DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2010/50

Lillebaelt Offshore Cable

Geophysical and geotechnical works for Lillebaelt Offshore Cable

Niels Nørgaard-Pedersen, Sara Borre,
Zyad Al-Hamdani & Steen Lomholt

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1. Introduction

In connection to the power cable project across Lillebælt-Fænø Sund, GEUS has performed marine geophysical and geotechnical investigations for Energinet.dk. Two separate surveys took place in May and in November 2010.

The purpose of the investigations was to locate any objects, wrecks, cables etc. present in the investigation area. Furthermore, determination of the seabed type, and shallow geology shall enable an evaluation of the possible jetting and/or trenching for excavation of cable trenches.

The geophysical and geotechnical investigations consisted of:

- Dual frequency side-scan sonar to provide full coverage with the purpose of seabed classification and object localisation
- High-frequency shallow seismic profiling with the purpose of mapping the geology in the top sediments
- Shallow seismic profiling by sparker in order to evaluate the relationship between deeper structures and the top sediment geology
- Magnetometry in order to scan the area for any iron objects
- Vibrocoring as a supplement for the geological interpretation and for preliminary geotechnical data for excavation of cable trenches
- Laboratory tests on sediment samples in order to provide information about the soil stratification, geological classification and the strength parameters of the soil

2. Field work

2.1 Survey Area

The survey area across Lillebælt and through Fænø Sund is shown in Fig 1. In the northern part, Lillebælt has been surveyed in a polygonal area (about 1 km^2) and two alternative adjoining cable corridors, A and B have been investigated in detail. Southward through Fænø Sund, corridor A continues across Teglgårds Bugt. A detailed multibeam mapping of corridor A (Fig. 2) was performed by CT Offshore in December 2009 for Energinet.dk, and the DTM model with grid size 0.8 x 0.8 m was made available for the GEUS survey (Fænøsund Multibeam Survey, Report Rev 1). The bathymetrical maps shown in this report are based on this data set, with additional lower resolution data for parts of corridor B from the Danish Maritime Safety Administration.

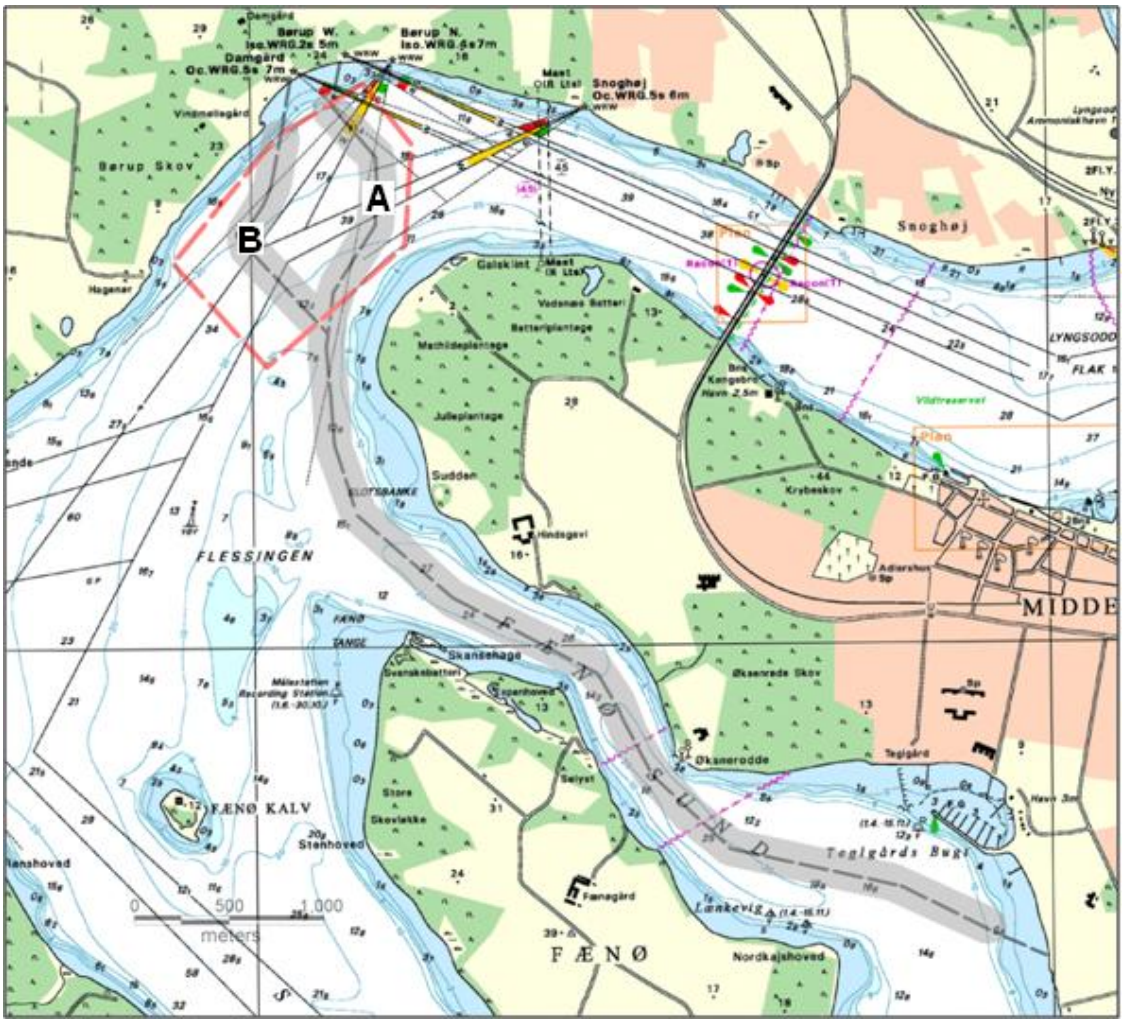

Fig. 1. Survey area Lillebælt- Fænø Sund. The 200 m wide survey corridors along center lines are indicated by grey. The red polygon in the northern part delineates the Lillebælt channel survey area with the two alternative cable corridors A and B.

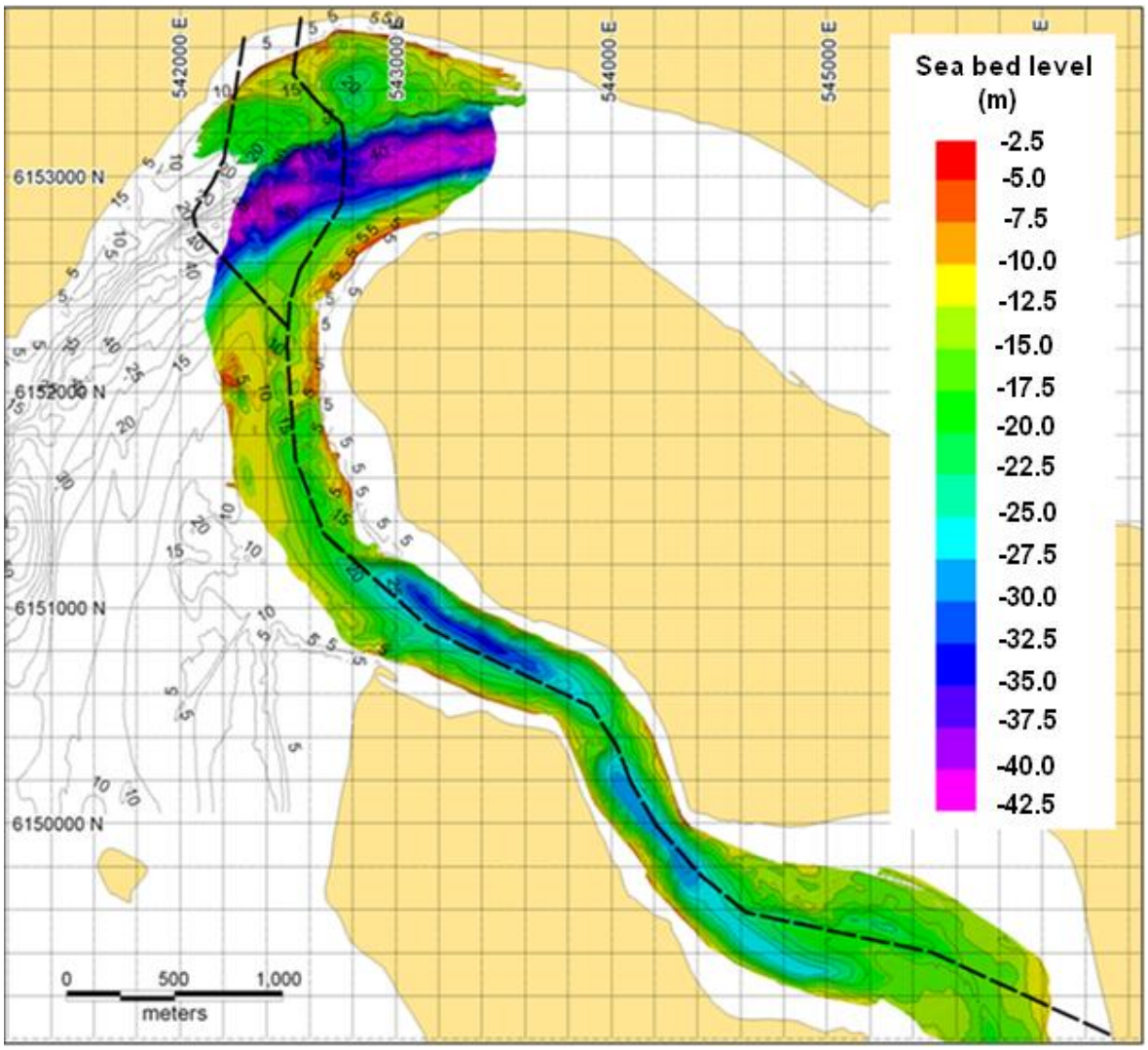

Fig. 2. Multibeam bathymetry (coloured) based on CT Offshore Survey for Energinet.dk, December 2009. Lower resolution bathymetric contour lines outside the area mapped by multibeam, are based on Danish Maritime Safety Administration data. Depths are in the range -7 to -48 m in the survey area.

2.2 Details of CT Offshore Multibeam Survey

Contractor: CT Offshore
Client: Energinet.dk
Measuring period: 2.-7. December 2009
Multibeam head: R2Sonic 2024
Positioning: DGPS (C-Nav GPS M2050 + RTG correction signal)
DTM grid size: 0.8 x 0.8 m

2.3 Survey vessels M/V Madog and M/V Laura

M/V Madog chartered from Nordmarine DK ApS Shipping was used as survey vessel during the first survey part, primo May 2010. M/V Laura chartered from 'Skibsprojekt Christoffer ApS' was used for the second survey part which took place in November 2010. Both ships provide stable platforms for geophysical acquisition / bottom sampling /sediment coring survey projects. For further ship specifications, see Appendix A.

2.4 Mobilisation

Mobilisation on M/V Madog took place prior to a similar geophysical cable survey for Energinet.dk in Læsø Rende, ultimo April, 2010. Field work took place from the 3rd to the 4th of May, 2010.

Mobilisation on M/V Laura took place prior to a geophysical survey by GEUS ultimo October 2010. Field work took place 12th to the 15th of November, 2010.

2.5 Surveys

M/V Madog, 3-4th May 2010:
Energinet.dk's representative bordered the ship in Fredericia in the evening, 3rd of May, 2010 and the ship left immediately for the survey area a few kilometers away.

The geophysical part of the survey lasted until 6:00 AM (UTC), 4th of May. A continuous acquisition of raw data from Sparker, Sub-bottom profiler, Magnetometer, Side-scan sonar, and Echo sounder was carried out throughout the geophysical survey. This data served as base for later processing and mapping. Three parallel lines (1-3) with a distance of 60 m in between and a length of ca. 7 km were surveyed along the survey corridor A (Fig. 3). The mid line was placed along coordinates given by Energinet.dk. Moreover two shorter cross lines (4 and 5) were surveyed in the northern Lillebælt channel area.

Five vibro-coring sites were chosen along the center line, and coring took place during the 4th of May. Sediment cores were retrieved successfully from all sites. Hereafter the vessel sailed to Fredericia harbour for disembarkment of crew members and Energinet.dk's representative.

During the survey period, weather conditions were fine with light to moderate winds (< 8 m/s), and wave heights less than 0.5 m. This part of Lillebælt and Fænø Sund is normally characterised by strong currents up to 3 knots. Strong currents conditions made ship alignment on pre-determined survey lines especially difficult in the northernmost part of the survey area, where additionally shallow water depths made accurate and safe navigation a challenge. Also exact position anchoring for vibrocoring was a challenge due to the strong currents in the northern Lillebælt channel area as well as in Fænø Sund.

M/V Laura, 12-15th Nov., 2010:
M/V Laura left Svendborg 6:00 (UTC), 12th November and arrived to the survey area 12:30. After careful depth soundings along the shallowest parts of the survey area, a side-scan sonar/chirp survey was initiated at 13:30. 18:15 the survey had to be interrupted due to increasingly strong currents (4-5 knots) and strong winds in the Lillebælt channel area, and the ship went to Middelfart port nearby. At 6:30, 13th of November, the survey was resumed and side scan sonar/chirp lines in the Lillebælt channel area and in Fænø Sund were completed at 10:30. Hereafter sparker lines was sailed in the Lillebælt channel area, and the ship went to the port in Middelfart at 18:00, in order to prepare vibrocoring equipment and take on board vibrocoring subcontractor personnel. At 12:00, 14th November, the ship sailed out for the first coring site. Four vibrocores from two sites in the Lillebælt channel area were successfully retrieved before the ship went to port in Middelfart at 19:00. Vibrocoring was resumed at 7:00, 15th November, and further six vibrocores were successfully retrieved from Fænø Sund before the survey came to an end at 13:00, where personnel were disembarked in Middelfart.

During the survey period, weather conditions were changeable with periods of strong winds (up to 15 m/s) and currents varying between 1 and 5 knots. Wave heights were however <1 m due to the protected nature of the survey area.

2.6 Participants

M/V Madog survey crew from GEUS included Niels Nørgaard-Pedersen (Geologist, project manager), Sara Borre (Geophysicist, seismic interpreter), and Jacob Geltzer (Technician). Lars-Georg Rödel (Technician) participated in the mobilisation phase. Rune Bert Jørgensen (Geologist, Rambøll) was chartered as additional geophysical surveyor. Subcontractor Johnny Bjerregaard Jørgensen (Bjerregaard Montage, ApS) was responsible for vibro-coring. Energinet.dk's representative was Erik F. Pedersen.

M/V Laura survey crew from GEUS included Niels Nørgaard-Pedersen (Geologist, project manager) and Jacob Geltzer (Technician). Jens Skov (consultant for GEUS) was chartered as additional geophysical surveyor. Subcontractor Johnny Bjerregaard Jørgensen (Bjerregaard Montage, ApS) was responsible for vibro-coring. Energinet.dk was not represented.

3 Methods and equipment

In the following, the methods and equipment used are described in detail. Further equipment specifications are listed in Appendix A.

3.1 Positioning

For positioning, a Simrad Seatex 20 GPS and a Thales Sagitta GPS were used. Differential correction was not used. The accuracy is about 3-5 m. All positions are given in UTM zone 32 North, ellipsoid WGS 84 or in geographical decimal degrees. Positions of measuring equipment was calculated dynamically and precisely by the navigation computer in relation to the ships position and movement.

3.2 Side-scan Sonar / chirped sub-bottom profiler

As side-scan sonar GEUS used a BenthosTeledyne 1625 combined side-scan sonar and sub-buttom profiler. This is a dual frequency side-scan sonar operating at 100 and 400 kHz simultaneously, with selectable swath from 25 to 500 meters. The maximum resolution of the side-scan is 4.5 cm. The instrument also contains a build in sub-bottom profiler which operates within the 1 to 10 kHz range. This will be used in cooperation with the Geo-Source 200 system. A detailed description is given in Appendix A.

To further improve the accuracy of the side-scan data, the position of the fish relative to the tow point is monitored by an Ore Trackpoint 3 USBL system. For further description of the system, see the datasheet in Appendix A.

3.3 Sub-bottom profiling

A combination of the Benthos Teledyne side-scan sonar/ chirped sub-bottom profiler and the Geo-Source 200 sparker was used. The Benthos is used to map fine grained near surface sediment layers and the Geo-Source 200 is used for deeper penetration.
The Geo-Source 200 is a high resolution Multi-tip sparker system designed for use with the Geo-Spark 1000 pulsed power supply and the Geo-Resources single channel 8 sensors mini-streamer. The sparker has an effective seabed penetration of approximately 30 meters below seabed with c. 30 cm resolution, and operates with a 200 tip array pulsed at between 50 and 1000 joule per ping. A detailed description of the seismic equipment is given in Appendix A.

3.4 Magnetometer

A Geometrics G-882 marine magnetometer was used. The magnetometer has automatic hemisphere switching, capable of operating down to a depth of 2750 m. The operating range is 20,000 to 100,000 nT. The absolute accuracy <3 nT throughout range. The system features include very high sensitivity measurements of total field and gradient combined with rapid sampling.

Ideally the magnetometer shall be towed as far away from the vessel as possible in order to reduce magnetic noise from the vessel. However, in shallower water (<10 m) lay back has to be reduced in order to prevent bottom contact and potential damage of

the equipment. The magnetometer was preferably positioned about 50 m behind the vessel at water depths >10 m. The lay back was controlled through remote steering of the cable winch. The position of the fish relative to the tow point was monitored by an Ore Trackpoint 3 USBL system. For further description of the system, see the datasheet in Appendix A.

3.5 Vibrocoring

GEUS' vibrocorer W. Schmidt VKG 6/3 was used with a core barrel length of 3 m (M/V Madog) and 4 m (M/V Laura) respectively. The VKG is an electrically driven vibrocorer system, vibrating at around 28 Hz, coring bottom samples in up to 100 m water depth (Appendix A). PVC core liners with an inner diameter of 106 mm were used.

It was attempted to retrieve a duplicate set of cores (A and B) from each selected site. However, very strong currents prevented exact anchoring positioning at core sites LB1, LB4 and LB5, and several times one of the two anchors from the stern lost their grip in the sea bottom. Accordingly, only one set of cores were retrieved from the above mentioned sites.

3.6 Laboratory tests

This outlines the details for the offshore and onshore laboratory testing.

Core liners with samples were cleaned, cut into one-meter lengths and labeled. In the bottom sections containing clayey sediments, vane shear test were performed with a Geonor H-60 hand-held Vane Tester, capable of measuring shear strengths up to 200 kPa.

Subsamples were taken from the bottom of each core section (A cores only) and from the core top. Hereafter the core sections were sealed with core liner tubes and durable tape and placed carefully in transport boxes.

After return to the GEUS sediment laboratory, cores were cut into two halves, for a detailed core description and further sampling of representative sediment types. Laboratory analyses performed included water content, wet and dry bulk density, organic content, hydrometer and sieve analyses. The duplicate cores were preserved whole in the core barrel liner for the possibility later to perform advanced geotechnical tests such as thermal resistivity, compressibility and triaxial tests.

Results from the laboratory testing aim at providing information about:

- Soil stratification and the geological classification of the soil layer
- Classification and identification parameters
- Strength and deformation parameters of the soils
- Thermal resistivity

The classification is based on:

- Geological visual description incl. colour, continuously performed
- Grain size analyses, sieve and/or hydrometer, wet and dry unit weight, water content, organic matter content, vane shear test results

3.6.1 Water content determination

The water content is determined in percentage of natural condition sample weight. The samples are dried at 105 °C to constant weight. The analyses are carried out partly to the standard DS 405.11 and partly to DS 204 (se references).

3.6.2 Loss on ignition determination

The organic content and the content of chemically-bonded water are determined with the loss on ignition analysis. The loss on ignition is determined in weight % of material dried at 105 °C. The analyses are carried out partly to the standard DS 405 and partly to DS 204 (se references).

3.6.3 Grain size distribution

For sandy and gravelly samples, the grain size distribution was determined by sieve analysis. For samples with a larger amount of clay and silt, hydrometer analysis was used in supplement to sieve analysis.

The total sample was dried and washed through a 0,063 mm sieve. The resulting sediment was sieved through a sieve column from 16 mm to 0,063 mm with ½ phi intervals, which corresponds to 15 sieves. The method is adapted in relation to the standards DS405.9, DS/EN 933-1, as more sieves than described in this standard have been used.

The particle size distribution of grain size fractions smaller than 0.063 mm was determined with Hydrometer analysis based on Stokes law using gravity sedimentation in 0,002 M Sodiumpyrophosphate. Na4P2O7 .10 H2O. The total particle size distribution was obtained by combining the Hydrometer analysis with the sieve analysis.

3.6.4 Thermal resistivity

Thermal resistivity measurements were performed at VIA University College's Geo laboratory in Horsens, Denmark. The measurements were performed on whole core duplicates in order to avoid disturbance and draining of water content.
Thermal resistivity measurements were performed with a non steady-state measurement probe TP02 of the company Hukseflux mounted in a TPSY02 system. The system is particularly suitable for analysis of soils, sediments, thermal backfill materials etc. It has accuracy (depending on sample) of +/- 3% + 0.02 W/mK. See

http://www.hukseflux.com for further information about the instrument and measurement principles.

Core sections selected for measurement were cut in 30-50 cm long subsections immediately before measuring took place. All measurements were performed with the probe inserted from the direction of the deepest level and upward in the core stratigraphy (core section placed upward down). The probe inserted into the central part of the core section is 15 cm long and few mm thick. If possible, six measurement series were performed on each core section sample. The heating cycle duration was 200 s. After four measurement series, the samples were saturated in water at least 24 hrs and two last measurements series were performed on saturated core material. This was done, as sandy and coarser material samples unavoidable were losing water during each progressive measurement series. Moreover, it is assumed that the samples in-situ have been water-saturated.

4 Data Acquisition and Processing

4.1 Data handling

Survey data was acquired online and saved on the acquiring computer in a Raid 1 Hard disc setup. As an extra precaution, daily external backups were taken of each measurement computer. This external backup served as transport media along with the data stored on the computer itself. Raw data were finally stored in our resident database at GEUS. The data formats used for the raw data is XTF and SEGY.

4.2 Navipac

The integrated navigation and data acquisition software NaviPac was used. It records the antenna position and distributes offset corrected navigation data for the individual instruments. NaviPac allows for survey planning through quickly creation of planned survey area and survey lines. More details on NaviPac are found in Appendix A.

4.3 Isis Side scan Acquisition Software

ISIS side scan software was used for recording, processing, and presenting side scan data as single line data and as mosaics. The interpretation of side scan and chirp data were performed by Isis® Sonar™ and TEI's Triton-Map™ software. ISIS offers a wealth of display options to ensure high data quality. Typical windows for monitoring raw sensor information include a waterfall display for the sonar imagery, a signal voltage display for each incoming ping, and a parameter display for navigation, motion sensor, etc., and file storage.

4.4 Magnetometer

The data recorded by the Geometrics G-882 marine magnetometer were cleaned for noise by the use of *GeoSOFT Oasis montaj 6.0* software. The magnetic data were plotted line through line and closely examined for characteristic anomaly spikes. All spikes larger than 10 nTesla were listed with associated position data.

5 General geology of the Lillebælt- Fænø Sund area

Lillebælt was created in the Quaternary by glacier and meltwater channel erosion dividing the region into the landscapes of Jylland and Fyn (Houmark-Nielsen, 1987; Larsen, 2002). The Pre-Quaternary is lying relatively high in the region (Binzer and Stockmarr, 1994), and Eocene clays and upper Oligocene to Lower Miocene sandy to clayey deposits crops out in coastal cliffs along Lillebælt and Fænø Sund (Dybkjær and Rasmussen, 2000; Larsen, 2002).

The submarine geology of the Lillebælt Channel is quite well-known from previous geotechnical and geological investigation along the two Lillebælt Bridge transects and the natural gas pipeline crossing a few kilometers to the east of the cable survey area. A summary of the geological conditions along these transects follows here:
From about 100-120 m below sea level, Eocene layers of very heavy clay with tuff beds are found. Resting on this, an Eocene sequence of multi-colored plastic Røsnæs-and Lillebælt Clay occur. In the upper part of this sequence calcium carbonate content is increasing and some concretional zones may be found. At level -15 to -20 m, a boundary (hiatus) against the Oligocene mica clay – locally with iron-lithified sandstone beds (Øxenrade Sandstone) – occurs. The mica clay is covered with mica sand and clay layers of lowermost Miocene age. The boundary between Pre-Quaternary and the Quaternary represents an erosional surface developed as well from glacier erosion as from meltwater streams and marine bottom currents. Glacial deposits in the form of till/moraine are found on both side of the Lillebælt channel and consist of sandy and clayey till with a high content of heavy clay. Meltwater deposits are met as up to 10 m thick sandy deposits. Holocene marine deposits consist mostly of mud and sand or gravelly lag and shell debris. Erosion and deposition are intricately related to the relatively strong current regime and bathymetrical variation of the Lillebælt channel/shoulder system.

The sandstone unit known as ‘Øxenrade Sandstone’ (Rasmussen, 1995; Larsen, 2002) contains banding of iron-enriched units (up to 30% iron) making this specific lithology quite compact and resistant. The Øxenrade sandstone crops out in the costal cliff in Teglgårds Bugt just south of Middelfart (about 1 km north of the planned cable alignment).

6 Seismic survey data

Seismic lines were recorded with sparker and chirp. Three parallel lines with a distance of 60 m in between were surveyed along cable corridor A, from Lillebælt through Fænø Sund (Fig. 3). Moreover, a grid of crossing lines was surveyed in the northern Lillebælt area, covering the two alternative cable corridors, A and B. Examples of the seismic sections are given in Figs. 4 a-g (sparker), and Figs. 5 a-b (chirp) and all interpreted seismic profiles are presented in the data CD accompanying this report.

Three seismic horizons are indicated on the interpreted profiles:

- 'Sea bottom surface' representing the top of the Holocene sediment cover (if present)
- 'Top Glacial' representing the surface of till or meltwater deposits originating from the last glacial and late glacial period
- 'Top Pre-Quaternary' representing the erosional surface of Eocene-Lower Miocene clay and sand(–stone) successions

The Top Pre-Quaternary surface appears to lie relatively close to the sea bottom along most of the profile. North of the Lillebælt Channel, stratified Pre-Quaternary deposits are mostly found <1 m below sea bed (Figs. 4a-c). Pre-Quaternary beds appear to crop out along the steep channel escarpment (Øxenrade sandstone based on vibro core data) and possible are exposed also in parts of the most shallow platform area to the north of the channel. In the deep Lillebælt channel, Eocene 'Lillebælt Clay' is found below a few decimetres of stony and gravelly lag sediments. This appear mostly massive and unstratified, but a delicate stratification occasionally is visible under the deeper part of the Lillebælt channel (Figs. 4a-b). South of the Lillebælt channel and in Fænø Sund, Pre-Quaternary deposits in many cases appear to be glacially disturbed (Figs. 4d-g)

Top Glacial deposits lie close to the sea bottom from the central part of the Lillebælt channel and southward through Fænø Sund. A marked Top Pre-Quaternary /Base Glacial reflector is observed under a thicker ?late glacial unit constituting the core of the southern shoulder of the Lillebælt channel north of Fænø (Fig 4a).

Holocene deposits are quite variable in thickness, from few decimetres to non-existent in higher lying areas characterised by current erosion, to up to 5-8 m in some of the deeper basins in Fænø Sund (Figs. 4e-g).

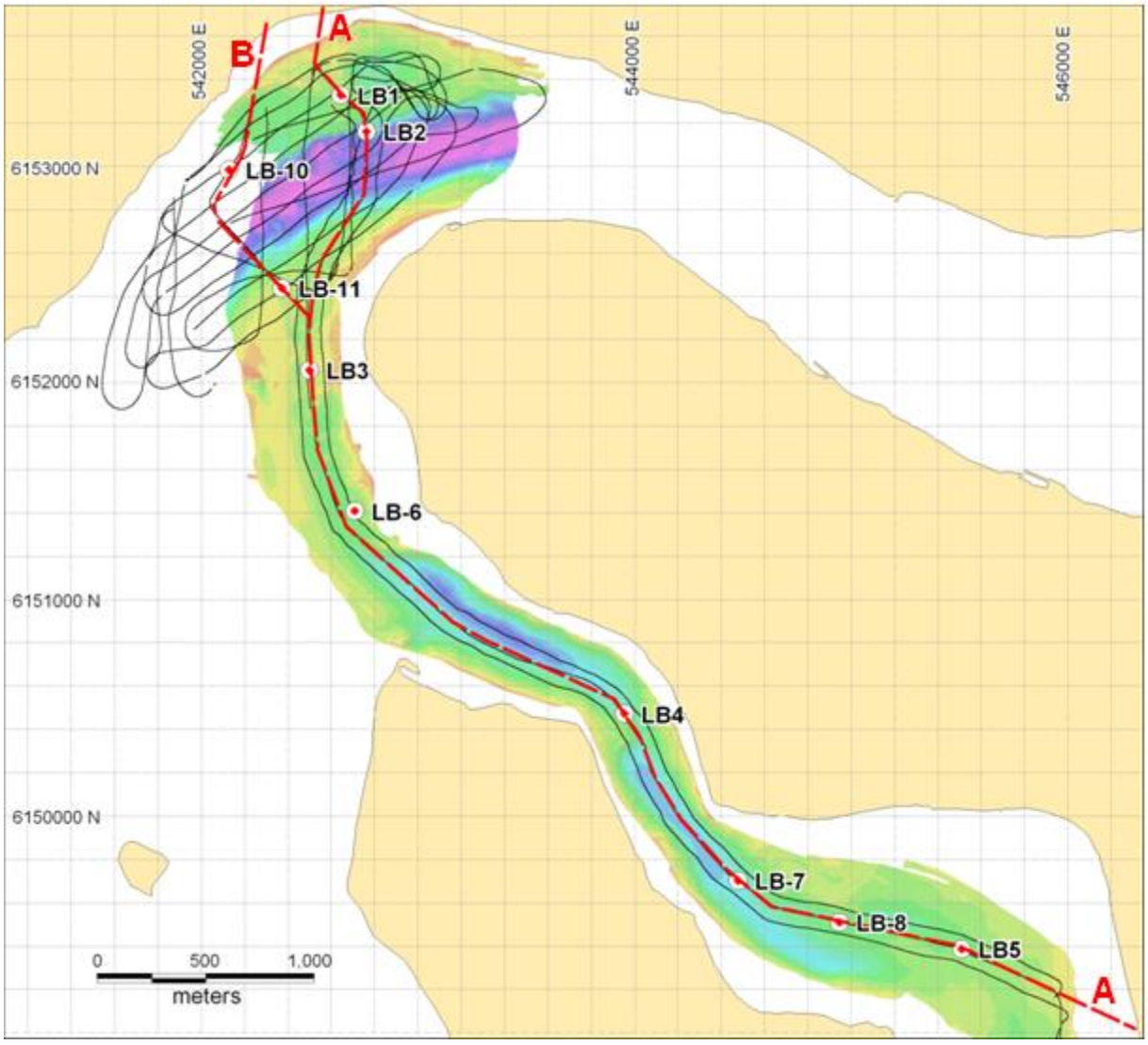

Fig. 3. Seismic sparker lines (black), center cable corridors A and B (red), and vibrocore sites (LB 1- 11). Multibeam bathymetry (cf. fig. 2) as background.

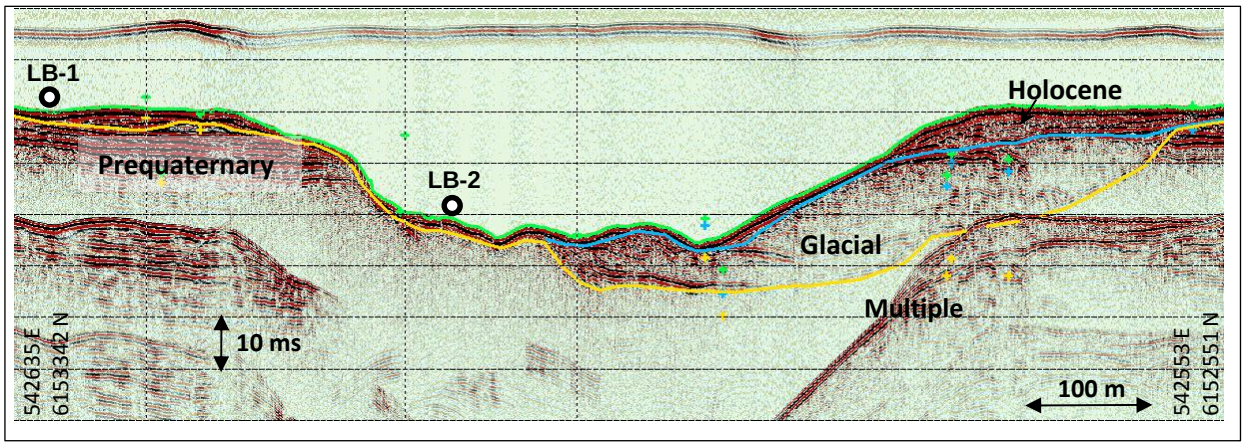

Fig. 4 a. Sparker seismic section (corridor A, North) with interpretation of major horizons and seismic units. Core sites LB1 –LB2 are indicated. Signatures for identified seismic reflector boundaries:'Top-Prequaternary' (yellow); 'Top Glacial' (blue), Sea-bottom (green). Single crosses are ghosts of crossing lines from the later survey and have not been time-adjusted.

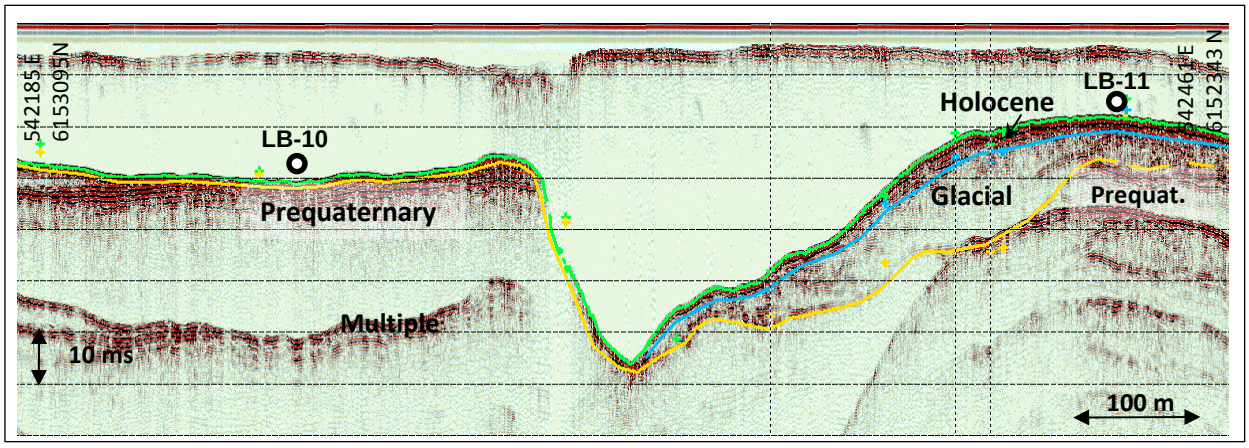

Fig. 4 b. Sparker seismic section (corridor B) with interpretation of major horizons and seismic units. Core sites LB10 and LB11 are indicated. Signatures for identified seismic reflector boundaries:'Top-Prequaternary' (yellow); 'Top Glacial' (blue), Sea-bottom (green).

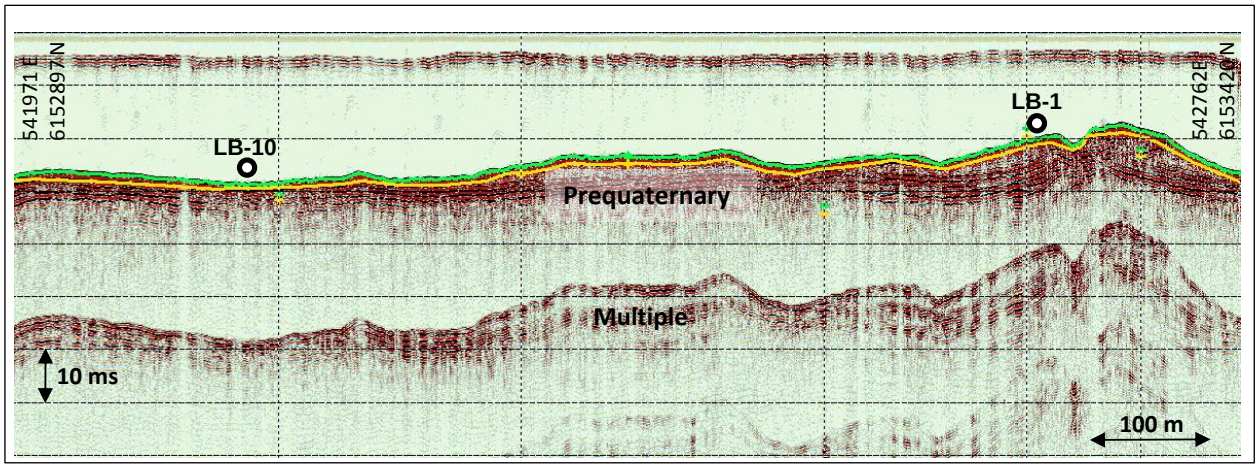

Fig. 4 c. Sparker seismic section between core sites LB-10 and LB-1 (North of Lillebælt channel) with interpretation of major horizons and seismic units. Signatures for identified seismic reflector boundaries:'Top-Prequaternary' (yellow); 'Top Glacial' (blue), Sea-bottom (green).

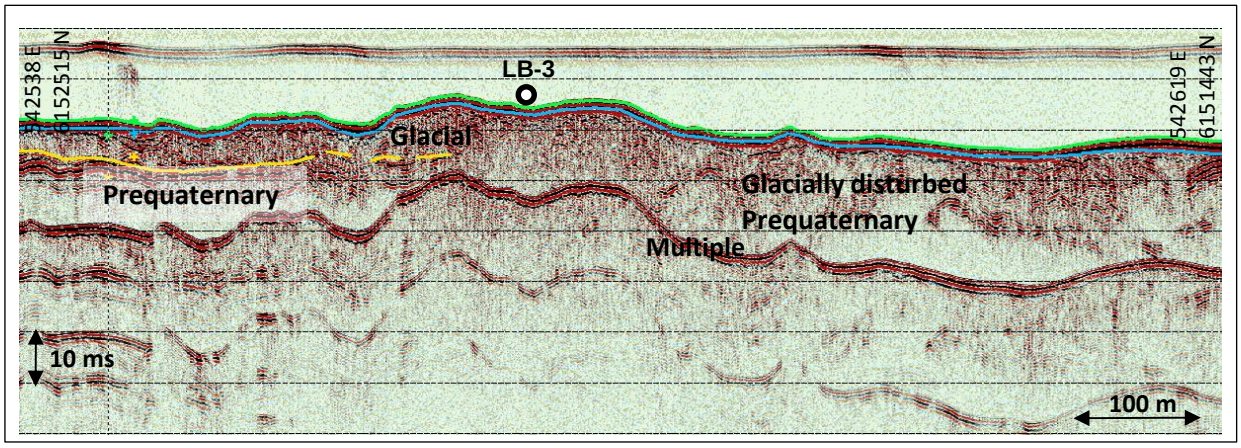

Fig. 4 d. Sparker seismic section near core site LB-3, north of Fænø, with interpretation of major horizons and seismic units. Signatures for identified seismic reflector boundaries:'Top-Prequaternary' (yellow); 'Top Glacial' (blue), Sea-bottom (green).

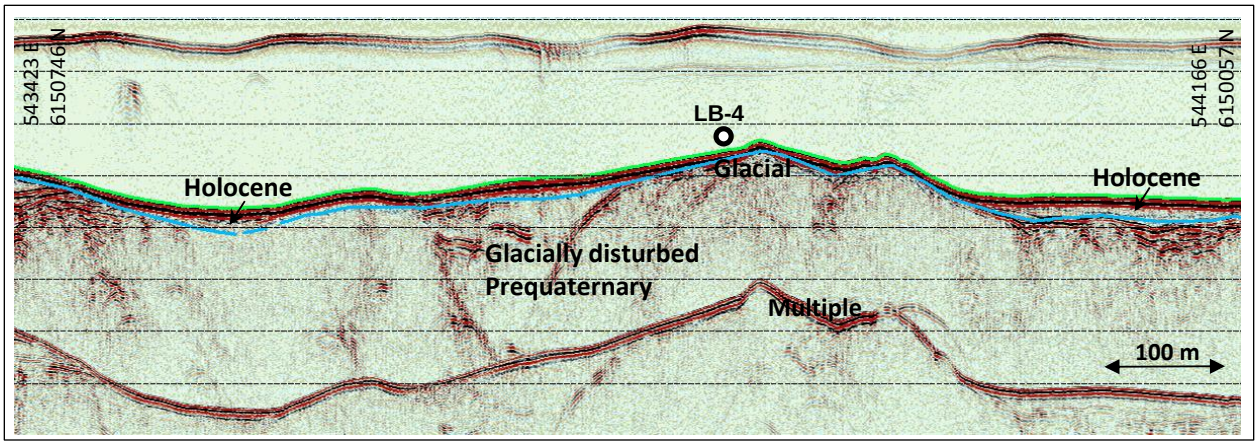

Fig. 4 e. Sparker seismic section from Fænø Sund near core site LB-4 with interpretation of major horizons and seismic units. Signatures for identified seismic reflector boundaries:'Top-Prequaternary' (yellow); 'Top Glacial' (blue), Sea-bottom (green).

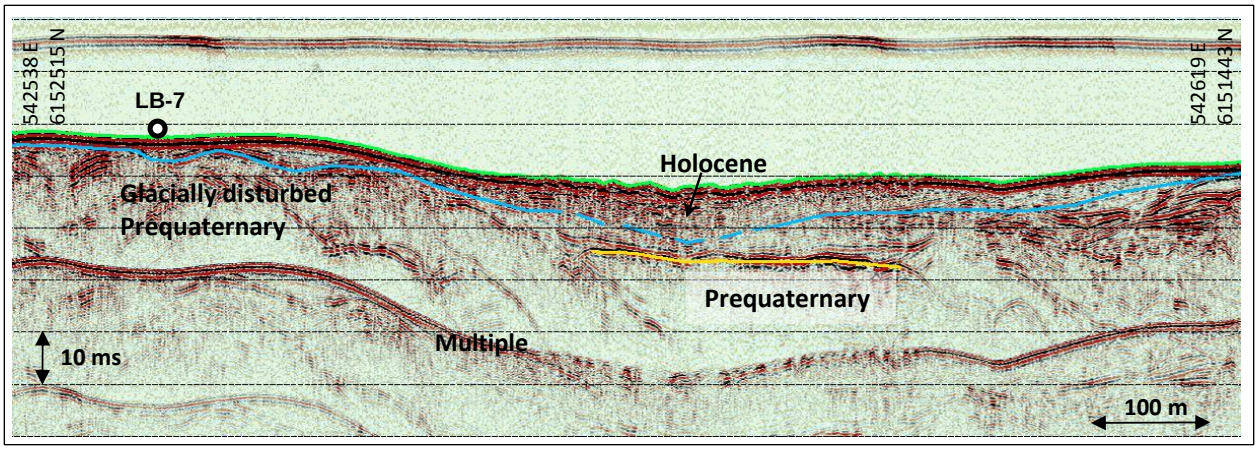

Fig. 4 f. Sparker seismic section from Fænø Sund near core site LB-7 with interpretation of major horizons and seismic units. Signatures for identified seismic reflector boundaries:'Top-Prequaternary' (yellow); 'Top Glacial' (blue), Sea-bottom (green).

