International Association of Oil & Gas Producers

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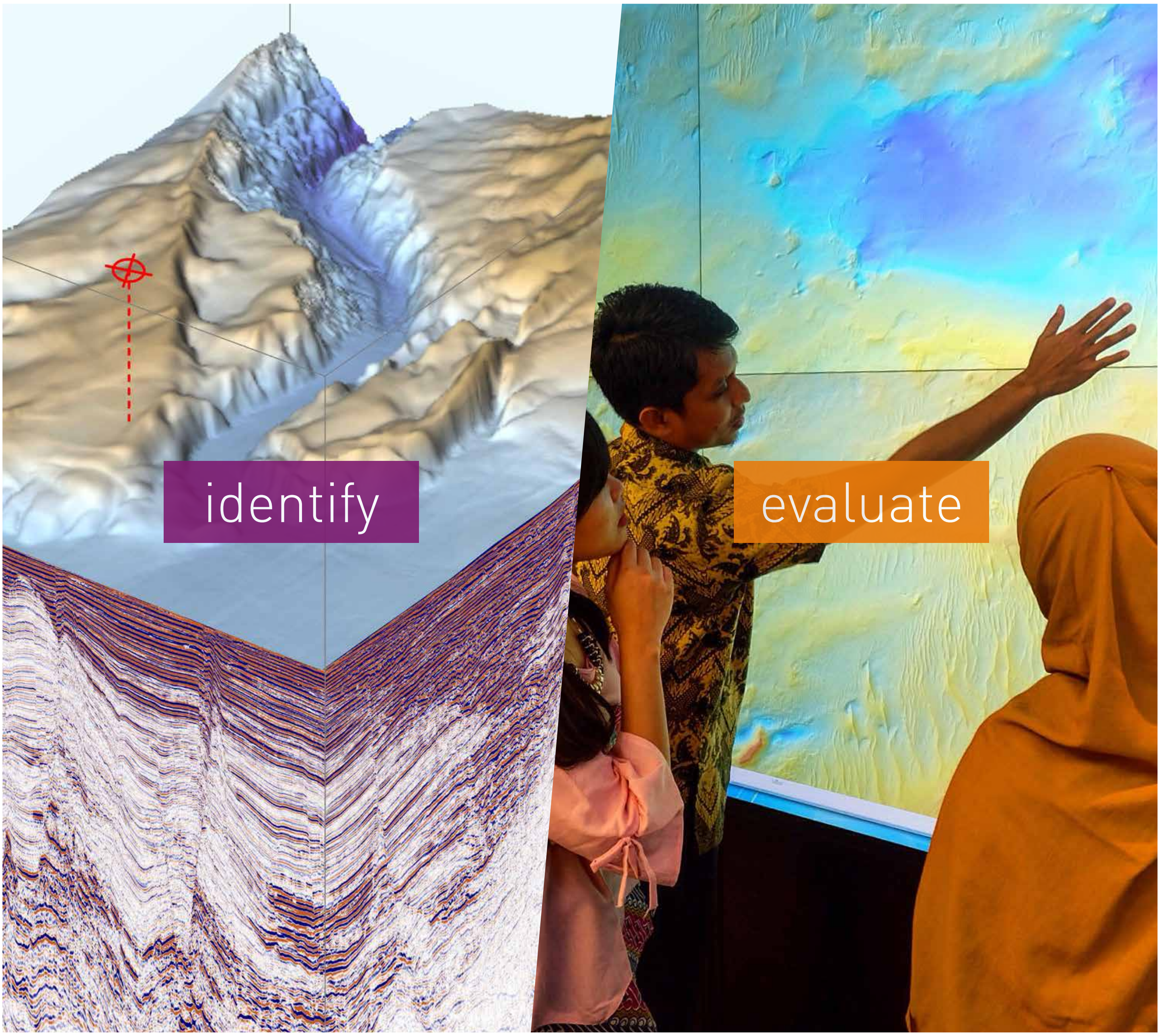
2017

Guidelines for the conduct of offshore drilling hazard site surveys



Acknowledgements

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Revision history

VERSION	DATE	AMENDMENTS
1.0	April 2011	Initial publication
1.2	April 2013	Minor amendment to section 2.3 and introduction of section 5.2.5
2.0	October 2017	Full revision reflecting the continued development of drilling hazard site survey rationale and the latest technologies and techniques now being applied in their delivery in all water depths and geological settings around the world.

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1. Introduction

This report provides guidance for the conduct of offshore drilling hazard site surveys (hereafter referred to as 'site surveys'). These guidelines address the conduct of geophysical and hydrographic site surveys of proposed offshore well locations and the use of exploration 3D seismic data to enhance, or to replace, acquisition of a site survey.

This report does not set out to provide guidance on geotechnical engineering requirements for design of anchoring systems, the analysis of jack-up rig foundation or platform foundation design; neither does it address detailed guidance on environmental survey requirements. Such works require expert guidance and involvement of geotechnical or structural engineers or environmental scientists who are conversant in the application of appropriate industry codes for these tasks.

These guidelines describe oilfield good practice.

It is impossible for the guidelines to address all the varying regulatory requirements that are in place in different countries around the world. Operators should make themselves aware of the local regulatory requirements that apply to marine site surveys.

The guidelines explain the impact that different types of offshore drilling units have on a site survey and the differing needs of shelf and deep-water environments.

The techniques described in this document can also be applied to other types of seabed surveys, e.g. pipeline or cable route surveys. While this report does not set out to directly address planning and delivery of such projects, it will be recognized that the same general thought processes and practices will be applicable to such projects.

A companion IOGP document *Conduct of offshore drilling hazard Site Surveys – Technical Notes* (hereafter 'The Technical Notes'), Report 373-18-2, was published in 2015, and provides supporting technical information and background theory on the various phases of a site survey project outlined in this report.

2. Objectives of site surveys

2.1 General

Site surveys are performed to minimize the risk of harm to personnel and equipment, and to protect the natural environment.

The objective of any site survey is to identify all possible constraints and hazards from man-made, natural and geological features which may affect the operational or environmental integrity of a proposed drilling operation, and to allow appropriate operational practices to be put in place to mitigate any risks identified. It is therefore important that the results of this work are properly communicated to project engineers responsible for well planning.

The proposed site survey area should be of adequate coverage to plan any potential relief well locations, and provide sufficient data to screen potential top-hole drilling hazards at these locations.

A properly conducted site survey for an offshore drilling location will require the input of a number of different technical professionals who should be suitably qualified and experienced in their respective disciplines. Overall project management of a site survey should be assigned to an individual who has a thorough understanding of the reasons for delivery of a site survey, an intimate knowledge of how the results will be applied, and first-hand experience of collecting and presenting those results.

The quality of any dataset selected for use in a site survey should be directly related to the types of conditions expected to exist within the area of interest.

The interplay of the physical environment with the type of intended operation has a fundamental impact on the scope and content of a site survey.

2.2 Physical environment

Depending on the physical environment and the intended operation, a site survey may need to review any, or all, of the following:

Table 1: Conditions to be addressed by a marine site survey

Man-made features	Natural seabed features	Subsurface geological features
• Platforms: active, abandoned, or toppled • Pipelines: on or buried below the seabed • Power and umbilical lines • Communications cables • Wellheads and abandoned well locations • Manifolds and templates • Pipeline terminations, valves and protection frames • Subsea isolation valves • Rock dumps • Scour protection material • Jack-up rig footprints • Non oil and gas infrastructure such as navigation buoys, wind turbines, etc. • Shipwrecks • Ordnance and chemical dumping grounds • Archaeological remains • Miscellaneous debris	• Seabed topography and relief • Seafloor sediments • Sand: banks, waves, and mega-ripples • Mud: flows, gullies, volcanoes, lumps, lobes • Fault escarpments • Diapiric structures • Gas vents and pockmarks • Unstable slopes • Slumps and mass transport deposits • Collapse features • Fluid expulsion features • Chemosynthetic communities • Methane derived authigenic carbonate (MDAC) • Gas hydrate mounds • Rock outcrops, pinnacles and boulders • Reefs • Hardgrounds • Seabed channels and scours	• Sedimentary sequences • Stratigraphy • Shallow gas charged intervals • Gas chimneys • Shallow water flow zones • Over-pressure zones • Buried infilled channels • Boulder beds • Buried slumps and mass transport complexes • Gas hydrate zones and hydrated soils • Faults • Erosion and truncation surfaces • Salt or mud diapirs and diatremes

More extensive information of the impact of individual hazards is provided in Appendix A.

2.3 Planning fundamentals

In planning a site survey programme, the interplay of rig type and its specification, the different conditions that might be expected in the planned area of operations, and well control response contingencies must be carefully taken into account. This must be considered as a first step in the planning stage of any site survey programme.

The site survey project manager should be advised of the proposed outline drilling programme and/or the conceptual field layout by the project engineer planning the well or development. This should be taken into account in setting the data needs of the project.

The tables in Appendix A review conditions and areas of concern for the three rig type groupings. The appropriate columns should be considered during the planning stage of a site survey programme.

Sufficient time should be allowed in delivery of a site survey programme to ensure the results are delivered in time:

- to ensure all local regulatory permitting requirements are met ahead of the proposed well spud date
- to ensure the drilling project team can include them, and properly mitigate any risk of hazards identified from them, in the final well design.

