Pan-European Catalogue of Key Parameters for Offshore Windfarm Siting – v1

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Executive Summary

The European Commission is committed to transforming the EU into a clean, resource-efficient and competitive economy, with the European Green Deal designed to make Europe the first climate-neutral continent in the world. Offshore Renewable Energy is a major source of green energy significantly contributing to the EU's 2050 Energy Strategy and the European Green Deal. This report describes how geology impacts offshore windfarms and associated infrastructure, and how the geological knowledge of European geological survey organisations (GSOs) can be used to assess site suitability.

The design of wind turbines and foundations may be impacted by a range of geological and geomorphological constraints at and near the seabed, outlined in the development of a Geo-Assessment Matrix (Annex 1 of this report). The Geo-Assessment Matrix is a comprehensive data inventory utilising harmonised geological nomenclature for countries in the European Economic Area, Southeastern Europe and the UK. Assessing the seabed for marine spatial planning and offshore windfarm development includes the evaluation of geological baseline data. The offshore geological landscape varies considerably and is directly linked to present-day and paleo-sedimentary, igneous or metamorphic settings and processes. Their pluriform nature explains much of the lateral and vertical heterogeneity identified in the seabed and the near-seabed subsurface. The design, development and installation of engineering structures associated with offshore windfarms, including piles, cables, suction caissons and gravity-based structures (GBS), requires advance knowledge of the seabed and underlying geology, to ensure that the seabed and subsurface conditions are suitable for planned activities and structures. Geology and engineering are interconnected disciplines, able to create added value by integrating geological knowledge with geotechnical and engineering principles. The Geo-Assessment Matrix aims to bridge the gap between geology and engineering to support the design and installation of offshore windfarms and associated infrastructure. The final output of the Matrix assists with creating regional offshore maps by creating re-attribution complexity assessments outlining how geology may impact offshore infrastructure.

The Geo-Assessment Matrix highlights key geological features associated with different geological settings or sedimentological and/or geomorphological processes, including lithological and morphological constraints. A matrix-style approach enables organisation and systematic analysis of data, ensuring all relevant geological and engineering factors can be considered, evaluated and translated into output that is intuitively meaningful to end-users. An additional benefit of this matrix-based approach is the flexibility, adaptability and scalability of the Geo-Assessment Matrix for future project updates. The data inventory can be adapted for broader- and/or or finer-scale geological features, making it a versatile tool in the short, medium and long-term over the course of the Geological Service for Europe (GSEU) project.

Results of the Geo-Assessment Matrix have grouped and/or simplified geological terminology, subdividing geological features according to a three-tiered scoring system based on the typical 'geological complexity' of each feature: (1) High complexity; (2) Medium complexity, and (3) Low complexity. High-complexity geological features are those that may be unsuitable, or may be difficult to engineer around easily. Medium-complexity geological features are those that may be suitable for foundations, but likely need additional engineering-design solutions or mitigation measures. Low-complexity features are those that are likely suitable for typical foundations (piled foundations, Gravity based structures, cables and suction caisson).

Existing datasets from the European Marine Observation and Data network (EMODnet), the Norwegian offshore mapping programme (MAREANO) and the Irish offshore mapping programme (INSS-INFOMAR) have been utilised to show the flexibility of the Geo-Assessment Matrix by re-attributing existing geo-spatial data products to create derived GSEU pan-regional offshore maps. The pan-European maps aim to identify areas of known relative geological complexity and may optimise the spatial planning of windfarms to help maximise efficiency. Such geological baseline data are critical for informed early decision making and the successful implementation of offshore windfarm projects.

Implications of the Geo-Assessment Matrix not only permits the creation of regional offshore maps utilising existing datasets (e.g., EMODnet, MAREANO and INFOMAR datasets), it also provides an easy-to-use tool that enable GSOs to easily create new constraint maps using in-house fine-scale seabed geology maps from higher resolution mapping purposes.

Abbreviations	
CBRA	Cable Risk Assessments
EC	European Commission
EGDI	European Geological Data Infrastructure
EU	European Union
EMODnet	European Marine Observation and Data network
GBS	gravity-based structures
GGM	Geological Ground Model
GSEU	Geological Service for Europe
GSO	Geological Survey Organisation
H2020	Horizon 2020
IGM	Integrated Ground Model
INSS-INFOMAR	Ireland’s offshore mapping program
LGM	Last Glacial Maximum
MAREANO	Norway’s offshore mapping programme
WP	Work Package
WTG	Wind Turbine Generator

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1. Introduction

Ambitious European energy and climate targets require an increase in wind capacity of at least 60 GW by 2030, and 300 GW by 2050. As governments develop their road maps for renewable energy from offshore wind around the UK, continental Europe and beyond, countries are seeing a major expansion in the number of offshore windfarm licenses granted. In preliminary studies, Geological Survey Organisations (GSOs) are often the first port of call regarding external queries for information on the availability of baseline data in the form of geological maps. Some GSOs also provide geological expertise to characterise the subsurface. As part of the Geological Service for Europe (GSEU) project, twenty-six GSOs share their expertise as part of Work Package 5 (WP5) “Coastal vulnerability assessment and optimised offshore windfarm siting”. Windfarm siting is the primary objective of Task 5.2 (hereby T5.2). Twenty-two countries are participating in T5.2, with each country at a different stage of offshore windfarm development, from the preparation of regional desk studies to the establishment of protocols or development of procedures for various stakeholders (Van Heteren et al. 2024).

The design and marine spatial planning of foundations for offshore wind turbines require detailed analysis of the seabed and up to 100 m of sediment or rock below the seabed surface. Buried landscapes of past depositional environments generate single and cumulative geological constraints that may pose engineering challenges in the subsurface in both previously glaciated and non-glaciated terrains. Prior to detailed site characterisation, marine spatial planners, governmental agencies and offshore windfarm developers require baseline geological knowledge to understand the seabed and subsurface complexity. To help support the ambitious targets for offshore renewable energy, this project represents an opportunity to establish standardised practices of assessing the geology offshore at a pan-European scale early throughout the accelerated development of offshore windfarms. GSEU also presents an opportunity of knowledge sharing between GSOs by integrating datasets and establishing scientific baselines intended to support informed decisions for offshore windfarm development.

Task 5.2 aims to allow nations to effectively communicate scientific concepts using standardised geological nomenclature, definitions and associated engineering constraints relating to geological features at and near the seabed surface. It also intends to establish and disseminate standardised best practices for suitability and impact assessment in targeted field studies before, during and after windfarm development. It is subdivided into the following three subtasks (T5.2a, b and c), outlined below:

a) Inventory and map surficial and subsurface parameters influencing cost, stability and performance of turbines, cables and hubs in shallow and deep waters;
b) Develop a ‘domain’ approach to characterise the dominant depositional setting and resultant physical characteristics of the sub-seabed stratigraphy; develop sediment-thickness and - quality models to assess the availability of suitable aggregates for hubs;
c) Search and identify potential seabed anomalies such as active faults or other geologically induced movements of the seabed, which could contribute to displacement of the turbines when anchored to the seabed.

This report presents the methodology and reattribution results of subtask T5.2a (inventory and mapping of subsurface parameters), named the ‘Geo-Assessment Matrix’ (*Annex 1*), or referred to as the ‘Matrix’. The Geo-Assessment Matrix is a pan-European data inventory of key parameters, relevant to offshore windfarm siting for countries across the European Economic Area (EEA) and the UK. Nomenclature used in this project utilises harmonised terminology jointly developed by Geoscience Australia, University College Cork, British Geological Survey, Geological Survey of Norway, Geological Survey of Ireland and Latrobe University (Dove et al. 2020; Nanson et al. 2023). A glossary of terminology and classifications is provided at the back of this report.

The aim of the Geo-Assessment Matrix is to bridge the gap between geology and engineering. It lists geological features, assessing their geological impact and associated engineering impact resulting in an ultimate 'geological complexity score', which is more easily understood by non-geologist decision makers than traditionally used classes of geological attributes. Based on this geological complexity score, a thematic suite of new reattributed derivative maps are being created from existing harmonised and open-source datasets, from sources that include the European Marine Observation and Data network (EMODnet Geology), Norway's offshore mapping programme (MAREANO) and Ireland's offshore mapping program (INSS-INFOMAR).

These reattributed maps will form the basis of the first pan-European products specific to offshore windfarm siting. They will provide baseline datasets, suitable and understandable for all parties in the offshore wind community, by highlighting areas with known (mapped) and unknown (i.e., areas that lack data) complexity in the subsurface. For example, sediment heterogeneity resulting from variable sedimentary processes is a critical characteristic of previously glaciated terrains. Proglacial lake settings translate into a relatively high likelihood of the presence of soft sediments or gassy soils, which may cause instability or punch-through during installation. The presence of till or moraines may result in refusal or tip damage while penetrating units with overconsolidated soils or due to the presence of boulders. As such, the identification and characterisation of geotechnically significant seismostratigraphic units can be targeted, underpinning the development of robust Geological Ground Models (GGM) that form the basis of Integrated Ground Models (IGM).

By creating output that can be understood by geologists and non-geologists alike, incorporation of geological data and expertise in the decision-making process related to offshore wind is made easier and more intuitive. The derived maps aim to support initial desktop studies and allow end-users, such as governmental and industry stakeholders, scientists, and marine spatial planners, to review which geological data and existing geological interpretations are available, and where relevant data and interpretations are missing. The development of understandable data products enables informed decisions that help to weigh various geological constraints regarding transmission cables or wind-turbine foundations. It also highlights what information is required to better understand the baseline geology and its impact on engineering, foundation design and installation.

The maps are still in the process of being developed; however, initial results of the translation process from existing geological datasets are presented in this report in the form of a data table (*Annex 2*).

1.1. Disclaimer

It is important to note that the information provided in this report, the Geo-Assessment Matrix and the derived map-based products, are based on preliminary data. They are intended for information purposes only.

The report, matrix and map-based products associated with this study are not a substitute for a comprehensive site investigation. Site conditions can also change over time because of natural or human activities. Therefore, periodic updates and revisions will be required to reflect the latest site conditions and data available.

2. Wind-Turbine Foundations, Cables and Constraints

The offshore wind industry utilises the following fixed foundation types: piles (drilled/grouted), gravity-based structures (GBS), suction caisson and associated infrastructure (export and inter-array cables). Typical considerations for turbine and substation foundations include water depth, soil conditions (seabed and subsurface geology), susceptibility to seafloor mobility, and the uniformity of deign versus optimisation of foundations for each location (Cook et al., 2022).
The depth of interest varies from:

- Shallow sub-seafloor (0 to 5 m) for inter-array and export cables
- Intermediate sub-seafloor (5-10 m) for anchoring and small structure foundations
- Deeper subsurface (10-100 m) for large structures, e.g., piled foundations (Cook et al., 2022).

Floating wind turbines are a relatively new technology that provides an alternative to the fixed foundations in deeper water depths (> 60 m, and likely to increase to 100-200 m), with projects being advanced. Compared to fixed foundations, the anchor design of floating turbines has some specifics, such as higher sensitivity to the conditions on, and within the upper 10 m the seabed surface. As the anchor design of floating wind turbines are rapidly evolving technology, they have not been incorporated into the Geo-Assessment Matrix thus far, although it is expected this will happen at later stages of this project. However, it is noted that there some existing crossovers that are possible between anchor design and fixed foundations. For example, anchor piles have similar constraints to piles in general, although the depth of interest is shallower in comparison to monopiles.

2.1. Geological Constraints per Country

Participating countries of Task 5.2 were asked to provide the top constraints per country regarding the development of offshore wind and associated infrastructure, with results presented in Table 2-1. The dominant constraint identified relates to previously glaciated terrains (e.g., in Poland, Denmark, UK, Finland, Norway, Ireland) and deep water (e.g., Malta, Croatia, Spain, Norway, Ireland). Results of this small study set the stage of the geological features collated as part of the Geo-Assessment Matrix.

Table 2-1 . Results of key constraints of participating countries in Task 5.2

	Cables		Fixed turbines												Floating windfarm experience	
	Constraint		Geohazards			Geological constraints										
	Peat/organic rich	Scour	Shallow gas (thermogenic/OM)	Volcanism	Active faulting	Glacial (boulders/TV/sediments	Packed ice on the seabed	Carbonate domain	Deep water (>200 m)	Shallow water (15-20 m)	Shallow bedrock	Mobile seabed	Geomorphology of coastline	Unknown – lack of data	Experience?	Planning?
Malta								x	x						N	Y
Croatia									x				x		N	
Spain (inc. Canary Islands)	x			x					x						N	Y
Poland			x			x									N	
Denmark	x	x				x									N	
Italy															N	
Finland						x	x								N	
Norway						x			x						N	
Slovenia	x										x				N	
UK						x					x				N	Y
Greece					x					x					N	Y
Ireland						x			x			x			N	
Iceland				x										x	N	?
Netherlands	x	x	x			x				x		x	x		N	N

The matrix serves as a resource that GSOs can refer to when mapping geological constraints at any scale and when trying to convey the typical seabed and subsurface challenges. One example of this is identification of mobile sediments, which can result in scour around piles or may create free span of cables, where the installed cable is unsupported along its length on the seabed, typically by 3 m (see glossary). Understanding such constraints can help perceive suitable mitigation techniques, such as scour protection.

To showcase how the Geo-Assessment Matrix can be used, we employ open-source datasets to create regional European maps that show the spatial distribution of typical constraints prior to mitigation techniques, in the form of multivariate Hex-maps. Hex-style maps are a powerful and versatile approach of spatial data visualisation and analysis, making it easier for the end-user to understand practical implications of complex geological challenges.

3. Methodology

Work undertaken as part of Task 5.2a was developed from a commercial BGS study produced on behalf of the Crown Estate (2014), Commissioned Report CR/14/073. The Geo-Assessment Matrix represents a newly developed product that syntheses more than eighty lithological, geological, morphological and geomorphological features that may pose engineering challenges in the subsurface, collated from case-studies, references and knowledge of GSOs. The pan-European maps, that are in the process of being created, utilises existing external datasets (e.g., EMODnet Geology) that uses the output information (Step 4, Section 3.1) from the Geo-Assessment Matrix to re-attribute the existing geo-spatial datasets.

3.1. Geo-Assessment Matrix Structure

The Geo-Assessment Matrix is the result of a four-step process *(Annex 1),* from collation of geological feature data to reattribution of geological descriptors to a complexity term. Using this matrix, two additional steps reattribute complexity values to existing data sets and create derived pan-European, hex-style geo-spatial products (Figure 3-1). This section describes the six-step methodology showing how geology can be visualised in terms of engineering implications:

- **Step 1**: Data inventory of geological features
- **Step 2**: Production of Geology matrix
- **Step 3**: Production of associated Engineering matrix
- **Step 4**: Reattribution between geology and engineering constraints to formulate a final 'geological complexity assessment' grading (i.e., high, medium or low complexity)
- **Step 5**: Translation and reattribution of existing datasets *(Annex 2)*
- **Step 6**: Creation of hex-maps.

Steps 1 to 6 in Figure 3-1 are presented as sections 3.1.1 to 3.1.6 in this report, explaining the rationale behind each step and the development of the Matrix. A matrix-style approach was adopted to enable organisation and systematic analysis of data, ensuring all relevant geological and engineering factors were considered and evaluated. An additional benefit of this approach is the flexibility, adaptability and scalability of the Geo-Assessment Matrix. The data inventory can be adapted for broader- and/or finer-scale geological features, making it a versatile tool in the short, medium and long term.

The reattribution of existing datasets and production of hex-maps (Steps 5 and 6) are additional products to the Matrix (Steps 1 to 4); however, these final steps had not been completed at the publication date of this report.

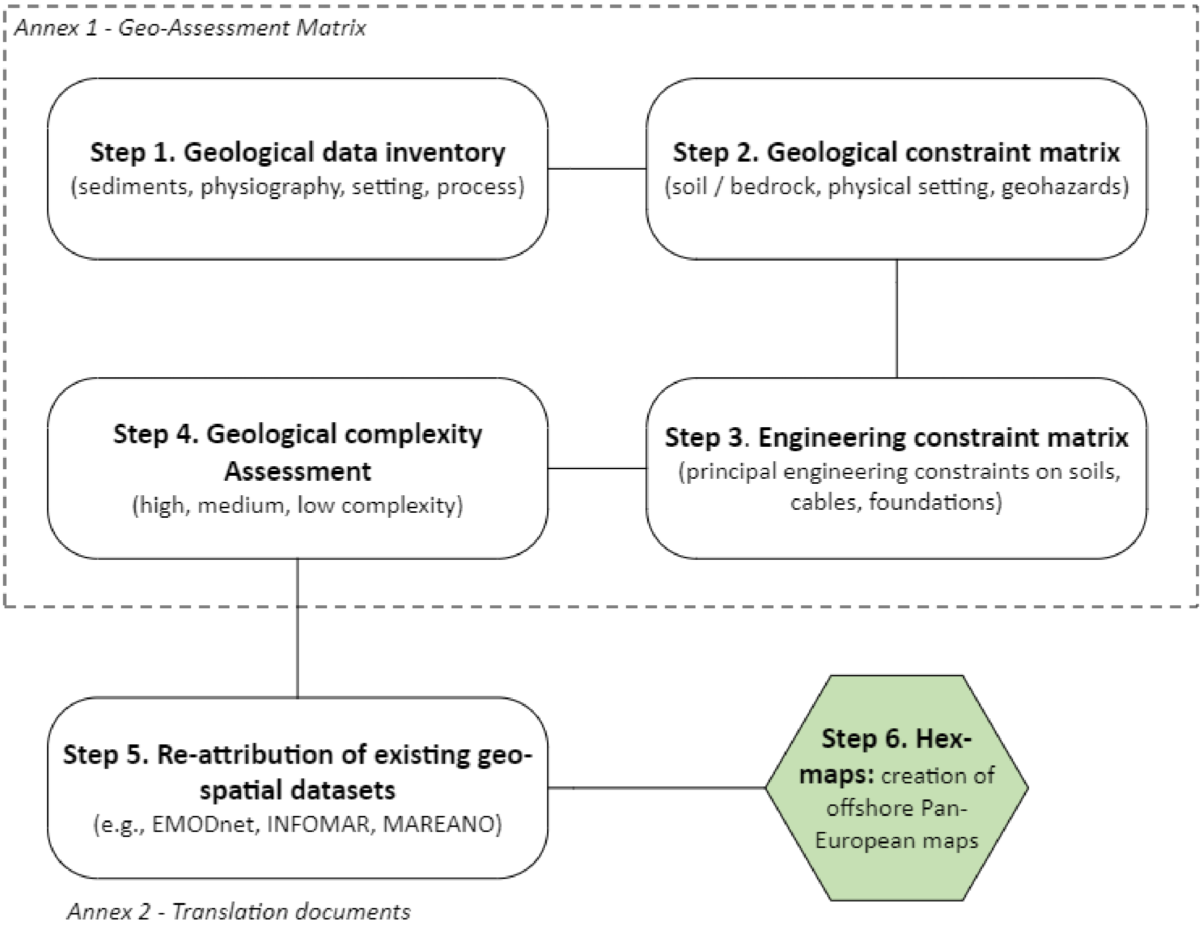

Figure 3-1. Overview of Geo-Assessment Matrix structure from Step 1 to Step 6, from the Geological data inventory to the Geological and Engineering constraints matrices and re-attribution to create the final map-based outputs.

3.1.1. Step 1: Geological Data Inventory

The Geo-Assessment Matrix includes a data inventory listing 84 geological features based on typical constraints identified in offshore development. An important feature of the data inventory is the use of harmonised geological terminology. See **Error! Reference source not found.** for details. This project predominantly uses the two-part classification scheme and structure of Dove et al. (2020) and Nanson et al. (2023). These two classification schemes provide a morphological and geomorphological glossary for a broad range of marine applications and rely on bathymetry data from which geomorphological units can be identified, supported by knowledge of the geological setting and/or processes (Nanson et al. 2023 and references therein):

1) **Settings** are classified as: *Glacial, Marine, Fluvial, Biogenic, Coastal (including lacustrine), Solid Earth*
2) **Processes** as far as they are not covered by the above settings are classified as: *Mass movement, Karst and Fluid Flow.*

Additional classifications, not included as part of the Dove et al. (2020) or Nanson et al. (2023) classifications, however, are important to be included from a foundation-constraints perspective. These include:

3) **Sediments** *(e.g., peat, glauconite)*
4) **Physiography** *(e.g., Shelf break, mound, terrace etc)*
5) **Post-depositional processes** *(e.g., concretions, shale/salt diapirs).*

These five geological groups allow for a wide range of existing data products (e.g., those contained in EMODnet, INSS-INFOMAR and MAREANO open-source datasets) to be used in the re-attribution process and to create pan-European map-based products (Step 5, Figure 3-1). It is noted that non-marine settings are included in the inventory because the current marine setting of sea basins refers only to the landward position of the modern coastline. In the past, some currently marine areas were terrestrial. Since the Last Glacial Maximum (LGM), for example, present-day shelf environments have undergone a transition from terrestrial glacial to estuarine, coastal plain and finally shallow marine environments, now either preserved at the seabed or buried as paleo-landscape remnants near the present-day seabed, up to 100 m depth.

3.1.2. Step 2: Geological Constraint Matrix

From the inventory of the 84 geological features (Step 1), the typical geological or geomorphological matrix, as observed in Annex 1, identified in the offshore environment are grouped into the following three dominant constraint categories Table 3-1):

(1) **Soil / bedrock constraints** (*vertical/lateral variability, rafts/boulders, coarse or soft soil units, overconsolidation/dense sands, bedrock at surface)*
(2) **Physical setting constraints** (*uneven ground, steep margins, active sedimentary systems – including mobile sediments, deep or shallow water*)
(3) **Geohazards** *(faults, submarine slope failure, volcanic activity, fluid flow, potential/active, organic soils).*

“Unknown” constraints refer to some features, such as polygonal faults, which are in the process of being researched at the time of writing this report (e.g., https://research.ugent.be/web/result/project/8180a538-a0fb-44f0-ab27-e414f933ece8/details/en).

Individual geological features can have multiple geological constraints associated with it. A few examples are outlined here; however, the reader is referred to Annex 1 where all information is outlined. For example:

- “Terraced environments” are identified as a physiographic constraint that may comprise uneven ground and can be found in both shallow and deep water.
- A “glaciotectonic raft” (or erratic) is identified as a glacially derived constraint that may induce vertical/lateral soil variability, and depending on the situation (e.g., if found at the seabed) may present uneven ground and/or have steep sides (>5-degree angle).
- A “marine bar form” is identified as a marine constraint that may pose uneven ground or mobile sediments

Table 3-1. Geological constraints matrix structure

Soil / bedrock constraints	Vertical/ lateral variability (heterogeneous soils)
	Rafts or boulders
	Coarse soil units (including gravel)
	Soft soil units - low shear strength
	Overconsolidation (clays / extremely dense sands)
	Strong bedrock at/near seabed
Physical setting constraints	Uneven ground
	Steep slopes/margins (>5-degree angle)
	Mobile sediments
	Active sedimentary system
	Shallow water (<15-20 m)
	Deep water (<200 m)
Geohazard constraints	Potential fault reactivation/seismic activity
	Potential submarine slope failure
	Potential volcanic activity
	Potential conduit for fluids
	Active fluid flow
	Organic soils/gassy sediments
Unknown constraints	Unknown

To further understand trends of the geological data inventory,

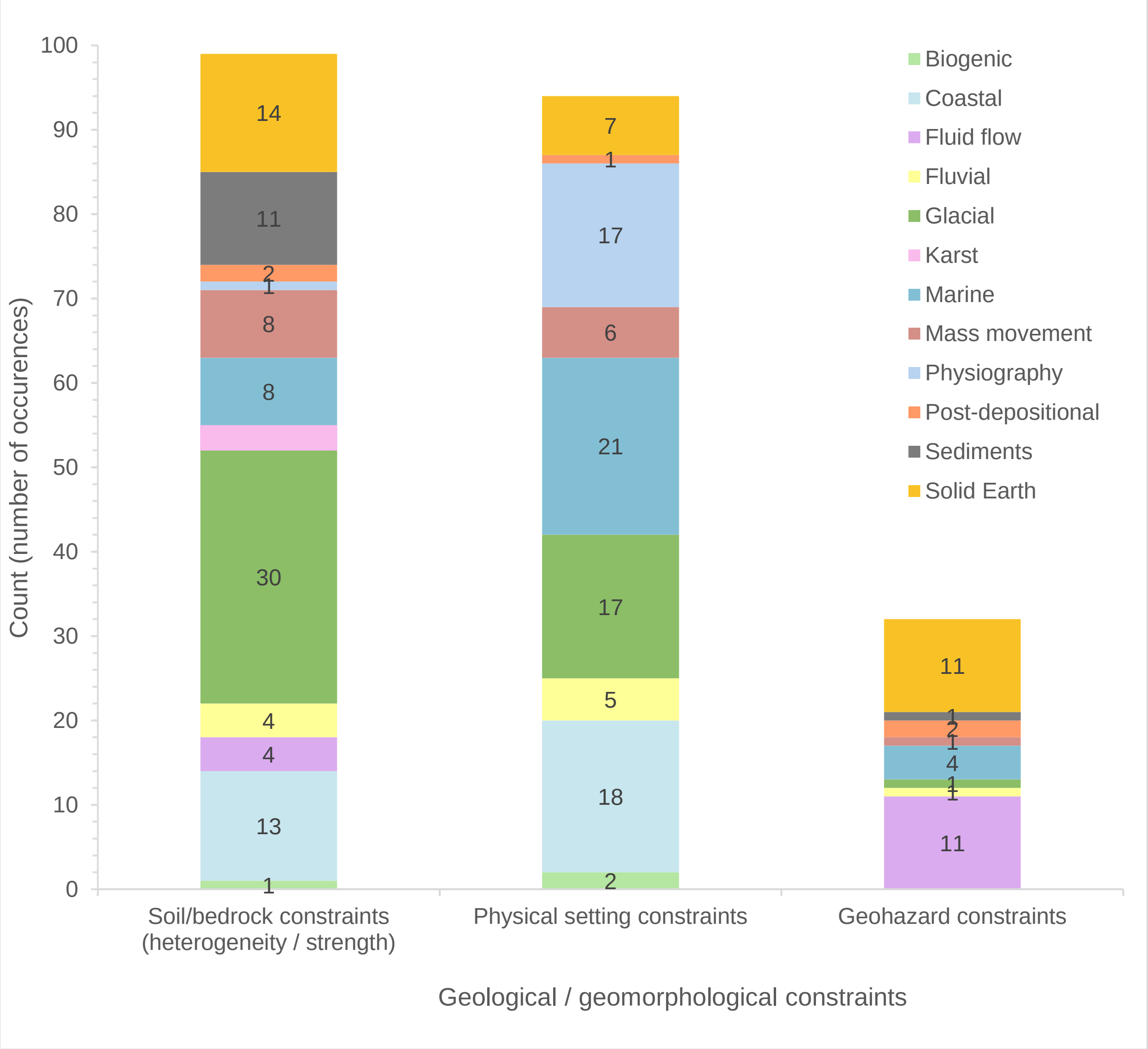

Figure 3-2 shows the dominant constraint per geological group (e.g., whether soil heterogeneity and strength, physical setting or geohazards). Overall, the physical setting of an offshore environment and soil/bedrock heterogeneity at/near the subsurface contain the greatest number of constraints (94 and 99, respectively):

- Glacial settings are associated with the highest number of soil constraints, typically relating to the number of different geomorphological features and processes involved in these sedimentary environments, such as proglacial lakes, eskers, moraines, proglacial channels, and tunnel valleys.
- Marine settings have the greatest number of constraints relating to the physical setting of an offshore environment. This is typically due to water depth (either too shallow or too deep for fixed foundations), active sedimentary systems (canyons/channels/valleys) and the presence of possible mobile sediments on the seabed.
- Solid Earth systems and fluid flow have the greatest number of geohazards, due to the presence of volcanos, faults and active fluid flow (including presence of pockmarks).

