DONG Energy

Gunfleet Sands 3: Demonstration Project

Archaeological Assessment of Offshore Geotechnical Cores

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1 Non-technical summary

Ahead of the installation of the Gunfleet Sands 3 Demonstration Project (GFS 3) and the offshore export cable connecting GFS 3 to an onshore substation, an archaeological review of the 18 vibrocores collected along the offshore export cable route was undertaken.

The cores were collected in order to mitigate the impact of the export cable route installation by providing archaeological information as specified in the Archaeological Written Scheme of Investigation (WSI) (MA Ltd., 2012)

This report presents an initial archaeological and palaeoenvironmental review of the offshore vibrocores collected. The samples included seven vibrocores extracted for archaeological assessment, eight vibrocores recovered for geotechnical and archaeological purposes and three re-drilled cores (**Figure 1**). The key aim of the tests was to assess the potential impact on sites or deposits of archaeological or palaeoenvironmental significance in the area.

The report considers the geomorphological and palaeo-environmental context of the export cable route area; this information has been drawn from the Environmental Impact Assessment (EIA) documentation which has been produced in support of the Environmental statement (ES).

Through an analysis of the core samples a relatively uniform sequence of deposits present across the cores has been identified. These appear to be associated with both Holocene and Pleistocene channels and are likely to be representative of in-fill deposits that demonstrate a long sequence of development.

These results indicate that the construction works have the potential to impact on deposits of archaeological and/ or palaeoenvironmental significance. As a result of the vibrocore survey it is recommended that archaeological involvement with the grapnel survey through a watching brief should take place. This would be particularly relevant for the areas of palaeochannels identified in this assessment. The method used for cable laying will determine whether a watching brief is possible for this activity. If no seabed material will be brought to the surface then it may not be possible. Instead it may be preferable to utilise the Protocol for Reporting Archaeological Discoveries should unexpected items or deposits be encountered.

In order to be able to fully understand the deposits and the evidence the cores provide on the palaeoenvironmental and geomorphological development of this area, there is a need to undertake sampling and assessment of the material to enable further requirements for analysis to be determined. It is recommended that assessment of the cores across the whole development (onshore and offshore) will be addressed together.

Previous archaeological borehole assessment for the onshore cores and the intertidal zone including mitigation was presented to the client (DONG Energy) by Maritime Archaeology Ltd. in July, 2012 (MA Ltd, 2012).

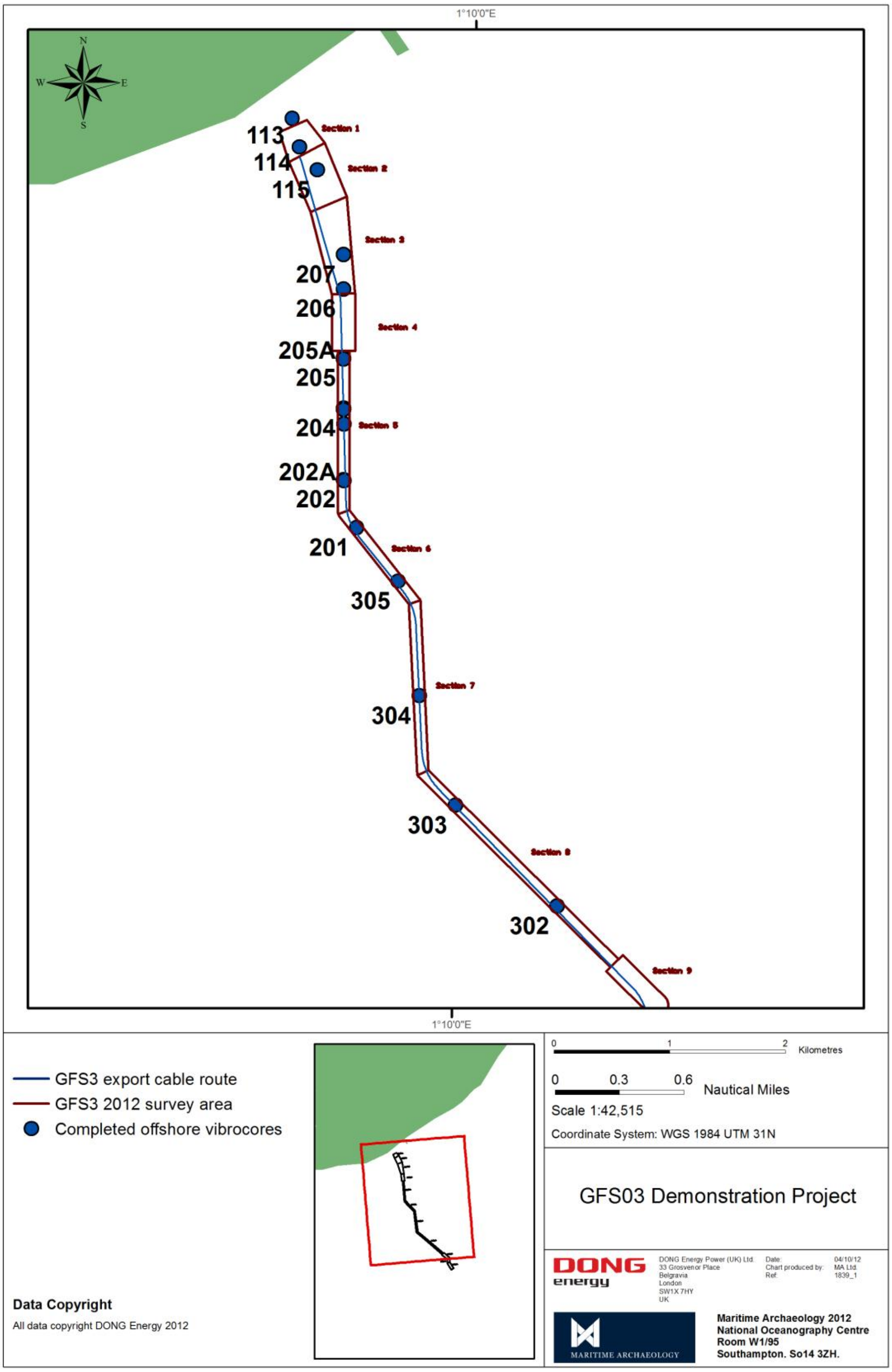

Figure 1 Completed offshore vibrocores

2 Introduction

MA Ltd. has been commissioned by DONG Energy to provide an archaeological review of vibrocores collected along the export cable route related to the Gunfleet Sands 3 Demonstration Project. Due to the potential to impact sites or deposits of archaeological and/ or palaeoenvironmental interest, information on the archaeological potential was provided to the borehole contractors prior to works and an archaeologist was present in the laboratory during the geotechnical core recording.

This report details the offshore core recording and initial characterisation of the vibrocores. This has enabled an archaeological interpretation of the area of impact along the export cable route and the formulation of further assessment recommendations.

2.1 Brief Scheme Background

The Gunfleet Sands (GFS) offshore wind farm, is located approximately 8.5 km southeast of Clacton-on-Sea in Essex. It consists of the operational GFS 1 and GFS 2 projects. Consent was granted for GFS 1 in 2004 and for GFS 2 in 2008. The combined GFS 1 and 2 projects consist of 48 operational turbines. The development is situated within the 12 nm territorial limit of England.

In August 2010, DONG Energy was awarded a demonstration lease by The Crown Estate for a site to the south-west of the GFS 2 array to construct two demonstration turbines. This is known as the Gunfleet Sands 3 - Demonstration Project (GFS 3). The majority of the GFS 3 site (approximately 80%) lies within the originally consented GFS 2 site. The GFS 3 turbines will require an additional export cable to connect the turbines to land (**Figure 1**) as the cable associated with GFS1&2 will not be sufficient to allow maximum capacity use of the GFS3 turbines.

An Environmental Statement (ES) was initially produced for GFS3 when it was planned to utilise the existing export cable from GFS1&2 (DONG 2010), this drew on works previously undertaken in relation to the GFS1&2 site. However, due to the requirement for an additional export cable the Marine Management Organisation (MMO) requested an addendum to the ES to cover the revised scope of works for the entire GFS3 scheme. DONG Energy has produced two addendum reports:

- GFS3 Onshore Addendum (considering all work above Mean High Water Spring (MHWS);
- GFS3 Offshore Addendum (considering all work below MHWS).

The Onshore and Offshore Addendum documents identify the known and potential archaeology within the development area, review potential impacts and put forward mitigation proposals. Further survey data was gathered in 2011 in the near-shore zone and in 2012 along the cable route for the purposes of planning the final path of the export cable route. An archaeological review of the data was undertaken by Maritime Archaeology Ltd in July, 2012 (MA Ltd, July 2012).

2.2 Project Design Details

The GFS3 project will involve the construction of two monopiles with a diameter up to 6m within the previously consented area of GFS2. Scour protection may be required around the turbine bases up to a radius of 20-25m. The turbines will be connected to land through an export cable route which reaches land at the Martello Bay coach and car park to the east of the junction of West Road and Hastings Avenue. An initial archaeological and palaeoenvironmental review of the onshore cable route and transition jointing bay was undertaken by MA Ltd. in August 2012 (MA Ltd.; 2012).

Installation of the proposed GFS 3 Export cable between the marine and terrestrial area will require Horizontal Directional Drilling (HDD) to establish a landfall under the beach. The export cable will be connected to the substation with a three core export transmission cable. From this point the cable will be laid for approximately 9km within until it reaches the wind turbines located circa 8.5km southeast of Clacton-on Sea. See **Figure 2** for details of the scheme plan.

Through the archaeological assessment works undertaken in support of the production of the ES it has been largely possible to avoid direct physical impacts on known archaeological sites. However, there are a number of construction activities which may impact on unknown or potential archaeological remains and/ or important geo-archaeological deposits.

2.3 GUNFLEET SANDS 3 OFFSHORE EXPORT CABLE ROUTE

This core assessment is specifically related to the stretch of the export cable route connecting the GFS3 wind farm to the landfall at Martello Bay (**Figure 2**).

This work forms part of Work Package 1 as outlined within the agreed WSI for the development. The archaeological borehole review for the onshore cores and the intertidal zone including mitigation was presented to the client (DONG Energy) by MA Ltd in July 2012 (MA Ltd, 2012).

2.3.1 Horizontal Direction Drilling (HDD) works

Installation of the cable between the marine and terrestrial area will require Horizontal Directional Drilling (HDD) at a diameter of 0.50 m. The anticipated length of the HDD route from the onshore entry point to the offshore exit point is 800m. There is a possibility that the HDD bore will pass through Pleistocene and Holocene deposits as it approaches the transition jointing bay; however, much of the HDD route is expected to be deeper than the channel deposits within the London Clay below. Within the c.0.50 m diameter of the bore all material will be liquefied. Current constraints mean that the HDD bore must pass at least 1 m below the sea defences which extent 6.45 m below the surface, so the lowest point of the HDD will be at least 7.5 m below the surface. Should the HDD drilling be below 3 m depth (onshore) then it should avoid most of the channel deposits (MA Ltd, August 2012).

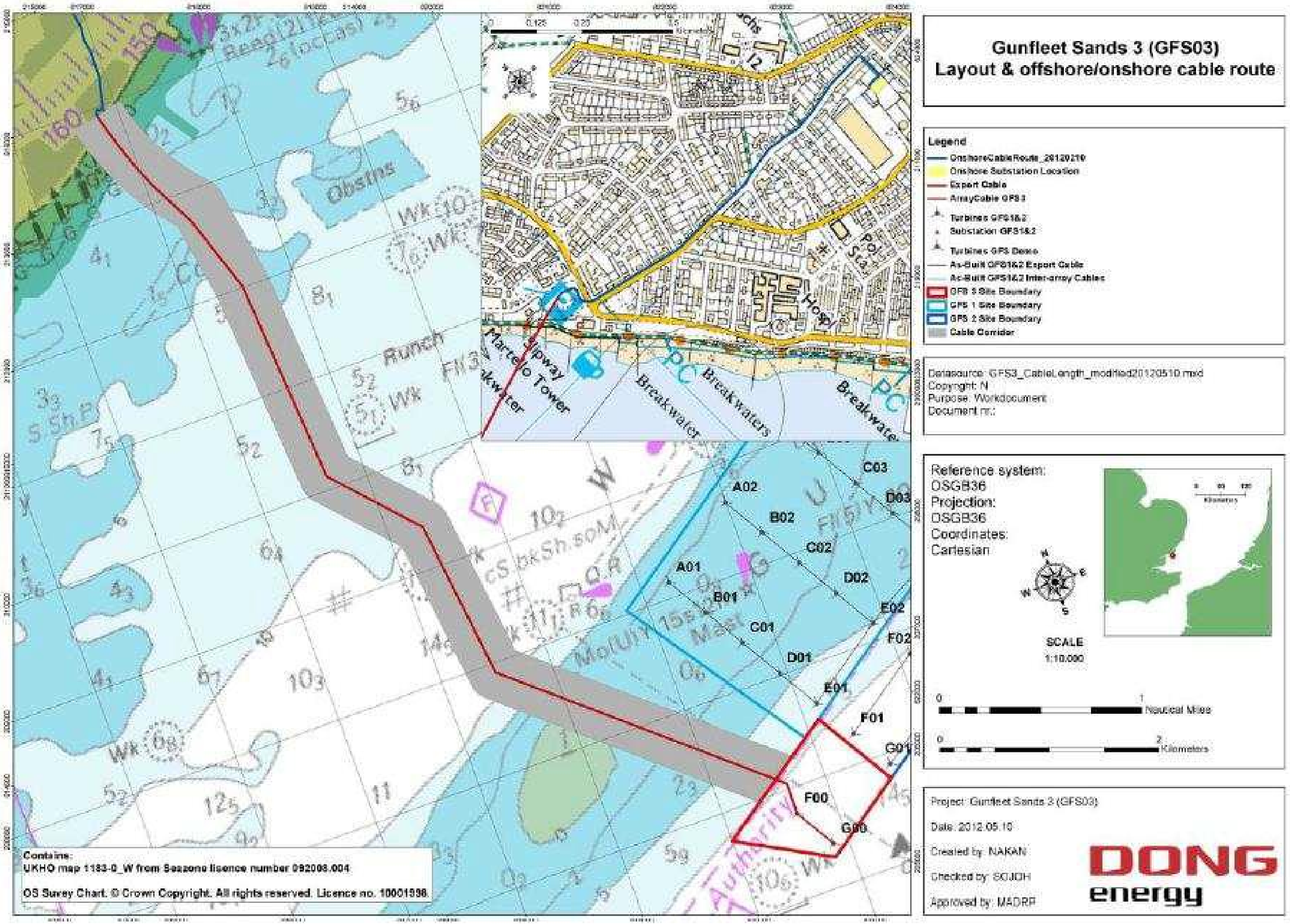

Figure 2. Detail of the scheme plan

2.3.2 Offshore export cable works

The proposed offshore export cable running between the landfall and GFS3 wind farm will be installed through either ploughing, jetting or trenching to a depth of between 1 – 3m, depending upon the local seabed conditions. In close proximity to the proposed GFS3 turbines the cables will rise to the surface for connection. In those areas scour protection will be extended to cover the cable entering the turbine foundation. The export cable works may impact on archaeological deposits, sites, features or environmental remains located within the planned route.

2.4 AGREED MITIGATION APPROACH

As outlined within the WSI, a staged approach to mitigation is required. It was agreed that a series of vibrocores would be the first stage in further assessing the potential to impact archaeology or palaeoenvironmental deposits.

Three vibrocores (113, 114 and 115) were drilled within the area of the planned HDD works. The vibrocores were drilled to depths between 2.10 - 2.22 m. All three cores were assessed for both archaeological and geotechnical purposes.

Seven vibrocores (201-207) were positioned along the export cable route based on the seismic interpretation undertaken by Wessex Archaeology (WA) to target potential pre-historic channel deposits. The vibrocore can penetrate to a depth of maximum 6 m, however, as a result of the local geological conditions none of the vibrocores succeeded in penetrating beyond 5.1 m, with average penetration depth for the archaeological viborcores being 5 m. Three of the cores (202, 204 and 205) were re-drilled and assigned additional core numbers (202a, 204a and 205a). The cores were reviewed for both archaeological and geotechnical purposes.

Further, five viborcores (301-305) were taken for geotechnical purposes; the locations of the cores have been determined by engineering requirements. All the geotechnical cores were also reviewed for archaeological potential. The results from the archaeological review of all the vibrocores described above are included in **Section 4** in this report.

2.5 PROJECT AIMS AND OBJECTIVES

All cores collected by ‘Marine Sampling Holland’ have been reviewed in terms of their archaeological and palaeoenvironmental potential. The results of this review have been used to assess the potential to impact archaeological or palaeoenvironmental deposits during the development and to determine whether further archaeological mitigation is required.

The outcomes of the archaeological review of the core samples are to:

- Characterise any submerged terrestrial deposits and prehistoric features in the area of impact;
- Undertake an initial interpretation of the results in relation to the known information on archaeology and palaeoenvironment within the area;
- Propose any required archaeological mitigation;
- Put forward proposals for assessment and potential analysis and dating of the material recovered within the cores.

3 Methodology

This section outlines the process of core splitting and recording in the laboratory.

The vibrocores (**Table 1**) were collected by the sub-contractor Marine Sampling Holland with a 2,500kg Hydraulic vibrocorer. The samples were taken in 110mm liners, using a core catcher and a cutting shoe.

All vibrocore positions (WGS84 UTM Zone 31N eastings and northings) and water depths at time of coring were provided by the contractor. Depth to Lowest Astronomical Tide (LAT) for the core locations was extracted from the bathymetry data provided by the Client (Note: the location for vibrocore 113 was not covered by the bathymetry data and the LAT height for VC113 is therefore not included in this report). All depths have been converted to Ordnance Datum (O.D.) by subtracting -2.29 (O.D. at Clacton-on Sea).

During the field operation, three of the vibrocores had to be re-drilled (202, 204 and 205). The original and the re-drilled cores (202a, 204a and 205a) were evaluated before splitting for best position in relation to potential channel features identified in the geophysical data. The assessment resulted in selecting 204a and 205 for archaeological analysis, while 204 and 205a were retained for geotechnical testing. Cores 202 and 202a were both opened and assessed for archaeological and geotechnical purposes.

The maximum possible penetration depth for the vibrocore is 6 m. However due to geological constraints the maximum depth was not always possible to reach. **Table 1** summarises the depth reached in all of the vibrocores collected.

3.1 SPLITTING AND RECORDING THE VIBROCORES

The 16 vibrocores were split and recorded at the sub-contractor Wiertsema & Partners' laboratory in Tolbert, Netherlands. A qualified archaeologist worked alongside the geotechnical staff to record the potential archaeological deposits and recover samples for transport back to the UK. The geotechnical team simultaneously collected the samples necessary for their engineering analysis.

The vibrocores were split using a manual core splitter into a working half and an archive half. Photos were taken of the deposits before work continued on half of the core.

Once the working half was laid out and cleaned, the cores were subject to detailed recording to determine the presence or absence of archaeological or palaeoenvironmental material of interest. Notes were made on:

- Sediment colour;
- Sediment type;
- Sedimentary architecture;
- Inclusions, including organics, macro-fossils and archaeological artefacts;
- The presence of polymorphs, and;
- Other datable material.

After recording the core was sealed and returned to storage facilities.

The archaeological information from the cores was added directly into archaeological record forms and striplogs were created for further archaeological interpretation (**Appendix 1**).

Vibrocore ID	Depth to start of core (LAT m)	Recovered Depth (m)	Location (WGS 84, UTM Zone 31N)	
			X	Y
113	n/a	2.10	371955.41	5737975.13
114	-2.15	2.22	372016.88	5737726.07
115	-2.93	2.15	372174.79	5737528.79
201	-6.93	5.00	372516.08	5734434.57
202	-7.52	3.85	372400.81	5734851.45
202a	-7.59	5.00	372403.16	5734841.86
203	-6.13	4.75	372402.30	5735331.22
204	-6.12	3.65	372400.06	5735467.36
204a	-6.10	4.35	372400.21	5735456.50
205	-6.34	4.00	372399.83	5735903.59
205a	-6.37	3.60	372399.78	5735894.46
206	-4.08	5.10	372399.44	5736500.19
207	-4.46	3.00	372400.45	5736796.57
301	-12.70	5.00	375188.36	5729812.08
302	-0.33	4.15	374246.83	5731162.40
303	-8.22	4.75	373366.39	5732036.01
304	-12.88	4.94	373054.17	5732982.27
305	-8.24	3.77	372871.93	5733973.21

Table 1. Summary of collected vibrocores

3.2 Interpretation of the Results

The contents of each of the cores were reviewed to determine their character and to assess whether there was significant archaeological or palaeoenvironmental data within them.

Further comparison of material within the cores was achieved through use of the RockWorks 15 software program which allowed an initial deposit model to be developed.

The results were then reviewed against the current understanding of the potential Pleistocene and Holocene sediments within the development area to improve the comprehension of the deposits represented within the cores.

Based on this information further recommendations were developed for additional assessment and analysis work on the cores and potential archaeological mitigation work on site.

4 Results

The recording of the individual cores was undertaken to a detailed level where any changes in colour, texture, composition etc. were documented.

Sections 4.1 - 4.16 outlines the lithological deposits present in each of the cores; it includes a description of each deposit and information on its nature and inclusions. **Section 4.17** comprises of a stratigraphic description of the units identified within the vibrocores. Striplogs of all the recorded cores are included in **Appendix 1**.

