples. Measurement of the moisture content was provided for all vibracore stations. The distributions at each location at each depth were discretized to determine the fraction in each of the five bin categories used in SSFATE (Table 6).

Table 6. 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
	4	Fine sand	75-130
Coarse	5	Coarse sand	>130

For all stations without hydrometer data, the remaining fraction (percent finer than fine sand) was split evenly in the three bins of clay, fine silt, and coarse silt. The depth-weighted sediment distribution used in the modeling (Figure 3) was produced at each of the vibracore station locations. The distribution was developed by assuming the nearest grab sample characterization represented the upper half meter, then that number was combined with all remaining samples to determine the depth weighted characterization for the target depth. For this analysis, the resulting sediment characterizations for the typical scenario (two-meter target depth) were used.

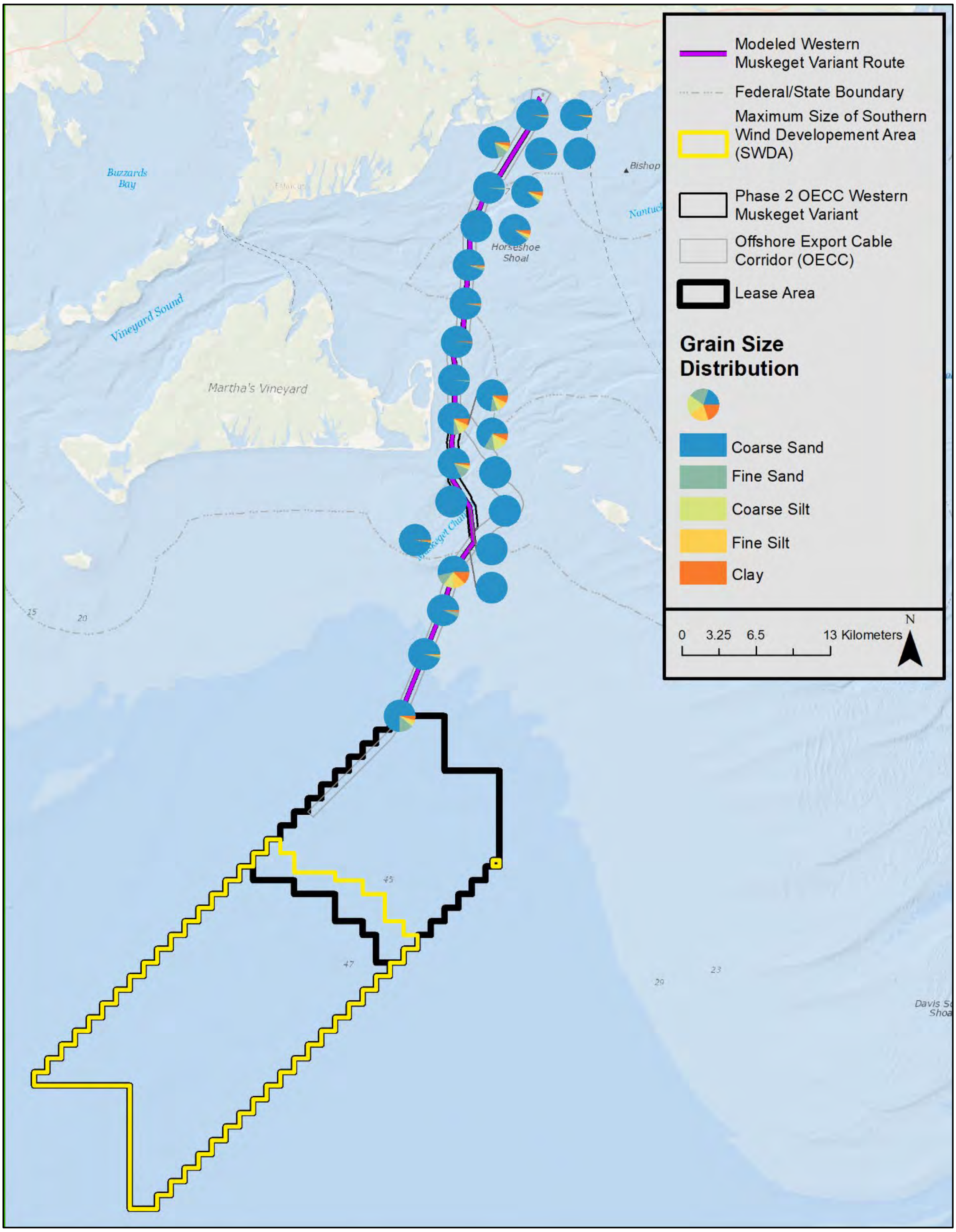


Figure 3. Sediment Grain Size Distributions along the Western Muskeget Variant route.

2.3 Sediment Modeling Results

SSFATE simulations were performed for each sediment disturbance activity. Sediment concentrations were computed on a grid with resolution of 50 m x 50 m in the horizontal dimension and 0.5 m in the vertical dimension. The model time step and output results saving interval was 5 minutes for the cable installation scenarios and 2 minutes for the dredging/overflow/disposal simulations. A smaller timestep was necessary for the dredging due to the faster production rate of the dredging operations. Model predicted concentrations are “excess” concentrations above the background concentration (i.e., a concentration of 0 mg/L is assumed for background, ambient conditions).

Results from the model runs are presented through a set of figures and tables. Maps of instantaneous TSS concentrations, time-integrated maximum TSS concentrations, duration of TSS ≥ 10 mg/L, and seabed deposition are provided for each modeled scenario. Tables quantifying the area exceeding TSS thresholds for specific durations as well as areas of seabed deposition exceeding thickness thresholds are presented for the representative offshore export cables. Mapped results are presented separately for each of the four model scenarios (Section 2.3.1 to 2.3.4), and tabular results are presented together in Section 2.3.5.

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

- **Maps of Instantaneous TSS Concentrations**: These figures show the instantaneous TSS concentrations at a moment in time. The plan view shows the maximum concentration throughout the water column and the vertical cross-section shows the cross-sectional variability of concentrations along a transect.
- **Maps of Time-integrated Maximum TSS Concentrations**: These figures show the maximum time-integrated water column concentration from the entire water column in scaled plan view. Most figures also include 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 that: (1) these concentrations do not persist throughout the entire simulation and may be just one time step; and (2) these concentrations do not occur concurrently throughout the entire modeled area but are the time-integrated spatial views of maximum predicted concentrations.
- **Maps of Duration of TSS Concentrations ≥10 mg/L:** These figures 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 figures show the 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 (1 mm and 20 mm) or to facilitate viewing the results.

2.3.1 TSHD Pre-Dredge

A snapshot of the instantaneous concentrations from the TSHD Pre-Dredge scenario is presented in Figure 4, the inset contains the vertical cross-section across the plume. This figure shows that at this instance, TSS concentrations above ambient are occurring throughout most of the vertical extent of the water column due to disposal activity releasing sediments in the upper water column.

In viewing the map of the time-integrated maximum concentrations footprint (Figure 5) the plume is present adjacent to the areas where sand wave dredging will occur, which is intermittent along the route. Further it can be seen that the plume may be present at varying orientations relative to the route centerline in response to the prevailing direction of the oscillating current synchronous with the simulated activity. In that sense it is noted that this footprint corresponds to the modeled time period and multiple perturbations of the footprint are possible, though the general trends are expected to be the same. The footprint and contours for the dredging, overflow and disposal activity show that excess concentrations are expected throughout the water column. This is due to the overflow release located at the surface and therefore a plume is noted throughout the water column as the sediments settle. Similarly, the dumping will initiate sediments approximately 6 m below the surface and therefore the resulting plume occupies waters throughout the majority of the water column. The plume of excess TSS at 10 mg/L and 750 mg/L extends up to 16 km and 5 km from the route centerline, though may be less extensive at varying locations along the route. Relatively high concentrations (>1,000 mg/L) are predicted at distances up to 5 km in response to the relatively high loading of dumping and swift transport of the dumped sediments.

The duration of exposure to TSS ≥10 mg/L above ambient is presented in Figure 6, and the seabed deposition is shown in Figure 7. Figure 5 illustrates that the simulation predicted that the affected areas are discontinuous in response to the intermittent nature of dredging. The map of exposure of the water column to TSS concentrations greater than 10 mg/L shows a much smaller footprint as compared to the map of maximum concentrations, indicating that at 10 mg/L the plume is very transient (i.e., present for less than one hour) in most locations. Most locations have exposures of less than one hour, though there are some areas with exposure of up to six hours. The deposition ≥1 mm was discontinuous and tended to stay near route.

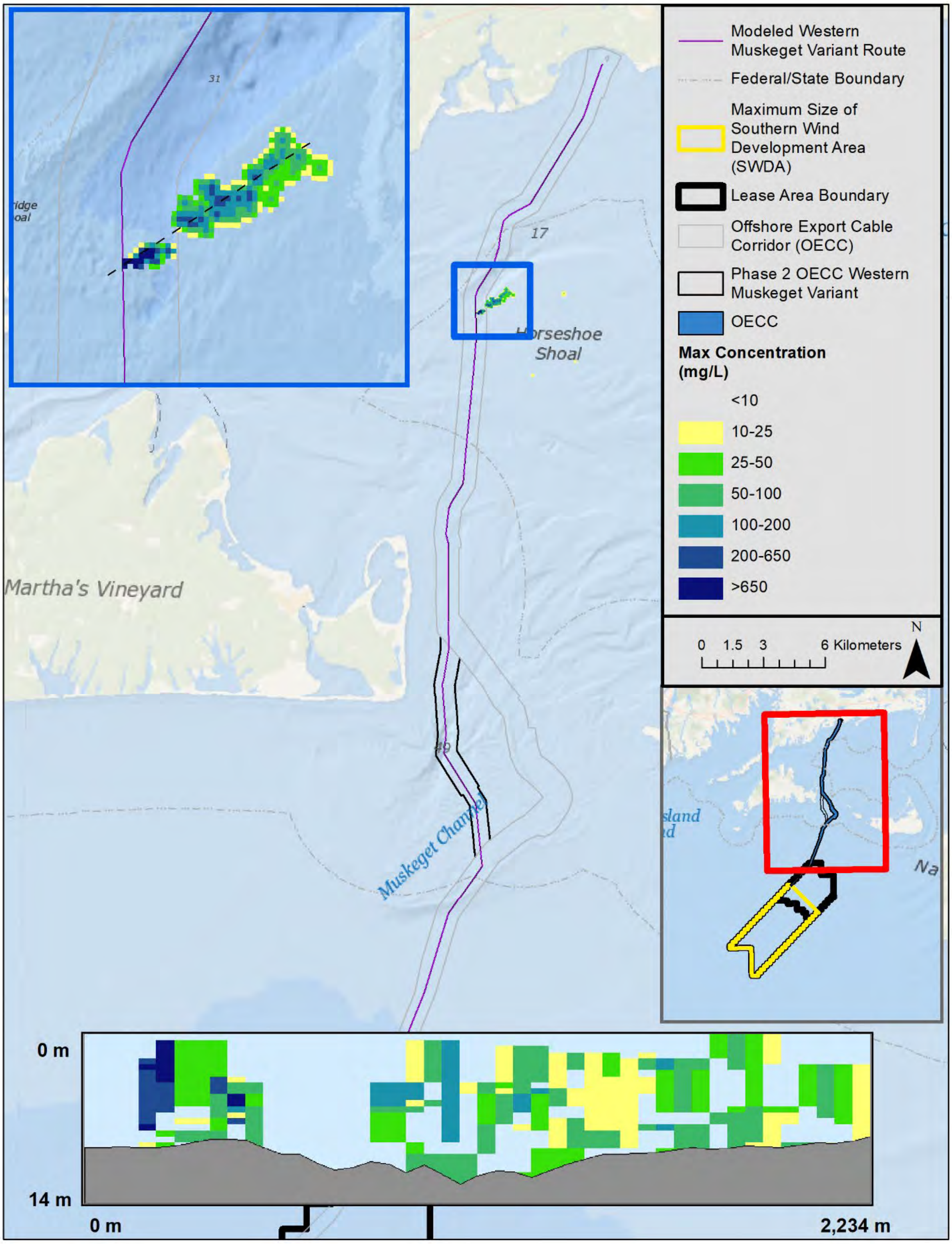


Figure 4. Snapshot of instantaneous TSS concentrations for a time step during simulation of TSHD dredging, overflow, and dredged material release operations for a representative cable route within the Western Muskeget Variant.[1]

