Capbreton Canyon Offshore Drilling Crossing Feasibility

Site Survey Synthesis Report

Report No.: C846_WPA_T01-02

30/03/2020

Inelfe

CATHIE
177 avenue Clémenceau
Nanterre
France

Tel: +33 1 47 32 48 30

Expertise, Seabed and Below

cathiegroup.com

Document control

Project Title	:	**Capbreton Canyon Offshore Drilling Crossing Feasibility**
Report Title	:	**Site Survey Synthesis Report**
Client Name	:	Inelfe

Client Ref.	:	Client reference
Document Ref.	:	C846_WPA_T01
Issue	:	02
Date	:	30/03/2020
Issue Status	:	Approved

Revision History		Date	Author	Reviewed	Approved
01a	Draft	24/10/19	PGA		
02	Approved	30/03/20	PGA		
	Choose an item.				

Project team		
PGA	Philippe Gauthier	Senior Engineer

1. Introduction

1.1 Project Description

The Biscay Bay Western Interconnection is a joint project being developed by INELFE on behalf of Réseau de Transport d'Electricité (RTE) and Red Eléctrica de España (REE) and supported by the European Union's Connecting Europe Facility (CEF). It consists of an High Voltage Direct Current (HVDC) power interconnection between France and Spain aimed at increasing the exchange capacity from 2800 to 5000 MW.

The interconnection consists of a dual connection, for a total of four HVDC cables plus two fiber optic cables. The interconnection will be 370 km long, running between the Cubnezais substation (near Bordeaux, France) and the Gatika substation (near Bilbao, Spain). A section of approximately 280 km will be submarine, crossing the Bay of Biscay. The interconnection will have two converter stations - one at each end of the link - that will convert the direct current to alternating current for connection to the electricity transmission grid of each Country.

Figure 1: Overview of the Biscay Gulf Western Interconnection link

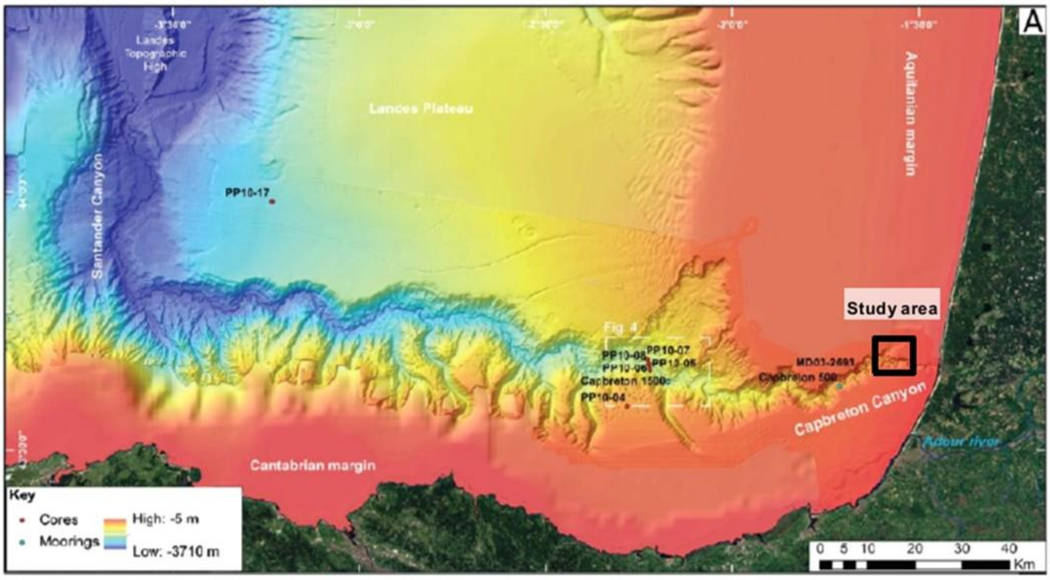
Along the offshore section, the link will cross the Capbreton Canyon, a geological formation characterized by slopes as steep as 80 degrees and a maximum depth ranging between approximately 100m and 300 m below LAT within the marine part of the considered corridor of least impacts. This canyon is considered as a major obstacle along the marine route of the link.

1.2 Capbreton Canyon

The Capbreton Canyon is a deep and narrow East-West incised located in the south-east of the Bay of Biscay and deeply incises the Aquitaine continental slope and shelf. It is a 300 km long meandering submarine structure that runs parallel with the north coast of Spain, before curving northwards and plunging into continental slope at a depth of 3500m below sea level where it converges with the south-North-directed Santander Canyon. Overview of Capbreton canyon is presented in Figure 2.

Considering the location of the canyon, the marine route of the double link would need to cross the canyon and therefore possible solutions to cross were considered. As part of the feasible technical solution to cross the Capbreton canyon, drilling was deemed a feasible solution for the crossing of this obstacle.

Figure 2: Capbreton Canyon overview



1.3 Pre-selection of the possible locations for the Capbreton Canyon crossing

At an early stage of the project, INELFE studied different crossing locations considering conventional installation and protection methods (seabed laying and burial) at different water depths along the canyons, but none of them were considered feasible because of installation concerns.

Trenchless solution has been considered based on the recommendations of Ifremer and Bordeaux University (EPOC Laboratory) based on several differential bathymetry datasets gathered over 14 years to characterize the morphological changes and extent of the canyon flanks and bottom. Key observations of the bathymetry comparison were that no significant evolution of the canyon wall and edge were identified and that the general shape and position of the canyon and its head remain stable all along the 14 years of observation.

