Empire Offshore Wind LLC

Empire Wind 1 Project

Article VII Application

Appendix B

Sediment Transport Analysis

June 2021

TABLE OF CONTENTS

FIGURES

TABLES

ACRONYMS AND ABBREVIATIONS

BOEM	Bureau of Ocean Energy Management
ConEdison	Consolidated Edison Company of New York, Inc.
cm	centimeters
cm/s	centimeters per second
Empire, the Applicant	Empire Offshore Wind LLC
EW 1	Empire Wind 1
ESPreSSO	Experimental System for Predicting Shelf and Slope Optics
ft	foot
ft/s	feet per second
HVAC	high-voltage alternating-current
in	inch
km	kilometer
kV	kilovolt
Lease Area	BOEM-designated Renewable Energy Lease Area OCS-A 0512
m	meter
mi	mile
mm	millimeter
MFE	mass flow excavation
mg/L	milligrams per liter
nm	nautical mile
NYISO	New York Independent System Operator, Inc.
NYSPSC or Commission	New York State Public Service Commission
PDE	project design envelope
POI	Point of Interconnection at the Gowanus 345-kV Substation
Project	EW 1 Project transmission facilities in New York
Project Area	The submarine export cable corridor, onshore cable corridor and onshore substation facilities within New York State jurisdiction
PSL	New York Public Service Law
SBMT	South Brooklyn Marine Terminal
Tetra Tech	Tetra Tech, Inc.

B.1 Introduction

Empire Offshore Wind LLC (Empire, or the Applicant) proposes to construct and operate the Empire Wind 1 (EW 1) Project as one of two separate offshore wind projects to be located within the Bureau of Ocean Energy Management (BOEM) designated Renewable Energy Lease Area OCS-A 0512 (Lease Area). This assessment is being submitted to the New York State Public Service Commission (NYSPSC or Commission) for the portions of the EW 1 Project transmission system located within the State of New York (collectively the Project) pursuant to Article VII of the New York Public Service Law (PSL).

The Project will interconnect to the New York State Transmission System operated by the New York Independent System Operator, Inc. (NYISO) at the Gowanus 345-kilovolt (kV) Substation (the point of interconnection, or POI). The Gowanus 345-kV Substation is owned by the Consolidated Edison Company of New York, Inc. (ConEdison). The Project's onshore facilities, including the onshore cable route, onshore substation, and the POI, are located entirely within Brooklyn, Kings County, New York.

The Article VII components of the EW 1 Project include:

- Two three-core 230-kV high-voltage alternating-current (HVAC) submarine export cables located within an approximately 15.1-nautical mile (nm, 27.9-kilometer [km])-long submarine export cable corridor from the boundary of New York State waters 3 nm (5.6 km) offshore to the cable landfall in Brooklyn, New York;
- A 0.2-mile (mi, 0.3-km)-long onshore cable route and substation including:
  - Two three-core 230-kV HVAC EW 1 onshore export cables buried underground from the cable landfall either directly to the cable terminations or to a vault within the onshore substation;
  - An onshore substation located at the South Brooklyn Marine Terminal (SBMT), which will increase the voltage to 345 kV for the onshore interconnection cables; and
  - Two 345-kV cable circuits, each with three single-core HVAC onshore interconnection cables, buried underground from the onshore substation to the POI.

Tetra Tech, Inc. (Tetra Tech) was contracted by Empire to evaluate the potential suspended sediment, transport and deposition associated with Project construction activities, including installation of submarine export cables. Disturbance of sediments during Project construction has the potential to affect water quality through increases to total suspended solids into the water column and deposition of sediments away from the location of sediment disturbance, including potentially outside the Project Area (i.e. submarine export cable corridor) through resuspension, dispersal, and subsequent sedimentation.

In order to provide a conservative estimate of potential maximum suspended sediment transport and deposition impacts, publicly available sediment and water circulation data covering the Project Area was used to develop the sediment transport model. The modeling was undertaken to quantify potential maximum plume dispersion; suspended sediment concentrations; and potential maximum sediment deposition thicknesses that may occur due to Project construction.

The sediment transport assessment contained herein includes a description of the Project components that were evaluated (Section B.1.1); a discussion of the modeling approach undertaken (Section B.1.2); a summary of the data sources and associated hydrodynamic and sediment characteristics applied (Section B.1.3); description of the model runs executed (Section B.1.4); and results of the analysis and associated conclusions (Sections B.1.5 and B.1.6).

B.1.1 Project Description

The offshore wind farm will be located in the Lease Area, which is approximately 14 mi (12 nm, 22 km) south of the southern shore of Long Island. The Project submarine export cables come ashore from the lower reaches of Upper New York Bay in southwestern Brooklyn, making landfall at the SBMT (**Figure B-1**). The onshore cable route then exits SBMT from the northeast corner, at the intersection of 2nd Avenue and 29th Street. The route then traverses north along 2nd Ave until entering the Gowanus POI on 28th Street.

Based on current understanding of site-specific conditions along the submarine export cable route to shore (submarine export cable corridor), Empire is currently recommending jetting[1], mechanical plowing, and mechanical trenching as the primary cable burial methodologies. In areas where these methods cannot be employed due to deeper burial requirements or other challenges such as vessel draft requirements, dredging or mass flow excavation (MFE) may be employed. In general, the submarine export cables will be buried to a target depth of 6 feet [ft] (1.8 meters [m])[2] below the seabed surface (except where deeper burial is required in federally maintained navigational features; see Section B.1.2); and installation will often be to a depth of 8 ft (2.5 m) to account for immediate sediment settling and to achieve the target burial depth.

B.1.2 Modeling Assumptions and the Project Design Envelope Approach

In order to evaluate how submarine export cable installation will affect suspended sediment concentrations, transport and deposition, Tetra Tech conducted a sediment transport analysis of the Project. Results from a previously developed publicly available hydrodynamic model were used to gather information regarding current velocity and direction along the submarine export cable corridor (Project Area). An analytical sediment transport model was developed to predict the fate and transport of sediment suspended by cable installation along the submarine export cable route. Tetra Tech used existing publicly available sediment data to inform the analytical model.

- The analytical model adopted a project design envelope (PDE) approach[3] to evaluate the effects of proposed submarine cable burial activities in terms of suspended sediment concentrations in the water column and sediment transport and deposition characteristics, such as deposition depth and sediment footprint, to assess potential Project effects on surrounding water quality and habitats. The model simulated installation impacts of one trench, although two trenches will be installed during construction; the trenches will be installed at separate times, however. The model simulated jet plow installation, the installation method proposed to be utilized for most of the submarine export cable installation area, which would result in greater disturbance of marine sediments than mechanical plow or mechanical cutter installation. Jet plowing therefore provides the maximum expected disturbance of seabed sediment in the Project Area. In some locations in the Project Area, jet plowing is not feasible or desired due to sediment materials or the presence of other submarine assets. In these locations the model simulated MFE. In other limited areas, underwater megaripples and sand waves are present on the seafloor, and pre-sweeping may be necessary prior to cable lay activities. Pre-sweeping involves

[1] Jetting includes jet plowing and vertical injection; jet plowing is modeled as the primary jetting method as it provides more conservative values for sediment modeling.
[2] Based upon guidance provided by the U.S. Army Corps of Engineers in letters dated September 20, 2018 and August 20, 2020, submarine export cables will be buried to a minimum target burial depth of 15 ft (4.7 m) below the current (and future) authorized depth or depth of existing seabed (whichever is deeper) of federally maintained navigation features (e.g. anchorages and shipping channels).
[3] A PDE is defined as "a reasonable range of project designs" associated with various components of the project (BOEM 2018).

smoothing the seafloor by removing ridges and edges, where present. This approach is consistent with BOEM's *Draft Guidance Regarding the Use of a Project Design Envelope in a Construction and Operations Plan* (BOEM 2018). This approach provides the Project reasonable flexibility to make prudent development and design decisions prior to construction. Therefore, for the purpose of this analysis, the Empire has assumed the following as the maximum design scenario:

- One proposed submarine export cable route;
- The use of a jet plow[4], since this is anticipated to be the cable installation method used for the majority of the submarine export cable installation;
  - A target burial depth submarine export cables of 8 ft (2.5 m);
  - A target burial depth for submarine export cables of 18 ft (5.5 m) for sections of the submarine export cable route that intersect federally maintained navigational features;
- The use of MFE in select locations where jet plowing will not be used for feasibility reasons:
  - A target removal height of up to 6 ft (2 m);
  - A pre-sweeping corridor width of 82 ft (25 m); and
  - A pre-sweeping corridor length of 82 ft (25 m);
- Activities during construction capture the maximum scenario for sediment disturbance where the disturbance is expected to be equal to or greater than that associated with operation or decommissioning activities; and
- Project activities during operations may include inspection and repair of subsea infrastructure (i.e., cables); however, any impacts are expected to be less than those anticipated during construction since they would only involve a portion of the overall project. Thus, this assessment focuses on activities and impacts during the construction phase of the Project.

[4] The jet plow's water nozzle temporarily loosens the soil, creating a narrow trench. The cable is fed into this trench as the plow moves along the ocean floor. Marine sediment resettles upon the cable, closing the trench with minimal impact to the sea floor. However, some marine sediments may stay suspended in the water column, temporarily increasing total suspended solids, and dispersion of the sediments may cause material to deposit outside the area of disturbance.

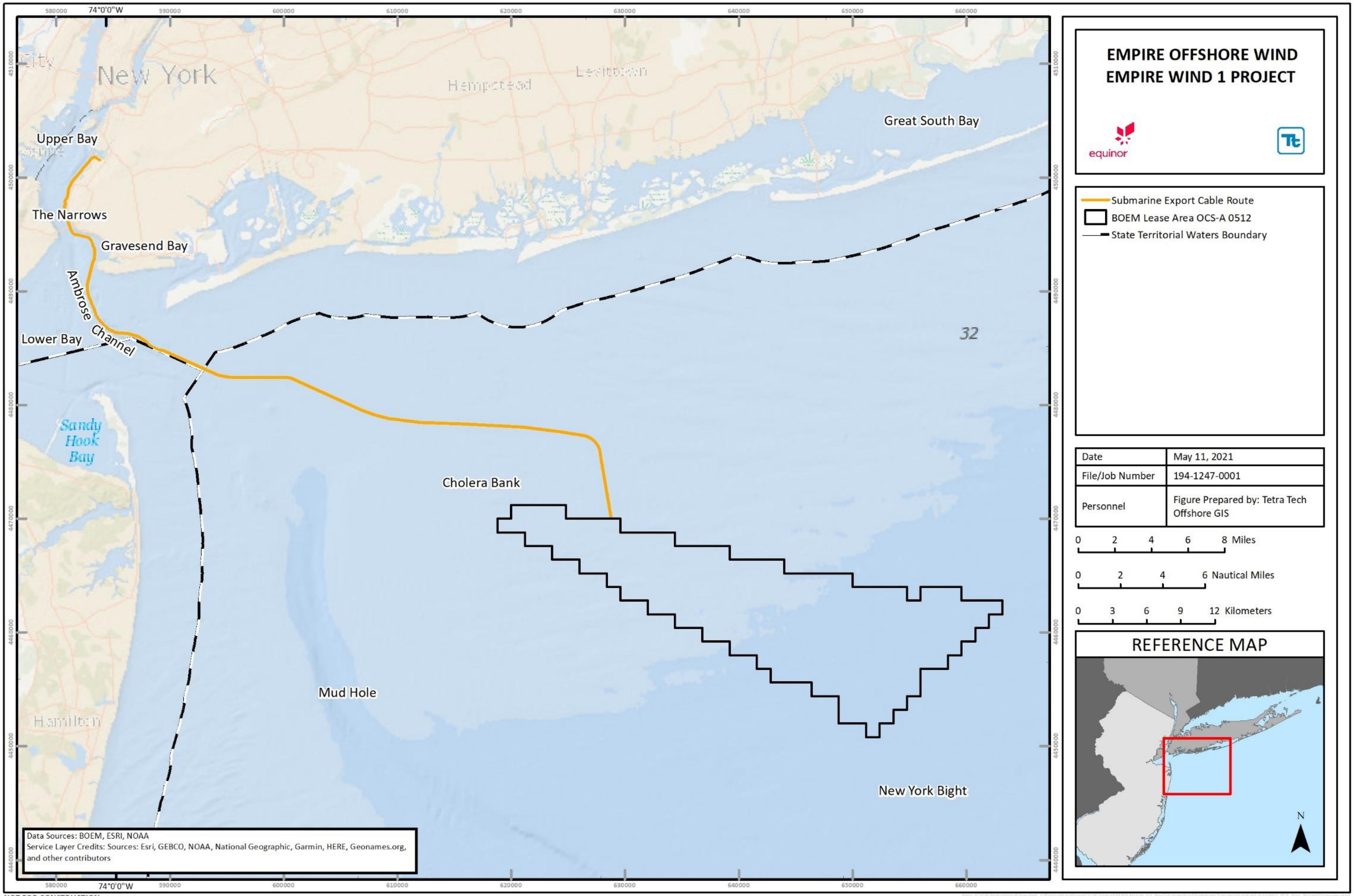

Figure B-1 Project Overview

B.2 Modeling Approach

The aim of this study is to evaluate the effects of proposed submarine export cable installation and burial activities in terms of suspended sediment concentrations in the water column and sediment deposition characteristics, such as deposition depth and sediment deposition footprint.

