Netherlands Enterprise Agency

Archaeological Assessment (Phase II)

Hollandse Kust (noord)

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Cultural Heritage Agency
Ministry of Education, Culture and Science

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Date 18-6-2018
Subject Archaelogical assesment of geophysical survey data report Hollandse Kust Noord

Reference

RW-2018-8

Dear Mr. Van Erp,

The Cultural Heritage Agency has assessed the report "Hollandse Kust (noord) - an archaeological assessment of geophysical survey data", version: revision 5.0, dated 11th of June 2018.
The Cultural Heritage Agency approves the content of this report, including the conclusions and recommendations.

Yours sincerely,

Drs. M. Snoek
Maritime Advisor
Cultural Heritage Agency

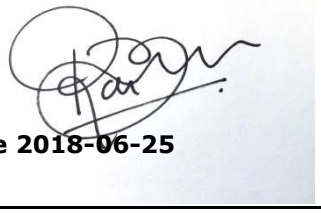
Netherlands Enterprise Agency

RVO.nl distribution

Document title: Archaeological Assessment phase II
Hollandse Kust (noord) Wind Farm Zone

Document subtitle: --

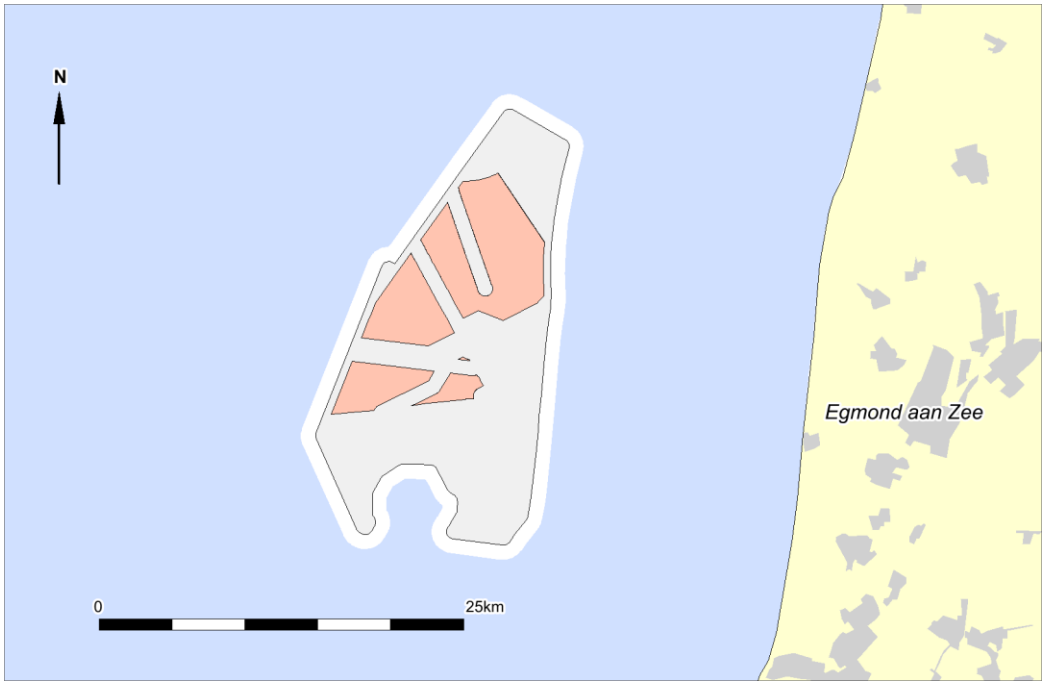
Author (s): Periplus Archeomare, R. van Lil and S. van den Brenk
Contract manager RVO.nl: Cynthia Mors
Project ID RVO.nl: WOZ2170027
Number of pages: 77 pages

Version	**Approved for public disclosure by contract manager RVO.nl**	**Approved for public disclosure by project manager offshore wind RVO.nl**
Final	**Name Cynthia Mors** **Signature**  **Date 2018-06-26**	**Name Ruud de Bruijne** **Signature**  **Date 2018-06-25**

Periplus Archeomare

Hollandse Kust (noord)

An archaeological assessment
Of geophysical survey results



Authors
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At the request of

Rijksdienst voor Ondernemend Nederland (RVO.nl)

Netherlands Enterprise Agency

Document Control	
Document 17007-02 Hollandse Kust (noord) – an archaeological assessment of geophysical survey data	
Revision	5.0
Date	11-06-2018
Periplus Archeomare Reference	17A007-02
RVO.nl reference	HKN_20180611_Periplus_Archaeological Assessment Report_17A007-02_Rev5.0_Final

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Colophon

Periplus Archeomare Report 17A007-02
Hollandse Kust (noord) – An archaeological assessment of geophysical survey results
Authors: R. van Lil and S. van den Brenk

At the request of RVO.nl
Contact: Mw. C. Mors

ISSN 2352-9547

Revision details

Revision	Description	Authors	Checked by	Autorisation	Date
5.0	Final comments incorp.	RvL/SvdB	BvM	BvM	11-06-2018
4.0	Final comments incorp.	RvL/SvdB	BvM	BvM	15-05-2018
3.0	Wind farm sites adjusted	RvL/SvdB	BvM	BvM	08-05-2018
2.0	Comments addressed	RvL/SvdB	BvM	BvM	01-03-2018
1.0	For Client Comments	RvL/SvdB	BvM	BvM	31-01-2018

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Table of contents

Table 1. Dutch archaeological periods

Period	Time in Years				
Post-medieval / Modern Times	1500	A.D.	-	Present	
Late medieval period	1050	A.D.	-	1500	A.D.
Early medieval period	450	A.D.	-	1050	A.D.
Roman Times	12	B.C.	-	450	A.D.
Iron Age	800	B.C.	-	12	B.C.
Bronze Age	2000	B.C.	-	800	B.C.
Neolithic (New Stone Age)	5300	B.C.	-	2000	B.C.
Mesolithic (Stone Age)	8800	B.C.	-	4900	B.C.
Paleolithic (Early Stone Age)	300.000	B.C.	-	8800	B.C.

Table 2. Administrative details

Location:	North Sea	
Toponiem Dutch:	Hollandse Kust (noord)	
Chart:	1801-01	
Coordinates	Centre	E 584 846, N 5 838 982
Geodetic datum: ETRS89	NW	E 589 059, N 5 853 752
Projection: UTM31N	NE	E 593 530, N 5 851 538
	SW	E 576 176, N 5 831 691
	SE	E 589 268, N 5 824 065
Depth (LAT):	15.0 to 34.5 meter, average 22.6 meter	
Surface area	310 square km	
Environment:	Tidal currents, salt water	
Area use:	Shipping lane, fishing and recreation, sand extraction	
Area administrator:	Rijkswaterstaat Zee en Delta	
ARCHIS-research report (CIS-code):	4551336100	
Periplus-project reference:	17A007-02	
Period	January – June 2018	

Samenvatting (Abstract in Dutch)

In opdracht van RVO.nl heeft Periplus Archeomare een archeologische analyse uitgevoerd van de resultaten van de geofysische onderzoeken voor het toekomstige windpark Hollandse Kust (noord).

Op de locatie voor het toekomstige windpark is een gebied met een oppervlakte van 310 km^2 opgenomen met *side-scan-sonar, magnetometer, multibeam echolood en profilering subbottom profiler*. De grote hoeveelheid onderzoeksgegevens is geanalyseerd om een archeologische beoordeling uit te voeren.

De analyse van de geofysische onderzoeksresultaten vormt, na het bureauonderzoek, de tweede stap in het archeologische proces. Uit het bureauonderzoek is gebleken dat er binnen de begrenzing van het geplande windpark in totaal 244 objecten en wrakken bekend waren. De meeste van deze objecten bestaan uit kleine voorwerpen, verloren kabels of kettingen, die niet als van archeologisch belang worden beschouwd. Voor 12 objecten (wrakken) is de archeologische waarde nog niet bepaald.

Twee van deze objecten zijn terug gevonden op de zeebodem. De andere tien objecten zijn niet terug gevonden. Van vijf van deze objecten was de originele positie (zeer) onnauwkeurig, deze liggen mogelijk buiten het onderzoeksgebied. De overige vijf objecten zijn mogelijk afgedekt met sediment (verplaatsende zandgolven) en daardoor niet gevonden tijdens de survey.

Afgezien van de twee bekende gevonden objecten zijn 129 contacten gerapporteerd met side scan sonar. De analyse van deze contacten heeft geresulteerd in een definitieve selectie van vier onbekende objecten en structuren die, op basis van hun vorm en afmetingen, van archeologische waarde zouden kunnen zijn.

Een samenvatting van alle zichtbare objecten met een archeologische verwachting is opgenomen in de onderstaande tabel.

Nr	Easting	Northing	L(m)	W(m)	H(m)	Omschrijving PPA	Classificatie PPA
10	592700	5846422	1.0	1.0	0.5	NCN 2118/16651, mogelijke wrakresten	Wrakresten
21	587094	5847292	9.8	1.0	0.3	Duidelijk object, gedeeltelijk begraven	Onbekend object
43	588396	5827503	14.3	10.4	2.3	NCN 2060, scheepswrak, deels gebroken en afgedekt met sediment	Wrakresten
78	585770	5834462	4.1	3.1	1.3	Duidelijk object	Onbekend object
110	579971	5839026	5.4	1.5	0.4	Duidelijk object	Onbekend object
131	586424	5829880	5.4	1.1	0.5	Langwerpig object loodrecht op stroomribbels	Onbekend object

Table 3. Objecten uit side scan sonar and multibeam met een archeologische verwachting

Zolang de werkelijke archeologische waarde van de objecten niet bepaald is, wordt geadviseerd geen activiteiten uit te voeren op deze locaties (zes zichtbare objecten en vijf afgedekte bekende objecten, elf in totaal), inclusief een bufferzone van 100 meter rondom. Dit geldt ook voor het aanleggen van kabelsleuven en verankeringen van werkschepen.

De bufferzone van 100 meter is een norm die van toepassing is op de bescherming van cultureel erfgoed. Deze afstand kan worden verkleind als kan worden onderbouwd dat de toegepaste verstoring geen effect heeft op het archeologisch object. Als bijvoorbeeld geen verankering wordt gebruikt tijdens het leggen van de kabels, kan de bufferzone worden verkleind. Reductie van de afstand moet worden goedgekeurd

door Rijkswaterstaat (RWS). Rijkswaterstaat is de handhavende instantie, handelend in opdracht van het ministerie van Economische Zaken en Klimaat. De Rijksdienst voor het Cultureel Erfgoed (RCE) treedt op als adviseur van Rijkswaterstaat.

In totaal zijn 1035 magnetische anomalieën waargenomen. 652 van deze anomalieën kunnen gerelateerd worden aan bekende pijpleidingen of kabels. Slechts zeven anomalieën kunnen gerelateerd worden aan zichtbare objecten aan het bodemoppervlak.

370 magnetische anomalieën kunnen niet worden gerelateerd aan bekende pijpleidingen en kabels of zichtbare objecten op het oppervlak van de zeebodem. 138 van deze magnetische anomalieën liggen binnen de definitieve sites. De anomalieën worden veroorzaakt door onbekende ijzerhoudende objecten in de zeebodem, die zijn afgedekt door sediment.

90 van de magnetische anomalieën binnen het onderzoeksgebied hebben een amplitude van 50 nT en meer. 35 van deze van deze anomalieën met een amplitude van 50 nT en meer vallen binnen de definitieve sites.

Met betrekking tot deze begraven objecten wordt geadviseerd om deze locaties, inclusief een bufferzone van 100 meter, te vermijden tijdens het installeren van windturbines en de kabels. Het moet worden benadrukt dat de aard van de magnetische anomalieën onbekend is. Dit betekent dat afgezien van mogelijke archeologische objecten ook andere type objecten kunnen worden aangetroffen, waaronder niet-gesprongen explosieven, ankers, stukken kettingen en kabels, puin, enzovoort.

Als het niet mogelijk is om de gerapporteerde magnetometerlocaties te vermijden, is aanvullend onderzoek nodig om de feitelijke archeologische waarde van de objecten te bepalen. Indien een UXO onderzoek wordt uitgevoerd binnen 100 meter van de locaties, wordt aanbevolen om dit onderzoek archeologisch te begeleiden. Afhankelijk van de uitkomst van het UXO-onderzoek kan worden besloten of aanvullend onderzoek (bijvoorbeeld door middel van ROV of duikonderzoek) nodig is. Als het UXO-onderzoek aangeeft dat het object geen archeologische waarde heeft, kan de locatie worden geschrapt.

Op basis van de resultaten van de verschillende onderzoeken en ter vermijding van de bestaande pijpleidingen en kabels, zijn de definitieve kavelgrenzen bepaald, rekening houdend met de minimale totale capaciteit van 700 MW. De definitieve kavels (92 km^2) beslaan een gebied van ongeveer een derde van het totaal onderzochte gebied (310 km^2). Het advies is daarom alleen van toepassing op de gebieden van de definitieve kavels. Binnen de kavels bevinden zich 38 locaties met mogelijke archeologische resten; 35 magnetometer locaties en 3 side scan sonar locaties.

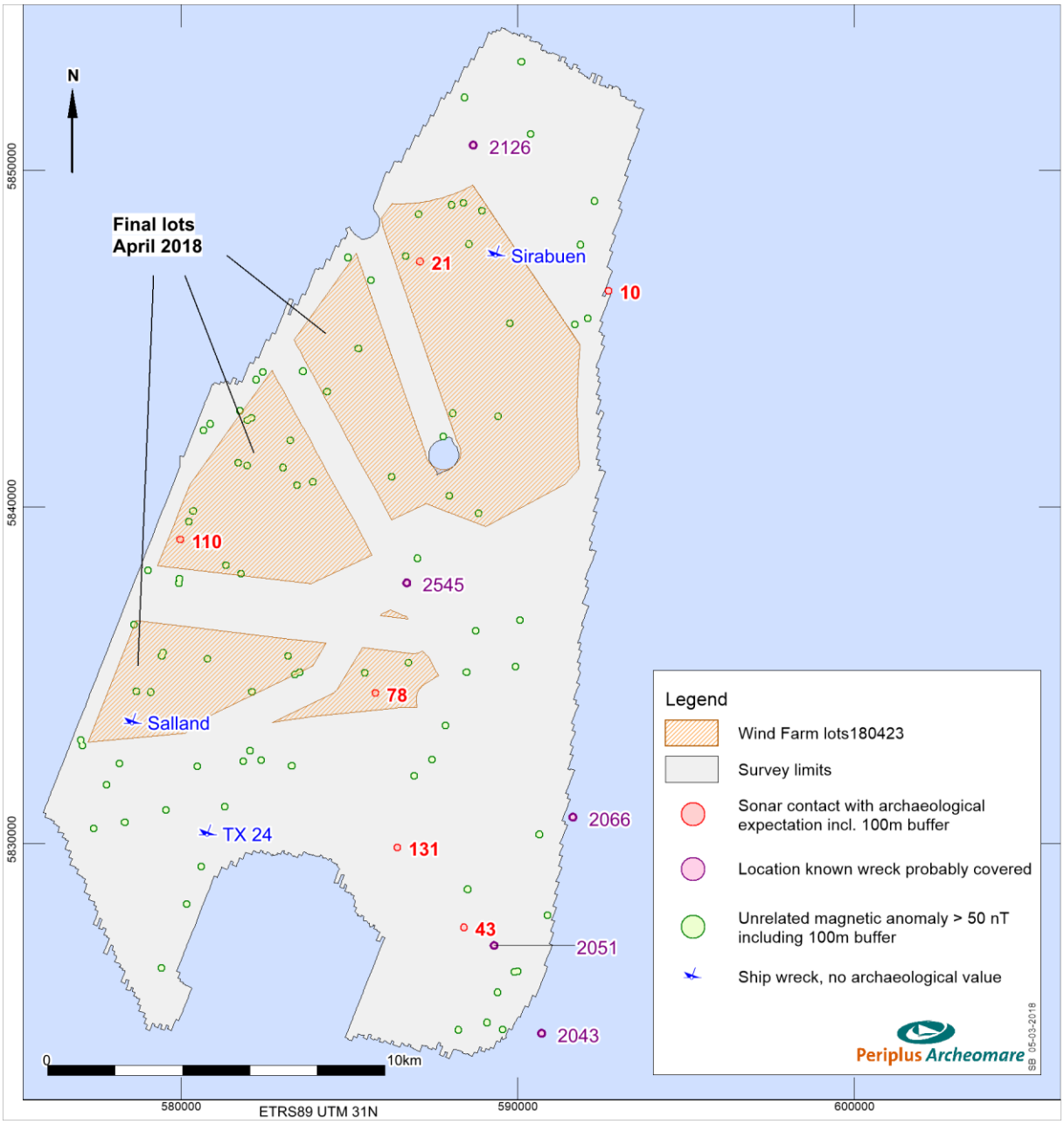

Figure 1. Bufferzones (100m) op schaal rondom de locaties met een archeologische verwachting.

Prehistorie

Uit de geïnterpreteerde seismische gegevens kan worden geconcludeerd dat goed bewaarde Laat Paleolithische en Mesolithische nederzettingsresten kunnen voorkomen in de paleo-riviervallei in het zuidelijke deel van het onderzoeksgebied. Interessante plekken zijn de oevers van kleine kreken en eolische duinen van de formatie Boxtel in de buurt van de vallei, vooral als die gebieden worden bedekt door veen of klei.

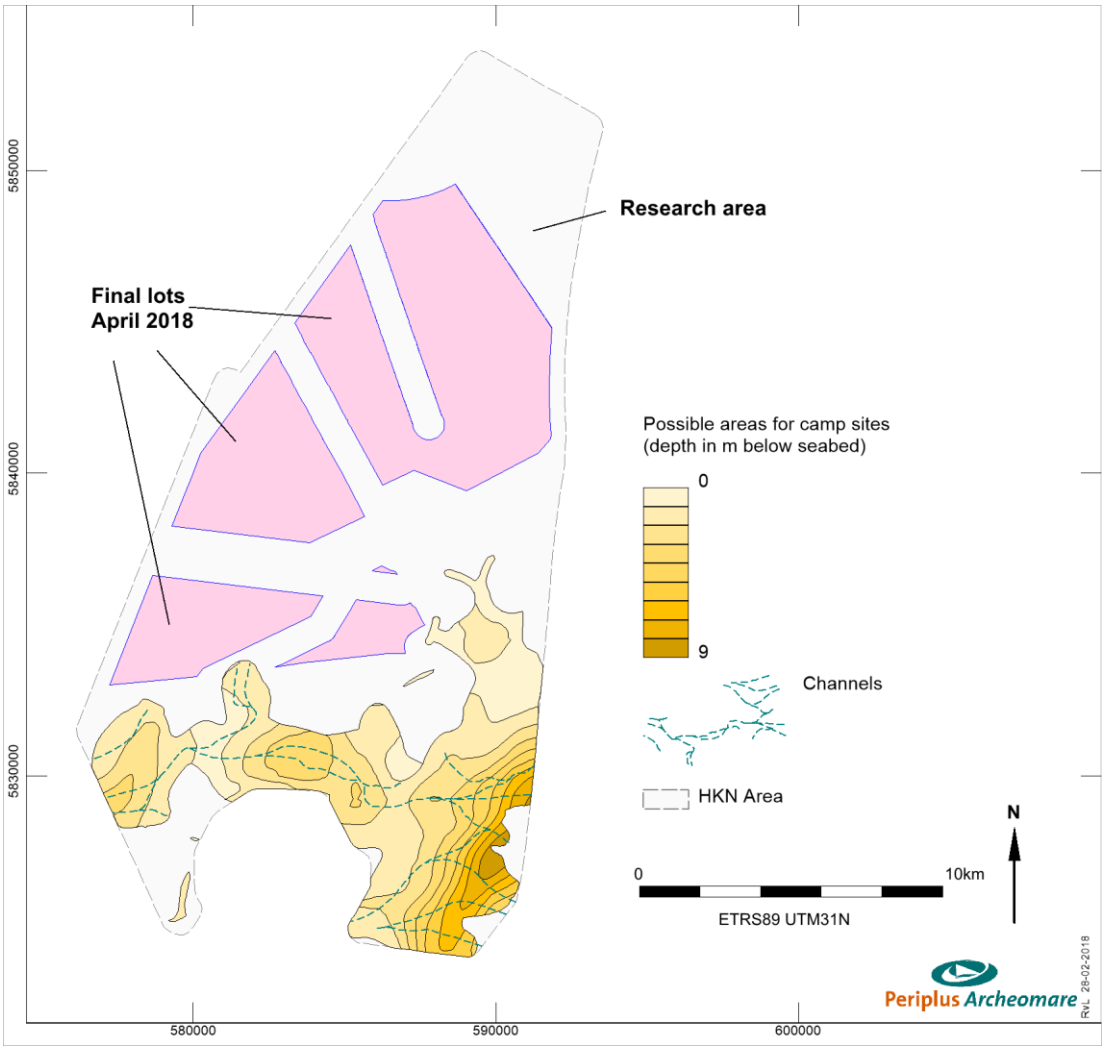

Figure 2. Possible areas for Late Paleolithic and Mesolithic camp sites.

In het uiteindelijke ontwerp van de kavels zullen de mogelijke gebieden voor Laat-Paleolithische en Mesolithische resten niet worden beïnvloed door de installatie van het windpark. Daarom wordt aanvullend onderzoek niet geadviseerd.

Tijdens de aanleg van het windmolenpark kunnen archeologische resten aan het licht komen die volledig begraven waren of niet als een archeologisch object zijn herkend tijdens het geofysisch onderzoek. We raden daarom passieve archeologisch begeleiding aan op basis van een goedgekeurd Programma van Eisen. Passief betekent dat een archeoloog niet tijdens de uitvoering van het werk aanwezig is, maar altijd op afroep beschikbaar. Hierdoor kunnen vertragingen tijdens de werkzaamheden voorkomen worden wanneer onverwacht archeologische vondsten gedaan worden. Eventuele vondsten dienen gemeld te worden aan het bevoegd gezag. Deze meldingsplicht voor archeologische vondsten dient in het bestek of Plan van Aanpak van het werk te worden opgenomen.

Het bevoegd gezag is de Minister van Economische Zaken en Klimaat op grond van de Wet windenergie op zee. Rijkswaterstaat (RWS) is door de Minister van Economische Zaken en Klimaat gemandateerd om het toezicht op grond van die wet uit te voeren. De Rijksdienst voor Cultureel Erfgoed (RCE) zal door RWS geconsulteerd worden ten aanzien van archeologische aspecten.

Summary

RVO.nl has contracted Periplus Archeomare B.V. to conduct an Archaeological assessment of geophysical survey results of the future Wind Farm Zone (WFZ) Hollandse Kust (noord) (HKN).

A large quantity of survey data (*side scan sonar, magnetometer, multibeam echosounder* and *subbottom profiling*) recorded within the wind farm zone covering a total area of 310 km^2 were analyzed in order to conduct an archaeological assessment.

The current analysis of geophysical survey results is the second and final step in the archaeological assessment, following the desk study. The desk study has shown that a total of 244 objects and wrecks were known within the boundary of the wind farm site. The majority of these objects consist of small objects, lost cables or chains, which are not considered to be of archaeological importance. For 12 (wreck) objects the archaeological value has not been determined.

Two of these known objects have been found exposed at the seabed. The other ten objects which were expected in the area have not been found. For five of these objects, the original positions were not accurate, so they may be locatied outside the wind farm area. The remaining five objects may be covered with sediments due to migration of the sand waves.

Apart from the two known objects found, 129 other contacts were reported with side scan sonar. The analysis of these contacts resulted in a final selection of four unknown objects and structures which may have an archaeological value, based on their shapes and dimensions.

A summary of all visible objects with a possible archaeological expectation is listed in the table below.

Nr	Easting	Northing	L(m)	W(m)	H(m)	Description_PPA	Classification_PPA
10	592700	5846422	1.0	1.0	0.5	NCN 2118/16651, possible wreck remains	Wreck remains
21	587094	5847292	9.8	1.0	0.3	Clear object, partly buried	Unknown object
43	588396	5827503	14.3	10.4	2.3	NCN 2060, wreck broken partly covered with sand	Wreck remains
78	585770	5834462	4.1	3.1	1.3	clear object	Unknown object
110	579971	5839026	5.4	1.5	0.4	clear object	Unknown object
131	586424	5829880	5.4	1.1	0.5	Linear object perpendicular to current ripples	Unknown object

Table 4. Summary of objects from sss and mbes with a possible archaeological value

As long as the archaeological value of the objects is not determined, it is advised not to conduct activities which could affect the locations with possible archaeological objects (six visible contacts and five covered known objects, eleven in total) including a buffer zone of 100 meters around. This also applies to cable trenching and anchorages of work vessels.

The buffer zone of 100 meters is a standard that applies to the protection of cultural heritage, this distance may be reduced if it can be substantiated that the applied disturbance has no effect on the archaeological object. For example, when no anchoring is used during cable lay operations the buffer zone can be decreased. Reduction of the distance has to be approved by Rijkswaterstaat (RWS). Rijkswaterstaat

is the enforcing authority, acting on behalf of the Ministry of Economic Affairs and Climate Policy. The Cultural Heritage Agency of the Netherlands (RCE) acts as an advisor to Rijkswaterstaat.