Two independent consultants performed preliminary feasibility assessments for trenchless solutions and several options for the crossing of the Capbreton canyon by an offshore drilling solution have been recommended, based on available documentation and preliminary surveys carried out at several areas over the canyon. Nevertheless, gathering of complementary information about the morphology, lithology at anticipated drilling locations was deemed necessary to allow validation of the crossing concept and performance of the design of the drilling solution.

A pre-selection of corridors to be considered for complementary surveys, where drilling solution for the crossing is deemed technical feasible based on the previous feasibility studies, has been carried out based on criteria developed in section 1.3.1.

The number of crossing corridors considered for complementary survey were limited to four (4).

1.3.1 Selected crossing options by offshore drilling

The approach consisted in the identification of most favourable corridors for the performance of the drilling under the Capbreton canyon and once identified, the performance of detailed surveys in order to collect sufficient information to support safe design of the Capbreton crossing.

In the absence of information and feedbacks related to other aspects (such as environmental or socio-political), the identification of pre-selected corridors to be considered for the crossings was based on the following technical considerations:

- Crossing corridors shall be located within less impact corridor.
- Corridors showing no significant evolution have been considered as potential corridors for the trenchless solution.
- Geological and geotechnical conditions along the route and local geology at drilling depth.

Preference should be given to routes where a thick (i.e. >20 m) homogeneous material is found as the target layer for trenchless solution. The material could be either rock or clayey soil. Coarse granular soils shall be avoided. The shallower the target layer, the better since it reduces the overall length of the crossing.

- Water Depth at the drilling Entry/Exit Locations

This should be limited to 30 m to mitigate the impact of the diving operations, the size of the casing structure and the size/capacity of the Jack-up platform. Marine operational means are considered as key parameters for the execution of the project.

- Overall trenchless drilling Length

Drilled length in excess of 1.5 km may require the use of dedicated method for the drilling as “Intersect method”. An intersect will require additional drilling Rig, platform, and casing on the Exit location. This is considered to add costs and risk to the project.

- Thickness of Overburden over the Bedrock

This affects the overall drilling length, since entry/exit attack angle.

Based on the criteria above and the data available, the crossing characterized by the shallowest water depth (both entry/exit point and Canyon section) and shortest drilling length are considered as the best technical choice. Among the proposed crossings, in particular, the crossings considered by Visser & Smith Hanab study, Figure 4, and referenced as part of Option 1 in Figure 3 meet these criteria. This option has been positioned in order to avoid areas identified as unstable, in particular the erosion area at the southern side of the Capbreton canyon head as shown in Figure 4 and Figure 5. Moreover, the feasibility study performed by Catalana de Perforacions proposes crossing corridors equivalent to Option 1 crossings.

Those crossings were deemed as the most likely to be considered by contractors for the crossing of Capbreton canyon.

Figure 3: Possible crossing locations of Capbreton Canyon

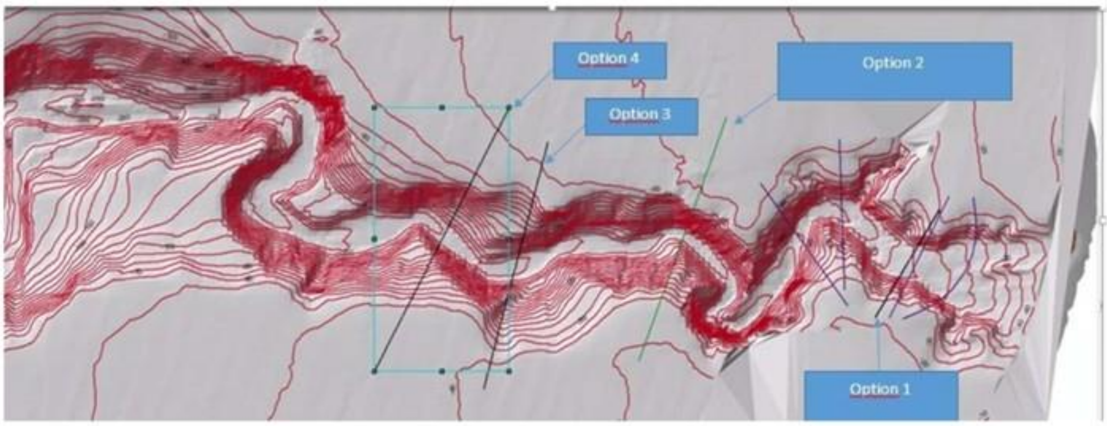


Figure 4: Shallowest Corridors (courtesy Visser & Smith)

