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MASS USA

VINEYARD WIND

Draft
Construction and Operations Plan

Volume III
Appendices

Vineyard Wind Project

October 22, 2018

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Submitted to
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October 22, 2018

Appendix III-K

Scour Potential Evaluation at Vineyard Wind

Vineyard Wind

Scour Potential Evaluation at Vineyard Wind

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C	05.07.2018	Figure test 2.7 updated	CLT	CLT

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TABLE OF CONTENTS

1. INTRODUCTION

Wood Thilsted Partners Ltd have been appointed by Vineyard Wind to provide technical assistance and expertise in support of the development of the foundations and cable route for the Vineyard Offshore Windfarm. This document has been compiled to provide an assessment of the potential scour development resulting from the construction of the planned offshore wind farm.

1.1 PROJECT BACKGROUND

Vineyard Wind is a planned offshore wind farm (800MW) located offshore of Massachusetts, just south of the island of Martha’s Vineyard (Figure 1-1). The project consists of the following substructures: wind turbine foundation (monopiles or jackets), up to two electrical service platforms (monopiles or jackets), inter-array cables and export cable.

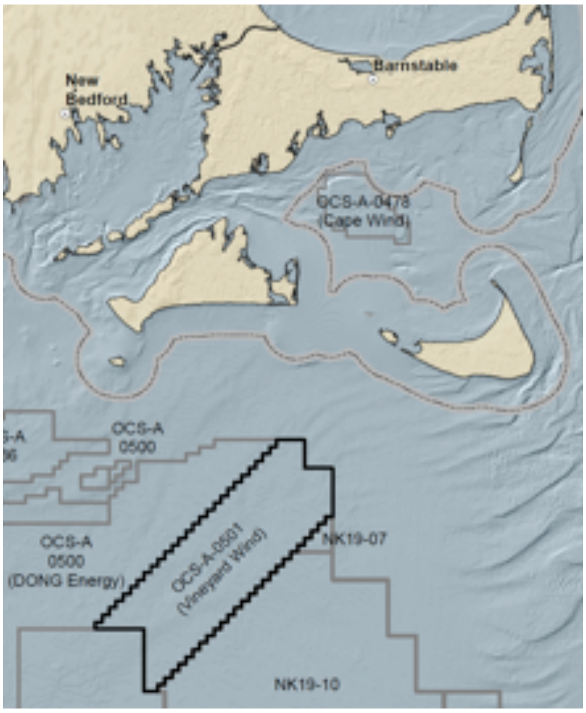


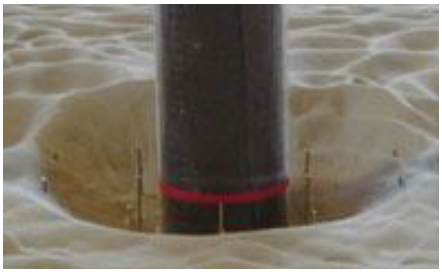
Figure 1-1 Location of Vineyard Wind

1.2 SCOUR IN OFFSHORE WINDFARMS

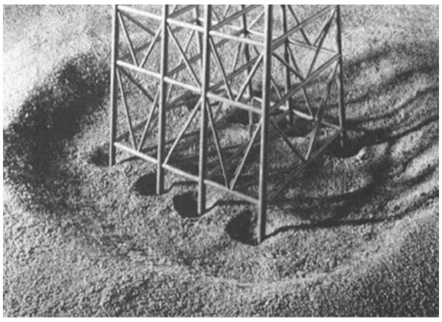
Scour is defined as the removal of sediment from around the base of an object due to the interaction of wave and current-induced flows with a structure and substrate. Any structures constructed as part of marine renewable development such as monopile foundations, jackets for WTGs as well as the cabling necessary for in-field transmission and power export are potential sources for scour at an offshore site. Scour will influence the design of the structure and alter the submerged terrain surrounding the site. Engineers developing such structures therefore have to choose between designing to allow scour to develop and using scour protection to minimize erosion.

Scour can be divided into four different categories as listed below:

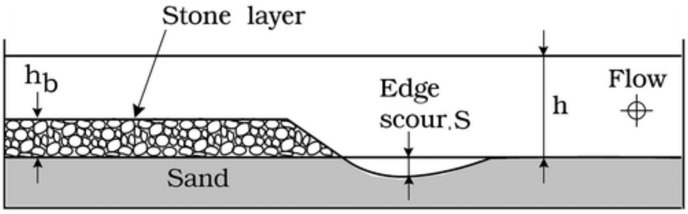
Local scour: The erosion of seabed material in proximity to a single foundation, e.g. a monopile or a single leg of a jacket foundation (Breusers, 1977)



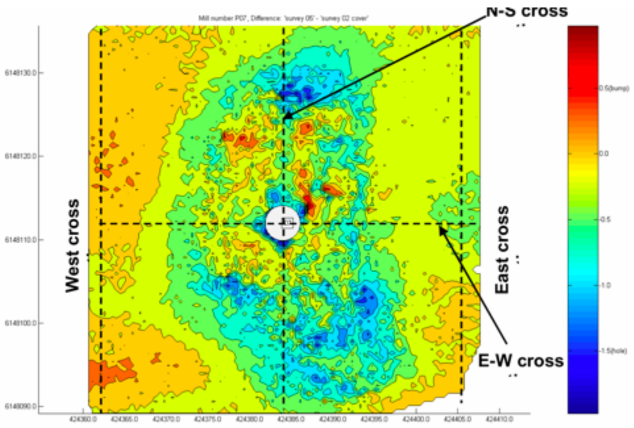
Global scour: The wider erosion around a structure consisting of multiple foundations, e.g. a jacket foundation with 3-4 legs (Judd, et al., 2007)



Edge scour (secondary scour): Erosion occurring in proximity to scour protection (Petersen, et al., 2014)



Far field scour: Erosion and deposition occurring at larger distances from the structure and wind farm including overall sea bed movements (Whitehouse, 1998)



1.3 THE CAUSES OF SCOUR

For scour to occur, three drivers must be present. These key drivers for scour potential of an offshore site include:

- Restriction in water flow – any stationary object placed on or with the water column will disturb the velocity profile of the water flow. The larger the object, the greater this disturbance.
- Current / waves – currents and waves are what will be disturbed by the restriction in the flow – both will have greater effect in shallower water.
- Mobile seabed surface – scour can only occur when the seabed is mobile. The presence of a rock or stiff clay at or close to the surface will restrict the quantity of scour that can occur.

