

UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Ocean Energy Management, Renewable Energy Programs

October 17, 2023

**Guidelines for Providing Geophysical, Geotechnical, and Geohazard Information Pursuant
to 30 CFR Part 585**

Guidance Disclaimer

This guidance document is not a rule, regulation, or other legally binding instrument, and the recommendations it contains may not apply to a particular situation, depending on case-specific facts and circumstances. Nothing in this document is intended to modify or amend any Federal statutes, regulations, permits, or leases, nor create any rights or cause of action or trust obligation that any person or party may enforce through litigation or otherwise against the United States Government or any of its employees or officers. This document is not legally enforceable. To the extent that there is any inconsistency between the provisions of this document and any Federal statutes, regulations, leases, or permits, the statutes, regulations, leases, or permits will control.

Effect

This guidance document withdraws and supersedes the previous guidance entitled, *Guidelines for Providing Geophysical, Geotechnical, and Geohazard Information Pursuant to 30 CFR Part 585* dated May 27, 2020, and will remain in effect until withdrawn.

Introduction and Regulations

The Bureau of Ocean Energy Management administers the U.S. Department of the Interior regulations, at 30 CFR part 585, which require the submission of a Site Assessment Plan (SAP; 30 CFR 585.605 through 585.613), Construction and Operations Plan (COP; 30 CFR 585.620 through 585.628), or General Activities Plan (GAP; 30 CFR 585.640 through 585.648), collectively referred to as ‘Plans’ in these guidelines, for BOEM review. Lessees must obtain BOEM approval prior to site assessment activities or the installation of any renewable energy facility, structure, or cable proposed on the Outer Continental Shelf (OCS). This document provides guidance pertaining to the requirements for a lessee to include a site investigation report, along with supporting data, as part of a Plan to evaluate the impact of seafloor and sub-seafloor conditions on the installation, operation, and structural integrity of a proposed project. BOEM

recommends following these guidelines to produce data that is of the quality necessary to characterize geological and geotechnical conditions and to identify hazardous features required for BOEM’s technical review of Plan submissions (30 CFR 585.613, 585.628, 585.648). Table 1 describes the main sections of this document, along with the most pertinent regulations. Lessees should be aware that the following table is not a comprehensive list of applicable regulations. Any activities proposed in a Plan will need to adhere to all regulations, statutes, and other legal binding authority applicable to geophysical and geotechnical data collection, hazard identification, and other offshore activities.

Table 1: Document topics cross-referenced with most pertinent regulations

Description	Section in Document	Regulations
Site assessment of hazards and geologic conditions	Section I. Site Characterization Investigations	30 CFR 585.610, 585.626, 585.646
Geophysical surveys	Section II. High-Resolution Geophysical Survey	30 CFR 585.610, 585.645, and used for 585.626
Geotechnical surveys	Section IV. Geotechnical Investigations	30 CFR 585.610, 585.626, 585.645

Lessees should refer to *Appendix B: Guidance for Site Characterization Survey Report and Data Deliverables* for information on report submissions and recommendations on formatting data submissions for each of BOEM’s regional offices receiving Plans for renewable energy development (30 CFR 585.607, 585.622, 585.642).

Lessees should be aware that BOEM has developed other guidelines related to regulations pertaining to archeological and environmental requirements that may necessitate higher data quality than the data needs for BOEM’s technical review. For example, archeological surveys call for higher resolution data and may therefore necessitate different equipment choices or survey design to achieve their intended purpose of cultural resource identification. Lessees are encouraged to review BOEM’s Guidance Portal for other pertinent guidelines, such as data collection recommendations for archeology and benthic habitats that may be more stringent to ensure geophysical and geotechnical data gathered is suitable for all intended purposes. BOEM guidelines have been and will continue to be updated periodically and the latest versions can be accessed on BOEM’s Guidance Portal (<https://www.boem.gov/about-boem/regulations-guidance/guidance-portal>).

This document replaces the guidance previously published on May 27, 2020. This update includes recommendations for geotechnical and geophysical surveys in deeper waters of the OCS where floating wind turbines are likely to be proposed instead of fixed bottom turbines. BOEM recognizes other methods and equipment choices not described in this document may be suitable and encourages lessees to contact BOEM with any questions, proposals, or concerns about using other equipment or technology for data collection or analysis.

If BOEM determines that the results of the surveys provided in a Plan are insufficient, BOEM may request the lessee to provide additional information. If a lessee fails to provide the requested information, as required by 30 CFR Part 585, BOEM may disapprove a SAP (30 CFR 585.613), COP (30 CFR 585.628), or GAP (30 CFR 585.648).

I. Site Characterization Investigations

This section provides guidance for producing an overall site investigation report that integrates the findings of your shallow hazards surveys and geologic surveys to determine potential to impacts to a proposed project (30 CFR 585.626). Proper siting is required to identify and mitigate potential risks to offshore facilities including foundations, moorings, and anchor systems for fixed and floating offshore wind turbines, as well as buried cables and other offshore infrastructure. Site characterization should account for the water depth and geology of the area, as well as the type of structure(s) proposed for installation.

BOEM recommends using a phased approach for data collection to prepare the submission of a comprehensive and fully integrated “overall site investigation report” (30 CFR 585.626). Site characterization investigations should consist of sequential phases: site reconnaissance, suitability assessment, and site-specific design. During the site reconnaissance phase, the lessee should gather and analyze existing knowledge using desktop studies and may consider performing a site reconnaissance survey, as described below in Section III.A.1., for the lease area and potential transmission corridor. Information gathered during site reconnaissance informs the next phase, determining the area of potential influence for suitability assessment. High resolution geophysical (HRG) investigations should capture the horizontal and vertical extent of seabed hazards, which could exist outside the area directly impacted from proposed project activities. For example, areas with steep seabed slopes and fine-grained sediments that occur outside the facility footprint, but within the lease area or cable route, could create potential geohazards, such as slope instability and turbidity flows that could influence the design of the project. If the region also experiences seismic activity, the influence of a geohazard may be compounded by liquefaction and slumping. Such hazards could pose significant risk to project facilities located some distance from the geohazard. Thus, all geohazards should be identified and mitigated by appropriate siting or other methodology to reduce risks. Once regional hazards are identified and a suitability assessment of the area of expected seabed disturbance has been analyzed, the scope of investigation may be reduced in area and depth to focus on site-specific design for foundation

and cable siting and installation. Plans should consider the regional geology, seafloor, and sub-surface conditions of the area, as well as best practices for safe installation and operation of proposed infrastructure to create a site-specific design that mitigates identified hazards. As reflected in Table 2 in Section III, each survey purpose should result in different levels of detail appropriate for the specific survey needs.

Information gathered during site reconnaissance should inform subsequent geophysical investigations needed initially to assess the suitability of the location for the proposed project and then later for site-specific design. Similarly, BOEM strongly recommends that lessees collect and analyze geophysical data in combination with previous studies and then use them to determine geotechnical investigation parameters and the methodology appropriate for creating a ground model. Additional guidance regarding planning a site investigation is provided in *Appendix A: Site Characterization Approach*, which also contains a list of additional recommended guidance documents and standards. Guidance for the collection of geophysical and geotechnical data, including laboratory testing and analysis, is provided in Sections III and IV, respectively.