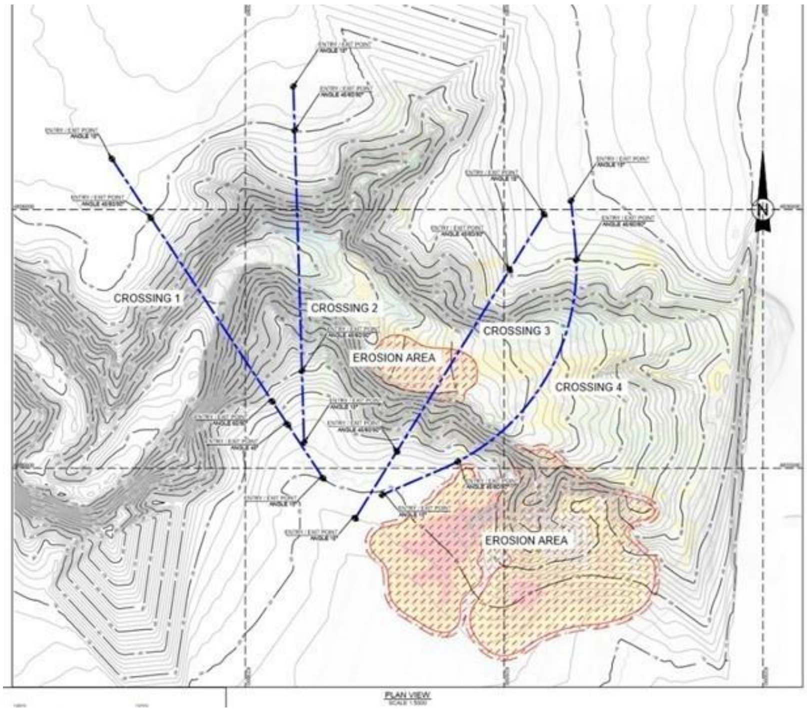
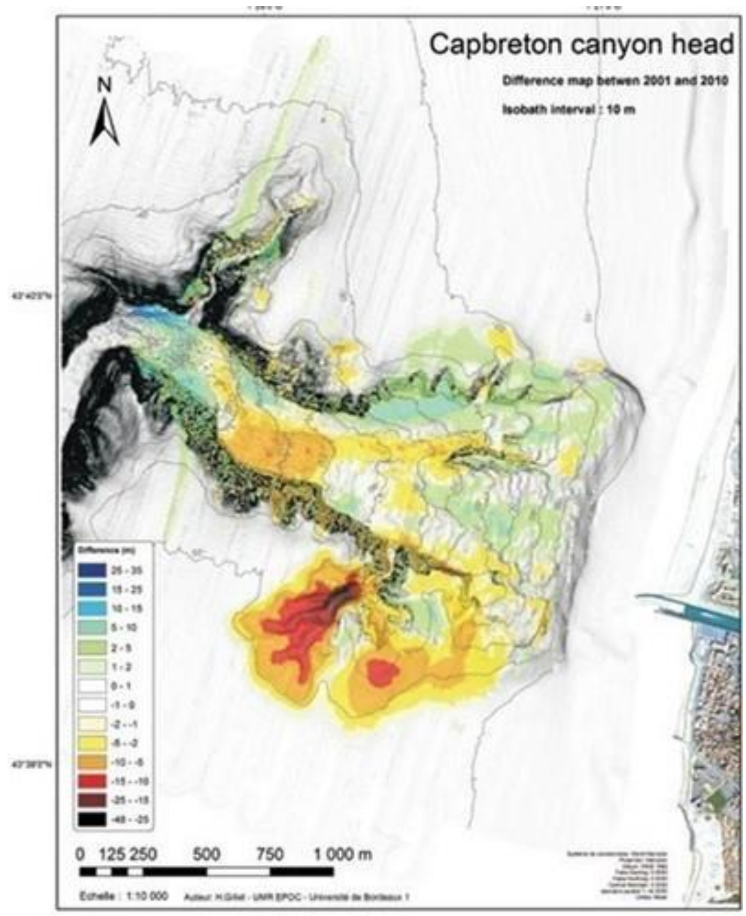


Figure 5: Bathymetry Comparison -Canyon head 2001-2010



1.3.2 Selected corridors to be surveyed

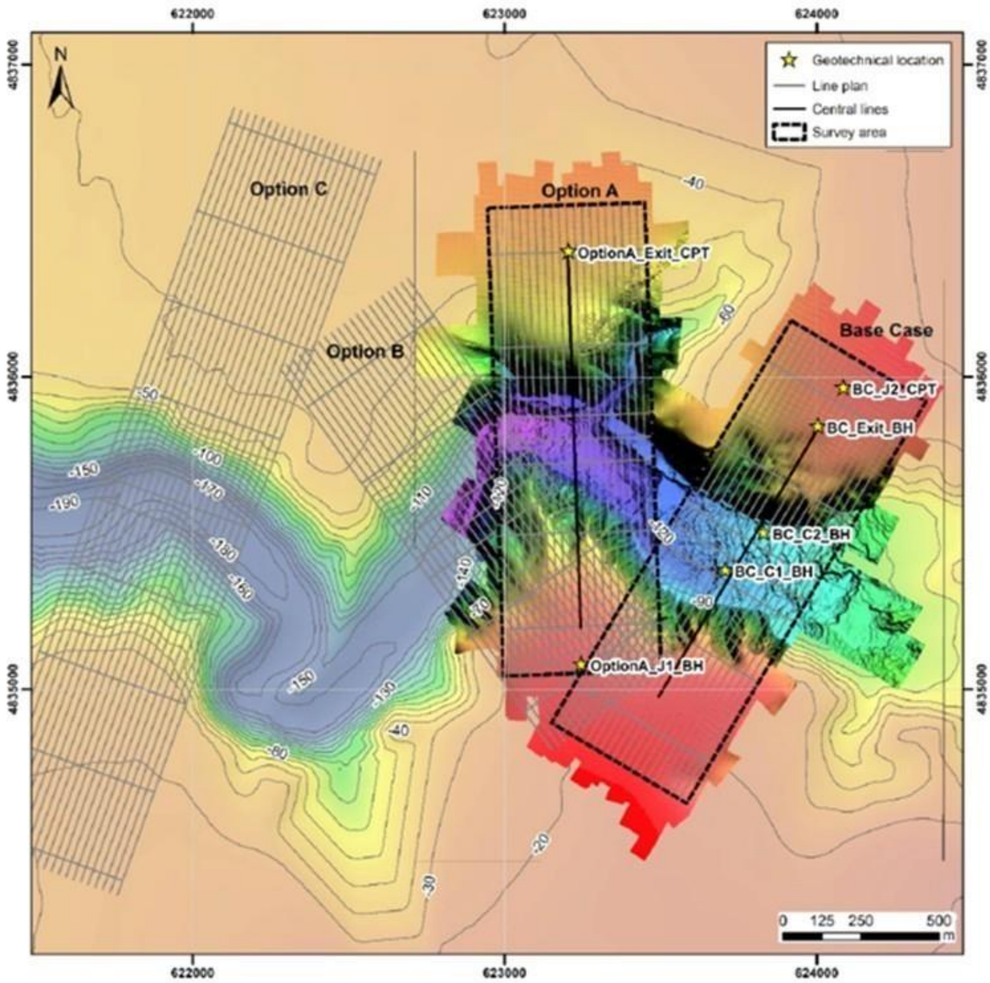
Several corridors have been considered at this stage in order to have back-up solutions in case main hazards to the trenchless execution are observed during the complementary surveys.

