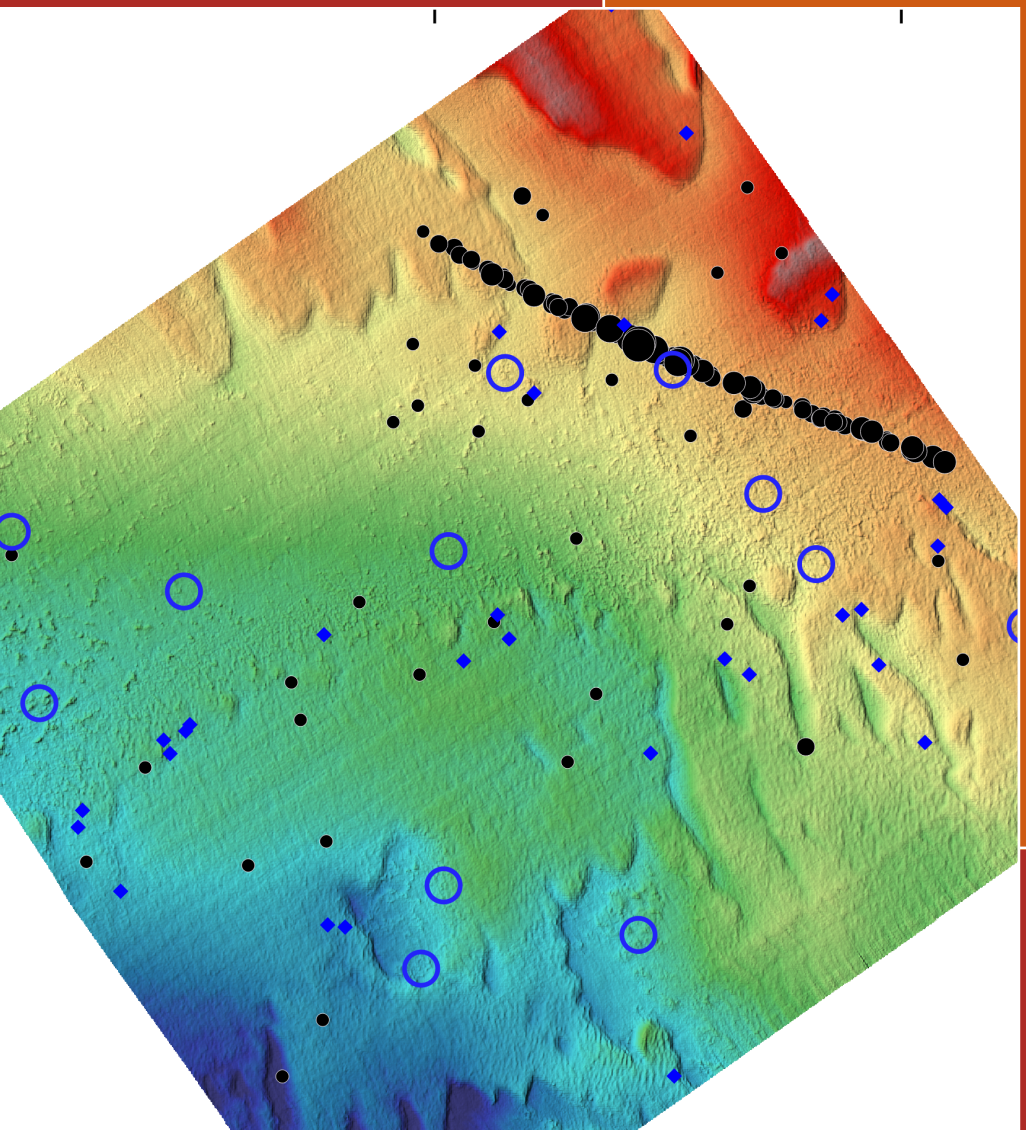
ADC Maritiem

Archaeological assessment ONE-Dyas well site Turkoois, North Sea

report 5083



W.B. Waldus
and A. Botman

Archaeological assessment geophysical survey ONE-Dyas well site Turkoois, North Sea

Geophysical survey with multibeam, side scan sonar and magnetometer

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ADC ArcheoProjecten

Colophon

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Client: GEOxyz

Photo's and figures: ADC ArcheoProjecten, unless otherwise specified

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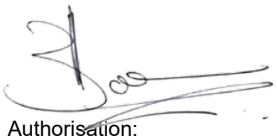

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Content

Table 1: Dutch archaeological periods.

Period	Abbreviation	Dates
Modern Times	NT	1500 AD – present
Medieval Times	XME	450 – 1500 AD
Late medieval period	LME	1050 - 1500 AD
Early medieval period	VME	450 - 1050 AD
Roman Times	ROM	12 BC – 450 AD
Iron Age	IJZ	800 – 12 BC
Bronze Age	BRONS	2000 - 800 BC
Neolithic (Stone Age)	NEO	5300 – 2000 BC
Mesolithic (Stone Age)	MESO	8800 – 4900 BC
Palaeolithic (Stone Age)	PALEO	before 8800 BC

Table 2: Administrative data project area.

Project	North Sea, ONE-Dyas well site Turkoois survey
Province	n.a.
Council	n.a.
Location	North Sea, Dutch Territorial Sea
Toponym	Turkoois
Coordinates	See figure 2
Scope project area	Survey area: 1 km2, Platform 200 x 200 m
Present use	Nature, fisheries, shipping
Oceanographic parameters	Open sea (North sea), tidal currents, salt water, depth varying 20-30 m LAT
Area administrator	Rijkswaterstaat Sea and Delta
Research protocol (KNA)	4103: geophysical field survey
Client	GEOxyz
Province	Groningen
Council	n.a.
Location	North Sea, Dutch Territorial Sea
Archis case identifier (CIS code)	4752873100
Present use	Fishery, shipping
Oceanographic parameters	Open sea (North sea), tidal currents, salt water, depth varying between 0 m and 24m -LAT
Area administrator	Rijkswaterstaat Sea and Delta, advised by the Cultural Heritage Agency
ADC project identifier	4210764
Period	18 July – 15 October
Management and location documentation	ADC ArcheoProjecten B.V., Amersfoort and GEOxyz BE, Zwevegem

Summary

On behalf of GEOxyz, ADC ArcheoProjecten has performed an archaeological assessment of geophysical survey data generated for the ONE-Dyas well site Turkoois. The survey was executed by GEOxyz in October 2019 using side scan sonar, magnetometer and multibeam sonar.

The archaeological assessment has not led to the identification of any (possible) archaeological contacts. Therefore no follow up research is advised, the archaeological procedure for the well site Turkoois can be ended with the finalization of this report.

Even though no (possible) archaeological contacts have been localized, there always is a small chance that undiscovered archaeological remains are covered under the seabed. This relatively small risk is acceptable and in case a possible archaeological find is encountered during construction, this should be reported to the authorities as indicated in Article 5.10 of the Dutch Heritage Act.