4.1 VIBROCORE 113

Table 2 outlines the deposits present in core 113; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 3** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment description
0.00	0.02	MARINE SAND- Sand, gravel mixed with shell
0.02−2.10	2.08	LONDON CLAY

Table 2. Lithological deposits in vibrocore 113

Figure 3. Image of vibrocore 113

4.2 VIBROCORE 114

Table 3 outlines the deposits present in core 114; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 4** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment Description
0.00	0.09	MARINE SAND- Sand, gravel mixed with shell
0.09−2.22	2.13	LONDON CLAY

Table 3. Lithological deposits in vibrocore 114

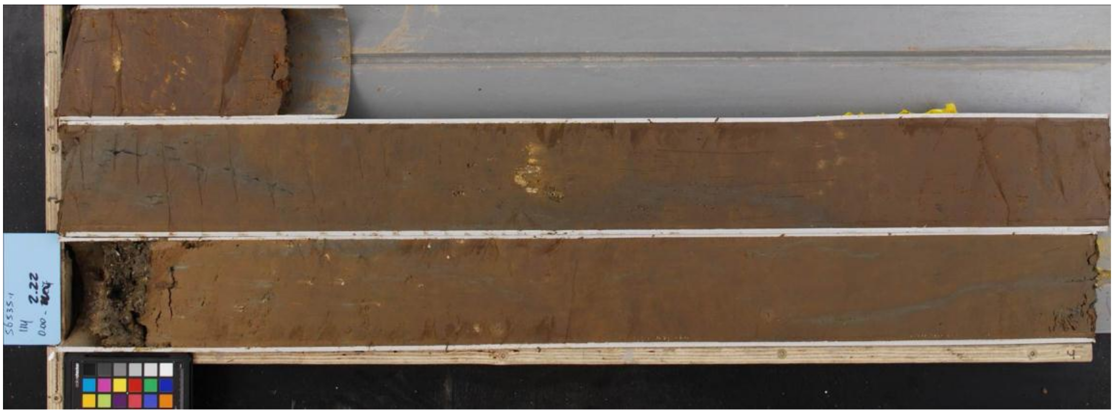

Figure 4. Image of vibrocore 114

4.3 VIBROCORE 115

Table 4 outlines the deposits present in core 115; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 5** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment Description
0.0	0.30	MARINE SAND- Sand, gravel mixed with shell
0.30	0.68	Slightly Silty SAND
0.98−2.15	1.17	LONDON CLAY

Table 4. Lithological deposits in vibrocore 115

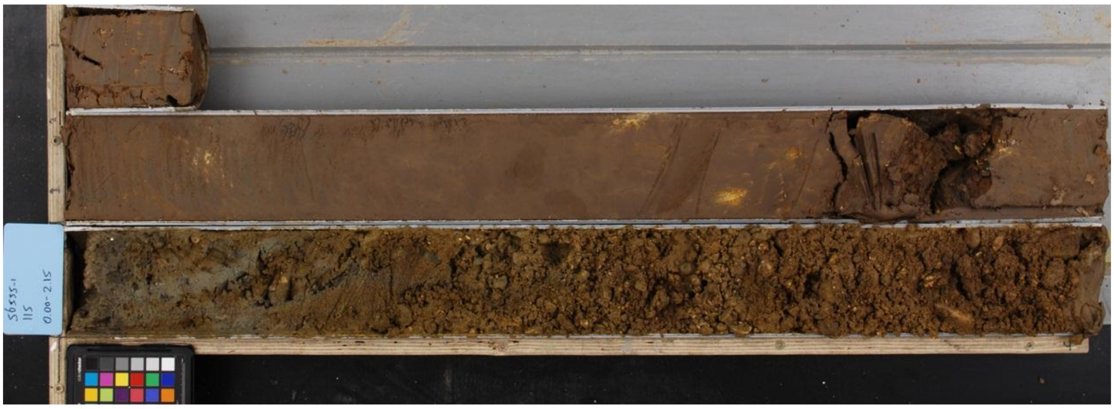

Figure 5. Image of vibrocore 115

4.4 VIBROCORE 201

Table 5 outlines the deposits present in core 201; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 6** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment Description
0.0	0.25	MARINE SAND- Sand, gravel mixed with shell
0.25	0.49	Silty CLAY- Organic
0.74	1.39	Clayey SILT- Pockets of sand
2.14	0.39	Clayey SILT- Fine sand
2.53	0.69	Sandy SILT- Gravel inclusions
3.22	0.49	Silty CLAY- Pockets of sand
3.71	0.64	Silty CLAY- Ripples and laminated sand layers
4.35–5.00	0.65	Silty CLAY – Laminated sand layers

Table 5. Lithological deposits in vibrocore 201

Figure 6. Image of vibrocore 201

4.5 VIRBROCORE 202

Table 6 outlines the deposits present in core 202; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 7** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment Description
0	0.52	MARINE SAND.-Sand, gravel mixed with shell
0.52	0.23	Silty CLAY- Organic
0.75	0.75	Silty CLAY- Shell inclusions
1.50	0.11	Clayey SILT- organic banding
1.61	0.47	Silty sandy CLAY-
2.08	1.02	Silty Sandy CLAY-
3.10−3.85	0.75	CLAY- Laminated sand layers

Table 6. Lithological deposits in vibrocore 202

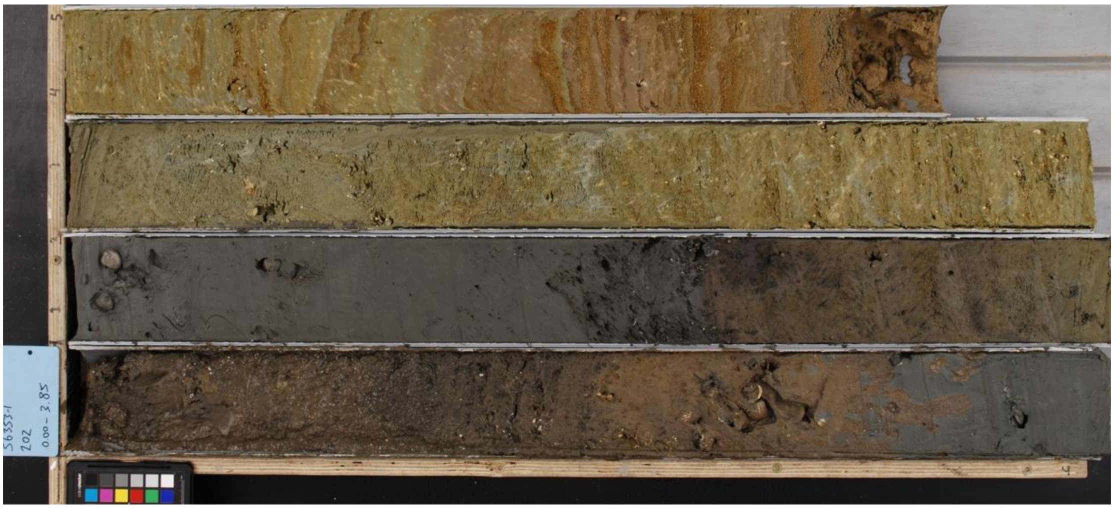

Figure 7. Image of vibrocore 202

4.6 VIBROCORE 202A

Table 7 outlines the deposits present in core 202a; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 8** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment Description
0	0.45	MARINE SAND- Sand, gravel mixed with shell
0.45	0.20	Slightly silty CLAY
0.75	0.80	Silty CLAY- Shell incusions
1.55	1.21	Silty CLAY- Sandy Pockets
2.76	0.34	Silty CLAY- Organic
3.10	0.64	Silty CLAY- Organic
3.74	0.16	Silty CLAY - Organic
3.90	0.47	Sandy SILT- Ripples and laminated layers
4.37	0.50	Sandy SILT- Laminated
4.87−5.00	0.13	Sandy GRAVEL- Lag deposit

Table 7. Lithological deposits in vibrocore 202a

Figure 8. Image of vibrocore 202a

4.7 VIBROCORE 203

Table 8 outlines the deposits present in core 203; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 9** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment Description
0–0.07	0.07	MARINE SAND-Sand, gravel mixed with shell
0.07	0.53	Soft SILT
0.60	1.30	Hard CLAY- Laminated layers
1.90	0.05	SAND- shell inclusions
1.95	1.55	Firm CLAY with shell inclusions
3.50	0.62	Clayey SILT with shell
4.12	0.42	SILT
4.54–4.75	0.21	Very silty SAND

Table 8. Lithological deposits in vibrocore 203

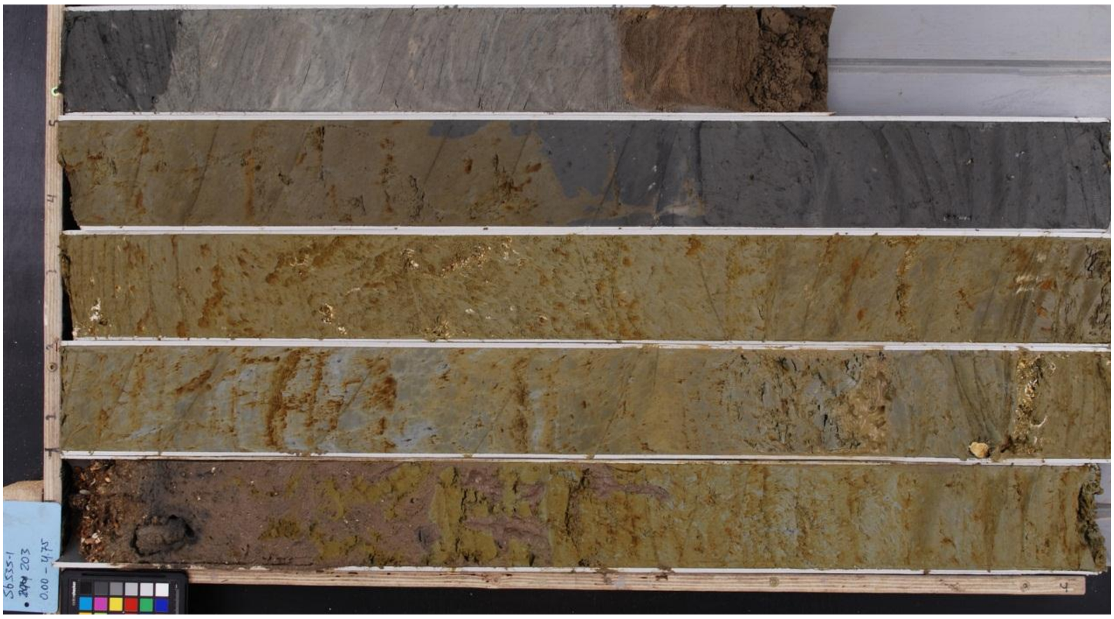

Figure 9. Image of vibrocore 203

4.8 VIBROCORE 204A

Table 9 outlines the deposits present in core 204a; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 10** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment Description
0-0.10	0.10	MARINE SAND.-Sand, gravel mixed with shell
0.10	0.43	Soft SILT
0.53	1.00	Sitly CLAY- Laminated
1.43	0.25	SAND- Fine, medium and coarse
1.68	0.53	Silty SAND- Laminated
2.21	1.72	CLAY with laminated sandy layers
3.93−4.35	0.42	Sandy GRAVEL

Table 9. Lithological deposits in vibrocore 204a

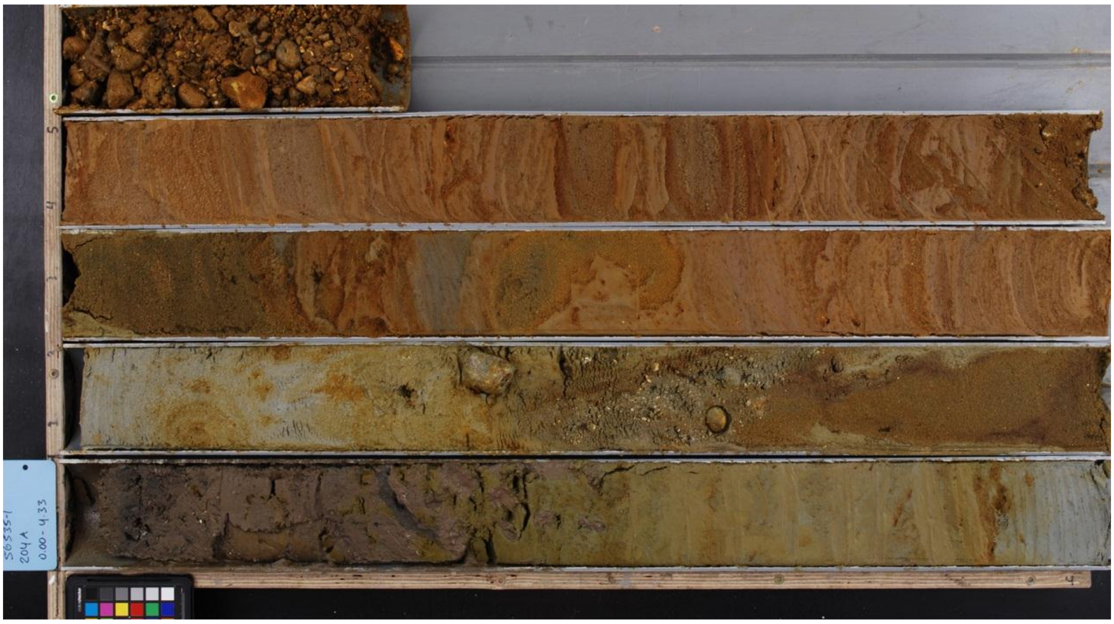

Figure 10. Image of vibrocore 204a

4.9 VIBROCORE 205

Table 10 outlines the deposits present in core 205; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 11** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment Description
0-0	0.02	MARINE SAND -Sand, gravel mixed with shell
0.02	0.13	Very Silty CLAY
0.15	1.78	Silty CLAY - Ripples and laminated sandy layers
1.93	0.37	Silty CLAY- Organic
2.30	0.60	Silty CLAY
2.90−4.00	1.10	Silty CLAY – Laminated sand layers

Table 10. Lithological deposits in vibrocore 205

Figure 11. Image of vibrocore 205

4.10 VIBROCORE 206

Table 11 outlines the deposits present in core 206; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 12** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment Description
0	0.22	MARINE SAND.-Sand, gravel mixed with shell
0.22	2.22	Silty CLAY- Organic
2.44−5.10	2.66	Silty sandy CLAY- Ripples and laminated sandy layers

Table 11. Lithological deposits in vibrocore 206

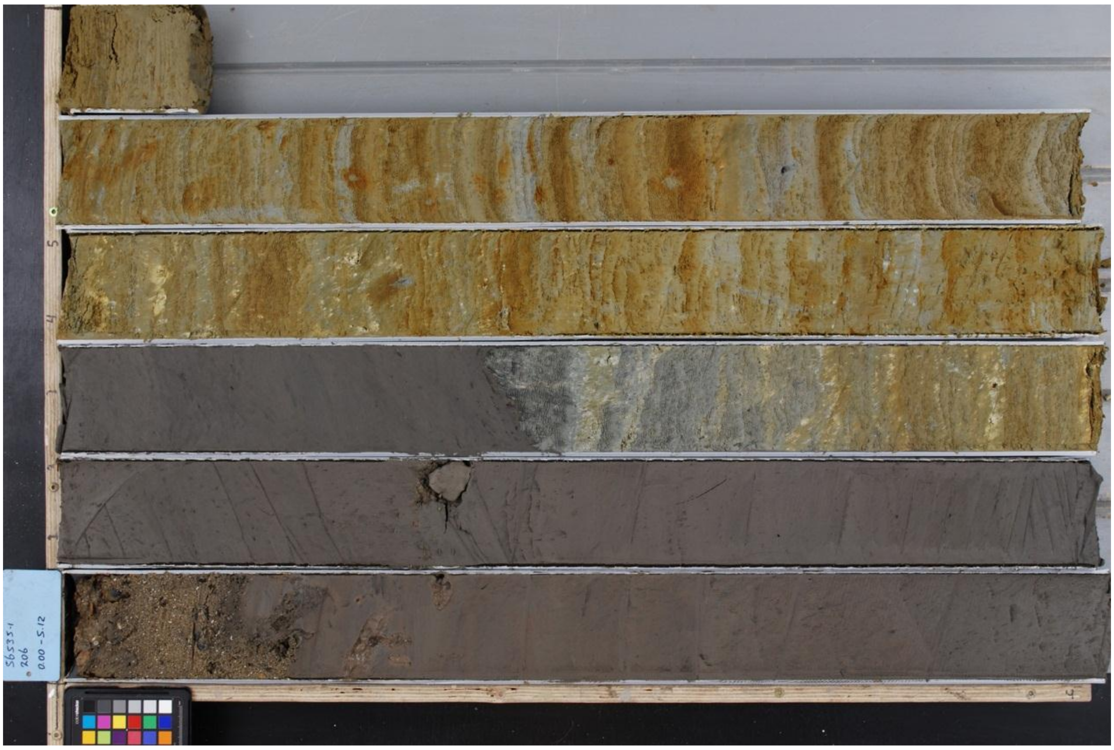

Figure 12. Image of vibrocore 206

4.11 VIBROCORE 207

Table 12 outlines the deposits present in core 207; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 13** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment Description
0	1.05	Silty CLAY- Organic
1.05	0.66	Silty CLAY- slightly sandy
1.71	0.68	Silty CLAY- very sandy
2.39	0.39	SAND – mixed with gravel
2.78–3.00	0.22	LONDON CLAY

Table 12. Lithological deposits in vibrocore 207

Figure 13. Image of vibrocore 207

4.12 VIBROCORE 301

Table 13 outlines the deposits present in core 301; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 14** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment Description
0	0.30	Sandy SILT
0.30	1.05	Silty Organic CLAY
1.35	3.40	Slightly silty fine laminated SAND
4.75–5.00	0.25	Sandy, silty CLAY- with shell inclusions

Table 13. Lithological deposits in vibrocore 301

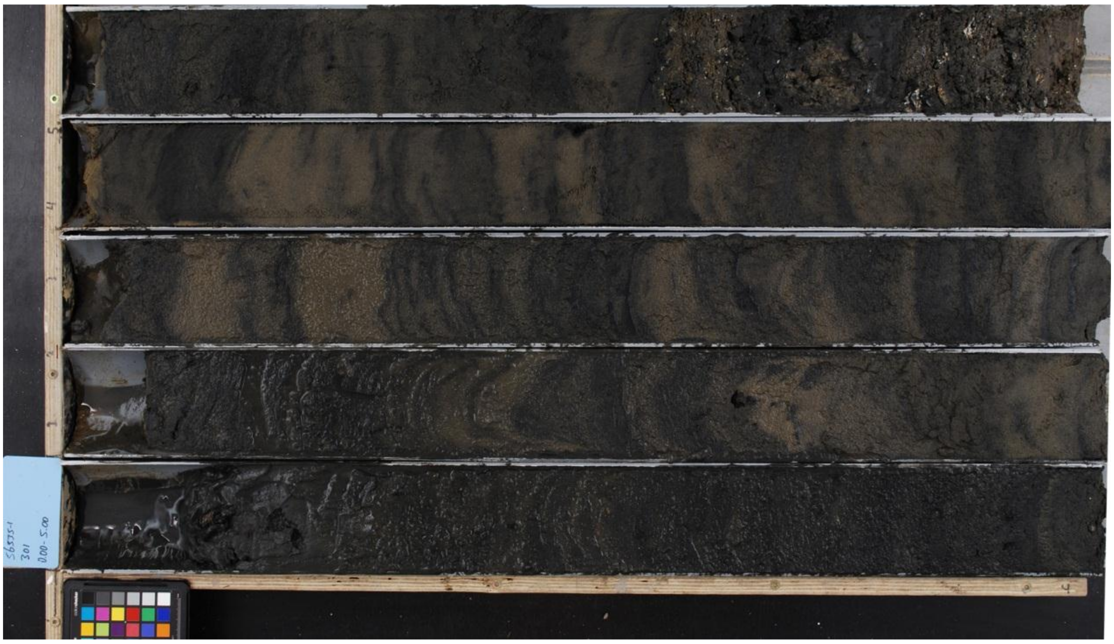

Figure 14. Image of vibrocore 301

4.13 Vibrocore 302

Table 14 outlines the deposits present in core 302; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 15** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment Description
0	2.32	Fine SAND
2.32	0.04	Medium coarse SAND
2.36–4.15	1.79	Fine SAND

Table 14. Lithological deposits in vibrocore 302

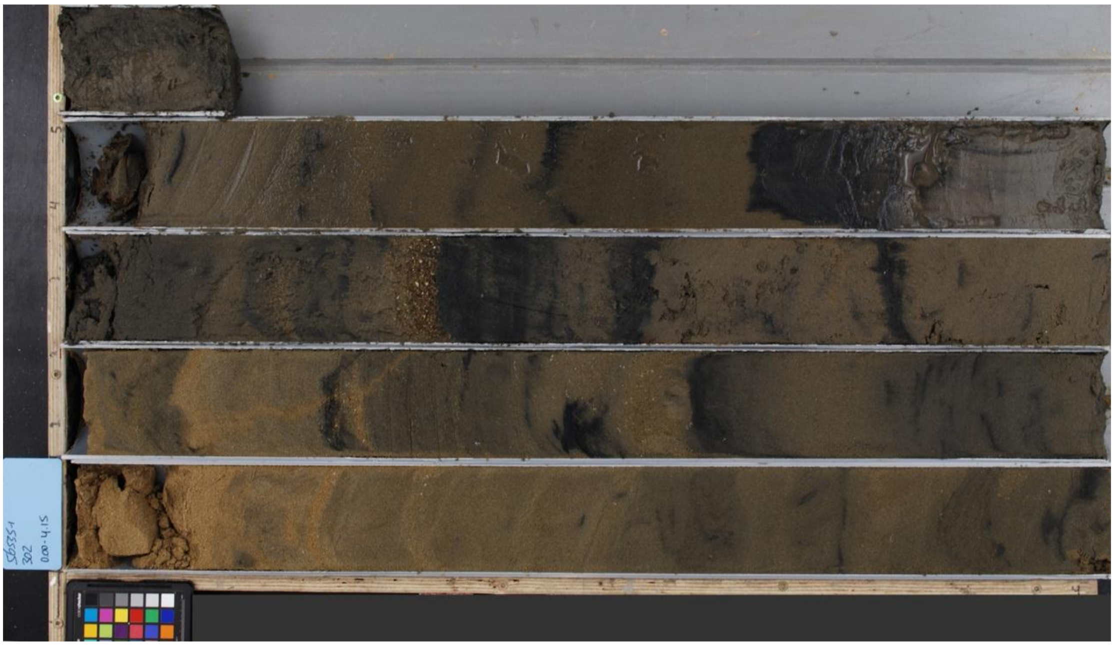

Figure 15. Image of vibrocore 302

4.14 VIBROCORE 303

Table 15 outlines the deposits present in core 303; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 16** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment Description
0−4.75	4.75	Silty CLAY

Table 15. Lithological deposits in vibrocore 303

Figure 16. Image of vibrocore 303

4.15 VIBROCORE 304

Table 16 outlines the deposits present in core 304; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 17** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment Description
0	1.14	Silty laminated CLAY
1.14	0.54	Silty Sandy CLAY
1.68	1.92	Very Silty CLAY
3.60	0.37	Organic Silty, sandy CLAY
3.97	0.23	Sandy SILT
4.20–4.94	0.74	Gravely SAND

Table 16. Lithological deposits in vibrocore 304

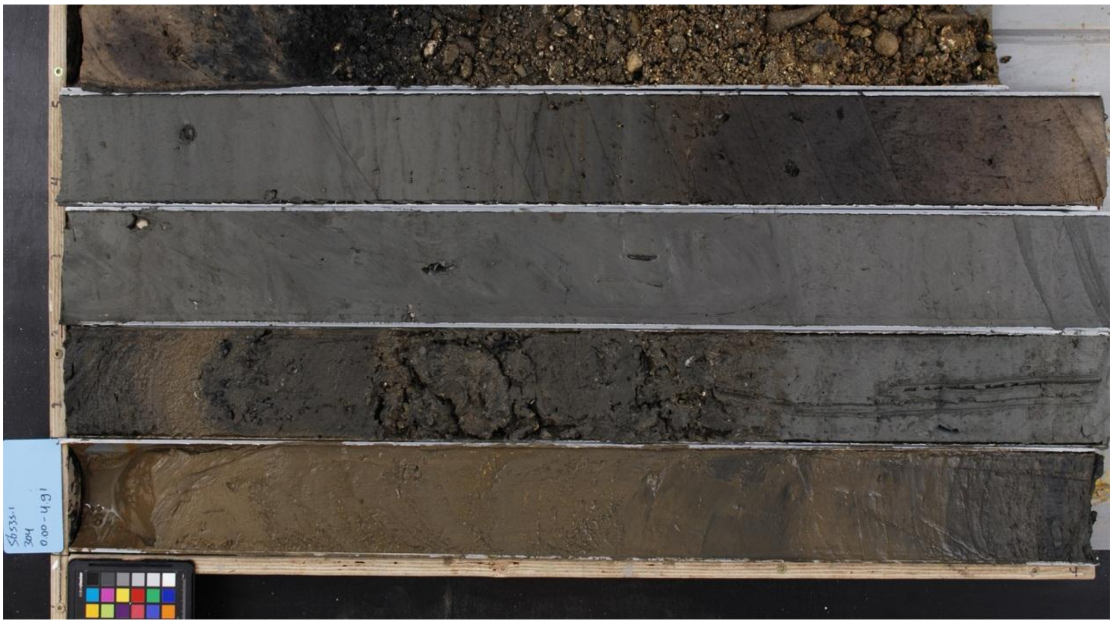

Figure 17. Image of vibrocore 304

4.16 Vibrocore 305

Table 17 outlines the deposits present in core 305; it includes a description of the lithological deposits and information on their nature and inclusions. **Figure 18** illustrates the core before recording.