The modeling approach uses the publicly available Experimental System for Predicting Shelf and Slope Optics (ESPreSSO) hydrodynamic model to develop information regarding current velocity and flow direction in the Project Area. This model has been used to obtain velocities and flows for other sediment transport models in the region (Tetra Tech 2015). ESPreSSO uses the Regional Ocean Modeling System. The Regional Ocean Modeling System is a three-dimensional, free-surface, terrain-following ocean model that solves the Reynolds-averaged Navier-Stokes equations using the hydrostatic vertical momentum balance and Boussinesq approximation (Haidvogel et al. 2000; Shchepetkin and McWilliams 2005). The ESPreSSO model domain extends from the center of Cape Cod, Massachusetts southwards to Cape Hatteras, North Carolina, with 3-mi (5-km) horizontal resolution and 36 terrain-following vertical levels. Approximately 95 percent of the Project Area falls inside the model domain, which allows model outputs to be used to gather the circulation characteristics along the submarine export cable corridor. The current speed and direction from the ESPreSSO model help determine the path of the suspended sediments generated by submarine cable jet plowing activities. More details about the hydrodynamic data used in the sediment transport model are provided in Section B.3.1.

An analytical sediment transport model was developed to assess the suspended sediment water column concentrations and sediment deposition characteristics as a result of the submarine cable jet plowing activities. Regional average sediment data such as density and grain size distribution were derived from previously conducted studies near the Project Area (such as the Poseidon Project[5], **Figure B-2**, ESS Group 2013). These sediment characteristics were used to inform the calculations of volume and concentrations of suspended sediment due to jet plowing operations.

Calculations were made along the submarine export cable corridor based on the different current velocities available from the ESPreSSO model and sediment characteristics from the Poseidon Project. More detail about the sediment characteristics and the analytical model is provided in Sections B.3.2 and B.4, respectively. The final results of the analytical model include the extent and duration of suspended sediment concentrations within the water column along the submarine cable routes and the final sediment deposition thickness associated with the jet plowing operations.

[5] The Poseidon Project includes approximately 39.2 mi (63 km) of high-voltage direct-current submarine cable bundled with a fiber optic cable to be buried in the seafloor of Raritan Bay and the New York Bight with landfalls at Union Beach, in Monmouth County, New Jersey and Jones Beach on Long Island in Suffolk County, New York. This export cable route covers approximately 70 percent of the submarine export cable evaluation area within 3 nautical miles of Long Island, New York. Sediment data is available for 47 different locations along the submarine export cable route.

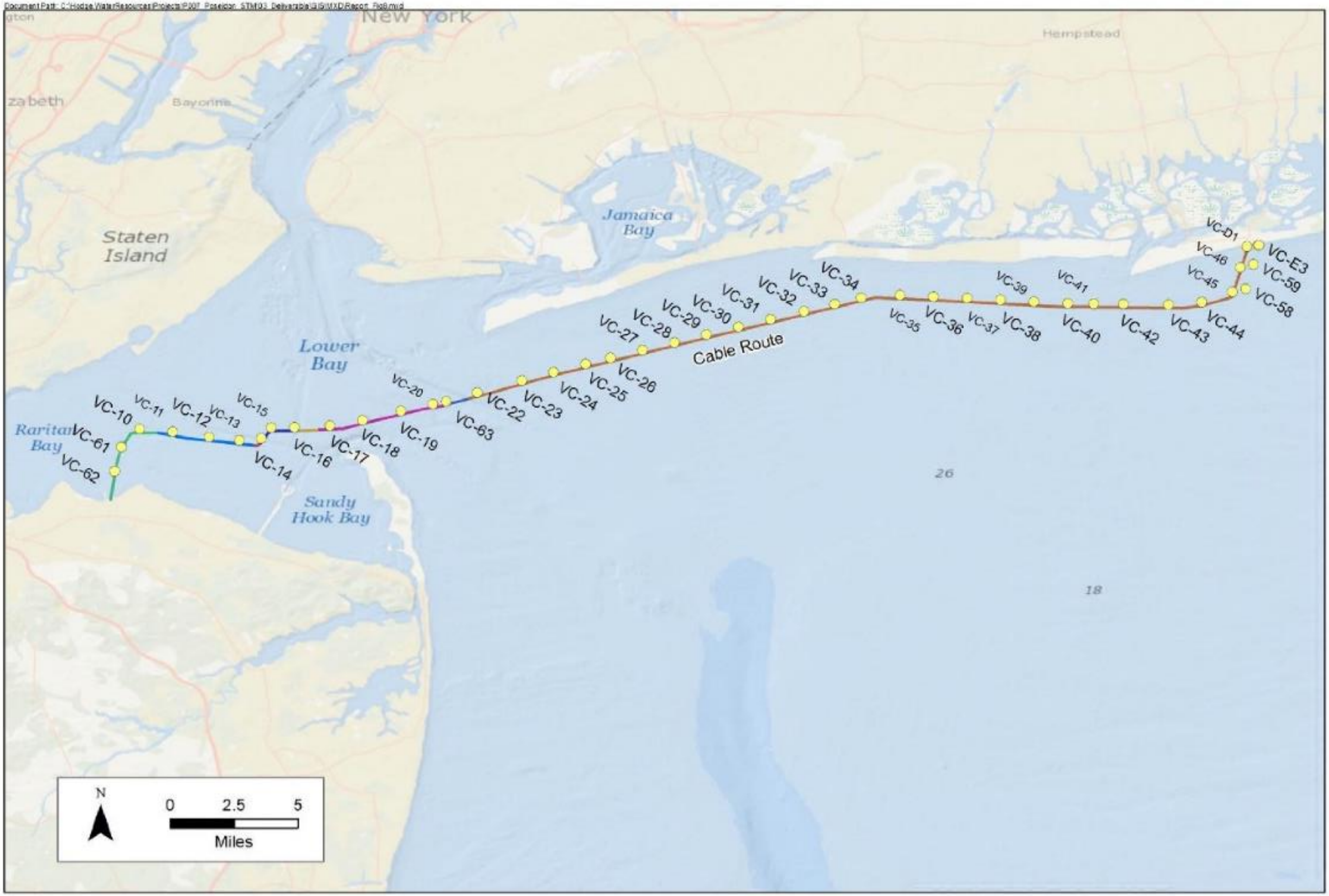

Figure B-2 Location of sediment sampling locations for the Poseidon Project (Source: ESS Group 2013)

B.3 Data Sources

B.3.1 Hydrodynamic Data

The ESPreSSO data set includes hourly simulations covering the period from October 2009 through February 2014.[6] The ESPreSSO model provides velocity, salinity, and temperature outputs at regularly spaced output stations throughout the Project Area. Hourly bottom velocity outputs at ESPreSSO model stations located within the Project Area were downloaded for the year 2012. A rolling 4-hour average velocity was calculated at each hourly time step for all stations. The 90th percentile of the rolling 4-hour average ebb and flood velocities was selected to represent the potential high velocities during these tidal periods. To represent the variability in the flow throughout the Project Area, data from stations closest to the submarine export cable route were selected and paired with the sediment data in the analytical model.

The velocity stations used in the analytical sediment transport model are shown in **Figure B-3**. For the purpose of this study, the stations were assigned station identification numbers from 1 through 36 (only 1 to 3 are in New York waters; 4 and 5 are the closest "Non-Riverine" stations to New York waters) for easy reference. Two additional stations, 1a and 2a, were used to simulate sections of the submarine export cable route that intersect federally maintained navigational features. Stations 1a and 2a have the same velocity characteristics as Stations 1 and 2 respectively, but modeling assumed a target burial depth of 18 ft (5.5 m). The stations were also assigned zones based on their proximity to the river mouth. All stations close to the river mouth were assigned "Riverine" zone and the rest were assigned "Non-Riverine" zone (this included consideration of Hudson/Passaic river flows associated with the New York/New Jersey Harbor). The current magnitudes at these stations ranged from 0.14 feet per second (ft/s) (4 centimeters per second [cm/s]) to 1.27 ft/s (39 cm/s).

Table B-1 lists the representative flood and ebb velocities at all the stations. MFE was simulated in New York State waters to model conservative suspended sediment estimates. Velocity from Station 1 was chosen to represent the hydrodynamic conditions present in the Narrows and velocity from Station 2 was chosen to represent the hydrodynamic conditions present near Gravesend Bay. Both ebb and flood velocities were used to calculate the possible maximum extent of sediment deposition and suspended sediment water column concentrations within the Project Area under these conditions.

Table B-1 Maximum Flood and Ebb Current Velocity from the ESPreSSO Model

Station ID	Longitude (W)	Latitude (N)	Depth (ft)	Flood Velocity (ft/s)	Ebb Velocity (ft/s)	Zone
1	-74.06	40.60	16	1.27	1.27	Riverine
1a	-74.06	40.60	16	1.27	1.27	Riverine
2	-74.02	40.56	20	1.20	1.19	Riverine
2a	-74.02	40.56	20	1.20	1.19	Riverine
3	-73.97	40.52	23	0.90	0.82	Riverine
4	-73.92	40.48	34	0.58	0.66	Non-Riverine
5	-73.82	40.49	60	0.24	0.44	Non-Riverine

[6] Model information can be accessed at http://www.myroms.org/espresso/.