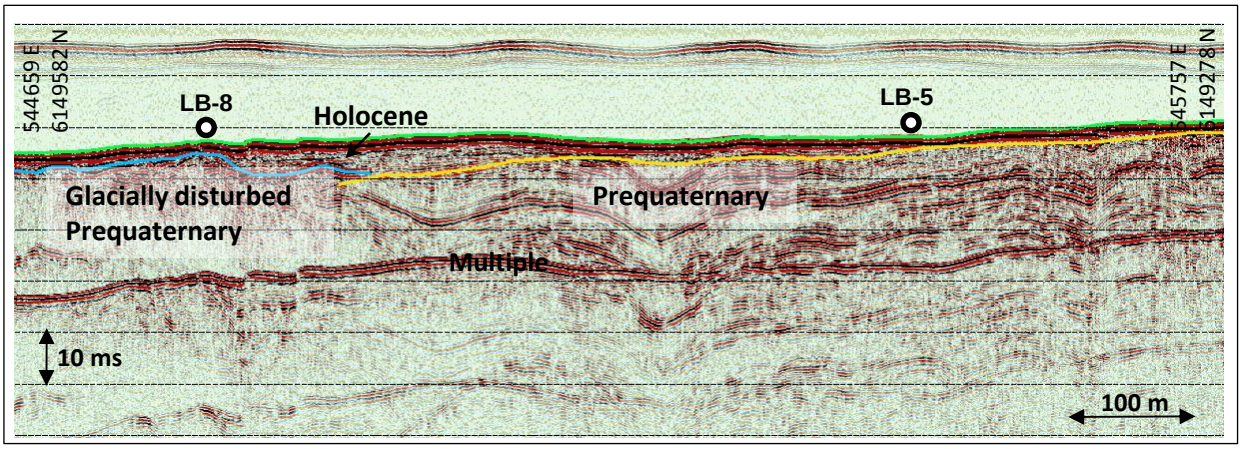

Fig. 4 g. Sparker seismic section from Fænø Sund through core sites LB-8 and LB-5 with interpretation of major horizons and seismic units. Signatures for identified seismic reflector boundaries:'Top-Prequaternary' (yellow); 'Top Glacial' (blue), Sea-bottom (green).

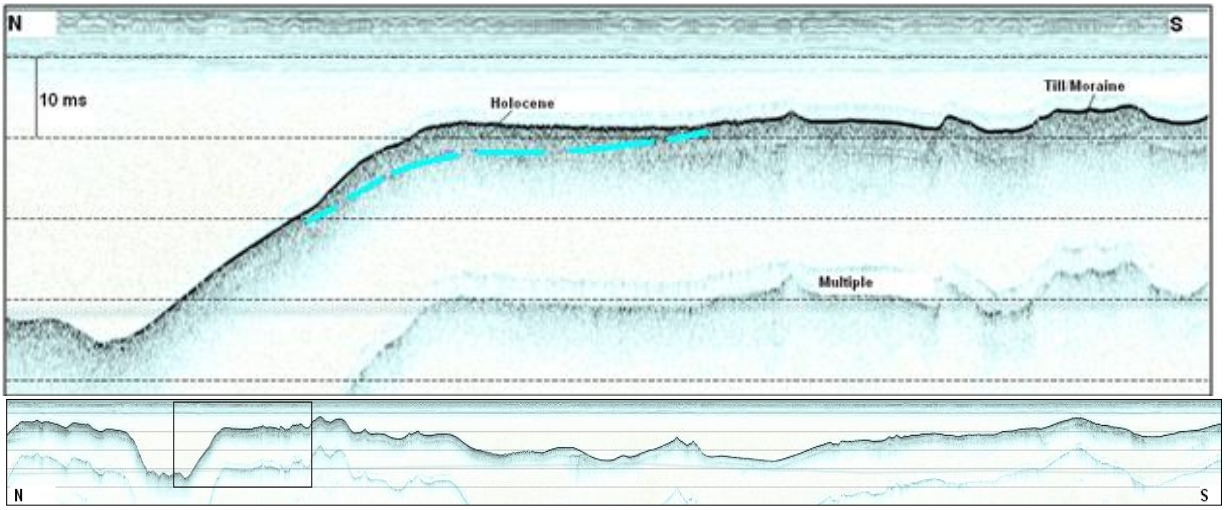

Fig. 5.a. Chirp seismic section from cable corridor A. The sandy and gravelly bottom limits the penetration of the high-frequency seismic signals.'Top-Glacial' (blue). The frame indicates the location of the close-up section above.

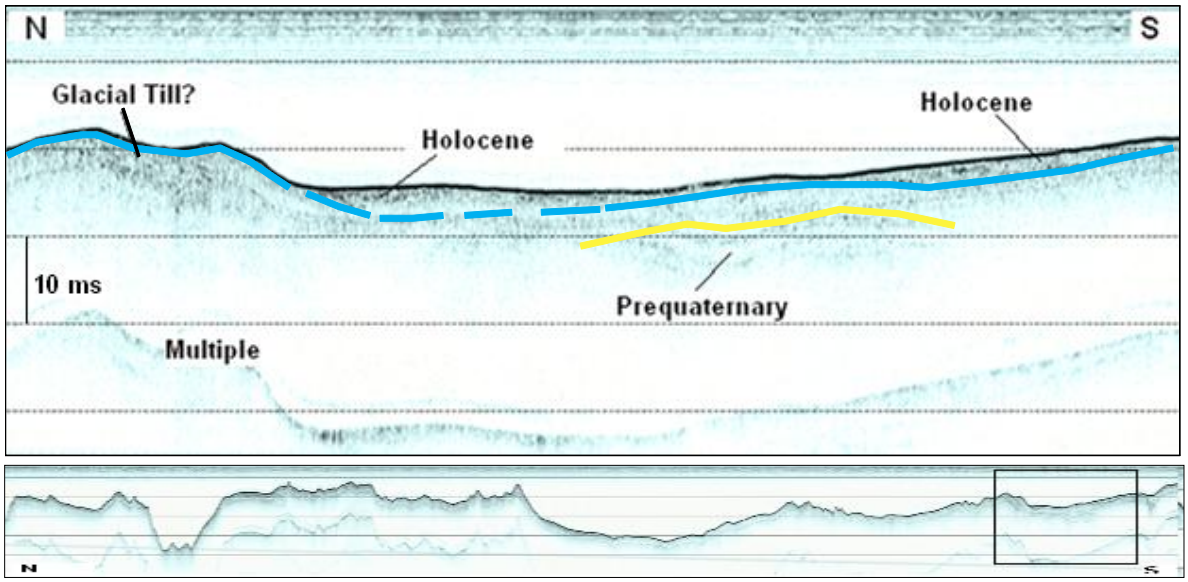

Fig. 5 b. Chirp seismic section from the southern part of Fænø Sund (line 1). Irregular stratification a few meters below the sea bottom is visible in the Holocene fill (mostly sand) of the sub-basin. The frame indicates the location of the close-up section above.

7 Vibrocore data

Ten sediment cores up to 3.5 m in length were taken, and from seven of the sites duplicate cores were retrieved. Eight of the sites are placed along the centerline of cable corridor A across the Lillebælt channel and southward in Fænø Sund (Fig. 3). In table 1 a short core description is given, and a summary of sediment analysis data is presented in table 2. Detailed core descriptions are given in Appendix B and sediment grain size distribution data are found on the data CD accompanying this report.

Core LB-1 from the shoulder north of the deep Lillebælt channel contains about 1 m of coarse sand and gravelly sediment with many bivalve shells (marine Holocene) resting on a 40 cm thick, dark brown, peaty sediment unit with sand layers (possibly limnic). Gravelly and sandy sediment in the basal part of the core may be of glacial or late glacial origin. Pre-Quaternary sediment was not recovered by the core, but seismic sections and site LB-10 core data as well as available data from previous bridge and pipeline construction surveys in the Lillebælt area, indicate that Pre-Quaternary sediments are lying close to the sea bottom in this area. LB-10 from the platform area north of the Lillebælt channel show layered glauconite-rich Øxenrade Sandstone (fragmentation caused during vibrocoring process) overlain by about 0.8 m of gravelly sand (reworked dark sandstone fragments) with marine shells (Holocene).

At the Lillebælt channel site LB-2, fat Eocene 'Lillebælt Clay' is found under a few decimetre thick stony and gravelly lag sediment.

Core LB-11 from the large bar region north of Fænø shows yellowish sand and gravel with shells (marine Holocene) down to at least 2 m below bottom.

The two core sites LB3 and LB4 B were taken from higher lying sites in Fænø Sund. Here glacial till deposits were found about 10-50 cm below sea bottom. The upper 0.5-1 metre of the till appears to be rather soft, whereas the till unit below is firm and overconsolidated. Based on the seismic profiles, the till units are probably not very thick (?2-4 m), and seismic sections indicate glacially disturbed Pre-Quaternary sediments below.

Core LB-6 contains 0.7 m Holocene sand and gravel above clayey till with a high content of reworked 'Lillebælt Clay'.

LB-7 shows 1 m of shelly sand (Holocene) on top of 0.9 m of sand and gravel with till clasts (Late glacial). Below firm glacial till is found.

LB-8 contains 1.5 of Holocene sand and gravel on top of glacial till.

LB-5 represents a Holocene sediment cover, at least 2.25 m thick. The Holocene sandy sediments probably rests on a thin glacial unit superimposed on the Prequaternary succession.

Core No.	Recovery (m)	Position UTM 32N	Depth (m)	General description
LB1-A	1.75	542643 E 61533288 N	20	Sand,crs. to med. gravelly, and shelly / thin peaty layer / gravel
LB2-A	1.62	542763 E 6153160 N	35	Stones-gravel / 'Lillebælt Clay'
LB3-A	1.90	542499 E 6152059 N	24	Till, soft in upper 1 meter
LB4-A	1.92	543952 E 6150472 N	22	Gravel (lag) / Till
LB5-A	2.25	545509 E 6149387 N	19	Coarse sand with shells and gravel
LB6-B	2.75	542708 E 6151408 N	18	Gravelly sand/ /Till
LB7-A	3.30	544478 E 6149703 N	27	Sand / meltwater sand and till
LB8-B	3.50	544945 E 6149510 N	21	Sand / gravelly sand / Till
LB10-B	2.00	542126 E 6152984 N	21	Sand (reworked Prequat.) / Prequat. Øxenrade Sandstone
LB11-B	2.00	542372 E 6152437 N	13.5	Gravelly sand

Table 1. List of vibrocores from the 10 coring sites. Detailed core descriptions are found in Appendix B.

Sample No.	Sample ID	Depth cm	Water Cont. %	Loss on Ign. %	Dry Density g/cm3	Clay %< 0,002 mm	Silt + clay %< 0,063 mm	Sand, fine % 0,063 mm - %	Sand, medium 0,2 mm - 0, %	Sand, coarse 0,6 mm - 2 m %	Gravel > 2 mm	Vane test kPa
1	LB 1-2 Top	0-5	23.40	2.05	1.3	-	4.64	20.40	67.63	6.39	0.94	-
2	LB 1-2 Bot	70-75	20.45	1.17	-	-	1.61	1.37	22.10	33.44	41.48	-
3	LB 1-1: 95-100	95-100	42.80	7.43	-	-	15.48	14.26	38.36	23.46	8.43	-
4	LB 1-1 Bot	170-175	10.67	2.54	-	-	4.89	12.73	18.95	14.07	49.37	-
5	LB 2A-2 Top	0-5	30.48	7.66	-	62.65	81.04	0.85	3.13	2.75	12.22	-
6	LB 2A-2 Bot	57-62	31.25	8.19	-	69.00	99.67	0.10	0.14	0.07	0.03	17.2
7	LB 2A-1 Bot	157-162	31.53	9.07	-	75.00	99.60	0.11	0.15	0.14	0.00	17.2
8	LB 3A-2 Top	0-5	18.01	1.10	0.895	-	6.95	17.12	63.29	11.65	0.99	-
9	LB 3A-2 Bot	85-90	16.25	1.73	0.79	15.20	40.91	26.15	25.11	5.26	2.58	10.8
10	LB 3A-1 Bot	185-190	14.42	2.43	0.855	8.30	29.15	18.06	22.90	9.41	20.48	>20
11	LB 4A-2 Top	0-5	14.97	1.20	-	-	2.63	7.59	38.34	31.04	20.40	-
12	LB 4A-2: 60-65	60-65	14.11	3.58	-	-	31.20	14.71	25.78	10.50	17.80	-
13	LB 4A-2 Bot	88-92	20.65	3.98	-	24.00	52.10	14.11	18.92	7.68	7.19	6.8
14	LB 4A-1: 120-12	120-125	16.21	5.08	-	-	64.74	16.15	12.66	3.62	2.83	-
15	LB 4A-1 Bot	187-192	16.59	4.37	-	23.00	60.32	17.99	14.74	4.22	2.72	10.6
16	LB 5A-3 Bot	33-38	19.51	0.41	0.94	-	1.18	12.73	77.46	8.60	0.04	-
17	LB 5A-2: 80-96	80-96	41.63	5.78	-	-	32.27	40.15	23.33	3.14	1.10	-
18	LB 5A-2 Bot	121-126	22.79	1.15	1.105	-	1.87	23.42	68.42	5.56	0.72	-
19	LB 5A-1 Bot	220-225	15.61	1.72	0.825	-	9.99	16.55	50.77	14.96	7.73	-
20	LB-6B 0 cm	0	18.23	1.30	-	-	1.43	2.24	71.12	17.30	7.91	-
21	LB-6B 73 cm	73	18.96	4.88	-	8.50	33.09	39.27	16.96	5.95	4.73	-
22	LB-6B 125 cm	125	26.02	7.21	-	46.50	67.71	15.51	10.52	3.08	3.19	-
23	LB-6B 172 cm	172	21.99	11.56	-	44.50	96.64	0.82	1.77	0.55	0.21	-
24	LB-6B 272 cm	272	26.41	12.48	-	62.00	99.87	0.06	0.05	0.02	0.00	>20
25	LB-7A 0 cm	0	17.15	2.07	-	-	4.51	24.64	37.44	13.01	20.40	-
26	LB-7A 100 cm	100	38.81	2.72	-	-	11.32	18.36	40.19	11.53	18.59	-
27	LB-7A 220 cm	220	16.44	6.49	-	33.50	74.53	11.38	8.65	2.86	2.58	-
28	LB-7A 335 cm	335	13.68	7.50	-	28.50	67.44	13.56	8.65	2.62	7.73	12.40
29	LB-8B 48 cm	48	18.09	0.75	-	-	1.53	26.35	69.00	2.99	0.12	-
30	LB-8B 133 cm	133	9.88	2.72	-	4.00	9.60	14.06	29.22	7.95	39.17	-
31	LB-8B 350 cm	350	14.06	5.67	-	24.00	57.76	19.13	14.67	4.99	3.45	11.20
32	LB-10A 35 cm	35	28.43	12.41	-	-	9.55	9.03	58.77	22.53	0.12	-
33	LB-10A 100cm	100	30.81	15.26	-	-	73.24	9.99	12.01	2.64	2.13	-
34	LB-11A 97cm	97	13.04	1.79	-	-	3.61	0.76	29.20	35.22	31.21	-

Table 2. Summary list of sediment core sample analyses. Detailed grain size data and graphic plots are found on the data CD accompanying this report.

Thermal resistivity measurements were performed on five of the duplicate, non-opened cores in a 30 cm interval at about 1 m core depth. Repetitive measurements were done in non-water saturated and water-saturated condition (table 3). Thermal resistivity values are ranging from about 1.0 to 2.4 W/mK, with a tendency to higher values in water-saturated condition. The effect of water drainage (during and post-coring) on the thermal resistivity results is expectedly high in core LB-11B, which contains highly permeable gravelly sand.

Core No.	Depth interval (cm)	Sediment type	Thermal Resistivity (W/mK)					
			Non water saturated				Water- saturated	
			λ1	λ2	λ3	λ4	λ5	λ6
LB-6A	67-100	Silt, clayey, rare gravel	1.36	1.44	1.45	1.37	1.31	1.81
LB-6A	140-167	Clay, firm, w. glacial smears	1.33	1.50	1.59	1.55	1.41	1.25
LB-7B	90-130	Sand, fine-medium	1.57	1.42	1.69	1.55	1.94	2.05
LB-8A	22-72	Sand, fine-med., clay linings	1.07	2.03	1.70	2.02	2.39	1.39
LB-10B	0-40	Sand, med.-coarse, reworked Pre-Quaternary	1.36	1.42	1.39	1.10	1.54	1.48
LB-11B	66-116	Stony-gravelly sand	-	-	0.13	-	1.37	1.01

Table 3. Thermal resistivity measurements. For each sample it was attempted to perform four measurements in non-water saturated condition ($\lambda 1 – \lambda 4$), followed by two measurements in water-saturated condition ($\lambda 5 – \lambda 6$). The sediment descriptions are based on the comparison of lithology of top and base sections of core liners and the sediment core description of duplicate core sections from the same sites (cf. Appendix B).

8 Side scan sonar data

The side scan sonar mosaic from Lillebælt Channel and Fænø Sund (Fig. 6) reveals different sea bed types (Fig. 7) reflecting sub-bottom geology, erosion/deposition history, bathymetry, and hydrodynamic conditions in the strongly current-influenced Lillebælt area.

The side scan sonar mosaic has been mapped in detail and classified into six different sea bed types (Fig. 7):

- Featureless sandy sea bed

  This bed type occurs over large part of the cable corridor in Fænø Sund. Vibrocore data reveal that it consists of fine- to medium grained sand with scattered shells and coarser particles.

- Rippled sandy sea bed

  These occur at the south eastern shoulder of the Lillebælt Channel as well as in some areas of Fænø Sund. The visible ripples have wave lengths of about 1-5m.

- Megarippled sandy sea bed

  The megaripple areas occur in Fænø Sund. The megaripples have wavelengths of 5-12 m and amplitudes of up to 0.5 m.

- Gravelly sea bed with scattered stones

  This bed type is found over major parts of the Lillebælt Channel area. It consists of coarse to fine gravel with scattered shells and stones. Only few stones exceed heights of 1 m.

- Exposed till and residual sediment

  Exposed glacial till and coarse residual (lag) sediments dominate the northwestern side of the cable corridor in Fænø Sund. Along the cable corridor center line, exposed till sea bed is only localised in the area north of Fænø.

- Pre-Quaternary bedrock

  Pre-quarternary bedrock is found along the escarpment at the northwestern margin of the deep Lillebælt channel. Moreover at some higher-lying areas at the platform northwest of the Lillebælt channel, Pre-Quaternary bedrock appears also to be exposed at the sea bed.

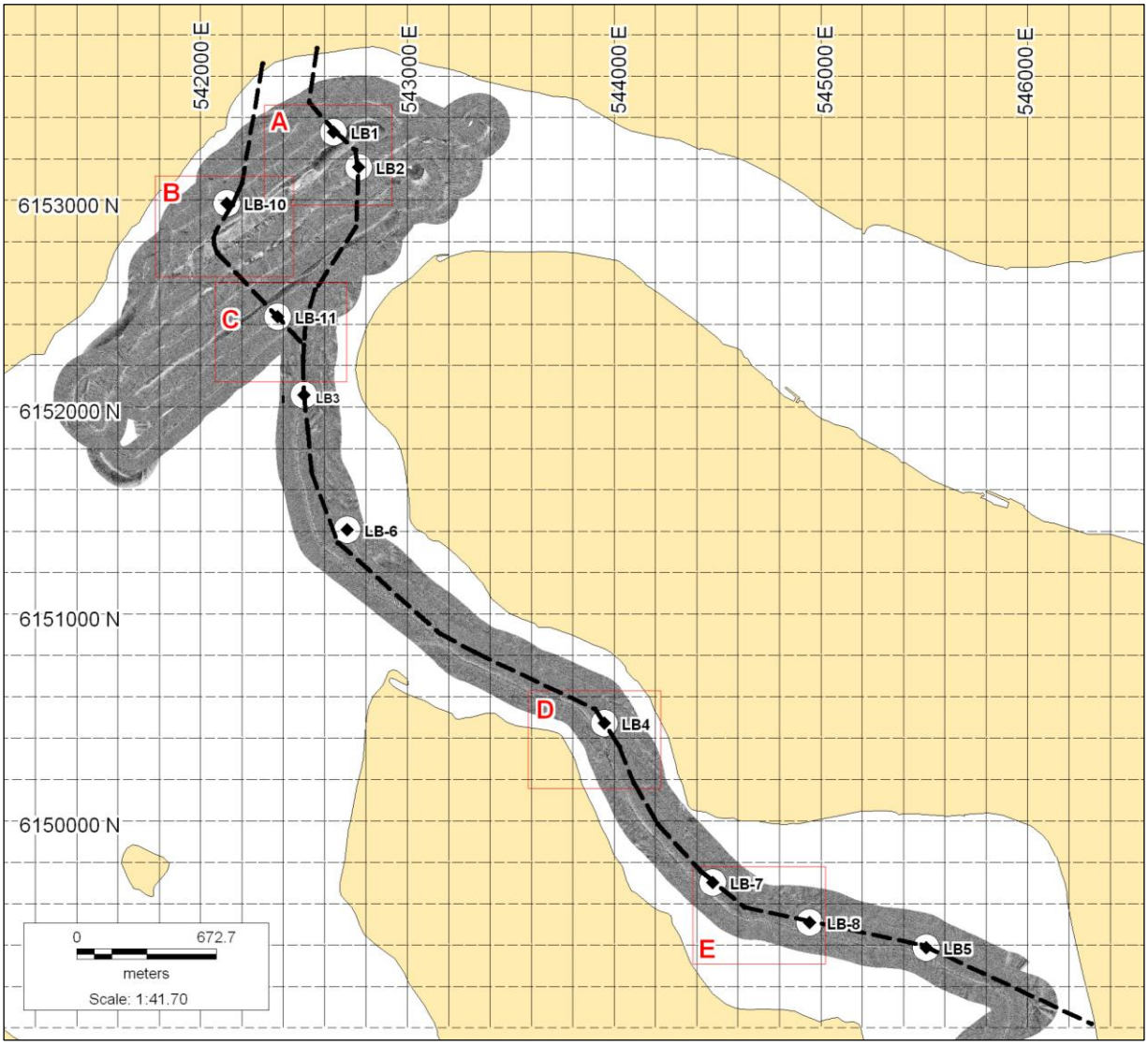

Fig. 6. Side-scan sonar mosaic with framed areas A-E shown close-up in Figs. 8-12. Cable corridor center lines and vibrocore sites are shown also.

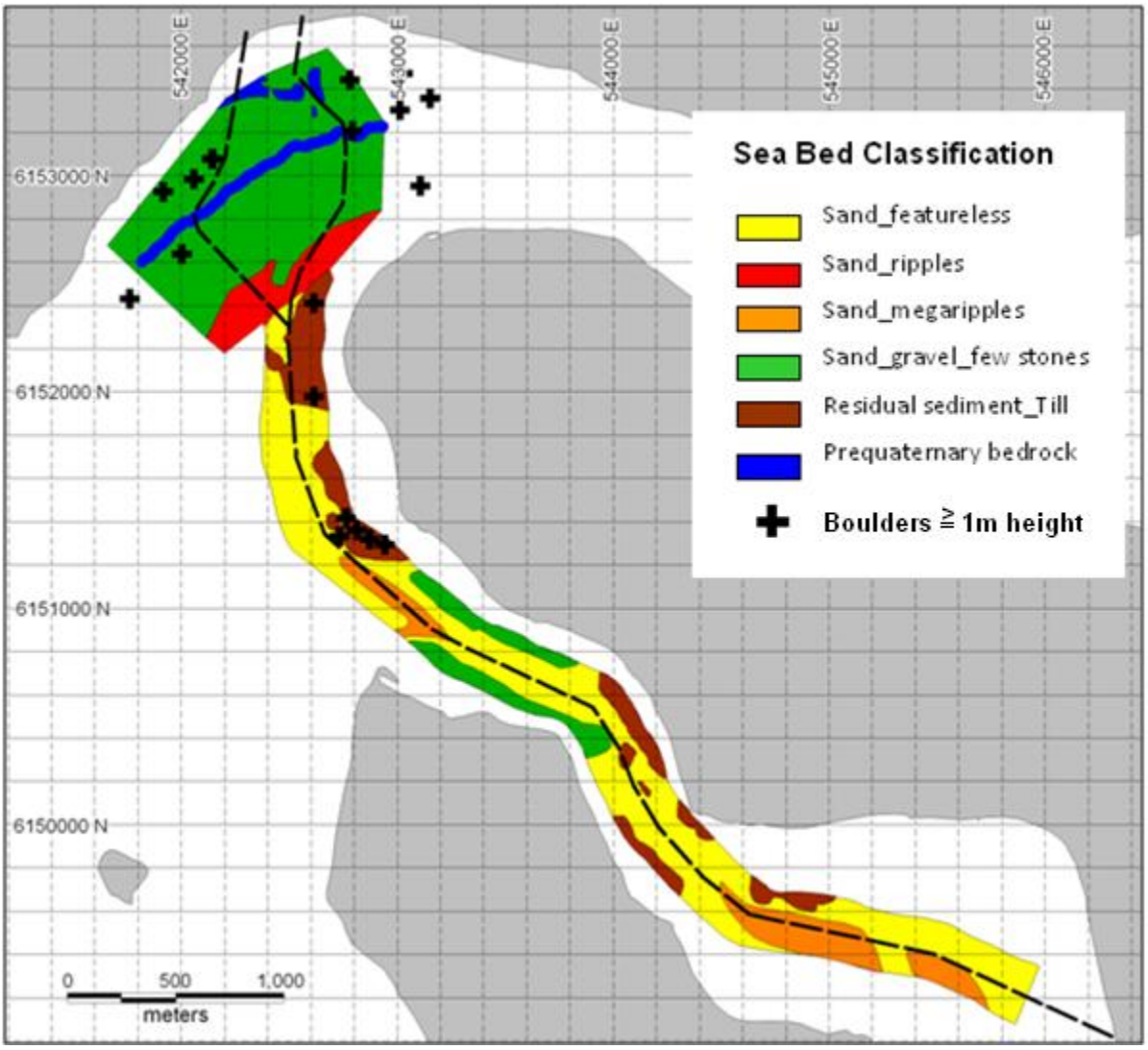

Fig. 7. Sea bed classification based on side–scan mosaic and single line determination of object/boulder height sizes.

The individual side scan sonar images have been visually scanned for occurrences of boulders/objects with heights ≥1 m above sea bottom. The position of the larger objects are shown in Fig. 7 and listed in table 4. It can be seen that their position is associated with the Till / Residual sediment sea bed type north of Fænø or the Sand-Gravel-Stone bed type in the northern part of the Lillebælt Channel. The latter ones may represent either local Pre-quarternary bed rock fragments or remnants of a former glacial sediment cover.

Examples of specific sea bed types are shown in Figs. 8-13 (frames A-E in Fig. 6).

ID no.	UTM E	UTM N	Height (m)
1	542943	6151294	1.0
2	542874	6151320	1.1
3	542732	6151332	1.0
4	542733	6151333	1.0
5	542813	6151362	1.0
6	542763	6151417	1.1
7	542615	6151977	0.9
8	542614	6152411	0.9
9	542780	6153442	1.6
10	542793	6153207	2.0
11	542147	6153077	1.1
12	542143	6153078	1.0
13	542058	6152983	1.5
14	541917	6152925	1.1
15	542003	6152637	1.2
16	541761	6152431	1.4
17	543106	6152951	1.4
18	543013	6153304	1.7
19	543013	6153304	1.6
20	543151	6153356	1.2
21	543026	6153473	1.5

Table 4. List of larger boulders/objects with estimated heights above sea bottom located in the surveyed area.

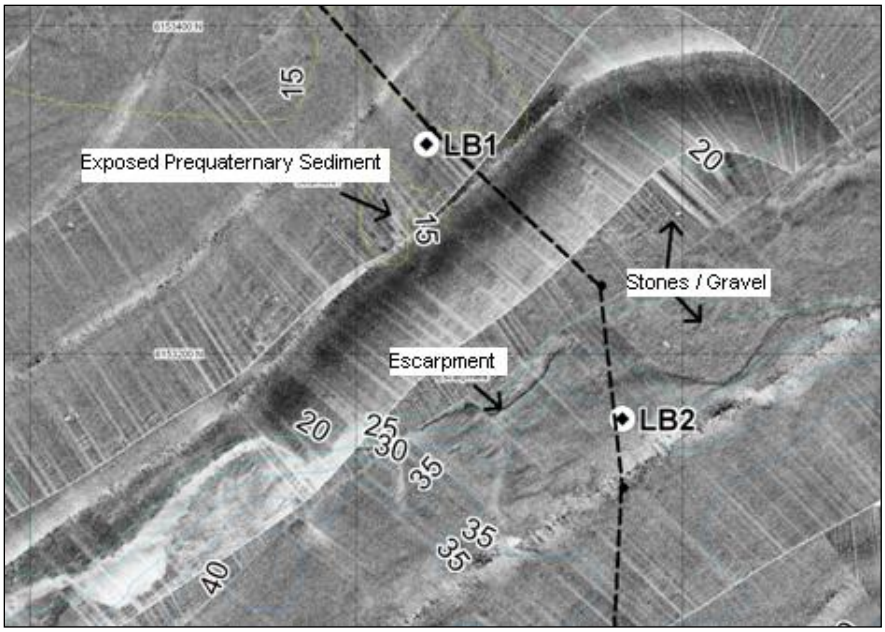

Fig. 8. (Frame A, Fig. 6). Side-scan sonar mosaic image from the northern margin of the Lillebælt channel (corridor A). The steep escarpment from the plateau area to the north toward the Lillebælt channel to the south is indicated. Scale: UTM 200m grid net.

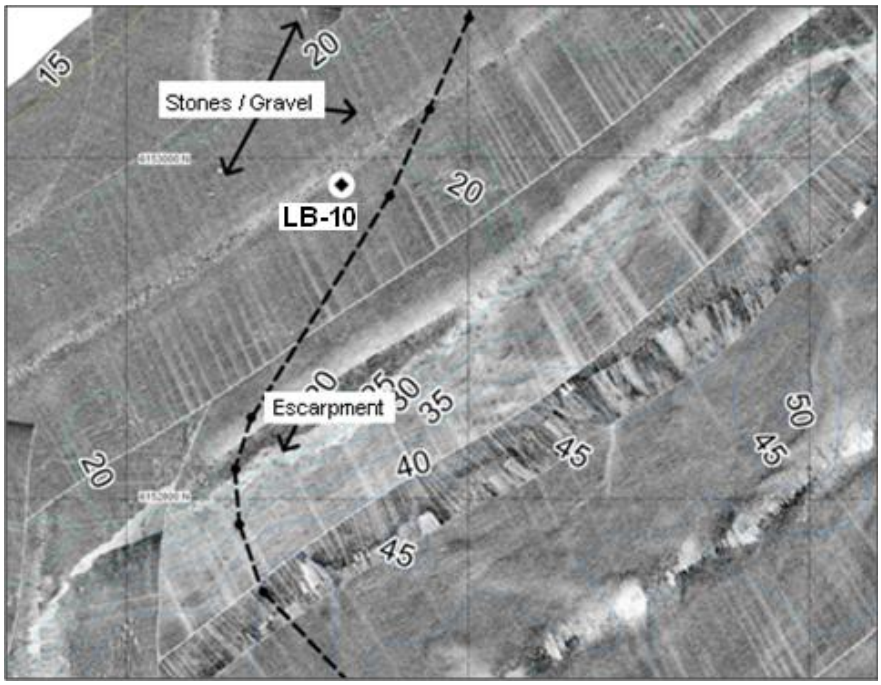

Fig. 9. (Frame B, Fig. 6). Side–scan sonar mosaic image from the northwestern margin of the Lillebælt channel (corridor B). Scale: UTM 200m grid net.

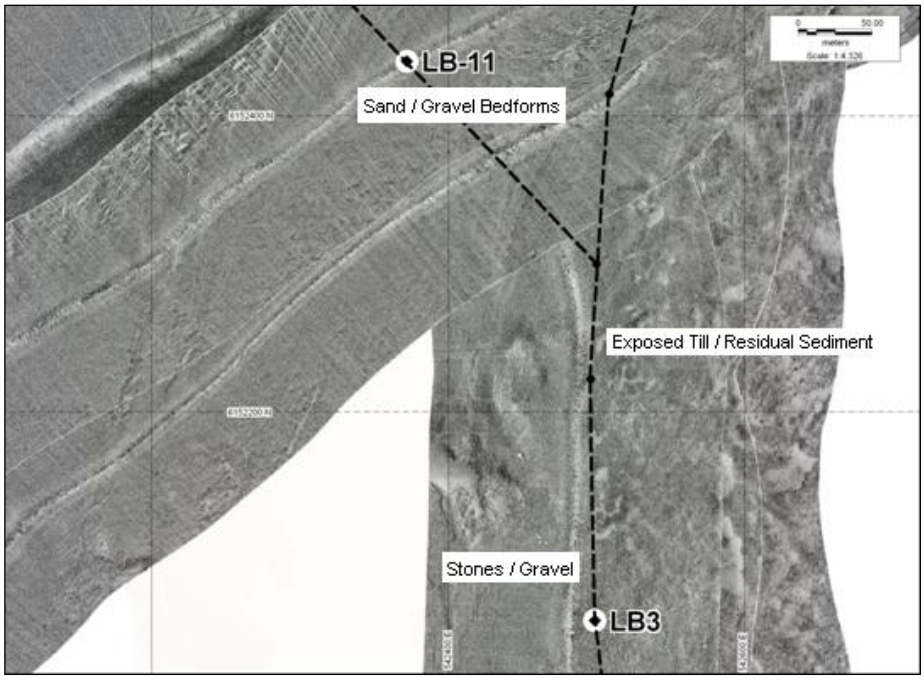

Fig. 10. (Frame C, Fig. 6). Side –scan sonar mosaic image from the junction between corridor A and B. Exposed till and residual sediment characterises the sea bottom at the entrance to Fænø Sund. Sandy and gravelly bed forms characterise the larger bar in the upper (northern) part of the image. Scale: UTM 200m grid net.

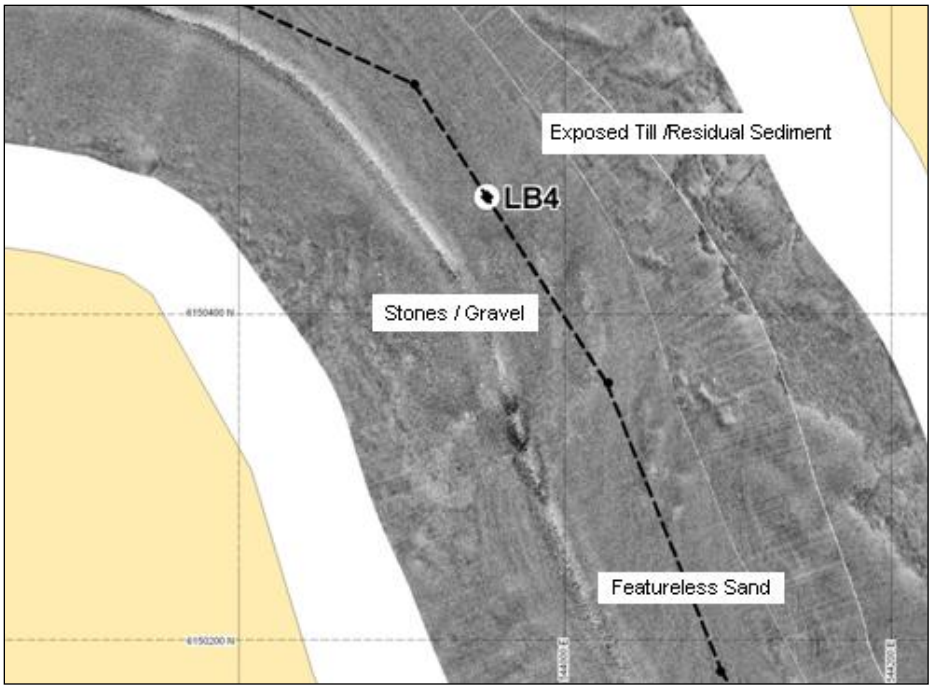

Fig. 11. (Frame D, Fig. 6). Side –scan sonar mosaic image from Fænø Sund near core site LB-4. Till and residual sediment characterises the sea bottom along the eastern and western margins of cable corridor. Scale: UTM 200m grid net.

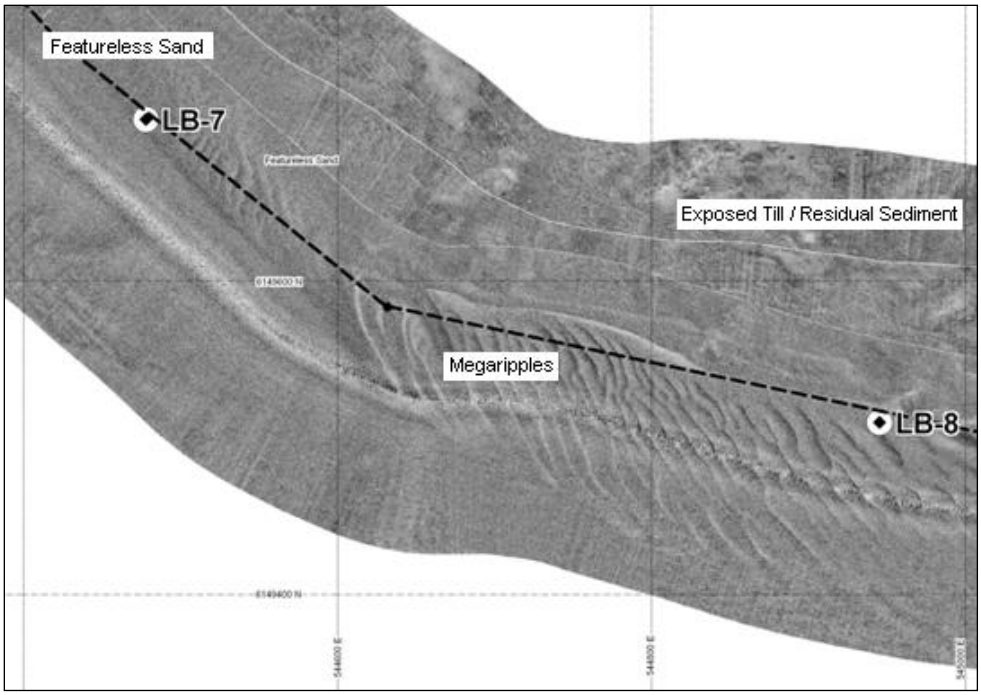

Fig. 12. (Frame E, Fig. 6). A larger field of mega-ripples (sandy sediment) observed in Fænø Sund between core sites LB-7 and LB-8. The wave lengths are about 5-12 m. Scale: UTM 200m grid net.

9 Magnetic anomaly data

The raw data recorded by the Geometrics G-882 marine magnetometer were cleaned for noise by the use of *GeoSOFT Oasis montaj 6.0* software. Only minor processing was applied to data. A b-spline function was used to remove minor electrical noise from data. The total amount of magnetic data acquired during the seismic survey in Lillebælt is illustrated in figure 13. It is only the magnetic data acquired along the cable route direction, which is used in the analysis of magnetic anomalies in this context.

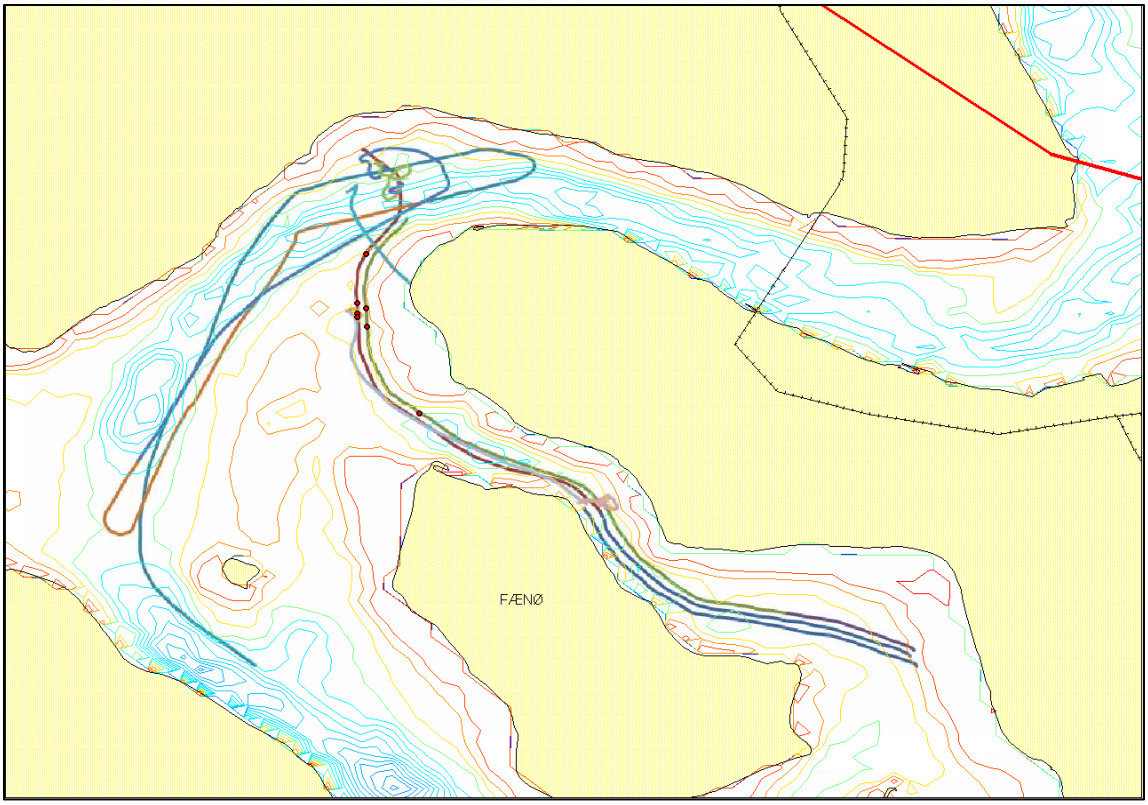

Fig. 13. Magnetic data, Lillebælt 2010.