Depth to top of stratum (m)	Thickness (m)	Sediment Description
0−1.98	1.98	Silty, sandy CLAY
1.98−2.25	0.27	Silty Sandy CLAY
2.35−2.44	0.09	Sandy Silty CLAY
2.44−3.77	1.33	LONDON CLAY

Table 17. Lithological deposits in vibrocore 305

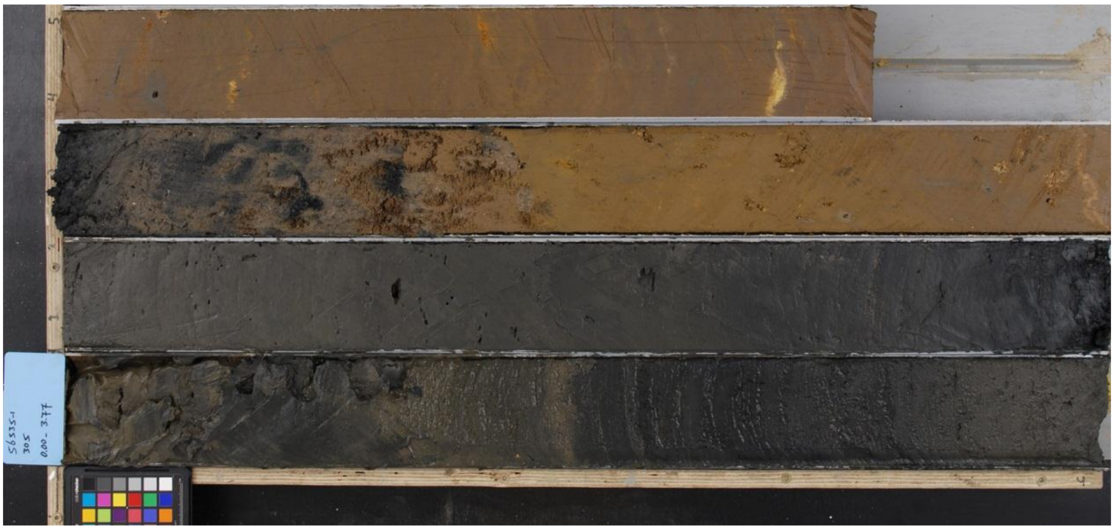

Figure 18. Image of vibrocore 305

4.17 Comparison of Cores

The material within the vibrocores, especially the cores collected for archaeological purposes (201-207), show some general similarity in the deposits represented. A review of their comparative depths and character is provided below in support of the initial interpretation provided in **Section 4**. Analysis of the cores revealed eight key stratigraphic units presented in **Table 18** and described below.

Unit	Interpretation
8. Marine Sand	Seabed sediment
7. Holocene deposit	Holocene seabed sediments
6. Holocene marine deposits/estuarine alluvium	Marine and estuarine deposits laid down in the Holocene.
5. Holocene humic clays	Peat forming due to rising ground water levels during the Holocene.
4. Holocene lag deposit	Concentration of gravel enhanced by the removal of fine sediment, water accumulated during the Holocene
3. Pleistocene marine deposits/estuarine alluvium	Pleistocene marine and estuarine deposits. Low energy in nature.
2. Pleistocene lag deposit	Concentration of gravel enhanced by the removal of fine sediment, water accumulated during the Pleistocene
1. London Clay	Ypresian (Lower Eocene Epoch)

Table 18. Key stratigraphic units

Unit 8 - Marine Sand: Present in most of the cores at varying thickness (**Table 19**). The marine sand is a mixed deposit including clay, sand, gravel and shell. It makes up the seafloor in the area closest to the shore (DONG Energy, 2011b:62). The marine sand was not located in the vibrocores taken in the southern part of the area (301-305) where the seafloor changes from mixed sediment towards a muddy and sandy sediment (DONG Energy, 2011b:62).

Core	Penetration depth (m)	Elevation LAT (m)	Elevation OD (m)	Description
201	0−0.25	-6.90− -7.15	-9.19 -9.44	MARINE SAND - sand, gravel mixed with shell
202	0−0.52	-2.93− -3.45	-5.22 -5.74	MARINE SAND - sand, gravel mixed with shell
202a	0−0.45	-7.59− -8.04	-9.88 -10.33	MARINE SAND - sand, gravel mixed with shell
203	0−0.07	-6.13− -6.20	-8.42 -8.49	MARINE SAND - sand, gravel mixed with shell
204a	0−0.10	-6.10− -6.20	-8.39 -8.49	MARINE SAND - sand, gravel mixed with shell
205	0−0.02	-6.34− -6.36	-8.63 -8.65	MARINE SAND - sand, gravel mixed with shell
206	0−0.22	-4.08− -4.30	-6.37 -6.59	MARINE SAND - sand, gravel mixed with shell
113	0−0.02	n/a	n/a	MARINE SAND - sand, gravel mixed with shell
114	0−0.09	-2.15− -2.24	-4.44 -4.53	MARINE SAND - sand, gravel mixed with shell
115	0−0.30	-2.93− -3.23	-5.22 -5.52	MARINE SAND - sand, gravel mixed with shell

Table 19. Unit 8 - Marine Sand

Unit 7 - Holocene deposit: Identified in five of the cores, comprises of sandy silts and clays. The unit refers to alluvial deposits where obvious channel features are not clearly noticeable within the core. **Table 20** summarises the location and depth of the deposit.

Core	Penetration depth (m)	Elevation LAT (m)	Elevation O.D. (m)	Description
115	0.30–0.98	-3.23– -3.91	-5.52– -6.20	Slightly silty SAND
301	0.30-–5.00	-12.70– -17.70	-14.99– -19.99	Silty CLAY, SAND and sandy CLAY
302	0.0–4.15	-0.33– -4.48	-2.62– -2.19	Fine to coarse SAND
303	0.0–4.75	-8.22– -12.97	-10.51– -15.26	Silty CLAY
305	0–2.44	-8.24– -10.68	-10.53– -12.97	Silty and sandy CLAY

Table 20. Unit 7 - Holocene deposit

Unit 6 - Holocene marine deposits/ estuarine alluvium The Holocene alluvium is present in all the archaeological cores (201-207) but also in core 304. The alluvium consists mostly of silt clay and is at time underlain and/or overlain by a humic Holocene deposit (Unit 5). **Table 21** summarises the location and depth of the deposit within the cores.

Core	Penetration depth (m)	Elevation LAT (m)	Elevation O.D. (m)	Description
201	0.25–2.53	-7.18– -9.46	-9.81– -11.75	SILT and silty CLAY
202	0–0.75	-7.52– -8.27	-9.81– -10.56	silty CLAY
202a	0.45–3.10	-8.04– -10.69	-10.33– -12.98	silty CLAY
203	0.70–1.90	-6.83– -8.03	-9.12– -10.32	SILT
204a	1.10–1.43	-7.20– -7.53	-9.49– -9.82	Silty CLAY and SILT
205	0.02–1.93	-6.36– -8.27	-8.65– -10.56	Silty CLAY
206	2.44–5.10	-6.53– -9.18	-8.82– -11.47	Silty CLAY
207	0–0.63	-4.46– -5.09	-6.75– -7.38	Silty CLAY
207	0.83–2.39	-5.29– -6.85	-7.58– -9.14	Silty CLAY
304	0.0–3.60	-12.88– -16.48	-15.17– -18.77	Sandy and silty CLAY

Table 21. Unit 6 - Holocene alluvium

Unit 5 - Holocene humic clays- This alluvial unit comprises of Holocene silty clays with significant bands or pockets of peat and organic material within the alluvial sequence. The unit was identified in six of the vibrocores as presented in **Table 22**.

Core	Penetration depth (m)	Elevation LAT (m)	Elevation O.D. (m)	Description
202	0.75–2.08	-8.27– -9.60	-10.56– -11.89	Sandy and silty CLAY
202a	3.10–3.90	-10.69– -11.49	-12.98– -13.78	Silty CLAY
205	1.93–2.90	-8.27– -9.24	-10.56– -11.53	Silty CLAY
206	0.22–2.44	-4.30– -6.52	-6.59– -8.81	Silty CLAY
207	0.63–0.83	-5.09– -5.29-	-7.38– -7.58	Silty CLAY
304	3.60–4.20	-16.48– -17.08	-18.77– -19.37	Silty CLAY

Table 22. Unit 5 Holocene humic clay

Unit 4 - Holocene lag deposit- The lag deposit consist of sands, pebbles and gravels. It was detected in five of the vibrocores and can indicate the base of a Holocene channel. The unit is significantly coarser than the overlaying silt and clay deposits. The unit appears to be situated at a depth between 1.5 and 3m depth except from core 304 where it lies approximately 1m deeper (**Table 23**).

Core	Penetration depth (m)	Elevation LAT (m)	Elevation O.D. (m)	Description
201	2.53–3.22	-9.46– -10.15	-11.75– -12.44	Loose sandy gravely SILT
203	1.90–1.95	-8.03– -8.07	-10.32– -10.36	Soft SAND with shell inclusions
204a	1.43–1.68	-7.53– -7.78	-9.82– -10.07	Fine- coarse SAND
207	2.39–2.73	-6.85– -7.19	-9.14– -9.48	Mixed SAND and GRAVEL
304	4.20–4.94	-17.08– -17.82	-19.37– -20.11	Gravely SAND

Table 23. Unit 4 - Holocene lag deposit

Unit 3 - Pleistocene marine deposits/estuarine alluvium - This unit is comprised of a series of sandy clays and silts and clayey sands. Horizontal ripples and laminated bedding of sands and clays is frequently visible, along with marine shell fragments. The unit was found in six of the cores as summarised in **Table 24**.

Core	Penetration depth (m)	Elevation LAT (m)	Elevation O.D. (m)	Description
201	3.22–5.00	-10.15– -11.93	-12.44 -14.22	Sandy SILT and CLAY
202	2.08–3.85	-9.60– -11.37	-11.89 -13.66	Sandy CLAY
202a	3.90–4.87	-11.39– -12.46	-13.66 -14.75	Sandy SILT
203	1.95–4.54	-8.08– -10.67	-10.37 -12.96	CLAY, SILT and SAND
204a	1.68–3.93	-7.78– -10.03	-10.07 12.32	SAND and CLAY
205	2.30–4.00	-8.64– -10.34	-10.93 -12.63	Silty and sandy CLAY

Table 24. Unit 3 - Pleistocene alluvium

Unit 2 - Pleistocene lag deposit - Represents a concentration of sand and gravel enhanced by the removal of fine sediment by water movement. The unit accumulated during the Pleistocene and is often overlain by Pleistocene alluvium deposits. The Pleistocene lag deposit was noted in three of the cores as shown in **Table 25**.

Core	Penetration depth (m)	Elevation LAT (m)	Elevation O.D. (m)	Description
202a	4.85–5.00	-12.46– -12.59	-14.75 -14.88	Sandy GRAVEL
203	4.54–4.74	-10.56– -10.87	-12.85 -13.16	Very silty SAND
204a	3.93–4.35	-10.03– -10.46	-12.32 -12.75	Sandy GRAVEL

Table 25. Unit 2 - Pleistocene lag deposit

Unit 1 - London Clay - Basal unit from the Ypresian period. Only five cores reached down to Unit 1 but it can be assumed that London Clay is the base for the whole area. London Clay can be seen at very shallow depths in cores 113-115 but as the cores extent further south the basal unit lies lower than 6m which is the maximum recovery depth for the vibrocore. **Table 26** summarises the cores containing Unit 1.

Core	Penetration depth (m)	Elevation LAT (m)	Elevation O.D. (m)	Description
113	0.02–2.10	n/a	n/a	Compact, slightly sandy CLAY
114	0.09–2.22	-2.24–-4.37	-4.53–-6.66	Compact, slightly sandy CLAY
115	0.98–2.15	-3.91–-5.08	-6.20–-7.37	Compact, slightly sandy CLAY
207	2.73–3.00	-7.19–-7.46	-9.48–-9.75	Compact, slightly sandy CLAY
305	2.44–3.77	-10.68–-12.01	-12.97–-14.30	Compact, slightly sandy CLAY

Table 26. Unit 1 - London Clay

5 Interpretation

Eighteen vibrocores were taken from a north to south direction running between core 113 and 305. Of the 18 cores, 16 were opened and reviewed for archaeological potential (**Figure 1**).

No specific archaeological material was identified within the cores. However, as outlined below, there is palaeoenvironmental evidence contained in the area. Therefore further, assessment, analysis and dating is required to provide more definitive interpretation of the evidence.At this stage it is possible to undertake an initial review of the palaeoenvironmental evidence and sediment units in relation to previous studies and current understanding of the area.

The recording has demonstrated the presence of a relatively uniform sequence of deposits across the cores; the evidence appears to indicate Holocene channels as well as a Pleistocene channel and their associated sequence of fill deposits in the area.

5.1 Sediment sequence

The sediment units have a clear 'base' of **London Clay**; sedimentary bedrock formed approximately 57 to 36 million years ago in the Ypresian Age (Brenchley & Rawson; 2006). London Clay was recorded in five locations (**Table 26**).

In three of the cores (202a, 203 and 204a) a layer of **Brown silt/ sand/ gravel** is visible (Unit 2). The layer consists mostly of sand and coarse gravel. The unit is summarised in **Table 25** and is interpreted as a lag deposit, meaning a concentration of gravel enhanced by the removal of fine sediment, in this case by water movement. The presence of this sand/ gravel layer indicates the base of a riverine or channel environment. Unit 2 may be related to the Pleistocene channel previously identified in this area (DONG Energy, 2011b), although further assessment and analysis is required in order to confirm this.

A sequence of very **sandy silts and clay** (Unit 3) with horizontal ripples and laminated bedding of sands and clays is noted in six of the cores (201, 202, 202a, 203, 204a and 205), as summarised in **Table 24.** Unit 3 probably represents an alluvial infilling of a Pleistocene river system. The laminated bedding characterises a dynamic environment where the large and heavier (sand) sediment has been deposited on the river floor by the flowing water, over time creating the cross-bedded horizontal outline.

In five of the cores (201, 203, 204a, 207 and 304) a layer of **brown silt/ sand/ gravel** is present (Unit 4, **Table 23**). The layer consists generally of sand and coarse gravel. The unit is interpreted as a lag deposit meaning a concentration of gravel enhanced by the removal of fine sediment. The deposit of this sand/ gravel layer indicates the base of a riverine or channel environment. Unit 4 may be related to the Holocene channel previously identified in this area and possesses a high archaeological potential.

Unit 5 is an alluvial unit that comprises of **Holocene silty clays** with significant peat horizons and organic material within the alluvial sequence. The unit was identified in six of the vibrocores (202, 202a, 205, 206, 207 and 304) as presented in **Table 22**. The peaty organic layers probably formed as a result of rising groundwater level during the Holocene period. Samples from this unit could be used for radiocarbon dating and are have the potential to, following further analysis, provide sea-level index points for the Northern Thames Estuary.

A **Holocene marine deposits/ estuarine alluvium** (Unit 6) is present in all the archaeological cores (201-207) and in core 304. The alluvium consists mostly of silty clay and is underlain by a humic Holocene deposit (Unit 5). **Table 21** summarises the location and depth of Unit 6 within the cores. This deposit could indicate a sequence of Holocene estuarine and marine silts building up over time and eventually turning into a shallow marine deposit.

Unit 7 has been identified as a **Holocene deposit**. It was identified in five cores (115, 301, 302, 303 and 305) and is comprised of sandy silts and clays. The deposit is overlain by the current seabed deposit (Unit 8). Unit 7 is presented in **Table 20.**

The current seabed deposit (Unit 8) is mostly made up by **Marine Sand**. Present in most of the cores, the marine sand is a mixed deposit including clay, sand, gravel and shell and makes up the seafloor in the area closest to the shore. In the southern part of the cable route the seafloor changes from mixed sediment towards muddy and sandy sediments. Unit 8 is summarised in **Table 19.**

5.2 POTENTIAL CHANNEL DEPOSITS

As outlined within the assessment documents produced as part of the Environmental Statement (DONG Energy, 2010), within the WSI for the project (MA Ltd, 2012) and in **Section 2.3** above, the area is of particular significance due to the presence of the Pleistocene sequence of Clacton Channel deposits. These deposits have been shown to contain evidence related to early human occupation of Britain. Additionally a Holocene channel has been previously identified in this area (Bridgeland et *al*.; 1999).

In relation to the potential for encountering the earlier Clacton Channel deposits within the area (DONG Energy, 2011b), indicate that the "The uppermost channel deposit, the Clacton Estuarine Beds, can be found to lie around c.3-5 m below ground level. The deposits have been covered by Holocene sediments and the landscape indicates a former marshland with winding creeks surviving in places as drains".

As part of the 2011 ES offshore addendum, Wessex Archaeology delineated two broad swaths of the northern part of the survey area as preserving prehistoric features, and a smaller channel feature in the near shore zone. In the archaeological assessment of geophysical survey data undertaken by MA Ltd (July, 2012), the channel bases were digitised from the full range of profiles and the lateral relationships of each was demonstrated, defining a complex channel sequence (**Figure 19**). These features are believed to be representative of the Holocene channel system that has been identified onshore (DONG Energy, 2010; DONG Energy, 2011a; Bridgeland *et al*., 1999). This channel system has also been detected towards the shore in CPTU tests undertaken for the project and is visible in the onshore cores (MA Ltd, August, 2012).

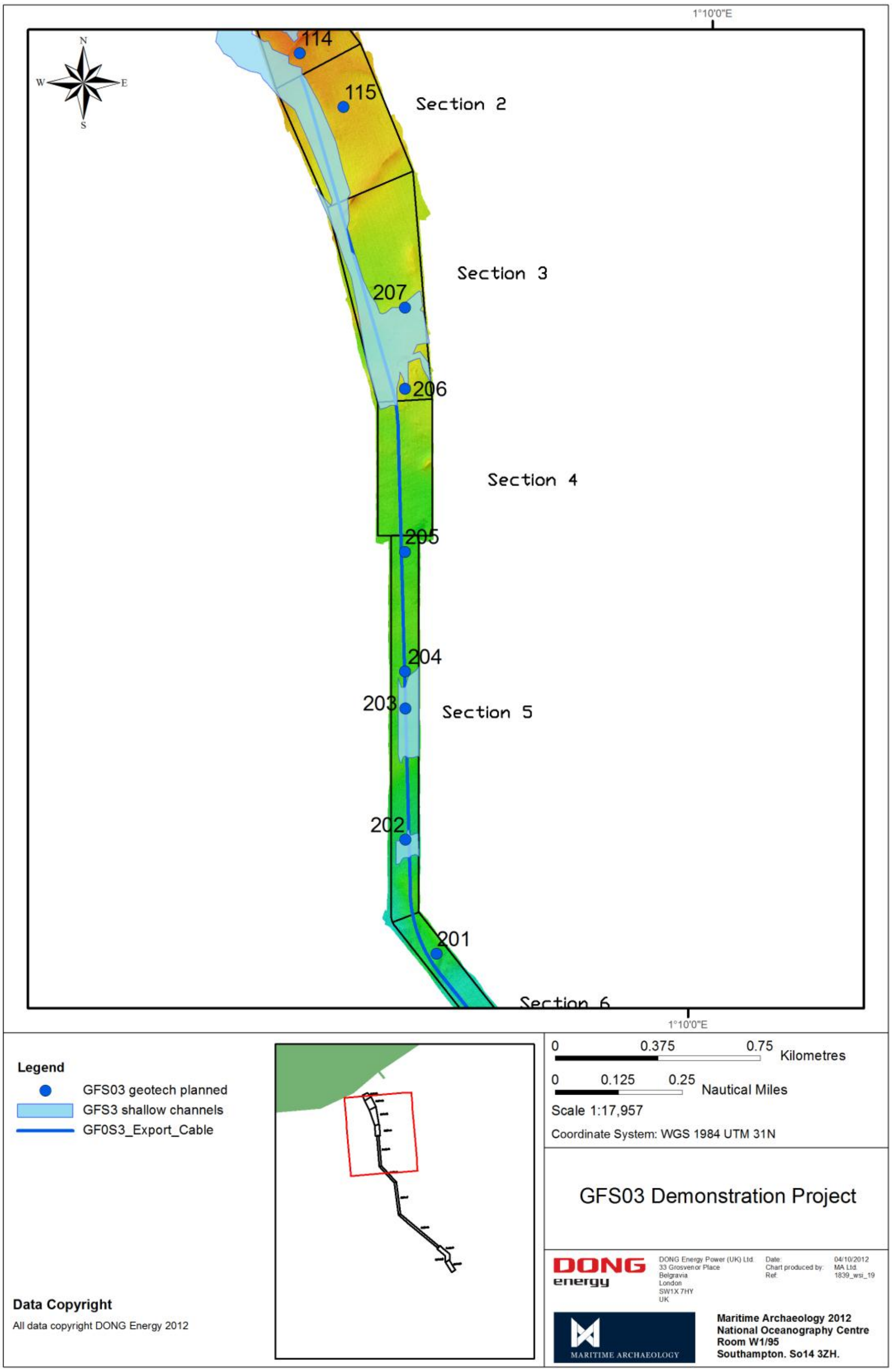

Figure 19. Channel features identified in the geophysical data

The ES document outlines (DONG: 2010);

"The underlying geology of the area is London Clay, upon which lie a series of gravel terraces dating to the Thames before it was diverted to the south during the Anglian glaciation around 450,000 years ago. The Clacton Channel deposits are believed to have been deposited during Marine Isotope Stage3 (MIS) 11, the Hoxnian interglacial period (c.425-380,000 BP) in a channel of the Thames-Medway river system.

In general terms the Clacton Channel deposits occur from depths of c.1m to c.20m below the surface. They extend in an arc from Seawick to the west, covering the historically low and marshy ground around the historic core of Jaywick, continuing to the east in the area to the south of West Road (including the golf course) and tapering off before Clacton Pier. Within this zone there are multiple channels, probably representing successive phases of downcutting. Clactonian tools, including the tip of a wooden spear, one the oldest known wooden artefacts in the world, have been found in the lower 'freshwater' gravels of the main channel which are also highly fossiliferous".

"The Clacton Channel deposits in the vicinity of the proposed landfall were explored by a series of boreholes and trenches carried out when the former Butlins holiday camp site was being redeveloped in 1987 (boreholes 11-15; Bridgland et al 1999). The upper deposits in the Clacton Channel are known as the 'estuarine beds' and while they contain an important fossil record, they do not contain the mammalian fauna and hominid artefacts that the lower, 'freshwater beds' do. These were found at a depth of 1.5 m - 2.5 m on the Butlins site although the lower freshwater gravels, from which most hominid material has been recovered, were only found at depths of 4 m or more".

The Offshore Addendum document (DONG: 2011b) outlines the following:

Holocene sea level rise indicates that the area of the proposed GFS 3 export cable route has the potential to contain terrestrial sites from the Palaeolithic, Mesolithic and possibly the Neolithic (500,000 before present (BP) to 2,400 before Christ (BC).

For the Lower Palaeolithic there is clear evidence of activity within the region. One of the main 'type sites' for the period is the Clacton Channel: a relict channel of the Thames-Medway system dating to MIS 11, the Hoxnian interglacial (c.425,000-380,000 BP), containing a rich fossil record associated with an assemblage of hominid tools. The relict channel - as it has been documented up to this point - cuts across the Jaywick Peninsula in a broadly south-west to north-east alignment over distance of some 3 km with a total width of c. 750 m. It extends from the western edge of Jaywick, across Clacton Golf Club into south-western Clacton extending almost as far as the pier. The Clactonian flint assemblage represents occupation along the early Thames/Medway watercourse for about 3 km, and is associated with faunal remains, palaeo-botanical data and a rare wooden spear.

The base of the main Clacton Channel lies at an elevation of 0 to 5 m ordnance datum (OD), which suggests that the deposits within it extend into the intertidal zone and probably slightly beyond Mean Low Water (which lies at c. -2 m below OD at Clacton).

A secondary, narrower channel identified on the Jaywick foreshore immediately south of the main Clacton Channel (Warren's Channel iv; Warren et al., 1936) is now believed to be considerably younger: MIS 5e, the Ipswichian Interglacial (130,000-114,000 BP). The base of this channel is at c. -5 m below OD.