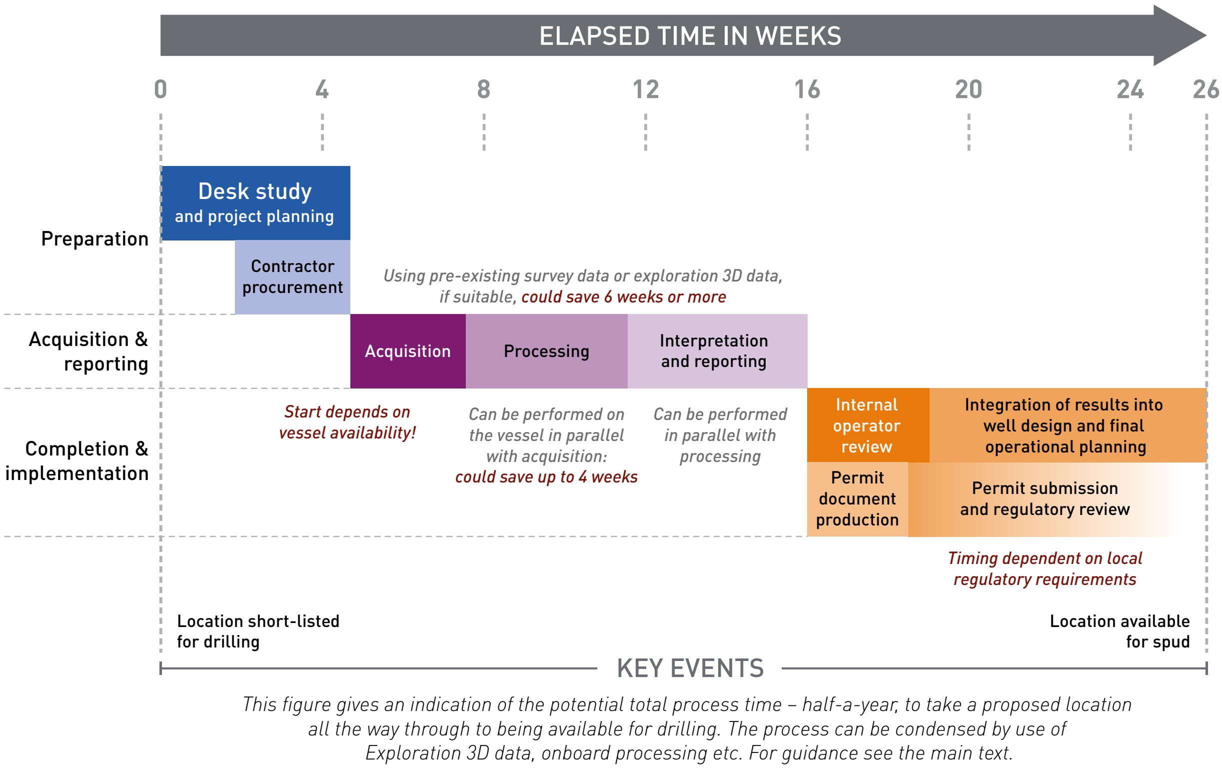

Figure 1: Site clearance: timing guidance

Figure 1 shows a conceptual timing line. The permitting period, which may include environmental, archaeological or other considerations, will be country specific.

Generally, it is recommended that a site survey programme should start six months, and no less than three months, ahead of the proposed well's spud date. This timing could be further extended if a geotechnical site investigation is required for review of jack-up foundation conditions.

2.4 Scope

Any site survey must include a review of all seafloor conditions and geology to a depth at least 200 m below the preferred setting depth of the first pressure containment casing string, or to a depth of 1000 m below seabed whichever is greater.

The identification and assessment of all relevant geological features should be performed within the context of a ground model that takes into account depositional and post-depositional processes.

The site survey report should include a discussion of all relevant geological, natural, and man-made features that have a direct bearing on operational risk.

2.5 Operations type

The type of rig to be used has a direct effect on the required scope of a site investigation. The full breadth of these effects is detailed in the table in Appendix A. This table should be used by a project manager to sense check that all potential concerns for the placement of a rig at a proposed location are being, or have been, addressed as part of the site survey programme.

2.5.1 Bottom founded and platform based rigs

These rigs only directly impact the seafloor over a small area immediately around the wellbore. The site survey can therefore be focused directly upon the well location, the corridor of approach onto location, and any possible stand-off locations.

The style of top-hole drilling used by these rigs is different to the other two generic rig groupings. Fundamentally the risk to the rig from a shallow gas blowout is greater.

The risk to the rig's integrity through loss of seabed support makes review of the shallow section for these rigs critical.

The analysis of jack-up rig foundation, or platform foundation design, requires dedicated geotechnical soil investigation. The investigation requires expert guidance and the direct involvement of geotechnical or structural engineers who are conversant with the application of appropriate industry codes for these tasks. Minimum requirements to geotechnical soil investigations are covered in industry guidelines and standards, e.g. The Society of Naval Architects and Marine Engineers (SNAME), Technical & Research Bulletin 5-5A, *Site Specific Assessment of Mobile Jack-up Units* and ISO 19905-1, *Petroleum and natural gas industries – Site-*

specific assessment of mobile offshore units – Part 1: Jack-ups, which are applicable for independent leg jack-ups.

2.5.2 Anchored rigs

These rigs impact a large area of the seabed and as a result a site survey will need to be performed over a larger area of the seafloor to assess anchoring conditions.

These rigs encounter a number of different concerns not generally applicable to bottom founded rigs (see Appendix A).

2.5.3 Dynamically Positioned (DP) rigs

These rigs impact a small area of the seabed, and therefore the site survey can be focused directly upon the well location and its immediate surroundings. However, their use in predominantly deep to ultra deep water brings special needs for a site survey programme (see Appendix A).

3. Site survey process

A site survey project process (Figure 2) can be considered to consist of four phases.

3.1 Desk study and project planning

A project should start with a desk study that should be considered as an integral part of the planning process. During this phase, a decision will be made as to whether new data, and which types of data, if any, need to be acquired.

In deep water areas, the desk study and any ensuing acquisition may need to address a semi-regional scope to consider topographic or geological issues that may be a threat to operations from outside of the direct area of proposed operations.

3.2 Data acquisition

The second phase is the acquisition of new data coverage, if such is required.

3.3 Data processing, interpretation and integration

All existing and new data are then processed, or reprocessed to improve their value, and interpreted to produce an integrated ground model of the seabed and subsurface conditions.

3.4 Reporting

The final stage of any site survey is the production of an integrated report that describes the conditions and operational risks identified across the site and – specifically – at the proposed drilling location.

4. Desk study and project planning

As the first stage in survey planning a desk study – or review – of pre-existing data should be performed to gain an understanding of the area and to highlight matters of particular concern that need to be addressed by the investigation.

4.1 Use of existing geoscience data

Use of exploration 3D or 2D seismic data, offset well data (logs, operations reports, industry databases, etc.), geotechnical boreholes, offset site surveys and any other relevant public domain data in an integrated fashion will allow an initial ground model of the seabed and shallow section to be developed. This can be used to design a survey programme appropriate to the location and rig.

Exploration 3D data may provide sufficient information to produce a site report such that new survey data will not be required (section 5.6 below). Otherwise the data will – as a minimum – provide a good guide to definition of line direction, line spacing, and the areas of uncertainty that the new site survey needs to clarify.

4.2 Pre-existing and proposed operations

An up-to-date database of offshore facilities: wells, platforms, pipelines, etc. that impact upon the operational area should be reviewed during the planning phase.

A check should also be made of any proposed third party exploration or development activities in the area that may impact the proposed operations.

4.3 Wrecks, submarine cables, sites of special interest

Local regulatory announcements, databases and nautical charts should be reviewed for the likely presence of wrecks, munitions dumping grounds, submarine cables and sites of special interest: archaeological, environmental, etc.

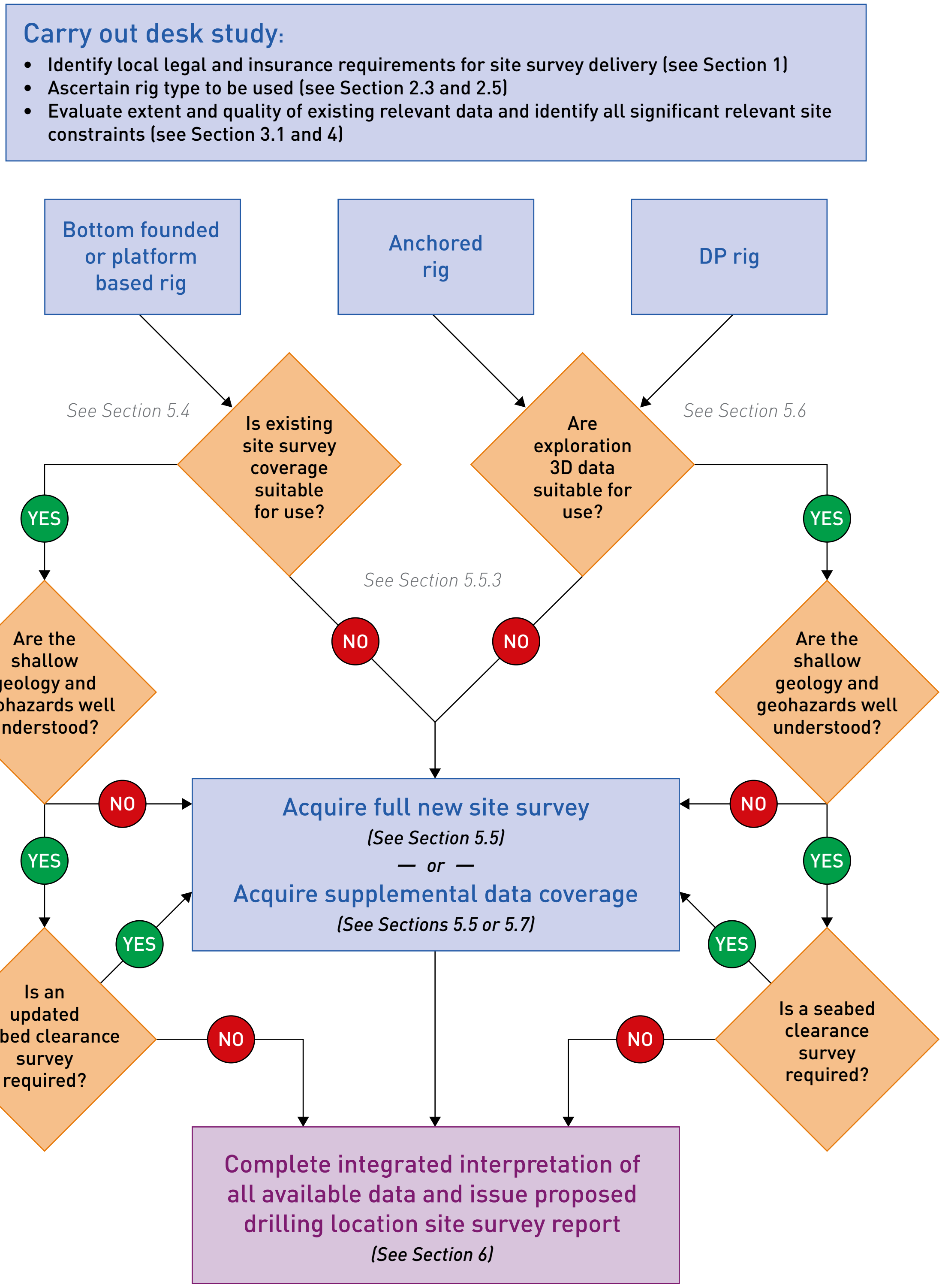

Figure 2: Site survey decision tree

5. Data requirements

5.1 General

Figure 2 presents a simple process for assessing the data needs of a project.