A total of 1035 magnetic anomalies have been observed. 652 of these anomalies can be related to known pipelines or cables. Only seven can be related to side scan sonar contacts.

A total of 370 magnetic anomalies cannot be related to known pipelines and cables, or visible objects at the seabed surface. 138 of those magnetic anomalies is located within the wind farm sites. The anomalies are related to unknown ferrous objects buried in the seabed, covered by sediments.

A total of 90 out of the 370 anomalies found within the investigation area have amplitude of 50 nT and more. 35 of those 90 anomalies with amplitude over 50 nT is located within the wind farm sites.

Concerning these buried ferrous objects, it is advised to avoid these locations including a buffer zone of 100 meters areas whilst installing wind turbines and the various inner field and export cables. It should be stressed that the origin of the magnetic anomalies is unknown and apart from possible archaeological remains any type of man-made objects can be encountered including unexploded ammunition, anchors, pieces of chains and cables, debris, etcetera.

If it is not feasible to avoid the reported magnetometer locations, additional research is required in order to determine the actual archaeological value of the reported locations. It is advised that the UXO research within 100 meter of the magnetometer anomalies are carried out under onboard archaeological supervision. Depending on the outcome of the UXO research it can be decided if additional research (for instance by means of ROV or dive investigations) is needed. If the UXO research indicates that the object has no archaeological value, the location can be omitted.

Based on the results of the various investigations, and avoiding the existing pipelines and cables, the definition of the final wind farm sites were determined, taken into account the minimum total capacity of 700 MW. The final sites (92 km2) cover an area about a third of the investigated area (310 km2). The advice therefore only applies to the final sites. Within the boundaries of those sites 38 locations could contain archaeological remains; 35 magnetometer locations and 3 side scan sonar locations.

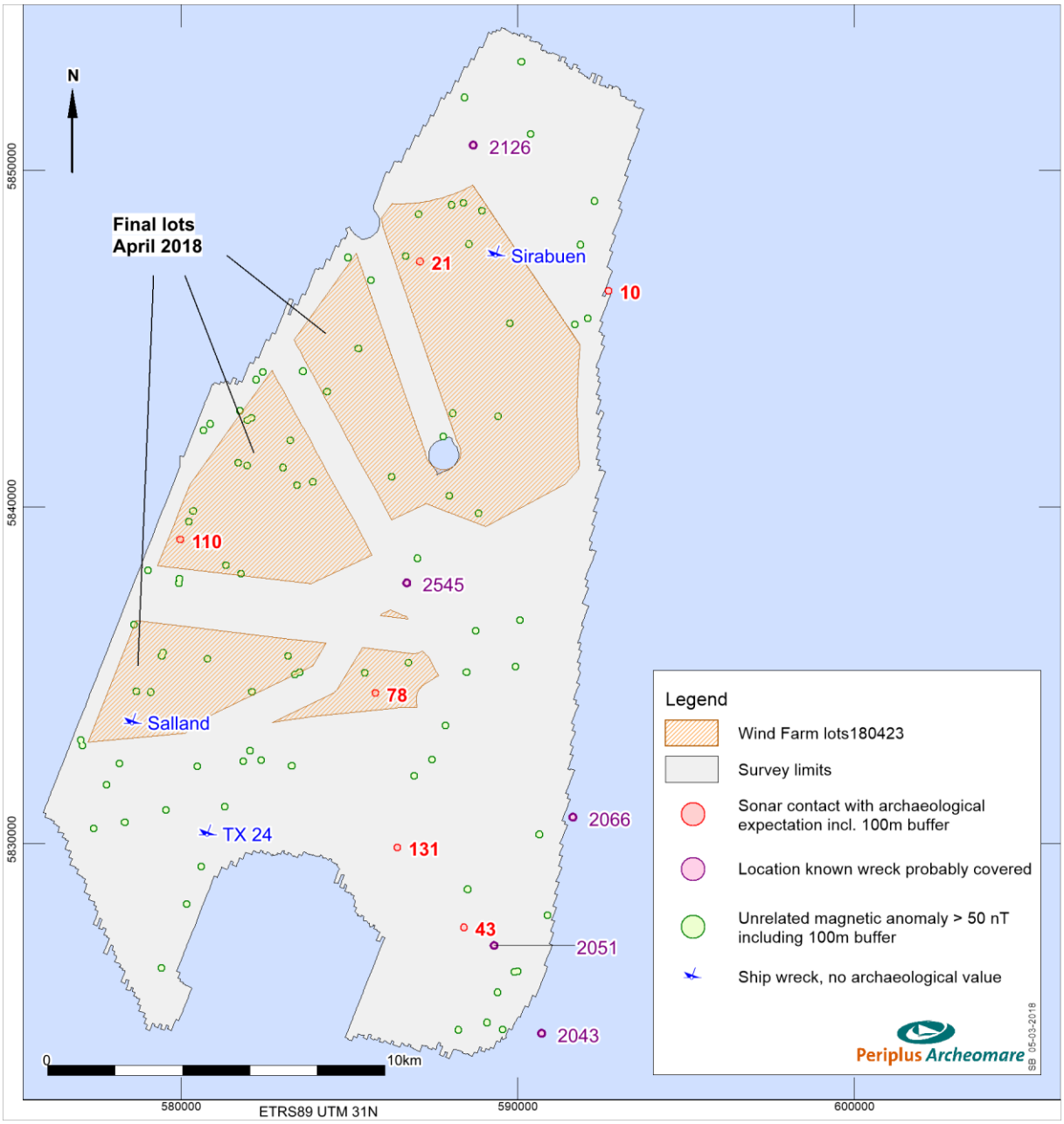

Figure 3. Buffer zones (100m) to scale around contacts with an archaeological expectation

Prehistory

From the interpreted seismic data can be concluded that well-preserved Late Palaeolithic and Mesolithic camp sites can occur in the palaeo-river valley in the southern part of the area of investigation. Areas of interest are the shores of small streams and aeolian dunes of the Boxtel Formation proximate to the valley, especially if those areas are cover by peat or clay.

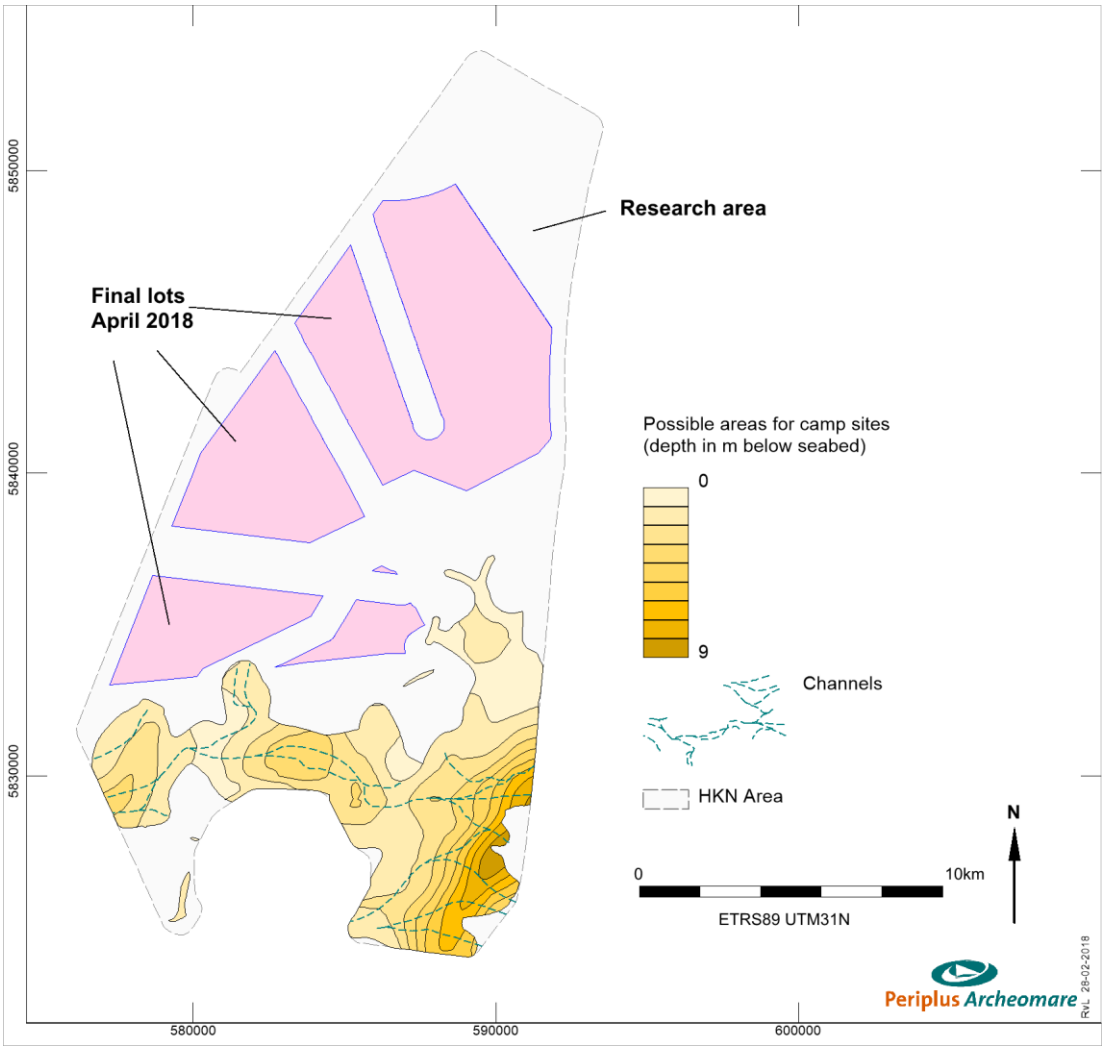

Figure 4. Possible areas for Late Palaeolithic and Mesolithic camp sites.

In the final design of the wind farm sites, the possible areas for Late Paleolithic and Mesolithic camp sites will not be affected by the wind Farm installation. Therefore, additional research is not advised.

During the installation of the wind turbines and cable lay operations, archaeological objects may be discovered which were completely buried or not recognized as an archaeological object during the geophysical survey. We recommend passive archaeological supervision based on an approved Program of Requirements. Passive archaeological supervision means that an archaeologist is not present during the execution of the work but always available on call. Following this recommendation would prevent delays during the work when unexpectedly archaeological remains are found. In accordance with the Erfgoedwet, it is required to report those findings to the enforcing authority. This notification must also be included in the scope of work.

Based on the Offshore Wind Energy Law the enforcing authority is the Minister of Economic Affairs and Climate Policy. The Minister of Economic Affairs and Climate Policy has mandated Rijkswaterstaat to enforce this law. Rijkswaterstaat consults with the Cultural Heritage Agency of the Netherlands (RCE) on archaeological aspects.

1 Introduction

1.1 Location

RVO.nl has contracted Periplus Archeomare B.V. to conduct an Archaeological assessment of geophysical survey results of the future Wind Farm Zone (WFZ) Hollandse Kust (noord) (HKN).

The area of investigation is located in the North Sea, 18.5 kilometers west of Egmond aan Zee. The area of investigation equals the plan area.

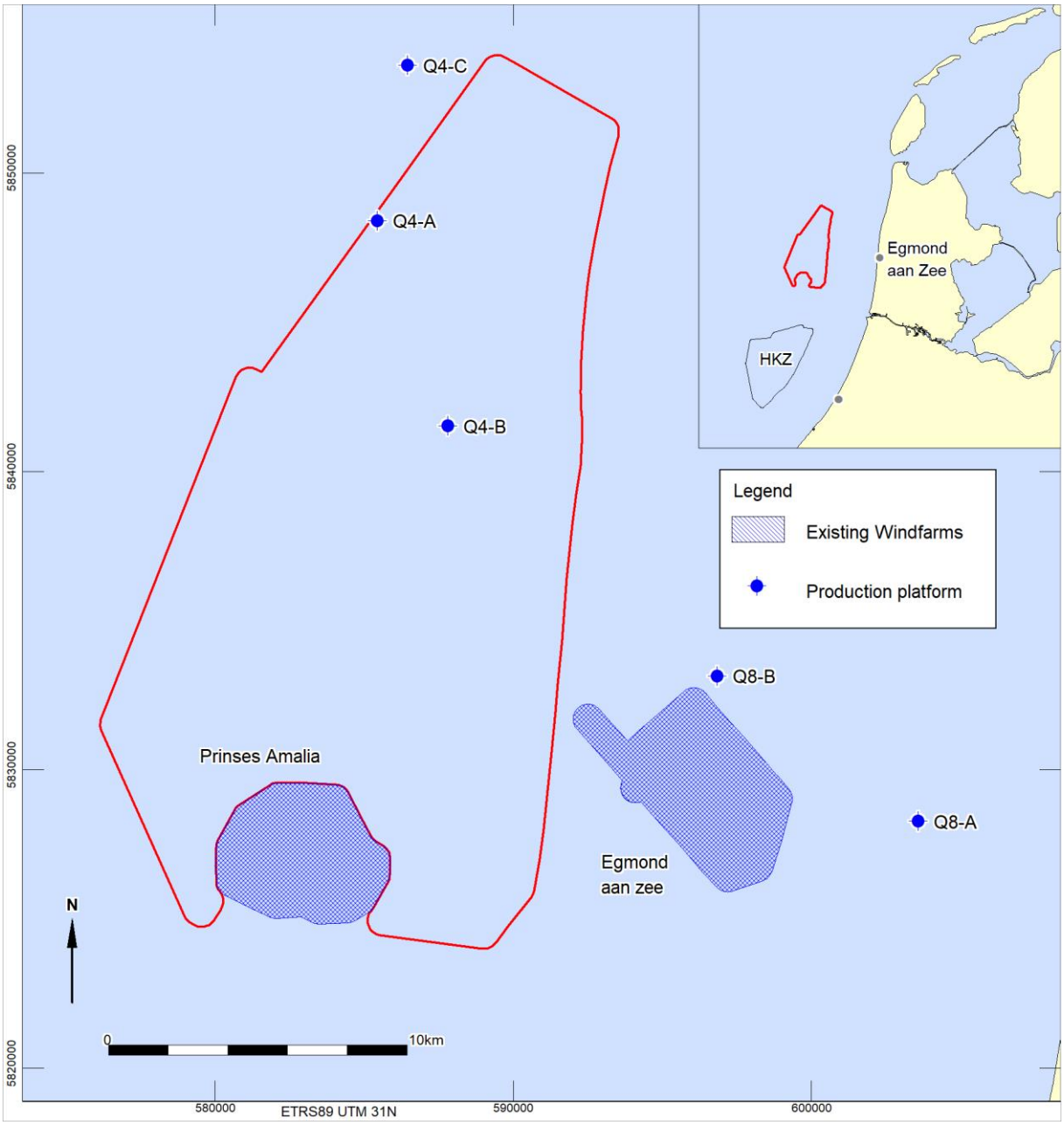

Figure 5. Location map of area of investigation

1.2 Background

The parties to the Energy Agreement for Sustainable Growth have agreed that 4,450 MW of wind power at sea will be in operation by 2023.[1] This means that an additional 3,500 MW of wind power at sea must be installed, in addition to the existing wind farms and the ones under construction.[2] Through an interim revision of the National Water Plan 2009-2015 the HKN-area – initially assigned as search area – was designated for offshore wind energy.

From July to September 2017 Fugro Survey B.V. (Fugro) conducted a geophysical survey to improve the bathymetrical, morphological and geological understanding of the Wind Farm Sites at HKN. The geophysical results will be used together with the geotechnical results to create a ground model. The ground model will serve as the base for the design and installation requirements.[3]

In the Erfgoedwet[4] the protection of the archaeological heritage is embedded. Planned activities, such as the installation of a wind farm in the North Sea, may affect the archaeological values if present. If the remains are in jeopardy there is a statutory obligation to conduct archaeological research. In line with this obligation an archaeological desk study has been carried out.

An archaeological desk study is the first step in the so-called *AMZ* cycle (Archeologische Monumenten Zorg). The *AMZ* cycle includes a description of procedures for subsequent phases of archaeological research to be performed in order to ensure the protection of archaeological heritage in the Netherlands.

The second phase of the *AMZ* cycle is an inventory archaeological field study. As a rule this field study comprises a geophysical survey of the sea bed. The survey executed by Fugro was not primarily set to provide data to be used in the course of archaeological research. However, a scan of the survey data acquired, prove these data to be fit for an archaeological assessment.

The separate phases of the AMZ-cycle are embedded in the Dutch Quality Standard for Archaeology (KNA Waterbodems 4.0). This standard dictates a mandatory workflow for archaeologists. A detailed description of the different phases of archaeological research is included in appendix 4.

1.3 Results desk study[5]

In May 2017 an archaeological desk study has resulted in specific information on the archaeological remains which are to be expected within the HKN WFZ. The study has proven that (remains of) ship wrecks and WWII plane wrecks are to be expected in the area. Figure 6 shows the known contacts which have been identified during the desk study. Locally *in situ* remains of Late Paleolithic and Early Mesolithic camp sites might be present.

[1] Energy Agreement for Sustainable Growth 2013.

[2] National Water Plan 2016 – 2021.

[3] Nieboer 2016.

[4] De Erfgoedwet became effective on the 1st of July 2016.

[5] Van den Brenk 2016.

Shipwrecks

A total of 14 shipwrecks are known in the area. Four ship wrecks have been identified and have no archaeological value. For the remaining 10 wrecks, details like names, types and date of sinking are not known, nor are the exact locations. Therefore, the cultural-historical value has not been determined yet.

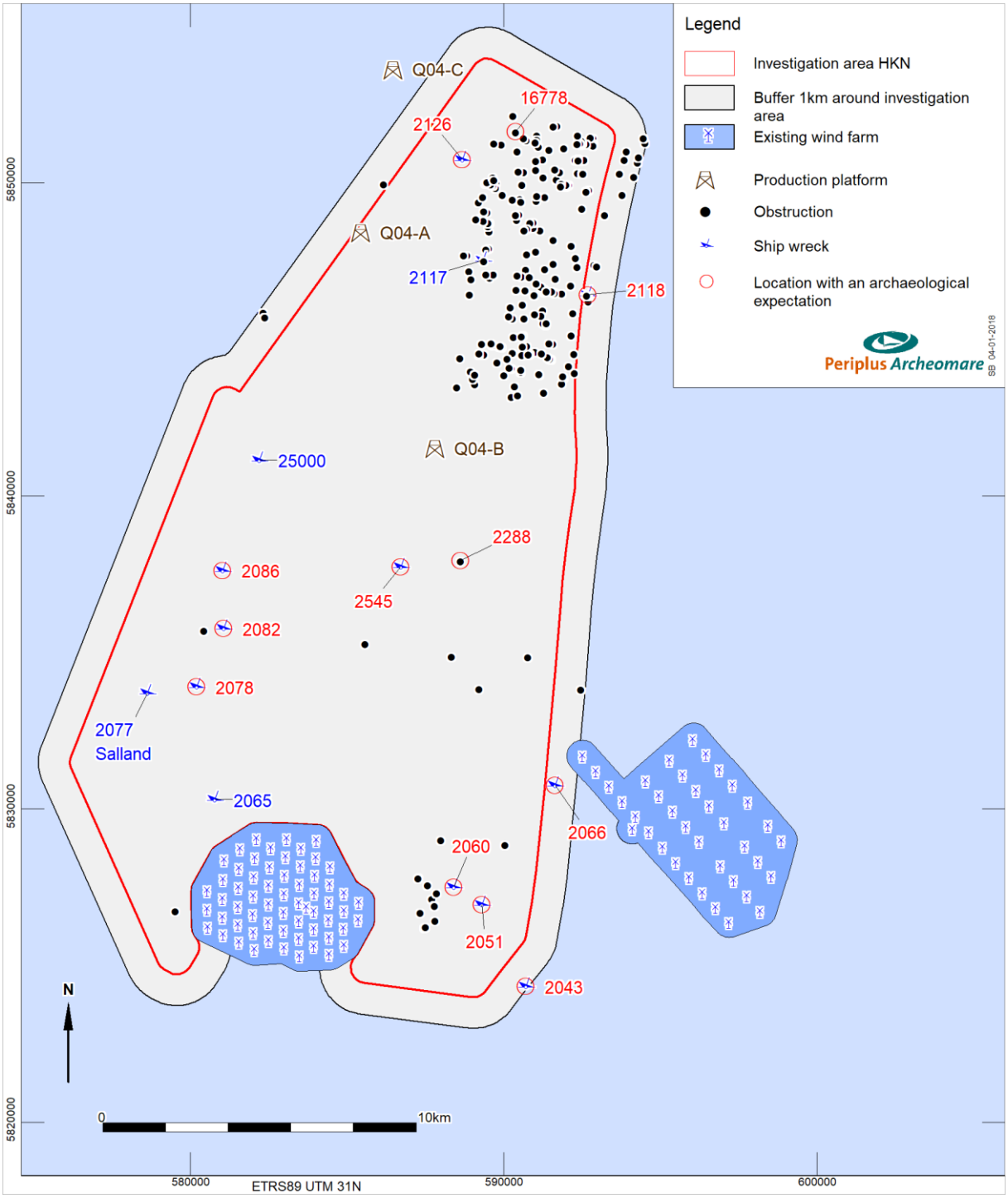

Figure 6. Overview of known objects and contacts in the area of investigation[6]

[6] Van den Brenk and van Lil, 2017.

Plane wrecks

During World War II, many airplanes crashed into the North Sea. Several sources are ambiguous about the number of aircraft still missing. It is at least hundreds. Remains are found on a regular base by fishermen or during sand extraction. In the vicinity of the area of investigation, four locations of plane wrecks are known. It is quite possible to expect plane wrecks within the area of investigation.

Prehistory

Remains of prehistoric camp sites are expected in situ in covered sand dunes and ridges (Wierden Member) and river dunes (Delwijnen Member) provided these units are un-eroded. Within the Basal Peat Bed and Velsen Bed well-preserved lost objects and dumps can be encountered. The archaeological levels of interest located under a cover of the Bligh Bank Member.

Remains of Neanderthaler camp sites can be expected within lacustrine clays of the Brown Bank Member and (fluvio)glacial deposits of the Uitdam Member, if these units are in fact present in the area.

At this stage little is known about the integrity of the Pleistocene landscape. The Pleistocene units are encountered at shallow depths. Erosion of these units and archaeological remains therein therefore seems likely. Locally the Basal Peat Bed and/or Velsen Bed might have protected the Pleistocene landscape against erosion. By means of subbottom profiling in combination with analysis of undisturbed borehole samples the Basal Peat Bed and Velsen Bed and the underlying well-preserved archaeological level can be mapped. In general the development of the wind farm is an opportunity to learn about the paleolithic and mesolithic landscape and related archaeology. It is unlikely however that archaeological remains of Paleolithic and Mesolithic camp sites can be identified with sufficient certainty (based on the geophysical and geotechnical surveys) to impose restrictions on wind farm development.

The lithostratigraphic units in which and the depth below the seabed at which archaeological remains are to be expected is summarized in the table below.

Unit	Depth top of unit	Archaeological remains	In situ
Southern Bight Formation - Bligh Bank Member	0	ship and plane wrecks	yes
		reworked flint and bone artifacts	no
Velsen Bed	0 – 8	lost objects, dumps	yes
Basal Peat Bed	0 – 10	lost objects, dumps	yes
Boxtel Formation - Wierden Member - Delwijnen Member	0 – 10	camps sites of hunters and gatherers; flint and bone artifacts; burnt nuts and seeds; charcoal; hunting gear	yes yes
Kreftenheye Formation	0 – 10	reworked flint and bone artifacts lost objects, dumps; possible camp sites	no yes
Eem Formation - Brown Bank Member	6 – 10	reworked flint and bone artifacts camps sites Neanderthaler; flint artifacts	no yes
Drente Formation - Gieten Member - Uitdam Member	?	camps sites Neanderthaler; flint artifacts	yes

In 2016, Deltares published a map describing the archaeological expectancy for prehistoric remains and settlements in the Dutch EEZ[7]. The expectancy within the HKN sites matches the results from the desk study.