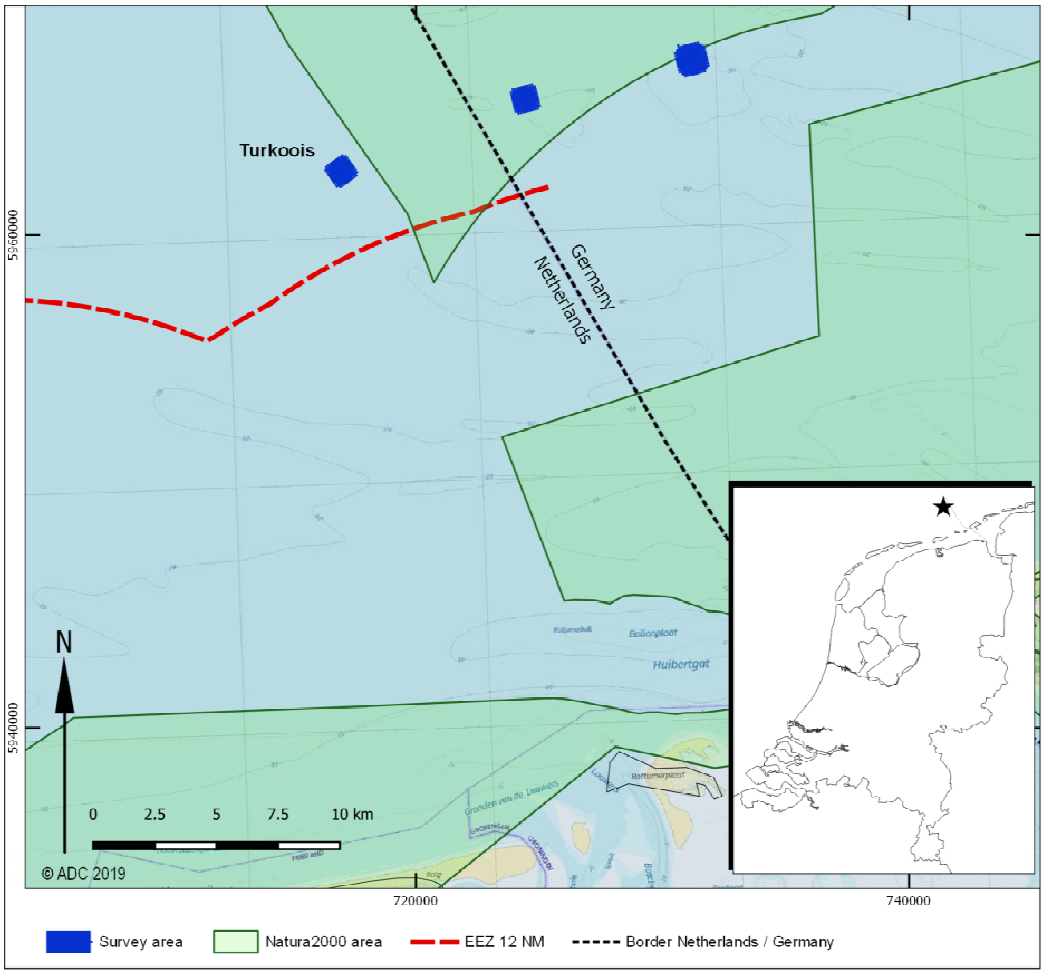

Figure 1: Well site Turkoois in the North Sea, north of Eemshaven

ID	X	Y
1	716.509,27	5.962.898,28
2	716.967,77	5.962.243,74
3	717.622,31	5.962.705,39
4	717.163,82	5.963.359,93

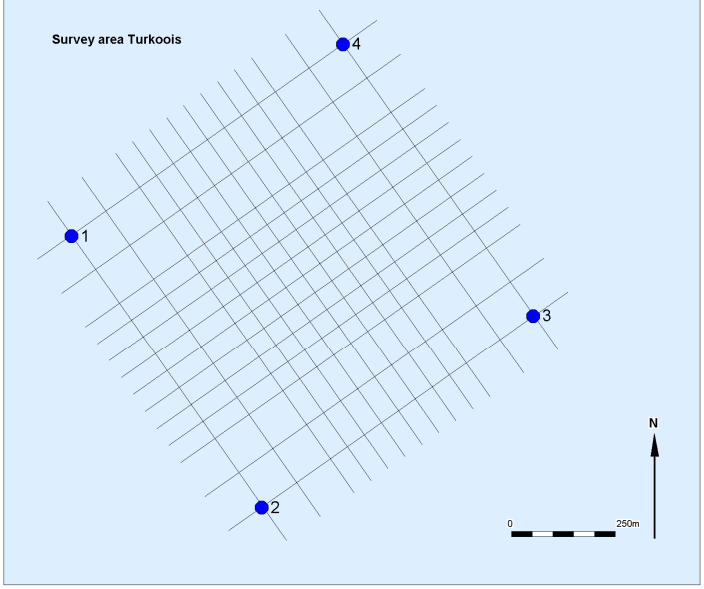

Figure 2: Coordinates (UTM31N ED50) of Well site Turkoois

1 Introduction and administrative data

On behalf of GEOxyz, ADC ArcheoProjecten has performed an archaeological assessment of geophysical survey data generated for the ONE-Dyas well site Turkoois (fig. 1 and 2). Turkoois is one of three planned well sites located in the Dutch territorial area. The other two well sites (Saphir and Tsavorit) are located in the German territorial sea. As part of the license procurement in accordance with the *Erfgoedwet*, an archaeological assessment is carried out.

The seabed will be disturbed to a limited extend by the well site. However, the planned works might affect possible archaeological remains on the seabed by anchoring or using a jack-up offshore installation vessel. To prevent damage to possible archaeological remains present on the seabed or protruding from the seabed this assessment was executed with the aim of locating them within the survey area. The prehistoric landscape of the deeper subsoil is not subject of this research.

The survey was executed by GEOxyz in October 2019 using side scan sonar, magnetometer and multibeam sonar. Although sub-bottom profiler data is excluded from the archaeological assessment, the data was acquired together with SSS, MBES and MAG to map the shallow geology. Raw data processing and primary classification was executed by geophysicists of GEOxyz.

The archaeological assessment of the SSS, MAG and MBES data was executed by Annette Botman (KNA Archeoloog/Prospector Waterbodems MA) and Wouter Waldus (Senior KNA Archeoloog Waterbodems ADC). The final quality check was performed by David Bouman (Senior KNA Archeoloog Waterbodems ADC).

The study is carried out and reported in accordance with the Dutch quality standard for archaeological research and survey (KNA 4.1, protocol 4103) and the Terms of Reference.[1] This report first describes the research design and requirements of the survey effort in chapter 2. Chapter 3 deals with the used methodology, such as the process of examining the data and the techniques used. Next, the results of the archaeological assessment are presented in chapter 4. This is followed by a conclusion in chapter 5, where the research questions will be answered. The report closes with recommendations in chapter 6.

[1] Waldus 2019.

2 Research objectives

2.1 Objective and research questions

The objective of the research is defined in the Terms of Reference. The geophysical survey aims to identify contacts with a possible archaeological value. The survey is focussed on wreckage remains or debris from ships or aircraft resting on or protruding from the seabed.

In the Terms of Reference the following research questions for the survey are formulated:

- Are there any phenomena visible on the seabed?
- Are these phenomena anthropogenic or of natural origin?
- If the phenomena are of natural origin, what are their characteristics?
- What is the classification of objects on the seabed if they are anthropogenic in nature (archaeological, unknown object, soil disturbance or nautical)?
- What is the nature of the archaeological objects identified?
- Is it possible to designate zones of high, middle or low marine activity (erosive/supplementary) based on the acoustic image?
- What is the relation between the contacts/anomalies and the topography of the seabed? Based on this relationship can high-risk areas be marked?
- If no acoustic phenomena can be observed, are there any indications that this is due to either natural erosion, sedimentation or human action?
- Which mitigating measures are necessary to forestall the intrusion of possibly existing archaeological sites?
- Is it possible to make a statement on the basis of this research about the structure of future archaeological research or supervision and, if so, which statements?

2.2 Requirements of the geophysical survey

The archaeological expectation determines which survey techniques to use. Within the possible cable routes shipwrecks from the Middle Ages and Modern Times and aircrafts from World War II are expected.[2] It is expected that wrecks of seafaring vessels should either be visible on the seabed or, when fully covered with sediment, will be detectable by a magnetometer. Such vessels would generally have a substantial amount of iron as part of its construction and equipment. Sonar contacts smaller than 4 m are less likely to be associated with wreck locations, unless shown in a particular pattern.

To detect archaeological remains on or partly in the seabed two techniques are most commonly used: high resolution side scan sonar (SSS) and high resolution multi-beam echo sounder (MBES). This equipment is deployed from a survey vessel to map the seafloor with a hundred percent coverage using acoustic signals. Their main limitation is the inability to trace archaeological remains that are completely covered by sediment.

Of these techniques, side scan sonar is the most suitable technique for the detection of objects on or partly in the seabed. For the resolution of the images, the distance between the sonar fish being towed by the survey vessel and the seafloor is important. The fish is kept at a certain height above the seafloor by a winch. This height is related to the range of the survey path in order to optimize for coverage and resolution.

Iron containing objects, covered by sediment or not, are generally mapped using a magnetometer. This device registers the earth's magnetic field and calculates deviations called anomalies. Iron objects can be detected as a discontinuity or anomaly in the local earth's magnetic field. This anomaly is recorded and processed.

[2] Van Lil & Van den Brenk 2018, Velthuis 2018b.

Within the archaeological assessment the magnetometer data is used to detect significant anomalies within the survey area. In the first place MAG anomalies that correlate with SSS contact might give an indication of the nature of the SSS anomaly. Secondly, not correlating anomalies with a minimum value of 50nT are considered potentially archaeological, even though this threshold is not based on any scientific data. It's a more or less generally accepted decision to filter this large amount of data. For an accurate MAG survey to detect nautical remains, a survey with smaller line spacing should be carried out. This is usually done for detailed UXO surveys.

As the multibeam echo sounder is generally directly attached to the survey vessel, the horizontal resolution will decrease as the water depth increases. The multibeam echo sounder is used in this study to get a bathymetric overview of the seabed and its features and to measure the depth of the seabed in relation to LAT.[3] This allows side scan sonar contacts and magnetic anomalies to be linked to a water depth.

The Terms of Reference detail the following survey specifications and requirements[4]:

- Frequency of the side scan sonar minimally at 450 kHz.
- Maximum range setting of 50 meter for the side scan sonar.
- A vessel track distance of maximum 40 meters is allowed to ensure 120% overlay between adjacent lines. Anomalies should be detected on two tracks to be eligible as a contact.
- A vessel track distance for the magnetometer of maximum 40 meter to ensure the detection of sizeable ferromagnetic (iron) wreck remains.
- The tow fish (SSS) will be towed at a height of 10-15% of the range.
- During data acquisition proper account should be taken of the speed of sound at the location of the transducer(s), in such a way that the measurements meet the requirements.
- Any offset between the transducing unit and GPS antenna must be checked by means of calibration at a fixed point.
- The submersible part must be positioned in such a way that minimal disturbance occurs due to prop wash, electrical interference and boat movement.
- The survey vessel requires an accurate positioning system (preferably RTK, but this might not be achievable at sea).
- The data are recorded and presented in geodetic datum ETRS98, projection in UTM Zone 31N.
- Data should be acquired as much as possible in calm weather and cornering should be avoided as this may result in unusable data.
- During the fieldwork a log is kept, in which relevant details are reported.
- Ship movements are corrected with an accurate motion sensor.
- The sailing speed is 3-4 knots to guarantee the highest possible resolution.
- The magnetometer data is presented by means of an anomaly map, which can be compared as a GIS layer with the contacts that emerge from the side scan sonar research.