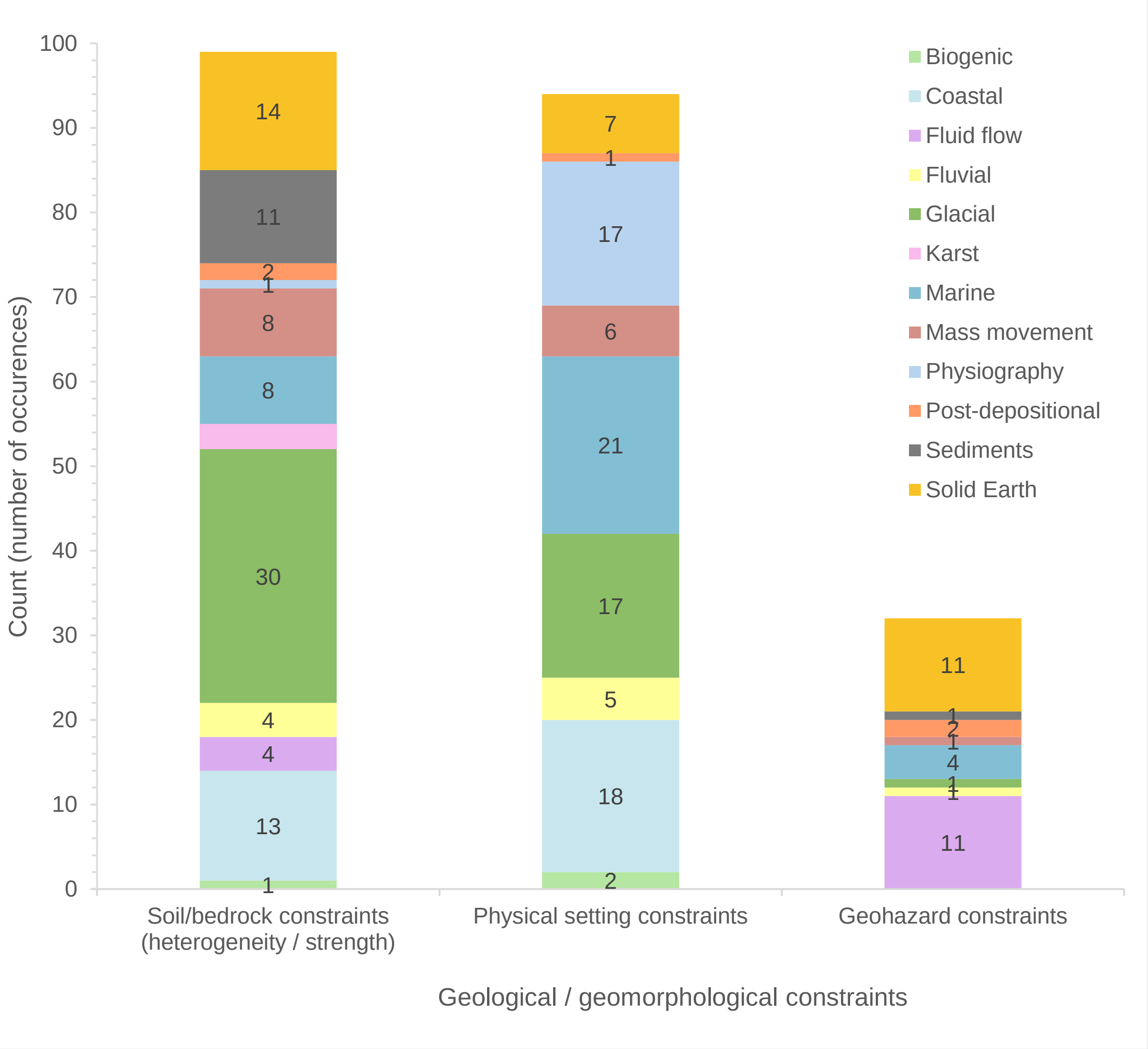

Figure 3-2. Analysis of the dominant geological / geomorphological constraints per setting

3.1.3. Step 3: Engineering Constraint Matrix

The next step of the Geo-Assessment Matrix links the geological constraints outlined in Step 2 to potential engineering constraints (Step 3). The engineering constraint matrix, as observed in Annex 1, is structured by the foundation type (**Table 3-2**). There are some crossover engineering properties which impact all foundation types; however, some properties may only impact individual foundations

- **Soil properties** (*e.g., low thermal conductivity, collapsable or compressible soils, soils that change character upon crushing, or sediments that may be an important resource*)
- **Cables** (*e.g., trenching technique selection, free span, cable deviation or abrasion of cables*)
- **Specific constraints for fixed foundations**:
    - Gravity-based structures (GBS) *e.g., uneven load distribution*
    - Piles (e.g., *increased lateral load or scour*)
    - Suction caisson and piles (*e.g., voids, punch through or pile run)*

- **Constraints that impact all foundation types** (GBS, suction caisson and piles), *e.g., refusal, damage to tool, increased or decreased overburden, etc.*

Table 3-2. Principal engineering constraint matrix structure

<table>
<tr><td colspan="4" rowspan="5">Soil properties</td><td>Low thermal conductivity / low water content, overheating</td></tr>
<tr><td>Compressible / contractive soils</td></tr>
<tr><td>Collapsable soils</td></tr>
<tr><td>Soil changes character upon crushing</td></tr>
<tr><td>Potential important resource</td></tr>
<tr><td colspan="4" rowspan="4">Cables</td><td>Cable/pipeline abrasion or bending</td></tr>
<tr><td>Free span development (unsupported cable for >3 m)</td></tr>
<tr><td>Cable plough deviation</td></tr>
<tr><td>Trenching technique selection</td></tr>
<tr><td rowspan="7">Fixed foundations</td><td rowspan="3"></td><td></td><td rowspan="3">Gravity based structures</td><td>Uneven load distribution / differential settlement</td></tr>
<tr><td rowspan="3">Suction caisson foundations</td><td>Seabed preparation (e.g., flattening)</td></tr>
<tr><td>Reduced skirt burial depth</td></tr>
<tr><td rowspan="4">Pile foundations</td><td rowspan="4"></td><td>Voids/ punch through / pile run</td></tr>
<tr><td rowspan="3"></td><td>Reduced shaft friction - soft sediments</td></tr>
<tr><td>Scour - removal of lateral support</td></tr>
<tr><td>Increased lateral load</td></tr>
<tr><td colspan="4" rowspan="10">All fixed foundations</td><td>Lateral variability in geotechnical values</td></tr>
<tr><td>Reduced overburden (vertical)</td></tr>
<tr><td>Increased overburden (vertical)</td></tr>
<tr><td>May not support hole while drilling</td></tr>
<tr><td>Poor drivability / refusal</td></tr>
<tr><td>Blowout</td></tr>
<tr><td>Damage to tool / foundation during installation</td></tr>
<tr><td>Unknown</td></tr>
<tr><td>Potentially unsuitable</td></tr>
<tr><td>Requires individual WTG siting investigation</td></tr>
</table>

Although the reader is referred to Annex 1, a few examples of translating geology to engineering constraints (*in italics)* are outlined below:

- “Peat” is identified as a lithological constraint that can have vertical/lateral variability of organic soils, *which has low thermal conductivity and is a compressible soil that may require cable plough deviation and requires site-specific ground investigation (e.g., Cable Risk Assessments [CBRA] and/or individual Wind Turbine Generator [WTG] planning).*
- “Terraced environments” are identified as a physiographic constraint that may comprise uneven ground and can be found in both shallow and deep water, *which may require cable plough deviation and requires site-specific ground investigation (e.g., CBRA and/or WTG planning).*
- A “glaciotectonic raft” (or erratic) is identified as a glacial constraint that may induce vertical/lateral soil variability, and depending on the situation (e.g., if found at the seabed) may present uneven

ground and/or have steep sides (>5-degree angle). *This may result in variable geotechnical properties, or if boulders are present, these may have poor drivability or lead to refusal resulting in tip damage and the site will require a site-specific ground investigation (e.g., CBRA and/or WTG planning).*
- A "marine bar form" is identified as a marine constraint that may pose uneven ground or mobile sediments, *which may result in scour around the seabed infrastructure and requires site-specific ground investigation (e.g., CBRA and/or WTG planning).*

Note the statement "requires individual windfarm generator (WTG) siting investigation" applies to all geological features to ensure the end-user is aware of the limitations of the products associated with T5.2.

3.1.4. Step 4: Geological complexity assessment

The final step of the Geo-Assessment Matrix is represented by the Geological Complexity Assessment rating per foundation type. Suction caisson, GBS, piled foundations and cables each have different installation and design requirements, depending on the geology. For this reason, the fixed foundations (suction caisson, GBS, piles) and cables each require a different 'complexity assessment' value, which in turn, will create *four* different map outputs.

To produce systematic scoring of geological complexity across multiple geological features between map-based products (Step 5), Table 3-3 was developed, utilising the geological constraints, as presented in Step 2. The geological complexity scores are defined and described herein after:

- **High complexity:** Geological features may be unsuitable or may not be able to be engineered around easily. These are typically (but not limited to) geohazards, such as organic soils, pockmarks, active sedimentary systems, slope instability, and soft sediments. There are instances where, for example, shallow water depth is not considered a high constraint for cable emplacement, however, is a high constraint for suction caisson and GBS foundations.
- **Medium complexity**: Geological features may be suitable for foundations, however, likely need additional engineering design/solutions mitigation measures. These are typically variable sedimentary features, such as heterogeneous sediments, mobile sediments, weak bedrock and gravel.
- **Low complexity**: Geological features are likely suitable for foundations. These are typically more predictable sediments, such as homogeneous or layered sediments or strong bedrock. Note that some features may still require mitigation measures.

Table 3-3. Geological Complexity Assessment Guide, ensuring standardised constraint assessment between map reattribution

		High complexity														Medium complexity							Low complexity		
	Geological constraints	**Shallow water depth (<15-20m)**	**>5-degree angle slopes**	**Organic soils (includes peat/coal/organic matter)**	**Mobile sediments (sand waves/ scour)**	**Pockmarks**	**MDAC**	**Active fluid flow**	**Active sedimentary system**	**Faults / potential seismicity**	**Unknown**	**Submarine slope failure**	**Volcanoes**	**Soft sediments <10 kPa**	**Carbonates/evaporites**	**Sediment cover <5 m**	**Hard overconsolidated clays / extremely dense sands**	**Normally consolidated clays / medium dense sands**	**Heterogeneous sediments**	**Soft sediments >10 kPa**	**Weak bedrock**	**Coarse sediments (gravel)**	**Homogenous sediments**	**Heterogeneous / layered sediments**	**Strong bedrock**
Foundation category	Suction caisson	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	S	U	S	U	U	S	U	U
	Gravity based structures	U	U	U	U	U	S	U	U	U	U	U	U	U	U	S	S	U	U	U	S	U	U	U	S
	Piles	S	S	U	U	U	S	U	U	U	U	U	U	U	U	U	U	S	S	S	S	S	S	S	U
	Cables	S	S	U	U	U	U	U	U	U	U	U	U	U	U	S	U	S	S	S	S	S	S	S	U

U = typically unsuitable; S = typically suitable

3.1.5. Step 5: Existing Geo-Spatial Data to GSEU Reattribution Process

The standardisation of the Geological Complexity Assessment in Step 4 permits the reattribution of multiple existing datasets (EMODnet, MAREANO and INSS-INFOMAR). This highlights the flexibility and useability of the data inventory, enabling the use of geological baseline data, critical for informed decision making and the successful implementation of offshore windfarm projects. The datasets identified in Table 3-4 are being utilised as part of the initial phase of the reattribution process. Note that the INSS-INFOMAR data was also created using the Nanson et al (2023) scheme.

Table 3-4. GIS layers from existing datasets undergoing GSEU re-attribution

Source dataset	Source dataset GIS layer name	Constraint type (GSEU)	Polygon/lines/Point
EMODnet	Quaternary lithology1	Sediments (pre-Holocene)	Polygon
EMODnet	Pre-Quaternary lithology1	Bedrock	Polygon
EMODnet	Seabed sediments	Sediments	Polygon
EMODnet	Geomorphology	Geological features	Polygon
EMODnet	Submerged landscapes	Geological features	Polygon
EMODnet	Volcanic emissions/centres	Geohazards	Polygons, lines and points
MAREANO	Seabed sediments	Sediments	Polygon
MAREANO	Landforms	Geological features	Polygon
MAREANO	Landforms	Geological features	Polyline
INSS-INFOMAR	Fluid flow	Geohazards	Polygon
INSS-INFOMAR	Fluvial landforms	Geological features	Polygon
INSS-INFOMAR	Solid Earth	Bedrock	Polygon
INSS-INFOMAR	Substrates	Sediments/bedrock	Polygon
INSS-INFOMAR	Various fields	Sediment waves/Iceberg	Polygon
INSS-INFOMAR	Glacial landforms	Geological features	Polygon
INSS-INFOMAR	Glacial linework	Geological features	Polyline
INSS-INFOMAR	Marine landforms	Geological features	Polygon
INSS-INFOMAR	Marine linework	Geological features	Polyline

An example of how an individual GIS layer is re-attributed according to the GSEU 'complexity assessment' is shown in Table 3-5, with a map-based example of the EMODnet Geomorphology layer shown in Figure 3-3A. Note, that Table 3-5 is not the full list of data being attributed, however it provides an overview of the process involved in the re-attribution process. The translation process highlights a reduction in terms for the purpose of GSEU, for example:

- 'bank' and 'bank crest' become 'sediment bank', with *relief* becoming the common constraint;
- 'bench', 'contourite deposit' and 'contourite drift' become 'marine barform', with *active sedimentary system* becoming the common constraint.

An example of the reattribution results is shown in Figure 3-3B, highlighting the reduction of attributes from the original source layer (Figure A) to the GSEU layer (Figure B). This grouping, or simplification, of geological nomenclature enables the systematic updating of typical geological constraints typically identified per geological feature.

Table 3-5. Example of EMODnet Geomorphology layer to GSEU translation and Geological complexity Assessment

EMODnet Geomorphology layer	GSEU translation	Setting	Type of constraint	Hazard translation / assumptions	Suction Casisson foundation	Gravity based foundation	Piled foundation	Export cables
area with pockmarks	Pockmark (field)	Fluid flow	Geohazard, relief	Active fluid flow	Medium complexity	Medium complexity	Medium complexity	Medium complexity
area with slide deposits	Depositional zone	Mass movement	Lithology, relief	Heterogeneous sediments	High complexity	High complexity	Medium complexity	Medium complexity
bank	Sediment bank	Marine	Relief	>5-degree slope	High complexity	High complexity	Medium complexity	High complexity
bank crest	Sediment bank	Marine	Relief	>5-degree slope	High complexity	High complexity	Medium complexity	High complexity
beach ridge	Beach	Coastal	Lithology, relief	Shallow water depth (<15-20 m)	High complexity	High complexity	Medium complexity	Medium complexity
beachrock	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	High complexity	Low complexity	High complexity	High complexity
bedform	Sediment waves/dunes	Marine	Lithology	Active sedimentary system	Medium complexity	High complexity	Medium complexity	Medium complexity
bench	Marine barform	Marine	Lithology, relief	Active sedimentary system	High complexity	High complexity	High complexity	High complexity
canyon	Submarine canyon	Marine	Lithology, relief	Active sedimentary system	High complexity	High complexity	High complexity	High complexity
channel	Submarine channel	Marine	Lithology, relief	Active sedimentary system	High complexity	High complexity	High complexity	High complexity
collapsed blocks	Erratic blocks and rafts (non-glacial origin)	Mass movement	Lithology, relief	Rafts or boulders	High complexity	High complexity	High complexity	High complexity
cold seep	Pockmark (individually mapped)	Fluid flow	Geohazard, relief	Active fluid flow	High complexity	High complexity	High complexity	High complexity
contourite deposit	Marine barform	Marine	Lithology, relief	Active sedimentary system	High complexity	High complexity	High complexity	High complexity
contourite drift	Marine barform	Marine	Lithology, relief	Active sedimentary system	High complexity	High complexity	High complexity	High complexity
coral mound	Reefs (ancient, buried and present day)	Biogenic	Lithology, relief	Active sedimentary system / hardground	High complexity	High complexity	High complexity	Medium complexity
current channel	Submarine channel	Marine	Lithology, relief	Active sedimentary system	High complexity	High complexity	High complexity	High complexity
debris-avalanche deposit	Depositional zone	Mass movement	Lithology, relief	Heterogeneous sediments	High complexity	High complexity	Medium complexity	Medium complexity

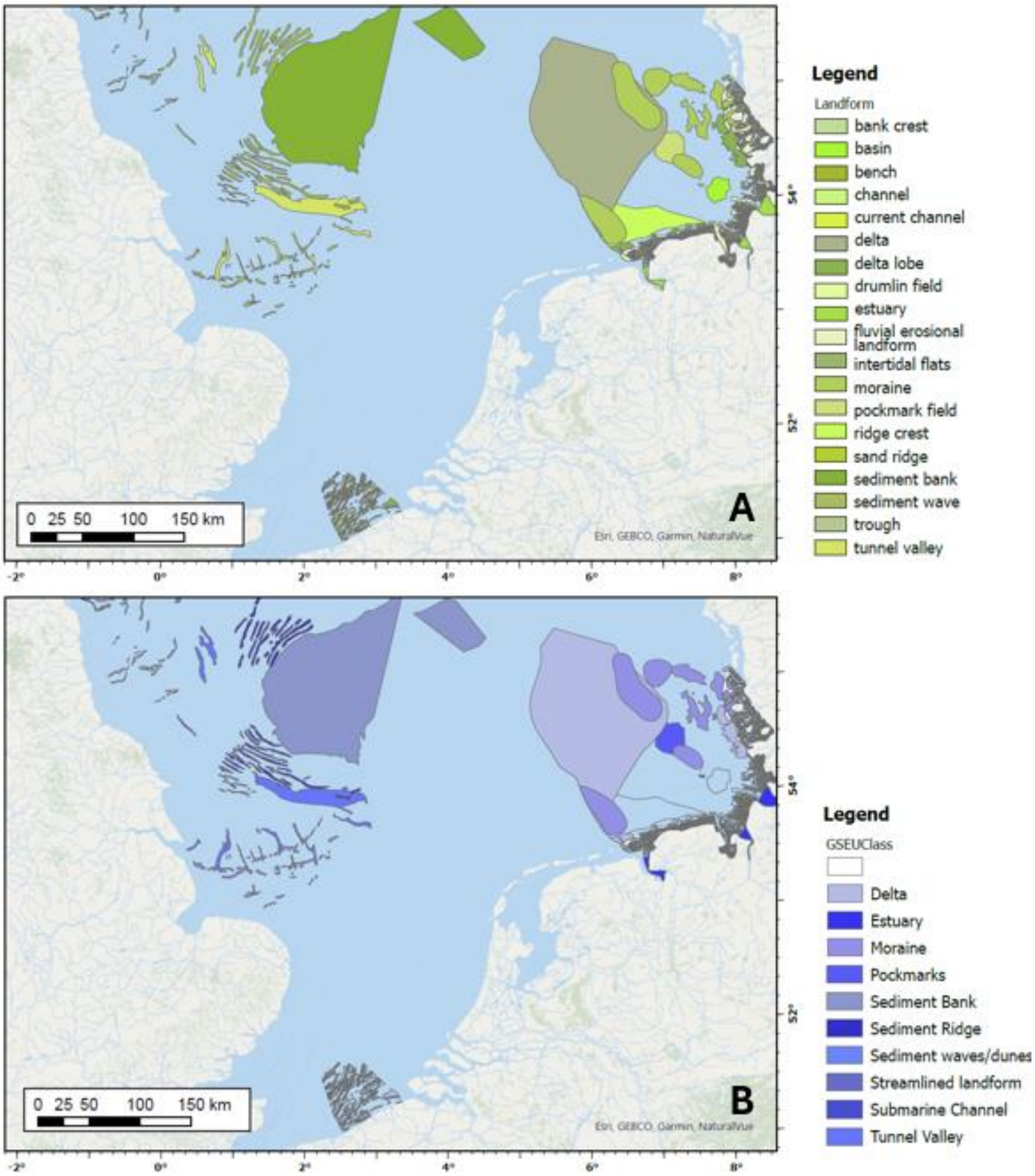

Figure 3-3 (A) Map showing EMODnet Geomorphology attributes across the Southern North Sea (n=19). (B) Map showing GSEU translation of the EMODnet Geomorphology layer, with a reduced number of geomorphological terms after the reattribution process (n=10). Background image from World Ocean Base dataset compiled by ESRI, Garmin, GEBCO, NOAA NGDC, and other contributors.

3.1.6. Step 6: Creation of Offshore pan-European Hex maps

The final step to create pan-European maps is the creation of the reattributed polygons into hex maps. Hex maps enable the display of multivariate data and offers several benefits to the end-user, which in the case of the EGDI platform, includes GSO's, policy makers, stakeholders and marine spatial planners. The hex maps allow for visual and aesthetic clarity that enhances the readability of complex multivariate datasets and can highlight spatial patterns and relationships in the data. Additionally, where data is missing, the hex map display may assist in the planning of additional surveys or data collection. Hex maps can also be scaled to show different levels of detail and have the ability to zoom in or zoom out from macro (pan-European) scale to micro (country) scale. This makes them suitable for the EGDI platform, as the ability to display data at different levels of detail is currently being developed by the Work Package 7.

Hexagons are commonly used by ArcPro, Business Analyst Pro and Briskness Analyse Web App users and use 'Uber H3 hexagons', a widely adopted global grid system, and abbreviated to *H3 hexagons* (Thompson et al. 2024). ArcGIS Pro and Business Analyst Pro allow user-defined hexagons and grids at any resolution (Table 3-7). Products support all 16 H3 hexagon resolutions, through the Generate Tessellation tool (ArcGIS Pro) and the Generate Grids and Hexagons tool (Business Analyst Pro). Business Analyst Web App provides data in six H3 hexagon resolutions, starting at resolution 2 (average radius of 98.2 miles) through resolution 7 (a 0.8-mile radius), Table 3-7. For the GSEU project, resolution sizes 6 and 7 are being trialled.

Table 3-6. Hexagon area differences between ESRI resolution sizes (2 to 7)

Resolution	Average hexagon area		Average radius (apothem)	
2	86,801.8 km^2	33,514.4 miles^2	158.1 km	98.2 miles
3	12,393.4 km^2	4,785.1 miles^2	59.7 km	37.1 miles
4	1,770.3 km^2	683.5 miles^2	22.6	14 miles
5	252.9 km^2	97.6 miles^2	8.5 km	5.3 miles
6	36.1 km^2	13.9 miles^2	3.2 km	2 miles
7	5.2 km^2	2.0 miles^2	1.2 km	0.8 miles

Creation of the hex-maps is ongoing, however a draft (version 1) of the reattribution process of the selected datasets (Table 3-4) is completed (Annex 2). An example of a preliminary offshore hex-map is shown in Figure 3-4, showing the EMODnet Geomorphology translated layer into GSEU translated data (i.e., high to low complexity assessment) into a hex map.