In addition to the terrestrial geomorphological observations, there is support for the existence of offshore Pleistocene sequences from the discovery of mineralised mammal teeth recovered by fishermen off Clacton. These observations are now supplemented by the evidence from the GFS 3 export cable route geophysical survey of previously unidentified offshore Pleistocene channels. As the Clacton Channel indicates, all of these channels - besides the scientific value of their fossil records - also have the potential to contain Lower Palaeolithic archaeological material. The June 2011 offshore geophysical survey, as well as observations on the land, indicates the survival of Early-Mid Holocene alluvial sediments in relict drainage systems along the coast. One such area was identified during investigations in the 1980s in the area of the proposed HDD landfall for the GFS 3 export cable (Bridgland et al., 1999, 136-138; Figure 12.5).

Indications that such features extend underwater have been found offshore in this same area. A borehole, c. 120 m offshore and c. 200 m west of the proposed cable route, carried out by the EA ahead of recent coastal works encountered a sequence of sediments extending to a depth of 4.1 m below the sea floor. The lowest fill was soft dark brown silt, overlain by a yellow brown silt containing horizons of organic material below marine sand. Some 150 m to the south-east of this location, the geophysical survey identified a feature containing a very similar sequence. The size and fill of this feature and its proximity to the Holocene alluvial sequence described above perhaps indicates the presence of an Early-Mid Holocene drainage system in this area.

The preliminary review of the cores appears to support the interpretation that the Holocene alluvial sediments and channel systems extend in a southerly direction underwater and can be found along the export cable route. It is also likely that the Pleistocene channel sequence identified from the geophysical survey data and visible in the vibrocores can be found in the offshore area.

The alluvial sequence (Unit 6), including the alluvial deposit with organic banding (Unit 5) and the basal gravely sequence (Unit 4), appears to be comparable to the Holocene sediments also encountered on the onshore area (MA Ltd, 2012). However the alluvial Unit 3, and the basal gravel Unit 2 are more likely to be related to the earlier Pleistocene Clacton Channel deposit.

Figure 20 shows vibrocore 202a and the sub-bottom profile where the units recorded in the viborocore correlate with the continuous reflectors visible in the sub-bottom data. The reflector has captured the Holocene channel deposits and the underlying Pleistocene fills clearly.

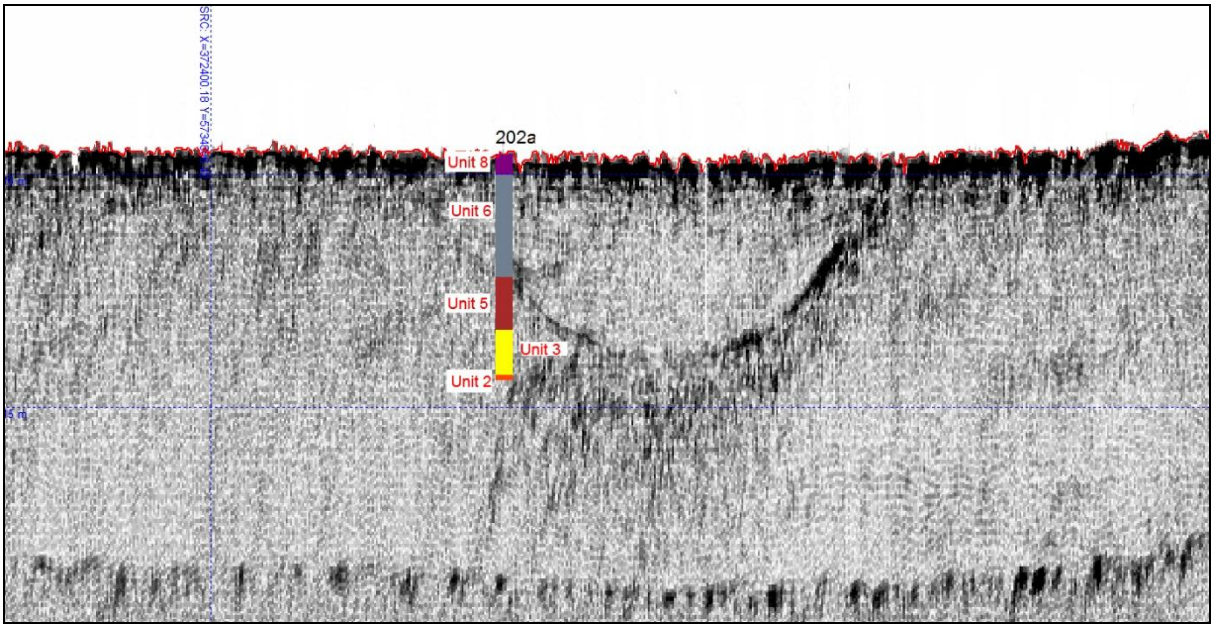

Figure 20 Sub bottom profile, Line; CL_005 and vibrocore 202a (Purple- Unit 8, Grey- Unit 6, Red- Unit 5, Yellow- Unit 3, Orange- Unit 2)

Units 2 and 3 indicate that the Pleistocene Channel deposits appear to be extending for c. 2.5-4 km offshore along the export cable route. The alluvial Unit 3 is noted in vibrocores (201-205). Unit 2 is found in at a depth of 3.93m in vibrocore 204a, but lies deeper in 202a (4.85 m) and 203 (4.54 m). As Unit 2 was not located in vibrocore 205, 202, and 201 it can be assumed that the Pleistocene Channel base is located in the vicinity of core 202a, 203 and 204a with sloping channel edges not containing the lag deposit (Unit 2), to the north (205) and the south (202 and 201) (**Figure 21**).

A very similar sequence of Holocene and Pleistocene channels deposits was identified by Wessex Archaeology (WA) from the sub bottom, boomer survey undertaken in 2011 (DONG Energy; 2011b; 154). The anticipated fills (sediment units) interpreted by WA do correlate to an extent with the results from the core review, confirming a basal Pleistocene unit underlying an alluvial deposit and a Holocene cut and fill deposit (MA Ltd., April, 2012).

The Holocene and Pleistocene dates of the channels and possible areas of stable land surface provide the potential for this area to have been used by human populations during the Mesolithic and Neolithic periods. No archaeological material was noted within the cores, though artefacts of this date has been found in the surrounding areas (Bridgeland, 1999) and may therefore be dispersed across the land surface, so their potential presence should not be discounted especially in the basal gravelly deposits (Unit 2 and Unit 4).

Further analysis of the cores should seek to gain detailed information on the environment of deposition throughout the sequence, including whether there were marine, brackish or freshwater conditions. Obtaining a date for the organic rich sediments within the cores will refine the understanding of channel development. The successive layers of organics are likely to represent marine transgression and alternating periods of stability and change.

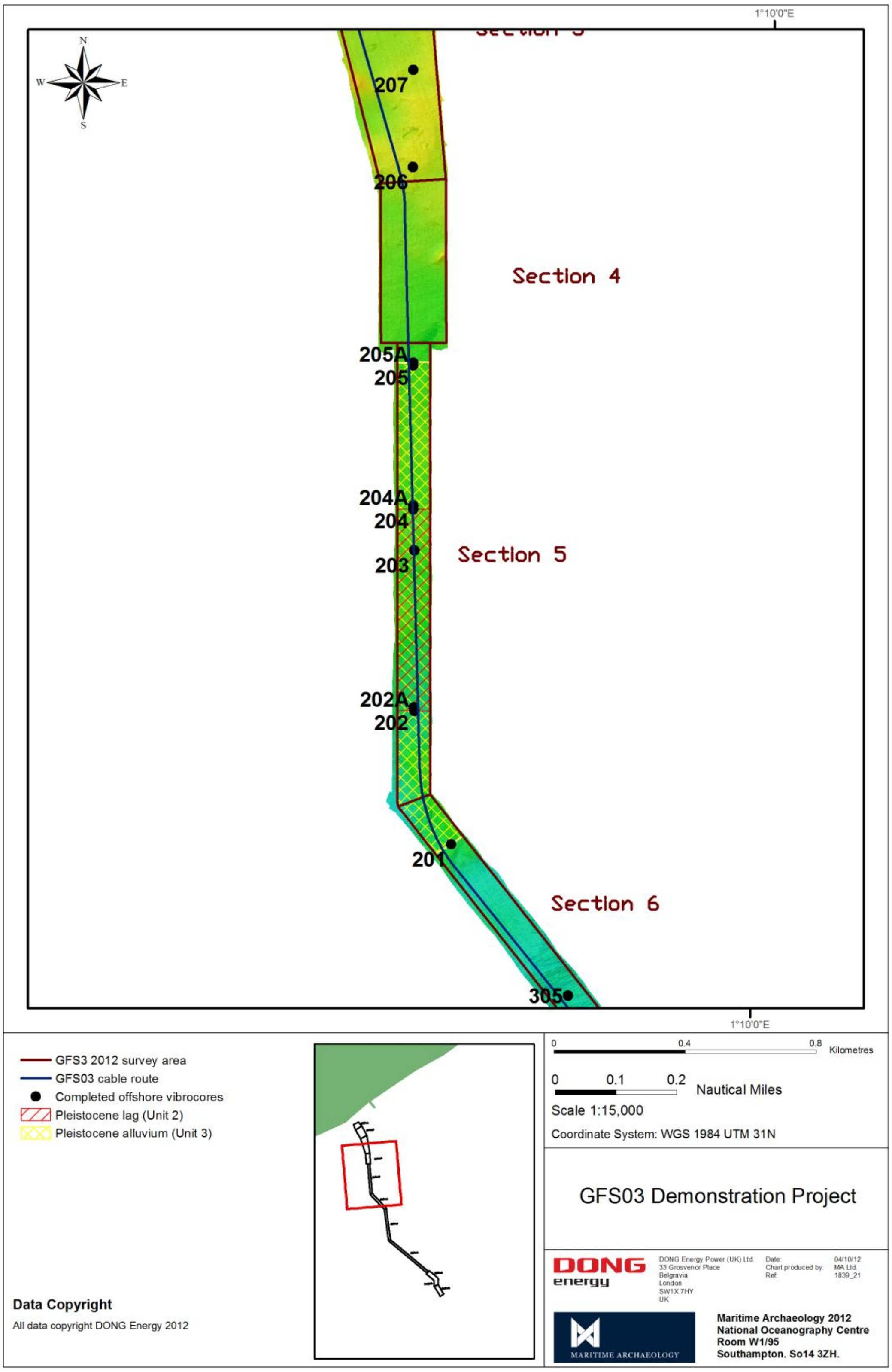

Figure 21 Areas containing unit 2 and 3

6 Conclusions and Recommendations

Vibrocoring in the offshore zone has determined that sequences of palaeochannel deposits are present along the planned offshore export cable route. The proposed offshore export cable route between the landfall and GFS3 wind farm will be installed through either ploughing, jetting or trenching to a depth of between 1 – 3m. Therefore it is possible that the cable will impact on Holocene and Pleistocene fills. **Table 27** summarises the units potentially impacted by the export cable trench.

Core	Unit	Penetration depth (m)	Elevation LAT (m)	Elevation O.D. (m)
201	6	0.25−2.53	-7.18 − -9.46	-9.47 − -11.75
201	4	2.53−3.22	-9.46 − -10.15	-11.75 − -12.44
202	6	0−0.75	-7.52 − -8.27	-9.81 − -10.56
202	5	0.75−2.08	-8.27 − -9.60	-10.56 − -11.89
202	3	2.08−3.85	-9.60 − -11.37	-11.89 − -13.66
202a	6	0.45−3.10	-8.04 − -10.69	-10.33 − -12.98
203	6	0.07−1.90	-6.20 − -8.03	-8.49 − -10.32
203	4	1.90−1.95	-8.03 − -8.08	-10.32 − -10.37
203	3	1.95−4.54	-8.08 − -10.67	-10.37 − -12.96
204a	6	0.10−1.43	-6.20 − -7.53	-8.49 − -9.82
204a	5	1.43−1.68	-7.53 − -7.78	-9.82 − -10.07
204a	3	1.68−3.93	-7.78 − -10.03	-10.07 − -12.32
205	6	0.02−1.93	-6.36 − -8.27	-8.65 − -10.56
205	5	1.93−2.90	-8.27 − -9.24	-10.56 − -11.53
205	3	2.90−4.00	-9.24 − -10.34	-11.53 − -12.63
206	5	0.22−2.44	-4.30 − -6.52	-6.59 − -8.81
206	6	2.44−5.10	-6.52 − -9.18	-8.81 − -11.47
207	6	0−0.63	-4.46 − -5.09	-6.75 − -7.38
207	5	0.63−0.83	-5.09 − -5.29	7.38 − -7.58
207	6	0.83−2.39	-5.29 − -6.85	-7.58 − -9.14
207	4	2.39−2.73	-6.89 − -7.19	-9.18 − -9.48
304	6	0 −3.60	-12.88 − -16.48	-15.17 − -18.77

Table 27. Summary of units potentially impacted by the planned construction

Due to the presence of buried land surfaces which are extant along the cable route, it is recommended that archaeological involvement with the grapnel survey and cable laying through a watching brief will take place. As the grapnel survey involves bringing anchors to the surface along with items or deposits they have come into contact with, it is recommended to have an archaeologist on board to undertake a watching brief. This would be particularly relevant for the areas of palaeochannels. The method used for cable laying will determine whether a watching brief is possible for this activity. If no seabed material will be brought to the surface then it may not be possible. Instead it may be preferable to utilise the Protocol for Reporting Archaeological Discoveries should unexpected items or deposits be encountered.

6.1 RECOMMENDATIONS FOR FURTHER CORE AND DATA ASSESSMENT AND ANALYSIS

There is a need to undertake sampling, assessment and analysis of the material represented within the recovered cores in order to be able to fully understand their character and the evidence they provide on the palaeoenvironmental and geomorphological development of this area. There are clear questions over the date and nature of the deposits represented and their relationship to the known evidence of the Clacton Channel deposits.

It is acknowledged that specialist assessment and analysis of the cores will be required. Now that initial review of both the onshore and offshore cores has been undertaken. Recommendations for further assessment and analysis has considered all cores together as they provide information on the same channel systems. The first assessment stage will establish the presence/absence of the proxies selected for interrogation, the standard of preservation and concentration can provide a valuable tool for objectively determining the necessity or validity of a more comprehensive analytical programme.

A number of techniques are recommended in the first assessment stage with three primary areas of focus:

- Microfossils such as pollen (used as a regional proxy indicator).
- Macrofossils such as insect remains and waterlogged plant remains including seeds and wood (all site specific indicators which provide comment on vegetation type, rates of change etc.).
- The collection of material suitable for radiocarbon and Optically Stimulated Luminescence dating (to provide a site chronology)

6.1.1 Onshore cores recommended for further assessment and analysis

After archaeological re-examination of the terrestrial cores a number of boreholes contained deposits which were highlighted as having palaeoecological potential.

Of particular interest was core 101B which contained almost 1.5m of material interpreted as of alluvial origin. Cores 101A_2, 104, 112B, 112C, and 112D also contained deposits of similar material approximately 1m in depth. The remaining cores, 105, 106, 112A and 112E contained less significant deposits. Alluvium was wholly absent from core 101A_1.

In light of this it is recommended that core 101B is subject to a comprehensive programme of assessment and selected material from 104 and 101B is also examined.

Table 28 summarises the cores recommended for further analysis.

6.1.2 Offshore cores recommended for further assessment and analysis

A similar set of recommendations will be made for the vibrocores collected in the offshore zone. The recommended assessment and analysis for the holocene deposits will focus on two of the offshore vibrocores, 304 and 305 which contain substantial deposits of alluvium and what appears to be organic rich material.

To establish whether any of the deposits in the cores are of Pleistocene origin and how they relate to the Clacton Channel deposits further Optically Stimulated Luminescence (OSL) sampling is recommended. Unit 3, identified in cores 201, 202, 202a, 203, 204a and 205 qualifies for OSL dating but focus should be put on cores 203 and 204a that contain up to 2.59m of the sandy sediment. Even though the liners have been opened and the deposits subjected to light, it is likely that enough material can be acquired for the control samples. This method has proofed to be successful for the Humber REC project (Marine Aggregate Levy Sustainability Fund: 2011).

Four further vibrocores, 202a, 301, 302 and 303 contain deposits of alluvium and organics intercalated to varying degrees by sand suggesting that they have been subject to episodes of reworking. In contrast to 304 and 305 which appear to be relatively homogeneous. The remaining vibrocores, 113, 114, 115, 201, 202, 205, 206 and 207 are of marginal palaeoecological interest; however they may hold further information of archaeological interest and could be sieved for artefacts/ecofacts.

Table 28 summarises the cores recommended for further analysis.

	Insect/waterlogged plant remains	Radiocarbon dating	Pollen analysis	OLS dating
101B	25 sub samples	3 sub samples	16 sub samples	
104	3 sub samples	2 sub samples	n/a	
304	9 sub samples	3 sub samples	8 sub samples	
305	6 sub samples	3 sub samples	8 sub samples	
203	n/a	n/a	n/a	6 Sub Samples
204a	n/a	n/a	n/a	6 Sub Samples

Table 28 Summary of cores recommended for further assessment and analysis

7 References

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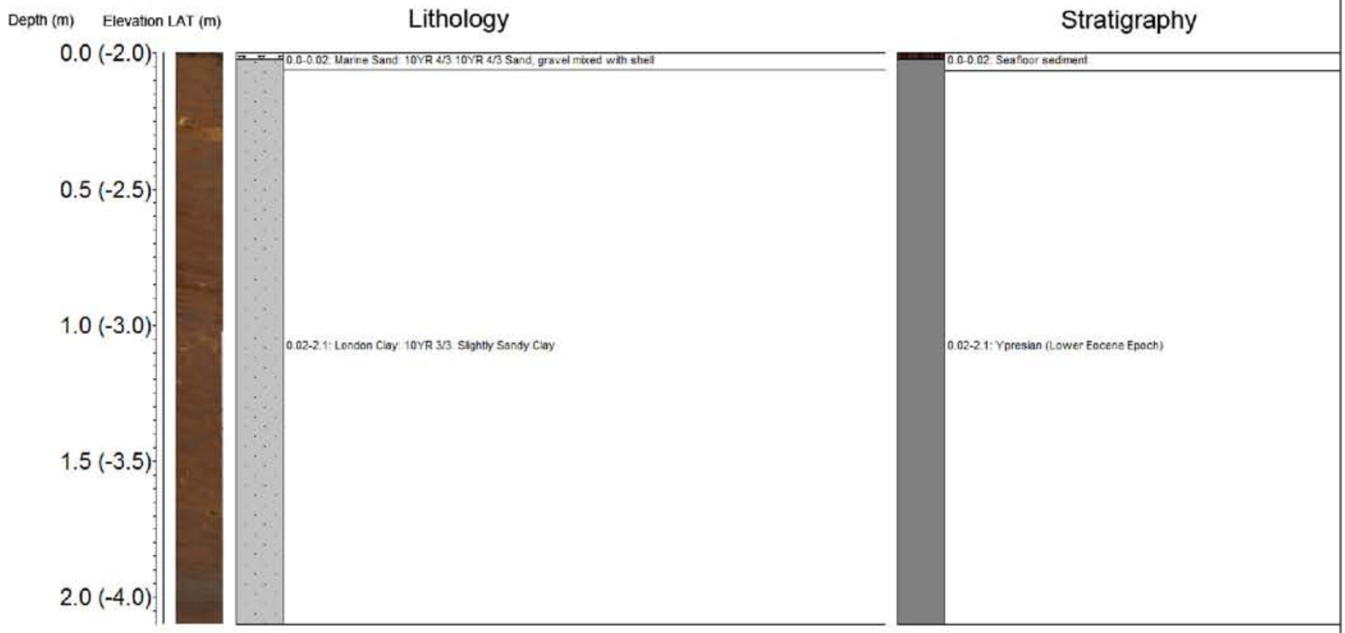
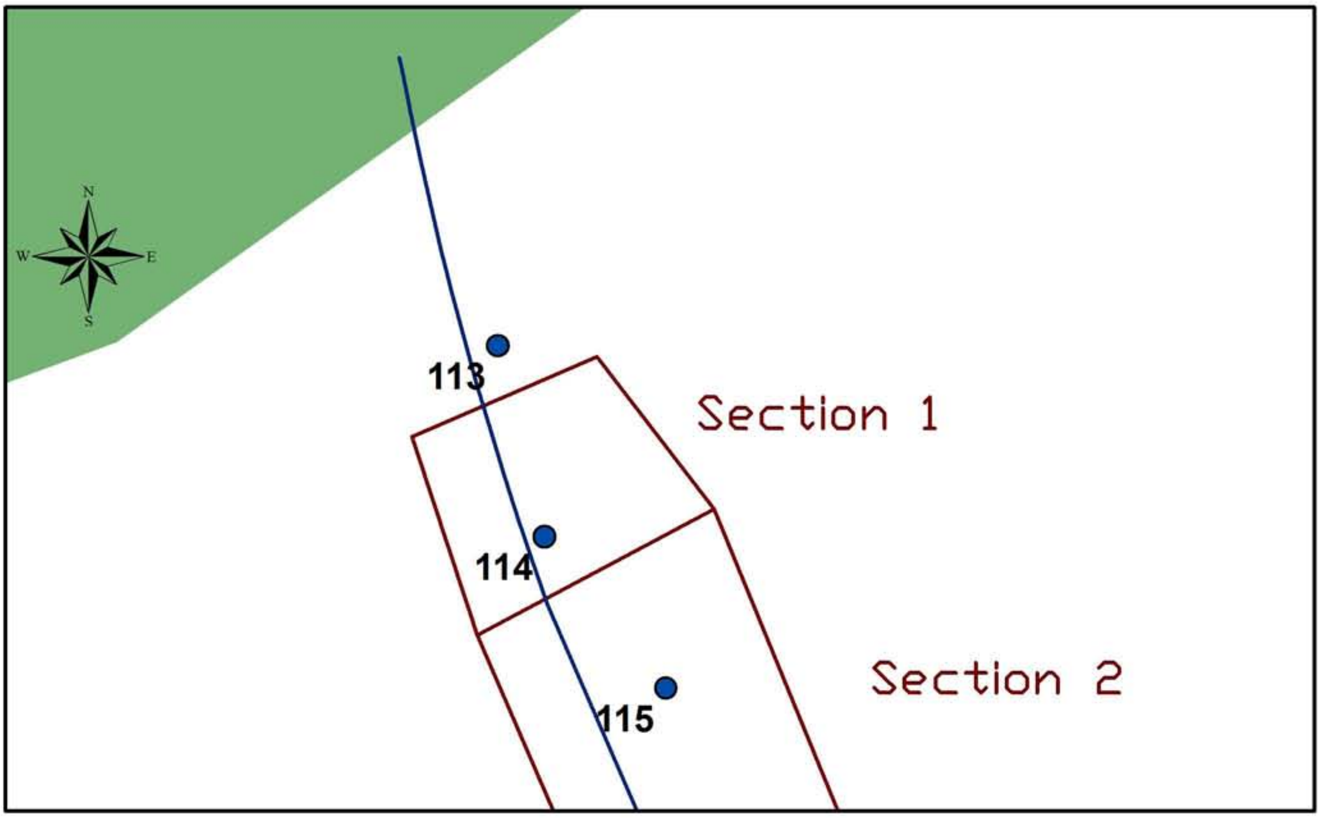
8 Appendices

8.1 APPENDIX 1: VIBROCORE STRIPLOGS

Vibrocore 113





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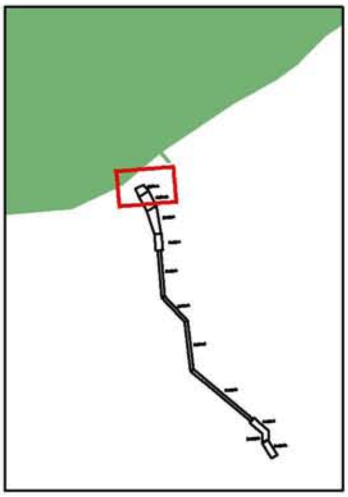
- GFS3 2012 survey area
- Completed offshore vibrocores