The data analysis in the Cable route has been concentrated on 3 line segments (Figure 14, 15):

- A northern line (line 1), is composed of two line segments O and B
- A mid line (line 2), composed of line segment A and part of segment B1 and
- A southern line (line 3), composed of line segment m and part of B1.

All three lines are running more or less parallel with the Lillebælt cable corridor A.

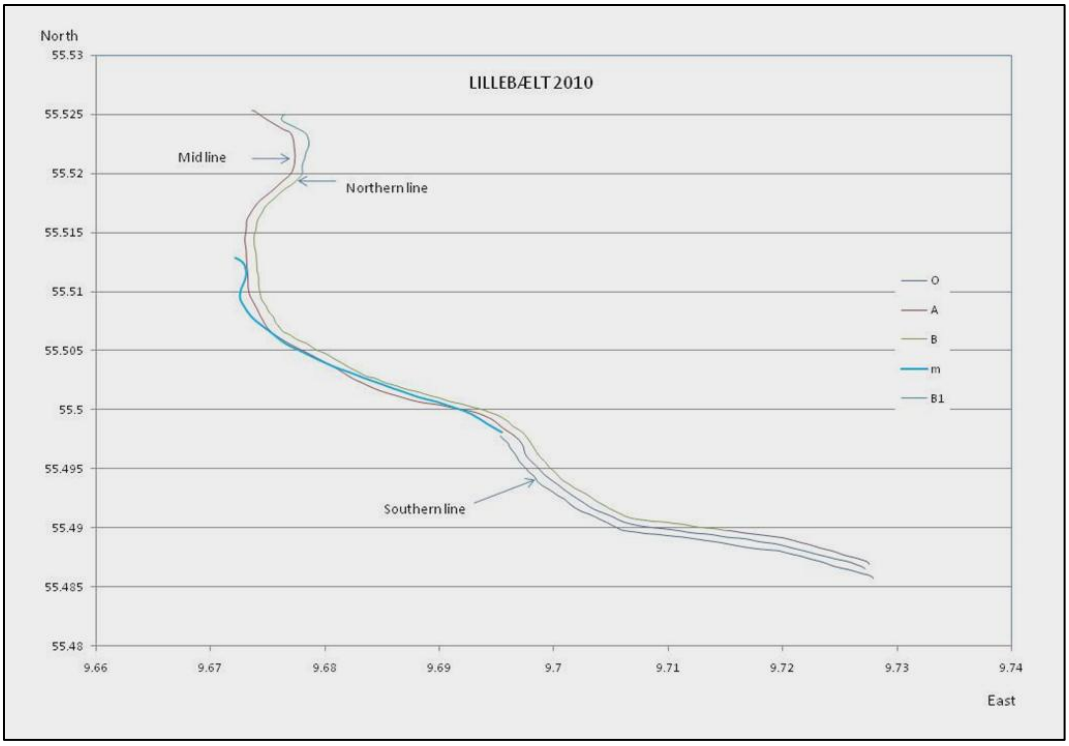

Fig. 14. Magnetic survey along the cable route in Lillebælt, 2010.

The North line

The northern line is composed of a western part with some noise influence from the ship due to severe sea condition, shallow water and strong current and an eastern part (Fig. 15). Four anomalies are observed on the North line dataset. Anomaly 4 constitutes a group of anomalies between point 2005 and 2018 (Fig. 16). Max amplitude is ± 20 nT. See table 5 for start and end positions of the anomaly.

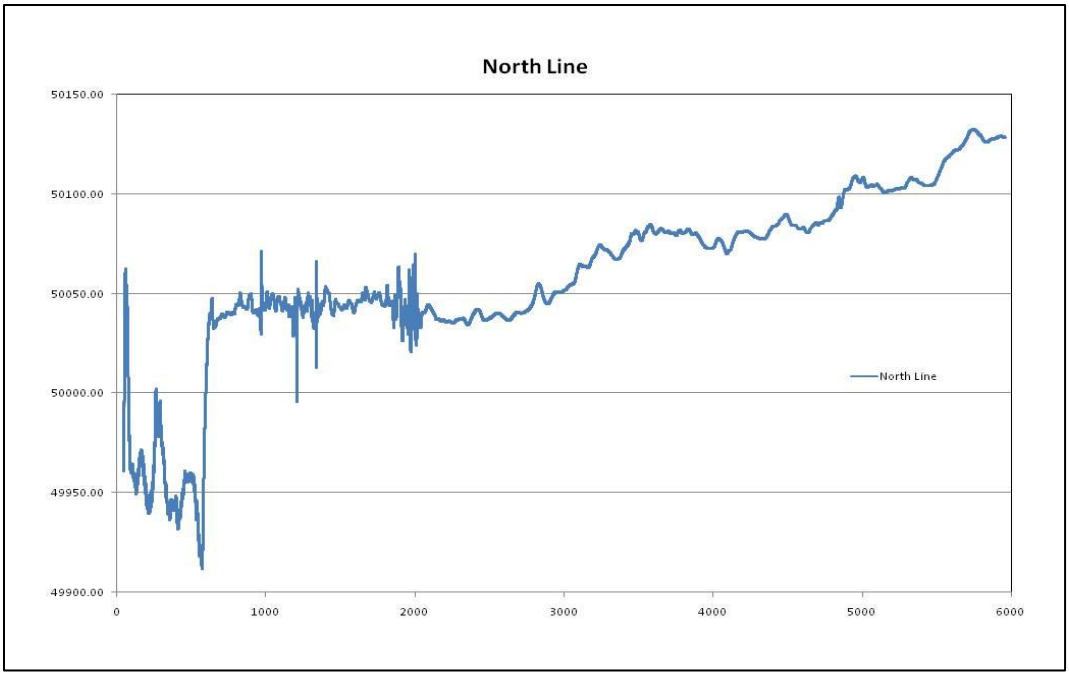

Fig. 15. Magnetic survey along the cable route in Lillebælt, 2010 Line 1 (north line).

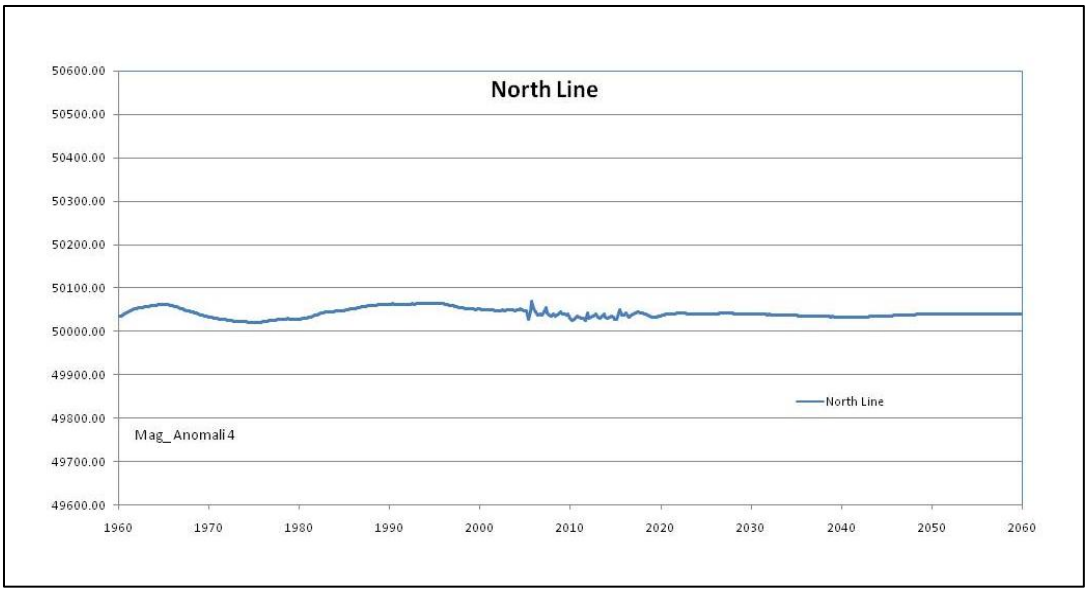

Fig. 16. Magnetic anomaly no. 4 at line 1 (north line). A group of anomalies is found between data points 2005 and 2018.

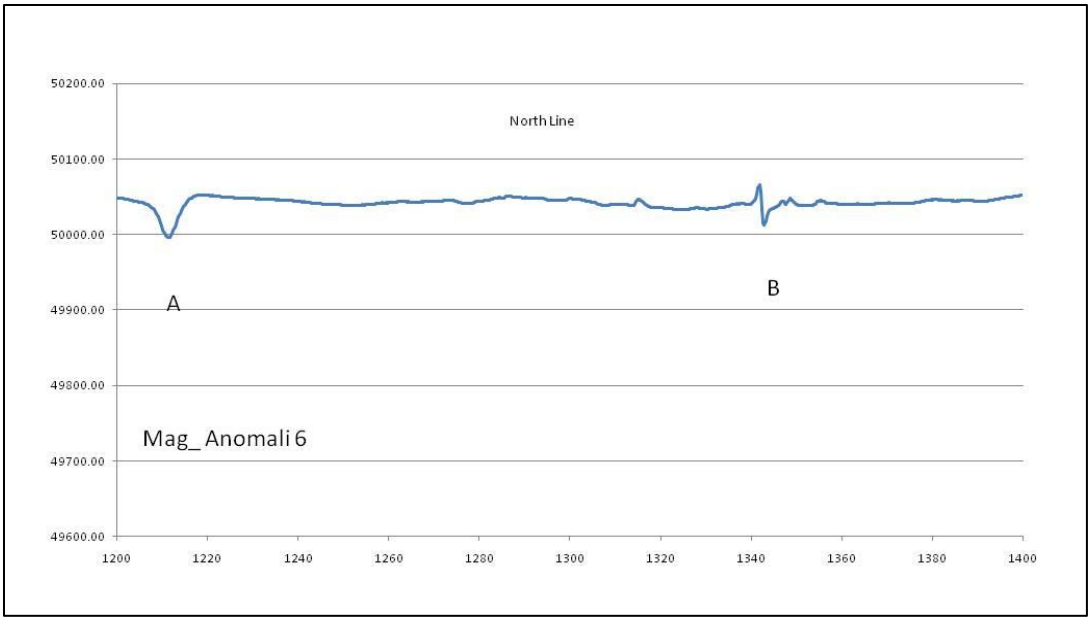

Fig. 17. Magnetic anomaly no. 6A and 6B at line 1 (north line).

Anomaly 6A is a single monopole amplitude anomaly near point 1210 with Max amplitude at - 45 nT and 6B is a dipole with Max amplitudes at ± 25 nT. See table 5 for start and end positions of the anomaly.

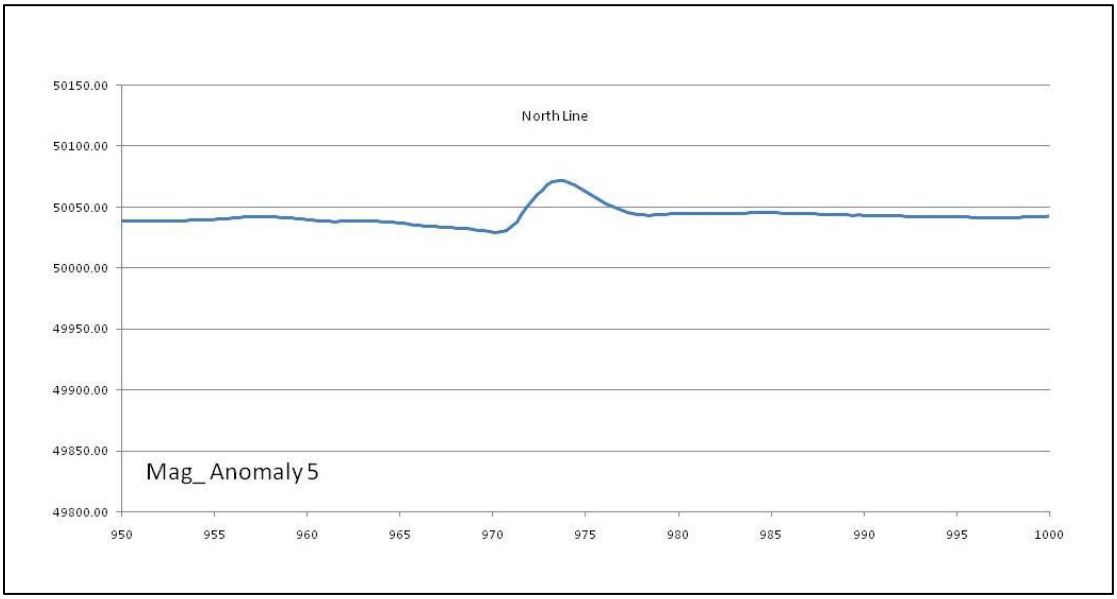

Fig. 18. Magnetic anomaly no. 5 at line 1 (north line).

Anomaly 5 is a dipole with Max amplitude at - 12 and 28 nT. See table 5 for start and end positions of the anomaly.

The Mid line

The mid line is composed of two line segments indicated with blue and red color in figure 19. Four anomalies are observed in the Mid line dataset.

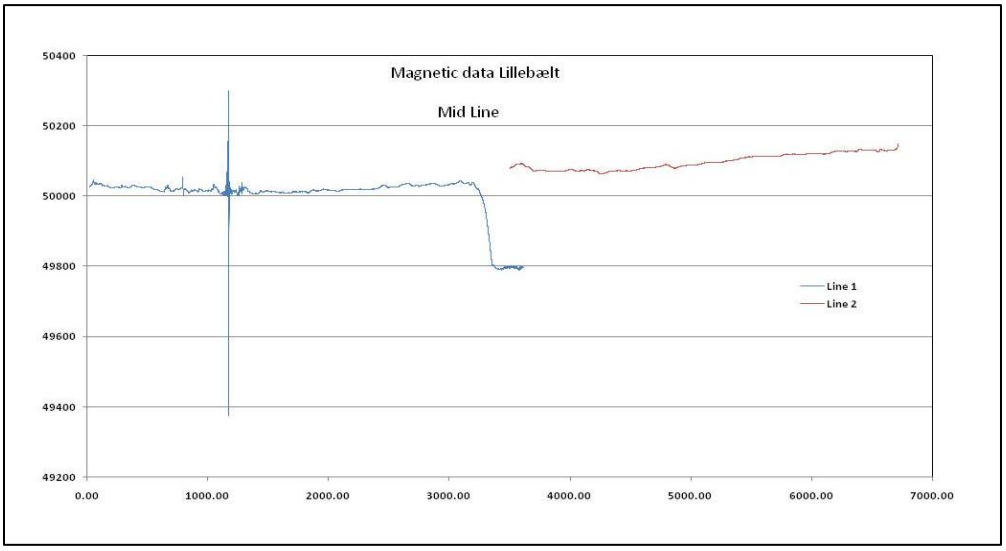

Fig. 19, Magnetic survey along the cable route in Lillebælt, 2010. Line 2 (mid line).

Anomaly 1 constitute of a group of anomalies between point 1150 and 1185 (Fig. 20). A very pronounced dipole anomaly with Max amplitude is 300 and -650 nT. See table 5 for start and end positions of the anomaly.

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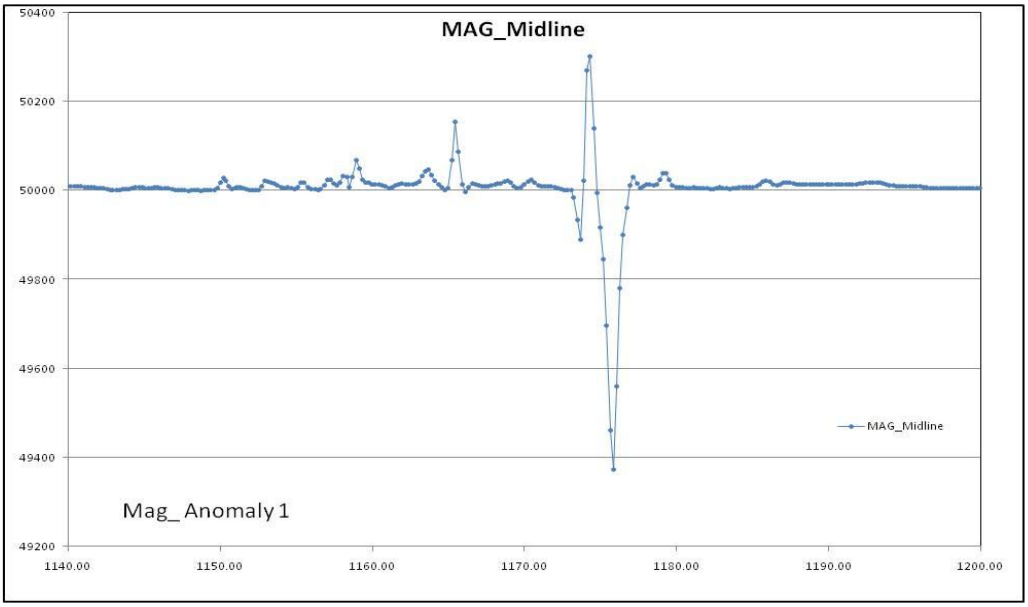


Fig. 20. Magnetic anomaly no 1 at the Mid Line.

Anomaly 2A is a dipole amplitude anomaly near point 1260 with Max amplitudes at -10 and + 18 nT (Fig. 20). Anomaly 2B is also a dipole with Max amplitudes at -21 and +15 nT. See table 5 for start and end positions of the anomaly.

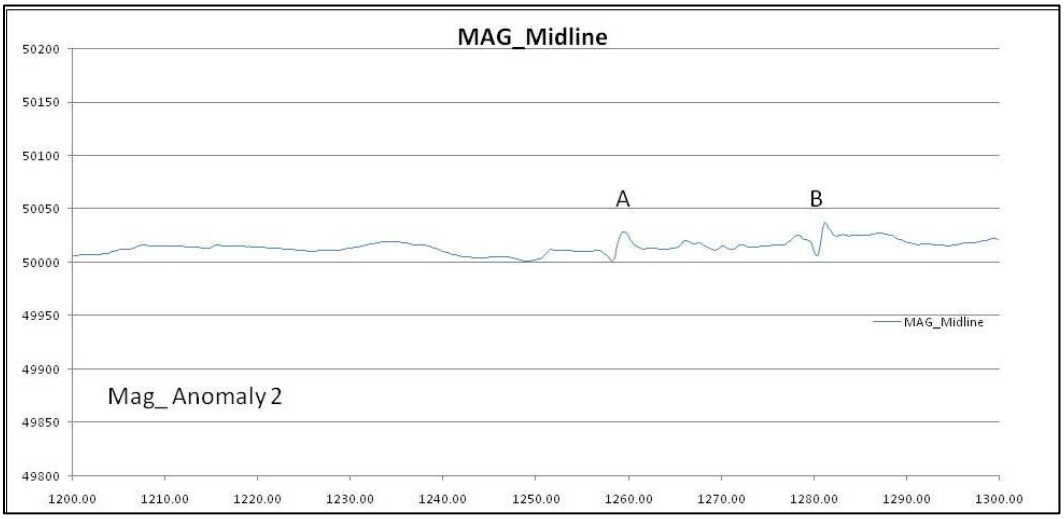


Fig. 21. Magnetic anomaly no 2A and 2B at line 2 (mid line).

Anomaly 3 is a dipole with Max amplitude at - 12 and 28 nT (Fig. 21). See table 5 for start and end positions of the anomaly.

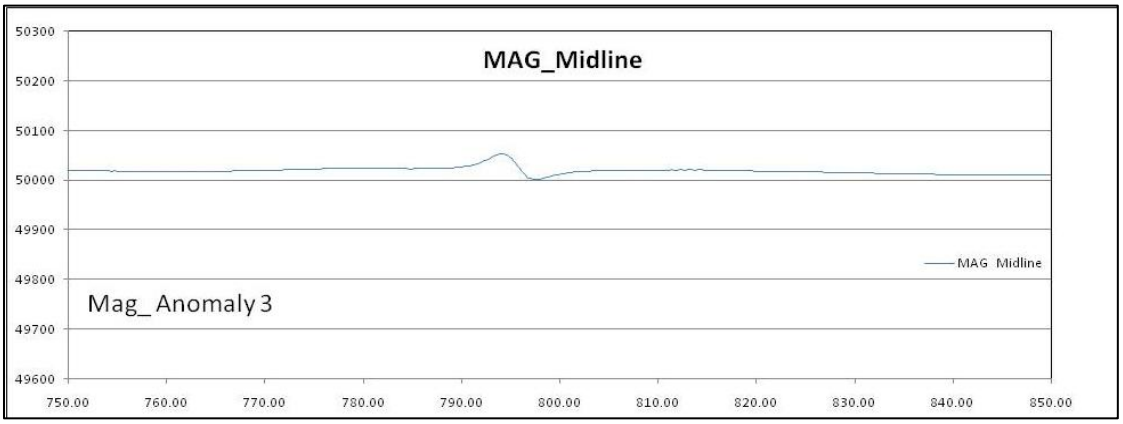


Fig. 22. Magnetic anomaly no 3 at Line 2 (mid line)

South line

No anomalies have been found on the south line.

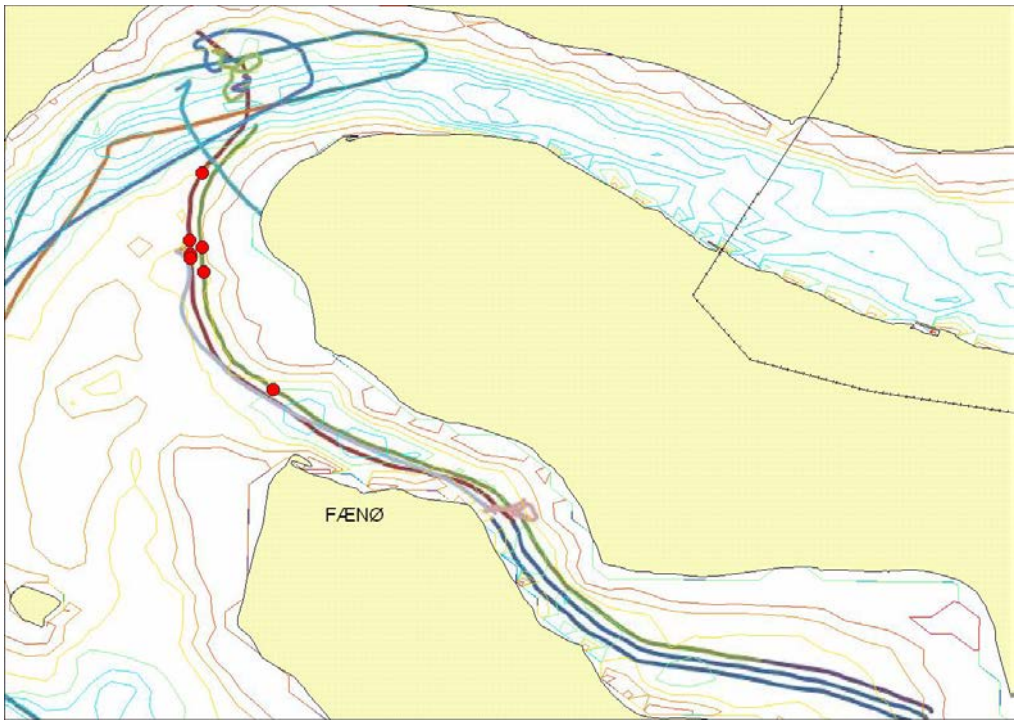


Fig. 23. Anomalies (red dots) located on magnetic data in the Lillebælt cable route.

The anomalies mapped on data from the Lillebælt cable route are located in the western part of the survey area at the southern flank of the Lillebælt or near the entrance to Fænø Sund. The magnitude and location of the anomalies are listed in Table 5.

		Start		Max		End		amplitude	
		East	North	East	North	East	North	Max nT	
North line	Mag Anomali 4	9.6792153	55.505094	9.679262	55.5050699	9.6795152	55.5049562	+/-20	Dipole
	Mag Anomali 5	9.6792284	55.505087	9.6792689	55.5050664	9.6795152	55.5049562	-12, +28	Dipole
	Mag Anomali 6(A)	9.674023	55.5132042	9.6740373	55.5131032	9.674044	55.5130349	-45	Single
	Mag Anomali 6(B)	9.6741182	55.5117741	9.6741241	55.5117442	9.6741362	55.511685	+/-25	Dipole
Mid Line	Mag Anomali 1	9.6730826	55.5137934	9.6731178	55.5135333	9.6731226	55.5134895	-650, +300	Dipole
	Mag Anomali 2A	9.6731584	55.5127157	9.673158	55.5127247	9.6731603	55.5126765	-10, +18	Dipole
	Mag Anomali 2B	9.6731687	55.5124969	9.6731692	55.5124863	9.6731701	55.5124665	-21, +15	Dipole
	Mag Anomali 3	9.6740593	55.5173979	9.6739881	55.5173115	9.6739404	55.5172485	-12, +28	Dipole

Table 5. Anomalies mapped on magnetic data. Lillebælt Cable Route 2010.

As it can be seen on figure 15, more noisy data are acquired in shallow waters especially on the western part of the survey data. This was caused by shorter distance from ship to magnetometer in shallow water, to avoid bottom contact and potential

damage of the equipment, together with locally strong currents in the Lillebælt and steep banks. An example on data quality compared to layback can be seen in figure 24.

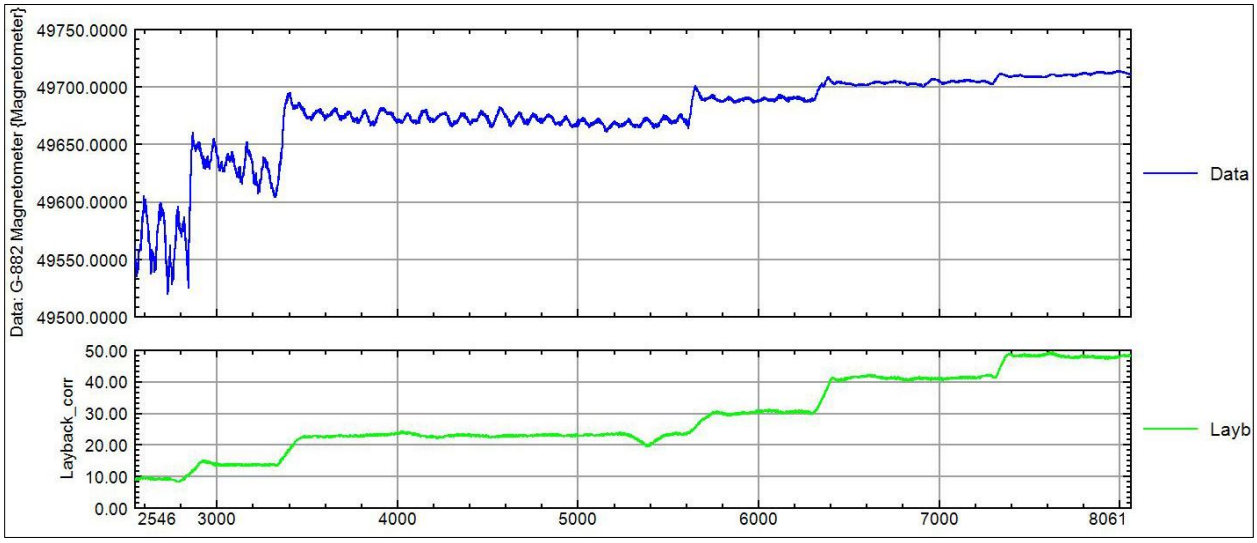


Fig. 24. Magnetic data and lay back acquired at R/V Madog.

It is obvious that the distance from ship to magnetometer, has to be more that 40 m, before acquired data are almost unaffected by ship noise. Data are still valid to evaluate magnetic anomalies, despite of noise influence on data quality.

10 Alignment sheet data presentation

Overlapping alignment sheets with a parallel presentation of bathymetry, side-scan sonar bed type classification, seismic profiles, and vibrocore profiles along the surveyed cable corridors A and B have been produced in AutoCad with Rambøll A/S as subcontractor (example in Fig. 25). The charts for the investigated cable corridors are in A3 paper size scale 1:5000. The alignment sheets are presented in Appendix C, and pdf files and DWG format data are included in the Data CD accompanying this report.

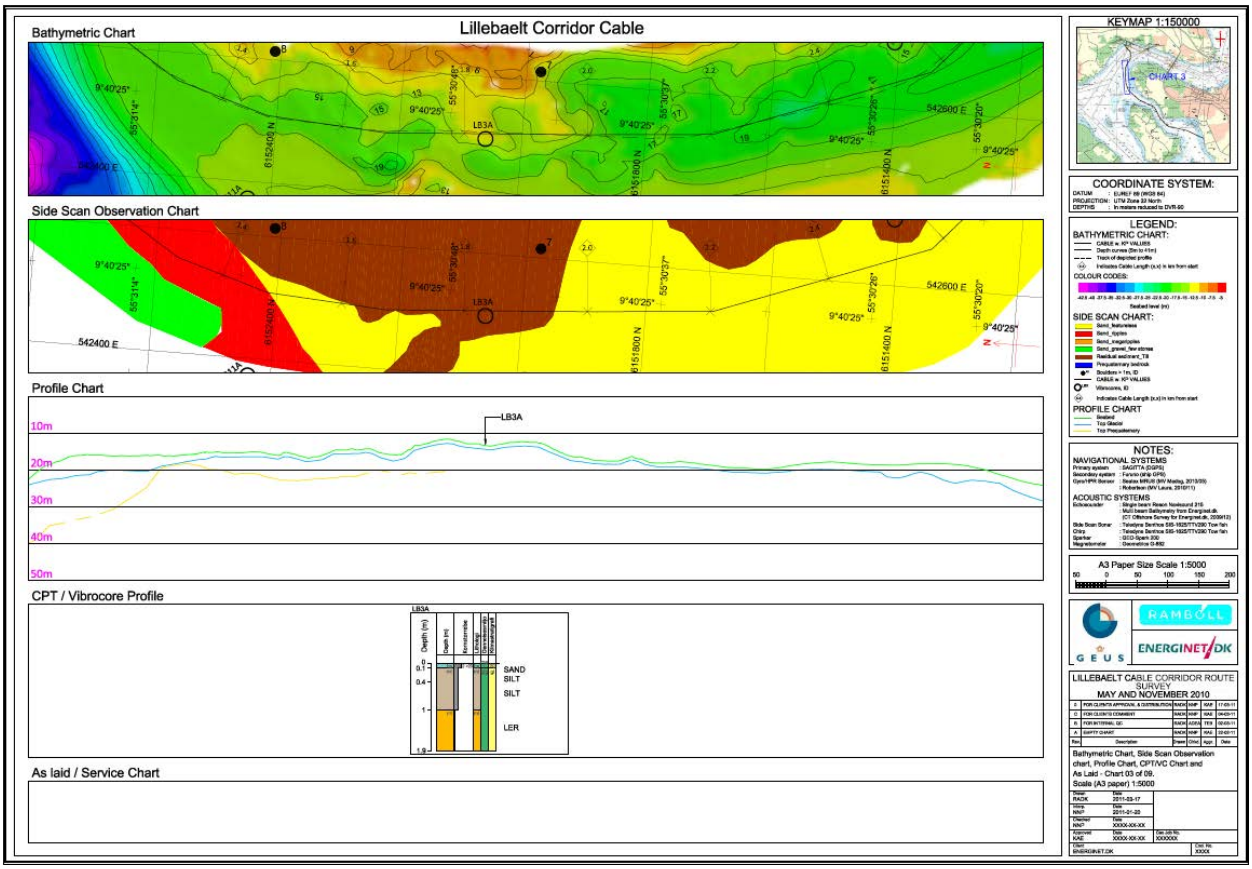


Fig. 25. Example of alignment sheet presentation of bathymetry, side-scan sonar observations, seismic profile chart, and vibrocore profile (chart 3 of 9 along cable corridor A).

11 Geological model based on the geophysical, geological, and geotechnical results

The survey data reveal that Pre-quarternary deposits are lying within a few meters from the sea bottom in the northern Lillebælt channel area (Figs. 26, 27). Stratified and iron-cemented 'Øxenrade Sandstone' units are found immediately below the sea bottom over a large area of the platform north of the Lillebælt channel. This sandstone also forms the upper steep escarpment of the northern Lillebælt channel margin. In the Lillebælt channel, Eocene 'Lillebælt Clay' is found under a thin (<1 m) cover of gravel and stones.

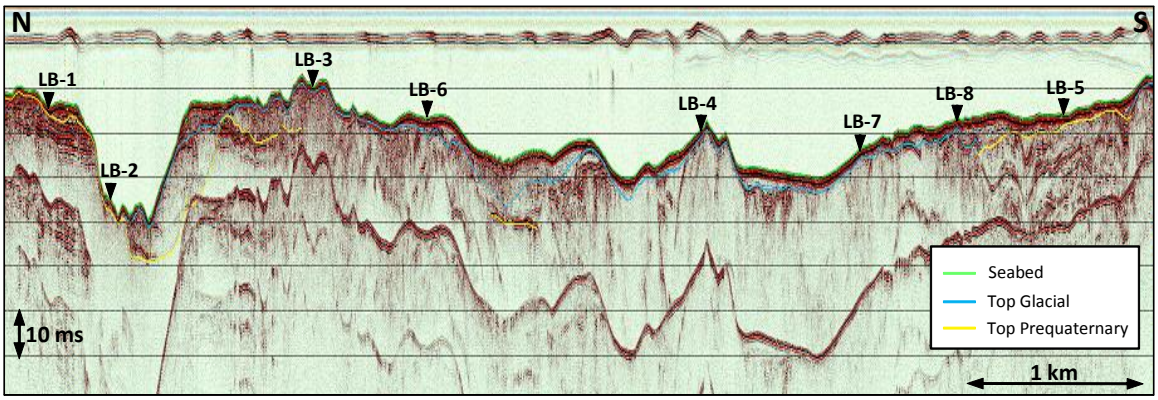
The southern margin of the Lillebælt channel appears to have been formed by glacial erosion followed by ?late glacial deposition of a thicker sequence, topped by a younger Holocene depositional wedge (Figs. 26, 27). In this respect, the northern channel region is dominated by erosional features and limited present day sedimentation, whereas the southern channel region show depositional features similar to inner river slings.

In the Fænø Sund corridor, Pre-Quaternary deposits are mostly covered by a few meter thick glacial till unit. Below this unit, Pre-Quaternary deposits appear to be have been disturbed (folding, thrusting) to various degree, and it can be expected that the till unit locally is dominated by reworked Pre-Quaternary material (e.g core LB-6). Only in the southernmost part of the Fænø Sund corridor, relatively undisturbed Pre-Quaternary deposits appear to lie within a few meters from the sea bottom.

Holocene, mostly sandy sediments up to 5-8 meter in thickness are found in deeper sub-basins in Fænø Sund (Fig. 26). Here larger areas of megaripples are found reflecting dynamic sediment transport under strong currents.

The sea bottom surface along the center corridor in Fænø Sund is dominated by sandy sediment with areas of till and coarse residual lag sediment mainly occurring in the higher-lying areas north of Fænø Sund. Scattered boulders are concentrated near these areas of exposed till. In the Lillebælt channel and the survey area north of it, scattered boulders are also found, but only few appear to be quite large (≥1 m above sea bottom).

a.



b.

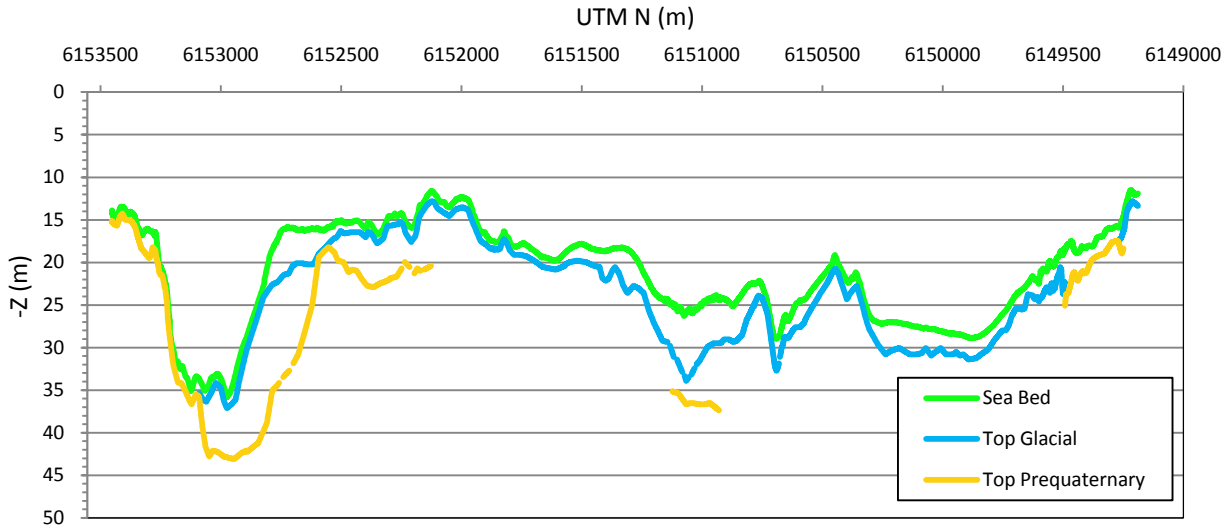
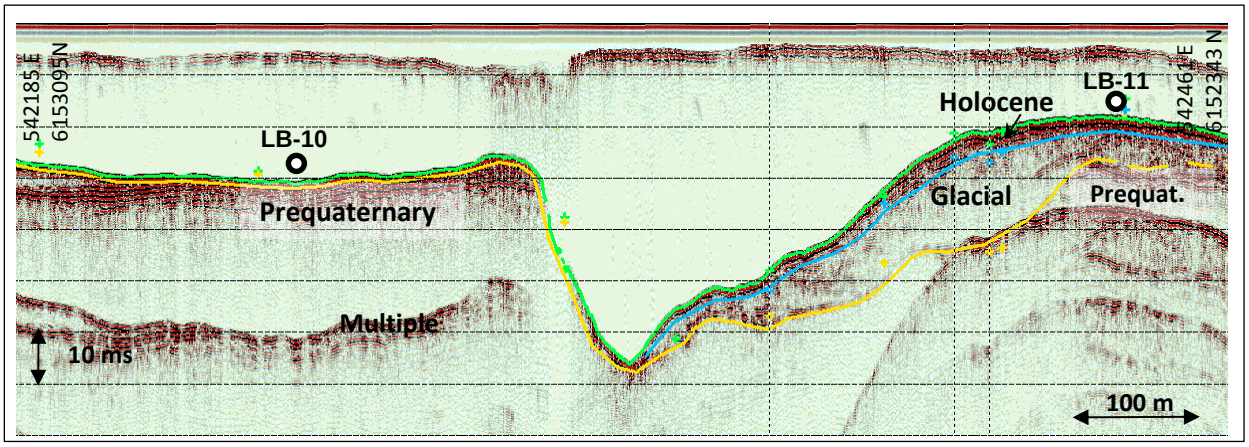


Fig. 26. (a) Sparker seismic profile of cable corridor A with interpreted geological horizons and location of vibrocore sites.(b) Depth profiles of interpreted geological horizons along cable corridor A.

a.



b.

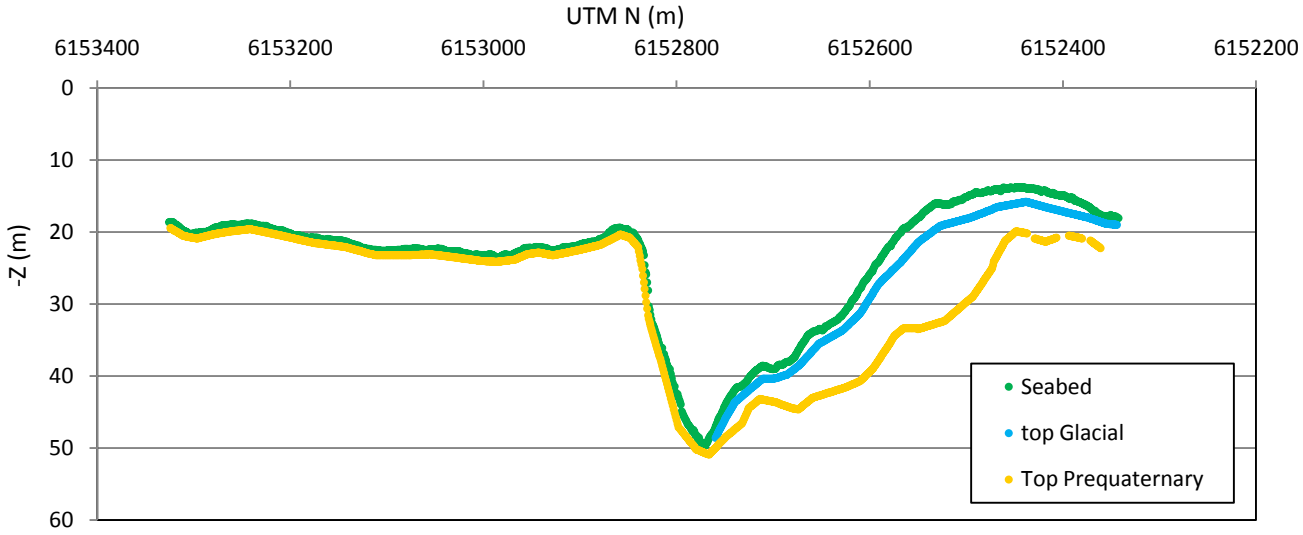


Fig. 27.(a) Sparker seismic profile of cable corridor B with interpreted geological horizons and location of vibrocore sites.(b) Depth profiles of interpreted geological horizons along cable corridor B.

12 Evaluation of the possibilities for jetting and need for trenching

The close to sea-bottom occurrence of firm glacial till and Pre-Quaternary sediments, which to some degree are lithified by iron cementation ('Øxenrade Sandstone') indicates that trenching may be necessary along a major part of the planned alignment. However, in the sections where Holocene sand and mud deposits are found to be several meters thick (figs. 26, 27), it would be possible to use jetting over continuous stretches of up to 1 km or so. In the deep Lillebælt channel, where firm 'Lillebælt Clay' is found few decimetres from the seabed, trenching appears to be necessary.