Four general areas of practice are common within the industry:

- use of pre-existing site survey data
- use of an exploration 3D seismic dataset
- use of an exploration 3D seismic dataset combined with limited site survey data acquisition
- use of a newly acquired site survey.

Whatever generic approach is followed, the data made available for interpretation must allow for analysis of the conditions and hazards listed in section 2.2 and detailed in Appendix A to be properly addressed for the type of rig in use. In particular, for bottom founded rigs, data standards need to be considered most carefully.

5.2 Area of study

Any study should address the total area likely to be impacted by drilling activity. The area should consider any potential relief well locations.

5.2.1 Bottom founded rigs and platform based rigs

Data coverage should provide full cover to a minimum distance of 500 m around the drilling location and the immediate line of approach onto location.

Data should allow proper study of any obstructions that might be present on the seabed during the final transit of the rig on to location and the commencement of leg pinning activity for a jack-up rig.

Tieline data should be acquired to existing relevant geotechnical borehole(s) and offset well(s) in the vicinity that show similar soil stratigraphy and that allow unambiguous interpretive geological correlation of conditions back to the proposed location.

5.2.2 Anchored rigs

Data coverage should provide full cover to a distance of 250 m beyond the maximum likely anchor radius around the proposed drilling location.

5.2.3 Dynamically Positioned (DP) rigs

Data coverage should provide full cover to a distance of 500 m beyond the maximum likely diameter of the seabed acoustic array used to maintain the rig's position on location.

5.2.4 Location uncertainty

If the proposed well location has not been finalised at the time of planning, the survey area should be designed to take into account the full positional uncertainty of the final surface location of the well and to meet the guidance set out above (sections 5.2.1 to 5.2.3 inclusive).

5.2.5 Relief wells

Potential relief well locations should be considered in planning a site survey. This may include extending acquisition cover, or 3D seismic data review, to screen their acceptability and define baseline conditions.

In responding to a well control incident, no relief well should be spudded until new site survey data have been acquired, processed and analysed for the final agreed relief well location(s) to fully assess the presence of any changes to baseline conditions in post-event seabed and subsurface conditions that might be encountered during relief well drilling as a result of the incident.

5.3 Total depth of study

The total depth of study below seabed should be to at least 200 m below the preferred setting depth of the first pressure containment casing string, or to a depth of 1000 m below seabed, whichever is greater, irrespective of rig type.

The combined dataset to be used must therefore be capable of properly imaging geological conditions to this depth.

5.4 Use of a pre-existing site survey

Pre-existing site survey data should be re-used whenever possible. The quality and validity of these data should be carefully assessed prior to committing to their use in producing a report for a new drilling location.

If the pre-existing survey fails to cover the full project scope required, either spatially or in depth, it will need to be supplemented by data from another source.

Subject to local operator policy, regulatory, or insurance requirements, for guidance purposes the maximum age validity of pre-existing hydrographic and geophysical site survey data can be considered as:

Table 2: Pre-existing data age validity guidance

Activity condition	Seabed data [a]	Subsurface data [b]
No activity	5 years	10 years
Marine or engineering activity	1 year	10 years
Inside 500 m Zone	Pre-installation [c]	10 years
Well control incident or well integrity concern	Invalid	Invalid

[a] Seabed Data are considered to be multi-beam bathymetry and side scan sonar.

[b] Subsurface Data are considered to include sub-bottom profiler or High Resolution multi-channel data acquired as part of a site survey operation.

[c] At locations where a jack-up rig will be operating in close proximity to existing installations, e.g. alongside a platform or within a facility 500 m zone, alternative seabed clearance survey approaches to update pre-existing survey results should be evaluated, e.g. use of sector scanning sonar or ROV visual, etc., to be undertaken immediately prior to the jack-up rig installation.

The guidance given in Table 2 is subject to local activity levels, as indicated in the table, and presence of active geological conditions. If the pre-existing data do not meet the guidance given in Table 2 then a new survey should always be acquired.

In a prospect area where it is believed that there are ongoing active seabed processes (e.g. mobile sandwaves or scour) the operator should always consider updating pre-existing data to directly identify potential for, and the rate of, any change if the existing seabed data are greater than one year in age.

If it is known that a rig has been installed more recently than the existing site survey data new data should be acquired.

If a well control incident (an uncontrolled underground or surface flow) has taken place on the prospect, field or in an immediately adjacent area since acquisition of a pre-existing survey, any existing seabed and subsurface data should be considered invalid. In such a case, a new survey should always be acquired.

If new well drilling is to be performed from an existing platform where there is a recognised well integrity concern, e.g. unexplained annular pressure activity, consideration should be given to renewing seismic imagery of the top-hole interval below, and seabed survey data around, the platform.

5.5 Acquisition of a new site survey

When a new site survey is considered necessary, the survey should be designed to specifically address the expected operational requirement. For each type of data, the Technical Notes provide greater detail on equipment selection and survey delivery.

The following fundamentals should be considered in survey design, specification, and delivery.

5.5.1 Use of a new site survey

A new site survey will involve gathering of all the following standard data types except where specified in section 5.5.2 below.

Positioning

Surface positioning of the survey vessel should be based on augmented Global Navigation Satellite Systems (GNSS), e.g. Differentially Corrected GNSS (DGNSS) or Clock and Orbit Corrected GNSS (also referred to as SDGNSS or Precise Point Positioning PPP) that typically yield sub-metre positioning accuracy. It is recommended that two fully independent surface positioning systems should be used.

The correct use of GNSS positioning is critical to the success of an offshore drilling hazard site survey. It is recommended that the GNSS are operated in line with the Guidelines for GNSS Positioning in the oil and gas industry, issued jointly by IOGP and IMCA. It describes good practice for the use of global satellite navigation systems (GNSS) in, among other, offshore survey and related activities for the oil and gas industry. These documents can be downloaded from www.iogp.org or www.imca-int.com.

Except in water depths of less than 25 m where it may be impractical or where layback to the towed equipment is less than 50 m, it is recommended that the position of towed sensors should be determined by a vessel mounted acoustic positioning system, e.g. a tracking Ultra Short Baseline System (USBL) that, when properly calibrated, typically yields a relative positioning accuracy of better that 1% of slant range from vessel transducer to transponder on the tow fish.

Bathymetry

Bathymetry data should be acquired using a swathe bathymetry system to measure accurate water depths across the area.

Where swathe bathymetry data are acquired, it is recommended that backscatter values from the seabed returns are logged and processed for use in seabed characterisation to support and complement the side scan sonar data.

Single beam echo sounder data should be used to verify the results of swathe bathymetry data to check for gross error.

As a minimum, however, bathymetric data should be obtained using a hull mounted, narrow single beam hydrographic echo sounder operating at the appropriate frequency for the water depth range across site.

The bathymetry systems should be set up to accurately record data across the range of water depths expected in the survey area. Care should be taken in selection of operating frequencies such that the individual systems do not interfere with each other.

The bathymetry systems should be used in conjunction with an accurate motion sensor to compensate for vessel motion.

Water column sound velocity should be determined as a minimum at the start and end of data acquisition, and at suitable intervals throughout the project, by use of a CTD (Conductivity, Salinity and Temperature Depth probe) or a direct reading sound velocity probe suitable for use in the maximum water depths expected within the survey area.

Water depths should be corrected for vessel draft, tidal level and referenced to the appropriate vertical datum (LAT, MSL, etc.).

The final processed digital terrain model (DTM) data cell size covering the entire survey area, without gaps, should reflect the frequency of the system being used, data density and altitude above seabed of the transducer head.

Side scan sonar

A dual channel, dual frequency, side scan sonar system should be used to provide acoustic seabed imagery to define man-made and natural seabed features across the area.

Systems should be operated at no less than 100 kHz.

Line spacing and display range should be designed to ensure a minimum of 200% coverage of the survey area in the prime survey line direction, with orthogonal tie-lines.

For detailed inspection of contacts or inspection of pre-determined bottom-founded rig sites, extra lines should be run using a frequency of 400 kHz or greater.

Recorded data should be image processed to improve subsequent computer aided analysis and mosaicing of the data. Such mosaics should be output as geo-referenced, high resolution, digital models of the seabed for presentation in the final report.

In certain circumstances, the use of alternative specialist tools may be beneficial in providing higher resolution imagery, e.g. Synthetic Aperture Sonar (SAS), or in safe access to locations where the use of towed sensors may be restricted, e.g. sector scanning sonar.

Sub-bottom profilers

A suite of sub-bottom acoustic profilers should be operated to provide a continuous and very high resolution image of the shallow geological conditions.

Subject to local soil conditions, the systems should be capable of achieving a resolution of 0.3 m vertical bed separation in the upper 50 m below seabed.