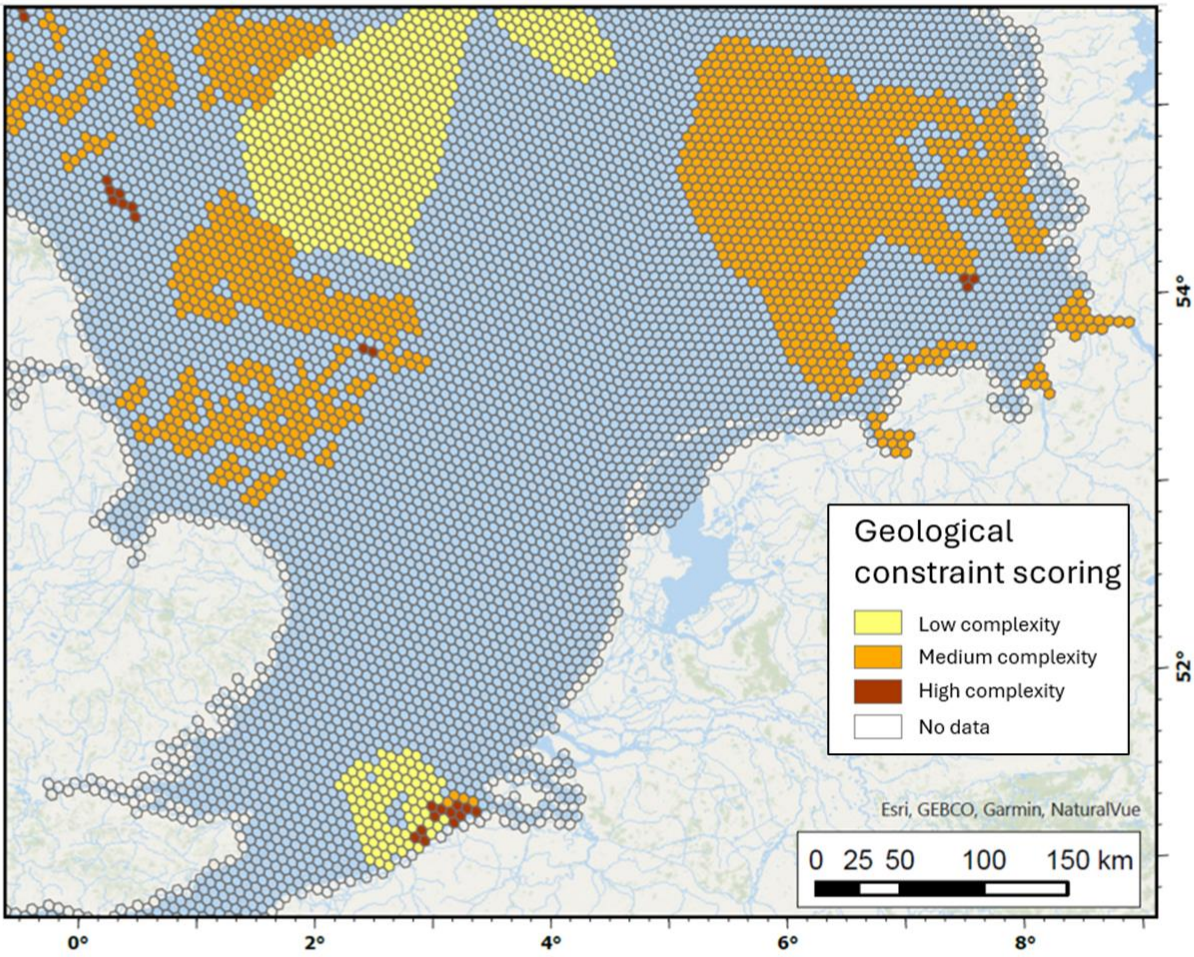

Figure 3-4. Map showing example of the EMODnet Geomorphology layer translated into a GSEU hex-map via the reattribution processes across the Southern North Sea. 1 = Low complexity, 2 = medium complexity, 3 = High complexity. Background image from World Ocean Base dataset compiled by ESRI, Garmin, GEBCO, NOAA NGDC, and other contributors. Example using 'Resolution 6' H3 Hexagons.

4. Geo-Assessment Matrix: Future Development & Summary

As governments develop their road maps for renewable energy from offshore wind around the UK, continental Europe and beyond, countries are seeing a major expansion in the number of offshore windfarm licenses granted. T5.2, optimised windfarm siting, aims to improve knowledge sharing between GSO's by providing open lines of communication between geoscientists, create standardised geological nomenclature used between disciplines (e.g., geotechnical engineering) and to establish a foundation of knowledge on how geology impacts engineering, as developed in the Geo-Assessment Matrix, and how **e**ngineering constraints can be attributed to geological features to create user-friendly maps, as outlined in this project.. The Geo-Assessment Matrix identifies key geological factors that impact technical operations in the offshore environment. As technology and policies evolve, the Geo-Assessment Matrix can be easily adapted for different purposes. One example is the development of floating offshore windfarm structures. It is suggested that over the next 12 months (and beyond), an attempt to insert information relevant to floating windfarms would be prudent.

In conclusion, this phase of T5.2a concludes the development of the Geo-Assessment Matrix and the reattribution process of existing datasets that form the foundation of producing pan-European map-based products. The development of the hex-maps is ongoing and will be completed for Deliverable D5.4, version 2 of this project.

5. Appendix I – Glossary

TERM	DEFINITION	REFERENCE(S)
Anchor	Device to prevent or restrict vessel/structure movement.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Anisotropic stiffness	Variability in soil stiffness both laterally and vertically. Prone to differential settlement	Giles, D.P., Griffiths, J.S., Evans, D.J.A. and Murton, J.B., 2017. Chapter 3 Geomorphological framework: glacial and periglacial sediments, structures and landforms. Geological Society, London, Engineering Geology Special Publications, 28(1), pp.59-368.
Anisotropic permeability	Variability in permeability both laterally and vertically	Giles, D.P., Griffiths, J.S., Evans, D.J.A. and Murton, J.B., 2017. Chapter 3 Geomorphological framework: glacial and periglacial sediments, structures and landforms. Geological Society, London, Engineering Geology Special Publications, 28(1), pp.59-368.
Anisotropic strength	Variability in soil strength and behaviour both laterally and vertically	Giles, D.P., Griffiths, J.S., Evans, D.J.A. and Murton, J.B., 2017. Chapter 3 Geomorphological framework: glacial and periglacial sediments, structures and landforms. Geological Society, London, Engineering Geology Special Publications, 28(1), pp.59-368.
Bearing capacity	Capacity of soil to support the loads that are applied by the foundation.	Barnes, G. (2017). Soil mechanics. Bloomsbury Publishing.
Cables	See Export cables	https://www.windandwaterworks.nl/cases/export-and-inter-array-cable-installation#:~:text=Cabling%20is%20a%20critical%20component,substation%20to%20the%20onshore%20network.
Cable Burial Risk Assessment (CBRA)	Cable burial has long been regarded as the optimal protection technique against external hazards (e.g., interaction with vessel anchors). The Cable Burial Risk Assessment (CBRA) Guidance offers a standardised, repeatable and qualitative method to improve risk management of subsea cables for offshore windfarms, improve conservative estimates of residual risk, and ultimately reduce the installation and insurance costs for subsea cables.	The Carbon Trust. (2015). Cable Burial Risk Assessment Methodology - Guidance for the Preparation of Cable Burial Depth of Likely suitableing Specification. https://www.carbontrust.com/our-work-and-impact/guides-reports-and-tools/cable-burial-risk-assessment-cbra-guidance-and-application-guide
Compressible soils	Highly compressible horizons potentially present in the subsurface	Giles, D.P., Griffiths, J.S., Evans, D.J.A. and Murton, J.B., 2017. Chapter 3 Geomorphological framework: glacial and periglacial sediments, structures and landforms. Geological Society, London, Engineering Geology Special Publications, 28(1), pp.59-368.
Constraint	See Engineering constraint and Geological constraint and Geomorphological constraint	
Driven pile	Pre-made piles installed into the ground by percussion, pressing or vibration.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Engineering constraint	Static feature that can be addressed by routine engineering processes	Dimmock, P.S., Riera, R., Tam, T.A. and Boylan, N., 2023, January. Geohazard or Geo-engineering constraint?. In Offshore Site Investigation Geotechnics 9th International Conference Proceeding (Vol. 2067, No. 2071, pp. 2067-2071). Society for Underwater Technology.

Export cables	Export cables transport electricity from the offshore substation to the onshore network (see Landfall glossary entry).	https://www.windandwaterworks.nl/cases/export-and-inter-array-cable-installation#:~:text=Cabling%20is%20a%20critical%20component,substation%20to%20the%20onshore%20network.
Foundation types	Includes fixed turbines (gravity-based structures, suction caisson, pile design)	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Freespan, free-span, or free span	The scenario whereby a section of installed cable or pipeline becomes exposed and is unsupported along its length on the seabed for a distance, typically greater than 3m. This can result in exposure to vessel equipment (e.g., anchor or trawling gear interactions) and/or can lead to exposure to vortex-induced vibrations (VIV - see below for glossary definition).	Offshore Engineer article (https://www.oedigital.com/news/459021-free-span-analysis)
Geohazard	A geohazard is a geological state, feature or process that presents a risk to development. Term is restricted to dynamic processes that may impact the development	Dimmock, P.S., Riera, R., Tam, T.A. and Boylan, N., 2023, January. Geohazard or Geo-engineering constraint?. In Offshore Site Investigation Geotechnics 9th International Conference Proceeding (Vol. 2067, No. 2071, pp. 2067-2071). Society for Underwater Technology.
Geological constraint	A geological feature that does not have a topographic expression at seabed or is buried in the subsurface and may impact development	Nanson, R., Arosio, R., Gafeira, J., McNeil, M., Dove, D., Bjarnadóttir, L., Dolan, M.F.J., Guinan, J., Post, A., Webb, J. and S. Nichol. 2022. A two-part seabed geomorphology classification scheme. Part 2: Geomorphology classification framework and glossary - Version 1.0. Published 14th April 2023. DOI: 10.5281/zenodo.7804019
Geological feature	A broad term encompassing seabed or subsurface physical features present within area of interest	Nanson, R., Arosio, R., Gafeira, J., McNeil, M., Dove, D., Bjarnadóttir, L., Dolan, M.F.J., Guinan, J., Post, A., Webb, J. and S. Nichol. 2022. A two-part seabed geomorphology classification scheme. Part 2: Geomorphology classification framework and glossary - Version 1.0. Published 14th April 2023. DOI: 10.5281/zenodo.7804019
Geomorphological constraint	A morphological feature with process of formation interpreted and has a topographic expression at the seabed that may impact development	Nanson, R., Arosio, R., Gafeira, J., McNeil, M., Dove, D., Bjarnadóttir, L., Dolan, M.F.J., Guinan, J., Post, A., Webb, J. and S. Nichol. 2022. A two-part seabed geomorphology classification scheme. Part 2: Geomorphology classification framework and glossary - Version 1.0. Published 14th April 2023. DOI: 10.5281/zenodo.7804019
Geomorphology	Morphological feature on the seabed with a topographic expression that is classified in terms of process and setting	Nanson, R., Arosio, R., Gafeira, J., McNeil, M., Dove, D., Bjarnadóttir, L., Dolan, M.F.J., Guinan, J., Post, A., Webb, J. and S. Nichol. 2022. A two-part seabed geomorphology classification scheme. Part 2: Geomorphology classification framework and glossary - Version 1.0. Published 14th April 2023. DOI: 10.5281/zenodo.7804019
Gravity base structure (GBS)	A concrete or ballasted steel structure, supported by a shallow foundation, that may or may not have skirts.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.

Inter-array cables	Cables within a specific development area (as opposed to export cables), typically between wind turbines or other renewable energy generating units and hub platforms.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Jacket	A Jacket structure is a welded tubular space frame consisting of vertical or battered legs, supported by a lateral bracing system.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Landfall	The term landfall refers to the point at which the export cables (see glossary entry above) carrying power from an offshore windfarm reach the shore. This is where the offshore and onshore infrastructure is connected – an important step in bringing renewable wind energy into the power grid.	Orsted webpage (https://us.orsted.com/renewable-energy-solutions/offshore-wind/offshore-wind-farm-construction/bringing-wind-power-ashore)
Lateral loading	Stress applied to the structure in a horizonal plane.	Anastassopoulos, C., Charles, J.A. and Gourvenec, S., 2023, January. Effect of CPT profile resolution on minimum required size of monopile for ultimate limit state design. In Offshore Site Investigation Geotechnics 9th International Conference Proceeding (Vol. 393, No. 400, pp. 393-400). Society for Underwater Technology.
Monopile	A single cylindrical steel pile (see pile for definition).	Barnes, G. (2017). Soil mechanics. Bloomsbury Publishing.
Overconsolidation	If the present-day (effective overburden) pressure being exerted on the soil unit is not high enough to account for the strength of that unit, then it is said to be overconsolidated. This can typically happen when (1) soil has been removed (eroded) from over the unit, meaning it has experienced more loading and therefore Possibly unsuitable stresses in the past, (2) the unit has experienced significant loading from ice sheets in the past, or (3) the soil unit has experienced desiccation in the past.	Barnes, G. (2017). Soil mechanics. Bloomsbury Publishing.
Periglacial process	Periglacial processes refer to the forms and processes that occur in a cold climate environment, characterised by the freezing and thawing of water	Shiklomanov, N.I. and Nelson, F.E., 2013. Thermokarst and civil infrastructure. In Treatise on geomorphology (pp. 354-373).
Pile	A long, slender structural member (typically a hollow steel cylinder) used to transmit loads applied at its top to the ground at Likely suitable levels.	Barnes, G. (2017). Soil mechanics. Bloomsbury Publishing.
Pile refusal	Where a pile cannot be completely driven to its target depth without further intervention, typically associated with reaching the maximum energy transfer for a given hammer system. Turbine locations are typically chosen to avoid areas where piling is likely to be problematic. For some sites, a vessel will	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.

	be mobilised with drilling equipment to mitigate the risk to the project schedule in cases of pile refusal	https://www.thecrownestate.co.uk/media/2860/guide-to-offshore-wind-farm-2019.pdf
Pile run	During installation, a pile may suddenly and catastrophically go into freefall. This uncontrolled fall can pose a serious risk to the lives of the crew onboard the vessel. This is termed a pile run, and can occur when unexpected voids are encountered or where unexpected very soft soils are encountered beneath dense and/or stiff to very stiff soils.	Ciavaglia, F., Morgan, N. and Casanovas, C., 2023, January. High-level engineering considerations for the concept selection of fixed offshore wind turbine foundations. In Offshore Site Investigation Geotechnics 9th International Conference Proceeding (Vol. 2080, No. 2087, pp. 2080-2087). Society for Underwater Technology.
Piled jacket	Fixed typically steel framed structure with pile foundations.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Process	The term “Process” grouped geomorphic units formed by groups of similar processes. Also, see 'Setting'	Nanson, R., Arosio, R., Gafeira, J., McNeil, M., Dove, D., Bjarnadóttir, L., Dolan, M., Guinan, J., Post, A., Webb, J. and Nichol, S., 2023. A two-part seabed geomorphology classification scheme. Part 2: Geomorphology classification framework and glossary-Version 1.0.
Prone to liquefaction	Prone to liquefaction on disturbance or overloading	Giles, D.P., Griffiths, J.S., Evans, D.J.A. and Murton, J.B., 2017. Chapter 3 Geomorphological framework: glacial and periglacial sediments, structures and landforms. Geological Society, London, Engineering Geology Special Publications, 28(1), pp.59-368.
Punch-through	Rapid, uncontrolled penetration of a jack-up rig's leg and spudcan (see spudcan for definition), which can be used to install some foundations. Often caused when unexpected voids are encountered or where unexpected very soft soils are encountered beneath dense and/or stiff to very stiff soils.	DeGroot, D.J., Westgate, Z.J. and Yetginer-Tjelta, T.I., 2023, January. Geological and geotechnical challenges of the East Coast United States for offshore energy transition. In Offshore Site Investigation Geotechnics 9th International Conference Proceeding (Vol. 82, No. 111, pp. 82-111). Society for Underwater Technology.
Rock dumping / rock placement	Installation of rock or gravel in the form of protective structures, typically around foundations or over cables, etc.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Rockhead	The surface of the bedrock beneath the soil cover.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Setting	The term “Setting” groups geomorphic units that are generally formed in specific depositional environments	Nanson, R., Arosio, R., Gafeira, J., McNeil, M., Dove, D., Bjarnadóttir, L., Dolan, M., Guinan, J., Post, A., Webb, J. and Nichol, S., 2023. A two-part seabed geomorphology classification scheme. Part 2: Geomorphology classification framework and glossary-Version 1.0.

Shaft friction	Refers to the axial pile capacity component associated with the interface friction between the pile walls and the surrounding material.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Skirt or skirt embedment	Skirts are vertical plates below gravity base or mudmat structures, that penetrate into the seabed. Embedment is the penetration depth below seabed.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Solid Earth	The “Solid Earth” system, although not a “Setting” per se, is defined this way as it includes several different processes and can often be considered the general background for other Settings and Processes. See 'Setting' and 'Process'	Nanson, R., Arosio, R., Gafeira, J., McNeil, M., Dove, D., Bjarnadóttir, L., Dolan, M., Guinan, J., Post, A., Webb, J. and Nichol, S., 2023. A two-part seabed geomorphology classification scheme. Part 2: Geomorphology classification framework and glossary-Version 1.0.
Spudcan	Inverted cones mounted at the base of a jack-up leg, which provide stability to lateral forces on the jack-up rig when installed on the seabed.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Suction caisson/suction pile/suction bucket/suction can	A cylindrical caisson foundation that is installed using a combination of self weight and suction. A pile/deep skirted foundation that is installed using suction pumps for assistance. The suction caisson technology functions very well in a seabed with soft clays or other low strength sediments. The presence of soil layers which have different properties (strength, stiffness, permeability etc.) and exhibit different behaviour under stress can have a large impact on the installation of suction buckets.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee. Remmers, J., Reale, C., Pisanò, F., Raymackers, S., & Gavin, K. (2019). Geotechnical installation design of suction buckets in non-cohesive soils: A reliability-based approach. Ocean Engineering, 188, 106242.
Tethered foundations	Floating structures that are held in place by anchors or piles. Structures that are held in place by anchors.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Thermal conductivity	The property of a material to conduct heat, typically measured in watts per metre kelvin. Typically, is computed from the linear portion of the plot of temperature vs. the natural log (ln) of time.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.

Trenching (cables & pipelines)	In order to protect cables and pipelines from risk of interactions with vessels anchors and fishing gear, the asset is often buried in the shallow subsurface (typically ≤2 m below seabed). This is often often done through placing the asset in a linear trench that has been excavated by specialist equipment, which can include seabed ploughs, jetting equipment, and chain cutting tools. For an example, see this short video: https://www.youtube.com/watch?v=d9tRmJLOCdg	Powell, T.A., White, D.J., Alvarez-Borges, F. and Fearn, M., 2023, January. In-situ testing in trench backfill: Evidence of evolving backfill density. In Offshore Site Investigation Geotechnics 9th International Conference Proceeding (Vol. 476, No. 483, pp. 476-483). Society for Underwater Technology.
Tripod	A structure supported by three separate foundations.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Unconfined or uniaxial compressive stress (UCS) test	Laboratory test for determining the maximum axial compressive stress of a soil or rock specimen at zero confining stress	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Undrained shear strength	In the context of soil mechanics, resistance to shear failure of the soil without dissipation of the pore water pressure generated by the applied shear stresses.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Unexploded Ordnance (UXO)	Explosive objects that did not explode when they were employed and still pose a risk of detonation.	Cook, M., Barwise, A., Carey, N., Carrington, T., Dix, J., Giuliani, G., Hobbs, R., James, L., Wood, A. M., Lawrence, M., Jones, D. L., Morgan, N., Orren, R., Osborne, J., Andrade, M. P., Rushton, D., Searle, A., Smith, A., Wilson, P. (2022). Guidance Notes for the Planning and Execution of Geophysical and Geotechnical Ground Investigations for Offshore Renewable Energy Developments. Society for Underwater Technology - Offshore Site Investigation & Geotechnics Committee.
Variable particle sizes	Variability in particle sizes both laterally and vertically, e.g., clay, silt, sand , gravel, cobbles and boulders all potentially present	Giles, D.P., Griffiths, J.S., Evans, D.J.A. and Murton, J.B., 2017. Chapter 3 Geomorphological framework: glacial and periglacial sediments, structures and landforms. Geological Society, London, Engineering Geology Special Publications, 28(1), pp.59-368.
Vortex-Induced Vibrations (VIV)	Exposed, hanging (see freespan for explanation) cables and pipelines can, under certain flow conditions, experience sustained periods of vibration due to the transfer of energy from the fluid to the structure. These vibrations (VIV) may promote fatigue and significantly degrade the service life and performance of the asset.	Kim, W. J., & Perkins, N. C. (2002). Two-dimensional vortex-induced vibration of cable suspensions. Journal of Fluids and Structures, 16(2), 229-245.

6. Appendix II – References

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7. Appendix III – Geological Feature Inventory

Geological feature inventory comprising the foundation to the Geo-Assessment Matrix. Definitions and classifications from Nanson et al. (2023), Dove et al. (2020) and others included to be developed as part of T5.2 (this report).

Step 1 of Geo-Assessment Matrix - Geological Data Inventory				References		
Geological feature Inventory	**Sediments, Physiography, Setting, Process**	**Constraint type**	**Definition**	**Nanson et al. 2023**	**Dove et al. 2020**	**New GSEU**
Peat (organic-rich)	**Sediments**	Lithology	Superficial deposits. Type of soil formed by the partial decomposition of vegetation matter. Includes submerged forests.	N	N	Y
Glauconite	**Sediments**	Lithology	Superficial deposits. Glauconite is an iron potassium mica with a characteristically green colour and low strength, often found in peloidal form. Glauconite generally forms under reducing conditions within a shallow marine depositional environment. Glauconite can be characterised as sand-sized grains but transforms into fine-grained soil upon shearing due to particle crushing.	N	N	Y
Soft mud	**Sediments**	Lithology	Superficial deposits. May include marine mud basins including soft glaciolacustrine/glaciomarine (not overconsolidated) mud deposition or other soft, muddy shelfal deposits.	N	N	Y
Soft interbedded sediment	**Sediments**	Lithology	Superficial deposits	N	N	Y
Firm to hard mud	**Sediments**	Lithology	Superficial deposits	N	N	Y
Sand	**Sediments**	Lithology	Superficial deposits	N	N	Y
Gravel	**Sediments**	Lithology	Superficial deposits	N	N	Y
Diamicton	**Sediments**	Lithology	Superficial deposits	N	N	Y
Carbonate sands	**Sediments**	Lithology	Calcareous and carbonate soils can be identified by their reaction with dilute hydrochloric acid, producing carbon dioxide that bubbles off. The grains consists partially or completely of calcium carbonate and may be formed of the skeletal remains of microscopic marine plant and animal remains. Calcium carbonate is a relatively soft mineral compared with silica-based soils	N	N	Y
Evaporites	**Sediments**	Lithology	Any of a variety of individual minerals found in the sedimentary deposit of soluble salts that results from the evaporation of water. Can influence shallow structures (e.g. diapirism).	N	N	Y
Basin / Basin plain / intraslope basin	**Physiography**	Relief	A depression more or less equidimensional in plan and of variable extent and usually greater than 10 km in largest dimension. (Stagpoole and Mackay, 2022).	N	Y	N
Shelf break	**Physiography**	Relief	The line along which there is a marked increase in slope at the seaward margin of a shelf	N	Y	N
Mound	**Physiography**	Relief	A distinct elevation with a rounded profile generally less than 500 m above the surrounding relief as measured from the deepest isobath that surrounds most of the feature. Sides are usually steeper than 5 degrees.	N	Y	N
Terrace	**Physiography**	Relief	A flat or gently sloping region, generally long and narrow, bounded along one edge by a steeper descending slope and along the other by a steeper ascending slope. Usually less than two degrees. (Stagpoole and Mackay, 2022)	N	Y	N
Trough	**Physiography**	Relief	A long depression generally wide and flat-bottomed with symmetrical and parallel sides. Sides usually steeper than 5 degrees. (Stagpoole and Mackay, 2022)	N	Y	N
Ridge	**Physiography**	Relief	An elongated elevation of varying complexity, size and gradient. Variable steepness, but usually has sloping sides greater than 5 degrees.	N	Y	N
Moat	**Physiography**	Relief	An annular or partially annular bathymetric low typically located at the base of isolated raised features.	N	Y	N