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Scale 1:9,857

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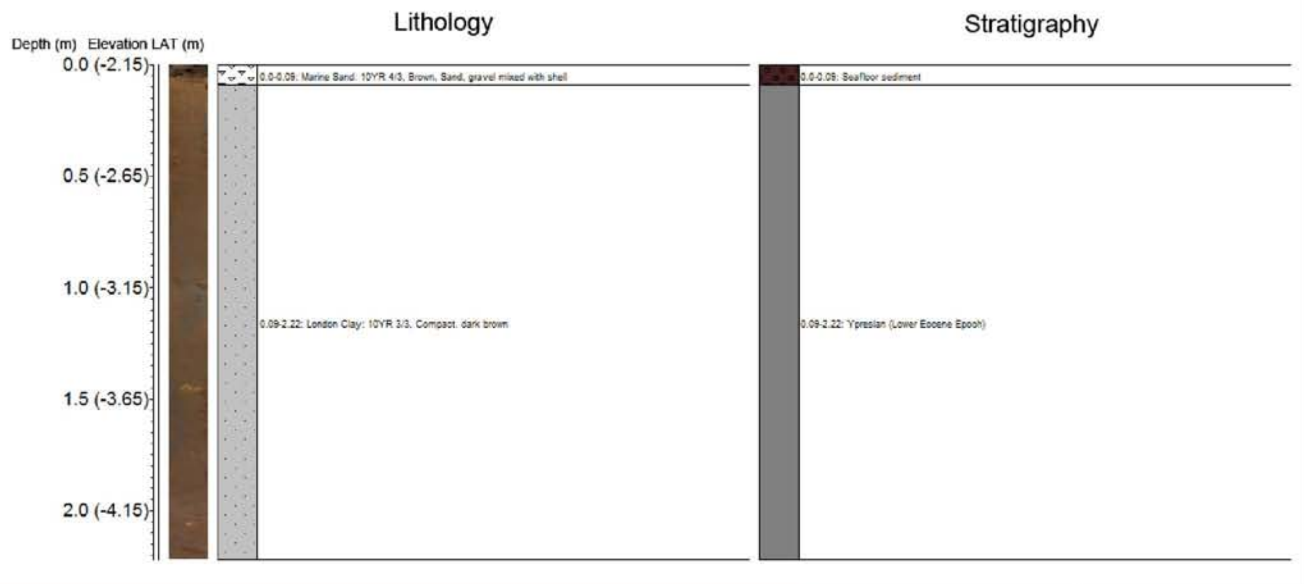
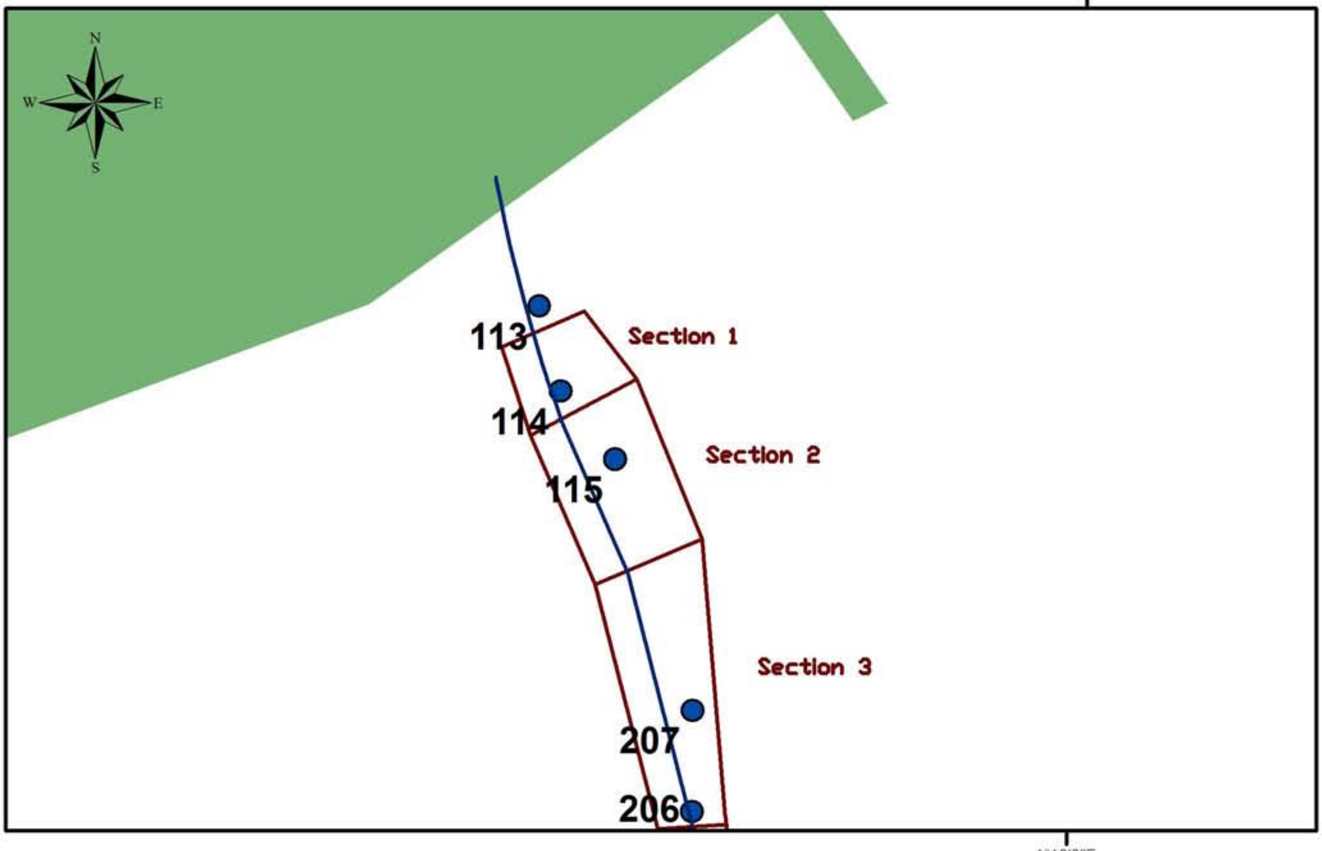
Vibrocore 114

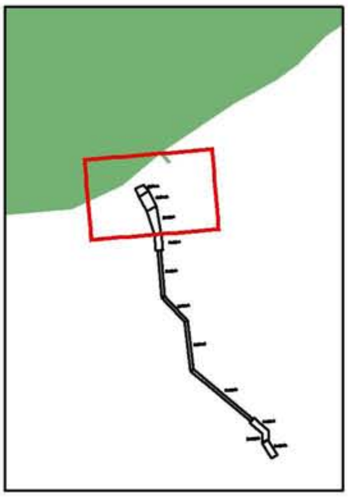




GFS3 export cable route

GFS3 2012 survey area

Completed offshore vibrocores



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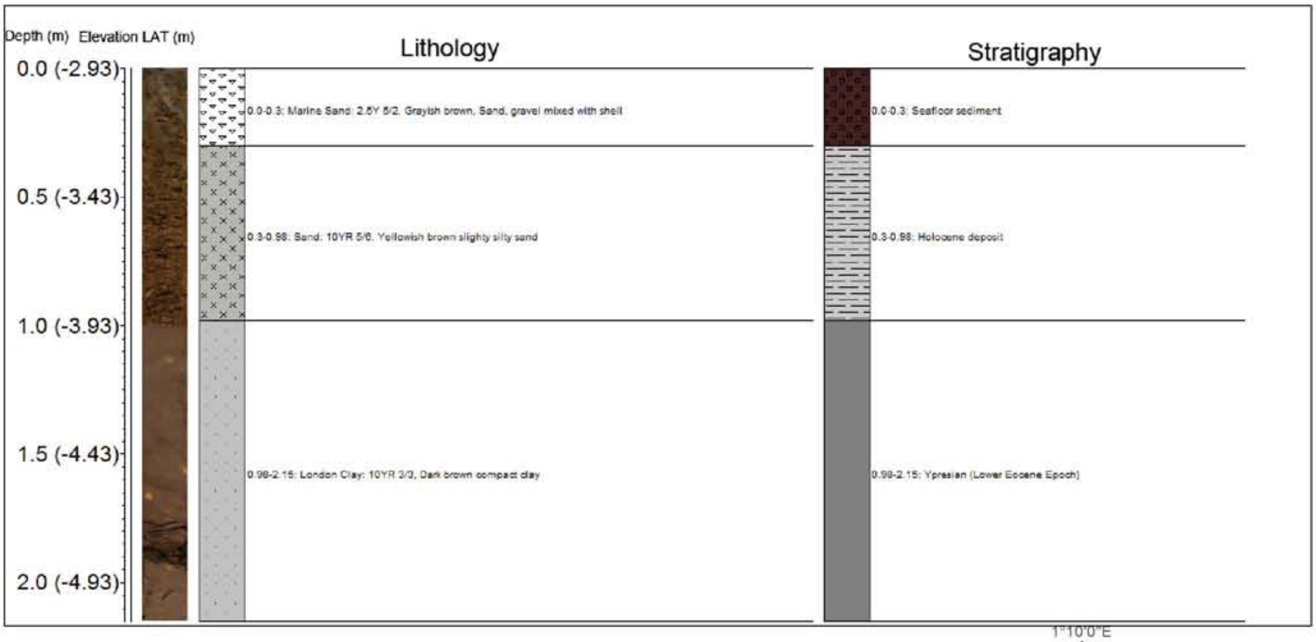
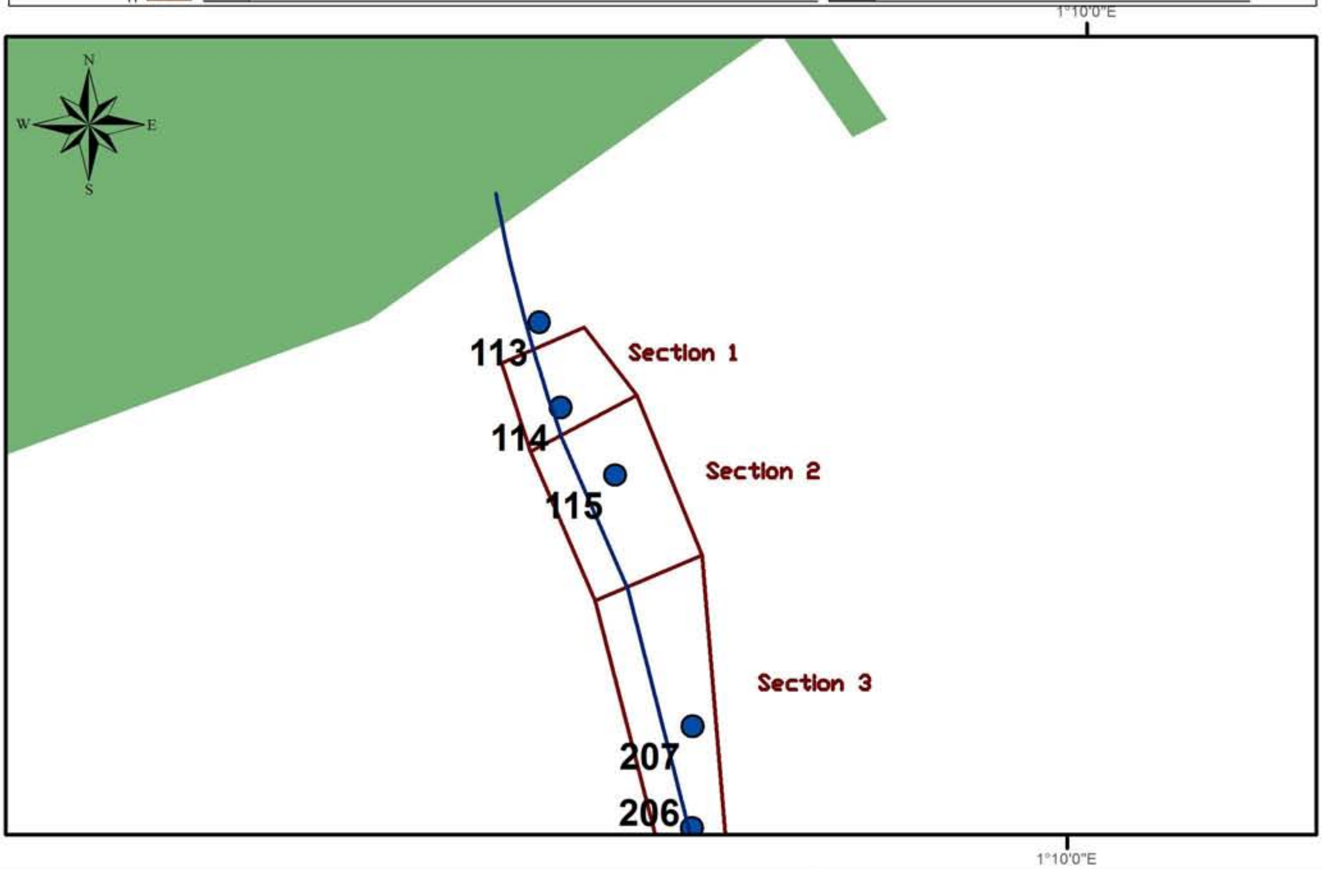
Vibrocore 115





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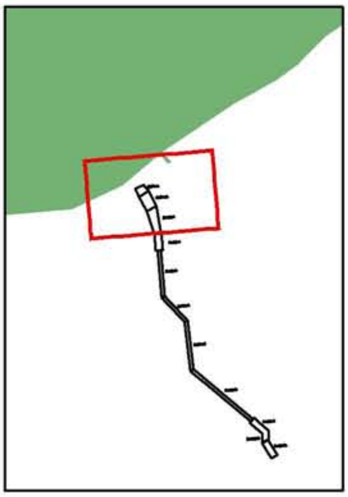
- GFS3 2012 survey area
- Completed offshore vibrocores



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0 0.05 0.1 Nautical Miles

Scale 1:22,048

Coordinate System: WGS 1984 UTM 31N

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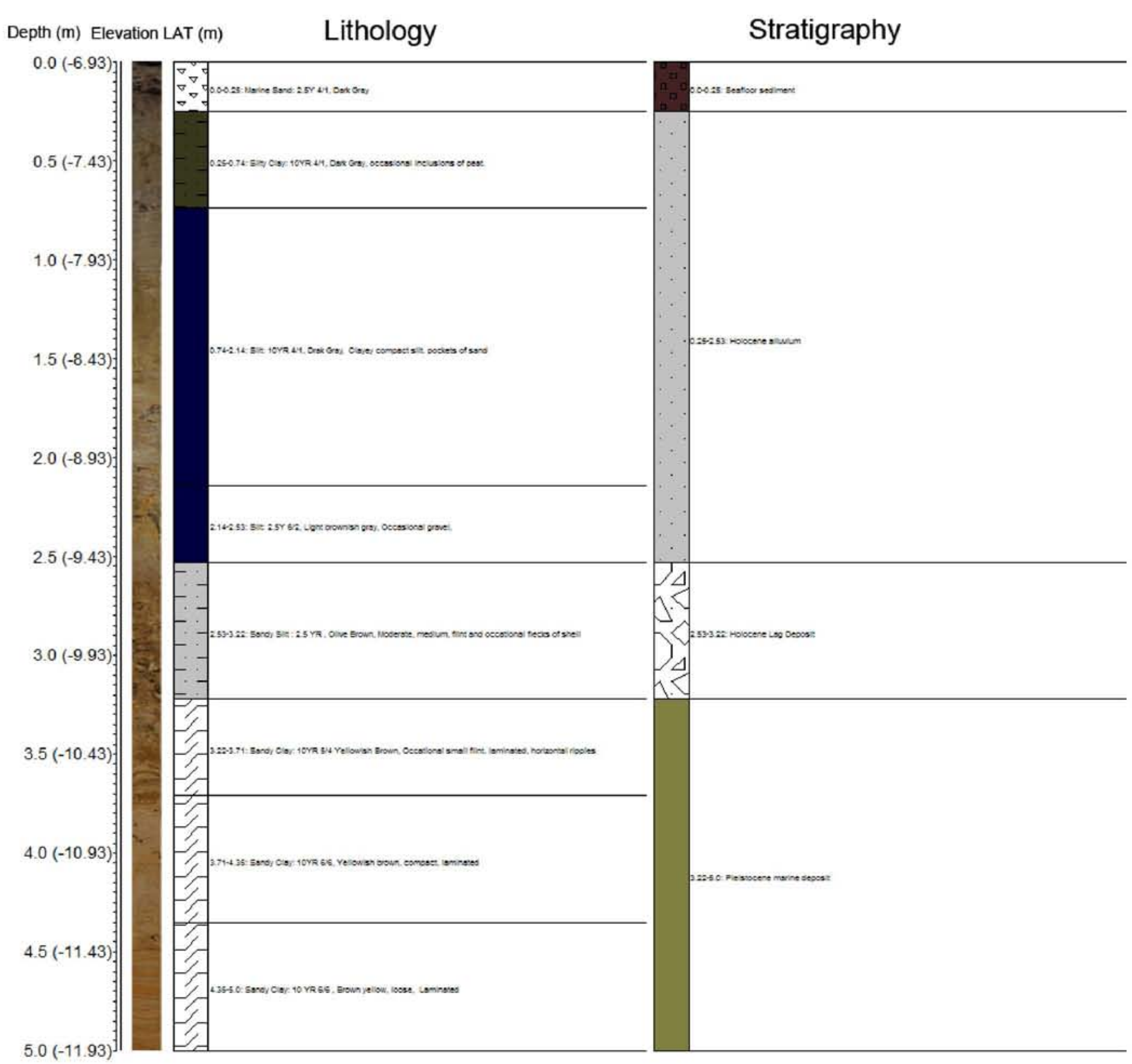
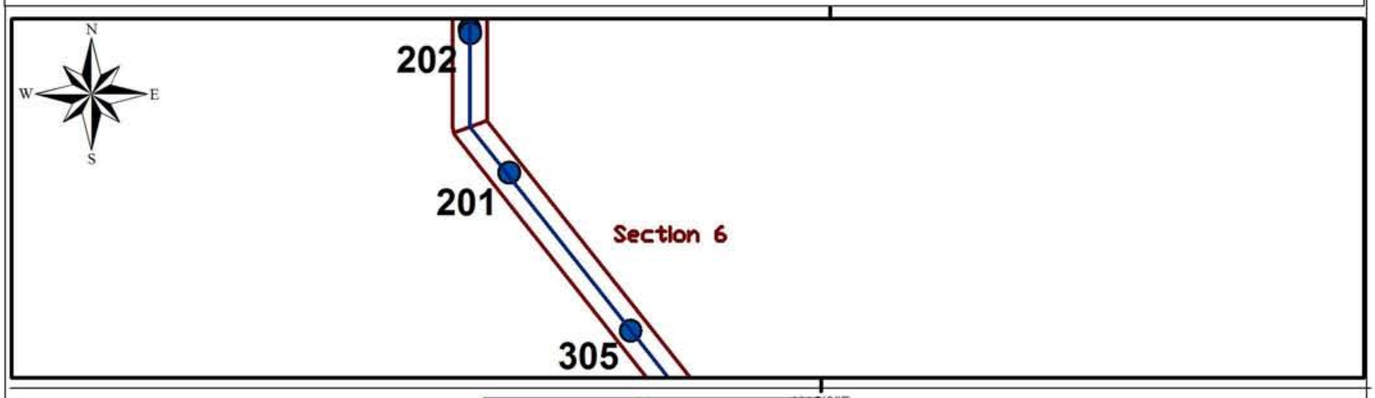
Vibrocore 201





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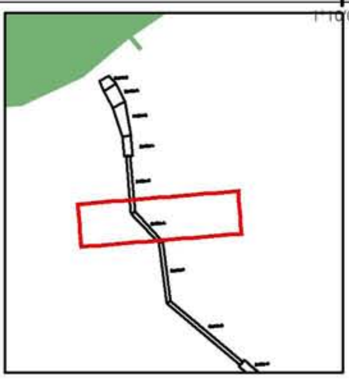
- Completed offshore vibrocores



1°10'0"E

0.08 Nautical Miles

210 Meters

Scale 1:22,048

Coordinate System: WGS 1984 UTM 31N

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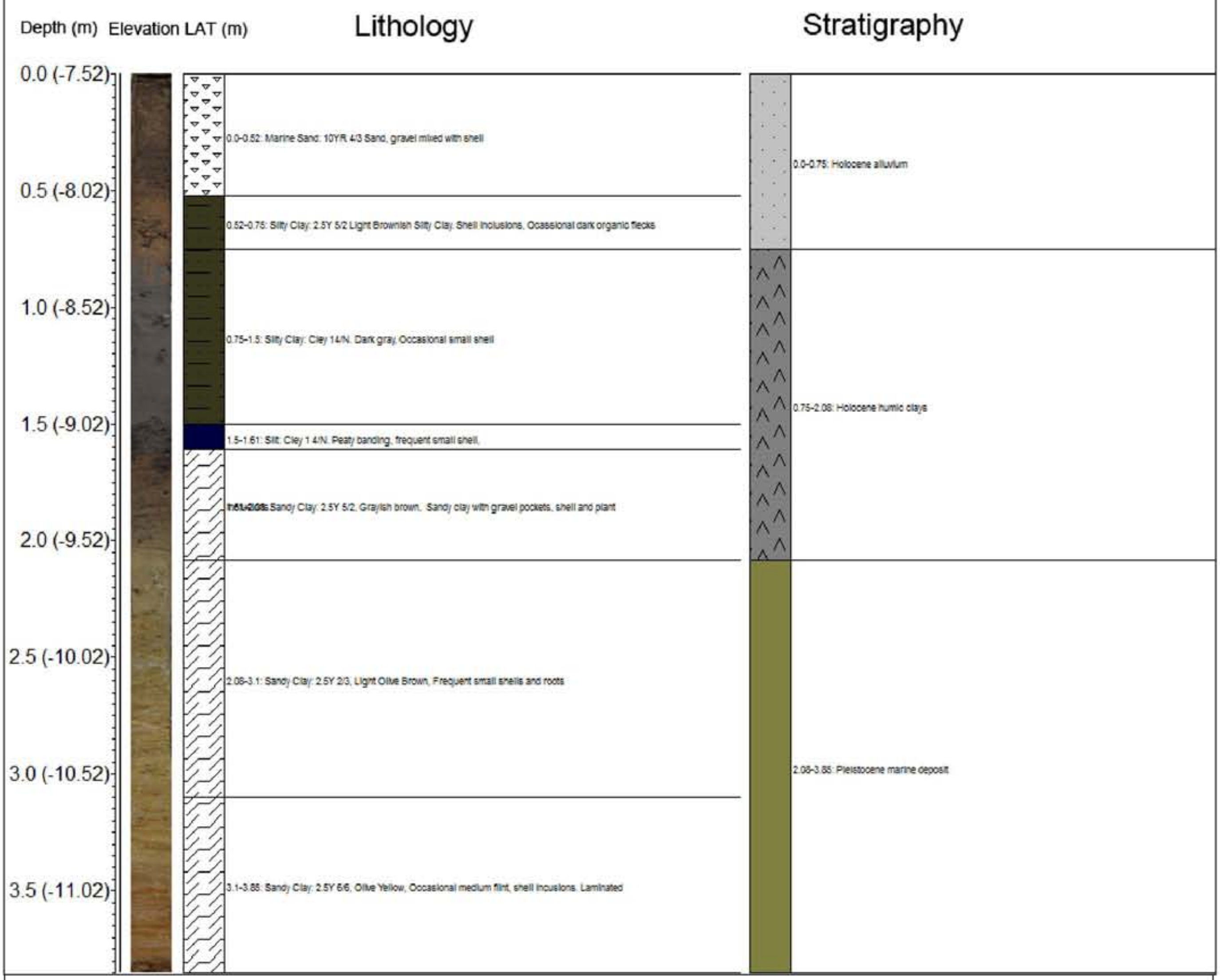
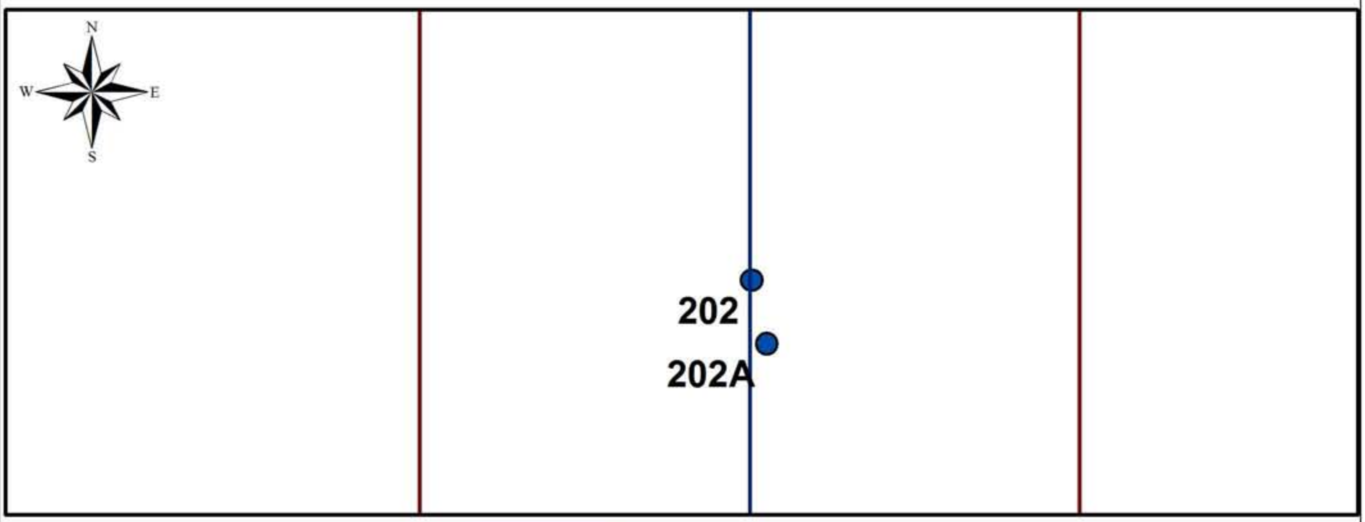
Vibrocore 202