[3] LAT = Lowest Astronomical Tide

[4] Velthuis 2018b.

3 Methodology

3.1 Geophysical survey

The measurements were acquired with three survey vessels the *GeoOcean II*, (fig. 3).The fieldwork was executed from 27 September – 17 October 2019 including mobilization and demobilization. The survey vessels covered the project area by sailing along the survey lines as predetermined in the survey plan.

Figure 3: Survey vessel Geo Ocean II.

In table 3 an overview of the systems and settings used during acquisition is given. For positioning a Trimble – BD982 GPS or Applanix PosMV system was used. Daily reports were drafted containing specifications for the operational mode of the equipment.

Table 3: Geophysical equipment and main settings.

Vessel	Area	Item	Instrumentation
Geocean II	Offshore WD 10 m to 32 m	MBES	R2Sonic 2024
		SSS	Edgetech 4200MP 300/600 kHz @ 600 kHz
		Magnetometer	Geometrics G882AR (10 Hz pingrate), piggyback on SSS
		SBP	Innomar SES 2000 Medium 100

The survey plan can be summarized as follows and is visualized in figure 4:

- One main centre line 1.0 km length
- One main crossing line 1.0 km length
- Main lines 1.0 km length, 4 lines offset 50 m either side of the main centre line and remaining lines at 100 m spacing.
- Crossing lines 1.0 km length, 4 lines offset 50m either side of the main crossing lines and remaining lines at a 100m spacing
- The side scan sonar recorded both HF (600 kHz) and LF data (300 kHz) with a 7 5m range along the two proposed locations at 50m spacing. The HF data was used for interpretation.

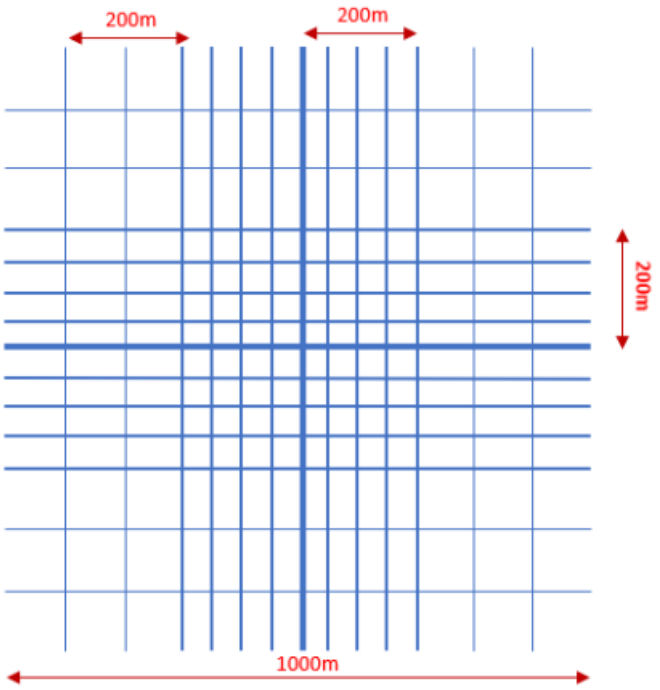

Figure 4: Lineplan of the survey.

3.2 Processing and interpretation

The processing and interpretation is carried out in three steps: raw data processing, data assessment and data interpretation.

Raw data processing

The raw data from the survey was processed with SonarWiz (section 1-10) and Delph Sonar (section 10-11). The multibeam data are processed to generate a digital elevation model (DEM) using BeamWorx AutoClean. For the magnetometer data Geosoft Oasis Montaj was used.

After the hydrographic processing of the data, the data was made available to ADC for archaeological interpretation in ED50 UTM31N:

- SSS: Excel targetlist, trackplots in csv format, mosaic and targest in Geotiff.
- MBES: Excel targetlist and MBES data in pts format and Geotiff.
- MAG: Excel targetlist and MAG data in Geotiff.

Data assessment

The surveyor ensured that a marked SSS contact was observed on two or more different lines and provided a contact description. The assessment of the data was subsequently carried out by ADC based on the following criteria:

- Sonar contacts are possibly of archaeological interest if their length is minimal 4 meters and man-made, based on expert judgement. However, a contact of lesser dimensions may also be of archaeological interest if a pattern with other contacts and /or anomalies relate to possible archaeological wreckage or debris;
- MAG anomalies are considered to be related to sonar contacts if the distance is 30 meters or less. This distance is based on the line spacing of 25m, as an anomaly only indicates the proximity of a ferro-magnetic object and could be situated on either side of the survey line.
- MAG anomalies within 30 meters of an infrastructure is considered to be related to that infrastructure;
- MAG anomalies are possibly of archaeological interest if their value is at least 50 nT/m.

Data interpretation

The contacts and anomalies eligible for analysis are reviewed and the characteristics of a contact or a set of contacts are described based on the relevant sonar images. MAG anomalies are not described. The interpretation is performed by considering all correlation and analysis outcomes leading up to a classification into one of the four categories. These are:

Category 1: Objects with an archaeological potential, i.e.:
- contacts clearly resembling the shape of a ship or aircraft;
- contacts in a combination of (concentrated) objects indicating a dismantled wreck or loose ballast and/or cargo;
- contacts possibly representing an archaeological object largely covered in sediment, and clearly not a natural phenomenon;

Category 2: Objects that are probably recent and largely on the seafloor (dredging obstacles);

Category 3: Soil disturbances or deviations from a predominantly flat soil pattern, created by nature or by anthropogenic actors. Anthropogenic in nature are ship-related traces such as tow tracks and anchor tracks, but also soil disruptions due to underwater work (wells, dredging tracks, etc.).

Category 4: Nautical objects: cables, buoy anchors etc.

4 Results of the survey

4.1 Multibeam and geology

In general, the bathymetric image shows a gradual slope of the seabed from south to north (figure 5). The large scale geological features consist of depressions and platforms in the seabed. The depth ranges from -25 m LAT in the southern part of the project area to -21,9m LAT in the north.
There seem to be no large scale sand waves of a mobile sand-layer. Geological data from the DINO database (figure 6) indicate the presence of 'keileem', a loamy sediment with boulders dating from the Saalian under a thin layer of mobile sand (figure 7).

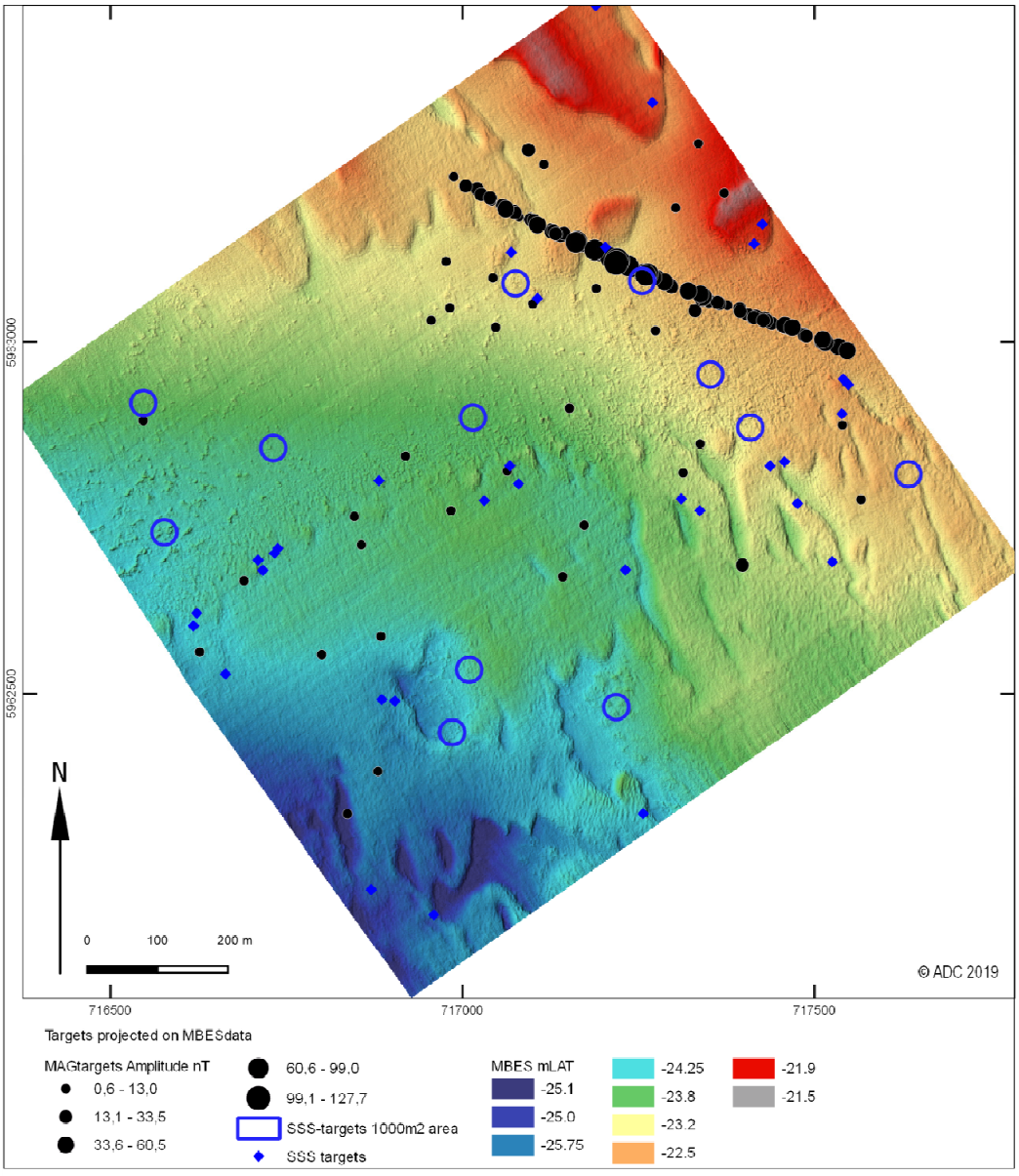

Figure 5: Combined overview of MAG and SSS targets plotted on a multibeam layer of the survey area.