Plateau / topographic high	**Physiography**	Relief	A generally closed-contoured, relatively flat-topped bathymetric high with one or more relatively steep sides.	N	Y	N
Depression/ hole	**Physiography**	Relief	A general term for a closed-contour bathymetric low. Depressions vary in scale from small local features to larger basins. They generally have lower gradient sides than holes.	N	Y	N
Glacifluvial delta	**Glacial**	Lithology, relief	There are many kinds of deltas; all have relatively flat delta plains, frequently triangular (fan) shaped in plan view, and steeper delta front slopes. In cross-section, the archetypal delta consists of flat-lying topset beds over steeper foreset beds, which rest on bottomset beds that are usually thin and fine-grained. The typical glacifluvial delta usually consists of coarser-grained sediments, and their front slopes are steep with foreset beds generally dipping 10-30° Glacifluvial deltas are also referred to as glacier-fed deltas as terrestrial proglacial meltwater streams/rivers carry sediments from a glacier to the marine/lacustrine environment	Y	N	N
Glacifluvial outwash plain (sandur)	**Glacial**	Lithology, relief	Laterally extensive flat plain of sand and gravel with braided streams of glacial meltwater flowing across them when active.	Y	N	N
Grounding zone wedge	**Glacial**	Lithology, relief	A sedimentary depocenter formed at the grounding zone of an icesheet/ice-shelf system, formed of dipping diamicton beds overlain by horizontal sheets of diamicton, mainly subglacial till. Till emerging from beneath the glacier along a line-source is redistributed by subaqueous debris flows, producing diamicton beds that dip away from the margin. GZWs are usually asymmetrical in long-profile, steeper in the ice-distal direction	Y	N	N
Erratic or glaciotectonic raft	**Glacial**	Lithology, relief	Large rock or boulder carried by a glacier or by floating ice and deposited when the ice melted, well away from its place of origin and therefore contrasting with the parent/surrounding rock	Y	N	N
Hill-hole pair	**Glacial**	Lithology, relief	A discrete hill of ice-thrust material, often slightly deformed, situated down glacier from a depression of approximately the same size and shape. Either pre-existing drift or bedrock may be contained in the dislocated hill	Y	N	N
Hummocky terrain	**Glacial**	Lithology	Includes: Crevasse squeeze ridges. A landscape with a highly irregular surface, characterised by a series of small mounds, ridges and depressions. Associated with glacier/ice sheet grounding zones.	Y	N	N
Ice-contact delta	**Glacial**	Lithology, relief	Includes: Ice proximal fan. Ice-contact deltas form at glacier margins and develop from e.g. ice proximal grounding line fans or other submerged depositional units	Y	N	N
Meltwater channel	**Glacial**	Lithology, relief	Includes: Proglacial meltwater channel. A channel produced by the flow of glacial meltwater. Where the channel is subglacial, pressurized water may flow upslope as well as downslope, producing an undulating channel long-profile	Y	N	N
Open tunnel valley	**Glacial**	Lithology, relief	A large subglacial, steep-sided channel cut into unconsolidated sediment or bedrock by meltwater and forms a topographic expression on the seabed. The channel may have a reverse gradient in places	Y	N	N
Buried tunnel valley	**Glacial**	Lithology, relief	A large subglacial, steep-sided channel cut into unconsolidated sediment or bedrock by meltwater. The channel may have a reverse gradient in places	Y	N	N
Moraine	**Glacial**	Lithology, relief	A mound, ridge or other distinct accumulation of generally unsorted, unstratified glaciogenic sediment, predominantly till, deposited chiefly by direct contact with glacier ice, commonly subglacial. See De Geer moraine, end moraine, fluted moraine, interlobate moraine, kame moraine, lateral moraine	Y	N	N
Kettle hole	**Glacial**	Lithology, relief	Steep-sided hollow produced by the melt-out of an original deposit which also contained finer materials that were removed by wind or water action	Y	N	N
Streamlined landform	**Glacial**	Lithology, relief	Includes: Crag and tail /Drumlin/ Flute/ Groove. Streamlined landforms have been sculpted and moulded by glacier ice, moving in a coherent direction. These landforms can consist of bedrock, unconsolidated sediments or both. They are formed parallel to the ice flow direction and are considered good palaeo-flow indicators. Elongation is considered to be positively correlated with higher ice flow velocities	Y	N	N
Esker	**Glacial**	Lithology, relief	Sinuous elongate ridges of glaciofluvial sands and gravels, usually stratified and imbricated. Rarely exceed 700 m width and 50 m height. Form by depositional from meltwater streams in tunnel systems running perpendicular to the ice front.	Y	N	N
Glaciolacustrine	**Glacial**	Lithology	Stratified sediments that display rhythmic or cyclic repetition of beds that form in subaqueous settings such as lakes and oceans, but also in glaciofluvial systems	Y	N	N
Iceberg plough mark (field)	**Glacial**	Lithology	Groove or furrow caused by the impact and movement of grounded icebergs along the sea or lake floor	Y	N	N

U-shaped valley (e.g. Fjord)	**Glacial**	Relief	A valley having a pronounced parabolic cross-profile suggesting the form of a broad letter ‘U’ with steep parallel walls and a broad, nearly flat floor; specifically a valley carved by glacial erosion, such as a glacial trough or fjord	Y	N	N
Coarse lag deposits	**Marine**	Lithology	Typically coarse-grained material (dominated by gravel with boulders) derived from Pleistocene glacial sediments that have been modified during the Holocene by winnowing, seafloor polishing and transport of the finer fraction to be redeposited elsewhere. Also can occur as near shore heterogeneous deposits associated with transgressive system tracts in non- glacial environments.	Y	N	N
Marine bar form	**Marine**	Lithology, relief	Includes: Contourite drift/ sediment apron/ sediment drift/ sediment lobe/energetic wave or current regime. Tend to be larger than CURRENT-INDUCED BEDFORMS (e.g. Venditti, 2013), are often forced by macro-scale topography (e.g. channels – point bar; headlands - banner), and develop over longer periods of time	Y	N	N
Sediment bank	**Marine**	Relief	Formed by interactions between current instabilities (commonly generating cyclonic flows) and unconsolidated sediment at the seabed. SEDIMENT BANKS are the largest Current-induced BEDFORMS within the Submarine Setting and require sufficiently rapid current flows and high rates of sediment supply.	Y	N	N
Sediment waves/dunes	**Marine**	Lithology	Sediment waves/dunes have a broad range of morphologies and represent transverse bedforms larger than ripples (wavelength 0.6–10 m, height 0.1–1 m).	Y	N	N
Submarine canyon	**Marine**	Lithology, relief	Includes: Canyon/ canyon head / canyon mouth / tributary canyon. Steep-sided, GENERALLY V-shaped valleys with heads at or near the CONTINENTAL SHELF edge. They extend across the CONTINENTALSLOPE and are commonly linked to numerous tributaries, similar to unglaciated river-cut canyons on land	Y	N	N
Submarine channel	**Marine**	Lithology, relief	Formed by sediment-laden turbidity currents and other sediment-rich gravity currents or by fluvial incision during low-stands and buried during sea level rise.	Y	N	N
Submarine fan	**Marine**	Lithology, relief	Develop on the CONTINENTAL SLOPE, RISE and ABYSSAL PLAIN, normally at the mouths of SUBMARINE CANYONS. They are constructed principally from the deposits of sediment gravity flows (mainly turbidity currents and debris flows) as terrigenous and shallow marine sediment is redistributed into deeper water	Y	N	N
Submarine or submerged delta	**Marine**	Lithology, relief	Submarine tidal deltas, develop from the nearshore to the shelf break or submerged coastal riverine/estuarine deltas and pro-deltas deposits	Y	N	N
Submarine gully	**Marine**	Lithology, relief	Small-scale (<10 km) confined channels, generally on the order of tens of meters deep and often linear in planform. SUBMARINE GULLIES are commonly found within or alongside SUBMARINE CANYONS on the continental slope and may represent an incipient stage of canyon development	Y	N	N
Alluvial fan	**Fluvial**	Lithology, relief	Usually cone-shaped forms with surface slopes radiating away from an apex located at the point where the feeder SUBAERIAL CHANNEL splits to form DISTRIBUTARY CHANNELS. Their fan-like geometry can be modified by the confinement of neighbouring fans or valley walls	Y	N	N
Buried Submerged river valley/ channel	**Fluvial**	Lithology, relief	Form via combinations of fluvial and coastal processes (see Additional Attributes: Marginal marine process classification); they widen by lateral SUBAERIAL CHANNEL erosion and weathering, and lengthen by both headward erosion and progradation in their lower reaches. SUBAERIAL VALLEYS can form networks with a variety of drainage patterns.	Y	N	N
Open Submerged river valley/ channel	**Fluvial**	Lithology, relief	Form via combinations of fluvial and coastal processes (see Additional Attributes: Marginal marine process classification); they widen by lateral SUBAERIAL CHANNEL erosion and weathering, and lengthen by both headward erosion and progradation in their lower reaches. SUBAERIAL VALLEYS can form networks with a variety of drainage patterns	Y	N	N
Beach	**Coastal**	Lithology, relief	A wave-deposited body of sand or gravel formed along open coast (marine), estuarine and lacustrine shorelines (beach face, shoreface, sandy shoal etc.)	Y	N	N
Estuary	**Coastal**	Lithology, relief	Estuaries are classified into the following estuarine behavioural types: Generic fjord (fjord, fjard, ria), spit-enclosed drowned river valley, funnel-shaped river valley, embayment and tidal inlet	Y	N	N
Coastal bar form	**Coastal**	Lithology	Any type of BARFORM formed in a Coastal Setting (e.g., nearshore bar, berm, shoreface terrace, beach cusp etc)	Y	N	N
Delta	**Coastal**	Lithology	A discrete shoreline sedimentary protuberance formed where a river enters a body of water and supplies sediment more rapidly than it can be redistributed by basial processes	Y	N	N
Barrier	**Coastal**	Lithology	Elongate accumulations of sand or coarser sediment primarily deposited by waves and longshore currents, rising above the present sea level, often impounding terrestrial drainage or blocking off a LAGOON in the BACKBARRIER (modified from Griffin et al., 2012; Woodroffe, 2002). Can be sub-classified using their number of attachment points to the mainland (cf. SALIENT/TOMBOLO; BAY-MOUTH; SPIT).	Y	N	N
Back barrier (flats and lagoons)	**Coastal**	Lithology	A relatively protected area between the BARRIER and the mainland, which may be occupied by FLATS or a LAGOON.	Y	N	N

Tidal flat	**Coastal**	Lithology	Low gradient intertidal to supratidal surfaces formed in fine-grained sediment	Y	N	N
Rocky coast	**Coastal**	Lithology	Any length of coast that is predominantly characterised by rock (rather than sediment or vegetation)	Y	N	N
Buried or exposed eustatic escarpment (excessive seabed gradient)	**Solid** Earth	Relief	Escarpments formed by sea level stand stills that can be totally or partially covered by transgressive sediment tracts. Vary in length from few km to various tens of kms.	Y	N	Y
Bedrock outcrop/subcrop (undifferentiated)	**Solid** Earth	Lithology	A relief formed by bedrock of unspecified lithology and genesis cropping out of the surrounding seabed. Subcropping of bedrock can be common and covered by thin sediment covers in sediment starved shelves.	Y	N	Y
Bedrock outcrop/subcrop; carbonate	**Solid** Earth	Lithology	A relief formed by bedrock of unspecified lithology and genesis cropping out of the surrounding seabed. Subcropping of bedrock can be common and covered by thin sediment covers in sediment starved shelves.	N	N	Y
Bedrock outcrop/subcrop; sedimentary; clastic	**Solid** Earth	Lithology	A relief formed by bedrock of unspecified lithology and genesis cropping out of the surrounding seabed. Subcropping of bedrock can be common and covered by thin sediment covers in sediment starved shelves.	N	N	Y
Bedrock outcrop/subcrop; igneous	**Solid** Earth	Lithology	A relief formed by bedrock of unspecified lithology and genesis cropping out of the surrounding seabed. Subcropping of bedrock can be common and covered by thin sediment covers in sediment starved shelves.	N	N	Y
Bedrock outcrop/subcrop; metamorphic	**Solid** Earth	Lithology	A relief formed by bedrock of unspecified lithology and genesis cropping out of the surrounding seabed. Subcropping of bedrock can be common and covered by thin sediment covers in sediment starved shelves.	N	N	Y
Fractured bed rock	**Solid** Earth	Structure	Bedrock of unspecified lithology and genesis that has multiple fractures or fracture networks causing discontinuities in the host rock that can be exploited by erosion.	Y	N	Y
Seamount	**Solid** Earth	Relief	Any geographically isolated topographic unit on the seafloor taller than 1000 m. Most seamounts are formed by igneous activity close to mid-ocean ridges, island arcs, or in mid-plate settings, although blocks of continental crust, stranded during the opening of ocean basins, or at compressional settings, can form nonvolcanic seamounts	Y	N	N
Volcano or volcanic feature	**Solid** Earth	Geohazard	A mountain or hill, typically conical, having a crater or vent through which lava, rock fragments, hot vapour, and gas are or have been erupted from the earth's crust	Y	N	N
Tectonic lineament (fault)	**Solid Earth**	Structure, Geohazard	A discrete surface, or zone of discrete surfaces, expressed as fractures at seabed, separating two rock masses across which one mass has slid past the other	Y	N	N
Tectonic escarpment	**Solid** Earth	Relief	An escarpment that forms because of unspecified faulting activity	Y	N	N
Tectonic depression	**Solid** Earth	Relief	A depression generated by an unspecified tectonic/structural process. Includes tectonic graben, basin, half graben, tectonic valley	Y	N	N
Depositional zone	**Mass movement**	Lithology, relief	Include: Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc. The most downslope zone of a mass movement, within which the displaced material lies above the original ground surface. Its lower limit is set by the geometry of the TOE. The DEPOSITIONAL ZONE of SLIDES tends to be dominated by a compressional regime (e.g. thrust and fold systems), whereas for FLOWS the material tends to disperse forming fans or aprons at the base of the slope.	Y	N	N
Evacuation zone	**Mass movement**	Lithology, relief	Includes: Headwall domain; depletion zone; extensional domain) can include all mass movement (topple/fall/debris flows. The most upslope zone of a mass movement, within which the remobilized material lies below the original ground surface. Its upper limit is set by the geometry of the HEAD SCARP and this zone is normally dominated by extension features such as Blocks or elongated Ridges	Y	N	N
Erratic blocks and rafts (non-glacial)	**Mass movement**	Lithology, relief	Large rock or boulder carried by rivers, lateral drift or gravity transport contrasting with the country rock that can be found from the shelf to the abyssal plains	Y	N	N
Submerged Carbonate karst	**Karst**	Lithology	Submerged landscape where the dominant geomorphic process was dissolution of carbonate rocks; characterised by distinctive landforms, e.g. caves, CARBONATE DOLINES, underground drainage	Y	N	N

Submerged Salt karst	**Karst**	Lithology	Submerged landscape where the dominant geomorphic process was dissolution of salt (halite); characterised by distinctive rough terrain and landforms, e.g. dolines.	Y	N	N
Submerged Sandstone karst	**Karst**	Lithology	Submerged landscape where the dominant geomorphic processes were a combination of chemical weathering and other erosional processes of sandstone (quartz); characterised by distinctive rough terrain and landforms, e.g. runiform.	Y	N	N
Mud volcano	**Fluid flow**	Geohazard, relief	A positive topographic unit, usually conical, formed by the periodic upwelling of sediments (mud) fluidised by gas and water (Etiope, 2015). It can develop as a single isolated cone (that can be several hundreds of meters high) or, more frequently, as groups of cones.	Y	N	N
Pockmark (individually mapped)	**Fluid flow**	Geohazard, relief	A concave crater-like Depression formed by gas and/or fluid expulsion, typically one to tens of meters in diameter but can be up to a few hundred meters wide (Hovland et al., 1987). Pockmarks tend to be characteristic V-shaped depressions, with circular, or elliptical geometry. However, they can also present a W-shaped profile or more complex geometries.	Y	N	N
Pockmark (field)	**Fluid flow**	Geohazard, relief	A concave crater-like Depression formed by gas and/or fluid expulsion, typically one to tens of meters in diameter but can be up to a few hundred meters wide (Hovland et al., 1987). Pockmarks tend to be characteristic V-shaped depressions, with circular, or elliptical geometry. However, they can also present a W-shaped profile or more complex geometries.	Y	N	N
Hydrothermal vent	**Fluid flow**	Geohazard, relief	Fissures on the oceanic crust in volcanically active sites (e.g. mid-ocean ridges, back-arc spreading centres, and hot-spot or arc-related submarine volcanoes), from which geothermally heated water is released. Circulating seawater is heated by a heat source such as a magma chamber or associated hot rock and, during heating and chemical reaction with the surrounding rock, undergoes a suite of chemical modifications	Y	N	N
Shallow Gas	**Fluid flow**	Geohazard	The presence of shallow biogenic or hydrocarbon-originated gas charged sediment. Any gas pocket encountered above the setting depth of the first pressure containment string, in a borehole.	Y	N	N
Outcropping methane-derived authigenic carbonate (MDAC)	**Fluid flow**	Lithology	Exposed authigenic carbonate structures, mostly in the form of hardground with positive relief, associated with the seepage of methane rich fluids as a result of the anaerobic methane oxidation coupled with sulphate reduction by associations of archaea and bacteria	Y	N	N
Reefs (ancient, buried and present day)	**Biogenic**	Lithology, relief	In-situ, positive relief, persistent build-ups of primarily skeleton-supported framework (+ internal binding), that influence the local sedimentary environment (Klement, 1967), and supports (or supported) living communities during active accretion.	Y	N	N
Concretions	**Post-depositional**	Lithology	Concretions form nodular growths comprised of various minerals that form within the host rock and vary in size, shape, composition & distribution	N	N	Y
Submerged salt or shale domes/diapir	**Post-depositional**	Lithology, relief	Submerged positive feature sitting on top of a salt diapir (halokinetic structure) of regular or irregular plan view shape usually covered by a relatively thick pile of sediment cover that can be unstable due to halokinetic dynamics (dissolution, flow or uplift). They can be common in continental passive margins or in accretionary wedges. A distinct elevation, often with a rounded profile, one km or more in diameter that is the geomorphologic expression of a diapir formed by vertical intrusion of salt. Commonly found in a PROVINCE of similar features.	N	N	Y
Polygonal faulting	**Post-depositional**	Structure	Layer-bound arrays of normal faults confined to specific stratigraphic intervals called 'tiers' and typically hosted in fine-grained sediments	N	N	Y

8. Appendix IV – Consortium Partners

Consortium partners WP5 (WP5.2 optimised offshore windfarm siting are indicated)

	Partner Name	Acronym	Country	Task 5.2
1	EuroGeoSurveys	EGS	Belgium	
2	Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek	TNO	Netherlands	✓
3	Sherbimi Gjeologjik Shqiptar	AGS	Albania	
4	Vlaamse Gewest	VLO	Belgium	✓
5	Bureau de Recherches Géologiques et Minières	BRGM	France	✓
6	Ministry for Finance and Employment	MFE	Malta	✓
7	Hrvatski Geološki Institut	HGI-CGS	Croatia	✓
8	Institut Royal des Sciences Naturelles de Belgique	RBINS-GSB	Belgium	✓
9	Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy	PGI-NRI	Poland	✓
10	Institut Cartogràfic i Geològic de Catalunya	ICGC	Spain	✓
11	Česká Geologická Služba	CGS	Czechia	
12	Department of Environment, Climate and Communications - Geological Survey Ireland	GSI	Ireland	✓
13	Agencia Estatal Consejo Superior de Investigaciones Cientificas	CSIC-IGME	Spain	✓
14	Bundesanstalt für Geowissenschaften und Rohstoffe	BGR	Germany	
15	Geološki zavod Slovenije	GeoZS	Slovenia	
16	Federalni Zavod za Geologiju Sarajevo	FZZG	Bosnia and Herzegovina	
17	Istituto Superiore per la Protezione e la Ricerca Ambientale	ISPRA	Italy	✓
18	Regione Umbria	-	Italy	
19	State Research and Development Enterprise State Information Geological Fund of Ukraine	GIU	Ukraine	
20	Institute of Geological Sciences National Academy of Sciences of Ukraine	IGS	Ukraine	
21	M.P. Semenenko Institute of Geochemistry, Mineralogy and Ore Formation of NAS of Ukraine	IGMOF	Ukraine	
22	Ukrainian Association of Geologists	UAG	Ukraine	
23	Geologian Tutkimuskeskus	GTK	Finland	✓

24	Geological Survey of Serbia	GZS	Serbia	
25	Ministry of Agriculture, Rural Development and Environment of Cyprus	GSD	Cyprus	✓
26	Norges Geologiske Undersøkelse	NGU	Norway	✓
27	Latvijas Vides, ģeoloģijas un meteoroloģijas centrs SIA	LVGMC	Latvia	
28	Sveriges Geologiska Undersökning	SGU	Sweden	✓
29	Geological Survey of Denmark and Greenland	GEUS	Denmark	✓
30	Institutul Geologic al României	IGR	Romania	✓
31	Szabályozott Tevékenységek Felügyeleti Hatósága	SZTFH	Hungary	
32	Eidgenössisches Departement für Verteidigung, Bevölkerungsschutz und Sport	VBS (DDPS)	Switzerland	
33	Elliniki Archi Geologikon kai Metalleftikon Erevnon	HSGME	Greece	✓
34	Laboratório Nacional de Energia e Geologia I.P.	LNEG	Portugal	✓
35	Lietuvos Geologijos Tarnyba prie Aplinkos Ministerijos	LGT	Lithuania	
36	Geologische Bundesanstalt	GBA	Austria	
37	Service Géologique de Luxembourg	SGL	Luxembourg	
38	Eesti Geoloogiateenistus	EGT	Estonia	
39	Štátny Geologický ústav Dionýza Štúra	SGUDS	Slovakia	
40	Íslenskar Orkurannsóknir	ISOR	Iceland	✓
41	Instituto Português do Mar e da Atmosfera	IPMA	Portugal	✓
42	Jarðfeingi	Jardfeingi	Faroe Islands	✓
43	Regierungspräsidium Freiburg	LGRB	Germany	
44	Geologischer Dienst Nordrhein-Westfalen	GD NRW	Germany	
45	Landesamt für Geologie und Bergwesen Sachsen-Anhalt	LfU	Germany	
46	Vlaamse Milieumaatschappij	VMM	Belgium	
47	Norwegian Petroleum Directorate	NPD	Norway	
48	United Kingdom Research and Innovation - British Geological Survey	UKRI-BGS	UK	✓

9. Annexes

1 Geo-Assessment Matrix (.pdf, 660 KB)

2. Reattribution process of open-source datasets and GSEU nomenclature (.pdf 100 KB)

Annex 1 - Geo-Assessment Matrix

STEP 1

GEOLOGICAL DATA INVENTORY

Depth of interest: Offshore windfarm siting focuses on - Upper 100 m (max) of the seabed (piled foundation)

Geological feature inventory	Sediments, Physiography, Setting, Process Setting = Glacial, Marine, Fluvial, Coastal, Solid Earth, Process = Mass movement, Karst, Fluid flow, Biogenic, Post-depositional	Constraint type Relief (topographic feature, positive or negative) Lithology (lithological/soil consideration) Structure (faults, fractures) Geohazard (potential)	Definition
Peat (organic-rich)	**Sediments**	**Lithology**	Superficial deposits. Type of soil formed by the partial decomposition of vegetation matter (Cook et al., 2022). Includes submerged forests.
Glauconite	**Sediments**	**Lithology**	Superficial deposits. Glauconite is an iron potassium mica with a characteristically green colour and low strength, often found in peloidal form. Glauconite generally forms under reducing conditions within a shallow marine depositional environment. Glauconite can be characterised as sand-sized grains but transforms into fine-grained soil upon shearing due to particle crushing.
Soft mud	**Sediments**	**Lithology**	Superficial deposits. May include marine mud basins including soft glaciolacustrine/glaciomarine (not overconsolidated) mud deposition or other soft muddy shelfful deposits.
Soft interbedded sediment	**Sediments**	**Lithology**	Superficial deposits
Firm to hard mud	**Sediments**	**Lithology**	Superficial deposits
Sand	**Sediments**	**Lithology**	Superficial deposits
Gravel	**Sediments**	**Lithology**	Superficial deposits
Diamicton	**Sediments**	**Lithology**	Superficial deposits
Carbonate sands	**Sediments**	**Lithology**	Calcareous and carbonate soils can be identified by their reaction with dilute hydrochloric acid, producing carbon dioxide that bubbles off. The grains consists partially or completely of calcium carbonate and may be formed of the skeletal remains of microscopic marine plant and animal remains. Calcium carbonate is a relatively soft mineral compared with silica-based soils (Mitchell and Soga, 2005).
Evaporites	**Sediments**	**Lithology**	Any of a variety of individual minerals found in the sedimentary deposit of soluble salts that results from the evaporation of water. Can influence shallow structure (e.g. faulting)
Basin / basin plain / intraslope basin	**Physiography**	**Relief**	A depression more or less equidimensional in plan and of variable extent. (Stagpoole and Mackay, 2022)
Shelf break	**Physiography**	**Relief**	The line along which there is a marked increase in slope at the seaward margin of a SHELF. Also called SHELF BREAK.
Mound	**Physiography**	**Relief**	A distinct elevation with a rounded profile generally less than 500 m above the surrounding relief as measured from the deepest isobath that surrounds most of the feature. Sides are usually steeper than 5 degrees. (Stagpoole and Mackay, 2022)
Terrace	**Physiography**	**Relief**	A flat or gently sloping region, generally long and narrow, bounded along one edge by a steeper descending slope and along the other by a steeper ascending slope. Usually less than two degrees. (Stagpoole and Mackay, 2022)
Trough	**Physiography**	**Relief**	A long depression generally wide and flat-bottomed with symmetrical and parallel sides. Sides usually steeper than 5 degrees. (Stagpoole and Mackay, 2022)
Ridge	**Physiography**	**Relief**	An elongated elevation of varying complexity, size and gradient. Variable steepness, but usually has sloping sides greater than 5 degrees. (Stagpoole and Mackay, 2022)
Moat	**Physiography**	**Relief**	An annular or partially annular bathymetric low typically located at the base of isolated raised features (modified from IHO, 2019).
Plateau / topographic high	**Physiography**	**Relief**	A generally closed-contoured, relatively flat-topped bathymetric high with one or more relatively steep sides (modified from IHO, 2019).
Depression/ hole	**Physiography**	**Relief**	A general term for a closed-contour bathymetric low. DEPRESSIONS vary in scale from small local features to larger basins. They generally have lower gradient sides than HOLES.
Glacifluvial delta (aka. glacier-fed delta)	**Glacial**	**Lithology, relief**	There are many different kinds of deltas; all have relatively flat delta plains, frequently triangular (fan) shaped in plan view, and steeper delta front slopes. In cross-section, the archetypal delta consists of flat-lying topset beds over steeper foreset beds, which rest on bottomset beds that are usually thin and fine-grained. The typical GLACIFLUVIAL DELTA usually consists of coarser-grained sediments, and their front slopes are steep with foreset beds generally dipping 10-30° (Excerpt from Bell et al. 2016, adapted from Bell et al. 1997. In: Dowdeswell et al., 2016). GLACIFLUVIAL DELTAS are also referred to as glacier-fed deltas as terrestrial proglacial meltwater streams/rivers carry sediments from a glacier to the marine/lacustrine environment (Benn and Evans, 2010).
Glacifluvial outwash plain (sandur)	**Glacial**	**Lithology, relief**	Laterally extensive flat plain of sand and gravel with braided streams of glacial meltwater flowing across them when active. (Excerpt from Bell et al. 2016, adapted from Bell et al. 1997. In: Dowdeswell et al., 2016).
Grounding zone wedge	**Glacial**	**Lithology, relief**	A sedimentary depocentre formed at the grounding zone of an icesheet/ice-shelf system, formed of dipping diamicton beds overlain by horizontal sheets of diamicton, mainly subglacial till. Till emerging from beneath the glacier along a line-source is redistributed by subaqueous debris flows, producing diamicton beds that dip away from the margin. GZWs are usually asymmetrical in long-profile, steeper in the ice-distal direction (Excerpt from Bell et al. 2016, adapted from Bell et al. 1997. In: Dowdeswell et al., 2016).
Erratic or glaciotectonic raft	**Glacial**	**Lithology, relief**	Large rock or boulder carried by a glacier or by floating ice and deposited when the ice melted, well away from its place of origin and therefore contrasting with the country rock (Excerpt from Bell et al. 2016, adapted from Bell et al. 1997. In: Dowdeswell et al., 2016)
Hill-hole pair	**Glacial**	**Lithology, relief**	A discrete hill of ice-thrust material, often slightly deformed, situated down glacier from a depression of approximately the same size and shape. Either pre-existing drift or bedrock may be contained in the dislocated hill (Excerpt from Bell et al. 2016, adapted from Bell et al. 1997. In: Dowdeswell et al., 2016).
Hummocky terrain (including crevasse squeeze ridges)	**Glacial**	**Lithology**	A landscape with a highly irregular surface, characterised by a series of small mounds, ridges and depressions. Associated with glacier/ice sheet grounding zones.
Ice-contact delta (includes ice proximal fan)	**Glacial**	**Lithology, relief**	ICE-CONTACT DELTAS form at glacier margins and develop from e.g. ice proximal grounding line fans or other submerged depositional units (Benn and Evans, 2010).