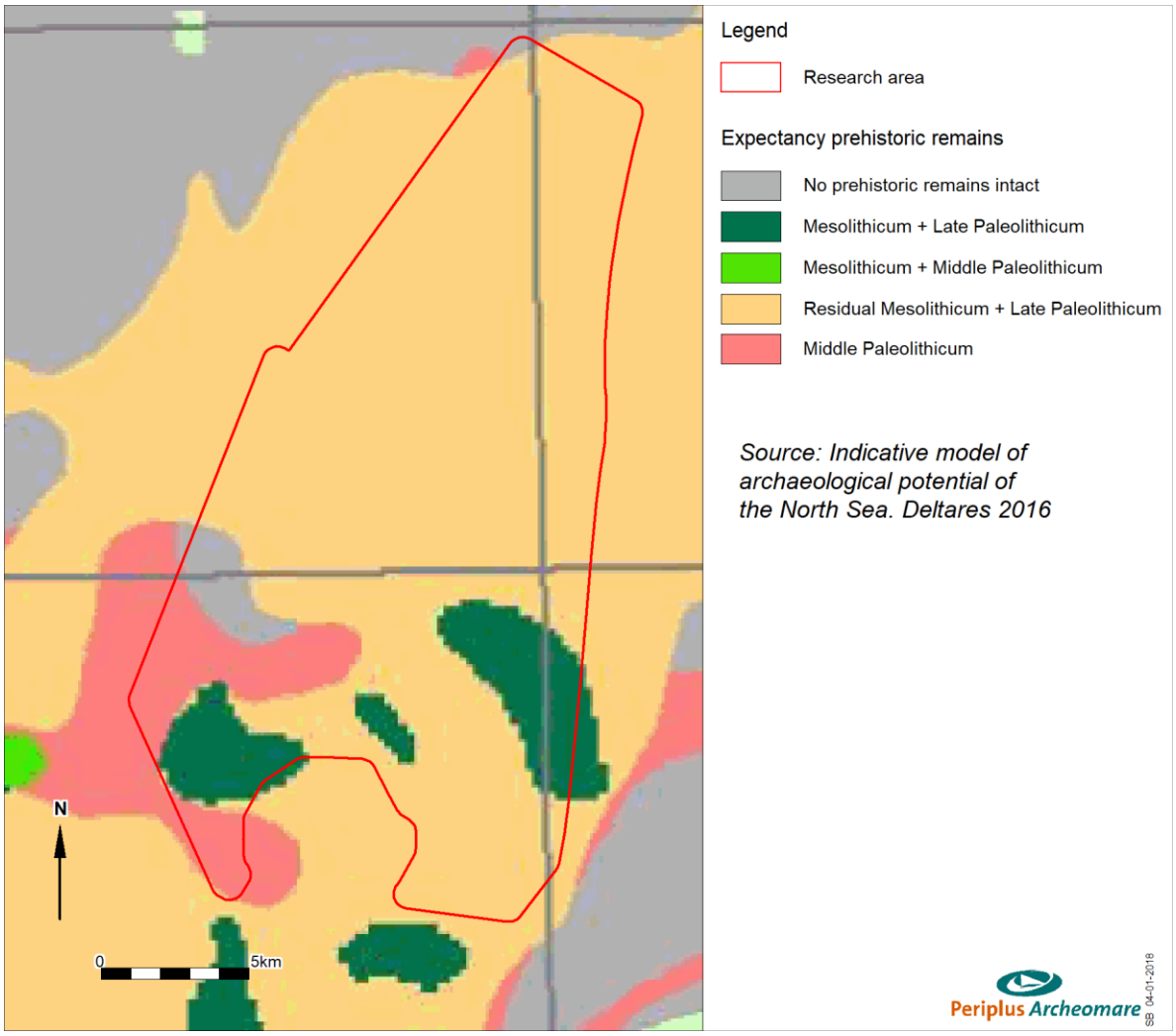

Figure 7. Archaeological expectation for prehistoric remains and settlements (Deltares 2016)

[7] Vonhögen – Peeters 2016.

1.4 Objective

The purpose of the archaeological assessment is to test the desk study based expectancy for archaeological remains in the area. The expectancy covers remains of shipping related objects (wrecks), airplanes from World War II and prehistoric settlements.

The goals set for this assessment are:

- To determine the historical or archaeological value of contacts found in the geophysical survey;
- The validate the locations of known wrecks;
- Assess the prehistoric landscape based on the seismic data.

1.5 Research questions

For the inventory archaeological field study, the following research questions have been defined in the program of Requirements[8]:

primary question:
Are any archaeological remains present within the Area of Interest and to what extent are these remains traceable?

With respect to side scan sonar, magnetometer and multibeam survey:

Are there any phenomena visible on the seabed?

If so:

What is the description of these phenomena?

Do these phenomena have a man-made or natural origin?

If these phenomena can be designated to be man-made:

What classification can be attached?

If these phenomena can be classified as archaeological:

Is it possible to interpret the nature of the archaeological objects?

If these phenomena can be identified as natural:

What is the nature of these natural phenomena?

Based on the acoustic image is it possible to designate zones of high, middle or low activity on the seabed?

If so:

How can these zones be interpreted?

General:

What is the relation between the observed objects and the topography of the seabed? Based on this relationship can risk-prone areas be marked selectively? Risk-prone areas are areas where the probability of archaeological remains is considered to be high. The risk involves both the degradation of archaeological remains by the development of the wind farm as the risks in terms of costs, progress

[8] Van den Brenk and van Lil, 2017

and image of the wind energy project itself because of the presence of archaeological remains and the measures to be taken accordingly.

If no acoustic phenomena can be observed:

Are there any clues that this is a consequence of either natural erosion, sedimentation or human interference?

With respect to subbottom profiler- and sampling:

Based on seismic profiles and geotechnical data is it possible to map the Pleistocene landscape?

If so:

What is the depth of the Pleistocene landscape compared to the present seabed?

From Pleistocene to Holocene deposits is the transition gradual or instantaneous (erosive)?

Can zones be identified where prehistoric settlement remains can be expected?

If so:

Could these expected settlement remains be affected by the installation of the cables based on their vertical position related to the seabed?

Are there any indications observed on the seismic profiles for the presence of buried (man-made) objects?

If so:

Based on the presence of buried objects and its correlation with side scan sonar, magnetometer en multibeam data can something be said about the nature of these buried objects?

Are there any mitigating measures necessary to avoid disturbance of possible archaeological remains?

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2 Methodology

2.1 Introduction

As part of the installation of wind farm related infrastructure (monopiles, cables, power station, etc.) a geophysical survey has been carried out by Fugro. The objectives and the general outcome of the survey activities including the minimum technical, functional and procedural requirements are described in a Scope Work.[9]

The following methods have been deployed:

- sidescan sonar (Edgetech 4200-FS dual frequency 300/600 kHz. SSS)
- single beam echo sounder (SBES)
- magnetometer (MAG)
- multibeam echo sounder (Kongsberg EM2014 MBES 400 kHz.)
- sub-bottom profiler; pinger (SBP)
- ultra high resolution seismic; sparker (UHR)

The results of the survey and geotechnical activities have been recorded in reports, listings, drawings and images. The input for the archaeological assessment consists of the deliverables listed in table 5.

SSS	- XTF-files of all side scan records - event listings containing all contacts observed - geotiffs of all contacts listed
MAG	- event listings containing all anomalies observed
MBES	- validated multibeam XYZ point cloud dataset (grid 25x25cm)
SBP/UHR	- representative subbottom profiles
BH/VC	- descriptions of the bore samples (if applicable)
CPT	- Cone penetration tests (if applicable)
Report	- survey reports

Table 5. Data used for the archaeological assessment

2.2 Geophysical survey

The geophysical survey was carried out by Fugro Survey BV (Fugro) between 30 July – 03 November 2017 using the survey vessels MV Fugro Gauss an MV Fugro Meridian.

For all lines the multibeam, side scan sonar, subbottom profiler and magnetometer were used simultaneously with a line spacing of 100 m and cross lines 2000m. Multichannel seismic survey UHR data were acquired with a line spacing of 500 m for the main lines and cross lines.

[9] De Wolff, 2017

2.3 Known objects

Fugro has summarized the side scan sonar contacts and magnetometer anomalies encountered within the survey area in detailed event listings. From different databases the occurrence of objects within the area is known. The contacts included in the survey event listings are compared with the database objects in the area. For this comparison four different datasets are used:

- The Hydrographic Service database (hereafter referred to as Nlhono database);
- The Rijkswaterstaat SonarReg database (hereafter referred to SR database);
- The Dutch Cultural Heritage Agency database ARCHIS;
- The Dutch Nationaal Contact Nummer database (hereafter referred to as NCN);

The National Contact Number (NCN)

The NCN database combines the data from three governmental databases:

- The Dutch Continental Shelf and Westerschelde wrecks register from the Hydrographic Service of the Royal Netherlands Navy;
- The SonarReg object database of Rijkswaterstaat;
- The ARCHIS database (the official archaeological database of the Ministry of Cultural Heritage)

The permission for the use of the NCN database for the analysis was granted by the owner (Rijkswaterstaat Sea and Delta).

The NCN database contains all basic information (E, N and description) of the Nlhono, SR and Archis databases. More detailed information is gathered through the other datasets.

In addition to ship wrecks information on contacts referred to as ‘foul’ or ‘obstruction’ is included. From these objects the origin is not always known, but information on the location, dimensions and other valuable information is listed. Besides the databases other sources containing information on wrecks and historic finds are consulted for comparison with the survey results.

All known data is combined and plotted in a GIS. In this way an overview is made of the areas in which archaeological remains are present or to be expected. The known contacts are a reference framework for the assessment of data recorded during the route survey.

2.4 Archaeological assessment of survey data

The geophysical and hydrographic survey techniques employed include side scan sonar (SSS), magnetometer (MAG), multibeam (MBES) and subbottom profiling (SBP). The natures of those methods differ, with coherent strengths and weaknesses.

Table 6 provides a summary of the objective(s) the methods employed and the nature of those methods in terms of seabed penetration and coverage. Data are cross-correlated because the methods are complementary. E.g. multibeam data can aid in the interpretation of a side scan sonar contact by

providing information on its height with respect to the surrounding seabed, the occurrence of scouring next to the contact, and the accuracy and precision of the object. CPT's and borehole data can aid in the determination of geological units from seismic strata.

Method	Objective	Seabed		Accuracy and Precision	Cross Correlation
		Penetration	Coverage		
SSS	Identification of outcropping objects; seabed classification	No	Full	High	MBES / MAG
MBES	Charting of seabed morphology; identification of scours	No	Full	Very high	SSS
MAG	Identification of magnetic anomalies induced by ferromagnetic objects	Yes*1	Full*2	Accuracy = high Precision = poor*3	SSS
SBP/UHR	Identification of seismic strata and buried objects such as pipelines, cables and boulders	Yes	No Profile data beneath sailed line	High	BH/VC/CPT*4 MAG
BH/VC	Determination physical properties of sediments and lithostratigraphy	Yes, up to 60 to 80m beneath the seabed	No Point location	High	CPT/ SBP/UHR
CPT	Determination of physical properties of sediments and lithostratigraphy	Yes, up to 50 to 80 m beneath the seabed	No Point location	High	BH/VC/ SBP/UHR

Table 6. Characteristics of geophysical and geotechnical methods employed

*1 detection dependent on size of the ferromagnetic object, depth of burial, height of magnetometer above the seabed and distance cross course
*2 distant and/or deeply buried objects can be missed.
*3 precision: perpendicular to ship heading = ½ * spacing of sailed lines
parallel to ship heading = appr. 1m
*4 interpretation of geology through correlation of seismic data with BH/VC/CPT-data

With *side scan sonar* all objects and structures on the seabed can be made visible. Seabed sediment of different composition can be distinguished by their characteristic reflection. *Multibeam* images reveal the morphology of the seabed. Large objects and scouring can be mapped. Smaller objects, like thin cables, or flat objects lying on the seabed often are impossible to identify in *multibeam* images.

The strength of side scan sonar resides in the ability to visualize differences in reflectivity of seabed sediments and exposed objects. Variations in seabed composition cannot be observed in multibeam data, unless those variations are accompanied by morphological changes. This also applies for objects which are barely elevated above the seabed. Another strength of side scan sonar is full coverage is accomplished with a limited of survey lines. A limitation of side scan sonar buried objects cannot be found with this technique.

The strength of multibeam lies in the high accuracy and high precision images of the seabed morphology the technique provides. Sand waves and current ripples can clearly be observed in side scan sonar data,

but can the height of those sedimentary structures can far better be established by means of multibeam. However buried objects generally cannot not be traced with multibeam, scours caused by shallowly buried objects can lead to the identification of buried objects.

In this study side scan sonar and multibeam data were combined in the identification of objects which are of potential archaeological interest. The listing of potential archeological objects is considered to be complete as far as it concerns exposed objects, although the presence of buried non-ferro-magnetic archaeological objects or objects which erroneously have been labeled as non-archaeological, can never be fully excluded.

Magnetometer contacts are identified by the presence of ferro-metalic objects which induce an anomaly in the earth magnetic field. These objects can be buried or lying on the seabed. Unlike *side scan sonar* and *multibeam* the contacts are tagged at the sailed survey line. The actual object can be located at both sides of the survey line. Given the 100 meter spacing of the run lines the precision perpendicular to the line is in the order of 50 meter. The precision parallel to the run line is in the order of one meter.

The strength of a magnetometer lies in its ability to trace buried objects, if those objects are ferro-magnetic. The technique provides a strong tool in mapping continuous linear structures like buried cables and pipelines. Also an indication of the presence and distribution of isolated ferro-magnetic objects in a area of investigation is obtained.

An important limitation of the magnetometer is the poor precision of the positions of the objects found. An object has to be boxed in by sailing additional lines with a magnetometer to pinpoint the location of the object. Further, the measured amplitude of a magnetic anomaly is dependent on the interaction of different parameters, such as the size of the object, the depth of burial, the height of the magnetometer above the seabed and the distance cross course. Because of this it is very hard to establish the size of the object which caused the anomaly. Thirdly buried objects cannot be seen. Therefore it is not possible to identify the nature of the buried object.

The listing of magnetometer anomalies is expected to be complete as far as it concerns large ferro-magnetic objects. As the line spacing employed is 100 meter it cannot be excluded that especially small distant buried objects have been missed.

Fugro processed their survey data and produced detailed event listings of the *side scan sonar* and *magnetometer* contacts encountered within the survey areas. Alike the known objects the locations of the contacts are plotted in a GIS.

In the course of this archaeological assessment a selection is made based on the dimensions of the reported contacts. All contacts have been assessed, and the fraction of contacts larger than or equal to four (4) meter is looked into in more detail, because these objects are considered to be more likely to be related to wreck sites than the smaller contacts. This choice is based on best professional judgment and not prescribed by legislation or the KNA. Purpose of this analysis is to identify contacts that could reflect potential archaeological sites.

This is done by analyses of:

- *side scan sonar* images included in the survey reports;
- raw *side scan sonar* data (XTF-files);
- raw *multibeam*-data (xyz-files);
- values of magnetic anomalies reported in the survey reports;
- comparison of *side scan sonar* and *magnetometer* contacts;

Apart from the survey data studied the geological constellation and seabed morphology of the area are taken into account as outcrops of geological strata and sedimentary structures can lead to (apparent) anomalies in the *side scan sonar* record.

The *side scan sonar* images are scanned in order to define potential archaeological sites. A selection of contacts was made of contacts to be studied in detail. The interpretation and selection of *side scan sonar* contacts is based on best professional judgment. If desired or needed the exact nature of the contacts observed can be established with certainty through the execution of additional research by means of a ROV or divers in a following phase.

Fugro has acquired and processed shallow seismic data using a sub-bottom profiler (SBP), a single channel sparker (SPK) and an ultra-high resolution multi-channel sparker (UHR). The processing involved an analysis of seismic profiles which had a line spacing of 100 m for the main lines and 2000 m for the cross lines. Observed seismic strata have been digitized and – based on known geological data from the area – lithostratigraphic units have been identified. The base of each lithostratigraphic unit has been interpolated into a grid. The results have been summarized and reported. In addition to the identification and occurrence of lithostratigraphic units seismic anomalies which are expected to reflect potential hazardous phenomena have been identified.

2.5 Data Analysis

The first step in the data analysis is to cross-reference known objects within the surveyed area with the survey data. For the comparison the results of the desk study and the survey datasets were used. All the known objects were projected in a GIS together with the survey data.

For the cross-reference we have assumed that all present possible contacts and anomalies have been reported and described by the survey contractor. Only the raw data is used, when available, to verify the description of found objects and anomalies as reported.

The positions of the interpreted contacts from the different surveys were compared with the positions of the known objects collected from the databases. Besides that, all the positions of both the survey contacts and the known objects were plotted on the high resolution *multibeam* grid to visualize the morphological influence of the presence of these objects. This assisted in the determination of possible archaeological value of the present remains. If an object had a potential archaeological value, the description of the object was finalized.

Besides the objects detected from the *side scan sonar* survey also the *magnetometer* contacts were plotted on the high resolution *multibeam* grid. For the *magnetometer* contacts that corresponded with the *side scan sonar* contacts within 50 meters of each other, these contacts were considered to be related. When at the position of the *magnetometer* anomaly no visible object was recognized the size of the anomaly was leading. If the magnetic anomaly of a contact is more than 50 nT (nano-Tesla) then it is stated that the contact could possibly be of archaeological value. All the *magnetometer* contacts above 50 nT but within 25 meter of the existing cable and pipeline routes are exempt for further investigation. It has to be stressed that within this assessment no distinction can be made between anomalies related to possible archaeological objects or anomalies related to (for example) unexploded ordinance (UXO's).

An archaeological assessment has been undertaken for all visible contacts. This interpretation is based on best 'professional judgment'.

The interpreted seismic data have been assessed in order to test the archaeological expectation with respect to remains of prehistoric settlements in the area. The archaeological desk study has resulted in the identification of lithostratigraphic units which could contain archaeological levels. The grids produced by Fugro have been used to get an insight both the lateral and vertical distribution of the lithostratigraphic units and the expected archeological levels herein. Thus testing the desk study based archaeological expectation. An important factor included in the assessment is the integrity of layer boundaries, because erosion by natural processes poses a significant threat to archaeological levels. Based on the assessment, zones within the wind farm zone which are expected to contain archaeological remains are mapped and presented. The results are reviewed in the context of the activities planned in order to predict possible influence on the potential archaeological remains.

The analysis was executed in January 2018 by R. van Lil and S. van den Brenk (both KNA senior prospector). The investigation is carried out according to specifications set up within the Dutch Quality Standard for Archaeology (*KNA Waterbodems 4.0; protocol 4103*).

2.6 Used Sources

The following sources were used for the analysis:

- Survey data Fugro, original survey data and reported interpretations;
- Archaeological desk study Periplus (17A007-01, RVO.nl reference WOZ2170027);
- ARCHIS database Cultural Heritage Agency;
- Archeomare Database;
- Nlhono database Hydrographic Service of the Royal Netherlands Navy;
- Wrecksite.eu;
- Database, Nationaal Contact Nummer (NCN).

For a complete list of used sources and literature see the reference list at page 66.

Italic written words are explained in the glossary at page 65.

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3 Results

3.1 Seabed bathymetry and morphology

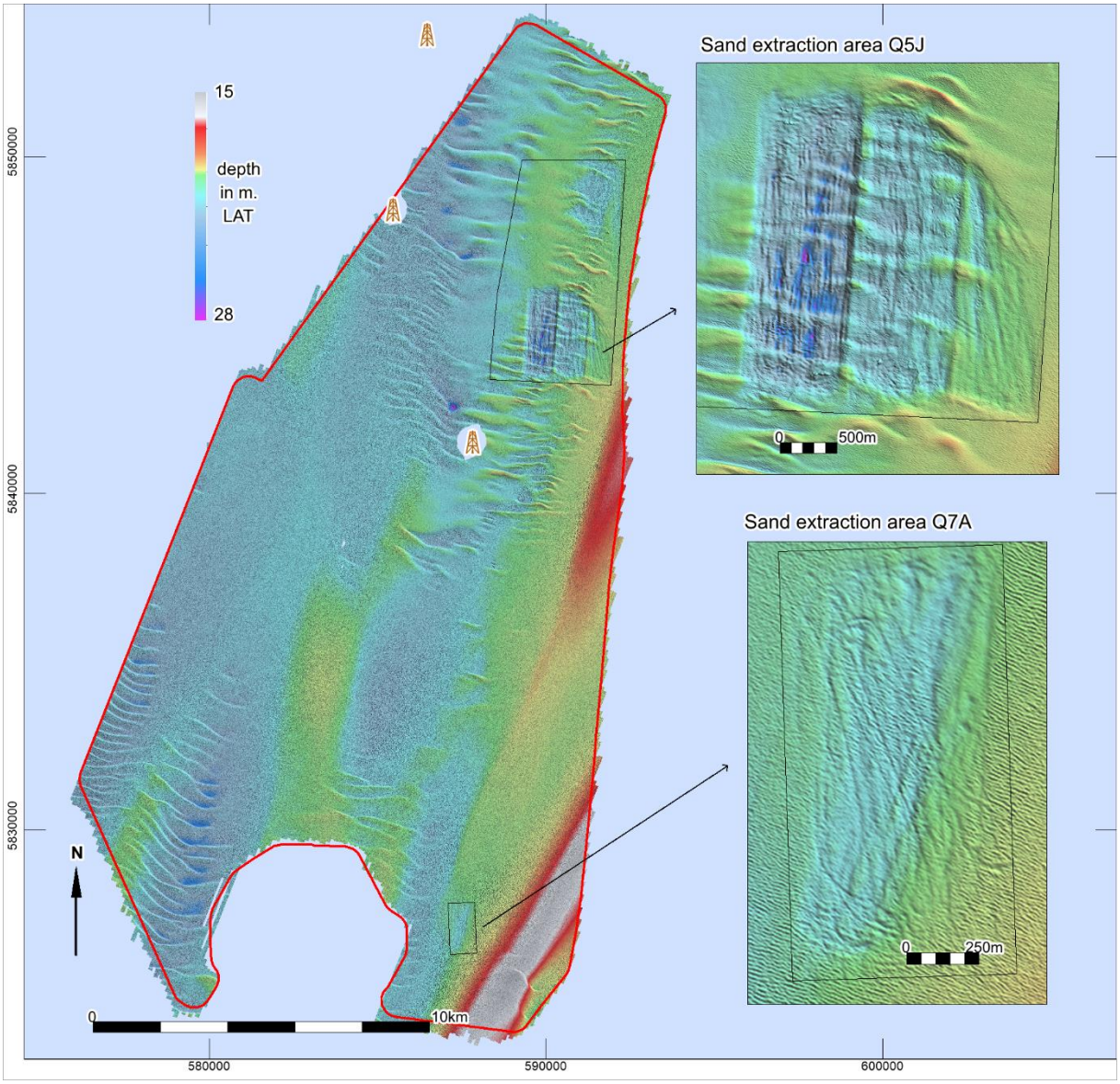


Figure 8. Bathymetry based on the multibeam recordings (source data: Fugro 2017)

Based on the 2017 survey data the water depth within the HKN WFZ varies from 15.6 to 27.9 mLAT.

Seabed

The seabed is characterized by a complex pattern of bedforms with large to very large dunes of various orders. These dunes are NW to SE oriented, with an average wavelength between 123 m and 830 m and a height ranging from 0.5 m to 5.9 m. Superimposed on the major sand dunes, other minor dunes with < 9 m average wavelength and height ranging from 0.3 m to 0.7 m are present.

The shallow area in the southeast is formed by southwest-northeast oriented shoreface-connected ridges. These features are very large sand ridges oriented oblique to the coast. They are 2-30 km long and up to 10 m high. West of the shoreface-connected ridges the area is characterized by north-south oriented sand

ridges. The distance between these ridges is 4.5- 5 km. The difference in height between the sand ridges and surrounding lows is approximately 5 m.

In different parts of the area, sand waves are superimposed on the sand ridges. Sand waves are dynamic bed forms with wavelengths of the order of 100-1000 m and amplitudes between trough and crest in the order of several meters. The sand waves present in this area have varying dimensions and are quite irregular. The typical height of the sand waves is 1-2 m (trough-crest) with the largest sand waves not exceeding 2.5 m. Wavelengths vary widely from approximately 280 to 650 m (trough to trough). Each of the morphological features in the area has its typical migration rate. The largest, the shoreface-connected ridges, are relatively stable and move with 0 – 1 m/year. Also the north-south oriented ridges are stable, with similar migration rates. Sand waves have a migration rate in the order of 1-10 m/year. Van der Meulen et al. (2004) reported a migration rate of over 20 m/year near the island of Texel, with typical migration rates decreasing southwards to a stationary (0 – 3 m/year) field near the entrance of the Rotterdam Harbour. Observed migration rates in the Prinses Amalia Wind Park, in the southern part of the study area, were recently assessed to be in the order of 4 m/year by Deltares.[10] The final migration rates will be determined in the upcoming Morhodynamical assessment.

[10] Forzoni et al 2017

3.2 Known objects: As Found positions versus database positions

Based on the desk study 244 objects (whereof 14 ship wrecks) are known within the HKN WFZ.

The SSS contacts and MAG anomalies encountered during this survey have been stored in event listings. The positions of the contacts and anomalies in these listings are compared with the theoretical positions of objects in the NCN database. In order to conduct this comparison all SSS contacts and MAG anomalies found within a range of 50 meters around the database locations are selected.

The outcome of this comparison can be:

- The As Found position of a ship wreck is in agreement with the database position of a known wreck;
- The As Found position of a contact is in agreement with the position of a contact listed in the database, but the interpretations do not match;
- The As Found position of a ship wreck is not in agreement with the database position of a known wreck;
- A wreck listed in the database has not been found;
- A new wreck has been found.

An overview of the As Found- versus Not Found known objects is presented in the next figure.

