UNITED STATES DEPARTMENT OF THE INTERIOR

Bureau of Ocean Energy Management, Renewable Energy Programs

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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 does this document 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. Federal statutes, regulations, leases, and permits take legal precedence over the guidance offered in this document.

Cancellation

This guidance document cancels 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 cancelled.

Introduction

The Bureau of Ocean Energy Management (BOEM) administers the U.S. Department of the Interior regulations at 30 CFR Part 585, "Renewable Energy on the Outer Continental Shelf." Those regulations require a lessee to submit to BOEM 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, Plans).[1] BOEM

[1] BOEM has issued a Notice of Proposed Rulemaking (NOPR) to modernize its regulations ("88 FR 5968 - Renewable Energy Modernization Rule"). Regulations identified here and throughout this document will likely change if the proposed modernization rule is finalized. Proposed changes include removing the requirement for a site assessment plan and reducing the number of geotechnical borings required for a construction and operations plan. https://www.federalregister.gov/documents/2023/01/30/2023-00668/renewable-energy-modernization-rule.

must approve a Plan before a lessee may conduct any activities on the Outer Continental Shelf (OCS) described in that Plan.

Regulations in Part 585 require lessees to include the results of survey campaigns used to investigate their project area and easement as part of any Plan submission. Hazard and geological survey campaigns and the associated geophysical and geotechnical data collected are referred to as site investigations. Site characterization refers to the analysis and interpretation of data collected. In these guidelines, a marine site investigation report (MSIR) refers to the integration of geological, geophysical, and geotechnical data in a document that identifies and assesses hazards for a proposed project. The MSIR and supporting data satisfy the regulatory requirement for an "overall site investigation report" for COPs (30 CFR 585.626) and the requirement for geophysical, geological, and hazard surveys, for Plans. Lessees should include data and information in their MSIR that demonstrates the technical feasibility of their proposed project within their project area and transmission corridor. The MSIR will help BOEM evaluate the impact of seafloor and sub-seafloor conditions on the installation, operation, and structural integrity of any proposed OCS facilities. BOEM recommends following these guidelines to produce data that is of the quality necessary to characterize geological and geotechnical conditions and to identify potentially hazardous features. BOEM requires such data for its technical review of any submitted Plan (30 CFR 585.613, 585.628, 585.648). Activities proposed in all Plans must adhere to all statutes, regulations, applicable lease terms, and other relevant legally binding authority.

Lessees should refer to "Appendix B: Guidance for MSIR and Data Deliverables" for information on report and data submission to BOEM's regional offices (30 CFR 585.607, 585.622, 585.642).
Lessees should be aware that BOEM guidelines for archeological and environmental surveys recommend higher data quality than suggested in this document for BOEM's technical review. For example, BOEM recommends higher resolution data for archeological surveys, which may affect equipment choices and survey designs to identify cultural resources. Lessees are encouraged to review BOEM's guidance portal for other pertinent data collection guidance to maximize the use of geophysical and geotechnical data for other purposes. Lessees are referred to the "NOI Checklist" on the guidance portal to ensure data and reports submitted with COPs are sufficient to support required analysis under the National Environmental Policy Act. BOEM guidelines will continue to be updated periodically with the latest versions accessible on BOEM's guidance portal (https://www.boem.gov/about-boem/regulations-guidance/guidance-portal).

This guidance includes updated recommendations for site investigations on the U.S. OCS in deeper waters where floating wind turbines are likely to be proposed. BOEM recognizes other methods and equipment choices not described in this document may be suitable to provide the appropriate data. Lessees should contact BOEM with any questions, proposals, or concerns about using other equipment or technology for data collection or analysis.

If BOEM determines that the data submitted with any Plans 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 the associated Plans (30 CFR 585.613, 585.628, and 585.648).

I. Site Investigations

This section provides a recommended approach for site investigations that are used to produce an MSIR that integrates the findings of lessee's shallow hazards and geologic surveys to determine potential impacts to a proposed project. Proper siting of offshore facilities is required to mitigate potential hazards to foundations, moorings, and anchor systems for fixed and floating offshore wind turbines, buried cables or pipelines, and other offshore infrastructure. Site investigations should account for the area's water depth, geology, and proposed facilities.