STEP 2

GEOLOGICAL CONSTRAINT MATRIX

	(1) Soil / bedrock constraints						(2) Physical setting constraints					(3) Geo-hazards						
Geological feature inventory	Spatial soil variability (lateral/vertical)	Rafts or boulders	Coarse soil units (including gravel)	Soft soil units - low shear strength	Overconsolidation (clays / extremely dense sands)	Strong bedrock at/near seabed	Uneven ground (relief)	Steep slopes/margins (>5 degree angle)	Active sedimentary system (inc. mobile sediments)	Shallow water (<15-20 m)	Deep water (<200 m)	Potential fault reactivation/seismic activity	Potential submarine slope failure	Potential volcanic activity	Potential conduit for fluids	Active fluid flow	Organic soils/gassy sediments	Unknown
Peat (organic-rich)	x			x													x	
Glauconite				x														
Soft mud				x														
Soft interbedded sediment				x														
Firm to hard mud					x													
Sand			x															
Gravel			x															
Diamicton	x	x			x													
Carbonate sands																		
Evaporites																		
Basin / basin plain / intraslope basin				x														
Shelf break								x	x									
Mound							x	x										
Terrace							x			x	x							
Trough							x	x										
Ridge							x	x										
Moat							x	x										
Plateau / topographic high							x	x										
Depression/ hole							x	x										
Glacifluvial delta (aka. glacier-fed delta)	x		x				x	x										
Glacifluvial outwash plain (sandur)	x		x				x											
Grounding zone wedge	x	x		x	x													
Erratic or glaciotectonic raft	x	x					x	x										
Hill-hole pair	x						x											
Hummocky terrain (including crevasse squeeze ridges)	x																	
Ice-contact delta (includes ice proximal fan)	x		x				x	x										

STEP 3

PRINCIPAL ENGINEERING CONSTRAINT MATRIX (pre- or during installation)

													Piles													
											Suction Caisson															
	Soil properties					Export and interarray cables				Gravity Based Structures (GBS)							All fixed foundation types									
Geological feature inventory	Low thermal conductivity/low water content, overheati	Compressible/ contractive soils	Collapsable soils	Soil changes character upon crushing	Potential important resource	Cable/pipeline abrasion or bending	Freespan development	Cable plough deviation	Trenching technique selection	Uneven load distribution/differential settlement	Seabed preparation (e.g., flattening)	Reduced skirt burial depth	Voids/ punch through/ pile run	Reduced shaft friction - soft sediments	Scour - removal of lateral support	Increased lateral load	Lateral variability in geotechnical values	Reduced overburden (vertical)	Increased overburden (vertical)	May not support hole while drilling	Poor drivability/refusal	Blowout	Damage to tool/foundation during installation	Unknown	Potentially unsuitable	Requires individual WTG siting investigation
Peat (organic-rich)	x	x						x	x	x																x
Glauconite		x		x																	x					x
Soft mud													x	x						x						x
Soft interbedded sediment													x	x												x
Firm to hard mud																										x
Sand			x		x															x						x
Gravel					x			x	x											x			x			x
Diamicton						x															x		x			x
Carbonate sands		x		x																						x
Evaporites		x								x																x
Basin / basin plain / intraslope basin																										x
Shelf break								x																		x
Mound								x																		x
Terrace								x																		x
Trough								x																		x
Ridge								x																		x
Moat								x																		x
Plateau / topographic high								x																		x
Depression/ hole								x																		x
Glacifluvial delta (aka. glacier-fed delta)									x	x	x						x								x	x
Glacifluvial outwash plain (sandur)									x	x	x						x								x	x
Grounding zone wedge									x	x	x															x
Erratic or glaciotectonic raft										x	x						x				x		x			x
Hill-hole pair										x	x										x		x			x
Hummocky terrain (including crevasse squeeze ridges)										x	x						x									x
Ice-contact delta (includes ice proximal fan)									x	x	x						x								x	x

STEP 4

GEOLOGICAL COMPLEXITY ASSESSMENT

	Dominant constraint	Dominant foundation types					
Geological feature inventory	Dominant constraint / assumptions (pre-mitigation measures)	Suction caisson	Gravity Based Structures (GBS)	Piles	Export and interarray cables	Comments	Example of references
Peat (organic-rich)	Organic soils	High complexity	High complexity	High complexity	High complexity	Organic soils can also be associated with biogenic gas due to the breakdown of organic matter. Fibrous peats have the ability to reinforce soils, causing issues for cable trenching works, and can also provide fluid migration pathways.	Smitha, S.A., Suzukia, P. and Faleidea, T.S., Multi-Sensor Core Logging of Shallow Seabed Sediments for Subsea Power Cable Design: A North Sea Case Study.
Glauconite	Crushable soil	High complexity	High complexity	High complexity	Medium complexity	Crushing of glauconite results in high pile friction and transition from sand to clay-like behaviour. May result in pile fatigue or refusal. Difference in properties between allogenic (reworked) vs. authogenic (insitu). Reworked glauconite can wash away weaker minerals.	Westgate, Z., McMullin, C. and DeGroot, D., 2022, December. Glauconite Sand Challenges for US Offshore Wind Development. In International Conference on Offshore Mechanics and Arctic Engineering (Vol. 86618, p. V001T02A002). American Society of Mechanical Engineers.
Soft mud	Soft sediments	High complexity	High complexity	High complexity	High complexity	A hard stratum overlying a weaker one presents a danger that may cause a foundation to punch through the softer sediments. Low strength means soft muds will not bear large loads. Acid sulphate soils (ASS) may contain harmful substances affecting cables, when exposed and/or dredged in coastal areas (Finland).	Coughlan, M., Trafford, A., Corrales, S., Donohue, S., Wheeler, A.J. and Long, M., 2023. Geological and geotechnical characterisation of soft Holocene marine sediments: A case study from the north Irish Sea. Engineering Geology, 313, p.106980.
Soft interbedded sediment	Soft sediments	Medium complexity	High complexity	Medium complexity	Medium complexity	A hard stratum overlying a weaker one presents a danger that may cause a foundation to punch through the softer sediments	Coughlan, M., Trafford, A., Corrales, S., Donohue, S., Wheeler, A.J. and Long, M., 2023. Geological and geotechnical characterisation of soft Holocene marine sediments: A case study from the north Irish Sea. Engineering Geology, 313, p.106980.
Firm to hard mud	Homogenous sediments	Medium complexity	High complexity	Medium complexity	Medium complexity		Le, T.M.H., Eiksund, G.R., Strøm, P.J. and Saue, M., 2014. Geological and geotechnical characterisation for offshore wind turbine foundations: A case study of the Sheringham Shoal wind farm. Engineering geology, 177, pp.40-53.
Sand	Homogenous sediments	Low complexity	High complexity	Low complexity	Low complexity	Present-day sands may be related to mobile sediments	Harris, J.M., Whitehouse, R.J. and Sutherland, J., 2011, January. Marine scour and offshore wind: lessons learnt and future challenges. In International conference on offshore mechanics and arctic engineering (Vol. 44373, pp. 849-858). Le Bot, S., Van Lancker, V., Deleu, S., De Batist, M., Henriet, J.P. and Haegeman, W., 2005. Geological characteristics and geotechnical properties of Eocene and Quaternary deposits on the Belgian continental shelf: synthesis in the context of offshore wind farming. Netherlands Journal of Geosciences, 84(2), pp.147-160.
Gravel	Coarse soil units (including gravel)	High complexity	High complexity	Medium complexity	Medium complexity	Hard substate that may be difficult to penetrate.	Van den Eynde, D., Baeye, M. and Van Lancker, V., Effect of wind farms on the siltation of gravel beds (https://www.health.belgium.be/en/eden2000-full-report)
Diamicton	Hard overconsolidated clays	High complexity	Medium complexity	Medium complexity	Medium complexity	Over consolidated clay or associated presence of boulder fields can cause challenges for construction (e.g., Fi	Solhjell, E., Moellenbeck, D., Yang, S. and Lakeman, J.W., 2024, April. Geotechnical Properties of Subglacial Till at Baltic Sea Offshore Wind Farm Sites. In Offshore Technology Conference (p. D021S019R002). OTC. Evans, D.J., Roberts, D.H. and Phillips, E., 2024. The late Quaternary glacial depositional environment at Filey Bay, eastern England: Accretionary mechanisms for thick sequences of tills and stratified diamictons. Proceedings of the Geologists' Association.
Carbonate sands	Crushable soil	Medium complexity	Medium complexity	Medium complexity	Medium complexity	The crushability of carbonate grains make carbonate sands unreliable foundation materials (Murff, 1987; Jewell and Khorshid 2000; Kolk, 2000). Calcareous sands are difficult to classify and can be highly contractive.	Watson, P.G., Bransby, M.F., Delimi, Z.L., Erbrich, C.T., Finnie, I., Krisdani, H., Meecham, C., O'Neill, M., Randolph, M.F., Rattley, M. and Silva, M., 2019, November. Foundation design in offshore carbonate sediments-building on knowledge to address future challenges. In XVI Pan-American Conference on Soil Mechanics and Geotechnical Engineering (XVI PCSMGE), From Research to Applied Geotechnics (pp. 240-274).
Evaporites	Uneven ground	Medium complexity	High complexity	Medium complexity	Medium complexity	Can form doming features in the subsurface or at seabed (diapirs)	Duffy, O., Hudec, M., Peel, F., Apps, G., Bump, A., Moscardelli, L., Dooley, T., Fernandez, N., Bhattacharya, S., Wisian, K. and Shuster, M., 2023. The role of salt tectonics in the energy transition: An overview and future challenges. Tektonika, 1(1).
Basin / basin plain / intraslope basin	Soft soil units	High complexity	High complexity	Medium complexity	Medium complexity	Soft sediments likely to be deposited in deep basins	https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Shelf break	Steep slopes	Medium complexity	High complexity	Medium complexity	Medium complexity	May require seabed preparation before installation of GBS foundations.	https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Mound	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity	May require seabed preparation before installation of GBS foundations.	https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Terrace	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity	Terraces likely to have steeper slopes than mounds (for example)	https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Trough	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity	Sometimes, troughs can be dynamic environments and mobile sediments can be present.	https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Ridge	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity	May require seabed preparation before installation of GBS foundations.	https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Moat	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity	May require seabed preparation before installation of GBS foundations.	https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Plateau / topographic high	>5 degree slope	High complexity	High complexity	Medium complexity	Medium complexity	May require seabed preparation before installation of GBS foundations.	
Depression/ hole	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity	May require seabed preparation before installation of GBS foundations.	
Glacifluvial delta (aka. glacier-fed delta)	Uneven ground / coarse soil units / homogeneous soils	Medium complexity	Medium complexity	Medium complexity	Medium complexity	May require seabed preparation before installation of GBS foundations. Variable soil units provide a challenge for suction caisson, particularly where potential thick gravel beds are interbedded with finer-grained soil units. Thick gravel beds can reduce friction along the outer surface. Potential for coarse gravel beds, and variability in soil profiles over the delta. This makes selecting a cable trenching tool more challenging as some tools can handle dense, coarse soil units whereas some cannot.	Evans, D.J., Roberts, D.H., Bateman, M.D., Clark, C.D., Medialdea, A., Callard, L., Grimoldi, E., Chiverrell, R.C., Ely, J., Dove, D. and Ó Cofaigh, C., 2021. Retreat dynamics of the eastern sector of the British–Irish Ice Sheet during the last glaciation. Journal of Quaternary Science, 36(5), pp.723-751.
Glacifluvial outwash plain (sandur)	Uneven ground / coarse soil units / homogeneous soils	Medium complexity	Medium complexity	Medium complexity	Medium complexity	May require seabed preparation before installation of GBS foundations. Variable soil units provide a challenge for suction caisson, particularly where potential thick gravel beds are interbedded with finer-grained soil units. Thick gravel beds can reduce friction along the outer surface. Potential for coarse gravel beds, and variability in soil profiles over the Sandur. This makes selecting a cable trenching tool more challenging as some tools can handle dense, coarse soil units whereas some cannot.	Evans, D.J., Roberts, D.H., Bateman, M.D., Clark, C.D., Medialdea, A., Callard, L., Grimoldi, E., Chiverrell, R.C., Ely, J., Dove, D. and Ó Cofaigh, C., 2021. Retreat dynamics of the eastern sector of the British–Irish Ice Sheet during the last glaciation. Journal of Quaternary Science, 36(5), pp.723-751.
Grounding zone wedge	Hard overconsolidated clays / extremely dense sands	High complexity	High complexity	High complexity	High complexity	Variable soil conditions which may include heavily overconsolidated subglacial tills. Diamicton can be clast-rich, with cobble to boulder-sized clasts, unfavourable for most/all subsurface structures. May prove problematic for suction caisson where soil heterogeneity is unfavourable. Where present near-surface (e.g., <5 m sediment cover above), may prove problematic for certain cable/pipeline trenching equipment.	Evans, D.J., Phillips, E.R., Hiemstra, J.F., Auton, C.A. 2006. Subglacial till: formation, sedimentary characteristics and classification. Earth-Science Reviews. Vol. 78. p 115-176.
Erratic or glaciotectonic raft	Rafts or boulders	High complexity	High complexity	High complexity	High complexity	If unaccounted for, can provide significant challenge/constraint to most/all subsurface foundations (e.g., pile refusal / tip damage, damage / refusal or uneven emplacement of suction caisson and skirts for gravity base structures, cable/pipeline plough pop-up or deviation, poor penetration for drag embedment anchors). Significant and unexpected vertical and lateral variability in ground conditions incl. geotechnical parameters.	Dove, D., Arosio, R., Finlayson, A., Bradwell, T. and Howe, J.A., 2015. Submarine glacial landforms record Late Pleistocene ice-sheet dynamics, Inner Hebrides, Scotland. Quaternary Science Reviews, 123, pp.76-90.
Hill-hole pair	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity	Potential for bedrock, restricting pile driving. Uneven surface with variable slope angles for GBS. Variable, deformed ground conditions unsuitable for suction caisson. Variable slope angles and lateral variability for cable and pipeline trenching, incl. possible encountering bedrock at seabed.	Evans, D.J., Roberts, D.H., Bateman, M.D., Clark, C.D., Medialdea, A., Callard, L., Grimoldi, E., Chiverrell, R.C., Ely, J., Dove, D. and Ó Cofaigh, C., 2021. Retreat dynamics of the eastern sector of the British–Irish Ice Sheet during the last glaciation. Journal of Quaternary Science, 36(5), pp.723-751.
Hummocky terrain (including crevasse squeeze ridges)	Heterogeneous sediments	High complexity	High complexity	Medium complexity	Medium complexity		Evans, D.J., Roberts, D.H., Bateman, M.D., Clark, C.D., Medialdea, A., Callard, L., Grimoldi, E., Chiverrell, R.C., Ely, J., Dove, D. and Ó Cofaigh, C., 2021. Retreat dynamics of the eastern sector of the British–Irish Ice Sheet during the last glaciation. Journal of Quaternary Science, 36(5), pp.723-751.
Ice-contact delta (includes ice proximal fan)	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity	May require seabed preparation before installation of GBS foundations. Variable soil units provide a challenge for suction caisson, particularly where potential thick gravel beds are interbedded with finer-grained soil units. Thick gravel beds can reduce friction along the outer surface. Potential for coarse gravel beds, and variability in soil profiles over the delta. This makes selecting a cable trenching tool more challenging as some tools can handle dense, coarse soil units whereas some cannot.	Evans, D.J., Roberts, D.H., Bateman, M.D., Clark, C.D., Medialdea, A., Callard, L., Grimoldi, E., Chiverrell, R.C., Ely, J., Dove, D. and Ó Cofaigh, C., 2021. Retreat dynamics of the eastern sector of the British–Irish Ice Sheet during the last glaciation. Journal of Quaternary Science, 36(5), pp.723-751.

