Fugro

Sillimanite D12-B Geophysical and Geotechnical Surveys

Dutch Sector, North Sea

Report 1 of 2: Sillimanite D12-B Geophysical Site and Route Survey

Volume 3 of 3: Route Survey Results

Sillimanite D12-B to D12-A and to D15-FA Routes Survey

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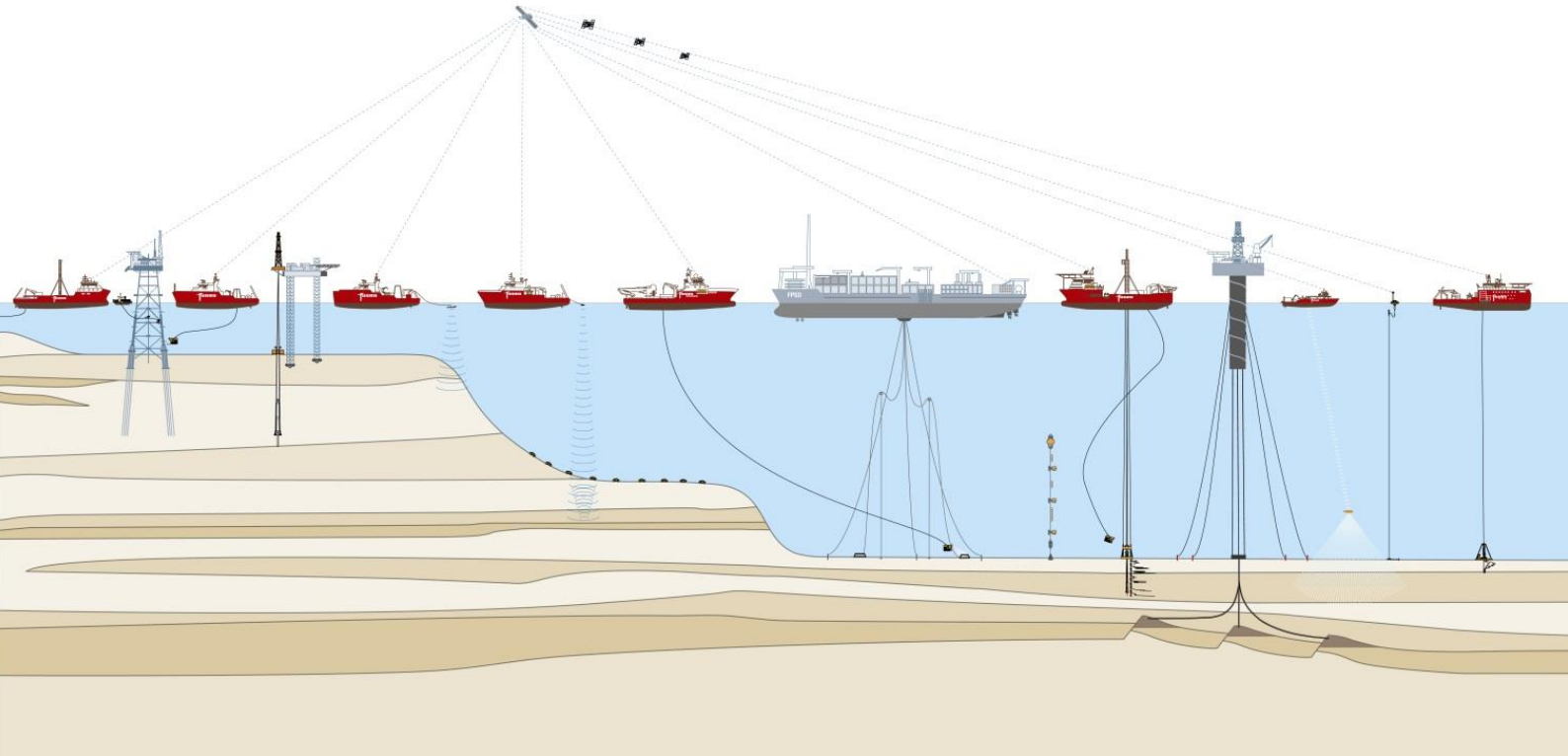
Wintershall Noordzee B.V.

Revision 1



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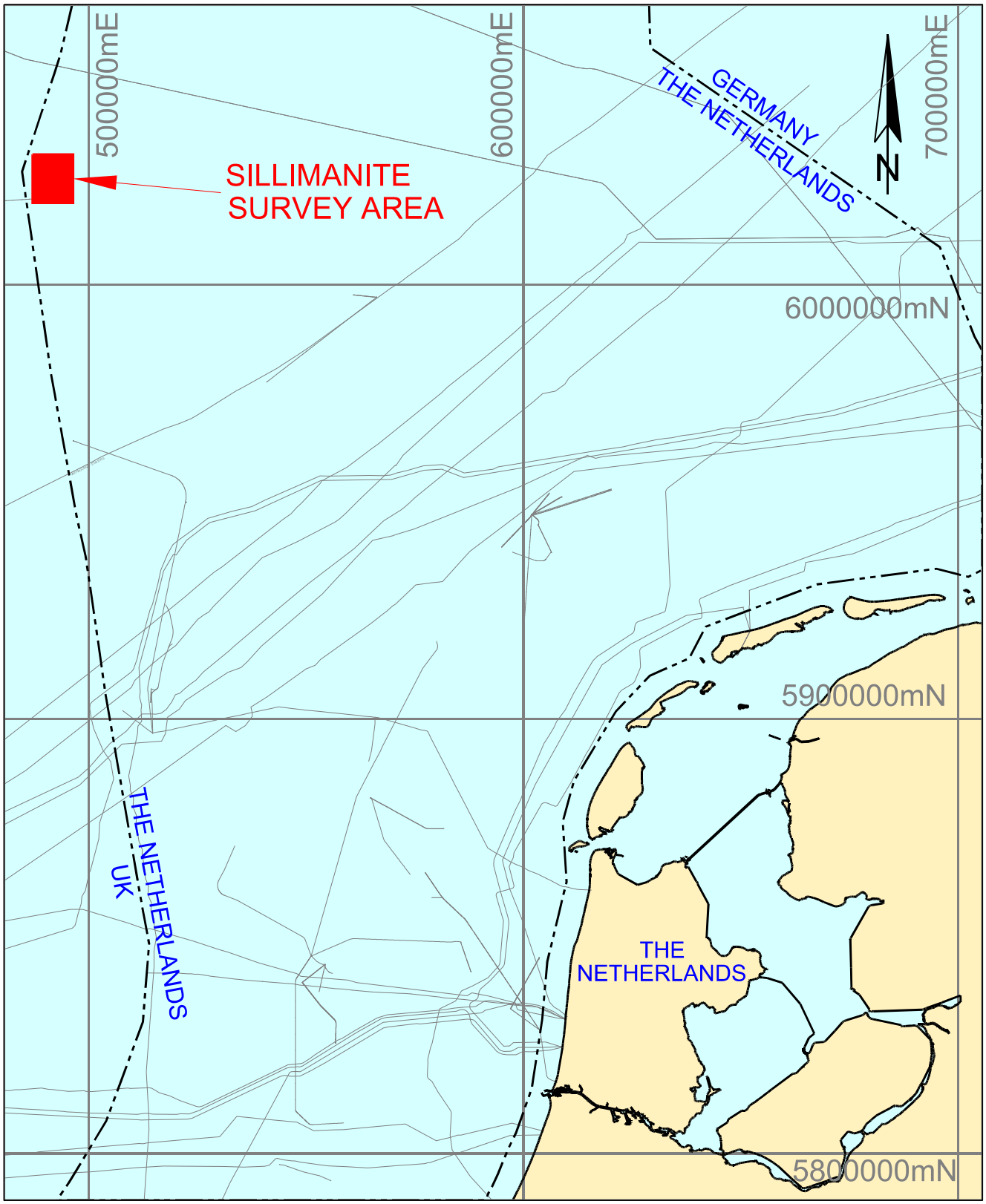
REPORT AMENDMENT SHEET

Issue No.	Report section	Page No.	Table No.	Figure No.	Description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KEYPLAN

DOCUMENT ARRANGEMENT

REPORT 1: SILLIMANITE D12-B GEOPHYSICAL SITE AND ROUTE SURVEY

VOLUME 1: OPERATIONS& CALIBRATIONS

VOLUME 2: SITE SURVEY RESULTS: SILLIMANITE D12-B SITE SURVEY

VOLUME 3: ROUTE SURVEY RESULTS

REPORT 2: GEOTECHNICAL SITE AND ROUTE SURVEY

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ABBREVIATIONS

BH	Borehole
BSF	Below seafloor
CM	Central Meridian
CPT	Cone penetrometer test
D	Debris
DE	Debris end
DS	Debris start
ED50	European Datum 1950
FAOL	Fugro Alluvial Offshore Limited
FEBV	Fugro Engineers B.V.
FSBV	Fugro Survey B.V.
LAT	Lowest Astronomical Tide
MAG	Magnetometer
MBES	Multibeam echo sounder
nmh	No measurable height
SBES	Single beam echo sounder
SBP	Sub-bottom profiler
SC	Spudcan depression
SSS	Sidescan sonar
TM	Transverse Mercator
UHRS	Ultra high resolution sparker
UTC	Universal Time Constant
UTM	Universal Transverse Mercator
VC	Vibrocore
XING	Cable or pipeline crossing

UNITS

Hz / kHz	Hertz / kilohertz
m / km	Metres / kilometres
m/s	Metres per second
s / ms	Seconds / milliseconds
T / nT	Tesla / nanotesla

EXECUTIVE SUMMARIES

Sillimanite D12-B to D12-A route

Introduction

Survey Dates:	10 to 14 April 2017
Equipment (Geophysical):	Sidescan sonar (SSS), single beam echo sounder (SBES), multibeam echo sounder (MBES), sub-bottom profiler (SBP) and ultra-high resolution sparker (UHRS)
Coordinate System:	Datum: ED50. Projection: UTM Zone 31N, CM 3°E

Bathymetry

The seafloor along the pipeline route is essentially flat, with a very gentle regional dip to the south-east (< 0.1°). Water depth ranges from 28.5 m LAT to 32.8 m LAT.

Seabed Features and Sediments

The seafloor sediments across the pipeline route consist of fine to medium SAND. The seafloor is smooth and featureless and there are no sedimentary structures present that could indicate sediment transport.
A total of fifteen (15) debris items were interpreted within the survey area. Contact S_D12_0005 and S_D12_0006 are interpreted as man-made objects with significant dimensions (23.9m x 9.4m x 1.1m and 6.5m x 3.8m x 1.4m). The origin of the remaining debris items is unknown.

Shallow Geological Conditions

The strata within the limit of SBP data penetration (the top approximately 30 m BSF), are interpreted as Saalian (Middle Pleistocene) to Holocene in age. The subsurface geology is primarily characterised by a series of sub-horizontal reflectors. Based on differences in seismic character, four (4) main seismic units were identified and these are summarised below:

Unit	Geological Formation	Seismic Horizon	Depth to base [m bsb]	Soil Description
A	New Zeeland Gronden	H10	4.0 – 14.0	Medium dense to dense fine to medium SAND, with shells and shell fragments, locally silty
B	Botney Cut	H15/H20	9.0 – 17.5	Very low strength to medium strength silty, sandy CLAY, with closely spaced very thin to thin beds of silty sand and/or sandy silt
C	Bolders Bank / Dogger Bank	H20	11.0 – >15.0	Medium strength to very high strength silty sandy CLAY or interbedded dense to very dense fine SAND and SILT
D	Cleaver Bank	H30	>30.0	Interbedded very high strength to extremely high strength slightly sandy CLAY and dense to very dense SAND, locally gravelly

Conclusions and Recommendations

The seafloor topography is flat and featureless and is not expected to cause any obstruction to the planned pipelines.

A total of fifteen (15) debris items and two (2) depressions were interpreted along the planned pipeline route.

A total of seven (7) magnetic anomalies were observed along the planned pipeline route. Two (2) anomalies possibly originate from the infrastructure associated with the D12-A platform. Three (3) anomalies are most probably caused by small ferrous objects of unknown origin in shallow burial.

Diffraction hyperbolae and/or enhanced amplitude reflections, possibly representing coarser material (e.g. shell debris, gravel), were observed at different depths within Unit A. Small-scale buried palaeochannel features and internal reflectors were observed locally within Units C and D. Lithological and strength variations in the soil properties can be expected over short distances within these units due to depositional variations (e.g. channel cut and fill, erosion surface, gravel layers).

No seismic anomalies and no faults were interpreted within the survey area. However, the presence of (especially deeper) faults cannot be fully excluded from SBP data.

No other evidence of hazards, obstructions or anomalies that may present a hazard to pipeline installation was observed within the survey area.

Sillimanite D12-B to D15-FA route

Introduction

Survey Dates:	10 to 14 April 2017
Equipment (Geophysical):	Sidescan sonar (SSS), single beam echo sounder (SBES), multibeam echo sounder (MBES), sub-bottom profiler (SBP) and ultra-high resolution sparker (UHRS)
Coordinate System:	Datum: ED50. Projection: UTM Zone 31N, CM 3°E

Bathymetry

The seafloor along the pipeline route is essentially flat, with a very gentle regional dip to the south-east (< 0.1°). Water depth ranges from 28.4 m LAT to 40.9 m LAT.

Seabed Features and Sediments

The seafloor sediments across the D12-B survey area consist of fine to medium SAND. The seafloor is smooth and featureless and there are no sedimentary structures present that could indicate sediment transport.
Seventeen (17) debris items, two (2) wet stored mattresses and one (1) depression were observed within the survey area. The sonar contact S_D15_0007 is interpreted as a possible wooden wreck (8.8m x 2.7m x 0.7m). The origin of the remaining debris items is unknown.

Shallow Geological Conditions

The strata within the limit of SBP data penetration (the top approximately 30 m BSF), are interpreted as Saalian (Middle Pleistocene) to Holocene in age. The subsurface geology is primarily characterised by a series of sub-horizontal reflectors. Based on differences in seismic character, four (4) main seismic units were identified and these are summarised below:

Unit	Geological Formation	Seismic Horizon	Depth to base [m bsb]	Soil Description
A	New Zeeland Gronden	H10	3.5 – 15.0	Medium dense to dense fine to medium SAND, with shells and shell fragments, locally silty
B	Botney Cut	H15/H20	13.0 – 16.5	Very low strength to medium strength silty, sandy CLAY, with closely spaced very thin to thin beds of silty sand and/or sandy silt
C	Bolders Bank / Dogger Bank	H20	9.5 – >25.0	Medium strength to very high strength silty sandy CLAY or interbedded dense to very dense fine SAND and SILT
D	Cleaver Bank	H30	>30.0	Interbedded very high strength to extremely high strength slightly sandy CLAY and dense to very dense SAND, locally gravelly

Conclusions and Recommendations

The seafloor topography is flat and featureless and is not expected to cause any obstruction to the planned pipelines.

A total of twenty (20) sonar contacts were interpreted along the planned pipeline route.

A total of twenty (20) magnetic anomalies were observed along the planned pipeline route. Two (2) anomalies possibly originate from the infrastructure associated with the D15-FA platform. Eight (8) anomalies were caused by existing infrastructure. The remaining anomalies are most likely caused by small ferrous objects of unknown origin in shallow burial.

Diffraction hyperbolae and/or enhanced amplitude reflections, possibly representing coarser material (e.g. shell debris, gravel), were observed at different depths within Unit A. Small-scale buried palaeochannel features and internal reflectors were observed locally within Units C and D. Lithological and strength variations in the soil properties can be expected over short distances within these units due to depositional variations (e.g. channel cut and fill, erosion surface, gravel layers).

No seismic anomalies and no faults were interpreted within the survey area. However, the presence of (especially deeper) faults cannot be fully excluded from SBP data.

No other evidence of hazards, obstructions or anomalies that may present a hazard to pipeline installation was observed within the survey area.

1. INTRODUCTION

Wintershall Noordzee B.V. is planning to develop Sillimanite D12 Block in the Dutch Sector of the North Sea. Wintershall Noordzee B.V. contracted Fugro to perform geophysical and geotechnical surveys at the proposed D12-B well site and along two proposed pipeline routes between the proposed D12-B well location and the D12-A platform location and between the proposed D12-B well location and the D15-FA platform location.

This report comprises results of the geophysical route surveys.

The purpose of the survey was to identify any shallow geological or topographical conditions which could pose a risk to this infrastructure installation.

The objectives of the project can be summarised as follows:

- establish water depths reduced to Lowest Astronomical Tide (LAT);
- identify seafloor features and obstructions (debris clearance);
- identify the sub-surface stratigraphy.