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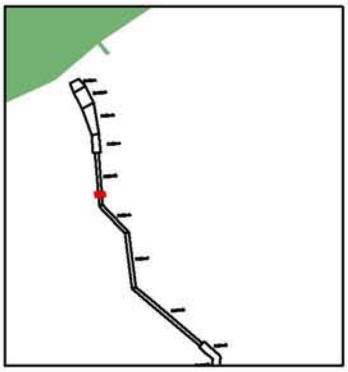

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Scale 1:1,146

Coordinate System: WGS 1984 UTM 31N

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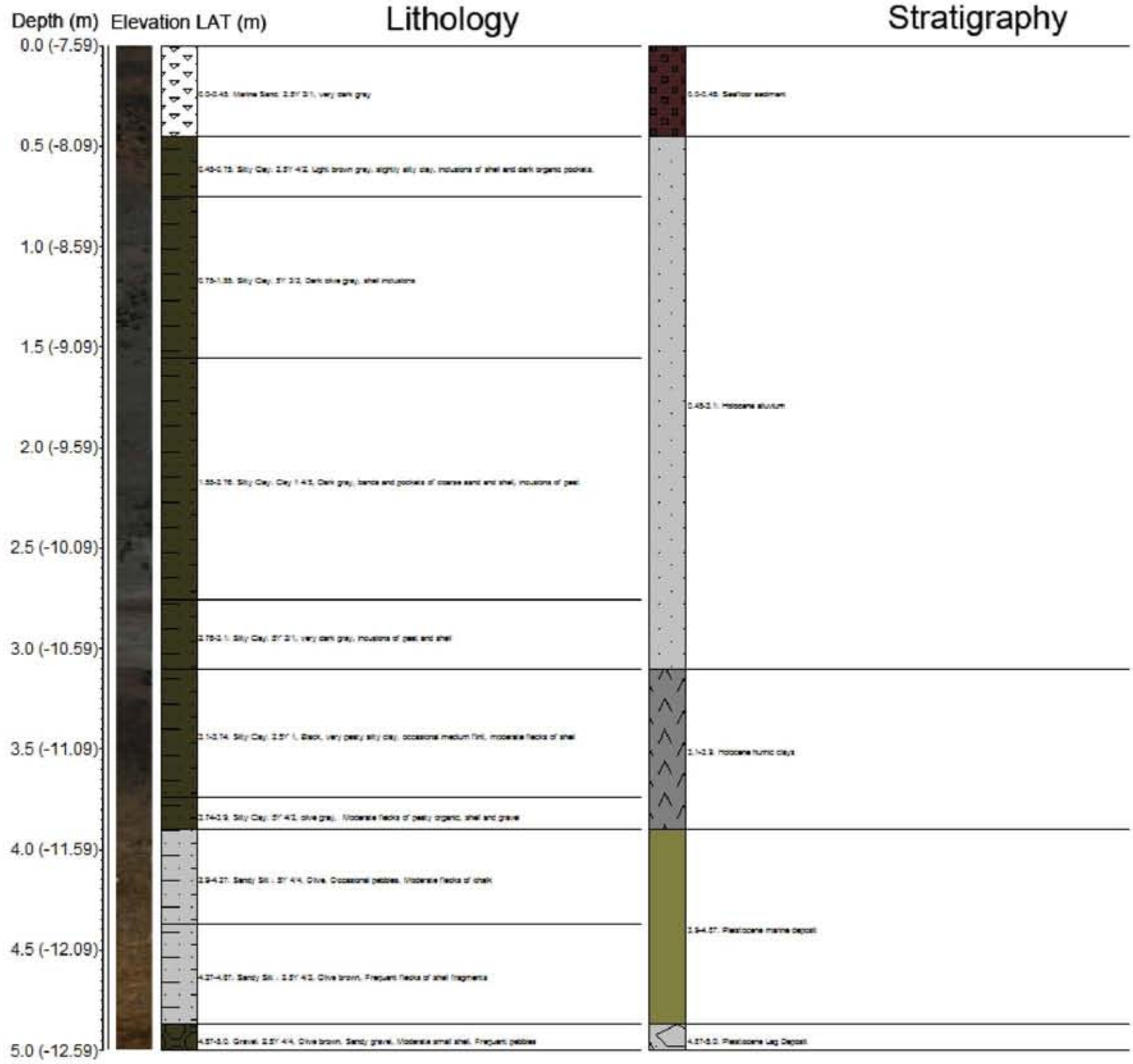
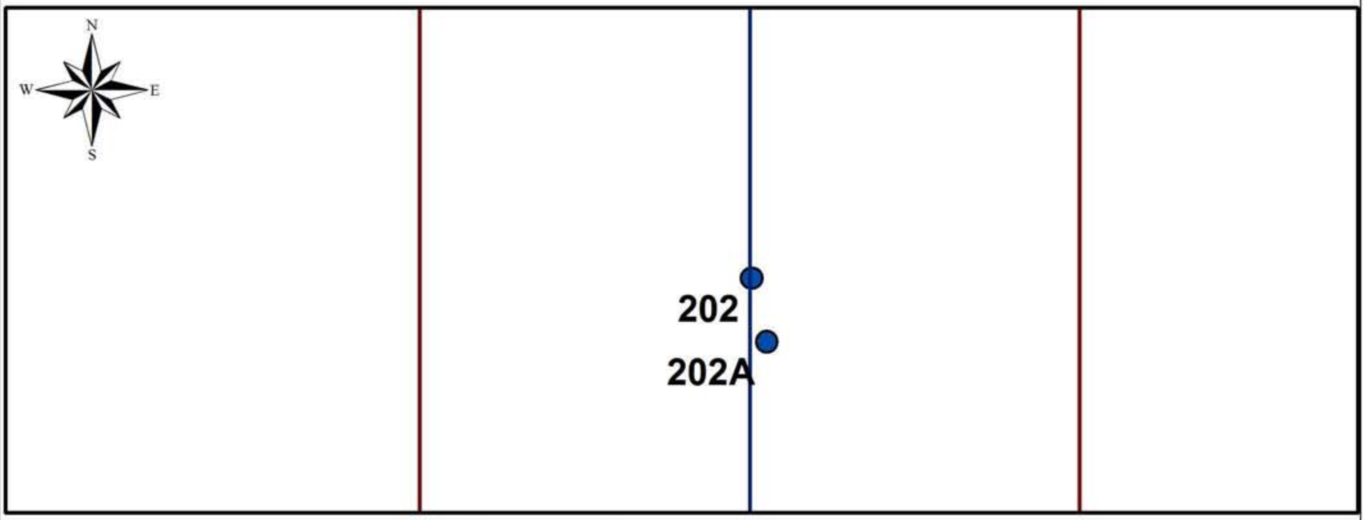
Vibrocore 202a

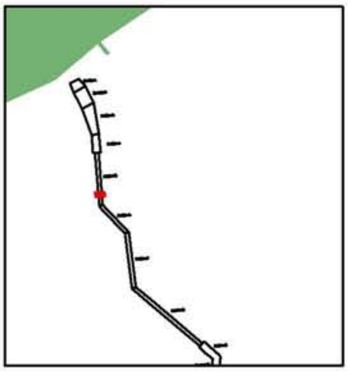




GFS3 export cable route

GFS3 2012 survey area

Completed offshore vibrocores



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Coordinate System: WGS 1984 UTM 31N

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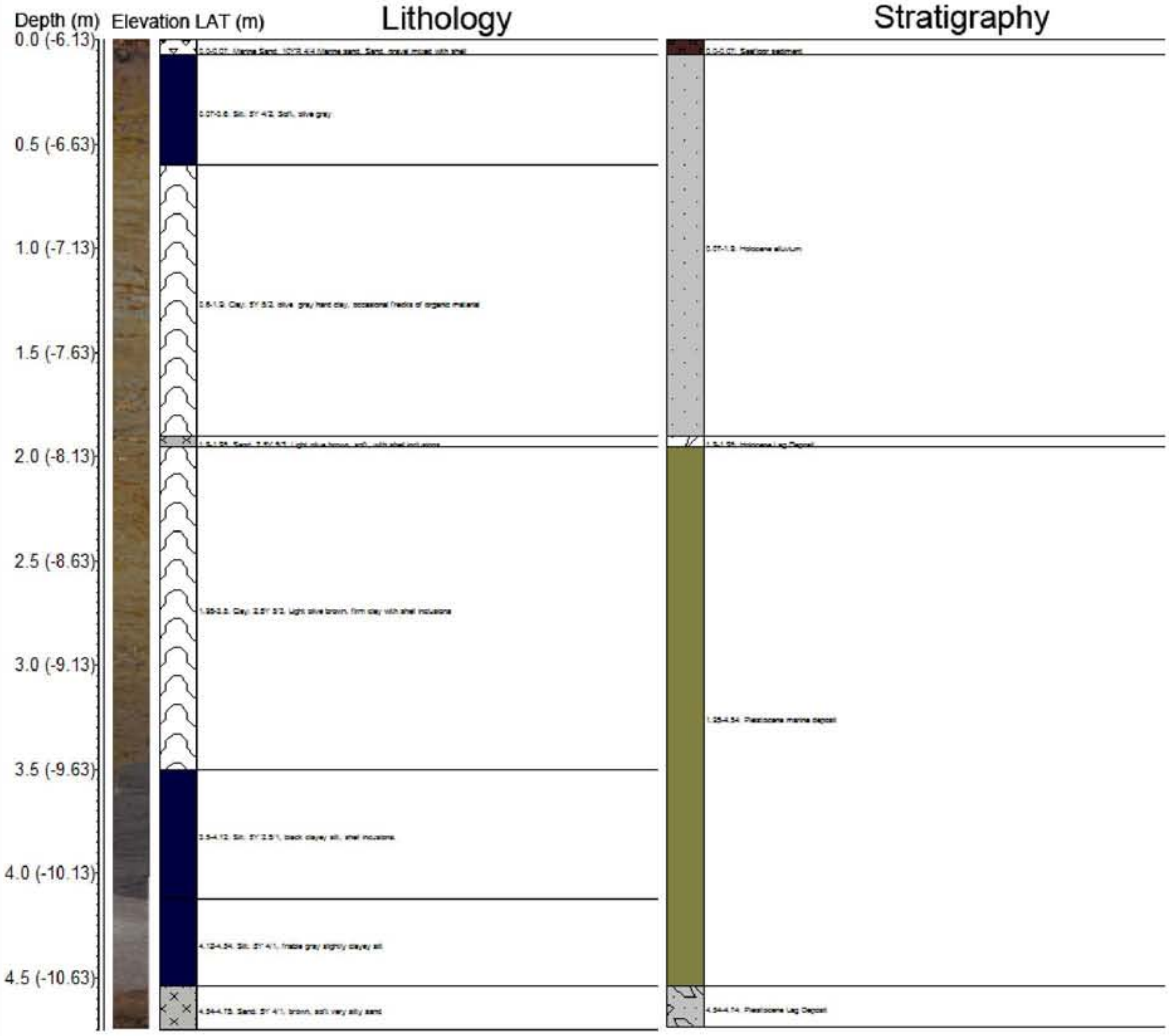
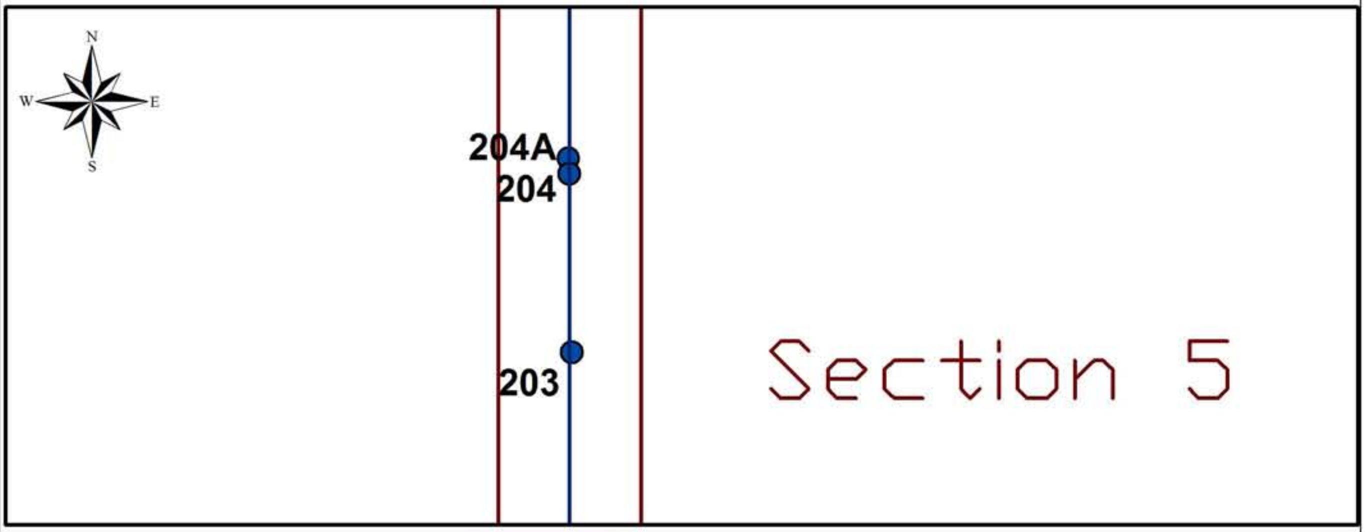
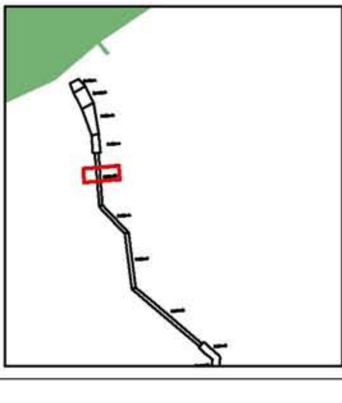
Vibrocore 203





GFS3 export cable route
GFS3 2012 survey area
Completed offshore vibrocores



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Coordinate System: WGS 1984 UTM 31N

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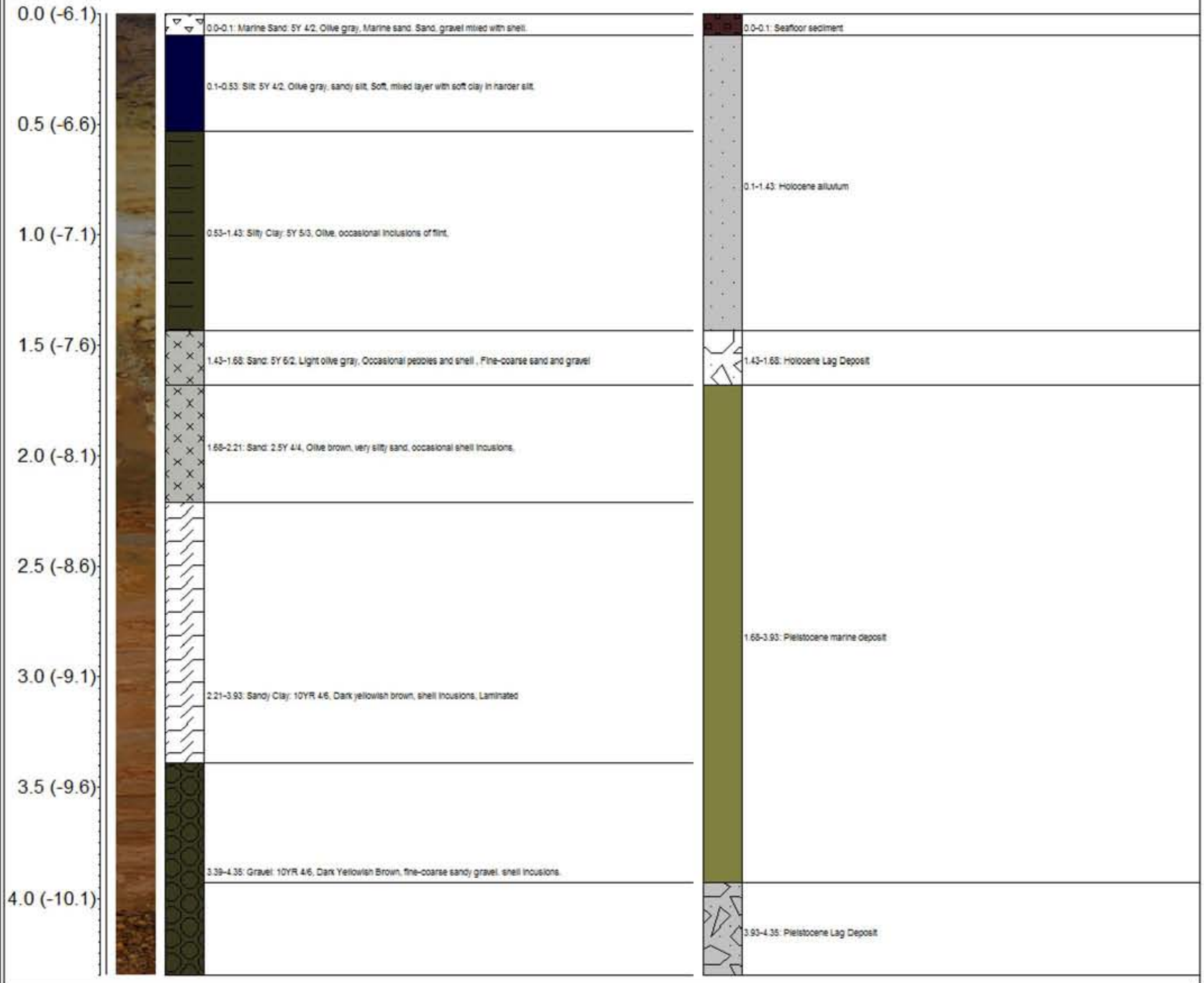
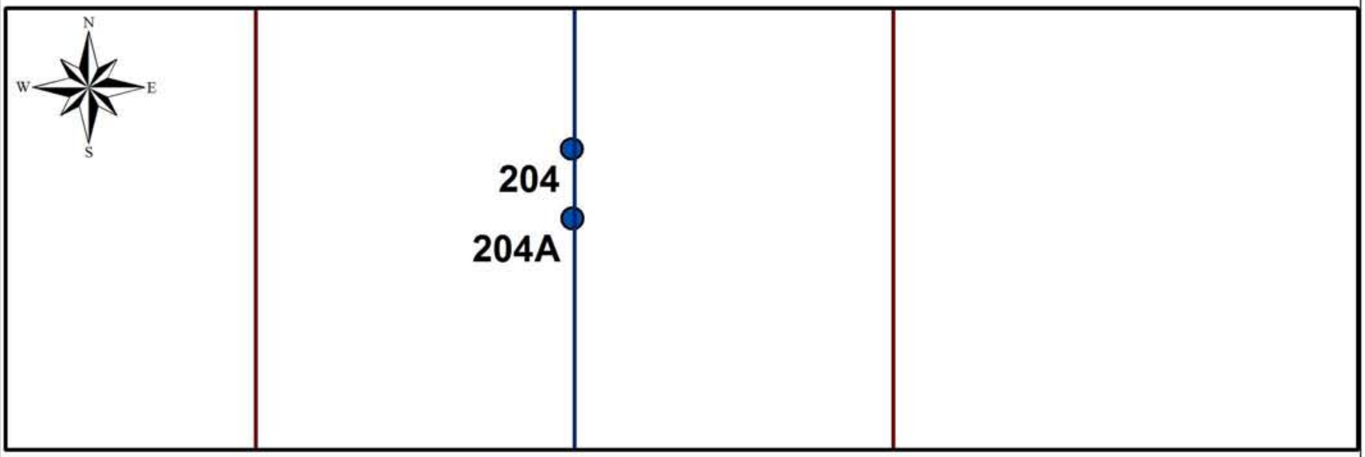
Vibrocore 204a





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- GFS3 2012 survey area
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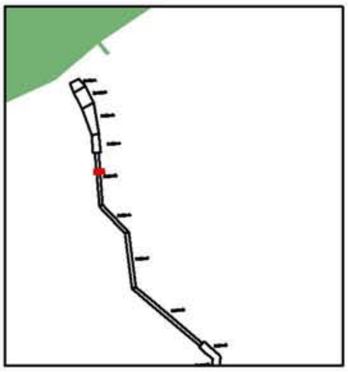