Notes:

1. Inset at bottom shows the vertical cross-section across the plume from southwest (bottom left) to northeast (top right).

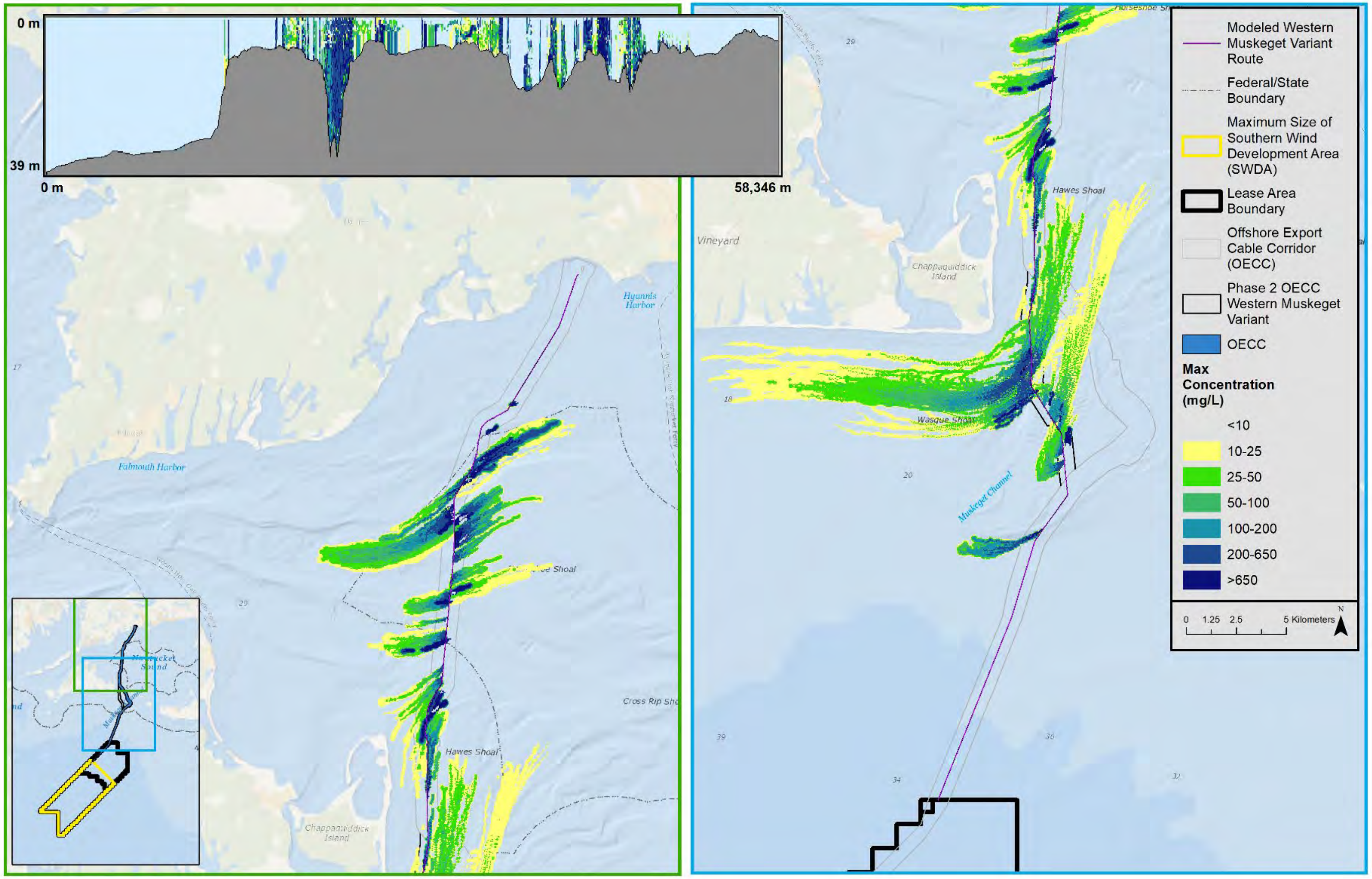


Figure 5. Map of time-integrated maximum concentrations associated with TSHD dredging, overflow, and dredged material release operations for a representative cable route within the Western Muskeget Variant. [1]

Notes:

1. Inset shows a vertical cross-section.

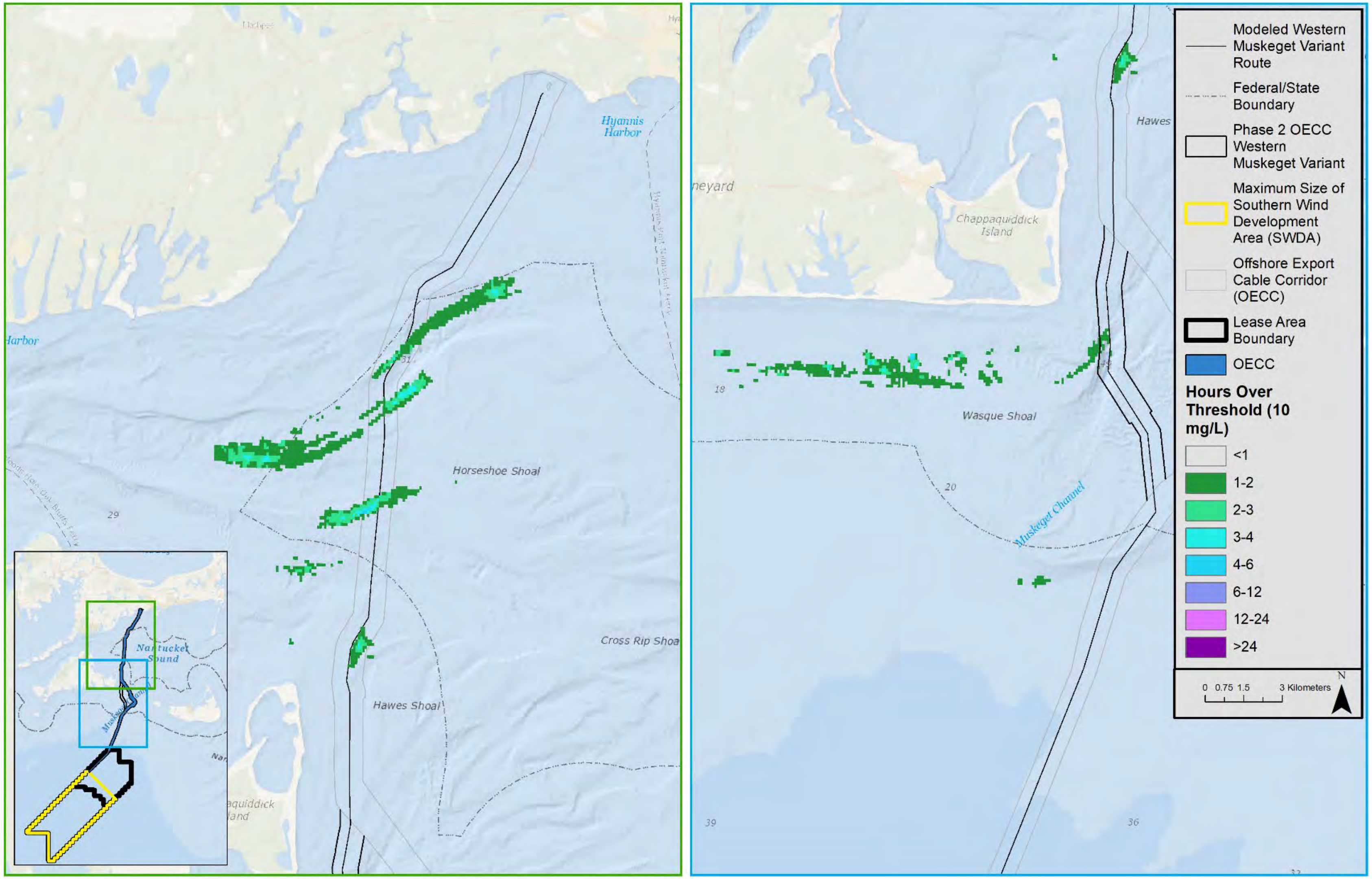


Figure 6. Map of duration of TSS ≥ 10 mg/L associated with TSHD dredging, overflow, and dredged material release operations for a representative cable route within the Western Muskeget Variant.