Fugro conducted this survey between 10 and 14 April 2017. M.V. Fugro Frontier was used as the survey vessel.

The survey was performed by deploying multibeam echo sounder (MBES), single beam echo sounder (SBES), high resolution sidescan sonar (SSS), sub-bottom profiler (SBP), and multichannel ultra-high resolution (UHR) seismic equipment.

In addition to the geophysical survey, a geotechnical investigation (sampling and CPT testing) was carried out along both routes (Ref. 1).

The start and end coordinates of the proposed D12-B to D12-A and D12-B to D15-FA are specified in Table 1.1 and Table 1.2 respectively.

Table 1.1: Start and end coordinates of the proposed D12-B to D12-A route

Datum ED50, UTM Zone 31 N				
Location	**Latitude North**	**Longitude East**	**Easting [m]**	**Northing [m]**
Start Route (D12-B side)	54° 24’ 37.17”	002° 48’ 52.00”	487956	6029322
End Route (D12-A side)	54° 20’ 20.35”	002° 52’ 10.81”	491526	6021376

Table 1.2: Start and end coordinates of the proposed D12-B to D15-FA route

Datum ED50, UTM Zone 31 N				
Location	**Latitude North**	**Longitude East**	**Easting [m]**	**Northing [m]**
Start Route (D12-B side)	54° 24’ 34.73”	002° 48’ 45.45”	487838	6029247
End Route (D15-FA side)	54° 19’ 18.85”	002° 56’ 25.43”	496123	6019469

All coordinates in this report are, unless otherwise specified, in International Spheroid 1924, Datum ED 50, projection type Universal Transverse Mercator, Zone 31 North.

All final depths are reduced for tide to Lowest Astronomical Tide (LAT) using post processed GNSS height data. All GNSS heights are referenced to LAT by using the Danish Technical University 2010 (DTU10MSS) model in combination with the Dienst Hydrografie MSL to LAT model. The time zone was GMT + 1 hour.

2. RESULTS

The following results should be read in conjunction with the D12-B to D12-A route and the D12-B to D15-FA route **Alignment Charts** in Appendix A.1 and Appendix A.2 respectively.

2.1 D12-B to D12-A Route Survey

2.1.1 Bathymetry

The water depths recorded during the survey along the proposed D12-B to D12-A route ranges between 28.5 m LAT and 32.8 m LAT with the seabed gently deepening to the south east. Localised variations in water depths occur due to scouring of up to 1.5 m depth around the D12-A Platform location.

Refer to Figure 2.1 for a cross profile showing the depth below LAT along the route and to Figure 2.2 for an overview of the bathymetry within the survey area.

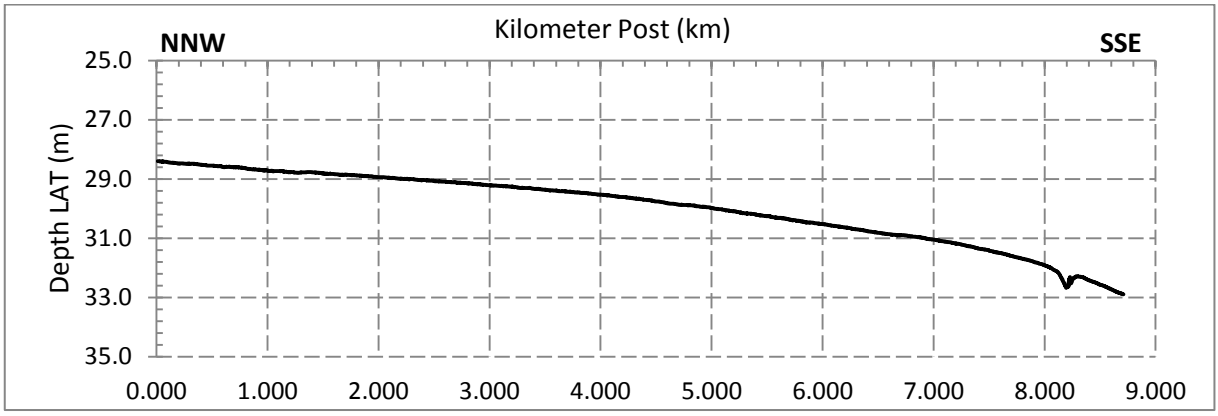


Figure 2.1: Cross profile along the D12-B to D12-A route

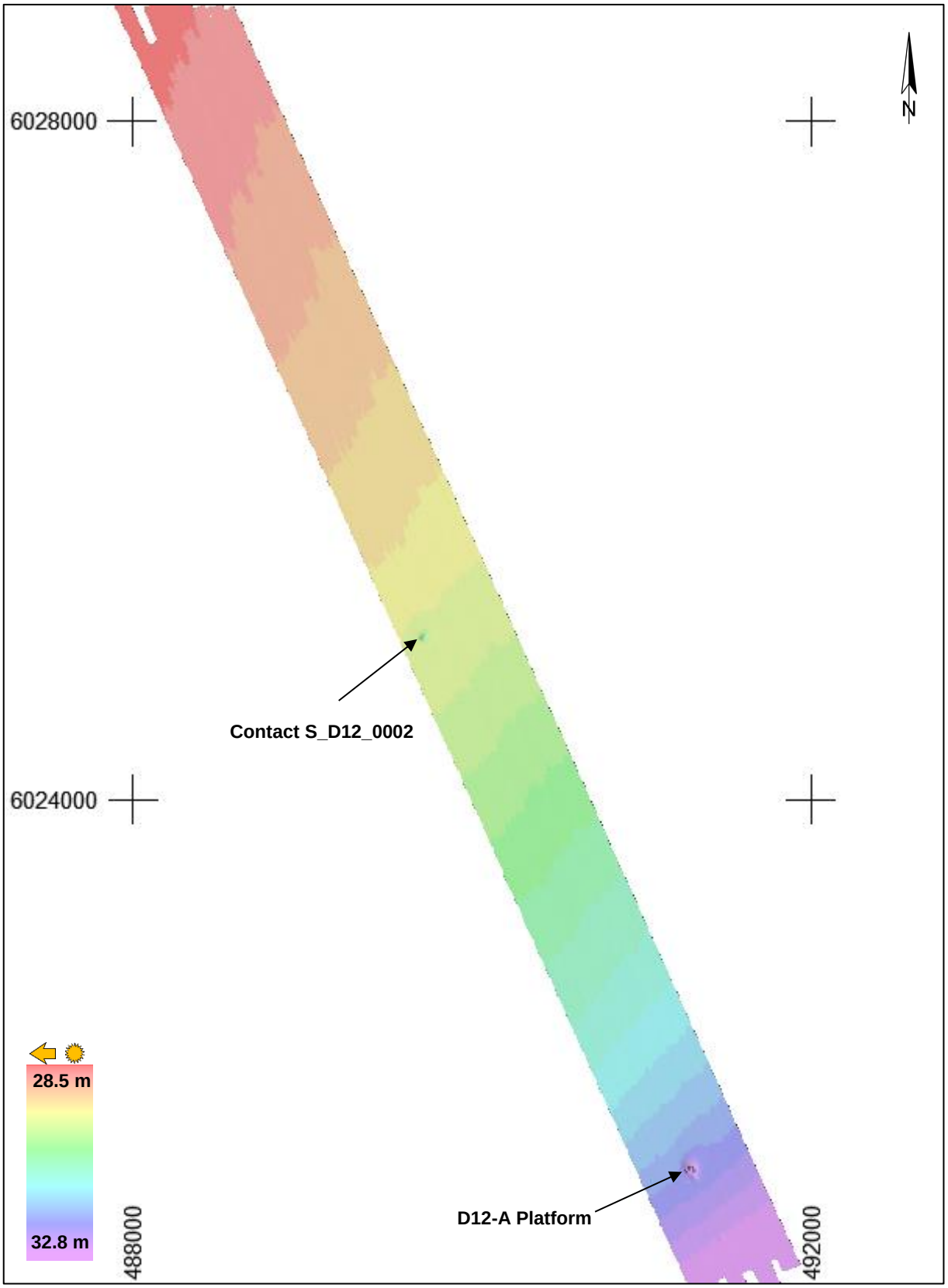


Figure 2.2: MBES image of the D12-B to D12-A route survey corridor

2.1.2 Seafloor Features, Sediments and Contacts

The sidescan sonar records show a featureless seafloor with a low to medium reflectivity, interpreted as a continuous cover of fine to medium SAND, and is consistent with the CPT results from the geotechnical campaign (Ref. 1). No sedimentary structures indicating sediment transports were observed, apart from scouring around the D12-A platform and contact S_D12_0005.

A total of fifteen (15) debris items and two (2) depressions were interpreted within the survey area.

Contact S_D12_0005 is a large man-made object that could be identified in the SSS, MBES and the SBP data. Based on the SBP data it appears to be partly buried. The seabed is scoured around the object. An area with further debris associated with the object was observed directly to the south (Contact S_D12_0006). Refer to Figure 2.3 for an SSS data example.

The pipeline route terminates close to the existing D12-A platform. A rock dump and mattress sections were observed around the platform. Several debris items were interpreted in the vicinity of the platform. Refer to Figure 2.4 for a data example of the SSS data around the D12-A platform.

Refer to Table 2.1 for further details about the observed SSS contacts.

Table 2.1: Sidescan sonar contacts in the D12-B to D12-A route survey

KP	DCC	Easting	Northing	SSS Target	Comments/Dimensions (L x W x H)
	[m]	[m]	[m]	ID	[m]
2.783	23.4	489280	6026318	S_D12_0001	Depression; 2.2 x 1.9 x 0.2
4.200	178.7	489719	6024962	S_D12_0002	Debris; 23.9 x 9.4 x 1.1
4.207	190.9	489711	6024950	S_D12_0003	Area with debris associated with S_D12_0002; 6.5 x 3.8 x nmh
5.914	−193.6	490761	6023551	S_D12_0004	Debris; 2.0 x 0.4 x 0.1
5.916	−124.8	490699	6023521	S_D12_0005	Debris; 2.4 x 1.0 x 0.2
7.469	−17.7	491238	6022060	S_D12_0006	Debris; 2.3 x 0.9 x nmh
7.684	−19.0	491327	6021865	S_D12_0007	Debris in 0.2 m deep depression; 2.1 x 1.4 x nmh
7.671	42.4	491266	6021851	S_D12_0008	Debris; 1.1 x 0.4 x 0.1
7.672	72.3	491239	6021838	S_D12_0009	Debris; 3.0 x 1.3 x nmh
7.796	26.9	491331	6021744	S_D12_0010	Debris; 1.7 x 0.5 x nmh
7.912	102.2	491310	6021607	S_D12_0011	Debris in 0.2 m deep depression; 1.3 x 0.9 x 0.2
8.141	91.0	491414	6021403	S_D12_0012	Debris in 0.25 m deep depression; 1.6 x 0.9 x 0.4
8.141	100.8	491405	6021399	S_D12_0013	Depression; 1.1 x 1.1 x 0.2 m
8.157	33.5	491473	6021412	S_D12_0014	Debris in 0.5 m deep depression; 1.1 x 1.1 x nmh

Figure 2.3: SSS record of Contact S_D12_0005 and S_D12_0006 in the D12-B to D12-A route survey

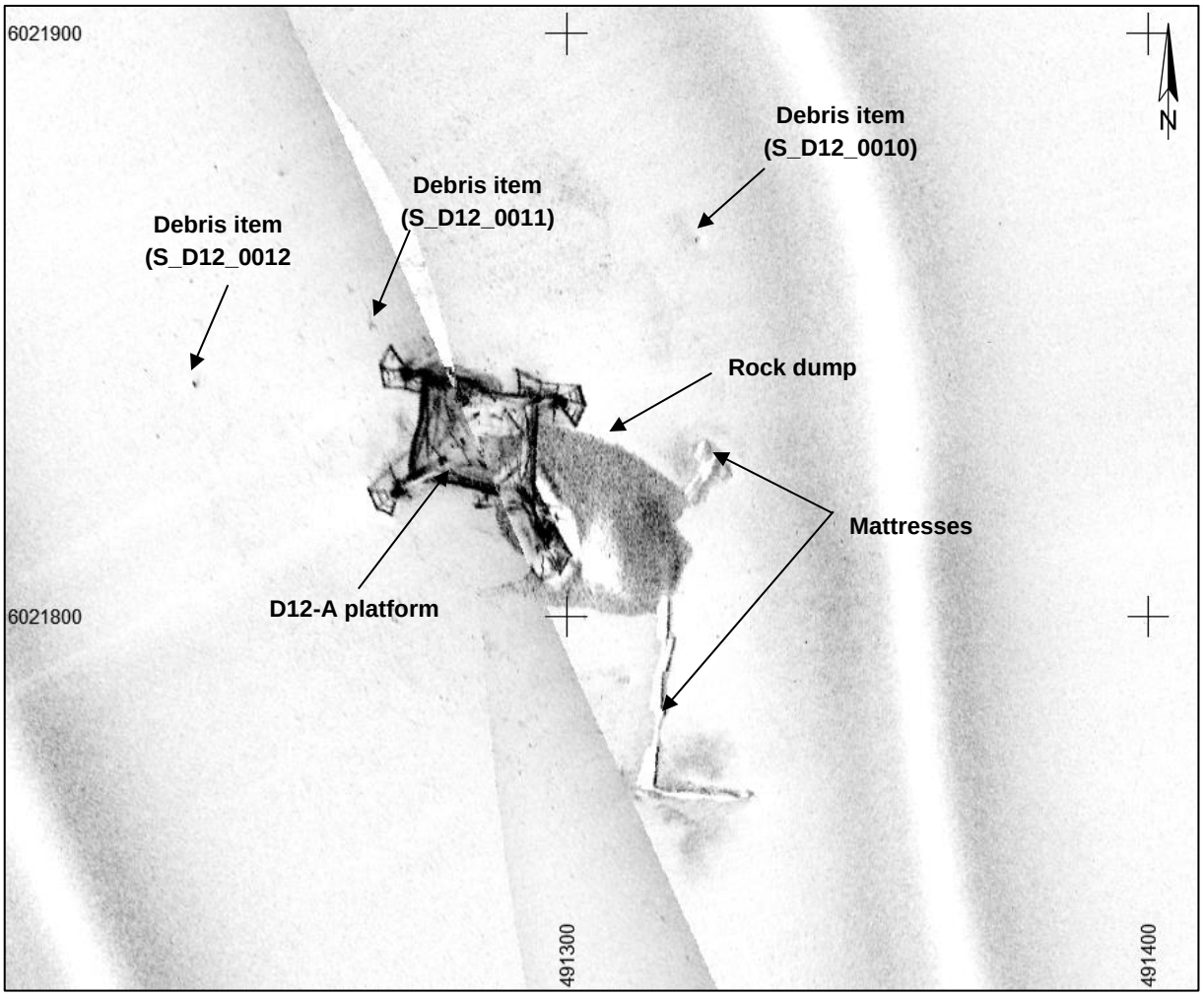


Figure 2.4: SSS mosaic image of the D12-B to D12-A pipeline route end at the D12-A platform area

2.1.3 Pipelines and Cables

The D12-A to D15-FA 10 inch pipeline and 3 umbilical approach the D12-A platform from the east. The umbilical makes a loop to the north before reaching the platform.

2.1.4 Magnetic Anomalies

A magnetometer survey was conducted along the centre line of the D12-B to D12-A route by running two survey lines in opposite directions. A total of seven (7) magnetic anomalies were observed from the data. Two (2) anomalies, M_D12_06 and M_D12_07 were recorded close to the D12-A platform and possibly originate from the infrastructure associated with the platform.

The anomalies M_D12_01, M_D12_02 and M_D12_03 had no corresponding sidescan sonar contacts and are most probably caused by small ferrous objects of unknown origin in shallow burial. The anomalies, M_D12_04 and M_D12_05 were recorded close to the D12-A platform and possibly originate from the infrastructure associated with the D12-A platform. The anomalies M_D12_06 and M_D12_07 were interpreted to be caused by the existing D12-A to D15-FA-1 10 inch pipeline.

Refer to Table 2.2 for further details about the observed magnetic contacts.