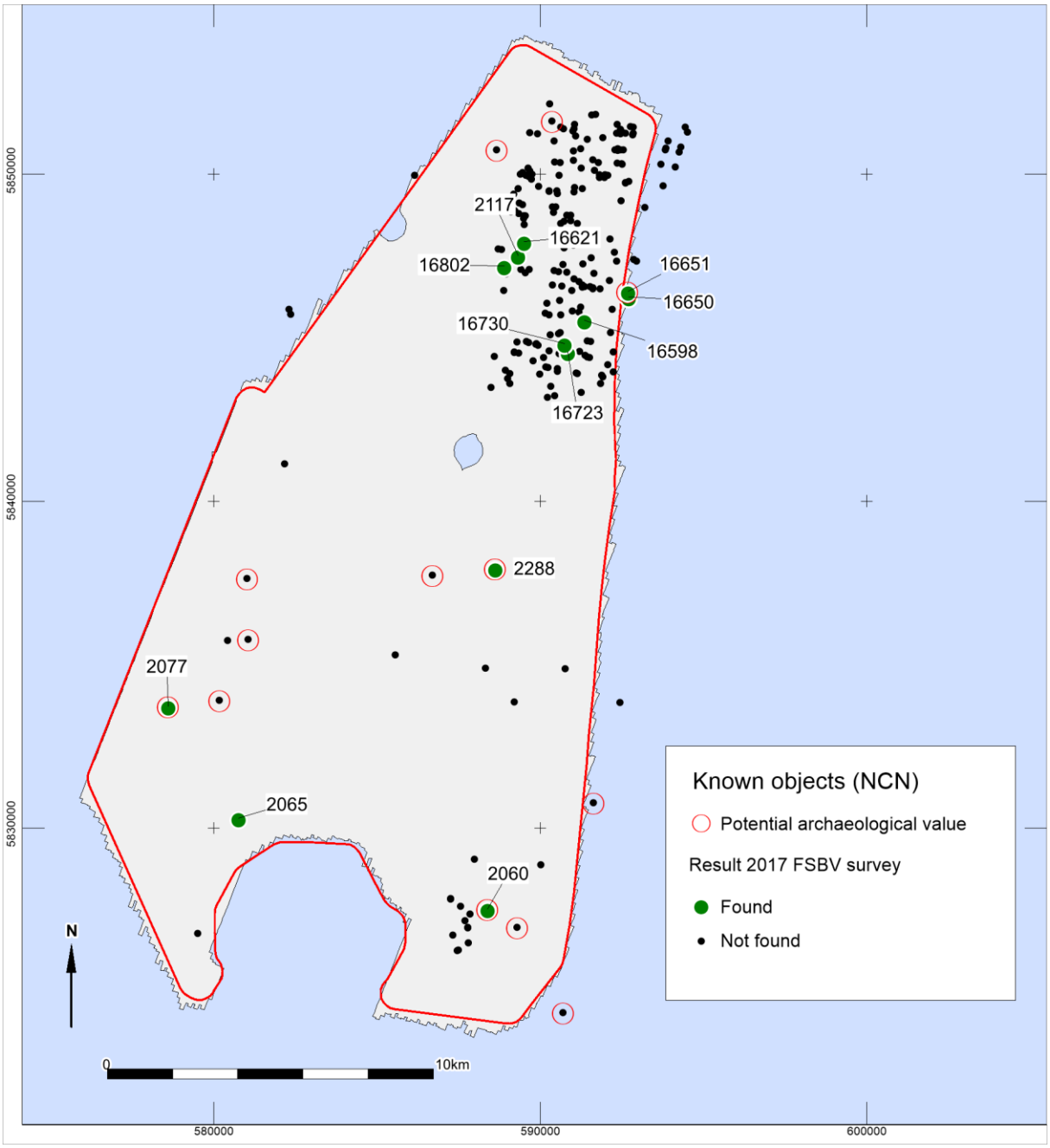


Figure 9. Known objects found or not found during the survey

The detailed results are discussed in the next paragraphs.

NCN found

13 known NCN objects were found during the survey; 12 by side scan sonar and 1 by magnetometer.

NCN	Easting	Northing	R95	Arch. Exp.	Original description	Found
2060	588397	5827512	5	yes	Wreck; unknown; HY 09223 Wreck is broken; partially covered with sand	Wreck
2065	580767	5830306	20	no	Wreck; TX 24, posacc 20m, HY11320	Wreck
2077	578616	5833718	20	no	Wreck; unknown, posacc 20m, 42.2x7.6m. Marhis: wreck of Salland, Dutch cargo vessel, sunk february 1953	Wreck
2117	589328	5847520	5	no	Wreck Sirabuen; Norwegian cargo vessel, built 1921, sunk 1956 after colission posacc 20m; 43x11m;HY12322	Wreck
2118	592677	5846416	20	yes	Wreck; posacc 20m, 60x15m;HY12322	debris
2288	588628	5837944	5	yes	Obstruction; HY 09223 Hr.Ms. Luymes. Wrakkenbladen van MO100 en Wk 2520 samengevoegd. Total area wreck remains ca. 300 x 100 mtr.	Debris
16598	591363	5845542	5	no	Contact 1x1x0.1m	Magnetic anomaly 27 nT
16621	589516	5847933	5	no	Contact/seabed disturbance 2.6x1.2x0.2m	Boulder
16650	592704	5846240	5	no	Contact 1.9x1.2x0.2m	Debris
16651	592694	5846419	5	no	Contact/seabed disturbance 1.4x1.3x0.3m	Debris
16723	590840	5844561	5	no	Contact 1.2x1.1x0.1m	Boulder/debis
16730	590746	5844819	5	no	Contact 1.8x1x0.1m	Gravel/debris
16802	588898	5847197	5	no	Elongated contact 1.7x0.5x0.1m	Debris

Table 7. Listing of known objects found during the survey

Three of the found NCN objects have an archaeological expectation. The results of the survey are discussed below.

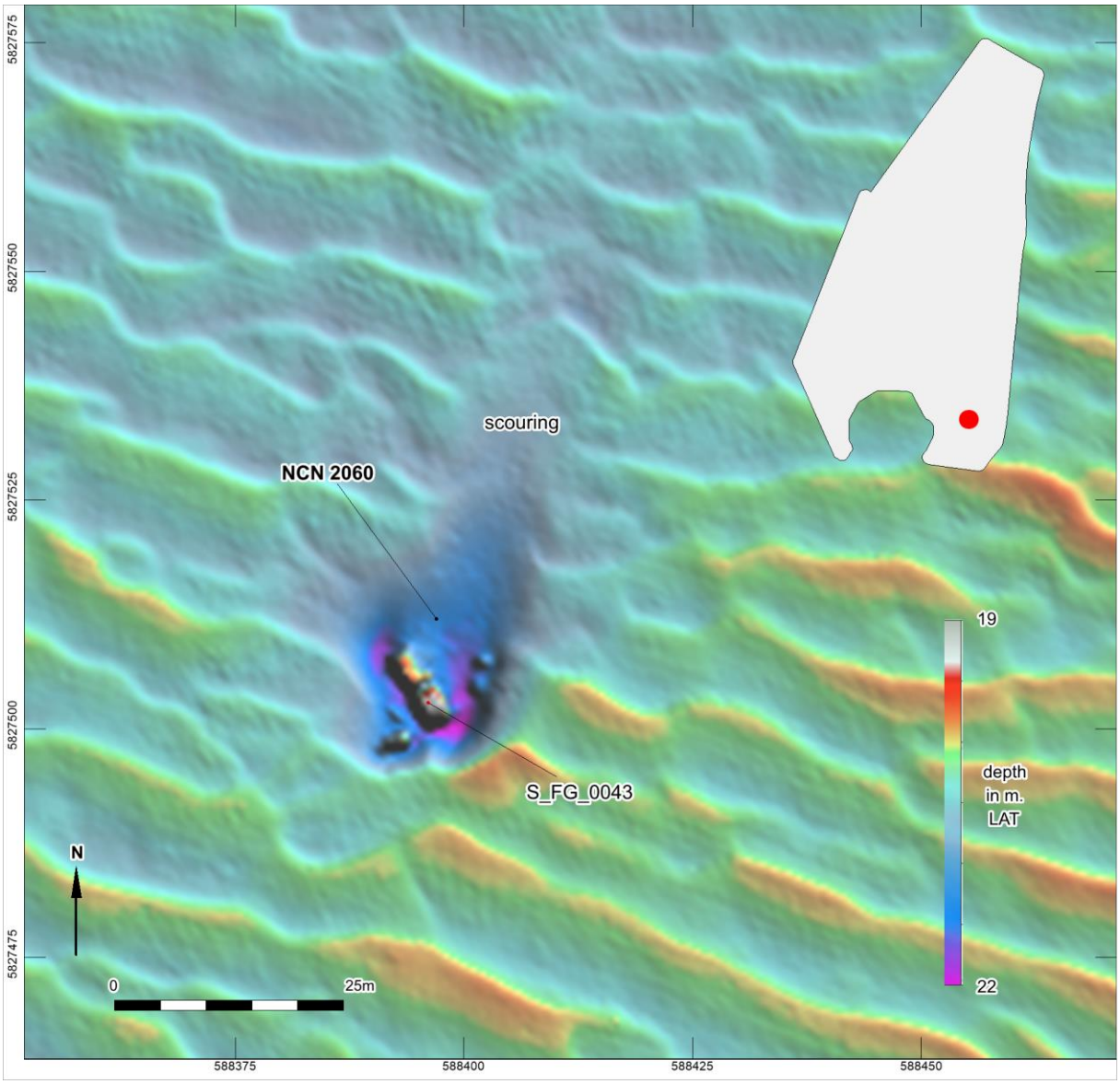


Figure 10. Multibeam image of NCN 2060

NCN 2060 represents the site of an unknown wreck, found and described by the Dutch Hydrographic Service as '*nlhono 2251, wreck is broken, patially covered with sand*'. Several objects and structures were found with multibeam at the theoretical location of NCN 2060. Additional information about this wreck is not available, so the archaeological value is known.

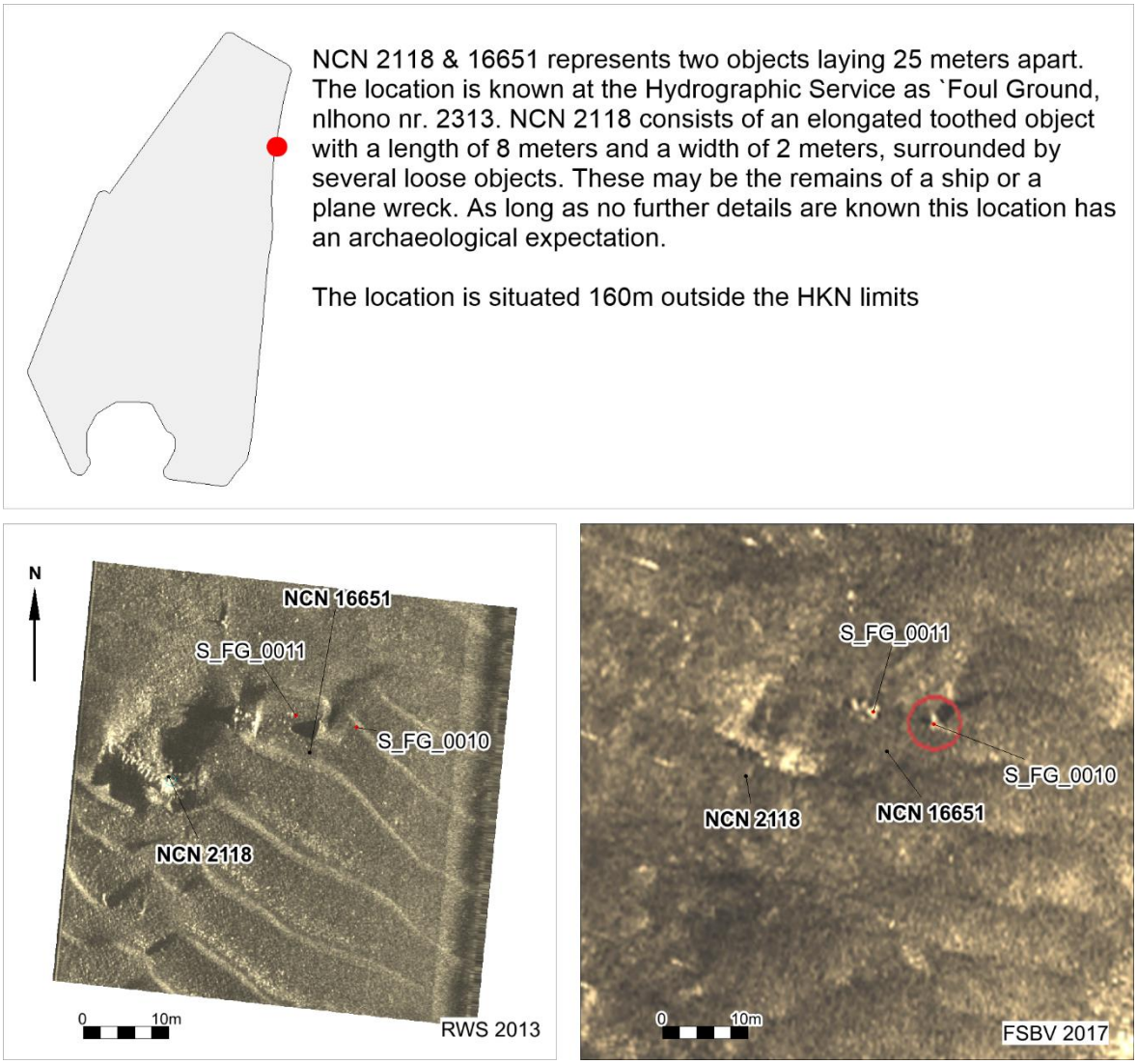


Figure 11. Side scan sonar images of NCN 2118 and 16651

NCN 2118/16651 represent the site of unknown wreck remains. The site was originally discovered by the Dutch Hydrographic Service (nlhono 2251) and described as *foul ground*. A survey by Rijkswaterstaat in 2013 revealed details which suggested that it may be the remains of a ship or plane wreck. Additional information is not available, so the archaeological value is known. It was found with side scan sonar at the theoretical location of NCN 2118.

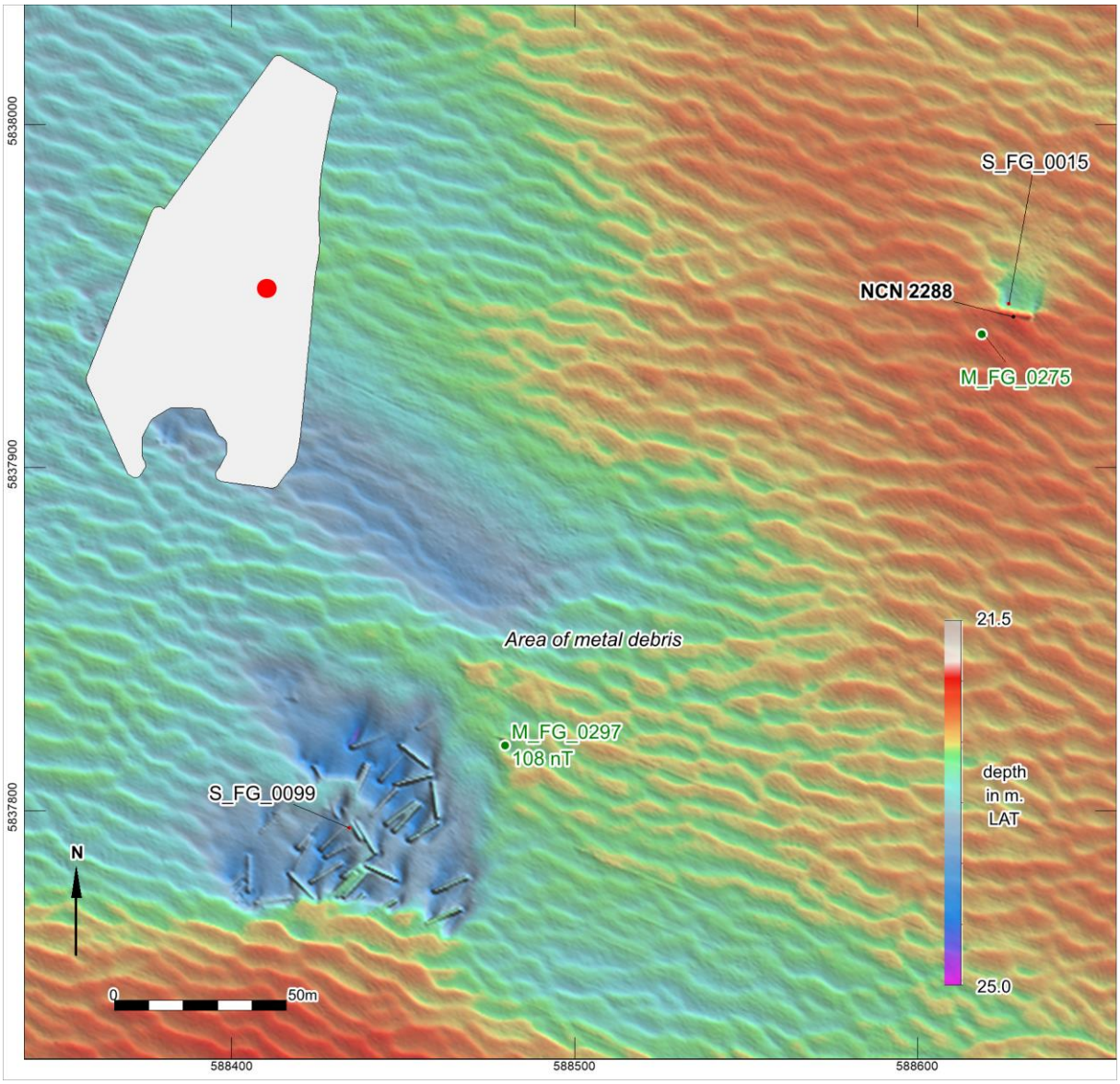


Figure 12. Multibeam image of NCN 2288

NCN 2288 refers to location Nlhono 2520 of the Dutch Hydrographic Service. It is described as '*an obstruction with wreck remains ca. 300 x 100 meter*'. Exactly at the theoretical location an oblong object was found by Fugro with side scan sonar and multibeam. The object has a length of 10 meter and a diameter of 0.7m. 225 meter to the southwest, a cluster of likewise objects was found. At the site described by Fugro as *'area of metal debris'*, an magnetic anomaly of 108 nT was measured.

Most likely the cluster consist of pieces of 20 inch pipelines, dumped or lost at the location. The site does not longer have an archaeological expectation but the objects might form obstacles for the windfarm construction.

NCN wrecks with no archaeological expectation

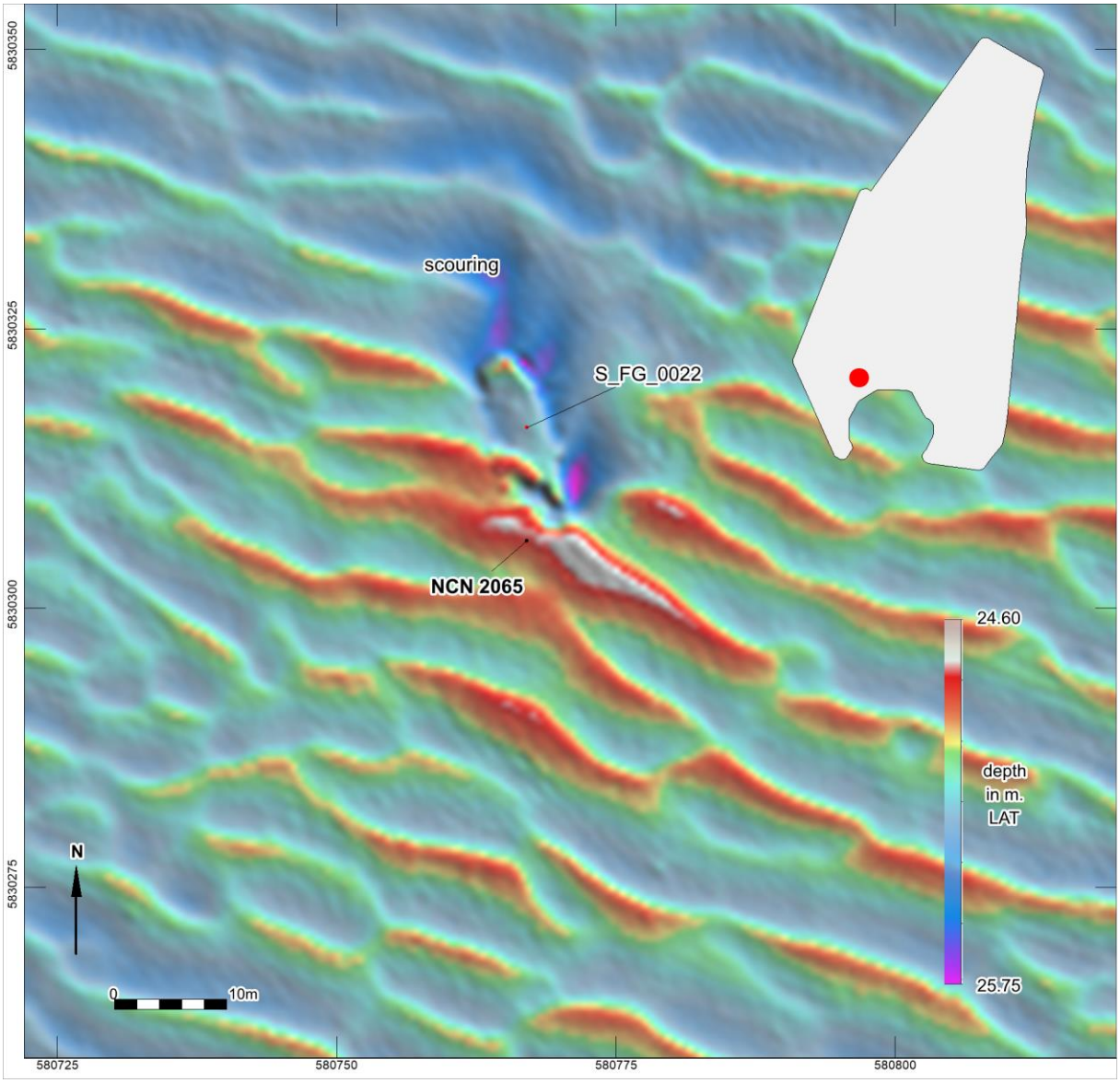


Figure 13. Multibeam image of NCN 2065

NCN 2065 represents the wreck of a fishing vessel TX 24, sunk 29-05-1957. The wreck does not have an archaeological value but can form an obstacle during the construction of the windfarm. It was found with multibeam at the theoretical location of NCN 2065.

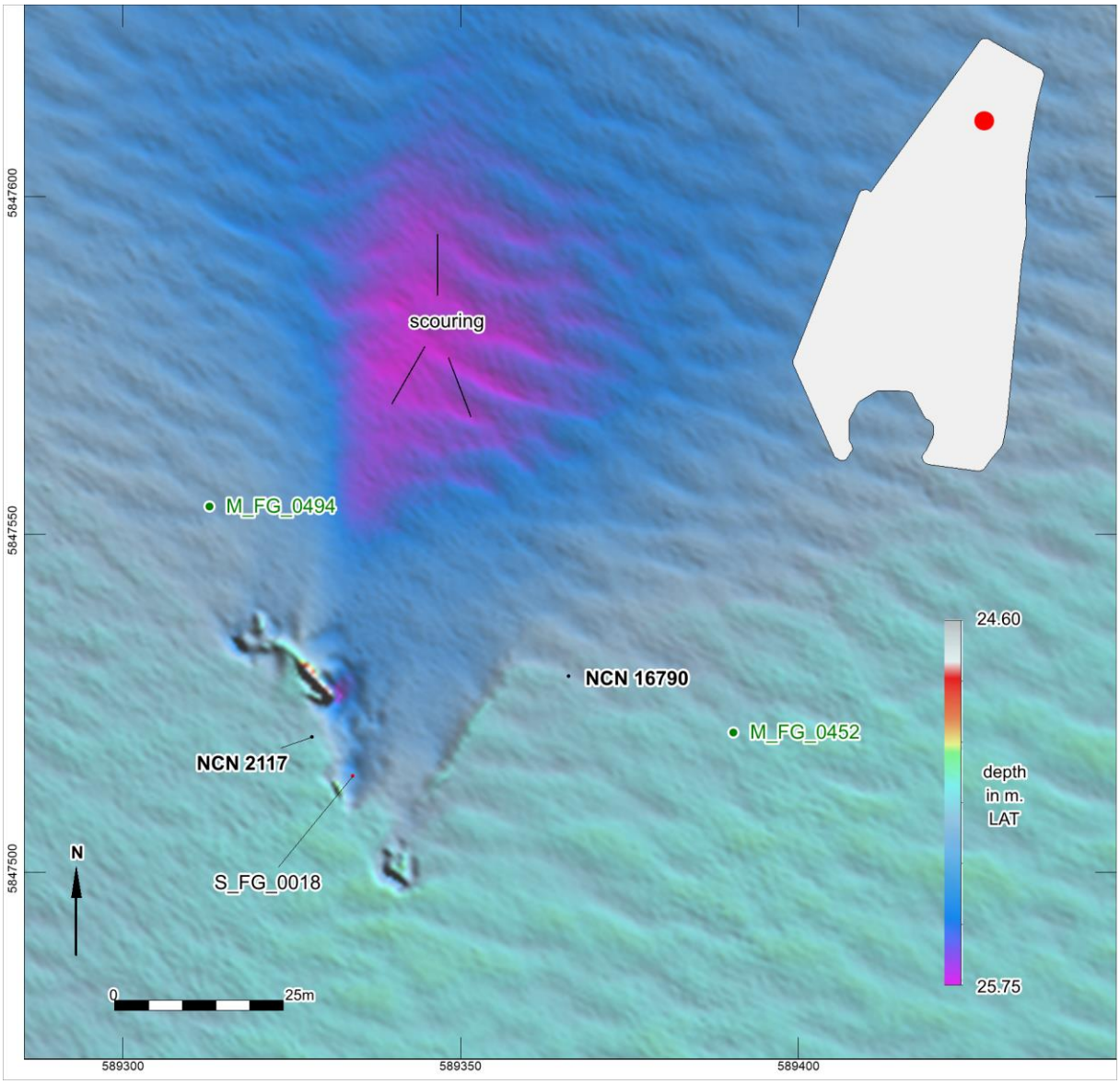


Figure 14. Multibeam image of NCN 2217/NCN 16790

NCN 2117 and NCN 16790 represent the wreck of the Nowegian cargo vessel Sirabuen, sunk in January 10, 1956. The wreck does not have an archaeological value but can form an obstacle during the construction of the windfarm. It was found with multibeam at the theoretical location of NCN 2117.