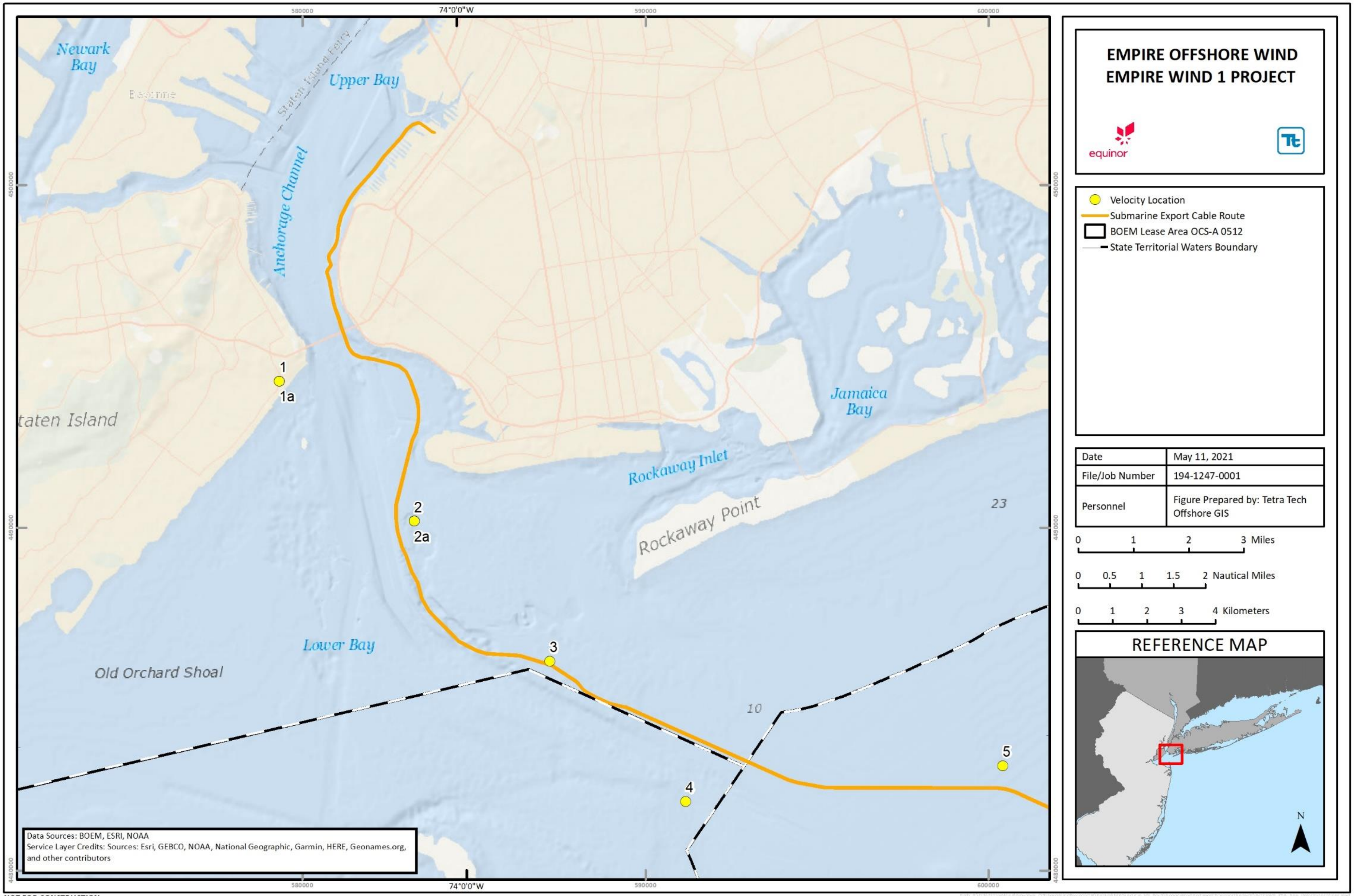

Figure B-3 Velocity Station IDs

B.3.2 Sediment Characteristic Data

As Project-specific sediment density data and grain size distribution data were not available, Tetra Tech used publicly available Poseidon Project sediment data to inform the analytical sediment model (**Figure B-2**, ESS Group 2013). The Poseidon Project data included percent gravel, sand, and fines; specific gravity; and D50 data for 47 locations along a submarine electric cable route in Raritan Bay and the New York Bight.

Based on the sediment characteristics of the stations in the Poseidon Project, the Project Area was divided into two zones:

I. Riverine: For stations close to the river mouth, sediment characteristics were calculated by averaging all stations that were close to the river. These stations typically had high fine sediment content.

II. Non-Riverine: For stations not close to the river mouth, sediment characteristics were calculated by averaging all other stations. These stations typically had high sand content.

Other than percent gravel, the sediment data only provided percent sand and percent fines as the sediment breakdown. Tetra Tech made an assumption to divide the sediment equally into finer classes. The percent sand class was equally divided into percent coarse sand and percent fine sand. Fine sand was further equally divided into percent fine sand and percent very fine sand. The percent fines class was equally divided into percent silt and percent clay. This was done so that a finer scale modeling effort could be completed with the sediment distribution presented in an un-biased manner and for a broader range of size classes consistent with the full range of particle size distribution typical for marine sediments in the region. Settling velocities were assigned to these classes. Density values were calculated by averaging the density for the two different zones. **Table B-2** shows the fine sediment particle percentages for the two zones in the Project Area.

Table B-2 Sediment Particle Size Distributions[7]

Sample	Density (kg/m^3)	Fine Sand (%)	Very Fine Sand (%)	Silt (%)	Clay (%)	Total Fine Sediment (%)
Riverine	2,746	9.38	9.38	30.87	30.87	80.49
Non-Riverine	2,692	21.93	21.93	4.79	4.79	53.44
Sand Wave	2,746	40.00	40.00	0.00	0.00	80.00

When cables are buried using jet plowing, only fine sand and smaller particle sizes are suspended into the water column sufficiently to be transported away from the immediate trench. Larger particle sizes re-settle immediately into the trench. Therefore, the fine sand and smaller sediment particle classes were most appropriate to assess jet plowing impacts in the analytical sediment transport model and the percent gravel was not used.

MFE was simulated in New York State waters where standard cable burial methodologies cannot be employed due to deeper burial requirements or other challenges such as vessel draft requirements. The MFE tool generates a large volume column of water that travels vertically down to the seabed fluidizing the sediments. Studies show the presence of sand deposits in the areas along the submarine export cable route where MFE is proposed to be used (Coch 2016). For this process, only fine sand and very fine sand are assumed to be

[7] Based on data from the Poseidon Project. Note that particle size distribution may not match Project-specific geotechnical data when available.

suspended into the water column and transported away due to ambient currents. A conservative estimate of 80 percent fine sediment is made, with the fine sediment equally divided between fine sand and very fine sand. This is in agreement with the percentage of fine sediment observed in the region (ESS Group 2013) and with the type of sediment present in the sand waves (Coch 2016).

B.4 Sediment Transport Model

This section describes the methodology followed to develop the conservative analytical sediment transport model to characterize the potential maximum sediment transport and deposition scenario for the jet plow and MFE activities. Assumptions used to develop a PDE approach for the sediment transport analysis are listed in detail in Section B.4.1.

B.4.1 Model Setup and Parameterization

Jet plowing utilizes high-pressured water jets to fluidize soil as the machine traverses along a submarine cable route. The cable descends into a temporary trench incised by the jetting blades and is subsequently buried as the fluidized sediments re-settle inside the trench. During jet plow operations, monitoring of burial allows the operator to adjust the angle of the jetting blades and the water pressure to obtain desired burial depth while minimizing sediment mobilization into the water column.

MFE uses a device that draws in seawater from the side pipes and produces a downwards flow from a nozzle suspended a couple of meters above the seabed. The bed material is shifted and trenched with the force of the jet and flushed away. The overall volume of material released for each clearance operation varies, based on the site-specific conditions.

By design, coarser sediments settle immediately to fill the trench and bury the cable or settle in the immediate vicinity (typically within a foot) (Tetra Tech 2012, 2015; Vinhateiro et al. 2013). Earlier studies have shown that sediments coarser than 0.2 millimeter (mm) settle immediately over the trench (Tetra Tech 2015). A conservative approach was taken by assuming that sediments finer than 0.25 mm (fine sand) would be mobilized into the water column and transported by the ambient currents varying distances depending on a number of factors.

The height of the sediment plume above the seabed is dependent on local hydrodynamics, sediment size distribution, and the jet plow operating parameters. Previous studies have shown that the plume of sediment released during jet plowing reaches heights of roughly 7 ft (2 m) above the seabed (Tetra Tech 2012, 2015). The suspended sediment plume is then dispersed by local tidal currents and moves in the direction of the dominant current, which for this project could be northward during flood tides and southwards during ebb tides. Tidal conditions and currents will be dependent on current conditions during each phase of Project construction. The analytical sediment transport model simulated transport for both the maximum flood and ebb conditions to better estimate potential transport in both directions.

Settling velocity determines the time it takes for a fine grain sediment to settle down based on Stokes Law. Based on the sediment grain size distribution, representative sediment classes were selected and settling velocities assigned to those classes (USGS 2005). However, in many instances, the fine clay and silt sediment particles become cohesive when they are forced into resuspension by the jet plow, causing them to have settling velocities similar to larger sized particles (Van Rijn 2018; Swanson et al. 2015). The settling velocities determine the duration for which the resuspended sediment stays in the water column before eventually settling to the seabed. These velocities have been assigned to each sediment class based on a United States Geological Survey study (USGS 2005). **Table B-3** lists the different sediment classes and the associated settling velocities used for the modeling.

Table B-3 Project Sediment Particle Diameter Classes and Settling Velocity

Sediment Class	Settling Velocity (cm/s)
Fine Sand	3.000
Very Fine Sand	1.000
Silt	0.126
Clay	0.023

B.4.2 Methodology

This section describes how the analytical sediment transport model was implemented to calculate the maximum suspended sediment water column concentrations and deposition depths. The approach assumes that the fine sediments released from the jet plow are released at a fixed height. The sediment particles are then transported by local tidal currents and settle down at fixed rates over the horizontal sea floor (Tetra Tech 2012, 2015; Vinhateiro et al. 2013; Swanson et al. 2015). No secondary resuspension of sediment particles was considered. Resuspension is a result of the naturally occurring bottom currents and turbulence and is therefore not directly related to jet plowing activities. The model focuses on the initial dispersion of particles due to jet plowing activities that may generate brief episodes of elevated fine sediment concentrations in the water column and the resulting transport and deposition of these suspended sediments.

The expected sediment transport was calculated for each velocity location. It was assumed that these stations would be representative of the general conditions of the submarine export cable route. Each station was assigned the representative flood and ebb velocities that corresponded to the velocity station and sediment characteristics based on the project zone it fell in. The flood and ebb velocities were used to calculate the maximum extent of sediment deposition and the duration for which the sediment remained in suspension for each sediment class at all stations.

The travel speed of the jet plow was assumed at 656 feet per hour (200 meters per hour)[8]. For the model analysis, it was assumed that 30 minutes of trenching activities were suspended at each time step. Based on the provided specifications, for most stations, the trench was conservatively assumed to be 328 ft (100 m) long[9], 3.5 ft (1 m) wide, and 8 ft (2.5 m) deep. Therefore, for each sediment location, the maximum volume of potential sediment fluidized in the water column was 8,830 cubic feet (250 cubic meters) if all of it is fine sand or smaller. For stations with a target burial depth of 18 ft (5.5 m), the volume of sediment fluidized in the water column was 19,423 cubic feet (550 cubic meters). This volume of sediment was assumed to be instantaneously suspended at time step 0 seconds in the analytical sediment transport model. This conservative assumption results in a higher concentration of suspended sediments in the water column than if a smaller volume of sediments at a shorter time step were suspended. However, it does not impact deposition depths.

For MFE, it was assumed that the removal volume had a height of 6 ft (2 m). Based on the expected MFE removal procedures provided by Empire, at any given timestep, an 82-ft (25-m)-long and 82-ft (25-m)-wide corridor was cleared. The model assumes that the entire sediment volume (40,344 cubic feet [1,242 cubic meters]) was instantaneously suspended in the water column. The sediment was blown to the edge of the 82-ft

[8] The assumed jet plow speed is a conservative assumption for methods likely to be used for the Project. A vertical injection method, if used, is expected to be significantly slower.
[9] As a conservative assumption, the model assumed that all the fine material dislodged by the jet plow during the 30 minute time interval would be dispersed into the water column at the same time.

(25-m)-wide corridor and allowed to deposit starting at the edge of the corridor. It was also assumed that the 82-ft (25-m)-wide corridor will have the same suspended sediment concentration as that at the edge of the corridor.