Table 2.2: Magnetometer anomalies in the D12-B to D12-A route

Datum ED50, UTM Zone 31 N								
MAG Target	**Easting**	**Northing**	**KP**	**DCC**	**Amplitude**	**Monopole / Dipole**	**Line**	**Comments**
	[m]	**[m]**		**[m]**	**[nT]**			
M_D12_01	489214	6026504	2.586	7.8	4.9	Dipole	D12CL	
M_D12_02	489626	6025583	3.595	8.86	2.7	Dipole	D12CL	
M_D12_03	491156	6022191	7.316	2.91	18.3	Dipole	D12CLma	
M_D12_04	491309	6021897	7.647	-15.56	99	Dipole	D12CLma	Near platform
M_D12_05	491316	6021889	7.657	-18.89	16.6	Dipole	D12CLma	Near platform
Infrastructure								
M_D12_06	491360	6021760	7.793	-6.1	24	Dipole	D12CLa	D12-A to D15-FA-1 10 inch pipeline
M_D12_07	491389	6021759	7.806	-32.1	32	Dipole	D12CLma	D12-A to D15-FA-1 10 inch pipeline
Notes: Due to the characteristics and detection spectrum of 1-channel magnetometer, the position of anomalies stated above should be treated as approximate.								

2.1.5 Shallow Geology

The shallow geological interpretation was based on single channel pinger (SBP) data.

This section should be read in conjunction with the **Alignment Charts** in Appendix A.1.

The Sillimanite D12-B to D12-A route survey area is located in the central part of the North Sea basin and the shallow geology comprises sediments that were deposited during a number of Quaternary glacials and interglacials. The strata within the top approximately 30 m BSF (the limit of SBP data penetration), are interpreted as Saalian (Middle Pleistocene) to Holocene in age.

The subsurface geology is primarily characterised by a series of sub-horizontal reflectors. Based on differences in seismic character, four (4) main seismic units were identified (see Table 2.3).

Table 2.3: Summary of shallow geological conditions along the pipeline routes

Age	Unit	Geological Formation	Basal Horizon	Depth to base [m BSF]	Soil Description
Holocene	A	New Zeeland Gronden	H10	4.0 – 14.0	Medium dense to dense fine to medium SAND, with shells and shell fragments, locally silty
Late Weichselian	B	Botney Cut	H15/H20	9.0 – 17.5	Very low strength to medium strength silty, sandy CLAY, with closely spaced very thin to thin beds of silty sand and/or sandy silt
Weichselian	C	Bolders Bank / Dogger Bank	H20	11.0 – >15.0	Medium strength to very high strength silty sandy CLAY or interbedded dense to very dense fine SAND and SILT
Saalian	D	Cleaver Bank	-	>30.0	Interbedded very high strength to extremely high strength slightly sandy CLAY and dense to very dense SAND, locally gravelly

Note:
- No geotechnical data are available from Unit C , description based on Ref. 2
- Soil description for Units B and D based on Ref.1
- Depths in metres BSF are approximations

Seismic Unit A (New Zeeland Gronden Fm. - Holocene)

Unit A is the uppermost interpreted seismic unit, observed throughout the entire survey area. The unit is characterised by semi-transparent horizontal, parallel, low amplitude reflections. Within this unit, reflection hyperbolae or high-amplitude reflections are observed on the SBP data, suggesting the presence of coarser material, e.g. shells debris or gravel. The high-amplitude reflections occur at various depths, primarily between KP 1.0 and KP 2.0 (Figure 2.5).

Unit A represents Holocene marine sediments that were deposited during the last postglacial transgression. The unit comprises fine to medium SAND, locally very silty, as shown by the results of sampling and CPT testing performed within the survey area (see Report 3, Ref. 1).

The base of Unit A (Horizon H10) is a sub-horizontal surface, interpreted as erosional, and the unit has a thickness that ranges between approximately 4.0 m and 13.6 m.

Seismic Unit B (Botney Cut Fm. – Late Weichselian)

Unit B is characterised by acoustically well-bedded, continuous high amplitude reflections (see Figure 2.5).

Unit B is interpreted as the Botney Cut Formation, deposited in a glaciolacustrine environment. The unit comprises very low strength to medium strength silty, sandy CLAY, often with lamination and/or thin beds of sand/silt (Ref.1).

The unit is present only in the northern part of the pipeline route, until approximately KP 1.8.

Seismic Unit C (Bolders Bank / Dogger Bank Fm.– Weichselian)

Unit C is variable internally as observed on the SBP data. Locally, the unit is characterised by a chaotic acoustic nature with variable diffuse/low (but locally high) amplitudes. Locally, the unit shows bedded nature, with semi-continuous, horizontal but mostly inclined reflections of low to moderate amplitude. Within the unit internal erosion surface(s) can be observed (see Figure 2.6).

The top of Unit C is an erosion surface, truncated by the base of Unit A. The unit is locally absent and the base of Unit A (Horizon H10) directly overlies Unit D. The unit pinches-out towards the north-west between two unconformities (Horizons H15 and H20).

Unit C is interpreted to represent glacial deposits of the Bolders Bank and/or Dogger Bank Formations. The two formations have not been differentiated. No geotechnical data are available from this unit. Public domain sources indicate that the unit most likely comprises interbedded dense to very dense fine SAND and SILT and/or medium strength to very high strength silty sandy CLAY.

Seismic Unit D (Cleaver Bank Fm - Saalian)

Unit D is characterised by a chaotic seismic facies, with locally semi-transparent and locally high-amplitude reflections. The horizon that marks the top of this unit (Horizon H20) is characterised by high amplitude reflections.

Internal channelling features and diffractions with high amplitudes can be observed locally within the unit, the latter could be indicative of the presence of coarser material (e.g. gravel). Locally, internal high-amplitude reflectors can be observed, indicating that unit is variable internally (see Figure 2.6).

This unit is interpreted to represent the Cleaver Bank Formation, which was deposited in glaciomarine and glaciolacustrine depositional environment, with minor intercalations of glacial deposits. The unit comprises stiff to hard sandy CLAY with interbeds of dense to very dense SAND, locally gravelly (Ref.1).

The depth to the base of Unit D lies beyond the penetration depth of the SBP data.

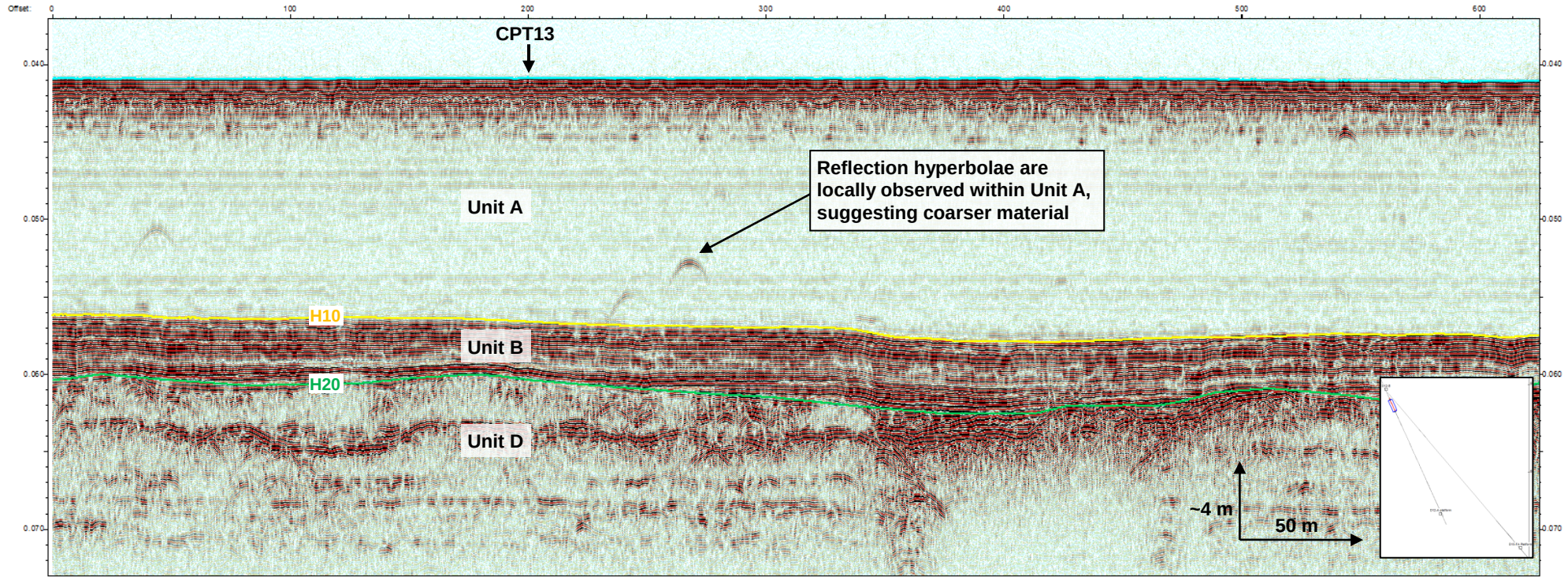


Figure 2.5: SBP data example on line D12CL_SBP_merged

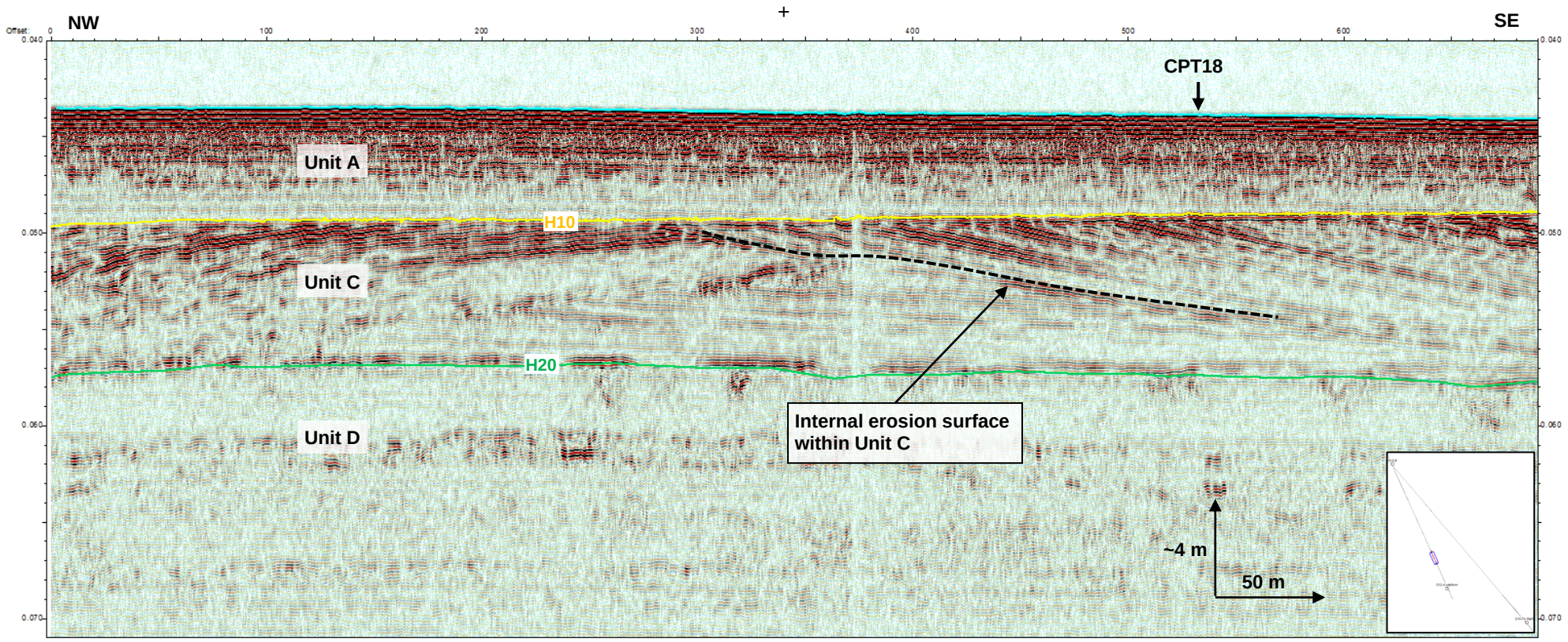


Figure 2.6: SBP data example on line D12CL_SBP_merged

2.2 D12-B to D15-FA Route Survey

2.2.1 Bathymetry

The water depths recorded during survey along the proposed D12-B to D15-FA route ranges between 28.4 m LAT and 40.9 m LAT with the seabed gently deepening to the south east. Localised variations in water depths occur due to scouring of up to 1.0 m depth around the D15-FA platform location.

Refer to Figure 2.7 for a cross profile along the route and to Figure 2.8 an overview of the bathymetry within the survey area.

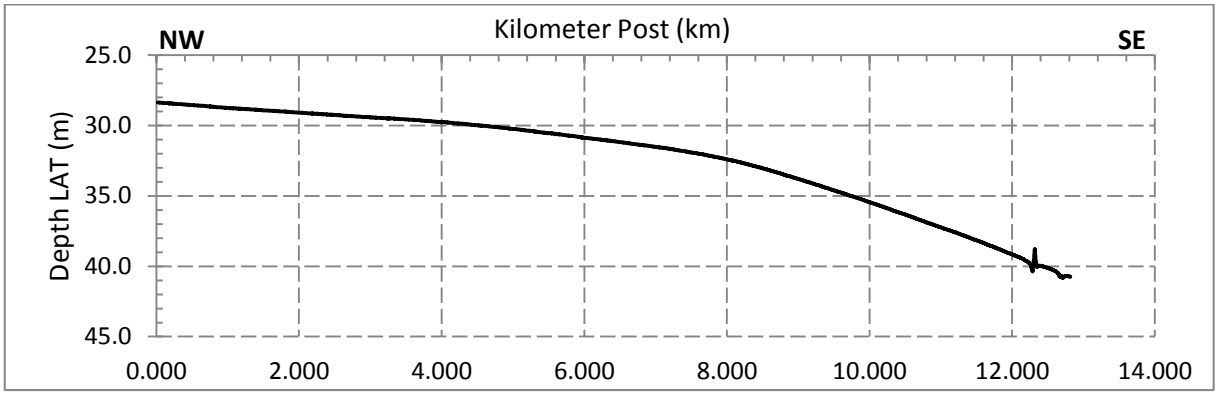


Figure 2.7: Cross profile along the D12-B to D15-FA route

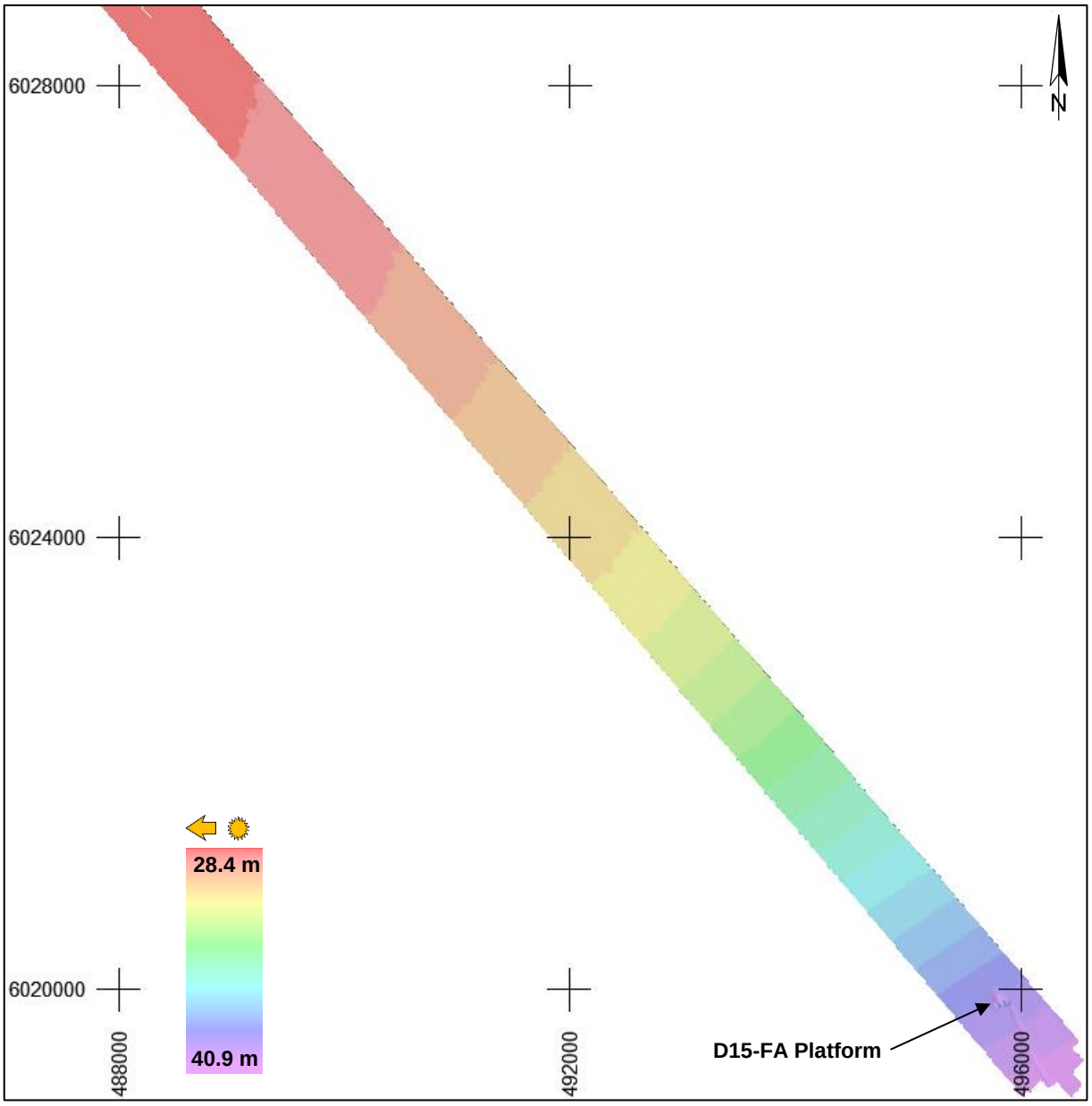


Figure 2.8: MBES image of the D12-B to D15-FA route survey corridor

2.2.2 Seafloor Features, Sediments and Contacts

The sidescan sonar records show a featureless seafloor with a low to medium reflectivity, interpreted as a continuous cover of fine to medium SAND, and is consistent with the CPT results from the geotechnical campaign (Ref.1). No sedimentary structures indicating sediment transports were observed, apart from scouring around the D15-FA platform.