The crossing of the steep northern margin of the Lillebælt channel constitutes a challenge for finding the optimal cable alignment. Based on bathymetrical data, cable corridor A appears as the crossing with the least steep escarpment. Geological data reveal a quite similar subsurface structure of the Lillebælt channel and platform area north of it. Therefore considerations based mainly on bathymetry should be decisive for the cable alignment north of the Lillebælt channel.

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Appendix A.

Equipment specifications

Survey Vessel M/V Madog

M/V Madog is originally build to fit the science and research programmes for Bangor University in the UK, working mainly in the English Channel and the Irish Sea. M/V Madog has proved to be seaworthy enough to work with ROV and survey in the North Sea 60 to 100 Nautical miles offshore in winds up to 10 to 14 meters per second. Her ability to provide a stable platform in rough sea makes her very suitable for research projects / larger scale diving operations / Bottom sampling. Vibro core / CBT and survey projects

Her live aboard facilities, fuel and water capacities allows journeys with endurances up to + 14 days working around the clock.

M/V Madog is rigged with 4 point morring-handeling-winches which make her ideal for diving - sample -ROV works. Her 66 M/ 2 spacious aft-deck with 2 cranes 1x 5 TM support crane and 1 x 10 TM which reaches out over the stern makes her a multi functional work platform for various tasks. Her large survey room with direct access and view over the aft-deck can accommodate up to 6 technicians working at the time.

With regards to fuel consumption, M/V Madog is one of the most cost-effective ships available on market despite her large size as she only consumes around 33 liters per hour, running at 5 knots survey speed or 75 on cruising speed.

M/V Madog has a passenger insurance which covers 12 scientists / technicians / operators

Madog M/V, 2009

Trade area
GMDSS A2 trade permit North Europe

Insurance
Everads hull Machinery and full P&I 4x4 RDS
Ships Particulars
Madog: V4DR
Flag: St. Kitt & Navis
Owner's operators: Nord-Marine DK ApS Denmark
Nominated Crew: 5: 2. officers. 2 A/B´s 1 Professional Cook.
LOA 29,65 Meter
Beam 7,00 Meter
Draft 3.20 to 3.80 Meter

Cruising speed 10,00 Knots
Fuel capacity 26 CBM
Freshwater 26 CBM
Ballast water 35 CBM
Sewage tank 3 CBM
toilet tank 2 CBM
Sluge Oil tank 2 CBM

Fuel consumption cruising 75 lt. per hours 5 knots or while working on site 35 lt. per hours

Engine and deck
1 x 442 KW Lister – Blackstone low speed engine
1 x Deutz 200 AMP + hydraulik pump 130lt/min 240bar
1 x MVM 35 KWA 380
1 x back-up Hydraulic station 70 lt./min 200 bar
1 x back up Hydraulic pump main- engine 60 lt./min 180 bar
1 x 1/1 - 4 blade pitch propel
1 x 64KW bow- thrusters

Deck Arrangement
1 x 66 M/2 free aft deck
2 x 2 Hydraulic split-winch rigged for 4 point Anchoring
1 x 33 TM EFFER Crane with cable winch rigged with 80 meters carbon fiber wire SWL 3 tons Lifting height 25 meter above sea level
1 x 6 TM Hiab Crane lifting height 10 meter above sea level
3/4 “hydraulic snap connection for underwater tools on deck
Cargo hold 10 CBM

Accommodation
Accommodation for 12 passengers
Live- aboard: 4 persons in double-cabins and persons 4 in single cabins
Recommended for live-aboard 8 guests then all in single cabins
1 Technicians / survey room
1 Salon
3 toilets
2 showers
Laundry facilities
TV-DVD in cabins and saloons

Navigational aids
2 x daylight ARPA radars
1 x Gyro
1x A-AIS
1 x Max-sea Commander digital chart systems with AIS messenger system incorporated
R/D GPS solution for RTK
3 x VHF
5 x portable VHF PELTOR-Headset system
1 x NAVTEX
Inmarsat Fleetbroad band 250 (E-mail- Internet – Satphone)

Radio station licence GMDSS A2
Conventional Email Address: info@nord-marine.dk
Inmarsat: rv.madog@amosconnect.com
Sat- phone: 870773152383

M/V LAURA

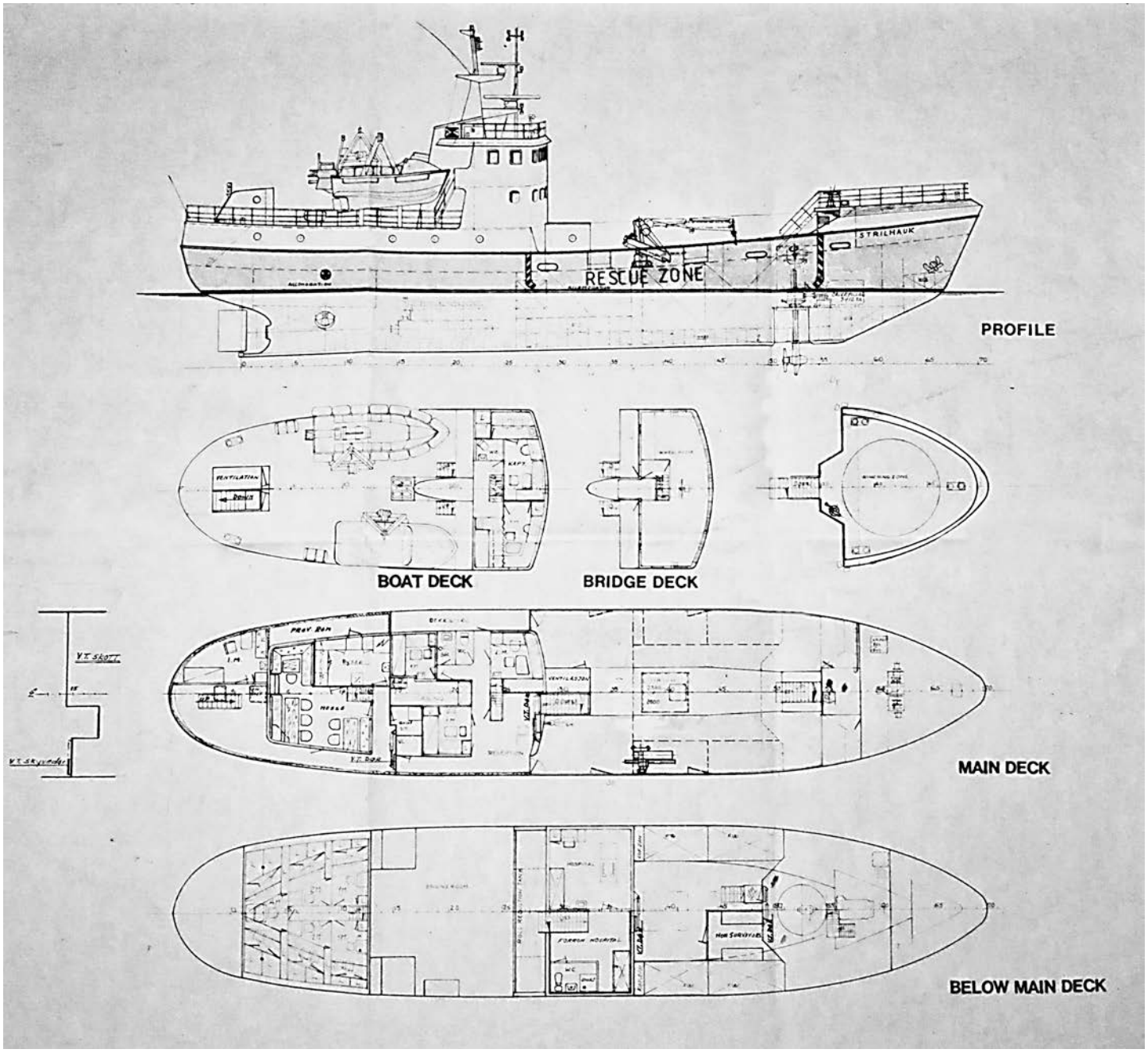
Survey Vessel

- Sidescan Sonar Survey
- Multibeam Survey
- ROV and Video Survey
- Vibro-Coring
- Bottom Sampling
- Diving Platform
- POD Handling
- Bird Observation
- Trial Fishery
- Guard Vessel

Skibsprojekt Christoffer ApS
info@roedship.com · www.roedship.com

M/V LAURA

Generel Arrangement:



Skibsprojekt Christoffer ApS
info@roedship.com · www.roedship.com

M/V LAURA

Specifications:

Flag:	Faroe Islands
Year built/rebuilt:	Brødrene Lothe A/S, Haugesund, Norway, 1959
Class:	1A1 ICE-C
Identification:	Call sign: OZ2055, IMO no: 8621408, DnV no: 05172, MMSI no: 231 394 000
GT:	344 t
NT:	103 t
DWT:	151 t
LOA:	41.86 meters
BR:	8.40 meters
Rescue Freeboard:	0.80 meters
Draft:	Max. 4 meters
Main Engines:	1 x Wichmann Diesel 600 BHP 6ACA Azimuth thruster: Aquamaster UL 601/3500 with 1 x Caterpillar 650 BHP The thruster is also approved as propulsion machinery Stern thruster: 1 x Schottel 225 HP
Auxiliary Engines:	2 x Volvo Penta MD 100 BK w/Stamford MC 40 B each 100 KW, 250 V, 50HZ and 40 KW, 380 V, 50 HZ 1 x John Deer Visa JD-80 generator
Tank Capacity:	Fuel oil: 50.36 m^3, fresh water: 74.20 m^3
Speed:	Max. 12 knots
Cranes:	1 x hydraulic crane, Tico, 3 t 1 x hydraulic crane, 400 kilos
Navigation Equipment:	JRC JMA-5225 ARPA radar 1 x radar Furuno 3 cm ARP JRC JLR-20 Satellite Compass 1 x autopilot Robertson 1 x satellite navigator GPS 1 x Gyro compass
Communication Equipment:	1 x Furuno GMDSS A1, A2 1 x VHF Sailor RT 144 & 1 x VHF Sailor RT 2048 3 x VHF portable 3 x VHF portable 1 x helicopter communication equipment 1 x helicopter beacon 1 x radar transponder 1 x Navtex 1 x mobile telephone GSM, 1 x satellite phone Iridium & internal intercom 1 x Fleetbroadband 250
Other equipment:	1 x 10 ft container on deck with office space for surveyors
Rescue equipment:	1 x FRB Mob.boat
Firefighting:	Fi-Fi I: 1 x pump 150 m^3/hour, 1 x monitor, throw length 30 meters
Accommodation:	Capacity for up to 10 surveyors

Skibsprojekt Christoffer ApS
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Jørgen Roed
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Fleet Manager
Thomas Roed
Phone +45 40 41 60 00

Commercial Manager
Søren Roed
Phone +45 40 38 24 44

Skibsprojekt Christoffer ApS
info@roedship.com · www.roedship.com

NaviSound 200 Series

PRODUCT SPECIFICATION

PORTABLE HYDROGRAPHIC SINGLE-BEAM ECHOSOUNDERS

- ***Portable, highly compact, lightweight unit***
- ***Broadband frequency agile***
- ***Multiple bottom digitizing with single frequency for sediment and vegetation surveys***
- ***Supports single or alternating channel operations***
- ***High-performance, easy-to-operate, and very reliable***

RESON's NaviSound 200 Series are highly portable, single-beam echosounders that offer a range of high-performance features. With a selection of models, the NaviSound 200 Series supports a wide range of hydrographic survey applications.

NaviSound 200 echosounders provide reliable depth measurements in a convenient, easy-to-operate unit. Advanced features include multiple bottom digitizing with a single frequency for sediment and vegetation surveys. Besides its compact size and low weight, the NaviSound 200 enclosure provides the highest possible water resistance.

An affordable side-looking sonar (SLS) option that records dual-sided imagery is also available for selected NaviSound 200 models.

Individual NaviSound 200 models are as follows:

- **NaviSound 215:** Enhanced single-beam echosounder that uses one receiver channel to operate two transducers in true real-time, alternating frequency operation
- **NaviSound 210:** Basic, one-channel, single-beam echosounder for hydrographic survey operations
- **NaviSound 205:** One-channel single-beam echosounder for light surveying

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Fax +44 1224 709 910
Email: sales@reson.co.uk

RESON, GmbH · GERMANY
Tel +49 431 720 7180
Fax +49 431 720 7181
Email: reson@reson-gmbh.de

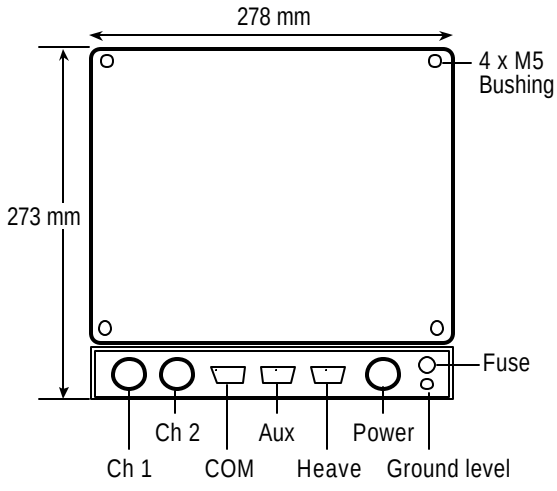
www.reson.com

NaviSound 200 Series System Specifications

TECHNICAL DETAILS

Frequencies:	User-selectable frequencies from 15-600 kHz. Standard 28-35 and 190-225 kHz
Impedance:	100 Ohm (others on request)
Max power:	300 W
Power control:	Manual or automatic
Pulse length:	Manual, 5 steps
Units:	Meters & feet
Resolution:	1 cm (210 & 215) 1 dm (205)
Accuracy:	1 cm at 210 kHz (1 sigma), 7 cm at 33 kHz (1 sigma) (assuming correct sound velocity, transducer draft)
TVC detection level:	20 Log (depth)
Additional feature:	Built-in barcheck utility
Sound velocity calibration:	1350 - 1600 m/sec in 1 m/sec step
Transducer draft comp:	0 - 99.99m
Graphics:	
Recording:	11 cm wide thermal paper recorder
Resolution:	800 pixels (gray shades)
Transfer speed:	20 lines/sec
Serial interfaces:	1: Communication 2: Heave input 3: Auxiliary input (DGPS) 4: Repeater output
Dimensions:	273 x 278 x 115 millimeters (11 x 11 x 4.5 inches)
Weight:	5.5 kg (12 lbs)
Supply voltage:	10 - 28 VDC (external AC converter available)
EMC radio noise:	CE approved

REAR VIEW



MODEL COMPARISON

NaviSound	205	210	215
Output resolution:	dm	cm	cm
Depth Range:	0.5-100m	0.2-600m	0.2-600m
Channels/Transducers:	1/1	1/1	1/2
Max. sounding rate (PRF):	5 Hz	20 Hz	20/10 Hz
Heave input:	-	✓	✓
NMEA output:	✓	✓	✓
DESOxx output protocol:	-	✓	✓
Supports SLS option	-	✓	✓
AC Converter Option	✓	✓	✓

Scope of delivery: NaviSound 200 Series User's Manual, DC power cable, RS-232C communication cable for PC, spare paper, transducer connector(s), and fuses & thermal head cleaning kit

RESON

Version: B42-PDF-0202

SIS-1625 Seafloor Imaging System

SIDE SCAN SONAR/ PROFILER

Combined Chirp/CW Side Scan Sonar/ Sub-bottom Profiling System

The SIS-1625 Seafloor Imaging System has quickly become the industry standard for shallow water (<2000M) seafloor survey operations. This field proven, highly versatile survey tool offers a fully digital platform capable of collecting high resolution chirp side scan/sub-bottom data, as well as a full suite of customer selected sensor data. The high resolution, extended range chirp data and multiple data sensor capability provide the surveyor with a significant savings in instrument cost and survey time.

One Workstation

Topside system consists of:

- Chirp DSP based side scan sonar, operating at 100/400 kHz simultaneously, allows a full 1000 meter swath, with resolution equivalent to much higher frequency systems.
- Chirp DSP/CW based sub-bottom profiling, operating in the 1 to 10 kHz region, allows maximum sediment penetration with greatly improved resolution.
- Gain, TVG, image correction, color palette, and other programmable parameters are under trackball control.
- Digital interface provided for thermal graphic recorders.

One Tow Vehicle—TTV-290

The TTV-290 is a fully digital platform with standard Chirp side scan/sub-bottom transducer arrays, digital multiplexor, subsea electronics, and RS-232 ports for optional sensors.

- Hydrodynamically stable tow vehicle includes pitch, roll and heading sensors, optional position responder/ transponder, and other customer selected sensors.
- 0.5° side scan sonar horizontal radiation pattern,combined with broad band Chirp DSP match filter processing, provides optimal cross-track and along track resolution.
- Tow vehicle operates in depths up to 2000 meters.

ACOUSTICS
FLOTATION
GEOPHYSICAL
HYDROPHONES
MODEMS
LOCATOR
ROBOTICS

TELEDYNE BENTHOS
A Teledyne Technologies Company

49 Edgerton Drive • North Falmouth, MA 02556 USA
Tel: 508 563-1000 • Fax: 508 563-6444 • E-mail: info@benthos.com
www.benthos.com

SIS-1625 Seafloor Imaging System

One Cable—CL-160 Communications Link

The comm link was designed through a program to develop a full ocean depth telemetry module for a multisensor seafloor mapping system.

- Two-way communication with tow vehicle over single coax with digital high speed multiplexor. Standard cable length—up to 10,000 meters.
- Digital multiplexor for single coaxial tow cables. Communication rates: sonar data—up to 5 megabit/sec; uplink status—9600 bits/sec; downlink command—9600 bits/sec.

SPECIFICATIONS

CL-160 Shipboard Sub-System

Chirp Processing:	Sonar/status control PC based workstation; 5-DSP based sonar matched filter processing channels.
Display:	High resolution video display.
Recording:	Large capacity hard drive, DVD writable, other..
Status Display:	Vehicle pitch, roll, heading (standard); speed, altitude, and depth (optional). Customer input ship position, vehicle position, event marks; all status data recorded.
Sonar Display:	Side scan port, starb; dual channel sub-bottom; all sonar data recorded.
Corrections:	Slant range and speed; beam angle/grazing angle.
Multiplexor:	Digital MUX for coaxial cables (ADSL).
Sonar Data:	up to 5 megabit/sec.
Uplink Status:	9600 bit/sec.
Downlink Command:	9600 bits/sec.
Power Supply:	110/220 VAC autosensing.

Side Scan

Side Scan Transducers:	Multi-element array, dual channel 100/400 kHz 0.5° horizontal beam; 60° vertical beam.
Frequency:	100/400 kHz band swept FM; 4.5 cm resolution.
Processing:	Calibrated transmit waveform stored in ROM; match filter FFT digital signal processing.
Swath Selection:	25 meters to ±500 meters.

Sub-Bottom

Transducer:	Transmit projector array; line array receiving hydrophone; 30° conical radiation pattern.
Frequency:	1 kHz to 10 kHz swept FM (4 KW output), synchronous with side scan.
Resolution:	5 cm.
Processing:	Calibrated transmit waveform stored in ROM; matched filter FFT digital signal processing.
Scale Selection:	25 meters to 500 meters full scale.

TTV-290 Tow Vehicle Sub-System

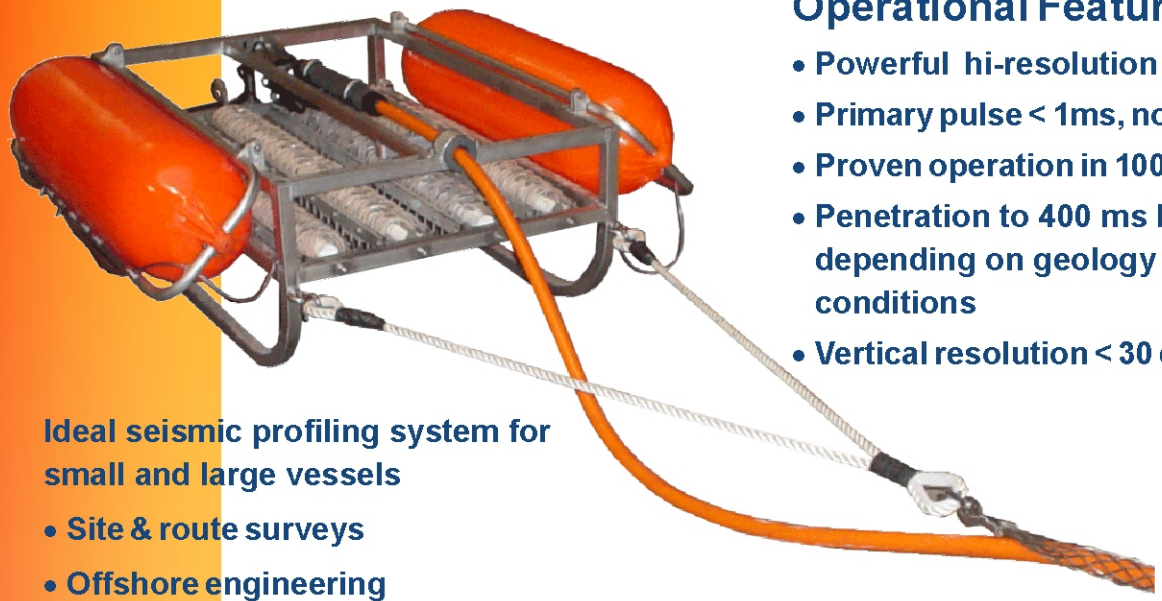
Depth rating:	2000 meters.
Vehicle Dimensions:	18 inches (45 cm) OD x 64 inches (162.6 cm) long.
Weight:	In air: 300 lbs (136 Kg); in water: 170 lbs (77 Kg).

TELEDYNE BENTHOS
A Teledyne Technologies Company

49 Edgerton Drive • North Falmouth, MA 02556 USA
Tel: 508 563-1000 • Fax: 508 563-6444 • E-mail: info@benthos.com
www.benthos.com

Geo-Source 200 - 400

Marine Multi-Tip Sparker System



Operational Features

- Powerful hi-resolution seismic source
- Primary pulse < 1ms, no ringing
- Proven operation in 1000 m water depth
- Penetration to 400 ms below seabed, depending on geology and survey conditions
- Vertical resolution < 30 cm

Ideal seismic profiling system for small and large vessels

- Site & route surveys
- Offshore engineering
- Mineral exploration
- Oceanographic research

INNOVATIVE Preserving Electrode Mode

The innovative Geo-Source 200 has been designed for operation with the Geo-Spark 1000 pulsed power supply (PPS) using the patented **Preserving Electrode Mode.** This mode uses a NEGATIVE electric discharge pulse instead of a positive pulse.

(Please note that this negative pulse is NOT the same as the simple reversal of the positive polarity of a 'standard' power supply.)

Maintenance free electrodes 5 year guarantee

The Preserving Electrode Mode **reduces the tip wear to practically zero**. You can shoot day after day, week after week, month after month with practically **NO tip maintenance.**

Always a stable acoustic pulse

Zero tip wear is essential for the **acoustic repeatability** of the pulse, which depends largely on a constant, unaltered electrode surface and tip insulation.

Efficient & Cost Effective

With the Geo-Spark HV power supplies you will save a lot of time and money, since the electrodes do NOT burn off like in all other systems.

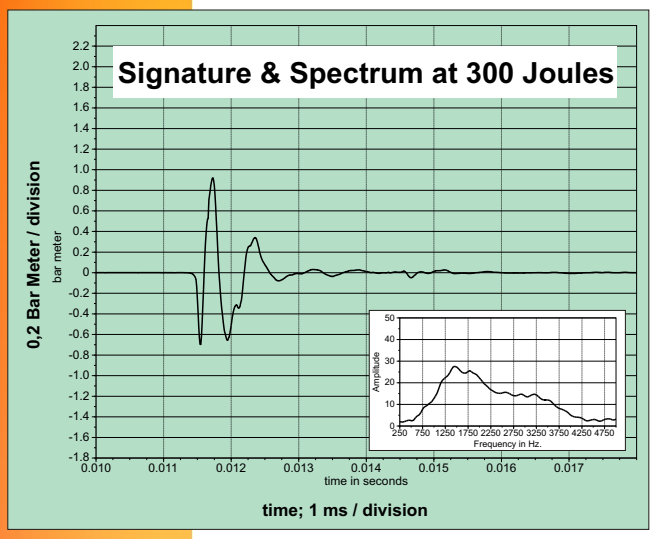
You don't need to trim tips during the survey. There is no need to have any stock of consumables.

Examples of Records

To see examples of our sparker records, please visit the 'Downloads' page on our website: ***www.geo-spark.com***

Geo-Source 200-400

Technical Specifications



Source Geometry

The electrode modules are evenly spaced in a planar array of 0.75 m x 1.00 m. This geometry not only enhances the downward projection of the acoustic energy, it also reduces the primary pulse length, since all tips are perfectly in phase.

Control of Source Parameters 400 tips

The advanced Geo-Source 200 design gives you total control of:

Source depth, Joules per tip, Number of tips in use, and Electrode configuration.

- Two floats provide a stable towing configuration and insure the proper depth of the electrode tips. This is critical to achieve constructive interference between the primary pulse and its own sea-surface reflection (surface ghost).
- Four individually powered electrode modules of 50 or 100 tips each allow you to distribute the energy from the Geo-Spark power supply over 50, 100....., up to 400 tips. (Each tip has an exposed surface area of 1.4 mm^2.)
- **200 tips,** the classic 200 tip configuration is normally used with the Geo-Spark 1000 PPS and consists of four 50-tip electrode modules. This configuration gives an excellent hi-res pulse over the 100 to 500 J power range.
- **400 tips,** for higher energies above 1000 J, and in particular with the Geo-Spark 2000, we recommend a 400 tip configuration with 4 x 100-tip electrode modules

Coaxial High Voltage (HV) Power/Tow Cable

The Geo-Source 200 is towed by a very high quality, Kevlar-reinforced, coaxial power/tow cable with stainless steel kellum grip. This dedicated high voltage (HV) cable contains **4 x 10 mm^2** inner cores (negative) plus a **40 mm^2** braiding (ground-referenced). It is designed to have a very low self-inductance to preserve the high dI/dt pulse output of the Geo-Spark 1000 PPS.

The coaxial structure of the HV cable reduces the electromagnetic interference to the absolute minimum.

The wet end of the cable is terminated with four special HV connectors to the electrode modules and a ground connector to the frame. Connecting or disconnecting the cable to the Geo-Source 200 takes only 10 minutes; so you can work on, or handle, the sparker and the HV cable as independent units.

The dry end of the cable is terminated at the Geo-Source 200 patch panel, which allows you to select the number of electrode arrays in use

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Geo-Spark 1000 - 1500 - 2000

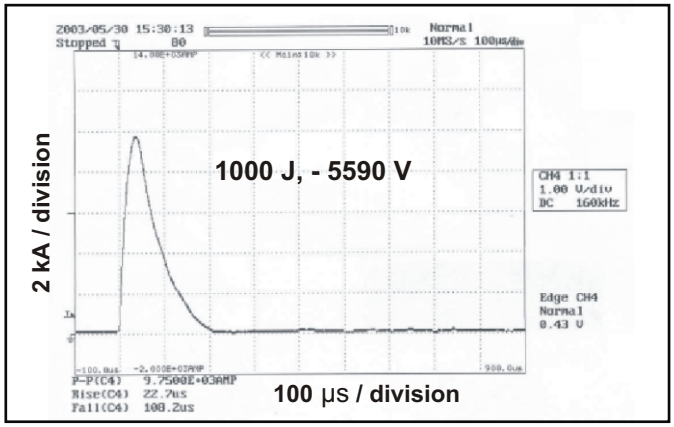
Solid State Pulsed Power Supplies

Operational Features

- 100 to 1000-1500-2000 J real power
- No electrical oscillations
- User-friendly & 100 % safe
- Modular internal design

Cutting-Edge Pulsed Power Technology

The Geo-Spark 1000 -1500 - 2000 are revolutionary high voltage (HV) power supplies based on cutting-edge 'pulsed power' technology. The systems use an extremely reliable, state-of-the-art thyristor switch that can generate very short (60 - 200 µs) high voltage pulses of up to 10 kA at -5.6 kV.



Applications

- Very high resolution seismic acquisition e.g. site & route surveys

Is typically combined with:

- Geo-Source 200-400-tip sparkers (marine and fresh water)
- Geo-Boomer 300-500 Joules
- Borehole Sparkers
- Pulsed power projects & research

100 % Safety Features

All possible features have been integrated into the systems to safeguard against potential human error.

- To open and gain access to the high voltage (HV) connection box, the 230 V mains CE-form connector must first be physically removed.
- High voltage can only be activated when the HV connection box is completely closed.
- If the HV connection box is opened, even partially, during operation, the HV will automatically switch off and the unit will generate a final trigger to discharge the capacitors.
- Similarly, when the HV is switched off normally by pushing the red stop button, an automatic final trigger will discharge the capacitors.
- When the HV connection box has been opened completely, both poles (zero and negative) will automatically be shorted.
- The systems contain internal bleed-off resistors to eliminate any possibility of unwanted charging effects.
- A power lock limits the output to Geo-Boomer to 300 J.

Preserving Electrode Mode

These pulsed power supplies are fundamentally different from any other HV power supplies. They have been designed specifically to power the Geo-Source range of multi-tip sparkers in our patented **'**Preserving Electrode Mode**'.** In this mode the electrodes have a negative potential with respect to the source frame (= ground), thereby reducing electrode wear to almost zero.

Negative Electric Discharge Pulse

There is no other unit commercially available that allows you to generate a negative high voltage pulse with such a high dI/dt ratio.

No Electrical Oscillations

The pulse output has NO electrical oscillations, which affect the acoustic signature. The integrated capacitor bank consists of two (1000 PPS), three (1500) or four (2000 PPS) indestructible 32 µF capacitors rated for more than 200 million (= 2 x 10^8) discharges. For example, a ¼ second discharge rate would give continuous work for 1½

Low Power Consumption

The Geo-Spark 1000 -1500 - 2000 PPS can be operated from an ordinary 230 V/16 A mains socket or from a portable 230 V/3.5 kVA generator.
The systems do not draw excessive peak currents.

Geo-Spark 1000 - 1500 - 2000

Solid State Pulsed Power Supplies

Safe and Intuitive Operation

All connections, command buttons, switches and status LEDs are front-mounted to ensure direct safe access and intuitive operation.

Flexible Energy Output

The systems feature a very flexible energy output, ranging from 100 to 2000 J (in steps of 100 J), that can be modified while online.

This is achieved by:

- varying the operating voltage (selectable from -2000 V to -5600 V);
- varying the capacitance (selectable from 32 µF to 64 or 128 µF).

Microprocessor Control

All internal initialising and safety procedures are microprocessor-controlled and the current system status can be monitored via a comprehensive series of LEDs. This provides an easy and straightforward system operation that is basically limited to the following actions:

- switching on/off the control unit (230 V/50-60 Hz single phase);
- selecting the capacitance and voltage;
- activating/deactivating the HV generation.

Triggering

Remote triggering of the unit is implemented by a TTL pulse, which is internally converted into a fibre-optic signal to the thyristor trigger device. There is no need for any external opto-isolator on the trigger line. During standby between survey lines, the unit will NOT trip - it will slowly bleed off but will remain ready for the next line.

USB connection on front

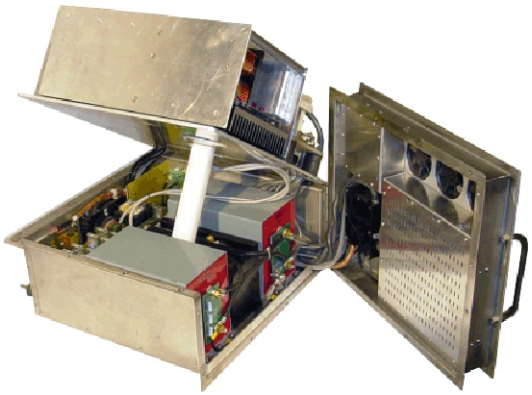
This new feature allows to connect a PC and provides direct access to the control software. You can check the usage data and the system functionality. It also allows customise the control software and internal configuration.

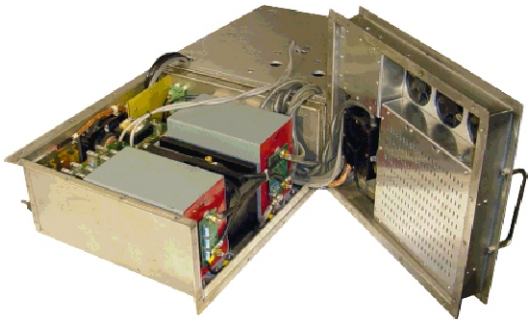
Modular Internal Architecture

The pictures below give an idea of the advanced modular architecture that allows the opening and inspection of the systems without disconnecting any units.

The internal construction comprises three main individual compartments:

- upper compartment with pulsed HV module, thyristor stack and relay/opto-control PCB;
- lower compartment with the pulse capacitors, capacitor switch, etc.
- front compartment with line filter, mains breaker, HV connection box, main control PCB and cooling fans.





Quality Built to Last

These pulsed power supplies are built to last, electronically and mechanically. Ten rubber shock absorbers in a sturdy, high quality polyester flight case support the compact inner housing that contains the actual unit.

Additionally, rubber shock absorbers support each vibration-sensitive component inside the inner housing.

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Geo-Sense Mini-Streamers

Single Channel Arrays of 8 to 24+ Elements

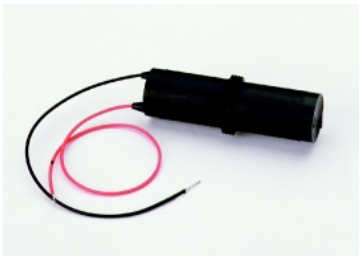
Applications

For use with our VHR single channel data acquisition systems: Geo-Trace, Mini-Trace, or any other recording system

- **Site and route surveys**
- **Sand searches**
- **Oceanographic research**

AQ-2000 Hydrophone

Geo-Sense streamers are equipped with the AQ-2000 hydrophones - the latest innovative acoustic sensor technology for both shallow and deep water exploration.



The AQ-2000 is well suited for applications that require stable performance over a wide range of water depths.

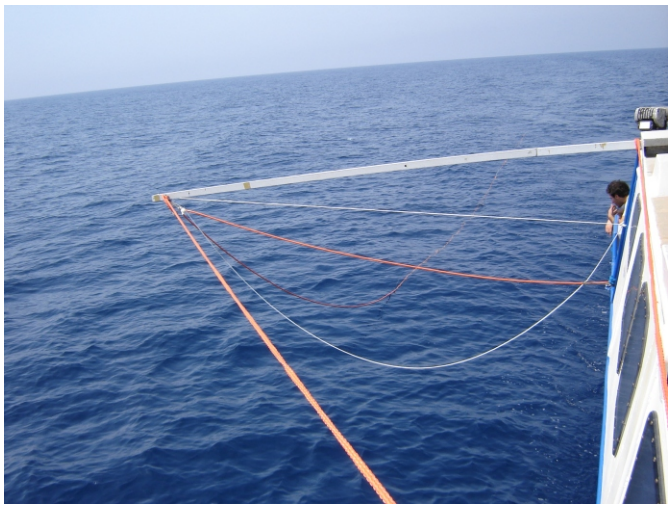
It has excellent acceleration-cancelling qualities and an exceptionally wide frequency bandwidth.

The AQ-2000 can be installed into standard array configurations or integrated into custom-moulded packages.

Every hydrophone is tested for sensitivity, capacitance and insulation to ensure the highest quality product for all very high resolution seismic operations.

Operational Features

- **Specifically designed for the high frequency spectrum emitted by VHR sources (sparkers, boomers, pingers)**
- **The short 8-element array has proven successful down to 4500 m water depths**
- **The active length and number of elements can be configured to your requirements**
- **Can be used with any Third Party recording system (in combination with the Geo-Sense Filter/Gain Interface)**



Tow Cable

Length:	Standard 50 m to 100 m
Diameter:	11 mm
Type:	3 x 2 x 24 AWG screened twisted pair
Insulation:	Polyurethane
Strain member:	Double reverse spiral Kevlar

Active Section & Jacket

Number of elements:	8 to 24+
Spacing of elements:	0.4 m standard
Length of active section:	2.8 m / 9.2 m (for 8 / 24elements)
Length of jacket:	4.8 m / 11.2 m (approx.)
Jacket size ID & OD:	20.5 mm & 26.5 mm
Jacket material:	Unreinforced polyurethane
Buoyancy:	Slightly negative
Array fluid:	Shell Sol T/ Isopar

Power to Preamplifier

For streamers other than Geo-Sense, a standard battery box of 12 V DC from penlight batteries can be used.

Geo-Sense Mini-Streamers
Technical Specifications

AQ-2000 Hydrophone

Electrical Specifications

Leads:	Two 28 AWG stranded conductors (red and black), Hytrel® insulation, 12.7 cm length each
Connector:	None
Polarity:	A positive increase in acoustic pressure generates a positive voltage on the red conductor
Capacitance:	4.5 nF +/- 25% at 20°C and 1 kHz
Resistance:	500 MΩ minimum across leads or to sea water at 20°C and
100%	relative humidity, 50 V DC
Dissipation:	0.02 typical

Performance

Sensitivity @ 100 Hz
Free-field voltage:
-201 dB re 1 V/µPa +/- 1.5 dB

Sensitivity Change
Versus frequency: +/- 0.25 dB from 1 Hz to 1 kHz
(+/-2.0 dB from 1 kHz to 10 kHz)
Versus depth : < 0.5 dB to 1000 m
Versus temperature: < 0.03 dB per 1°C change

Acceleration Sensitivity
Output is <1.5 mV/g due to acceleration in any of the three major axes at 20 Hz

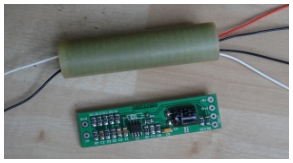
Mechanical
Resonance typically 20 kHz in water
Maximum operating depth of 2000 m
Destruction depth of more than 7000 m

Physical Specifications

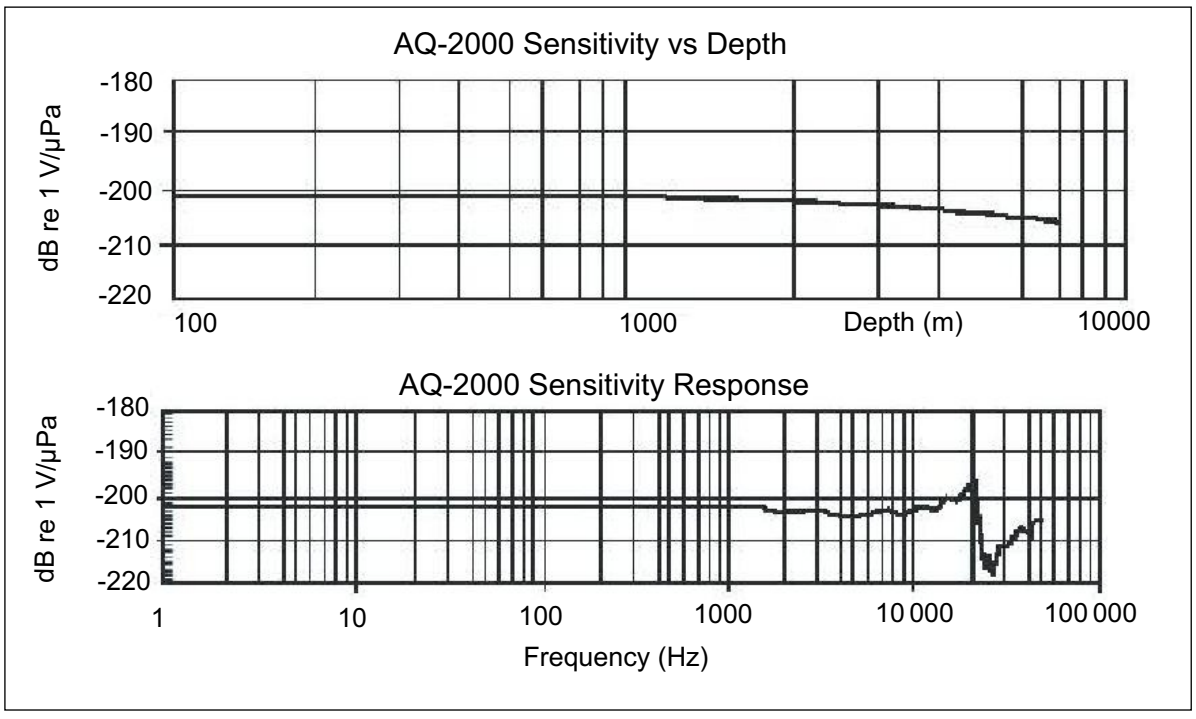
Materials:	Fluoroelastomer, high strength epoxy, Hytrel® insulated leads
Weight in air:	14 grams
Size:	4.56 cm long x 1.32 cm diameter
Displacement:	6.24 cc
Temperature:	Operating: -10°C to 50°C
	Storage: -40°C to 60°C

Pre-Amplifier

Size: 60 x 16 mm
Gain: 26 dB
Ground reference:
Single-ended



Power : 9 -12 V DC (polarity protected)
High-pass: -3 dB: 3 Hz
Low-pass: -3 dB:13 kHz
Output impedance: 60 Ω



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Geo-Sense Filter/Gain Interface

Application & Functionality

- **Interfaces the Geo-Sense VHR single channel mini-streamers to any Third Party recording system**
- **Provides high quality analogue frequency filters and two-stage analogue gain**

Analogue Frequency Filtering

There are four settings for analogue filtering:

1) bandpass filter of 80 Hz - 2.5 kHz,

This is usually the best setting for the sparker spectrum. Other filter settings can be provided.

2) high-pass (low-cut) filter of 80 Hz

To remove low frequency noise, it is usually sufficient to filter only the low frequencies, which are difficult to remove digitally.

3) low-pass (high-cut) filter of 2.5 kHz

To cut out the high frequencies.

4) no filter

Analogue Gain

To minimise distortion and to avoid saturation, the seismic signal is amplified in two stages:

1) 0-6-12-18 dB (four levels), the first stage gain is applied after the high- pass filter;

2) 0-6-12-18 dB (four levels), the second stage gain is applied after the low-pass filter.

By using the maximum gain setting for both stages, you can achieve a total amplification of 36 dB.

Operational Features

- **Dedicated 4-pin connection to power the pre-amplifier of the Geo-Sense streamer and to receive the signal**
- **Standard BNC connections for signal output to any seismic recorder and signal input from any Third Party streamer**
- **Audio output to headphone on front panel**
- **Mains power 110-230 V AC / 50-60 Hz**

General Features

The Geo-Sense filter/gain interface is designed to operate with the Geo-Sense mini-streamers and allows the Geo-Sense mini-streamers to be used with ANY digital recording system.

