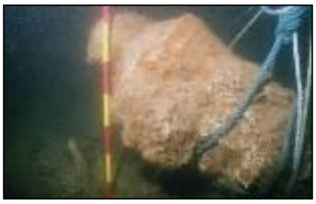
Appendix A16.12 Marine Archaeological Geophysical Survey Undertaken as Part of the Environmental Impact Assessment





GREATER DUBLIN DRAINAGE SCHEME
MARINE GEOPHYSICAL SURVEY
OFF VELVET STRAND, BURROW, CO. DUBLIN
15R0092

THE ARCHAEOLOGICAL DIVING COMPANY LTD.

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Project Director **Dr. Niall Brady**

Beverley Studios, Church Terrace, Bray, Co. Wicklow info@adco-ie.com

THE ARCHAEOLOGICAL DIVING COMPANY LTD.

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LIST OF ABBREVIATIONS

ADCO	The Archaeological Diving Company Ltd
DAHG	Department of Arts, Heritage and the Gaeltacht
E	Easting
HW	High Water
IH	Irish Hydrodata Ltd
ITM	Irish Transverse Mercator
LW	Low Water
N	Northing
NGR	National Grid Reference
OPW	Office of Public Works
RMP	Record of Monuments and Places
RPS	Record of Protected Structures
S	South
W	West

EXECUTIVE SUMMARY

The Archaeological Diving Company Ltd (ADCO) was appointed by Jacobs, consulting engineers for Irish Water to undertake a marine geophysical survey off Velvet Strand, Burrow townland, Co. Dublin, where it is proposed to extend an outfall pipe for the Greater Dublin Drainage project.

The survey focuses on the *c.* 80m-wide footprint for the pipe trench, which is to run 4.1km offshore.

The existing archaeological record indicates there are no known archaeological features within the sub-tidal survey area. However, intertidal survey for the GDD project in 2015 identified the remains of a shipwreck immediately inshore of the survey area, at the north end of the development corridor. Historic records of shipwreck also indicate the presence of recorded shipwreck events buried in the sands along the intertidal foreshore to the north and south of the development corridor.

The marine geophysical survey was carried out by Irish Hydrodata Ltd on 24-26 September 2015, deploying bathymetry, side-scan sonar, magnetometer and sub-bottom profile devices. Sea conditions were favourable during the inshore work with conditions deteriorating offshore, but it proved possible to acquire usable data throughout the survey area.

The survey conducted was comprehensive and thorough. The location of the new shipwreck identified by intertidal survey is highlighted in the magnetometer survey, suggesting that the wrecksite is perhaps more extensive than the visible remains indicate and that the wreck includes ferrous metal components. However the absence of indicators in the sub-bottom profile survey data may qualify this by indicating a relatively small-scale craft.

The bathymetry data suggests the presence of one anomaly, but this may be a natural variation rather than the presence of something more significant.

The side-scan sonar data shows the footprints of a spud barge that was located on site immediately prior to the 2015 survey. A number of small-scale side-scan sonar anomalies are also evident in the data, and these appear to be isolated rocks or

pieces of debris; no one instance suggests the presence of archaeologically significant remains.

The sub-bottom profile data shows the presence of natural sands as the underlying stratigraphy of the upper 4m of seabed.

The outfall pipe trench will be tunnelled across the foreshore to a point that lies between Borehole 1 and Borehole 2. The pipe trench may be dredged seawards from where the tunnelled limit ends. A second option considers tunnelling the full length of the outfall pipe.

It is recommended that the site of the new wreck is avoided during site investigations and construction. If avoidance is not possible, it will be necessary to excavate fully the new wrecksite prior to the construction of the outfall, to preserve the site by record.

It is appropriate to conduct dive inspection of the anomalies identified by marine geophysical survey that lie within the development footprint, to further qualify their archaeological potential in advance of dredging works commencing. This recommendation applies to eleven side-scan sonar anomalies forming six clusters of targets that cannot otherwise be explained as relict features associated with the presence of the spud barge.

Ground disturbance activities associated with site investigations works and construction phase works on land and at sea will be archaeologically monitored under licence from the DAHG, with the proviso to resolve fully any archaeological material that occurs during such works.

Recommendations are subject to the approval of the National Monuments Service of the Department of Arts, Heritage and the Gaeltacht.

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1.0 INTRODUCTION

The Archaeological Diving Company Ltd (ADCO) was appointed by Jacobs, consulting engineers for Irish Water to undertake a marine geophysical survey off Velvet Strand, Burrow townland, Co. Dublin, where it is proposed to extend an outfall pipe for the Greater Dublin Drainage project.

The survey focuses on the *c.* 80m-wide footprint for the pipe trench, which is to run 4.1km offshore.

The survey was carried out by Irish Hydrodata Ltd (IH) on 24-26 September 2015, deploying bathymetry, side-scan sonar, magnetometer and sub-bottom profile devices, under licence from the Department of Arts Heritage and Gaeltacht, 15R0092 Sea conditions were favourable throughout the inshore work, with conditions deteriorating offshore.

The marine geophysical data was processed by IH, who prepared a series of charts and presented the primary data to ADCO for archaeological interpretation. Usable data was acquired throughout the survey area.

The current report presents the archaeological observations, and includes an impact assessment of the proposed development works and a set of mitigation proposals to ensure the proper recording and observation of archaeological material associated with the project.

2.0 LOCATION[1]

The survey area extends approximately 4.1km long by 80m wide, from a point on the mean Low Water Mark that is located mid-way along the shoreline of Velvet Strand, in Burrow townland, Co. Dublin (Figure 1).

Reference	ING Easting	ING Northing	ITM Easting	ITM Northing
LWM, centre	325415	242277	725338	742301
Offshore limit, centre	329559	242249	729481	742273

Table 1: Coordinates that define the centerline of the survey area.

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[1] Details provided by Jacobs, consulting engineers for the project.

3.0 PROPOSED DEVELOPMENT

It is proposed to extend an outfall pipe for the Greater Dublin Drainage project that will run 4.1km east from the shoreline on Velvet Strand. Design options include a fully tunnelled pipe that would have minimal surface impact along its length, and a combination of tunnelling and dredging that would have significant surface impacts along its length.

4.0 THE RECEIVING ENVIRONMENT

The existing archaeological environment has been dealt with separately by ADCO, as part of an archaeological assessment of different marine geophysical data acquired for the present project over a wider area.[2] In addition, ADCO carried out an intertidal survey for the project in advance of borehole site investigations, which has contributed further insight.[3] For the purposes of the present report, comments are restricted to the active marine environment.

The survey area crosses the recorded route of a fibre-optic cable offshore (Figure 1). There are no recorded archaeological features within the survey area, although Velvet Strand is a place that has a significant number of shipwrecks (Table 2, Figure 1). The sites are recorded as being partially exposed at particular low waters. A combination of timber and metal remains exist, and the presence of copper bolts on one site indicates the potential for pre-19th century remains. There are nine separate entries but it is probable that three entries are duplications, representing a distinction between recorded locations on 19th-century Admiralty Charts and locations recorded by fieldwork in more recent times (i.e. sites W0030, W00541 and W00842 appear to be the same as sites W00857, W00859 and W00858 respectively). It is unusual to find such a concentration of shipwreck remains along a relatively short extent of shoreline. One site (W00860) occurs *c*. 300m south of Borehole 1.

When new fieldwork was carried out on Velvet Strand in 2015 for the present project, a previously unrecorded shipwreck was identified within the development area on the north side of the proposed pipe trench route, bringing the total number of shipwreck on this section of Velvet Strand to ten (Table 2). The new discovery observed a series of six framing timbers whose eroded tips are exposed above the covering sands,

[2] Niall Brady, 'Marine archaeological assessment, Greater Dublin Drainage Project, Portmarnock Outfall', unpublished report of the Archaeological Diving Company Ltd, May 2014.

[3] Niall Brady, 'Greater Dublin Drainage Scheme, intertidal inspection, Velvet Strand, Burrow townland, Co. Dublin, 15D0019, 15R0025', unpublished report of the Archaeological Diving Company Ltd, DRAFT 2015.

forming a bow-shaped plan that is orientated North-South and extends over an area measuring 10m-long and 3.2m-wide. There is no indication of fastenings, whether timber or metal, and it appears that the remains are those of the starboard side of a vessel.

The gently shelving nature of the sandy seabed across the intertidal foreshore of the survey area extends as shallow water some distance out to sea, and may offer some explanation for the concentration of wrecks. It may be that the strand was a suitable place on which to abandon vessels. It is equally plausible that vessels encountered difficulties while navigating along the coastline, running aground in the shallow waters and being lost.

The presence of a shipwreck (W0967) off the north shore of Ireland's Eye and 600m south of the proposed pipe trench highlights the potential of the sea-scape further offshore.

Marine Geophysical survey conducted in 2013 for the GDD scheme did not present material of archaeological interest across the wider sea area surveyed. However, that survey work was unable to present a clear assessment of the inshore area, as an active surf zone compromised the integrity of the side-scan sonar data, leaving a *c*. 400m wide gap offshore of the Low Water Mark.

One concludes from the existing knowledge base that there is high archaeological potential for wreckage along Velvet Strand. The presence of a new wreck observed on the north side of the pipe trench presents a known constraint on the intertidal foreshore. There is no clear indication to date of wreckage within the sub-tidal pipe trench area that extends seawards from the Low Water Mark.

Reference	Location	ING E	ING N	Description	Proximity to development
W00830	Velvet Strand	326130	241153	Marked on Admiralty Chart 2831 (1866).	1.5km South of pipe trench.
W00841	Velvet Strand	325756	241498	Marked on Admiralty Chart 1415 (1869).	1.02km South of pipe trench.
W00842	Velvet Strand	326258	240911	Marked on Admiralty Chart 1415 (1869).	1.8m South of pipe trench.
W00856	Velvet Strand	324889	243269	Wooden wreck exposed in 2002-3. Orientated E-W, *c*. 20 frames and some hull planking. Treenails, dowel holes, copper bolts.	875m North of pipe trench.
W00857	Velvet Strand	325898	241079	2 vertical timbers extend 35cm from seabed, attached by a metal plate and iron bolts, possibly a rudder piece.	1.4km South of pipe trench.
W00858	Velvet Strand	326193	240838	Timber and metal uprights exposed.	1.8km South of pipe trench.

Reference	Location	ING E	ING N	Description	Proximity to development
W00859	Velvet Strand	325621	241501	Lower hull of wooden wreck, 7.8m long, 5.2m wide, orientated NNW-SSE, 20 oak frames on W side of vessel, 7 on E side. Planking visible on both sides, treenails.	950m South of pipe trench.
W00860	Velvet Strand	325428	242154	Timber wreck. No further details are available.	300m South of pipe trench.
W00861	Velvet Strand	324978	243585	Wooden wreck, sometimes exposed at LW. Curving line of 38 futtocks attached to hull planking. Two other lines of timber run parallel.	1.18km North of pipe trench.
New Wreck	Velvet Strand	325259	242328	Observed in 2015. Series of 6 framing timbers exposed, forming a bow-shaped plan that is the starboard side of a vessel orientated N-S, over a 10m-long and 3.2m-wide area. No indication of fastenings.	Within impact area of the outfall pipe trench. 7m N of a straight line between Boreholes 1 and 2, and 80m E of Borehole 1.
W00967	Ireland's Eye	328640	241626	GSI INSS G 159. 14m long, 4m wide, 1m high anomaly on seabed.	600m South of pipe trench.

Table 2: Shipwreck Sites on Velvet Strand in proximity to proposed pipe trench.