The sediment concentration at the release location was determined based on the estimated bed sediment and the percentage of sediment in each class. The sediment concentrations of each class were added together to calculate the total volume of sediment resuspended at the release point. With time, the sediment plume was allowed to grow based on the velocity at that location. The sediment plume does not grow in the vertical direction and is always close to the bottom of the water column. The duration of suspension for each sediment class was calculated using the release height and sediment class settling velocity. The maximum extent of travel for each sediment class was calculated using the current velocity and sediment settling velocity. Sediment particles in each class were assumed to settle out of the water column at a linear rate. The suspended sediment concentrations at each location along the trench were calculated based on the sediment left in the water column at the time and the size of the plume.

The point of deposition for each particle was calculated based on the settling velocity of each sediment class. Coarser sediments with higher settling velocity settle out of the water column faster and closer to the release point as compared to finer sediments. The finer sediment classes stay in the water column for longer periods of times and are advected further than the coarser sediments. In addition, the finer clay and silt sediment `particles, which are typically cohesive, undergo enhanced settling due to flocculation and settle out of the water column with large-sized particles (Van Rijn 2018; Swanson et al. 2015). Sediments were assumed to settle out of the water column at a linear rate for each sediment particle class. This assumes that varying sized sediments within each class are evenly distributed within the plume. Sediment classes larger than medium silt all deposited within an hour, while fine silts and clays stayed in suspension for several hours. In addition, the model did not explicitly simulate dispersion, which could cause some particles to be transported farther than estimated and could result in a larger area of deposition. Instead, dispersion was represented by the plume growth in terms of spreading of the sediment particles based on the ambient currents and the settling velocity.

B.5 Results

This section describes the sediment transport analytical model results in terms of suspended sediment concentrations, deposition depth, and distance at which the sediment is deposited. Results of the conservative analytical sediment transport model representing the submarine export cable route are provided at all locations with available velocity data.

B.5.1 Suspended Sediment Concentrations

Table B-4 and **Table B-5** list the predicted maximum suspended sediment concentrations by distance from the trench centerline at locations perpendicular to the trench centerline for all sample stations for flood and ebb currents. **Figure B-4** through **Figure B-7** show the estimated maximum suspended sediment concentrations at two representative stations, riverine and non-riverine for maximum ebb and flood tides. **Figure B-8** and **Figure B-9**[10] show the expected maximum instantaneous suspended sediment concentrations along the submarine export cable route at any given time step along the cable installation route[11]. It is important

[10] Sediment transport analysis **Figure B-8** and **Figure B-9** reflect a minor difference in route centerline from the route that is depicted in **Figure B-1**. Both routes are within the submarine export cable siting corridor that is under evaluation.
[11] **Figure B-8** and **Figure B-9** represent the instantaneous maximum suspended sediment concentrations at any given point of time predicted for the submarine export cable route. These concentrations do not occur at all locations

to note that these concentrations do not occur at all locations simultaneously. Due to jet plow speed, only small sections of the submarine export cable route would be disturbed at any given time during Project construction and that is why the model used the volume of sediment put into suspension in 1 hour of jet plow travel (200-m trench length). In addition, due to the depth of water within the Project Area, the plume should not be visible from the surface. The plume concentrations are typically lower at all Non-Riverine stations due to lesser fine sediment content, plume dispersion, and sediment deposition.

B.5.1.1 Riverine Stations

In the Riverine area, submarine export cables had two target burial depths: 8 ft (2.5 m) (Stations 1 through 3) and 18 ft (5.5 m) (Stations 1a and 2a). Maximum plume horizontal distances varied between 1,150 and 3,280 ft (350 and 1,000 m) (**Table B-4** and **Table B-5**). Suspended sediment travelled farther at Stations 1 and 1a due to the velocity distribution in the longitudinal and lateral direction at those stations.

Suspended sediment concentrations were typically below 500 milligrams per liter (mg/L) at a distance of 1,640 ft (500 m) from trench centerline during flood and ebb tides. Studies have shown suspended sediment concentrations of anywhere from 50 to 1,000 mg/L at distances around 1,000 ft from the centerline (Tetra Tech 2012, Tetra Tech 2015). The sediment plume was confined near the substrate layer and is not expected to reach the surface. Data collected in the Riverine Area at Stations 2, 2a and 3 indicated that plume travel distances would be around 1,640 ft (500 m) during flood tides and around 1,150 ft (350 m) during ebb tides. Stations 1 and 1a had a maximum plume distance of 3,280 ft (1,000 m) during both flood and ebb tides. This is due to the high current velocity at Stations 1 and 1a. Expected maximum suspended sediment concentrations were between 0 and 1,661 mg/L at 1,640 ft (500 m) from the trench centerline. Station 1a and Station 2a had higher suspended sediment concentrations compared to the other Riverine stations due to the deeper burial depths (18 ft [5.5 m] as opposed to 8 ft [2.5 m]).

The potential maximum suspended sediment concentrations were dependent on the burial depth and total percent fines at each sampling location. Stations with deeper burial depths or higher percentages of fine sediment particle classes had higher concentrations of suspended sediments because more particles were suspended due to jet plowing. If a station had a total percent fine sediment composition of 50 percent, half of the disturbed sediments would be mobilized into the water column following resuspension by the jet plow. Assuming a trench depth of 8 ft (2.5 m), slightly over 4 ft (1.25 m) of fine sediments would be resuspended into the water column. The highest concentrations occurred at the release point, and concentrations decreased further from the trench. These concentrations, specifically at the trench, were confined close to the substrate. For Riverine stations, which had 80 percent fine sediments, nearly all of the material disturbed by the jet plow would be released into the water column (**Table B-4** and **Table B-5**). These stations were located at the mouth of the river, and the conservative sediment transport model predicted that maximum suspended sediment concentration would be greater than $2.7*10^6$ mg/L at the release point during flood and ebb conditions for stations with a trench depth of 8 ft (2.5 m). For Station 1a and 2a, with have a trench depth of 18 ft (5.5 m), the potential maximum suspended sediment concentration at the release point was determined to be $6.1*10^6$ mg/L.

The plumes were predicted to travel 1,150 to 1,640 ft (350 to 500 m) from the trench centerline for Stations 2, 2a, and 3. The suspended sediment concentrations were typically very low at these distances; for flood tides the suspended sediment concentration decreased below 300 mg/L at a distance of 1,150 ft (350 m), and for ebb

simultaneously. Due to jet plow speed, only small sections of the submarine export cable corridor would be disturbed at any given time during Project construction.

tides the concentrations decreased below 100 mg/L at a travel distance of 1,150 ft (350 m). At Stations 1 and 1a, the sediment plume travelled more than 3,280 ft (1,000 m). Station 1 had a concentration of 1,032 mg/L at a distance of 1,150 ft (350 m) for the flood tide and a concentration of 1,843 mg/L at a distance of 1,150 ft (350 m) for ebb tide. Station 1a had a concentration of 2,270 mg/L at a distance of 1,150 ft (350 m) for the flood tide and a concentration of 4,054 mg/L at a distance of 1,150 ft (350 m) for ebb tide. Sediments at stations in the Riverine area were dominated by silts and clays. Silts and clays stay in suspension for several hours and are therefore transported further due to currents. Due to the higher percentage of very fine sediment, expected maximum concentrations were high, around $4*10^4$ mg/L within 328 ft (100 m) of the trench centerline, and 1,600 mg/L within 1,640 ft (500 m) of the trench centerline (**Table B-4** and **Table B-5**).

B.5.1.2 Non-Riverine Stations

At the Non-Riverine stations, which are comprised of sandier bed sediments, maximum plume distances were typically between 328 and 1,640 ft (100 and 500 m). The plume travelled further distances during the flood tide as compared to the ebb tide. The total distance the sediment plumes traveled was dependent on the current velocities. Suspended sediment concentrations were always below 500 mg/L at a distance of 1,150 ft (350 m) from trench centerline during flood and ebb tides. Results for Stations 4 and 5 indicated that the plume would travel to a maximum distance of 2,460 ft (750 m) during the flood tide, although the maximum suspended sediment concentrations at that distance would be typically less than 30 mg/L. During ebb tides, the maximum plume distance travelled is typically around 820 ft (250 m). Expected maximum suspended sediment concentrations drop to anywhere between 0 to 373 mg/L at 820 ft (250 m) from the trench centerline. Maximum plume distance at any station, depends on the current velocity and its components perpendicular and parallel to the direction of the trench.

The sediment transport model predicted that maximum suspended sediment concentrations would be around $1.79*10^6$ mg/L for Non-Riverine stations at the release point during flood and ebb conditions. The plumes were predicted to travel 492 to 2,460 ft (150 to 750 m) from the trench centerline. The type of fine sediments at each station impacted the maximum plume concentrations. Fine sand, the coarsest fine sediment particle class that was modelled, has a settling velocity of 3 cm/s and remains in suspension for approximately one minute. Therefore, at Non-Riverine stations, suspended sediment concentrations decreased by close to 75 percent within one minute of jet plowing operations and within 32 ft (10 m) of the trench centerline (**Figure B-6**, and **Figure B-7**; considered representative). This reduced the amount of sediment that could be transported in the water column due to currents, and most of the fine sand deposits within 16 ft (5 m) of the trench centerline. Concentrations decreased to 1.8*103 mg/L or less within 328 ft (100 m) of the trench centerline (**Table B-4** and **Table B-5**).

B.5.1.3 General Observations

While the maximum suspended sediment concentrations were relatively high for both Riverine and Non-Riverine stations, these concentrations decreased rapidly with time. The coarser fine particles, such as fine sand, remained in suspension for about one minute, while the very fine sediments (clay) remained in suspension for about four hours, a relatively short period of time. In areas that consist predominantly of gravels and sands, the analysis indicates a limited extent of increased sediment concentrations, as the larger grain size sediments immediately deposit in the trench. In locations that are dominated by fine sand, silts, or clays, these sediments can be released into the water column and temporarily increase total suspended solids near the trench and cause sediment deposition outside of the trench, but eventually settle down to background concentrations (Tetra Tech 2012, 2015; Vinhateiro et al. 2013). Preliminary assessment of seabed mobility suggests that seabed sediment along the submarine export cable route is very mobile, which means these kinds of temporary increases in suspended sediment would also be expected to occur naturally after major storms. **Table B-6** and **Table B-7** present the time varying suspended sediment concentrations for flood and ebb tides respectively for both Riverine and Non-Riverine stations. The concentrations decreased rapidly with time, and water column concentrations are expected to return to ambient conditions within 4 hours.

Mass Flow Excavation

Based on the analysis, the maximum suspended sediment concentration would be $5.49*10^6$ mg/L. The plume was predicted to travel up to 82 ft (25 m) in the Narrows during flood tide and 164 ft (50 m) during ebb tide. Near Gravesend Bay the plume was predicted to travel around 16 ft (5 m) during both flood and ebb tide (**Table B-8**, **Table B-9**). The plume travels for such shorter distance as compared to jet plowing because of the difference in sediment composition. Fine sand and very fine sand settle out quickly in comparison to silt and clay. The suspended sediment concentration drops by 50 percent within 60 seconds of suspension in the water column.