These drivers can be considered in a similar manner to the classical fire triangle (see Figure 1-2) – remove one of the three core elements and no scour will occur. However, if one or more of these is abundant then increased scour will occur.

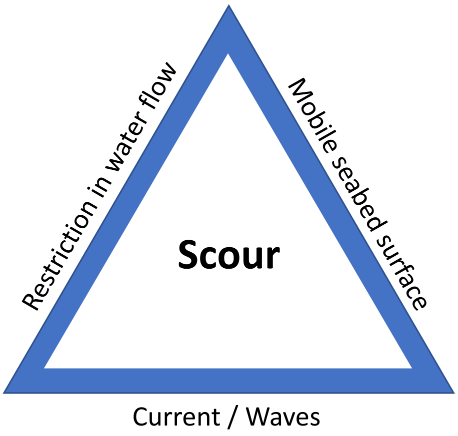


Figure 1-2 The Scour triangle

When unacceptable levels of scour are predicted, such that the structural integrity is affected or the seabed disturbance is unacceptably large, then scour prevention measures must be applied. Scour prevention is normally undertaken by minimizing the restriction in the water flow (efficient structural design) and applying scour protection such as rock amour onto the seabed to prevent the mobile seabed from being able to move.

1.4 PREDICTING SCOUR

Extensive research has been carried out on predicting and quantifying scour for offshore wind farms. This includes practical considerations based on extensive experience on laboratory experiments and existing windfarm installations (Whitehouse, et al., 2006) (Harris, et al., 2010) as well as theoretical modelling using computational fluid dynamics (CFD) (Qi, et al., 2014). Both approaches utilize knowledge of the prevailing conditions of the site as well as the type and dimensions of the offshore structures. However, the accuracy of all such approaches remain modest.

Whitehouse et al. has provided comprehensive summaries on scour forecasting and assessment and prefaces that "*prediction of scour at offshore windfarm foundations in areas with mobile seabeds is a challenging topic*". This is particularly true for areas with shallow water, strong currents and wave action (Whitehouse, et al., 2006). Actual field testing is also lacking, meaning that "*scour research has been hampered by a dearth of prototype scour observations and much of the existing knowledge* *is derived from physical and numerical work which has had very little validation with field data"* (Melling, 2014).

The state-of-the-art of scour assessment and protection design in practice therefore necessitates a holistic and practical approach taking into consideration site conditions in comparison to previous projects, use of general guidelines and application of preventative or remedial measures for cases of uncertainty of scour formation (Zaaijer, et al., 2004). This is the approach applied for Vineyard Offshore Wind in this document.

2. THE POTENTIAL FOR SCOUR PROCESSES AT VINEYARD WIND SITE

2.1 SITE CONDITIONS

Mobile seabeds and increased currents and waves will increase the potential for scour. This section assesses both these causes of scour in reference to the proposed development of the Vineyard Offshore Wind farm.

With water depths of 30m+ for the site, the influence of waves can be neglected and scour potential is predominantly controlled by currents (Whitehouse, Harris, Mundon, & Sutherland, 2010). Currents in the area are relatively low with depth-averaged current speeds of approximately 0.58 kn (0.30 m/s; from the tidal stream potential dataset on the Marine Cadastre website) to 0.6 kn (0.31 m/s) verified by RI OSAMP metocean data buoy measurements for bottom currents nearby the wind farm development area (see Section 2.2.4 of Volume II). This is much lower than the tidally dominated currents seen at European wind farms such as those in the Thames Estuary off the UK (eg. London Array and Thanet) which have average current speeds of 1.5 – 2.0+ kn (Melling, 2014). For these reasons, the scour potential due to hydrodynamic forces for Vineyard Wind is expected to be significantly less than those observed at other windfarms with greater current and shallower depth.

At a basic level, scour potential at a proposed offshore site can be based on observing natural features on the seabed. For sandy seabed substrates, these include assessing indicators of soil mobility (Whitehouse, et al., 2010):

- Ripple marks
- Megaripples
- Sandwaves
- Obstacle marks – scour and deposition around rocks or other debris on seafloor

The most comprehensive dataset for the site is the 2016 geophysical survey. This survey consisted of three parallel survey lines 60m (197ft) apart, with adjacent corridor centerlines spaced 900m (0.49Nm) apart. Tie lines were planned every 1km (0.54Nm). These survey lines consisted of high resolution multi-beam echo sounder, side scan sonar, sub bottom profiler and magnetometer. Four of these lines were ultra-high resolution and extended out to cover the SW of the site, to inform potential future development.

The planned lines for the 2016 geophysical survey are shown in Figure 2-1 and the measured bathymetry of the site is illustrated in Figure 2-2[1].