For large-scale projects, such as those typically proposed in a COP, BOEM recommends using a phased approach for data collection to prepare a comprehensive and fully integrated MSIR (30 CFR 585.626). The sequential phases should consist of: site reconnaissance, suitability assessment, and site-specific design. Depending on the scope of the proposed project and the type of Plan, all phases may not be applicable.

A. Site reconnaissance

During the site reconnaissance phase, the lessee should gather and analyze existing information and data for the project area and potential transmission corridor using desktop studies and may consider a site reconnaissance survey, as described below in section III.A.1. of this guidance. Information gathered during site reconnaissance should inform the next phase, the suitability assessment.

B. Suitability Assessment

Regulations require lessees to submit Plans that identify the presence of potential hazards and assess their likely effects on a proposed facility (585.610, 585.626, 585.645).[2] A suitability assessment refers to the process of identifying potential hazards to the proposed project and assessing the feasibility of all potential design concepts a lessee may choose to employ in their offshore facilities. The "area of potential influence" refers to the portion of seabed that could impact the installation or operations of an offshore facility and may be determined based on desktop studies integrated with available geophysical and geotechnical data.

Lessees should consider that such hazards could exist outside the proposed project area. For example, areas with steep seabed slopes and fine-grained sediments that occur outside the proposed project area could create potential geohazards, such as slope instability and turbidity

[2] Although the proposed Renewable Energy Modernization Rule may change the current regulations, requirements to assess potential geological hazards that could impact a project proposed in a Plan are expected to remain.

flows, that could influence project design. If the proposed project area also experiences seismic activity, a geohazard may be compounded by liquefaction and slumping. Such hazards could pose significant risk to project facilities located some distance from the geohazard.

Additionally, lessees may consider a wide range of foundation options initially, but the suitability assessment may indicate that some foundations are not technically or economically feasible in all or parts of their project area. Thus, for the suitability assessment all hazards that may impact a proposed project should be identified and conceptually mitigated by appropriate siting or other methodologies. Additional, targeted detailed investigations can then be considered to support site-specific design.

C. Site-Specific Design

Following the suitability assessment that has defined the area of potential influence and determined the technical feasibility of project design concepts using appropriate mitigations, the investigation may be focused on site-specific design for foundation and transmission siting and installation. Plans should consider the regional geology, seafloor, and sub-surface conditions of the project area. To facilitate site-specific design, lessees can create a ground model by integrating high resolution geophysical (HRG) data, described in section III, with geotechnical core data, described in section IV. As reflected in table 1 in section III of this document, HRG surveys should result in different levels of detail appropriate for the specific survey purpose. BOEM strongly recommends that lessees use desktop studies and collect and analyze geophysical data to determine geotechnical investigation parameters. Plans also should incorporate best practices for safe installation and operation of proposed facilities to create a site-specific design that mitigates identified hazards.

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

Additional guidance regarding planning a site investigation is provided in *Appendix A: Site Investigation Approach*, which also contains a list of additional recommended guidance documents and standards.

II. Pre-Survey Coordination with BOEM

In accordance with lease stipulations, lessees must 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 addresses potential historic preservation, environmental, and technical issues before a lessee mobilizes for a survey. This guidance document focuses on technical project concerns. Lessees are referred to BOEM's Guidance Portal for other relevant renewable energy guidelines and are encouraged to engage with BOEM staff 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 will be identified and assessed by the surveys;
- survey methodology including line spacing, line orientation, and expected resolution;
- field techniques and equipment (specifications of data acquisition systems);
- application of innovative 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

HRG surveys should be designed around the proposed end use of collected data. For example, data for archeological or environmental reviews 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 BOEM's needs. 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 to identify potential hazards to the proposed project. BOEM also will use the results to assess 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 be present during survey operations to oversee field activities, verify data quality, and provide real time assurance of adequate site conditions.[3] The representative should be knowledgeable of survey operations, data acquisition techniques, installation requirements, and BOEM regulations. Surface and subsurface hazards may require changes to project siting and cable routing. An on-site representative may be able to make necessary adjustments during ongoing surveys to accommodate these hazards and changes. This efficiency would avoid additional survey and mobilization costs.