Meltwater channel (includes proglacial meltwater channel)	**Glacial**	**Lithology, relief**	A channel produced by the flow of glacial meltwater. Where the channel is subglacial, pressurized water may flow upslope as well as downslope, producing an undulating channel long-profile (Excerpt from Bell et al. 2016, adapted from Bell et al. 1997. In: Dowdeswell et al., 2016).	x																									x		x	x						x									x	Heterogeneous sediments	High complexity	High complexity	Medium complexity	Medium complexity	Channel infill can have very different grain sizes and geotechnical properties to those of the surrounding deposits into which they are cut. Can lead to uneven distribution of loads beneath GBS, lateral variability in geotechnical values across the footprint of a monopile, heterogeneous (and coarse-grained) soils that negatively impact on suction caisson performance, reduced anchor penetration depths, and may require changes in cable & pipeline trenching approaches/tools due to the variability along the planned trenching route (the corridor). Can be engineered around but must be accounted for in planning foundation design.	Evans, D.J., Roberts, D.H., Bateman, M.D., Clark, C.D., Medialdea, A., Callard, L., Grimoldi, E., Chiverrell, R.C., Ely, J., Dove, D. and Ó Cofaigh, C., 2021. Retreat dynamics of the eastern sector of the British–Irish Ice Sheet during the last glaciation. Journal of Quaternary Science, 36(5), pp.723-751.
Open tunnel valley	**Glacial**	**Lithology, relief**	A large subglacial, steep-sided channel cut into unconsolidated sediment or bedrock by meltwater and forms a topographic expression on the seabed. The channel may have a reverse gradient in places (Excerpt from Bell et al. 2016, adapted from Bell et al. 1997. In: Dowdeswell et al., 2016).							x	x	x																			x																		x	Steep slopes	High complexity	High complexity	High complexity	High complexity		
Buried tunnel valley	**Glacial**	**Lithology, relief**	A large subglacial, steep-sided channel cut into unconsolidated sediment or bedrock by meltwater. The channel may have a reverse gradient in places (Excerpt from Bell et al. 2016, adapted from Bell et al. 1997. In: Dowdeswell et al., 2016).	x				x			x																				x									x				x		x			x	Heterogeneous sediments	High complexity	High complexity	Medium complexity	Medium complexity	Channel infill can have very different grain sizes and geotechnical properties to those of the surrounding deposits into which they are cut. Can lead to uneven distribution of loads beneath GBS, lateral variability in geotechnical values across the footprint of a monopile, heterogeneous (and coarse-grained) soils that negatively impact on suction caisson performance, reduced anchor penetration depths, and may require changes in cable & pipeline trenching approaches/tools due to the variability along the planned trenching route (the corridor). Can be engineered around but must be accounted for in planning foundation design.	Huuse, M. and Kristensen, T.B., 2016. Pleistocene tunnel valleys in the North Sea Basin. Geological Society, London, Memoirs, 46(1), pp.207-208. Stewart, M.A., Lonergan, L. and Hampson, G., 2013. 3D seismic analysis of buried tunnel valleys in the central North Sea: morphology, cross-cutting generations and glacial history. Quaternary Science Reviews, 72, pp.1-17. Stewart, M.A. and Lonergan, L., 2011. Seven glacial cycles in the middle-late Pleistocene of northwest Europe: Geomorphic evidence from buried tunnel valleys. Geology, 39(3), pp.283-286.
Moraine	**Glacial**	**Lithology, relief**	A mound, ridge or other distinct accumulation of generally unsorted, unstratified glaciogenic sediment, predominantly till, deposited chiefly by direct contact with glacier ice, commonly subglacial. See De Geer moraine, end moraine, fluted moraine, interlobate moraine, kame moraine, lateral moraine (Excerpt from Bell et al. 2016, adapted from Bell et al. 1997. In: Dowdeswell et al., 2016).	x	x			x																			x		x		x	x						x				x		x			x	>5 degree slope, heterogeneous/overconsolidated sediments	High complexity	High complexity	Medium complexity	Medium complexity	Potential for highly variable ground conditions and overconsolidation. Potential for obstructions such as cobble beds and boulders.	Evans, D.J., Roberts, D.H. and Phillips, E., 2024. The late Quaternary glacial depositional environment at Filey Bay, eastern England: Accretionary mechanisms for thick sequences of tills and stratified diamictons. Proceedings of the Geologists' Association. Cotterill, C.J., Phillips, E., James, L., Forsberg, C.F., Tjelta, T.I., Carter, G. and Dove, D., 2017. The evolution of the Dogger Bank, North Sea: A complex history of terrestrial, glacial and marine environmental change. Quaternary Science Reviews, 171, pp.136-153. Phillips, E., Cotterill, C., Johnson, K., Crombie, K., James, L., Carr, S. and Ruiter, A., 2018. Large-scale glacitectonic deformation in response to active ice sheet retreat across Dogger Bank (southern central North Sea) during the Last Glacial Maximum. Quaternary Science Reviews, 179, pp.24-47. Phillips E., Johnson, K., Ellen, R., Plenderleith, G., Dove, D., Carter, G., Dakin, N., Cotterill, C. 2022. Glacitectonic evidence of ice sheet interaction and retreat across the western part of Dogger Bank (North Sea) during the Last Glaciation. Proceedings of the Geologists' Association 133, 87–111.
Kettle hole	**Glacial**	**Lithology, relief**	Steep-sided hollow produced by the melt-out of an original deposit which also contained finer materials that were removed by wind or water action (Excerpt from Bell et al. 2016, adapted from Bell et al. 1997. In: Dowdeswell et al., 2016).	x																x											x								x								x	Uneven ground	Medium complexity	High complexity	Medium complexity	Medium complexity	May be infilled with soils of varying geotechnical properties compared with the surrounding units into which they are emplaced. Can also contain peat so potential for shallow gas. Can be engineered around but must be accounted for in planning foundation design.	Dove, D., Arosio, R., Finlayson, A., Bradwell, T. and Howe, J.A., 2015. Submarine glacial landforms record Late Pleistocene ice-sheet dynamics, Inner Hebrides, Scotland. Quaternary Science Reviews, 123, pp.76-90.
Streamlined landform (Crag and tail /drumlin/ flute/ groove)	**Glacial**	**Lithology, relief**	Streamlined landforms have been sculpted and moulded by glacier ice, moving in a coherent direction. These landforms can consist of bedrock, unconsolidated sediments or both. They are formed parallel to the ice flow direction and are considered good palaeo-flow indicators. Elongation is considered to be positively correlated with higher ice flow velocities (Stokes and Clark, 1999, 2002; Krabbendam et al., 2016)	x	x			x	x	x	x																				x		x	x						x				x		x			x	Variable geotechnical properties depending on formation	High complexity	High complexity	Medium complexity	Medium complexity	Similar to moraines, there is a potential for vertical and lateral variability across and beneath these landforms. As they have experienced ice loading, they may consist of overconsolidated soil units and may contain cobble to boulder sized clasts. Drumlins can be comprised of sediment or bedrock and would require to be assessed individually.	Dove, D., Evans, D.J., Lee, J.R., Roberts, D.H., Tappin, D.R., Mellett, C.L., Long, D. and Callard, S.L., 2017. Phased occupation and retreat of the last British–Irish Ice Sheet in the southern North Sea; geomorphic and seismostratigraphic evidence of a dynamic ice lobe. Quaternary Science Reviews, 163, pp.114-134.
Esker	**Glacial**	**Lithology, relief**	Sinuous elongate ridges of glaciofluvial sands and gravels, usually stratified and imbricated. Rarely exceed 700 m width and 50 m height. Form by depositional from meltwater streams in tunnel systems running perpendicular to the ice front.	x		x		x																				x					x	x						x									x	Heterogeneous sediments	High complexity	High complexity	Medium complexity	Medium complexity	Typically comprise sand and gravel deposited by meltwater within or beneath an ice mass. Can be dense. Eskers are also possible resources for aggregates (e.g., Finland).	Dove, D., Arosio, R., Finlayson, A., Bradwell, T. and Howe, J.A., 2015. Submarine glacial landforms record Late Pleistocene ice-sheet dynamics, Inner Hebrides, Scotland. Quaternary Science Reviews, 123, pp.76-90.
Glaciolacustrine	**Glacial**	**Lithology**	Stratified sediments that display rhythmic or cyclic repetition of beds that form in subaqueous settings such as lakes and oceans, but also in glaciofluvial systems (Giles et al. 2017)	x			x																										x			x	x												x	Soft sediments	Medium complexity	High complexity	Medium complexity	Medium complexity	A hard stratum overlying a weaker one presents a danger that may cause a foundation to punch through the softer sediments.	Emery, A.R., Hodgson, D.M., Barlow, N.L., Carrivick, J.L., Cotterill, C.J., Richardson, J.C., Ivanovic, R.F. and Mellett, C.L., 2020. Ice sheet and palaeoclimate controls on drainage network evolution: an example from Dogger Bank, North Sea. Earth Surface Dynamics, 8(4), pp.869-891.
Iceberg ploughmark (field)	**Glacial**	**Lithology**	Groove or furrow caused by the impact and movement of grounded icebergs along the sea or lake floor (Excerpt from Bell et al. 2016 In: Dowdeswell et al., 2016).							x																																					x	Uneven ground	Low complexity	High complexity	Low complexity	Low complexity	May require seabed preparation before installation of GBS foundations.	Evans, D.J., Roberts, D.H., Bateman, M.D., Clark, C.D., Medialdea, A., Callard, L., Grimoldi, E., Chiverrell, R.C., Ely, J., Dove, D. and Ó Cofaigh, C., 2021. Retreat dynamics of the eastern sector of the British–Irish Ice Sheet during the last glaciation. Journal of Quaternary Science, 36(5), pp.723-751.
U-shaped valley (e.g. Fjord)	**Glacial**	**Relief**	A valley having a pronounced parabolic cross-profile suggesting the form of a broad letter 'U' with steep parallel walls and a broad, nearly flat floor; specifically a valley carved by glacial erosion, such as a glacial trough or fjord (Excerpt from Bell et al. 2016, adapted from Bell et al. 1997. In: Dowdeswell et al., 2016).								x			x																																	x	>5 degree slope	High complexity	High complexity	High complexity	High complexity		Stoker, M.S., Bradwell, T., Howe, J.A., Wilkinson, I.P. and McIntyre, K., 2009. Lateglacial ice-cap dynamics in NW Scotland: evidence from the fjords of the Summer Isles region. Quaternary Science Reviews, 28(27-28), pp.3161-3184.
Coarse lag deposits	**Marine**	**Lithology**	Typically coarse-grained material (dominated by gravel with boulders) derived from Pleistocene glacial sediments that have been modified during the Holocene by winnowing, seafloor polishing and transport of the finer fraction to be redeposited elsewhere. Also can occur as near shore heterogeneous deposits associated with transgressive system tracts in non-glacial environments.		x	x		x																								x											x					x	Coarse soil units (including gravel)	Medium complexity	High complexity	Medium complexity	Low complexity	Potential for highly variable ground conditions and overconsolidation. Potential for obstructions such as cobble beds and boulders. Hard substate that may be difficult to penetrate.	Mellett, C.L., Long, D. and Carter, G., 2015. Geology of the seabed and shallow subsurface: The Irish Sea.
Marine bar form (Contourite drift/ sediment apron/ sediment drift/ sediment lobe/energetic wave or current regime)	**Marine**	**Lithology, relief**	Tend to be larger than CURRENT-INDUCED BEDFORMS (e.g. Venditti, 2013), are often forced by macro-scale topography (e.g. channels – point bar; headlands - banner), and develop over longer periods of time (e.g. Dury, 1970).							x																	x	x					x		x	x	x		x	x							x	Active sedimentary system	High complexity	High complexity	High complexity	High complexity	Indicative of mobile sediments. Mobility may remove sediment from around the foundation and buried skirt, anchor, or conversely may increase lateral loading on side of foundation. Mobility may remove sediment overlying the buried cable which will leave it at risk from anchor interactions, and conversely may increase the sediment volume overlying the buried cable which can result in the cable exceeding the thermal threshold and hotspots developing.	https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Sediment bank	**Marine**	**Relief**	Formed by interactions between current instabilities (commonly generating cyclonic flows) and unconsolidated sediment at the seabed. SEDIMENT BANKS are the largest Current-induced BEDFORMS within the Submarine Setting and require sufficiently rapid current flows and high rates of sediment supply.								x																				x			x															x	>5 degree slope	High complexity	High complexity	Medium complexity	High complexity	Flat-topped stable banks can be developed - however margins of banks may have steep slopes	https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Sediment waves/dunes	**Marine**	**Lithology**	Sediment waves/dunes have a broad range of morphologies and represent transverse bedforms larger than ripples (wavelength 0.6–10 m, height 0.1–1 m).							x																	x	x								x	x										x	Active sedimentary system	Medium complexity	High complexity	Medium complexity	Medium complexity	May require scour mitigation measures if mobile sediments. Mobility may remove sediment overlying the buried cable which will leave it at risk from anchor interactions, and conversely may increase the sediment volume overlying the buried cable which can result in the cable exceeding the thermal threshold and hotspots developing.	https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Submarine canyon (canyon/ canyon head / canyon mouth / tributary canyon)	**Marine**	**Lithology, relief**	Steep-sided, GENERALLY V-shaped valleys with heads at or near the CONTINENTAL SHELF edge. They extend across the CONTINENTALSLOPE and are commonly linked to numerous tributaries, similar to unglaciated river-cut canyons on land (Amblas et al., 2018; Covault,2011; Harris and Baker, 2011; Huang et al., 2014; Pratson et al., 2007; Puig et al., 2014).	x					x	x	x	x		x		x											x	x	x		x					x									x	x	Active sedimentary system	High complexity	High complexity	High complexity	High complexity	Typically extremely dynamic environments incl. sediment gravity flows / landslides, internal tides with high current velocities, mobile bedforms. Bedrock is often exposed along steep canyon flanks and terraces, also leading to very variable ground conditions. High water depths make submarine canyons unsuitable for all fixed foundations, and very unfavourable for anchoring systems. May be used for cables and pipelines but comprehensive due diligence / hazard assessments must be undertaken.	https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Submarine channel	**Marine**	**Lithology, relief**	Formed by sediment-laden turbidity currents and other sediment-rich gravity currents (Klaucke and Hesse, 1996; Peakall et al., 2000; Peakall and Sumner, 2015) or by fluvial incision during low-stands and buried during sea level rise..	x						x	x	x		x		x											x	x	x		x					x									x	x	Active sedimentary system	High complexity	High complexity	High complexity	High complexity	Highly dynamic setting with mass flows that can damage / sever subsea cables and pipelines. Typically found along steep slopes (e.g., continental margins) and therefore not suitable for any foundation type. Typically found in deeper water environments, and therefore less favourable for fixed foundations.	https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Submarine fan	**Marine**	**Lithology, relief**	Develop on the CONTINENTAL SLOPE, RISE and ABYSSAL PLAIN, normally at the mouths of SUBMARINE CANYONS. They are constructed principally from the deposits of sediment gravity flows (mainly turbidity currents and debris flows) as terrigenous and shallow marine sediment is redistributed into deeper water (Clark et al., 1992; Covault, 2011; Deptuck and Sylvester, 2018; Shanmugam, 2016).							x	x	x		x		x											x	x	x							x									x	x	Active sedimentary system	High complexity	High complexity	High complexity	High complexity	Highly dynamic setting with mass flows that can damage / sever subsea cables and pipelines. Typically found along continental margins down to abyssal plains and therefore not suitable for any foundation type. Typically found in deeper water environments, and therefore unsuitable for fixed foundations and very unfavourable for anchors.	https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Submarine or submerged delta	**Marine**	**Lithology, relief**	Submarine tidal deltas, develop from the nearshore to the shelf break or submerged coastal riverine/estuarine deltas and pro-deltas deposits	x		x				x	x					x															x							x			x						x	Heterogeneous sediments	Medium complexity	High complexity	Medium complexity	Medium complexity		https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Submarine gully	**Marine**	**Lithology, relief**	Small-scale (<10 km) confined channels, generally on the order of tens of meters deep and often linear in planform. SUBMARINE GULLIES are commonly found within or alongside SUBMARINE CANYONS on the continental slope and may represent an incipient stage of canyon development (Amblas et al., 2018; Gales et al., 2013; Izumi, 2004; Micallef and Mountjoy, 2011; Pratson et al., 2007)							x	x	x		x													x	x	x							x									x	x	Active sedimentary system	High complexity	High complexity	High complexity	High complexity	Highly dynamic setting with mass flows that can damage / sever subsea cables and pipelines. Typically found along continental margins down to abyssal plains and therefore not suitable for any foundation type. Typically found in deeper water environments, and therefore unsuitable for fixed foundations and very unfavourable for anchors.	https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Alluvial fan	**Fluvial**	**Lithology, relief**	Usually cone-shaped forms with surface slopes radiating away from an apex located at the point where the feeder SUBAERIAL CHANNEL splits to form DISTRIBUTARY CHANNELS. Their fan-like geometry can be modified by the confinement of neighbouring fans or valley walls (modified from Goudie, 2006).		x	x					x	x																																			x	Active sedimentary system	High complexity	High complexity	High complexity	High complexity		https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Buried submerged river valley/ channel	**Fluvial**	**Lithology, relief**	Form via combinations of fluvial and coastal processes (see Additional Attributes: Marginal marine process classification); they widen by lateral SUBAERIAL CHANNEL erosion and weathering, and lengthen by both headward erosion and progradation in their lower reaches. SUBAERIAL VALLEYS can form networks with a variety of drainage patterns	x																													x																x	Heterogeneous sediments	Medium complexity	High complexity	Medium complexity	Medium complexity		
Open submerged river valley/ channel	**Fluvial**	**Lithology, relief**	Form via combinations of fluvial and coastal processes (see Additional Attributes: Marginal marine process classification); they widen by lateral SUBAERIAL CHANNEL erosion and weathering, and lengthen by both headward erosion and progradation in their lower reaches. SUBAERIAL VALLEYS can form networks with a variety of drainage patterns	x						x	x	x				x																	x					x											x	Active sedimentary system	High complexity	High complexity	High complexity	High complexity		https://nora.nerc.ac.uk/id/eprint/514946/1/Seabed_Geomorpholgy_classification_BGS_Open_Report.pdf Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B
Beach	**Coastal**	**Lithology, relief**	A wave-deposited body of sand or gravel formed along open coast (marine), estuarine and lacustrine shorelines (beach face, shoreface, sandy shoal etc.)			x					x	x	x													x																					x	Shallow water depth (<15-20 m)	High complexity	High complexity	Medium complexity	Medium complexity	Exposure of near shore cables may result from coastal processes; increasing risk to cables from external threats. Cables can be protected via Horizontal drilling (HDD).	Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B Development and demonstration of Systems Based Estuary Simulators (EstSim) Project FD2117/PR2
Estuary	**Coastal**	**Lithology, relief**	Estuaries are classified into the following estuarine behavioural types: Generic fjord (fjord, fjord, ria), spit-enclosed drowned river valley, funnel-shaped river valley, embayment and tidal inlet (EstSim R&D project Record FD2117/PR2)	x			x				x	x	x																							x	x	x					x						x	Shallow water depth (<15-20 m)	High complexity	High complexity	Medium complexity	Medium complexity	A hard stratum overlying a weaker one presents a danger that may cause a foundation to punch through the softer sediments. Exposure of near shore cables may result from coastal processes; increasing risk to cables from external threats. Cables can be protected via Horizontal drilling (HDD).	Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B Development and demonstration of Systems Based Estuary Simulators (EstSim) Project FD2117/PR2
Coastal bar form	**Coastal**	**Lithology**	Any type of BARFORM formed in a Coastal Setting (e.g., nearshore bar, berm, shoreface terrace, beach cusp etc)	x		x						x	x											x					x	x	x					x					x			x			x	Active sedimentary system	High complexity	High complexity	Medium complexity	Medium complexity	Exposure of near shore cables may result from coastal processes; increasing risk to cables from external threats. Cables can be protected via Horizontal drilling (HDD).	Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B Development and demonstration of Systems Based Estuary Simulators (EstSim) Project FD2117/PR2
Delta	**Coastal**	**Lithology**	A discrete shoreline sedimentary protuberance formed where a river enters a body of water and supplies sediment more rapidly than it can be redistributed by basial processes (modified from: Elliott, 1986).	x		x	x			x	x	x	x											x					x	x						x					x			x			x	Heterogeneous sediments	Medium complexity	High complexity	Medium complexity	High complexity	Exposure of near shore cables may result from coastal processes; increasing risk to cables from external threats. Cables can be protected via Horizontal drilling (HDD).	Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B Development and demonstration of Systems Based Estuary Simulators (EstSim) Project FD2117/PR2
Barrier	**Coastal**	**Lithology**	Elongate accumulations of sand or coarser sediment primarily deposited by waves and longshore currents, rising above the present sea level, often impounding terrestrial drainage or blocking off a LAGOON in the BACKBARRIER (modified from Griffin et al., 2012; Woodroffe, 2002). Can be sub-classified using their number of attachment points to the mainland (cf. SALIENT/TOMBOLO; BAY-MOUTH; SPIT).			x						x	x											x					x	x											x			x			x	Shallow water depth (<15-20 m)	High complexity	High complexity	Medium complexity	Medium complexity	Exposure of near shore cables may result from coastal processes; increasing risk to cables from external threats. Cables can be protected via Horizontal drilling (HDD).	Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B Development and demonstration of Systems Based Estuary Simulators (EstSim) Project FD2117/PR2
Back barrier (flats and lagoons)	**Coastal**	**Lithology**	A relatively protected area between the BARRIER and the mainland, which may be occupied by FLATS or a LAGOON.				x						x																							x	x					x						x	Shallow water depth (<15-20 m)	High complexity	High complexity	Medium complexity	Medium complexity	A hard stratum overlying a weaker one presents a danger that may cause a foundation to punch through the softer sediments. Exposure of near shore cables may result from coastal processes; increasing risk to cables from external threats. Cables can be protected via Horizontal drilling (HDD).	Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B Development and demonstration of Systems Based Estuary Simulators (EstSim) Project FD2117/PR2