The resulting marine site investigation report should include site-specific information to determine engineering feasibility and to evaluate all shallow hazards, geotechnical properties, and relevant geology, including, but not limited to, anthropogenic hazards, slope stability, seabed topography and morphology, rock outcrops and boulders, sub-cropping rock and buried boulders, bedforms, sediment mobility, hardgrounds, pockmarks, scour, soil type, stratigraphy, sediment variability, soil strength, deformation and consolidation, and information on other factors, such as cyclic loading and soil sensitivity. Regional hazards information should also be presented in the site characterization report, including seismology, volcanic activity, and the presence of gas, gas hydrates, diapirs, or over-pressured sands near the seabed surface.

II. Pre-Survey Coordination with BOEM

Lessees, in accordance with the stipulations in their lease, coordinate with BOEM prior to the initiation of survey activities through submission of a survey plan and may schedule a pre-survey meeting. This coordination assists in ensuring that surveys are designed and conducted in a manner that is likely to provide the information required for BOEM to review a plan. This coordination serves as an opportunity to address potential historic preservation issues, as well as any environmental or technical concerns, well in advance of the date a lessee intends to mobilize for a survey. This guidelines document focuses on technical project concerns. Lessees are referred to BOEM's [Guidance Portal](#) for other relevant renewable energy guidelines to ensure appropriate staff are engaged with BOEM early in the development process.

Pre-Survey coordination may include, but is not limited to, discussions regarding:

- the scope and purpose of the survey

- survey logistics (proposed survey area, dates, times, etc.)
- how potential hazards were identified and are expected to be assessed by the surveys
- data to be acquired including line spacing and expected resolution
- field techniques and equipment (specifications of data acquisition systems)
- new types of technology or alternative survey methods
- data processing and analysis
- data and information to be submitted
- maximum expected extent of bottom-disturbing activities (horizontal and vertical extents, types of activities contributing to bottom-disturbance, etc.)
- site-specific considerations

III. High-Resolution Geophysical Survey

High-resolution geophysical (HRG) surveys should be designed around the proposed end use of collected data. For example, data for archeological or environmental review purposes may have more stringent data quality needs, thus lessees should refer to BOEM's [Guidance Portal](#) under the Renewable Energy Guidance tab to find recommendations for archeologic and benthic surveys and other relevant guidance to ensure data quality meets all regulatory requirements. Keeping in mind the purpose of the survey, other factors that lessees should consider when planning an HRG survey include, but are not limited to, water depths, areal coverage, seismic penetration depth, line spacing, site conditions, resolution, and ground truthing techniques. BOEM will review the results and interpretation of HRG surveys to assess seafloor and sub-surface conditions and identify potential hazards to the proposed project, as well as potential impacts to the marine environment based on the proposed project's siting, design, construction, and operation.

For all survey campaigns, BOEM recommends that a lessee representative who is knowledgeable of survey operations, data acquisition techniques, installation requirements, and BOEM regulations be present during survey operations to oversee field activities, verify data quality, and provide real time assurance of adequate site conditions. Surface and subsurface hazards can require cable route or project siting changes, and it is often more efficient to make these determinations during survey operations to avoid additional survey and mobilization efforts.

A. Survey Coverage

The area surveyed should be sufficient to encompass a full sea floor search of the project area that may be affected by the activities proposed in the Plan, including all seafloor-disturbing activities. These activities may include, but are not limited to, geotechnical exploration (e.g., borings, vibracores, etc.), construction activities, installations (e.g., facilities, cable arrays, transmission cables, etc.), decommissioning, and any other activities associated with anchoring mechanisms or appurtenances. In areas of significant or regional geohazards (e.g., slumping,

faulting, slope stability, etc.), a broader survey area may be required to assess these hazards and their potential impact on the proposed facility.

BOEM recommends that the suitability assessment survey area be as large as practical in cases where uncertainty exists regarding proposed project locations or methodologies. A larger survey area will give the lessee greater flexibility for placement of structures and methods of construction, operation, maintenance, and decommissioning in the future.

The lessee should conduct the HRG survey along a series of regularly spaced and parallel track lines, as well as tie-lines running perpendicular to the track lines. The survey grid should be oriented with respect to the bathymetry, geologic structure, shallow features, transmission corridor, and proposed renewable energy structure locations, whenever possible. Line spacing and survey design should be site-specific. Survey line spacing is dependent upon a variety of factors, including water depth, equipment employed, and the desired resolution of the survey data. The information included in these guidelines provides only generalized, minimum recommendations. In some instances, tighter line spacing may be necessary to obtain the appropriate level of coverage and data quality to properly assess hazards, feasibility, and potential impacts.

1. Site Reconnaissance Survey

Although BOEM does not have specific recommendations for site reconnaissance survey methodologies, if a lessee would like to use site reconnaissance data as part of a phased survey approach, data resolution and the schedule of activities should be considered. Site reconnaissance surveys are designed for broad coverage at low resolution. Due to the lower data density with large line spacing, infill is often necessary to provide sufficient information to generate an acceptable site characterization report. The lessee should keep in mind the amount of time that occurs between the reconnaissance survey and the site characterization survey. The seabed is a dynamic environment, and if an extended period of time passes between survey efforts, the resulting data set may not be sufficient to support a Plan.

2. Suitability Assessment Survey

The suitability assessment survey area should provide coverage of the entire area that could be influenced by the proposed activity and allow assessment of any geohazards in the surrounding environment that could impact the proposed project. The area of influence includes the installation site and sufficient surrounding area to account for anchors or any other equipment that may disturb the seafloor during activities. Resolution and coverage of data acquired in the suitability assessment will be dependent on water depths and geohazards encountered or expected in and/or around the project area.

i. Lease area

The suitability assessment survey for the lease area should include areas experiencing bottom-disturbing activity and provide an assessment of any geohazards in the surrounding environment that could influence the following activities:

- geotechnical exploration
- manmade hazard identification
- installation of data collection structures (e.g., meteorological towers, some buoys or other site assessment equipment)
- the installation of renewable energy generators and any associated equipment and structures
- inter-array cable installation
- any other project-related activities that have the potential to impact the seafloor, such as jack-up construction vessels

BOEM recommends that, in order to achieve sufficient coverage of the area that could be physically influenced by lease activities, line spacing for suitability assessment HRG surveys (e.g., bathymetry, magnetometer/gradiometer, sonar, sub-bottom profiler, and seismic) should not exceed a primary line spacing of 150 m throughout the lease area in a grid survey pattern with a maximum tie-line spacing of 500 m. Tighter line spacing may be appropriate depending on site conditions, resolution requirements, or other factors.

ii. Transmission corridor

The transmission corridor runs within a project easement that connects onshore facilities to a lease area. The survey should cover the entire area of physical seabed disturbance, including areas where lay barge anchors may be placed during cable or pipeline installation. The suitability assessment survey should provide sufficient data to ensure that geohazards can be mitigated, including potential impacts from geohazards identified outside the transmission corridor. These guidelines refer to the portion of the project easement located on the OCS. If a transmission corridor passes through state waters, it will be subject to the applicable state regulations.

The HRG survey pattern along the transmission route should capture the proposed cable route centerline and offset parallel lines on either side with a maximum line spacing of 150 m, however lessees should ensure data also conforms with archeology and other BOEM guidelines. A minimum of two offset parallel lines are recommended; however, the ultimate number of offset parallel lines may be increased to provide sufficient coverage of the entire area that could be physically disturbed by installation activities.