A total of twenty (20) sonar contacts were interpreted along the route. Refer to Table 2.4 for further details about the observed objects.

Table 2.4: Sidescan sonar contacts in the D12-B to D15-FA route survey

KP	DCC	Easting	Northing	SSS Target	Comments/Dimensions (L x W x H)
	[m]	[m]	[m]	ID	[m]
0.260	32.5	488304	6028647	S_D15_0001	Debris; 3.4 x 1.1 x 0.2
0.461	-357.4	488732	6028745	S_D15_0002	Debris; 1.9 x 1.1 x 0.1
0.648	-267.2	488784	6028544	S_D15_0003	Debris; 6.9 x 2.5 x 0.3 (Debris in 0.3 m deep depression)
1.977	163.7	489314	6027252	S_D15_0004	Debris; 2.0 x 1.5 x 0.7
3.833	33.6	490613	6025920	S_D15_0005	Debris; 1.0 x 0.4 x 0.3
4.366	-67.3	491035	6025578	S_D15_0006	Debris; 3.4 x 0.8 x nmh
5.934	52.2	491957	6024305	S_D15_0007	Wreck; 8.8 x 2.7 x 0.7 Possibly wooden wreck. Also in database Dienst der Hydrografie.
6.643	-254.8	492650	6023962	S_D15_0008	Debris; 3.1 x 1.3 x 0.2
9.815	-28.1	494527	6021396	S_D15_0009	Debris; 0.9 x 0.3 x nmh
9.819	333.4	494254	6021159	S_D15_0010	Debris; 2.0 x 1.0 x 0.4
9.831	-278.6	494729	6021545	S_D15_0011	Depression 3.7 x 1.1 x 0.2 m deep
10.954	-324.6	495490	6020718	S_D15_0012	Debris; 3.0 x 1.8 x 0.3
11.084	72.0	495271	6020363	S_D15_0013	Debris; 3.8 x 1.4 x 0.6 Debris in 0.4 m deep depression
11.168	-37.2	495409	6020369	S_D15_0014	Debris; 1.9 x 0.5 x 0.1
11.452	-13.1	495574	6020137	S_D15_0015	Debris; 2.0 x 1.0 x 0.1
11.601	27.8	495639	6019997	S_D15_0016	Possible debris; 2.1 x 0.7 x nmh
11.755	-33.2	495785	6019919	S_D15_0017	Debris; 1.2 x 0.9 x nmh
11.835	29.7	495789	6019817	S_D15_0018	Debris; 1.3 x 0.5 x 0.2 Debris near platform rock dump
11.836	28.2	495791	6019817	S_D15_0019	Debris; 1.4 x 0.7 x 0.1 Debris near platform rock dump
11.978	-90.6	495973	6019786	S_D15_0020	Wet-stored mattress; 5.4 x 3.1 x nmh
11.983	-95.3	495980	6019785	S_D15_0021	Wet-stored mattress 5.6 x 3.4 x nmh
12.376	32.5	495917	6019217	S_D15_0022	Debris; 4.7 x 0.7 x 0.1

Contact S_D15_0007 is a large object that could be identified on both SSS and MBES data. A possible wooden wreck is listed at 3 m distance from the observed contact (at Easting 491955, Northing 6024300) in the database of the Dienst der Hydrografie van de Koninklijke Marine. It is likely that this listing concerns the same object as was detected during the survey. Refer to Figure 2.9 for an SSS data example.

In the southern part of the route frequent patches of higher SSS reflectivity indicate the presence of pockets of coarser sediments. Refer to Figure 2.10 for a data example. Herring spawn on gravel and similar habitats (e.g. coarse sand, maerl, shell) where there is a low proportion of fine sediment and well-oxygenated water (Ref. 4). So, the observed patches are suitable herring spawning grounds.

A number of trawl scars cross the southern part of the route in a west to east direction. These features display minimal disturbance to the seabed and therefore their influence on seabed conditions is negligible.

The pipeline route terminates close to the existing D15-FA platform (Figure 2.11). The platform is surrounded by rock dump and mattress sections. A total of five (5) pipelines and two (2) umbilicals approach the platform from the west. The D15-FA to L10-AC 36 inch pipeline approaches the platform from the east and lies exposed towards the south-east of the platform.

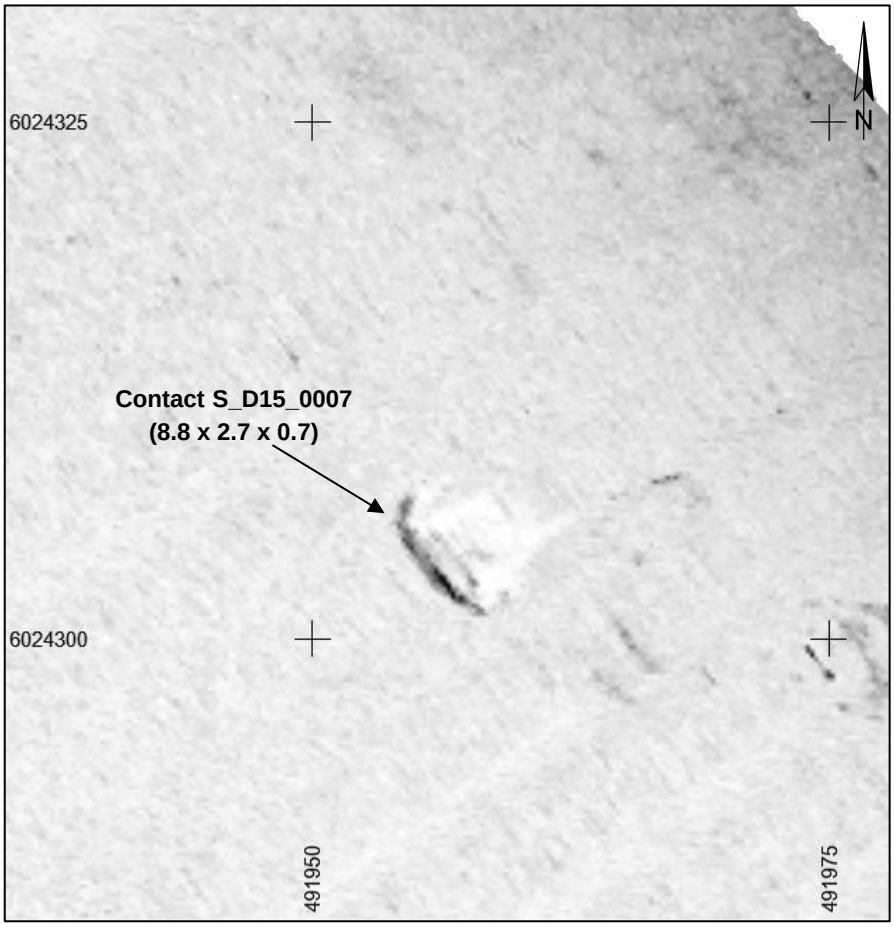


Figure 2.9: SSS record of contact S_D15_0007, a possible wooden wreck, within the D12-B to D15-FA route survey area

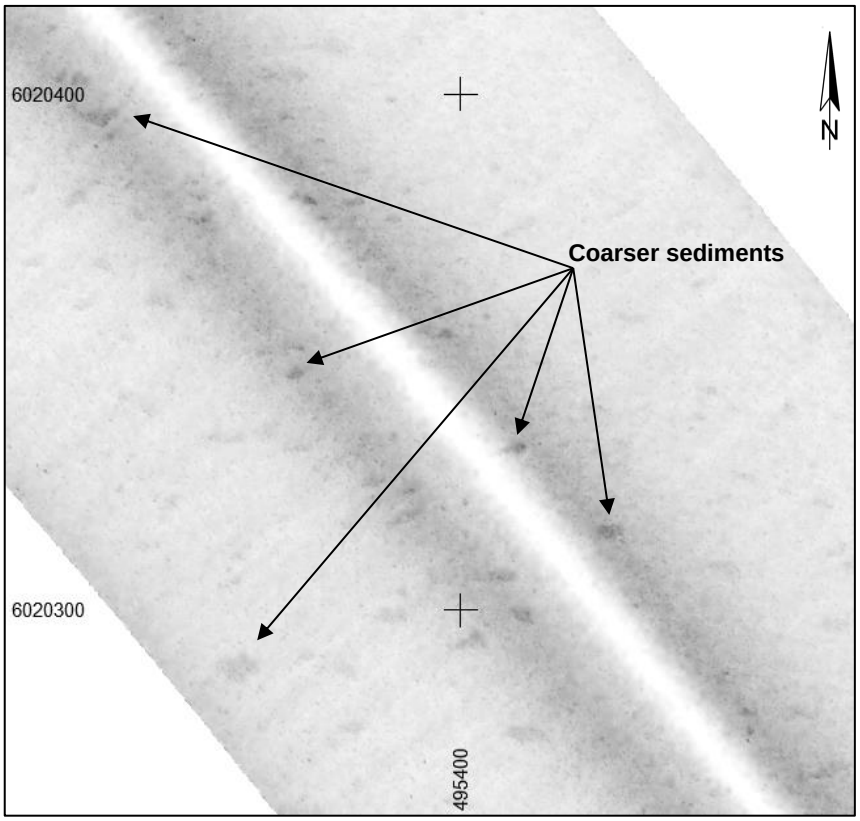


Figure 2.10: SSS record of patches of higher reflectivity, interpreted as pockets of coarser sediments, within the D12-B to D15-FA route survey area

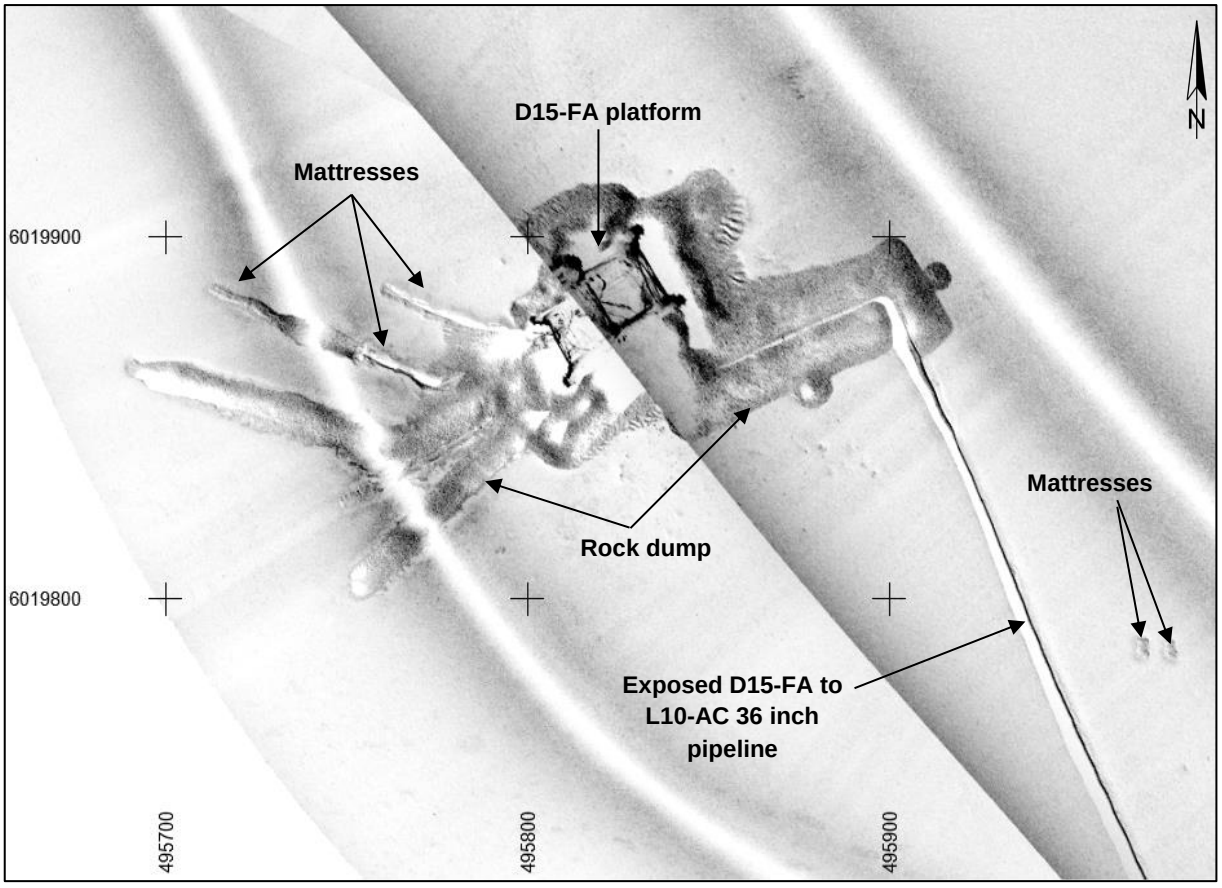


Figure 2.11: SSS record of the D12-B to D15-FA route end at the D15-FA platform area

2.2.3 Pipelines and Cables

The following pipelines and umbilicals connect to the D15-A platform from the west:

- D12-A to D15-FA 13 inch umbilical;
- D12-A to D15-FA-1 10 inch pipeline;
- Wingate to D15-FA-1 12/2 inch bundle;
- Minke to D15-FA 8 inch pipeline;
- D15-FA to Minke 3inch umbilical;
- D18a-A to D15-A 8 inch pipeline;
- D18a-A to D15-A 2 inch umbilical.

One pipeline approaches the platform from the east and lies exposed towards south-east of the platform:

- D15-FA to L10-A 36 inch pipeline.

2.2.4 Magnetic Anomalies

A magnetometer survey was conducted along the centre line of the D12-B to D15-FA route by running two survey lines in opposite directions. A total of twenty (20) magnetic anomalies were observed along the route. A number of anomalies are likely to originate from the same object as they were recorded from both survey lines. Two anomalies, M_D15_11 and M_D15_12 were recorded close to the D15-FA platform and possibly originate from the infrastructure associated with the platform.

Eight (8) anomalies were caused by existing infrastructure. The rest of the anomalies had no corresponding sidescan sonar contacts and are most likely caused by small ferrous objects of unknown origin in shallow burial.

Refer to Table 2.5 for further details of the observed magnetic contacts.