The systems chosen should be run simultaneously to provide imagery that penetrates to in excess of the foundational depth of interest. This can be considered to be equivalent to a depth equal to the greater of 30 m or the anticipated spud-can penetration plus one-and-a-half times the spud-can diameter for a jack-up rig, or the maximum expected anchor penetration for an anchored rig.

Recorded data should be signal processed to further improve data quality. Final data should be interpreted using an integrated interpretation and mapping system.

Magnetometers and Gradiometers

A magnetometer can be used to measure total magnetic field strengths to investigate ferrous objects lying on – or buried immediately beneath – the seafloor, or to attempt to determine the position of cables, pipelines or abandoned wells that cannot be identified by acoustic sensors.

The system should be capable of a sampling rate of at least 1 Hz and have a sensitivity of at least one nanotesla (1 nT).

The sensor should be towed as close to the seabed as possible and sufficiently far away from the vessel to isolate the sensor from the magnetic field of the survey vessel.

As magnetometers measure total magnetic field strength they cannot be used in the vicinity of large infrastructure such as platforms, which swamp the magnetic signature of smaller features.

Use of a gradiometer system, which measures the magnetic gradient between two or more closely spaced magnetometers, should be considered for more precise results (e.g. in identifying munitions) and on surveys close to large structures, such as platforms.

Data should be recorded digitally. Recorded data should be processed to allow subsequent computer aided analysis and modelling to be undertaken.

2D and 3D multi-channel high resolution seismic

A multi-channel High Resolution (HR) digital seismic survey should be conducted over proposed drilling locations to investigate top-hole geological conditions across the area. The exception to this is where the use of exploration 3D seismic data is deemed an appropriate substitute (see section 5.6 below).

Where initial review or offset drilling experience indicates that the shallow section or the perceived conditions are particularly complex, acquisition of a purpose designed HR, or UHR, 3D survey should be considered. Such surveys must be designed on a site specific basis.

The primary interest of such surveys is from the seabed to a depth at least 200 m below the preferred setting depth of the first pressure containment casing string, or to a depth of 1000 m below seabed whichever is greater.

All HR seismic surveys should be designed on a site specific basis to take into account the varying conditions present and specific goals of the project, but in general will conform to the outline specifications below.

- **Source type**: surveys should make use of a seismic source that delivers a simple, stable, and repeatable source signature that is near to a minimum phase output, and has a useable frequency content across the 20–250 Hz band (HR) or 60–500 Hz band (UHR).
- **Tow depths**: source and streamer tow depths are normally specified to be no greater than 3 m and preferably less.

  However, new approaches to acquisition and processing, that are entering practice, may result in the selection of deeper tow depths or slanted streamers, combined with de-ghosting to allow delivery of data with a broader frequency bandwidth (e.g. broadband seismic techniques).
- **Streamer type**: use of digital solid streamers is preferred.
- **Recording system**: the recording system should record at no greater than a 1 millisecond sample interval. Field high-cut filters should be set no lower than 300 Hz.
- **Fold of cover**: should generally not be less than 24 for 2D HR survey.
- **Offsets**: the maximum offset recorded should preferably be no less than the total depth of interest below mudline that the survey is attempting to image except in water depths greater than 750 m. The minimum offset recorded should be no greater than half the water depth.
- **Record length**: an equivalent two-way time sufficient to fully image the proposed setting depth of the first pressure containment casing string, or to a penetration of 1000 m below seabed, whichever is greater.

All seismic data acquired should undergo full, multi-channel, digital signal processing to provide an optimally imaged dataset of migrated seismic data for output to, and analysis on, an interpretation workstation.

Seabed samples

Samples should be acquired to ground truth seabed and shallow soil provinces that are defined during the site survey or that were pre-defined during the desk study.

For an anchored rig, it may be necessary to acquire shallow seabed soil evaluation data using a suite of tools appropriate to the soil conditions. Where samples are retrieved they should always be comprehensively logged and may need to be sent ashore for analysis.

If sampling is aimed at defining suspected sensitive environments, care should be taken to acquire a control sample away from the suspect target area.

Seabed photographs

Where appropriate, seabed photographs and/or video footage using equipment suited to the seabed type, tidal current conditions and visibility expected in the area, may aid in ground truthing of acoustic data and allow investigation of discrete areas of concern that are identified during a survey.

Particular attention should be given to potential sensitive seabed environments including:

- unusual bedforms
- gas/fluid escape features
- MDAC
- gas hydrate mounds
- fish spawning grounds
- benthic communities
- suspected archaeological remains.

Seabed imagery may also be used to establish the absence of sensitive features or habitats prior to use of invasive sampling techniques.

5.5.2 Water depth control on acquisition parameters

Water depth affects the appropriateness of certain types of equipment and the way in which they are deployed. The acquisition scope should be modified accordingly:

- **Water depths less than 25 m**: A full suite of data should be acquired using vessel mounted or towed equipment as detailed above.
- **Water depths of greater than 25 m to 150 m**: a full suite of data should be acquired using vessel mounted or towed equipment as detailed above. Towed sensors should always be positioned by acoustic means to allow accurate positioning of all data.
- **Water depths of greater than 150 m to 750 m**: a full suite of data should be acquired using vessel mounted or towed equipment as detailed above. Deep tow sensors should always be positioned by acoustic means to allow accurate positioning of all data. In water depths greater than 500 m, preference is for the use of Autonomous Underwater Vehicle (AUV) deployed sensors rather than towed systems.
- **Water depths of greater than 750 m**: depending on operational type (Figure 2) in these water depths a full suite of data may not need to be acquired because exploration 3D seismic data may fulfil site survey requirements (see section 5.6 below).

  However, where there is a need in these water depths to acquire seabed clearance data (e.g. in settings of complex seabed morphology, when an anchored rig is to used) preference is for the use of AUV deployed swathe bathymetry, side scan sonar, and sub-bottom profiler systems over surface towed or hull mounted equipment.

5.5.3 Survey line spacing

Survey line spacing will depend on the type of programme being acquired. However, as a basic guide, main direction line spacing can be considered to be as follows:

Table 3: Main line spacing guidance

Data type	**Water depth range**			
	<25 m	**25 to 150 m**	**150 m to 750 m**	**>750 m**
Swathe bathymetry	⩽50 m	50 m – 150 m	200 m	150 m (AUV)
Side scan sonar / profiler	50 m	100 m	200 m 300 m (Deep Tow)	150 m (AUV)
2D HR seismic	25 m – 50 m	50 m	50 m – 100 m	⩾150 m

Additional cross lines should be acquired normal to the main line direction at an increased spacing (as a guide three to five times the spacing of the main line direction spacing) to provide ties for interpretation and processing.

If the final drilling location is known at the time of the survey, thought should be given to acquiring extended location lines and closer line spacing either side of the location in both line directions.

Wherever possible, to support interpretation, tie line(s) should be acquired to relevant offset wells, geotechnical boreholes, or other data calibration points.

5.6 Use of exploration 3D seismic data on a standalone basis

The use of exploration 3D seismic data on a standalone basis as a replacement for acquisition of a site survey for deep water well locations is a generally acceptable practice within certain limits (section 5.6.2 below) assuming data are appropriately processed, or reprocessed, for the purpose (section 5.6.3 below). On this basis, exploration 3D seismic data can be used to derive bathymetric, geological and geohazards information.

Exploration 3D seismic data is not a substitute for side scan sonar or sub-bottom profiler data for the detection and mapping of objects and obstructions on the seabed and variations in shallow soils that may interfere with anchoring. For this reason, special consideration will need to be given for anchored rigs in deep water where a side scan sonar and sub-bottom profiler survey, possibly acquired using an AUV, may be needed as a supplement to a study based on exploration 3D data.

Exploration 3D seismic data is not a substitute for sub bottom profiler data for the identification and mapping of geology and hazards in the top 100 m below the seabed and is not a replacement for a site survey when using a bottom founded drilling rig.

Not all exploration 3D seismic data lend themselves to this type of study and an acceptable dataset can be rendered unsuitable through trace or sample decimation, etc.

Data should be reviewed carefully at the outset of a project to study the complexity of the location's setting as part of a preliminary hazards severity assessment or desk study. The results of such a study might indicate:

- that the data clearly indicate that the setting of the study area is as complex as to require a supporting site survey
- the data fail to meet minimum data acceptability criteria set out below and may require reprocessing, or replacement, or to be supplemented by acquisition of a site survey that provides an improved basis for study
- the data are adequate for use as a site survey replacement and meet the minimum data acceptability criteria set out below.

5.6.1 Exploration 3D seismic data types

For site survey studies, generally only exploration 3D seismic data acquired using towed streamer methods are considered acceptable for studying the shallow section.

Other forms of exploration 3D seismic data, through their acquisition geometry, are less likely to immediately provide an appropriate continuous image of the seabed or shallow section, for example wide azimuth towed streamer, ocean bottom cable and node based 3D seismic datasets.

However, in all cases, careful reprocessing of the data may deliver improvements that meet the data acceptability criteria stated below.

5.6.2 Minimum exploration 3D seismic data acceptability criteria

Exploration 3D data to be used for site survey studies should be used at their optimum spatial, temporal, bit resolution and sampling interval.

Data should always be loaded to a workstation at no less than 16, and preferably 32, bit data resolution. Data should be unscaled.

The dataset to be used should provide a sufficiently resolute image of the seabed and shallow section to allow an accurate analysis of conditions to be made.

A preliminary review of the exploration 3D dataset under consideration should indicate that it fulfils the following basic standards:

- **Frequency content**: the dataset should possess a useable frequency content up to, and preferably beyond, 60 Hz to the full depth of interest below seabed.
- **Seafloor reflection**: should be free of gaps and defined by a wavelet of stable shape and phase to allow auto-tracking of the seabed event with minimum user intervention and guidance.
- **Acquisition artefacts**: such as cross-line statics and/or amplitude striping, though possibly identifiable in the shallow section, should not detract from the overall interpretation of a picked event when mapped in time or amplitude. Similarly time slices, or windowed attribute extractions should be devoid of, or show minimal, acquisition artefacts to the detriment of their interpretation.
- **Merge points**: between datasets of differing origin or vintage that cross a study area should be marked by minimal – and preferably no – time or phase shifts and amplitude changes across the joins that might otherwise be to the detriment of the interpretation.
- **Bin sizes**: preferably less than 25 × 25 m in both directions.