A. Survey Coverage

The area surveyed should be sufficient to encompass a seafloor profile of the project area and transmission corridor(s) that may be affected by the activities proposed in the Plans, including all bottom-disturbing activities. Survey coverage must also be sufficient to determine the presence and potential effect of hazards to the activities proposed in a Plan. 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 appropriate to assess these hazards and their potential impact on the proposed project.

BOEM recommends that during the suitability assessment, the survey area be informed by regional desktop studies and be as large as practical when uncertainty exists regarding proposed project locations or design. A larger survey area will give the lessee greater flexibility for siting structures and using various methods of construction, operation, and maintenance.

The lessee should conduct the HRG survey along a series of regularly spaced, parallel track lines and include regularly spaced 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 facility 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. In some instances, tighter line spacing may be necessary to obtain the appropriate level of coverage and data quality to properly detect and assess hazards, feasibility, and potential impacts. The information included in these guidelines provides only generalized, minimum recommendations.

1. *Site Reconnaissance Survey*

BOEM does not have specific recommendations for site reconnaissance survey methodologies. If a lessee wants to conduct a site reconnaissance survey as part of a phased survey approach, data resolution and the schedule of activities should be considered. Site reconnaissance surveys are

[3] The sea-state is affected by metocean conditions that may not always be suitable for HRG data collection. A representative can provide expertise to ensure the quality of data collected based on real-time site conditions.

designed for broad coverage with wide line spacing at low resolution. Due to the resultant lower data density, infill is often necessary to provide sufficient information to generate an acceptable MSIR. The lessee should keep in mind the amount of time that occurs between the reconnaissance survey and the suitability assessment survey. The seabed is a dynamic environment. If an extended period of time passes between survey efforts, the resulting data set may not be sufficient to support the Plans.

2. Suitability Assessment Survey

A suitability assessment survey should be designed to detect and assess shallow hazards that could impact the proposed project. The area of potential influence includes the project area, transmission corridor, and sufficient surrounding area to account for environmental conditions that may impact proposed facilities or activities. Data resolution and coverage acquired in the suitability assessment survey will be dependent on water depths, line spacing, and shallow hazards encountered or expected in and around the project area and transmission corridor. HRG investigations should capture the horizontal and vertical extent of seabed hazards that could impact the proposed facility.

i. Project area

The suitability assessment survey for the project area should include areas that will experience bottom-disturbing activity. The survey should also assess any shallow hazards in the surrounding environment that could influence or could be influenced by the following activities:

- geotechnical exploration;
- anthropogenic hazard identification;
- installation of data collection structures (e.g., meteorological towers, buoys, or other site assessment equipment);
- the installation of any renewable energy facilities;
- inter-array cable or pipeline 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 suitability assessment survey area, primary line spacing for HRG surveys (e.g., bathymetry, magnetometer, gradiometer, sonar, sub-bottom profiler, and seismic) should not exceed 150 meters (m) in a grid 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 connects offshore wind energy facilities to the onshore electric grid and includes the project easement. The transmission corridor survey should cover the entire area of expected 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 potential impacts from shallow hazards can be mitigated, including potential impacts from shallow hazards 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 submerged lands and waters, it will be subject to the applicable State regulations.

The HRG survey pattern along the transmission route should capture the proposed cable or pipeline route centerline and include offset parallel lines on either side with a maximum line spacing of 150 m. However, lessees should ensure data also conforms with BOEM's archeological and other guidelines. BOEM recommends a minimum of two parallel lines offset and on either side of the centerline. However, lessees may need additional offset parallel lines to provide sufficient coverage of the entire area that could be physically disturbed by installation activities.

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

3. *Site-Specific Design Survey*

Data collected, analyzed, and described in an MSIR should demonstrate the technical feasibility of the proposed facility design(s) for the project area and easement. Lessees may use a site-specific design survey to obtain additional detail and higher data resolution than the suitability assessment survey. 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 facilities;
- inter-array cable or pipeline installation;
- export cable or pipeline 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

Lessees should deploy survey instrumentation in a manner that minimizes interference between systems, results in the least environmental impact practicable, and records all data at the optimal sampling rate 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. 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 percent 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 an acoustic positioning system, such as ultra-short baseline (USBL) positioning, to improve the reliability of positioning sensors. If such a system is not used in a towed array, layback distances should be calculated, recorded, and cross-checked with feature matching techniques to provide accurate positioning of sensors.