The interface is also designed to accept signal input, via BNC cable, from any other type of streamer.

It is a stand-alone unit that applies high quality, non-distorting analogue filters and two-stage gains to a single-channel seismic signal.

If you are working with a seismic recording system that has no suitable analogue front-end, then the Geo-Sense filter/gain interface would be an essential part of your system.

Audio Control

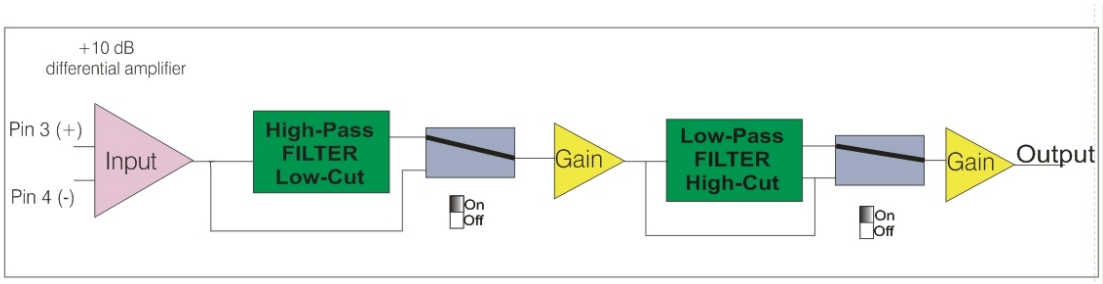
You can now listen to your streamer using a headphone connected to the audio socket on the front panel.

Geo-Sense Filter/Gain Interface

Technical Data & Schematics

Filter & Gain Parameters

First stage	Switchable high-pass (low-cut) filter / 80 Hz 4th order
Second stage	Switchable amplifier / 0-6-12-18 dB
Third stage	Switchable low-pass (high-cut) filter / 2.5 kHz 4th order
Fourth stage	Switchable amplifier / 0-6 -12-18 dB



Dedicated Geo-Sense Streamer Connection

The 4-pin connection is used for both the signal input from the streamer and the 12 V DC power supply to the streamer's internal pre-amplifier. This power supply replaces the standard battery box (which is normally also provided with the mini-streamer).

The four pins are assigned as follows:

- Pin 1 — +12 V DC power to pre-amplifier
- Pin 2 — Ground shield (earth)
- Pin 3 — Positive (+) signal from pre-amplifier
- Pin 4 — Ground signal from pre-amplifier

BNC Input and Output

The two BNC connections at the rear of the unit are for the single-ended input from the streamer, and the signal output to any digital recorder (with four settings for signal level voltage peak to peak of 0.3, 1, 3 and 10 V).

Optional Functions

- Customised filter settings are available on request.

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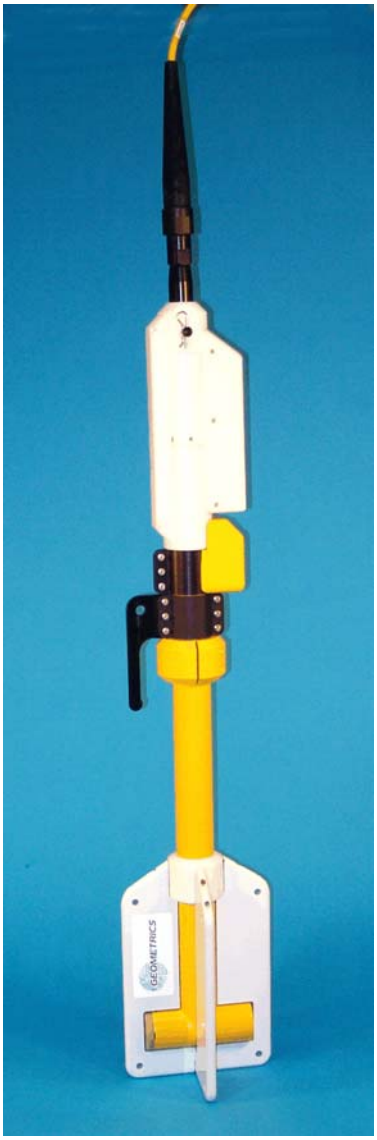
G-882 MARINE MAGNETOMETER

- ***CESIUM VAPOR HIGH PERFORMANCE – Highest detection range and probability of detecting all sized ferrous targets***
- ***NEW STREAMLINED DESIGN FOR TOW SAFETY – Low probability of fouling in lines or rocks***
- ***NEW QUICK CONVERSION FROM NOSE TOW TO CG TOW – Simply remove an aluminum locking pin, move tow point and reinsert. New built in easy carry handle!***
- ***NEW INTERNAL CM-221 COUNTER MODULE – Provides Flash Memory for storage of default parameters set by user***
- ***NEW ECHOSOUNDER / ALTIMETER OPTION***
- ***NEW DEPTH RATING – 4,000 psi !***
- ***HIGHEST SENSITIVITY IN THE INDUSTRY – 0.004 nT/Hz RMS with the internal CM-221 Mini-Counter***
- ***EASY PORTABILITY & HANDLING – no winch required, single man operation, only 44 lbs with 200 ft cable (without weights)***
- ***COMBINE TWO SYSTEMS FOR INCREASED COVERAGE – Internal CM-221 Mini-Counter provides multi-sensor data concatenation allowing side by side coverage which maximizes detection of small targets and reduces noise***



G-882 with Weight Collar Depth Option & Altimeter

Very high resolution Cesium Vapor performance is now available in a low cost, small size system for professional surveys in shallow or deep water. High sensitivity and sample rates are maintained for all applications. The well proven Cesium sensor is combined with a unique and new CM-221 Larmor counter and ruggedly packaged for small or large boat operation. Use your computer and standard printer with our MagLogLite™ software to log, display and print GPS position and magnetic field data. The G–882 is the lowest priced high performance full range marine magnetometer system ever offered.

The G-882 offers flexibility for operation from small boat, shallow water surveys as well as deep tow applications (4,000 psi rating, telemetry over steel coax available to 10Km). The G-882 also directly interfaces to all major Side Scan manufacturers for tandem tow configurations. Being small and lightweight (44 lbs net, without weights) it is easily deployed and operated by one person. But add several streamlined weight collars and the system can quickly weigh more than 100 lbs. for deep tow applications. Power may be supplied from a 24 to 30 VDC battery power or the included 110/220 VAC power supply. The tow cable employs high strength Kevlar strain member with a standard length of 200 ft (61 m) and optional cable length up to 500m with no telemetry required.

A rugged fiber-wound fiberglass housing is designed for operation is all parts of the world allowing sensor rotation for work in equatorial regions. The shipboard end of the tow cable is attached to an included junction box or optional on-board cable for quick and simple hookup to power and output of data into any Windows 98, ME, NT, 2000 or XP computer equipped with RS-232 serial ports.

The G-882 Cesium magnetometer provides the same operating sensitivity and sample rates as the larger deep tow model G-880. MagLogLite™ Logging Software is offered with each magnetometer and allows recording and display of data and position with Automatic Anomaly Detection and automatic anomaly printing on Windows™ printer! Additional options include: MagMap2000 plotting and contouring software and post acquisition processing software MagPick™ (free from our website.)

The G-882 system is particularly well suited for the detection and mapping of all sizes of ferrous objects. This includes anchors, chains, cables, pipelines, ballast stone and other scattered shipwreck debris, munitions of all sizes (UXO), aircraft, engines and any other object with magnetic expression. Objects as small as a 5 inch screwdriver are readily detected provided that the sensor is close to the seafloor and within practical detection range. (Refer to table at right).

The design of this high sensitivity G-882 marine unit is directed toward the largest number of user needs. It is intended to meet all marine requirements such as shallow survey, deep tow through long cables, integration with Side Scan Sonar systems and monitoring of fish depth and altitude.

Typical Detection Range For Common Objects

Ship 1000 tons	0.5 to 1 nT at 800 ft (244 m)
Anchor 20 tons	0.8 to 1.25 nT at 400 ft (120 m)
Automobile	1 to 2 nT at 100 ft (30 m)
Light Aircraft	0.5 to 2 nT at 40 ft (12 m)
Pipeline (12 inch)	1 to 2 nT at 200 ft (60 m)
Pipeline (6 inch)	1 to 2 nT at 100 ft (30 m)
100 KG of iron	1 to 2 nT at 50 ft (15 m)
100 lbs of iron	0.5 to 1 nT at 30 ft (9 m)
10 lbs of iron	0.5 to 1 nT at 20 ft (6 m)
1 lb of iron	0.5 to 1 nT at 10 ft (3 m)
Screwdriver 5 inch	0.5 to 2 nT at 12 ft (4 m)
1000 lb bomb	1 to 5 nT at 100 ft (30 m)
500 lb bomb	0.5 to 5 nT at 50 ft (16 m)
Grenade	0.5 to 2 nT at 10 ft (3 m)
20 mm shell	0.5 to 2 nT at 5 ft (1.8 m)

MODEL G-882 CESIUM MARINE MAGNETOMETER SYSTEM SPECIFICATIONS

OPERATING PRINCIPLE:	Self-oscillating split-beam Cesium Vapor (non-radioactive)
OPERATING RANGE:	20,000 to 100,000 nT
OPERATING ZONES:	The earth's field vector should be at an angle greater than 6° from the sensor's equator and greater than 6° away from the sensor's long axis. Automatic hemisphere switching.
CM-221 COUNTER SENSITIVITY:	<0.004 nT/ √Hz rms. Up to 20 samples per second
HEADING ERROR:	±1 nT (over entire 360° spin)
ABSOLUTE ACCURACY:	<2 nT throughout range
OUTPUT:	RS-232 at 1,200 to 19,200 Baud
MECHANICAL:	
Sensor Fish:	Body 2.75 in. (7 cm) dia., 4.5 ft (1.37 m) long with fin assembly (11 in. cross width), 40 lbs. (18 kg) Includes Sensor and Electronics and 1 main weight. Additional collar weights are 14lbs (6.4kg) each, total of 5 capable
Tow Cable:	Kevlar Reinforced multiconductor tow cable. Breaking strength 3,600 lbs, 0.48 in OD, 200 ft maximum. Weighs 17 lbs (7.7 kg) with terminations.
OPERATING TEMPERATURE:	-30°F to +122°F (-35°C to +50°C)
STORAGE TEMPERATURE:	-48°F to +158°F (-45°C to +70°C)
ALTITUDE:	Up to 30,000 ft (9,000 m)
WATER TIGHT:	O-Ring sealed for up to 4,000 psi (9000 ft or 2750 m) depth operation
POWER:	24 to 32 VDC, 0.75 amp at turn-on and 0.5 amp thereafter
ACCESSORIES:	
Standard:	View201 Utility Software operation manual and ship kit
Optional:	Telemetry to 10Km coax, gradiometer (longitudinal or transverse), reusable shipping case
MagLog Lite™ Software:	Logs, displays and prints Mag and GPS data at 10 Hz sample rate. Automatic anomaly detection and single sheet Windows printer support

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE ***12/03***

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MAGELLAN®
PROFESSIONAL

Sagitta™

The Turnkey RTK Receiver

Features

- Easy to use and lightweight GNSS receiver
- Real-time precision ranging from meter to centimeter
- Multi-application positioning sensor

Accurate, Easy To Use And Lightweight

The Sagitta receiver from Magellan is intended for small and medium-scale marine surveys for which position precision and ease of use are equally important. Sagitta offers real-time precision ranging from the meter to the centimeter level, depending on how it is operated (Operating modes available include: WAAS/EGNOS, DGPS, EDGPS, KART or LRK®).

Its fast 10-Hz (raw data) and 20-Hz (computed data) output rates make it the ideal tool for many types of kinematic applications such as bathymetry or coastal works, sea trials or trajectory. Surprisingly, for its size, Sagitta boosts levels of performance comparable to those of the most sophisticated equipment available today. Thanks to its low weight and small size, it can easily be carried from site to site.

Flexible

Sagitta comes in two versions: single-frequency and dual-frequency. Its 16-channel GNSS differential core is housed in a single, versatile unit that can be combined with additional optional software or hardware to meet a variety of requirements: screen & keypad (TRM100), UHF or HF/MF radio (U-Link or HM-Link transmitter/receiver), etc.

Benefiting from a high degree of flexibility in its design, Sagitta can also be used as a reference station. You just need to add a U-Link station kit to deliver UHF signals over distances of 40 km or more. To even more increase your project flexibility Sagitta is also compatible with several data format (RTCM, Magellan, CMR/CMR+).

Extended Performance

Sagitta now also offers a unique full BACKUP™ feature where a second position fix is computed to guarantee an extreme position availability. With our dual-frequency LRK kinematic processing technology - today a standard renowned for its outstanding performance – Sagitta provides fast, reliable, real-time centimeter-level positioning combined to a fully operational radio link up to 40 km. With LRK, you will be able to work at greater distances than conventional RTK.

Sagitta Technical Specifications

Applications

- High-Precision Positioning
- Marine Surveying
- Trajectory

Sagitta Configurations

	Standard Features	Firmware Options	Hardware Options
Sagitta-01	Compact-case receiver NAP 001 antenna with standard supply Firmware: DGPS, EDGPS, BACKUP	KART REFSTATION RELATIVE OTF	Rx 4812 U-Link Reception Module Rx 1635 HM-Link Reception Module (x1) Tx 4800 U-Link Transmission Module TRM100 keyboard & screen
Sagitta-02	Compact-case receiver NAP 002 antenna with standard supply Firmware: DGPS, EDGPS, BACKUP	KART LRK REFSTATION RELATIVE OTF	Rx 4812 U-Link Reception Module Rx 1635 HM-Link Reception Module (x1) Tx 4800 U-Link Transmission Module TRM100 keyboard & screen

Standard Supply List

- NAP 001 or NAP 002 geodetic antenna; Diameter: 143 mm (5.63"); Weight: 0.35 kg (0.77 lb)
- Power cable, RS232 serial cable (x 1)
- Receiver mounting kit

Performance Figures[1]

Real-Time Centimeter LRK Mode (L1/L2)

- Operating range up to 40 km (5 SVs or more) with OTF kinematic initialization
- OTF initialization time: 30 seconds, typical
- Precision:
  - In KR Fast Mode (20 Hz max. and 5-ms latency): 10 mm + 0.5 ppm, XY; 20 mm + 1.0 ppm, Z
  - In KA Synchronous Mode (1 Hz and 1-s latency): 5 mm + 0.5 ppm, XY; 10 mm + 1.0 ppm, Z

Real-Time Centimeter KART Mode (RTK L1)

- Operating range up to 12 km (5 SVs or more) with OTF kinematic initialization
- OTF initialization time: 10 minutes, typical
- Precision: same as LRK Mode

Real-Time Decimeter EDGPS Mode

- No operational limits of distance; U-LINK radio reception required
- Data convergence time: 2 minutes, typical
- Precision: 20 cm + 2 ppm, XYZ

Real-Time Metric WAAS/EGNOS Mode

- Service area as defined for the system of satellites used. The different systems available are: WAAS in North America, EGNOS in Europe and MSAS in Japan
- Precision: 1 to 2 meters, XY; 3 meters, Z

Technical Specifications

GPS/GNSS

- 16 x L1 channels - 12 x L2 channels (Sagitta-02 only)
- C/A code and L1 phase, P code and L2 phase with multi-path processing
- Differential modes: WAAS/EGNOS, Numeric RTCM Version 2.2, messages 1,3, 5, 9, 16, 18 & 19

Raw Data:

10 Hz output rate

Computed Data:

- 20 Hz output rate - Latency < 5 ms (0.005 s)
- User Coordinate System: -Local datum, projection, geoid model

Interface

- GPS and Radio Antenna connectors: all female TNC
- 3 two-way I/O ports (one RS232, two RS422) with baud rates from 1200 to 115200 bauds
- AUX port (1 PPS output, external event input, RTCM input on RS422, etc.)
- TRM100 display also available on VGA output
- NMEA 0183 messages: RTCM, Magellan format, CMR/CMR+
- User messages via ConfigPack™

Electrical

- Power source: 9 to 36V DC, floating input
- Consumption (mobile receiver): 7 to 15 W (Sagitta-01); 8 to 16 W (Sagitta-02)

Environmental

- IP 52 compliant, rigid aluminum case
- Operating temperature range: -20 to +55°C (antennas: -40 to +70°C)
- Storage temperature range: -40 to +70°C
- Vibration: EN 60945 & ETS 300 019 (Shocks)
- EMI: EN60945, Class B FCC Part15

Physical

- H x W x D: 65 x 265 x 215 mm (2.56 x 10.43 x 8.46")
- Weight: 2 kg (4.41 lb)

Radio Module Options

Tx 4800 U-Link UHF Transmission

- Transmission module operating in UHF band 410 to 470 MHz
- Data formats: LRK (RTK) and RTCM
- Modulation type: GMSK at 4800 bits/s
- Radiated power: 4W or 0.5W (according to local authorization)
- CXL-70 3 dB antenna
- Norm ETS 300-113 - Certified in Europe, the US and most other countries
- R & TTE 1999/5/CE
- EMI specifications: EN60945

Rx 4812 U-Link UHF Reception (built-in module)

- Reception module operating in UHF band 410 to 470 MHz
- Reception module designed to be integrated into the receiver
- Modulation type: GMSK 4800 bits/s or DQPSK 1200 bits/s (NDS 100 type)
- CXL-70 3 dB antenna

Rx 1635 HM-Link HF/MF Reception (1 built-in module)

- Reception module designed to be integrated into the receiver
- Dual-channel in HF band 1.6 to 3.5 MHz; BCPSK modulation (NDS 200 type)
- Dual-channel in MF band 270 to 330 kHz; MSK modulation
- DHM 5000 dual-band antenna - H x Diameter: 245 x 135 mm (9.64 x 5.31")

TRM100 Keyboard & Screen Option

- 1/4 VGA screen and keyboard terminal
- Dimensions (H x W x D): 125 x 255 x 40 mm (4.92 x 10.0 x 1.57")
- One-meter cable for connection of TRM100 unit to receiver
- TRM100 mounting kit

TRM 100 keyboard/screen terminal

[1] All performance figures are 1 RMS values based on test conducted in Nantes, France,in normal conditions of GPS receptions,(normal ionospheric activity, 5 SVs used and HDOP < 4) on a clear site.

[1] Tests in different locations under different conditions may produce different results.

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www.pro.magellanGPS.com

MAGELLAN® PROFESSIONAL

GEUS Vibrocorer

Vibrocorer: VKG (VibrationsKernGerät)

Technical data and crane requirements:	VKG-6	VKG-3
Height (operational)	7.4 m	4.7 m
Base (foot)	4.6 m	3.6 m
Weight inclusive drilling rod and 6 contraweight @ 50 kg.	850 kg.	550 kg
Same inclusive max sediment in the liner	1000 kg	700 kg
Coreliner PVC outside	110 mm	110 mm
Core diameter	106 mm	106 mm
Corelength max	6.0 m	3.0 m
Working area	6 x 9 m	5 x 6 m
Crane lifting capacity	2 ton	1 ton
Crane lifting height over rails	7.5 m	5.0 m
Crane boom length from shipsside to drillingpoint min.	2.5 m	3.5 m
Hoisting wire non-rotating	12 mm	12 mm

Working depth	0 – 100 m
Mooring:	Treepoint mooring
Power:	380 V 3 phase+ ground 50 Hz
Fuse:	Min 25 A
Electromotor	4 kW/2880 rpm
Working current	10 – 16 A (20 A short)
Vibro-frequency	28 Hz
Drilling force	30 kN

Personnal: One driller, one crane operator and two assistants

Navigations software - NaviPac

The NaviPac software is integrated navigation and data acquisition software specifically suited for applications like:

- General navigation
- Hydrographic & oceanographic surveying
- Geophysical & seismic surveying

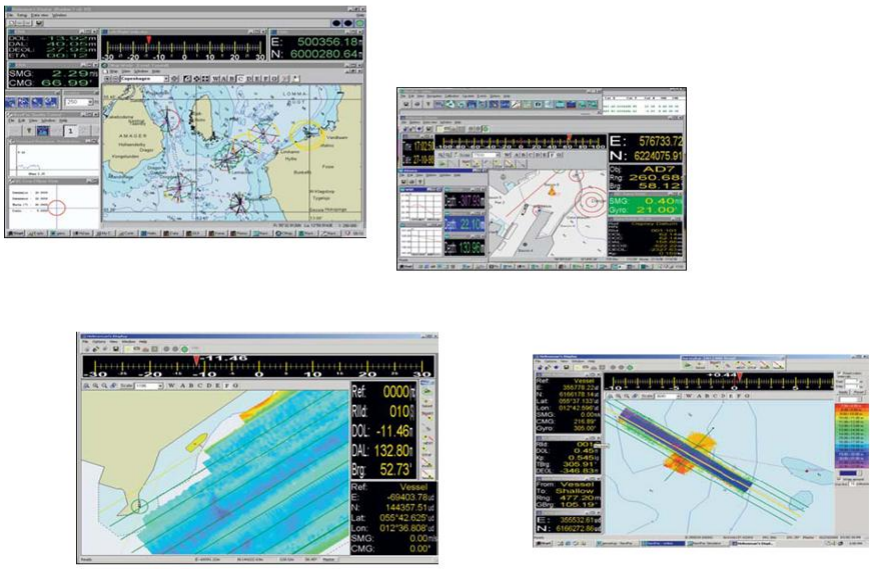
MODULARITY – NaviPac is modularity through use of multi tasking, multithreading and networking capabilities of the Windows NT, Windows 2000 and Windows XP operating system. The software is highly flexible and user configurable and the user interface adhere to The Microsoft Interface Guidelines making it very intuitive and easy to operate (figure 4).

NAVIGATION SET-UP – The NaviPac set-up module provides easy selection of geodetic parameters, navigation systems, devices, offsets and port settings.

DEVICE I/O DRIVERS – A vast number of field-tested device I/O drivers are provided for most available positioning systems, GPS/DGPS receivers, gyros, motion/attitude sensors, tide-gauges, single beam echosounders, magnetometers, dynamic positioning systems, autopilots, etc. Generic I/O drivers allow definition or customization of own device I/O drivers. Data is interfaced via RS232, a LAN or via a digital I/O interface

TIME SYNCHRONIZATION – Time stamping of sensor data, incoming as well as outgoing, can be done in two ways, either by the internal computer clock or by he PPS output available from most GPS receivers. Using the PPS output data are synchronized relative to the GPS/UTC time frame, resulting in an accuracy of a few milliseconds.

SURVEY PLANNING – NaviPac allows for survey planning through quickly creation of planned survey area and survey lines. A variety of methods for creation of survey lines is provided, e.g. by click-and-drag (of mouse/trackball), input of survey line coordinates, offset (parallel) survey lines, cross lines, circles, arcs etc. Survey lines can easily be adapted to fit a defined survey area. Creation of templates allows input of other data formats.



Figur 4. NaviPac skærmbilleder side scan sonar.

DELPH SEISMIC

SUB-BOTTOM IMAGERY ACQUISITION AND INTERPRETATION TOOL

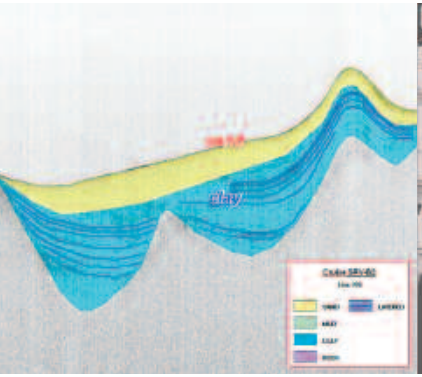
DELPH SEISMIC is a real-time and batch survey productivity tool, compatible with most digital and analog sub-bottom profilers. Beyond the traditional scrolling display, its global viewer mode and mapping tools provide advanced interpretation capabilities.

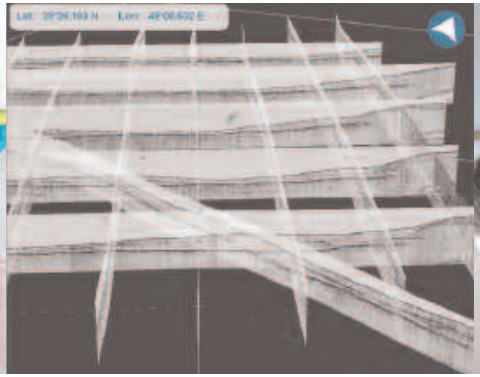
FEATURES

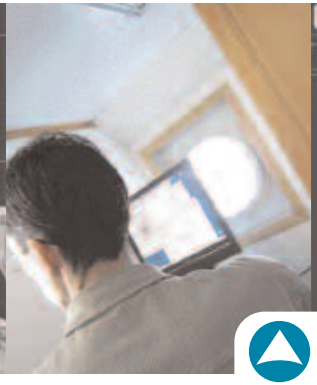
- One screen display of km-long survey lines
- Manual and automatic reflector identification
- On screen annotation and drawing tools
- Crossing profiles one click browsing
- 3D display of both imagery and interpretation

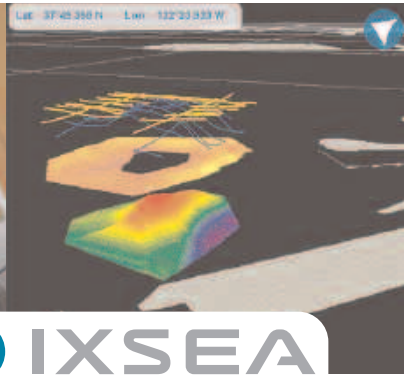
BENEFITS

- Improvement of the interpretation production line
- Interpretation productivity boost
- Ready to use imagery data
- Improve your understanding of the survey field
- Easy profiles correlation for interpretation









APPLICATIONS

- Offshore mining preparation
- Geotechnical, scientific and environmental investigation
- Pipe pre-laying and pre-dredging survey

DELPH SEISMIC INTERPRETATION

SUB-BOTTOM IMAGERY ACQUISITION AND INTERPRETATION TOOL

DETAILED FEATURES

Acquisition

IXSEA's ECHOES SBP interface with multi-ping capability
Interfaces with most digital and analog sources
24 Bits acquisition of 1 to 6 analog channels
Master and slave modes
Asynchronous acquisition of two analog systems
Industry standard XTF or SEGY format logging

Processing

Band pass and time varying filters
Automatic and time varying gain control
Horizontal stacking
Navigation filtering and speed correction
Topo correction with swell and heave compensation
Multiple removal and signature deconvolution

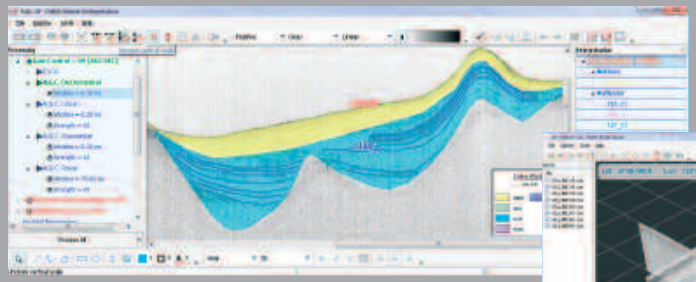
Interpretation

Manual and semi-automatic horizon picking and export
Thickness computation between two horizons
Crossing lines browsing and interpretation correlation
Annotation and drawing on the seismic profile
Outputs to industry standard formats

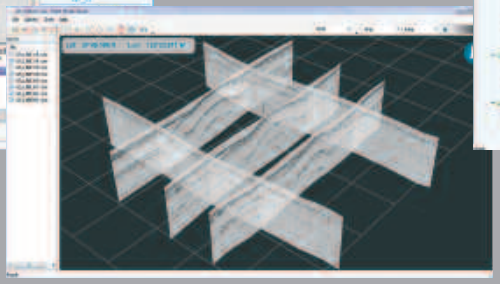
Mapping

DTM generation
Real-time and post processed seismic GeoSections
3D display of the DTMs with the interpretation vectors
3D display of GeoSections
Geographic correlation with other sensor data

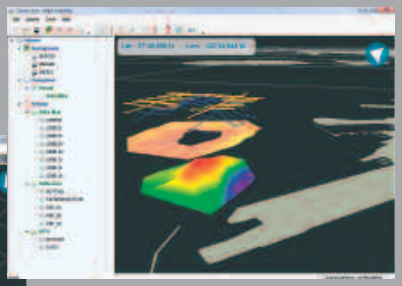
WORKSPACE OVERVIEW



Delph Seismic Interpretation



Delph Mosaic Viewer – GeoSection Display



Delph Road Map - DTM Display

REQUIREMENTS & COMPATIBILITY

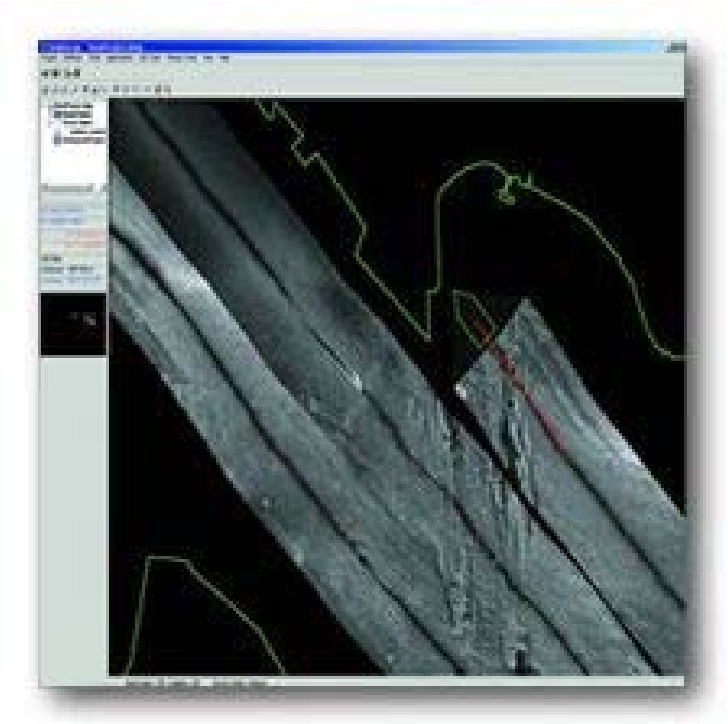
Minimum workstation configuration: Pentium IV, Windows XP

IXSEA : • EMEA : +33 (0)1 30 08 98 88 • AMERICAS : +1 (781) 937 8800 • ASIA : +65 6747 4912 • www.ixsea.com

2008-01-PS-DELSEI

Isis Sidescan Acquisition Software

This complete software suite has the options of logging the sidescan and the sub-bottom profiler data, process the data and produce a mosaic image of the seabed as shown in the figure. It has the ability to export these images in a geotiff format which can be read directly by any GIS software, like MapInfo.



ISIS online mosaic screenshot.

ISIS continues to be the most advanced sidescan sonar acquisition system available today. Isis® Sonar™ is the tool of choice for a variety of applications including: mine-hunting, hydrography, archaeology, environmental studies, oilfield engineering, civil engineering, oceanography, and law enforcement.

Real-time Sensor Quality Control

ISIS offers a wealth of display options to ensure high data quality. Typical windows for monitoring raw sensor information include a waterfall display for the sonar imagery, a signal voltage display for each incoming ping, and a parameter display for navigation, motion sensor, etc., and file storage. A real-time link with TEI TritonMap™ provides for on-line mosaic production, an invaluable tool for assessing seabed coverage and the quality of geo-referencing between adjacent lines (figure 6).

Reliable, Precise Sonar Data Acquisition

ISIS systems are active throughout the world, incorporating over 20 years of field experience in hardware and software design. Incoming sidescan sonar and ancillary sensor data are time-stamped to

millisecond accuracy, thereby ensuring the final data products can be properly corrected during processing. Wide Compatibility,

Compatible with All Sidescan Sonars
ISIS interfaces with any sidescan sonar available today. Analogue or digital, regardless of the manufacturer -- we offer a custom interface that is intuitive to set up and is designed around the sonar's communication requirements. All data are stored in TEI's open XTF (eXtended Triton Format), an industry-standard, non-proprietary format.

Comprehensive Data Correction & Analysis
Numerous tools exist within ISIS for correcting and analyzing data and generating reports. Bottom-tracking, time-varying gain, slant range correction, and layback may all be applied to the imagery on-screen without affecting the raw data being logged. Events, scale lines, and notes can be associated with the imagery. A powerful ASCII report tool allows practically any information stored in the XTF file to be extracted in user-defined formats.

GIS Mosaicing
A mosaicing link exists between Isis® Sonar™ and TEI's TritonMap™ GIS product. These mosaics may be overlain on navigation charts or other background information. Contours, navigation hazards, or contacts may be overlain on the mosaics as they are being built.

SonarWiz.MAP+SBP

SonarWiz.MAP+SBP: the fastest, friendliest acoustic mapping package available now includes a sub-bottom profiler acquisition and processing module.

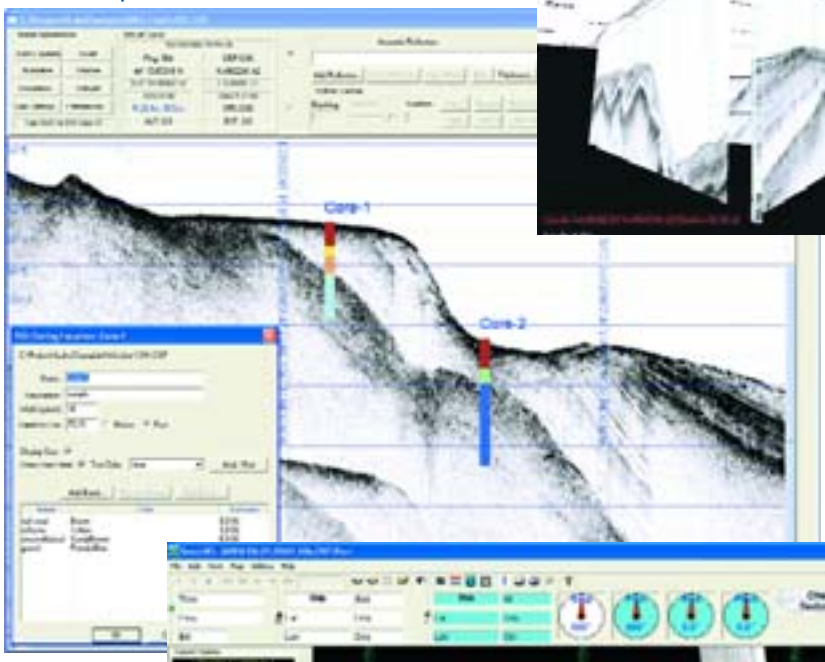
SonarWiz.MAP+SBP produces real-time and post-processed mosaics and SBP profiles at any resolution and size, quickly and on-the-fly.

In real-time acquisition mode, it supports most sonar systems, in addition to navigation, fathometer and magnetometer input.

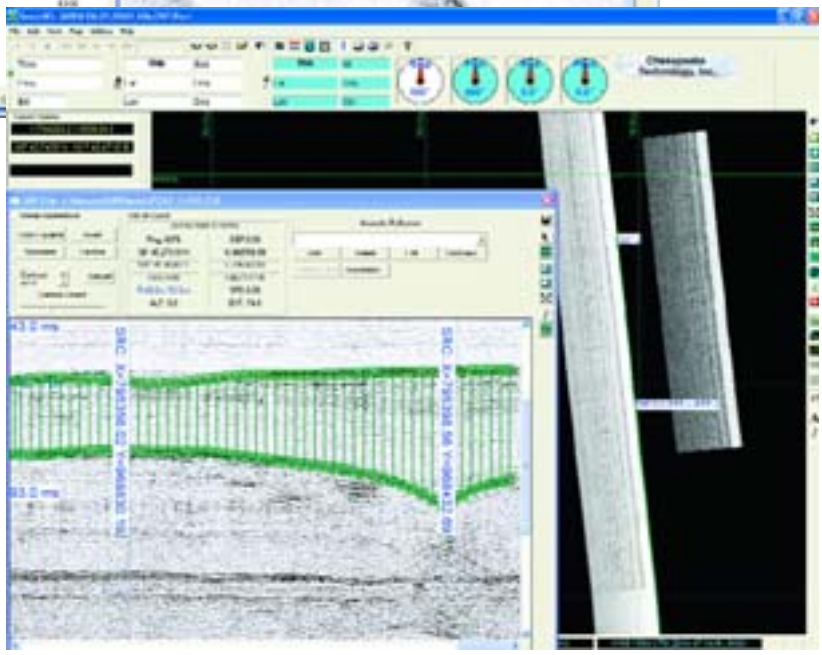
In post-processing mode, it will handle most of the common sidescan and sub-bottom data file types as well as S-57, VPF, BSB, GeoTiff and many more charting, GIS and CAD formats.

Runs on Windows 2000, XP, Vista and later

Core Sample

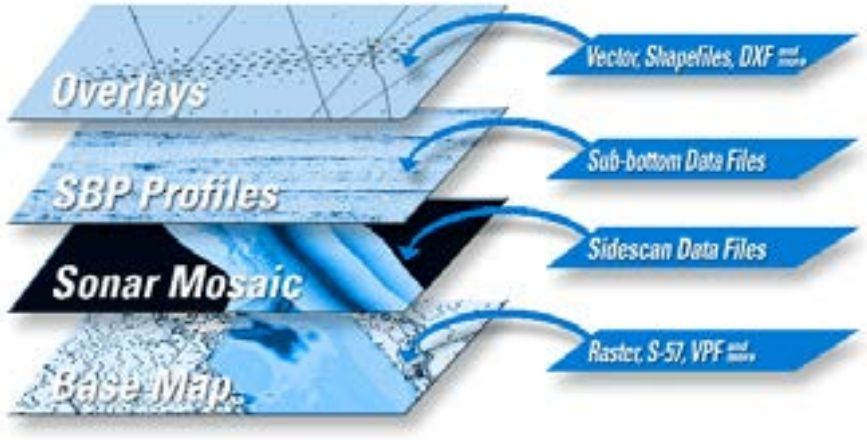


3-D Video



Reflector Digitizing with Thickness Computation

SonarWiz.MAP+SBP Display Capabilities



Chesapeake Technology Inc.

650.967.2045

www.chesapeaketech.com

SonarWiz.MAP+SBP

SonarWiz.MAP+SBP: Interactive visualization tools such as zoom, pan, measure and on-the-fly image scaling make SonarWiz.MAP+SBP an indispensable tool for sonar mosaic production and sub-bottom profile interpretation.

Contact identification and feature digitizing tools allow features to be located and classified on the mosaic during or after data acquisition. Graphic, tabular and application specific files (HTML, MS Word, ESRI Shapefiles) provide multiple data export routes. Export SBP profile sections with custom annotations and scale lines.

Sub-Bottom Profiler Module Features…

- **Broad File Type Support**—XTF, SEG-Y, CODA (.COD and .CDA), Edgetech JSF, Tritech SBP V4Log and Syqwest StrataBox data file formats are currently supported with more formats on the way.
- **Intuitive Mapping**—The SBP Option maps your sub-bottom data in a 2D plan view by rotating the vertical trace 90 degree into the map surface providing a plan view of your data. Individual files may be moved, trimmed, split, image enhanced just by a simple right-click in the map view.
- **Classical Profile Views**—In addition to a plan view of all of your SBP data files, SonarWiz.MAP+SBP also provides multiple profile views of your SBP files that are "cursor-linked" with the map view. The profile views allow infinite scroll and pan over the entire SBP data file and complete customization of the vertical and horizontal scale lines and event marking.
- **Acoustic Reflector Generation**—SonarWiz.MAP+SBP profile view provides a simple interface for digitizing acoustic reflectors in the profile. Reflectors are displayed in the map view and on the profile view as they are digitized. SonarWiz.MAP+SBP includes a complete export tool that will save the digitized reflectors in CAD, GIS and ASCII formats.
- **Isopach and Thickness Tool**—SonarWiz.MAP+SBP thickness tool compares any pair of reflectors and automatically generates the thickness vector for the area of intersection of the reflectors. This is a huge time saving feature.
- **3D Viewer**—Included with all SonarWiz.MAP products is a 3D visualization package that displays mosaics, maps and SBP profiles in an interactive 3D display. Exports movie files and JPEG images.
- **Core Processing**—Show your interpretations right on the SBP profile using the new Core mapping tool.

SonarWiz.MAP Features…

- Real time data acquisition and display: supports most sonar systems, plus navigation, fathometer and magnetometer input.
- Real-time and post processed sonar mosaic production.
- Real-time survey-line generator, editor and steering indicator makes line following a breeze.
- Real-time QC-sonar waterfall display.
- Interactive and on-the-fly scaling.
- Sonar file importing: supports most sonar file formats.
- Comprehensive selection of pre-defined geodetic datums, coordinate systems and map projections, plus support for user defined datums and projections.
- Support for basemaps and overlays includes BSB, S-57, VPF/VMAP, ECW, DXF, Shapefiles, GeoTiff and much more.
- Bottom Tracker: manual and automatic modes.
- Comprehensive signal processing and gain control including Beam Angle Correction, Destriping, Non-linear per-channel TVG, AGC, layback.
- On-screen feature digitizing and attribution.
- Target capture and reporting.
- On-screen tools simplify difficult tasks such as adjusting survey lines.
- Printed output to any Windows supported printer or plotter.
- Output mosaics to GeoTiff (TIF/TFW) with user specified resolution.
- Output digitized features and reports to ESRI shapefiles, AutoCAD DXF, and simple ASCII files.
- Full online HTML help system, unmatched customer support and a yearly maintenance agreement available for extended upgrade and support options.

Chesapeake Technology Inc.

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GeoGraphix

SOFTWARE OVERVIEW

GeoGraphix® software delivers a unique blend of geoscience, engineering and economic decision support capabilities on Windows®.

Visit us at: www.geographix.com

Integrated GeoscienceSuites

By tightly integrating our best-in-class geophysical and geologic technologies with powerful data management and mapping tools we have created the ultimate geoscience solution suites that increase asset understanding and provide the highest quality products.

Discovery™
The Discovery™ suite is a Windows®-based geologic and geophysical interpretation system that combines industry-leading technologies supported by a common data and project architecture. Geoscientists use this tightly integrated system to easily interpret reservoirs, support field development and exploit mature assets. The Discovery suite is the ultimate integrated collaborative environment for geologists and geophysicists to develop highly accurate interpretations of their assets or exploration plays.

Discovery™ on OpenWorks®
GeoGraphix Discovery™ technology now directly accesses OpenWorks® and SeisWorks® data and projects without data transfer or replication. Discovery on OpenWorks technology directly links to Landmark's OpenWorks system, the most widely used project data-management application in the exploration and production (E&P) industry. For geoscience professionals, this means that they can choose between any Landmark or Discovery application to support their interpretation process without complicating their project environment.