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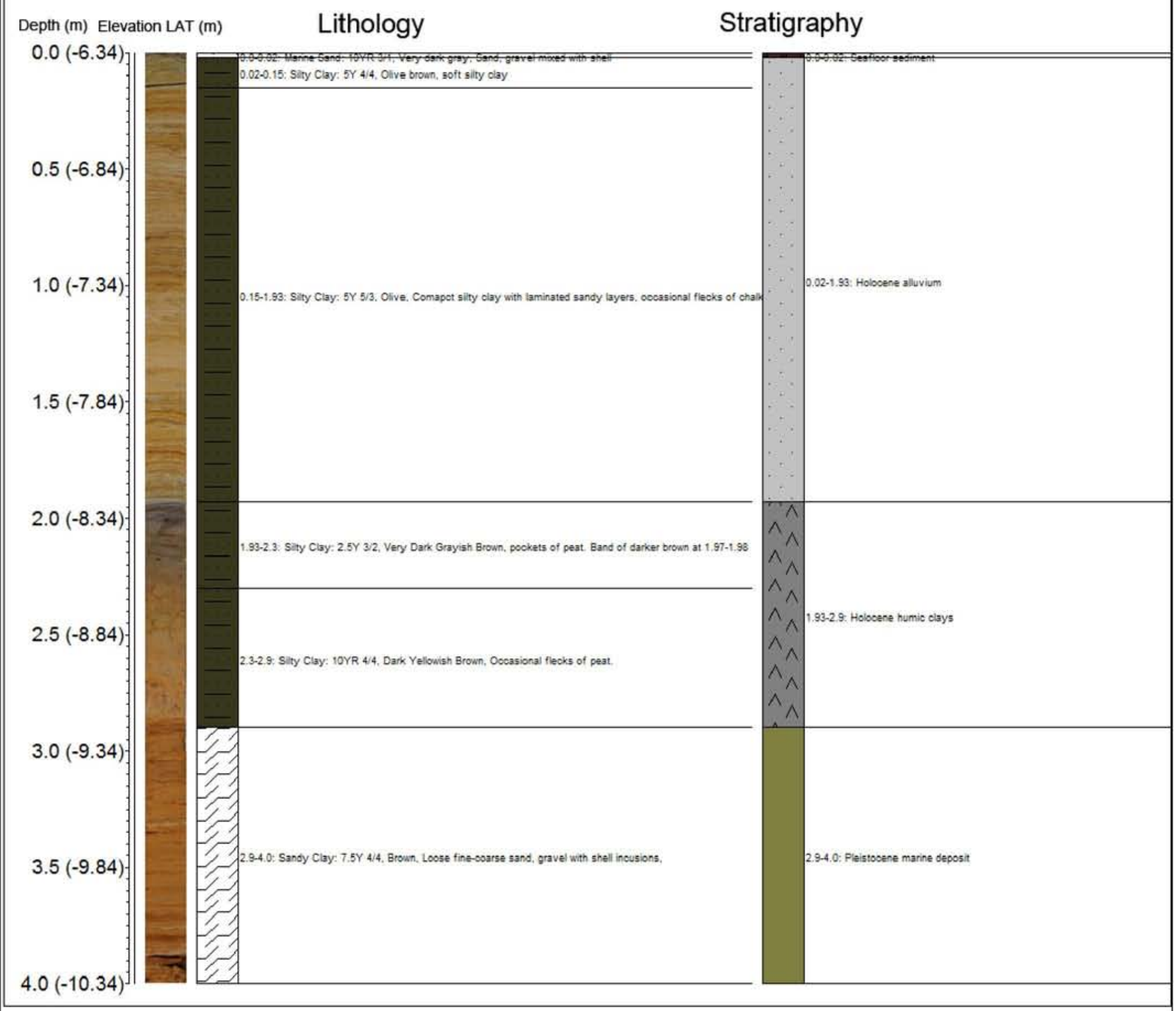
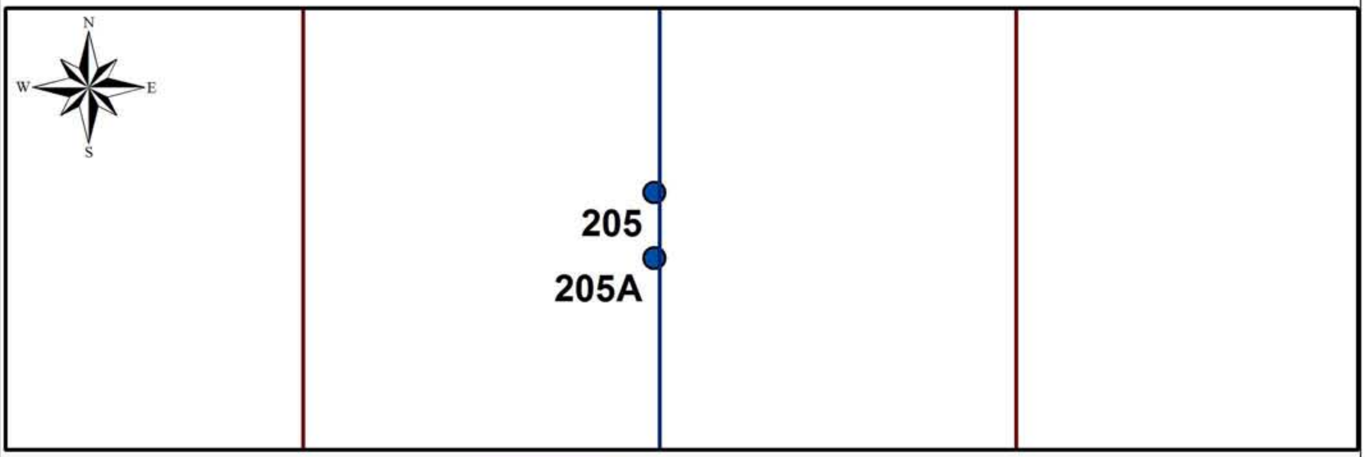
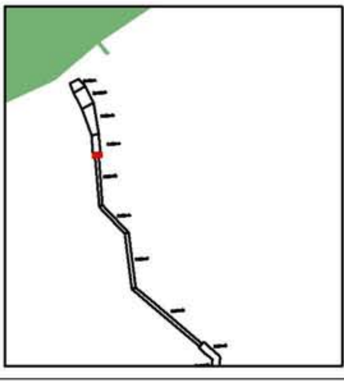
Vibrocore 205





- GFS3 export cable route
- GFS3 2012 survey area
- Completed offshore vibrocores



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8 Meters

Scale 1:1,061

Coordinate System: WGS 1984 UTM 31N

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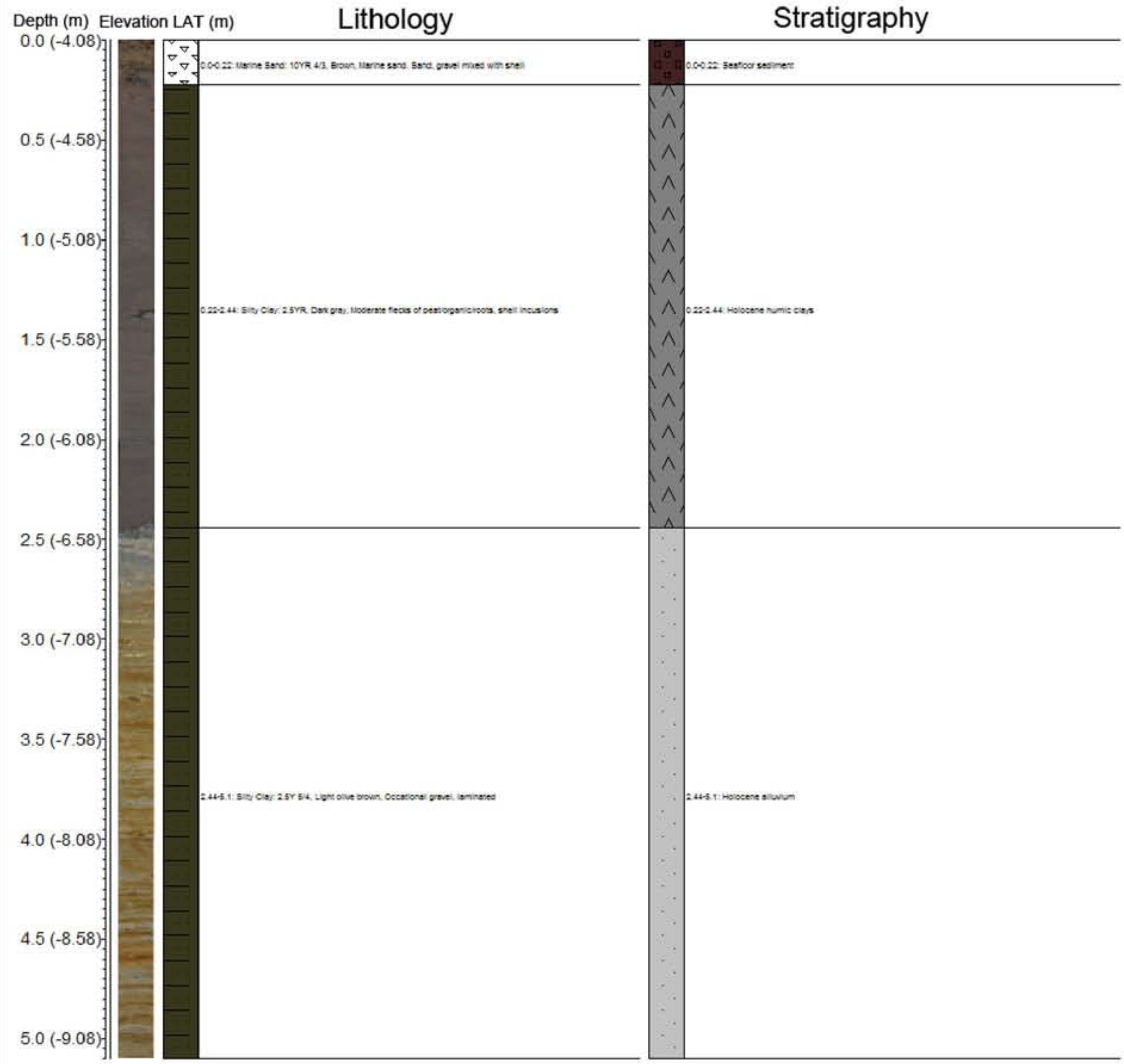
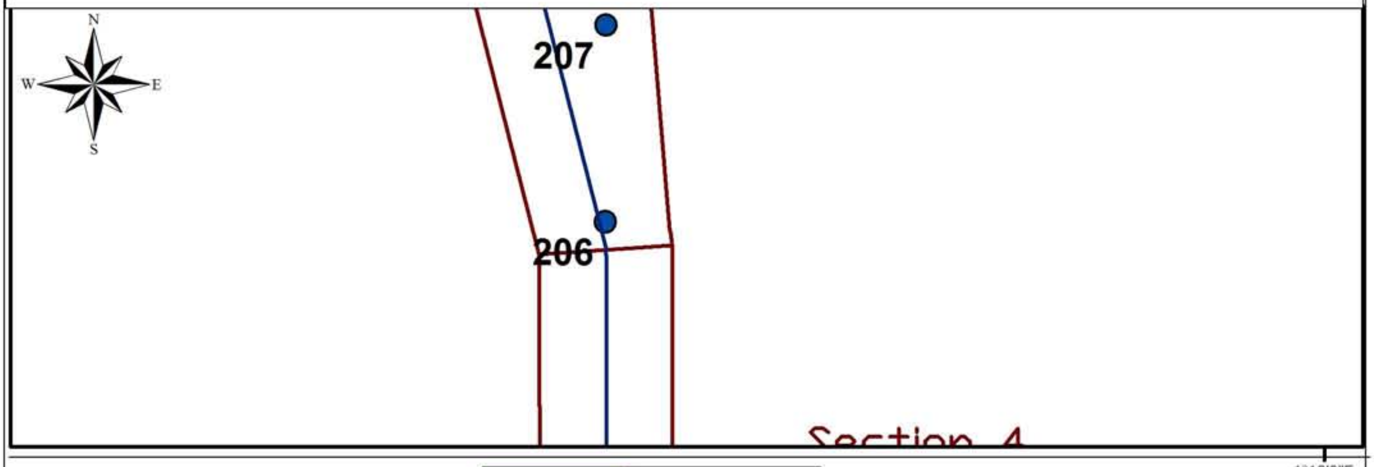
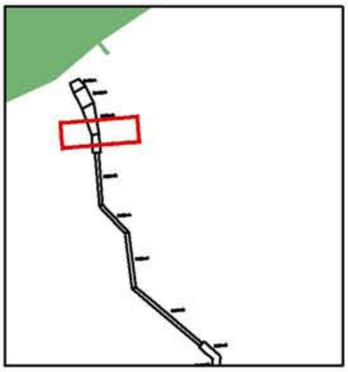
Vibrocore 206





- GFS3 export cable route
- GFS3 2012 survey area
- Completed offshore vibrocores



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Coordinate System: WGS 1984 UTM 31N

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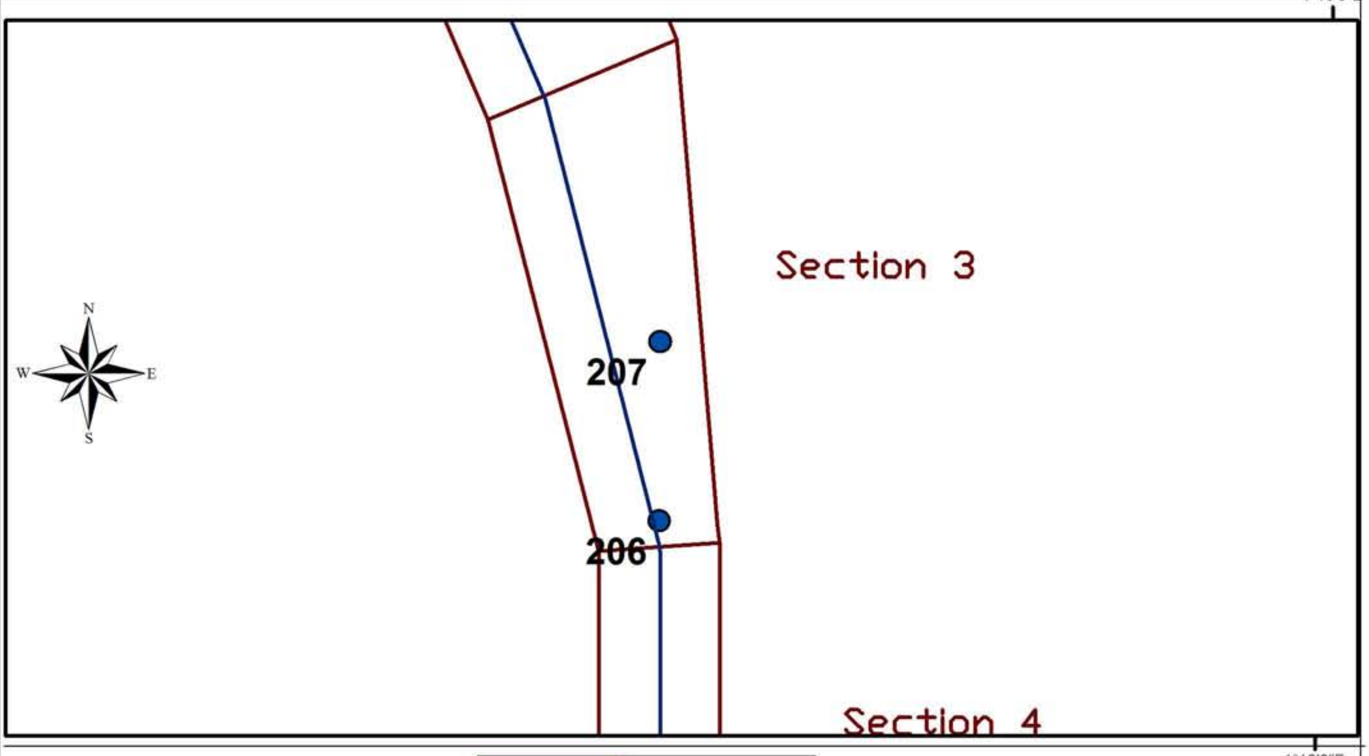
Vibrocore 207



- GFS3 export cable route
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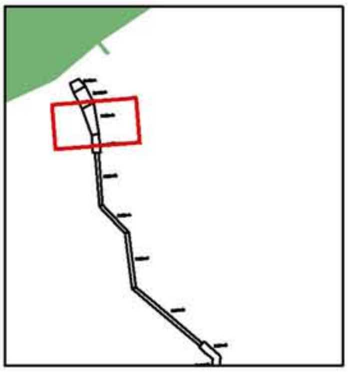
- Completed offshore vibrocores



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Coordinate System: WGS 1984 UTM 31N

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UK

Date:	15/08/12
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Ref:	1839

MARITIME ARCHAEOLOGY

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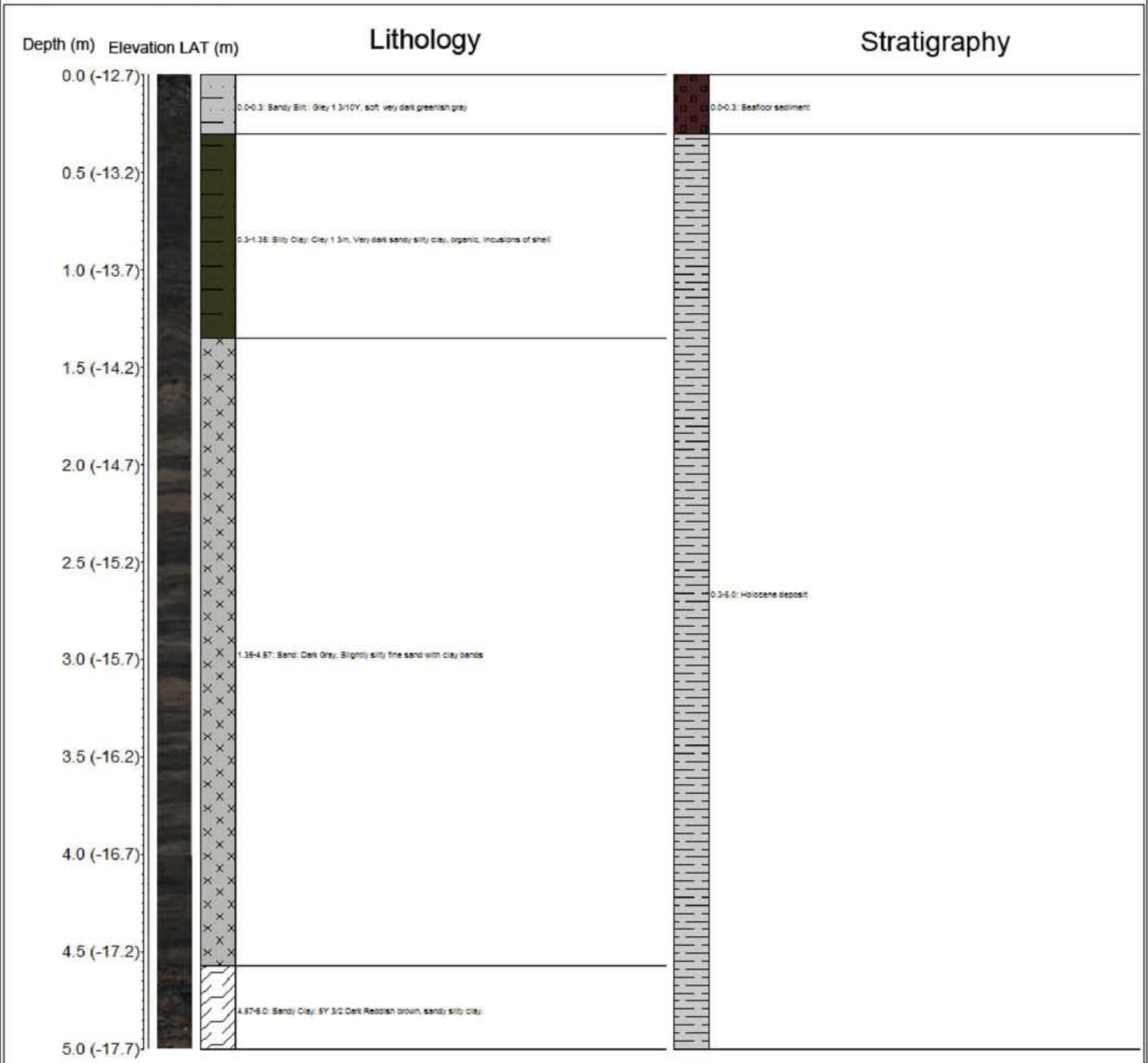
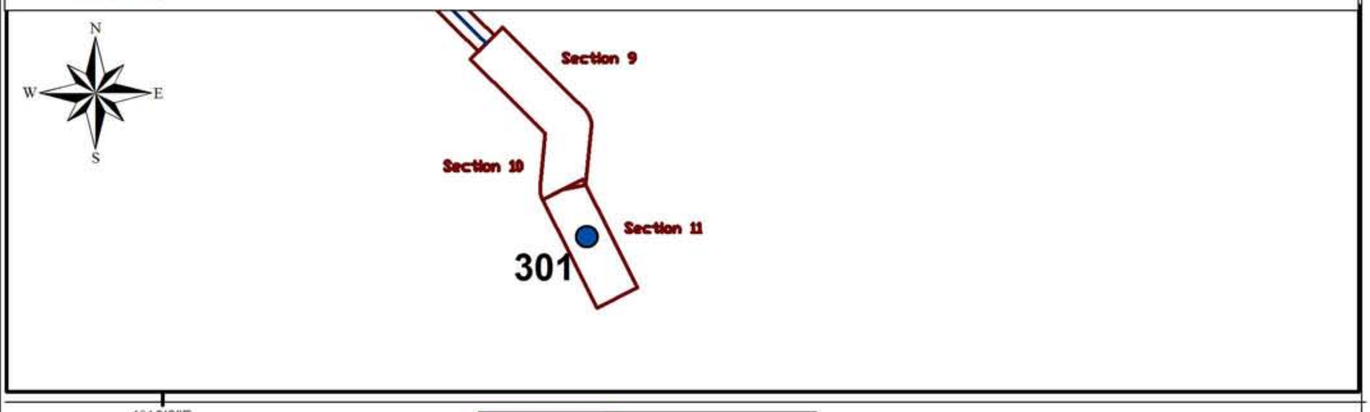
Room W1/95
Southampton. So14 3ZH.