Tidal flat	**Coastal**	**Lithology**	Low gradient intertidal to supratidal surfaces formed in fine-grained sediment (Woodroffe, 2002).				x						x																					x	x						x						x	Shallow water depth (<15-20 m)	High complexity	High complexity	Medium complexity	Medium complexity	A hard stratum overlying a weaker one presents a danger that may cause a foundation to punch through the softer sediments. Exposure of near shore cables may result from coastal processes; increasing risk to cables from external threats. Cables can be protected via Horizontal drilling (HDD).	Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B Development and demonstration of Systems Based Estuary Simulators (EstSim) Project FD2117/PR2
Rocky coast	**Coastal**	**Lithology**	Any length of coast that is predominantly characterised by rock (rather than sediment or vegetation)		x				x		x		x														x															x		x			x	Shallow water depth (<15-20 m)	High complexity	High complexity	High complexity	Medium complexity	Boulders can occur occasionally, especially in the areas of Rapakivi granite bedrock, and De Geer moraine fields (e.g., Finland). Exposure of near shore cables may result from coastal processes; increasing risk to cables from external threats. Cables can be protected via Horizontal drilling (HDD).	Dove et al. (2020) https://zenodo.org/records/4075248 Nanson et al. (2023) - https://zenodo.org/record/7804019#.ZGZl6qXMK3B Development and demonstration of Systems Based Estuary Simulators (EstSim) Project FD2117/PR2
Buried or exposed eustatic escarpment (excessive seabed gradient)	**Solid Earth**	**Relief**	Escarpments formed by sea level stand stills that can be totally or partially covered by transgressive sediment tracts. Vary in length from few km to various tens of kms.	x							x																		x		x	x															x	Uneven ground	Medium complexity	High complexity	Medium complexity	Medium complexity	Depends on the gradient of the seabed slope.	Micallef, A., Foglini, F., Le Bas, T., Angeletti, L., Maselli, V., Pasuto, A. and Taviani, M., 2013. The submerged paleolandscape of the Maltese Islands: Morphology, evolution and relation to Quaternary environmental change. Marine Geology, 335, pp.129-147.
Bedrock outcrop/subcrop (undifferentiated)	**Solid Earth**	**Lithology**	A relief formed by bedrock of unspecified lithology and genesis cropping out of the surrounding seabed. Subcropping of bedrock can be common and covered by thin sediment covers in sediment starved shelves.						x	x																		x		x	x												x		x			x	Strong bedrock - undifferentiated	High complexity	Low complexity	High complexity	High complexity	Depending on the lithology and strength of the bedrock, pile driving may be successful however that would require significant weathering of rockhead to reduce the bedrock to strengths comparable with unlithified deposits (e.g., stiff clay characteristics).	Berry, T.W., Fish, P.R., Price, S.J. and Hadlow, N.W., 2020. Chapter 10 Periglacial geohazards in the UK. Geological Society, London, Engineering Geology Special Publications, 29(1), pp.259-289. Schläppy, M.L., Šaškov, A. and Dahlgren, T.G., 2014. Impact hypothesis for offshore wind farms: explanatory models for species distribution at
Bedrock outcrop/subcrop; carbonate	**Solid Earth**	**Lithology**	A relief formed by bedrock of unspecified lithology and genesis cropping out of the surrounding seabed. Subcropping of bedrock can be common and covered by thin sediment covers in sediment starved shelves.	x					x																		x		x	x												x		x			x	Variable geotechnical properties	High complexity	Medium complexity	Medium complexity	Medium complexity	Carbonate rock (including chalk) can have highly variable geotechnical properties, from putty-like (soil) to strong bedrock	
Bedrock outcrop/subcrop; sedimentary; clastic	**Solid Earth**	**Lithology**	A relief formed by bedrock of unspecified lithology and genesis cropping out of the surrounding seabed. Subcropping of bedrock can be common and covered by thin sediment covers in sediment starved shelves.						x																		x		x	x												x		x			x	Strong bedrock	High complexity	Low complexity	High complexity	High complexity		
Bedrock outcrop/subcrop; igneous	**Solid Earth**	**Lithology**	A relief formed by bedrock of unspecified lithology and genesis cropping out of the surrounding seabed. Subcropping of bedrock can be common and covered by thin sediment covers in sediment starved shelves.						x																		x		x	x												x		x			x	Strong bedrock	High complexity	Low complexity	High complexity	High complexity		
Bedrock outcrop/subcrop; metamorphic	**Solid Earth**	**Lithology**	A relief formed by bedrock of unspecified lithology and genesis cropping out of the surrounding seabed. Subcropping of bedrock can be common and covered by thin sediment covers in sediment starved shelves.						x																		x		x	x												x		x			x	Strong bedrock	High complexity	Low complexity	High complexity	High complexity		
Fractured bed rock	**Solid Earth**	**Structure**	Bedrock of unspecified lithology and genesis that has multiple fractures or fracture networks causing discontinuities in the host rock that can be exploited by erosion.						x	x								x	x																													x	Uneven ground	High complexity	High complexity	High complexity	High complexity	Depending on the original porosity of the host bedrock, the secondary porosity is controlled by the density of the fracture or discontinuity network. Fractures and joints may act as conduits for surface and ground water increasing likelihood of weathering resulting in variable ground conditions.	Petrie, H.E., Eide, C.H., Haflidason, H., Brendryen, J. and Watton, T., 2024. An integrated geological characterization of the Mid-Pleistocene to Holocene geology of the Sørlige Nordsjø II offshore wind site, southern North Sea. Boreas. Petrie, H.E., Eide, C.H., Haflidason, H. and Watton, T., 2022. A conceptual geological model for offshore wind sites in former ice stream settings: the Utsira Nord site, North Sea. Journal of the Geological Society, 179(5), pp.jgs2021-163.
Seamount	**Solid Earth**	**Relief**	Any geographically isolated topographic unit on the seafloor taller than 1000 m. Most seamounts are formed by igneous activity close to mid-ocean ridges, island arcs, or in mid-plate settings, although blocks of continental crust, stranded during the opening of ocean basins, or at compressional settings, can form nonvolcanic seamounts (Harff et al., 2016; Harris and Baker, 2020).	x					x		x				x	x														x		x															x	x	Volcano/>5 degree slope	High complexity	High complexity	High complexity	High complexity	Unsuitable for all infrastructure types due to typically deep water settings, steep slopes, extremely strong lithologies, and associated hazards (e.g., seismic activity).	Bray, L., Reizopoulou, S., Voukouvalas, E., Soukissian, T., Alomar, C., Vázquez-Luis, M., Deudero, S., Attrill, M.J. and Hall-Spencer, J.M., 2016. Expected effects of offshore wind farms on Mediterranean marine life. Journal of Marine Science and Engineering, 4(1), p.18.
Volcano or volcanic feature	**Solid Earth**	**Geohazard**	A mountain or hill, typically conical, having a crater or vent through which lava, rock fragments, hot vapour, and gas are or have been erupted from the earth's crust (modified after Huggett, 2017).						x		x				x		x												x																	x	x	Volcano	High complexity	High complexity	High complexity	High complexity	Unsuitable for all infrastructure types due to typically deep water settings, steep slopes, extremely strong lithologies, and associated hazards (e.g., seismic activity). Geohazard considered where dynamic geological event or process that is a risk to development.	Ercilla, G., Casas, D., Alonso, B., Casalbore, D., Galindo-Zaldívar, J., García-Gil, S., Martorelli, E., Vázquez, J.T., Azpiroz-Zabala, M., DoCouto, D. and Estrada, F., 2021, May. Offshore geological hazards: charting the course of progress and future directions. In Oceans (Vol. 2, No. 2, pp. 393-428). MDPI.
Tectonic lineament (fault)	**Solid Earth**	**Structure, Geohazard**	A discrete surface, or zone of discrete surfaces, expressed as fractures at seabed, separating two rock masses across which one mass has slid past the other (Asch et al., 2021).	x					x						x			x	x										x		x															x	x	Faults/ potential seismicity	High complexity	High complexity	High complexity	High complexity	Unsuitable for all infrastructure types due to vertical and lateral variation, presence of bedrock (generally unfavourable) and associated hazards (e.g., seismic activity). Faults only considered geohazard if active. Geohazard considered where dynamic geological event or process that is a risk to development.	Ercilla, G., Casas, D., Alonso, B., Casalbore, D., Galindo-Zaldívar, J., García-Gil, S., Martorelli, E., Vázquez, J.T., Azpiroz-Zabala, M., DoCouto, D. and Estrada, F., 2021, May. Offshore geological hazards: charting the course of progress and future directions. In Oceans (Vol. 2, No. 2, pp. 393-428). MDPI.
Tectonic escarpment	**Solid Earth**	**Relief**	An escarpment that forms as a result of unspecified faulting activity (Huggett, 2017).						x		x				x														x																	x	x	>5 degree slope	High complexity	High complexity	High complexity	High complexity	Unsuitable for all infrastructure types due to typically steep slopes, strong lithologies, and associated hazards (e.g., seismic activity).	Micallef, A., Foglini, F., Le Bas, T., Angeletti, L., Maselli, V., Pasuto, A. and Taviani, M., 2013. The submerged paleolandscape of the Maltese Islands: Morphology, evolution and relation to Quaternary environmental change. Marine Geology, 335, pp.129-147.
Tectonic depression	**Solid Earth**	**Relief**	A depression generated by an unspecified tectonic/structural process. Includes tectonic graben, basin, half graben, tectonic valley							x					x												x					x															x	>5 degree slope	High complexity	High complexity	Medium complexity	High complexity		
Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	**Mass movement**	**Lithology, relief**	The most downslope zone of a mass movement, within which the displaced material lies above the original ground surface (modified from: Cruden, 1993). Its lower limit is set by the geometry of the TOE. The DEPOSITIONAL ZONE of SLIDES tends to be dominated by a compressional regime (e.g. thrust and fold systems), whereas for FLOWS the material tends to disperse forming fans or aprons at the base of the slope.	x	x			x		x																				x	x						x				x					x	Heterogeneous sediments	High complexity	High complexity	Medium complexity	Medium complexity	In-situ MTDs (i.e., buried or at seabed surface, ancient) may be mapped in the subsurface and penetrated via CPTs to determine lithology Present-day mass movement may cause impact damage to WTGs and cables (or lateral displacement inducing tensions or kinks).	Fisher, J.E., Esmailzadeh, S. and Fillingham, J.N., 2023, April. Geological and Geotechnical Considerations for Floating Offshore Wind Infrastructure within the US Atlantic OCS. In Offshore Technology Conference (p. D021S028R002). OTC.
Evacuation zone (aka. Headwall domain; depletion zone; extensional domain) can include all mass movement (topple/fall/debris flows etc)	**Mass movement**	**Lithology, relief**	The most upslope zone of a mass movement, within which the remobilized material lies below the original ground surface (modified from: Cruden, 1993). Its upper limit is set by the geometry of the HEAD SCARP and this zone is normally dominated by extension features such as Blocks or elongated Ridges (Nissen et al., 1999).	x	x			x		x	x	x				x												x	x		x							x									x	>5 degree slope	High complexity	High complexity	Medium complexity	High complexity	In-situ headscarps (i.e., buried or at seabed surface, ancient) may be mapped in the subsurface and penetrated via CPTs to determine lithology of sediments infilling the headscarp. Present-day mass movement may cause impact damage to WTGs and cables (or lateral displacement inducing tensions or kinks).	Fisher, J.E., Esmailzadeh, S. and Fillingham, J.N., 2023, April. Geological and Geotechnical Considerations for Floating Offshore Wind Infrastructure within the US Atlantic OCS. In Offshore Technology Conference (p. D021S028R002). OTC.
Erratic blocks and rafts (non-glacial origin)	**Mass movement**	**Lithology, relief**	Large rock or boulder carried by rivers, lateral drift or gravity transport contrasting with the country rock that can be found from the shelf to the abyssal plains	x	x					x	x																					x							x				x		x			x	Rafts or boulders	High complexity	High complexity	High complexity	High complexity	In-situ MTDs (i.e., buried or at seabed surface, ancient) may be mapped in the subsurface and penetrated via CPTs to determine lithology. Present-day mass movement may cause impact damage to WTGs and cables (or lateral displacement inducing tensions or kinks)	Fisher, J.E., Esmailzadeh, S. and Fillingham, J.N., 2023, April. Geological and Geotechnical Considerations for Floating Offshore Wind Infrastructure within the US Atlantic OCS. In Offshore Technology Conference (p. D021S028R002). OTC.
Submerged Ccarbonate karst	**Karst**	**Lithology**	Submerged landscape where the dominant geomorphic process was dissolution of carbonate rocks; characterised by distinctive landforms, e.g. caves, CARBONATE DOLINES, underground drainage (modified after Field, 2002)						x																		x							x													x	Uneven ground	High complexity	High complexity	High complexity	High complexity	Can pose a serious risk to the lives of those onboard the installation vessel. Can result in the complete loss of a foundation. Hard substrate so could cause abrasion of surface-laid cables and pipelines.	Dusart, J., Tarits, P., Bazin, S., Isorna, R. and d'Eu, J.F., 2022. Marine karst environment characterization using joint geophysical and geotechnical data. Near Surface Geophysics, 20(4), pp.349-364.
Submerged salt karst	**Karst**	**Lithology**	Submerged landscape where the dominant geomorphic process was dissolution of salt (halite); characterised by distinctive rough terrain and landforms, e.g. dolines (modified after Field, 2002).						x																		x							x													x	Uneven ground	High complexity	High complexity	High complexity	High complexity	Can pose a serious risk to the lives of those onboard the installation vessel. Can result in the complete loss of a foundation. Hard substrate so could cause abrasion of surface-laid cables and pipelines.	Duffy, O., Hudec, M., Peel, F., Apps, G., Bump, A., Moscardelli, L., Dooley, T., Fernandez, N., Bhattacharya, S., Wisian, K. and Shuster, M., 2023. The role of salt tectonics in the energy transition: An overview and future challenges. Tektonika, 1(1).
Submerged sandstone karst	**Karst**	**Lithology**	Submerged landscape where the dominant geomorphic processes were a combination of chemical weathering and other erosional processes of sandstone (quartz); characterised by distinctive rough terrain and landforms, e.g. ruiniform.						x																		x							x													x	Uneven ground	High complexity	High complexity	High complexity	High complexity	Can pose a serious risk to the lives of those onboard the installation vessel. Can result in the complete loss of a foundation. Hard substrate so could cause abrasion of surface-laid cables and pipelines.	Dusart, J., Tarits, P., Bazin, S., Isorna, R. and d'Eu, J.F., 2022. Marine karst environment characterization using joint geophysical and geotechnical data. Near Surface Geophysics, 20(4), pp.349-364.
Mud volcano	**Fluid flow**	**Geohazard, relief**	A positive topographic unit, usually conical, formed by the periodic upwelling of sediments (mud) fluidised by gas and water (Etiope, 2015). It can develop as a single isolated cone (that can be several hundreds of meters high) or, more frequently, as groups of cones.				x											x	x	x									x						x											x	x	Active fluid flow	High complexity	High complexity	High complexity	High complexity	Geohazard if active. Geohazard considered where dynamic geological event or process that is a risk to development.	Ercilla, G., Casas, D., Alonso, B., Casalbore, D., Galindo-Zaldívar, J., García-Gil, S., Martorelli, E., Vázquez, J.T., Azpiroz-Zabala, M., DoCouto, D. and Estrada, F., 2021, May. Offshore geological hazards: charting the course of progress and future directions. In Oceans (Vol. 2, No. 2, pp. 393-428). MDPI.
Pockmark (individually mapped)	**Fluid flow**	**Geohazard, relief**	A concave crater-like Depression formed by gas and/or fluid expulsion, typically one to tens of meters in diameter but can be up to a few hundred meters wide (Hovland et al., 1987). Pockmarks tend to be characteristic V-shaped depressions, with circular, or elliptical geometry. However, they can also present a W-shaped profile or more complex geometries.				x											x	x	x									x						x												x	Active fluid flow	High complexity	High complexity	High complexity	High complexity	Individually mapped pockmarks. Pockmarks only considered geohazard if active. Geohazard considered where dynamic geological event or process that is a risk to development.	Coughlan, M., Roy, S., O'Sullivan, C., Clements, A., O'Toole, R., & Plets, R. (2021). Geological settings and controls of fluid migration and associated seafloor seepage features in the north Irish Sea. *Marine and Petroleum Geology* , *123* , 104762.
Pockmark (field)	**Fluid flow**	**Geohazard, relief**	A concave crater-like Depression formed by gas and/or fluid expulsion, typically one to tens of meters in diameter but can be up to a few hundred meters wide (Hovland et al., 1987). Pockmarks tend to be characteristic V-shaped depressions, with circular, or elliptical geometry. However, they can also present a W-shaped profile or more complex geometries.				x											x	x	x									x						x												x	Active fluid flow	Medium complexity	Medium complexity	Medium complexity	Medium complexity	In some areas, multiple pockmarks over one area. Here, individual pockmarks are not mapped - would require further investigation. Pockmarks only considered geohazard if active. Geohazard considered where dynamic geological event or process that is a risk to development.	Coughlan, M., Roy, S., O'Sullivan, C., Clements, A., O'Toole, R., & Plets, R. (2021). Geological settings and controls of fluid migration and associated seafloor seepage features in the north Irish Sea. *Marine and Petroleum Geology* , *123* , 104762.
Hydrothermal vent	**Fluid flow**	**Geohazard, relief**	Fissures on the oceanic crust in volcanically active sites (e.g. mid-ocean ridges, back-arc spreading centres, and hot-spot or arc-related submarine volcanoes), from which geothermally heated water is released. Circulating seawater is heated by a heat source such as a magma chamber or associated hot rock and, during heating and chemical reaction with the surrounding rock, undergoes a suite of chemical modifications (modified after Harff et al., 2016).																x											x																	x	x	Active fluid flow	High complexity	High complexity	High complexity	High complexity		Aish, A., Ashworth, J., Barrio-Frojan, B., Benjamins, S., Bolam, S., Brazier, P., Brockington, S., Chaniotis, P., Clements, A., Coggan, R. and Coltman, N., 2010. Marine habitats. In UK Marine Monitoring and Assessment Strategy (2010) Charting Progress 2 Healthy and Biological Diverse Seas Feeder Report (pp. 68-271). Department for Environment Food and Rural Affairs.
Shallow gas	**Fluid flow**	**Geohazard**	The presence of shallow biogenic or hydrocarbon-originated gas charged sediment. Any gas pocket encountered above the setting depth of the first pressure containment string, in a borehole (from Cook et al., 2022).																x																x								x				x	Active fluid flow	High complexity	High complexity	High complexity	High complexity	Can lead to blowouts when drilling. Blowout Preventers (BOPs) are required for drilling in potentially gassy soils. Difficult to engineer around, avoidance is typically the main approach to de-risking developments in areas of gassy soils. Geohazard considered where dynamic geological event or process that is a risk to development.	Mellett, C.L., Long, D. and Carter, G., 2015. Geology of the seabed and shallow subsurface: The Irish Sea.
Outcropping methane-derived authigenic carbonate (MDAC)	**Fluid flow**	**Lithology**	Exposed authigenic carbonate structures, mostly in the form of hardground with positive relief, associated with the seepage of methane rich fluids as a result of the anaerobic methane oxidation coupled with sulphate reduction by associations of archaea and bacteria (Hovland et al., 1987).					x																					x					x									x				x	Hard substrate	High complexity	Medium complexity	Medium complexity	Medium complexity	Creates a hard surface that is recognised as a special habitat that must be preserved. Potential fluid flow to determine if current or past fluid flow.	Capozzi, R., Guido, F.L., Oppo, D. and Gabbianelli, G., 2012. Methane-Derived Authigenic Carbonates (MDAC) in northern-central Adriatic Sea: Relationships between reservoir and methane seepages. Marine Geology, 332, pp.174-188.
Reefs (ancient, buried and present day)	**Biogenic**	**Lithology, relief**	In-situ, positive relief, persistent build-ups of primarily skeleton-supported framework (+ internal binding), that influence the local sedimentary environment (Klement, 1967), and supports (or supported) living communities during active accretion. Definition modified from a range of sources: (Cumings, 1932; Goudie, 2006; Harris and Baker, 2020; Klement, 1967; Lo Iacono et al., 2018).						x	x	x																		x													x					x	Active sedimentary system / hardground	High complexity	High complexity	High complexity	Medium complexity	Kaskela, A. & Rinne, H. 2018: Vedenalaisten Natura-luontotyyppien mallinnus Suomen merialueella (In Finnish). Geological Survey of Finland, Research report 6/2018, 36 p. Rinne, H., Kaskela, A., Downie, A.-L., Tolvanen, H., von Numers, M., Mattila, J., 2014. Predicting the occurrence of rocky reefs in a heterogeneous archipelago area with limited data. Estuar. Coast. Shelf Sci. 138, 90–100.	Pearce, B., Fariñas-Franco, J.M., Wilson, C., Pitts, J., deBurgh, A. and Somerfield, P.J., 2014. Repeated mapping of reefs constructed by Sabellaria spinulosa Leuckart 1849 at an offshore wind farm site. Continental Shelf Research, 83, pp.3-13. Guinan, J., McKeon, C., O'Keeffe, E., Monteys, X., Sacchetti, F., Coughlan, M. and Nic Aonghusa, C., 2021. INFOMAR data supports offshore energy development and marine spatial planning in the Irish offshore via the EMODnet Geology portal. Quarterly Journal of Engineering Geology and Hydrogeology, 54(1), pp.qjegh2020-033.
Concretions	**Post-depositional**	**Lithology**	Concretions form nodular growths comprised of various minerals that form within the host rock and vary in size, shape, composition and distribution (Todd, 1902)	x	x																					x					x											x		x			x	Boulders	High complexity	High complexity	Medium complexity	Medium complexity	E.g., more than 10% of the Finnish marine areas (seabed) are covered by Ferromanganese concretions. They are often located on the sandy/silty seabed substrate, but subsurface sediment may also be fine, e.g. (glacial) clay (e.g., Finland).	Zhamoida, V., Grigoriev, A., Ryabchuk, D., Evdokimenko, A., Kotilainen, A.T., Vallius, H. and Kaskela, A.M., 2017. Ferromanganese concretions of the eastern Gulf of Finland–Environmental role and effects of submarine mining. Journal of marine systems, 172, pp.178-187.
Submerged salt or shale domes/diapir	**Post-depositional**	**Lithology, relief**	Submerged positive feature sitting on top of a salt diapir (halokinetic structure) of regular or irregular plan view shape usually covered by a relatively thick pile of sediment cover that can be unstable due to khalokinetic dynamics (dissolution, flow or uplift). They can be common in continental passive margins or in accretionary wedges. A distinct elevation, often with a rounded profile, one km or more in diameter that is the geomorphologic expression of a diapir formed by vertical intrusion of salt. Commonly found in a PROVINCE of similar features.							x								x					x									x															x	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity		Lopes, F.C., Cunha, P.P. and Le Gall, B., 2006. Cenozoic seismic stratigraphy and tectonic evolution of the Algarve margin (offshore Portugal, southwestern Iberian Peninsula). Marine Geology, 231(1-4), pp.1-36. Duffy, O., Hudec, M., Peel, F., Apps, G., Bump, A., Moscardelli, L., Dooley, T., Fernandez, N., Bhattacharya, S., Wisian, K. and Shuster, M., 2023. The role of salt tectonics in the energy transition: An overview and future challenges. Tektonika, 1(1).
Polygonal faulting	**Post-depositional**	**Structure**	Layer-bound arrays of normal faults confined to specific stratigraphic intervals called 'tiers' and typically hosted in fine-grained sediments															x			x																								x		x	Unknown - potential conduit for fluids?	Medium complexity	Medium complexity	Medium complexity	Medium complexity	Ongoing research regarding polygonal faulting - e.g., VLAIO funding ongoing in clay tectonics https://research.ugent.be/web/result/project/8180a538-a0fb-44f0-ab27-e414f933ece8/details/en	Verschuren, M., 2019. Outcrop evidence of polygonal faulting in Ypresian marine clays (Southern North Sea Basin) leads to a new synthesis. Marine Geology, 413, pp.85-98.

Annex 2 - Reattribution of open-source datasets and GSEU nomenclature (V1)

Data source and layer	Layer name from data source	GSEU translation (simplified)	Setting	Type of constraint	Hazard translation / assumptions	Suction	Gravity based foundation	Piles	Cables
MAREANO landforms	Drumlin	Streamlined landform (Crag and tail /Drumlin/ Flute/ Groove)	Glacial	Lithology, relief	Variable geotechnical properties depending on formation	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO landforms	Morene ridge	Moraine	Glacial	Lithology, relief	>5 degree slope, heterogeneous/overconsolidated sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO landforms	Ice-marginal moraine	Moraine	Glacial	Lithology, relief	>5 degree slope, heterogeneous/overconsolidated sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO landforms	Ice marginal deposit	Diamict	Sediments	Lithology	Hard overconsolidated clays	Higher complexity	Medium complexity	Medium complexity	Medium complexity
MAREANO landforms	Glacitectonic hole	Hill-hole pair	Glacial	Lithology, relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
MAREANO landforms	Glacitectonic hill	Hill-hole pair	Glacial	Lithology, relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
MAREANO landforms	Grounded iceberg depression	Iceberg ploughmark (field)	Glacial	Lithology	Uneven ground	Lower complexity	Higher complexity	Lower complexity	Lower complexity
MAREANO landforms	Grounding zone wedge	Grounding zonewedge	Glacial	Lithology, relief	Hard overconsolidated clays / extremely dense sands	Higher complexity	Higher complexity	Higher complexity	Higher complexity
MAREANO landforms	Corrugation ridges	Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO landforms	Area with slide deposits from landslide	Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO landforms	Area with slide deposits from rockslide	Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO landforms	Area with slide deposits, unspecified	Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO landforms	Slide block	Erratic blocks and rafts (non-glacial origin)	Mass movement	Lithology, relief	Rafts or boulders	Higher complexity	Higher complexity	Higher complexity	Higher complexity
MAREANO landforms	Landslide fan	Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO landforms	Slide area	Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO landforms	Submarine fan	Submarine fan	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
MAREANO landforms	Canyon	Submarine canyon (canyon/ canyon head / canyon mouth / tributary canyon)	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
MAREANO landforms	Ridge, unspecified	Ridge	Physiographic	Relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
MAREANO landforms	Area with ridges	Ridge	Physiographic	Relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
MAREANO landforms	Sediment wave field	Sediment waves/dunes	Marine	Lithology	Active sedimentary system	Medium complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO landforms	Sand/gravel pit (subaqueous)	Sand	Sediments	Lithology	Homogenous sediments	Lower complexity	Higher complexity	Lower complexity	Lower complexity
MAREANO lines	Fault (subaqueous)	Tectonic lineament (fault)	Solid Earth	Structure, Geohazard	Faults/ potential seismicity	Higher complexity	Higher complexity	Higher complexity	Higher complexity
MAREANO lines	Drumlin	Streamlined landform (Crag and tail /Drumlin/ Flute/ Groove)	Glacial	Lithology, relief	Variable geotechnical properties depending on formation	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO lines	Channel margin (subaqueous)	Open Submerged river valley/ channel	Fluvial	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
MAREANO lines	Esker (glaciofluvial ridge)	Esker	Glacial	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO lines	Landslide front (subaqueous)	Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO lines	Iceberg ploughmark	Iceberg ploughmark (field)	Glacial	Lithology	Uneven ground	Lower complexity	Higher complexity	Lower complexity	Lower complexity
MAREANO lines	Glacial meltwater channel	Meltwater channel (includes proglacial meltwater channel)	Glacial	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO lines	Sediment wave	Sediment waves/dunes	Marine	Lithology	Active sedimentary system	Medium complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO lines	Ridge, unspecified	Ridge	Physiographic	Relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
MAREANO lines	Drumlin-like form	Streamlined landform (Crag and tail /Drumlin/ Flute/ Groove)	Glacial	Lithology, relief	Variable geotechnical properties depending on formation	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO lines	Channel, unspecified (subaqueous)	Open Submerged river valley/ channel	Fluvial	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
MAREANO lines	Landslide scarp	Evacuation zone (aka. Headwall domain; depletion zone; extensional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	>5 degree slope	Higher complexity	Higher complexity	Medium complexity	Higher complexity
MAREANO lines	Current channel	Submarine channel	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
MAREANO lines	Ice-marginal moraine	Moraine	Glacial	Lithology, relief	>5 degree slope, heterogeneous/overconsolidated sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO lines	Recessional moraine	Moraine	Glacial	Lithology, relief	>5 degree slope, heterogeneous/overconsolidated sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO lines	Morene ridge	Moraine	Glacial	Lithology, relief	>5 degree slope, heterogeneous/overconsolidated sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO lines	Parallel ridges and grooves on the surface	Ridge	Physiographic	Relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Landforms	area with pockmarks	Pockmark (field)	Fluid flow	Geohazard, relief	Active fluid flow	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Landforms	area with slide deposits	Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	bank	Sediment bank	Marine	Relief	>5 degree slope	Higher complexity	Higher complexity	Medium complexity	Higher complexity
EMODnet Landforms	bank crest	Sediment bank	Marine	Relief	>5 degree slope	Higher complexity	Higher complexity	Medium complexity	Higher complexity
EMODnet Landforms	beach ridge	Beach	Coastal	Lithology, relief	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	beachrock	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Landforms	bedform	Sediment waves/dunes	Marine	Lithology	Active sedimentary system	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	bench	Marine barform (Contourite drift/ sediment apron/ sediment drift/ sediment lobe/energetic wave or current regime)	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	canyon	Submarine canyon (canyon/ canyon head / canyon mouth / tributary canyon)	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	channel	Submarine channel	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	colapsed blocks	Erratic blocks and rafts (non-glacial origin)	Mass movement	Lithology, relief	Rafts or boulders	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	cold seep	Pockmark (individually mapped)	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	contourite deposit	Marine barform (Contourite drift/ sediment apron/ sediment drift/ sediment lobe/energetic wave or current regime)	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	contourite drift	Marine barform (Contourite drift/ sediment apron/ sediment drift/ sediment lobe/energetic wave or current regime)	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	coralmound	Reefs (ancient, buried and present day)	Biogenic	Lithology, relief	Active sedimentary system / hardground	Higher complexity	Higher complexity	Higher complexity	Medium complexity
EMODnet Landforms	current channel	Submarine channel	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	debris-avalanche deposit	Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	debris avalanche	Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	debris flow	Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	delta	Delta	Coastal	Lithology	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Higher complexity
EMODnet Landforms	delta lobe	Delta	Coastal	Lithology	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Higher complexity
EMODnet Landforms	dome	Submerged salt or shale domes/diapir	Post-depostitional	Lithology, relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Landforms	drumlin	Streamlined landform (Crag and tail /Drumlin/ Flute/ Groove)	Glacial	Lithology, relief	Variable geotechnical properties depending on formation	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	drumlin field	Streamlined landform (Crag and tail /Drumlin/ Flute/ Groove)	Glacial	Lithology, relief	Variable geotechnical properties depending on formation	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	dune	Sediment waves/dunes	Marine	Lithology	Active sedimentary system	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	dune field	Sediment waves/dunes	Marine	Lithology	Active sedimentary system	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	escarpment	Tectonicescarpment	Solid Earth	Relief	>5 degree slope	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	esker	Esker	Glacial	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	estuary	Estuary	Coastal	Lithology, relief	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	fan	Submarine fan	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	fluvial erosional landform	Submarine channel	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	glacial scoring mark	Iceberg ploughmark (field)	Glacial	Lithology	Uneven ground	Lower complexity	Higher complexity	Lower complexity	Lower complexity
EMODnet Landforms	gully	Submarine gully	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	gully thalweg	Submarine gully	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	ice rafted debris field	Erratic or Glaciotectonic raft	Glacial	Lithology, relief	Rafts or boulders	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	intertidal flats	Tidal flat	Coastal	Lithology	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	lagoon	Back barrier (flats and lagoons)	Coastal	Lithology	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	marginal moraine	Moraine	Glacial	Lithology, relief	>5 degree slope, heterogeneous/overconsolidated sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	marine canyon	Submarine canyon (canyon/ canyon head / canyon mouth / tributary canyon)	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	marine valley	Submarine channel	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	moat	Moat	Physiographic	Relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Landforms	moraine	Moraine	Glacial	Lithology, relief	>5 degree slope, heterogeneous/overconsolidated sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	moraine ridge	Moraine	Glacial	Lithology, relief	>5 degree slope, heterogeneous/overconsolidated sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	mound	Mound	Physiographic	Relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Landforms	mud cone	Mud volcano	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	mud volcano	Mud volcano	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	pinnacle	Seamount	Solid Earth	Relief	Volcano/>5 degree slope	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	ploughmarks (Iceberg)	Iceberg ploughmark (field)	Glacial	Lithology	Uneven ground	Lower complexity	Higher complexity	Lower complexity	Lower complexity
EMODnet Landforms	ploughmarks field	Iceberg ploughmark (field)	Glacial	Lithology	Uneven ground	Lower complexity	Higher complexity	Lower complexity	Lower complexity
EMODnet Landforms	pockmark	Pockmark (individually mapped)	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	pockmark field	Pockmark (field)	Fluid flow	Geohazard, relief	Active fluid flow	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Landforms	prodelta	Delta	Coastal	Lithology	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Higher complexity
EMODnet Landforms	reef	Reefs (ancient, buried and present day)	Biogenic	Lithology, relief	Active sedimentary system / hardground	Higher complexity	Higher complexity	Higher complexity	Medium complexity
EMODnet Landforms	ridge crest	Ridge	Physiographic	Relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Landforms	ridge, unspecified	Ridge	Physiographic	Relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Landforms	ripple	Marine barform (Contourite drift/ sediment apron/ sediment drift/ sediment lobe/energetic wave or current regime)	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	rocky outcrop	Rocky coast	Coastal	Lithology	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Higher complexity	Medium complexity
EMODnet Landforms	salt dome	Submerged salt or shale domes/diapir	Post-depostitional	Lithology, relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Landforms	sand bar	Marine barform (Contourite drift/ sediment apron/ sediment drift/ sediment lobe/energetic wave or current regime)	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	sand field	Marine barform (Contourite drift/ sediment apron/ sediment drift/ sediment lobe/energetic wave or current regime)	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	sand ribbon field	Marine barform (Contourite drift/ sediment apron/ sediment drift/ sediment lobe/energetic wave or current regime)	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	sand ridge	Marine barform (Contourite drift/ sediment apron/ sediment drift/ sediment lobe/energetic wave or current regime)	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	sand wave field	Sediment waves/dunes	Marine	Lithology	Active sedimentary system	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	seamount	Seamount	Solid Earth	Relief	Volcano/>5 degree slope	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	sediment bank	Sediment bank	Marine	Relief	>5 degree slope	Higher complexity	Higher complexity	Medium complexity	Higher complexity
EMODnet Landforms	sediment wave	Sediment waves/dunes	Marine	Lithology	Active sedimentary system	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	sediment wave field	Sediment waves/dunes	Marine	Lithology	Active sedimentary system	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	shallow inlets and bays	Beach	Coastal	Lithology, relief	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	shallow marine valley	Submarine channel	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Landforms	shelf break	Terrace	Physiographic	Relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Landforms	slide area	Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	slide escarpment	Evacuation zone (aka. Headwall domain; depletion zone; extensional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	>5 degree slope	Higher complexity	Higher complexity	Medium complexity	Higher complexity
EMODnet Landforms	slide fan	Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity