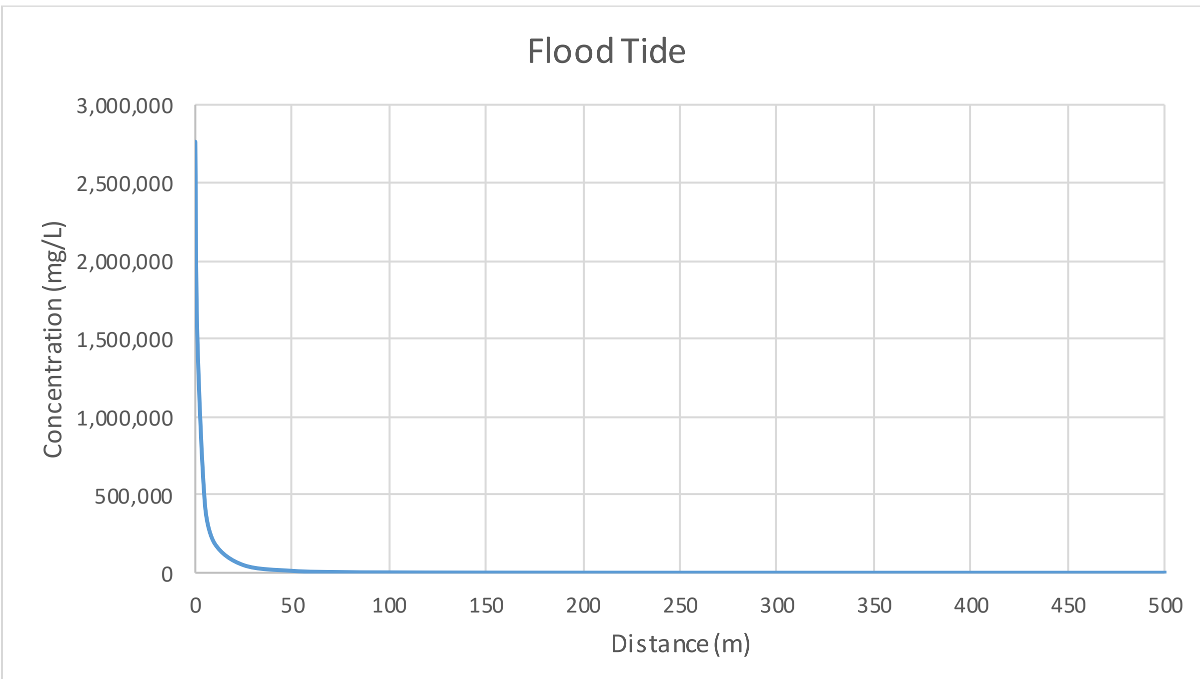

Figure B-4 Maximum Flood Tide Suspended Sediment Concentrations at Representative Riverine Station (Station 2)

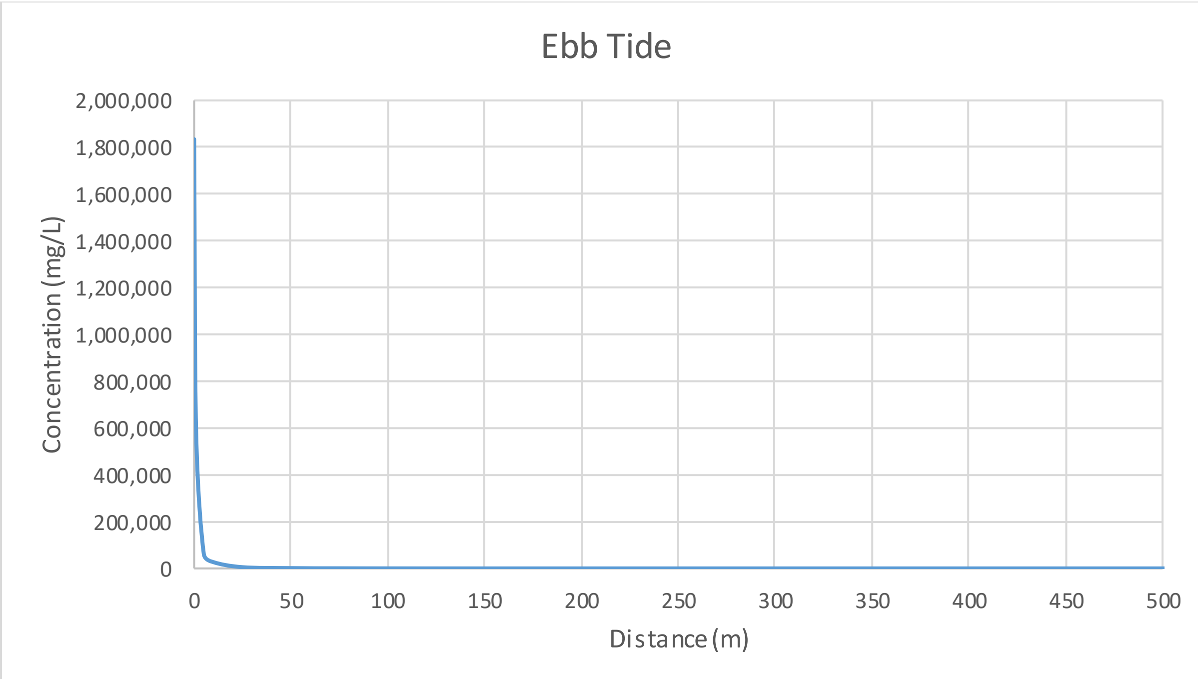

Figure B-5 Maximum Ebb Tide Suspended Sediment Concentrations at Representative Riverine Station (Station 2)

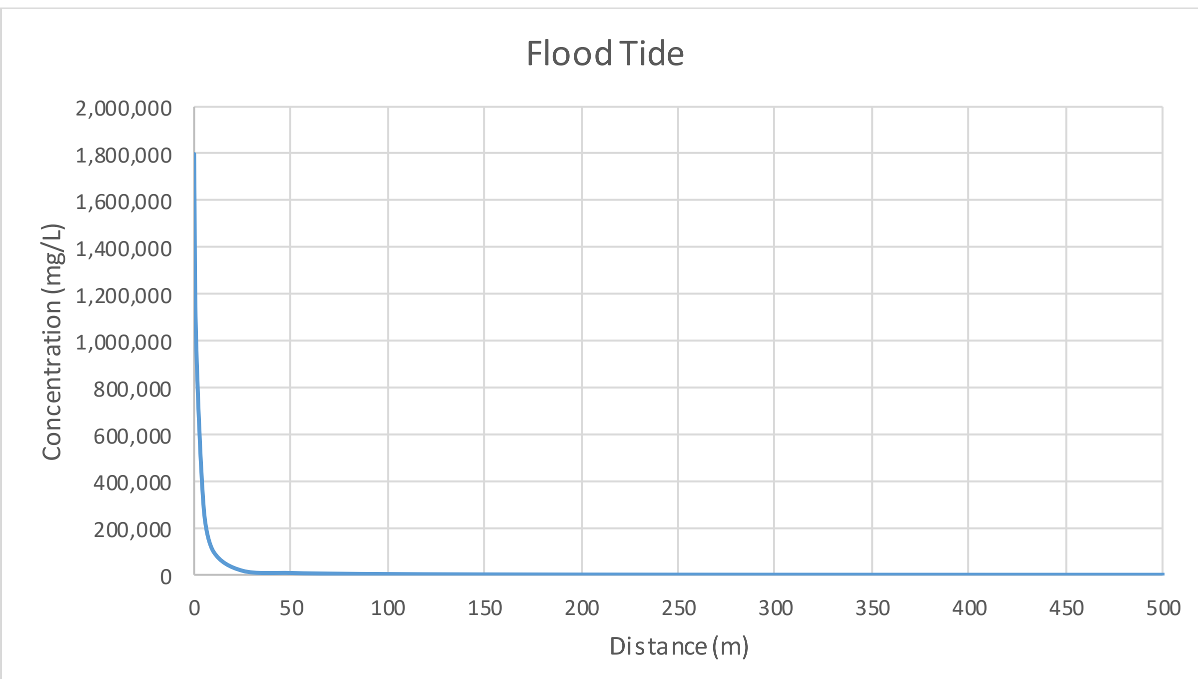

Figure B-6 Maximum Flood Tide Suspended Sediment Concentrations at Representative Non-Riverine Station

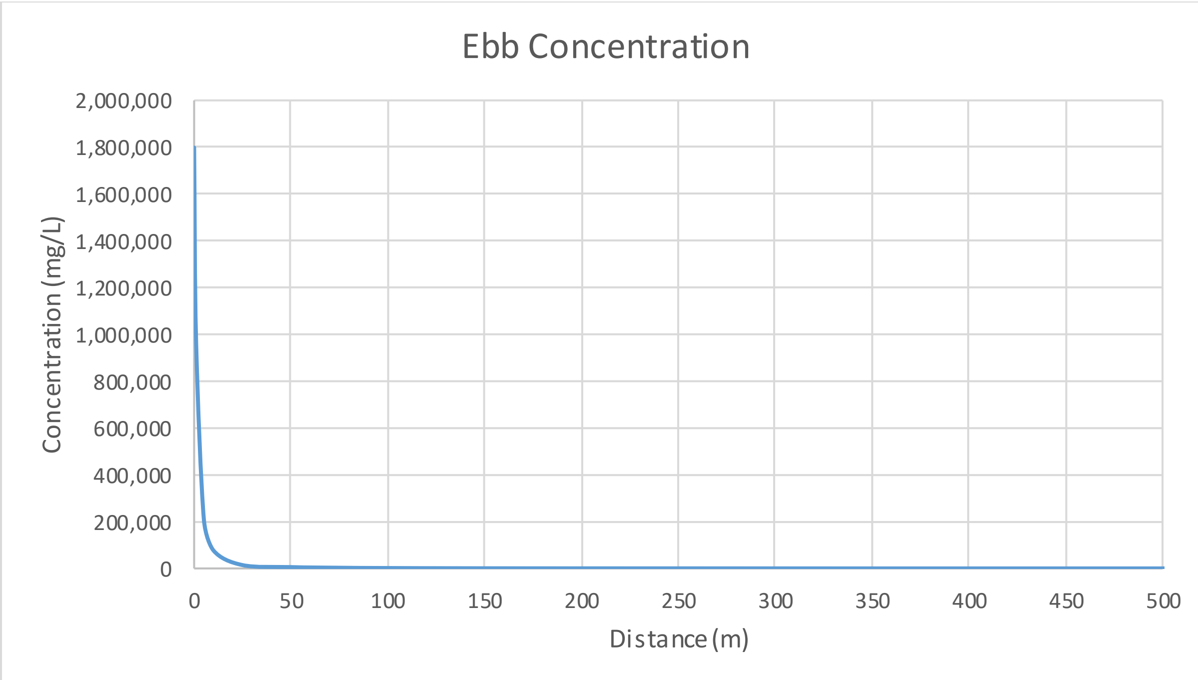

Figure B-7 Maximum Ebb Tide Suspended Sediment Concentrations at Representative Non-Riverine Station