Four corridors have been selected for carry out complementary survey as follows:

- Base Case corridor;
- Option A corridor;
- Option B corridor;
- Option C corridor.

Order of preference has been agreed with respectively, the “Base Case”, “Option A”, “Option B” and “Option C”, from more favourable to less favourable configurations. The different corridors are illustrated in Figure 6.

Figure 6: Selected crossing corridors for complementary survey



CATHIE

2. Site survey Campaign

2.1 Survey Approach

Considering the lack of information along the potential crossing locations, survey campaign was defined in order to gather detailed information along proposed corridors. This campaign was separated in two stages:

- Firstly, a geophysical campaign in order to confirm one corridor and one back-up option. During this campaign, shallow and deep structural information was gathering thanks to the deployment of dedicated geophysical equipment as sub bottom profiler and deep 2D seismic operated with multi-channels streamer associated with airgun sources.
- In a second time, a Geotechnical campaign to be performed over the corridors surveyed during the previous phase for the collection of mechanical and lithological information on the different layers present in order to provide needed information for the performance of a safe design of the trenchless solution for the crossing.

In practice, in order to implement above strategy, below steps was performed:

- Geophysical survey performed over corridors following a priority order defined in advance – Base case corridor and option A.
- If no major obstruction or geo-hazard is identified during the survey of a corridor, this survey is validated and a second corridor is surveyed, the survey was limited to 2 corridors.
- Results of the detailed geophysical survey was used for the location of the deep geotechnical sampling and testing to be performed on the flanks and within the canyon in order to collect sample to characterise mechanical properties of the material.
- Integration of the different sets of data, geotechnical and geophysical, have been performed including canyon morphological information, geo-hazard identification, as well as structural and mechanical properties of encounter soil layers along surveyed corridors.

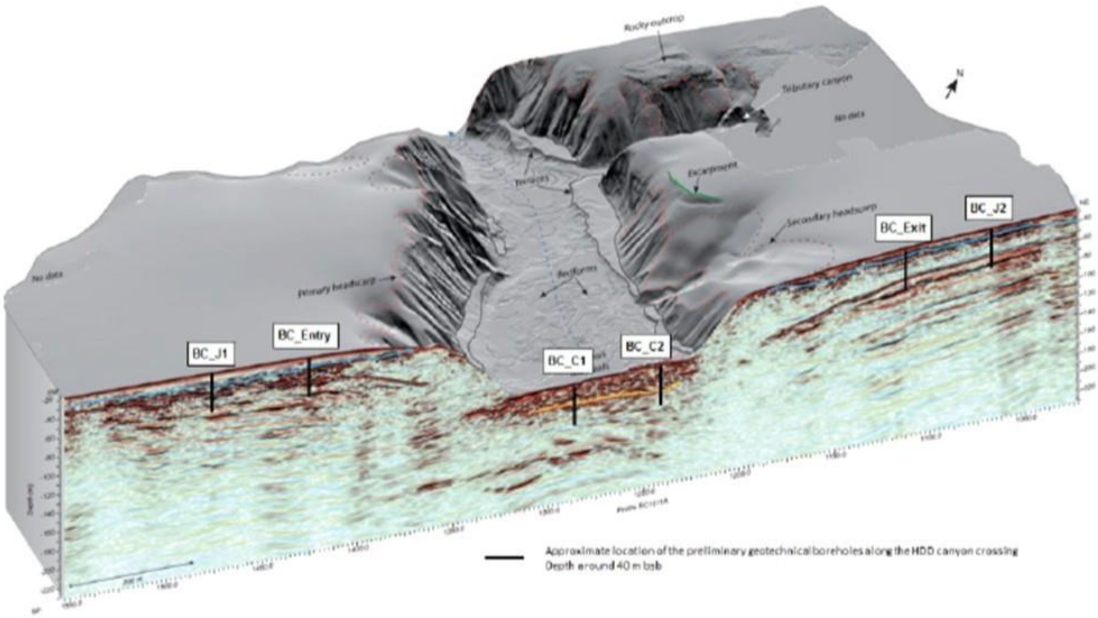
2.2 Geophysical survey

2.2.1 Geophysical campaign objectives

The main objectives of the geophysical campaign were to identify and assess any show stoppers (i.e. surface obstructions or rock outcrops for the structure’s installation, faulting system, soil lateral variability / gravels, canyon flank instabilities and bedrock) to optimize and select which corridor to survey, and to highlight any marker horizons within the 2D seismic dataset. The interpretation was focussed therefore on the shallow sediment cover unit, top of bedrock and the seabed and sub-seabed features that may represent a possible obstruction for the drilling installation or stability through lifetime.