The survey corridor width can vary with water depth, increasing in width as the seabed deepens. BOEM recommends a minimum corridor width of 2-4 times water depth to allow for sufficient characterization in case cable repair is required and to provide flexibility in cable routing. If hazards or obstructions are identified during survey operations, it may be necessary to increase the width of the survey corridor or adjust the corridor path to allow for safe passage of the transmission lines. A minimum of three equidistant tie-lines should be surveyed along the cable route and the tie-lines should not exceed a line spacing of 500 m.

3. Site-Specific Design Survey

The site-specific design survey may include additional detail and higher data resolution than the suitability assessment survey to ensure foundation design feasibility. Tighter line spacing may be appropriate depending on site conditions. The site-specific design survey should include areas expected to experience bottom-disturbing activity related to the following activities:

- geotechnical exploration
- installation of data collection structures (e.g., meteorological towers or some buoys or other site assessment equipment)
- the installation of renewable energy generators and any associated equipment and structures
- inter-array cable installation
- export cable installation
- any other project-related activities that have the potential to impact the seafloor, such as jack-up construction vessels
- facilities including foundations, moorings, and anchor systems for fixed and floating offshore wind turbines

B. Data Acquisition Instrumentation

The instrumentation should be deployed in a manner that minimizes interference between systems, results in the least environmental impact practicable, and records all data at the optimal sampling rate of the equipment for the depth and sweep rates. All data recorders should interface with the navigation system to ensure proper integration of positioning information. All instruments should perform to the manufacturer's specifications, and all recorded data should be readable, accurate, and contain sufficient metadata. The specifications provided below apply to the suitability assessment survey and the site-specific design survey.

1. Navigation and Positioning

The navigation system should continuously determine the surface position of the survey vessel. Uncertainty of the navigation system and quality control methods should conform to the

requirements of Special Order Surveys, as defined by the International Hydrographic Organization (IHO), (IHO Standards for Hydrographic Surveys, 2020). For special order surveys, the total allowable horizontal uncertainty at a 95% confidence level is 2 m. Position fixes should be digitally logged continuously along the vessel track. Geodesy information should be clearly presented and consistent across all data types.

BOEM recommends the use of a vessel-mounted acoustic positioning system, such as ultra-short baseline (USBL) positioning, to improve the reliability of positioning towed sensors. If a vessel-mounted acoustic positioning system is not used, layback distances should be calculated, recorded, and cross-checked with feature matching techniques to provide accurate positioning of towed sensors. Total horizontal uncertainty for equipment positioning should be better than 10 m.

2. Bathymetry

BOEM encourages the use of swath bathymetry systems to obtain full bathymetric data coverage of the project area. The system should be set to record with a sweep appropriate to the range of water depths expected and in a manner that ensures a full sea floor search. Data should be consistent with the IHO Special Order survey standards from 0 to 40 m water depths and with 1a survey standards beyond 40 m water depth (IHO Standards for Hydrographic Surveys, 2020). Lessees should also follow IHO hydrographic survey guidelines for quality control and data processing (IHO Standards for Hydrographic Surveys, 2020).

In areas of greater water depth, BOEM recommends a tiered approach to data acquisition (as described in Table 2). No recommended resolution is provided for surveys used for site reconnaissance to encourage lessees to incorporate all available and relevant information into desktop studies. For suitability assessment surveys, BOEM recommends the use of a system that can produce gridded data with resolution of at least 0.5 m in water depths shallower than 50 m and 1 m or 2% of water depth resolution in water depths beyond 50 m. For site-specific design footprint areas where ground disturbing activities are planned (e.g., floating anchor footprint, anchor chain drag areas), BOEM recommends the use of a system that can produce gridded data with resolution of 1 m in water depths beyond 100 m to ensure potential hazards are identified. Backscatter values from the seabed returns should also be logged and processed as appropriate.

Table 2: Recommended resolution by survey purpose and water depth

Survey Purpose	Water Depth (m)	Gridded Data Resolution (m)
Suitability Assessment	0-50m	0.5 m
	50m-100m	1 m or 2% WD

	>100m	2% WD
Site-Specific Design	0-100m	0.5 m
	>100m	1 m

To improve bathymetric data accuracy, the system should be calibrated, and appropriate corrections applied to the data. A heave compensator should be used in conjunction with the system to remove the effects of vessel movement from the data. Water column sound velocity should be measured at regular intervals using a conductivity temperature depth (CTD) sensor or velocity probe capable of recording the maximum water depth expected in the survey area. Water depths should be corrected for vessel draft and tidal level and appropriately referenced to mean lower low water (MLLW).

Bathymetric light detection and ranging (LIDAR) methods are often used in areas with complex and rugged shorelines and provide seamless coverage between the land and sea. These systems are typically aircraft mounted and use two different frequencies of laser pulses to determine water depths and shoreline morphology. Depending on water clarity, LIDAR systems can be cost effective in extensive areas of shallow water, typically less than 30 m deep, where traditional survey methods are difficult and labor intensive. LIDAR has been successfully used to depths of 50 m in very clear waters.

3. Magnetometer/Gradiometer

A magnetometer and/or gradiometer should be employed to detect ferrous metals or other magnetically susceptible materials. The magnetometer should be towed no more than 6 m above the seafloor and in a way that minimizes interference from the vessel hull and the other survey instruments. A depth sensor or altimeter should be used to ensure the proper height of the magnetometer.

Magnetometer sensitivity should be 1.0 gamma (γ), or one nanotesla (nT), or less, and the data sampling interval should not exceed one second. Background noise level should not exceed 3 γ peak-to-peak. Magnetometer data should be recorded on a digital medium in such a way that the data can be linked electronically to the positioning and depth data. Time, position, altitude, and recorder speed should be annotated on all output data.

All pipeline and in-service cable crossing locations should be identified. If the cables are not observed in the bathymetric, side-scan sonar, or sub-bottom profiler data then BOEM recommends the use of a magnetometer to determine the precise location of the proposed cable crossing and in-service cable.

4. Sonar

Side-scan sonars, or similar technologies like synthetic aperture sonar, provide an acoustic picture of the seabed by measuring the amplitude of the backscattered return signals. This backscattered photo-like image shows regions of enhanced acoustic reflectivity and absorption, as well as acoustic shadows from objects with both positive and negative relief. Because the changes in acoustic backscatter are relative, it is necessary to calibrate the data by ground truthing or by collecting sediment samples from regions of different acoustic character.

BOEM recommends the use of a towed, dual-channel, dual-frequency side-scan sonar system to provide continuous planimetric imagery of the seafloor in order to characterize seabed habitats and sediment distribution, locate surficial boulders, and identify anthropogenic hazards and cultural resources. To provide sufficient definition of features, BOEM encourages the use of a system that operates at as high a frequency as practical based on the factors of line spacing, instrument range, and water depth. Systems with operational frequencies >200 kHz are generally recommended for site characterization, although higher operational frequencies may be required to resolve discrete targets.

The survey line spacing and instrument range should be designed to provide 100% coverage of the seafloor and a resolution of small, discrete targets 0.5 m to 1.0 m in diameter at maximum range similar to bathymetric resolution recommendations provided in Table 2. In general, the side-scan sonar sensor should be towed above the seafloor at a distance that is 10% to 20% of the range of the instrument, however the distance will depend on the power of the instrument.