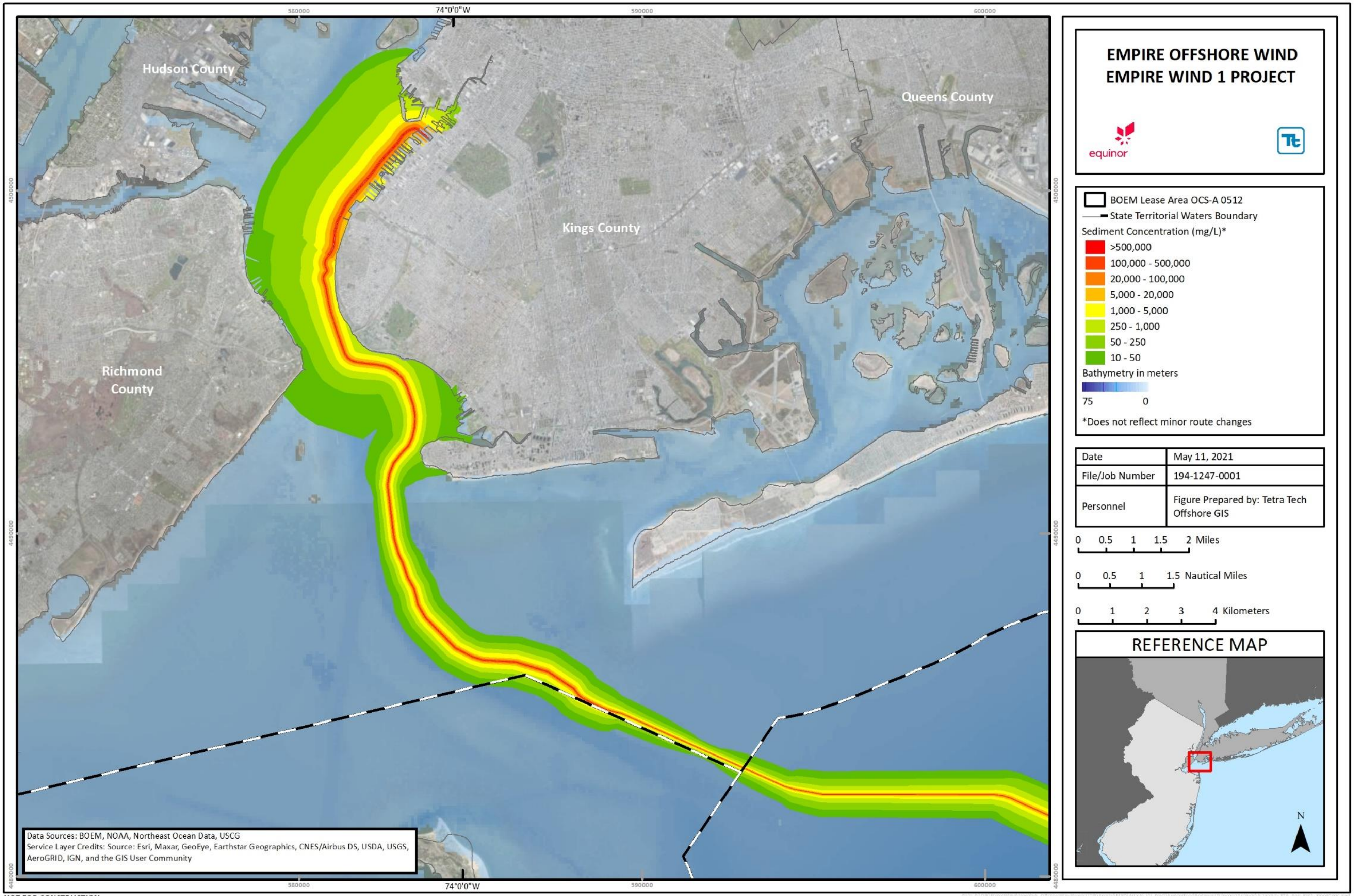

Figure B-8 Maximum Flood Tide Suspended Sediment Concentrations along the EW 1 Submarine Export Cable Route[10,11]

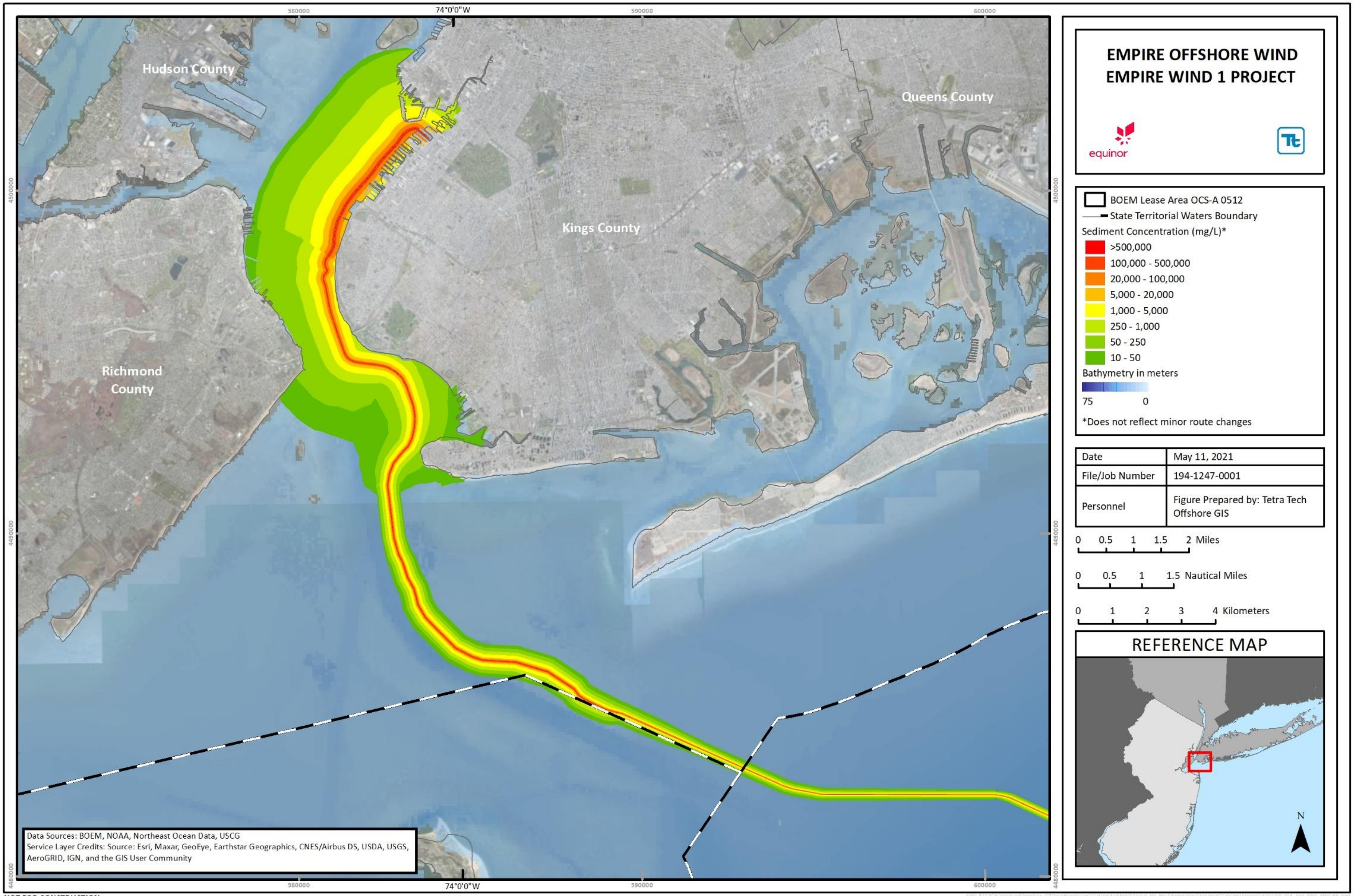

Figure B-9 Maximum Ebb Tide Suspended Sediment Concentrations along the EW 1 Submarine Export Cable Route[10,11]

Table B-4 Project Maximum Suspended Sediment Concentrations for Flood Conditions (With Distance)

Sample	Project Element	Total Fines (%)	Distance from Trench (m) / Maximum Sediment Concentration (mg/L)															
			0	1	5	10	25	50	75	100	150	250	350	500	800	1,000	2,500	5,000
1	Riverine	80%	2,762,705	1,632,896	582,726	297,957	104,409	41,557	23,480	15,032	7,442	2,553	1,032	499	166	89	0	0
1a	Riverine	80%	6,077,951	3,592,371	1,281,997	655,506	229,699	91,425	51,657	33,070	16,373	5,616	2,270	1,097	366	197	0	0
2	Riverine	80%	2,762,705	1,535,461	433,317	187,011	48,383	12,070	4,191	2,316	912	202	29	0	0	0	0	0
2a	Riverine	80%	6,077,951	3,378,013	953,298	411,424	106,442	26,555	9,221	5,096	2,006	444	64	0	0	0	0	0
3	Riverine	80%	2,762,705	1,585,919	490,370	237,221	72,941	24,232	10,847	5,400	2,145	684	271	64	0	0	0	0
4	Non-Riverine	53%	1,798,287	718,041	63,447	27,628	6,382	1,360	591	297	84	0	0	0	0	0	0	0
5	Non-Riverine	53%	1,798,287	947,432	178,949	64,405	15,065	6,233	3,262	1,812	923	373	167	38	0	0	0	0

Table B-5 Project Maximum Suspended Sediment Concentrations for Ebb Conditions (With Distance)

Sample	Project Element	Total Fines (%)	Distance from Trench (m) / Maximum Sediment Concentration (mg/L)															
			0	1	5	10	25	50	75	100	150	250	350	500	800	1,000	2,500	5,000
1	Riverine	80%	2,762,705	1,639,153	597,165	314,071	113,544	47,801	27,826	18,582	9,910	3,905	1,843	755	281	165	0	0
1a	Riverine	80%	6,077,951	3,606,136	1,313,763	690,957	249,797	105,162	61,216	40,880	21,802	8,591	4,054	1,661	619	363	0	0
2	Riverine	80%	2,762,705	1,509,432	410,125	173,942	41,417	8,949	3,442	1,838	668	102	0	0	0	0	0	0
2a	Riverine	80%	6,077,951	3,320,750	902,276	382,673	91,117	19,687	7,572	4,044	1,470	225	0	0	0	0	0	0
3	Riverine	80%	2,762,705	1,550,091	459,102	207,807	59,798	16,585	5,869	3,335	1,375	334	68	0	0	0	0	0
4	Non-Riverine	53%	1,798,287	656,110	57,874	24,939	5,018	1,073	437	204	42	0	0	0	0	0	0	0
5	Non-Riverine	53%	1,798,287	427,949	51,009	18,917	2,891	616	151	1	0	0	0	0	0	0	0	0

Table B-6 Project Maximum Suspended Sediment Concentrations (mg/L) for Flood Conditions (With Time)

Sample	Project Element	Total Fines (%)	Time (s) / Maximum Sediment Concentration (mg/L)															
			0	10	20	30	60	90	120	150	240	300	600	1,200	1,800	3,600	7,200	14,400
1	Riverine	80%	2,762,705	1,086,991	655,051	457,460	220,761	139,449	98,851	74,257	39,156	28,715	9,561	2,293	825	175	14	0
1a	Riverine	80%	6,077,951	2,391,380	1,441,113	1,006,412	485,673	306,788	217,473	163,365	86,143	63,173	21,035	5,044	1,815	385	31	0
2	Riverine	80%	2,762,705	2,064,762	1,619,268	1,311,253	781,404	540,393	402,319	311,385	171,309	127,133	42,889	10,212	3,651	766	60	0
2a	Riverine	80%	6,077,951	4,542,477	3,562,389	2,884,757	1,719,088	1,188,864	885,102	685,048	376,880	279,693	94,356	22,467	8,032	1,685	133	0
3	Riverine	80%	2,762,705	1,808,793	1,317,278	1,018,190	565,963	380,680	280,025	215,719	119,040	88,964	31,183	7,795	2,861	622	50	0
4	Non-Riverine	53%	1,798,287	1,408,618	1,115,788	888,303	437,365	271,176	185,720	126,118	49,575	38,596	15,159	4,173	1,605	371	31	0
5	Non-Riverine	53%	1,798,287	1,133,211	784,722	570,326	241,372	139,479	92,129	61,410	23,932	18,847	8,210	2,768	1,244	387	43	0

Table B-7 Project Maximum Suspended Sediment Concentrations (mg/L) for Ebb Conditions (With Time)

Sample	Project Element	Total Fines (%)	Time (s)															
			0	10	20	30	60	90	120	150	240	300	600	1,200	1,800	3,600	7,200	14,400
			Maximum Sediment Concentration (mg/L)															
1	Riverine	80%	2,762,705	926,964	539,333	371,333	177,000	111,761	79,434	59,891	31,969	23,627	8,105	2,007	735	159	13	0
1a	Riverine	80%	6,077,951	2,039,321	1,186,533	816,933	389,399	245,874	174,754	131,760	70,332	51,979	17,831	4,416	1,617	351	28	0
2	Riverine	80%	2,762,705	2,155,432	1,739,434	1,437,617	888,742	626,871	472,480	368,772	205,808	153,548	52,396	12,552	4,497	946	74	0
2a	Riverine	80%	6,077,951	4,741,951	3,826,754	3,162,758	1,955,231	1,379,117	1,039,456	811,299	452,778	337,805	115,272	27,615	9,892	2,080	164	0
3	Riverine	80%	2,762,705	2,038,321	1,589,055	1,283,802	767,132	534,960	402,275	314,596	178,274	134,644	48,459	12,348	4,571	1,004	81	0
4	Non-Riverine	53%	1,798,287	1,439,011	1,158,474	934,010	471,472	296,494	204,823	139,853	55,363	43,144	16,840	4,561	1,735	394	33	0
5	Non-Riverine	53%	1,798,287	1,531,108	1,298,560	1,094,634	612,159	414,059	302,268	215,612	93,548	76,052	33,574	10,122	4,062	992	86	0