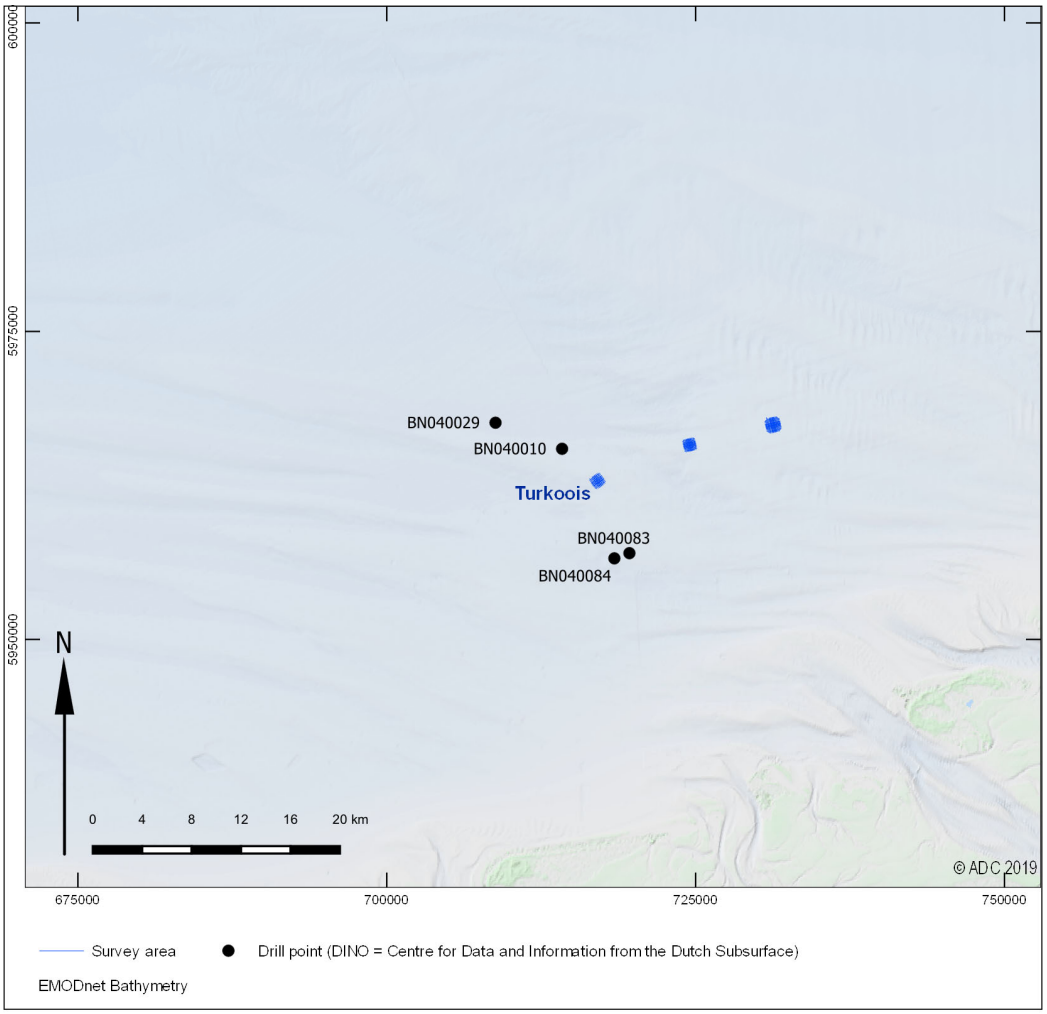

Figure 6: DINO geological cores in the proximity of the research area.

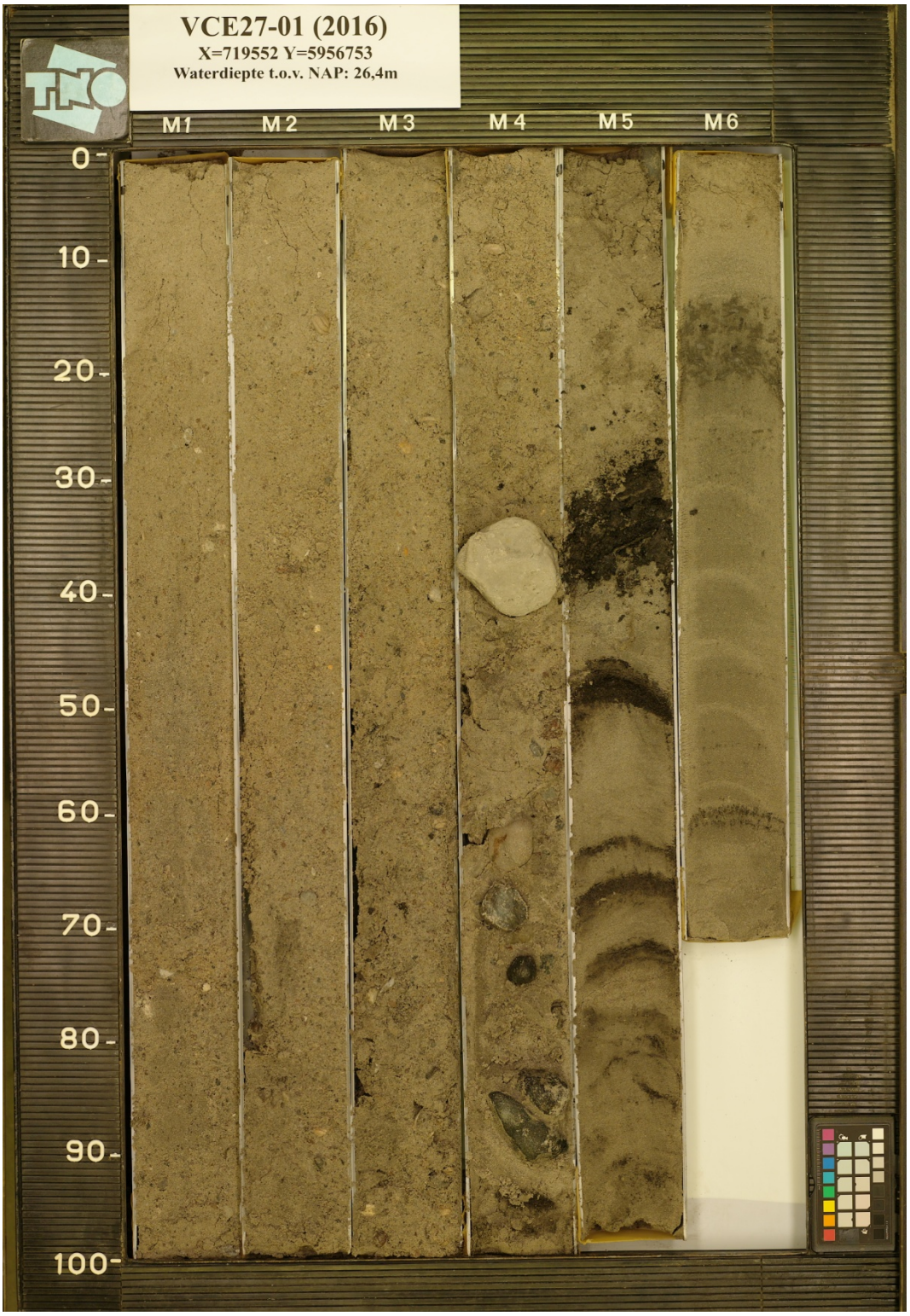

Figure 7: Core BN040083.

4.2 Side scan sonar

GEOxyz/ADC identified 33 SSS contacts within the survey area (appendix 1). Contacts 1-12 are classified as boulder fields, natural features (category 3). The boulders vary in size from 5,2 x 2,2 x 0,2 meters to 1,8 x 1,4 x 0,1 meters. The density in the boulder fields varies from 2-10 boulders / 1000 m^2. Figure 8 shows a boulder field as it was discerned in the SSS data and figure 9 gives an overview of all contacts in the surveyed area. The other 21 contacts are relatively small isolated objects. None of the reported SSS contacts seems to have an archaeological relevance and are all classified as category 3.