Table 2.5: Magnetometer anomalies in the D12-B to D15-FA route

Datum ED50, UTM Zone 31 N								
MAG Target	**Easting**	**Northing**	**KP**	**DCC**	**Ampli-tude**	**Monopole / Dipole**	**Line**	**Comments**
	[m]	**[m]**		**[m]**	**[nT]**			
M_D15_01	488493	6028466	0.520	5.5	4.1	Dipole	D15CLm	
M_D15_02	488780	6028124	0.966	7.3	3.6	Dipole	D15CLm	
M_D15_03	490850	6025683	4.167	6.0	11.4	Monopole	D15CLa	Same anomaly as M_D15_04
M_D15_04	490852	6025679	4.171	7.6	10	Monopole	D15CLm	Same anomaly as M_D15_03
M_D15_05	492370	6023893	6.515	3.5	4.6	Monopole	D15CLm	
M_D15_06	492377	6023884	6.527	4.1	5.6	Dipole	D15CLm	
M_D15_07	492931	6023225	7.387	7.8	9.4	Dipole	D15CLa	Same anomaly as M_D15_08
M_D15_08	492935	6023224	7.391	5.1	10.1	Dipole	D15CLm	Same anomaly as M_D15_07

Datum ED50, UTM Zone 31 N								
MAG Target	**Easting**	**Northing**	**KP**	**DCC**	**Ampli-tude**	**Monopole / Dipole**	**Line**	**Comments**
	[m]	**[m]**		**[m]**	**[nT]**			
M_D15_09	494442	6021440	9.726	8.3	5.4	Dipole	D15CLa	Same anomaly as M_D15_10
M_D15_10	494448	6021442	9.729	2.7	22.2	Dipole	D15CLm	Same anomaly as M_D15_09
M_D15_11	495808	6019771	11.883	44.7	72.4	Dipole	D15CLa.1	Near platform
M_D15_12	495819	6019765	11.894	40.4	74.7	Dipole	D15CLa.1	Near platform
Infrastructure								
M_D15_13	495706	6019888	11.727	47.2	2.8	Dipole	D15CLa.1	D12-A to D15-FA-1 10 inch pipeline
M_D15_14	495740	6019873	11.761	30.9	43.6	Dipole	D15CLma	D12-A to D15-FA-1 10 inch pipeline
M_D15_15	495754	6019847	11.790	37.0	138.9	Dipole	D15CLma	Wingate to D15-FA-1 12/2 inch bundle
M_D15_16	495742	6019827	11.797	59.1	27.5	Dipole	D15CLa.1	Minke to D15-FA 8/3 inch bundle
M_D15_17	495769	6019825	11.816	39.8	94.1	Dipole	D15CLma	D18a-A to D15-A 8/2 inch bundle
M_D15_18	495755	6019812	11.817	58.9	40.4	Dipole	D15CLa.1	D18a-A to D15-A 8/2 inch bundle
M_D15_19	496032	6019584	12.170	-5.1	656.2	Dipole	D15CLa.1	D15-FA to L10-AC 36 inch pipeline
M_D15_20	496034	6019577	12.177	-2.1	1008.6	Dipole	D15CLma	D15-FA to L10-AC 36 inch pipeline
Note: Due to the characteristics and detection spectrum of 1-channel magnetometer, the position of anomalies stated above should be treated as approximate.								

2.2.5 Shallow Geology

The shallow geological interpretation was based on single channel pinger (SBP) data.

This section should be read in conjunction with the **Alignment Charts** in Appendix A.2.

The Sillimanite D12-B to D15-FA survey area is located in the central part of the North Sea basin and the shallow geology comprises sediments that were deposited during a number of Quaternary glacials and interglacials. The strata within the top approximately 30 m BSF (the limit of SBP data penetration), are interpreted as Saalian (Middle Pleistocene) to Holocene in age.

The subsurface geology is primarily characterised by a series of sub-horizontal reflectors. Based on differences in seismic character, four (4) main seismic units were identified: (see Table 2.6).

Table 2.6: Summary of shallow geological conditions along the pipeline routes

Age	Unit	Geological Formation	Basal Horizon	Depth to base [m BSF]	Soil Description
Holocene	A	New Zeeland Gronden	H10	3.5 – 15.0	Medium dense to dense fine to medium SAND, with shells and shell fragments, locally silty
Late Weichselian	B	Botney Cut	H15/H20	13.0 – 16.5	Very low strength to medium strength silty, sandy CLAY, with closely spaced very thin to thin beds of silty sand and/or sandy silt
Weichselian	C	Bolders Bank / Dogger Bank	H20	9.5 – >25.0	Medium strength to very high strength silty sandy CLAY or interbedded dense to very dense fine SAND and SILT
Saalian	D	Cleaver Bank	-	>30.0	Interbedded very high strength to extremely high strength slightly sandy CLAY and dense to very dense SAND, locally gravelly

Note:
- No geotechnical data are available from Unit C , description based on Ref. 2
- Soil description for Units B and D based on Ref.1
- Depths in metres BSF are approximations

Seismic Unit A (New Zeeland Gronden Fm. - Holocene)

Unit A is the uppermost interpreted seismic unit, observed throughout the entire survey area. The unit is characterised by semi-transparent horizontal, parallel, low amplitude reflections. Within this unit, reflection hyperbola or high-amplitude reflections are observed on the SBP data, suggesting the presence of coarser material, e.g. shells debris or gravel (see Figure 2.12). The high-amplitude reflections occur at various depths, primarily between KP 1.0 and KP 2.0.

Unit A represents Holocene marine sediments that were deposited during the last postglacial transgression. The unit comprises fine to medium SAND, locally very silty, as shown by the results of sampling and CPT testing performed within the survey area (see Report 3, Ref.1).

The base of Unit A (Horizon H10) is a sub-horizontal surface, interpreted as erosional, and the unit has a thickness that ranges between approximately 3.5 m and 15.5 m metres.

Seismic Unit B (Botney Cut Fm. – Late Weichselian)

Unit B is characterised by acoustically well-bedded, continuous high amplitude reflections (see Figure 2.12).

Unit B is interpreted as the Botney Cut Formation, deposited in a glaciolacustrine environment. The unit comprises very low strength to medium strength silty, sandy CLAY, often with lamination and/or thin beds of sand/silt (Ref.1).

The unit is present only in the northern parts of the pipeline route, until approximately KP 1.6.

Seismic Unit C (Bolders Bank / Dogger Bank Fm.– Weichselian)

Unit C is variable internally as observed on the SBP data. Locally, the unit is characterised by a chaotic acoustic nature with variable diffuse/low (but locally high) amplitudes. Locally, the unit shows bedded nature, with semi-continuous, horizontal but mostly inclined reflections of low to moderate amplitude. Within the unit an internal erosion surface(s) can be observed (see Figure 2.13).

The top of Unit C is an erosion surface, truncated by the base of Unit A. The unit is locally absent and the base of Unit A (Horizon H10) directly overlies Unit D. The unit pinches-out towards the north-west between two unconformities, i.e. Horizons H15 and H20 (see Figure 2.13).

Unit C is interpreted to represent glacial deposits of the Bolders Bank and/or Dogger Bank Formations. The two formations have not been differentiated. No geotechnical data are available from this unit. Public domain sources indicate that the unit most likely comprises interbedded dense to very dense fine SAND and SILT and /or medium strength to very high strength silty sandy CLAY.

Seismic Unit D (Cleaver Bank Fm - Saalian)

Unit D is characterised by a chaotic seismic facies, with locally semi-transparent and locally high-amplitude internal reflections. The horizon that marks the top of this unit (Horizon H20) is characterised by high amplitude reflections.

Internal channelling features and diffractions with high amplitudes can be observed locally within the unit, the latter could be indicative of the presence of coarser material, e.g. gravel. Locally, internal high-amplitude reflectors can be observed, indicating that unit is variable internally (see Figure 2.12).

This unit is interpreted to represent the Cleaver Bank Formation, which was deposited in glaciomarine and glaciolacustrine depositional environment, with minor intercalations of glacial deposits. The unit comprises stiff to hard sandy CLAY with interbeds of dense to very dense SAND, locally gravelly (Ref.1).

The depth to the base of Unit D lies beyond the penetration depth of the SBP data.

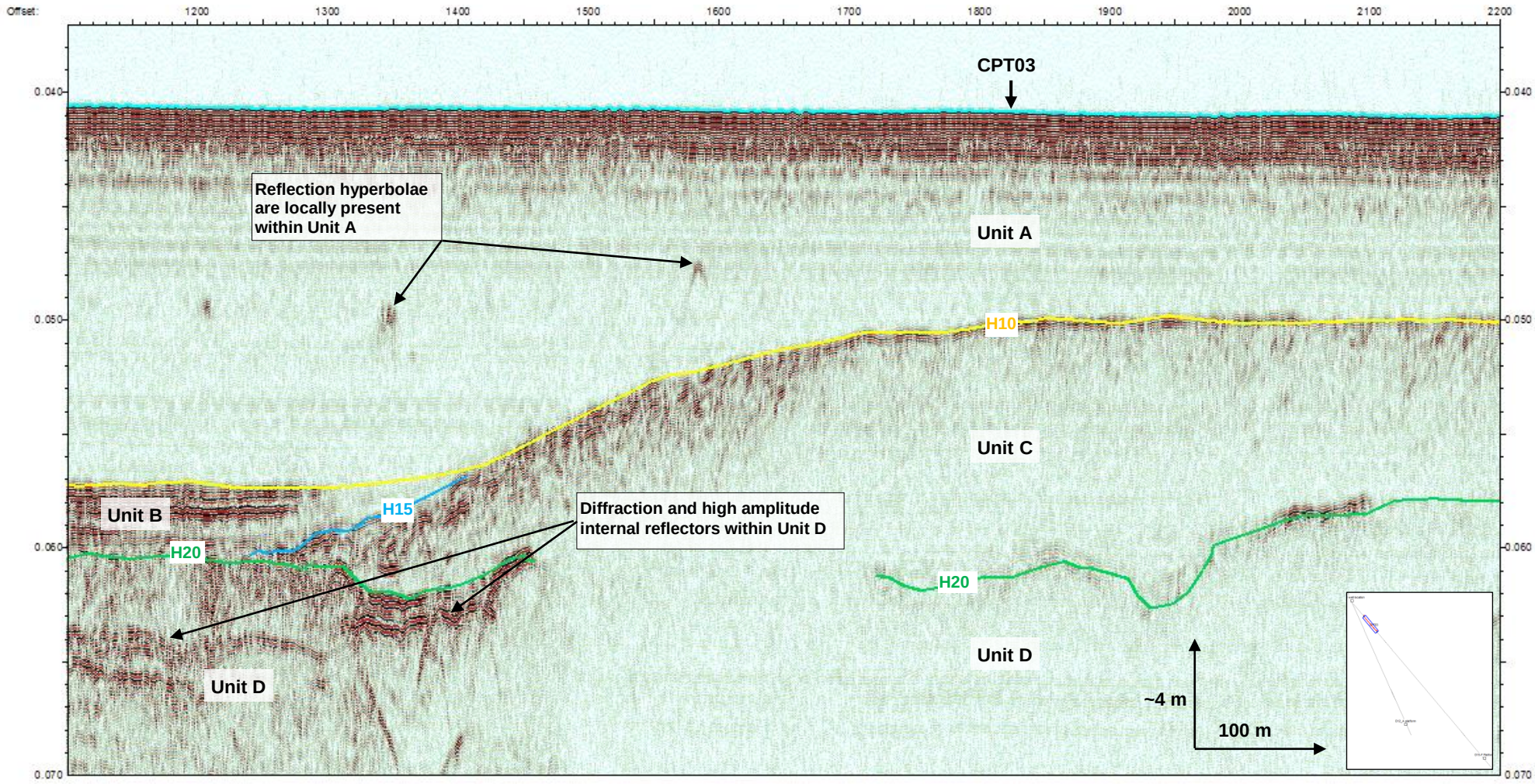


Figure 2.12: SBP data example on line D15CL_SBP_merged

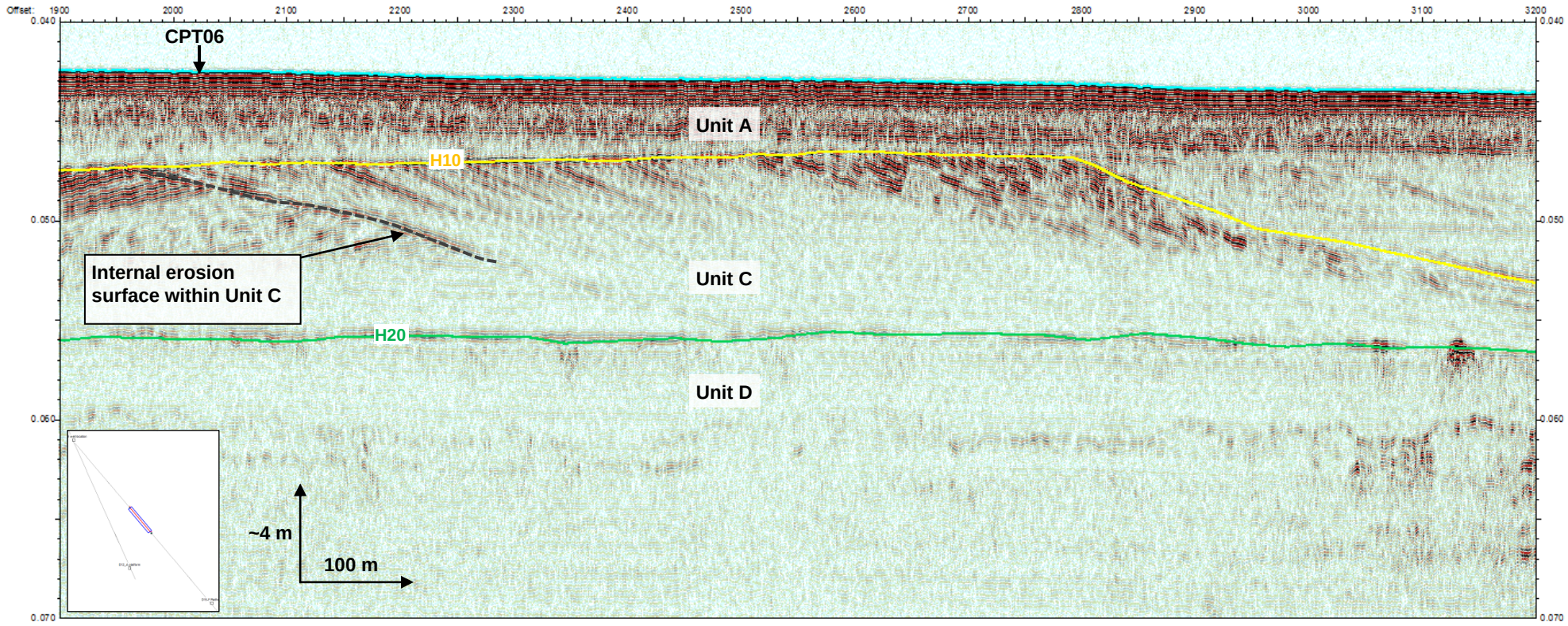


Figure 2.13: SBP data examples on line D15CLa_SBP_merged

3. CONCLUSIONS AND RECOMMENDATIONS

The seafloor topography along the planned pipeline routes is flat and featureless and is not expected to cause any obstruction to the pipelines. There are no sedimentary structures present that could indicate sediment transport.

A total of fifteen (15) debris items and two (2) depressions were interpreted along the planned D12-B and D12-A pipeline route. A total of twenty (20) sonar contacts were interpreted along the planned D12-B and D15-FA pipeline route.

A total of seven (7) magnetic anomalies were observed along the planned D12-B and D12-A pipeline route. Two (2) anomalies were recorded close to the D12-A platform and possibly originate from the infrastructure associated with the platform. Three (3) anomalies had no corresponding side scan sonar contacts and are most likely caused by small ferrous objects of unknown origin in shallow burial.

A total of twenty (20) magnetic anomalies were observed along the planned D12-B and D15-FA pipeline route. Two (2) anomalies were recorded close to the D15-FA platform and possibly originate from the infrastructure associated with the platform. Eight (8) anomalies were caused by existing infrastructure. The remaining anomalies had no corresponding side scan sonar contacts and are most likely caused by small ferrous objects of unknown origin in shallow burial.

Diffraction hyperbolae and/or enhanced amplitude reflections, possibly representing coarser material (e.g. shell debris, gravel), were observed at different depths within Unit A. Small-scale buried palaeochannel features and internal reflectors were observed locally within Units C and D. Lithological and strength variations in the soil properties can be expected over short distances within these units due to depositional variations (e.g., channel cut and fill, erosion surface, gravel layers).

No seismic anomalies and no faults were interpreted within the survey area. However, the presence of (especially deeper) faults cannot be fully excluded from SBP data.

No other evidence of hazards, obstructions or anomalies that may present a hazard to pipeline installation was observed within the survey area.