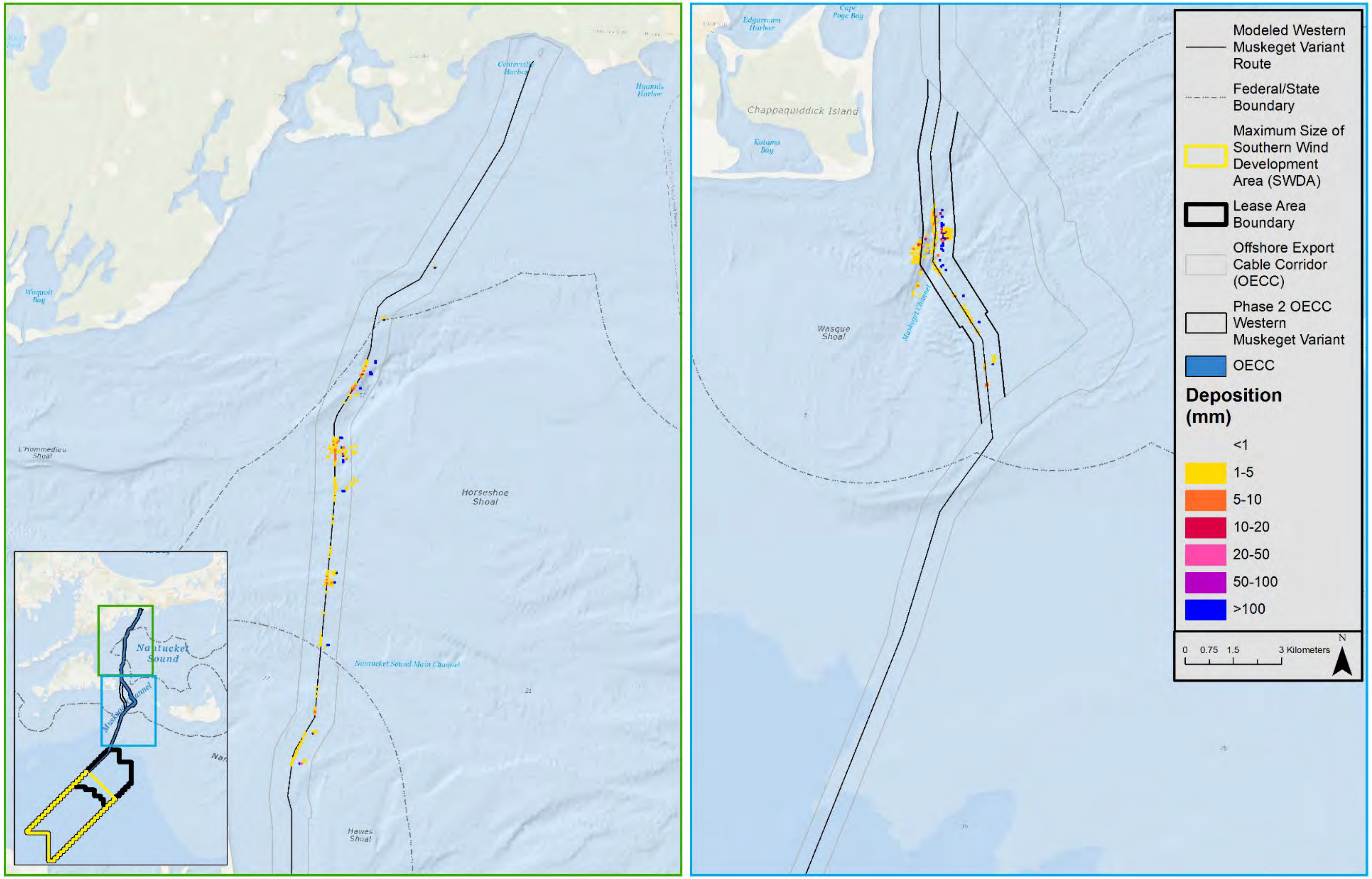


Figure 7. Map of deposition thickness associated with TSHD dredging, overflow, and dredged material release operations for a representative cable route within the Western Muskeget Variant.

2.3.2 Cable Installation

Subsequent to the pre-installation dredging via TSHD, cable installation will take place. A snapshot of the instantaneous concentrations from the representative cable installation scenario is presented in Figure 8, the inset contains the vertical cross-section across the plume. This figure shows that at this instance, TSS concentrations are local to the bottom of the water column.

The map of maximum time-integrated concentrations is presented in Figure 9, the duration of exposure to TSS above ambient ≥10 mg/L is presented in Figure 10, and the seabed deposition is shown in Figure 11. The overall footprint shows that the plume, as delineated by excess concentrations of 10 mg/L and greater, remains relatively close to the route centerline for the majority of the route. Some areas of the plume, as delineated by the 10 mg/L contour, were transported away from the centerline in response to the currents or due to the relatively higher volume of finer material present. Water column concentrations above 10 mg/L generally remain along the route centerline, with the 10 mg/L contour extended ~1.85 km from the centerline, though typically remaining within ~200 m or less from the centerline. The cross-sectional view of the maximum concentration (Figure 9) runs along the centerline and shows that the plume is contained within the bottom of the water column close to the disturbance.

Deposition was mainly centered around the route centerline with deposition ≥1.0 mm limited to within ~100 m from the centerline (Figure 11). Deposition was not predicted to reach 5 mm. The results indicate that most of the mass settles out quickly and is not transported for long by the currents.

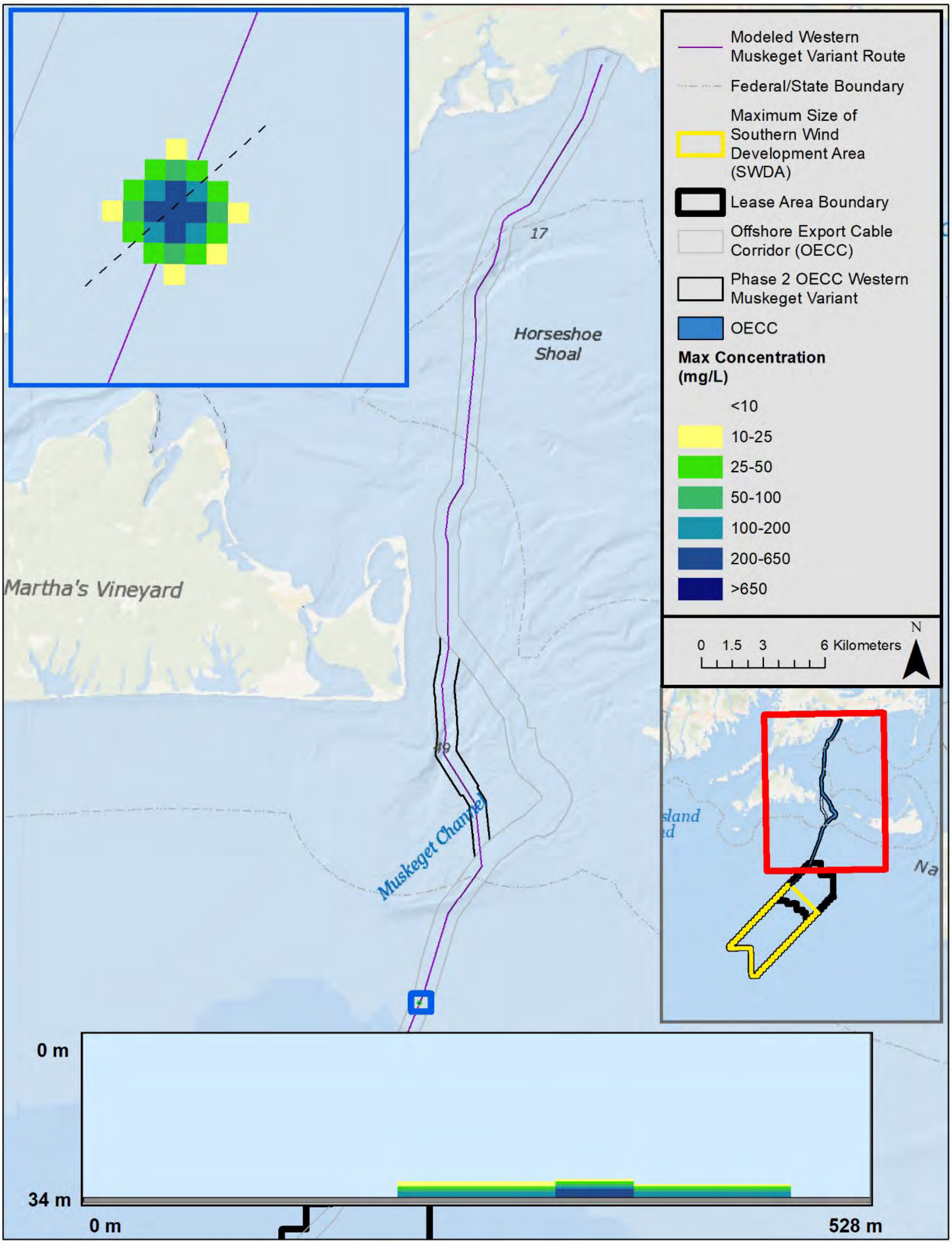


Figure 8. Snapshot of instantaneous TSS concentrations for a time step during simulation of representative cable installation within the Western Muskeget Variant.[1]

Notes:

1. Inset at bottom shows the vertical cross-section across the plume from northeast (top right) to southwest (bottom left).

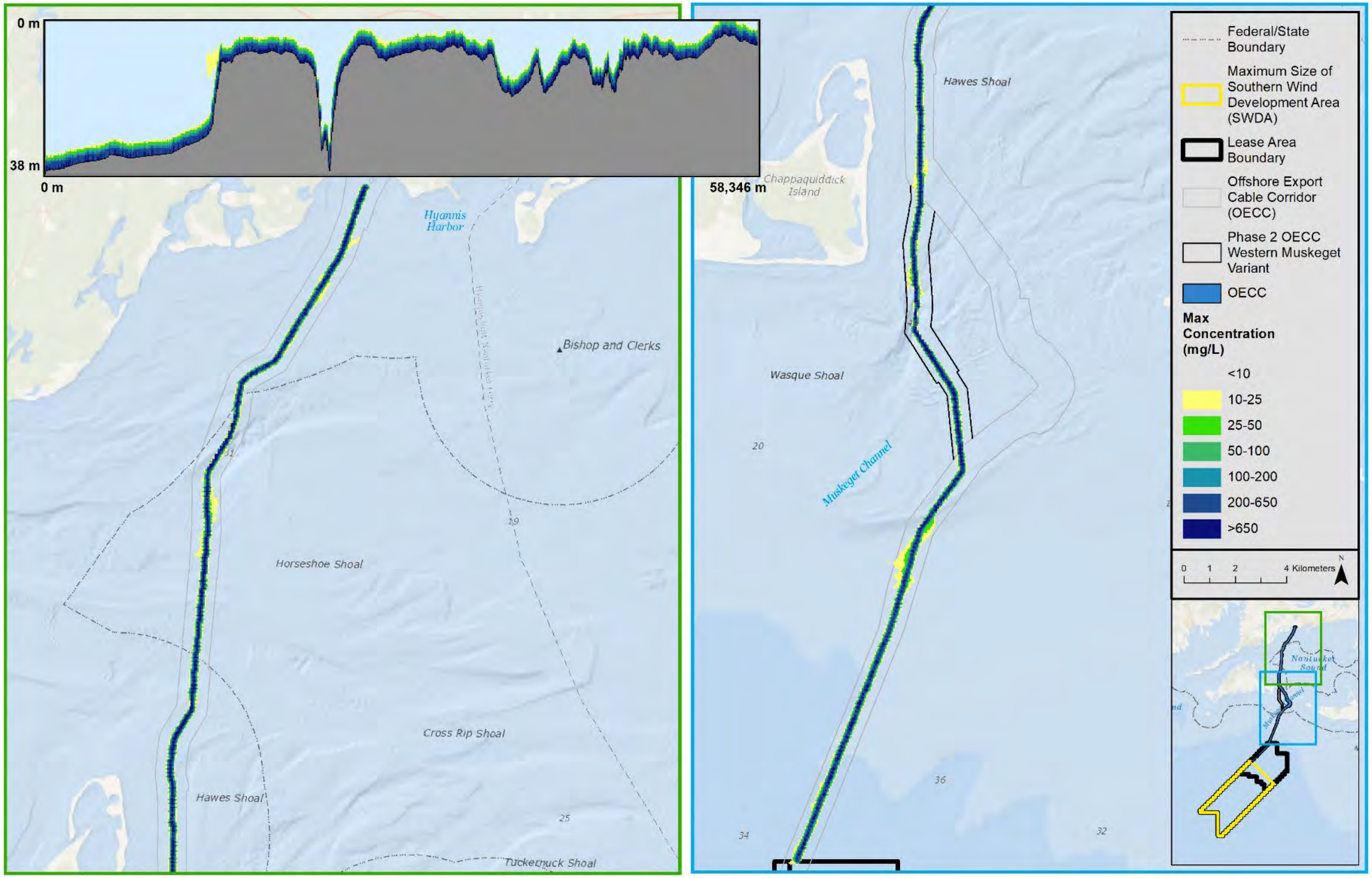


Figure 9. Map of time-integrated maximum concentrations associated with representative cable installation within the Western Muskeget Variant.[1]