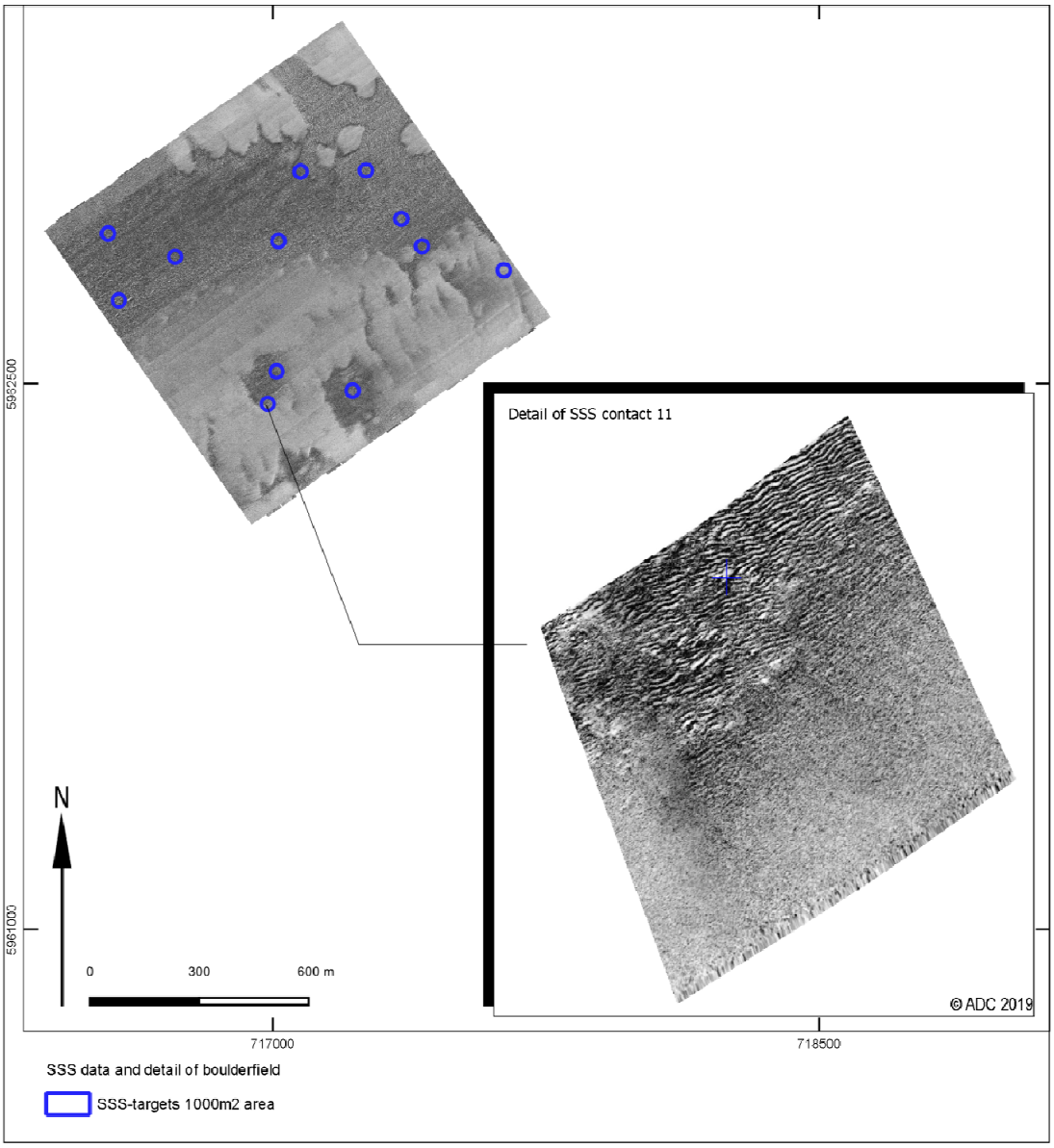

Figure 8: SSS contact 11, example of a boulder field.

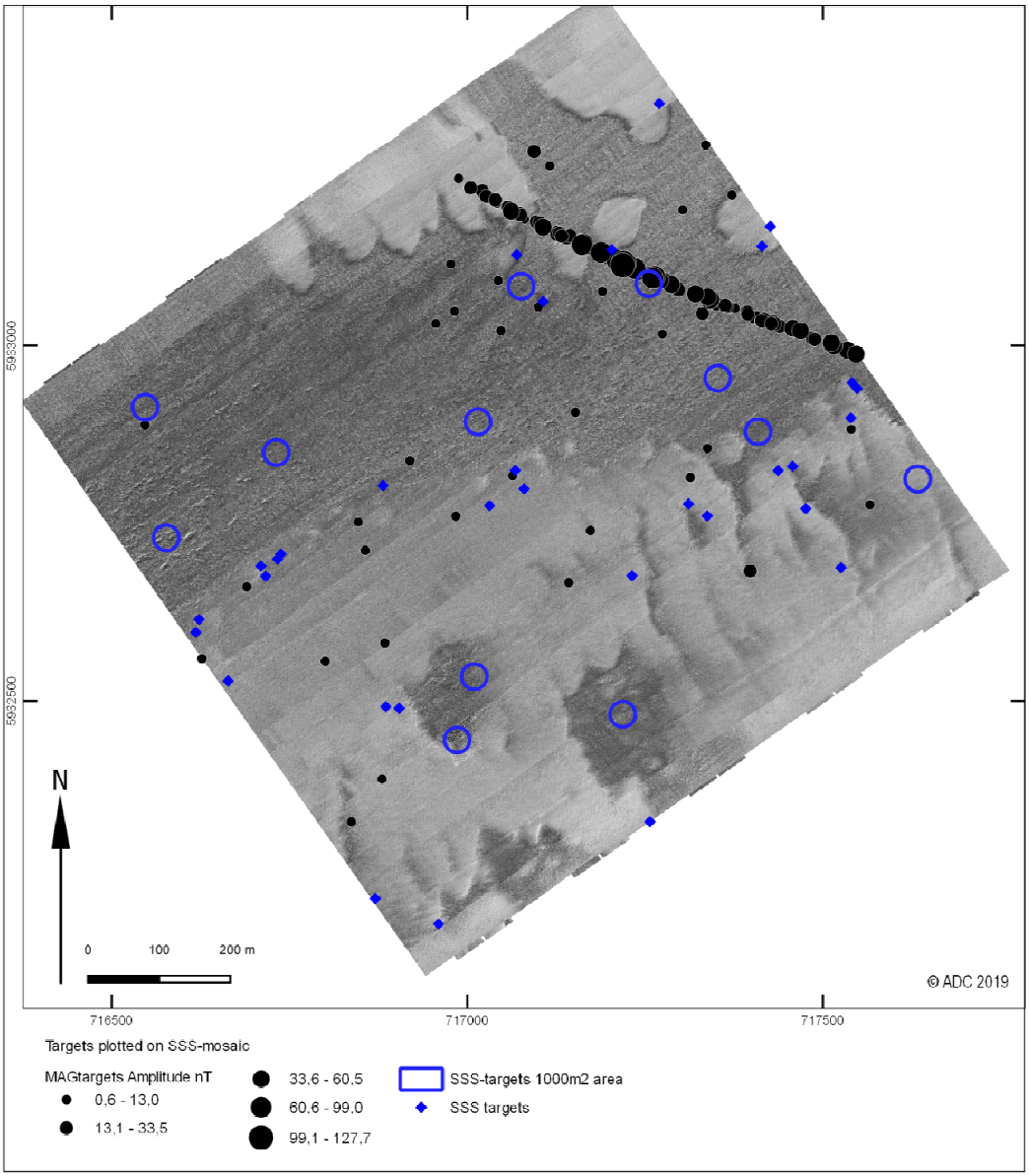

Figure 9: SSS mosaic with survey lines and SSS contacts .

4.3 Magnetometer

A total of 111 MAG anomalies were detected in the survey area (figure 10, Appendix 2). All anomalies with values above 50 nT can be correlated to the Telecom Cable Winterton-Borkum in the north of the survey area. Some of the isolated MAG contacts have correlation with the reported SSS contacts. Even though their value is low, it can never be ruled out that one of these contacts might be of archaeological potential. However, since they don't surpass the 50 nT threshold, these anomalies are not reported as locations with archaeological potential.