The data should be digitally recorded and visually displayed to monitor data quality and identify targets of interest during acquisition. The data should be post-processed to improve data quality for interpretation and mapping. For example, adjusting for slant range effects and variable speed along line is appropriate. Both individual lines and mosaics should be output at gridded data resolutions provided in Table 2.

5. Sub-bottom Profilers

BOEM recommends collection of sedimentary structure data 10 m beyond the depth of disturbance. For example, penetration depths should be 10 m greater than the maximum depth of disturbance from a meteorological tower or wind turbine foundation, the maximum expected anchor/spud penetration for an anchored rig or work barge, or the depth of cable burial. BOEM recommends the collection of 0.3 m-resolution data in the upper 10 m of sediments. There are several equipment choices and methodologies that can provide sufficient subsurface stratigraphy information depending on the regional geology, contractor expertise, and project design.

It is important to note that these systems rely on the interpretation of reflections from acoustic impedance changes that may or may not correlate to geologic formation boundaries. Often the

acoustic impedance changes because of sedimentary variations, but other factors, such as consolidation, pore water, biologic colonies, and gas presence, can affect the acoustic character or severely reduce penetration. Because the information on sediment characteristics gathered from sub-bottom profiles is more qualitative than quantitative, the data needs ground truthing, or calibration, from subsurface sediment samples, such as cores or borings as described in the following sub-part of this section 6. *Seabed Sampling*, as well as Section IV explaining geotechnical investigations.

When choosing sub-bottom profiler systems, the lessee should be aware that the National Marine Fisheries Service (NMFS) currently considers sound levels above 160 dB re 1 μ Pa (RMS) to constitute Level B harassment under the Marine Mammal Protection Act. Sounds above 180 dB re 1 μ Pa (RMS) are considered Level A harassment. Thus, BOEM recommends that, where practicable, sound should be kept below these levels.

Note that NMFS requires marine mammal monitoring plans for sound levels above these thresholds. Earlier advancement of offshore wind in the Atlantic led to informal programmatic consultation between BOEM and NMFS. The resulting Letter of Concurrence (LoC) issued by NMFS June 2021 revises mitigation, monitoring, and reporting conditions for non-ESA-listed marine mammals.¹ BOEM intends to require data collection activities for Atlantic OCS leases comply with Best Management Practices and Project Design Criteria outlined in the LoC.² Similar efforts may occur in other regions to ensure all lease conditions are up to current practice and to promote consistent and efficient review of survey plans.³ The Record of Decision for the Atlantic OCS Proposed Geological and Geophysical Activities Mid Atlantic and South Atlantic Planning Areas, Final Programmatic Environmental Impact Statement requires BOEM include specific mitigation measures for HRG activities undertaken for renewable energy development in the leases covering planning areas in the Mid- Atlantic and South Atlantic.⁴

i. High Frequency Sonar Systems

High-frequency acoustic sub-bottom profiler data may be used to determine the shallow sediment distribution, assess cable burial feasibility, and identify subsurface features. The systems provide continuous and very high-resolution data on subsurface geological features

¹ The Letter of Concurrence can be accessed: <https://media.fisheries.noaa.gov/2021-12/OSW-surveys-NLAA-programmatic-rev-1-2021-09-30-508-.pdf>

² BOEM's guidance for Best Management Practices and Project Design Criteria is available online: <https://www.boem.gov/sites/default/files/documents/PDCs%20and%20BMPs%20for%20Atlantic%20Data%20Collection%2011222021.pdf>

³ See published FAQs on the programmatic consultation for more information:

<https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/Protected-Species-FAQ.pdf>

⁴ DEPARTMENT OF INTERIOR, BUREAU OF OCEAN ENERGY MGMT., RECORD OF DECISION, ATLANTIC OCS PROPOSED GEOLOGICAL AND GEOPHYSICAL ACTIVITIES MID ATLANTIC AND SOUTH ATLANTIC PLANNING AREAS, FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT 1 (2014), available at

<https://www.boem.gov/sites/default/files/oil-and-gas-energy-program/GOMR/Record-of-Decision-Atlantic-G-G.pdf>

within the uppermost section of sediment. The sub-bottom profiler system, CHIRP for example, should be capable of achieving a resolution of vertical bed separation of at least 0.3 m in the uppermost sediments, depending on the substrate.

In regions where traditional sub-bottom profiler frequency ranges (2 to 16 kHz) achieve less than 10 m of penetration, BOEM recommends either reducing the frequency range of the system and/or the use of a lower frequency (0.5 to 12 kHz) system.

The data should be digitally recorded, allow signal processing to improve data quality, and allow the export of data to a workstation for integrated interpretation and mapping.

ii. Medium Penetration Seismic Systems

A medium penetration seismic system, such as a boomer, bubble pulser, or other low frequency system, can be used to provide information on sedimentary structure that exceeds the depth limitations of sonar systems. The system should be capable of penetrating greater than 10 m beyond any potential disturbance depth with a vertical resolution of at least 3 m. The seismic source should deliver a simple, stable, and repeatable signature that is close to minimum phase output with usable frequency content.

Based on the results of previous surveys conducted in support of offshore renewable energy projects, BOEM has found that multi-channel streamer systems generally provide the highest resolution data when using a 16- to 48-channel streamer system positioned less than 1 m from the sea surface system and a dual or triple plate source. The data should be processed to improve image quality by suppressing or removing multiples and enhancing the signal to noise ratio.

Lessees should be aware that acquisition and processing of shallow water multi-channel seismic data is highly technical and complex. Therefore, the collection of multi-channel data may or may not hold a strong advantage over single-channel systems depending on the survey objective, contractor expertise, project design, and site conditions.

Medium penetration seismic data should contain minimal data artifacts and minimal over printing of seabed multiples to allow for the identification of laterally continuous horizons 10 m beyond the maximum depth of disturbance.

6. Seabed Sampling

Major components of the geologic interpretation include the description of the surficial and sub-surface sediments, thickness of the various sediment deposits, and identification of distinct horizons. Therefore, BOEM recommends the collection of the borings or vibracores as part of the geophysical survey effort for ground truthing the geophysical data. Furthermore, grab samples collected as part of the benthic habitat survey should also be used for interpretation of

surficial sediment conditions and included in the site characterization report. Lessees are referred to BOEM's [Guidance Portal](#) for the appropriate recommendations for sampling methodology and requirements for benthic and other necessary survey campaigns. The following section focuses on recommendations for geotechnical data needed to support project feasibility.

IV. Geotechnical Investigations

Seabed samples are required for a variety of reasons, including ground-truthing interpreted geophysical data, geotechnical investigations, benthic analysis, and archaeological interpretation. It is recommended that the most stringent sampling guidelines be followed to ensure the samples are of sufficient quality to be used for all intended purposes. The geotechnical investigation needs to provide an adequate level of subsurface information to assess potential seabed impacts, as well as ensure installation feasibility for each planned structure that is founded in the seafloor. This section provides guidance on determining the scope of a geotechnical survey, as well as on the collection, testing, and analysis recommended to support project feasibility. Lessees should refer to BOEM's [Guidance Portal](#) for benthic and archaeological guidelines as well as other relevant documents to ensure surveys are designed to meet all regulatory requirements.