2. *Bathymetry*

BOEM encourages the use of swath bathymetry systems to obtain full bathymetric data coverage of the surveyed area.[4] 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 seafloor search of the surveyed area. Data acquisition 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 (See IHO, “Standards for Hydrographic Surveys,” 2020). Lessees should also follow IHO hydrographic survey guidelines for quality control and data processing (See IHO, “Standards for Hydrographic Surveys,” 2020).

[4] Swath bathymetry is a method that utilizes a multibeam echosounder to acoustically determine the water depth and topography of the seafloor.

BOEM recommends the use of a system that can produce gridded bathymetric data at various waters depths with the resolutions provided in table 1. BOEM does not provide a recommended resolution for site reconnaissance surveys to encourage lessees to use available and relevant information for their desktop studies. Backscatter values from the seabed returns should also be logged and processed as appropriate.

Table 1: 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 should be 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 if appropriate. Water column sound velocity should be measured at regular intervals using a conductivity temperature depth 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.

Bathymetric light detection and ranging (LIDAR) methods are often used to provide seamless coverage in areas of extensive shallow water. LIDAR 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 or Gradiometer*

A magnetometer or gradiometer should be employed to detect ferrous metals or other magnetically susceptible materials. The tool should be positioned 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 and gradiometer sensitivity should be 1.0 gamma (γ) or one nanotesla (nT) or less. The data sampling interval should not exceed one second. Background noise level should not exceed 3 γ peak-to-peak. Magnetic 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 anticipated pipeline and cable crossing locations should be identified. If existing infrastructure like cables or pipelines are not observed in the bathymetric, side-scan sonar, or sub-bottom profiler data, BOEM recommends the use of a magnetometer to determine the precise location of the proposed cable or pipeline crossings.

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, the data must be calibrated by ground truthing or by collecting sediment samples from regions of different acoustic character.

BOEM recommends using a dual-channel, dual-frequency side-scan sonar system to provide continuous planimetric imagery of the seafloor. Such a system provides data used 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 kilohertz (kHz) are generally recommended for site investigation, although higher operational frequencies may be required to resolve discrete targets.

The survey line spacing and instrument range should be designed to ensure complete coverage of the seafloor in the surveyed area and resolution of small, discrete targets 0.5 m to 1.0 m in diameter at maximum range similar to bathymetric resolution recommendations in table 1. In general, the side-scan sonar sensor should be positioned at a height above the seafloor that is 10 percent to 20 percent of the range of the instrument, however the height will depend on the power of the instrument. Additionally, to ensure complete coverage, BOEM recommends that the survey provide at least 150 percent overlap of the seafloor between any two adjacent survey lines.

The data should be digitally recorded and visually displayed to monitor data quality and to 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 1.

5. *Sub-bottom Profilers*

BOEM recommends collection of sedimentary structure data 10 m beyond the depth of seafloor disturbance. For example, penetration depths should be 10 m greater than the maximum depth of disturbance from a meteorological tower or wind turbine foundation, an anchor or spud penetration, or the depth of cable or pipeline 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.

Sub-bottom profilers rely on the interpretation of reflections from acoustic impedance changes that may or may not correlate to geologic formation boundaries. Acoustic impedance changes may result from sedimentary variations, but other factors, such as consolidation, pore water, biologic colonies, and gas presence, can affect the acoustic impedance or severely reduce penetration. Consequently, 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 section III.B.*6, Seabed Sampling,* and section IV, *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 µPa based off root mean square levels (RMS) to constitute level B harassment under the Marine Mammal Protection Act. NMFS considers sound levels above 180 dB re 1 µPa (RMS) to constitute level A harassment. Thus, BOEM recommends that, where practicable, sound should be kept below these levels.

NMFS requires marine mammal monitoring plans for sound levels above these thresholds. BOEM and NMFS conducted an informal programmatic consultation during initial offshore wind development on the U.S. Atlantic OCS. The resulting letter of concurrence (LoC) issued by NMFS in June 2021 revises mitigation, monitoring, and reporting conditions for non-Endangered Species Act-listed marine mammals.[5] Through lease stipulations, BOEM intends to require data collection activities for Atlantic OCS leases comply with the best management practices and project design criteria outlined in the LoC.[6, 7] BOEM must include in its leases specific

[5] 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

[6] 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

[7] 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

mitigation measures for HRG activities undertaken for renewable energy development on the OCS offshore the U.S. mid-Atlantic and southeast coasts.[8]

i. High Frequency Sonar Systems

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

[8] 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

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 borings or vibracores as part of the 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 MSIR. Lessees are referred to BOEM's Guidance Portal for the appropriate recommendations for sampling methodology and requirements for benthic and other necessary survey campaigns.