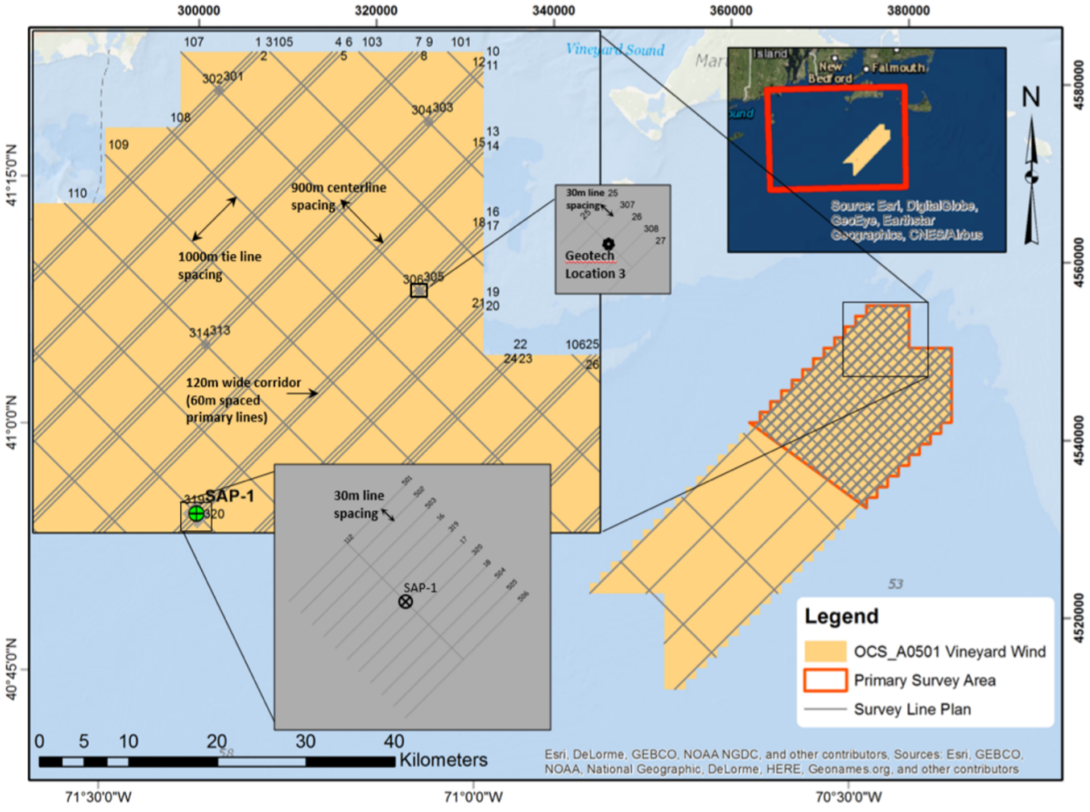


Figure 2-1 Line plan of global geophysical survey

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[1] Note: full survey was not completed due to weather conditions, however, the majority of the survey was completed and coverage throughout the site was obtained.

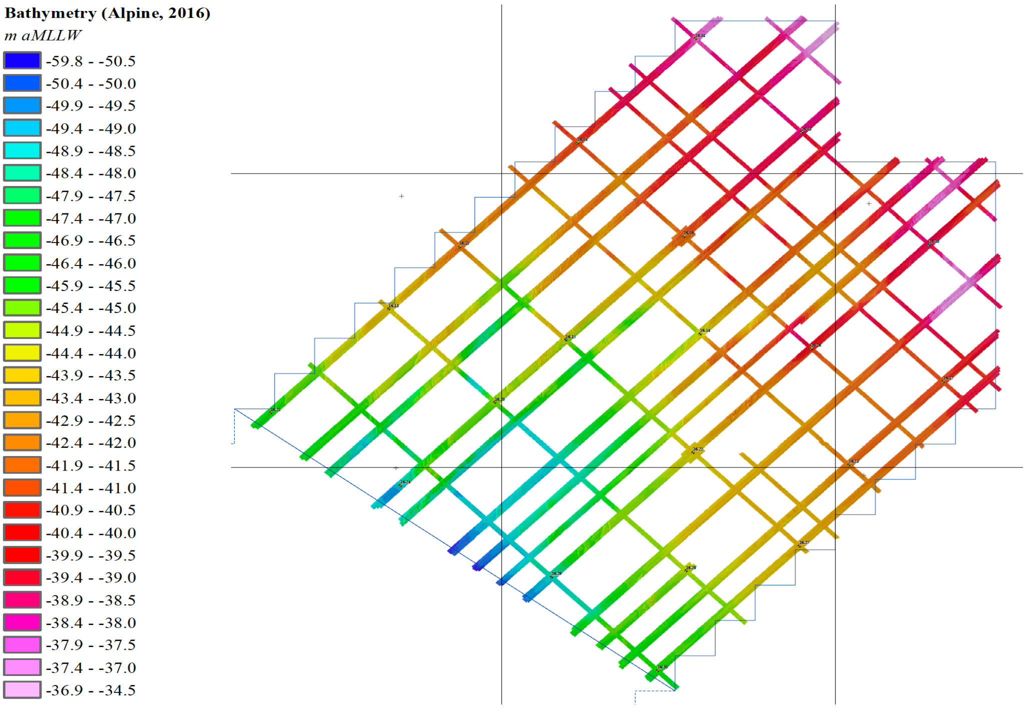


Figure 2-2. 2016 geophysical site survey results

The survey results showed very homogenous seafloor conditions in the wind farm development area, dominated by fine sand and silt sized sediments, fining into deeper water. Water depths range from 35-52 m (114.8-170.6 ft) over a gently sloping seafloor that dips down toward the south-southwest. Localized patches of sand ripples (<0.5 m height) and small megaripples (0.5-0.8 m height) are randomly distributed throughout the area (see example in Figure 2-3), referred to as rippled scour depressions. These features represent the only perturbations in relief on an otherwise relatively flat, featureless seafloor that slopes gradually offshore.

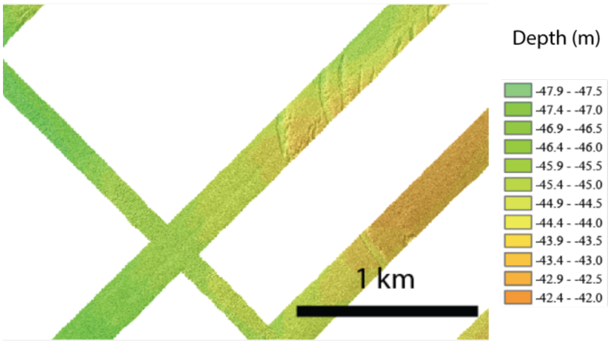


Figure 2-3 Excerpt of bathymetric data showing localized ripples and small megaripples indicating limited soil mobility and scour potential.

Examples of the typical seabed at the wind farm development are the two locations planned for meteorological / oceanographic buoys (referred to as SAP-1 (2016) and SAP-2 (2016) locations) where a 300m (984ft) square box at 30m (98ft) line spacing and one tie line through the center of the area was surveyed. The location of these two areas are illustrated in Figure 2-4.

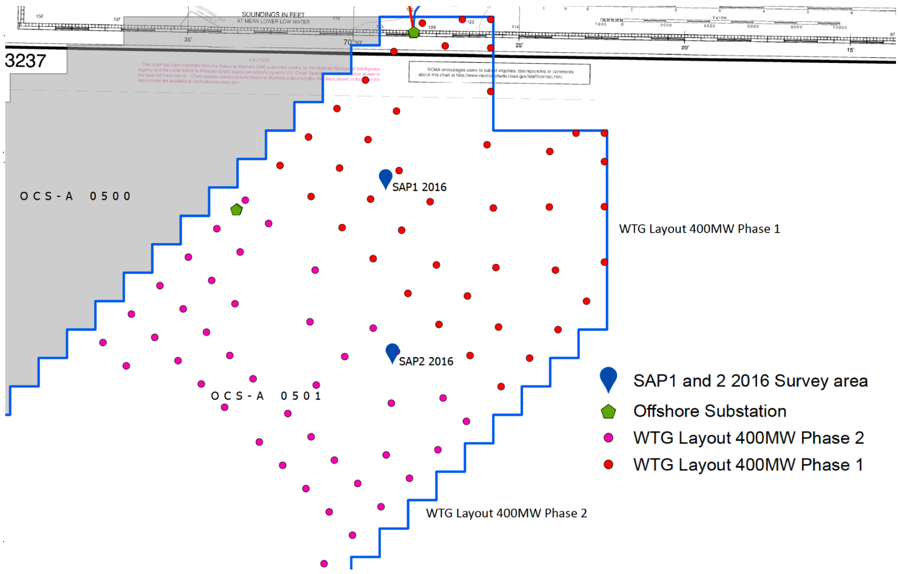


Figure 2-4 Location of survey areas SAP-1 (2016) and SAP-2 (2016)

The bathymetry of the SAP-1 (2016) and SAP-2 (2016) survey areas is illustrated in Figure 2-5.