Notes:

1. Inset shows a vertical cross-section along entire representative centerline.

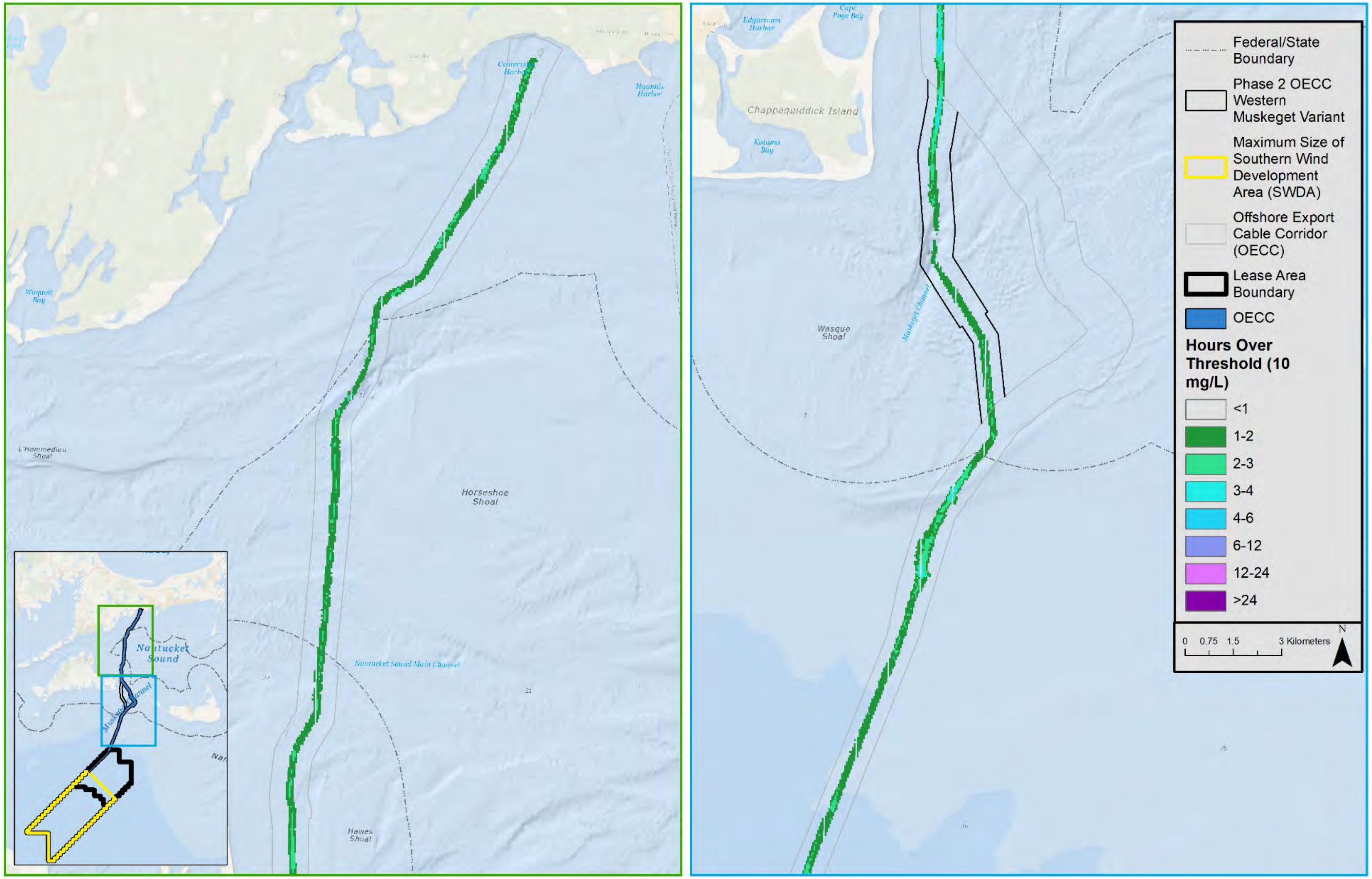


Figure 10. Map of duration of TSS ≥ 10 mg/L associated with representative cable installation within the Western Muskeget Variant.

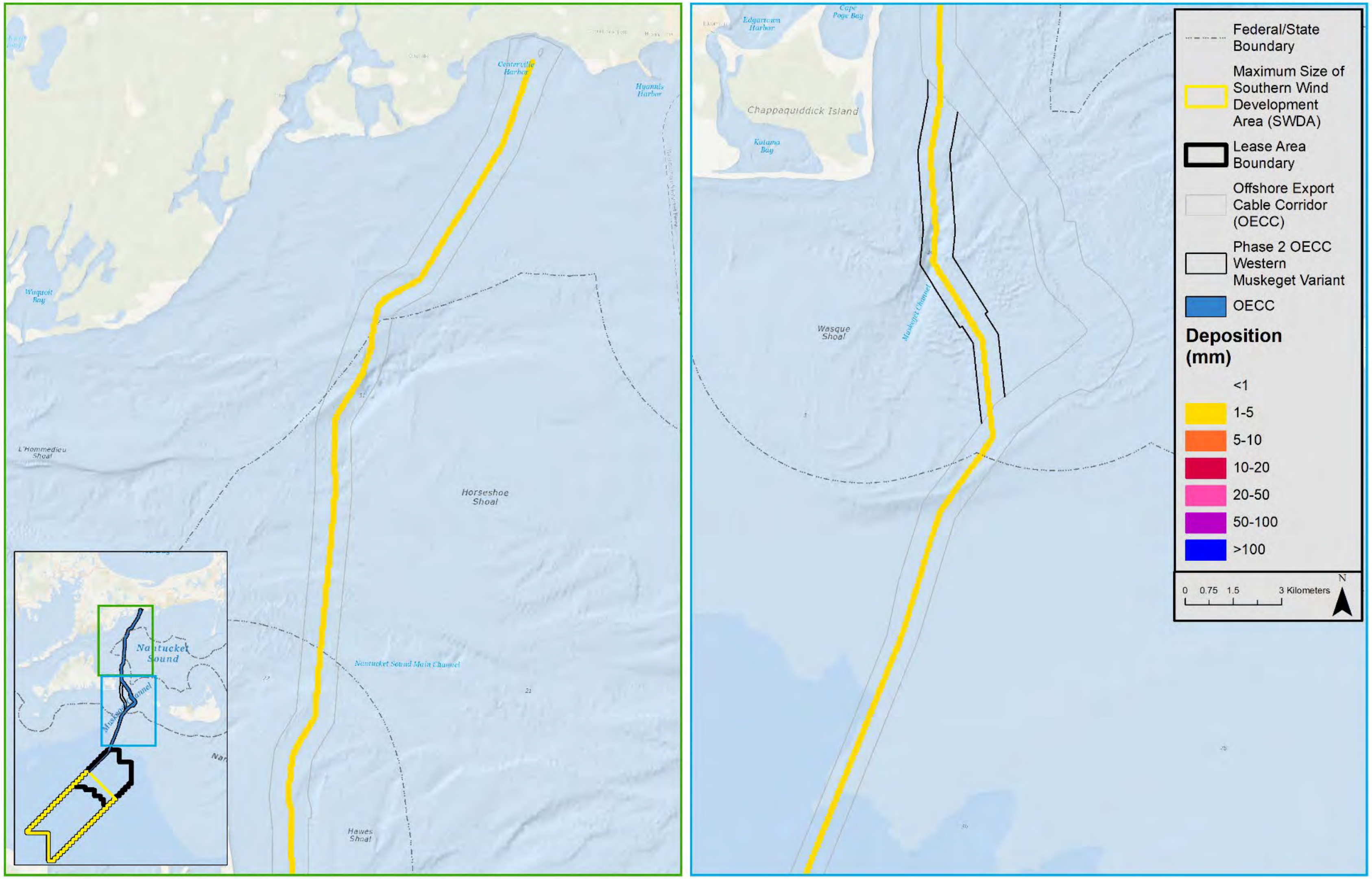


Figure 11. Map of deposition thickness associated with representative cable installation within the Western Muskeget Variant.

2.3.3 Limited TSHD Pre-Dredge

A snapshot of the instantaneous concentrations from the Limited TSHD Pre-Dredge scenario is presented in Figure 12 with an inset that contains the vertical cross-section across the plume. This figure shows that at this instance, TSS concentrations above ambient are occurring throughout most of the vertical extent of the water column due to disposal activity releasing sediments in the upper water column.

The maps of the time-integrated maximum concentration for the limited TSHD scenario (Figure 13), the duration of exposure to TSS ≥10 mg/L (Figure 14), and the seabed deposition (Figure 15) show that results for the limited TSHD scenario are similar in trend to those of the TSHD, but are reduced in size and intensity due to the fact that this scenario is dredging less sediments. The plume was transported by the prevailing direction of the oscillating currents synchronous with the simulated activity. The plume extent was similar to the TSHD Pre-Dredge scenario (~16 km), but occurred in a different location (i.e., Vineyard Sound) due to the timing of the currents. Due to sediment introduction at the surface and approximately 6 m below the surface, the plume extends throughout the water column as the sediments settle. Relatively high TSS concentrations (1,000 mg/L) subside within the first hour and concentrations ≥10 mg/L diminish within three hours. The exposure to above-ambient TSS ≥10 mg/L occur for a relatively short time period and generally remains near the route centerline.

As expected, the areas of deposition associated with the Limited TSDH Pre-Dredge were smaller for all thresholds than the TSHD Pre-Dredge. The deposition ≥1 mm was discontinuous and tended to stay close to the route centerline.