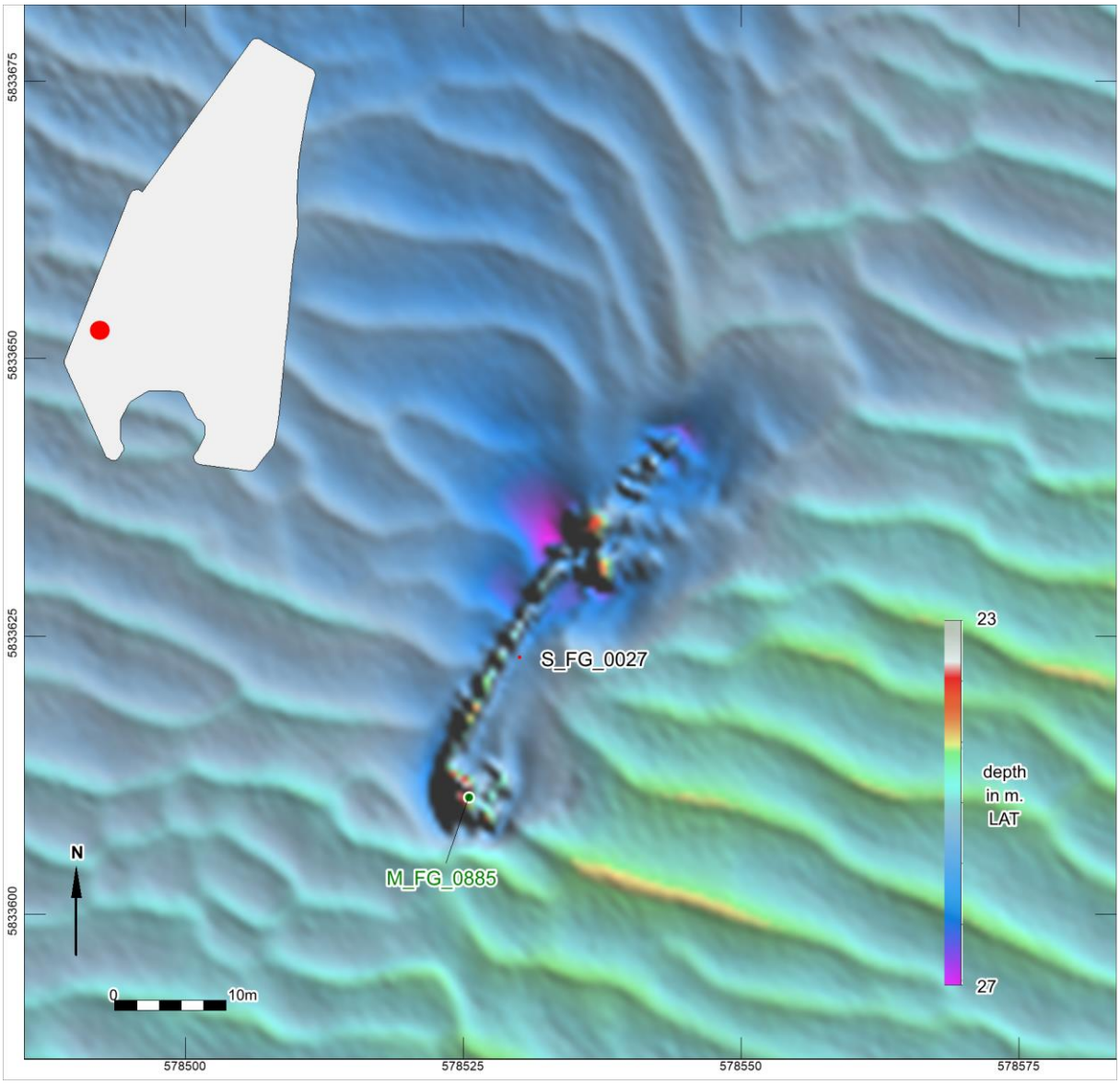


Figure 15. Multibeam image of NCN 2077

NCN 2077 represents the wreck of the cargo vessel Salland, sunk on January 29th 1953. The wreck does not have an archaeological value but can form an obstacle during the construction of the windfarm. It was found with multibeam at 128 meter southwest of the theoretical location of NCN 2077.

NCN with an archaeological expectation – not found

Nine NCN contacts with an archaeological expectation were not found during the survey.

NCN	Easting	Northing	R95	Description	Results survey
2043	590712	5824349	5	Wreck; unknown; BDS 1452/2004	Outside survey area
2051	589301	5826959	20	Wreck Eton; Buyskes HY01129; British cargo ship built 1890 sunk 25-08-1912	No contacts found within 110m
2066	591639	5830773	20	Wreck; unknown; posacc 20m; Buyskes HY01129	Outside survey area
2078	580189	5833909	1000	Wreck; unknown; posacc 1000m; Buyskes HY00087 wreck not found	No contacts found within 210m
2082	581060	5835778	1000	Wreck; unknown; posacc 1000m; Buyskes HY00087 wreck not found	No contacts found within 400m
2086	581029	5837632	1000	Wreck; unknown; posacc 1000m; Buyskes HY00087 wreck not found	No contacts found within 700m
2126	588678	5850747	20	Wreck; unknown; posacc 20m;HY10322	No contacts found within 570m
2545	586708	5837737	20	Wreck; unknown; 67.9m	No contacts found within 630m
16778	590379	5851639	5	Seabed disturbance 17.4x2.3x0.2m	No contacts found within 560m

Table 8. NCN contacts with an archaeological expectation – not found

The most plausible reason for not finding these objects is the uncertainty of the position. Three known wrecks have a position accuracy of 1000 meters. The positions are therefore not reliable. Two objects were outside the survey area. The remaining five objects may not exist anymore, or are they are covered by sediment due to the migration of the sand waves.

Summary of known objects

The desk study has shown that a total of 230 contacts and 14 wrecks are known within the boundaries of the wind farm zone HKN. The majority of the contacts consist of small objects, lost cables or chains, and are not considered to be of archaeological importance. For 10 wrecks and 2 contacts the archaeological value had not been determined. Only three sites with wreck remains (recent and of potential archaeological value) were found during the geophysical survey. One site turned out to be not a wreck but an obstruction with no archaeological value.

The other wrecks and contacts which, based on the findings of the desk study were expected in the area, have not been found. The positions of these objects were not reliable or they are likely to be covered with sediments due to migration of the sand waves in the area.

Known Objects	Total
Total known objects	**244**
Known objects with an archaeological expectation found	**2**
Expected known objects with an archaeological expectation covered with sediment	**5**

Table 9. Summary of known objects

3.3 Sidescan sonar

Fugro has identified 131 side scan sonar contacts within the HKN WFZ zone. The classification of the contacts is listed below.

Classification	Total
Boulder	47
Debris	66
Field of debris	1
Gravel	5
Spud Can	3
Unknown	5
Wreck	4
Total	**131**

Table 10. Side scan sonar contacts identified in the HKN WFZ

All contacts which match known objects have been discussed in the previous paragraph. The remaining *side scan sonar* contact and images have been scanned and checked for the presence of potential archaeological contacts. This is done by analyses of:

- *Side scan sonar* images included in the survey reports;
- Raw *side scan sonar* data (XTF-files);
- Raw *multibeam*-data (xyz-files) ;
- Comparison of *side scan sonar* and magnetometer contacts.

Apart from the survey data studied the geological constellation and seabed morphology of the area are taken into account as outcrops of geological strata and sedimentary structures can lead to (apparent) anomalies in the *side scan sonar* record.

All contacts larger than four meter are examined in detail, because these objects are considered to be more likely to be related to wreck sites than the smaller contacts. This choice is based on best professional judgment and not prescribed by legislation or the KNA. Purpose of this analysis is to identify contacts that could reflect potential archaeological sites. This selection of large contacts comprises a total of 40 contacts. Contacts identified by Fugro as pipelines and cables are not included in this selection. For a complete listing of the result of this examination is referred to Appendix 3. A summary of the outcome of the detailed inspection of selected contacts is presented in the table below.

Interpretation Periplus	Total
Boulder	3
Cable	3
Debris	7
Dredge mark	5
Exposed pipeline	1
Well-head Q04-08	1
Geologic outcrop	12
Unknown object	5
Wreck remains	4
Total	**40**

Table 11. Results of the assessment of selected side scan sonar contacts

The majority of the reviewed contacts has been classified as natural phenomena (sedimentary features) or dredge marks within the sand extraction areas. Three contacts have been classified as pieces of cables or chains, which are very common finds in the North Sea.

Side scan sonar contact 76 is classified by Fugro as a 'possibly mine-like object'. The multibeam image shows three circular elevations of the seabed, one of which is very distinct. It has a diameter of 2.5 m and a height of 1.3 m. No magnetic anomalies have been observed at the location. The location of contact 76 coincides with borehole location Q04-08. It concerns a suspended gas exploration well which was drilled by Wintershall in 1998. The circular structure possibly represents some sort of cap on the conductor pipe which is still in place. It is unclear why no magnetic anomaly has been encountered related to this structure. 25 meter southwest of contact 76 a triangular leg footprint can be seen.

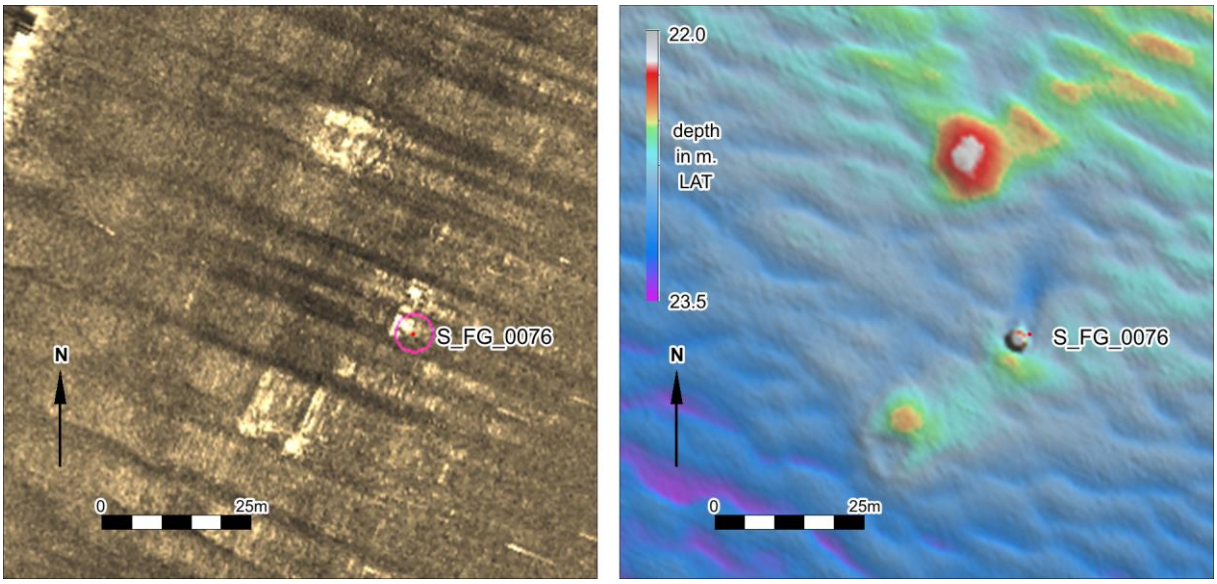


Figure 16. Side scan sonar image (left) an multibeam image (right) of contact S-FG-0076

Six of the 40 contacts represent wreck remains or could not be identified, but might represent archaeological objects because of their dimensions.

Nr	Easting	Northing	L(m)	W(m)	H(m)	Description_PPA	Classification_PPA
10	592700	5846422	1.0	1.0	0.5	NCN 2118/16651, possible wreck remains	Wreck remains
21	587094	5847292	9.8	1.0	0.3	Clear object, partly buried	Unknown object
43	588396	5827503	14.3	10.4	2.3	NCN 2060, wreck broken partly covered with sand	Wreck remains
78	585770	5834462	4.1	3.1	1.3	clear object	Unknown object
110	579971	5839026	5.4	1.5	0.4	clear object	Unknown object
131	586424	5829880	5.4	1.1	0.5	Linear object perpendicular to current ripples	Unknown object

Table 12. Summary of the archaeological assessment of the side scan sonar records.

The two wreck locations registered in the NCN database have been discussed in section 3.2. The results with examples of the four unknown objects are discussed below.

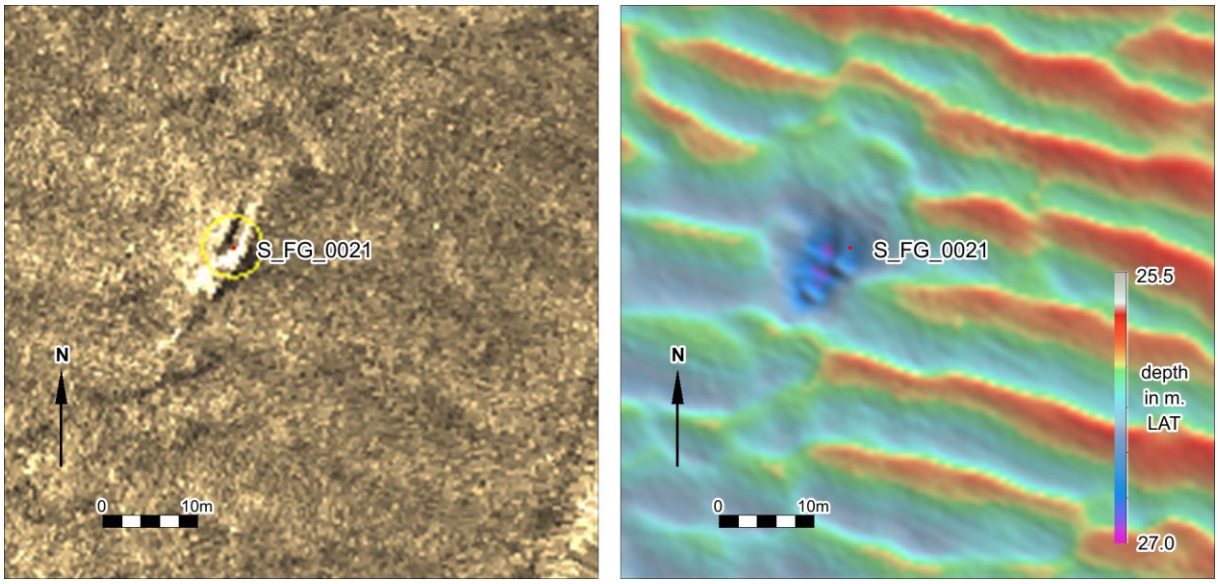


Figure 17. Side scan sonar image (left) an multibeam image (right) of contact S-FG-0021

Sonar contact 21 appears at the multibeam image as a structure buried in the sea bed with scouring. The multibeam image shows several objects. No magnetic anomalies have been observed at the location. Because the structure cannot be identified it might be of potential archaeological interest.

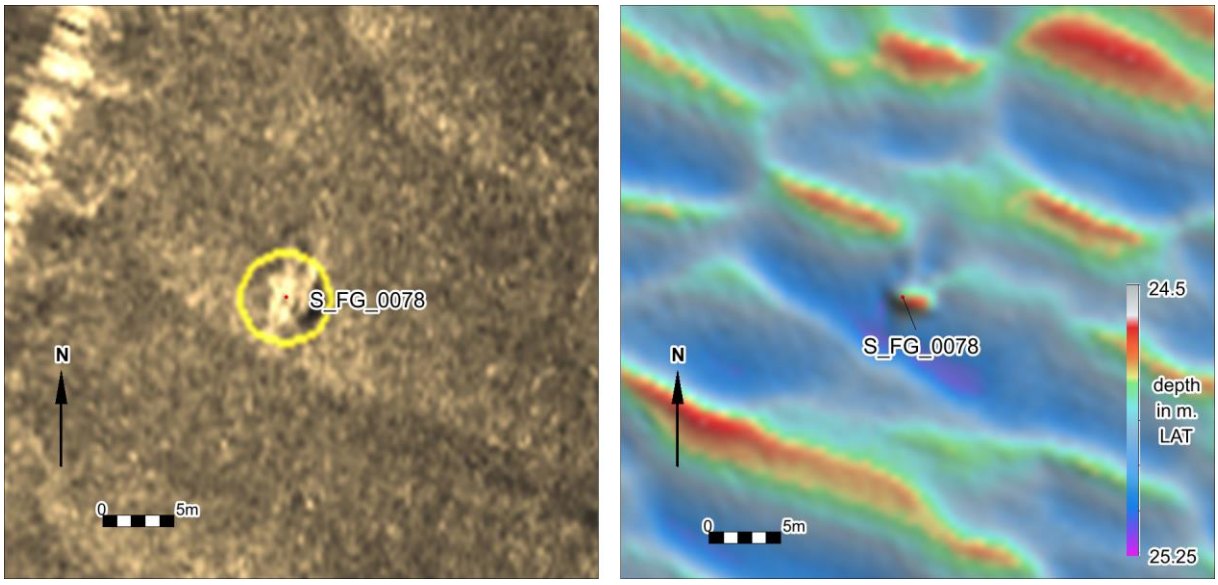


Figure 18. Side scan sonar image (left) an multibeam image (right) of contact S-FG-0078

Sonar contact 78 is classified by Fugro as debris with dimensions 4.1x3.1x1.3 m. The multibeam image shows an object between sand ripples. No magnetic anomalies have been observed at the location. It may be a lost or dumped object. Because the object cannot be identified it might be of potential archaeological interest.

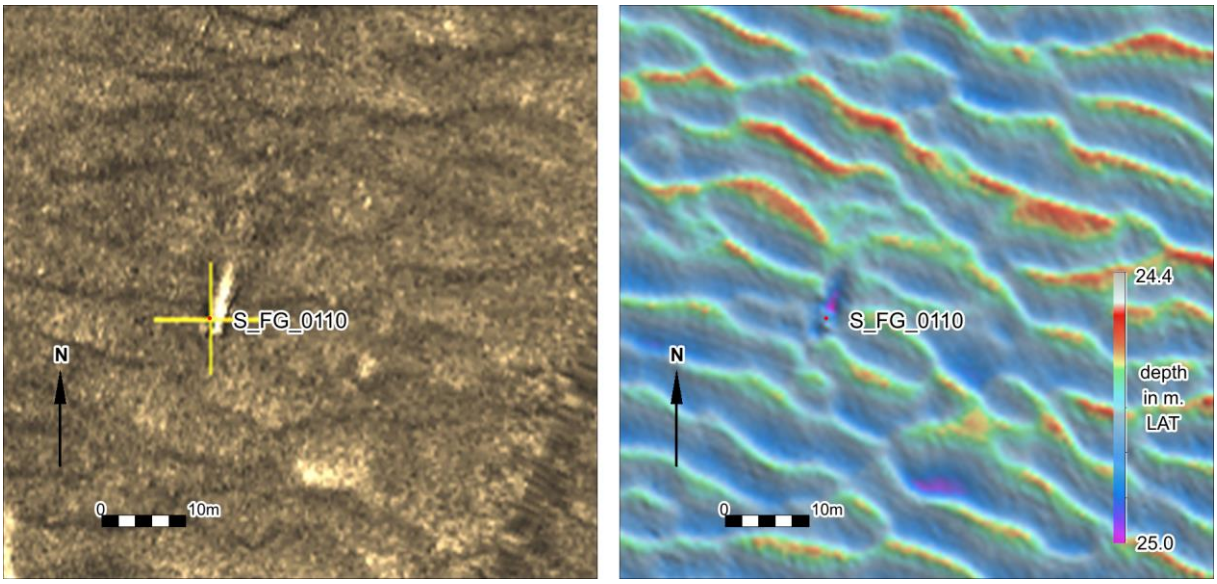


Figure 19. Side scan sonar image (left) an multibeam image (right) of contact S-FG-0110

Sonar contact 110 is classified by Fugro as debris with dimensions 5.4x1.5x0.4 m. The multibeam image shows an object between sand ripples with scouring to the north. No magnetic anomalies have been observed at the location. It may be a lost or dumped object. Because the object cannot be identified it might be of potential archaeological interest.

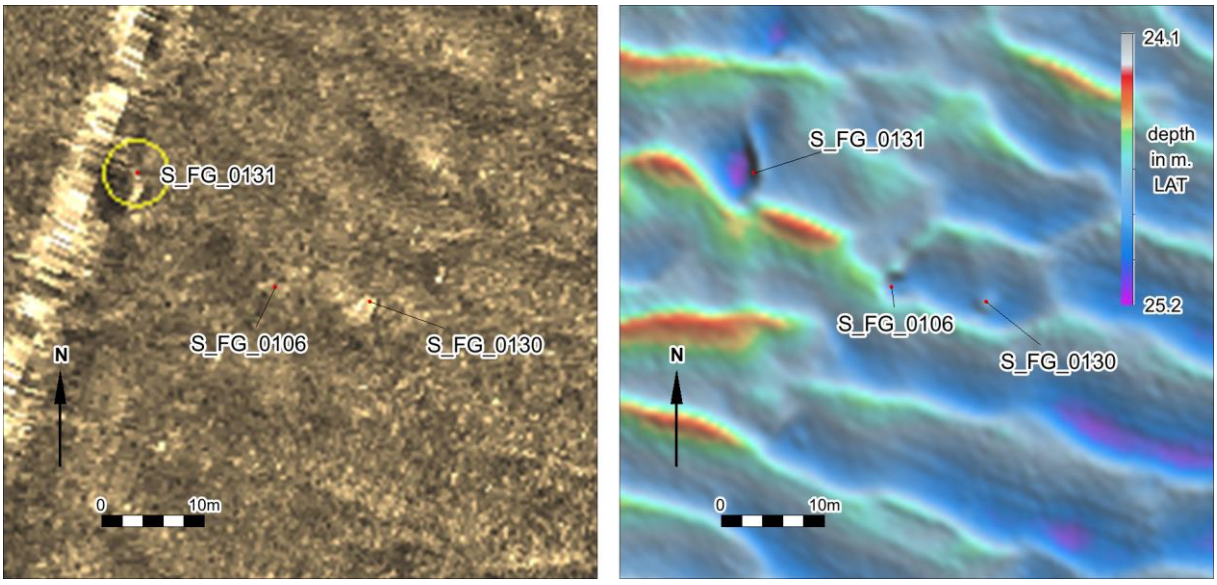


Figure 20. Side scan sonar image (left) an multibeam image (right) of contacts S-FG-106, 130 & 131

Sonar contacts 106, 130 and 131 form a cluster within 10 m of each other. They are classified by Fugro as a boulder and debris. The multibeam image shows small objects at locations 106 and 130, while 131 forms an elongated object with a length of 6m perpendicular to the sand ripples. No magnetic anomalies have been observed at the location. It may be lost or dumped objects. Because the objects cannot be identified they might be of potential archaeological interest.