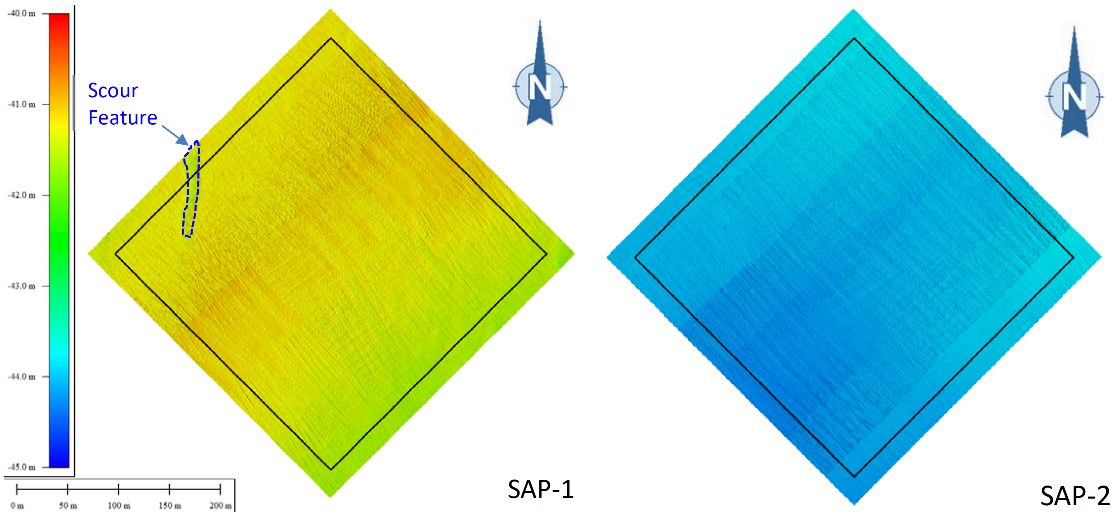


Figure 2-5 Bathymetry of SAP-1 (2016) and SAP-2 (2016) survey areas

The most pronounced bathymetric feature is an apparent shallow scour feature, approximately 30 cm deep, located along the northwest edge of the SAP-1 (2016) survey area. Other than this, the seafloor is predominantly flat and featureless, mapped as pitted sand, and displays down slope gradients of 0.1˚ or less.

The bathymetric data shows that the undeveloped site has low energy, and existing seabed mobility levels are relatively minimal, reinforcing the anticipated conclusion that the current velocities, and therefore this contribution to the scour triangle is minimal.

2.1.1 Ground conditions below surface

The soil properties below surface is an important factor for scour potential as layers of hard substrate would prevent scour developing at depth. The Vineyard site typically consists of a sand layer that extends >20 m in depth. There is no hard substrate close to the surface (e.g. rock or stiff clay geology) and the contribution of soil type will remain constant during any potential scour development.

2.2 IMPACT ASSESSMENT OF MONOPILES

2.2.1 Local scour

Scour can occur due to both tidal currents and wave induced currents, or a combination of both. In general terms, steady (tidal) currents are more likely to create a scour pit than wave induced currents.

(Boon, et al., 2004) provides a methodology for assessment of scour due to wave induced currents based on Kuelegan Carpenter number. This indicates that a KC of less than 6, and in the absence of currents, scour will not occur, while values in the range 6 to 200 indicate that scour depth will increase with increasing KC. Calculation considering both significant and maximum wave height, and the pile diameter, give results in the range 2.9 to 6.6 for monopiles. It is therefore considered reasonable to assume that wave induced scour will be negligible.

To estimate steady state scour under tidal currents, it is necessary to determine the threshold depth averaged current velocity at which particle motion is initiated (Vos, et al., 2011). This is based on an estimate of the Shields parameter which is in turn dependent on various parameters including water depth and particle size. The result of this analysis indicates that at maximum current conditions, the site plots slightly above the onset of general transport of sediment. There is therefore potential for scour pits to develop, although their formation is likely to be relatively slow.

A plot of the relationship between water depth and scour is shown in Figure 7 – with local scour data from three windfarms situated in the Thames Estuary off the UK. These windfarms are all situated in area where there are much higher currents than predicted at Vineyard. Monopiles at Vineyard are expected to have a diameter between 7.5 and 10.3m and this combined with the water depth ranges gives h/D ratios (water depth h over pile diameter D) of 3.4 to 6.5 for this project. This is indicated on Figure 7 in blue. From Figure 7, it can be seen that the depth of the scour hole (S) is anticipated to be limited to a maximum of 1.5 times the pile diameter. For a 10.3m diameter monopile, this equates to a scour hole of 15.5m as indicated in Figure 2-7.