- **Sample interval**: processed output sample interval should preferably be 2 milliseconds and certainly be no more than 4 milliseconds.
- **Imaging**: attention to definition of an accurate velocity model in the shallow section in processing should have allowed optimum structural and stratigraphic resolution to have been achieved in the migrated volume. The shallow section should show no indication of under, or over, migration artefacts.
- **Multiple energy**: should either be unidentifiable or at a level that does not interfere with the analysis of the shallow section.
- **Data coverage**: the available exploration seismic data coverage should fully meet the guidelines for data coverage set out in section 5.2 above.

A careful assessment of any exploration 3D dataset being considered for use should always be undertaken against these criteria and in consideration of the project's geological setting before accepting an exploration 3D data set for use in place of any element of site specific data acquisition.

In water depths of less than 300 metres, for example, the above criteria are generally not met because of the frequency content of the data and the long seismic recording offsets. Exploration 3D seismic data is therefore not a suitable replacement for a site survey when a jack-up or bottom founded rig is to be used, or when seabed clearance is required for an anchored rig.

In water depths between 300 and 750 metres, the above quality criteria for exploration 3D data may be met, on a case by case basis, and therefore may be sufficient to replace the need for the HR2D element of a site survey or more.

In waters deeper than 750 m, 3D data would normally be expected to be of sufficient quality to replace the need for all site specific acquisition. Even so data should still be carefully assessed for their quality before a final decision is made.

Depending on the absolute data quality, exploration 3D seismic data may however still be adequate to support, or complement, the identification of deeper drilling hazards regardless of whether they may fully replace the acquisition of high resolution 2D multi-channel seismic data. Exploration 3D seismic data, therefore, should always be included in support of the final interpretation effort by geohazard and 3D seismic specialists.

5.6.3 Use of targeted exploration 3D seismic data reprocessing

Reprocessing of exploration 3D data, either through production of a near trace or short offset volume, output of a high resolution velocity model (e.g. using FWI or other techniques) or by application of other processing techniques (e.g. de-ghosting) can deliver significant improvements in resolution, data quality, or interpretational information. Such approaches should be considered especially if the original exploration 3D dataset fails to meet the minimum data acceptability criteria set out in section 5.6.2 above.

5.7 Enhancing the value of an exploration 3D seismic dataset

Where review of exploration 3D seismic data leaves some uncertainty on site conditions, the acquisition of a focused survey programme to calibrate the results of the review of the exploration 3D seismic dataset can assist in reducing interpretational risk or uncertainty.

Such work may entail the acquisition of various types of data:

5.7.1 Seabed samples

These may be acquired to calibrate variation in exploration 3D seabed reflection amplitude or appearance to variation in shallow soils.

5.7.2 Targeted 2D high resolution seismic data

The acquisition of a grid of tie-lines, across particular features of interest, or to directly tie in the top-hole section of any available relevant offset wells to a proposed location, can significantly assist in confirming interpretation and improving analyses performed otherwise solely on the basis of exploration 3D data.

5.7.3 Side scan sonar data

If the exploration 3D data indicate the presence of potentially sensitive seabed conditions, or public information suggests the presence of existing infrastructure (submarine cables, etc.) dumping grounds, or wrecks in the area, the acquisition of side scan sonar data to ensure a clear seabed should be considered.

5.8 Use of exploration 3D seismic data in a development scenario

In the case of a field development, use of an exploration 3D dataset will normally provide an excellent basis for an initial field-wide desk study to support initial field layout concept screening.

Use of such data will also assist in design decisions for any subsequent engineering quality bathymetric and geophysical site investigation data acquisition campaign.

Therefore use of exploration 3D datasets should be considered as an integral part in the phased development of an integrated ground model of the seabed and shallow subsurface for the field under development to complement, and fill in any gaps in, bathymetric or geophysical site survey data coverage.

However, field development project geohazard decisions should not be based solely on the use of standalone exploration 3D data. Acquisition of bathymetric and geophysical site survey data should always be acquired to ensure a clear site prior to installation, to affirm the long term integrity of the locations selected and to record the baseline seafloor environmental conditions in the area.

6. Geohazards analysis and reporting

Seismic interpretation, the identification and analysis of potential geohazards and the writing of technical reports to convey results to the end users should be performed by qualified, experienced skilled geoscientists who have specialised in high resolution geophysics and identification of well site geohazards.

6.1 Purpose of the report

The report's purpose is to describe and assess seafloor and top-hole geological conditions to help plan safe and efficient rig emplacement and drilling operations and to assist in identifying potentially sensitive seabed environments.

The report is the permanent record of the site investigation.

The site survey report for an offshore drilling location is the means by which information that has been collected and analysed is communicated to the end users through the provision of a descriptive ground model illustrated using maps, cross-sections, figures, text, etc.

6.2 Scope of reporting

Site survey reports should provide an integrated assessment of all relevant data to describe constraints upon the emplacement of the rig at the proposed location, and top-hole geological conditions to a depth at least 200 m below the preferred setting depth of the first pressure containment casing string, or to a depth of 1000 m, whichever is greater.

Constraints to the proposed drilling operations, including man made features, should be assessed and described.

It is recommended that a summary is provided at the start of the report in order to present the essential findings and conclusions about the site in an easily accessible form.

Reports should draw upon all relevant existing and newly acquired data for the site in question. This may include or make reference to:

- desk study reports
- pre-existing site survey reports
- exploration 2D or 3D seismic data
- top-hole logs from offset wells
- geotechnical soil investigation data
- information about man-made features such as existing wells, shipwrecks, and oil field infrastructure

- newly acquired hydrographic and geophysical data
- environmental data including benthic samples and seabed photographs.

It is important that any links with environmental or geotechnical engineering investigations are identified and there is consistency of results between the reports.

The content of the report should be carefully planned with the operational objectives in mind, and adjusted on the basis of the site conditions encountered during the survey.

Pre-drilling site survey reports should be concise, objective, user-friendly and clearly understandable, regardless of the technical background of the reader.

The Technical Notes provide guidance on expected content for a site survey report.

6.3 Identifying sources of risk

A key objective of a site survey is to assess geohazards and to enable the risk posed to drilling operations by the seabed and geological conditions to be managed and reduced.

The presence of hazards must be determined through rigorous and consistent analysis and clearly reported in the text, maps, and other graphics that make up the site survey report. For each hazard identified, hazard potential should be stated in terms of the likelihood that the particular condition exists at a specific locality.

The Technical Notes provide guidance for the assessment of shallow gas.

6.4 Consideration by rig type

The site survey report should address three phases of the drilling operation:

- bringing the rig onto location and stabilizing it before spudding-in
- spudding the well
- top-hole drilling.

If the rig type is not known at the time the site survey report is prepared, the report should address concerns for all the rig types that could be used for the proposed drilling operation.

6.4.1 Bottom-founded rigs and platform based rigs

Reports for bottom-founded rigs should address the shallow foundation conditions for rig leg emplacement to whichever is greater: 30 m below seabed or the expected leg penetration depth plus one-and-a-half times the diameter of the spud can.

The report should address the expected drilling conditions across the top-hole section to whichever is greater: 200 m below the preferred setting depth of the first pressure containment casing string or to a depth of 1000 m below seabed.

The report should also consider the seabed conditions within a 200 m radius of the proposed well location(s), along the approach route to location, around any temporary stand-off locations and any potential relief well locations.

6.4.2 Anchored rigs

Reports for anchored rigs should focus on the seafloor and shallow soil conditions to a distance 250 m beyond the maximum likely anchor radius, the top-hole drilling conditions for the proposed location and any potential relief well locations.

If anchor locations are known, special attention should be paid to the anchor and catenary touchdown area where the seafloor will be disturbed by anchor chain and/or wire rope. The expected type and strength of the seabed soils where the anchors will be set should be described.

The report should consider the seabed conditions in a 200 m radius around the proposed well location(s) and the expected drilling conditions across the top-hole section to 200 m below the preferred setting depth of the first pressure containment casing string or to a depth of 1000 m below seabed, whichever is greater.

6.4.3 Dynamically Positioned (DP) rigs

Reports for DP rigs should consider the expected drilling conditions across the top-hole section: to 200 m below the preferred setting depth of the first pressure containment casing string, or to a depth of 1000 m below seabed, whichever is greater, and any potential relief well locations.

Special attention should be paid to the seabed and shallow soil conditions in the immediate vicinity of the proposed well location(s) within a radius of 200 m or out to the maximum distance that the DP rig's seabed acoustic reference network is to be laid from the well.

6.5 Deliverables

Report deliverables can be provided in both digital media and paper forms.

Integrated digital methods of compiling, presenting and delivery of report information are encouraged. In particular, GIS and web-based methods allow ease of retrieval for future reference, results integration with other types of information and rapid archiving and retrieval.

IOGP have published a Seabed Survey Data Model (SSDM) to define an industry standard GIS data model for seabed surveys. This model can be used as a deliverable standard for survey data, results and maps between operators and survey contractors, as well as for the long term management of seabed survey data. The SSDM documentation and supporting material can be downloaded from www.iogp.org.

All raw and processed data from the positioning and survey sensors should be delivered in agreed industry standard electronic form as individual files per line as described in the Technical Notes.