A. Scope of Geotechnical Investigation

The scope of the geotechnical investigation should be based on the results of desktop studies, geophysical surveys and other previous investigations, as well as the location and approximate dimensions of the proposed infrastructure to be installed on the seabed. Integrated with geophysical surveys and initial studies, the geotechnical investigation(s) should allow for a thorough understanding of the stratigraphic and geoengineering properties of the sediment that may affect the foundations or anchoring systems of the structures including potential geohazards, such as faulting, ground shaking, liquefaction, submarine landslides and slumping, erosion and scour.

Geotechnical investigations may be performed in phases to provide the appropriate level of geotechnical design parameters and recommendations for the project as it progresses from preliminary to final design stage. Depending on the adequacy of desktop studies and geophysical investigations, some preliminary borings may be useful in determining the initial project layout and design. If there are numerous geohazards or extensive heterogeneity in the survey area, the geotechnical investigation may include additional sampling and analyses to identify the vertical and horizontal extent of geohazards and characterize site conditions. Conversely, if initial investigations demonstrate that an area is relatively free of hazards and homogeneous, fewer geotechnical investigations may be sufficient to characterize the site (30 CFR 585.626). Sampling and testing of foundation sediments within any proposed transmission corridor should also be sufficient to thoroughly categorize sub-seafloor conditions.

The proposed type of foundation(s) will also affect the scope of the geotechnical investigation. For example, monopiles are typically governed by lateral capacities and the damping characteristics of the sediments, while jacket or tripod foundations will be governed by vertical capacities. Anchors for floating structures are designed primarily on type and shear strength of the sediments. Limited onboard laboratory tests and preliminary pile design calculations during exploration can help direct the final scope of the exploration to make sure it is sufficient. Geotechnical investigations should also include pile driving feasibility studies, especially in dense sandy, gravelly, or glauconitic sediments. Noise mitigation requirements for large pile driving hammers are becoming more important as larger foundations require hammers with greater energy. Ongoing research on long term cyclic loading effects on foundations may result in revisions to current pile capacity analyses and should be closely followed and utilized when appropriate.

B. Geotechnical Exploration

A geotechnical exploration program should consist of a combination of drilling and sampling of the sediments using boring methods and in-situ methods, such as cone penetrometer (CPT) probes using the results of the HRG survey and prior analysis to select locations and depths of soil samples while avoiding benthic habitats, archaeological resources, existing infrastructure, and manmade hazards such as munitions and explosives of concern (MEC). The type of exploration method should be based on the anticipated sediment types and characteristics, as well as the proposed foundation, anchorage, or other structure types and dimensions.

The principal purposes of the exploration activities are to: (1) assess the suitability of sediments to support the renewable energy structure or associated transmission cable under all operational and environmental conditions including potential geohazards; and (2) document soil characteristics necessary for design and installation of all structures and transmission cables.

Jack-up platforms or specialized vessels with heave compensating systems should be used, depending on the water depth, ocean conditions, and type of exploration method. Seabed founded sampling devices or remote operated vehicles may also be appropriate, especially in deeper waters.

Geotechnical explorations should provide for:

- Adequate in-situ testing, boring, or sampling (i.e., cone penetrometer test (CPT), drilled borings, vibracores, etc.) at each foundation or anchor location, at 1.0 km intervals along the proposed transmission cable route to shore, and include examination of all important sediment and rock strata to determine their strength classification, deformation properties, and dynamic characteristics.

- A sufficient number of “deep” borings (with soil sampling and testing) within the project area to determine the vertical and lateral variation in seabed conditions and to provide the relevant geotechnical data required for facility design.
 - The suggested soil boring depth for “deep boring” should be at least 10 m deeper than the design penetration of the foundation or anchor. If geohazards are present, the necessary depth of investigation is dependent on the nature of the geohazard. For example, to assess slope stability, investigations may need to penetrate the seafloor to define higher strength sediments that would define a potential slip circle. There may also be conditions, such as very soft or unstable sediments that warrant greater depths.
 - The number of deep borings will depend on the heterogeneity of the area. In some cases, the number of borings or probes may be reduced if relatively uniform conditions are present, whereas areas with highly variable subsea soil conditions may need a higher number of deep borings to adequately characterize the stratigraphic and geoengineering properties for each foundation design (30 CFR 585.626). Depending on the sediment and geologic conditions, it may be appropriate to use CPT probes instead of deep borings at selected locations. The depth of deep borings or CPT probes may be reduced if very dense sediment or bedrock is encountered before reaching the recommended depth.

Any variation from the recommended number of borings or drilling depth should be dependent on the conditions encountered.

C. Laboratory Testing

Selected samples obtained from the borings should be subjected to laboratory testing to aid in classification and to allow determination of the geotechnical properties necessary for design, such as unit weight, grain size distribution, specific gravity, compressibility, density, shear strength, and dynamic properties for assessment of seismic and cyclic loading conditions, as well as analysis of geohazards such as slope stability and liquefaction.

The laboratory tests should be performed in accordance with American Society for Testing and Materials (ASTM) standards, and the laboratory should maintain accreditation from the US Army Corps of Engineers, the American Association of State Highway and Transportation Officials Materials Reference Laboratory, or equivalent. For site characterization, BOEM recommends following ASTM soil classification system standards D2487 and D2488.

D. Geotechnical Engineering Analyses

Geotechnical investigations should be able to:

- Provide analysis of in-situ and laboratory soil test data to estimate foundation soil response to anticipated static and dynamic loads.
- Determine foundation embedment depth and predict susceptibility of the foundation to liquefaction and other geohazards.
- Evaluate the potential for seafloor erosion and scour in the context of empirically derived current velocity data for the project area.
- Be integrated with the results of the geophysical investigations to provide a comprehensive analysis of geologic hazards that may affect the site.

In some cases, the information gathered during geotechnical investigation for engineering or siting purposes may provide information that informs the archaeological investigation, even if not explicitly designed to do so. BOEM encourages lessees to coordinate with their Qualified Marine Archaeologist (QMA) during the planning for geotechnical testing and, to the extent possible, to incorporate the relevant results of geotechnical investigation into the archaeological analysis. This may include visual inspection of vibracores for the presence of intact paleosols, subsampling of organic materials for paleoenvironmental analysis, radiometric dating, or other applicable analyses. (See the archeology guidelines under the Renewable Energy Guidance tab on BOEM's [Guidance Portal](#) for further details).

V. Contact Information

For further information or inquiries please contact the Office of Renewable Energy Programs at (703) 787-1300 or renewable_reporting@boem.gov for Atlantic leases, for leases in the Gulf of Mexico, please contact the Office of Resource Evaluation at 504-736-2710 or GeohazardGOMR@Boem.gov, and for Pacific leases please contact 805-384-6305 or renewableenergypocs@boem.gov.