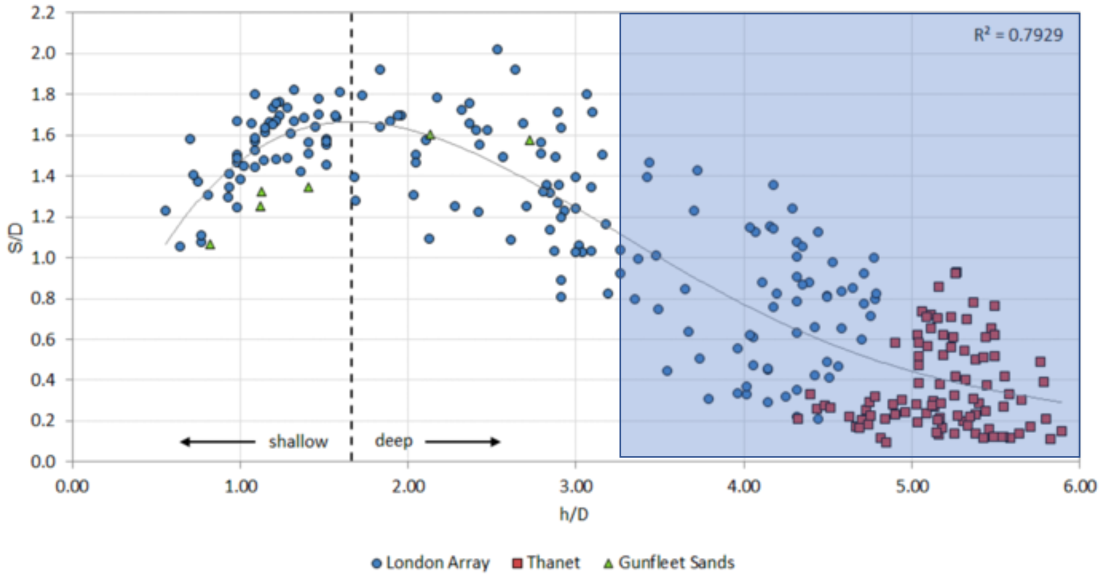


Figure 2-6 A plot of the scour vs monopile diameter (S/D) and normalized water depth (h/D) for three windfarm locations located in the UK. The blue area is representative for monopile foundations at Vineyard Wind.

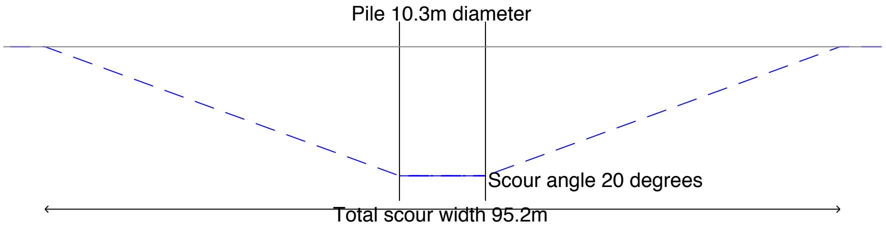


Figure 2-7 illustrates the size of a scour pit when the scour is allowed to freely develop. The scour pit would be developed through a process where a) strong vortex currents in close proximity the pile will initially dig a scour pit close to the pile and then b) the scour pit would gradually be filled by sand farther from the pile which would then be removed by vortex currents and then the process would repeat. The freely developing scour process would result in a scour pit with an angle of approximately 20 degrees as illustrated on the figure. To prevent the scour pit process from developing, the radial extent of the scour protection must be sufficient to block the strong vortex currents in close proximity to the pile. This will prevent the scour process from developing. Therefore, the radial extent of the scour protection is significantly less that the radius of a freely developing scour pit.

2.2.2 Scour protection

Whilst it would be possible to design for such scour depths as shown in Figure 2-7, in practice they are unwanted as it results in an uneconomical design, large scour holes and technical challenges due to large shifts in the natural frequency of the structure (van der Tempel, Zaaijer, & Subroto, 2004). It is therefore considered prudent to allow for placement of scour protection around all monopile foundations.

The lateral extent of the scour protection should be taken to the limit of the scour pit which may form. Based on pile diameters in the range 10 m, the radial extent of a scour pit may be in the range of 25m. The relatively fine nature of the scour protection means that the thickness is not governed by the grading, but is dependent on the practical thickness which can be placed. An appropriate value for the scour protection thickness to resist effects of scouring processes is estimated to be 0.3m on basis of design recommendation of (CIRIA/CUR, 1991), with an allowance of approximately 30% recommended as a tolerance on the volume of material required. This therefore computes as between approximately 650 m3 scour protection which is approximately equivalent to approximately 1,300 tonnes of rock per turbine.

The derived volumes based on a scour protection thickness of 0.3 m are considered the best estimate of the scour protection system which will be required, however, a larger scour protection system could potentially be required following refined analyses in the detailed design phase where other design aspects could drive the design of the scour protection, eg. ensuring adequate stiffness to achieve an acceptable natural frequency of the turbine. Scour protection thickness up to 1-2 m are frequently seen in Europe and these thicknesses have therefore been considered the upper bound envelope for the scour protection sizing.

2.2.3 Global scour

Global scour is not applicable for monopiles, as there is only one pile disturbing the water column. In design, some global scour allowance may be appropriate to account for the survey tolerances / natural variation in water depths.

2.2.4 Secondary scour

With scour protection installed around offshore structures, the only scouring left will be secondary scour. Scour protection structures usually consist of deposited stones in the proximity of the offshore structure. Here, erosion occurs through the stones (Hansen, Simonsen, Nielsen, Pedersen, & Høgedal, 2007) as well as along the outer edge (Ugelvig Petersen, Mutlu, & David, 2014). However, no ”*study is available yet investigating the three dimensional flow… and resulting edge scour adjacent to stone layers in current*” (Ugelvig Petersen et al., 2014).

The question of using scour protection as a cost-effective way of mitigating the effect of scour is covered in a paper by Zaaijer et al. (Zaaijer & Tempel, 2004). However, scour depths from secondary scour around protection structures are recorded to be less than 3m for a range of different conditions and scour protection structure types in an extensive study carried out by Petersen et al. (Ugelvig Petersen et al., 2014). Based on case studies (Whitehouse, et al., 2011) report that the typical depth of secondary scour depth is in the order of approximately 0.12 times monopile diameter. For a monopile with diameter 10.3m and scour protection structure with a diameter of 50m and a height of 0.5m and secondary scour angle of 20 degrees, this will correspond to a total volume displacement of 621 m^3 and a scour area of 147 m^2.

2.2.5 Far field scour

Far-field scour is the least understood and studied of the scour types. Defining the extent of scour by identifying a position in which there is no change to depth is impractical, as distinguishing between "*significant changes in bed elevation and bed morphology*" and areas where "*little change happened*" is unfeasible (Melling, 2014). Melling et al. concludes that there is no current answer for "*how the extent of a scour hole is defined and what objective criteria can be used to delimit its boundary*".

In his "*Scour of Marine Structures: A manual for practical applications*", WhiteHouse mentions "*overall seabed*" movement but doesn't analyze it in his calculations nor in field studies (R. Whitehouse, 1998). In his doctoral thesis, Thor Ugevilg Petersen mentions far field effects in his laboratory tests of scour at monopiles, but also doesn't provide a quantitative analysis (Ugelvig Petersen et al., 2014).

However, full-scale measurements of local scours for an entire offshore wind farm is provided by Hansen et al. for Horns Rev 1 (Hansen, et al., 2006). Erosion here was evaluated for all the monopiles with scour protection and at relatively large distances from unprotected monopiles. Here, only secondary scouring is relevant and far-field analysis indicates that at large distances, re-deposition of soil is as prevalent as erosion. The graph in Figure 2-8 from Hansen et al. taken shows seabed profiles at distances of up to 25m from the turbine in which the black line is the depth from the pre-installation survey (2002) and the cyan line is from the post-installation survey (2005). The sand bed east of turbine number was approximately 0.3 m eroded, whereas backfilling in the order of 0.2 m has occurred on the western side.