Glossary

Term	Definition
Acoustic seabed imagery	Images derived from acoustic reflection data processed to illustrate seabed: topography, features, and changes in texture.
Anchor radius	The radius of the smallest circle that includes all the seabed anchor positions for a semi-submersible rig.
Archaeological remains	Objects that are of historical interest. These may be man-made, for example shipwrecks, or human or animal remains of any age.
Auto-tracking	The process by which seismic horizons are automatically tracked in a seismic dataset by an interactive seismic interpretation system.
AUV	Autonomous Underwater Vehicle. A self propelled, untethered underwater vehicle that is able to be programmed to swim along a predefined survey track to collect data from sensors installed on it.
Backscatter	The amplitude of the acoustic echo sounder energy reflected by the seabed that may be processed into maps that provide information about seabed features and texture.
Benthic samples	Seabed samples recovered by grabs or corers that are normally taken for environmental investigations.
Bottom founded rig	Mobile drilling rig such as a jack-up rig or a drilling barge that relies on a seabed foundation for stability during drilling.
Boulder beds	Accumulations of boulder sized material, greater than 30cm across, buried in sediments. Typically found in the base of buried channels or within glacial sediments.
Broadband seismic	Seismic data that through a combination of acquisition and, or, processing techniques, enhances the useable frequency bandwidth at both low and high frequencies.
Buried infilled channels	Ancient eroded channels that have been infilled and buried by sediment.
Buried slumps	Ancient submarine landslides that have been buried by sediment.
Chemosynthetic communities	Discrete life forms normally in the vicinity of the seabed that exist only because of specific, localised chemical conditions.
Clock and orbit corrected GNSS	See Precise Point Positioning GNSS.
Communications cables	Cables on or beneath the seabed laid either between continents and islands or to offshore installations.
CTD	Conductivity, Temperature and Depth meter. Device for making real time measurements of conductivity and temperature against depth over the full water column to derive the speed of sound in water to calibrate e.g. echo sounder and USBL observations.
De-ghosting	Seismic processing techniques aimed at removing secondary wavefield noise, commonly referred to as ghosts, caused by the depth of source and receiver, that otherwise corrupts the recorded data.
Desk study	Exercise to derive as much information as possible about the site conditions in an area from existing data and public domain information.

DGNSS	Differentially corrected GNSS. A method of improving GNSS solution for position in plan and height by applying corrections to satellite observations. Corrections are calculated between observed and calculated ranges at reference station(s) of known position.
Diapiric structures	Positive geological structures formed by the deformation of plastic material, for example salt or clays. They can be associated with hydrocarbon accumulations and may also have a surface expression that in the marine case would result in a bathymetric high.
Diatreme	A volcanic, or injective, feature piercing sedimentary strata.
Dynamically positioned (DP) rig	Mobile drilling rig that relies on thrusters automatically controlled by a dynamic positioning system for station keeping during drilling.
Erosion and truncation surface	Geological interface that marks the lower limit of erosion and on which deposition has subsequently taken place. Erosion and truncation surfaces therefore mark unconformities in the sequence of geological deposition.
Exploration 3D seismic data	3D seismic reflection data collected for the purpose of exploring for oil and gas rather than studying geohazards and the shallow section.
Fault escarpments	Bathymetric ridges on the seabed aligned with underlying geological faults.
First pressure containment casing string	The first casing to be installed in a well that will enable the pressure inside the well to be controlled.
Fluid expulsion features	Seabed depressions such as pockmarks believed to have been caused by the expulsion of pore water or gas.
Fold of cover	The number of seismic traces, each recorded at a different source to receiver offset, that are combined together in multi-channel seismic reflection profiling.
FWI	Full Waveform Inversion (FWI) utilises the entire seismic wavefield to generate refined, high-resolution velocity models for seismic imaging and characterisation.
Gas chimney	A zone within the sub-seabed section where the vertical migration of gas is taking place. This is often characterised by energy scattering and absorption on seismic reflection data and a lack of coherent reflectors.
Gas hydrate mounds	Accumulations or build ups of gas hydrate at seabed normally over a seabed seep in deep water or at high latitudes.
Gas hydrate zones	Parts of the sub-seabed section where gas hydrate is present.
Gas vents	See fluid expulsion features.
Geohazard	Geological condition that has the potential to cause harm to man or damage to property.
Geotechnical boreholes	Boreholes drilled into the seabed for the purposes of carrying out in-situ geotechnical testing, or to collect samples for geotechnical testing and analysis.
Geotechnical engineering	The branch of civil engineering concerned with the engineering behavior of earth materials.
GIS	Geographic Information System. A computer based system for capturing, storing, analysing and presenting geospatial data.

Global Navigation Satellite System (GNSS)	Generic term for satellite based navigation systems like GPS, Glonass, Galileo and others that provide autonomous global positioning of GNSS receivers.
Gradiometer	A system which measures the magnetic gradient using two or more closely spaced magnetometers.
Ground model	Three dimensional representation of the earth constructed from a database of any valid input data.
Ground truthing	Calibration of geological interfaces interpreted from seismic data using samples.
Habitat	An ecological or environmental area inhabited by a particular animal or plant species.
Hardgrounds	Hard material, such as cemented sediment, coral or rock, at seabed.
HR	High Resolution multi-channel survey techniques focussed on delivering imagery in the 20-250Hz frequency range.
Jack-up rig footprint	Depression left on the seabed after a jack-up rig leg has been withdrawn.
Layback to towed equipment	Horizontal distance from the survey vessel to a towed sensor.
Magnetometer	An instrument used to measure the strength and / or direction of the magnetic field in the vicinity of the instrument.
Manifolds and templates	Examples of facilities placed on the seabed for the purposes of drilling and / or production.
Mass transport complexes	MTCs, see Slump.
Maximum offset	The maximum horizontal source to receiver offset in a multi-channel seismic survey.
Mega-ripples	Current ripples normally present on a sandy seabed having a wavelength of greater than 0.5 metre.
Methane Derived Authigenic Carbonate (MDAC)	Methane Derived Authigenic Carbonates (MDACs) are the product of anaerobic oxidation of methane primarily by the action of sulfate-reducing bacteria that results in the precipitation of carbonate (aragonite, calcite, etc.).
Migrated volume	The end product of a fully processed 3D seismic survey.
Minimum offset	The minimum horizontal source to receiver offset in a multi-channel seismic survey.
Minimum phase output	The output of a seismic source where the energy is front-end loaded in the first energy peak of the pulse and is not followed by a larger peak.
Mosaic	Compilation of side scan sonar records to form a geo-referenced seabed acoustic image.
Motion sensor	An instrument for measuring horizontal and vertical motion, and attitude of for example a survey vessel. This information is needed to correct, e.g. multi or single beam echo sounder data and USBL data for vessel motion.
Mud volcano	Formations created by geo-excreted liquids and gases. See diatreme.
Mudline	Seabed. Term often used when the seabed is composed of particularly soft, water saturated sediment.

Multiple energy	Noise on seismic records caused by reverberations between strong reflecting interfaces, such as the seabed and the sea surface.
Near trace or short offset volume	A processed 3D seismic dataset that uses only traces recorded by the receivers positioned closest to the seismic source with most vertical incidence angle. The data will contain the highest frequencies and thus the best vertical resolution, but will be affected by noise especially in the deeper part of the section.
Ocean bottom cable	Seismic recording cable placed on the seabed with four component receivers that will have the capability to record s-waves as well as p-waves.
Offset well	Existing well from which information is available to tie back to and assist with making predictions about conditions at a proposed well location.
Offshore drilling unit	Facility from which offshore wells are drilled. For example a mobile drilling unit.
Operator	Company having responsibility for drilling an offshore well.
Over-pressure zone	Sub-seabed layer having a pressure above normal hydrostatic pressure.
Pinning activity for a jack-up rig	Procedure by which jack-up rig legs are initially lowered to contact with the seabed to secure the rig to the seabed and make it resistant to lateral movement.
Platform based rig	Drilling rig mounted on a fixed wellhead/production platform.
Precise point positioning (PPP)	A global GNSS augmentation technique that corrects for GNSS satellite orbit and clock errors and employs additional modelling techniques to further correct, and improve, the point positioning accuracy of the mobile GNSS receiver.
Project engineer	The operator's project engineer responsible for overall well or development planning and interface to the site survey project manager.
Project manager	Can refer to either or both of: the operator staff member responsible for planning and delivery of the site survey, and the contractor representative responsible for actioning the operator's plans.
Protection frames	Structure placed over a seabed installation normally to protect it from trawl nets or dropped objects.
Record length	The length of time that seismic signals are recorded following the firing of a seismic source.
Recording system	Instrument for recording seismic signals.
Reefs	Sedimentary features, built by the interaction of organisms and their environment, that have synoptic relief and whose biotic composition differs from that found on and beneath the surrounding sea floor, for example a coral reef.
Rock dump	Mound of rock or gravel placed on the seafloor for example to stabilise and/or protect a pipeline or submarine cable.
Salt or mud diapirs	See Diapiric structures and Diatremes.
Sample decimation	Resampling of digital seismic data at a longer interval than originally used.
Sample interval	Time interval between successive samples in a digital seismic record.
Sandwave	Mobile submarine sand dune created by currents. Typically up to 10 metres high but occasionally higher.

Seabed acoustic array	A number of acoustic transponders strategically placed on the seabed to position either surface vessels, for example drilling rigs, or sub-sea installations.
SDGNSS	Satellite differentially corrected GNSS. See Precise Point Positioning.
Seabed characterisation	Classification of seabed topography and sediments through investigation.
Seabed clearance data	Dataset that enables objects and obstructions on the seabed to be located and identified.
Sector scanning sonar	Sector scanning sonars provide radial sonar coverage of a sector of the water column and seabed around an underwater vehicle (e.g. an ROV) or seabed frame and are used for collision avoidance purposes or seabed clearance verification. The data are typically displayed showing radial range and direction to targets.
Sedimentary sequence	Succession of sediments that makes up the geological sequence.
Seismic source	Source of controlled seismic energy that is used in reflection and refraction seismic surveys.
Streamer	Receiving system for marine seismic surveys that is towed behind a survey vessel. Usually consists of a large number of hydrophones arranged in groups and may extend to several km in length.
Semi-regional	Area of study extending beyond a single well to include several wells, prospects or developments.
Shallow gas blowout	An incident where shallow gas is released from the well after a gas zone has been penetrated before the first pressure containment casing string has been set and the BOP has been installed on the well.
Shallow section	The geological section above the setting depth of the first pressure containment casing string in a well.
Shallow water flow zone	Overpressured geological interval from which pore water flows into a well causing difficulties in well control and effective cementing of casing.
Side scan sonar	Instrument for scanning the seabed to either side of a survey line using acoustic pulses. Can detect objects on the seabed, and variations in seabed topography and seabed sediment type.
Single beam echo sounder	Instrument for measuring water depth immediately below a survey vessel.
Slump	Movement of a sediment mass under the influence of gravity. An example is the outflow of sediment from a seabed expulsion feature such as a mud volcano. Also known as gravity transport.
Sound Velocity probe	Instrument for making real time measurements of the speed of sound in water to calibrate echo sounder readings.
Source signature	Output wavelet, or waveshape, of a particular seismic source from which frequency, output power and phase may be determined.
Spud	The commencement of the drilling of a well.
Spud can	Base of a jack-up rig leg.
Stand-off location	Area of seabed that has been surveyed and established as a safe place for a rig to be placed while waiting to move onto an intended drilling location.