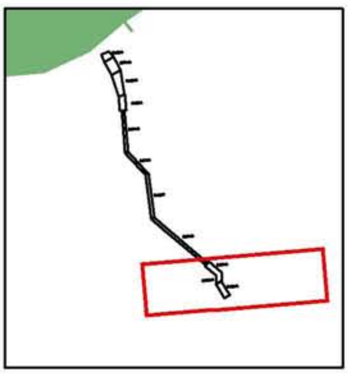
Vibrocore 301





1°10'0"E

- GFS3 export cable route
- GFS3 2012 survey area
- Completed offshore vibrocores



0.08 Nautical Miles 160 Meters

Scale 1:33,503

Coordinate System: WGS 1984 UTM 31N

GFS03 Demonstration Project

DONG energy

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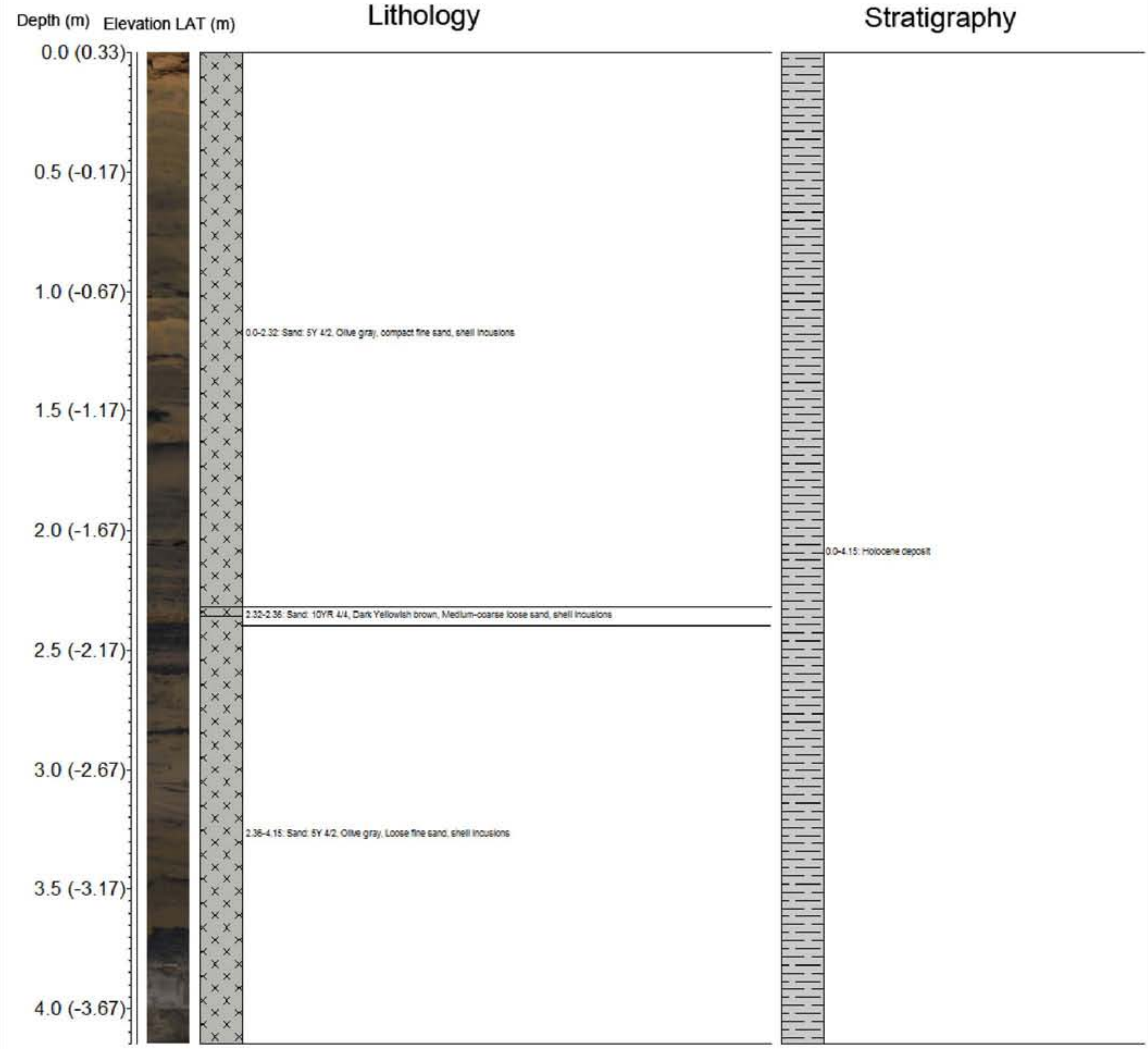
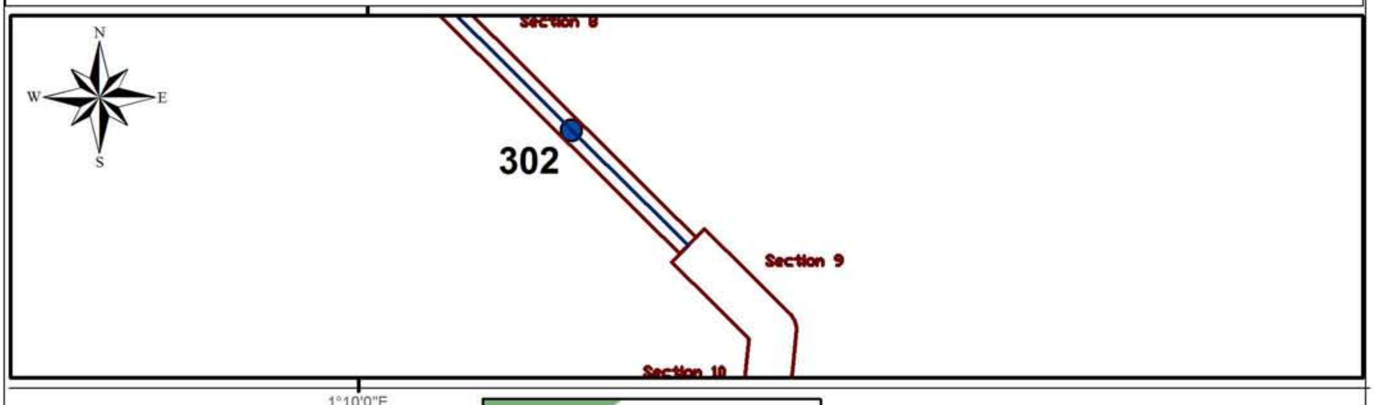
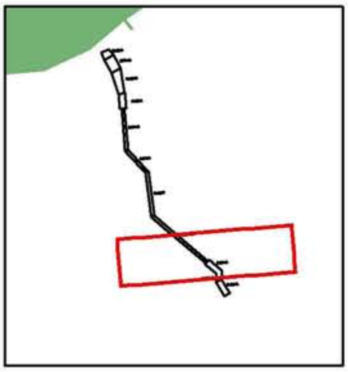
Vibrocore 302





- GFS3 export cable route
- GFS3 2012 survey area
- Completed offshore vibrocores



0.08 Nautical Miles

150 Meters

Scale 1:32,379

Coordinate System: WGS 1984 UTM 31N

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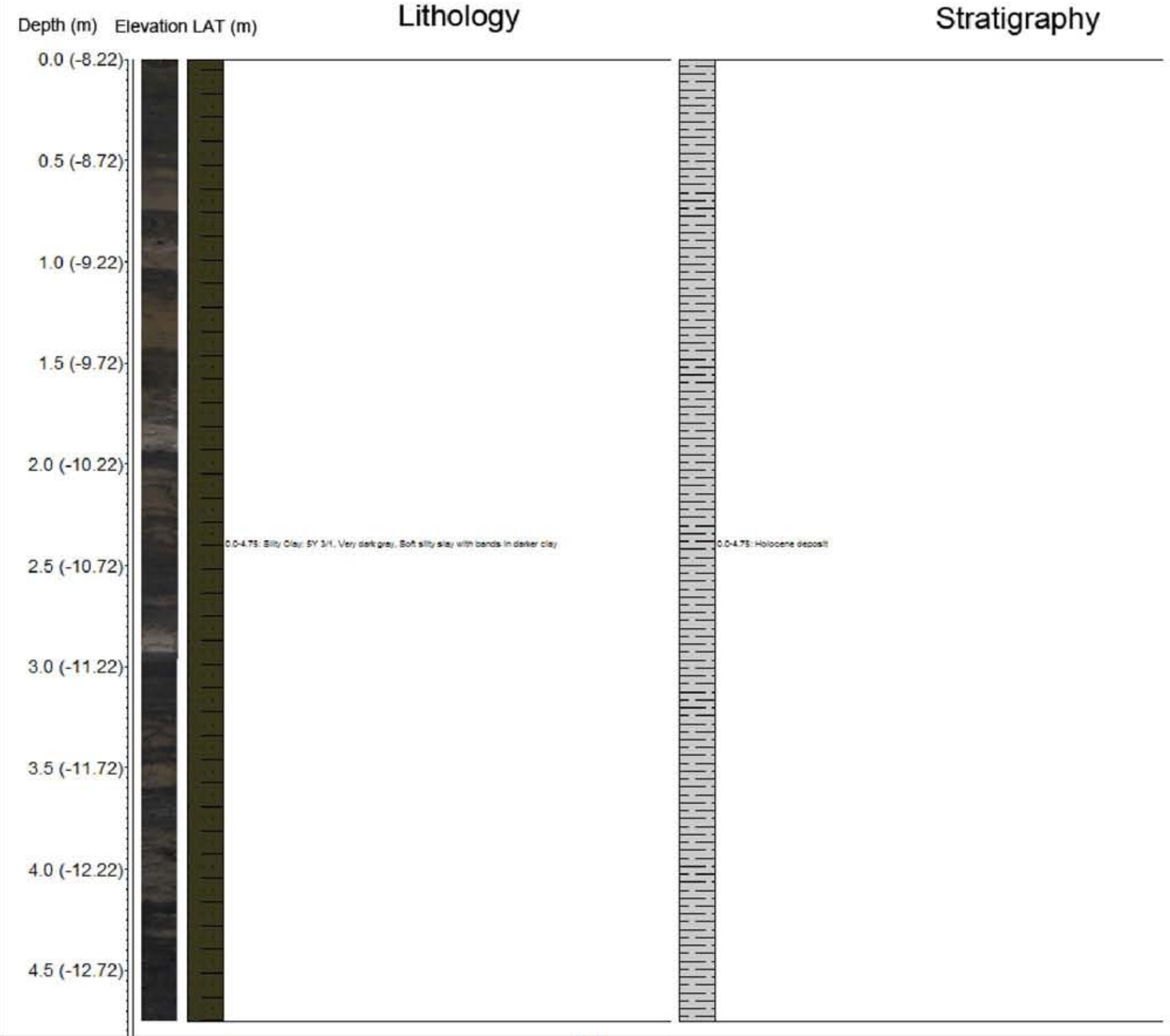
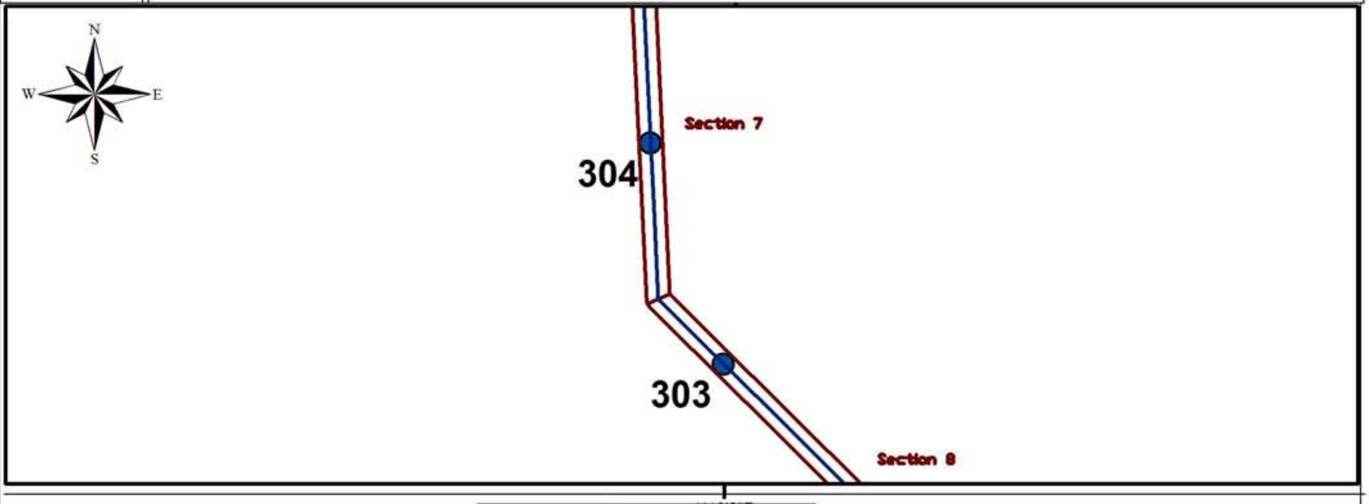
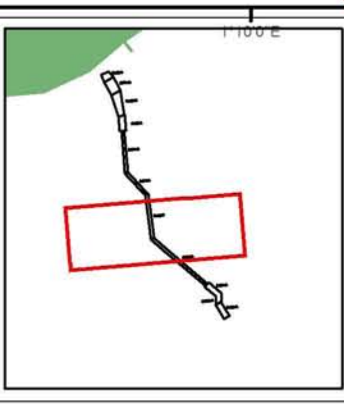
Vibrocore 303





- GFS3 export cable route
- GFS3 2012 survey area
- Completed offshore vibrocores



0.1 Nautical Miles
200 Meters

Scale 1:32,379

Coordinate System: WGS 1984 UTM 31N

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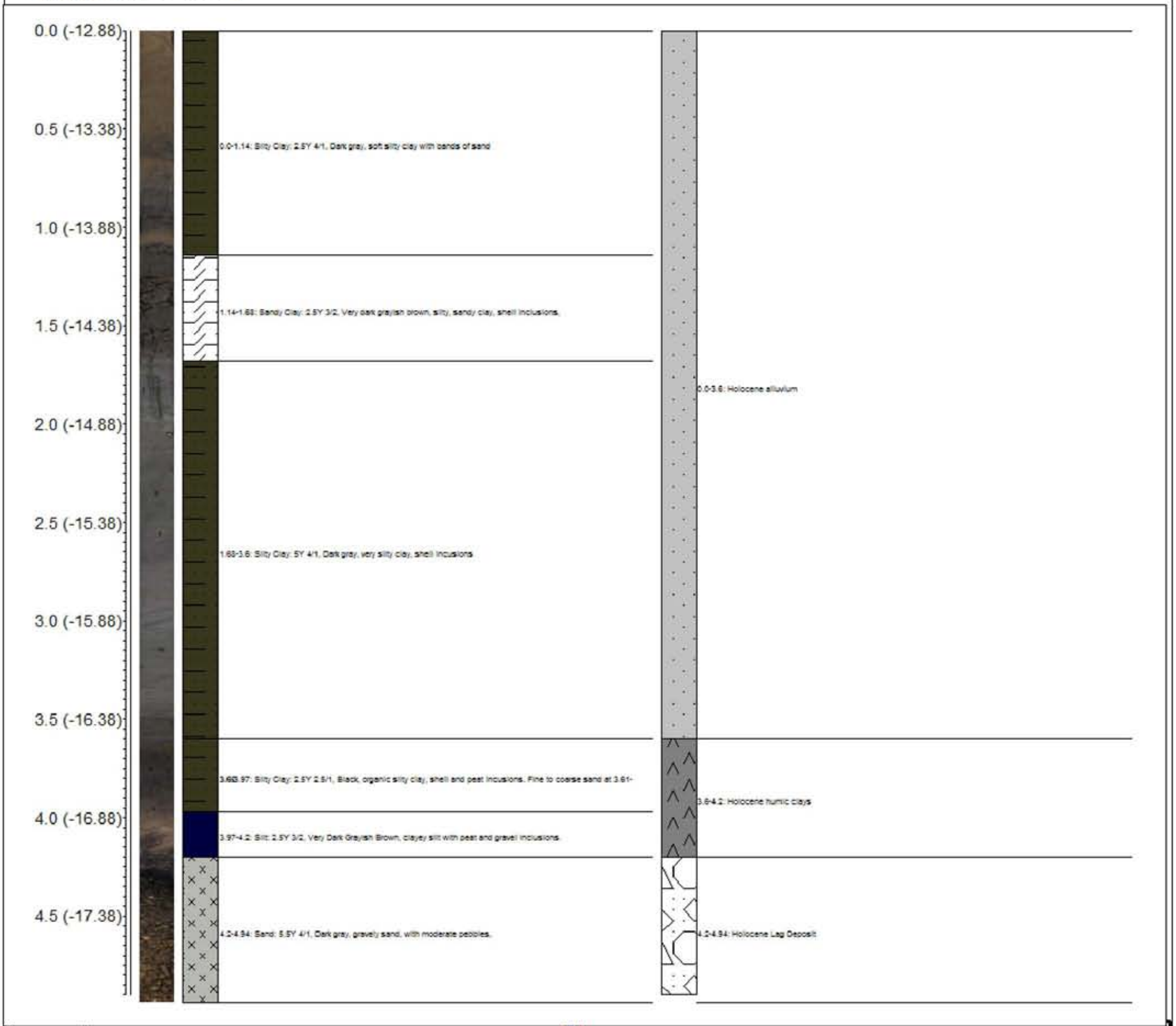
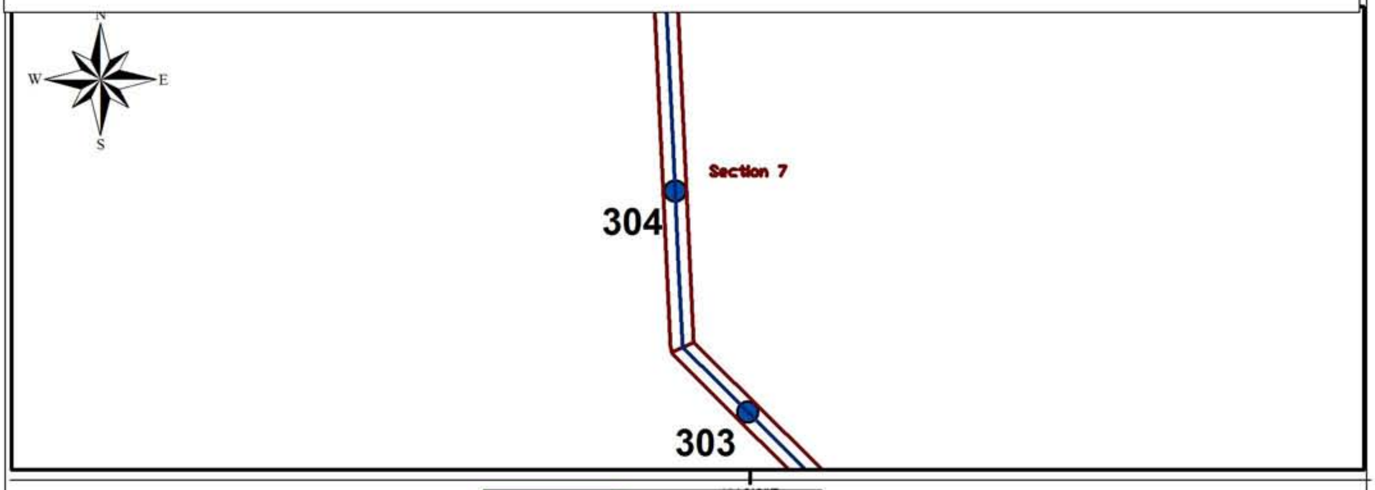
Vibrocore 304

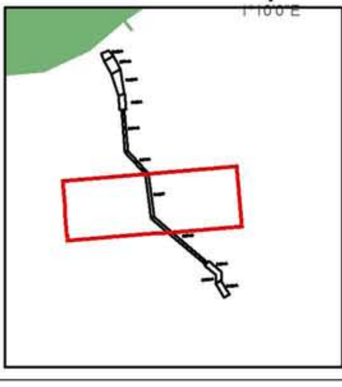




GFS3 export cable route

GFS3 2012 survey area

Completed offshore vibrocores



0.1 Nautical Miles

200 Meters

Scale 1:32,379

Coordinate System: WGS 1984 UTM 31N

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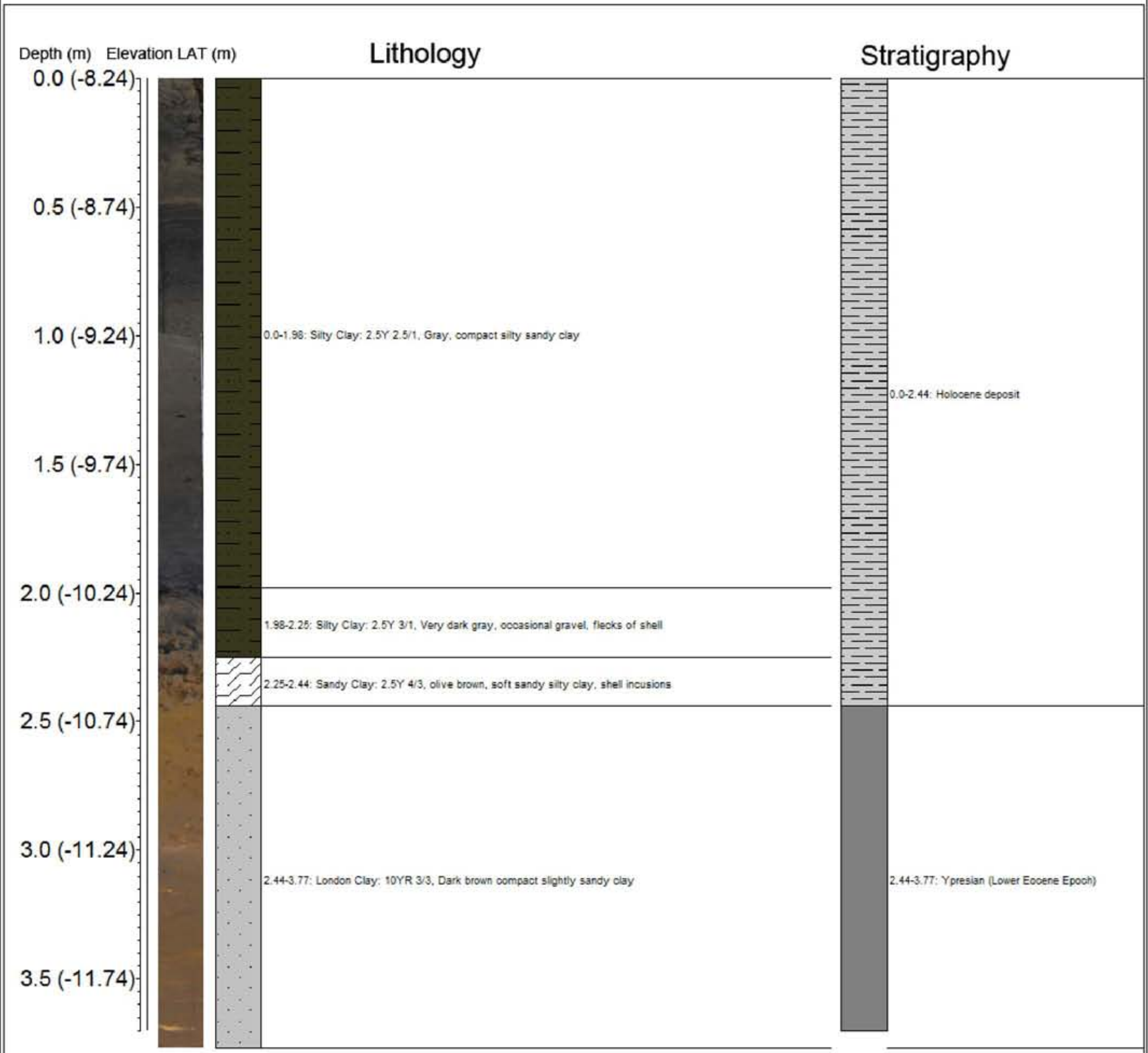
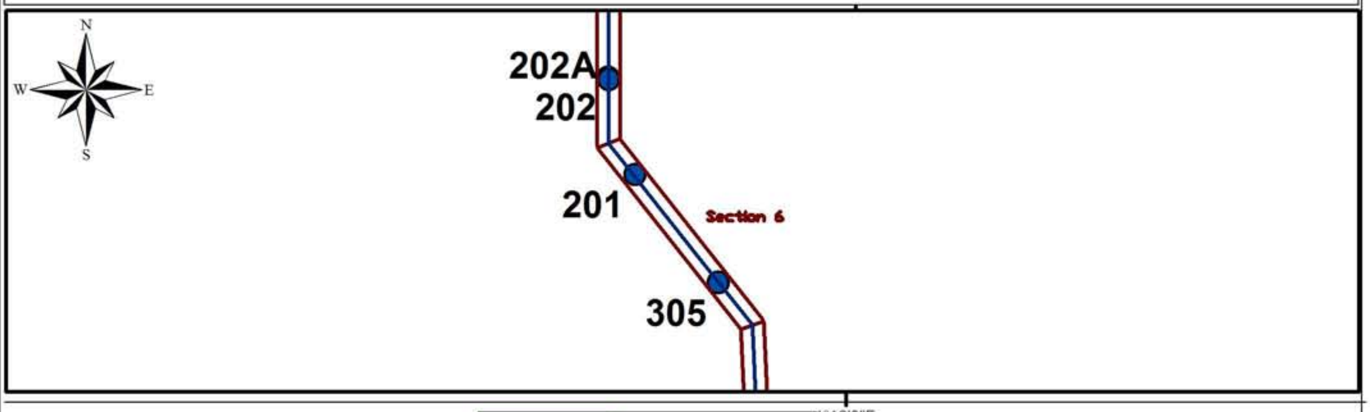
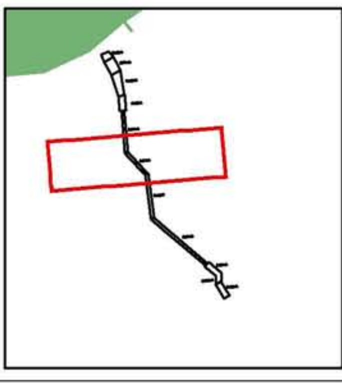
Data Copyright

Vibrocore 305





GFS3 export cable route
GFS3 2012 survey area
Completed offshore vibrocores



0.08 Nautical Miles
170 Meters

Scale 1:32,379

Coordinate System: WGS 1984 UTM 31N

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