Table B-8 Project Maximum Suspended Sediment Concentrations (mg/L) for MFE (With Distance)

Sample	Project Element	Tide Condition	Total Fines (%)	Distance from Edge of Corridor (m)															
				0	1	5	10	25	50	75	100	150	250	350	500	800	1,000	2,500	5,000
				Maximum Sediment Concentration (mg/L)															
MFE 1	Narrows	Flood	80%	5,492,000	4,750,715	2,688,438	1,294,060	218,867	0	0	0	0	0	0	0	0	0	0	0
MFE 2	Gravesend Bay	Flood	80%	5,492,000	3,817,707	633,268	0	0	0	0	0	0	0	0	0	0	0	0	0
MFE 1	Narrows	Ebb	80%	5,492,000	4,807,249	2,919,960	1,619,011	326,791	28,849	0	0	0	0	0	0	0	0	0	0
MFE 2	Gravesend Bay	Ebb	80%	5,492,000	3,902,752	737,686	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B-9 Project Maximum Suspended Sediment Concentrations (mg/L) for MFE (With Time)

Sample	Project Element	Tide Condition	Total Fines (%)	Time (s)															
				0	10	20	30	60	90	120	150	240	300	600	1,200	1,800	3,600	7,200	14,400
				Maximum Sediment Concentration (mg/L)															
MFE 1	Narrows	Flood	80%	5,492,000	4,012,764	2,945,690	2,160,629	781,623	368,924	195,133	92,568	0	0	0	0	0	0	0	0
MFE 2	Gravesend Bay	Flood	80%	5,492,000	4,716,891	3,985,883	3,305,049	1,586,242	907,002	548,123	285,895	0	0	0	0	0	0	0	0
MFE 1	Narrows	Ebb	80%	5,492,000	3,812,315	2,707,325	1,942,631	680,965	318,552	168,354	80,052	0	0	0	0	0	0	0	0
MFE 2	Gravesend Bay	Ebb	80%	5,492,000	4,756,330	4,054,380	3,391,952	1,671,714	979,356	604,348	320,768	0	0	0	0	0	0	0	0

B.5.2 Sediment Deposition Rates

Table B-10 and **Table B-11**[12] list the deposition thicknesses at locations perpendicular to the trench centerline for all stations under the maximum flood and ebb currents. **Figure B-10** and **Figure B-11** show the maximum predicted sediment deposition along the submarine export cable route[13]. It is important to note that deposition does not occur at all locations simultaneously due to the jet plow travel speed. The sediment resuspended due to jet plow operations moves in the direction of the local ambient current and then eventually settles and deposits in a layer along the marine seabed. For the analytical sediment transport model, it was assumed that sediments finer than 0.25 mm (fine sand) would be mobilized in the water column and transported by the ambient currents, which would distribute sediments in each particle class uniformly over the marine seabed. All sediments coarser than 0.25 mm would re-deposit in or immediately adjacent to the trench (and therefore, not be considered suspended).

The deposition thickness was highest in the vicinity of the jet plow, as fine sand tends to deposit close to the trench centerline due to its higher settling rate. Most of the coarser fine sediments settled to the marine floor within 16 ft (5 m) of the trench, and deposition depths decreased rapidly. At stations that were dominated by clays and silts, such as Station 1, sediment deposition was predicted to be 0.27 inches (in, 0.69 centimeters [cm]) at 82 ft (25 m) from the trench centerline during flood conditions and 0.22 in (0.57 cm) at 82 ft (25 m) during ebb conditions.

For MFE, the highest predicted deposition thickness was 32.80 in (83.32 cm) during flood tide and 28.5 in (72.39 cm) during ebb tide for the Narrows (**Table B-12**). The thickness reduced to 7.18 in (18.26 cm) within 82 ft (25 m) during flood tide and to 6.25 in (15.89 cm) within 82 ft (25 m) during ebb tide. For Gravesend Bay, the highest predicted deposition thickness was 79.25 in (201.31 cm) during flood tide and 86.16 in (218.85 cm) during ebb tide (**Table B-12**). It dropped down to 24.65 in (62.63 cm) within 16 ft (5 m) during flood tide and to 28.29 in (71.86 cm) within 16 ft (5 m) during ebb tide. For both locations, the deposition thickness fell below 0.004 in (0.01 cm) within 246 ft (75 m) during both flood and ebb tides. As discussed previously, the model did not evaluate secondary resuspension that could occur after initial deposition, as this would not be caused by the jet plow. This could result in the recently deposited sediment being transported further than estimated, however it would be expected that as this resuspended sediment is dispersed over a wider area, the thickness of deposited sediments will reduce.

---

[12] Sediment transport analysis **Figure B-10** and **Figure B-11** reflect a minor difference in route centerline from the route that is depicted in **Figure B-1**. Both routes are within the submarine export cable siting corridor that is under evaluation.
[13] **Figure B-10** and **Figure B-11** represent the instantaneous maximum sediment deposition at any given point of time. These concentrations do not occur at all locations simultaneously. Due to jet plow speed, only small sections of the export cable route would be disturbed at any given time during Project construction.

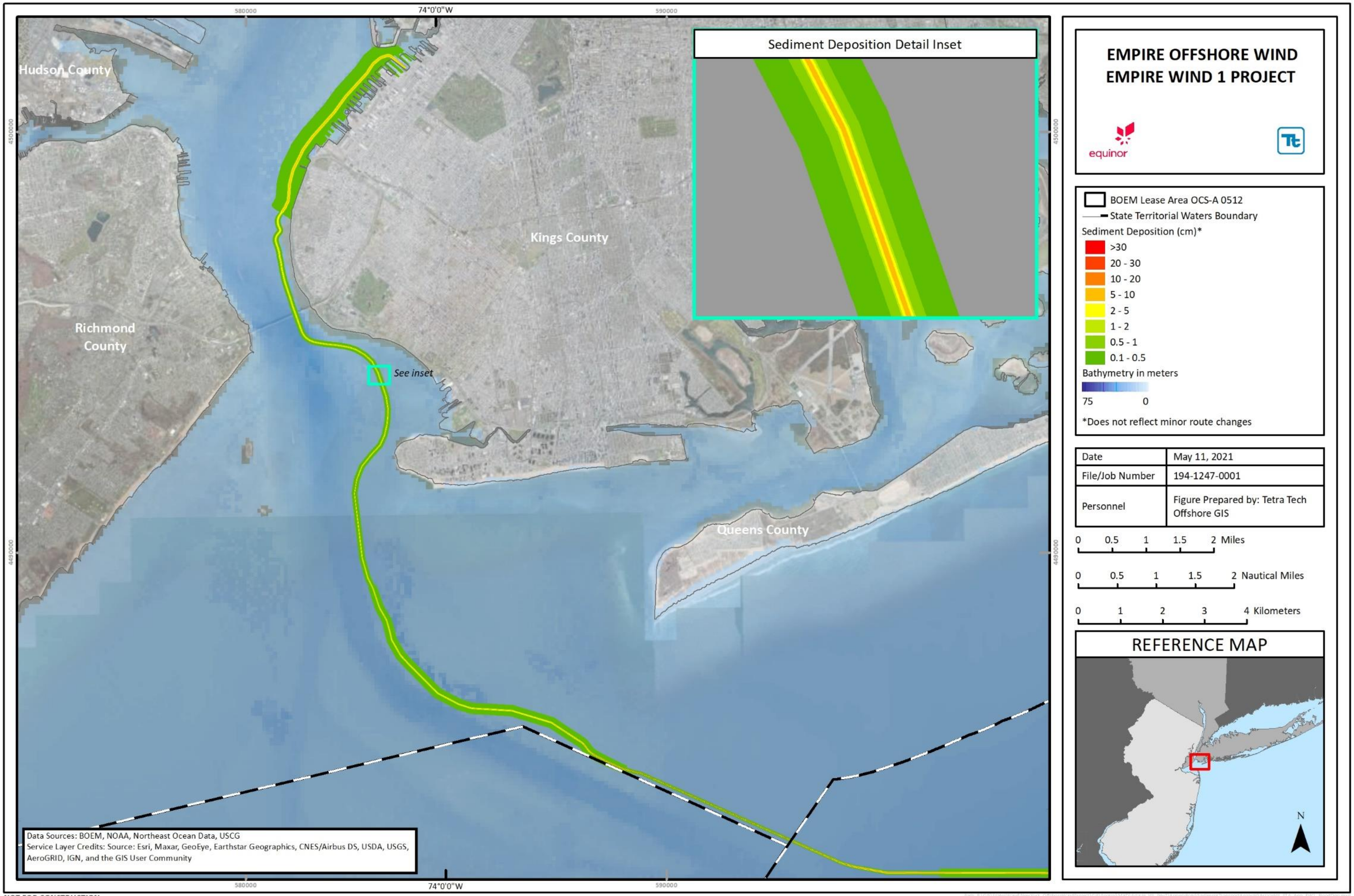

Figure B-10 Maximum Flood Tide Sediment Deposition along the EW 1 Submarine Export Cable Route[12,13]

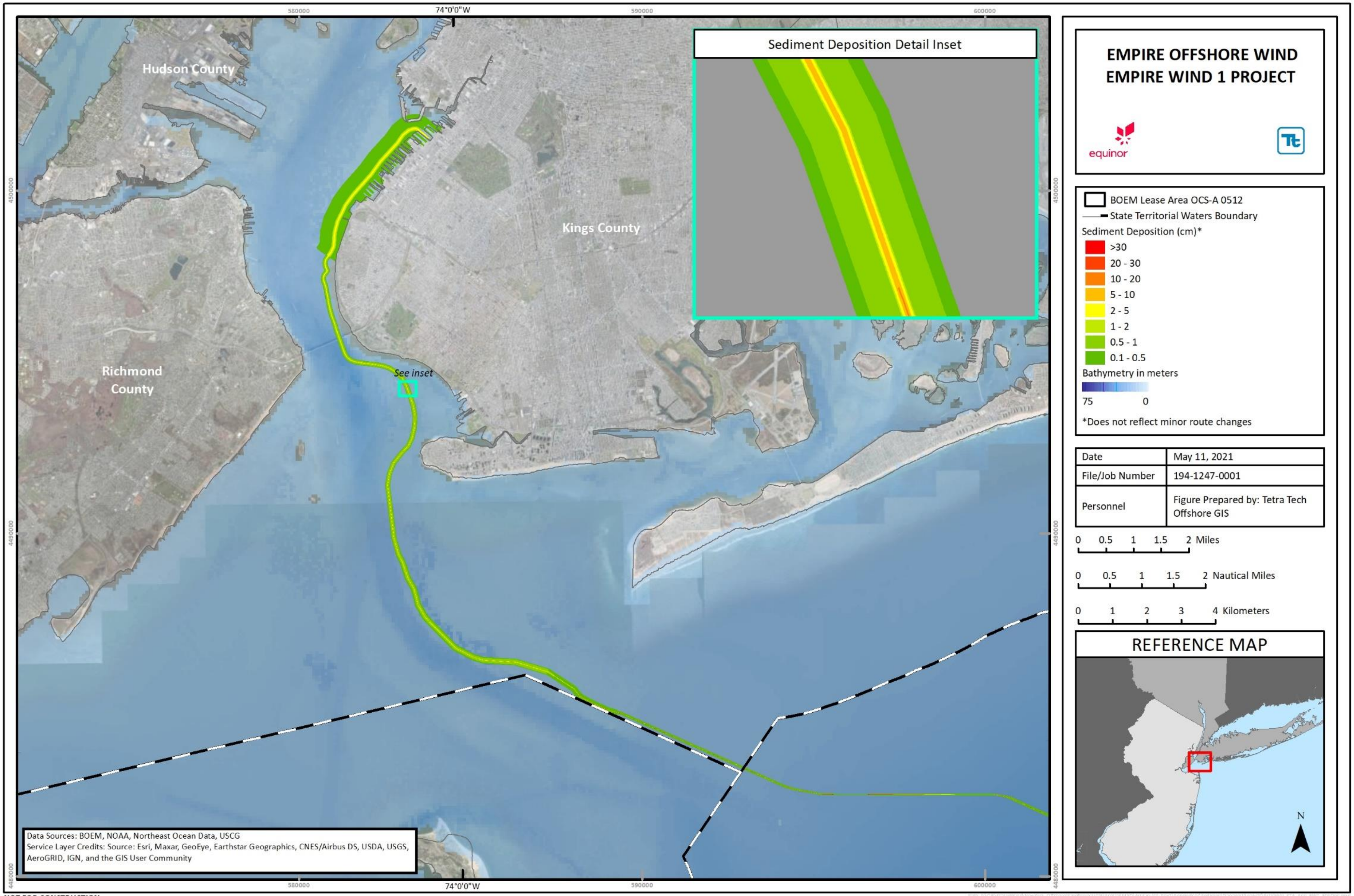

Figure B-11 Maximum Ebb Tide Sediment Deposition along the EW 1 Submarine Export Cable Route[12,13]