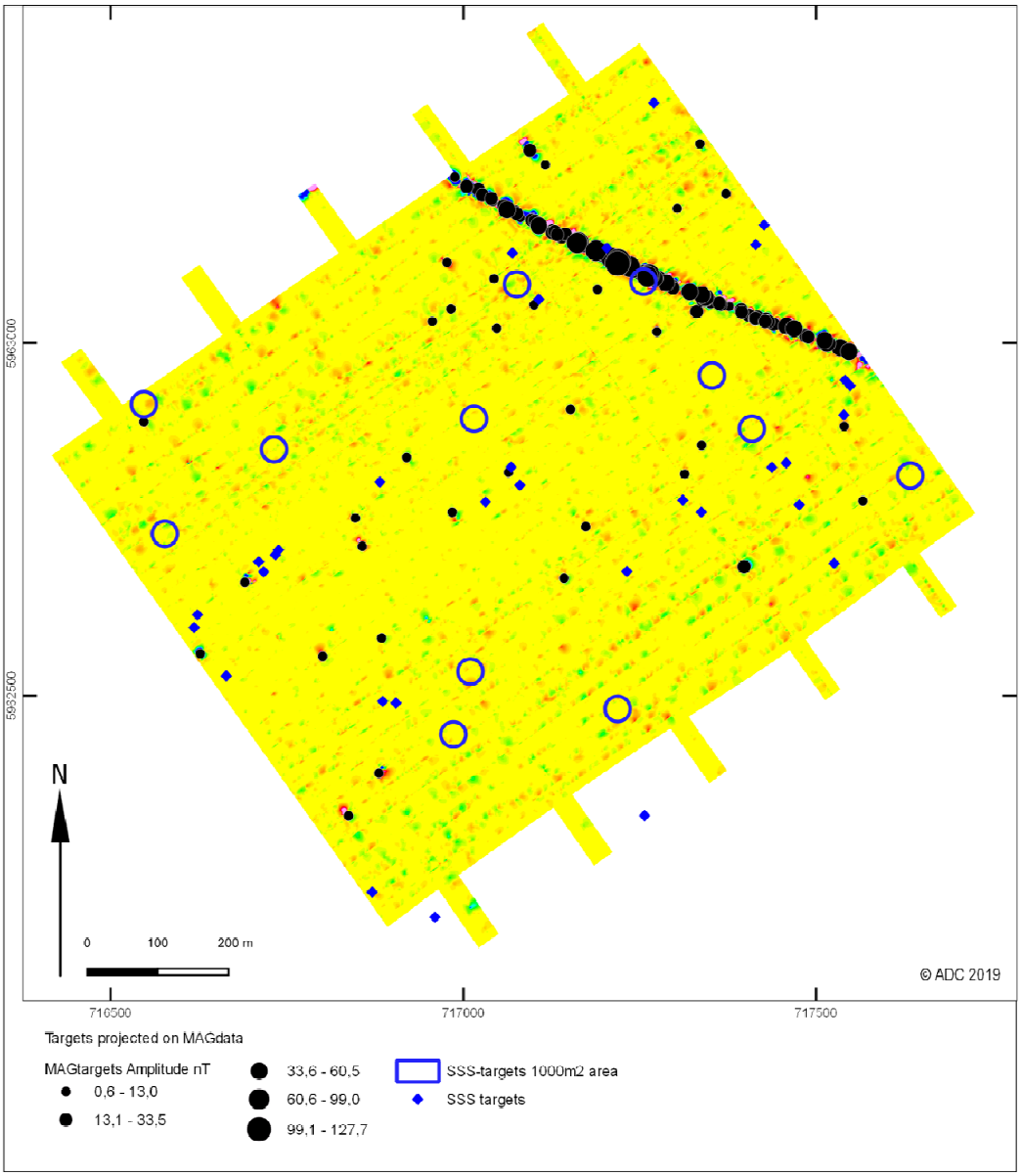

Figure 10: Overview of MAG anomalies.

5 Conclusions

The research questions specified for the geophysical survey can be answered as follows:

- *Are there any phenomena visible on the seabed?*
  A total of 33 side scan sonar contacts and 111 magnetic anomalies were detected.
  Sonar contacts are categorized in one of four categories:
  Category 1: Archaeological contact
  Category 2: Non archaeological contact
  Category 3: Soil disturbance or geological feature
  Category 4: Nautical object

  The SSS contacts are classified as boulder fields and therefore category 3. The MAG contacts with values above 50 nT are related to the Telecom Cable Winterton-Borkum.

- *Are these phenomena anthropogenic or of natural origin?*
  The SSS contacts have been classified as natural phenomena and the MAG contacts with a value above 50 nT are related to a telecom cable.

- *If the phenomena are of natural origin, what is the nature of these natural phenomena?*
  Based on the multibeam data and DINO geological corings in the proximity of the research area, these boulder fields can be associated to the so called ‘keileem’, of boulder loam. These are sediments which have been formed during the Saalian.

- *What is the classification of objects on the sediment if they are anthropogenic in nature (archaeological, non-archaeological object, soil disturbance or nautical)?*
  This question can not be answered due to the results of the survey.

- *What is the nature of the archaeological objects identified?*
  This question can not be answered due to the results of the survey.

- *Is it possible to designate zones of high, middle or low marine activity (erosion/supplementation) based on the acoustic image?*
  The seabed is characterised by a relatively flat surface with depressions and elevations. The mobile sand layer is relatively thin in this area. Therefore no specific zones of marine activity can be designated.

- *What is the relation between the contacts/anomalies and the topography of the seabed? Based on this relationship can high-risk areas be marked?*
  The boulder fields are a natural phenomenon that can be associated to the geological genesis of this research area.

- *If no acoustic phenomena can be observed, are there any indications that this is due to either natural erosion, sedimentation or human action?*
  Not applicable, as some acoustic phenomena have been observed.

- *Which mitigating measures are necessary to prevent the disturbance of possibly existing archaeological sites?*
  No(possible) archaeological contacts have been identified. Therefore this question is not relevant.

- *Is it possible to make a statement on the basis of this research about the structure of future archaeological research or supervision and, if so, which statements?*
  As learnt form various offshore surveys, archaeological remains might be discovered in the same research area during follow up surveys with higher data density .

6 Recommendations

The archaeological assessment of the SSS, MAG and Multibeam data of the well site Turkoois has not led to the identification of any (possible) archaeological contacts. Therefore no follow up research is advised, the archaeological procedure for the well site Turkoois can be ended with the finalization of this report.

Even though no (possible) archaeological contacts have been localized, there always is a small chance that undiscovered archaeological remains are covered under the seabed. This relatively small risk is acceptable and in case a possible archaeological find is encountered during construction, this should be reported to the authorities as indicated in Article 5.10 of the Dutch Heritage Act.

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Internet resources

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https://archis.cultureelerfgoed.nl/
https://geoweb.rijkswaterstaat.nl/GeoWeb41/
https://www.rijkswaterstaat.nl/
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List of figures and tables