Source: Karl Brady, *Shipwreck Inventory of Ireland*, 2009, with supplemental observations arising from intertidal inspection by ADCO in 2015. Note: sites located within the proposed development area are highlighted in blue

5.0 2015 MARINE GEOPHYSICAL SURVEY

5.1 Survey Methodology

Irish Hydrodata Ltd (IH) carried out the marine geophysical survey work in accordance with the following proposed methodology, subject to on-site conditions:

1) It was intended to carry out the survey at 20m line spacing East-West and 100m line-spacing North-South, deploying bathymetry, side-scan sonar, magnetometry, and sub-bottom profiling equipment.
2) A Marine Mammal Observer (MMO) was to be present before and during the sub-bottom profiling and side-scan sonar element of the work.
3) Site work was to take place over a two (2) day period, weather permitting.
4) Positioning of the survey vessel was to be achieved using Trimble Ag132 DGPS with OMNISTAR corrections.
5) Tidal data was to be recorded at Howth, and be used for reduction of bathymetric data to datum (Ordnance Datum Malin).
6) The shallow parts of the survey area were to be surveyed at around High Water (HW) to ensure that the complete survey area was covered.

7) IH would use its own licensed survey vessel for the work. The *Bluefin* is a 21' launch with cabin and fully equipped with safety equipment including in-hull echosounder transducers.
8) Bathymetric data would be acquired using a Knudsen 320M simultaneous dual frequency (33kHz, 210kHz) precision survey echosounder. Data was to be acquired at a rate of about one depth every 0.3m along the survey lines. Extra lines were to be surveyed if particular areas portrayed rapid changes in profile that may not otherwise be picked up during the course of the planned survey.
9) An L^3-Klein System 3000 simultaneous dual frequency digital side-scan sonar system was to be employed for the side-scan sonar survey. Data from both frequencies is logged digitally using 'SonarPro' software. The side-scan range to be set to 50m or 37.5m port and starboard to ensure better than 100% overlap and good data beneath the towfish. If objects of particular interest are discovered during the course of the planned survey, then extra sweeps were to be made as appropriate.
10) A Geometrics G881 marine magnetometer was to be employed for this aspect of the survey.
11) A Datasonics chirp sub-bottom profiling system was to be used. Survey lines to be steamed at 20m line spacing parallel to the proposed pipeline route. Additional cross-lines would be surveyed as required.
12) A Hobo water level recorder was to be deployed at a suitable location adjacent to the survey area for the duration of the field works, to record tidal levels.

The primary data would be processed by IH, who would present the primary data to ADCO to review and interpret archaeologically.

5.2 Site work

Site work took place on 24-26 September 2015, using the *Bluefin* launch as the survey vessel (Appendix 1). Bathymetry and Side-scan sonar were deployed on 24 September, and Magnetometer and Sub-bottom Profile on 24-26 September. Work focused on the inshore section before moving offshore. Weather conditions were good during the first half of 25 September but deteriorated during the day forcing site work to be postponed. The survey was continued and completed on 26 September. A MMO was aboard during the survey work, and a report has issued separately on that aspect of the job.[4]

5.3 Survey Grid

The survey footprint extended approximately 4.5km long by 90m wide as indicated in Table 3, including the proposed outfall trench. Data was acquired on a survey grid that comprised five East-West survey lines at approximately 20m intervals, and forty-four North-South survey lines at approximately 100m intervals (Appendix 1). The survey grid reached 155m inshore from the Low Water Mark. The grid achieved is comprehensive and meets the proposed method statement.

[4] Margaret Haberlin, 'Marine Mammal Observer report for Irish Hydrodata Ltd, Greater Dublin Drainage Project, 24-26 September 2015'.

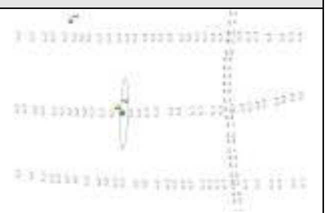
Ref.	ING East	ING North	ITM East	ITM North	WGS84 Lat	WGS84 Long
SW	325068.31	242288.65	724992.06	742313.09	53° 24.967 ’	-6° 7.182 ’
NW	325068.31	242378.96	724992.06	742403.39	53° 25.0157'	-6° 7.1799'
SE	329625.51	242247.59	729548.29	742272.01	53° 24.8790'	-6° 3.0731'
NE	329627.07	242341.23	729549.85	742365.64	53° 24.9294'	-6° 3.0694’

Table 3: Survey Corridor co-ordinates.
Source: IH, grid coordinates provided by Jacobs.

5.4 Bathymetry survey

The bathymetry survey affirms the information provided on Admiralty Charts and in the 2013 marine survey, and provides much greater detail. Velvet Strand comprises a gently sloping long sandy beach, with minimal variation along its course seawards. The bathymetric survey commenced *c.* 180m above the Low Water Mark (LWM), and provides a continuous record of sea depths out to the offshore point (see figures as part of Appendix 1). There is a consistent and gentle slope seaward, with depths remaining shallow inshore. The 2m depth contour is achieved 450m off the LWM; the 3m contour at 700m; the 4m contour at 1km offshore; the 5m contour a 1.4km offshore, and so on. The progressive gentle slope continues for over 2.8km offshore, at which point there is a more distinct slope. This occurs at a point that is in line with and north of Ireland’s Eye, and marks a defined drop in seabed. Contours fall from 9m to 15m over a horizontal distance of only 400m, after which there is a gentler but clear slope out to the offshore limit of the survey area, where water depths reach 20.5m.

There is a single localized anomaly in the dataset, which relates to a slight shallowing at coordinate ITM 727458E 742353N (Table 4, Figure 2 b1). The topography forms a 19m-long narrow shallow, where seabed rises to 5.7m in an area where the ambient depth is 6.3m. As is described below, this location corresponds with a slight fluctuation in the magnetic signature, and suggests that dive inspection is warranted to assess the archaeological risk more directly.

Ref	ITME	ITMN	Description	Arch. Potential & Recom	Image
b1	727458	742353	Linear shallow of 5.7m that appears to be 19m long. The magnetometer passed over this location (ping 985) and registered a slight fluctuation in the magnetic field (mg7), suggesting	Unclear potential. Dive inspection required.	 Detail from bathymetry mapping, showing

Ref	ITME	ITMN	Description	Arch. Potential & Recom	Image
			the presence perhaps of some debris or a small-scale localised natural variation.		soundings in vicinity of b1.

Table 4: Possible anomaly detected in the bathymetry data.
Source: IH, bathymetry data.

5.5 Side-scan sonar survey

Side-scan sonar survey is a key marine geophysical survey technique employed to acquire an image of the seabed surface and for detecting the presence of features or objects that may lie exposed on the surface. It is most useful for constructing an understanding of the surface layer of the seabed. It is less useful for gaining an understanding of the underlying deposits, since side-scan sonar is unable to detect features that lie underneath the covering seabed layer.

The sonar operates by emitting sonic pulses on a variety of frequencies that are adjusted to suit the extent of coverage and the quality of the seabed images. The present survey was conducted at both high and low resolution, which maximises the information gain. The sonic pulses extend from below the device and reach across a swathe on either side that is set at a pre-determined range or distance from the device.

In the present instance the range was set at 50m, 100m and 37.5m port and starboard, to ensure ample overlap between survey lines and the acquisition of a very comprehensive data set.

Current guidelines for archaeological prospection propose 50m spacing.[5] With regard to the GDD project, the spacing exceeded these guidelines and constitutes a very robust data set for examination, analysis and assessment of potential impacts on marine archaeology and cultural heritage.

The sonar fish was towed astern with laybacks of up to 15m. The primary data files received for analysis were not corrected for layback. Layback was applied individually when the shortlist of anomalies were identified.

The seabed portrayed was generally clearly imaged. It included the surf zone, which was not clearly imaged in the 2013 survey. Only one survey line presented unclear detail (line 24150800). The data on line 24150800 was captured while moving East offshore, and the data is full of wash that obscures the seabed visualization but not to

[5] R. Pletts, J. Dix, R. Bates, *Marine Geophysics Data Acquisition, Processing and Interpretation, Guidance Notes*. English Heritage 2013, p. 18.

the extent that this line of data was unusable. In general, the data sets reveal a seabed that is for the most part featureless sand (Plate 1). The only indication of a different surface was highlighted in one location where there is an expanse of cobbling. It is located in the middle of the survey corridor some 750m from the offshore limit of the survey box and 3.5km seaward of the Low Water Mark (Plate 2). It is recorded as an anomaly, albeit of most likely natural origin (ss16).

There was no indication of the fibre-optic cable that crosses beneath the survey area. Fibre-optic cables are typically of quite small diameter, possibly of the order of 50mm or less, and would normally be buried in areas such as this. It is extremely unlikely that anything of this proportion would show up on side-scan or magnetometer.

A total of twenty-five side-scan sonar anomalies were observed in the primary data sets (Figure 2, Table 5). The anomalies are distributed across the survey extent. No anomaly presents clear unambiguous indication of archaeological material. There is no clear indication of shipwreck debris, fish weirs or other suggestion of potential archaeological interest.

Particular attention was given to the sonar signature of the seabed close to where the newly recorded shipwreck is located on the intertidal foreshore. The evidence for the wrecksite was visible during Low Water in April 2015, as a series of timbers protruding above the covering sands (Plates 3-4). The size of such timbers is small, and arguably too small to be detected in sonar data sets. Anomaly ss29 is an unclear image of a possible irregularity, positioned 28m Northwest of the actual wreck site.

The expanse of cobbles observed (ss16) is considered to be most likely natural in origin, as is a short expanse of mud (ss3).

In eight instances (ss9, ss10, ss14, ss15, ss17, ss22, ss23, ss27), the presence of isolated and small-scale anomalies that measure 1m in diameter and less in size are considered to be either isolated rock or debris.

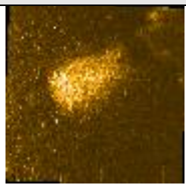
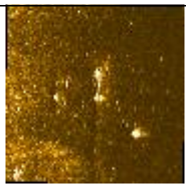
The data includes a series of images that have dragmarks associated with a complex of four-to-six anomalies 1m or so in size that form near-squared shapes, measuring 11m-18m across (Plate 3). There was no suggestion of such anomalies in the 2013 survey data sets. Immediately prior to the present survey, a spud barge was deployed on site to conduct site investigations. The side-scan sonar images are consistent with footprints left by such a barge, with the dragmarks representing where anchor lines cut into the surface deposits. The seabed image reproduced on Plate 5 also shows a confusion of scar marks to one side of where the barge was positioned; the scar marks may represent trawl marks from fishing activity. A close correspondence between anomalies observed in the 2015 data sets and the recorded positions on the Vibro-core boreholes occur in the following instances, and explains the nature of these sonar anomalies as the footprint and dragmarks of the spud barge positioned overhead or close by to conduct the site investigations: ss10 relates to VC2; ss7 and ss8 relate to VC3; ss6 and ss26 relate to VC5; ss5, ss19, ss20 related to VC6; ss13 related to VC9.

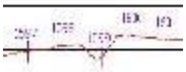
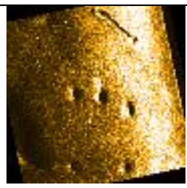
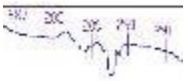
The dynamic nature of the surface sands is suggested by the absence of any significant variation in the sonar image of the seabed at the locations of VC4, VC7, VC8, VC10 and VC11.

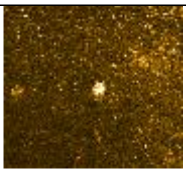
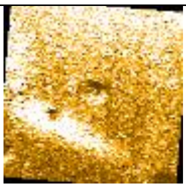
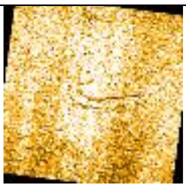
If many of the sonar anomalies can be explained by the recent presence of the spud barge on site, there remains a series of anomalies that cannot be explained in this way. The remaining anomalies occur singly and in groups, and present a series of six locations that warrant further consideration: ss4; the cluster of ss11, ss12, ss24; the cluster of ss15, ss22; ss16; the cluster of ss17, ss23, ss25; and ss18. It is recommended that dive inspection is carried out at these locations, to ascertain further the nature of the anomaly and assess their archaeological risk.