Summary of side scan sonar contacts

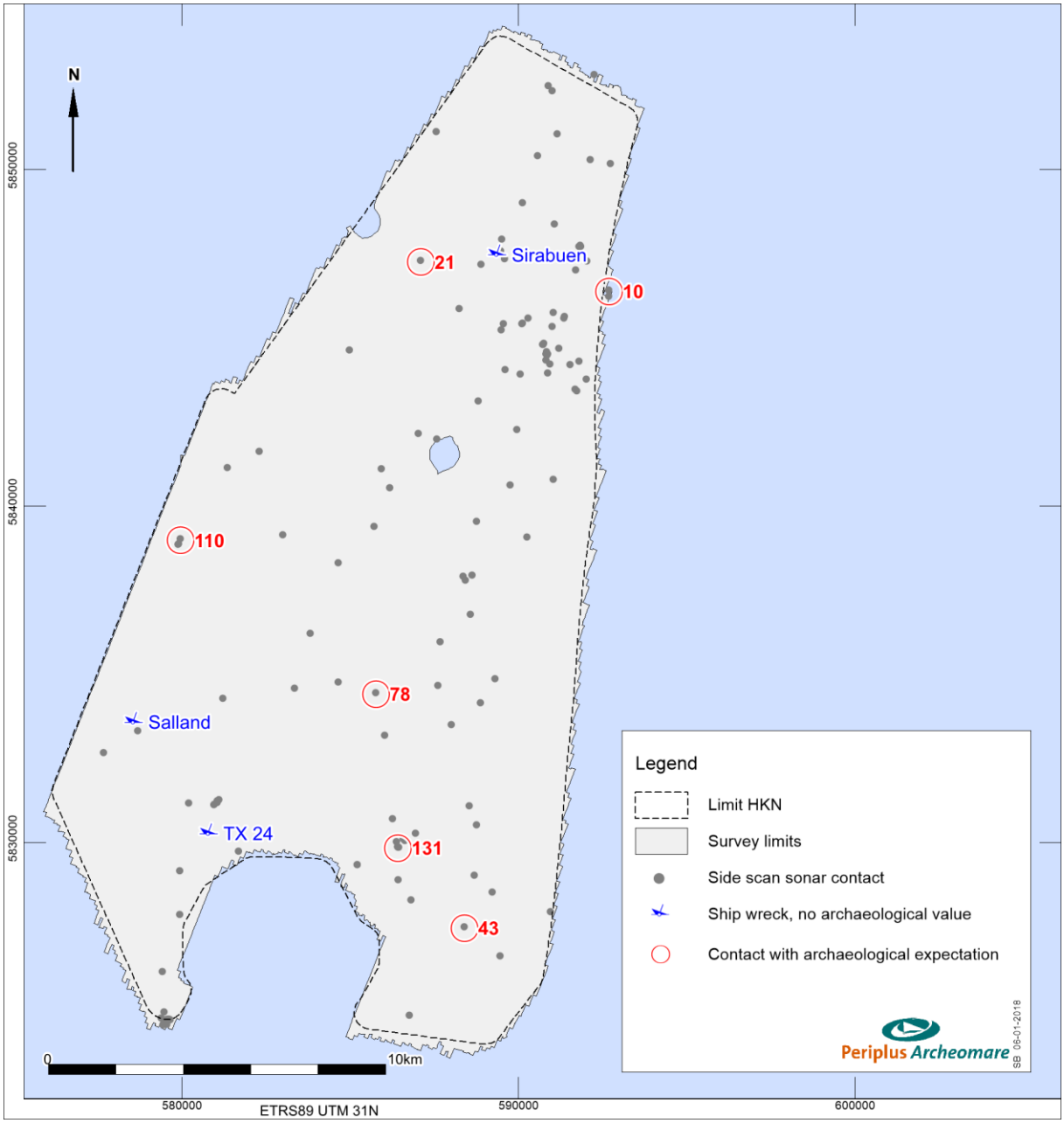


Figure 21. Overview of the side scan sonar contacts with an archaeological expectation

3.4 Multibeam

Apart from the multibeam images discussed in the previous sections no multibeam-features have been observed which are interpreted to reflect the presence of archaeological objects or structures.

3.5 Magnetometer

Besides the objects that are visible on the geophysical data and are selected as possibly archaeological valuable there also are large *magnetometer* anomalies which are not observed on the *side scan sonar* or *multibeam* data. Although the nature of these objects is not known it is possible that the anomalies represent archaeological remains buried in the seabed, and therefore have to be taken into account within this assessment.

A total of 1035 magnetic anomalies have been observed within the area of investigation. A classification is listed in the table below.

Classification	**Total**
Cables	419
Debris	6
Pipelines	233
Unknown	370
Wellhead	1
Wrecks	6
Total	**1035**

Table 13. Classification of the magnetic anomalies

652 of these anomalies can be related to known pipelines or cables. Six anomalies are related to sites with debris, also detected by side scan sonar. Six anomalies van be related to ship wrecks. One anomaly probably represents a wellhead.

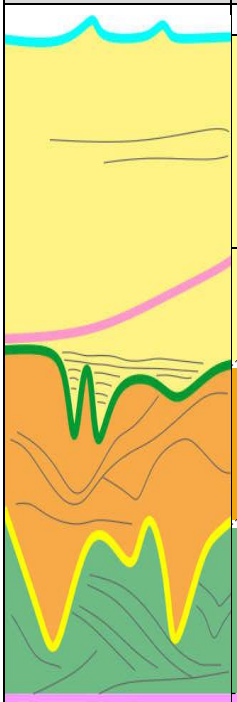
A total of 370 magnetic anomalies cannot be related to known pipelines and cables, or visible objects at the seabed surface. They are related to unknown ferrous objects buried in the seabed, covered by sediments 90 of these anomalies have an amplitude of 50 nT and more. An overview is presented in the figure below.

Figure 22. Overview of the magnetic anomalies

3.6 Subbottom data

The archaeological desk study indicated that the combined thickness of the Holocene sequence is expected to range from 0 to 10 meters in the area.[11] The variations in thickness are partly due to the occurrence of morphological features such as sand waves. The Holocene sequence was based on the desk study expected to consist of the Bligh Bank Member, the Velsen Bed (Naaldwijk Formation) and/or the Basal Peat Bed.

The results of the geophysical survey confirm this expectation. As shown in the table below, the base of the Bligh Bank Member (Unit A) has been found at 0 to 8 meters below the seabed and the Velsen Bed / Wormer Member (Unit B) have been found depths ranging from 0 to 15 meters below the seabed.

Schematic Log	Seismic Units	Base of Reflector	Base of Unit min/max depth in m below seabed (1)	Geometry of the base of the Unit	Indicative lithology (2)	Depositional environment	Formation	Age
	A	H01	0 / 8	Uneven surface	Fine to coarse SAND with CLAY and SILT laminae, locally GRAVEL	Marine	Southern Bight	Holocene
	B	H05	0 / 15	Erosional surface	Very fine to medium SAND, locally CLAY levels and PEAT	Coastal and Lagoonal	Naaldwijk Wormer MB Velsen Bed	Holocene
	C	H10	3 / 42	Erosional surface	Fine to coarse SAND; GRAVEL and minor CLAY	Fluvio-periglacial	Boxtel / Kreftenheye	Upper Pleistocene
	D	Unk.	From literature approx. 60 to 70 m	Not visible	Fine to coarse SAND with local CLAY and SILT	Fluvial	Yarmouth Roads	Lower to Middle Pleistocene
	E	Unk.	From literature approx. 30 to 130 m	Not visible	Fine to coarse SAND with CLAY intercalation	Fluvio-deltaic	Winterton Shoal	Lower to Middle Pleistocene

Notes:
1. The seismo stratigraphy presented has been derived from Ref. 2 , Fugro Reports (Ref 14 to 19) and scientific literature
2. Lithology tied to offset boreholes
3. N/A = Not Applicable

Table 14. Overview of the interpreted seismic Units[12]

[11] Brenk 2017.

[12] From: Wagner en Marchetti, 2017.

The greater depths have been found at locations where early Holocene tidal channels have incised underlying Pleistocene units. In the southern and southeastern part of the wind farm area local occurrences of peat are present at the base of the Holocene sequence. Peat occurrences often coincide with channels with an infill of alternating clay, silt and sand layers. Fugro interpreted the base of Unit B (Wormer Member / Velsen Bed) to be discordant. The peat is found at the base of the channels and in places extents outside the channels as marked layer topping the underlying Pleistocene units. The peat layer presumably comprises the Basal Peat Bed which formed due to the Early Holocene transgression, though the presence of peat deposited during *interstadials* occurring within the Weichselian cannot be excluded.

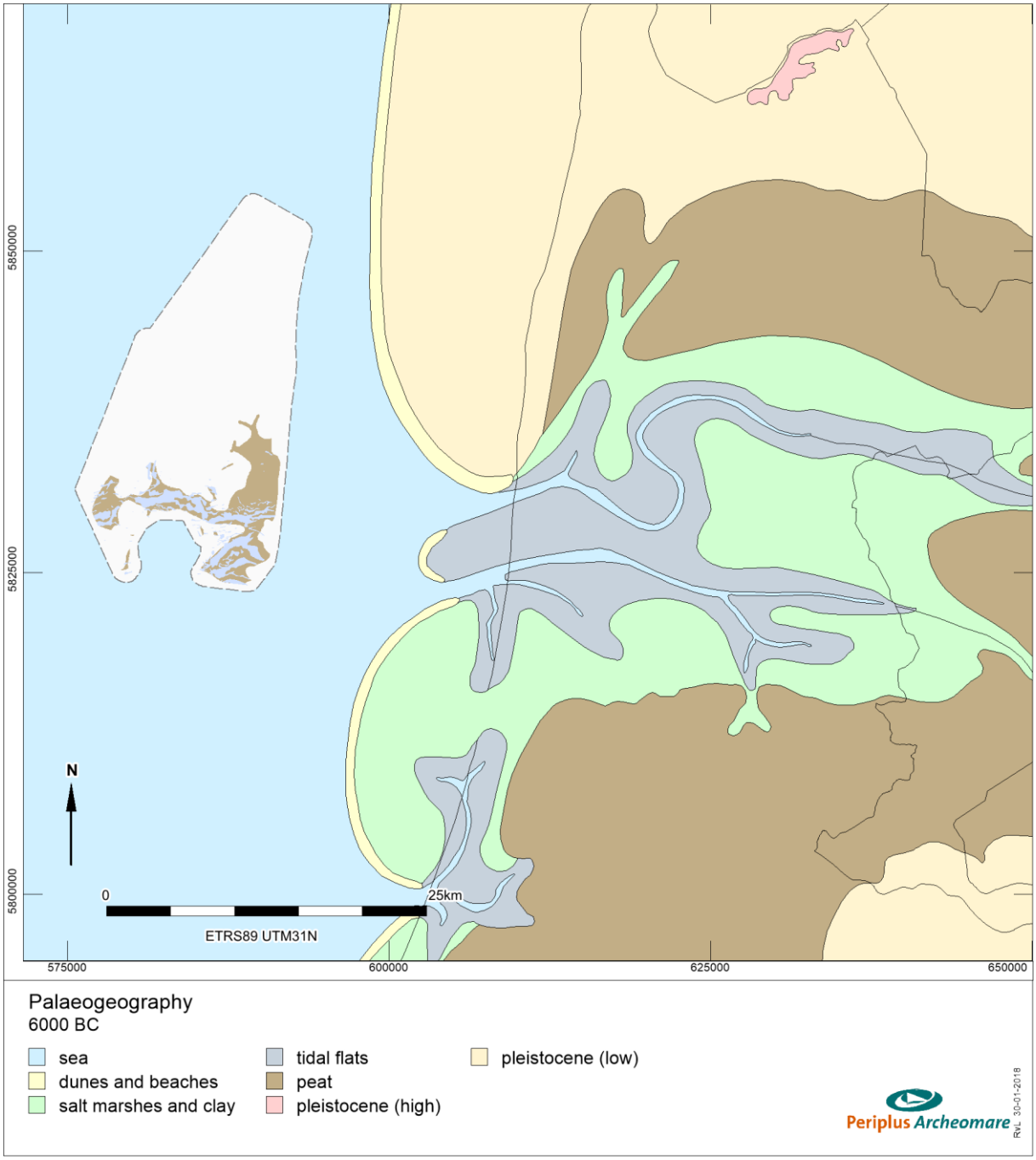


Figure 23. Occurrences of peat and channels in the HKN WFZ in the context of the prehistoric landscape 6000 BC.

Figure 23 shows a palaeogeographic map of the northwestern part of the Netherlands on which the occurrences of peat and Holocene channels as mapped by Fugro have been projected. Clearly the tidal channels of the tidal inlet of Bergen (in Dutch known as the 'Zeegat van Bergen') extents westward into the southern part of the Hollandse Kust (noord). The salt marshes and clay shown in the palaeogeographic map presumably were also present in the plan area. Those deposits also part of Wormer Member and are likely to be present in the higher parts of the landscape surrounding the channels. The thickness of the Holocene sequence ranges from 0 to 10 meters mellow the seabed. Those Holocene Units include (from bottom to top) the Basal Peat Bed, the Velsen Bed at the base of the Wormer Member and Bligh Bank Member. The light grey parts in figure 24 represent areas where the Holocene Units are absent. In other words, those are the locations where outcrops of Pleistocene Units occur. If not covered by the Early Holocene Basal Peat Bed and/or clayey Velsen Bed, the top of the Pleistocene deposits is, due to the shallow occurrence, likely to be eroded. Currently no borehole sample data have been studied to verify this assumption. In places where the Basal Peat Bed is present peat might have protected the underlying Pleistocene landscape against erosion.

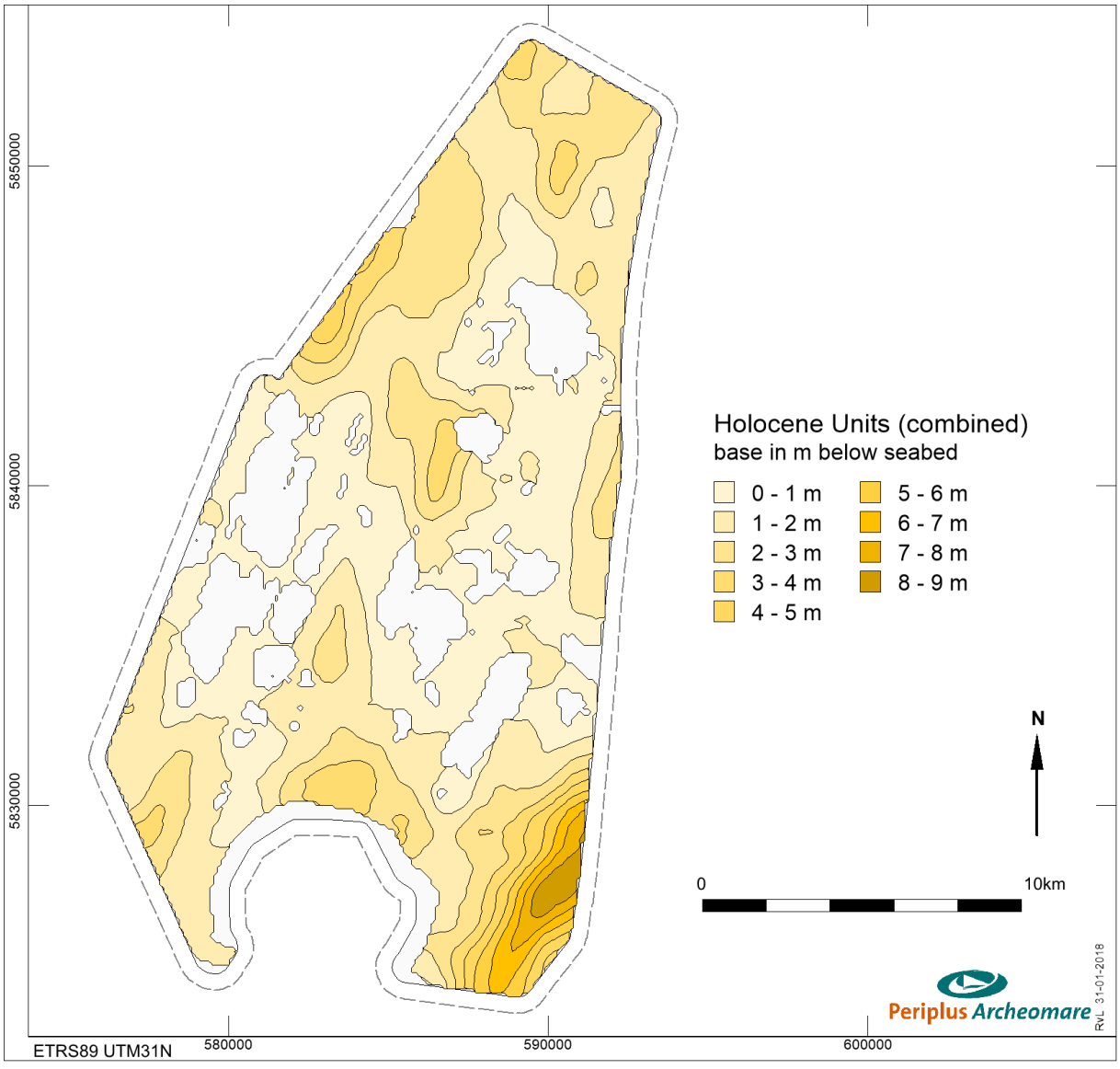


Figure 24. Depth of the base of the Holocene sequence

The cumulative area where the Holocene thickness is less than 2 meters is 21 ha (70% of the total plan area). The considerable thickness in the southeastern part of the area is related to the presence of a sand ridge.

The top of the Pleistocene sequence consists of the fine to coarse sand, gravel and minor clay. No distinction was, or could be, made between the Kreftenheye and Boxtel Formation (combined as Unit C). The Kreftenheye Formation consists of poorly sorted sand and fine gravel deposited by the predecessors of the Rhine during the Early and Middle Weichselian. Sand, silt, clay and local peat deposited in the valleys of small streams (Boxtel Formation; Singraven Member) and well sorted aeolian sands (cover sands of the Boxtel Formation; Wierden Member) have been locally deposited on the river sands of the Kreftenheye Formation. The combined thickness of the Kreftenheye Formation and Boxtel Formation ranges from 2 to 19 meters; the base is located at 5 to 20 meters below the seabed. In areas where the base of the Kreftenheye – Boxtel sequence is situated at greater depth, channels have incised underlying units (not shown in figure 23!). The presence of numerous buried channels has been described by Fugro as characteristic for Unit C. The base of the unit is erosional.

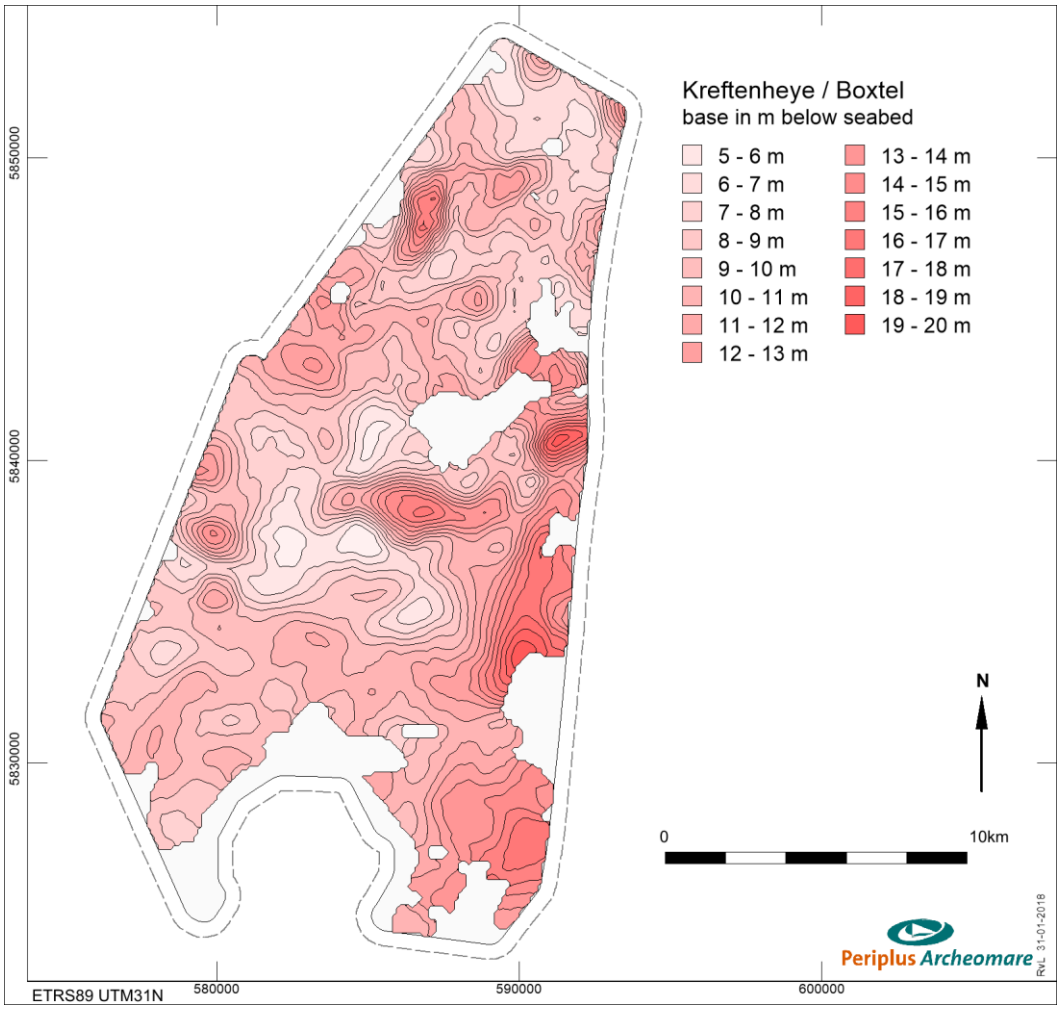


Figure 25. Depth of the base of the combined sequence of the Kreftenheye and Boxtel Formations

As shown in table 14 and figure 26 the deeper seated deposits have been interpreted as the Yarmouth Roads Formation (Unit D) and Winterton Shoal Formation (Unit E). According to the current nomenclature

the Yarmouth Roads Formation is referred to as 'Formation 4.1.1.'[13] With reference to literature Fugro expects the base to be located at 60 to 70 meters below the seabed (appr. -80 to -90 mLAT).

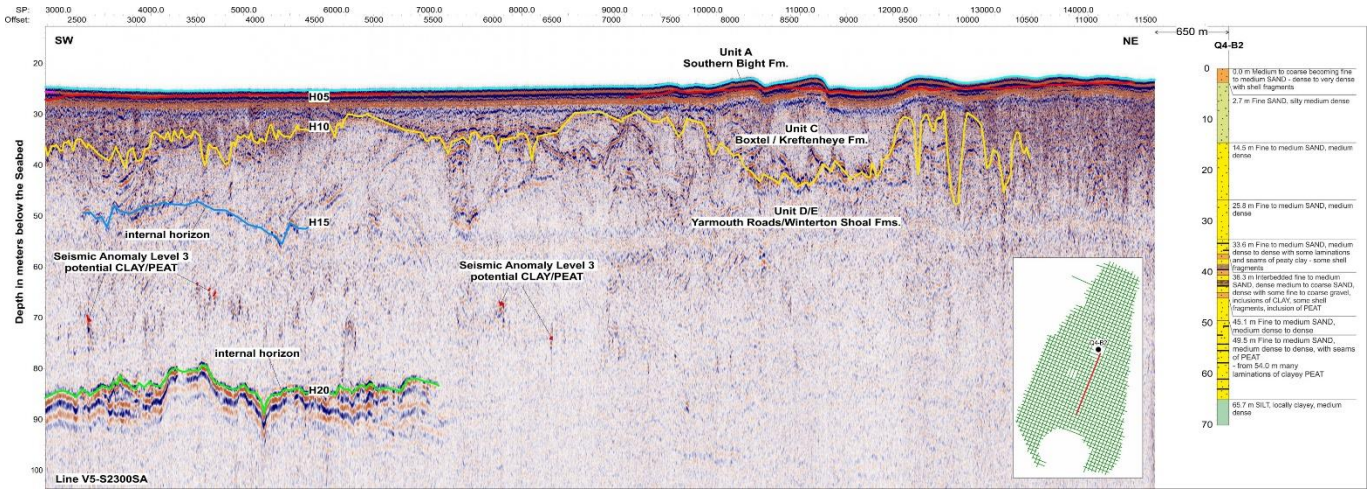


Figure 26. UHR line V5-S2300SA, with stratigraphy from BH Q4-B2 (from: Fugro Report GH216-R1)

The units found in the encountered in the plan area differ considerably with the units one would expect based on the units mapped near shore on land.