Geophysical survey was performed over the corridors Base Case and Option A. This survey consisted in acquisition of seabed, sub-seabed and deep information along the corridor in order to better define and refine the seabed and sub seabed features and stratigraphy. 3D imagery block (see Figure 7) showing seabed feature and deep stratigraphy is presented to illustrate the result obtained during the first phase of the detail survey campaign.

Figure 7: 3D block imagery



2.2.2 Main Findings of Geophysical campaign and Engineering Constraints

Following the interpretation of the geophysical data collected during the detailed survey of the corridors, the main findings and engineering constraints identified are the following:

- Extreme seabed gradient and slope instability
  - High gradients up to 80° are occur on the canyon flanks;
  - Canyon flanks are incised by gullies and sometimes by a network of gullies forming complex head scarps;
  - The head scarps evolution through time and the slope stability over the canyon flanks should be assessed as part of a dedicated slope stability analysis, in order to evaluate the possible slope instability occurrence and their impact on the project development (drilling installation and during the cable lifetime).

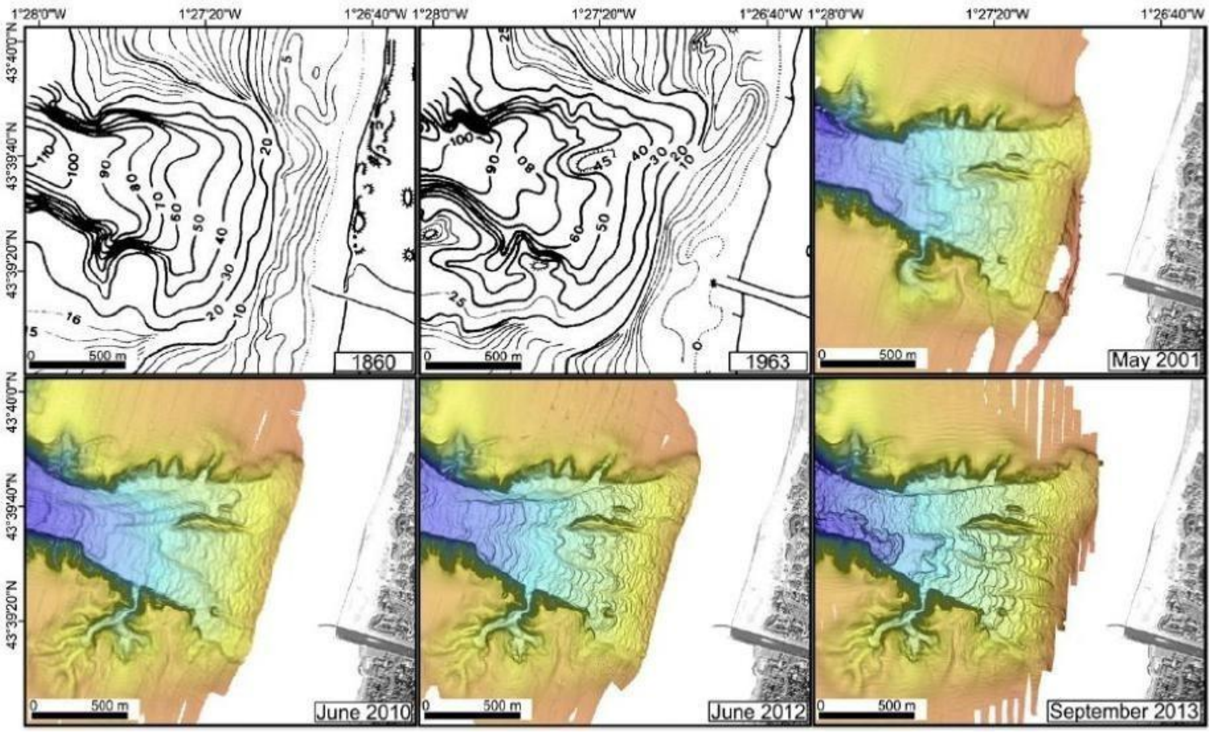
- Highly variable shallow sediments
  - The flat plateau area includes fine to coarse sand deposits;
  - The areas within the gullies network and on the canyon, flanks are characterised by occurrence of possible destabilised or pseudo-destabilized sediments, which are supposed to be sandy or clayey. This is the case within the northern part of the Base Case area;
  - The rocky escarpments along with the rock outcropping areas were identified and mapped by the seabed and sub-seabed analysis. The occurrence of these outcrops should be carefully considered and possibly avoided or mitigated for the drilling operations;

  - The canyon floor and terraces are assumed to be characterised by coarser sediments, such as coarse sand and gravel, and with patches of clay (from flank destabilization and canyon head). Turbidity and mass-transport deposits certainly occur within the canyon floor and induce vertical lithological variability;
  - Paleochannels were identified within the 2D UHR seismic lines and were mapped;
  - Erosion surfaces were described by high amplitude reflectors visible on the 2D UHR seismic lines. These surfaces may correspond to coarser material, possible coarse sand to gravel or even cemented layers.