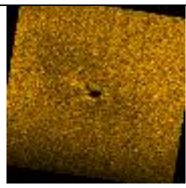
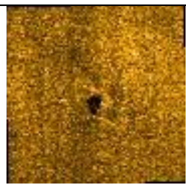
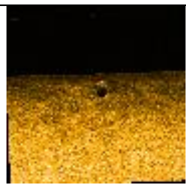
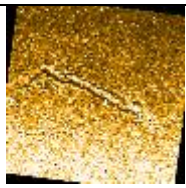
There is no variation in the sonar trace at the location of the bathymetric anomaly b1.

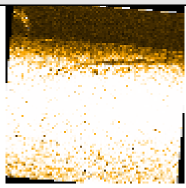
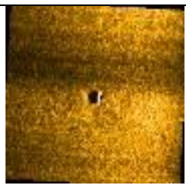
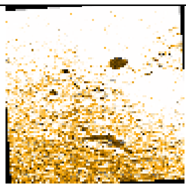
As is described below in section 5.6, the magnetometer tracklines coincided with the locations of several of the sonar anomalies but there are only two instances (ss4, ss8) where there was indication of fluctuation in the ambient magnetic field. The magnetic fluctuations are quite small in scale and are not considered to be sufficiently strong to indicate the presence of metal content. Anomaly ss8 is associated with the spud barge location for VC3 and requires no further consideration. Anomaly ss4 cannot be explained by the presence of the spud barge and it is very close to the bathymetric anomaly b1. Dive inspection is recommended in this instance.

Ref	ITME + Layback	ITMN + Layback	E layback	N layback	Description	Arch. Potential & Recom	Image
ss3	727657.2	742393.3	727652	742407	Localised anomaly, poorly defined, 10m in extent. Mud expanse. Located 21m N of and outside survey area.	Low. Nothing further required.	
ss4	727446.9	742366.2	727443	742380	Localised occurrence of 4 anomalies less than 1m each in size, over 10m-long area. Possibly rocks but located 28m North of b1. Magnetometer	Low. Dive inspection required.	

Ref	ITME + Layback	ITMN + Layback	E layback	N layback	Description	Arch. Potential & Recom	Image
					(ping 1598) registered a slight fluctuation in the magnetic field, suggesting the presence perhaps of some debris or a small-scale localised natural variation.		 Magnetometer data profile
ss5	727336.7	742352.8	727336	742367	Anomaly with distinct image of dragmark or cable, reaching over 100m in length. Probably associated with spud barge. VC6 positioned 40m to S.	Low. Nothing further required.	
ss6	726873.4	742267.2	726870	742282	Linear thin dragmark or cable lying across seabed, visible over c. 150m. Probably associated with spud barge. 60m S of VC5.	Low. Nothing further required.	
ss7	725976.8	742366.8	725992	742368	Linear feature defined on seabed, 11m long, within 5m of ss8. Probable dragmark from spud barge anchor. 26m N of VC3. Magnetometer (ping 917) did not register any anomaly.	Low. Nothing further required.	
ss8	725973.5	742347.9	725987	742368	Sequence of three rounded anomalies in a line, close to adjoining two related features forming a squared shape 12 x 15m. Close to ss7. Probable footprint of spud barge. 26m N of VC3. Magnetometer (ping 288-289) registered a slight fluctuation in the magnetic field, suggesting the presence perhaps	Low. Nothing further required.	  Magnetometer data profile

Ref	ITME + Layback	ITMN + Layback	E layback	N layback	Description	Arch. Potential & Recom	Image
					of some debris or a small-scale localised natural variation.		
ss9	725202.9	742376.7	725218	742374	Isolated rounded feature 1m in diameter. Rock or debris. It is 37m NE of the new wreck on the intertidal foreshore.	Low. Given its proximity to the wrecksite it should be considered within the context of any future intertidal work in that location.	
ss10	725545.5	742349.9	725531	742344	Isolated rounded anomaly less than 1m in size. Probable rock or debris. 10m W of VC2. Magnetometer (ping 259-260) did not register an anomaly.	Low. Nothing further required.	
ss11	728325.4	742332.9	728310	742333	Cluster of four anomalies *c.* 1m in diameter forming parallelogram plan 13 x 18m in size. Close to ss12 and ss24. Appears to be footprint of spud barge, but 115m E of VC8. Magnetometer (ping 435-6) did not register any anomaly.	Low. Dive inspection required.	
ss12	728364.5	742340.3	728349	742341	Dragmark forming L-shape on seabed, 16m and 20m long, Within 40m of ss11. Appears to be footprint of spud barge, but 156m E of VC8	Low. Dive inspection required.	
ss13	728659.3	742321.2	728644	742319	Defined anomaly at outer limit of range, on clear sandy bed. Linear in shape c. 3m long. Possible dragmark. On	Low. Nothing further required.	

Ref	ITME + Layback	ITMN + Layback	E layback	N layback	Description	Arch. Potential & Recom	Image
					location of VC9 Magnetometer (ping 457) did not register any anomaly.		
ss14	729191.1	742378.7	729176	742378	Isolated anomaly *c*. 1m in diameter with suggestion of scour area around it. Sandy bed. Rock. 5m N of and outside survey area.	Low. Nothing further required.	
ss15	729277.5	742334.5	729262	742333	Isolated defined anomaly with scour area around, 1.4m long, 0.9m high off seabed. Probable rock or debris. 5m from ss22.	Low. Dive inspection required.	
ss16	728786.5	742336.4	728801	742337	Extensive area of shoaling/boulder spread, measuring at least 60m E/W by 15m wide. Natural feature. Coordinate taken at centre of feature on its E side.	Low. Dive inspection required.	
ss17	728552	742298.7	728567	742297	Small isolated anomaly on sandy bed, *c*. 1m in diameter. Rock or debris. Probably same as ss23, ss25	Low. Dive inspection required.	
ss18	727673.2	742316	727687	742314	*c*. 18m long dragmark scar on sandy seabed. Magnetometer (ping 1774) did not register any anomaly.	Low. Dive inspection required.	
ss19	727371	742306.3	727386	742307	Cluster of 5 anomalies *c*. 1m in diameter, forming square shape 18 x13m in size. 40m SE of VC6 and probably related to it.	Low. Nothing further required.	

Ref	ITME + Layback	ITMN + Layback	E layback	N layback	Description	Arch. Potential & Recom	Image
ss20	727275.1	742315.6	727288	742313	Sinuous dragmark scar crossing sonar view, *c.* 80m long. Magnetometer passed (ping 799) did not register any anomaly. 80m W of VC6. Considered to be anchor scar of spud barge.	Low. Nothing further required.	
ss22	729265.4	742323.7	729265	742338	Debris-like anomaly *c.* 6m long, 0.6 high off the seabed. Rock or debris. Within 5m of ss15, and may be the same feature.	Low. Dive inspection required.	
ss23	728558.2	742315.6	728556	742300	Small anomaly on sandy bed, isolated but close to ss17, ss25 possibly the same? Rock or debris.	Low. Dive inspection required.	
ss24	728315.1	742308	728319	742322	Cluster of four anomalies *c.* 1m in size each, forming squared shape in outline 11m x11m, on sandy bed. Appears to be footprint of spud barge, but 120m E of VC8	Low. Dive inspection required.	
ss25	728547	742298.8	728561	742299	Small anomaly *c.* 50cm in size casting an acoustic shadow indicating it stands 70cm off the seabed. Close to ss17, ss23. Rock or debris.	Low. Dive inspection required.	
ss26	726868.6	742350.3	726882	742350	Focus of four circular anomalies (1m in diameter) forming sub-square shape, *c.* 8x12m. Probable footprint of spud barge associatred with VC5, 30m to S. Magnetometer (ping 1868-69) did not register any anomaly.	Low. Nothing further required.	

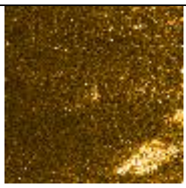
Ref	ITME + Layback	ITMN + Layback	E layback	N layback	Description	Arch. Potential & Recom	Image
ss27	726870.2	742249.3	726885	742240	Isolated anomaly *c.* 80cm in diameter on featureless sandy bed. Probable rock or debris. Outside survey area to S.	Low. Nothing further required.	
ss29	725170.1	742394.1	725169	742377	Possible anomaly indicated in the general area of the newly identified wrecksite on the intertidal foreshore.	Low-Medium. Should be considered within the context of any future intertidal work.	

Table 5: List of anomalies detected in the side-scan sonar data.
Source: IH, sonar files.

5.6 Magnetometer survey

The magnetometer is specifically designed to detect fluctuations in the background magnetic field. It can be a useful tool to chart variations in the underlying geology of an area of seabed that is revealed in large-scale and continuous shifts in the magnetic signature, measured in nanotesla (nT). It is also useful for detecting metal objects, which can be indicated as sharply-defined localized and relatively small-scale variations in the magnetic signature. Magnetometry has the advantage over sonar that it can penetrate below the seabed surface, and consequently it can detect objects and formations that are buried. However, it cannot reveal the depth of burial. In contrast to side-scan sonar, the magnetometer only acquires data from directly underneath the survey instrument; it does not have the swathe capability of sonar. Current guidelines for archaeological prospection recommend line spacing at 30m – 50m intervals.[6]

As noted in relation to the side scan sonar data, the spacing used during the GDD survey described above is suitable for detecting anomalies which could potentially comprise archaeological material and is therefore suitability robust for informing the assessment of potential impacts on marine archaeology and cultural heritage.

[6] R. Pletts, J. Dix, R. Bates, *Marine Geophysics Data Acquisition, Processing and Interpretation, Guidance Notes*. English Heritage 2013, p. 28.

The possibility for insight is achieved by sifting the data for smaller-scale fluctuations, in the order of 10-20 nT. The data is presented in a series of profile graphs that highlight the presence of such fluctuations as sharply-defined spikes and dips, which indicate the presence of a localised anomaly (Appendix 1). A total of six targets are identified (Table 6). The distribution of the magnetometer anomalies is shown on Figures 2. The anomalies are focused on the inshore section of the survey area. Of particular interest is the presence of two magnetometer anomalies very close to the charted position of the new shipwreck on the intertidal foreshore (mg4 is positioned 9m north of the wrecksite, Anomaly mg5 is positioned 18m northeast of the site). Allowing for the positional issues associated with towed survey array, the location of mg4 is considered to be a close association with the wrecksite, and indicates the presence of ferrous metal fittings with the wrecksite.

The presence of another significant anomaly 44m south of the wrecksite (mg2) highlights the further archaeological potential in this area, which is known to retain significant numbers of shipwreck sites.

There is no correspondence with magnetometer anomalies identified in the 2014 survey. The 2015 tracklines do not correspond with those of 2014, and this explains the absence of direct correspondence.

There is little direct correspondence with side-scan sonar anomalies. It is partly explained by the fact that many of the side-scan sonar anomalies were observed away from the centre of the magnetometer survey trackline, and consequently they lie outside the detectable range for the magnetometer. There are ten instances where side-scan sonar anomalies occurred directly under magnetometer survey tracklines (Table 5). There is no clear indication of magnetic anomaly in any of these cases, but there is small-scale fluctuation recorded in two cases (ss4, ss8). In the case of ss8, the side-scan sonar anomaly appears to be a record of the spud barge that was on site immediately prior to the present survey. Anomaly ss4 however is not located close to the position of the spud barge and is situated 29m north of bathymetry anomaly b1. It is not a sharp fluctuation but it serves to highlight the location as one that deserves further consideration. The fact that there is also a slight magnetic fluctuation where the bathymetric anomaly is located (mg7, b1), in the order of 5nT, is a further indication of an anomaly that warrants dive inspection to assess further the archaeological risk of the location.