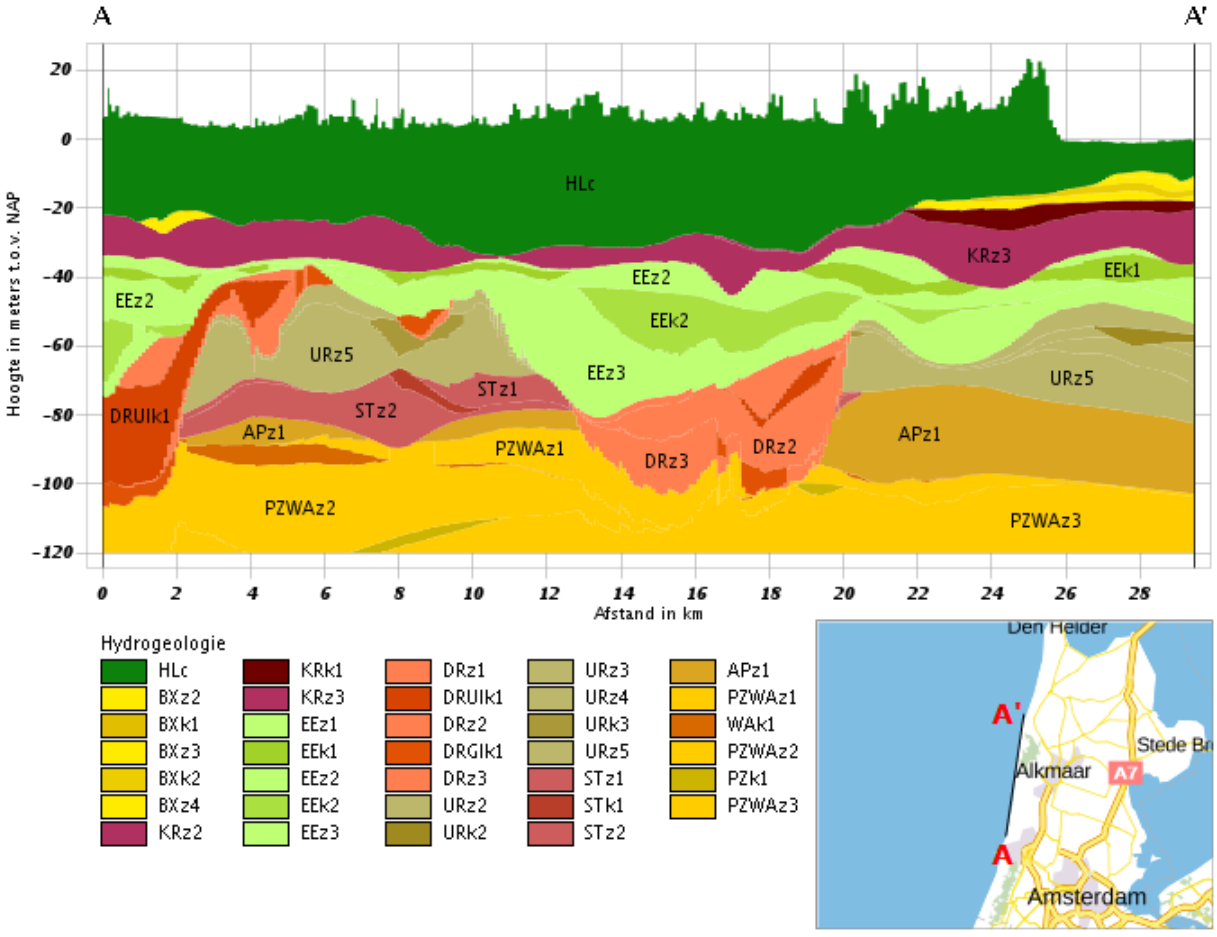


Figure 27. Geological profile between Wijk aan Zee (A) and Petten (A[1])

[13] Rijsdijk 2005.

A profile parallel to the coast line shows that the Kreftenheye along the full length of the profile has been deposited on marine sand with layers of clay which have been deposited during the Eemian interglacial period and are part of the Eem Formation. The thickness of the Eem Formation varies from 2 to approximately 30 meters. The Eem Formation has been deposited on glacial deposits the Drente Formation and fluvial deposits of the Urk Formation.

The base of the Drente Formation is located at depths varying from 40 to over 100 mLAT. The base of the Urk Formation is situated around 80 mLAT; the undifferentiated Peize/Waalre Formations are located around 90 to 100 mLAT. The open marine seismic deltaic facies and fluvial deposits of the Eridanos and Rhine-Meuse system are the onshore equivalents of the Winterton Shoal Formation and the Yarmouth Roads Formation.

Especially striking is the apparent absence both the marine sands of the Eem Formation and the glacial deposits of the Drente Formation. Horizon H20 represents a strong seismic reflector which has been encountered at depths ranging from 70 to just over 100 mLAT in the central and southern part of the plan area. H20 has been interpreted by Fugro to be related to presence of an intraformational clay layer within the Winterton Shoal Formation.

Shallow occurrences of boulder clay of the Gieten Member within the Drente Formation and lake and lake shore deposits at the top of the Brown Bank Member within the Eem Formation are expected to be potential containers for archaeological remains in the form of Middle Paleolithic camp sites. The presence of those units and therefore the archaeological potential has not been confirmed by the geophysical survey.

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4 Synthesis

For this investigation different research questions are defined in the Program of Requirements.[14]
Based on the results of de data analysis the research questions are answered.

Primary question:

Are any archaeological remains present within the Area of Interest and to what extent are these remains traceable?

Yes. An archaeological expectation is assigned to a total of 11 objects. Two known objects and four new objects have been found during this survey campaign. Five known wrecks with an archaeological expectaction have not been found and may be covered with sediment.

With respect to side scan sonar, magnetometer and multibeam survey:

Are there any phenomena visible on the seabed?

Yes. A total of 131 contacts visible at the surface are reported with side scan sonar and multibeam.

A total of 370 magnetic anomalies cannot be related to known pipelines and cables, or visible objects at the seabed surface. They are related to unknown ferrous objects buried in the seabed, covered by sediments. 90 of these anomalies have an amplitude of 50 nT and more.

General	Total
Side scan sonar contacts	**131**
Magnetometer contacts	**1035**
Overlap sonar magnetometer	**7**
Unidentified magnetometer > 50nT	**90**

Table 15. Summary of all contacts

If so:

What is the description of these phenomena?

A summary of the original side scan sonar classification is listed in the table below

Classification	Total
Cables	419
Debris	6
Pipelines	233
Unknown	370
Wellhead	1
Wrecks	6
Total	**1035**

Table 16. Side scan sonar contacts identified in the HKN WFZ

[14] Van Lil and van den Brenk, 2017.

Do these phenomena have a man-made or natural origin?

None of the assessed contacts smaller than 4 meter has been interpreted as potential archaeological object or structure. After reviewing a selection of 40 contacts larger than four meters in more detail, a number of contacts can be interpreted as natural phenomena such as sedimentary features. A summary is listed in the table below.

Interpretation Periplus	Total
Boulder	3
Cable	3
Debris	8
Dredge mark	5
Exposed pipeline	1
Geologic outcrop	12
Unknown object	4
Wreck remains	4
Total	**40**

Table 17. Results of the assessment of selected side scan sonar contacts

Four of the unknown objects were assigned with an archaeological expectation.

If these phenomena can be designated to be man-made:

What classification can be attached?

The man-made phenomena consist of (remains of) shipwrecks, an exposed pipeline and loose pieces of cables and chains, which were lost or dumped at sea.

If these phenomena can be classified as archaeological:

Is it possible to interpret the nature of the archaeological objects?

An archaeological expectation is assigned to a total of 6 objects, a summary is listed below.

Nr	Easting	Northing	L(m)	W(m)	H(m)	Description_PPA	Classification_PPA
10	592700	5846422	1.0	1.0	0.5	NCN 2118/16651, possible wreck remains	Wreck remains
21	587094	5847292	9.8	1.0	0.3	Clear object, partly buried	Unknown object
43	588396	5827503	14.3	10.4	2.3	NCN 2060, wreck broken partly covered with sand	Wreck remains
78	585770	5834462	4.1	3.1	1.3	clear object	Unknown object
110	579971	5839026	5.4	1.5	0.4	clear object	Unknown object
131	586424	5829880	5.4	1.1	0.5	Linear object perpendicular to current ripples	Unknown object

Table 18. Summary of objects from sonar and multibeam with a possible archaeological value

The resolution of the data is not high enough to discuss details about the found objects with an archaeological expectation. In case operations are planned within 100 meters of the objects, or in case indirect consequences such as scouring because of the installation of infrastructure are to be foreseen within 100 meters of the objects, the developer is legally obliged to carry out additional research, e.g. by means of an ROV or divers, to determine the archaeological value.

If these phenomena can be identified as natural:

What is the nature of these natural phenomena?

The phenomena interpreted as natural consist of sedimentary features.

Based on the acoustic image is it possible to designate zones of high, middle or low activity on the seabed?

The seabed is characterized by a complex pattern of bedforms with large to very large dunes of various orders. These dunes are NW to SE oriented, with an average wavelength between 123 m and 830 m and a height ranging from 0.5 m to 5.9 m. Superimposed on the major sand dunes, other minor dunes with < 9 m average wavelength and height ranging from 0.3 m to 0.7 m are present. The largest bedforms, the shoreface-connected ridges, are relatively stable and move with 0 – 1 m/year. Also the north-south oriented ridges are stable, with similar migration rates. Sand waves have a migration rate in the order of 1-10 m/year.

If so:

How can these zones be interpreted?

See the answer to the previous question

General:

What is the relation between the observed objects and the topography of the seabed? Based on this relationship can risk-prone areas be marked selectively?

Larger objects like ship wrecks show clear scouring at the north side caused by the dominant currents in a northerly direction.

If no acoustic phenomena can be observed:

Are there any clues that this is a consequence of either natural erosion, sedimentation or human interference?

This question is given the results of the investigation not applicable.

<u>With respect to subbottom profiler- and sampling:</u>

Based on seismic profiles and geotechnical data is it possible to map the Pleistocene landscape?

Yes, the data provided by Fugro is fit to map the Pleistocene landscape.

If so:

What is the depth of the Pleistocene landscape compared to the present seabed?

The top of the Pleistocene landscape has been found at depths ranging from 0 to 10 meters below the current seabed. The variation in depth is closely related to the morphology of the seabed. The largest depth is encountered underneath a sand ridge in the southeastern part of the area. In major part of the wind farm area (70%) the Pleistocene landscape is found within 2 meters below the seabed including an area of 4 hectare where the Pleistocene is exposed at the seabed.

The top of the Pleistocene Units comprise the Kreftenheye and Boxtel Formations. The units were not mapped separately. The Kreftenheye Formation consists of fluvial sediments of a braided river system (Rhine); the Boxtel Formation consists of small scale fluvial deposits of sand, loam and peat and well-sorted aeolian sands. The deposits date from the last ice age (Weichselien).

From Pleistocene to Holocene deposits is the transition gradual or instantaneous (erosive)?

Based on the seismic data the transition between the Pleistocene and Holocene Units has been interpreted to be discordant (erosive). Tidal channels related to the palaeo valley of the Vecht river are found in the southern part of the plan area. Within this valley widespread occurrence of peat (Basal Peat Bed) which presumably is overlain by Early Holocene clay (Velsen Bed). In places where the peat is present the top of the Pleistocene landscape could be intact.

Can zones be identified where prehistoric settlement remains can be expected?

Within the top of Late Pleistocene cover sands (Wierden Member / Boxtel Formation) and river dunes (Delwijnen Member / Boxtel Formation) numerous sites of (pre)historic settlements are known. Because no distinction could be made between the Kreftenheye and Boxtel Formation it is not known where the Boxtel Formation occurs. The river valley could have provided fit conditions for hunting and could have been used for the installation of camp sites. Late Palaeolithic and Mesolithic camp sites can therefore be expected within the valley area and along higher valley edges. The integrity and preservation of remains can be high in areas which are covered with peat and clay.

At this stage the interpretation is solely based on the seismic data; no borehole data are available to provide a better insight in the deposits present and reconstruction of the actual depositional environment. However, the seismic data provide sufficient information to support the conclusion that the change that prehistoric camp sites have been preserved intact outside the clay and peat covered river valley is small.

If so:

Could these expected settlement remains be affected by the installation of the cables based on their vertical position related to the seabed?

The final sites and related cable trajectories within the Hollandse Kust (noord) Wind Farm Zone are located outside the clay and peat covered river valley. Because of this, the change that intact settlement remains will be affected by the installation of the cables is considered small.

Are there any indications observed on the seismic profiles for the presence of buried (man-made) objects?

No, in no sub-seabed geohazards have been reported which are expected to comprise archaeological remains. The change of tracing prehistoric remains from the Late Palaeolithic and Mesolitic by means of seismics is very small, because sites are often solely characterized by the presence of very small flint artefacts.

If so:

Based on the presence of buried objects and its correlation with side scan sonar, magnetometer and multibeam data can something be said about the nature of these buried objects?

This question is not applicable.

Are there any mitigating measures necessary to avoid disturbance of possible archaeological remains?

The data currently available do not suffice to answer this question. The detailed information on the lithostratigraphy and integrity of archaeological levels herein (which is needed to answer this question) can be obtained by borehole analysis.

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5 Summary and recommendations

A large quantity of survey data (*side scan sonar, magnetometer, multibeam echosounder* and *subbottom profiling*) recorded within the wind farm zone covering a total area of 310 km^2 were analyzed in order to conduct an archaeological assessment.

The current analysis of geophysical survey results is the second and final step in the archaeological assessment, following the desk study. The desk study has shown that a total of 244 objects and wrecks were known within the boundary of the wind farm site. The majority of these objects consist of small objects, lost cables or chains, which are not considered to be of archaeological importance. For 12 (wreck) objects the archaeological value has not been determined.

Two of these known objects have been found exposed at the seabed. The other ten objects which were expected in the area have not been found. For five of these objects, the original positions were not accurate, so they may be locatied outside the wind farm area. The remaining five objects may be covered with sediments due to migration of the sand waves.

Apart from the two known objects found, 129 other contacts were reported with side scan sonar. The analysis of these contacts resulted in a final selection of four unknown objects and structures which may have an archaeological value, based on their shapes and dimensions.

A summary of all visible objects with a possible archaeological expectation is listed in the table below.

Nr	Easting	Northing	L(m)	W(m)	H(m)	Description_PPA	Classification_PPA
10	592700	5846422	1.0	1.0	0.5	NCN 2118/16651, possible wreck remains	Wreck remains
21	587094	5847292	9.8	1.0	0.3	Clear object, partly buried	Unknown object
43	588396	5827503	14.3	10.4	2.3	NCN 2060, wreck broken partly covered with sand	Wreck remains
78	585770	5834462	4.1	3.1	1.3	clear object	Unknown object
110	579971	5839026	5.4	1.5	0.4	clear object	Unknown object
131	586424	5829880	5.4	1.1	0.5	Linear object perpendicular to current ripples	Unknown object

Table 19. Summary of objects from sss and mbes with a possible archaeological value

As long as the archaeological value of the objects is not determined, it is advised not to conduct activities which could affect the locations with possible archaeological objects (six visible contacts and five covered known objects, eleven in total) including a buffer zone of 100 meters around. This also applies to cable trenching and anchorages of work vessels.

The buffer zone of 100 meters is a standard that applies to the protection of cultural heritage, this distance may be reduced if it can be substantiated that the applied disturbance has no effect on the archaeological object. For example, when no anchoring is used during cable lay operations the buffer zone can be decreased. Reduction of the distance has to be approved by Rijkswaterstaat (RWS). Rijkswaterstaat is the enforcing authority, acting on behalf of the Ministry of Economic Affairs and Climate Policy. The Cultural Heritage Agency of the Netherlands (RCE) acts as an advisor to Rijkswaterstaat.

A total of 1035 magnetic anomalies have been observed. 652 of these anomalies can be related to known pipelines or cables. Only seven can be related to side scan sonar contacts.

A total of 370 magnetic anomalies cannot be related to known pipelines and cables, or visible objects at the seabed surface. 138 of those magnetic anomalies is located within the wind farm sites. The anomalies are related to unknown ferrous objects buried in the seabed, covered by sediments.

A total of 90 out of the 370 anomalies found within the investigation area have amplitude of 50 nT and more. 35 of those 90 anomalies with amplitude over 50 nT is located within the wind farm sites.

Concerning these buried ferrous objects, it is advised to avoid these locations including a buffer zone of 100 meters areas whilst installing wind turbines and the various inner field and export cables. It should be stressed that the origin of the magnetic anomalies is unknown and apart from possible archaeological remains any type of man-made objects can be encountered including unexploded ammunition, anchors, pieces of chains and cables, debris, etcetera.

If it is not feasible to avoid the reported magnetometer locations, additional research is required in order to determine the actual archaeological value of the reported locations. It is advised that the UXO research within 100 meter of the magnetometer anomalies are carried out under onboard archaeological supervision. Depending on the outcome of the UXO research it can be decided if additional research (for instance by means of ROV or dive investigations) is needed. If the UXO research indicates that the object has no archaeological value, the location can be omitted.

Based on the results of the various investigations, and avoiding the existing pipelines and cables, the definition of the final wind farm sites were determined, taken into account the minimum total capacity of 700 MW. The final sites (92 km2) cover an area about a third of the investigated area (310 km2). The advice therefore only applies to the final sites. Within the boundaries of those sites 38 locations could contain archaeological remains; 35 magnetometer locations and 3 side scan sonar locations.

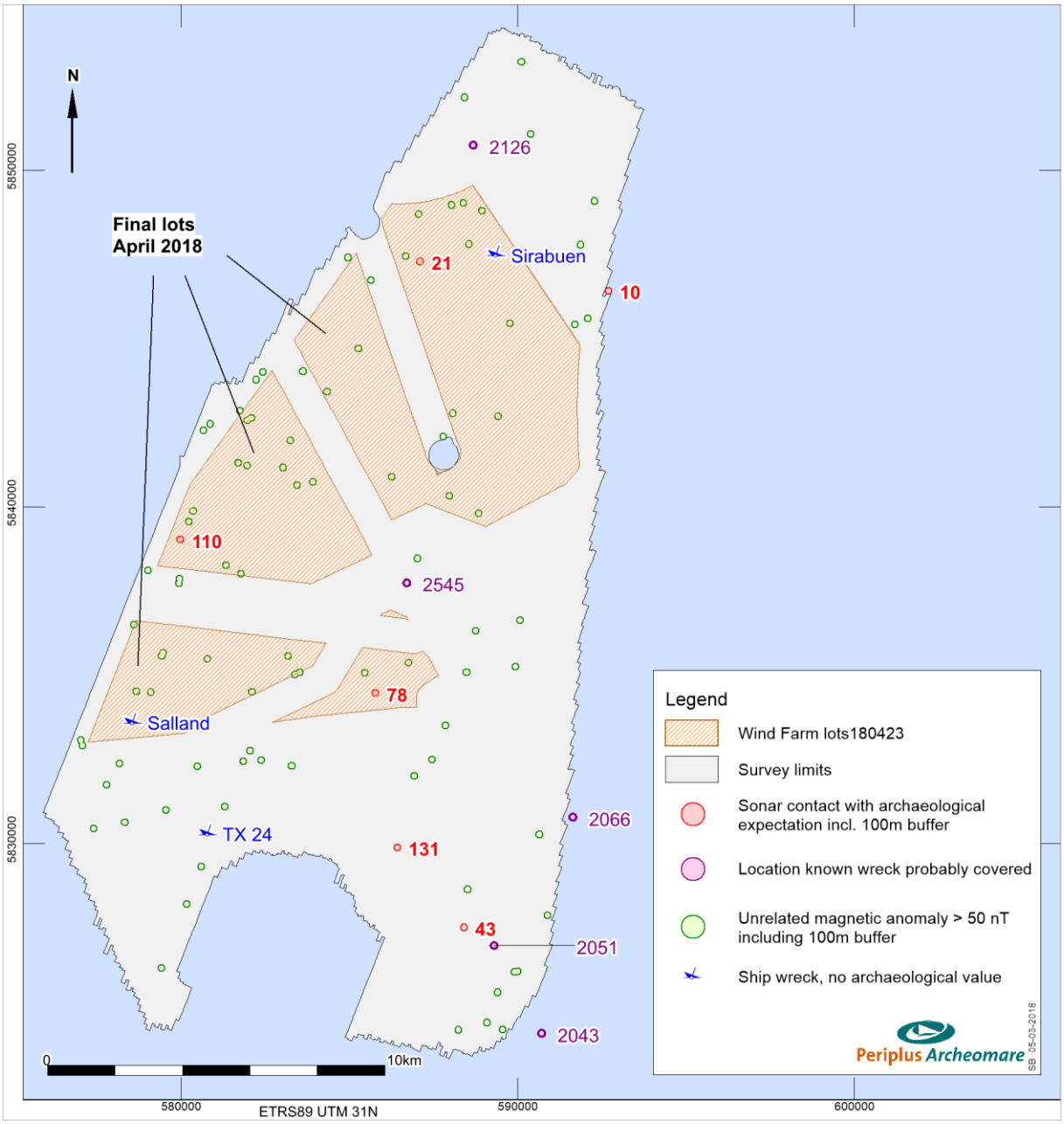


Figure 28. Buffer zones (100m) to scale around contacts with an archaeological expectation

Prehistory

From the interpreted seismic data can be concluded that well-preserved Late Palaeolithic and Mesolithic camp sites can occur in the palaeo-river valley in the southern part of the area of investigation. Areas of interest are the shores of small streams and aeolian dunes of the Boxtel Formation proximate to the valley, especially if those areas are cover by peat or clay.

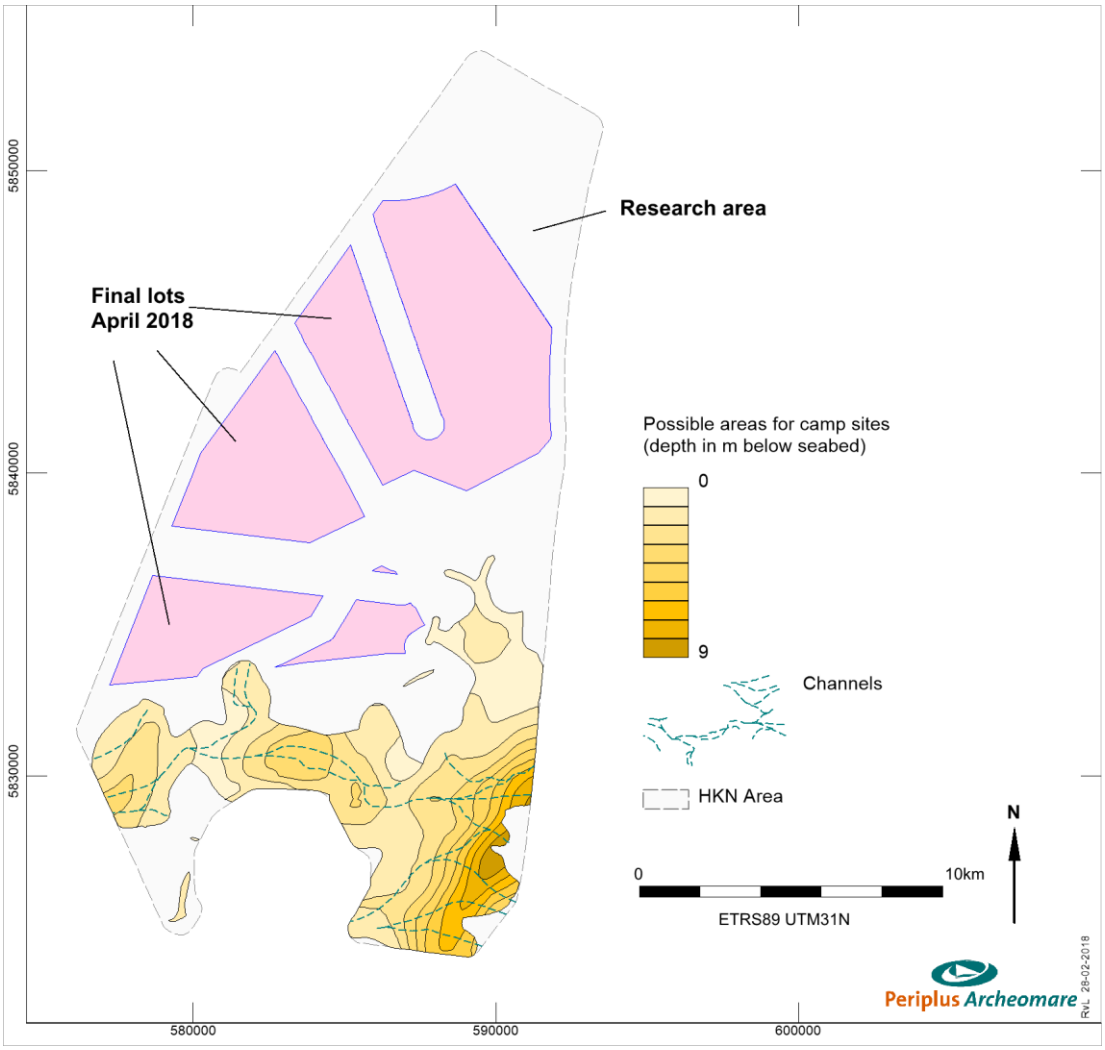


Figure 29. Possible areas for Late Palaeolithic and Mesolithic camp sites.

In the final design of the wind farm sites, the possible areas for Late Paleolithic and Mesolithic camp sites will not be affected by the wind Farm installation. Therefore, additional research is not advised.

During the installation of the wind turbines and cable lay operations, archaeological objects may be discovered which were completely buried or not recognized as an archaeological object during the geophysical survey. We recommend passive archaeological supervision based on an approved Program of Requirements. Passive archaeological supervision means that an archaeologist is not present during the execution of the work but always available on call. Following this recommendation would prevent delays during the work when unexpectedly archaeological remains are found. In accordance with the Erfgoedwet, it is required to report those findings to the enforcing authority (Rijkswaterstaat). This notification must also be included in the scope of work.