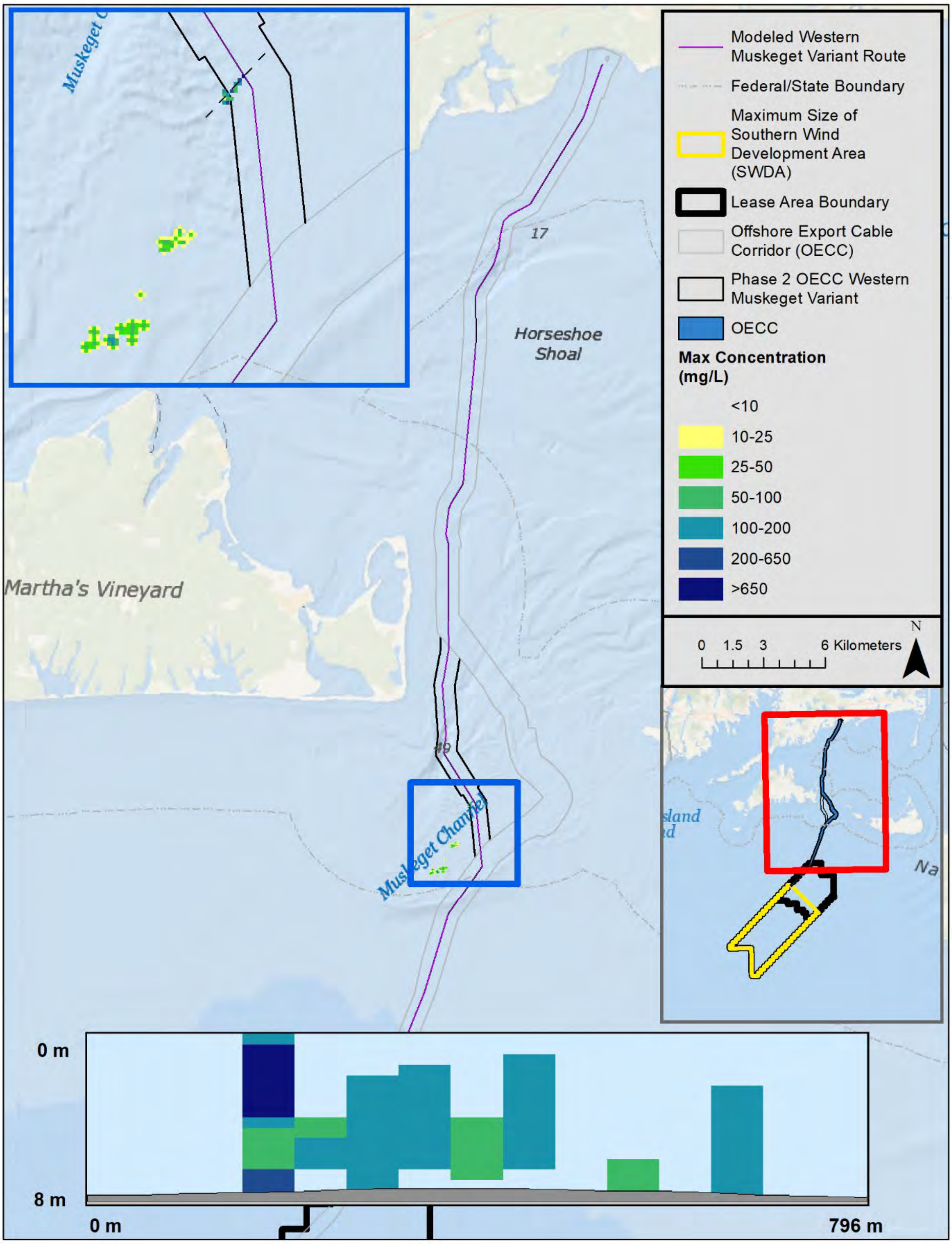


Figure 12: Snapshot of instantaneous TSS concentrations for a time step during simulation of limited TSHD dredging, overflow, and dredged material release operations for a representative cable route within the Western Muskeget Variant.[1]

Notes:

1. Inset at bottom shows the vertical cross-section across the plume from northeast (top right) to southwest (bottom left).

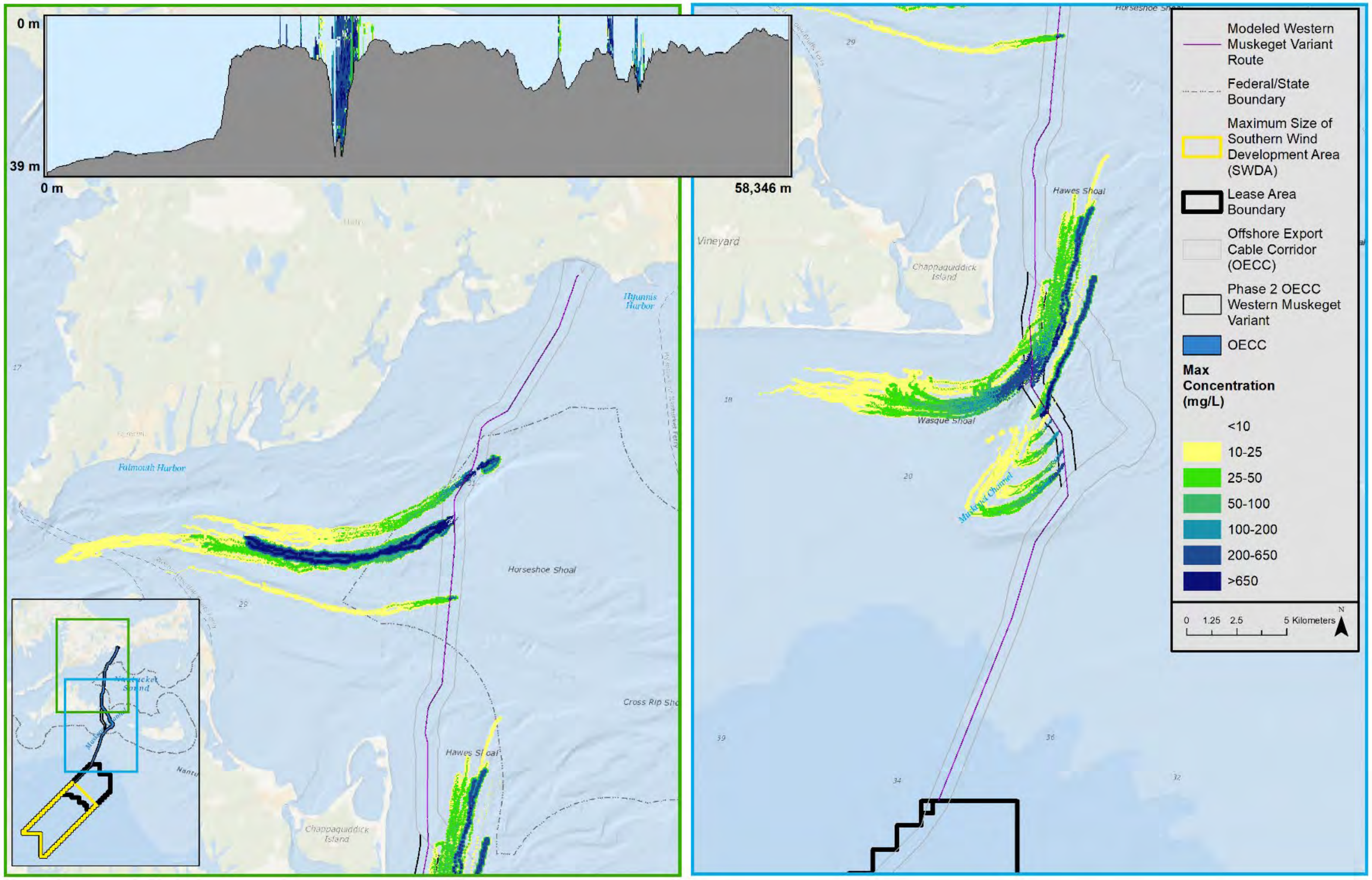


Figure 13. Map of time-integrated maximum concentrations associated with limited TSHD dredging, overflow, and dredged material release operations for a representative cable route within the Western Muskeget Variant.[1]

Notes:

1. Inset shows a vertical cross-section along the route centerline.

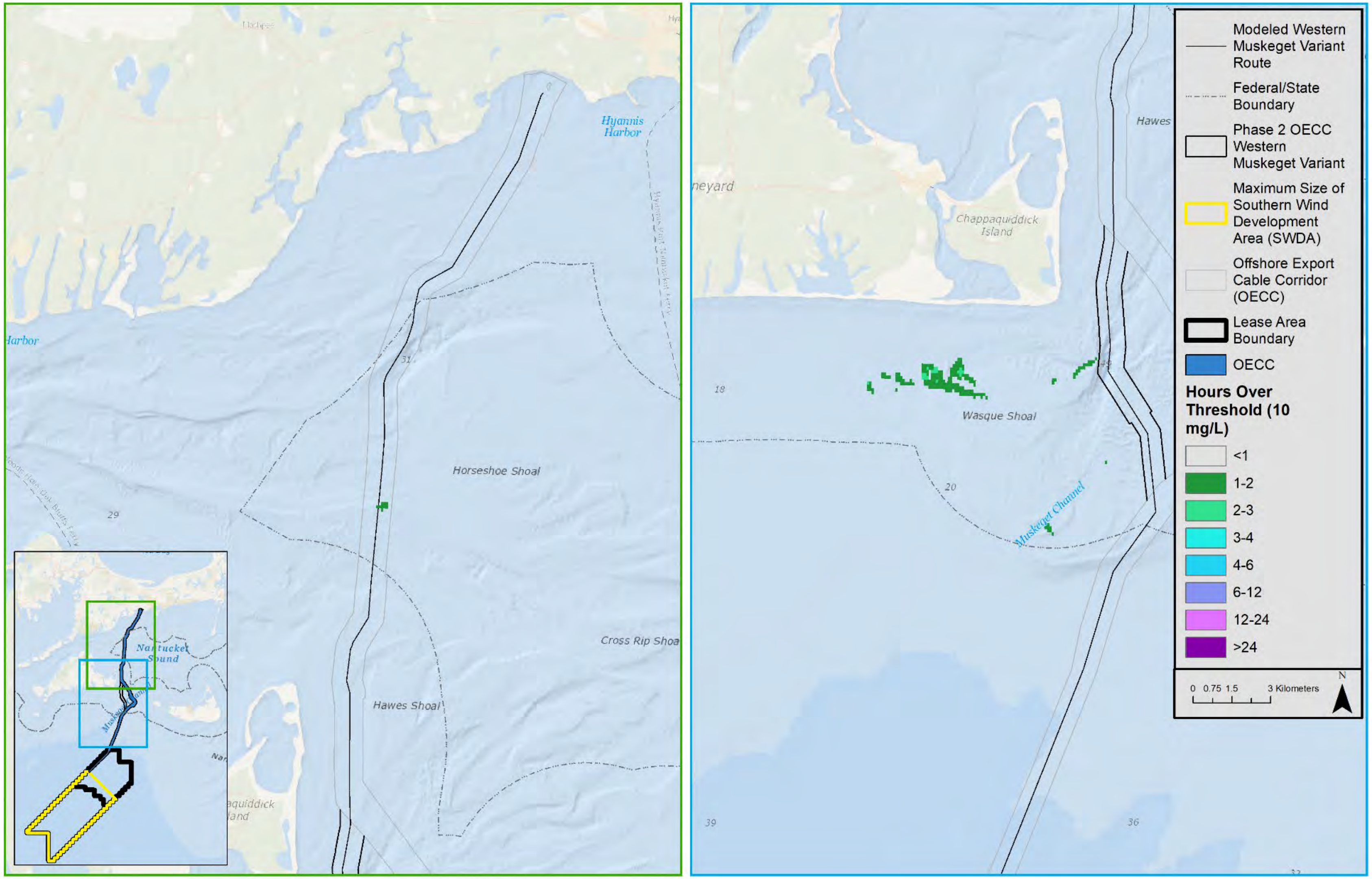


Figure 14. Map of duration of TSS ≥ 10 mg/L associated with limited TSHD dredging, overflow, and dredged material release operations for a representative cable route within the Western Muskeget Variant.