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. BOEM recommends 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 must provide an adequate level of subsurface information to assess potential seabed impacts and to ensure installation feasibility for each planned structure that is founded in the seafloor. This section provides guidance on a geotechnical investigation's scope, data collection, testing, and analysis to support project feasibility. Lessees should refer to BOEM's Guidance Portal for benthic and archaeological guidelines and 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, any previous investigations, and the location and approximate dimensions of the proposed facilities. Integrated with geophysical surveys and desktop studies, the geotechnical investigation must provide a thorough understanding of the stratigraphic and geoengineering properties of the sediment that may affect proposed facility foundations or anchoring systems. The combination of geological, geophysical, and geotechnical investigation must identify and analyze 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 design parameters and recommendations as the project progresses from preliminary to final design. Depending on the adequacy of desktop studies and geophysical investigations, 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 585.610, 585.626, 585.645). Sampling and testing of foundation sediments within any proposed transmission corridor should also be sufficient to thoroughly categorize sub-seafloor conditions.

The proposed foundation types 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 comprise a combination of drilling and sampling of the sediments. The program should use boring and in-situ methods, such as cone penetrometer (CPT) probes. The program should use 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. The method of exploration should be based on the anticipated sediment types and characteristics, the proposed foundation or anchorage, and structure types and dimensions.

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

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., CPT, drilled borings, vibracores, etc.) should demonstrate feasibility of foundation or anchor locations, be collected 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. Those properties include unit weight, grain size distribution, specific gravity, compressibility, density, shear strength, and dynamic properties for assessment of seismic and cyclic loading conditions. Samples also should support 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. The laboratory should maintain accreditation from the U.S. 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 during the planning for geotechnical testing. To the extent possible, lessees should 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. For Pacific leases please contact 805-384-6305 or renewableenergypocs@boem.gov.

Paperwork Reduction Act Statement

These guidelines provide clarification, description, or interpretation of requirements contained in 30 CFR. Part 585, subpart F. An agency may not conduct or sponsor a collection of information unless it displays a currently valid information collection control number issued by the Office of Management and Budget (OMB). OMB has approved the information collection requirements in 30 CFR. Part 585, subpart F under OMB Control Number 1010-0176. These guidelines do not impose additional information collection requirements subject to the Paperwork Reduction Act of 1995.

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.

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

BOEM Guidance Portal – BOEM Renewable Energy Guidance (https://www.boem.gov/about-boem/regulations-guidance/guidance-portal)

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 Investigations and Characterization

To help facilitate successful investigations BOEM would like to offer some recommended Best Management Practices to lessees to assist with their site investigation and characterization.

Site Investigation and Characterization Approach

Lessees are encouraged to use a phased approach for site characterization and associated investigations. 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 MSIR 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 gear 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 shallow hazards in the project area and transmission corridor.

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 investigations:

- 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
- Geophysical and Geotechnical Investigation Methodology 769 Assessment for Siting Renewable Energy Facilities on the Atlantic OCS. GeoServices, F.M., 2017.
- 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 MSIR and Data Deliverables

The lessee should present the overall site investigation in a comprehensive MSIR 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.

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 MSIR 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 an MSIR 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 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. Similarly, lessees submitting digital data for renewable projects in the Alaska Region should refer to Appendices 1 and 2 of BOEM NTL No. 2022- A01.

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 m.

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 described in table B-1.

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;

Data Type	Data format	Data Products
		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		
	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	Reflectors/horizons, formatting options include XYZ data, CSF files compatible with Sonar Wiz Software, image plots, and/or other formats approved by BOEM

Data Type	Data format	Data Products
	name and XY projected locations for the first, last, and every tenth SP or CDP	
	SEG-Y byte positions	Digital image plots of interpreted data with SPs/CDPs
	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	