Appendix 1 – Side Scan Sonar Contacts

LU3042-553

SSS Contact list

Area	Turkoois		Target detection			1mx1m							
Vessel	GOII		Number of targets			33							
Date	10-nov		Coordinate system			UTM31 N - ED50							
SSS Target	Geodetics		SSS Contact										Remarks
	Easting	Northing	Length	Width	Height	Description	Category	XTF file name	Image file	Date & Time		MAG Contact	Target
No.	(m)	(m)	(m)	(m)	(m)					dd/mm/yyyy	hh:mm		
SSS_Tu_001	717189,4	5963478,0	2,3	0,4	0,1	irregular object	3	0205_STU_XL01_161019H	HF_S_B2_0005	16-10-2019	10:22:12		
SSS_Tu_002	717269,8	5963340,5	2,5	1,2	0,2	circular object	3	0205_STU_XL01_161019H	HF_S_B2_0006	16-10-2019	10:22:19		
SSS_Tu_003	717069,3	5963127,6	2,3	0,3	0,1	elongated object	3	0216_STU_XL02_161019H	HF_S_B2_0008	16-10-2019	14:15:26		
SSS_Tu_004	717106,6	5963062,0	1,8	0,5	0,3	elongated object	3	0217_STU_XL03_161019H	HF_S_B2_0009	16-10-2019	14:32:37	GRAD_Tu_051	
SSS_Tu_005	717203,1	5963134,9	1,4	0,5	0,2	irregular object	3	0217_STU_XL03_161019H	HF_S_B2_0010	16-10-2019	14:31:45		
SSS_Tu_006	717426,1	5963167,5	0,9	0,3	0,1	rounded object	3	0206_STU_XL04_161019H	HF_S_B2_0011	16-10-2019	10:48:33		
SSS_Tu_007	716881,4	5962802,8	1,0	0,6	0,2	rounded object	3	0206_STU_XL04_161019H	HF_S_B2_0012	16-10-2019	10:44:30		
SSS_Tu_008	716709,6	5962689,8	1,2	0,7	0,2	irregular object	3	0206_STU_XL04_161019H	HF_S_B2_0013	16-10-2019	10:43:15		
SSS_Tu_009	716737,7	5962706,4	1,2	0,4	0,1	irregular object	3	0206_STU_XL04_161019H	HF_S_B2_0014	16-10-2019	10:43:27		
SSS_Tu_010	716716,5	5962675,3	1,8	0,6	0,2	irregular object	3	0206_STU_XL04_161019H	HF_S_B2_0016	16-10-2019	10:43:14		
SSS_Tu_011	716622,7	5962614,5	1,2	0,6	0,2	rounded object or 2 objects nearby	3	0206_STU_XL04_161019H	HF_S_B2_0017	16-10-2019	10:42:29		
SSS_Tu_012	717414,3	5963139,6	3,0	0,7	0,3	elongated object	3	0215_STU_XL05_161019H	HF_S_B2_0020	16-10-2019	13:49:09		
SSS_Tu_013	717067,4	5962824,1	1,1	0,6	0,2	rounded object	3	0214_STU_XL06_161019H	HF_S_B2_0022	16-10-2019	13:31:14	GRAD_Tu_015	
SSS_Tu_014	717079,8	5962798,3	1,4	0,7	0,3	rounded object	3	0214_STU_XL06_161019H	HF_S_B2_0023	16-10-2019	13:31:12		
SSS_Tu_015	717031,1	5962774,6	2,2	0,5	0,2	elongated object	3	0214_STU_XL06_161019H	HF_S_B2_0024	16-10-2019	13:30:48		
SSS_Tu_016	716733,2	5962699,5	2,9	1,1	0,0	irregular object	3	0214_STU_XL06_161019H	HF_S_B2_0025	16-10-2019	13:28:36		
SSS_Tu_017	716663,5	5962527,8	1,5	0,4	0,2	elongated object	3	0214_STU_XL06_161019H	HF_S_B2_0026	16-10-2019	13:27:37		
SSS_Tu_018	716617,9	5962596,4	1,8	0,3	0,4	rounded object	3	0214_STU_XL06_161019H	HF_S_B2_0028	16-10-2019	13:27:40		
SSS_Tu_019	716885,4	5962491,7	1,2	0,8	0,1	small rounded object	3	0213_STU_XL09_161019H	HF_S_B2_0030	16-10-2019	13:09:15		
SSS_Tu_020	716904,1	5962489,4	2,4	0,8	0,3	irregular object	3	0213_STU_XL09_161019H	HF_S_B2_0031	16-10-2019	13:09:09		
SSS_Tu_021	717310,9	5962776,9	2,0	0,3	0,2	elongated object	3	0213_STU_XL09_161019H	HF_S_B2_0032	16-10-2019	13:05:52		
SSS_Tu_022	717539,2	5962897,8	1,3	0,9	0,2	rectangular shaped object	3	0208_STU_XL10_161019H	HF_S_B2_0033	16-10-2019	11:30:17		
SSS_Tu_023	717457,4	5962829,9	1,4	0,6	0,2	rounded object	3	0208_STU_XL10_161019H	HF_S_B2_0034	16-10-2019	11:29:37		
SSS_Tu_024	717437,1	5962823,8	1,4	0,5	0,1	elongated object	3	0208_STU_XL10_161019H	HF_S_B2_0035	16-10-2019	11:29:30		
SSS_Tu_025	717337,2	5962760,2	1,6	0,9	0,1	elongated object	3	0208_STU_XL10_161019H	HF_S_B2_0036	16-10-2019	11:28:45		
SSS_Tu_026	717231,5	5962675,8	1,3	0,6	0,1	rounded object	3	0208_STU_XL10_161019H	HF_S_B2_0038	16-10-2019	11:27:54		
SSS_Tu_027	717548,1	5962939,4	2,6	0,7	0,2	elongated object - probably geology	3	0211_STU_XL11_161019H	HF_S_B2_0039	16-10-2019	12:24:16		
SSS_Tu_028	717476,0	5962770,4	2,0	0,4	0,4	rounded object	3	0210_STU_XL12_161019H	HF_S_B2_0040	16-10-2019	12:09:41		
SSS_Tu_029	717525,4	5962687,3	1,7	0,6	0,2	irregular object	3	0210_STU_XL12_161019H	HF_S_B2_0041	16-10-2019	12:09:37		
SSS_Tu_030	716870,4	5962221,3	1,6	0,9	0,2	rounded object	3	0210_STU_XL12_161019H	HF_S_B2_0042	16-10-2019	12:04:39		
SSS_Tu_031	716959,4	5962185,7	2,0	0,6	0,3	elongated object	3	0209_STU_XL13_161019H	HF_S_B2_0043	16-10-2019	11:52:24		
SSS_Tu_032	717256,7	5962329,7	1,2	0,6	0,1	irregular object	3	0209_STU_XL13_161019H	HF_S_B2_0045	16-10-2019	11:49:45		
SSS_Tu_033	717540,9	5962947,4	2,3	1,1	0,2	elongated contact - possible geology	3	0211_STU_XL11_161019H	HF_S_B2_0046	16-10-2019	12:24:16		

Appendix 2 – Magnetometer Contacts

No.	Easting	Northing	AS_Field_\	Description	Max_nT	Min_nT	Amplitude_	Magnetic_	Apparent_'	Depth_of_I	Survey_Alt	SSS_Contai	MBES_Con	Target
GRAD_Tu_	717063.6	5962816.5	28,7	Monopole	-0,6	0	0,6	0,3	0,1	0,7	3,2			
GRAD_Tu_	717151.8	5962905.9	3,6	Dipole	-0,2	0,5	0,7	0,1	0,3	1	3,5			
GRAD_Tu_	716883.9	5962581.3	15	Dipole	-0,5	0,5	0,9	0,2	0,7	1,4	3,3			
GRAD_Tu_	716856.3	5962711.5	89,8	Monopole	0	0,9	0,9	3,9	0,1	0,8	3			
GRAD_Tu_	717337.5	5962855.2	2,1	Dipole	-0,2	0,7	0,9	0,1	0,1	0,8	3,8			
GRAD_Tu_	717189.9	5963076	3,1	Monopole	-0,1	1	1,1	1,3	1	1,8	3,1			
GRAD_Tu_	716919.3	5962837.8	28,2	Monopole	-1,3	0	1,3	0,6	0,6	1,5	3,6			
GRAD_Tu_	716982	5963048.4	3,5	Monopole	0	1,4	1,4	1,3	0,3	1	3			
GRAD_Tu_	717566.1	5962776	7,2	Monopole	-0,1	1,4	1,5	0,1	0,2	1	3,8			
GRAD_Tu_	717043.2	5963091.3	17,4	Monopole	0	1,5	1,5	1	0	0,5	2,8			
GRAD_Tu_	716955.6	5963030.7	9	Dipole	-0,2	1,4	1,6	0,3	0,1	0,8	3,3			
GRAD_Tu_	717539.7	5962881.9	3	Monopole	0	1,7	1,7	0,3	1,2	1,6	3			
GRAD_Tu_	717115.8	5963252.7	4,1	Monopole	0	1,7	1,7	0,3	0,8	1,6	3			
GRAD_Tu_	717303	5963190.9	6,9	Monopole	-0,2	1,6	1,8	5,5	1,2	1,7	3,6			
GRAD_Tu_	717372	5963211.9	22,9	Monopole	0	1,8	1,8	1,4	1,4	1,8	2,7			
GRAD_Tu_	717173.1	5962739.4	164,6	Monopole	0	1,9	1,9	0,2	0,7	1,5	3,7			
GRAD_Tu_	716546.7	5962888.2	2,4	Dipole	-0,7	1,2	1,9	0,6	0,1	0,8	3,3			
GRAD_Tu_	717047.1	5963020.8	23,8	Monopole	-0,2	1,7	1,9	0,1	0,3	0,9	3,4			
GRAD_Tu_	717335.1	5963282.4	12,2	Monopole	-0,1	2	2,1	0,6	1,3	1,8	3,3			
GRAD_Tu_	717313.5	5962814.1	19,6	Dipole	-1,7	0,5	2,2	0,6	0,2	0,9	3,4			
GRAD_Tu_	717274.2	5963016	2,6	Monopole	-2,2	0,1	2,2	0,8	0,7	1,5	3,2			
GRAD_Tu_	717099.9	5963054.4	22,3	Dipole	-1,3	0,9	2,2	0,8	0,4	1,1	3,8			
GRAD_Tu_	716846.4	5962751.7	22,6	Dipole	-1,3	1,3	2,6	0,6	0,2	1	2,9			
GRAD_Tu_	717484.5	5963014.2	2,5	Monopole	-2,6	0,1	2,7	38,9	0,8	0,8	3,9	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	716800.2	5962555.5	5,2	Monopole	-0,1	2,7	2,8	0,8	0,1	0,6	3,3			
GRAD_Tu_	716976.6	5963114.4	13	Monopole	0,1	3,1	3,1	1	0,5	1,3	3,1			
GRAD_Tu_	716836.8	5962329.3	4	Dipole	-1,3	2,1	3,4	0,3	2,2	1,8	3,2			
GRAD_Tu_	716983.8	5962760.1	51	Dipole	-1,1	2,3	3,4	0,3	0,7	1,4	3,5			
GRAD_Tu_	717462.6	5963017.2	8,9	Dipole	-5,2	-0,3	4,9	11,3	10,7	2,1	3,7	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	716880	5962389.9	47,5	Dipole	-4,7	1,2	5,9	0,8	0,2	0,6	3,3			
GRAD_Tu_	717142.5	5962666.5	18,7	Monopole	-5,6	0,6	6,1	2,1	0,1	0,8	3,4			
GRAD_Tu_	717411.3	5963037	3	Monopole	-0,7	7,5	8,2	20,1	0,8	1	4	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717125.4	5963162.1	147	Monopole	-8,8	0,4	9,1	27	8,9	2,6	3,6	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	716987.7	5963235	7,1	Dipole	-8,4	0,9	9,3	0	0,7	1,3	3,5	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717041.4	5963200.8	8	Dipole	-2,3	7,7	10	27,5	7,9	2	3,3	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717376.5	5963052.3	33,3	Dipole	-8,3	2,6	10,9	10,3	0,6	0,9	3,4	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717074.1	5963188.8	2	Monopole	-10,6	0,4	11	1178,5	15,8	3	3,2	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	716689.8	5962660.5	4,1	Monopole	0	12,3	12,4	9,5	1,5	1,4	3,1			
GRAD_Tu_	717080.4	5963178	2	Monopole	-12,2	0,6	12,8	0	43	4,1	3,3	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	716626.8	5962559.4	11,9	Monopole	-13,4	-0,5	12,9	6,3	0,9	0,8	3,4			
GRAD_Tu_	717397.8	5962682.7	52,7	Dipole	-11,1	2,2	13,2	2,1	3,2	1,4	3			
GRAD_Tu_	717280.2	5963091.3	15,4	Dipole	-10,8	3,5	14,3	12,7	54,8	3,5	3,4	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717194.7	5963124.9	2	Dipole	-3,5	11,7	15,2	31,4	4,2	0,8	3,2	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717364.8	5963055	3,3	Dipole	-1,3	14	15,3	48,9	4,4	1,5	3,3	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717295.5	5963081.4	5,6	Monopole	-15,1	0,2	15,3	7,3	10,5	2,3	3,4	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717416.7	5963037	3,2	Dipole	-6,5	9,4	15,9	20,9	4,1	1,4	4	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717021	5963217.9	15	Dipole	-14,5	1,5	16	14,8	0,6	0,8	3,5	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717439.5	5963026.8	52,2	Dipole	-7,5	9,6	17,2	9	0,8	1,1	3,1	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717318.6	5963074.8	4,7	Dipole	-15,6	1,7	17,3	3,3	27,5	2,6	3,3	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717026.7	5963209.8	2,3	Dipole	-0,9	16,7	17,6	14,7	5	1,7	3,2	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717393.9	5963047.2	17,8	Dipole	-11,9	6,8	18,7	786,5	0,9	0,9	3,5	Associated	Associated	Associated with Teleco Cable Winterton-Borkum 1