References

- American Society for Testing and Materials, ASTM D2488 Standard Practice for Description and Identification of Soils (Unified Soil Classification System), Book of Standards, v04.08.
- American Society for Testing and Materials, ASTM D2487 Standard Practice for Classification of Soil for Engineering Purposes, Book of Standards, v04.08.
- Ashley, G.M., 1990. Classification of large-scale subaqueous bedforms; a new look at an old problem. *Journal of Sedimentary Research*, 60(1), pp.160-172. Defines Sandwaves and megaripples in Table 5, but uses different wavelengths

- Chiocci, F. L., Cattaneo, A., & Urgeles, R. (2011). Seafloor mapping for geohazard assessment: State of the art. *Marine Geophysical Research*, 32(1–2), 1–11.
<https://doi.org/10.1007/s11001-011-9139-8>
- Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments, the Society for Underwater Technology, 2014
- Geotechnical & Geophysical Investigations for Offshore and Nearshore Developments, International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), September 2005.
- International Cable Protection Committee (ICPC) Recommendations 1 through 14 (<http://www.iscpc.org/>).
- International Hydrographic Organization, IHO Standards for Hydrographic Surveys, Special Publication S-44 Edition 6.1.0, 2020.
- Marine Soil Investigations, NORSOK Standard G-001, October 2004
- Recommended Practice DNV-RP-J301, Subsea Power Cables in Shallow Water Renewable Energy Application, DNV, 2014.
- Standard for Geotechnical Site and Route Surveys, Minimum Requirements for the Foundation of Offshore Wind Turbines, BSH, 2003.

Appendix A

Best Management Practices for Site Characterization

To help facilitate successful investigations BOEM would like to offer some recommended Best Management Practices to lessees for their site characterization activities.

Site Characterization Approach

Lessees are encouraged to use a phased approach for site characterization. Investigations should begin with desktop studies and site reconnaissance surveys that inform subsequent geophysical data collection, which is then used to guide the geotechnical investigations. The submitted report should provide data along with appropriate analysis to demonstrate how the proposed infrastructure is feasible given the site-specific conditions.

BOEM recommends that lessees initiate a desktop study at the beginning of their project planning. Desktop studies review available site-specific information about general conditions, seismic activity, existing geotechnical and geophysical data, meteorological and oceanographic data, anthropogenic hazards (such as fishing methods and areas, cables, pipelines, lease blocks, and shipwrecks), identify marine sanctuaries and protected areas. Desktop studies can also reveal local, state, and federal regulations and required permitting processes.

Data collected during site reconnaissance studies may identify potential obstacles to project success, inform the lessee about regional site conditions, and help guide survey equipment choices and design. Additionally, site reconnaissance surveys can be helpful between the desktop study and suitability assessment phase because they typically collect lower resolution data at greater line spacing, thus requiring less financial investment but providing information to assist in planning subsequent geophysical and geotechnical investigations.

The geophysical surveys should be tailored to the various phases of acquisition and to site-specific conditions, risks, and hazards. For example, a site reconnaissance survey could reveal a laterally extensive submarine landslide scarp that extends from the continental shelf to the continental slope. Under such a circumstance, a suitability assessment survey would provide an additional level of detail that is needed to analyze and assess the feature's potential to impact the project area. A site-specific design survey would provide additional resolution in areas of bottom disturbing activities to ensure that slope stability or other geohazards would not impact the placement of an anchor mooring.

As described in the previous example, the lateral extent and depth of the seabed potentially impacted by hazards can be much larger than the area of seabed disturbed by a foundation or anchor system. When lessees design their survey and make equipment choices based on

anticipated site conditions, they can collect higher quality data, reduce redundancy, and more efficiently use vessel time. Such efforts may also generate information that reduces data processing, as well as improves interpretation and analysis efforts.

Furthermore, geotechnical investigation parameters should be defined using the findings of the geophysical investigation. Observed and anticipated sediment conditions, combined with project-specific needs for the proposed infrastructure, determine the appropriate geotechnical exploration methodology and spatial distribution for adequate site characterization. The data from the desktop study, geophysical survey, and geotechnical investigations combined, inform the lessee and BOEM about site conditions and geohazards in the project area.

Geophysical and geotechnical investigations are highly specialized, and each project and situation is different. Therefore, BOEM reviews survey plans on a case-by-case basis to promote the highest likelihood of achieving the data quality recommendations.

Additional Guidance Documents

Lessees are encouraged to use the following documents for additional guidance in performing site characterization surveys and activities:

- Geotechnical & Geophysical Investigations for Offshore and Nearshore Developments, International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), September 2005
- Marine Soil Investigations, NORSOK Standard G-001, October 2004
- Recommended Practice DNV-RP-J301, Subsea Power Cables in Shallow Water Renewable Energy Application, DNV, 2014
- Standard for Geotechnical Site and Route Surveys, Minimum Requirements for the Foundation of Offshore Wind Turbines, BSH, 2003
- International Hydrographic Organization, IHO Standards for Hydrographic Surveys, S-44 Edition 6.1.0, 2020
- International Cable Protection Committee (ICPC) Recommendations 1 through 14
- ASTM D2488 Standard Practice for Description and Identification of Soils (Unified Soil Classification System), Book of Standards, v04.08
- ASTM D2487 Standard Practice for Classification of Soil for Engineering Purposes, Book of Standards, v04.08
- Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments, the Society for Underwater Technology, 2014

In case of a conflict between these BOEM guidelines and the above-referenced documents, the BOEM guidelines should be given precedence.

Appendix B

Guidance for Site Characterization Survey Report and Data Deliverables

The lessee should present the overall site investigation in a comprehensive site characterization report along with the supporting data. The overall site investigation results include the integration of surface and subsurface geophysical data analysis, geotechnical investigation results, suitability assessment survey results, site-specific design survey results, and any other relevant information used to characterize the area.

The lessee should make best efforts to avoid numerous revisions and supplemental data submittals. If additional data is collected for site characterization after the submittal of a site characterization report, the main body of the report should be updated to include new data and/or analysis, all affected figures and charts should be updated, and a new revised document should be submitted to BOEM.

One of the best methodologies for review and analysis of geophysical and geotechnical data is a 3-D geologic model. A 3-D geologic model brings together bathymetric data, surficial data imagery, sub-bottom data imagery, and sediment samples and provides the viewer with an opportunity to see all the data in a single space. This technique can improve understanding and reduce the time and effort to review site characterization conclusions and analysis.

The lessee must submit one electronic version of the plan or application (30 CFR 585.607, 585.622, and 585.642). All submitted documents must be 508 compliant and lessees should provide digital versions, such as Adobe PDF, of all large format map layouts. The digital version of the report should be submitted on an external hard drive or secure file transfer protocol site. All data submitted by the lessee is expected to contain comprehensive metadata compatible with IHO survey standards as appropriate.

Lessees are encouraged to provide the results of the overall site characterization activities in a report containing the following:

1. Description of Surveyed Area OCS lease number(s), block number(s), and lease area(s); and minimum and maximum water depths of the survey area.
2. Reproducible (photocopy) geographic area map (generally page size = 8.5" x 11" and/or 11" x 17" fold-out), showing proposed facility and any transmission cable route relative to nearby geographic features.
3. Personnel list noting functional responsibilities (i.e., a list of the individuals involved in survey planning, fieldwork, and report preparation, and a brief description of their duties).

4. A summary of field operations, including unusual incidents.

5. Technical specifications of survey equipment and procedures:

- A brief description of the navigation system with a statement of its estimated accuracy for the surveyed area.
- A brief description of survey instrumentation including scale and sensitivity settings, sampling rates, and tow heights above the seafloor for the magnetometer and side scan sonar sensors.
- A diagram of the survey vessel, including its size, sensor configuration, navigation antenna location, cable lengths, and all offsets in X, Y, and Z directions from sensors to navigation antenna and/or the central reference point.
- Vessel speed, course changes, sea state, and weather conditions.
- A complete copy of the daily survey operations log (for the entire duration of the mobilization(s) and for each system used in the survey(s)).
- A description of survey procedures, including a statement of survey and record quality, a comparison of data from survey line crossings, and a discussion of any problems that may have affected the ability of the geophysicist or geologist to identify and analyze hazards in the surveyed area.
- Interpreted sample of each instrument record.