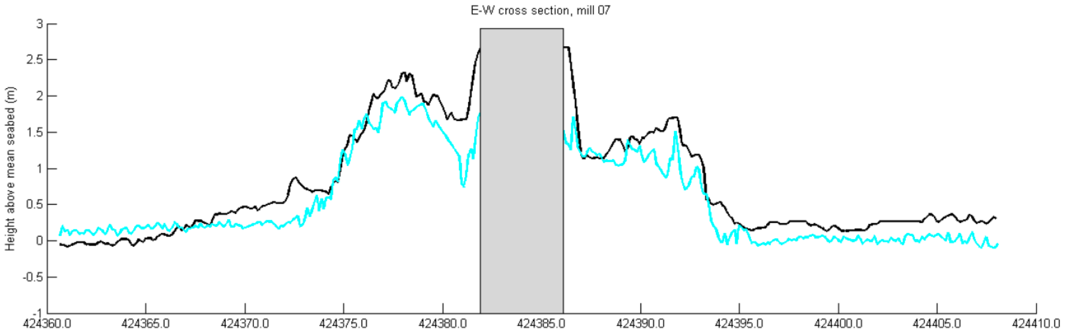


Figure 2-8. Measured seabed changes from 2002 to 2005, Horns Rev 1 Offshore Wind Farm

A programme of research and monitoring was undertaken at the Scroby Sands OWF by (Cefas, 2006), to observe, measure and quantify potential impacts of OWFs on coastal processes that may lead to disturbance of sedimentary environments or sediment transport. It was concluded that in the range 0-100 m from foundations, the seabed impact was scour pits as predicted. In the range 100-1000 m from foundation, the seabed impact was scour wakes, but was not significant with respect to the total bank volume change. Above 1000m there were no evidence of any impact. Much less overall seabed impact is expected at Vineyard Wind as the scouring potential is significantly less than at Scroby sands due to deeper water and less current.

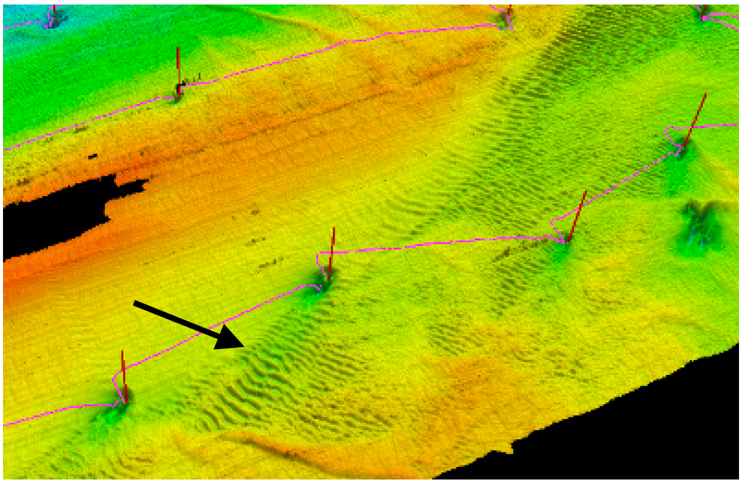
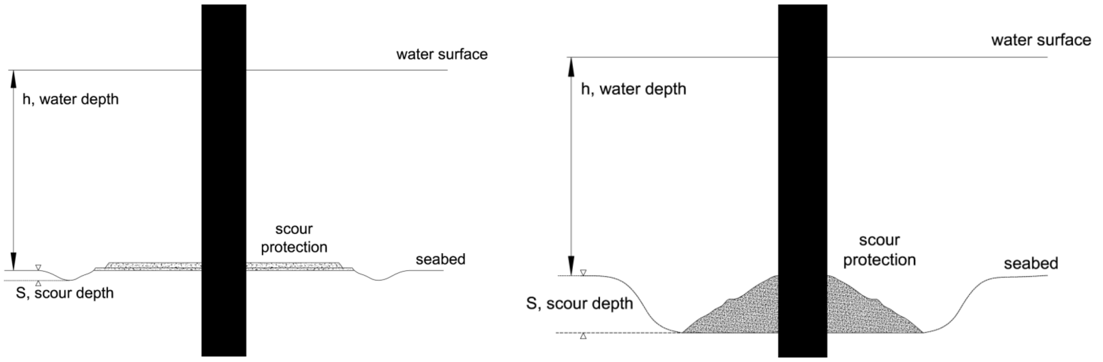


Figure 2-9. Results from the swathe bathymetry survey of Scroby Sands OWF. The red cylinders are monopoles and the intra-array cable route is shown as magenta. The black arrow shows a far field scour wake extending southeast to the lower monopile. Figure from (Cefas, 2006).

It is important to note that at Scroby Sands OWF, the scour protection was only placed *after* the scour hole had developed, which resulted in a very large secondary scour depth as illustrated in Figure 2-10. The consequence of the large secondary scour at Scroby Sands was to produce locally extensive scour holes of scour wakes which contains larger amplitude seabed features than the surrounding seabed. There are no reports available of similar significant far-field seabed disturbance for conventional scour protection systems being installed prior to pile installation, as is planned for the Vineyard Wind Project.



Conventional scour protection - the most common practice and the planned scour protection for Vineyard Wind:

The scour protection is placed *before* scour hole is allowed to develop. Secondary scour depth approximately 0.12 times diameter (Whitehouse, et al., 2011)

Unconventional scour protection solution applied at Scroby Sands OWF and Arklow Banks:

Placement of scour protection *after* the scour hole had developed. Secondary scour depth up to 1.6 times diameter (Whitehouse, et al., 2011)