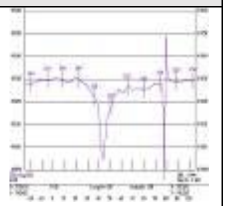
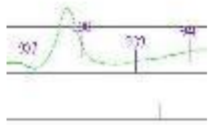
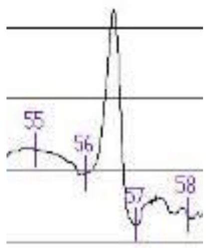
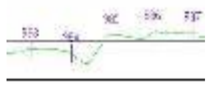
Ref	ITME	ITMN	Ping	Description	Arch. Potential & Recom	Image
mg1	725183	742361	250-251	Sharply defined dip in magnetic field, in location of new wreck site.	High. Should be considered within the context of any future intertidal work.	
mg2	725186	742308	254-255	Sharply defined magnetic anomaly.	High. Should be considered within the context of any future intertidal work.	
mg3	726453	742366	938	Small scale variation in magnetic field.	Low. Nothing further required.	
mg4	725192	742368	155	Sharply defined magnetic anomaly, in location of new wreck site.	High. Should be considered within the context of any future intertidal work.	
mg5	725228	742361	158	Small scale dip in surrounding magnetic signature.	Low. Should be considered within the context of any future intertidal work.	
mg6	725466	742342	56-57	Sharply defined localised fluctuation. Does not correspond with sonar anomaly and therefore is likely to be buried.	High. Be mindful of location during monitoring for dredging works.	
mg7	727457	742355	984-985	Small-scale localised fluctuation at location of slight ridge, b1.	Low. Dive inspection required.	

Table 6: List of anomalies detected in the magnetometer data.
Source: IH, magnetometer profiles.
Note: The vertical scale on the magnetometer graphs is at 10nT intervals.

5.7 Sub-bottom profiling

The sub-bottom profiler is designed to determine the nature of buried stratigraphy, and is of use for detecting variations in the underlying geology of seabed. It can distinguish between hard deposits such as rock and soft deposits such as clays. It can also distinguish variations within soft deposits, where sands and silts may overlie clays. From an archaeological perspective, sub-bottom profiling can discern significant cuts into the deposits, where sand or silt may fill a void in a clay deposit. The profiler can also reveal the presence of shipwreck, where the wrecksite is substantial enough to return a strong signal. Small-scale craft, such as typically-sized logboats or small skiffs, are unlikely to be identified because they lack the volume of timber and the hard-object cargo that otherwise provides the strength of signal needed to be visible in the datasets. In common with the magnetometer, the sub-bottom profiler only acquires data from directly underneath the survey instrument. Current guidelines for archaeological prospection recommend line spacing at 30m – 50m intervals.[7]

As noted in relation to the side scan sonar data, the spacing used during the GDD survey is suitable for detecting anomalies which could potentially comprise archaeological material and is therefore suitability robust for informing the assessment of potential impacts on marine archaeology and cultural heritage.

Sub-bottom profile survey in 2013 revealed a stratigraphy of sand across the survey area but was constrained by a shortfall of survey data across a 900m-wide area seaward of the LWM. The data acquired in 2015 is more comprehensive and it includes that area for which data did not exist in 2013. The results confirm the presence of sands throughout the survey area. The seaward slope is gentle and uninterrupted, and the sands occupy the upper 4m or so of seabed imaged (Plate 6). There are no hard returns or reflectors present, or other clear indications of anomalies that may be archaeological in nature. The survey did not pass directly over the new wrecksite. The closest survey lines were 3m to the east, and 8m to the north (Plate 7). In neither instance was anything indicated in the data traces. This indicates that the wreck is too small in scale to register in these data sets, as is suggested by the exposed tips of the timbers observed at Low Water.

[7] R**.** Pletts, J. Dix, R. Bates*, Marine Geophysics Data Acquisition, Processing and Interpretation, Guidance Notes*. English Heritage 2013, p. 26.

5.8 Conclusions

The marine geophysical survey conducted in 2015 has been comprehensive and thorough. The shortfalls of the 2013 survey, which included an extensive area inshore and immediately offshore of the LWM, have been covered in the 2015 survey and the data sets are robust.

The location of the new shipwreck identified by intertidal survey is highlighted in the magnetometer survey, suggesting that the wrecksite is perhaps more extensive than the visible remains indicate, and that the wreck includes ferrous metal components. However, the absence of indicators in the sub-bottom profile survey data may qualify this by indicating a relatively small-scale craft.

The bathymetry data suggests the presence of one anomaly, and while magnetometry shows a fluctuation in this location, the extent of magnetic variation is small scale and may indicate natural variation rather than the presence of something more significant. Nevertheless, it is recommended that the location be inspected by archaeological diving, to assess further the archaeological risk.

The side-scan sonar data shows what are interpreted as the footprints of the spud barge that was located on site immediately prior to the 2015 survey.

A number of small-scale side-scan sonar anomalies are also evident in the data, and these appear to be isolated rocks or pieces of debris; no one instance suggests the presence of archaeologically significant remains, but it is recommended that these locations are inspected by archaeological diving, to assess further the archaeological risk.

The sub-bottom profile data shows the presence of natural sands as the underlying stratigraphy of the upper 4m of seabed.

6.0 IMPACT ASSESSMENT

The outfall pipe trench will be tunnelled across the foreshore to a point that lies between Borehole 1 and Borehole 2. One option is to continue tunnelling the pipe seawards to its offshore terminus. A second option is to dredge the pipe trench seawards from where the tunnelled limit ends between Boreholes 1 and 2.

The excavation of boreholes represents direct impacts. Given the high archaeological potential of Velvet Strand, such site investigations work will require archaeological monitoring.

Tunnelling is unlikely to create extensive impact on the surface levels of the foreshore and may therefore have a reduced impact from an archaeological perspective, but the risings could reveal material of interest and these should be inspected.

Dredging of the pipe trench will create high impact along the pipe trench route, extending out to the sides of the way leave. All such ground disturbance activities have the potential to reveal new archaeological material and will require archaeological monitoring.

The newly discovered shipwreck on the intertidal foreshore is a site that lies within the impact area. The marine geophysical survey suggests that the visible extent of the site at Low Water does not provide the full extent of the vessel, and that the craft is bigger. If it is not possible to avoid impacts with this site, it will need to be archaeologically resolved in advance of site works commencing.

7.0 MITIGATION PROPOSALS

7.1 Project Specific Measures

AVOIDANCE. It is recommended that the site of the new wreck is avoided during site investigations and construction. To ensure avoidance, it may be necessary to erect a temporary barrier around the site, to protect it from inadvertent impacts. Such a barrier, if required by the DAHG, must be placed at least 5m distance from the exposed elements, to form a protective curtilage around the site.

EXCAVATION. If avoidance is not possible, it will be necessary to excavate fully the new wrecksite prior to the construction of the outfall, to preserve the site by record. Excavation would be carried out as an intertidal exercise under license from the Department of Arts, Heritage and Gaeltacht (DAHG), and would be done by a specialist team of maritime archaeologists. The footprint for consideration should extend to include the indications of outlying elements provided by anomalies ss29, mg1 and mg4.

DIVE INSPECTION. There are no clearly defined archaeologically significant anomalies detected in the marine geophysical data acquired in the subtidal zone. It is however appropriate to conduct dive inspection of the anomalies that lie within the development footprint that are not clearly relict features associated with the presence of the spud barge on site, to further inform their archaeological risk in advance of dredging commencing. The locations considered for diving are presented in Table 7.

Such work would be completed under license from DAHG and would be done by a specialist dive team of maritime archaeologists.

Dive Location	Anomalies	Aims
1	ss4, b1/mg7	To assess nature of linear anomaly in sand and potential for outlying metallic debris by extending to include ss4.
2	ss11, ss12, ss24	Assess nature of sonar anomaly complex.
3	ss15, ss22	Assess nature of sonar anomaly complex.
4	ss16	Assess nature of sonar anomaly, which appears to be expanse of cobbles. Work should focus on looking for debris trapped amongst cobbling.
5	ss17, ss23, ss25	Assess nature of sonar anomaly complex.
6	ss18	Assess nature of sonar anomaly.

Table 7: List of locations recommended for archaeological dive inspection to assess further the archaeological risk.

MONITORING. Ground disturbance activities associated with site investigations works and construction phase works on land and at sea will be archaeologically monitored under licence from the DAHG, with the proviso to resolve fully any archaeological material that occurs during such works.

7.2 Project Management Measures

All archaeological site work will be licensed by the DAHG. Licence applications (Detection Device, Dive Survey, and Excavation) take a minimum of three working weeks to be processed, and sufficient lead time is required to ensure that such permits are in place before construction works commence.

THE TIME SCALE for the pre-construction and construction phases should be made available to the archaeologist, with information on where and when the various elements and ground disturbances and dredging will take place.

SUFFICIENT NOTICE. It is essential for the developer to give sufficient notice to the archaeologist/s in advance of the pre-construction and construction works commencing. This will allow for prompt arrival on site to undertake additional surveys and to monitor ground disturbances. As often happens, intervals may occur during the construction phase. In this case, it is also necessary to inform the archaeologist/s as to when ground disturbance works will recommence.

DISCOVERY OF ARCHAEOLOGICAL MATERIAL. In the event of archaeological features or material being uncovered during the construction phase, it is crucial that any machine work cease in the immediate area to allow the archaeologist/s to inspect any such material.

ARCHAEOLOGICAL MATERIAL. Once the presence of archaeologically significant material is established, full archaeological recording of such material is recommended. If it is not possible for the construction works to avoid the material, full excavation would be recommended. The extent and duration of excavation would be a matter for discussion between the client and the licensing authorities.

ARCHAEOLOGICAL TEAM. It is recommended that the core of a suitable archaeological team be on standby to deal with any such rescue excavation. This would be complimented in the event of a full excavation. Excavation work of marine sites must be done by archaeologists specialized in Marine and Underwater Archaeology. The archaeological team for marine works must include an archaeological dive team working within current Health and Safety regulations for Safety at Work, and specifically *Safety in Industry (Diving Operations) Regulations, 1981: SI 422 of* 1981, and 2010 *SI (Draft)*, *HSA Diving Standards 2010*.

SECURE SITE OFFICES and facilities should be provided on or near those sites where excavation is required.

SECURE WET AND DRY STORAGE for artefacts recovered during the course of the monitoring and related work should be provided on or near those sites where excavation is required.

BUOYING of any such areas would be necessary once discovered and during excavation.

ADEQUATE FUNDS to cover excavation, post-excavation analysis, reporting and any testing or conservation work required should be made available.

MACHINERY TRAFFIC during construction must be restricted as to avoid any of the selected sites and their environs.

SPOIL should not be dumped on any of the selected sites or their environs.

PLEASE NOTE: All of the above observations and conclusions are based on the archaeological information and information supplied for the GDD scheme. Should any alteration occur, further assessment would be required.

PLEASE NOTE: Recommendations are subject to approval by the National Monuments Service of the Department of Arts, Heritage and the Gaeltacht.

8.0 APPENDIX 1: GREATER DUBLIN DRAINAGE MARINE OUTFALL. ARCHAEO-GEO SURVEY REPORT. IRISH HYDRODATA LTD.

Greater Dublin Drainage

Marine Outfall

Archaeo-Geo Survey

Report

Prepared by:	***Presented to:***
IRISH HYDRODATA Ltd. Rathmacullig West, Ballygarvan, Co. Cork. *P: 353-21-4311255* *F:353-21-4311740* *E:Admin@hydrodata.ie*	**ADCO** Castlecomer, Co Kilkenny. ADCO

September 18th 2015

Contents

1.0 INTRODUCTION

As part of the Greater Dublin Drainage (GDD) project, it is proposed to construct a marine outfall in the area offshore of Velvet Strand, Portmarnock, Co. Dublin (Fig. 1.1). The planning process requires that an archaeological assessment be carried out.

The Archaeological Diving Company Ltd (ADCO) of Castlecomer, Co. Kilkenny was contracted to carry out this assessment. Irish Hydrodata Ltd. (IHD) was sub-contracted by ADCO to acquire the necessary marine survey data to enable ADCO carry out the archaeological interpretation.