- Preliminary slope stability observation
  - The southern flank of the canyon head has been affected by significant erosion (between 2001 and 2010) leading to the downcutting of the southern network of gullies.
  - The northern flank, where Base Case is identified, the small incision first identified in 2001 seems to have evolved into a more complex morphology by 2013 and on the recently acquired geophysical data as part of this study.
  - Figure 8 illustrates the comparison of the morphological evolution based on datasets from Mazieres et al. (2014) and the present-day bathymetric data. It should be noted that bathymetric data are not at the same resolution.
  - Between 2001 and 2010, the southern flank of the canyon head was affected by major erosion leading to the downcutting of the north-facing gully network. According to older, low-resolution bathymetric data, it appears that this network of gullies was absent in 1860 but already present in 1963.
  - The study by Mazieres et al. (2014) shows that these gullies are almost imperceptible and appear as rough lineament because they were filled in 2001, reappeared in 2010, began to fill again over the period of 2010–2012 and stabilized over the period of 2012–2013. Downcutting of this network of gullies was observed during longest time-lapse (2001–2010) and we cannot ascertain whether it corresponds to a single event arising from a specific storm or several associated events
  - The plateau and the area of secondary gullies on the northern plateau appear stable since 2010.
  - The southern plateau seems stable from 1998 to date of the geophysical survey.

Considering the preliminary results, although that some geo-hazards have been identified in the vicinity of the cable corridor, no showstoppers to the feasibility of a trenchless solution for the crossing of the Capbreton canyon were identified during the geophysical survey. The geotechnical survey was activated in order to collect complementary and additional information over Base Case and Option A corridor.

Figure 8: Capbreton canyon head morphological evolution and sedimentation infill (Mazieres et al , 2014)



2.3 Geotechnical Survey

2.3.1 Geotechnical Campaign

Few months after the geophysical survey, a detailed geotechnical site investigation has been performed in order to acquire in-situ measurements and sampling boreholes at six locations: four within the Base Case (two within the canyon and two on the northern plateau) and two locations within Option A (one borehole on the northern plateau and another one on the southern plateau). Location of the geotechnical sampling and testing was adjusted accounting for preliminary results from the geophysical campaign.

During the geotechnical survey operation, a bathymetry discrepancy has been observed in the southern flank of the canyon within the corridor base case, at anticipated drilling entry point location. Single beam echosounder lines were acquired in several directions over the southern plateau to assess the extension of this observed event and a major bathymetry discrepancy has been identified and mapped. A maximum of 17m of difference has been observed between bathymetrical data acquired during the geophysical survey and the data acquired during the geotechnical survey. The bathymetry discrepancy is presented for illustration in Figure 9.

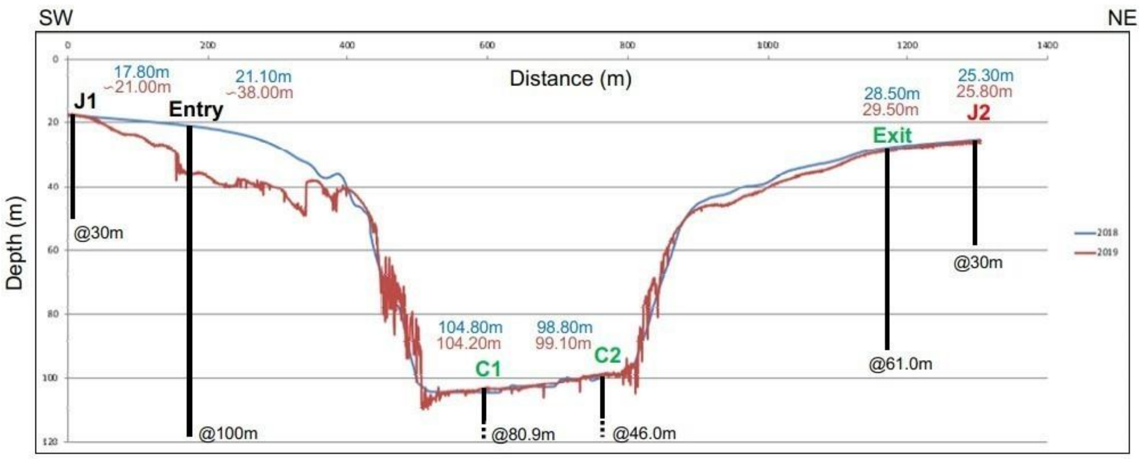
Both geophysical and geotechnical data were used to perform and update the ground model along the pre-selected corridors in order to:

- Associate a lithology to the stratigraphic units;
- Review the geophysical interpretation;
- Identify possible new horizons;

- Investigate the slope failure affected area in order to look for evidences of sediment destabilisation;
- Define geotechnical units by considering the geophysical results.

Example of the integration of both set of data is presented inFigure 10.

Figure 9: Bathymetry comparison Geophysical / Geotechnical survey along Base case corridor – Center line.