Utilities

Efficient data management is critical to any oil and gas company, providing an environment where your technical staff is interpreting and not searching for or validating data. Our data management utilities reduce effort and streamline data sharing.

SDE Connect
GeoGraphix's SDE Connect utility enables a direct connection to Oracle® spatial data engines so that you can display lease and cultural information on our mapping tools without exporting, importing and duplicating data. Because this connection is live, you can be confident that your maps are always current with the latest data available. Even create SDE layers as virtual snapshots of your data for when connections to the SDE server are not available or when you take your projects on the road.

SeisXchange™
We realize that many of our customers operate their geoscience IT technologies in a hybrid Unix/PC environment. SeisXchange™ technology reduces the effort to transfer geophysical 2-D and 3-D horizon picks, faults and seismic attributes between Discovery™ and Landmark's Unix-based interpretation tools.

WellXchange™
Want to use both GeoGraphix and Landmark geoscience environments yet are tired of manipulating data between these systems? GeoGraphix's WellXchange™ utility allows you to manually transfer or set up scheduled synchronizations between the Discovery™ GXDB and OpenWorks® databases. Well header, formations, log curves, fault data and production data are a few of the data types handled by this efficient data-transfer utility.

Engineering

GeoGraphix's engineering technologies help reservoir and production engineers maximize your asset's financial performance. Proactively and easily analyze and identify opportunities to optimize production and reservoir recovery.

Dynamic Surveillance System™ (DSS™)
Integrates all the information necessary for engineers to manage their assets. Monitoring all well and operations data enables engineers to proactively identify opportunities to increase production across an asset, while at the same time reducing downtime. By replacing spreadsheets with a dedicated surveillance tool, one engineer can easily manage an asset with more than 500 wells.

Economics Technologies

Designed for companies around the globe, our economic solutions accurately support your wide range of financial decisions, assess and report your company's reserves and help you manage a portfolio of projects all within one integrated system.

Economics Evaluation

ARIES™ System
ARIES™ System combines superior well and project management, sophisticated graphical analysis, and a robust economics engine to forecast production, economics, and reserves for all types of properties and assets. Designed to accurately support financial decisions across your company and forms the foundation for the reserve management and decision support tools described below.

ARIES™ International
Extends the power of ARIES™ technology so you can accurately model complex international fiscal contracts. Easily combines domestic and international results into the reserves and portfolio management systems, saving time and preserving accuracy.

Reserve Management

ARIES™ Reserves Management System (RMS)
Improves evaluation, approval, reconciliation and reporting of reserve values. Increases the accuracy, speed and your control of the results. Built-in government and corporate reports save additional time and effort. With the extra time, companies can easily update and report reserves throughout the fiscal year.

Decision Support

ARIES™ Decision Suite™
Enhances the risk analysis of ARIES™ software through graphical decision-tree analyses that support evaluations of individual economic cases and expected value summaries. Also enables Monte Carlo simulations through links from economic data to Crystal Ball® technology.

ARIES™ Portfolio
Supports capital allocation decisions. It aggregates all the inputs – property type, cash flows, capital expenditure, time frames and more – that managers consider when allocating capital for a project. With all the relevant data in one place, managers can easily create reports that help evaluate the impact a particular project will have on the company's bottom line.

ARIES™ Optimizer
Automates rigorous economic and financial analysis that is cumbersome to do manually. It quickly identifies the most effective combinations in the portfolio data set within the context of your corporate objectives. It helps produce insights which, when combined with your judgment, can produce better strategic decisions and value for your company.

Land Solutions

Because land management is such an integral part of exploration and exploitation of your assets, GeoGraphix has tightly integrated mineral interest and leasehold technology into our mapping system providing the complete picture.

LeaseMap®
GeoGraphix's LeaseMap® application is a powerful yet easy to use land-management tool that provides a complete understanding of any region's mineral interest and leasehold situation. Using industry standard reports and interactive maps, LeaseMap software helps you identify the details and status of mineral and lease holdings across your assets or in an area of interest. The lease information can be integrated with our mapping tools displaying geologic, geophysical and engineering data.

Geology Solutions

GeoGraphix's high-performance geology solutions are tightly integrated into either one of the two bundled mapping systems or geologic interpretation systems – four systems total, all designed to support basic and advanced geologic workflows.

Advanced Well Log Correlation
Whether you are trying to understand a regional trend or identify subtle unconformities in a complex reservoir across hundreds of wells, our advanced well log interpretation tools provide powerful interpretation workflows.

smartSECTION®
smartSECTION® technology specializes in high-performance well log correlation and advanced geologic interpretation by working with digital or raster logs and simulating paper-based log correlation workflows. Unique fault gapping tools are used to interpret structural relationships plus sequence stratigraphy tools allow geologists to accurately correlate large volumes of wells, interpret reservoir facies, build maps and identify drilling opportunities more efficiently than ever before.

Geologic Interpretation Systems
By combining our industry-leading geologic interpretation technologies into systems, we've made it easier for you to purchase the right components to support your most common interpretation workflows.

Basic Geologic Interpretation System
The Basic Geologic Interpretation System is composed of all of the basic geological interpretation applications that the petroleum geologist needs to interpret and map subsurface data. It combines our Mapping System with the Xsection™ application to extend the subsurface interpretation functionality. It is designed for the geoscientist who works primarily with well data and does not have the need to incorporate geophysics or well log analysis into the interpretation.

Geologic Interpretation System
The Geologic Interpretation System is our high-performance geologic application encompassing everything from gridding, contouring, cross sectioning and log analysis to production mapping, basemapping and well data management. Advancing beyond the Basic Interpretation System, we added PRIZM™ to include petrophysical analysis functionality to create the industry's leading product of its kind. Companies around the world use GeoGraphix's Geologic Interpretation System to improve the quality of their interpretations.

Mapping Systems
Whether you are creating base maps or need to display reservoir characteristics, our integrated mapping systems include the right combination of technologies to support your demanding mapping needs.

Base Map System
The Base Map System gives you everything you need to create powerful, informative base maps that derive maximum value from your data. It combines the DataManager™, GeoAtlas™ and LandNet components to deliver comprehensive base map and data management functionality plus basic gridding and contouring for a quick look at regional structure and trends.

Mapping System
The Mapping System takes the components of the Base Map System and adds more sophisticated gridding and contouring capabilities with the IsoMap® module. This system gives geologists a range of tools to address every possible geologic mapping challenge for a solid understanding of the subsurface structural, stratigraphic and reservoir configurations. From more efficient data management to presentation-quality output the first time around, this package delivers everything you need to put your data into context and communicate it effectively.

Geophysical Solutions

From comprehensive seismic interpretation to seismic modeling, GeoGraphix offers the geoscientist all the geophysical tools needed to gain true insight into reservoir opportunities and make the most of the information at hand.

Seismic Interpretation Systems
By combining our advanced data management and mapping systems with our full-featured seismic interpretation and analysis tools, we have created the ultimate environment for the geophysicist to produce high-quality prospects in a fraction of the time.

Seismic Interpretation System
Whether your play involves complex structural problems or subtle stratigraphic traps, having an integrated seismic tool that is sophisticated provides you with the power to accurately interpret your seismic data with confidence. GeoGraphix's Seismic Interpretation System combines the power of DataManager™ with the seismic interpretation capabilities of SeisVision™ 2D/3D to meet your mainstream geophysical needs.

Seismic Interpretation System with Advanced Mapping
The Advanced Mapping version of the Seismic Interpretation System adds the powerful gridding and contouring capabilities of IsoMap®, as well as the superior display capabilities of GeoAtlas™, to provide the ultimate geophysical tool set. Empower geoscientists to work on the same project with GeoGraphix's unique data management tools and common database.

Seismic Modeling
Interpreting seismic data sometimes is not enough to accurately pick well locations. Building seismic models to create synthetic traces correlated to well data is essential to increasing the quality of complex depositional environments.

LogM™ Advanced Synthetics
LogM™ Advanced Synthetics, running on either UNIX or Windows® desktops, allows you to tie the trace data with synthetics in real time. For added accuracy, the wavelet of the seismic can be extracted, and applied to the synthetic using WavX. 1-D modeling can be accomplished with AVO/AVA synthetics or fluid substitution. The result? More confidence in your interpretation accuracy.

LogM™ Modeling
LogM™ Modeling is an interactive add-on to the LogM Advanced Synthetics application and is available for both UNIX and Windows® desktops. It includes the industry standard for 2-D stratigraphic or structural modeling to predict seismic responses for stratigraphic changes or in highly structured areas where steeply dipping reflectors and complex velocity problems mask true bed geometry. As with LogM Advanced Synthetics, you can display the models directly in SeisVision™ to enhance the accuracy and confidence of your geophysical interpretation.

Seismic Processing
Are you dissatisfied with your seismic data? Instead of sending seismic data back to the processor for reprocessing, GeoGraphix provides you with the tools to perform post-stack processing right from your desktop.

SCAN™
SCAN™ technology is an add-on to the processing module, pSTAx®. With SCAN, the geoscientist can readily identify subtle discontinuities in the seismic data that may be related to geologic features. Based on Landmark's PostStack ESPTM™ technology, this tool provides a cost-effective alternative to outsourcing these types of projects.

pStaX
pSTAx® technology eliminates the need to send seismic data back to the processor for reprocessing. Instead, your geoscientists can perform post-stack processing flows directly from the desktop. Integrated with the SeisVision™ interpretation application, we've included all the mainstream post-stack processing functions, such as amplitude scaling, correlations, convolution, filtering, phase rotation and more, to create the ultimate desktop environment for evaluating the effects of new processing flows quickly and easily.

Our Strategy

Our vision is to help our customers optimize production and maximize their return on investment by providing the most comprehensive software solutions on a windows-based platform.

GeoGraphix is built upon these main objectives:

1. Price/Performance	To provide industry leading performance at a cost-effective price point.
2. Integration	Offer a complete integrated and flexible solution where all G&G workflows and project teams can access/leverage the same data.
3. Portability	Abilty to access and interpret data anywhere.

Best printed on legal size paper. | October 24, 2006

Appendix B.

Vibrocore descriptions

Geologisk legende/Geological legend

hl	Postglacial saltvandsler / Postglacial marine clay
hi	Postglacial saltvandssilt /Postglacial marine silt
hs	Postglacial saltvandssand / Postglacial marine sand
hg	Postglacial saltvandsgrus / Postglacial marine gravel
hp	Postglacial saltvandsgytje (inkl. Diatomégytje) / Postglacial marine gytja (incl. Diatom gytja)
ft	Postglacial ferskvandstørv/ Postglacial freshwater peat
ml	Glacial moræneler / Glacial clayey till
mi	Glacial moræneslit / Glacial silty till
oq	Oligocæn sandsten (Øxenrade Sandsten) / Oligocene sandstone (Øxenrade Sandstone)
ll	Eocæn ler, Lillebælt ler, plastisk ler/ Eocene Clay, Lillebælt Clay, Plastic Clay
s	Grus, Sand & Grus / Gravel, Sand & Gravel
g	Grus / Gravel

BORERAPPORT DGU arkivnr: 550915.117

Borested : Lillebælt, Fænø Sund

Projekt Nr.: 10230

Kommune :
Region :

Boringsdato : 4/5 2010 **Boringsdybde** : 1,75 meter **Terrænkote** : 20 meter u. DNN

Brøndborer : Danmarks Geologiske Undersøgelse
MOB-nr :
BB-journr :
BB-bornr : LB1A

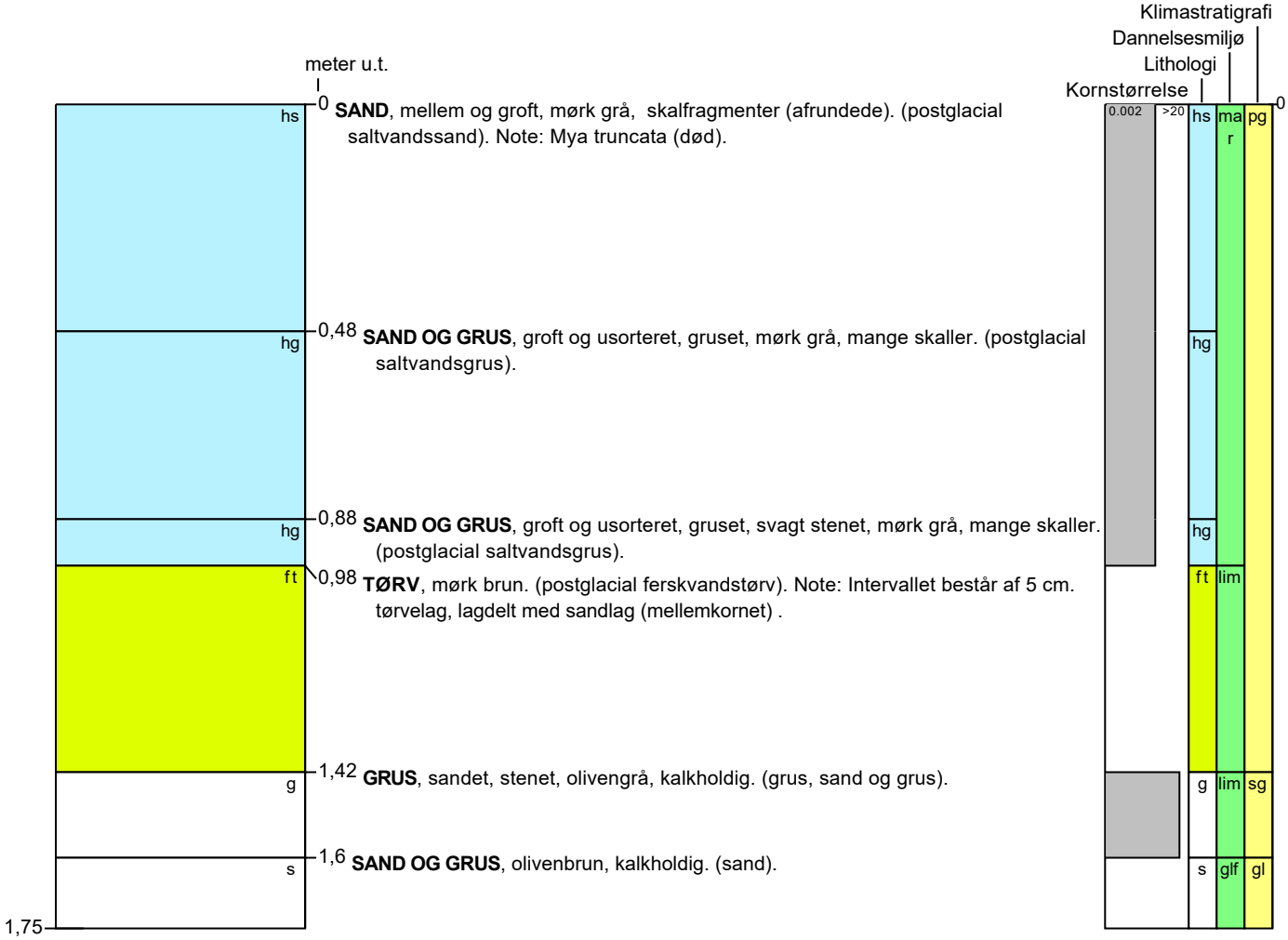
Prøver
- modtaget :
- beskrevet : 21/5 2010
- antal gemt : 0

Formål : Marin geoteknisk
Anvendelse :
Boremetode :

Kortblad : 1213 IINV
UTM-zone : 32
UTM-koord. : 542643, 6153328

Datum : WGS84
Koordinatkilde : GEUS
Koordinatmetode :

Notater : Boringen er beskrevet af Birger Larsen - GEUS



Aflejringsmiljø - Alder **(klima-, krono-, litho-, biostratigrafi)**

meter u.t.

0 - 0,98 marin - postglacial
0,98 - 1,42 limnisk - postglacial
1,42 - 1,6 limnisk? - senglacial?
1,6 - 1,75 glaciofluvial? - glacial?

BORERAPPORT DGU arkivnr: 550915.118

Borested : Lillebælt, Fænø Sund

Projekt Nr.: 10230

Kommune :
Region :

Boringsdato : 4/5 2010 **Boringsdybde** : 1,62 meter **Terrænkote** : 35 meter u. DNN

Brøndborer : Danmarks Geologiske Undersøgelse
MOB-nr :
BB-journr :
BB-bornr : LB2A

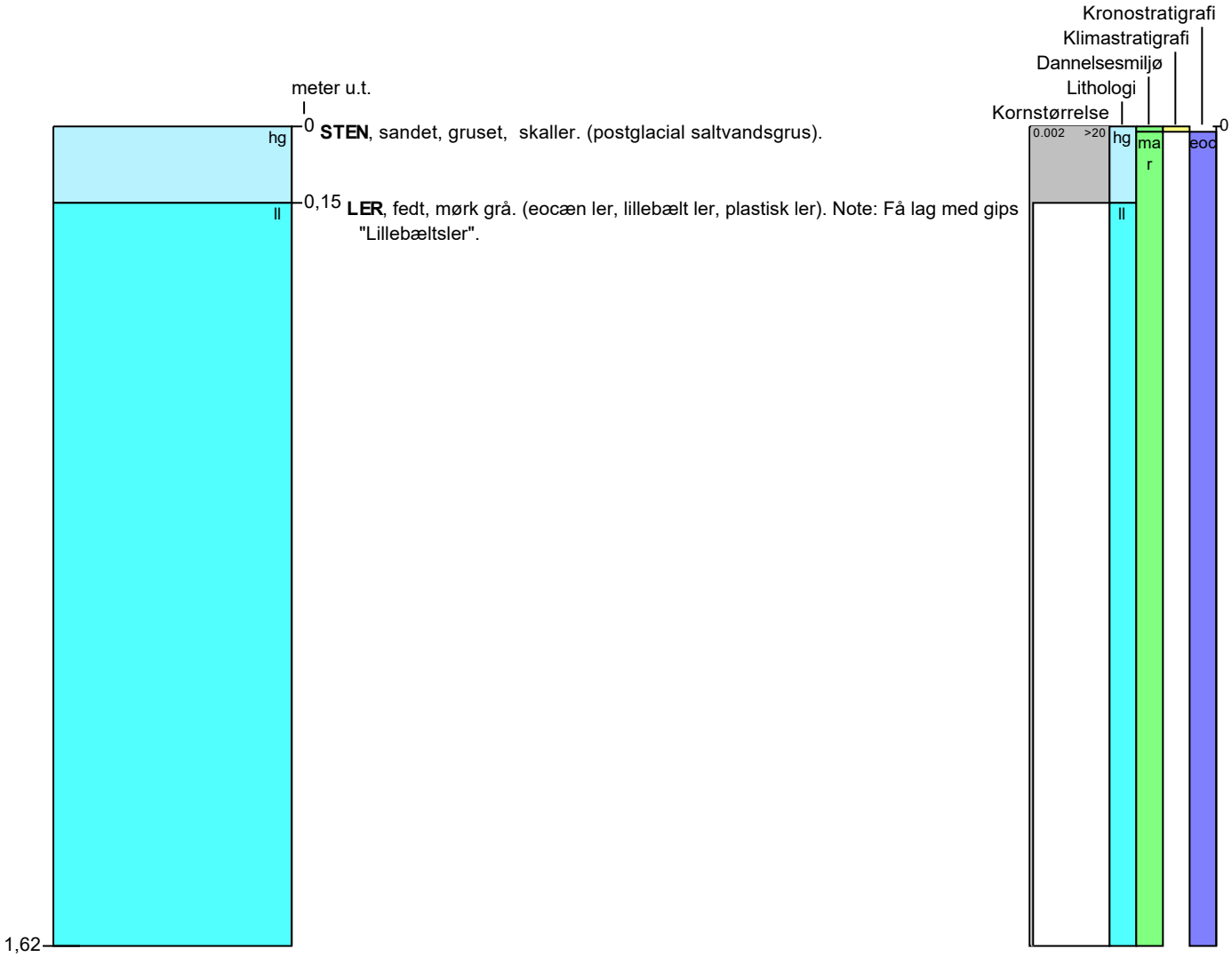
Prøver
- modtaget :
- beskrevet : 21/5 2010
- antal gemt : 0

Formål : Marin geoteknisk
Anvendelse :
Boremetode :

Kortblad : 1213 IINV
UTM-zone : 32
UTM-koord. : 542763, 6153160

Datum : WGS84
Koordinatkilde : GEUS
Koordinatmetode :

Notater : Boringen er beskrevet af Birger Larsen - GEUS



Aflejringsmiljø - Alder **(klima-, krono-, litho-, biostratigrafi)**

meter u.t.			
0	-	0,01	marin - postglacial
0,01	-	1,62	marin - eocæn

BORERAPPORT DGU arkivnr: 550915.119

Borested : Lillebælt, Fænø Sund

Projekt Nr.: 10230

Kommune :
Region :

Boringsdato : 4/5 2010 **Boringsdybde** : 1,9 meter **Terrænkote** : 24 meter u. DNN

Brøndborer : Danmarks Geologiske Undersøgelse
MOB-nr :
BB-journr :
BB-bornr : LB3A

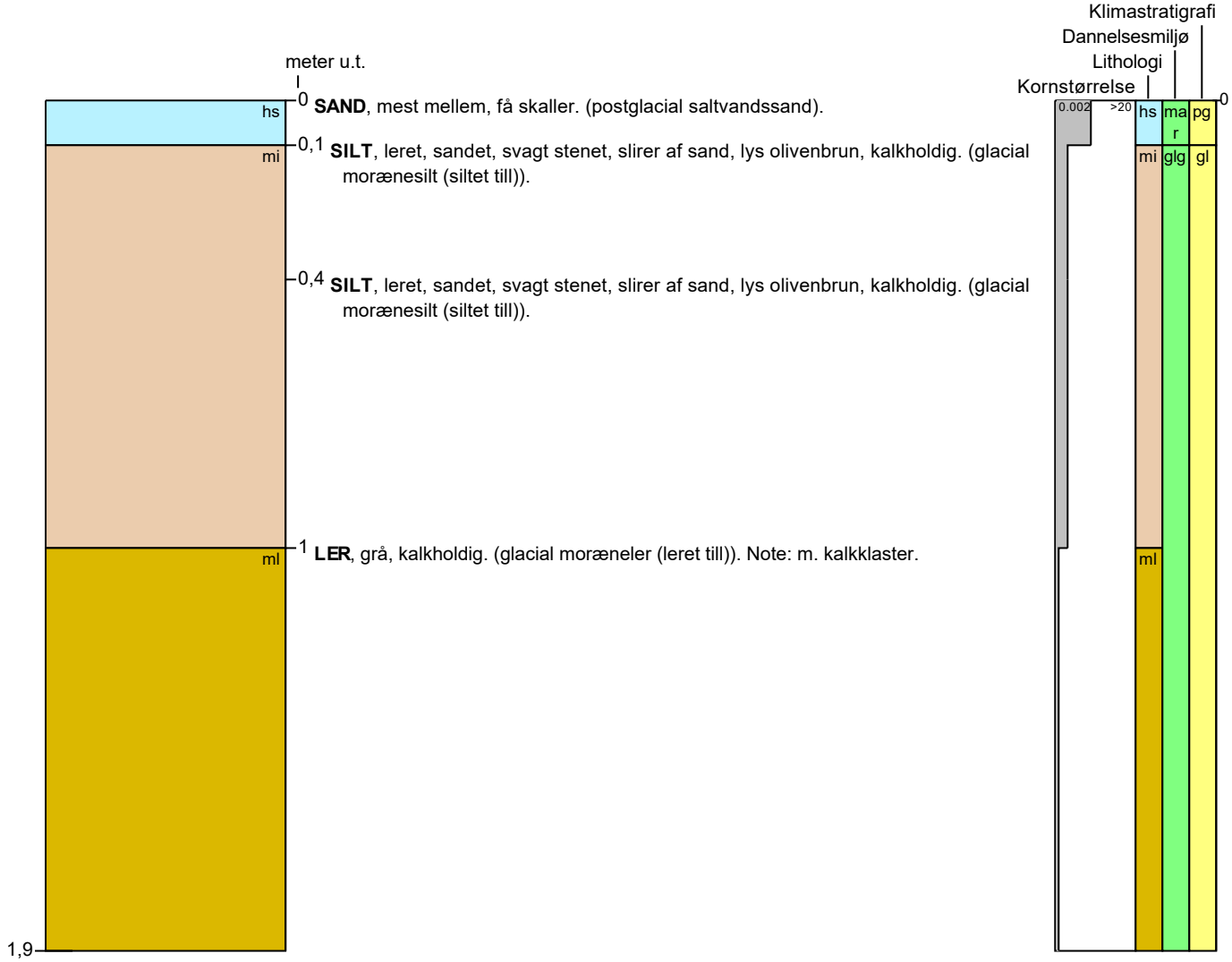
Prøver
- modtaget :
- beskrevet : 21/5 2010
- antal gemt : 0

Formål : Marin geoteknisk
Anvendelse :
Boremetode :

Kortblad : 1213 IINV
UTM-zone : 32
UTM-koord. : 542499, 6152059

Datum : WGS84
Koordinatkilde : GEUS
Koordinatmetode :

Notater : Boringen er beskrevet af Birger Larsen - GEUS



Aflejringsmiljø - Alder **(klima-, krono-, litho-, biostratigrafi)**

meter u.t.			
0	-	0,1	marin - postglacial
0,1	-	1,9	glacigen - glacial

BORERAPPORT DGU arkivnr: 550919. 17

Borested : Lillebælt, Fænø Sund

Projekt Nr.: 10230

Kommune :
Region :

Boringsdato : 4/5 2010 **Boringsdybde** : 1,92 meter **Terrænkote** : 22 meter u. DNN

Brøndborer : Danmarks Geologiske Undersøgelse
MOB-nr :
BB-journr :
BB-bornr : LB4A

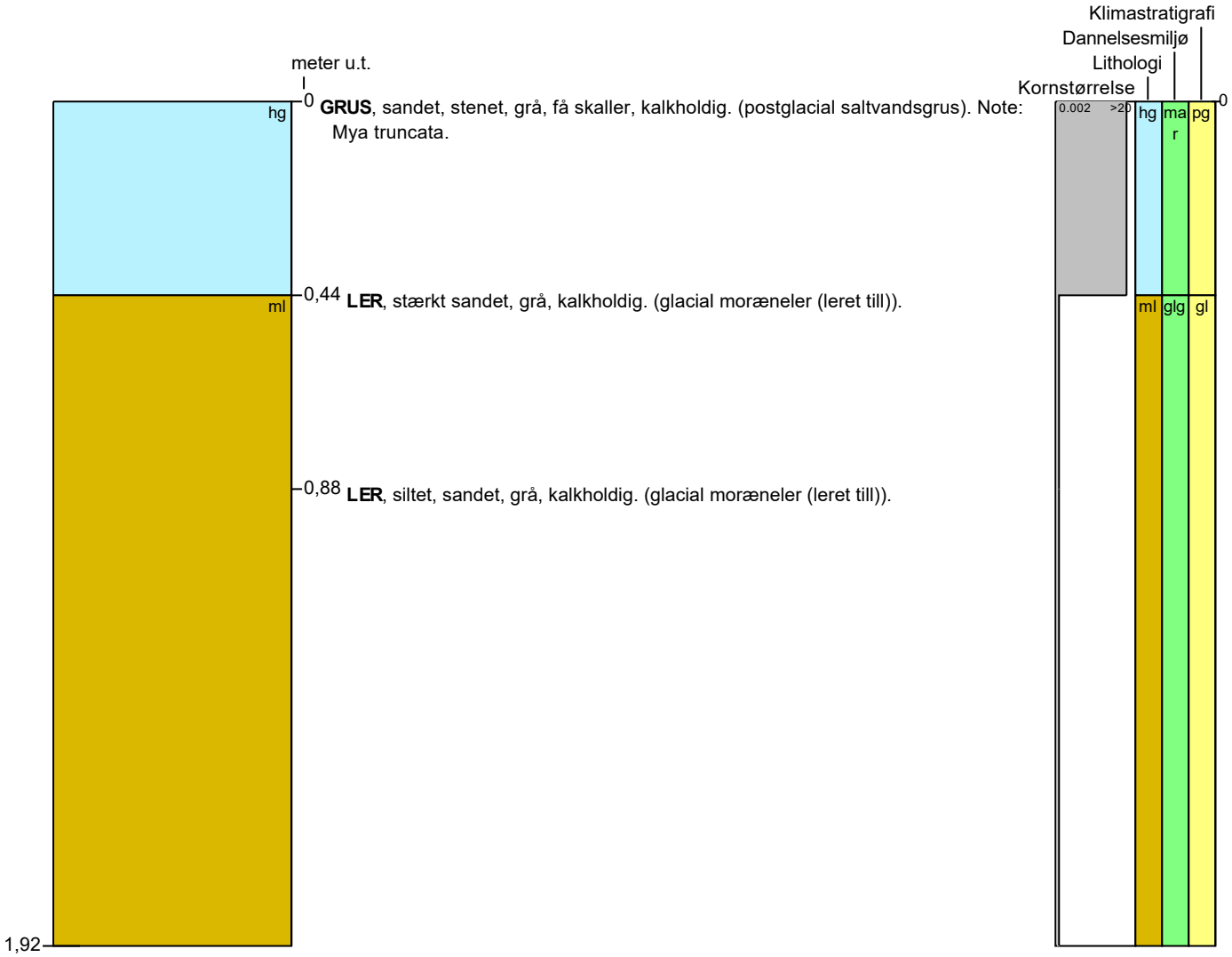
Prøver
- modtaget :
- beskrevet : 21/5 2010
- antal gemt : 0

Formål : Marin geoteknisk
Anvendelse :
Boremetode :

Kortblad : 1213 IISV
UTM-zone : 32
UTM-koord. : 543952, 6150472

Datum : WGS84
Koordinatkilde : GEUS
Koordinatmetode :

Notater : Boringen er beskrevet af Birger Larsen - GEUS



Aflejringsmiljø - Alder **(klima-, krono-, litho-, biostratigrafi)**

meter u.t.			
0	-	0,44	marin - postglacial
0,44	-	1,92	glacigen - glacial

BORERAPPORT DGU arkivnr: 550919. 18

Borested : Lillebælt, Fænø Sund

Projekt Nr.: 10230

Kommune :
Region :

Boringsdato : 4/5 2010 **Boringsdybde** : 2,25 meter **Terrænkote** : 18 meter u. DNN

Brøndborer : Danmarks Geologiske Undersøgelse
MOB-nr :
BB-journr :
BB-bornr : LB5A

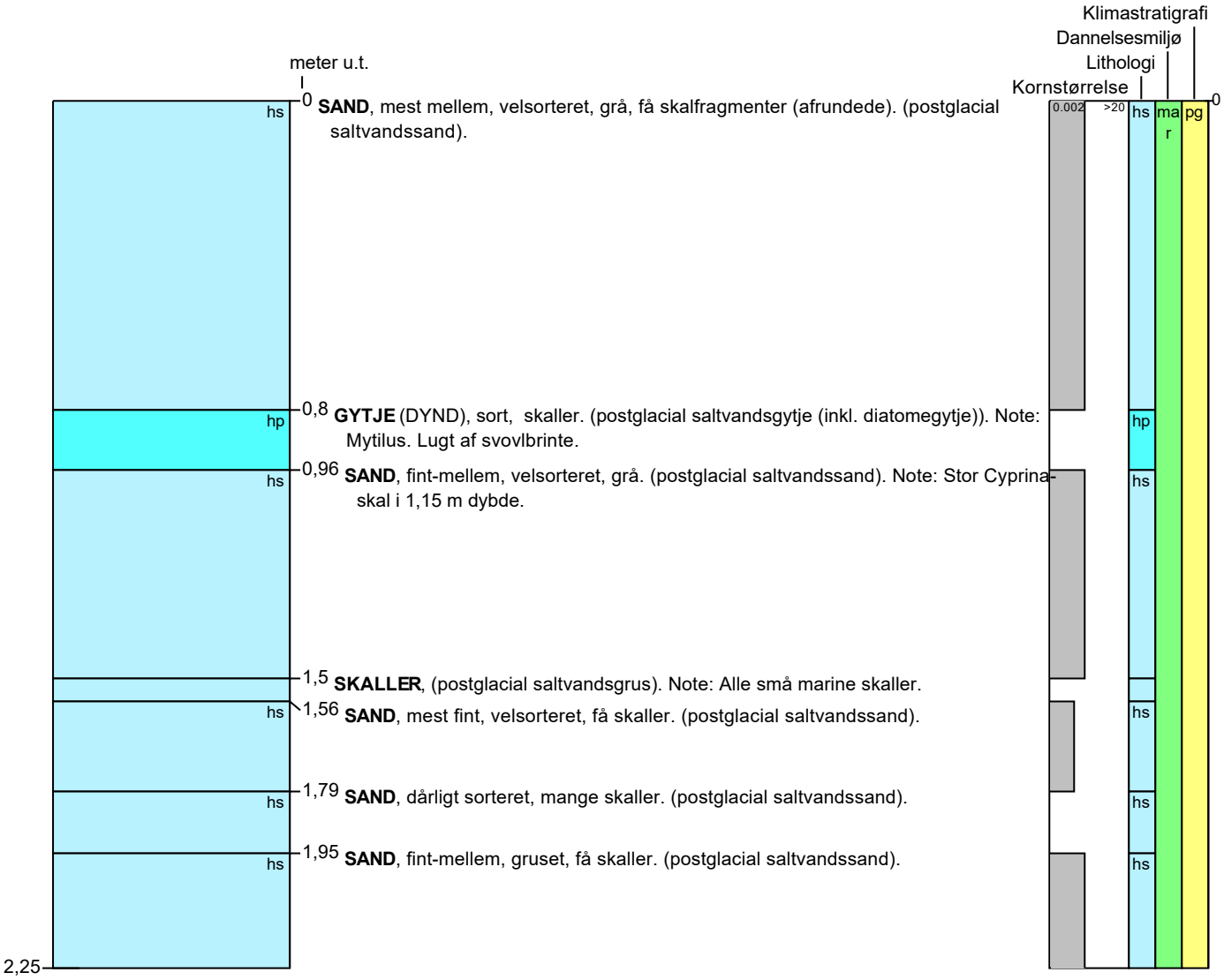
Prøver
- modtaget :
- beskrevet : 21/5 2010
- antal gemt : 0

Formål : Marin geoteknisk
Anvendelse :
Boremetode :

Kortblad : 1213 IISØ
UTM-zone : 32
UTM-koord. : 545509, 6149387

Datum : WGS84
Koordinatkilde : GEUS
Koordinatmetode :

Notater : Boringen er beskrevet af Birger Larsen - GEUS



Aflejringsmiljø - Alder **(klima-, krono-, litho-, biostratigrafi)**

meter u.t.

0 - 2,25 marin - postglacial

BORERAPPORT

DGU arkivnr: 550915.120

Borested : Lillebælt, Fænø Sund

Lillebælt Cable Project, Projekt nr. 10230

Kommune :
Region :

Boringsdato : 15/11 2010 **Boringsdybde** : 2,75 meter **Terrænkote** : 18 meter u. DNN

Brøndborer : Danmarks Geologiske Undersøgelse
MOB-nr :
BB-journr :
BB-bornr : LB6-B

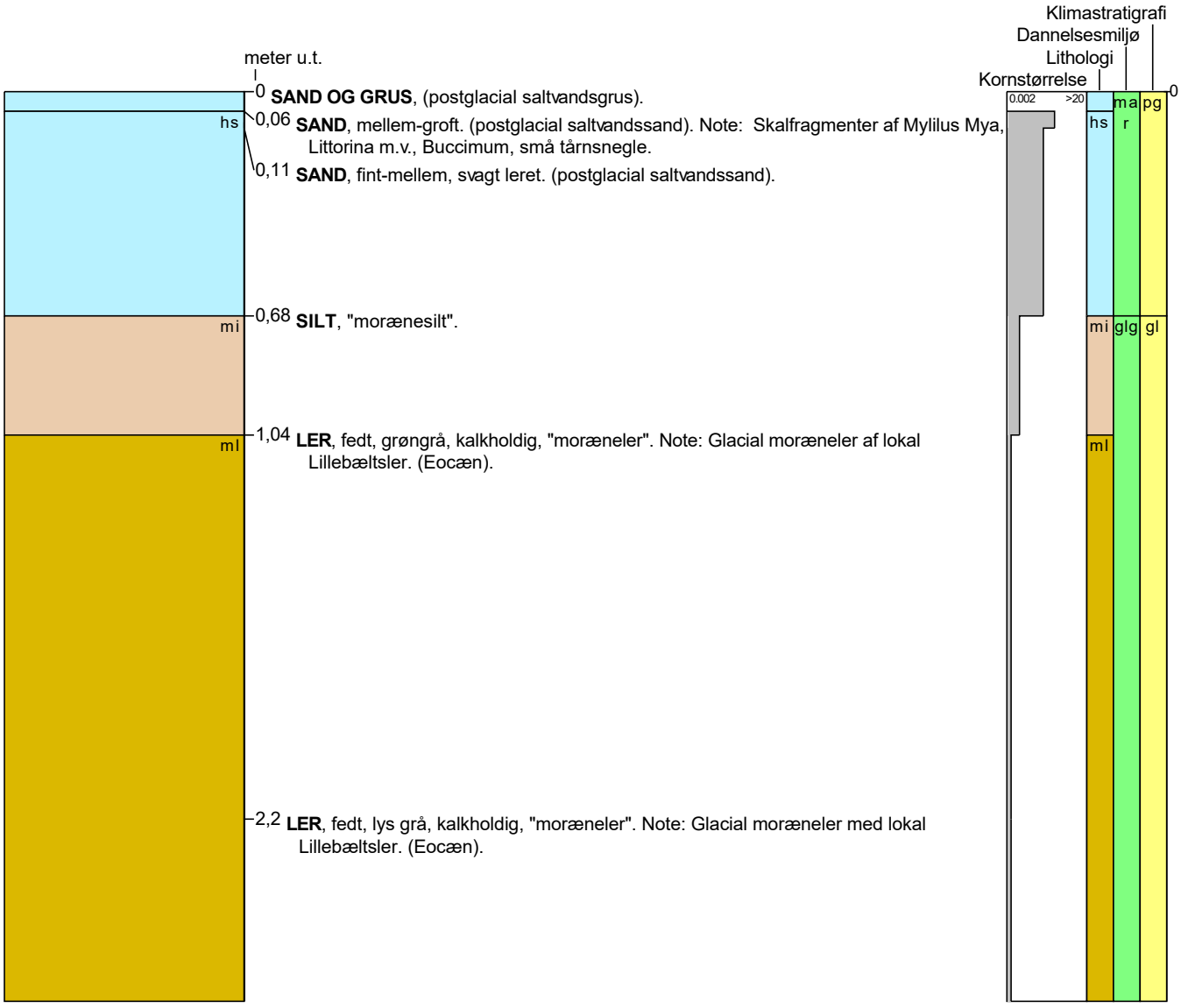
Prøver
- modtaget :
- beskrevet :
- antal gemt : 0

Formål : Marin geoteknisk
Anvendelse :
Boremetode : Vibrocore

Kortblad : 1213 IINV
UTM-zone : 32
UTM-koord. : 542708, 6151408

Datum : WGS84
Koordinatkilde : GEUS
Koordinatmetode :

Notater : Beskrevet af Birger Larsen



Aflejringsmiljø - Alder **(klima-, krono-, litho-, biostratigrafi)**

meter u.t.

0 - 0,68 marin - postglacial
0,68 - 2,75 glacigen - glacial

BORERAPPORT

DGU arkivnr: 550919. 19

Borested : Lillebælt, Fænø Sund

Lillebælt Cable Project, Projekt nr. 10230

Kommune :
Region :

Boringsdato : 15/11 2010 **Boringsdybde** : 3,56 meter **Terrænkote** : 27 meter u. DNN

Brøndborer : Danmarks Geologiske Undersøgelse
MOB-nr :
BB-journr :
BB-bornr : LB7-A

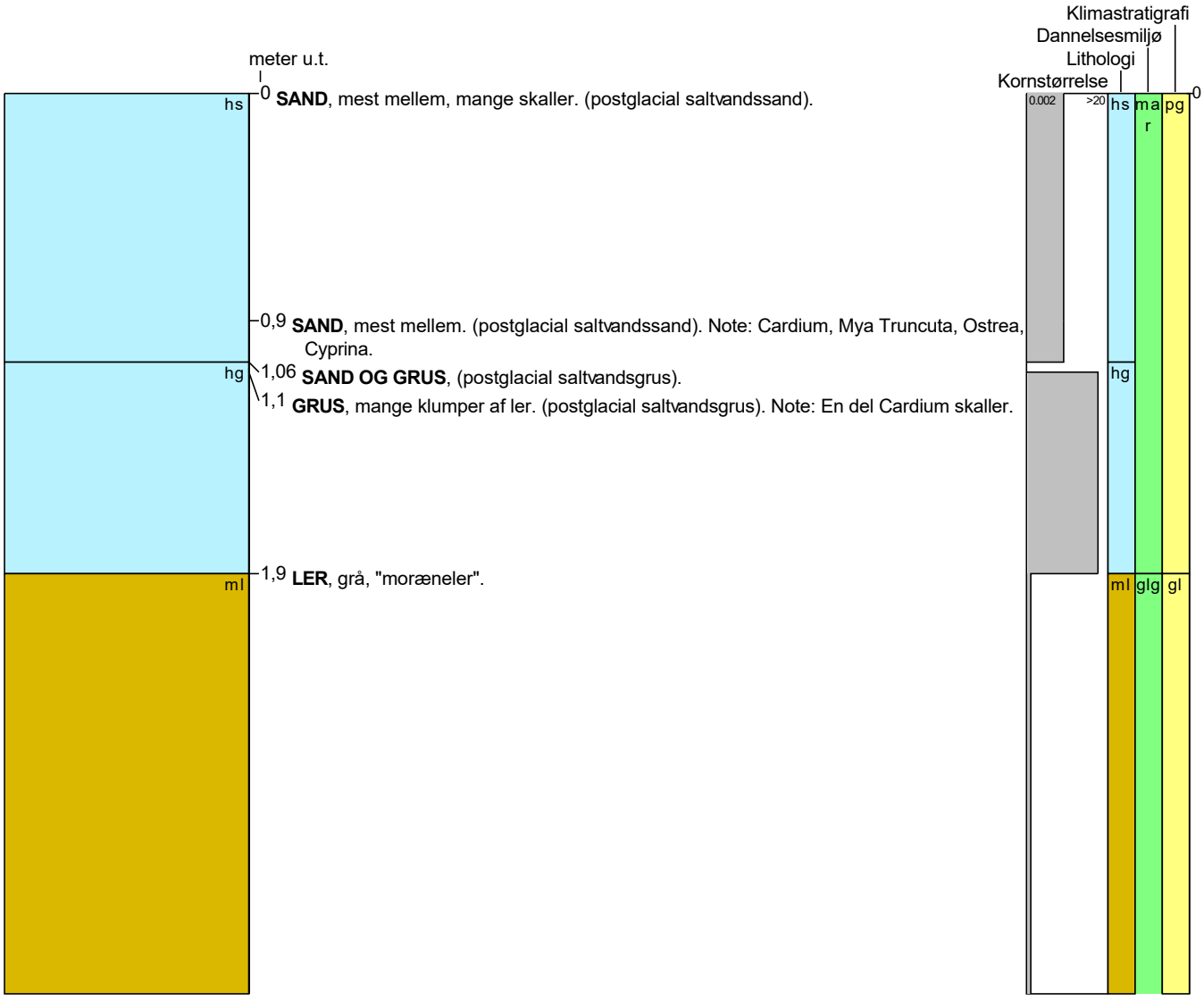
Prøver
- modtaget :
- beskrevet :
- antal gemt : 0

Formål : Marin geoteknisk
Anvendelse :
Boremetode : Vibrocore

Kortblad : 1213 IISV
UTM-zone : 32
UTM-koord. : 544478, 6149703

Datum : WGS84
Koordinatkilde : GEUS
Koordinatmetode :

Notater : Beskrevet af Birger Larsen



Aflejringsmiljø - Alder **(klima-, krono-, litho-, biostratigrafi)**

meter u.t.