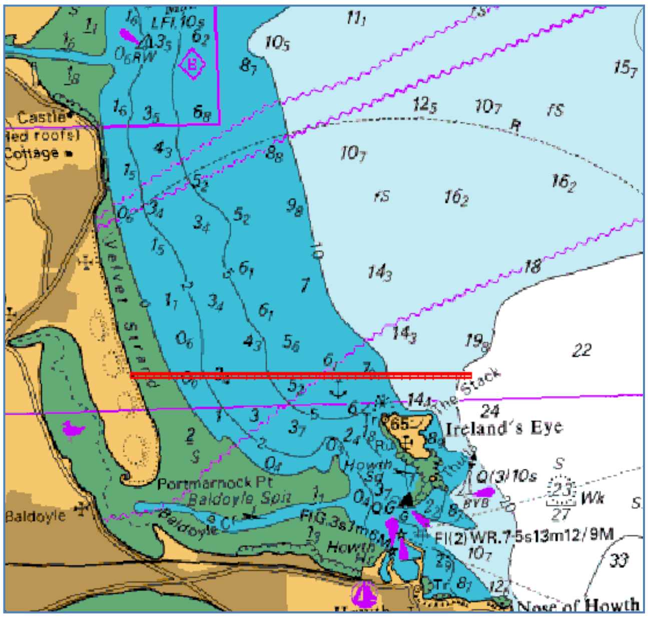


Fig. 1.1 Survey Area

The survey followed guidelines set out by the Department of Arts, Heritage and the Gaeltacht (DAHG) and included sidescan sonar, magnetometer, sub-bottom profiling and singlebeam bathymetry.

This report describes the survey and the data acquired. The interpretation of the data from an archaeological perspective was carried out by ADCO and is contained in a separate report.

In accordance with the *Code of Practice for the Protection of Marine Mammals during Acoustic Seafloor Surveys in Irish Waters (2014)* issued by DAHG, a qualified Marine Mammal Observer (MMO) was present before and during the sub-bottom profiling and sidescan sonar elements of the work. The MMO's function is to ensure that the area is clear of marine mammals at the time of the survey. On completion of the survey, a report was produced and is contained under separate cover. A copy of the report was sent to DAHG by the MMO.

2.0 SURVEY AREA

2.1 Survey Constraints

The main purpose of this study was to provide survey data that would satisfy archaeological assessment to DAHG specifications.

Weather plays a major part in the quality of the survey data. Generally, the calmer the weather conditions, the better the data quality. Thus, survey operations were planned to coincide with a relatively good weather window.

The intertidal area was surveyed at around HW to ensure that the complete survey area corridor was covered.

2.2 Survey Corridor

The survey area is a roughly rectangular corridor of approximately 90m x 4500m (Fig. 2.1). The survey corridor co-ordinates were supplied by the client on Irish National Grid and were converted to Irish Transverse Mercator using 'GridInquest' software. They are listed in Table 2.1

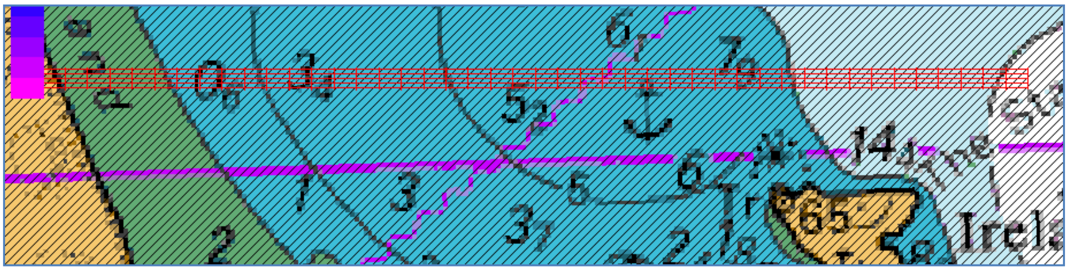


Fig. 2.1 Survey Corridor & Proposed Survey Lines

Point ID	ING East	ING North	ITM East	ITM North
1	325068.31	242288.65	724992.06	742313.09
2	325068.31	242378.96	724992.06	742403.39
3	329625.51	242247.59	729548.29	742272.01
4	329627.07	242341.23	729549.85	742365.64

Table 2.1 Survey Corridor co-ordinates

3.0 SURVEY WORKS PROGRAMME

Mobilisation to site was on August 24th 2015. The completed works programme is summarised in Table 3.1 below and described in more detail in the following paragraphs.

Date	Item
Aug. 24th 2015 Weather good	Mobilised to site. Fitted out survey vessel at Howth Harbour and tested the survey equipment. Completed bathymetric and sidescan sonar surveys
Aug. 24th 2015 Weather good at beginning but deteriorated	Commenced sub-bottom (Pinger) & magnetometer surveys at 08:00hrs Abandoned at 13:00hrs due to deterioration in weather conditions
Aug. 25th 2015 Weather good	Completed sub-bottom & magnetometer surveys. Demobbed vessel & survey equipment.
Aug. 26th to Sept. 2nd 2015	Preliminary data processing Draft deliverables supplied to ADCO

Table 3.1 Works Programme

<u>August 24th 2015</u>

Mobilisation to site was completed early on August 24th. On arrival, IHD liaised with the harbour master and harbour constable at Howth. The survey boat was launched in Howth Harbour and fitted out for bathymetric and sidescan sonar surveys. The equipment was tested over a period of about two hours. The weather was good for survey (wind westerly F2, with little or no waves) and bathymetric and sidescan surveys commenced at approx. 1400hrs. They were completed at approximately 1930hrs. MMO was on watch at all times. Sidescan sonar equipment was de-mobbed from vessel at Howth Harbour.

<u>August 25th 2015</u>

Sub-bottom and magnetometer equipment was fitted to survey vessel and tested. Survey commenced at 0800hrs when winds were light from SE with low swell. This good weather pertained for a number of hours and the intertidal part of the survey area was surveyed successfully. However, winds increased rather quickly to about F5 from the SE leading to a >1m swell which made the survey area unworkable. Survey was abandoned at approx. 13:00hrs and the survey boat returned to Howth Harbour. MMO was on watch at all times.

<u>August 26th 2015</u>

Strong winds prevented an early start to survey. At about noon, the weather had improved significantly and the MMO's watch began. Winds were now approximately F3 from the SW with waves of about 0.5m, allowing the survey to commence at about 13:00hrs. Survey was completed at approximately 16:45hrs and the survey boat returned to Howth Harbour. MMO was on watch at all times. The boat was demobbed and taken out of the water at the slipway at Howth Harbour.

4.0 PROJECT PERSONNEL

The project manager was Mr. Jim Walshe. BE, M.Eng.Sc, CEng, who has over 28-years' experience in the industry. Mr. Walshe has been involved in hundreds of surveys and in the production of the associated survey reports. He had complete involvement in the field work and reporting for this project.

Offline data processing and preliminary analysis was the responsibility of Mr. Tom Bruton BE, M.Eng.Sc., who has 27-years' experience in the industry. Mr. Bruton has been involved in hundreds of surveys and in the production of the associated survey reports. He had complete involvement in the field work and reporting for this project.

The marine mammal observer (MMO) was Ms. Margaret Haberlin B.Sc. (Zoology and Marine Ecology), who independently compiled a report of her findings.

5.0 SURVEY EQUIPMENT

5.1 Survey Vessel

IHD's own survey vessel 'Blue Fin' was used for the work. The vessel is a 21' launch with cabin and is fully equipped with safety equipment including in-hull echosounder transducers (Fig. 5.1). It holds a current Dept. of Transport P4 License for survey works and is ideal for shallow water work. The vessel was towed to the site and launched at a slipway in Howth harbour. The vessel operated out of Howth harbour.

Fig. 5.1 IHD Survey Vessel 'Blue Fin''

5.2 Horizontal Positioning

Positioning of the survey vessel was achieved using Trimble Ag132 DGPS (Fig. 5.2) with OMNISTAR corrections. This provided sub-meter horizontal accuracies. Positioning was on Irish Transverse Mercator (ITM). Equipment details are provided in Appendix A.

Fig. 5.2 Trimble Ag132 DGPS

5.3 Vertical Control/Tide Measurement

A Hobo water level recorder was deployed in Howth Harbour for the duration of the field works. The tide data was reduced to datum (Chart Datum) based on a series of manual observations taken at a TBM during the course of the works. The data was used for reduction of the bathymetric data to datum. The instrument was set to record at 10-minute intervals.

5.4 Bathymetric Survey

A Knudsen 320M simultaneous dual frequency (33kHz, 210kHz) precision survey echosounder (Fig. 5.3) was used to acquire the depth information. Speed of sound in water was measured using an Odom Hydrographics Inc. 'Digibar'. The survey was managed using the latest version of the hydrographic survey software package '*Hypack*'.

Fig. 5.3 Knudsen 320M Echosounder

5.5 Sidescan Sonar Survey

An L^3-Klein System 3000 (Fig. 5.4) simultaneous dual frequency digital sidescan sonar system was employed for the survey. The operating frequencies are 100kHz and 500kHz simultaneously, thereby providing a greater possibility of detecting objects and providing a clear image of the seabed. Data from both frequencies was logged digitally using 'SonarPro' software, for post-processing by ADCO. Data was logged in both SDF and XTF formats. The L^3-Klein System 3000 is described in detail in Appendix A.

Fig. 5.4 L^3-Klein System 3000 Towfish

5.6 Magnetometer Survey

A Geometrics G882 marine magnetometer (Fig. 5.5) was employed for this aspect of the survey. It is an extremely high resolution Caesium vapour, small size, system for professional surveys. The G882 is focused for operation in small boat, shallow water surveys. Data was logged in ASCII format for post-processing by ADCO. Equipment data sheets are provided in Appendix A.

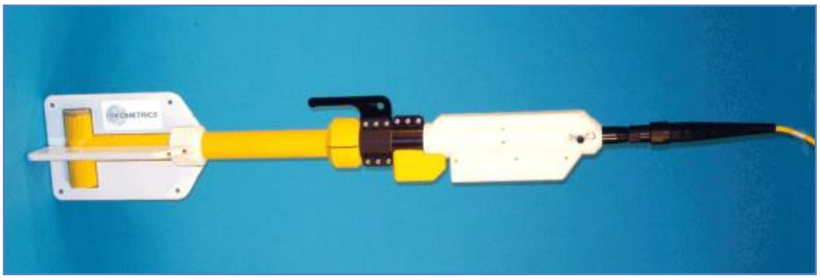


Fig. 5.5   Geometrics G882 Marine Magnetometer

5.7 Sub-bottom Profiling Survey

A Knudsen ‘chirp’ sub-bottom profiling system (Fig 5.6) was used to acquire sub-bottom data. This instrument has 15kHz and 3.5kHz bottom transmit arrays. Data was recorded in SEG-Y format for post-processing by ADCO. Equipment data sheets are provided in Appendix A.

Fig. 5.6   Knudsen Pinger (Chirp) – Wet-End and Top-side units (L to R)

6.0 SURVEY RESULTS

6.1 Bathymetric Survey

Method

The bathymetric survey was carried out on August 24th 2015. Survey lines were run at 20m line spacing parallel to the proposed pipeline route. Survey lines were also run at 100m line spacing perpendicular to the proposed centreline. Data was acquired at a rate of about one depth every 0.3m along the survey lines.

Results

The bathymetry was reduced to Chart Datum at Howth and a bathymetric chart prepared. The chart consists of 4no. drawing sheets which plot at 1:000 on A1-sized media. Reduced-scale versions of the drawings are shown in Figs. 6.1a-d.

Deliverables to ADCO

An AutoCAD drawing of the bathymetric chart was provided to ADCO.