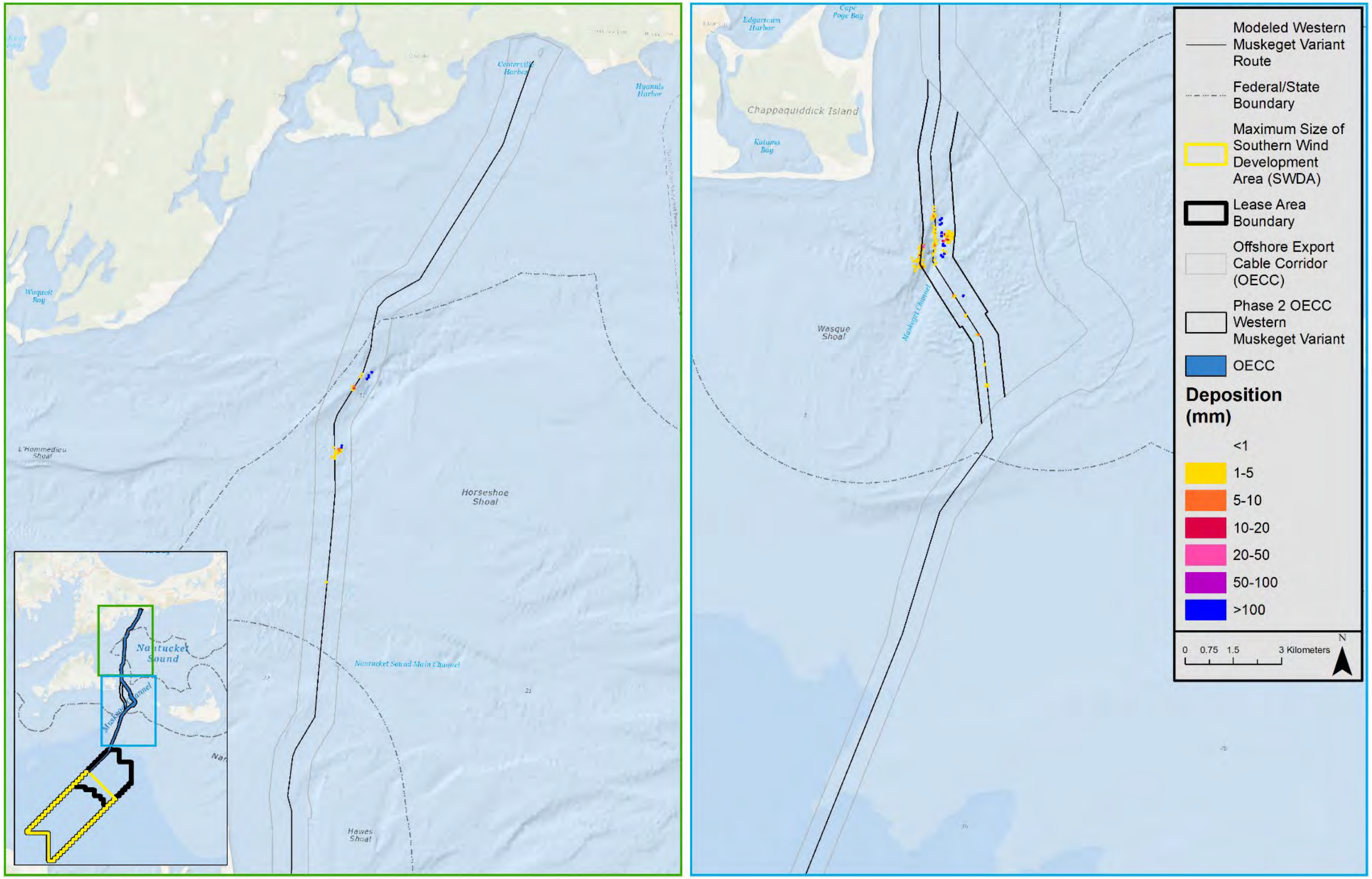


Figure 15. Map of deposition thickness associated with limited TSHD dredging, overflow, and dredged material release operations for a representative cable route within the Western Muskeget Variant.

2.3.4 Cable Installation aided by Jetting

A snapshot of the instantaneous concentrations from the Cable Installation aided by Jetting scenario is presented in with an inset that contains the vertical cross-section across the plume (Figure 16). This figure shows at that instance, TSS concentrations are local to the bottom of the water column.

For the Cable Installation aided by Jetting scenario, the maps of the time-integrated maximum concentration (Figure 17), the duration of exposure to TSS ≥10 mg/L (Figure 18), and the seabed deposition (Figure 19) show that results are similar to those from the Cable Installation simulation. The areas associated with the TSS concentrations were slightly larger for the one-hour duration of exposure for Cable Installation aided by Jetting, with maximum concentrations reaching 650 mg/L. Exposure to TSS concentrations ≥10 mg/L were predicted to subside within four hours.

Deposition ≥1 mm was mainly centered around the route centerline and deposition was not predicted to reach 5 mm. The results indicate that most of the mass settles out quickly and is not transported for long by the currents.

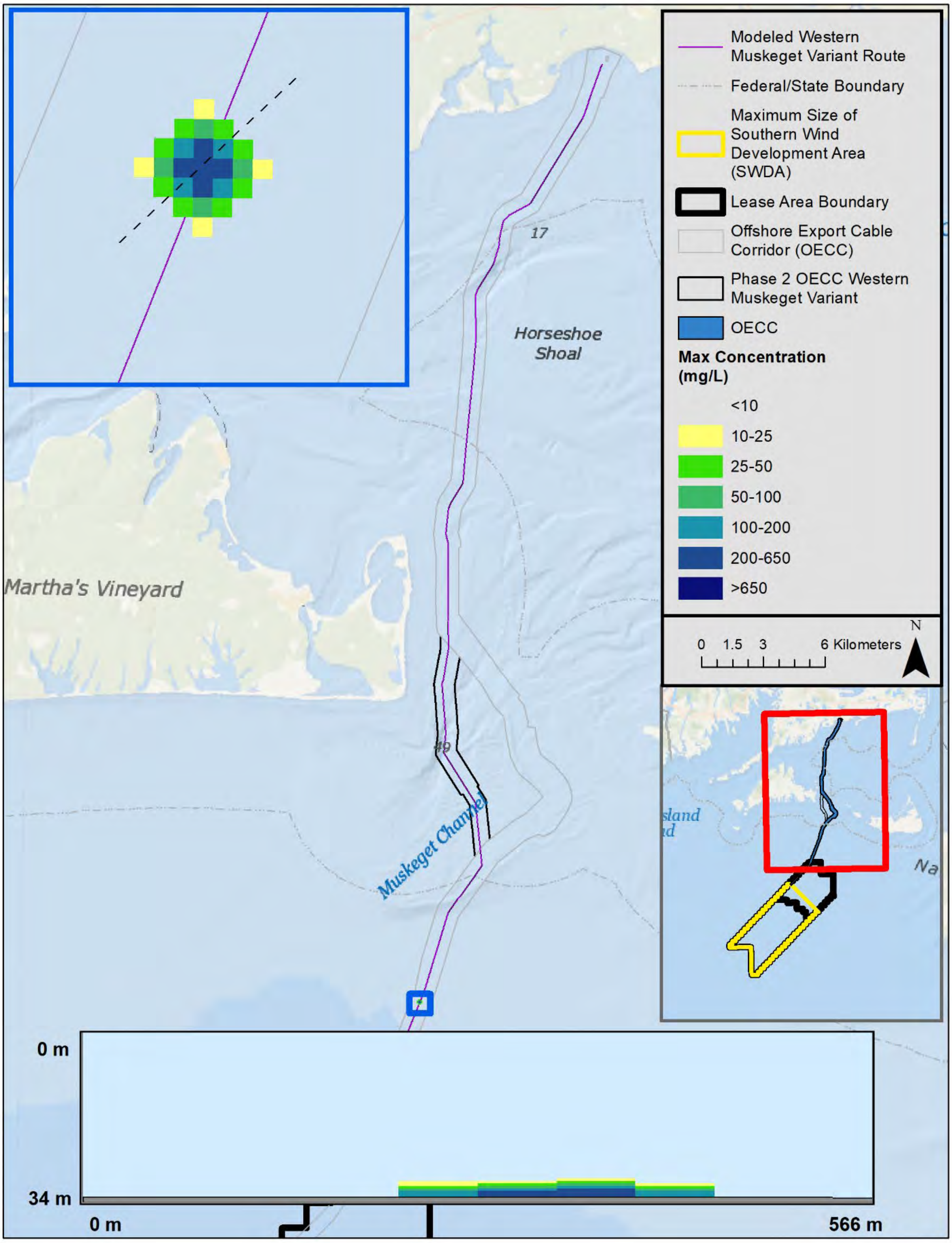


Figure 16. Snapshot of instantaneous TSS concentrations for a time step during simulation of representative cable installation aided by jetting within the Western Muskeget Variant.[1]

Notes:

1. Inset at bottom shows the vertical cross-section across the plume from northeast (top right) to southwest (bottom left).