0	-	1,9	marin - postglacial
1,9	-	3,56	glacigen - glacial
3,56	-	5,56	glacigen

BORERAPPORT

DGU arkivnr: 550919. 20

Borested : Lillebælt, Fænø Sund

Lillebælt Cable Project, Projekt nr. 10230

Kommune :
Region :

Boringsdato : 15/11 2010 **Boringsdybde** : 3,5 meter **Terrænkote** : 21 meter u. DNN

Brøndborer : Danmarks Geologiske Undersøgelse
MOB-nr :
BB-journr :
BB-bornr : LB8-B

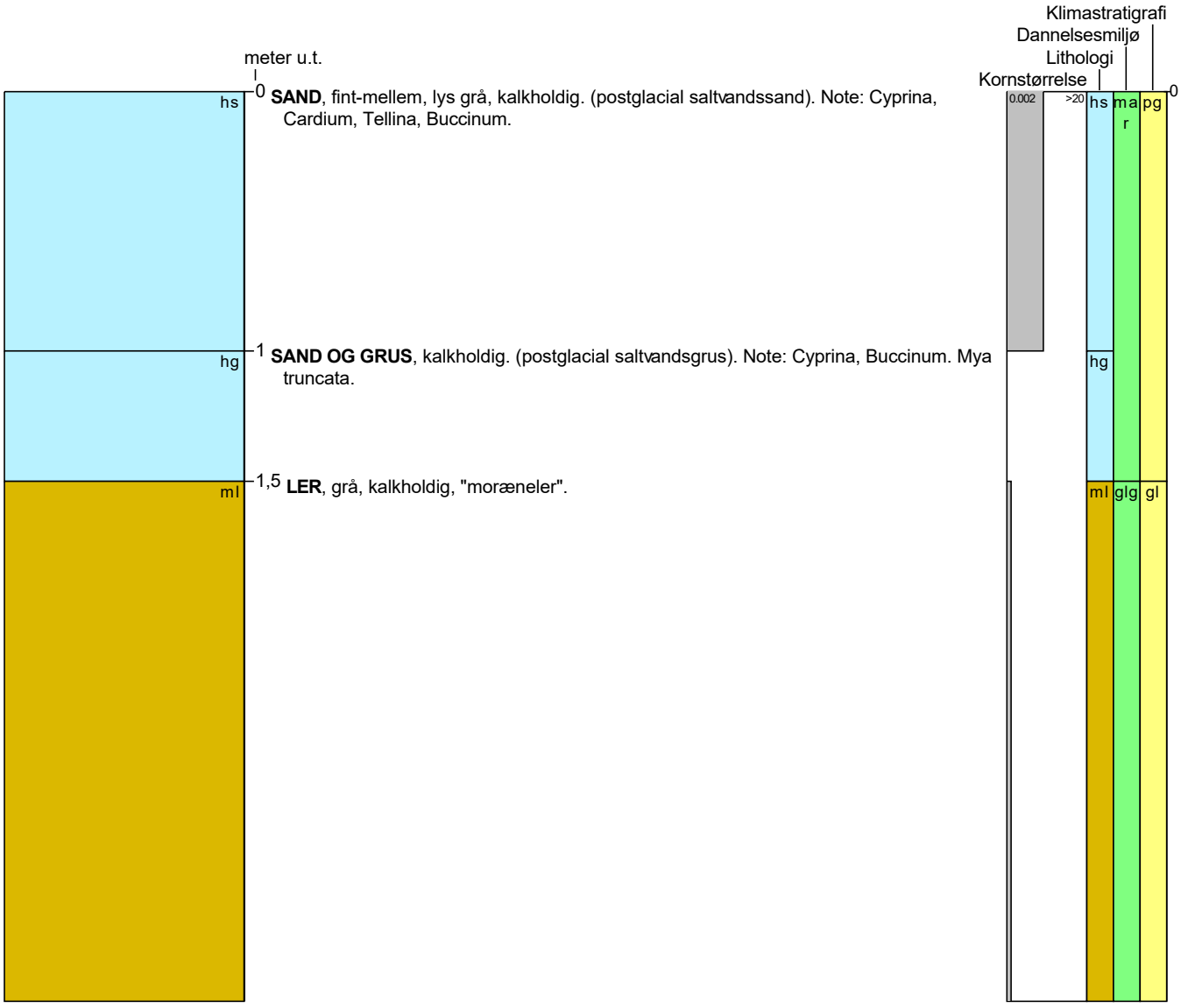
Prøver
- modtaget :
- beskrevet :
- antal gemt : 0

Formål : Marin geoteknisk
Anvendelse :
Boremetode : Vibrocore

Kortblad : 1213 IISØ
UTM-zone : 32
UTM-koord. : 544945, 6149510

Datum : WGS84
Koordinatkilde : GEUS
Koordinatmetode :

Notater : Beskrevet af Birger Larsen



Aflejringsmiljø - Alder **(klima-, krono-, litho-, biostratigrafi)**

meter u.t.

0 - 1,5 marin - postglacial
1,5 - 3,5 glacigen - glacial

BORERAPPORT

DGU arkivnr: 550915.121

Borested : Lillebælt

Lillebælt Cable Project, Projekt nr. 10230

Kommune :
Region :

Boringsdato : 14/11 2010 **Boringsdybde** : 2 meter **Terrænkote** : 21 meter u. DNN

Brøndborer : Danmarks Geologiske Undersøgelse
MOB-nr :
BB-journr :
BB-bornr : LB10-A

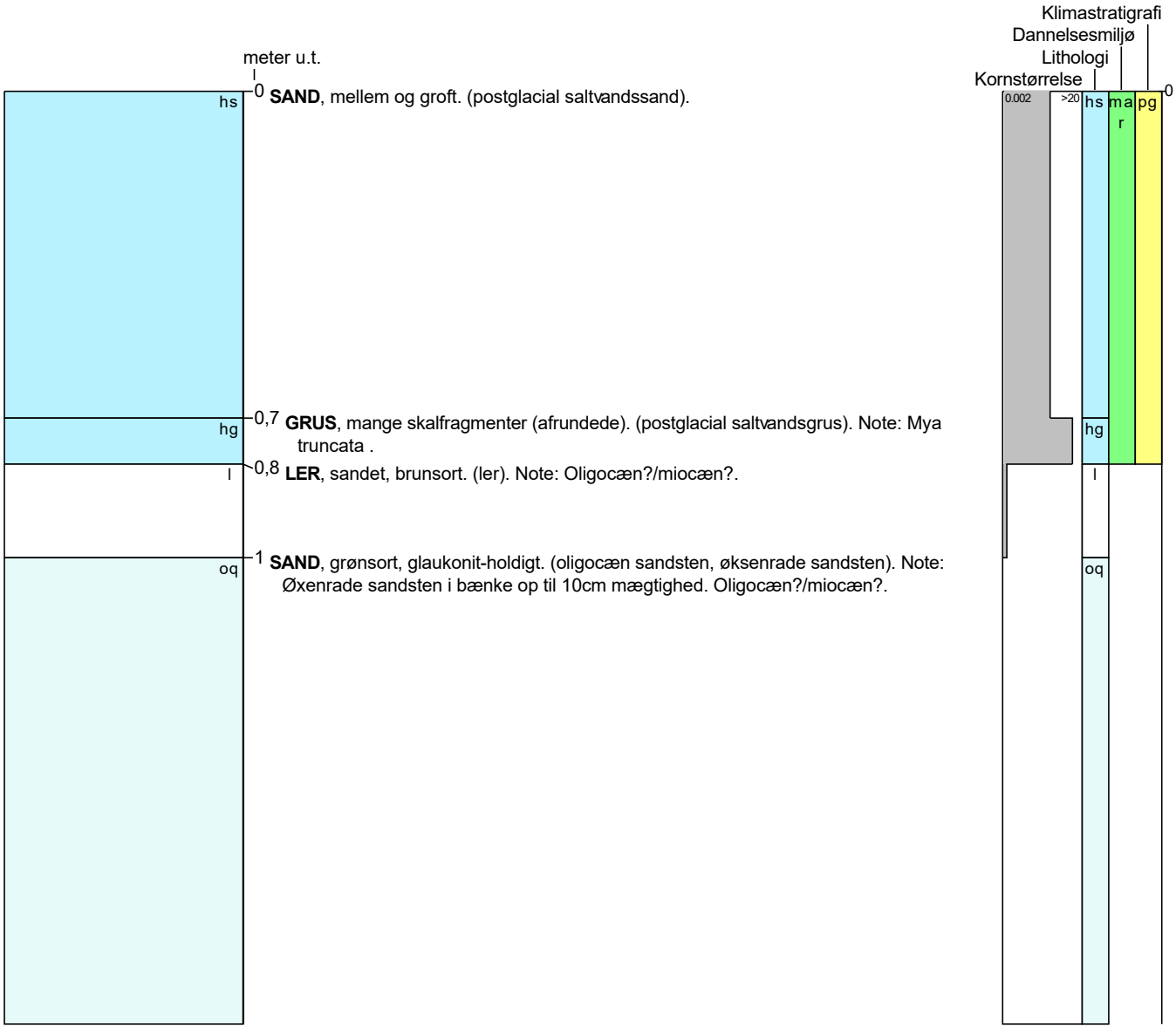
Prøver
- modtaget :
- beskrevet :
- antal gemt : 0

Formål : Marin geoteknisk
Anvendelse :
Boremetode : Vibrocore

Kortblad : 1213 IINV
UTM-zone : 32
UTM-koord. : 542126, 6152984

Datum : WGS84
Koordinatkilde : GEUS
Koordinatmetode :

Notater : Beskrevet af Birger Larsen



Aflejringsmiljø - Alder **(klima-, krono-, litho-, biostratigrafi)**

meter u.t.

0 - 0,8 marin - postglacial

BORERAPPORT

DGU arkivnr: 550915.122

Borested : Lillebælt

Lillebælt Cable Project, Projekt nr. 10230

Kommune :
Region :

Boringsdato : 14/11 2010 **Boringsdybde** : 2 meter **Terrænkote** : 13,5 meter u. DNN

Brøndborer : Danmarks Geologiske Undersøgelse
MOB-nr :
BB-journr :
BB-bornr : LB11-A

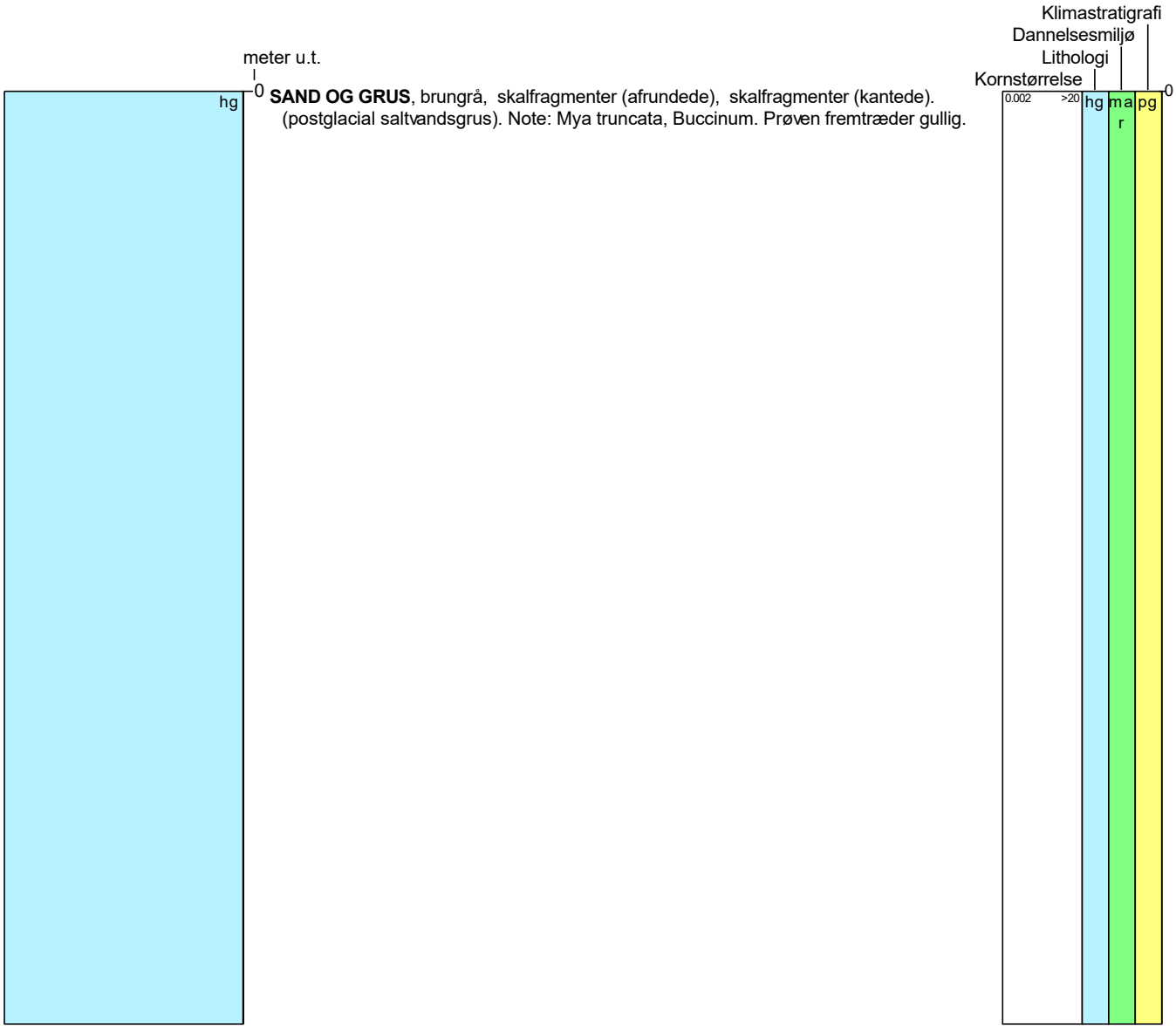
Prøver
- modtaget :
- beskrevet :
- antal gemt : 0

Formål : Marin geoteknisk
Anvendelse :
Boremetode : Vibrocore

Kortblad : 1213 IINV
UTM-zone : 32
UTM-koord. : 542372, 6152437

Datum : WGS84
Koordinatkilde : GEUS
Koordinatmetode :

Notater : Beskrevet af Birger Larsen



Aflejringsmiljø - Alder **(klima-, krono-, litho-, biostratigrafi)**

meter u.t.

0 - 2 marin - postglacial

Appendix C.

Alignment sheets:

- Corridor A (chart 01 to 09)
- Corridor B (chart 01 to 02)

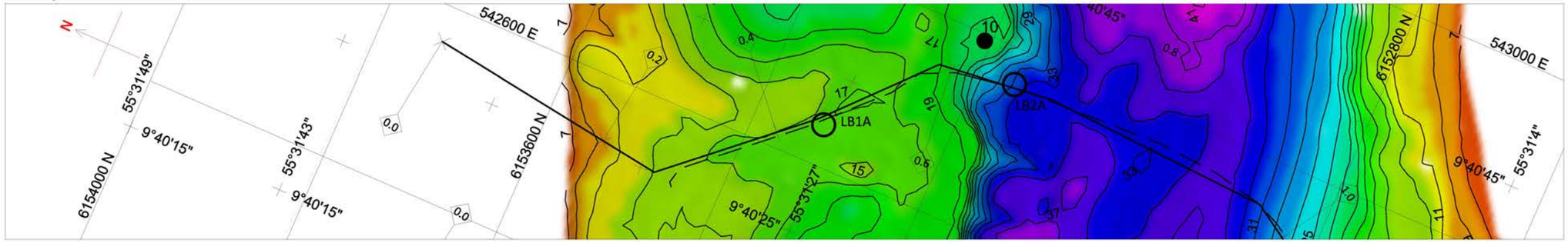
Appendix C.

Alignment sheets:

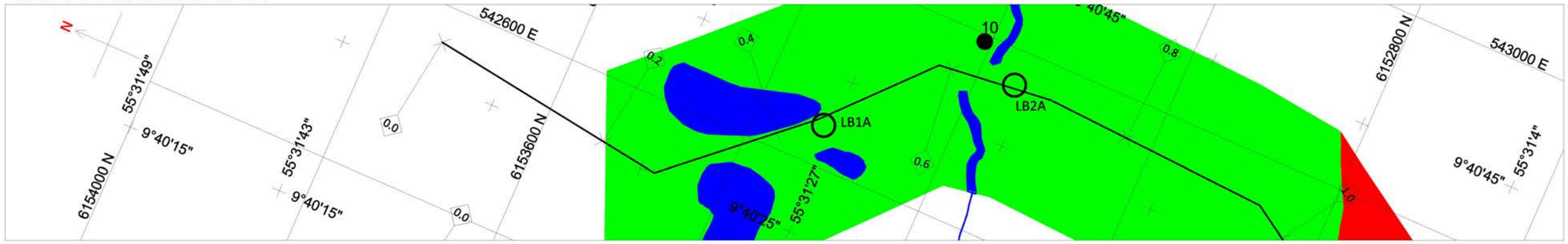
- Corridor A (chart 01 to 09)
- Corridor B (chart 01 to 02)

Lillebaelt Corridor Cable

Bathymetric Chart

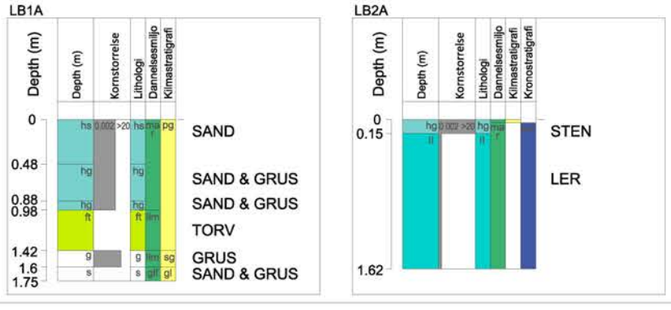


Side Scan Observation Chart



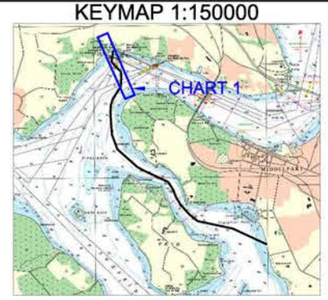
Profile Chart

CPT / Vibrocore Profile



As laid / Service Chart

KEYMAP 1:150000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth curves (5m to 41m)
- Track of depicted profile
- Indicates Cable Length (x.x) in km from start

COLOUR CODES:

-42.5 -40 -37.5 -35 -32.5 -30 -27.5 -25 -22.5 -20 -17.5 -15 -12.5 -10 -7.5 -5
Seabed level (m)

SIDE SCAN CHART:
- Sand_featureless
- Sand_ripples
- Sand_megaripples
- Sand_gravel_few stones
- Residual sediment_Till
- Prequaternary bedrock
- Boulders > 1m, ID
- CABLE w. KP VALUES
- Vibrocores, ID
- Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Glacial
- Top Prequaternary

NOTES:

NAVIGATIONAL SYSTEMS
Primary system : SAGITTA (DGPS)
Secondary system : Furuno (ship GPS)
Gyro/HPR Sensor : Seatex MRUS (MV Madog, 2010/05)
: Robertson (MV Laura, 2010/11)

ACOUSTIC SYSTEMS
Echosounder : Single beam Reson Navisound 215
: Multi beam Bathymetry from Energinet.dk (CT Offshore Survey for Energinet.dk, 2009/12)
Side Scan Sonar : Teledyne Benthos SIS-1625/TTV290 Tow fish
Chirp : Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker : GEO-Spark 200
Magnetometer : Geometrics G-882

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LILLEBAELT CABLE CORRIDOR ROUTE SURVEY
MAY AND NOVEMBER 2010

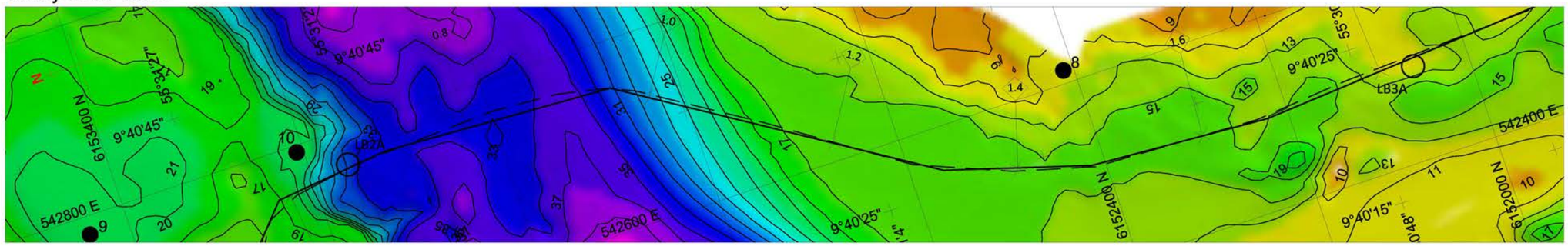
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	FOR CLIENTS APPROVAL & DISTRIBUTION	RADK	NNP	KAE	17-03-11
C	FOR CLIENTS COMMENT	RADK	NNP	KAE	04-03-11
B	FOR INTERNAL QC	RADK	ADEA	TEB	02-03-11
A	EMPTY CHART	RADK	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation chart, Profile Chart, CPT/VC Chart and As Laid - Chart 01 of 09.
Scale (A3 paper) 1:5000

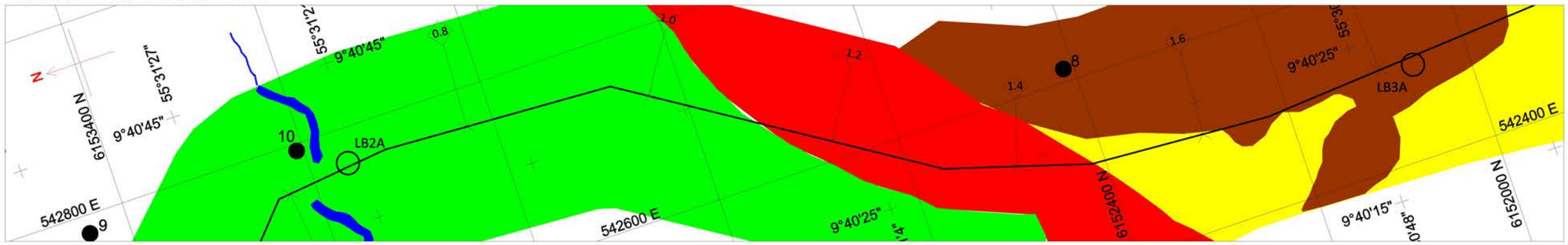
Drawn RADK	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Geo Job No. XXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Lillebaelt Corridor Cable

Bathymetric Chart

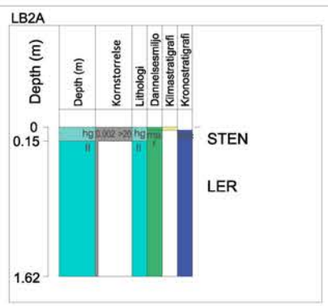


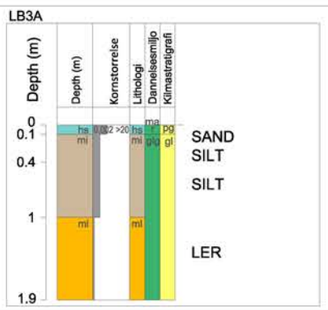
Side Scan Observation Chart



Profile Chart

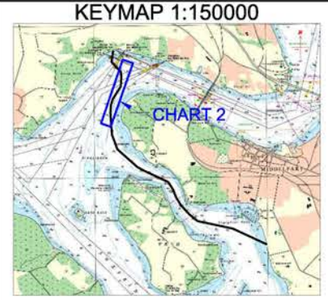
CPT / Vibrocore Profile





As laid / Service Chart

KEYMAP 1:150000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth curves (5m to 41m)
- Track of depicted profile
- Indicates Cable Length (x.x) in km from start

COLOUR CODES:

-42.5 -40 -37.5 -35 -32.5 -30 -27.5 -25 -22.5 -20 -17.5 -15 -12.5 -10 -7.5 -5
Seabed level (m)

SIDE SCAN CHART:
- Sand_featureless
- Sand_ripples
- Sand_megaripples
- Sand_gravel_few stones
- Residual sediment_Till
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- CABLE w. KP VALUES
- Vibrocores, ID
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PROFILE CHART
- Seabed
- Top Glacial
- Top Prequaternary

NOTES:

NAVIGATIONAL SYSTEMS

Primary system	: SAGITTA (DGPS)
Secondary system	: Furuno (ship GPS)
Gyro/HPR Sensor	: Seatex MRUS (MV Madog, 2010/05)
	: Robertson (MV Laura, 2010/11)

ACOUSTIC SYSTEMS

Echosounder	: Single beam Reson Navisound 215
	: Multi beam Bathymetry from Energinet.dk (CT Offshore Survey for Energinet.dk, 2009/12)
Side Scan Sonar	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Chirp	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker	: GEO-Spark 200
Magnetometer	: Geometrics G-882

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LILLEBAELT CABLE CORRIDOR ROUTE SURVEY
MAY AND NOVEMBER 2010

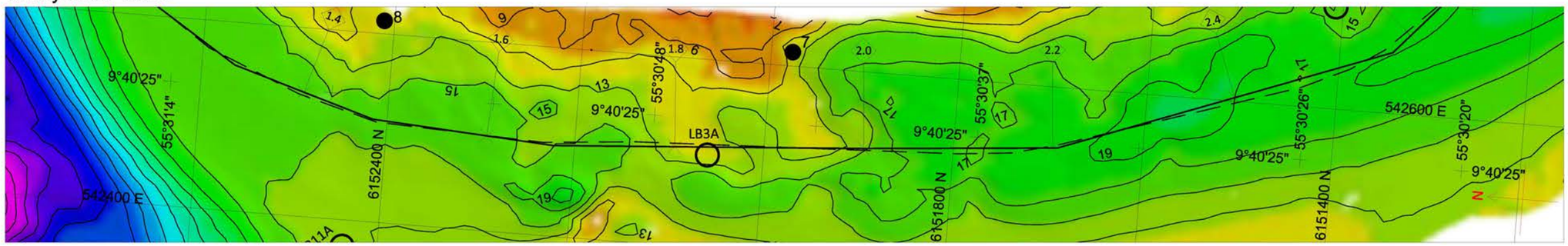
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	FOR CLIENTS APPROVAL & DISTRIBUTION	RADK	NNP	KAE	17-03-11
C	FOR CLIENTS COMMENT	RADK	NNP	KAE	04-03-11
B	FOR INTERNAL QC	RADK	ADEA	TEB	02-03-11
A	EMPTY CHART	RADK	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation chart, Profile Chart, CPT/VC Chart and As Laid - Chart 02 of 09.
Scale (A3 paper) 1:5000

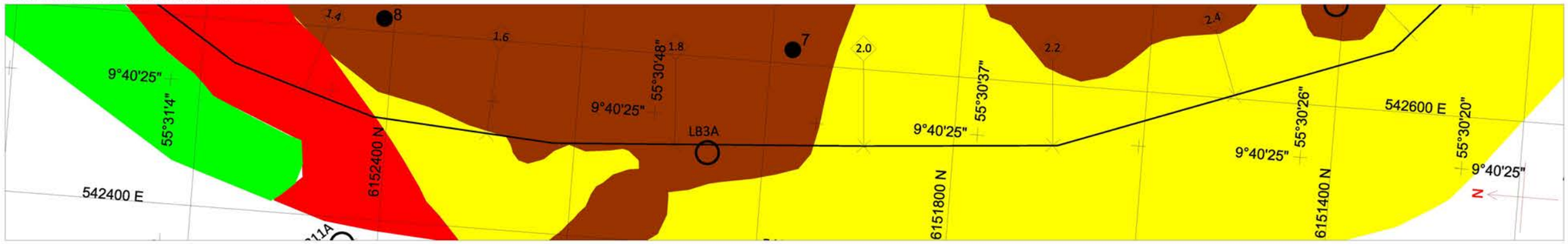
Drawn	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Lillebaelt Corridor Cable

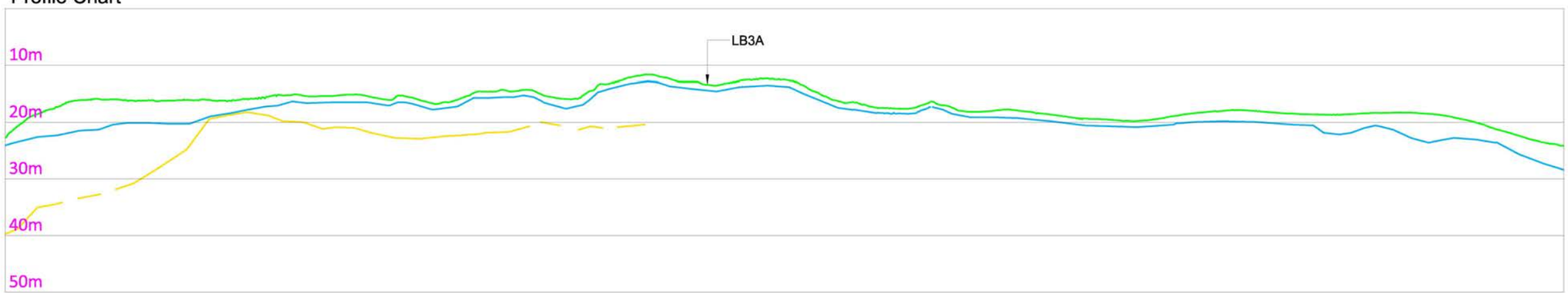
Bathymetric Chart



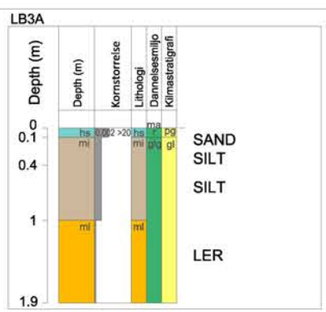
Side Scan Observation Chart



Profile Chart

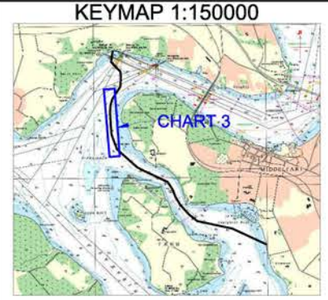


CPT / Vibrocore Profile



As laid / Service Chart

KEYMAP 1:150000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth curves (5m to 41m)
- Track of depicted profile
- Indicates Cable Length (x.x) in km from start

COLOUR CODES:

-42.5 -40 -37.5 -35 -32.5 -30 -27.5 -25 -22.5 -20 -17.5 -15 -12.5 -10 -7.5 -5
Seabed level (m)

SIDE SCAN CHART:
- Sand_featureless
- Sand_ripples
- Sand_megaripples
- Sand_gravel_few stones
- Residual sediment_Till
- Prequaternary bedrock
- Boulders > 1m, ID
- CABLE w. KP VALUES
- Vibrocores, ID
- Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Glacial
- Top Prequaternary

NOTES:

NAVIGATIONAL SYSTEMS

Primary system : SAGITTA (DGPS)
Secondary system : Furuno (ship GPS)
Gyro/HPR Sensor : Seatex MRUS (MV Madog, 2010/05)
: Robertson (MV Laura, 2010/11)

ACOUSTIC SYSTEMS

Echosounder : Single beam Reson Navisound 215
: Multi beam Bathymetry from Energinet.dk (CT Offshore Survey for Energinet.dk, 2009/12)
Side Scan Sonar : Teledyne Benthos SIS-1625/TTV290 Tow fish
Chirp : Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker : GEO-Spark 200
Magnetometer : Geometrics G-882

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LILLEBAELT CABLE CORRIDOR ROUTE SURVEY
MAY AND NOVEMBER 2010

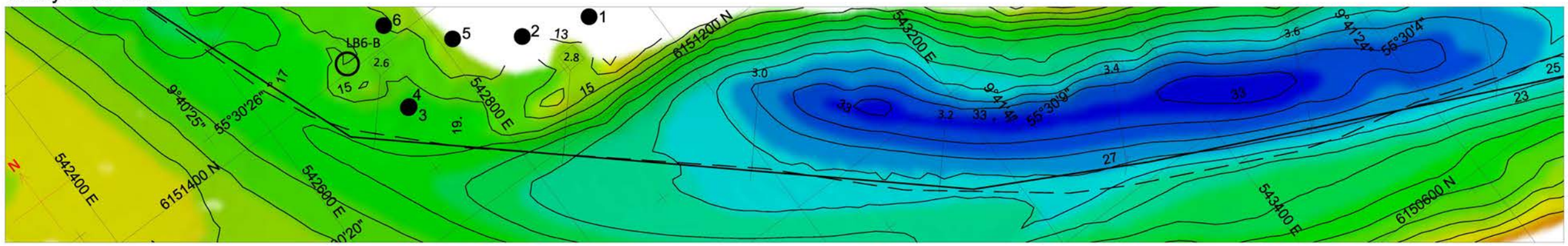
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	FOR CLIENTS APPROVAL & DISTRIBUTION	RADK	NNP	KAE	17-03-11
C	FOR CLIENTS COMMENT	RADK	NNP	KAE	04-03-11
B	FOR INTERNAL QC	RADK	ADEA	TEB	02-03-11
A	EMPTY CHART	RADK	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation chart, Profile Chart, CPT/VC Chart and As Laid - Chart 03 of 09.
Scale (A3 paper) 1:5000

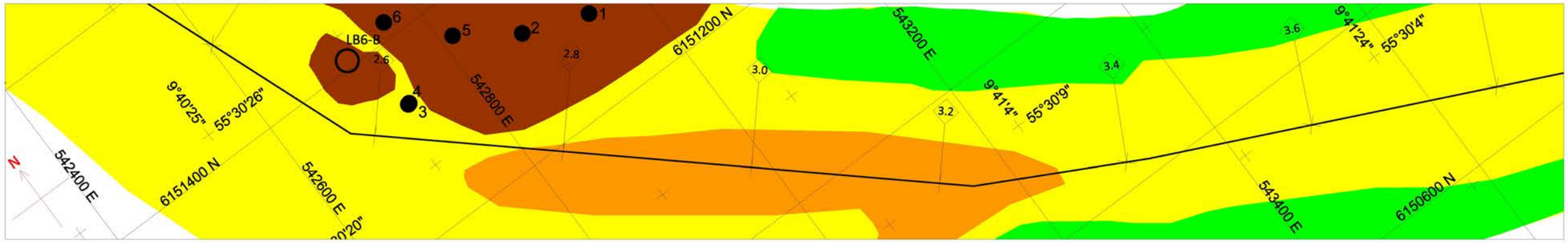
Drawn RADK	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Lillebaelt Corridor Cable

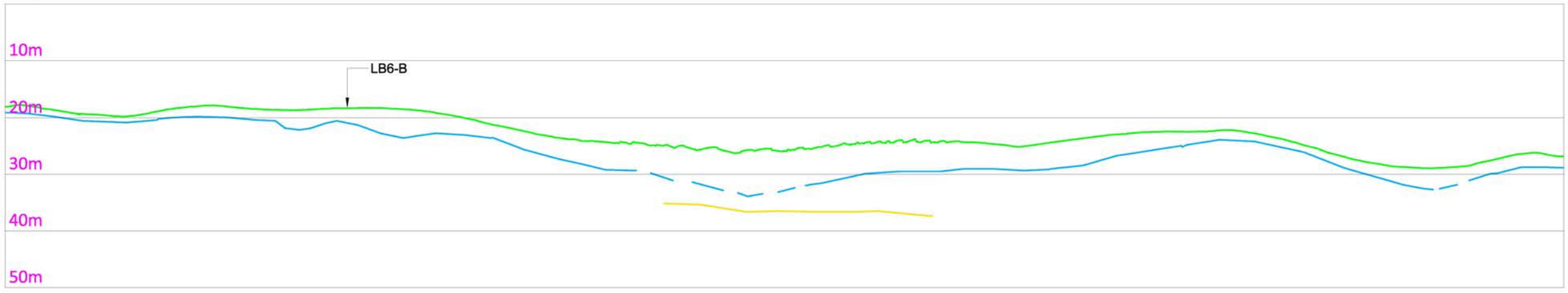
Bathymetric Chart



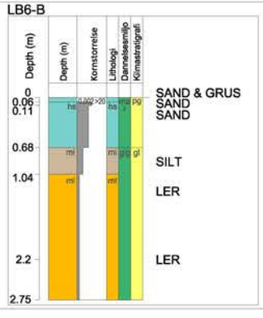
Side Scan Observation Chart



Profile Chart

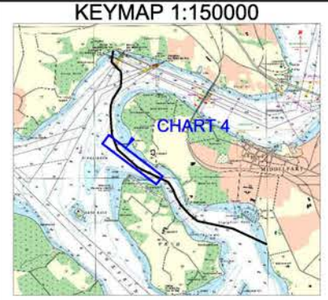


CPT / Vibrocore Profile



As laid / Service Chart

KEYMAP 1:150000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth curves (5m to 41m)
- Track of depicted profile
- Indicates Cable Length (x.x) in km from start

COLOUR CODES:

-42.5 -40 -37.5 -35 -32.5 -30 -27.5 -25 -22.5 -20 -17.5 -15 -12.5 -10 -7.5 -5

Seabed level (m)

SIDE SCAN CHART:
- Sand_featureless
- Sand_ripples
- Sand_megaripples
- Sand_gravel_few stones
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- Prequaternary bedrock
- Boulders > 1m, ID
- CABLE w. KP VALUES
- Vibrocores, ID
- Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Glacial
- Top Prequaternary

NOTES:

NAVIGATIONAL SYSTEMS

Primary system	: SAGITTA (DGPS)
Secondary system	: Furuno (ship GPS)
Gyro/HPR Sensor	: Seatex MRUS (MV Madog, 2010/05)
	: Robertson (MV Laura, 2010/11)

ACOUSTIC SYSTEMS

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	: Multi beam Bathymetry from Energinet.dk (CT Offshore Survey for Energinet.dk, 2009/12)
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Chirp	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker	: GEO-Spark 200
Magnetometer	: Geometrics G-882

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LILLEBAELT CABLE CORRIDOR ROUTE SURVEY
MAY AND NOVEMBER 2010

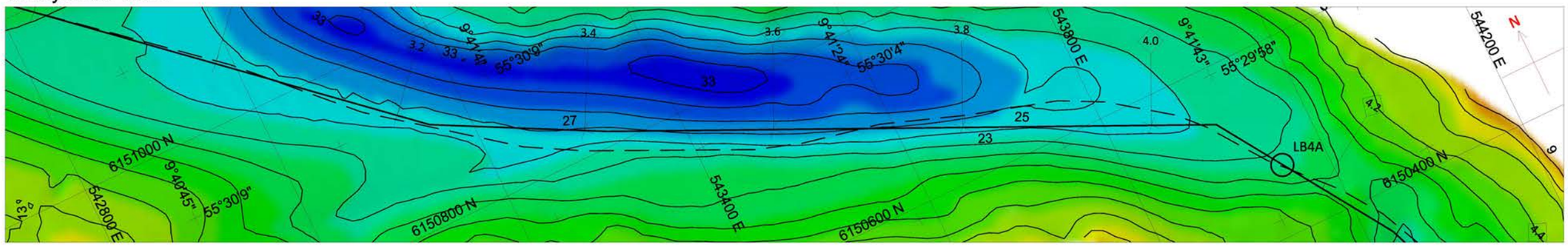
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	FOR CLIENTS APPROVAL & DISTRIBUTION	RADK	NNP	KAE	17-03-11
C	FOR CLIENTS COMMENT	RADK	NNP	KAE	04-03-11
B	FOR INTERNAL QC	RADK	ADEA	TEB	02-03-11
A	EMPTY CHART	RADK	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation chart, Profile Chart, CPT/VC Chart and As Laid - Chart 04 of 09.
Scale (A3 paper) 1:5000

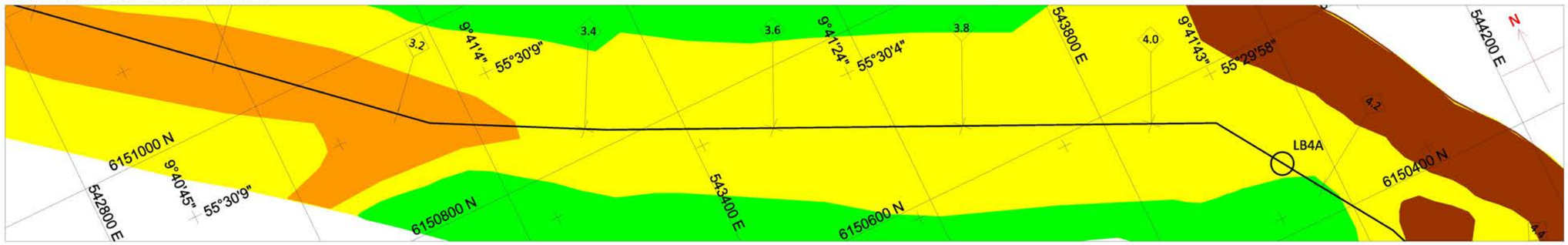
Drawn RADK	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Lillebaelt Corridor Cable