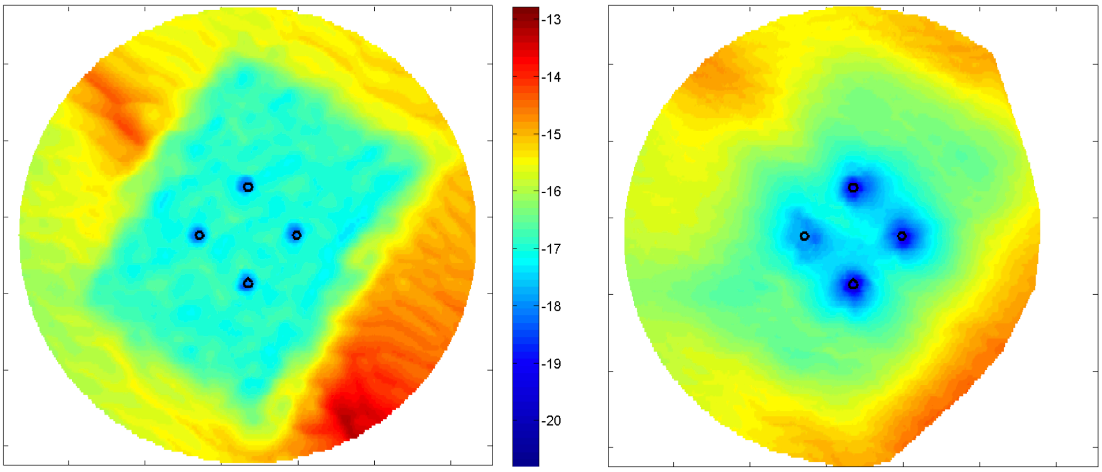
Figure 2-10. Placement of scour protection before or after development of scour hole

2.3 IMPACT ASSESSMENT JACKETS

2.3.1 Local scour

Local scour is considered the scour that occur locally around each of the jacket piles. The depth of the local scour holes is expected to be approximately 1.3 times the pile diameter according to (DNVGL-ST-0126, 2016), however, in extreme cases, a depth of 2.0 times pile diameter may occur (Sumer, et al., 2002).

Experience from scour development around 4-legged jacket foundation a Thornton Bank Phase 2-3 Offshore Wind Farm in Belgium is illustrated in Figure 2-11 (note that seabed dredging in this case was carried out prior to jacket installation). After jacket installation, the scour increased and four months after installation the average scour depths ranged between 1.4 and 1.9 m (0.7 – 0.95 times pile diameter) and the largest scour depth at each location (= maximum of the four piles) ranged between 1.7 and 2.7m (0.85 – 1.35 times pile diameter).



02.08.2011 shortly after dredging and pile installation

14.01.2012 shortly after a storm event

Figure 2-11. Monitoring of scour development around a four-legged jacket at Thornton Bank Phase 2-3 Offshore Wind Farm in Belgium. (Bolle, et al., 2012)

The scouring potential at Vineyard Wind is less severe than at Thornton Bank, and therefore the guidance 1.3 times the pile diameter (DNVGL-ST-0126, 2016) is considered well suited for scour estimation. For piles of diameters ranging from 1.5 m to 3.0m, this equates to a local scour hole depth of approximately 2.0-3.9 m around the jacket piles. With a slope angle of 20 degrees, this equates to scour hole volumes of approximately 25-197 m^3 per pile.

2.3.2 Global scour

Scour around jacket foundations is a combination of both local and global scour. The presence of the jacket itself will cause a minor restriction in the water column which is likely to lead to some global scour. Based on a 2 x 2 pile group, Sumer and Fredsøe suggested that the global scour depth can be approximated by 0.37 times the pile diameter (Sumer, et al., 2002), however, in the case where the distance between the pile centres is greater than 6 times the pile diameter, the global scour effects are negligible (Breusers, 1972) and (Hirai , et al., 1982). The distance between the pile centres is expected to be greater than 6 times the pile diameter for WTG and ESP jacket foundations, and therefore effects of global scour are considered negligible.

2.3.3 Scour protection

As reported in section 2.2.1 and 2.2.2, the scour development around jackets at Vineyard Wind are expected to be fairly limited. As also the technical benefits and cost benefit of adding scour protection are limited (as opposed to the monopile foundation), the scour protection to be deployed around the jacket foundations is expected to be designed minimally and be limited to mainly protecting the cables from free hanging on exit from the foundations.

2.3.4 Secondary scour

Refer to 2.2.4.

2.3.5 Far field scour

Refer to 2.2.5.

2.4 IMPACT ASSESSMENT – INSTALLATION VESSELS

Any scour processes arising from installation vessels operating alongside monopile, jacket and ESP foundations are temporary and very minor and thus to be considered negligible. This is confirmed by the findings from existing offshore wind farms reported by (Cefas, 2006) and Scroby sands and (Fugro Marine GeoServices, 2017).

3. THE POTENTIAL FOR SCOUR PROCESSES ALONG THE CABLE ROUTE

3.1 SITE SURVEY RESULTS

From 1 August to 13 September 2017, geophysical, geotechnical, and remote sensing surveys were conducted along the potential offshore export cable corridors. These survey results show that the cable corridors traverse over a significant variation in geology, with strong influence by tidal currents controlling local seabed morphology and grain size. The scour processes are more prevalent in shallower water along portions of the export cable routes due to increased tidal current flow. Constrictions in the seabed and shoreline geomorphology help funnel water masses through narrow passages which the tidal currents now maintain (e.g. Muskeget Channel).

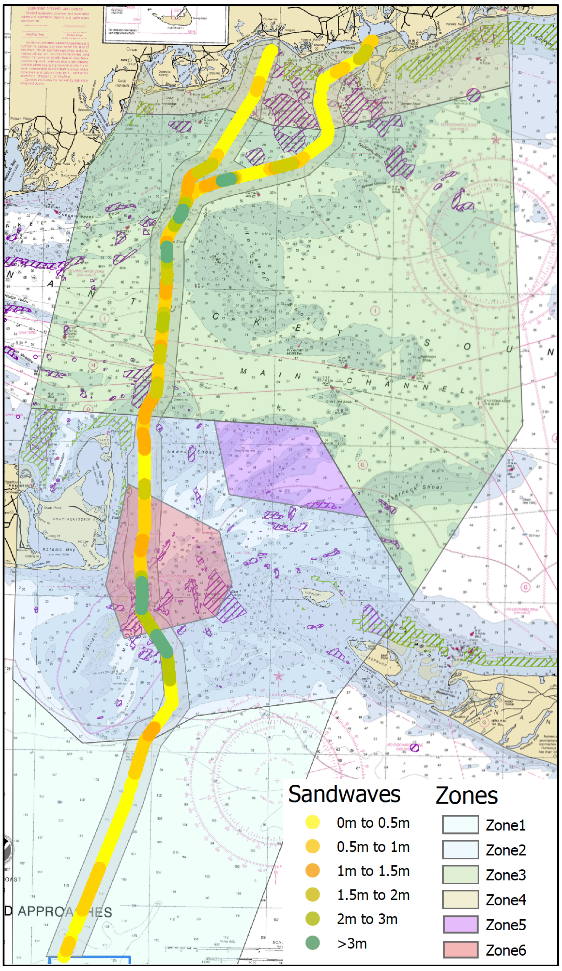


Figure 3-1. Maximum sand wave height along export cable corridors

Sandwaves are present in a significant part of the export cable corridor route area. In general, sandwaves indicate active reworking of surficial sediments. Sediment transport via sand wave migration occurs daily along the flanks of these bedforms. These features are typical of coastal marine environments where sand is a dominant constituent of the seafloor with active tidal currents on the water column. The maximum height of sand waves encountered along the cable corridors is illustrated in Figure 3-1

3.2 SCOUR POTENTIAL EVALUATION

To evaluate the potential scour process resulting from an in-place cable, a distinction is made between the seabed composition consisting of mobile sediments and coarse material. Finally, the special scenario of a cable crossing an existing cable is considered.