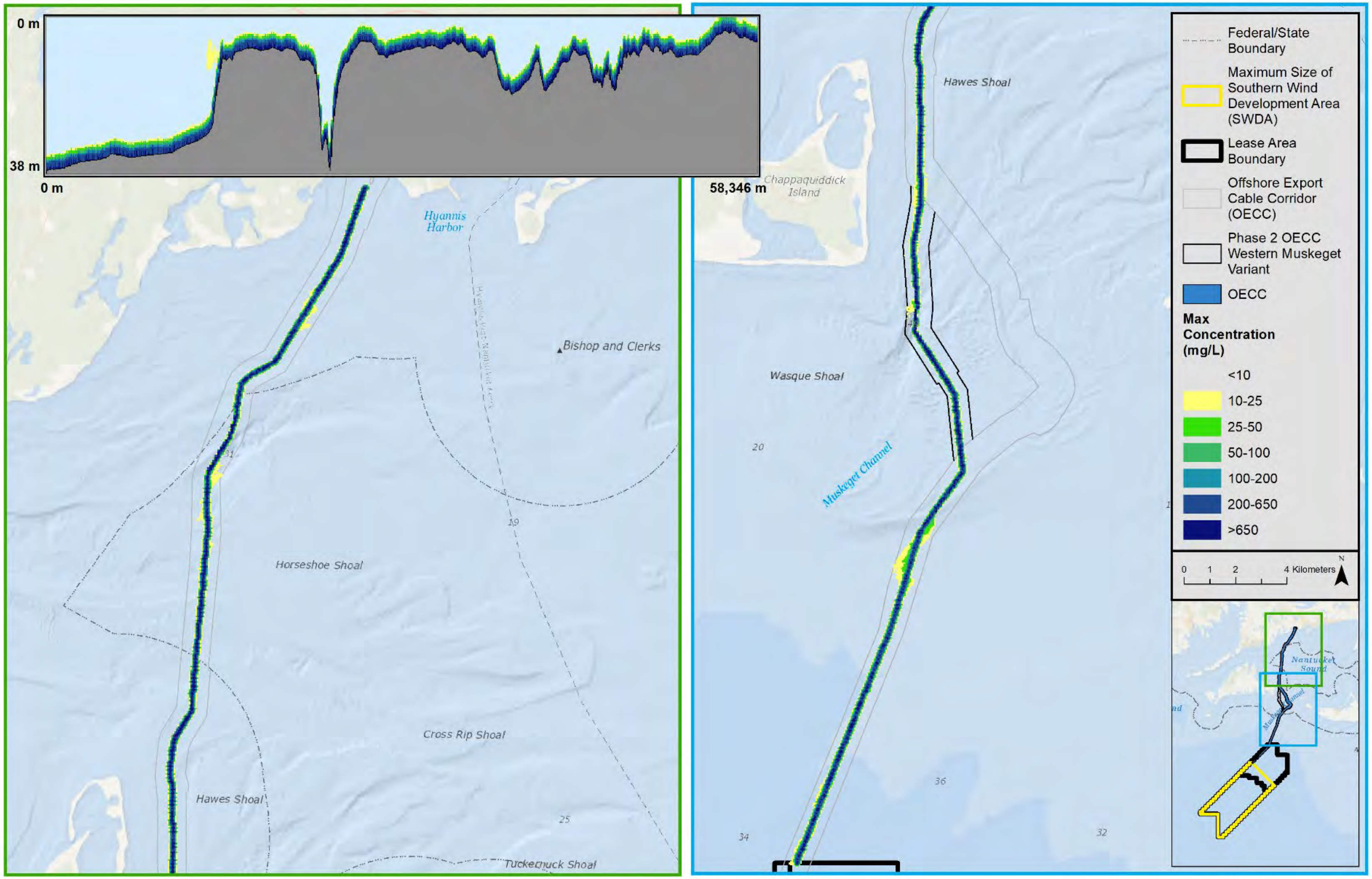


Figure 17. Map of time-integrated maximum concentrations associated with cable installation aided by jetting for a representative cable route within the Western Muskeget Variant.[1]

Notes:

1. Inset shows a vertical cross-section of entire representative route centerline.

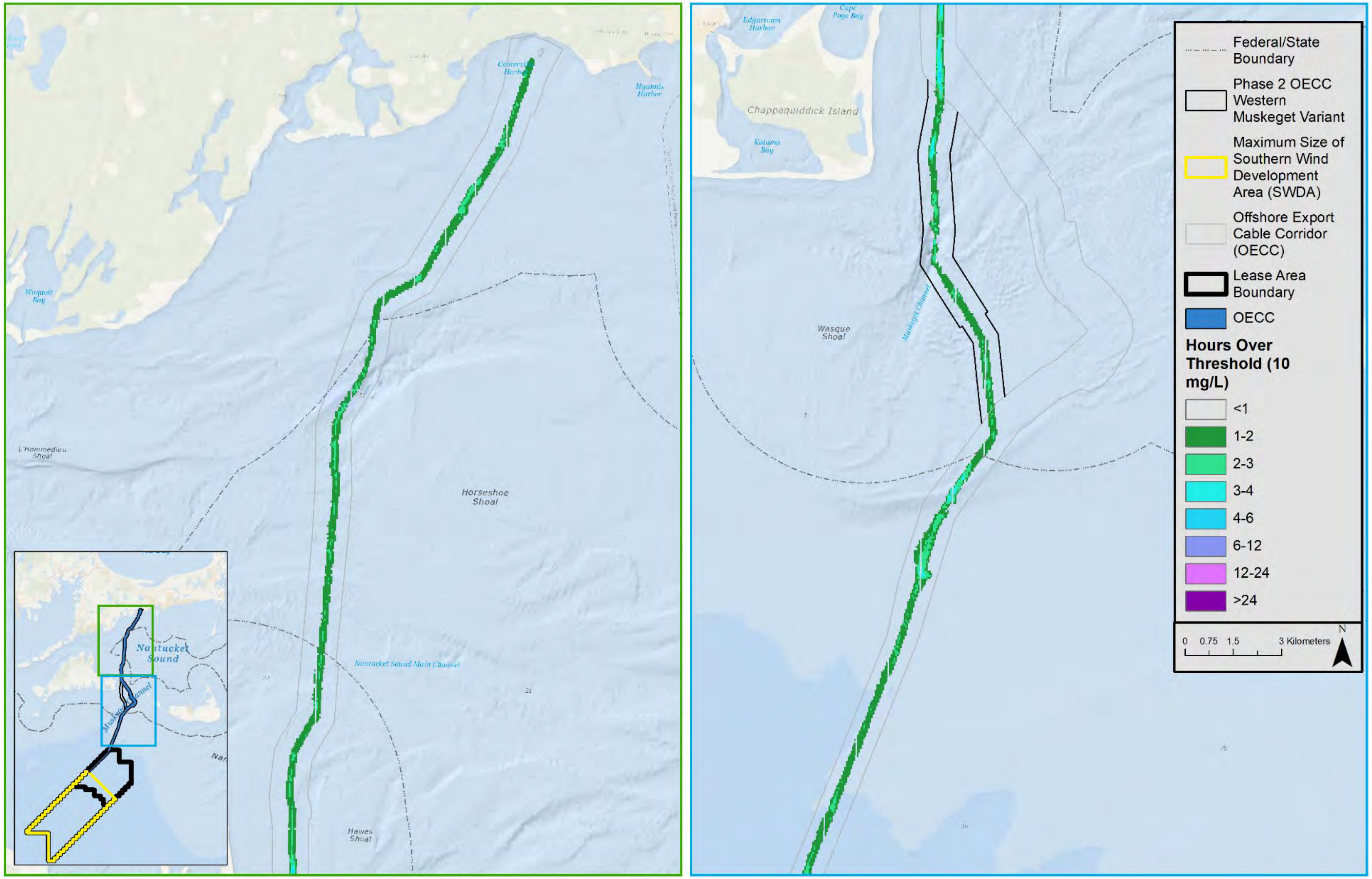


Figure 18. Map of duration of TSS ≥ 10 mg/L associated with cable installation aided by jetting for a representative cable route within the Western Muskeget Variant.

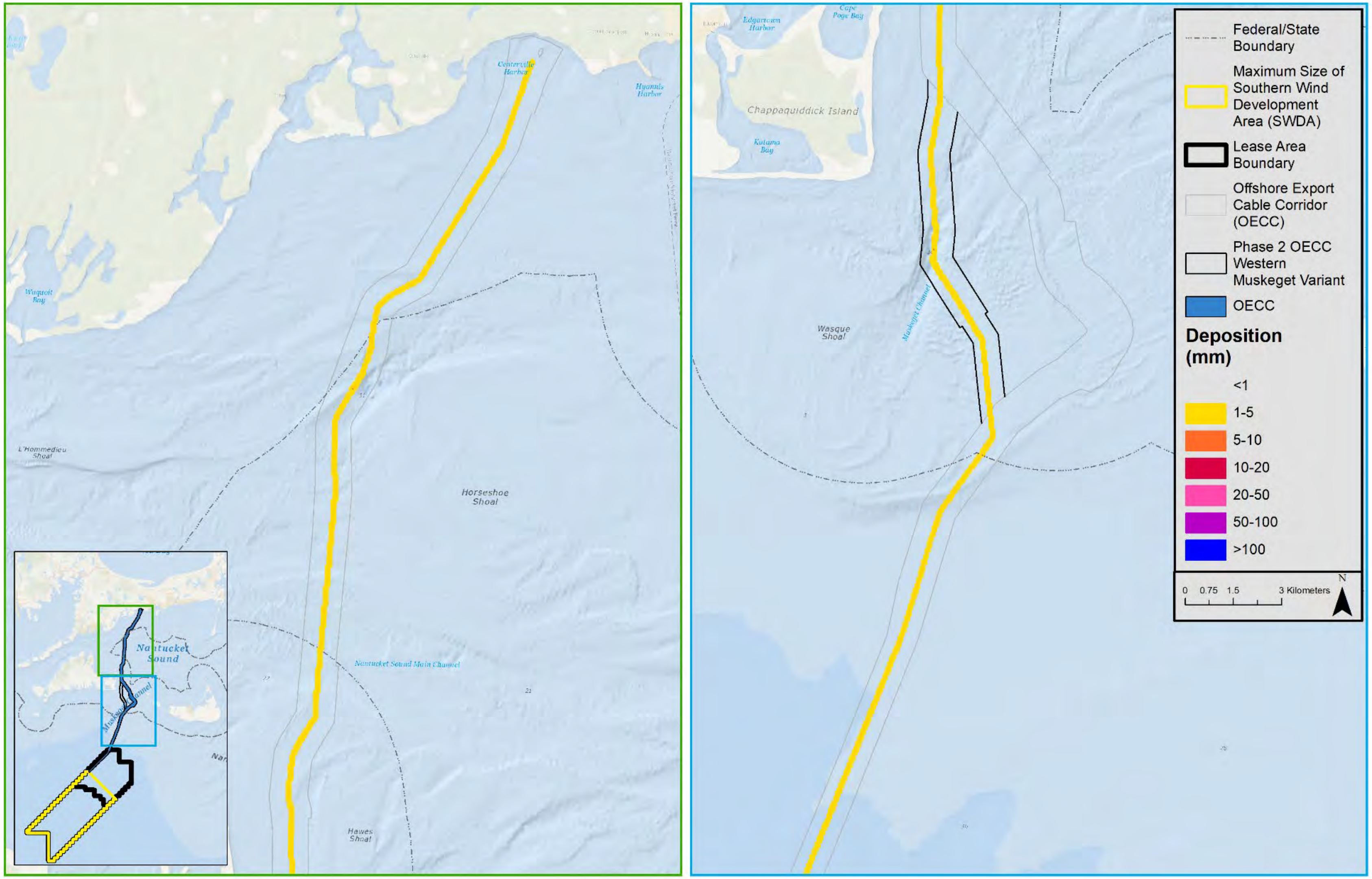


Figure 19. Map of deposition thickness associated with cable installation aided by jetting for a representative cable route within the Western Muskeget Variant.