6. Route Position List

The transmission cable route should be provided as a Route Position List (RPL) in both tabular and geographic information system (GIS) shapefile formats. The RPL and GIS formats should include information regarding installation or changes along the route (cable armoring, burial depths, alter courses where the cable changes direction, including turn angle, cable crossings, etc.).

Lessees should provide a copy of the post survey planned RPL in MS Excel compatible tabular format and in accordance with ICPC Recommendation 11. Typically, the header should include the following: system name, segment names, cable owners, RPL owner, RPL status, version number, issue date, datum, ellipsoid, depth units, vertical datum, and burial depth units. The body of the RPL should include the following items:

- Event number
- Event label
- As laid date
- Latitude degrees
- Latitude minutes
- Latitude direction
- Longitude degrees
- Longitude minutes
- Longitude direction

- Water depth
- Route distance
- Cumulative route distance
- Slack
- Cable distance
- Cumulative cable distance
- Cable type
- Burial depth

Events can include the following:

- Beach manhole (BMH)
- Alter course positions (A/C)
- Proposed Wind Turbine Generator (WTG) locations
- Any changes in cable protection or engineering design
- All cable and pipeline crossings and crossing angles
- Entry and exit positions for United Nations Law of the Sea and United States of America federally recognized waters including State Waters, Territorial Waters, Contiguous Zones and Exclusive Economic Zones.
- Entry and exit positions for hazard areas including, but not limited to: military exercise area, dumping zones, explosive ordnance zones, fishing zones, anchorages, shipping lanes, cable areas and lease blocks.

7. Charts

Lessees should annotate all charts with linear bar-scales (feet and meters), geographic and planar coordinates (latitude and longitude, eastings and northings), lease boundaries, lease numbers, proposed facility site(s) and cable transmission routes. Lessees are referred to the Renewable Energy Guidance tab on BOEM's [Guidance Portal](#) for further information on providing digital spatial data to BOEM for Plans submitted for the Pacific and Atlantic regions. Lessees submitting digital data for renewable projects in the Gulf of Mexico should refer to Appendices 1 (BOEM Recommended Format for Digital Maps) and 2 (BOEM Recommended Standard SEG-Y Submittal Format) of BOEM NTL No. 2022- G01 to ensure each BOEM region obtains information formatted appropriately for their database.

Lessees should submit the following set of charts at a standard scale (generally 1:10,000) and oriented to true north, except the Alignment Sheets, which are aligned with the cable route:

1. Navigation Post-Plot Chart(s) of the surveyed area, showing survey lines and directions, and navigational information at intervals of no more than 150 meters.
2. Bathymetry Chart(s), including imagery, contours, and slope gradients greater than 10 degrees. Contour intervals should be dependent on water depths and seafloor morphology and generally range from 0.3 m to 10 m.

3. Geologic Surface Features and Shallow Structure Chart(s), including: side scan sonar contacts, magnetic anomalies, seabed sediment classification, seabed features, shallow geologic structure interpreted from high frequency sub-bottom profiler (SBP) data, seabed sample locations and descriptions, and all identified hazards.
4. Subsurface Structure Chart(s), including subsurface structure of horizons identified in subsurface geologic investigations including relevant core, deep boring and CPT locations and results as practical.
5. Magnetic Contour Chart(s) including details on symbology that are provided in the archeology guidelines under the Renewable Energy Guidance tab on BOEM's [Guidance Portal](#).
6. Shallow Isopach Chart(s) showing thickness, in meters, of unconsolidated Holocene/late-Pleistocene sediments.
7. Subsurface Horizon Elevation Chart(s) showing elevation, in meters, of the horizons identified in the medium penetration seismic data.
8. Alignment Sheet(s) that have at least 3 panels: (1) geologic features and shallow geology, (2) bathymetry, and (3) seabed profile with digitized reflectors from the SBP data. All panels should be presented with the transmission route in the horizontal position and include the cable route, KPs, and survey extents. When the route changes direction, the panel view should rotate to keep the route horizontal and show sufficient overlap of data. All requirements listed for the geologic features maps are to be included in the geologic features and shallow geology panel. The bathymetry panel should contain contours and any routing information relevant to the installation or provided on the route position list. The seabed profile panel should contain slope indicators at the steepest point along the profile and any locations where the slope is sufficiently large and considered a hazard to the cable (typically greater than 5 degrees). BOEM recommends presenting the sub-bottom profile imagery from the nearest line on the seabed profiler panel, if this is not practical, the lessee may present the digitized reflectors used for interpretation. Seabed sample results are necessary on both the geologic features and seabed profile panels.

A standardized legend, map key, chart name and number, total number of charts, survey information panel, and location maps should be presented on all charts.

In all sediment descriptions, the primary sediment type should be in all capital letters and minor sediment constituents should be in lower case. This formatting should be included in all charts, sample logs, and figures presenting sediment descriptions and interpretations.

BOEM recommends that submitted charts contain the following symbology:

- Distinct hatch/color for the following surficial conditions where observed: coral, gas seepage, boulder field, clay, silt, sand, gravel, cobbles and boulders, sub-cropping rock (less than 0.5 m sediment over rock or hardground), rock, and hardground with very dense or consolidated sediments.
- Bathymetric and isopach contours with major and minor line styles and colors.
- Coverage boundaries.

- Annotated slope gradient symbols with direction where the seabed slope is greater than 10 degrees.
- Different line styles for sediment boundaries and inferred sediment boundaries.
- Isolated rock outcrop symbols annotated with height above seabed.
- Pockmark symbols annotated with diameter and depth.
- Seabed depression line style.
- Scarps annotated with height.
- Distinct line styles for channels and ridges.
- Bedform symbols annotated with wavelength and height.
- Subsurface faults with depth annotated along symbol/line style.
- Seabed scars.
- Feature descriptions with leaders pointing to features or areas.
- Distinguishable symbols for sediment samples and testing including cores, grab samples, deep borings, probes and CPTs; annotated with the sample ID.
- Magnetic anomalies annotated with ID.
- Sonar contacts annotated with contact ID.
- Linear sonar contacts, with distinctions for observed contacts and inferred locations.
- Wrecks, both charted and observed.
- Distinguishable symbols for in-service, out-of-service cables.
- Pipelines.
- Sample log that includes both illustrations and descriptions of all sediment samples collected.
- CPT log showing results and interpretation.

If additional features to those listed below are observed, they should also be presented on charts and identified in the legend with appropriate symbology.