No.	Easting	Northing	AS_Field_\	Description	Max_nT	Min_nT	Amplitude_	Magnetic_	Apparent_'	Depth_of_I	Survey_Alt	SSS_Contai	MBES_Con	Target
GRAD_Tu_	717155.7	5963146.2	6,7	Dipole	-16	2,8	18,8	47,9	7,3	2,1	3,4			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717485.4	5963009.7	23,9	Dipole	-18,2	1,7	19,8	22,2	7,9	1,6	3,3			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717143.1	5963153.4	49,7	Dipole	-18,8	1,4	20,2	65,9	1,1	0,7	3,4			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717297	5963078.1	2,7	Monopole	-19,7	0,5	20,3	7,5	11	1,7	3,2			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717139.2	5963151	57,1	Monopole	-19,8	0,7	20,5	2165,5	0,6	0,6	3			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717125.7	5963156.7	66,7	Dipole	-19,3	1,4	20,6	24,9	3,5	1,5	3,1			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717250.8	5963098.2	24,2	Monopole	-21,6	-0,8	20,8	8,5	0,6	0,6	3,3			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717129.3	5963158.2	104,9	Monopole	-20,4	0,4	20,8	37,8	93,9	5,1	4			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717404.4	5963039.7	36,1	Dipole	-6,4	14,8	21,1	11,5	13,6	2,1	3,7			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717429	5963034	7,7	Monopole	-21,8	0,4	22,2	60,8	1,5	1,4	4,1			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717413.4	5963034.3	2,2	Dipole	-8,3	14,2	22,5	28,2	4,1	1,4	3,8			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717414	5963034.9	2,1	Dipole	-8,4	14,4	22,8	36	2,9	1,4	3,9			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717350.1	5963058.6	13,9	Dipole	-1,4	21,5	23	5,6	0,4	0,7	3,9			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717075	5963183.7	3,6	Monopole	-22,5	0,7	23,3	33	3,3	1,5	3,2			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717093.9	5963273.1	2,5	Monopole	-0,5	22,8	23,3	22,1	6,1	1,6	3,2			
GRAD_Tu_	717234	5963109.3	2,6	Monopole	-23,6	0,2	23,8	34,8	38	2,2	2,9			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717039.3	5963205	13,4	Dipole	-23,5	0,5	24	31,9	6,2	2	3			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717432.3	5963030.4	11,4	Dipole	-23,7	1,1	24,7	39,2	11,4	1,9	3,4			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717255.9	5963101.8	2	Dipole	-21,3	3,8	25,1	25,6	0,7	0,6	3,2			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717427.5	5963030.7	50,6	Monopole	-25	0,3	25,3	66,9	2,8	1,5	3,7			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717057	5963194.5	3,9	Dipole	-22,8	3,4	26,3	0	61,4	3,8	3,2			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717330.6	5963044.8	12,4	Dipole	-25,2	1,2	26,5	8,5	1,3	1,2	3,7			
GRAD_Tu_	717169.2	5963137.8	8,5	Dipole	-24,2	3,1	27,3	14,7	0,2	0,4	3,8			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717362.4	5963056.5	37	Monopole	-0,1	27,5	27,6	44,7	9,7	1,8	3,3			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717394.5	5963043.9	3	Dipole	-25,5	2,2	27,7	17,8	1,5	1,1	3,5			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717488.7	5963008.5	10,4	Dipole	-28	1,5	29,4	30,6	25,8	2,9	3,6			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717096.9	5963174.4	2,9	Dipole	-27,1	2,4	29,5	10,7	4,2	1,5	3,4			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717144.3	5963154.3	72,2	Dipole	-27,9	1,8	29,7	79,4	0,9	0,7	3,3			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717455.4	5963022	2,6	Dipole	-1,9	28,4	30,3	175,5	11	2,4	3,5			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717101.4	5963173.2	3,6	Dipole	-5	26,1	31	7,4	5,8	1,4	3,2			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717458.4	5963020.8	3,2	Dipole	-2	29,1	31,1	61,2	27,7	2	3,4			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717277.5	5963092.8	3,7	Dipole	-2,9	28,6	31,5	8,1	3,9	1,3	3,7			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717132.6	5963153.7	56,6	Dipole	-3,6	28,2	31,8	79,6	3,3	1,4	3,1			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717004.5	5963221.8	2,1	Dipole	-4,5	28,9	33,4	81,2	3,4	1,5	3,3			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717512.1	5963001	7,6	Dipole	-32,7	1,3	34	78,2	6,9	1,5	3,5			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717341.1	5963062.8	30,4	Dipole	-1,3	34,5	35,8	33,2	5	1,4	3			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717342.6	5963064.9	2,1	Dipole	-1,4	34,7	36,1	35,9	1,7	1,1	3,1			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717534	5962993.5	2,5	Dipole	-37,6	1,5	39,1	810509,3	0,3	0,4	3,7			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717546.6	5962987.8	2,4	Dipole	-2,5	36,8	39,3	41,9	3,2	1,3	3,7			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717338.1	5963068.2	9,5	Monopole	-41,3	0,1	41,4	44,7	2,7	1,2	3,9			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717287.1	5963085.6	14,2	Dipole	-16,7	25,8	42,4	38	5,9	1,5	3,2			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717457.8	5963024.1	4,6	Dipole	-14	29,3	43,2	187	12,3	2,2	3,4			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717468.6	5963020.5	3,2	Dipole	-18,8	24,4	43,3	16,4	8,5	1,8	3,4			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717515.4	5962999.5	7,1	Dipole	-42,8	1	43,9	53,6	70,8	3,2	3,6			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717270.9	5963091.9	7,2	Monopole	-46	1,3	47,3	69,6	7,8	1,6	3,6			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717511.8	5963003.7	2,6	Dipole	-46,7	1,2	48	113,7	8,7	1,7	3,1			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717061.5	5963189.1	5	Dipole	-47	1,3	48,2	39,4	20,8	2,2	3,2			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717240.6	5963104.5	10,6	Dipole	-4,9	46	50,9	87,4	22,8	2	3,3			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717320.7	5963072.7	2,2	Dipole	-36,8	19,4	56,2	3,3	9,6	1,2	3,6			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717106.5	5963166.6	16,5	Dipole	-4,5	54,8	59,3	10	11,9	1,7	3,2			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717235.5	5963108.4	8,1	Dipole	-58,1	2,5	60,6	23,3	3,9	1,3	3,1			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717162.6	5963143.2	3,3	Monopole	0,7	74,1	73,4	50,5	9,8	1,2	3,2			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717220.2	5963110.8	2,5	Dipole	-68,2	5,9	74,1	37,7	88,3	3,2	2,9			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717161.1	5963142	4	Monopole	0,5	75,9	75,5	37,2	6,2	1	3,2			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717210	5963120.1	4,4	Monopole	-0,8	75,2	76	140,5	10,5	1,4	3,1			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717187.8	5963130.9	2,5	Monopole	-0,9	82,7	83,6	41,9	3,8	1,2	2,7			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717263.4	5963097	33,3	Dipole	-79,9	8,5	88,4	217,7	13,6	1,8	3			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717260.7	5963094.6	4,3	Dipole	-79,9	8,7	88,6	162,7	9,8	1,5	3,2			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717219.6	5963115.9	3,6	Dipole	-95,4	3,7	99,1	40,8	0,1	0,3	3,1			Associated Associated Associated with Teleco Cable Winterton-Borkum 1
GRAD_Tu_	717218.4	5963112.9	4,2	Dipole	-122,7	5	127,7	32,4	11,7	1,5	3			Associated Associated Associated with Teleco Cable Winterton-Borkum 1