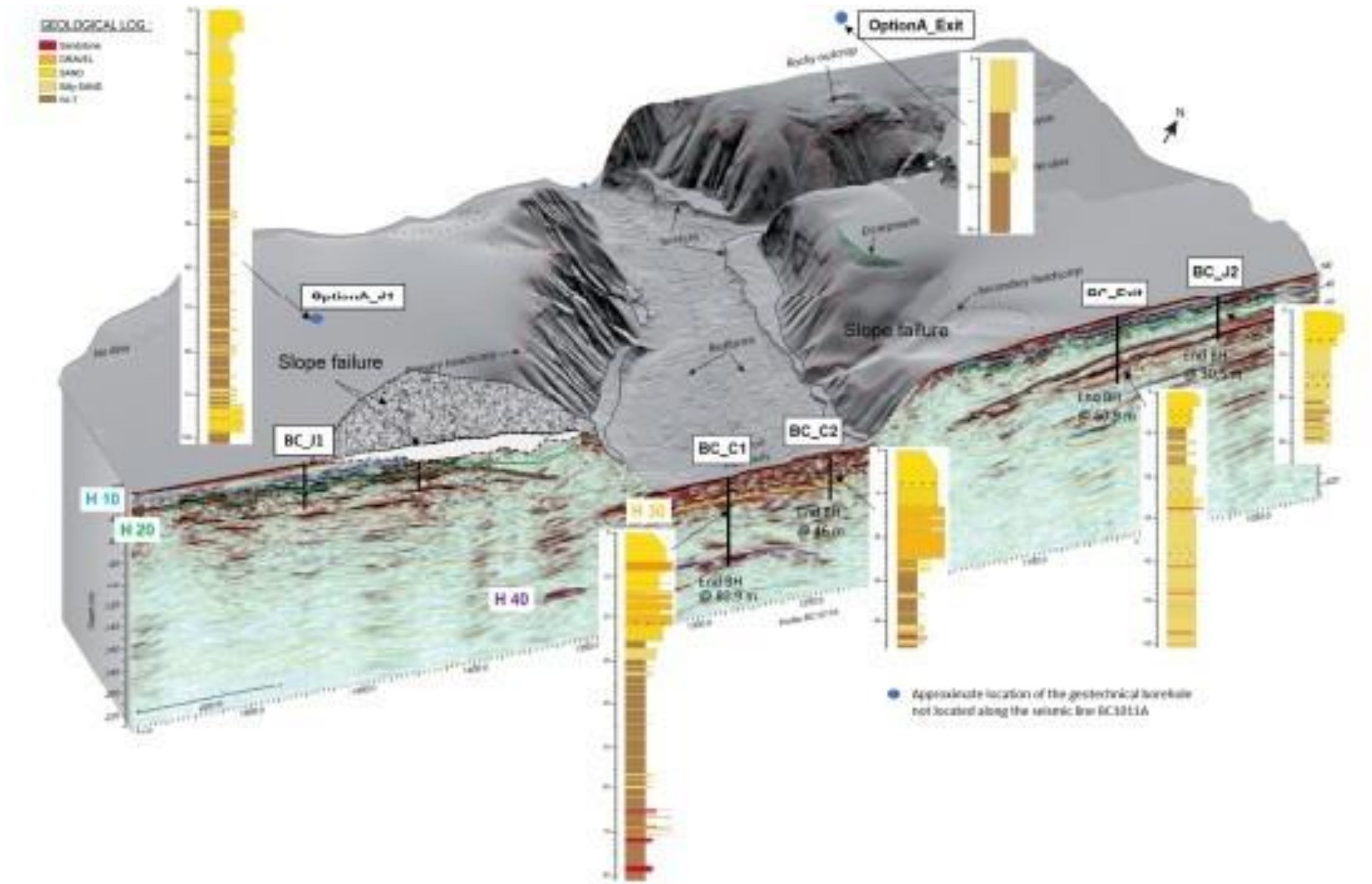


notes:

- *In blue, bathymetric data from the geophysical survey;*
- *In red, bathymetric data from the geotechnical survey.*

CATHIE

Figure 10: Integration of geophysical and geotechnical data – Capbreton canyon



2.3.2 Main Findings and Engineering Constraints observed after geotechnical survey

The main findings and engineering constraints identified following the performance of the geotechnical survey are summarised below as follows:

- Extreme seabed Gradient and slope instability:
    - A major slope instability event has been highlighted on the southern plateau. The base of the slide does not appear to follow a specific seismostratigraphic horizon and is assumed to be a silty sand layer, no borehole was performed at this location to avoid any human or material issues during the survey;