4. REFERENCES

Ref 1: Fugro, 2017. Report No. GH210-R3 (1), “Geotechnical Report Investigation Data Sillimanite Pipeline Routes Dutch Sector, North Sea”, Final issue 1, d.d. 17-05-2017

Ref 2: Silver Well – Sheet 54° N – 02° E. Rijks Geologische Dienst. Geologie van het Kwartair (Quaternary Geology)

Ref 3: Silver Well – Sheet 54° N – 02° E. Rijks Geologische Dienst. Holocene en Oppervlaktesedimenten (Seabed Sediments and Holocene)

Ref 4: Ellis, J.R., Milligan, S.P., Readdy, L.,Taylor, N. and Brown, M.J. 2012. Spawning and nursery grounds of selected fish species in UK waters. Sci. Ser. Tech. Rep., Cefas

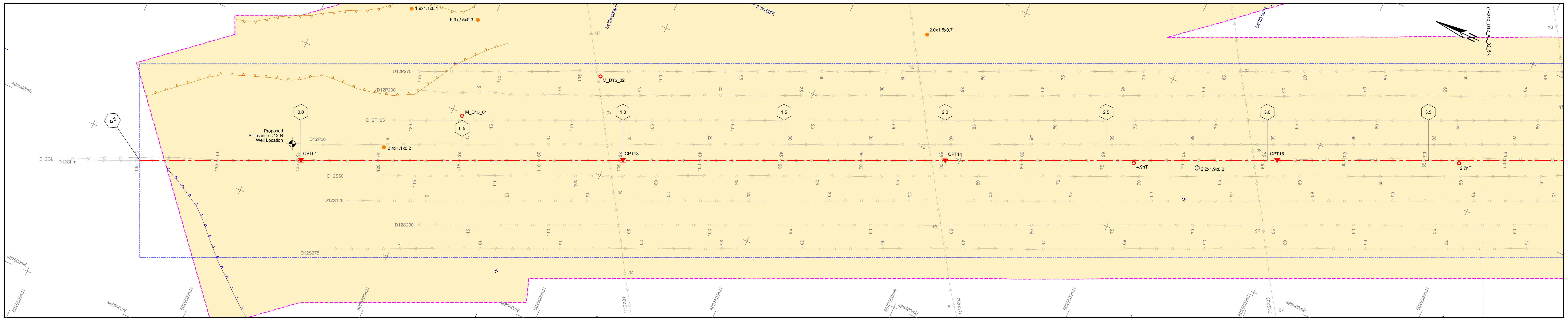
APPENDICES

A. CHARTS

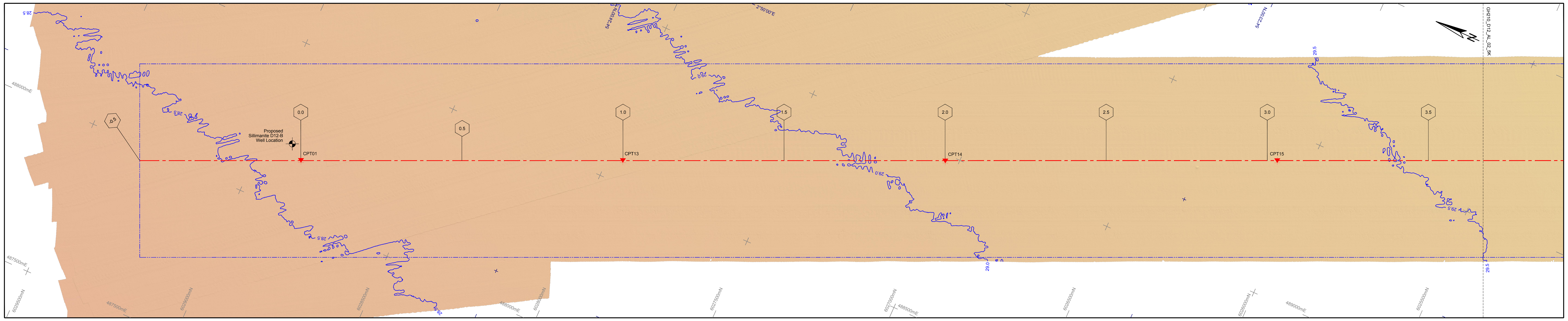
A. CHARTS

A.1 D12-B TO D12-A ROUTE

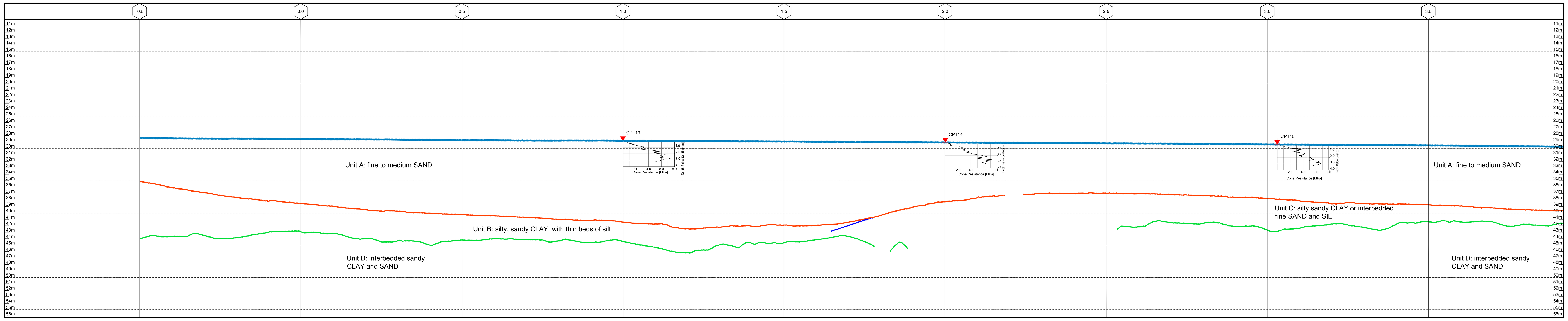
SEABED FEATURES AND TRACKPLOT



SHADED BATHYMETRIC RELIEF IMAGE AND CONTOURS



LONGITUDINAL PROFILE



ENGINEERING NOTES

LEGEND:

+	U.T.M. GRID
+	GEOGRAPHICAL GRID
0.0	KILOMETRE POST
	PROPOSED PIPELINE ROUTE
	EXISTING PIPELINES AND INFRASTRUCTURE
	SURVEY CORRIDOR
	SIDESCAN SONAR LIMIT
CPT07	CPT LOCATION WITH REFERENCE NUMBER

TRACK PLOT AND SEABED FEATURES

D12X04 100	VESSEL TRACK WITH FIX NUMBER AND LINE NAME (REFERENCED TO CRP POSITION)
	DUMP
	FINE TO MEDIUM SAND
	EXPOSED PIPELINE
	MATTRESS
	TRAWL SCAR
	INDICATIVE BOUNDARIES OF PALAEOCHANNEL
	EXTENT OF BOTNEY CUT FORMATION
l x w x h	SIDESCAN SONAR CONTACT / DEBRIS WITH DIMENSIONS IN METRES (nmh = NO MEASURABLE HEIGHT)
l x w x d	DEPRESSION WITH DIMENSIONS IN METRES (nmd = NO MEASURABLE DEPTH)
2.5nT	MAGNETOMETER CONTACT WITH AMPLITUDE IN NANOTESLA (nT)
	WRECK

BATHYMETRY

28.5	DEPTH CONTOUR AT 0.5 METRE INTERVALS

DEPTH RANGE PALETTE:
(DEPTH BELOW LAT IN METRES)

25.0 30.0 35.0 40.0 45.0 50.0

LONGITUDINAL PROFILE

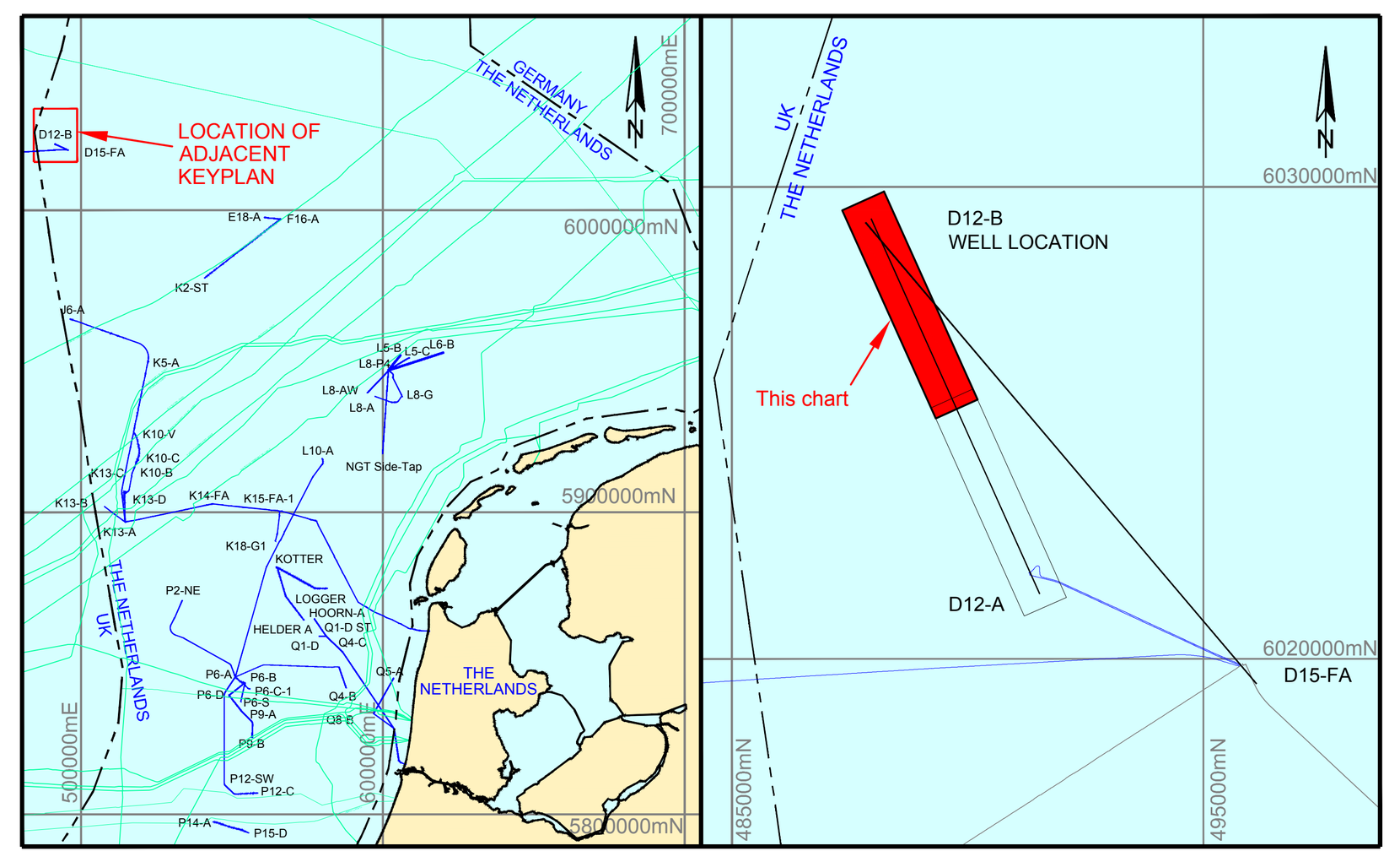
	SEABED
	BASE OF UNIT A
	INTERFACE BETWEEN UNIT B AND C
	TOP OF UNIT D

NOTES:

1) BATHYMETRY FROM R2SONIC 2024 MULTIBEAM ECHO SOUNDER, PROCESSED WITH 0.5 m BIN SIZE.
2) WATER DEPTH REDUCED TO LAT USING ELLIPSOIDAL HEIGHT FROM STARPACK BEST SOLUTION AND THE DTU13 © ELLIPSOID TO MSL MODEL.
3) SEABED FEATURES INTERPRETATION BASED ON EDGETECH 4200 SIMULTANEOUS DUAL-FREQUENCY (100 / 600 kHz) SIDESCAN SONAR DATA, RECORDED AT 100 m / 75 m RANGE.
4) ASSUMED ACOUSTIC VELOCITY OF SEDIMENTS IS 1600 m/s.
5) LONGITUDINAL PROFILE VERTICAL SCALE 1:250

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM	
GEODETIC DATUM	European Datum 1950
ELLIPSOID Semi-Major Axis Inverse Flattening	International 1924 6,378,388 297.000
PROJECTION Central Meridian (CM) Latitude of Origin False Easting False Northing Scale Factor at CM	ED50 / UTM zone 31N 03°00'00" E 00°00'00" N 500,000mE 0mN 0.9996
DATUM TRANSFORMATION Source	WGS84 to ED50 EPSG dX=89.5 dY=93.8 dZ=123.1 rX=0.000" rY=0.000" rZ=0.156" Scale=-1.200ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



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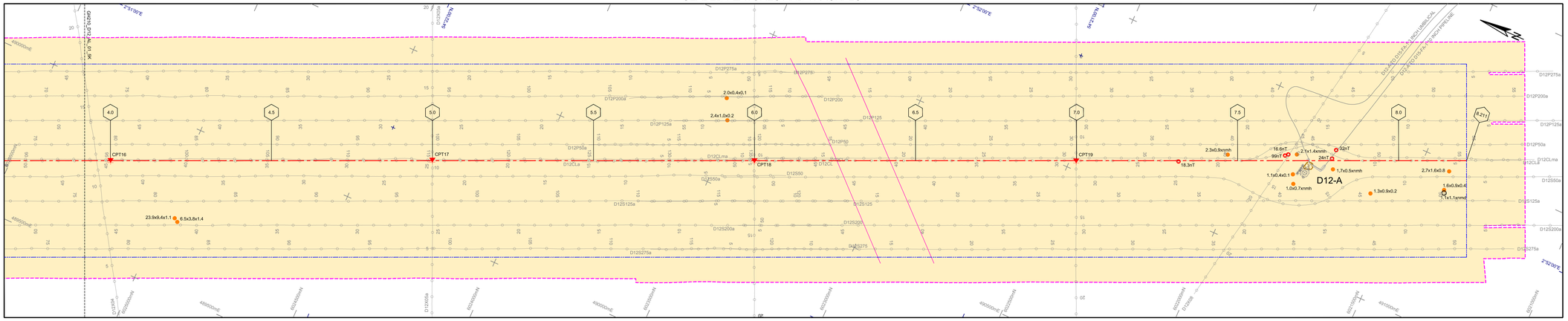
GEOPHYSICAL SURVEY
PROPOSED PIPELINE ROUTE
SILLIMANITE D-12 B TO D12-A
ALIGNMENT CHART
KP -0.500 TO KP 3.920

SCALE 1 : 5000

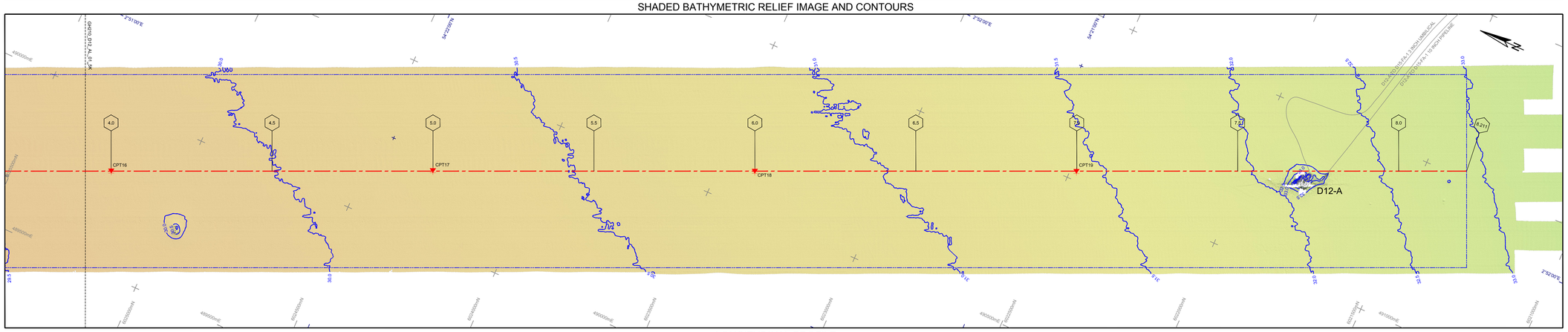
0 50 100 200 300 400 500 metres
0 100 500 1000 1500 feet

Vessel: FUGRO FRONTIER		Survey Date: APRIL 2017		Project Ref: GH210		
Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	30/05/2017	Issued for Approval	RNI	HS	BBK	OD
Client Ref:		Drawing No: GH210_D12_AL_01_5K		Sheet: 1 of 2		Encl: 5