Stratigraphy	A branch of geology that studies rock layers and layering (stratification) primarily used in the study of sedimentary rocks.
Sub-bottom profiler	Seismic reflection instrument for investigating the upper few tens of metres of the sub-seabed with as high a vertical resolution as possible.
Subsea isolation valves	Valves on submarine pipelines that automatically cut off the flow in the event of an emergency. They are often placed within a few hundred metres of a platform.
Subsurface data	Geophysical and geotechnical data for investigating sub-seabed geology.
Swathe bathymetry system	Instrument for measuring water depths within a defined swathe either side of a survey vessel track. Also referred to as a multi-beam echo sounder.
Synthetic aperture sonar (SAS)	A type of side scan sonar that uses techniques analogous to Synthetic Aperture Radar to combine successive pings coherently along the known track of the sonar transducer in order to increase the along-track resolution.
Time slice	Horizontal section through a 3D seismic volume that displays information at the same two way reflection time.
Top-hole drilling hazards	Geological conditions that impact on drilling operations in the top-hole section of a well.
Top-hole section	The shallow geological section above the setting depth of the first pressure containment casing string in a well.
Topography	The study of the earth's surface shape and features.
Towfish	Vehicle on which survey sensors are mounted that is towed behind a survey vessel.
Towed sensors	Survey sensors mounted on a towfish and towed behind a survey vessel.
Transponder	An electronic acoustic device that produces an acoustic response when it receives an acoustic signal from e.g. A vessel mounted transducer or another transponder.
UHR	Ultra High Resolution multi-channel survey techniques focussed on delivering imagery in the 60-500 Hz frequency range.
USBL	Ultra Short Baseline System: a subsea acoustic positioning system used to determine the position of towed or deployed sensors in the water column. A transponder or responder beacon is mounted on the sensor to be positioned and interrogated from a transducer of known position.
Unscaled	A processed seismic section in which the magnitude of reflection amplitudes is preserved in a meaningful way, and may be used, for example, in the identification of shallow gas.
Unstable slopes	Submarine slopes that have the potential to fail.
Velocity model	The assignment of different seismic velocities to certain discrete geological or reflection time intervals.
Vertical datum	Reference level for elevation and depth measurements.

Vessel mounted acoustic positioning system	A subsea acoustic positioning system that is permanently installed on a vessel. This system can either determine the relative position of acoustic transponders or responders mounted on other equipment (e.g. towfish) or absolute positions within a network of seabed acoustic transponders.
Vessel transducer	A transducer, to transmit and receive acoustic signals, that is either permanently installed in the hull of a vessel or deployed from the vessel for the acquisition of different data types; water depth (echo sounder), shallow geophysical data (sub bottom profiler), range and bearing to towed equipment (acoustic positioning system).
Wavelet	A seismic pulse usually consisting of one and a half to two cycles.
Wellhead	A general term used to describe the pressure containing component at the surface of an oil or gas well that provides the interface for drilling and production equipment.
Windowed attribute extractions	Analysis of the reflection amplitudes or other seismic attributes over a specific reflection time window carried out using an interactive seismic interpretation system.

Appendix A
Hazard impact tables

Constraint, hazard or concern	Impact on Operations			Investigatory data guidance
	Bottom founded rig or platform	Anchored rig	Dynamically positioned rig	
Water depth	Suitability of Rig: • Barge draught • Barge freeboard • Leg length • Expected seabed penetration - relative to vessel draught or leg length • Achievable air gap	Suitability of Rig: • Maximum permissible draught (coastal waters) • Anchor system limitations (limb length and winch capacity) • Boat support needs for anchoring • Riser length available • Maximum useable mud weight (in deep water) • Amount of fatigue loading on riser.	Suitability of Rig: • Riser length available • Maximum useable mud weight • Direction of departure in event of emergency disconnect, hanging off with riser fully deployed, or approaching back on to location to latch on to BOP.	Derived from results from a precise bathymetric survey using Swathe Bathymetry and single channel echo sounder systems (see section 5.5.1). For individual well locations in water depths greater than 750 m, that are not related to a field development, use of a properly depth converted exploration 3D Seabed event map may be an adequate replacement (see sections 5.5.2 and 5.6).
Natural seabed features • Seabed topography and relief • Seafloor sediments • Sand: banks, waves, and mega-ripples • Mud: flows, gullies, volcanoes, lumps, lobes • Fault escarpments • Diapiric structures • Gas vents and pockmarks • Unstable slopes • Slumps • Collapse features • Fluid expulsion features • Gas hydrate mounds • Rock outcrops, pinnacles and boulders • Reefs • Hardgrounds • Seabed channels and scours	Choice of: • Rig type (barge, mat or multi-leg jack up) • Well location Impacts on: • Risk of scour • Rig stability • Spud can damage.	Choice of: • Well location • Anchor locations • Catenary touchdown points. Impacts on: • Anchor deployment and slippage • Requirement for piggy back anchors • Difficulty of spudding the well • Leveling of wellhead • Wellhead scour caused by current focusing.	Choice of: • Well location • Difficulty of spudding the well • Levelling of wellhead • Layout of seabed acoustic array • Wellhead scour caused by current focusing. • Direction of departure in event of emergency disconnect, hanging off with riser fully deployed, or approaching back on to location to latch on to BOP.	Mapped on the basis of an integrated use of: • Bathymetric data • Backscatter data • Side scan sonar data • Profiler data See section 5.5.1. In some cases in shelf waters, where bottom founded rigs would operate, exploration 3D seismic imagery might assist an integrated study depending on 3D data quality. In water depths over 750 m exploration 3D data can replace the need for bathymetry or side scan sonar data (see sections 5.5.2 and 5.6).

Constraint, hazard or concern	Impact on Operations			Investigatory data guidance
	Bottom founded rig or platform	**Anchored rig**	**Dynamically positioned rig**	
Man-made features • Platforms: active, abandoned, or toppled • Pipelines: on or buried below the seabed • Power and umbilical lines • Communications cables • Wellheads and abandoned well locations • Manifolds and templates • Pipeline terminations, valves and protection frames • Subsea isolation valves • Rock dumps • Non oil and gas infrastructure such as navigation buoys, wind turbines, etc. • Ordnance and chemical dumping grounds • Miscellaneous debris	Choice of: • Well location • Emergency transit location(s) • Stand-off location(s) • Direction of approach onto and departure from location • Positional tolerance • Anchor locations to aid in bringing rig onto location. Can result in: • Structural damage to rig or seabed facilities • Spud can damage • Spills and emissions • Loss of Operator reputation.	Choice of: • Well location • Anchor locations and appropriate offsets to identified features • Design of anchor catenary profile • Requirement for mid-line anchor line buoys. Can result in: • Damage to seabed facilities • Spills and emissions • Loss of Operator reputation.	Choice of: • Well location • Direction to leave location when hanging off with riser fully deployed, or approaching back on to location to latch on to BOP. Can result in: • Damage to seabed facilities. • Spills and emissions • Loss of Operator reputation.	Presence identified from a desk study review of: • Nautical charts for the area • Communications cable databases • Published Pipeline and Cable route charts See section 4. Mapped from the integrated use of: • Side scan sonar data • Towed magnetometer data • Profiler data See section 5.5.1. When the above data are not acquired in water depths greater than 750 m, the well location should be visually inspected by the rig's ROV immediately prior to, and during spudding, of the well.
Environmentally sensitive environments To include but not be limited to: • Marine Sanctuaries • Fish spawning grounds • Cold water corals • Chemosynthetic communities.	Choice of an environmentally neutral: • Well location • Emergency transit locations • Stand-off Location(s) • Direction of approach onto and departure from location.	Choice of an environmentally neutral: • Well location • Anchor Locations • Catenary touchdown points.	Choice of an environmentally neutral well location.	Presence identified from a desk study review of: • Local laws, regulations and public announcements • Nautical charts for the area See section 1 and 4. Otherwise defined using similar methods to "Natural Seabed Features" above and in keeping with section 5.5.1.
Shipping and military training areas	Choice of: • Well location • Stand-off location(s) • Direction of approach onto and departure from location.	Choice of: • Well location • Anchor locations.	Choice of well location.	As defined on published nautical charts (see section 4).