2.3.5 Results Summary Tables

In reviewing the mapped modeling results for all scenarios, the largest difference between the figures is due to the extent TSHD was used. As expected, the dredging footprint for the “Limited TSHD Pre-Dredge + Cable Installation aided by Jetting” approach is smaller than the dredging footprint for the “TSHD Pre-Dredge + Cable Installation” approach. Note for all results tables, these scenarios were modeled along the Western Muskeget Variant route using “typical” parameters.

The model results of simulations of the Western Muskeget Variant show that the use of the TSHD for pre-cable installation dredging has the potential to generate temporary plumes that impact the entire water column and may extend several km from the route centerline. The cable installation activities may generate temporary plumes that are constrained to the bottom of the water column and do not extend far from the route centerline.

Results from all modeled scenarios were analyzed to determine the spatial area exposed to above-ambient TSS concentrations exceeding specific thresholds for various durations. 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. Post-processing included calculations with respect to duration threshold of one, two, three, four, six, 12, 24, and 48 hours; however, there were no areas over thresholds for the 12-, 24-, or 48-hour durations. Table 7 through Table 11 show the results for durations of one, two, three, four, and six hours, respectively. In reviewing these tables, it is helpful to keep in mind that the concentration grid resolution is 50 m in the horizontal plane. For a route 60 km long, the area covered by the grid cells along the route is therefore 3 km^2 (60,000 m x 50 m = 3 km^2). Further when the source is introduced to the concentration grid, the mass is spread out across a central cell and four neighboring cells and therefore the cell footprint of initial loading is close to 5 x 3 km^2 or 15 km^2. The dredge source is introduced in a smaller footprint since the dredging is intermittent and does not take place along the entire route.

These results tables illustrate that areas exposed to above-ambient TSS concentrations are largest when assessing concentrations above 10 mg/L, and that the areas rapidly decrease in size with increasing concentration threshold and increasing duration. For example, the Cable Installation aided by Jetting has 12.3 km^2 over 10 mg/L for 1 hour, which reduces to 0.01 km^2 over 650 mg/L for 1 hour (Table 7). Above-ambient TSS concentrations similarly decrease quickly with time: the concentrations over 10 mg/L reduce from 12.3 km^2 for 1 hour (Table 7) to 1.06 km^2 for 2 hours (Table 8), to 0.15 km^2 for 3 hours (Table 9) to zero for 4 hours (Table 10). Also, for this route, concentrations above 100 mg/L do not endure for 2 hours. Similar trends of rapid decrease of area with increasing time and/or increasing threshold are noted for all scenarios presented.

Table 12 summarizes the areas affected by sediment deposition over various thickness thresholds for the entire simulation route, and Table 13 summarizes areas affected by sediment deposition in Massachusetts (MA) state waters. The Cable Installation scenario resulted in a maximum thickness less than 5 mm, while the Cable Installation aided by Jetting was predicted to have a small area (0.01 km^2) of thickness at 5 mm. The TSHD scenarios result in deposition thicknesses greater than the cable installation scenarios, with some areas of 100 mm or greater. These areas are associated with the hopper disposal which disposes of the entire hopper of sediment in one location.

Table 7. Summary of area over threshold concentrations for 1 hour or longer for all scenarios.

Method	Concentration Thresholds in mg/L								
	10	50	100	150	200	300	650	750	1000
	Areas above Concentration Threshold (km²)								
TSHD Pre-Dredge	17.40	1.67	0.75	0.33	0.17	0.11	0.04	0.03	0.02
Cable Installation	12.10	5.62	2.14	0.47	0.04	-	-	-	-
Limited TSHD Pre-Dredge	2.26	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cable Installation aided by Jetting	12.30	5.82	2.38	0.62	0.13	0.04	0.01	-	-

Table 8. Summary of area over threshold concentrations for 2 hours or longer for all scenarios.

Method	Concentration Thresholds in mg/L								
	10	50	100	150	200	300	650	750	1000
	Areas above Concentration Threshold (km²)								
TSHD Pre-Dredge	3.85	0.37	0.07	0.01	0.01	-	-	-	-
Cable Installation	1.06	-	-	-	-	-	-	-	-
Limited TSHD Pre-Dredge	0.18	-	-	-	-	-	-	-	-
Cable Installation aided by Jetting	1.06	-	-	-	-	-	-	-	-

Table 9. Summary of area over threshold concentrations for 3 hours or longer for all scenarios.

Method	Concentration Thresholds in mg/L								
	10	50	100	150	200	300	650	750	1000
	Areas above Concentration Threshold (km²)								
TSHD Pre-Dredge	0.83	0.01	-	-	-	-	-	-	-
Cable Installation	0.15	-	-	-	-	-	-	-	-
Limited TSHD Pre-Dredge	-	-	-	-	-	-	-	-	-
Cable Installation aided by Jetting	0.15	-	-	-	-	-	-	-	-

Table 10. Summary of area over threshold concentrations for 4 hours or longer for all scenarios.

Method	Concentration Thresholds in mg/L								
	10	50	100	150	200	300	650	750	1000
	Areas above Concentration Threshold (km²)								
TSHD Pre-Dredge	0.09	0.01	-	-	-	-	-	-	-
Cable Installation	0.02	-	-	-	-	-	-	-	-
Limited TSHD Pre-Dredge	-	-	-	-	-	-	-	-	-
Cable Installation aided by Jetting	-	-	-	-	-	-	-	-	-

Table 11. Summary of area over threshold concentrations for 6 hours or longer for all scenarios.

Method	Concentration Thresholds in mg/L								
	10	50	100	150	200	300	650	750	1000
	Areas above Concentration Threshold (km^2)								
TSHD Pre-Dredge	-	-	-	-	-	-	-	-	-
Cable Installation	-	-	-	-	-	-	-	-	-
Limited TSHD Pre-Dredge	-	-	-	-	-	-	-	-	-
Cable Installation aided by Jetting	-	-	-	-	-	-	-	-	-

Table 12. Summary of deposition area over threshold concentrations for all complete routes in federal and state waters.

Method	Deposition Thresholds					
	1 mm	5 mm	10 mm	20 mm	50 mm	100 mm
	Areas of Deposition above Threshold (km^2)					
TSHD Pre-Dredge	1.23	0.29	0.17	0.13	0.12	0.12
Cable Installation	8.64	-	-	-	-	-
Limited TSHD Pre-Dredge	0.42	0.11	0.08	0.06	0.05	0.05
Cable Installation aided by Jetting	8.68	0.01	-	-	-	-

Table 13. Summary of deposition area over threshold concentrations in MA state waters for all complete routes.

Method	Deposition Thresholds					
	1 mm	5 mm	10 mm	20 mm	50 mm	100 mm
	Areas of Deposition above Threshold (km^2)					
TSHD Pre-Dredge	0.77	0.17	0.12	0.09	0.07	0.07
Cable Installation	4.82	-	-	-	-	-
Limited TSHD Pre-Dredge	0.38	0.08	0.07	0.04	0.04	0.04
Cable Installation aided by Jetting	4.85	-	-	-	-	-

2.3.6 Results Discussion

Simulations of sand wave dredging using a TSHD along the Western Muskeget Variant show that plumes originating from the source are intermittent along the route because of the intermittent need for dredging. For the TSHD Pre-Dredge scenario, the plume of excess TSS at 10 mg/L and 750 mg/L extends up to 16 km and 5 km from the route centerline, though may be less extensive at varying locations along the route. Relatively high concentrations (>1,000 mg/L) are predicted at distances up to 5 km from the route centerline in response to the relatively high loading of dumping and swift transport of the dumped sediments, but this high concentration only persists for less than two hours. In general, the excess concentrations over 10 mg/L from dredging can extend several km from the route centerline and may be present throughout the entire water column but are temporary and typically dissipate within six hours. The deposition greater than 1.0 mm associated with the TSHD drag arm is mainly constrained to within 80 m from the route centerline whereas the deposition greater than 1.0 mm associated with overflow and disposal extends to greater distances from the source, mainly within 1 km though such deposition can extend up to 2.3 km in isolated patches when subject to swift currents through Muskeget Channel (located within MA state waters). For the TSHD scenarios, releasing fine-grained material near the surface resulted in a more persistent plume that extended away from the route centerline. This was due to the fine grain material taking longer to settle as opposed to coarse sediments which tend to settle out faster and remain in proximity of the release location.

The simulations of the cable installation showed that both the footprint of the 10 mg/L excess concentration plume and the footprint of deposition over 1.0 mm stayed close to the route centerline. The maximum excursion of the 10 mg/L excess plume extended up to ~2 km, though typically less than 200 m from the route centerline. The excess concentrations stemming from cable installation, both with and without jetting for sand wave clearance, remain relatively close to the route centerline, are constrained to the bottom of the water column, and are also short-lived (typically dissipating within four to six hours). Deposition greater than 1.0 mm was limited to within 100 m from the route centerline for typical installation parameters; this trend holds true in both federal and state waters. For the cable installation scenarios, the resulting plume was predicted to remain near the release location and the sediment ultimately deposited along the route due to the combination of a relatively high fraction of coarse-grain material present along the Western Muskeget Variant and the introduction of sediment near the seabed.

These results illustrate that areas impacted by the plume follow similar trends regardless of the scenario. In general, trends of rapid decrease of area with increasing time and/or increasing concentration threshold are noted for all scenarios. While the plume patterns for the Cable Installation and Cable Installation aided by Jetting were similar, and TSHD Pre-Dredge and Limited TSHD Pre-dredge were similar, differences in the extent and persistence of the plumes and the extent and thickness of deposition may be attributed to route orientation relative to currents, timing of currents, installation parameters, volume suspended, the location in the water column where sediments are introduced, and sediment grain size distribution.

3 REFERENCES

Anchor QEA. 2003. Literature Review of Effects of Resuspended Sediments Due to Dredging Operations. Prepared for the Los Angeles Contaminated Sediments Task Force.

Foreman, J. 2002. Resuspension of sediment by the jet plow during submarine cable installation. Submitted to GenPower, LLC, Needham, MA. Submitted by Engineering Technology Applications, Ltd, Romsey, Great Britain.

Swanson, J. C., Isaji, T., & Galagan, C. 2007. Modeling the ultimate transport and fate of dredge-induced suspended sediment transport and deposition. Proceedings of the WODCON XVIII, 27.