8. Site Conditions and Hazards Assessment

The site conditions and hazards assessment portion of the report presents the interpretation of geophysical data and geotechnical investigations. This section should include a description of the conditions and an assessment of the potential for hazards within the surveyed area. Topics of discussion should include, but not be limited to:

- General geological background/setting.
- Sediment type classification.
- Sediment thickness.
- Seabed features including but not limited to: scarps, channels, ridges, bedforms, exposed rocky areas, boulders (surface and buried), pockmarks and/or depressions, and seabed scars.
- Bedform symbols with wavelength and height and discussed in the following terms (Ashley, G.M., 1990):

Table B-1: Bedform definitions

Name	Wavelength (meters)	Height (meters)
Sandwave	> 60	> 1.5
Megaripple	5 - 60	0.5 – 1.5
Ripple	< 5	< 0.5

- Slope gradients discussed as follows:

Table B-2: Slope gradient definitions

Classification	Gradient (Degrees)
Very Gentle	< 1
Gentle	1 to 4.9
Moderate	5 to 9.9
Steep	10 to 14.9
Very Steep	> 15

- Geologic interpretation of sub-bottom and medium penetration seismic data including but not limited to: buried channels, submarine canyons, river channels, exposed or buried hard bottom surfaces, shallow gas, gas hydrates, shallow-water flow, and karst areas.
- Fault activity, seismic shaking, and liquefaction potential.
- Bathymetry.
- Side scan sonar contacts or Remotely Operated Vehicle (ROV) video documentation.
- Magnetic anomalies.
- Unstable seafloor areas (e.g., slumping and sliding, areas of slope instability).
- Existing or planned cables and pipelines.
- Any other man-made potential obstruction or hazard including, but not limited to; disposal sites, dumping grounds, anchorage areas, shipwrecks, etc.

BOEM recommends providing examples of notable features observed in the data and discussion of how salient features are confirmed or refuted in different data streams.

9. Data

The lessee should provide digital copies of the data acquired for site characterization. All data should contain metadata identifying the vessel, collection dates and time, geocentric ellipsoid reference, projection information, and adequate information to identify the data. Lessees should provide the complete processed data sets in industry standard formats on external hard drives or other means. A summary table of expected data deliverables is provided in Table B-3. Metadata should include the vessel name, dates, geocentric ellipsoid used as a reference, the associated projection system, and adequate information to identify each attribute.

Lessees should include metadata for each spatial feature, in accordance with the FGDC Content Standard for Digital Geospatial Metadata (CSDGM) or International Standardization Organization's (ISO) 19115 metadata format and leases in the Atlantic and Pacific should also be consistent with spatial guidelines published under the Renewable Energy Guidance tab on BOEM's [Guidance Portal](#).

The report should include data type specific descriptions of the processing sequences, an assessment of overall data quality, and discussion of identified notable features.

10. Geotechnical data/analysis should include:

- (In tabular format) latitude/longitude, easting/northing, sample ID, core length/non-recovery, sediment type description, water depth, and sample type if not indicated in naming conventions for all grab samples and cores.
- Photos of all cores and grab samples that include sample ID, latitude/longitude, easting/northing, date and time of collection, vessel name, and water depth information.
- A description of all seabed exploration and sampling methods used.
- Results of all exploration and laboratory testing, including boring logs, soil profiles, cone penetrometer plots, graphs and tables of all lab results.
- Results of all geotechnical analyses such as pile capacity charts, lateral pile analyses, finite element analyses

11. Results and conclusions

The lessee should include a summary of conclusions and recommendations supported by the survey data and analyses, including a discussion of known or potential hazards to avoid, or that may require further investigation.

The results section should include a comprehensive Hazards Report that lists, in tabular form, all possible obstructions and hazards to both cable and turbine installation. The Hazards Report should include sonar and magnetometer contacts, pipeline and cable crossings, anthropogenic hazards, such as dump areas and anchorage zones, and geologic hazards. The report should include:

- Latitude/longitude
- Easting/Northing
- Water Depth
- Hazard Type (contact ID, cable or pipeline name, geologic feature)
- Distance and direction from cable route or proposed WTG location
- Additional hazard specific information such as crossing angle, sonar target dimension, magnetic anomaly strength, or contact description

Table B-3: Recommended Digital Data Deliverable Summary Table

Data Type	Data format	Data Products
Bathymetric Data		
	XYZ Data	Contours (ESRI Compatible)
	Metadata detailing processing parameters, illumination angles and coordinate systems	Geo-referenced image file
	Navigation Data (XYZ or ESRI shapefile)	Arc ASCII Grid and Layer Files
Magnetometer Data		
	XYZ Data	Summary of the magnetic anomalies observed during the investigation and a list of all magnetic anomalies in tabular format, including: dataset used, latitude/longitude, eastings/northings, sensor height above seabed, size, and interpretation
	Navigation Data (XYZ or ESRI shapefile)	Magnetic contours (ESRI compatible), geo referenced image file, and/or Arc ASCII grid and layer files
	ESRI compatible data file attributed with information provided in tabular format (see data products)	
Side Scan Sonar Data		
	Raw XTF data	Summary of the sonar contacts identified in the investigations in tabular format, including: dataset used, latitude/longitude; eastings/northings; length, width, and height; and interpretation
	Navigation Data (XYZ or ESRI shapefile)	Processed geo-referenced data imagery (mosaics and individual lines)
Geotechnical Data		

Data Type	Data format	Data Products
	ESRI compatible data file for all sediment samples attributed with information provided in tabular format (see data products)	Sediment sample information in a tabular format, including: latitude/longitude, easting/northing, sample ID, core length/non-recovery, sediment type description, water depth, and sample type if not indicated in naming convention
	Results of all exploration and laboratory testing including: boring logs, soil profiles, cone penetrometer plots, and graphs/tables of all lab results	Results of all geotechnical analysis, such as pile capacity, lateral pile analysis, and finite element analyses
	Sample photos of all cores and grab samples that include sample ID, latitude/longitude, easting/northing, date and time of collection, vessel name, and water depth information	
Geological and Hazards Assessment		
		Surface features, geologic interpretation, and hazards assessment (ESRI compatible)
		Near surface and surficial sediment descriptions and geologic interpretation (ESRI compatible)
Medium Penetration Seismic Data		
	SEG-Y data (final processed seismic data as 2D and/or 3D volumes) with navigation in text file format including line name and XY projected locations for the first, last, and every tenth SP or CDP	Reflectors/horizons, formatting options include XYZ data, CSF files compatible with Sonar Wiz Software, image plots, and/or other formats approved by BOEM
	SEG-Y byte positions	Digital image plots of interpreted data with SPs/CDPs

Data Type	Data format	Data Products
	List of lines, including SP and/or CDP ranges	Subsurface Horizon Elevation data as ESRI compatible contours and geo referenced image file/Arc ASCII grid file and layer files
	Navigation Data (XYZ, ESRI shapefile, or text file format) with line name and locations for the first, last and every tenth SP or CDP	Geologic structure interpretation as ESRI shapefiles, XYZ data, CSF files, or other formats approved by BOEM
	Digital image plots of uninterpreted data with shot points or CDP	
High Frequency Sonar or CHIRP Data		
	SEG-Y data with navigation in text file format, including line name and XY projected locations for the first, last, and every tenth SP or CDP	Reflectors/horizons as XYZ data, CSF files compatible with Sonar Wiz, image plots, and/or other formats approved by BOEM
	SEG-Y byte positions	Digital image plots of interpreted data annotated with location information
	List of lines, including start and end of line times	Isopach data for sediment thickness of the unconsolidated Holocene/late Pleistocene sediments
	Navigation Data (XYZ, ESRI shapefile, or text file format) with line name	Geologic structure interpretation as ESRI shapefiles, XYZ data, CSF files, or other formats approved by BOEM
	Digital image plots of uninterrupted data annotated with location information	