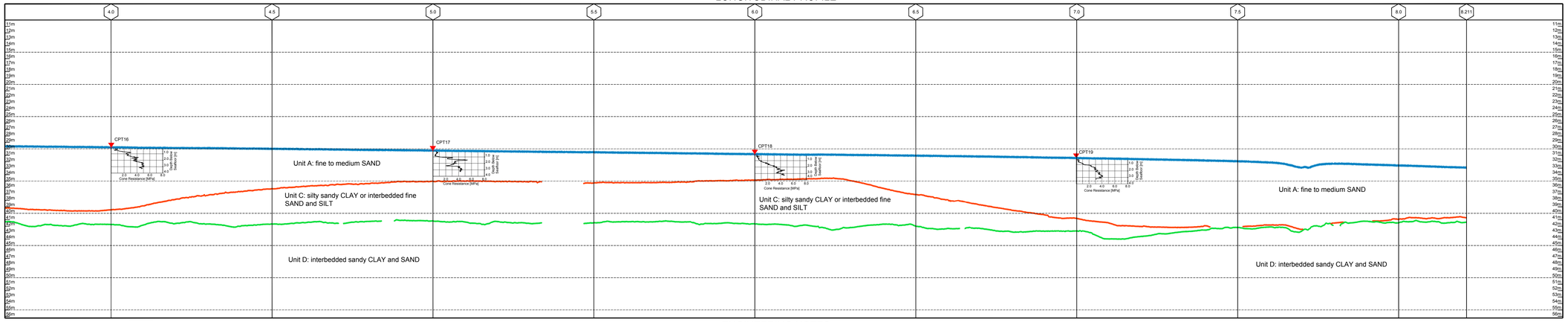
SEABED FEATURES AND TRACKPLOT



SHADED BATHYMETRIC RELIEF IMAGE AND CONTOURS



LONGITUDINAL PROFILE



ENGINEERING NOTES

LEGEND:

- U.T.M. GRID
- GEOGRAPHICAL GRID
- KILOMETRE POST
- PROPOSED PIPELINE ROUTE
- EXISTING PIPELINES AND INFRASTRUCTURE
- SURVEY CORRIDOR
- SIDESCAN SONAR LIMIT
- CPT07 — CPT LOCATION WITH REFERENCE NUMBER

TRACK PLOT AND SEABED FEATURES

- D12X04 / 100% — VESSEL TRACK WITH FIX NUMBER AND LINE NAME (REFERENCED TO CRP POSITION)
- DUMP
- FINE TO MEDIUM SAND
- EXPOSED PIPELINE
- MATTRESS
- TRAWL SCAR
- INDICATIVE BOUNDARIES OF PALAEOCHANNEL
- EXTENT OF BOTNEY CUT FORMATION
- l x w x h — SIDESCAN SONAR CONTACT / DEBRIS WITH DIMENSIONS IN METRES (mnh = NO MEASURABLE HEIGHT)
- l x w x d — DEPRESSION WITH DIMENSIONS IN METRES (mnd = NO MEASURABLE DEPTH)
- 2.5nT — MAGNETOMETER CONTACT WITH AMPLITUDE IN NANOTESLA (nT)
- WRECK

BATHYMETRY

- 28.5 — DEPTH CONTOUR AT 0.5 METRE INTERVALS

DEPTH RANGE PALETTE:
(DEPTH BELOW LAT IN METRES)

25.0 | 30.0 | 35.0 | 40.0 | 45.0 | 50.0

LONGITUDINAL PROFILE

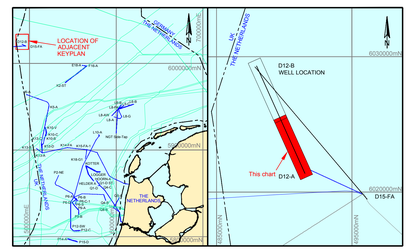
- SEABED
- BASE OF UNIT A
- INTERFACE BETWEEN UNIT B AND C
- TOP OF UNIT D

NOTES:

1) BATHYMETRY FROM R2SONIC 2024 MULTIBEAM ECHO SOUNDER, PROCESSED WITH 0.5 m BIN SIZE.
2) WATER DEPTH REDUCED TO LAT USING ELLIPSOIDAL HEIGHT FROM STARPACK BEST SOLUTION AND THE DTU13 © ELLIPSOID TO MSL MODEL.
3) SEABED FEATURES INTERPRETATION BASED ON EDGETECH 4200 SIMULTANEOUS DUAL-FREQUENCY (100 / 600 kHz) SIDESCAN SONAR DATA, RECORDED AT 100 m / 75 m RANGE.
4) ASSUMED ACOUSTIC VELOCITY OF SEDIMENTS IS 1600 m/s.
5) LONGITUDINAL PROFILE VERTICAL SCALE 1:250

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM	
GEODETIC DATUM	European Datum 1950
ELLIPSOID	International 1924
Semi-Major Axis	6,378,388
Inverse Flattening	297.000
PROJECTION	ED50 / UTM zone 31N
Central Meridian (CM)	03°00'00" E
Latitude of Origin	00°00'00" N
False Easting	500,000mE
False Northing	0mN
Scale Factor at CM	0.9996
DATUM TRANSFORMATION	WGS84 to ED50
Source	EPSG dX=89.5 dY=93.8 dZ=123.1 rX=0.000" rY=0.000" rZ=0.156" Scale=-1.200ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



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GEOPHYSICAL SURVEY
PROPOSED PIPELINE ROUTE
SILLIMANITE D-12 B TO D12-A
ALIGNMENT CHART
KP 3.670 TO KP 8.211

SCALE 1 : 5000

0 50 100 200 300 400 500 metres
0 100 500 1000 1500 feet

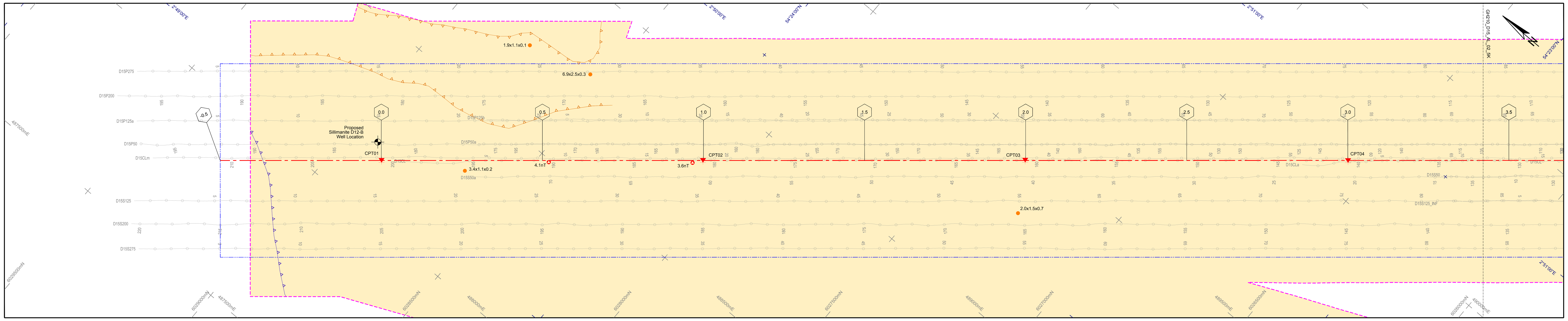
Vessel: FUGRO FRONTIER	Survey Date: APRIL 2017		Project Ref: GH210

Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	30/05/2017	Issued for Approval	RNI	HS	BBK	OD

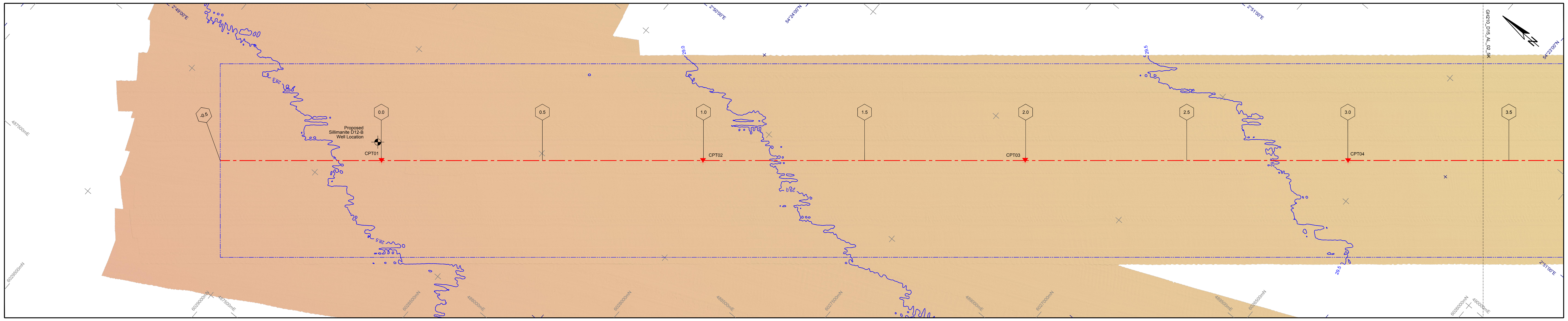
Client Ref:	Drawing No:	Sheet:	Encl:
	GH210_D12_AL_02_5K	2 of 2	6

A.2 D12-B TO D15-FA ROUTE

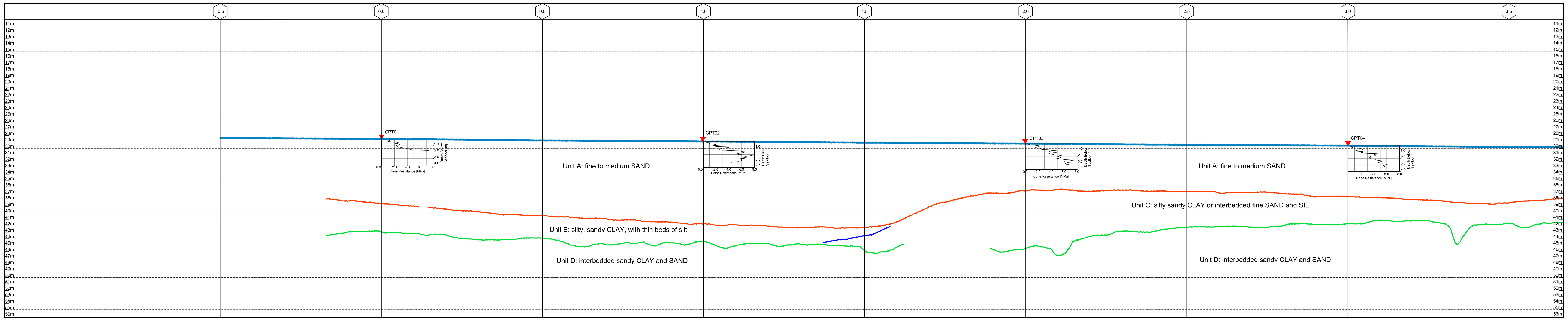
SEABED FEATURES AND TRACKPLOT



SHADED BATHYMETRIC RELIEF IMAGE AND CONTOURS



LONGITUDINAL PROFILE



ENGINEERING NOTES

LEGEND:

- U.T.M. GRID
- GEOGRAPHICAL GRID
- KILOMETRE POST
- PROPOSED PIPELINE ROUTE
- EXISTING PIPELINES AND INFRASTRUCTURE
- SURVEY CORRIDOR
- SIDESCAN SONAR LIMIT
- CPT07 — CPT LOCATION WITH REFERENCE NUMBER

TRACK PLOT AND SEABED FEATURES

- D12X04 100 — VESSEL TRACK WITH FIX NUMBER AND LINE NAME (REFERENCED TO CRP POSITION)
- DUMP
- FINE TO MEDIUM SAND
- EXPOSED PIPELINE
- MATTRESS
- TRAWL SCAR
- INDICATIVE BOUNDARIES OF PALAEOCHANNEL
- EXTENT OF BOTNEY CUT FORMATION
- l x w x h — SIDESCAN SONAR CONTACT / DEBRIS WITH DIMENSIONS IN METRES (nmh = NO MEASURABLE HEIGHT)
- l x w x d — DEPRESSION WITH DIMENSIONS IN METRES (nmd = NO MEASURABLE DEPTH)
- 2.5nT — MAGNETOMETER CONTACT WITH AMPLITUDE IN NANOTESLA (nT)
- WRECK

BATHYMETRY

- 28.5 — DEPTH CONTOUR AT 0.5 METRE INTERVALS

DEPTH RANGE PALETTE:
(DEPTH BELOW LAT IN METRES)
25.0 30.0 35.0 40.0 45.0 50.0

LONGITUDINAL PROFILE

- SEABED
- BASE OF UNIT A
- INTERFACE BETWEEN UNIT B AND C
- TOP OF UNIT D

NOTES:

1) BATHYMETRY FROM R2SONIC 2024 MULTIBEAM ECHO SOUNDER, PROCESSED WITH 0.5 m BIN SIZE.
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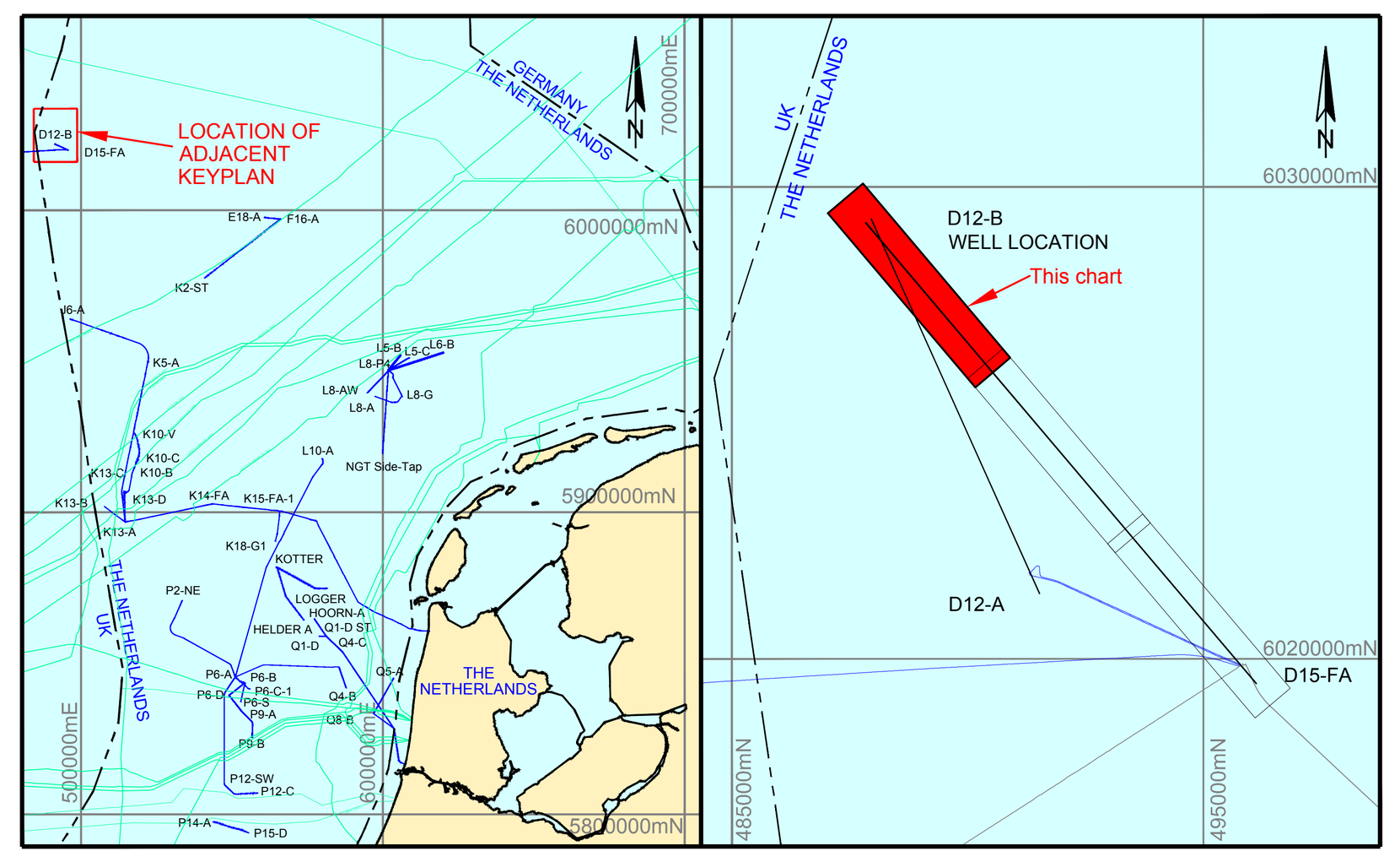
3) SEABED FEATURES INTERPRETATION BASED ON EDGETECH 4200 SIMULTANEOUS DUAL-FREQUENCY (100 / 600 kHz) SIDESCAN SONAR DATA, RECORDED AT 100 m / 75 m RANGE.
4) ASSUMED ACOUSTIC VELOCITY OF SEDIMENTS IS 1600 m/s.
5) LONGITUDINAL PROFILE VERTICAL SCALE 1:250