6.2 Sidescan Sonar Survey

Method

The sidescan sonar survey was carried out simultaneously with the bathymetric survey on August 24th. Survey lines were steamed at 20m line spacing parallel to the proposed pipeline route. Survey lines were also run at 100m line spacing perpendicular to the proposed centreline. The shallow water regions were surveyed at high water to maximise the coverage within the survey area. The sidescan towfish was towed off the aft quarter at laybacks of up to 15m. The layback distance and times were noted for use in post-processing. The sidescan range was set to 100m, 50m or 37.5m port and starboard to ensure better than 100% overlap and good data beneath the towfish. Data from the 100kHz and 500kHz frequencies were logged simultaneously.

Results

Preliminary post-processing of the data was achieved using ‘SonarPro’ software. A jack-up rig had been coring at a number of locations along the proposed centreline during the days before the sidescan sonar survey. The marks from the jack-up legs along with drag marks were evident on the sidescan sonar records. An example of this is presented in Fig. 6.2.

Deliverables to ADCO

The original sidescan data without slant-range correction was provided for review by ADCO to assess the archaeological potential. The digital was provided in both XTF and SDF formats. The survey position data are embedded in the sidescan data files allowing targets to be located. Layback positions and times were provided and must be applied in post-processing.

6.3 Magnetometer Survey

Method

The magnetometer survey was carried out simultaneously with the sub-bottom survey and over the same planned survey lines. Thus, the survey lines were steamed at 20m line spacing parallel to, and at 100m line spacing perpendicular to, the proposed centreline. The magnetometer towfish was towed off the aft quarter at a layback of 20m. Data was logged to hard disk using 'Hypack' hydrographic survey software. The survey was carried out on the morning of August 25th and the afternoon of August 26th.

Results

Preliminary post-processing of the data was achieved using 'Hypack' software. Magnetic signature profiles with survey event marks were plotted. Examples of a magnetic signature indicating a potential magnetic target are presented in Fig. 6.3a-b.

A survey trackplot with corresponding event marks was also provided. This enables any potential target to be located in plan. The layback has been accounted for in the survey trackplot. The survey trackplot drawing consists of 4no. drawing sheets which plot at 1:000 on A1-sized media. Reduced-scale versions of the trackplot drawing sheets are shown in Figs. 6.4a-d. Fig. 6.5 shows a reduced-scale version of the magnetic profiles along the longitudinal survey lines, while Fig. 6.6 shows the magnetic profiles along the short cross-lines.

Deliverables to ADCO

The magnetometer profile data with associated trackplot were provided in AutoCAD format to ADCO for archaeological assessment.

6.4 Sub-bottom Profiling Survey

Method

The sub-bottom (Knudsen pinger) survey was carried out simultaneously with the magnetometer survey and over the same planned survey lines. Thus, the survey lines were steamed at 20m line spacing parallel to, and at 100m line spacing perpendicular to, the proposed centreline. The pinger transducer was attached to a pole on an over-the-side mount. Data was logged to hard disk in SEG-Y and Knudsen proprietary formats using 'Knudsen Echo-Control' software. The survey was carried out on the morning of August 25th and the afternoon of August 26th.

Results

Preliminary post-processing of the data was achieved using 'Knudsen Post-Survey' software. An example of the sub-bottom data is shown in Fig. 6.7. A survey trackplot was also produced. This is the same as for the magnetometer survey (Fig. 6.4a-d).

Deliverables to ADCO

The original sub-bottom data was provided for review by ADCO to assess the archaeological potential. This was provided in SEG-Y format. The survey position data are embedded in the sub-bottom data files allowing targets to be located. A survey trackplot was also provided in AutoCAD format.