Table B-10 Project Deposition Depths for Flood Conditions

Sample	Project Element	Total Fines (%)	Distance from Trench (m) / Maximum Sediment Deposition (cm): 0	1	5	10	25	50	75	100	150	250	350	500	800	1,000	2,500	5,000
1	Riverine	80%	2.69	2.69	2.69	2.69	0.69	0.10	0.10	0.10	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00
1a	Riverine	80%	5.93	5.93	5.93	5.93	1.53	0.22	0.22	0.22	0.22	0.22	0.01	0.01	0.01	0.01	0.00	0.00
2	Riverine	80%	10.27	10.27	3.01	0.44	0.44	0.44	0.02	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00
2a	Riverine	80%	22.60	22.60	6.61	0.96	0.96	0.96	0.04	0.04	0.04	0.04	0.04	0.00	0.00	0.00	0.00	0.00
3	Riverine	80%	7.34	7.34	2.12	2.12	0.34	0.34	0.34	0.34	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
4	Non-Riverine	53%	36.15	36.15	11.19	0.19	0.19	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Non-Riverine	53%	18.95	18.95	5.45	5.45	0.15	0.15	0.15	0.15	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00

Table B-11 Project Deposition Depths for Ebb Conditions

Sample	Project Element	Total Fines (%)	Distance from Trench (m) / Maximum Sediment Deposition (cm): 0	1	5	10	25	50	75	100	150	250	350	500	800	1,000	2,500	5,000
1	Riverine	80%	2.17	2.17	2.17	2.17	0.57	0.57	0.09	0.09	0.09	0.09	0.09	0.00	0.00	0.00	0.00	0.00
1a	Riverine	80%	4.78	4.78	4.78	4.78	1.26	1.26	0.19	0.19	0.19	0.19	0.19	0.01	0.01	0.01	0.00	0.00
2	Riverine	80%	11.92	11.92	3.61	0.54	0.54	0.54	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
2a	Riverine	80%	26.22	26.22	7.94	1.18	1.18	1.18	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00
3	Riverine	80%	10.33	10.33	3.18	0.54	0.54	0.54	0.54	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00
4	Non-Riverine	53%	39.47	39.47	0.21	0.21	0.21	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Non-Riverine	53%	56.19	20.48	0.48	0.48	0.03	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table B-12 Project Deposition Depths for MFE

Sample	Project Element	Tide Condition	Total Fines (%)	Distance from Edge of Corridor (m) / Maximum Sediment Deposition (cm): 0	1	5	10	25	50	75	100	150	250	350	500	800	1,000	2,500	5,000
MFE 1	Narrows	Flood	80%	83.32	83.32	83.32	83.32	18.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MFE 2	Gravesend Bay	Flood	80%	201.31	201.31	62.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MFE 1	Narrows	Ebb	80%	72.39	72.39	72.39	72.39	15.89	15.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MFE 2	Gravesend Bay	Ebb	80%	218.85	218.85	71.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

B.6 Conclusions

Tetra Tech performed an analytical sediment transport study to conservatively evaluate the potential suspended sediment transport and deposition characteristics of installation of the Project's submarine export cables. The modeling was conducted using existing available data and a PDE approach to evaluate the effects of proposed submarine cable burial activities in terms of suspended sediment concentrations in the water column, and sediment deposition characteristics such as deposition depth and deposited sediment footprint, to allow for an assessment of potential Project effects on surrounding water quality and habitats. The conservative model assumed maximum trench dimension parameters and that all fine sediment (fine sand and smaller grain size sediment) disturbed by the jet plow during cable burial would be suspended in the water column; however, jet plow operations, including the angle of the plow blade and water pressure through the jet nozzles, can be adjusted during cable installation and could result in less sediment mobilizing in the water column.

The analytical sediment transport model yielded the following general conclusions:

- The suspended sediment concentration, deposition depth, and area of influence is dependent upon flood and ebb current velocities, burial depth, and the percentage of fine sediments in the sediment sample;
- The very fine sediments particles (silt and clay) remain in suspension for about 4 hours after being mobilized in the water column. Coarser particles (fine sand) settle at a faster rate, about 1 minute after being mobilized; and
- For jet plow during peak flood and ebb tides:
  - The initial maximum concentration at the release point is dependent on the percentage of fine particles (defined as particles in the fine sand class and smaller). At stations that are 80 percent fine particles, maximum concentrations at the trench line are approximately $2.7*10^6$ mg/L for a trench depth of 8 ft (2.5 m) and $6.1*10^6$ mg/L for a trench depth of 18 ft (5.5 m). This instantaneous concentration is conservatively high and assumes that all particles finer than fine sand are instantly mobilized in the water column and remain in suspension until they settle;
  - The suspended sediment concentrations diminish rapidly away from the release point, and at most stations over 80 percent of the suspended particles deposit within 16 ft (5 m) of the trench centerline. The typical concentration at 328 ft (100 m) is about 3,000 mg/L above background concentration for flood tides and about 2,700 mg/L above background concentration for ebb tides;
  - The suspended sediment concentrations drop rapidly with time. At most locations, the concentration drops by 75 percent within two minutes of jet plowing activity. The maximum concentration at two minutes is $8.8*10^5$ mg/L for flood tide and $1.03*10^6$ mg/L for ebb tide. Average concentration at two minutes is $1.5*10^5$ mg/L for flood tide and $1.8*10^5$ mg/L for ebb tide;
  - The plume suspended sediment concentrations are higher for locations with high very fine sediment contents, defined as sediments in the silt and clay classes. The Riverine stations are dominated by very fine sediment classes;
  - The deposition thicknesses were predicted to be greatest closest to the centerline trench. The maximum expected sediment deposition thickness under simulated conditions is 44 in (112 cm) at 0 m from the trench centerline. On average, deposition thicknesses were approximately 9.52 in (24 cm) 0 m from the trench centerline;

- Deposition thicknesses were predicted to decrease rapidly away from the trench. Average deposition thicknesses were less than 0.37 in (0.95 cm) within 82 ft (25 m) of the trench centerline for flood tides and less than 0.08 in (0.20 cm) within 82 ft (25 m) of the trench centerline for ebb tides. Deposition thicknesses were less than 0.004 in (0.01 cm) at all stations within 3,280 ft (1,000 m) of the trench centerline; and
- Stations that had high silt and clay contents had thicker deposition further from the trench centerline.

- For MFE during peak flood and ebb tides:
  - The initial maximum concentration was $5.49*10^6$ mg/L. The plume was predicted to travel to 82 ft (25 m) in the Narrows during flood tide and 164 ft (50 m) during ebb tide. Near Gravesend Bay the plume was predicted to travel around 16 ft (5 m) during both flood and ebb tide.
  - The suspended sediment concentration dropped by 50 percent within 60 seconds of suspension in the water column because the sediment was comprised of fine sand and very fine sand, which settle out quicker.
  - The highest predicted deposition thickness was 32.80 in (83.32 cm) during flood tide and 28.5 in (72.39 cm) during ebb tide for the Narrows. For Gravesend Bay, the highest predicted deposition thickness was 79.25 in (201.31 cm) during flood tide and 86.16 in (218.85 cm) during ebb tide.
  - For both locations, the deposition thickness fell below 0.004 in (0.01 cm) within 246 ft (75 m) during both flood and ebb tides.

B.7 References

BOEM (Bureau of Ocean Energy Management). 2018. Draft Guidance Regarding the Use of a Project Design Envelope in a Construction and Operations Plan. U.S. Department of the Interior, Bureau of Ocean Energy Management Office of Renewable Energy Programs. January 12, 2018. Available online at: https://www.boem.gov/sites/default/files/renewable-energy-program/Draft-Design-Envelope-Guidance.pdf

Coch, N.K. 2016. Sediment Dynamics in the Upper and Lower Bays of New York Harbor. *Journal of Coastal Research* 32 (4): 756-767. Available online at: https://doi.org/10.2112/JCOASTRES-D-15-00133.1. Accessed November 18, 2020.

ESS Group. 2013. Poseidon Project: Modelling of Sediment Dispersion during Installation of the Submarine Cable for Poseidon Project. September 2013. Available online at: http://documents.dps.ny.gov/search/Home/ViewDoc/Find?id=%7BDD88BA4B-AAF1-4A6A-B704-B10E14E78D2B%7D&ext=pdf. Accessed December 18, 2019

Haidvogel, D.B., H.G. Arango, K. Hedstrom, A. Beckmann, P. Malanotte-Rizzoli, and A.F. Shchepetkin. 2000. Model Evaluation Experiments in the North Atlantic Basin: simulations in nonlinear terrain-following coordinates. *Dynamics of Atmospheres and Oceans* 32(3-4): 239-281. Available online at: https://doi.org/10.1016/S0377-0265(00)00049-X

Shchepetkin, A. F., and J. C. McWilliams. 2005. The regional oceanic modeling system (ROMS): A split-explicit, free-surface, topography following-coordinate oceanic model. Institute of Geophysics and Planetary Physics, Los Angeles, California. Available online at: http://falk.ucsd.edu/roms_class/shchepetkin04.pdf

Swanson, C, T. Isaji, and C. Galagan. 2015. Modeling sediment dispersion from cable burial for Seacoast Reliability Project, Little Bay, New Hampshire. Prepared for Normandeau Associates, Inc., Bedford, NH. RPS ASA 2014-270. December 2015. Available online at: https://www.nhsec.nh.gov/projects/2015-04/application/2015-04_2016-04-12_app35_modeling_sediment_dispersion_cable_burial_srp_little_bay.pdf

Tetra Tech (Tetra Tech, Inc.) 2012. Block Island Wind Farm and Block Island Transmission System Environmental Report / Construction and Operations Plan. Available at: https://offshorewindhub.org/resource/1385. Last accessed March 8, 2019.

Tetra Tech. 2015. Virginia Offshore Wind Technology Advancement Project (VOWTAP) Research Activities Plan. Available online at: https://www.boem.gov/VOWTAP-RAP/. Last accessed March 8, 2019.

USGS (U.S. Geological Survey). 2005. USGS east-coast sediment analysis: Procedures, database, and GIS data: U.S. Geological Survey Open-File Report 2005-1001.

Van Rijn, L.C. 2018. Turbidity due to dredging and dumping of sediments. [Internet]. Available online at: https://www.leovanrijn-sediment.com/papers/Turbiditydredging2020.pdf

Vinhateiro, C, C. Galagan, D. Crowley, and T. Isaji. 2013. Results from modelling of sediment dispersion during installation of the proposed West Point Transmission Project power cable. ASA Project 2013–003. Final Report June 2013. Prepared for ESS Group, Inc.