EMODnet Landforms	slide scar	Evacuation zone (aka. Headwall domain; depletion zone; extensional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	>5 degree slope	Higher complexity	Higher complexity	Medium complexity	Higher complexity
EMODnet Landforms	submarine landslide	Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	terrace	Terrace	Physiographic	Relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Landforms	trough	Trough	Physiographic	Relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Landforms	tunnel valley	Tunnel valley	Glacial	Lithology	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Landforms	volcano	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Channel	Buried Submerged river valley/ channel	Fluvial	Lithology, relief	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Abandoned fluvial channel	Buried Submerged river valley/ channel	Fluvial	Lithology, relief	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Abandoned fluvio-glacial channel	Buried Submerged river valley/ channel	Fluvial	Lithology, relief	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Basin	Basin / Basin plain / intraslope basin	Physiographic	Relief	Soft soil units	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Buried fluvial channel	Buried Submerged river valley/ channel	Fluvial	Lithology, relief	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Buried tidal channel	Submarine channel	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Buried tunnel valley	Buried Tunnel valley	Glacial	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Channel inlet	Submarine channel	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Current channel	Submarine channel	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Current scour channel	Submarine channel	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Delta channel	Submarine channel	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Fluvial channel	Buried Submerged river valley/ channel	Fluvial	Lithology, relief	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Fluvial feature	Buried Submerged river valley/ channel	Fluvial	Lithology, relief	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Fluvio-glacial feature	Buried Submerged river valley/ channel	Fluvial	Lithology, relief	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Glacial meltwater channel	Meltwater channel (includes proglacial meltwater channel)	Glacial	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Meltwater Channel	Meltwater channel (includes proglacial meltwater channel)	Glacial	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Open fluvial channel	Open Submerged river valley/ channel	Fluvial	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Open tunnel valley	Open Tunnel valley	Glacial	Lithology, relief	Steep slopes	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Open undifferentiated channel	Open Submerged river valley/ channel	Fluvial	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Outflow channel from lake	Open Submerged river valley/ channel	Fluvial	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Paleo-channel	Submarine channel	Marine	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Paleovalley	Buried Submerged river valley/ channel	Fluvial	Lithology, relief	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Tunnel Valley	Buried Tunnel valley	Glacial	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Delta	Delta	Coastal	Lithology	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Higher complexity
EMODnet Submerged landscapes	Abandoned fluvial channel	Open Submerged river valley/ channel	Fluvial	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Ancient delta lobe	Submarine or submerged delta	Marine	Lithology, relief	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Delta	Delta	Coastal	Lithology	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Higher complexity
EMODnet Submerged landscapes	Flood delta	Delta	Coastal	Lithology	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Higher complexity
EMODnet Submerged landscapes	Paleo-deltaic lobes	Delta	Coastal	Lithology	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Higher complexity
EMODnet Submerged landscapes	Paleo-inlet	Buried Submerged river valley/ channel	Fluvial	Lithology, relief	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Submerged delta	Submarine or submerged delta	Marine	Lithology, relief	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Estuary	Estuary	Coastal	Lithology, relief	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Estuary	Estuary	Coastal	Lithology, relief	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Firth	Estuary	Coastal	Lithology, relief	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Fluvio-estuarine feature	Estuary	Coastal	Lithology, relief	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Sand bank	Sediment bank	Marine	Relief	>5 degree slope	Higher complexity	Higher complexity	Medium complexity	Higher complexity
EMODnet Submerged landscapes	Karst	Submerged Carbonate karst	Karst	Lithology	Uneven ground	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Sinkhole	Submerged Carbonate karst	Karst	Lithology	Uneven ground	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Lagoon	Back barrier (flats and lagoons)	Coastal	Lithology	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Paleo-lagoon	Back barrier (flats and lagoons)	Coastal	Lithology	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Lake	Back barrier (flats and lagoons)	Coastal	Lithology	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Submerged marine and freshwater lake	Back barrier (flats and lagoons)	Coastal	Lithology	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Brackish Lake	Back barrier (flats and lagoons)	Coastal	Lithology	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Salt Lake	Back barrier (flats and lagoons)	Coastal	Lithology	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Palaeo-Alluvial Plain	Buried Submerged river valley/ channel	Fluvial	Lithology, relief	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Coastal Landform	Coastal barform	Coastal	Lithology	Active sedimentary system	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Aeolian landform	Coastal barform	Coastal	Lithology	Active sedimentary system	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Beach	Beach	Coastal	Lithology, relief	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Beach rock	Bedrock outcrop/subcrop (undifferentiated)	Solid Earth	Lithology	Strong bedrock - undifferentiated	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Coastal dunes	Coastal barform	Coastal	Lithology	Active sedimentary system	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Depression	Depression/ hole	Physiographic	Relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Paleo-inlet	Buried Submerged river valley/ channel	Fluvial	Lithology, relief	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Paleo-isthmus	Coastal barform	Coastal	Lithology	Active sedimentary system	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Paleo-spit bar	Coastal barform	Coastal	Lithology	Active sedimentary system	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Paleo-washover fan	Coastal barform	Coastal	Lithology	Active sedimentary system	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Plateau	Plateau / topographic high	Physiographic	Relief	>5 degree slope	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Relict sand waves	Coastal barform	Coastal	Lithology	Active sedimentary system	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Sand body	Coastal barform	Coastal	Lithology	Active sedimentary system	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Submerged barrier island	Barrier	Coastal	Lithology	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Submerged beach area	Beach	Coastal	Lithology, relief	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Submerged coastal dunes	Coastal barform	Coastal	Lithology	Active sedimentary system	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Submerged dune area	Coastal barform	Coastal	Lithology	Active sedimentary system	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Submerged lagoon	Back barrier (flats and lagoons)	Coastal	Lithology	Shallow water depth (<15-20 m)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Topographic high	Plateau / topographic high	Physiographic	Relief	>5 degree slope	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Subaerial Landslide	Depositional zone (aka. Accumulation zone; compressional domain) can include all mass movement (topple/fall/debris flows etc)	Mass movement	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Submerged Forest	Peat (organic-rich)	Sediments	Lithology	Organic soils	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Terrace	Terrace	Physiographic	Relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	2. Fluvial	Open Submerged river valley/ channel	Fluvial	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	2a. Fluvial erosional	Open Submerged river valley/ channel	Fluvial	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	2b. Fluvial Depositional	Open Submerged river valley/ channel	Fluvial	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Wetlands	Peat (organic-rich)	Sediments	Lithology	Organic soils	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Mud diapir	Submerged salt or shale domes/diapir	Post-depostitional	Lithology, relief	Uneven ground	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Submerged landscapes	Peat	Peat (organic-rich)	Sediments	Lithology	Organic soils	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	salt marsh, swamp	Peat (organic-rich)	Sediments	Lithology	Organic soils	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Submerged landscapes	Swamp or marsh	Peat (organic-rich)	Sediments	Lithology	Organic soils	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	Pockmark area	Pockmark (field)	Fluid flow	Geohazard, relief	Active fluid flow	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Geohazards	cone	Pockmark (individually mapped)	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	depressions	Pockmark (individually mapped)	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	gas seep	Pockmark (individually mapped)	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	pockmark	Pockmark (individually mapped)	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	Pockmark area	Pockmark (field)	Fluid flow	Geohazard, relief	Active fluid flow	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Geohazards	depressions	Pockmark (individually mapped)	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	field	Pockmark (individually mapped)	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	pockmark area	Pockmark (field)	Fluid flow	Geohazard, relief	Active fluid flow	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Geohazards	trench pockmarks	Pockmark (individually mapped)	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	Volcanic fluid emissions	Pockmark (individually mapped)	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	fluid emissions	Pockmark (individually mapped)	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	non-volcanic fluid emissions	Pockmark (individually mapped)	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	fluid emission	Pockmark (individually mapped)	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	mud volcanoes	Mud volcano	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	mud volcanoes complex	Mud volcano	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	caldera	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	cone	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	crater	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	dike	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	eruptive fissure	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	fissure vent	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	flank collapse	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	flat-top edifice	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	lava border	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	lava flow	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	shield	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	eruptive fissure	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	lava border	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	bank	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	cone	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	cones and craters	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	dike	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	dike, dome	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity

EMODnet Geohazards	guyot	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	hill	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	hyaloclastite ridges	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	hyaloclastite ridges, dike	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	hyaloclastite ridges, dike, dome	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	hydrothermal field	Hydrothermal vent	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	island	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	lava dome	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	lava flow	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	ridge	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	seamount	Seamount	Solid Earth	Relief	Volcano/>5 degree slope	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	shield	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	tabular seamount	Seamount	Solid Earth	Relief	Volcano/>5 degree slope	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	vent	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	volcanic system	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	" "	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	bank	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	caldera, tuff cone	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	composite	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	composite, caldera	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	composite, cone	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	cone	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	cone, caldera	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	cone, fissure vent	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	cone, shield, fissure vent, caldera	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	fissure vent	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	guyot	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	hill	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	hydrothermal field	Hydrothermal vent	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	island	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	lava cone	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	lava dome	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	lava flow	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	ridge	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	seamount	Seamount	Solid Earth	Relief	Volcano/>5 degree slope	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	stratovolcano	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	tabular seamount	Seamount	Solid Earth	Relief	Volcano/>5 degree slope	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Geohazards	volcanic system	Volcano or volcanic feature	Solid Earth	Geohazard	Volcano	Higher complexity	Higher complexity	Higher complexity	Higher complexity
INSS-INFOMAR Fluid Flow	outcropping MDAC	Outcroppingmethane-derivedauthigeniccarbonate (MDAC)	Fluid flow	Lithology	Hard substrate	Higher complexity	Medium complexity	Medium complexity	Medium complexity
INSS-INFOMAR Fluid Flow	pockmark	Pockmark (individually mapped)	Fluid flow	Geohazard, relief	Active fluid flow	Higher complexity	Higher complexity	Higher complexity	Higher complexity
INSS-INFOMAR Fluid Flow	pockmark	Pockmark (field)	Fluid flow	Geohazard, relief	Active fluid flow	Medium complexity	Medium complexity	Medium complexity	Medium complexity
INSS-INFOMAR Fluvial landforms	channel	Open submerged river valley/ channel	Fluvial	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
INSS-INFOMAR Fluvial landforms	tunnel valley	Buried Tunnel valley	Glacial	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
INSS-INFOMAR Fluvial landforms	subaerial channel	Buried submerged river valley/ channel	Fluvial	Lithology, relief	Heterogeneous sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
INSS-INFOMAR Fluvial landforms	tunnel valley	Buried Tunnel valley	Glacial	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
INSS-INFOMAR Fluvial landforms	meltwater channel	Meltwater channel (includes proglacial meltwater channel)	Glacial	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
INSS-INFOMAR Fluvial landforms	tunnel valley	Open Tunnel valley	Glacial	Lithology, relief	Steep slopes	Higher complexity	Higher complexity	Higher complexity	Higher complexity
INSS-INFOMAR Fluvial landforms	subaerial channel	Open submerged river valley/ channel	Fluvial	Lithology, relief	Active sedimentary system	Higher complexity	Higher complexity	Higher complexity	Higher complexity
INSS-INFOMAR Fluvial landforms	meltwater channel	Meltwater channel (includes proglacial meltwater channel)	Glacial	Lithology, relief	Heterogeneous sediments	Higher complexity	Higher complexity	Medium complexity	Medium complexity
INSS-INFOMAR Solid Earth	bedrock outcrop (general)	Bedrock outcrop/subcrop (undifferentiated)	Solid Earth	Lithology	Strong bedrock - undifferentiated	Higher complexity	Lower complexity	Higher complexity	Higher complexity
INSS-INFOMAR Substrates	Surfacing glacial deposits and tills	Sediments	Lithology	Hard overconsolidated clays	Higher complexity	Medium complexity	Medium complexity	Medium complexity	
INSS-INFOMAR Substrates	Thicker accumulations of Postglacial soft sediment	Sediments	Lithology	Soft sediments	Higher complexity	Higher complexity	Higher complexity	Higher complexity	
INSS-INFOMAR Substrates	Sub-cropping and out-cropping bedrock	Solid Earth	Lithology	Strong bedrock - undifferentiated	Higher complexity	Lower complexity	Higher complexity	Higher complexity	
EMODnet Quaternary Lithology	andesite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	ash tuff, lapillistone, and lapilli tuff	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	basalt	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	basanite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	biogenic sediment	Reefs (ancient, buried and present day)	Biogenic	Lithology, relief	Active sedimentary system / hardground	Higher complexity	Higher complexity	Higher complexity	Medium complexity
EMODnet Quaternary Lithology	boulder gravel size sediment	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Quaternary Lithology	calcareous carbonate sediment	Carbonate sands	Sediments	Lithology	Crushable soil	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Quaternary Lithology	carbonate mud	Carbonate sands	Sediments	Lithology	Crushable soil	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Quaternary Lithology	carbonate mudstone	Carbonate sands	Sediments	Lithology	Crushable soil	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Quaternary Lithology	carbonate sedimentary rock	Bedrock outcrop/subcrop; carbonate	Solid Earth	Lithology	Variable geotechnial properties	Higher complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Quaternary Lithology	clastic sediment	Sand	Sediments	Lithology	Homogenous sediments	Lower complexity	Higher complexity	Lower complexity	Lower complexity
EMODnet Quaternary Lithology	clastic sedimentary material	Sand	Sediments	Lithology	Homogenous sediments	Lower complexity	Higher complexity	Lower complexity	Lower complexity
EMODnet Quaternary Lithology	clastic sedimentary rock	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	clay	Soft mud	Sediments	Lithology	Soft sediments	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	cobble gravel size sediment	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Quaternary Lithology	conglomerate	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Quaternary Lithology	diamicton	Diamict	Sediments	Lithology	Hard overconsolidated clays	Higher complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Quaternary Lithology	evaporite	Evaporites	Sediments	Lithology	Uneven ground	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Quaternary Lithology	grainstone	Bedrock outcrop/subcrop; carbonate	Solid Earth	Lithology	Variable geotechnial properties	Higher complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Quaternary Lithology	gravel	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Quaternary Lithology	igneous rock	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	limestone	Bedrock outcrop/subcrop; carbonate	Solid Earth	Lithology	Variable geotechnial properties	Higher complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet Quaternary Lithology	metamorphic rock	Bedrock outcrop/subcrop; metamorphic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	mud	Soft mud	Sediments	Lithology	Soft sediments	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	mud size sediment	Soft mud	Sediments	Lithology	Soft sediments	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	ooze	Soft mud	Sediments	Lithology	Soft sediments	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	organic rich sediment	Soft mud	Sediments	Lithology	Soft sediments	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	organic rich sedimentary material	Soft mud	Sediments	Lithology	Soft sediments	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	peat	Peat (organic-rich)	Sediments	Lithology	Organic soils	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	pebble gravel size sediment	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet Quaternary Lithology	rhyolite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	rock	Bedrock outcrop/subcrop (undifferentiated)	Solid Earth	Lithology	Strong bedrock - undifferentiated	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	sand	Sand	Sediments	Lithology	Homogenous sediments	Lower complexity	Higher complexity	Lower complexity	Lower complexity
EMODnet Quaternary Lithology	sand size sediment	Sand	Sediments	Lithology	Homogenous sediments	Lower complexity	Higher complexity	Lower complexity	Lower complexity
EMODnet Quaternary Lithology	sandstone	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	sediment	Sand	Sediments	Lithology	Homogenous sediments	Lower complexity	Higher complexity	Lower complexity	Lower complexity
EMODnet Quaternary Lithology	sedimentary material	Sand	Sediments	Lithology	Homogenous sediments	Lower complexity	Higher complexity	Lower complexity	Lower complexity
EMODnet Quaternary Lithology	silt	Soft mud	Sediments	Lithology	Soft sediments	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	tephritic phonolite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	tholeiitic basalt	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	trachyte	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	trachytic rock	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet Quaternary Lithology	unconsolidated material	Soft mud	Sediments	Lithology	Soft sediments	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	acidicIgneousMaterial	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	acidicIgneousRock	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	amphibolite	Bedrock outcrop/subcrop; metamorphic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	andesite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	anorthosite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	aplite	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	arenit	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	ashTuffLapillistoneAndLapilliTuff	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	basalt	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	basicIgneousRock	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	calcareousCarbonateSediment	Carbonate sands	Sediments	Lithology	Crushable soil	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	calcareousCarbonateSedimentaryMaterial	Carbonate sands	Sediments	Lithology	Crushable soil	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	calcareousCarbonateSedimentaryRock	Bedrock outcrop/subcrop; carbonate	Solid Earth	Lithology	Variable geotechnial properties	Higher complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	carbonateMudstone	Bedrock outcrop/subcrop; carbonate	Solid Earth	Lithology	Variable geotechnial properties	Higher complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	carbonateRichMudstone	Bedrock outcrop/subcrop; carbonate	Solid Earth	Lithology	Variable geotechnial properties	Higher complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	carbonateSediment	Carbonate sands	Sediments	Lithology	Crushable soil	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	carbonateSedimentaryRock	Bedrock outcrop/subcrop; carbonate	Solid Earth	Lithology	Variable geotechnial properties	Higher complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	carbonateWackestone	Carbonate sands	Sediments	Lithology	Crushable soil	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	chalk	Bedrock outcrop/subcrop; carbonate	Solid Earth	Lithology	Variable geotechnial properties	Higher complexity	Medium complexity	Medium complexity	Medium complexity

EMODnet pre-Quaternary Lithology	clasticSediment	Sand	Sediments	Lithology	Homogenous sediments	Lower complexity	Higher complexity	Lower complexity	Lower complexity
EMODnet pre-Quaternary Lithology	clasticSedimentaryMaterial	Sand	Sediments	Lithology	Homogenous sediments	Lower complexity	Higher complexity	Lower complexity	Lower complexity
EMODnet pre-Quaternary Lithology	clasticSedimentaryRock	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	clay	Soft mud	Sediments	Lithology	Soft sediments	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	claystone	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	coal	Peat (organic-rich)	Sediments	Lithology	Organic soils	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	compoundMaterial	Bedrock outcrop/subcrop (undifferentiated)	Solid Earth	Lithology	Strong bedrock - undifferentiated	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	conglomerate	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	dacite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	diamictite	Diamict	Sediments	Lithology	Hard overconsolidated clays	Higher complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	diorite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	doleriticRock	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	dolomite	Bedrock outcrop/subcrop; carbonate	Solid Earth	Lithology	Variable geotechnial properties	Higher complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	dolomiticSediment	Carbonate sands	Sediments	Lithology	Crushable soil	Medium complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	evaporite	Evaporites	Sediments	Lithology	Uneven ground	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	fineGrainedIgneousRock	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	gabbro	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	gabbroicRock	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	gneiss	Bedrock outcrop/subcrop; metamorphic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	granite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	granitoid	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	granodiorite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	gravelSizeSediment	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	gypsumOrAnhydrite	Evaporites	Sediments	Lithology	Uneven ground	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	igneousMaterial	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	igneousRock	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	impureCalcareousCarbonateSediment	Bedrock outcrop/subcrop; carbonate	Solid Earth	Lithology	Variable geotechnial properties	Higher complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	impureCarbonateSediment	Bedrock outcrop/subcrop; carbonate	Solid Earth	Lithology	Variable geotechnial properties	Higher complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	impureCarbonateSedimentaryRock	Bedrock outcrop/subcrop; carbonate	Solid Earth	Lithology	Variable geotechnial properties	Higher complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	impureLimestone	Bedrock outcrop/subcrop; carbonate	Solid Earth	Lithology	Variable geotechnial properties	Higher complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	intermediateCompositionIgneousRock	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	limestone	Bedrock outcrop/subcrop; carbonate	Solid Earth	Lithology	Variable geotechnial properties	Higher complexity	Medium complexity	Medium complexity	Medium complexity
EMODnet pre-Quaternary Lithology	marble	Bedrock outcrop/subcrop; metamorphic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	metamorphicRock	Bedrock outcrop/subcrop; metamorphic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	micaSchist	Bedrock outcrop/subcrop; metamorphic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	migmatite	Bedrock outcrop/subcrop; metamorphic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	monzogranite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	monzonite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	mud	Soft mud	Sediments	Lithology	Soft sediments	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	mudSizeSediment	Soft mud	Sediments	Lithology	Soft sediments	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	mudstone	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	orthogneiss	Bedrock outcrop/subcrop; metamorphic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	paragneiss	Bedrock outcrop/subcrop; metamorphic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	pegmatite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	peridotite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	phaneriticIgneousRock	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	phonolite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	phyllite	Bedrock outcrop/subcrop; metamorphic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	porphyry	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	pyroclasticRock	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	pyroxenite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	quartzDiorite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	quartzite	Bedrock outcrop/subcrop; metamorphic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	rhyolite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	rock	Bedrock outcrop/subcrop (undifferentiated)	Solid Earth	Lithology	Strong bedrock - undifferentiated	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	rockSalt	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	sand	Sand	Sediments	Lithology	Homogenous sediments	Lower complexity	Higher complexity	Lower complexity	Lower complexity
EMODnet pre-Quaternary Lithology	sandstone	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	sanstone	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	schist	Bedrock outcrop/subcrop; metamorphic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	sedimentaryMaterial	Sand	Sediments	Lithology	Homogenous sediments	Lower complexity	Higher complexity	Lower complexity	Lower complexity
EMODnet pre-Quaternary Lithology	sedimentaryRock	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	serpentinite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	shale	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	silicateMudstone	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	silt	Soft mud	Sediments	Lithology	Soft sediments	Higher complexity	Higher complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	siltstone	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	slate	Bedrock outcrop/subcrop; metamorphic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	syenite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	tholeiiticBasalt	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	tonalite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	tuffite	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	ultrabasicIgneousRock	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	ultramaficIgneousRock	Bedrock outcrop/subcrop; igneous	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet pre-Quaternary Lithology	wacke	Bedrock outcrop/subcrop; sedimentary; clastic	Solid Earth	Lithology	Strong bedrock	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet seabed sediments	Sand	Sand	Sediments	Lithology	Homogenous sediments	Lower complexity	Higher complexity	Lower complexity	Lower complexity
EMODnet seabed sediments	Coarse-grained sediment	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet seabed sediments	Mixed sediment	Soft interbedded	Sediments	Lithology	Soft sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet seabed sediments	Rock & boulders	Bedrock outcrop/subcrop (undifferentiated)	Solid Earth	Lithology	Strong bedrock - undifferentiated	Higher complexity	Lower complexity	Higher complexity	Higher complexity
EMODnet seabed sediments	Mud	Soft interbedded	Sediments	Lithology	Soft sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet seabed sediments	sandy Mud	Soft interbedded	Sediments	Lithology	Soft sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
EMODnet seabed sediments	muddy Sand	Soft interbedded	Sediments	Lithology	Soft sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Bare mountain	Bedrock outcrop/subcrop (undifferentiated)	Solid Earth	Lithology	Strong bedrock - undifferentiated	Higher complexity	Lower complexity	Higher complexity	Higher complexity
MAREANO seabed sediments	Biogenic material	Reefs (ancient, buried and present day)	Biogenic	Lithology, relief	Active sedimentary system / hardground	Higher complexity	Higher complexity	Higher complexity	Medium complexity
MAREANO seabed sediments	Gravel	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Gravel and stone	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Gravel, stone and block	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Gravel sand	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Gravelly sandy mud	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Gravel sludge	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Gravelly silty sand	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Hard sediments or sedimentary rocks	Bedrock outcrop/subcrop (undifferentiated)	Solid Earth	Lithology	Strong bedrock - undifferentiated	Higher complexity	Lower complexity	Higher complexity	Higher complexity
MAREANO seabed sediments	Sandy	Sand	Sediments	Lithology	Homogenous sediments	Lower complexity	Higher complexity	Lower complexity	Lower complexity
MAREANO seabed sediments	Sand, gravel and stone	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Sand, gravel, stone and block	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Sandy gravel	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Sandy mud	Soft interbedded	Sediments	Lithology	Soft sediments	Medium complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Sludge	Soft mud	Sediments	Lithology	Soft sediments	Higher complexity	Higher complexity	Higher complexity	Higher complexity
MAREANO seabed sediments	Sludge with blocks of sediments	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Mud and sand with gravel, stone and block	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Mud/sand and stone/block	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Silty gravel	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Silty sand	Sand	Sediments	Lithology	Homogenous sediments	Lower complexity	Higher complexity	Lower complexity	Lower complexity
MAREANO seabed sediments	Silty sandy gravel	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Stone and block	Gravel	Sediments	Lithology	Coarse soil units (inlcuding gravel)	Higher complexity	Higher complexity	Medium complexity	Medium complexity
MAREANO seabed sediments	Thin or disjointed sediment cover over bedrock	Bedrock outcrop/subcrop (undifferentiated)	Solid Earth	Lithology	Strong bedrock - undifferentiated	Higher complexity	Lower complexity	Higher complexity	Higher complexity