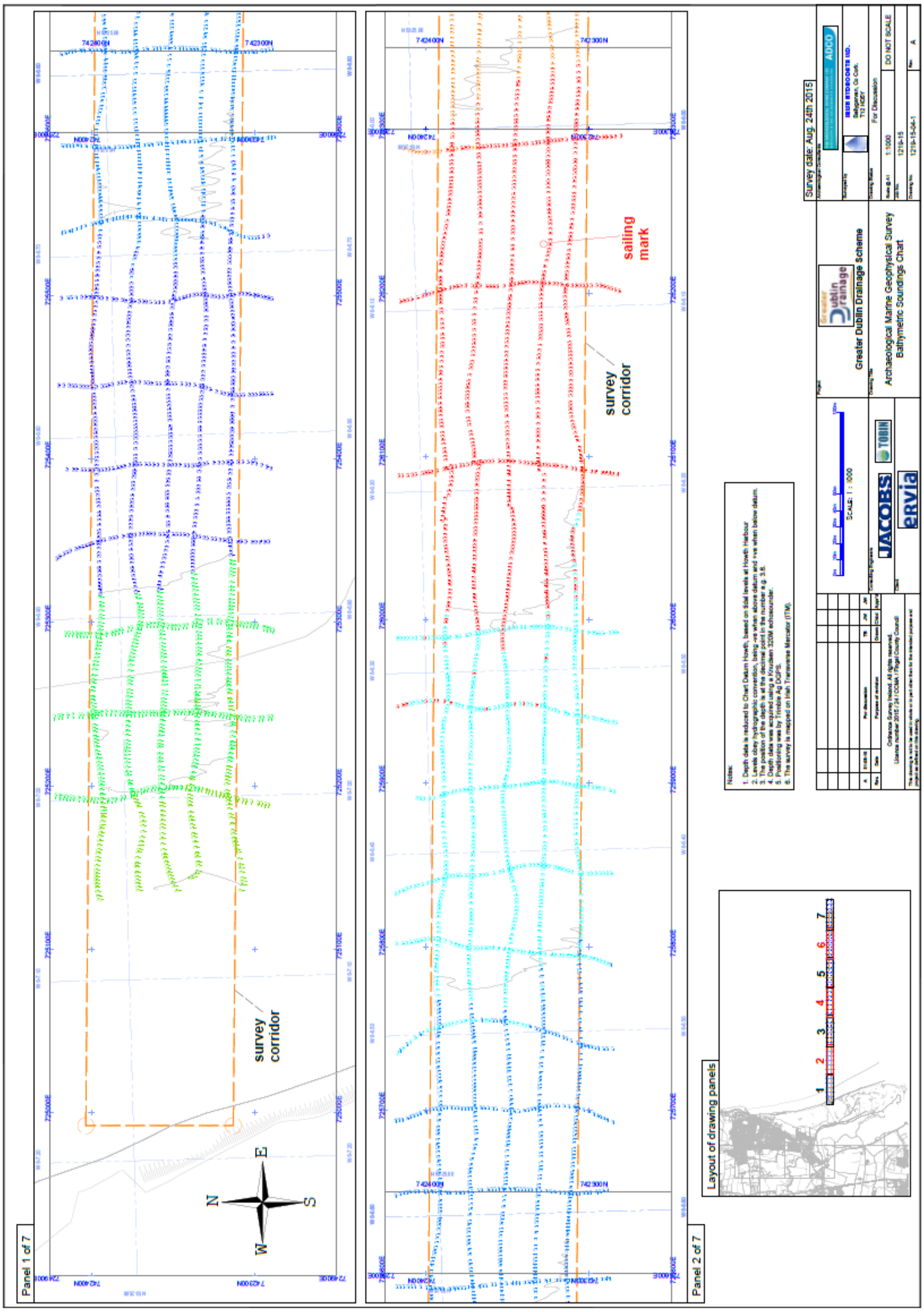


Fig. 6.1a   Bathymetric Chart – Sheet 1 of 4

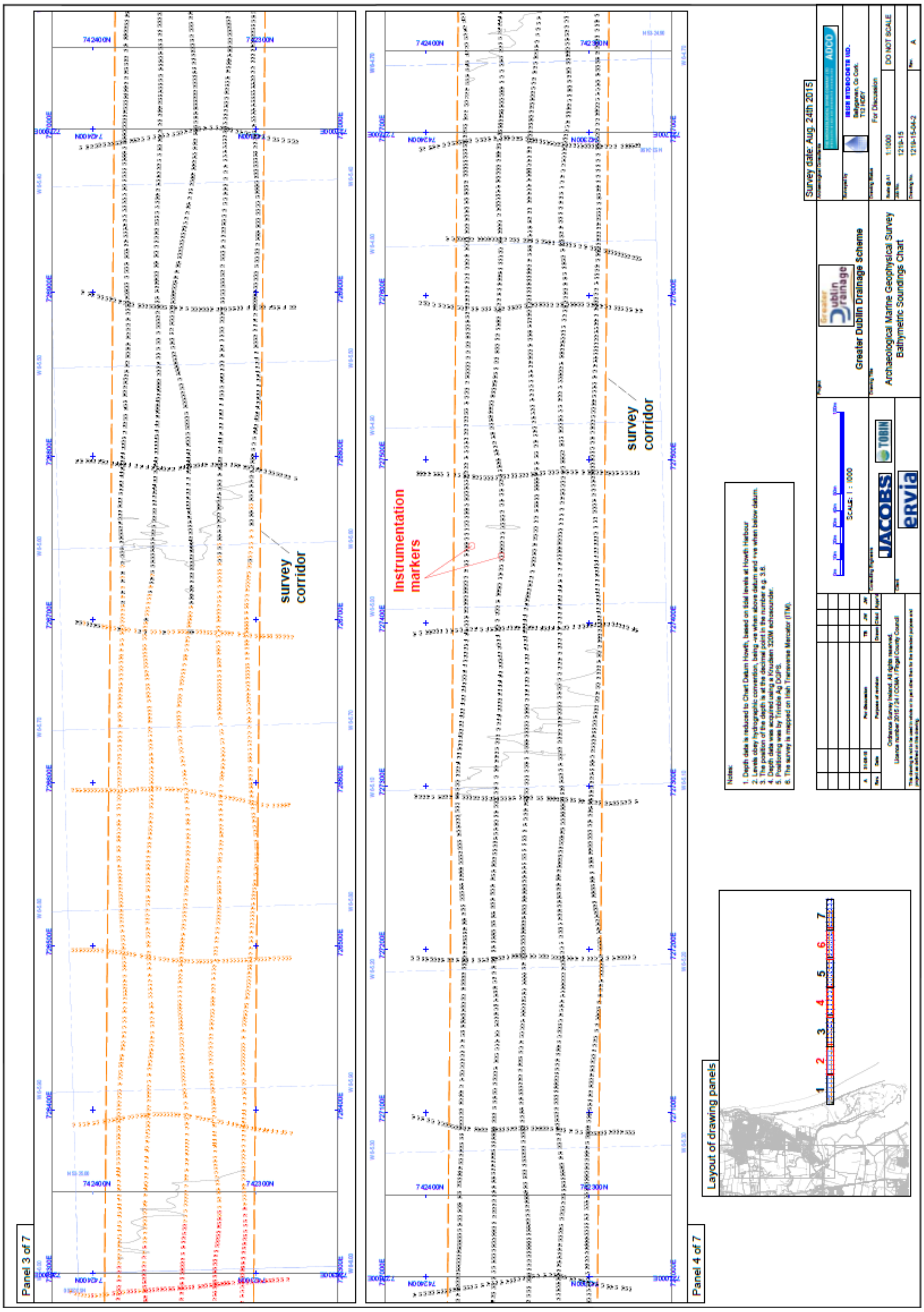


Fig. 6.1b   Bathymetric Chart – Sheet 2 of 4

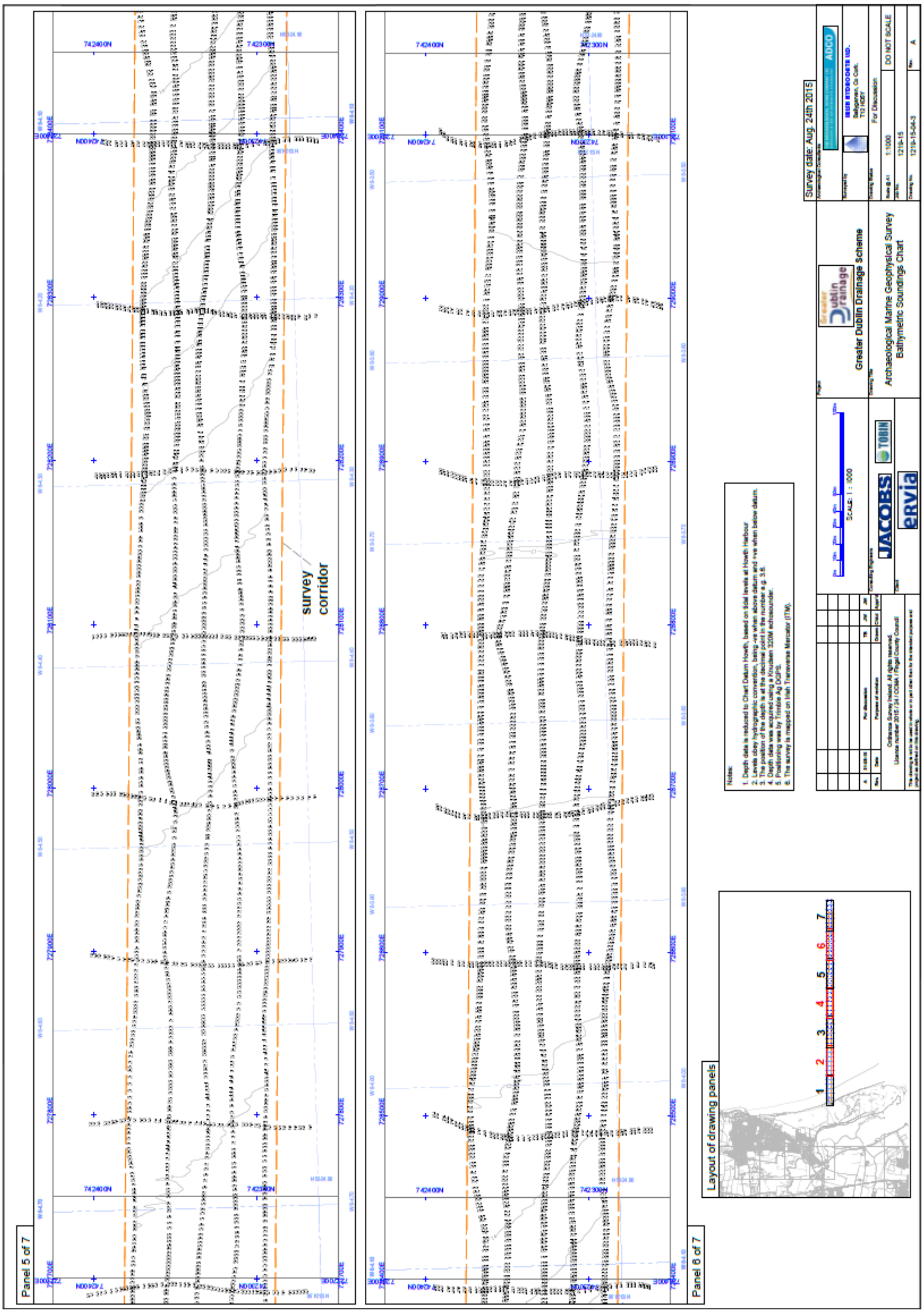


Fig. 6.1c   Bathymetric Chart – Sheet 3 of 4

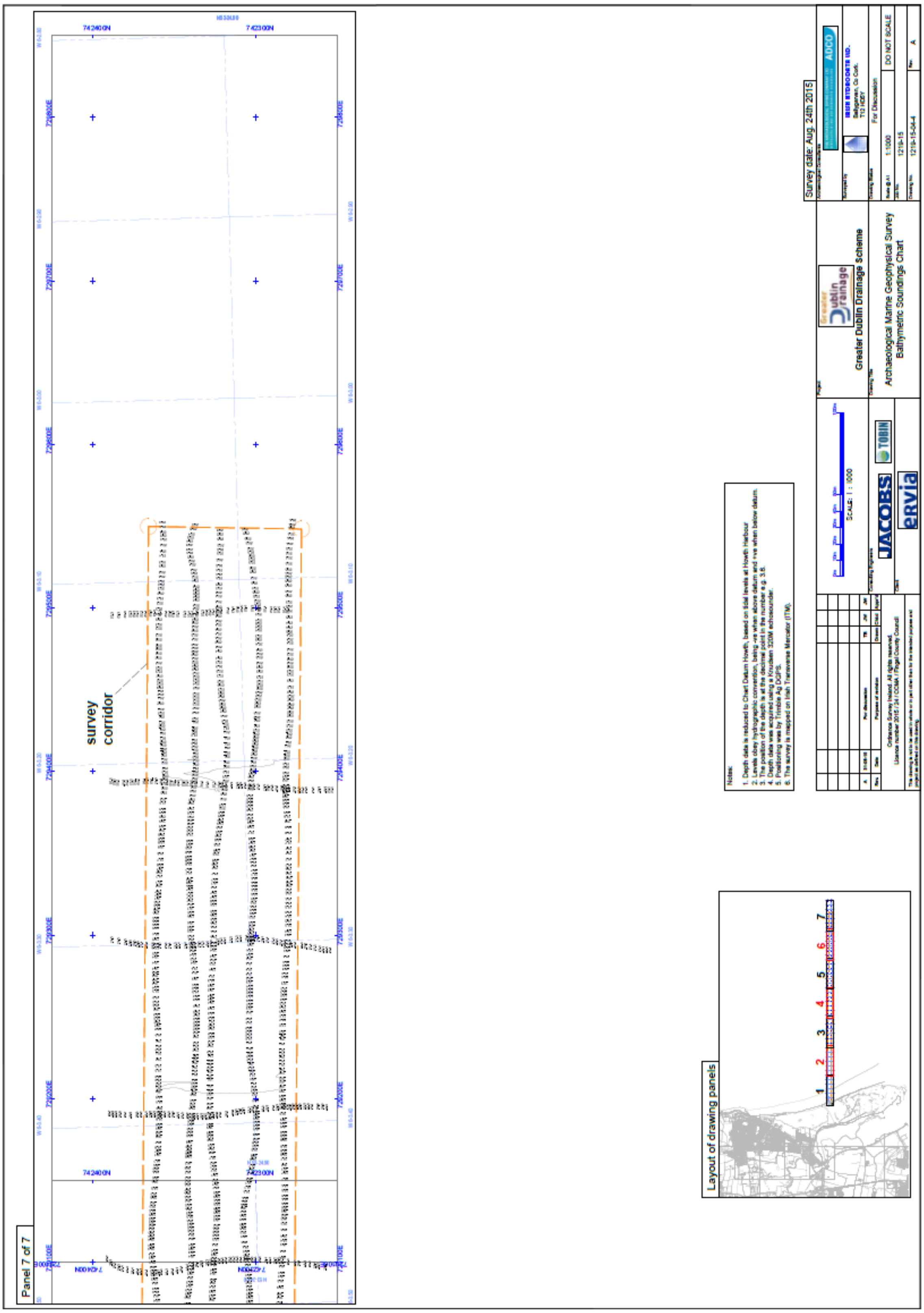


Fig. 6.1d Bathymetric Chart – Sheet 4 of 4

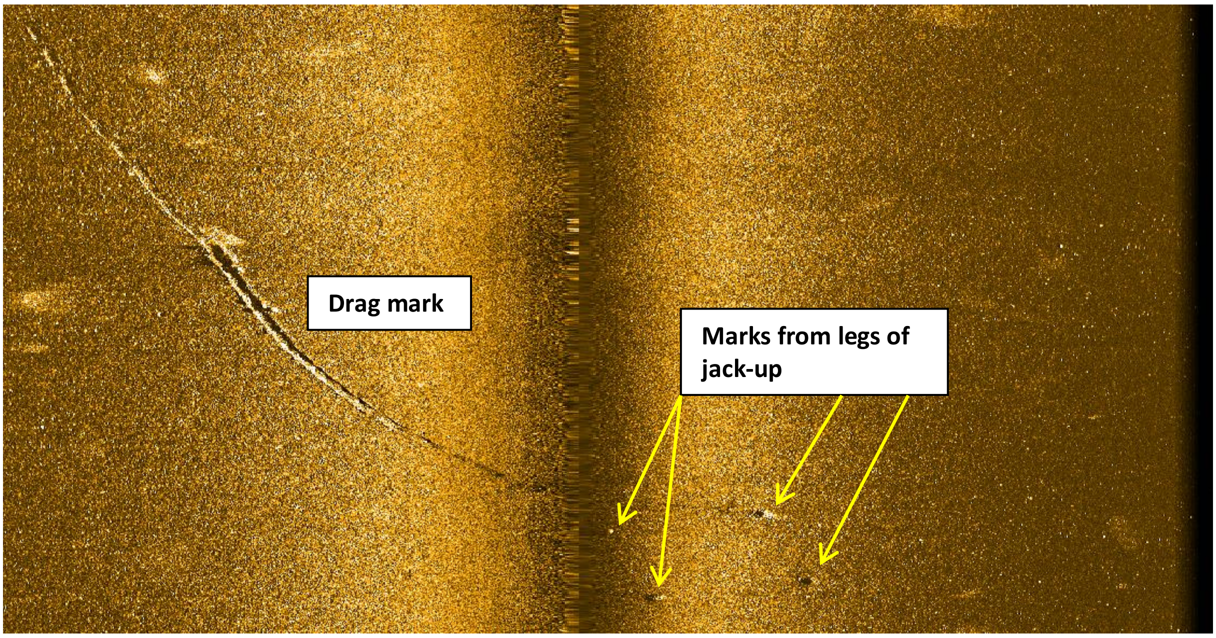


Fig. 6.2 Sidescan sonar record - Example