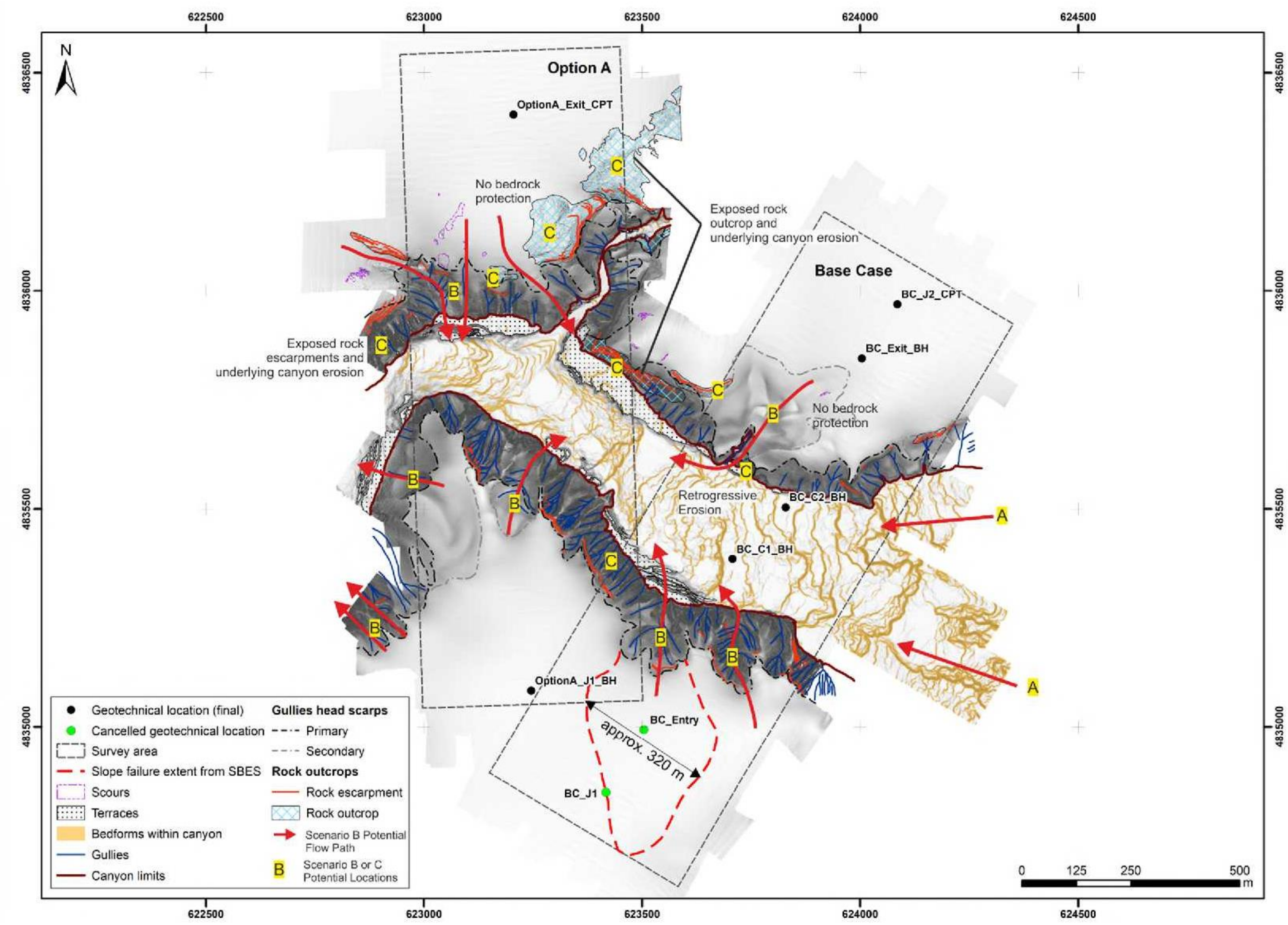
- High variability of shallow sediment: geotechnical soils units have been defined following integration between geophysical and geotechnical data, and laboratory testing results. Soils units identified along Base Case and Option A corridor are presented below and summarised in Table 1:
    - Within canyon: four units were defined;
    - On the southern plateau: corridor option A, four units were defined
    - On the northern plateau: five unites were defined
    - One unit (unit I and sub – units) is common for the southern and the northern plateau
    - Paleochannel infill material is considered as a distinct geotechnical unit

- Major Geohazard identification:
    - The Capbreton canyon is prone to sediment instability with active processes occurring on both the flanks and the base of the canyon – this has been confirmed through academic studies and visualised through the geophysical and geotechnical campaigns;
    - Evidence of potential mass transport deposit recorded in geotechnical cores;
    - After reinterpretation of seabed features and correlation of different datasets following the observation of the bathymetry discrepancy, possible area already affected by slope instabilities and / or sediment flows have been mapped and are illustrated in Figure 11;
    - Base Case and Option A corridors are affected by sediment instability observed during the geotechnical survey (see Figure 11).

Table 1: Summary of geotechnical units identified at Capbreton canyon

Unit	General Description
Ia	Fine to medium Sand
Ib	Fine Sand
Ic	Silty fine Sand
Paleochannel	Heterogenous material
South_II	Silty fine sand with laminae and beds of silt
South_III	Sandy silt with laminae and bed of fine sand
South IV	Silty fine to coarse sand with laminae and beds of sandy silt
South_V	Sandy silts
North_II_BC	Slightly fine to medium sand
North_II_A	Sandy Silt
North_III	Silty fine to medium Sand
North_IV	Silty fine to medium Sand with Beds of Sandstone
Canyon_Ia	Sligthtly gravelly fine to medium Sand
Canyon_Ib	Sandy fine to medium Gravel
Canyon_II	Silt with laminae and beds of fine sand
Canyon III	Silt with beds of sandstone

Figure 11: Seabed feature map and sediment flows – Capbreton canyon



3. Conclusions and Recommendations

Complementary detailed geophysical and geotechnical offshore survey campaigns have been performed over the two corridors deemed the most technically favourable to an offshore drilling solution for the crossing of the Capbreton canyon.

As part of the survey results, a major bathymetric discrepancy has been observed in the southern part of both surveyed corridors between the geophysical and the geotechnical surveys.

The analysis of the available bathymetric, geophysical and geotechnical data along with published academic literature has revealed that slope instability is a credible mechanism for the removal of sediment between 2018 and 2019 site survey campaign from the flank of Capbreton canyon with evidence of potential mass transport deposit recorded in geotechnical cores and bathymetric survey.

The observed phenomena leading to a major bathymetry discrepancy is considered to possibly occur on both sides of the canyon, along its whole extend, therefore the area of the canyon is considered to be at risk of further instability.

Considering above information and data available at date, definition of a geometry of area possibly subject to slope instability (surface and soil layers) is deemed not feasible.

Slope instability and sudden bathymetric change is considered as a major risk for the project development during the installation phase and for the integrity of the solution for the crossing (drilling). Long term installation of any structure and or of a jack-up over an instable seabed could lead to serious risk to the integrity of the personnel, equipment, goods and means deployed.

As the phenomena is not clearly defined, at this stage no mitigation measures can be recommended; however standard stabilisation or mitigation measures (dredging, scouring protection, soil improvement / reinforcement, etc…) are deemed, as a first approach, inappropriate considering the project and site specificities.

Therefore, Cathie Group recommends that proposed corridors, with associated envisaged trenchless solution, namely Base case, Option A, Option B and Option C, no longer to be considered as possible solution for the crossing of Capbreton canyon.