List of figures

List of tables

Glossary and abbreviations

Terminology	Description
AMZ	Archeologische Monumenten Zorg, a description of procedures to ensure the protection of National archaeological Cultural Heritage
CPT	Cone penetration test
Erratic	An (glacial) erratic is a piece of rock that differs from the size and type of rock native to the area in which it rests. These rocks are carried by glacial ice, often over distances of hundreds of kilometres. Erratics can range in size from pebbles to large boulders.
Ferrous	Material which is magnetic or can be magnetized, and well known types are iron and nickel
Holocene	Youngest geological epoch (from the last Ice Age, around 10,000 BC. to the present)
In situ	At the original location in the original condition
KNA	Kwaliteitsnorm Nederlandse Archeologie
Magnetometer	Methodology to measure deviations from the earth's magnetic field (caused by the presence of ferro-magnetic = ferrous objects)
Multibeam	Acoustic instrument that uses different bundles or beams to measure the depth in order to create a detailed topographic model
Pleistocene	Geological era that began about 2 million years ago. The era of the ice ages but also moderately warm periods. The Pleistocene ends with the beginning of the Holocene
PvE	Program of Requirements (Dutch: Programma van Eisen)
RCE	Ministry of Cultural Heritage (Dutch: Rijksdienst voor het Cultureel Erfgoed)
ROV	Remotely Operated Vehicle
Side scan sonar	Acoustic instrument that registers the amplitude of reflections of the seabed. The resulting images are similar to a black / white photograph. The technique is used to detect objects and to classify the morphology and type of soil
Current ripples	Asymmetrical wave pattern at the seabed caused by currents. The steep sides of the ripples are always on the downstream side.
Subbottom profiler	Acoustic system used to create seismic profiles of the subsurface.
Trenching	Construction of a trench for the purpose of burying a cable or pipeline
Vibrocore	Vibrocore bore is a special drilling technique where a core tube is driven by means of vibration energy in the seabed. In addition, the core tube is provided with a piston so that the bottom material in the core tube remains in place.

References

Literature

- Backes, F. and Yeo, R., 2017. Hollandse Kust (noord) Windfarm Zone Survey 2017, Dutch Continental Shelf, North Sea GH216 Field Report Volume 1 of 1 revision 2.
- Busschers, F.S., C.W. Dubelaar, J. Stafleu en D. Maljers, 2010: Lithological and sand grain-size variability in the three-dimensional GeoTOP model of Zuid-Holland, Delft.
- De Bruin, R., Forzoni, A., de Kleine, M., de Lange, G., Mesdag, C. and Vermaas, T., 2015. Geological study Hollandse Kust (zuid) Wind Farm Zone. Deltares rapport 1221136-000-BGS-0006.
- De Mulder, E. e.a., 2003: De ondergrond van Nederland, Groningen.
- De Wolff, R., 2017. Site Studies Wind Farm Zone Hollandse Kust (noord). Scope of Work Geophysical Survey
- Deeben, J., D.P. Hallewas & Th.J. Maarleveld, 2002: Predictive modelling in Archaeological Heritage Management of the Netherlands: the Indicative Map of Archaeological Values (2nd Generation), Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek 45, 9-56.
- Forzoni, A., T. Vermaas, C. Mesdag, M. Hijma, G. de Lange en M. de Kleine, 2017. Geological study Hollandse Kust (noord) Wind Farm Zone. Deltares project 11200513-002 reference 11200513-002-BGS-0001.
- Gaffney, V.L., K. Thomson en S. Fitch, 2005: The Archaeology and geomorphology of the North Sea, Kirkwall.
- Hessing, W.A.M., 2005: Het Nederlandse kustgebied, in: Bechert, T en W.J.H. Willems (red.), De Romeinse rijksgrens tussen Moezel en Noordzeekust, 89-102.
- Hijma, M., 2009: From river valley to estuary, The early-mid holocene transgression of the Rhine-Meuse valley, The Netherlands, Netherlands Geographical Studies 389, Utrecht.
- Huizer, J. en H.J.T. Weerts, 2003: Formatie van Maassluis, In: Lithostratigrafische Nomenclator van de Ondiepe Ondergrond, Geologische Dienst Nederland (DINOloket).
- IMAGO projectgroep, 2003: Eindrapportage IMAGO: Samenvatting en conclusies, RDIJ rapport 2003-13a.
- Kramer, E. e.a., 2003 (red.): Koningen van de Noordzee, 250-850, Leeuwarden / Nijmegen.
- Louwe Kooijmans, L.P., 1970-1971. Mesolithic Bone and Antler Implements from the North Sea and from the Netherlands.- Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek, 20-21: 69-70.
- Maarleveld, Th. J. en E.J. van Ginkel, 1990: Archeologie onder water, het verleden van een varend volk, Amsterdam.
- Maarleveld, TH.J. 1998: Archaeological heritage management in Dutch waters: exploratory studies, Almere.
- Nieboer, R., Marchetti, M. end Taliana, D., 2016. Geophysical Site Investigation Survey Dutch Continental Shelf, North Sea. Hollandse Kust (zuid) Wind Farm Development Zone Wind Farm Site I. Fugro Report No.: GH176-R1S.
- Nieboer, R., Marchetti, M. end Taliana, D., 2016. Geophysical Site Investigation Survey Dutch Continental Shelf, North Sea. Hollandse Kust (zuid) Wind Farm Development Zone Wind Farm Site II. Fugro Report No.: GH176-R02.
- Nieboer, R., Marchetti, M. end Taliana, D., 2016. Geophysical Site Investigation Survey Dutch Continental Shelf, North Sea. Hollandse Kust (zuid) Wind Farm Development Zone Wind Farm Site III. Fugro Report No.: GH176-R03.
- Nieboer, R., Marchetti, M. end Taliana, D., 2016. Geophysical Site Investigation Survey Dutch Continental Shelf, North Sea. Hollandse Kust (zuid) Wind Farm Development Zone Wind Farm Site IV. Fugro Report No.: GH176-R04.
- Reikwijdte en Detailniveau Transmissiesyteem wind op zee Hollandse Kust (zuid), 2015.
- Rieu, R., van Heteren, S., van der Spek, J.F., and de Boer, P.L., 2005: Development and preservation of a Mid-holocene Tidal-Channel Network Offshore the Western Netherlands. Journal of Sedimentary Research, 75-3, p 409-419.
- Rijsdijk, K.F, S. Passchier, H.J.T. Weerts, C. Laban, R.J.W. van Leeuwen & J.H.J. Ebbing, 2005: Revised Upper Cenozoic stratigraphy of the Dutch sector of the North Sea Basin: towards an integrated lithostratigraphic, seismostratigraphic and allostratigraphic approach. Netherlands Journal of Geoscience 84-2, p 129-146.
- Sier, M.M.; Cohen, K.M.; Kooistra, L.; Kubiak-Martens, L.; Moree, J.M.; Niekus, M.; Peeters, J.H.M.; Schiltmans, D.E.A.; Verbaas, A.; Verbruggen, F.; Vos, P.C.en Zeiler, J.T., Utrecht 2014. Twenty metres deep! The Mesolithic period at the site Yangtze Harbour in the Rotterdam Maasvlakte, the Netherlands. Early Holocene landscape development and habitation.
- Van den Brenk, S. and van Lil, R., 2017. Program of requirements Hollandse Kust Noord Wind Farm Zone – Archaeological field survey (geophysical stage).
- Van den Brenk, S. en van Mierlo, B.E.J.M., 2006. Archeologische assesment Maasvlakte II. Periplus Archeomare rapport 06A001.
- Van den Brenk, S., van Lil, R. en van den Oever, E.A., 2015. Desk study archaeological assessment Hollandse Kust (zuid). Periplus Archeomare rapport 15A024.

- Van Lil, R. en Muis, L.A., Amsterdam, 2014. Bureauonderzoek en Inventariserend veldonderzoek Noordzee – Zandwingebied Q13M. Periplus Archeomare rapport 14A014-09.
- Van Lil, R. en Muis, L.A., Amsterdam, 2015. Bureauonderzoek en Inventariserend veldonderzoek Noordzee – Zandwingebied Q16K. Periplus Archeomare rapport 15A004-01.
- Van Mierlo, B.E.J.M., van den Brenk, S. en Waldus, W.B., Amsterdam, 2009. Bureauonderzoek ontwikkeling Amstel & Zaan Field. Periplus Archeomare rapport 09A005.
- Verhart, L., 2005: Een verdronken land. Mesolithische vondsten uit de Noordzee, in: Louwe Kooijmans, L.P. e.a. (red.), de Prehistorie van Nederland, 157-160.
- Vonhögen-Peeters, L.M., van Heteren, S. and Peeters, J.H.M., 2016. Indicatief model van het archeologisch potentieel van de Noordzeebodem. Deltares rapport 1209133-000.
- Wagner, M. and Marchetti, M., 2017. Geophysical Site Investigation Survey Dutch Continental Shelf, North Sea. Hollandse Kust (noord) Wind Farm Zone Survey 2017. Fugro Report No.: GH216-R1.

Atlases and Maps

- GeoTOP-model Laag van Wijchen en Hollandveen Laagpakket
- Globale Archeologische Kaart van het Continentale Plat
- Noordzee atlas

Sources from the Internet

- Dienst der Hydrografie (www.hydro.nl)
- Dutch Federation of Aviation Archaeology (www.nfla.nl)
- Geologische Dienst Nederland – Data Informatie Nederlandse Ondergrond (www.dinoloket.nl)
- Noordzeeloket (www.noordzeeloket.nl)
- North sea paleolandscapes, University of Birmingham (http://www.iaa.bham.ac.uk)
- Olie en Gasportaal (www.nlog.nl)
- Stichting Aircraft recovery Group 40-45 (http://www.arg1940-1945.nl)
- Stichting Infrastructuur Kwaliteitsborging Bodembeheer (SIKB.nl)

Various sources

- Archis III, archeologische database Rijksdienst voor het Cultureel Erfgoed
- Databases Periplus Archeomare
- KNA Waterbodems 4.0
- Nationaal Contactnummer Nederland (NCN)
- SonarReg92, objectendatabase Rijkswaterstaat Noordzee en Delta

Appendix 1. Summary of contacts and known objects

General	Total	Within sites
Side scan sonar contacts	131	52
Magnetometer contacts	1035	174
Overlap sonar magnetometer	7	2
Unidentified magnetometer contacts (total)	370	138
Unidentified magnetometer contacts > 50nT	90	35

Objects with an archaeological expectation	Total	Within sites
Known objects with an archaeological expectation found	2	0
Known object covered with sediments	5	0
New object exposed at seabed, found by SSS	4	3
Total	**11**	**3**

Appendix 2. Listing of unidentified magnetic anomalies

> 50 nT and not related to known objects or side scan sonar contacts

ID	ETRS89 UTM31N		Amplitude (nT)	Anomaly type	Anomaly width (m)	Line	Classification
	Easting	Northing					
M_FG_0012	589934	5835255	52	Positive Monopole	34	V5-S6100	Unknown
M_FG_0056	588510	5828634	57	Positive Monopole	20	V5-S7200	Unknown
M_FG_0072	590640	5830265	72	Dipole	43	V5-S8600	Unknown
M_FG_0077	588229	5824457	100	Dipole	40	V5-S8500	Unknown
M_FG_0111	589088	5824672	139	Dipole	37	V5-S9200	Unknown
M_FG_0118	589896	5826175	66	Dipole	29	V5-S9400	Unknown
M_FG_0132	589999	5826190	67	Dipole	22	V5-S9500	Unknown
M_FG_0138	589549	5824470	132	Positive Monopole	20	V5-S9700	Unknown
M_FG_0141	590885	5827859	53	Positive Monopole	9	V5-S9700	Unknown
M_FG_0162	590058	5836636	75	Positive Monopole	27	V5-S5700	Unknown
M_FG_0213	586925	5832002	80	Negative Monopole	16	V5-S4500	Unknown
M_FG_0221	588477	5835085	62	Negative Monopole	11	V5-S4800	Unknown
M_FG_0224	587854	5833497	105	Negative Monopole	15	V5-S4800	Unknown
M_FG_0226	587449	5832488	89	Positive Monopole	15	V5-S4800	Unknown
M_FG_0238	592074	5845596	61	Dipole	37	V5-S4300	Unknown
M_FG_0256	588744	5836317	20342	Positive Monopole	17	V5-S4600	Unknown
M_FG_0287	591693	5845425	94	Positive Monopole	40	V5-S4000	Unknown
M_FG_0303	591864	5847792	1109	Dipole	93	V5-S3300	Unknown
M_FG_0316	586756	5835366	153	Dipole	48	V5-S3100	Unknown
M_FG_0325	588836	5839805	177	Positive Monopole	16	V5-S3400	Unknown
M_FG_0336	589419	5842686	78	Negative Monopole	62	V5-S2900	Unknown
M_FG_0341	592281	5849090	95	Positive Monopole	32	V5-S3200	Unknown
M_FG_0376	587963	5840328	112	Positive Monopole	39	V5-S2400	Unknown
M_FG_0393	589766	5845451	483	Dipole	37	V5-S2200	Unknown
M_FG_0394	587013	5838471	348	Dipole	25	V5-S2200A	Unknown
M_FG_0406	585453	5835062	53	Positive Monopole	17	V5-S2000A	Unknown
M_FG_0433	588067	5842782	51	Negative Monopole	27	V5-S1600	Unknown
M_FG_0434	587779	5842086	55	Negative Monopole	33	V5-S1600	Unknown
M_FG_0492	590376	5851080	70	Dipole	26	V5-S0700	Unknown
M_FG_0500	583283	5832298	82	Dipole	12	V5-S1000	Unknown
M_FG_0526	586247	5840889	65	Dipole	14	V5-S0600	Unknown
M_FG_0536	582371	5832475	133	Dipole	49	V5-S0100	Unknown

ID	ETRS89 UTM31N		Amplitude (nT)	Anomaly type	Anomaly width	Line	Classification
M_FG_0539	583374	5835012	136	Dipole	31	V5-S0100	Unknown
M_FG_0560	588939	5848797	170	Positive Monopole	7	V5-S0200	Unknown- Buried Target
M_FG_0561	588552	5847807	558	Negative Monopole	11	V5-S0200	Unknown- Buried Target
M_FG_0565	583525	5835084	169	Dipole	14	V5-S0200	Unknown
M_FG_0569	582048	5832750	71	Positive Monopole	10	V5-P0300	Unknown
M_FG_0571	583173	5835570	124	Positive Monopole	11	V5-P0300	Unknown
M_FG_0613	588033	5848973	175	Dipole	25	V5-P0700	Unknown
M_FG_0616	588387	5849031	158	Negative Monopole	17	V5-P0400	Unknown
M_FG_0624	581837	5832441	55	Negative Monopole	17	V5-P0400	Unknown
M_FG_0626	581294	5831085	76	Negative Monopole	17	V5-P0400	Unknown
M_FG_0627	580592	5829307	244	Negative Monopole	35	V5-P0400	Unknown
M_FG_0628	580156	5828190	55	Positive Monopole	12	V5-P0400	Unknown
M_FG_0629	579408	5826289	61	Dipole	16	V5-P0400	Unknown
M_FG_0636	582099	5834504	109	Negative Monopole	30	V5-P0900	Unknown
M_FG_0692	583911	5840736	51	Dipole	29	V5-P1500	Unknown
M_FG_0695	587050	5848692	51	Dipole	24	V5-P1500	Unknown
M_FG_0697	588417	5852167	61	Dipole	8	V5-P1500	Unknown
M_FG_0713	585263	5844710	92	Dipoles	47	V5-P1700	Unknown
M_FG_0718	586672	5847452	66	Dipole	42	V5-P1400	Unknown
M_FG_0733	583440	5840642	134	Dipole	34	V5-P1900	Unknown
M_FG_0743	580475	5832291	84	Dipole	10	V5-P1600	Unknown
M_FG_0750	584333	5843428	148	Positive Monopole	21	V5-P2100	Unknown
M_FG_0752	585641	5846731	201	Positive Monopole	15	V5-P2100	Unknown
M_FG_0772	579549	5830987	76	Dipole	32	V5-P2000	Unknown
M_FG_0775	580780	5835487	53	Negative Monopole	14	V5-P2500	Unknown
M_FG_0777	581776	5838018	65	Dipole	23	V5-P2500	Unknown
M_FG_0778	583018	5841167	78	Dipole	18	V5-P2500	Unknown
M_FG_0813	583247	5841974	75	Dipole	19	V5-P2600	Unknown
M_FG_0836	584955	5847410	117	Dipole	25	V5-P3000	Unknown
M_FG_0837	583616	5844030	160	Positive Monopole	6	V5-P3000	Unknown
M_FG_0839	581333	5838267	94	Dipole	14	V5-P3000	Unknown
M_FG_0842	578324	5830623	169	Negative Monopole	9	V5-P3000	Unknown
M_FG_0847	581955	5841219	243	Dipole	49	V5-P3500	Unknown
M_FG_0867	579098	5834494	68	Dipole	26	V5-P3700	Unknown
M_FG_0884	577785	5831735	60	Dipole	32	V5-P3900	Unknown
M_FG_0887	582086	5842637	118	Positive Monopole	29	V5-P3900	Unknown
M_FG_0899	578670	5834512	69	Positive Monopole	23	V5-P4100	Unknown
M_FG_0902	579935	5837724	492	Negative Monopole	21	V5-P4100	Unknown
M_FG_0904	582423	5844005	69	Dipole	16	V5-P4100	Unknown

ID	ETRS89 UTM31N		Amplitude (nT)	Anomaly type	Anomaly width	Line	Classification
M_FG_0908	581691	5841310	69	Dipole	20	V5-P3800	Unknown - wreck?
M_FG_0910	579463	5835670	102	Positive Monopole	22	V5-P3800	Unknown
M_FG_0911	579422	5835563	195	Positive Monopole	21	V5-P3800	Unknown
M_FG_0914	578159	5832369	143	Positive Monopole	19	V5-P3800	Unknown
M_FG_0916	577399	5830443	177	Positive Monopole	14	V5-P3800	Unknown
M_FG_0920	581742	5842852	59	Dipole	44	V5-P4300	Unknown
M_FG_0922	581967	5842577	94	Dipole	23	V5-P4000	Unknown
M_FG_0935	580226	5839557	267	Negative Monopole	18	V5-P4500	Unknown
M_FG_0936	580354	5839872	78	Negative Monopole	11	V5-P4500	Unknown
M_FG_0939	582226	5843779	471	Dipole	27	V5-P4200	Unknown
M_FG_0957	578595	5836503	62	Dipole	35	V5-P4900	Unknown
M_FG_0968	577016	5833063	92	Dipole	19	V5-P5100	Unknown
M_FG_0970	579016	5838108	77	Dipole	16	V5-P5100	Unknown
M_FG_0972	580658	5842268	54	Dipole	37	V5-P5100	Unknown
M_FG_0987	580858	5842465	68	Dipole	15	V5-P5000	Unknown
M_FG_0995	577067	5832900	68	Dipoles	75	V5-P5000	Unknown
M_FG_1016	590107	5853230	52	Negative Monopole	25	V5-X-P15000	Unknown
M_FG_1028	579949	5837865	61	Negative Monopole	15	V5-X-S3000	Unknown
M_FG_1046	589396	5825571	165	Dipole	21	V5-X-S11000	Unknown

Appendix 3. Listing of selected side scan sonar contacts

Contains a selection of 40 out of a total of 131 side scan sonar contacts with a possible Archaeological expectation, based on their size (larger than four meters) and characteristics.

Appendix 4. Phases of maritime archaeological research

The care for cultural heritage is legally required according to Dutch law. In order to comply with the requirements, all procedures and requirements for the archaeological research process haven been incorporated in the Dutch Quality Standard for Archaeology (KNA waterbodems, version 3.2). Below a brief description of the steps involved:

1. **Desk study**
   The purpose of a desk study is to collect and report all available historical data, geological information and information about disturbances in the past. The result is an archaeological expectation map or model.
   The desk study may be expanded with an analysis of sonar and multibeam data, if available.

   IF the outcome of the desk study shows that there is a risk of occurrence of Archaeology, then the next phase must be carried out:

2. **Exploratory field research (opwaterfase)**
   In order to test the archaeological expectation, a geophysical survey is carried out. The type of survey depends on the type of expected objects, local geology and expected depth of the objects below the seafloor. In practice, the research usually consists of a side scan sonar survey, if necessary, supplemented with multibeam echosounder recordings, subbottom profiling and magnetometer measurements. The requirements of the survey are based on the desk study and should be included in a program of requirements which must be approved by the enforcing authority (Rijkswaterstaat).

   IF potential archaeological objects are found, then the next phase must be carried out:

3. **Exploratory field research (onderwaterfase verkennend)**
   The suspected sites are investigated by specialized divers in order to identify the objects. The requirements of the underwater research are included in a program of requirements which must be approved by the enforcing authority (Rijkswaterstaat).

   IF as site is identified as an archaeological object or structure then the next phase must be carried out:

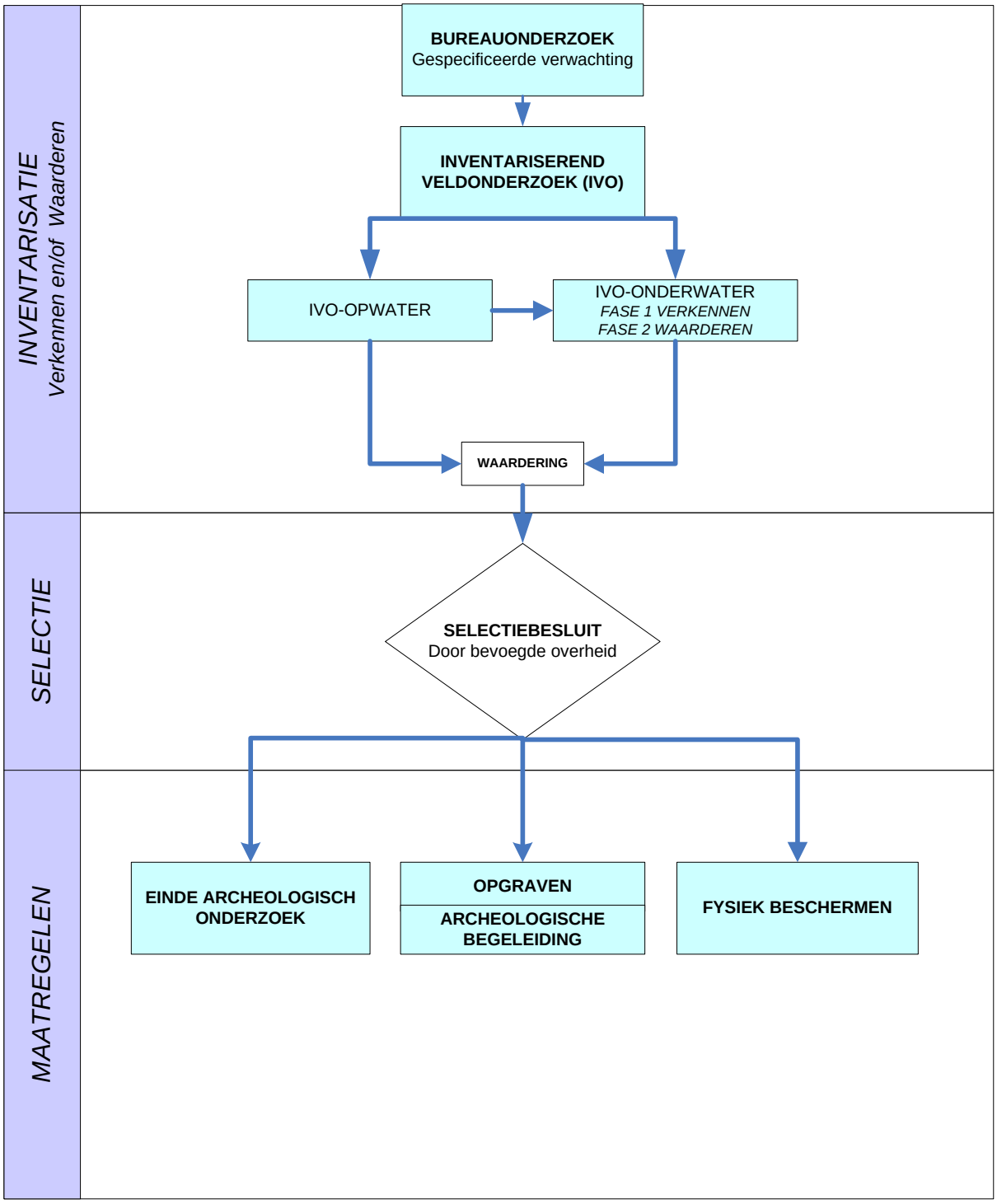
4. **Appreciative field research (onderwaterfase waarderend)**
   The archaeological remains at the site are thoroughly investigated and mapped by a specialized archaeological diving team and samples are collected for additional research. Then a decision will be made whether the archaeological remains are worth preserving. If the latter is the case, then there are two possibilities: either the remains can be preserved in situ (adjustment of plans) or the next phase will be conducted:

5. **Archaeological excavation**
   The archaeological remains are excavated under supervision of a senior maritime archaeologist. All remains need to be documented, registered and conserved. The requirements of the underwater research are included in a program of requirements which must be approved by the enforcing authority (Rijkswaterstaat).

The phases described above contain a number of decision points that are dependent on the detected archaeological objects. The figure on the next page shows these moments schematically.

Schematic overview KNA Waterbodems version 4.0

(AMZ cycle in Dutch)



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Netherlands Enterprise Agency (RVO.nl) | Juni 2018