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM	
GEODETIC DATUM	European Datum 1950
ELLIPSOID Semi-Major Axis Inverse Flattening	International 1924 6,378,388 297.000
PROJECTION Central Meridian (CM) Latitude of Origin False Easting False Northing Scale Factor at CM	ED50 / UTM zone 31N 03°00'00" E 00°00'00" N 500,000mE 0mN 0.9996
DATUM TRANSFORMATION Source	WGS84 to ED50 EPSG dX=89.5 dY=93.8 dZ=123.1 rX=0.000" rY=0.000" rZ=0.156" Scale=-1.200ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



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GEOPHYSICAL SURVEY
PROPOSED PIPELINE ROUTE
SILLIMANITE D12-B TO D15-A
ALIGNMENT CHART
KP -0.500 TO KP 3.670

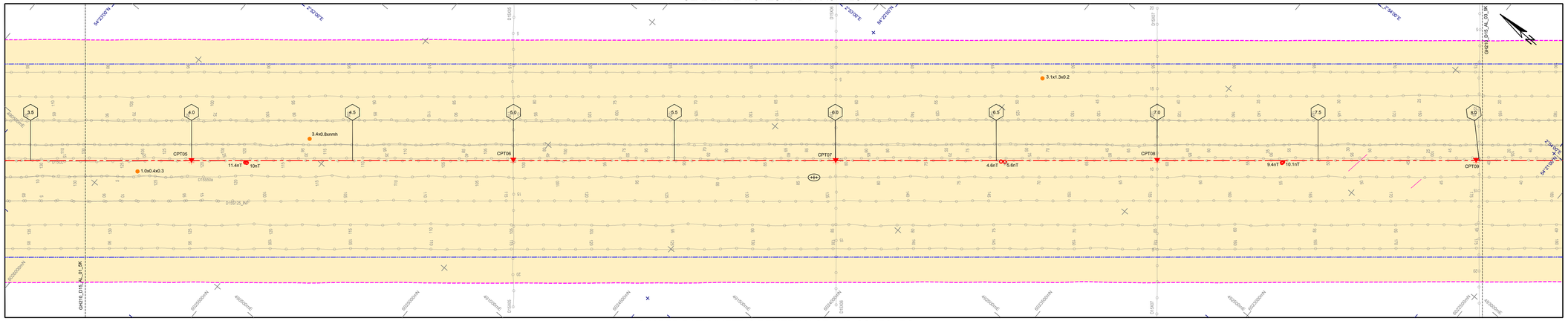
SCALE 1 : 5000

0 50 100 200 300 400 500 metres
0 100 500 1000 1500 feet

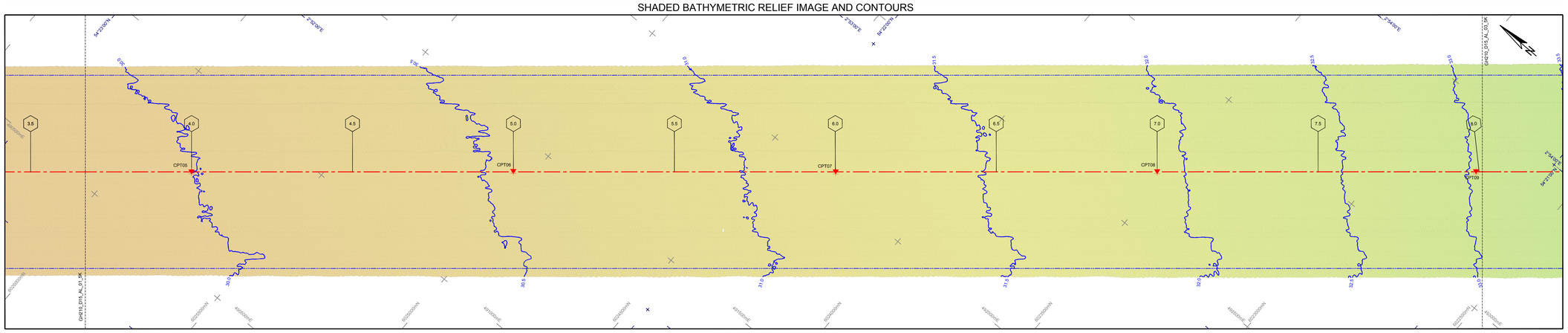
Vessel: FUGRO FRONTIER	Survey Date: APRIL 2017		Project Ref: GH210		
Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	30/05/2017	Issued for Approval	RNI	HS / RB	BBK	OD

Client Ref:	Drawing No:	Sheet:	Encl:
	GH210_D15_AL_01_5K	1 of 3	7

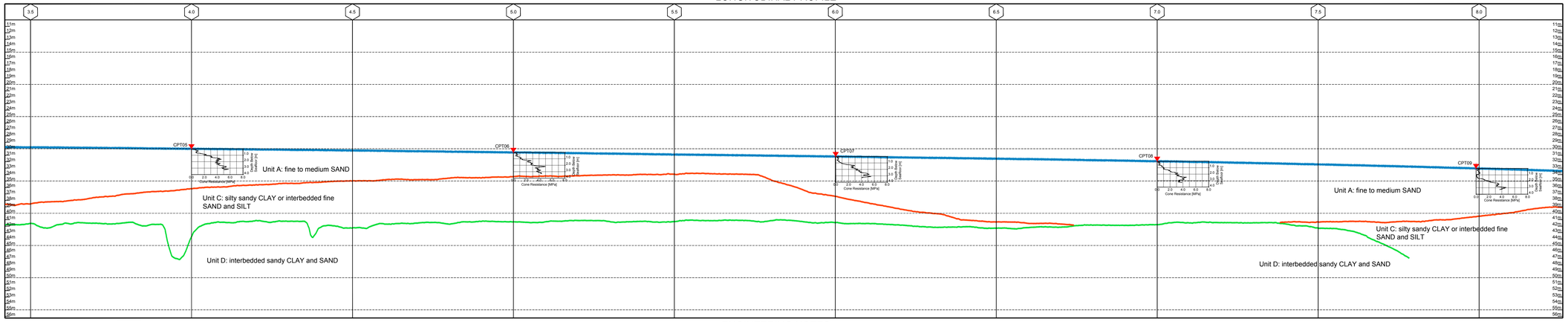
SEABED FEATURES AND TRACKPLOT



SHADED BATHYMETRIC RELIEF IMAGE AND CONTOURS



LONGITUDINAL PROFILE



ENGINEERING NOTES

LEGEND:

- U.T.M. GRID
- GEOGRAPHICAL GRID
- 0.0 — KILOMETRE POST
- PROPOSED PIPELINE ROUTE
- EXISTING PIPELINES AND INFRASTRUCTURE
- SURVEY CORRIDOR
- SIDESCAN SONAR LIMIT
- CPT07 — CPT LOCATION WITH REFERENCE NUMBER

TRACK PLOT AND SEABED FEATURES

- D12X04 / 000.1 — VESSEL TRACK WITH FIX NUMBER AND LINE NAME (REFERENCED TO CRP POSITION)
- DUMP
- FINE TO MEDIUM SAND
- EXPOSED PIPELINE
- MATTRESS
- TRAWL SCAR
- INDICATIVE BOUNDARIES OF PALAEOCHANNEL
- EXTENT OF BOTNEY CUT FORMATION
- l x w x h — SIDESCAN SONAR CONTACT / DEBRIS WITH DIMENSIONS IN METRES (mnh = NO MEASURABLE HEIGHT)
- l x w x d — DEPRESSION WITH DIMENSIONS IN METRES (mnd = NO MEASURABLE DEPTH)
- 2.5nT — MAGNETOMETER CONTACT WITH AMPLITUDE IN NANOTESLA (nT)
- WRECK

BATHYMETRY

- 28.5 — DEPTH CONTOUR AT 0.5 METRE INTERVALS

DEPTH RANGE PALETTE:

(DEPTH BELOW LAT IN METRES)

25.0 — 30.0 — 35.0 — 40.0 — 45.0 — 50.0

LONGITUDINAL PROFILE

- SEABED
- BASE OF UNIT A
- INTERFACE BETWEEN UNIT B AND C
- TOP OF UNIT D

NOTES:

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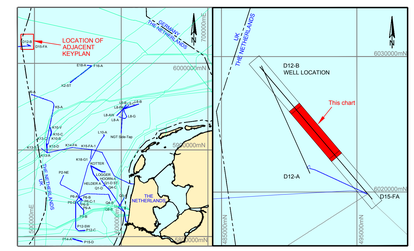
4) ASSUMED ACOUSTIC VELOCITY OF SEDIMENTS IS 1600 m/s.
5) LONGITUDINAL PROFILE VERTICAL SCALE 1:250

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM	
GEODETIC DATUM	European Datum 1950
ELLIPSOID	International 1924
Semi-Major Axis	6,378,388
Inverse Flattening	297.000
PROJECTION	ED50 / UTM zone 31N
Central Meridian (CM)	03°00'00" E
Latitude of Origin	00°00'00" N
False Easting	500,000mE
False Northing	0mN
Scale Factor at CM	0.9996
DATUM TRANSFORMATION	WGS84 to ED50
Source	EPSG dX=89.5 dY=93.8 dZ=123.1 dX=0.000" rX=0.000" dZ=0.156" Scale=-1.200ppm
VERTICAL DATUM	LOWEST ASTRONOMICAL TIDE (LAT)



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GEOPHYSICAL SURVEY
PROPOSED PIPELINE ROUTE
SILLIMANITE D12-B TO D15-A
ALIGNMENT CHART
KP 3.420 TO KP 8.260

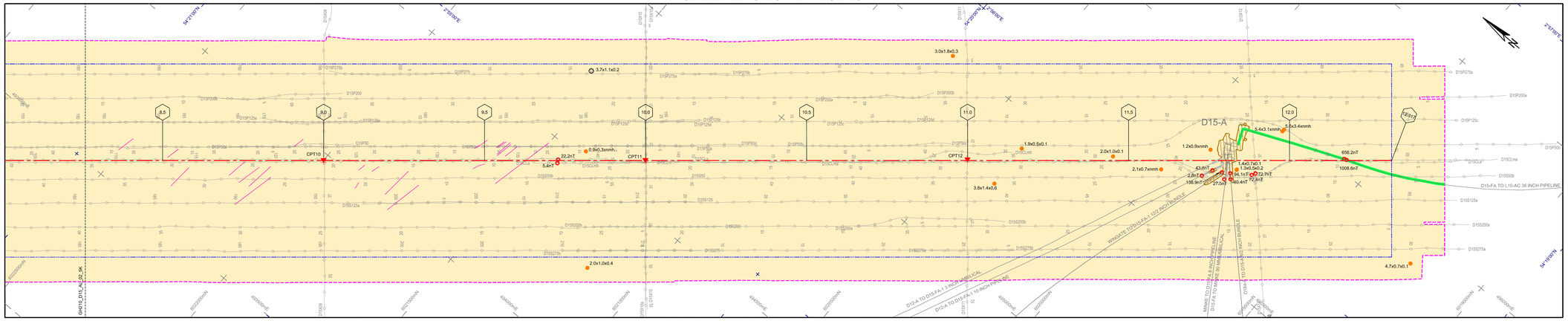
SCALE 1 : 5000

0 50 100 200 300 400 500 metres
0 100 500 1000 1500 feet

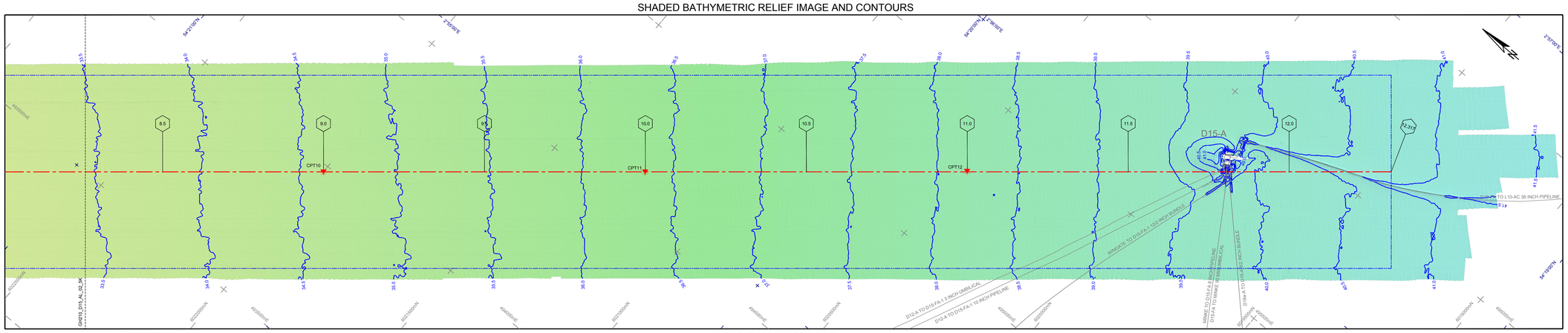
Vessel: FUGRO FRONTIER	Survey Date: APRIL 2017				Project Ref: GH210		
Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	30/05/2017	Issued for Approval	RNI	HS / RB	BBK	OD

Client Ref:	Drawing No:	Sheet:	Encl:
	GH210_D15_AL_02_5K	2 of 3	8

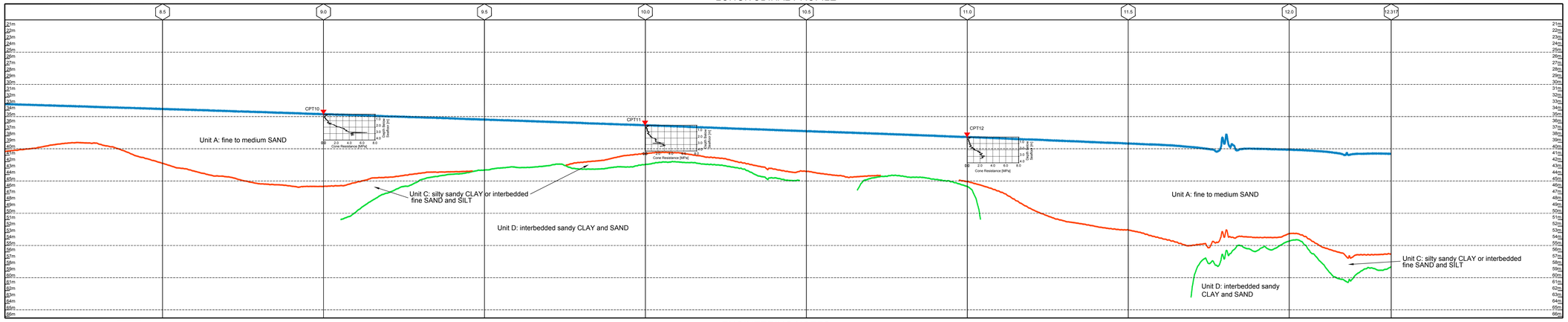
SEABED FEATURES AND TRACKPLOT



SHADED BATHYMETRIC RELIEF IMAGE AND CONTOURS



LONGITUDINAL PROFILE



ENGINEERING NOTES

LEGEND:

- U.T.M. GRID
- GEOGRAPHICAL GRID
- KILOMETRE POST
- PROPOSED PIPELINE ROUTE
- EXISTING PIPELINES AND INFRASTRUCTURE
- SURVEY CORRIDOR
- SIDESCAN SONAR LIMIT
- CPT07 — CPT LOCATION WITH REFERENCE NUMBER

TRACK PLOT AND SEABED FEATURES

- D12X04 / 500.0 — VESSEL TRACK WITH FIX NUMBER AND LINE NAME (REFERENCED TO CRP POSITION)
- DUMP
- FINE TO MEDIUM SAND
- EXPOSED PIPELINE
- MATTRESS
- TRAWL SCAR
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- SEABED
- BASE OF UNIT A
- INTERFACE BETWEEN UNIT B AND C
- TOP OF UNIT D

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GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM	
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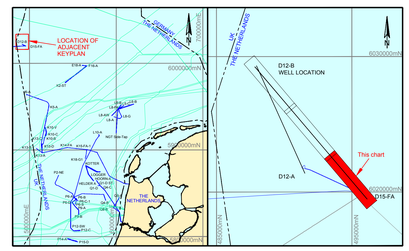

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GEOPHYSICAL SURVEY
PROPOSED PIPELINE ROUTE
SILLIMANITE D12-B TO D15-A
ALIGNMENT CHART
KP 8.010 TO KP 12.317

SCALE 1 : 5000

0 50 100 200 300 400 500 metres
0 100 500 1000 1500 feet

Vessel: FUGRO FRONTIER	Survey Date: APRIL 2017				Project Ref: GH210		
Issue No:	Date:	Description:		Interpr:	Drawn:	Chkd:	Appr:
1	30/05/2017	Issued for Approval		RNI	HS / RB	BBK	OD
Client Ref:		Drawing No: GH210_D15_AL_03_5K			Sheet: 3 of 3		Encl: 9