Constraint, hazard or concern	Impact on Operations			Investigatory data guidance
	Bottom founded rig or platform	**Anchored rig**	**Dynamically positioned rig**	
Archaeological remains To include but not be limited to: • Wrecks • War debris (mines etc.) • Possible submerged communities or human environments.	Choice of: • Well location • Stand-off location(s) • Direction of approach onto location.	Choice of safe: • Well location • Anchor locations and catenary touchdown points.	Choice of well location.	Defined by: • Local Laws and listings • Nautical charts See section 1 and 4. Mapped from the integrated use of: • Side scan sonar data • Towed magnetometer data • Profiler data See section 5.5.1 When the above data are not acquired in water depths greater than 750 m, the well location should be visually inspected by the rig's ROV immediately prior to, and during spudding, of the well.
Shallow soils • Sediment type • Soil strengths • Strength inversions • Gas inclusions • Rockhead • Hardpan or Hard grounds • Calcareous soils • Coral	Choice of: • Rig type • Well location • Spud can or foundation type • Drive pipe/conductor setting depth relative to leg penetration. Can impact upon: • Foundation stability • Spud can damage • Amount of leg penetration • Scour and differential rig settlement • Punch-through • Drive pipe/conductor driveability • Top-hole inclination.	Choice of: • Well location • Type of mooring system: all chain, all wire, or mixed wire and chain • Anchor type • Anchor fluke setting angle • Anchor and catenary touchdown placement • Requirement for piggy back anchors • Mud mat design due to wellhead instability • Length and strength of conductor • Conductor installation technique (drill and grout or jetting). Can impact upon: • BHA deflection, top-hole inclination and need to re-spud.	Choice of: • Well location • Mud mat design due to risk of wellhead instability • Length and strength of conductor • Conductor installation technique (drill and grout or jetting). Can impact upon: • BHA deflection, top-hole inclination and need to re-spud	Defined on the basis of an integrated use of: • Profiler data • Multi-Channel HR seismic data • Geotechnical soil data (where available) • Side scan sonar data • Offset well reports See section 4, 5.5.1 and 6.2. In shelf waters, occasionally, but more normally in deep waters, exceeding 750 m, integrated or standalone use of exploration 3D seismic seabed amplitude maps used with the data types listed above, where available, might assist, in assessing regional variability of seabed soils. See section 5.6 and 5.7.1.

<table>
<tr><th rowspan="2">Constraint, hazard or concern</th><th colspan="3">Impact on Operations</th><th rowspan="2">Investigatory data guidance</th></tr>
<tr><th>Bottom founded rig or platform</th><th>Anchored rig</th><th>Dynamically positioned rig</th></tr>
<tr><td>Shallow faults</td><td>Can result in:
• Lost circulation
• Flow to surface in event of underground blowout, leading to seabed cratering, and resultant loss of rig.
• BHA deflection
• Stuck pipe and/or twist-offs
• Casing hang-ups
• Requirement for additional casing strings.
• Casing collapse</td><td>Can result in:
• Lost circulation
• Broaching to surface in event of underground blowout leading to seabed cratering, loss of well and potential loss of rig stability in a gas plume.
• BHA deflection
• Stuck pipe and/or twist offs
• Casing hang-ups
• Requirement for additional casing strings
• Casing collapse.</td><td>Can result in:
• Lost circulation
• Broaching to surface in event of underground blowout leading to seabed cratering, loss of well and forced rig drive off.
• BHA deflection
• Stuck pipe and/or twist-off
• Casing hang-up
• Requirement for additional casing strings
• Casing collapse.</td><td>Defined on the basis of an integrated use of:
• Profiler data
• Multi-Channel HR seismic data
• Side scan sonar data
See section 5.5.1.

In shelf waters, but more normally in deep waters, exceeding 750 m, integrated or standalone use of exploration 3D seismic data depending on quality (see section 5.6.2) can be used in assessing the presence and geometry of shallow faulting.</td></tr>
<tr><td>Shallow gas charged intervals</td><td>Risk of:
• Minor gas flow at seabed or to rig floor
• Hydrate formation in polar latitudes
• Gas kick
• Blowout
• Uncontrolled flow to seabed
• Seabed cratering
• Loss of rig
• Uncontrolled environmental emissions.

Has direct impact on choice of:
• Rig type
• Well location
• Design(ed use) of diverter system
• Setting depth of surface casing string
• Shallow casing plan
• Mud weight choice</td><td>Can lead to:
• Minor gas flow at seabed or to rig floor
• Hydrate formation on wellhead (in water depths greater than 600 m or in Polar latitudes)
• Gas kick
• Blowout
• Loss of well
• Loss of vessel buoyancy in a gas plume
• Uncontrolled environmental emissions.

Has direct impact on choice of:
• Well Location
• Setting depth of surface casing string.
• Need for additional casing strings
• Riser or riserless drilling approach
• Mud weight choice
• Mud use (e.g. 'pump and dump')
• Drilling and cementing practices.</td><td>Can lead to:
• Minor gas flow
• Hydrate formation on wellhead (water depths greater than ~600 m)
• Gas kick
• Blowout
• Loss of well
• Loss of vessel buoyancy in a gas plume
• Uncontrolled environmental emissions.

Has direct impact on choice of:
• Well location
• Setting depth of surface casing string
• Need for additional casing strings
• Riser or riserless drilling approach
• Mud weight
• Mud use (e.g. 'pump and dump')
• Drilling and cementing practices.</td><td>Shallow gas is defined as any gas pocket encountered above the setting depth of the first pressure containment casing string.

Defined on the basis of an integrated use of:
• Multi-channel HR seismic data
• Offset well data
• Profiler data.

In deep waters, exceeding 750 m, integrated or standalone use of exploration 3D seismic data depending on quality (see section 5.6.2) can be used in assessing the presence of shallow gas and possible migration routes from depth.</td></tr>
</table>

Constraint, hazard or concern	Impact on Operations			Investigatory data guidance
	Bottom founded rig or platform	Anchored rig	Dynamically positioned rig	
Shallow water flow	Can lead to: • Uncontrolled artesian flow • Formation fracture and flow to surface outside casing/ conductor • Uncontrolled flow to seabed and cratering • Loss of foundation support to wellhead or rig foundations • Problem cementing surface casing string • Loss of integrity to surface casing string • Casing collapse • Loss of well. Has direct impact on: • Setting depth, and number, of shallow casing points. • Shallow drilling practices • Choice of mud weights • Cementing practices.	Can lead to: • Uncontrolled artesian flow • Formation fracture and flow to surface outside casing / conductor. • Uncontrolled flow to seabed and cratering • Loss of foundation support to wellhead • Problem cementing surface casing string • Loss of integrity to surface casing string • Casing collapse • Loss of well. Has direct impact on: • Setting depth, and number, of shallow casing points. • Shallow drilling practices (e.g. 'pump and dump') • Choice of mud weights • Cementing practices.	Can lead to: • Uncontrolled artesian flow • Formation fracture and flow to surface outside casing / conductor. • Uncontrolled flow to seabed and cratering • Loss of foundation support to wellhead • Problem cementing surface casing string • Loss of integrity to surface casing string • Casing collapse • Loss of well. Has direct impact on: • Setting depth, and number, of shallow casing points. • Shallow drilling practices ('pump and dump') • Choice of mud weights • Cementing practices.	Shallow water flow is defined as a water flow from an over-pressured aquifer at a depth above the setting depth of the surface casing. This is generally an issue of concern where the recent rate of shallow deposition has consistently exceeded 450 m per million years. Predicted on the basis of an integrated use of: • Multi-channel HR seismic data • Offset well data and reports In deep waters, exceeding 750 m, integrated or standalone use of exploration 3D seismic data depending on quality (see section 5.6.2) can be used in assessing the presence of intervals that may be prone to shallow water flow.
Gas hydrate or hydrated soils	Generally not an issue in shallow water except at polar latitudes. Formation of hydrate can lead to: • Loss of circulation • Underground blowout. Destabilization of natural hydrated soil conditions could lead to: • Loss of formation integrity • Loss of foundation support leading to well and rig collapse.	Formation of hydrate can lead to difficulty with • Emergency disconnect • Temporary and final well abandonment • Loss of circulation • Underground blowout. Destabilization of natural hydrated soil conditions could lead to: • Loss of formation integrity • Loss of foundation support leading to wellhead sinking and loss of well • Seabed [slope] failure.	Formation of hydrate can lead to difficulty with: • Emergency disconnect in a drive-off situation • Temporary and final well abandonment • Loss of circulation • Underground blowout. Destabilization of natural hydrated soil conditions could lead to: • Loss of formation integrity • Loss of foundation support leading to wellhead sinking and loss of well • Seabed [slope] failure.	Gas hydrate or hydrated soils may be considered to be a potential issue at polar latitudes or in deep water. Predicted on the basis of an integrated use of: • Water temperature probe data • Gross water depths • Heat flow data • Computer based hydrate stability models • Side scan sonar data • Profiler data • Multi-channel HR seismic data • Offset well data and reports. In deep water, exceeding 750 m, integrated or standalone use of exploration 3D seismic data depending on quality (see section 5.6.2) can be used in assessing indirect evidence for the presence of a hydrated shallow section.

Constraint, hazard or concern	Impact on Operations			Investigatory data guidance
	Bottom founded rig or platform	Anchored rig	Dynamically positioned rig	
Top-hole geology • Sedimentary sequences: sand, mud, clay, swelling clays or gumbo, marl, carbonates, salt, etc. • Stratigraphy • Buried infilled channels • Boulder beds • Buried slumps and mass transport complexes • Loose formations • Salt or mud diapirs and diatremes • Erosion and truncation surfaces • Dip angle.	Impacts upon choice of: • Length of drive pipe/ conductor • Setting depth of first pressure containment casing string and subsequent casing strings • Drilling and cementing practices.	Impacts upon choice of: • Length and strength of conductor • Conductor installation technique (drill and grout or jetting). • Setting depth of surface and first pressure containment casing strings • Drilling and cementing practices.	Impacts upon choice of: • Length and strength of conductor • Conductor installation technique (drill and grout or jetting) • Setting depth of surface and first pressure containment casing strings • Drilling and cementing practices.	Defined on the basis of an integrated use of: • Profiler data. • Multi-channel HR seismic data • Offset well and geotechnical borehole data. In shelf waters, but more normally in deep waters, exceeding 750 m, integrated or standalone use of exploration 3D seismic data depending on quality (see section 5.6.2) can be used in assessing the top-hole geology.

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This report provides guidance for the conduct of offshore drilling hazard site surveys (hereafter referred to as 'site surveys'). These guidelines address the conduct of geophysical and hydrographic site surveys of proposed offshore well locations and the use of exploration 3D seismic data to enhance, or to replace, acquisition of a site survey.