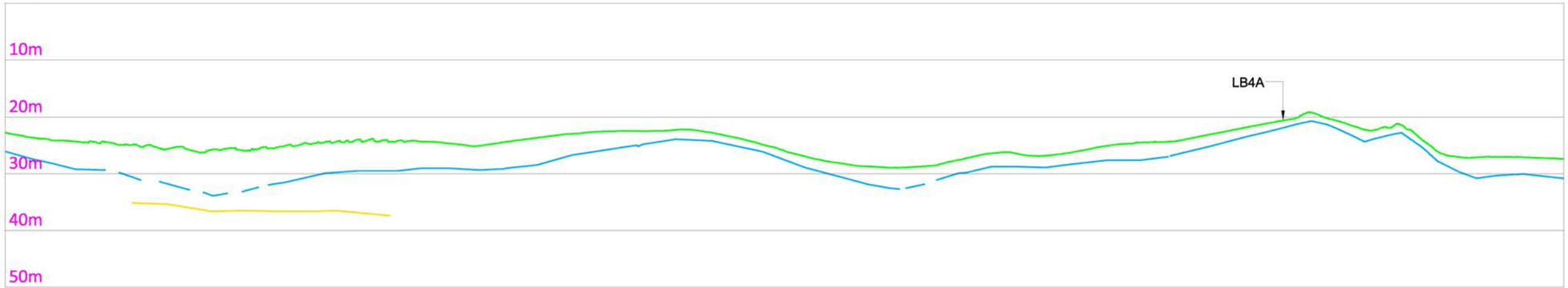
Bathymetric Chart



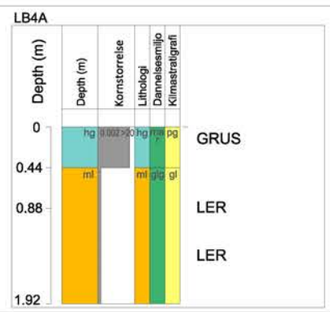
Side Scan Observation Chart



Profile Chart

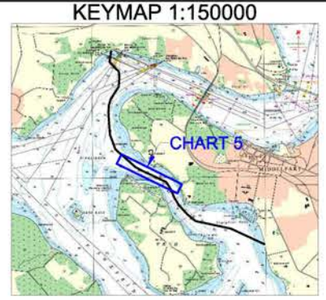


CPT / Vibrocore Profile



As laid / Service Chart

KEYMAP 1:150000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth curves (5m to 41m)
- Track of depicted profile
- Indicates Cable Length (x.x) in km from start

COLOUR CODES:

-42.5 -40 -37.5 -35 -32.5 -30 -27.5 -25 -22.5 -20 -17.5 -15 -12.5 -10 -7.5 -5
Seabed level (m)

SIDE SCAN CHART:
- Sand_featureless
- Sand_ripples
- Sand_megaripples
- Sand_gravel_few stones
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- Prequaternary bedrock
- Boulders > 1m, ID
- CABLE w. KP VALUES
- Vibrocores, ID
- Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Glacial
- Top Prequaternary

NOTES:

NAVIGATIONAL SYSTEMS

Primary system	: SAGITTA (DGPS)
Secondary system	: Furuno (ship GPS)
Gyro/HPR Sensor	: Seatex MRUS (MV Madog, 2010/05)
	: Robertson (MV Laura, 2010/11)

ACOUSTIC SYSTEMS

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	: Multi beam Bathymetry from Energinet.dk (CT Offshore Survey for Energinet.dk, 2009/12)
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Chirp	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker	: GEO-Spark 200
Magnetometer	: Geometrics G-882

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LILLEBAELT CABLE CORRIDOR ROUTE SURVEY
MAY AND NOVEMBER 2010

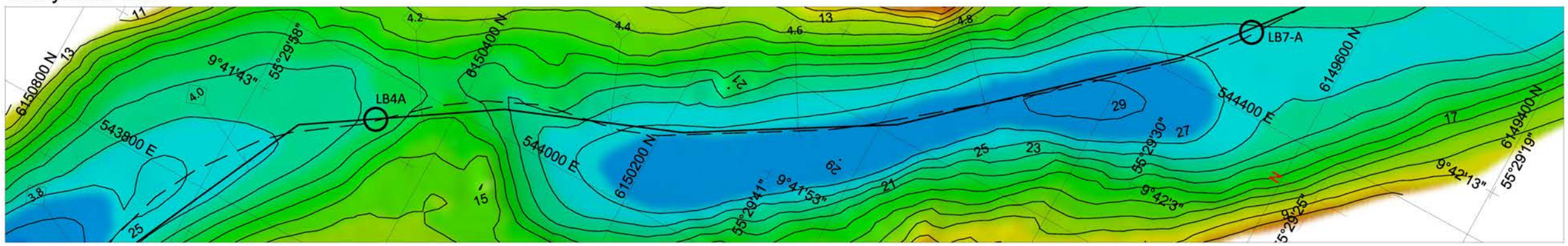
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	FOR CLIENTS APPROVAL & DISTRIBUTION	RADK	NNP	KAE	17-03-11
C	FOR CLIENTS COMMENT	RADK	NNP	KAE	04-03-11
B	FOR INTERNAL QC	RADK	ADEA	TEB	02-03-11
A	EMPTY CHART	RADK	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation chart, Profile Chart, CPT/VC Chart and As Laid - Chart 05 of 09.
Scale (A3 paper) 1:5000

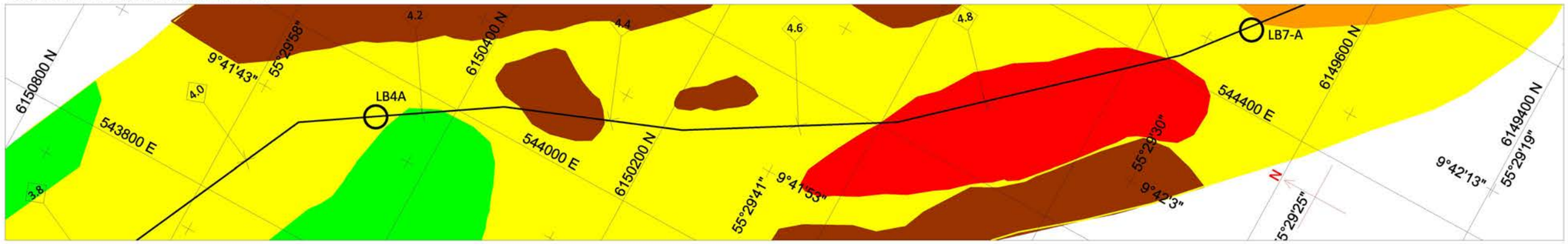
Drawn	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Lillebaelt Corridor Cable

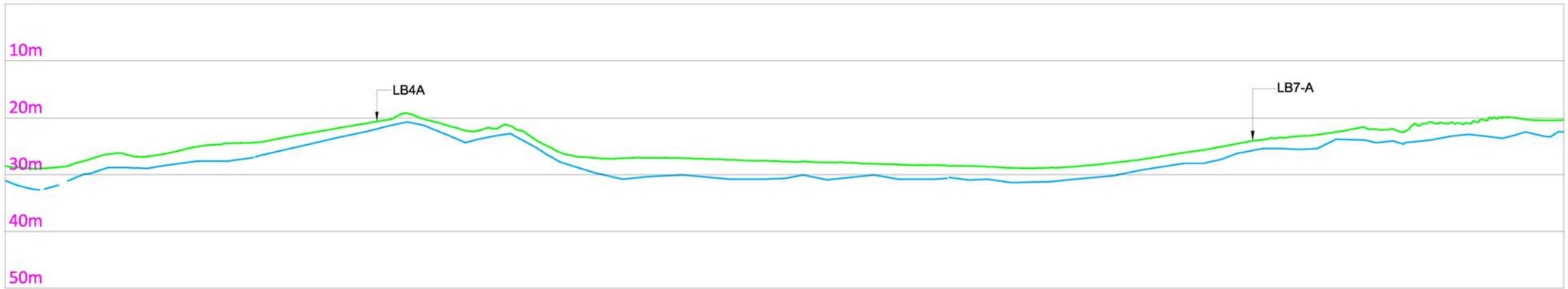
Bathymetric Chart



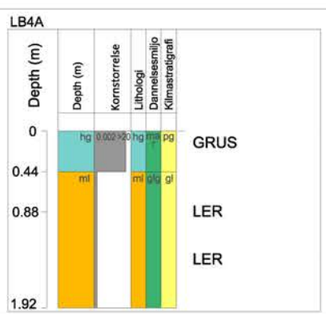
Side Scan Observation Chart

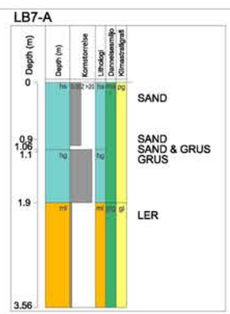


Profile Chart



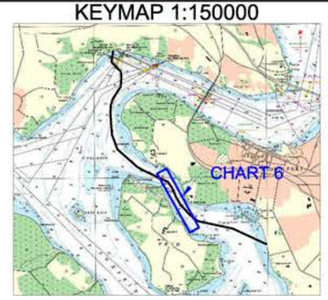
CPT / Vibrocore Profile





As laid / Service Chart

KEYMAP 1:150000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth curves (5m to 41m)
- Track of depicted profile
- x.x Indicates Cable Length (x.x) in km from start

COLOUR CODES:

-42.5 -40 -37.5 -35 -32.5 -30 -27.5 -25 -22.5 -20 -17.5 -15 -12.5 -10 -7.5 -5
Seabed level (m)

SIDE SCAN CHART:
- Sand_featureless
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- Sand_gravel_few stones
- Residual sediment_Till
- Prequaternary bedrock
- Boulders > 1m, ID
- CABLE w. KP VALUES
- LBX Vibrocores, ID
- x.x Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Glacial
- Top Prequaternary

NOTES:

NAVIGATIONAL SYSTEMS
Primary system : SAGITTA (DGPS)
Secondary system : Furuno (ship GPS)
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Sparker : GEO-Spark 200
Magnetometer : Geometrics G-882

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LILLEBAELT CABLE CORRIDOR ROUTE SURVEY
MAY AND NOVEMBER 2010

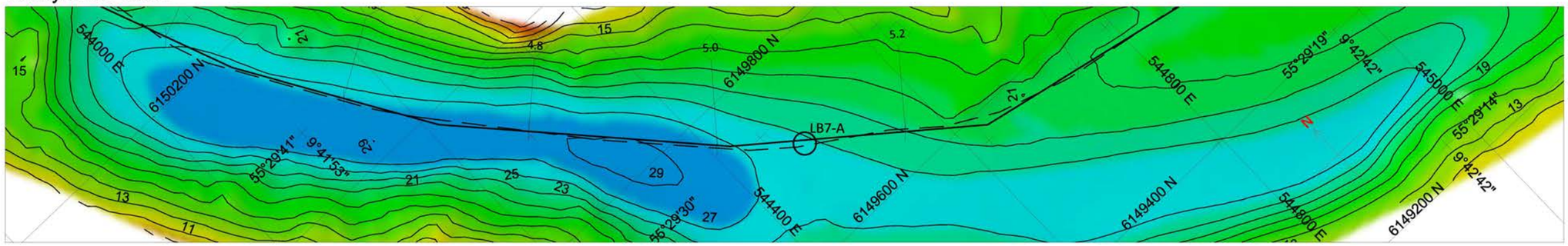
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	FOR CLIENTS APPROVAL & DISTRIBUTION	RADK	NNP	KAE	17-03-11
C	FOR CLIENTS COMMENT	RADK	NNP	KAE	04-03-11
B	FOR INTERNAL QC	RADK	ADEA	TEB	02-03-11
A	EMPTY CHART	RADK	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation chart, Profile Chart, CPT/VC Chart and As Laid - Chart 06 of 09.
Scale (A3 paper) 1:5000

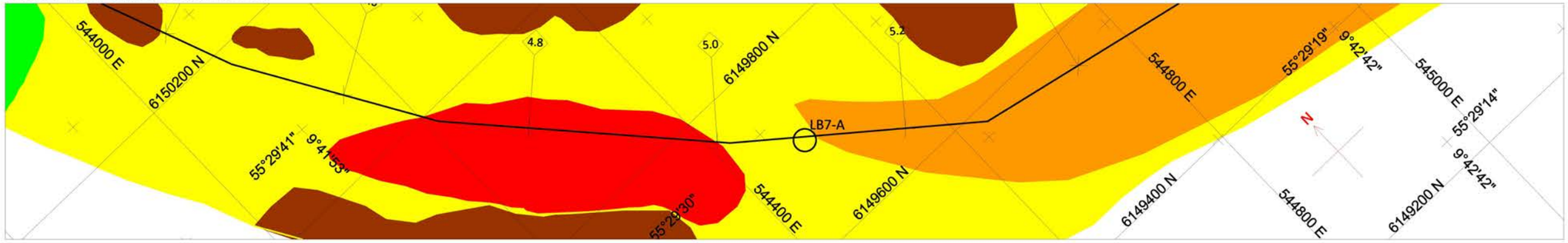
Drawn RADK	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Lillebaelt Corridor Cable

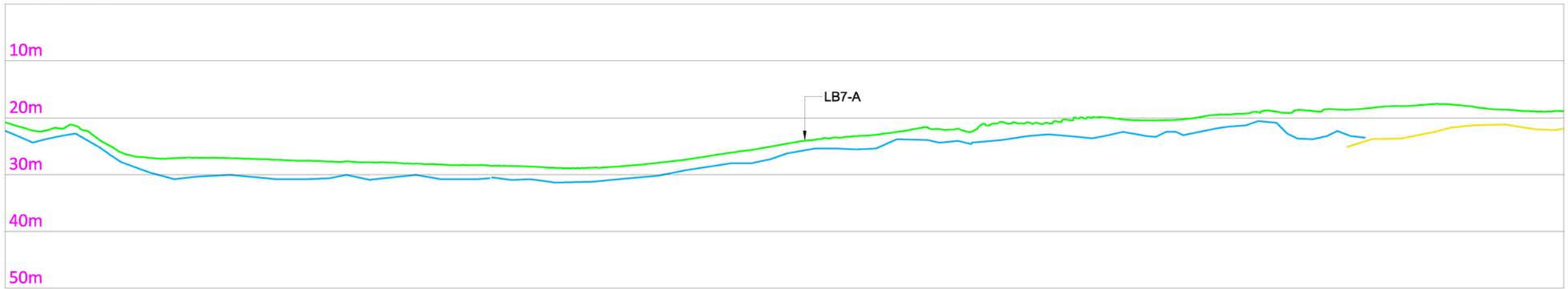
Bathymetric Chart



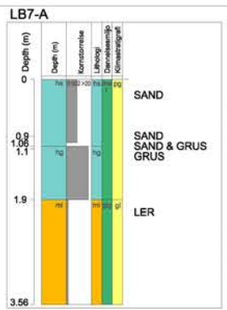
Side Scan Observation Chart



Profile Chart

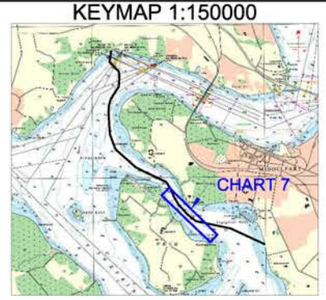


CPT / Vibrocore Profile



As laid / Service Chart

KEYMAP 1:150000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth curves (5m to 41m)
- Track of depicted profile
- Indicates Cable Length (x.x) in km from start

COLOUR CODES:

-42.5 -40 -37.5 -35 -32.5 -30 -27.5 -25 -22.5 -20 -17.5 -15 -12.5 -10 -7.5 -5
Seabed level (m)

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- Sand_featureless
- Sand_ripples
- Sand_megaripples
- Sand_gravel_few stones
- Residual sediment_Till
- Prequaternary bedrock
- Boulders > 1m, ID
- CABLE w. KP VALUES
- Vibrocores, ID
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PROFILE CHART
- Seabed
- Top Glacial
- Top Prequaternary

NOTES:

NAVIGATIONAL SYSTEMS

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Secondary system	: Furuno (ship GPS)
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	: Robertson (MV Laura, 2010/11)

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A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LILLEBAELT CABLE CORRIDOR ROUTE SURVEY
MAY AND NOVEMBER 2010

Rev.	Description	Drawn	Chkd.	Appr.	Date
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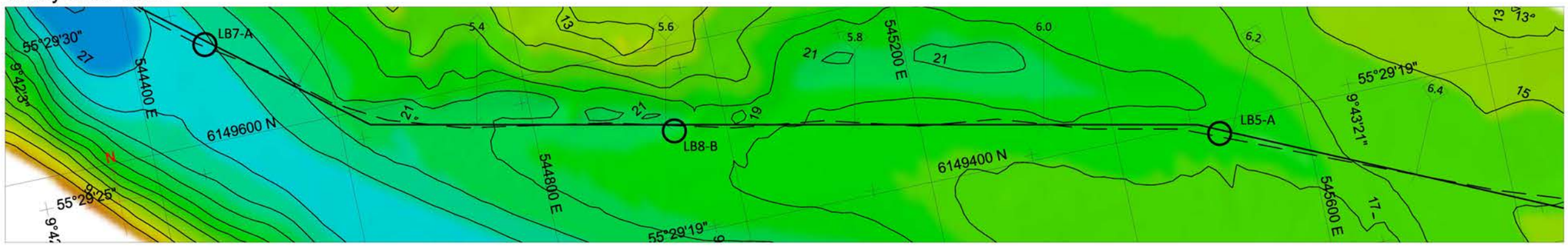
A	EMPTY CHART	RADK	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation chart, Profile Chart, CPT/VC Chart and As Laid - Chart 07 of 09.
Scale (A3 paper) 1:5000

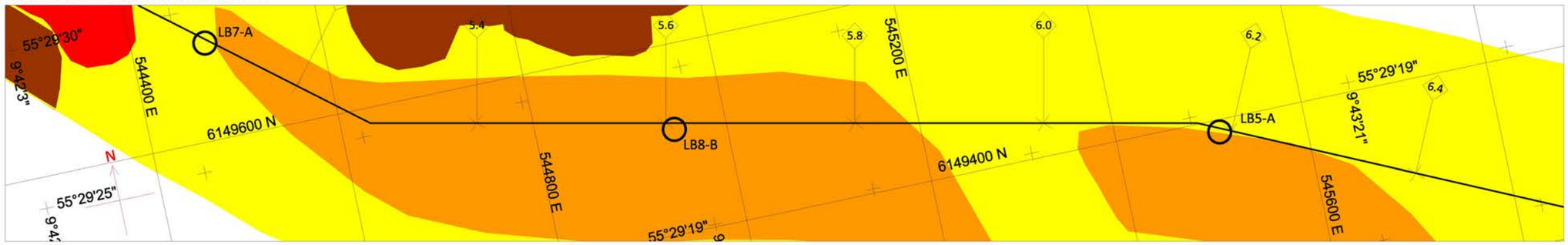
Drawn RADK	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Lillebaelt Corridor Cable

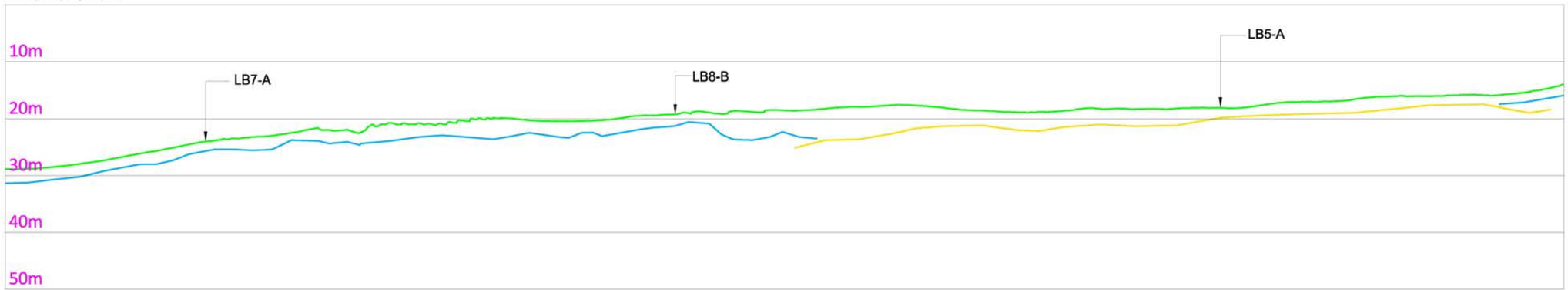
Bathymetric Chart



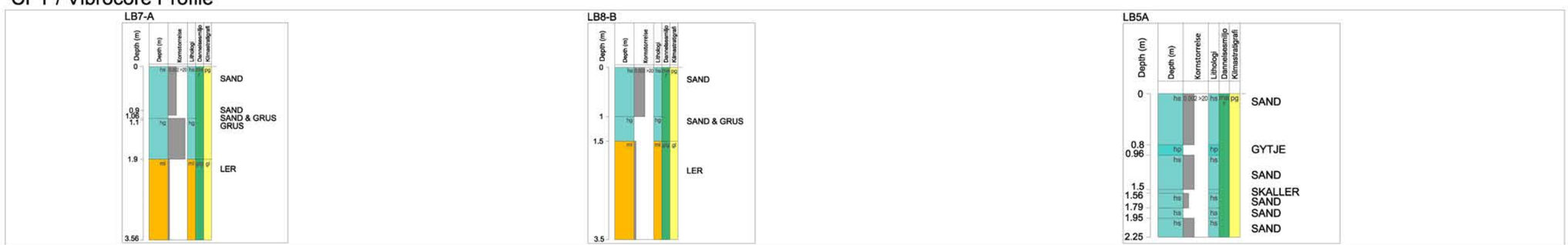
Side Scan Observation Chart



Profile Chart

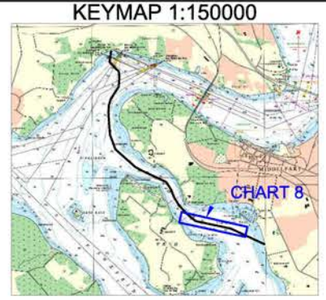


CPT / Vibrocore Profile



As laid / Service Chart

KEYMAP 1:150000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth curves (5m to 41m)
- Track of depicted profile
- Indicates Cable Length (x.x) in km from start

COLOUR CODES:

-42.5 -40 -37.5 -35 -32.5 -30 -27.5 -25 -22.5 -20 -17.5 -15 -12.5 -10 -7.5 -5
Seabed level (m)

SIDE SCAN CHART:
- Sand_featureless
- Sand_ripples
- Sand_megaripples
- Sand_gravel_few stones
- Residual sediment_Till
- Prequaternary bedrock
- Boulders > 1m, ID
- CABLE w. KP VALUES
- Vibrocores, ID
- Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Glacial
- Top Prequaternary

NOTES:

NAVIGATIONAL SYSTEMS

Primary system	: SAGITTA (DGPS)
Secondary system	: Furuno (ship GPS)
Gyro/HPR Sensor	: Seatex MRUS (MV Madog, 2010/05)
	: Robertson (MV Laura, 2010/11)

ACOUSTIC SYSTEMS

Echosounder	: Single beam Reson Navisound 215
	: Multi beam Bathymetry from Energinet.dk (CT Offshore Survey for Energinet.dk, 2009/12)
Side Scan Sonar	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Chirp	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker	: GEO-Spark 200
Magnetometer	: Geometrics G-882

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LILLEBAELT CABLE CORRIDOR ROUTE SURVEY
MAY AND NOVEMBER 2010

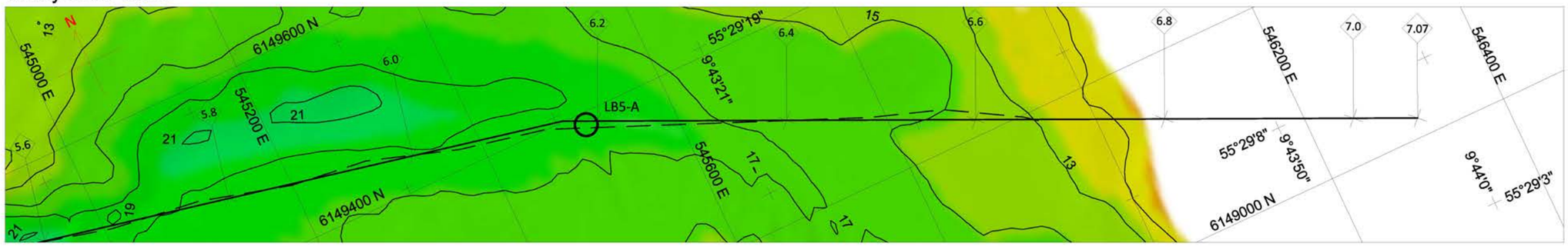
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	FOR CLIENTS APPROVAL & DISTRIBUTION	RADK	NNP	KAE	17-03-11
C	FOR CLIENTS COMMENT	RADK	NNP	KAE	04-03-11
B	FOR INTERNAL QC	RADK	ADEA	TEB	02-03-11
A	EMPTY CHART	RADK	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation chart, Profile Chart, CPT/VC Chart and As Laid - Chart 08 of 09.
Scale (A3 paper) 1:5000

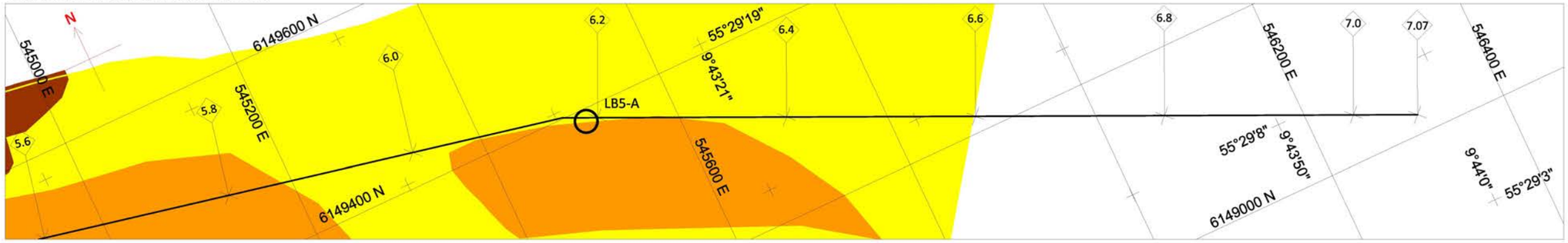
Drawn RADK	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Lillebaelt Corridor Cable

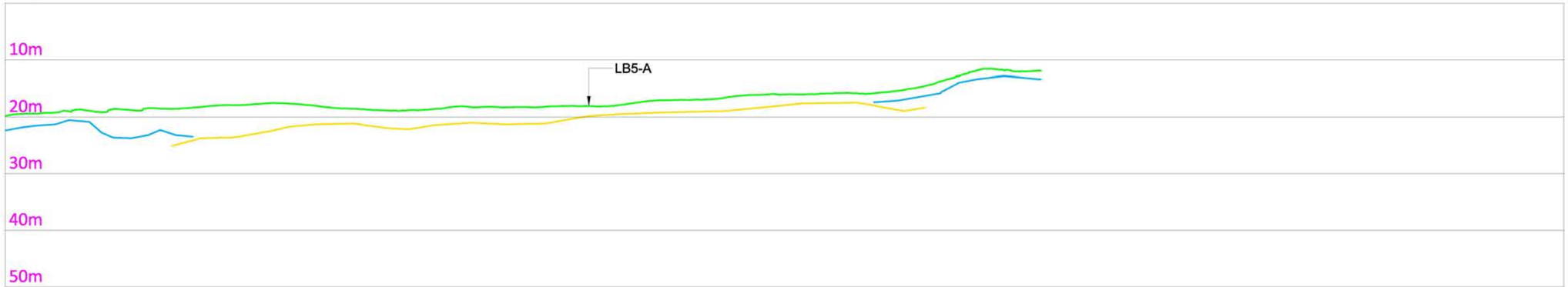
Bathymetric Chart



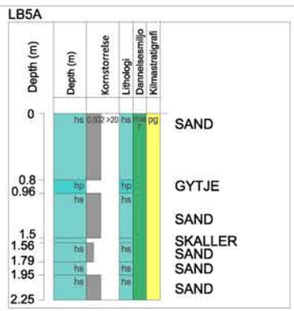
Side Scan Observation Chart



Profile Chart

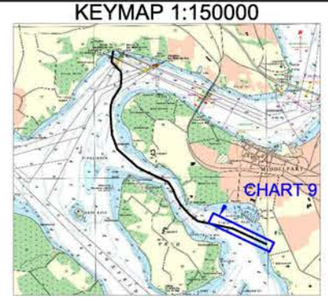


CPT / Vibrocore Profile



As laid / Service Chart

KEYMAP 1:150000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth curves (5m to 41m)
- Track of depicted profile
- x.x Indicates Cable Length (x.x) in km from start

COLOUR CODES:

-42.5 -40 -37.5 -35 -32.5 -30 -27.5 -25 -22.5 -20 -17.5 -15 -12.5 -10 -7.5 -5

Seabed level (m)

SIDE SCAN CHART:
- Sand_featureless
- Sand_ripples
- Sand_megaripples
- Sand_gravel_few stones
- Residual sediment_Till
- Prequaternary bedrock
- Boulders > 1m, ID
- CABLE w. KP VALUES
- LBX Vibrocores, ID
- x.x Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Glacial
- Top Prequaternary

NOTES:

NAVIGATIONAL SYSTEMS

Primary system : SAGITTA (DGPS)
Secondary system : Furuno (ship GPS)
Gyro/HPR Sensor : Seatex MRUS (MV Madog, 2010/05)
: Robertson (MV Laura, 2010/11)

ACOUSTIC SYSTEMS

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Chirp : Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker : GEO-Spark 200
Magnetometer : Geometrics G-882

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LILLEBAELT CABLE CORRIDOR ROUTE SURVEY
MAY AND NOVEMBER 2010

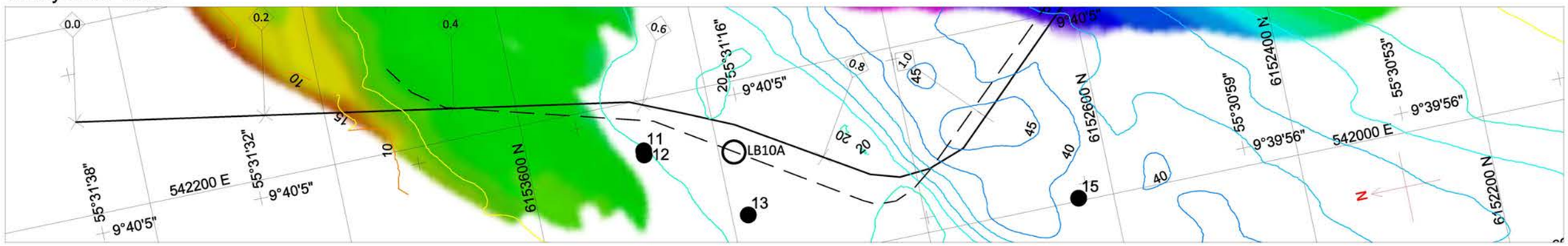
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	FOR CLIENTS APPROVAL & DISTRIBUTION	RADK	NNP	KAE	17-03-11
C	FOR CLIENTS COMMENT	RADK	NNP	KAE	04-03-11
B	FOR INTERNAL QC	RADK	ADEA	TEB	02-03-11
A	EMPTY CHART	RADK	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation chart, Profile Chart, CPT/VC Chart and As Laid - Chart 09 of 09.
Scale (A3 paper) 1:5000

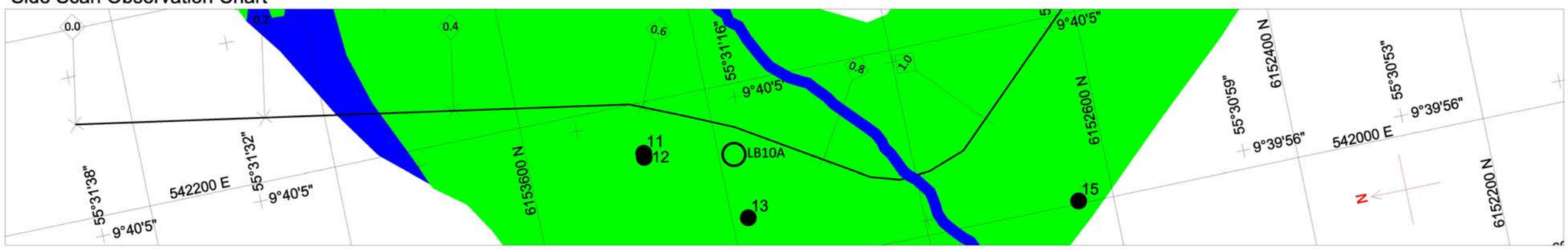
Drawn RADK	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Lillebaelt Corridor Cable - Line B

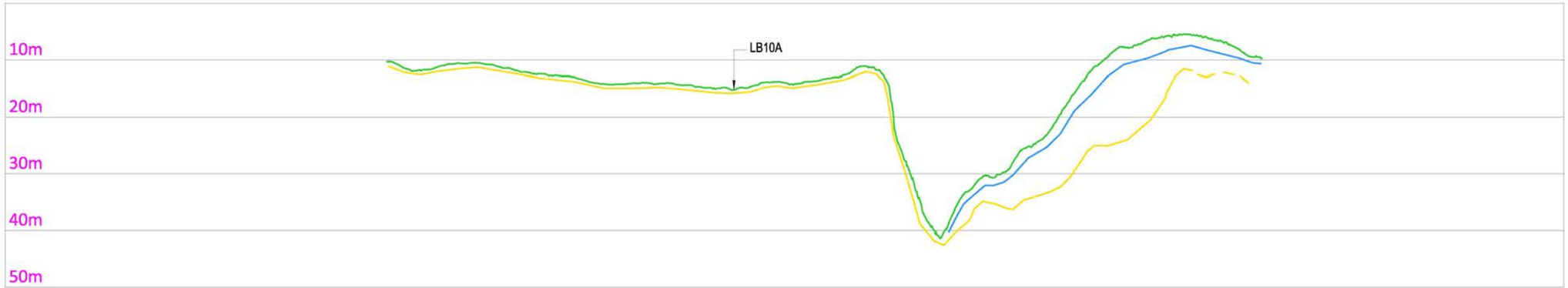
Bathymetric Chart



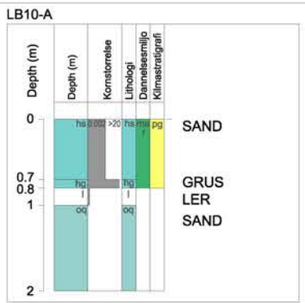
Side Scan Observation Chart



Profile Chart

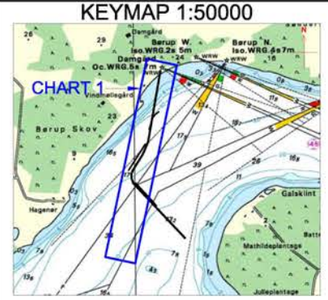


CPT / Vibrocore Profile



As laid / Service Chart

KEYMAP 1:50000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

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Seabed level (m)

SIDE SCAN CHART:
- Sand_featureless
- Sand_ripples
- Sand_megaripples
- Sand_gravel_few stones
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- Prequaternary bedrock
- Boulders > 1m, ID
- CABLE w. KP VALUES
- LBX Vibrocores, ID
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PROFILE CHART
- Seabed
- Top Glacial
- Top Prequaternary

NOTES:

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A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LILLEBAELT CABLE CORRIDOR ROUTE SURVEY
MAY AND NOVEMBER 2010

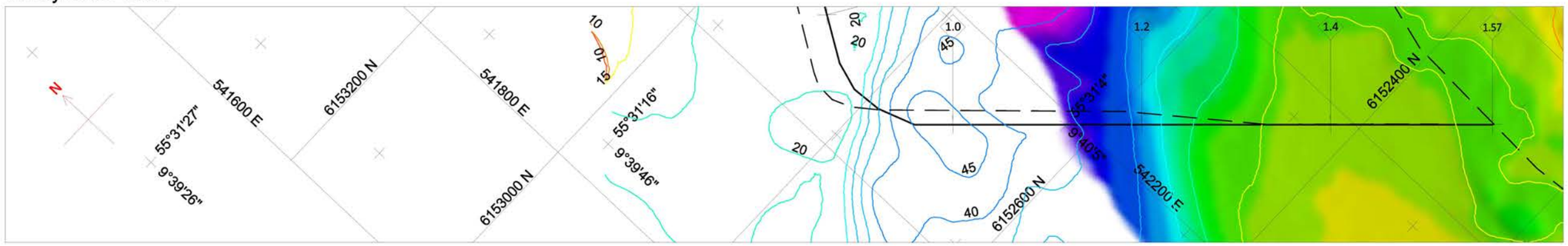
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	FOR CLIENTS APPROVAL & DISTRIBUTION	RADK	NNP	KAE	17-03-11
C	FOR CLIENTS COMMENT	RADK	NNP	KAE	04-03-11
B	FOR INTERNAL QC	RADK	ADEA	TEB	02-03-11
A	EMPTY CHART	RADK	ADEA	TEB	22-02-11

Bathymetric Chart, Side Scan Observation chart, Profile Chart, CPT/VC Chart and As Laid - Chart 01 of 02.
Scale (A3 paper) 1:5000

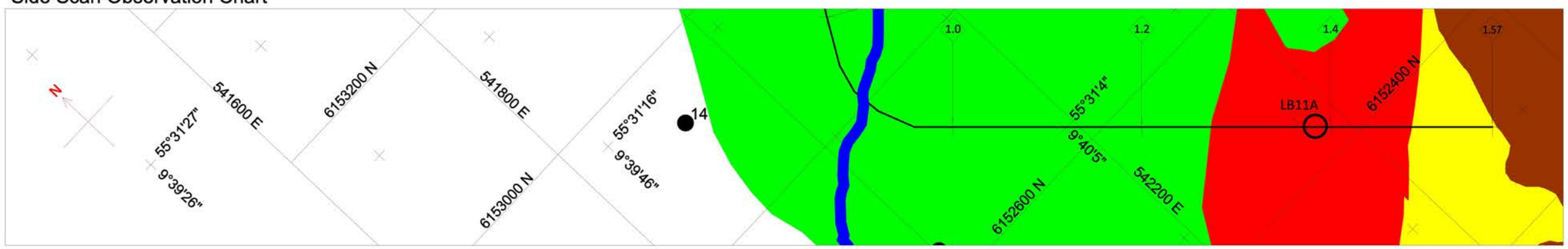
Drawn	Date		
RADK	2011-03-17		
Interp.	Date		
XXX	2011-01-20		
Checked	Date		
ADEA	XXXX-XX-XX		
Approved	Date	Ceo Job No.	
TEB	XXXX-XX-XX	XXXXXX	
Client		Encl. No.	
ENERGINET.DK		XXXX	

Lillebaelt Corridor Cable - Line B

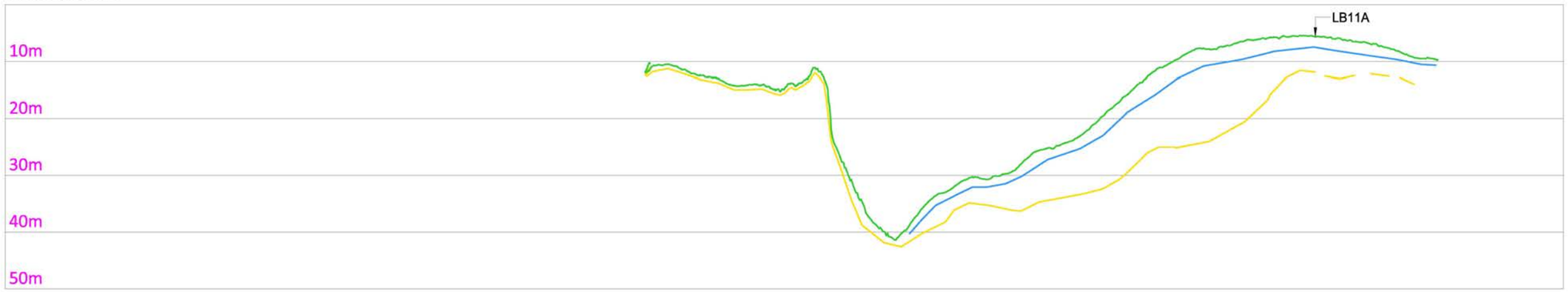
Bathymetric Chart



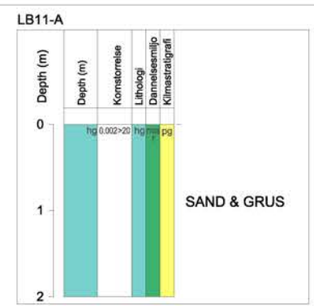
Side Scan Observation Chart



Profile Chart

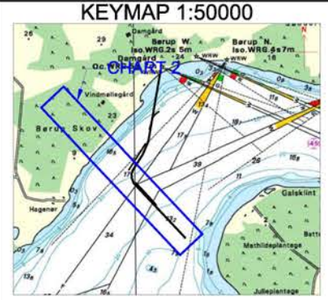


CPT / Vibrocore Profile



As laid / Service Chart

KEYMAP 1:50000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
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DEPTHS : In meters reduced to DVR-90

LEGEND:

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Seabed level (m)

SIDE SCAN CHART:
- Sand_featureless
- Sand_ripples
- Sand_megaripples
- Sand_gravel_few stones
- Residual sediment_Till
- Prequaternary bedrock
- Boulders > 1m, ID
- CABLE w. KP VALUES
- Vibrocores, ID
- Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Glacial
- Top Prequaternary

NOTES:

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Secondary system	: Furuno (ship GPS)
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Magnetometer	: Geometrics G-882

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LILLEBAELT CABLE CORRIDOR ROUTE SURVEY
MAY AND NOVEMBER 2010

Rev.	Description	Drawn	Chkd.	Appr.	Date
0	FOR CLIENTS APPROVAL & DISTRIBUTION	RADK	NNP	KAE	17-03-11
C	FOR CLIENTS COMMENT	RADK	NNP	KAE	04-03-11
B	FOR INTERNAL QC	RADK	ADEA	TEB	02-03-11
A	EMPTY CHART	RADK	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation chart, Profile Chart, CPT/VC Chart and As Laid - Chart 02 of 02.
Scale (A3 paper) 1:5000

Drawn	Date		
RADK	2011-03-17		
Interp.	Date		
NNP	2011-01-20		
Checked	Date		
NNP	XXXX-XX-XX		
Approved	Date	Ceo Job No.	
KAE	XXXX-XX-XX	XXXXXX	
Client		Encl. No.	
ENERGINET.DK		XXXX	