3.2.1 Areas of mobile sediments:

In areas where mobile sediments are present, the surficial sand layer can range from being fairly stable (as indicated by minor ripple features at seabed) to highly mobile (as indicated by large sand waves features at seabed). Natural scour in this case could expose a submarine cable in the troughs between bedforms if it is not buried deep enough. In either case, the burial depth of cables are planned to be below the mobile sand layer into the underlying stable sediment layer. As the cable burial depth is chosen not to expose the cable at the surface, no scour effects of the offshore cable are expected in areas of mobile sediments.

3.2.2 Areas of hard bottom

The areas of coarse material and hard bottom are typically encountered in areas with high volumes of water moving bi-directionally with the tides, high current velocity, deeper water thoroughfares resulting in an outwash of sand particle leaving only coarser surficial sediments. In these coarse materials, the cables are to be buried. However, in cases where the coarse materials do not allow full cable burial to be achieved, cable protection such as concrete mattresses, rock dumping, or ura-duct (see Figure 3-2) are often utilized as armoring to guard the cable against erosive forces and other risk factors. In this case, no scour is foreseen as the coarseness of the material would prevent the occurrence of scour processes despite the placement of armouring to guard the cable.

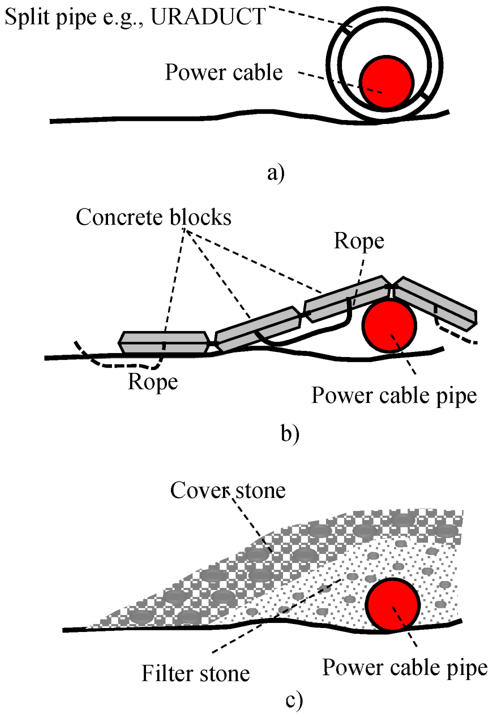


Figure 3-2. Examples of potential cable protection systems; (a) tubular product (eg. uraduct); (b) mattress covering; (c) rock dumping.

Hard bottom areas have been identified at sections of the route, predominantly through the Muskeget channel where currents area high. Specifically, cobbles, boulders and gravel have been identified in those areas which could be a challenge for installation. When it comes to the potential installation methods, jetting would be difficult to implement and a chain cutting solution might be more appropriate. However, if trenching is not possible in these areas, a surface lay with mattresses could be a suitable option or potentially the sections with boulders could be first cleared to create a more level surface to install the cable. Considering the entire route, an upper bound (worst case) estimate for amount of cable protection required is 10% of the length of the export cable route. Typical mattress sizes are 2.4 x 4.8 m or 3m x 6m, with thicknesses is often 150mm, but can be up to 300mm. Typical rock dumping is designed with stone sizes in the order 10-30cm to cover a width of approximately 3.5-5.0 m and an average height of 0.6 m, however, locally the rock dumping with could reach 7-9 m in width in areas of worse soil conditions.

3.2.3 Cable crossings

A cable crossing will need to be conducted in cooperation with National Grid. The anticipated method will be as follows:

1. The existing National Grid power cable will be carefully surveyed and inspected using an ROV, diver, or similar. Any survey will be defined, planned, executed, evaluated and documented according to the rules and regulations set forth by National Grid with agreement by Vineyard Wind.
2. Any existing debris surrounding the crossing points will be carefully removed. The plan and procedures for this work will be agreed upon with National Grid.
3. Depending on the depth of the National Grid cable and National Grid's requirements, there may be a concrete mattress or other means of protection placed between the National Grid cable and Vineyard Wind's proposed cables. Alternately, if there is sufficient vertical distance between National Grid's cable and Vineyard Wind's proposed cables and it is acceptable to National Grid, there may be no manmade physical barrier between the cables.
4. The new export cables will be protected with either additional concrete mattresses, controlled rock placement, or a similar physical barrier. Cable protection measures will be designed to protect the export cables against mechanical impact from above and respect the vertical distance and physical barrier (if any) to the National Grid power cable. The design of the crossing structure will be defined, planned, executed, evaluated and documented according to the rules and regulations set forth by National Grid, and in order to minimize the risk of fouling or snagging of fishing equipment.
5. If necessary, scour protection consisting of additional rocks and/or fond mattresses will be carefully placed on and around the crossings.
6. Final as-built surveys of the completed crossings will be undertaken. The surveys will be documented according to the rules and regulations set forth by and agreed upon with National Grid. As-built positions will be provided to NOAA for charting purposes.

Cable protection measures will be carefully designed to minimize possible effects of secondary scour around the applied cable protection at the crossing. If well designed, the cable crossing will result in very limited and negligible scour development, however, for the purpose of defining an extreme scenario, a local seabed lowering of 1 m^2 across an area of 50 m x 50 m is assumed due to secondary scour effects.

4. CONCLUSIONS

A holistic approach has been used to evaluate the scour potential for Vineyard Wind and cable route site taking into account the state of scour research and the methodologies presented previously, and the foundation types and diameters expected. On the site, significant scour is not expected due to the low currents. However, all foundations will have scour protection installed around them to reduce the effects of scour at the site. The envelope of the scour protection dimensions is presented in COP Volume I, which adds an additional measure of conservatism to the calculations presented herein.

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