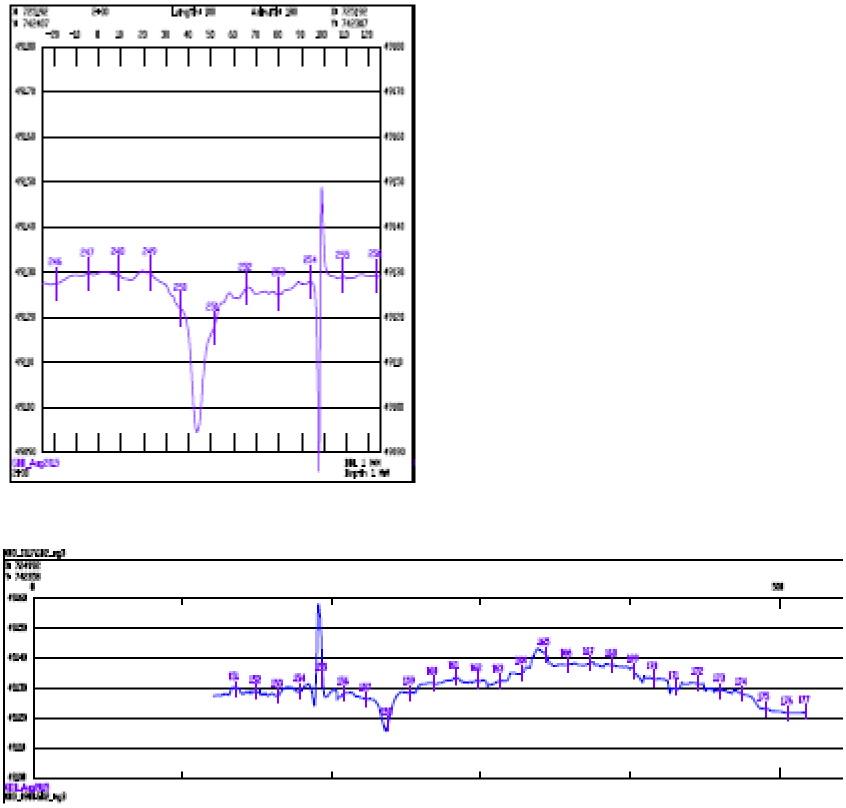


Fig. 6.3a-b Examples of magnetic target signatures

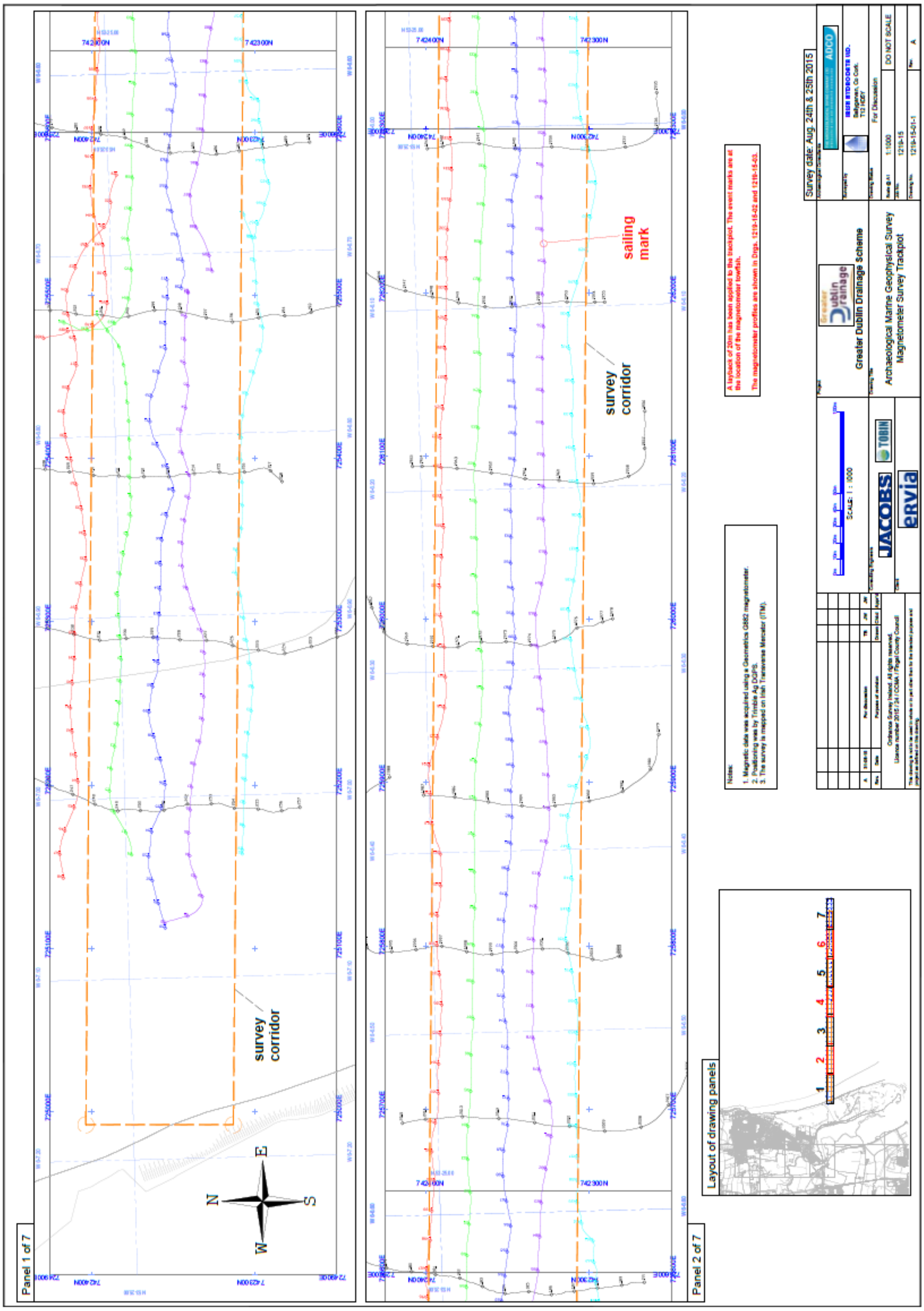


Fig. 6.4a Magnetometer and sub-bottom survey trackplot – Sheet 1 of 4

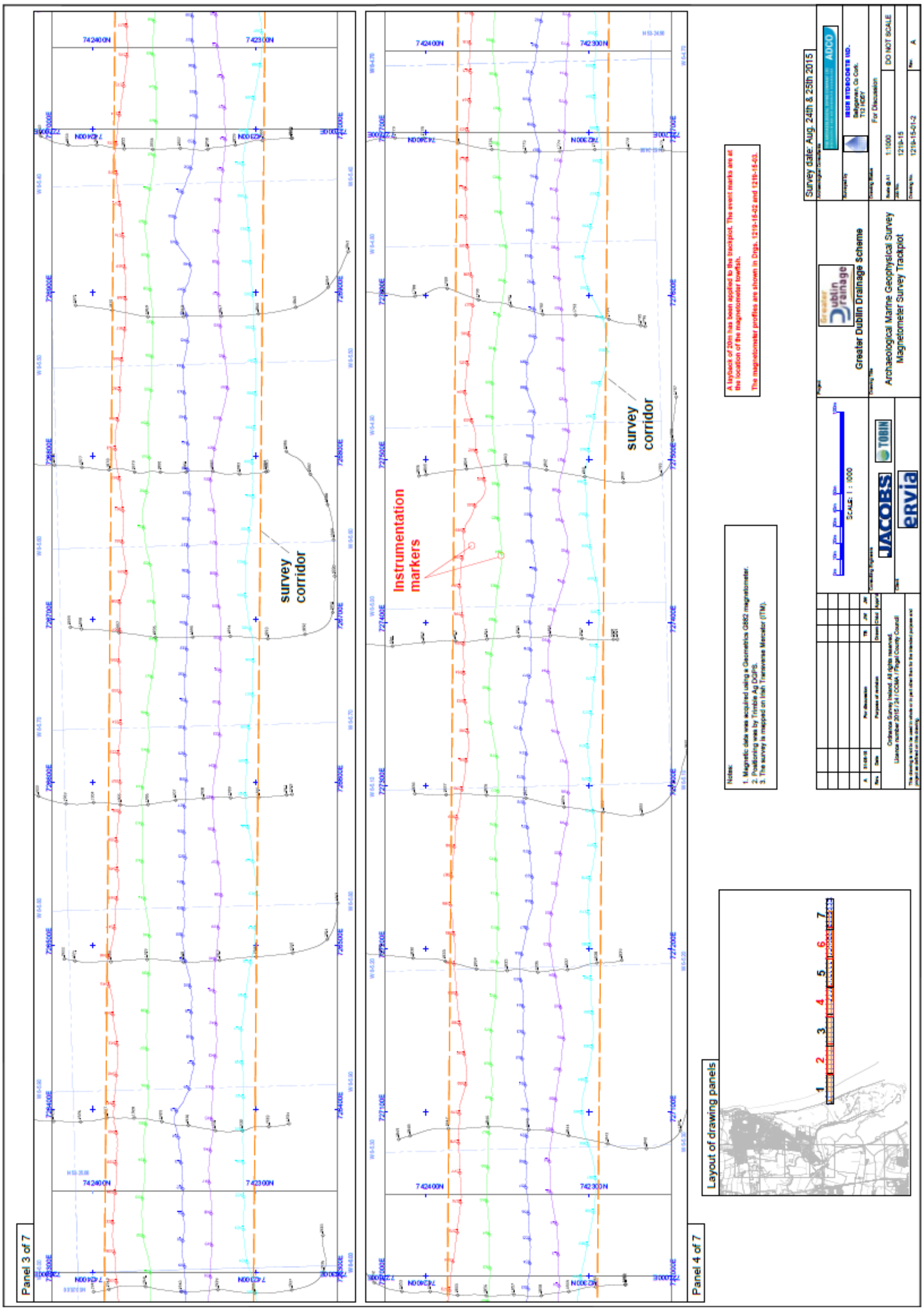


Fig. 6.4b Magnetometer and sub-bottom survey trackplot – Sheet 2 of 4

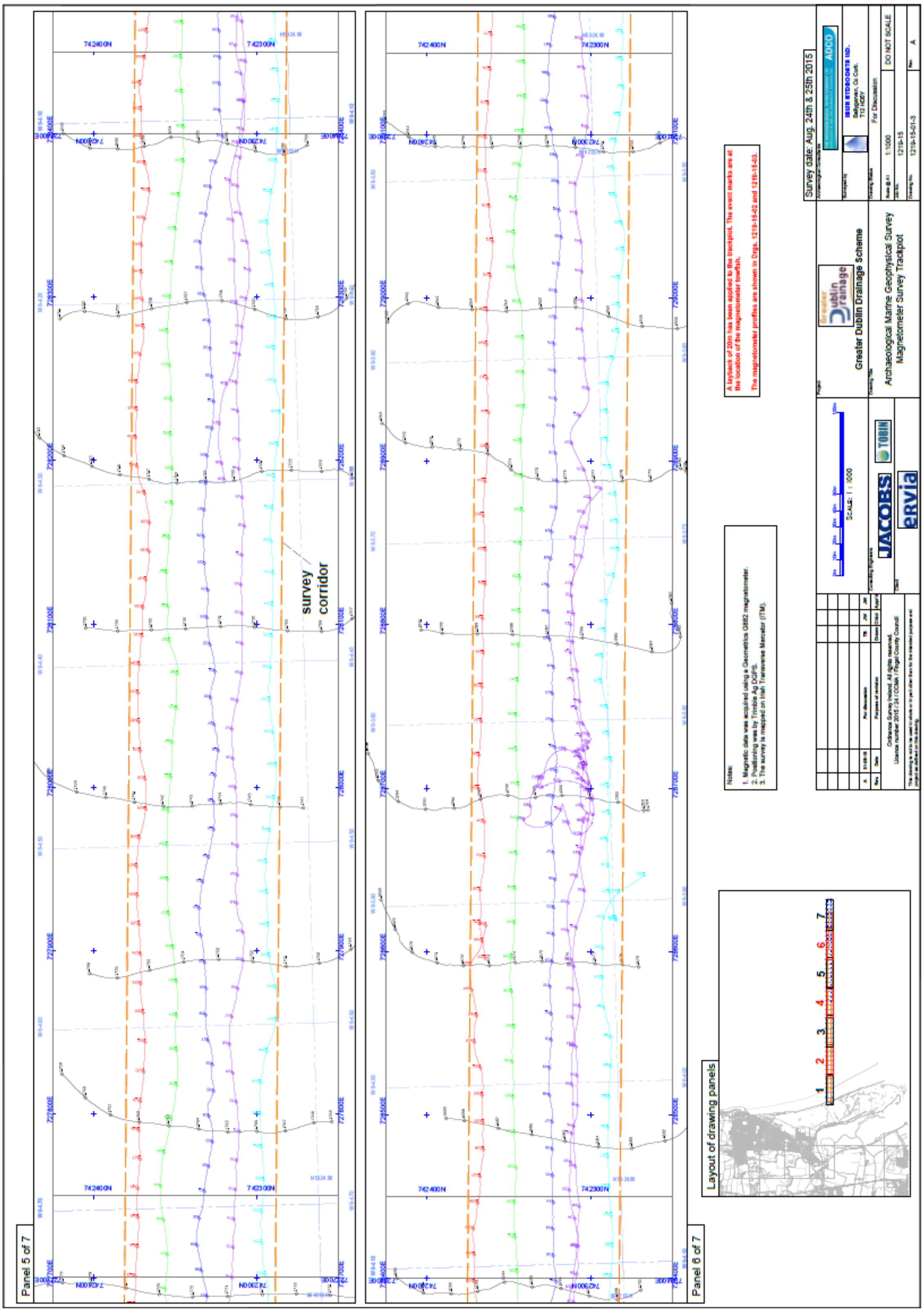


Fig. 6.4c Magnetometer and sub-bottom survey trackplot – Sheet 3 of 4

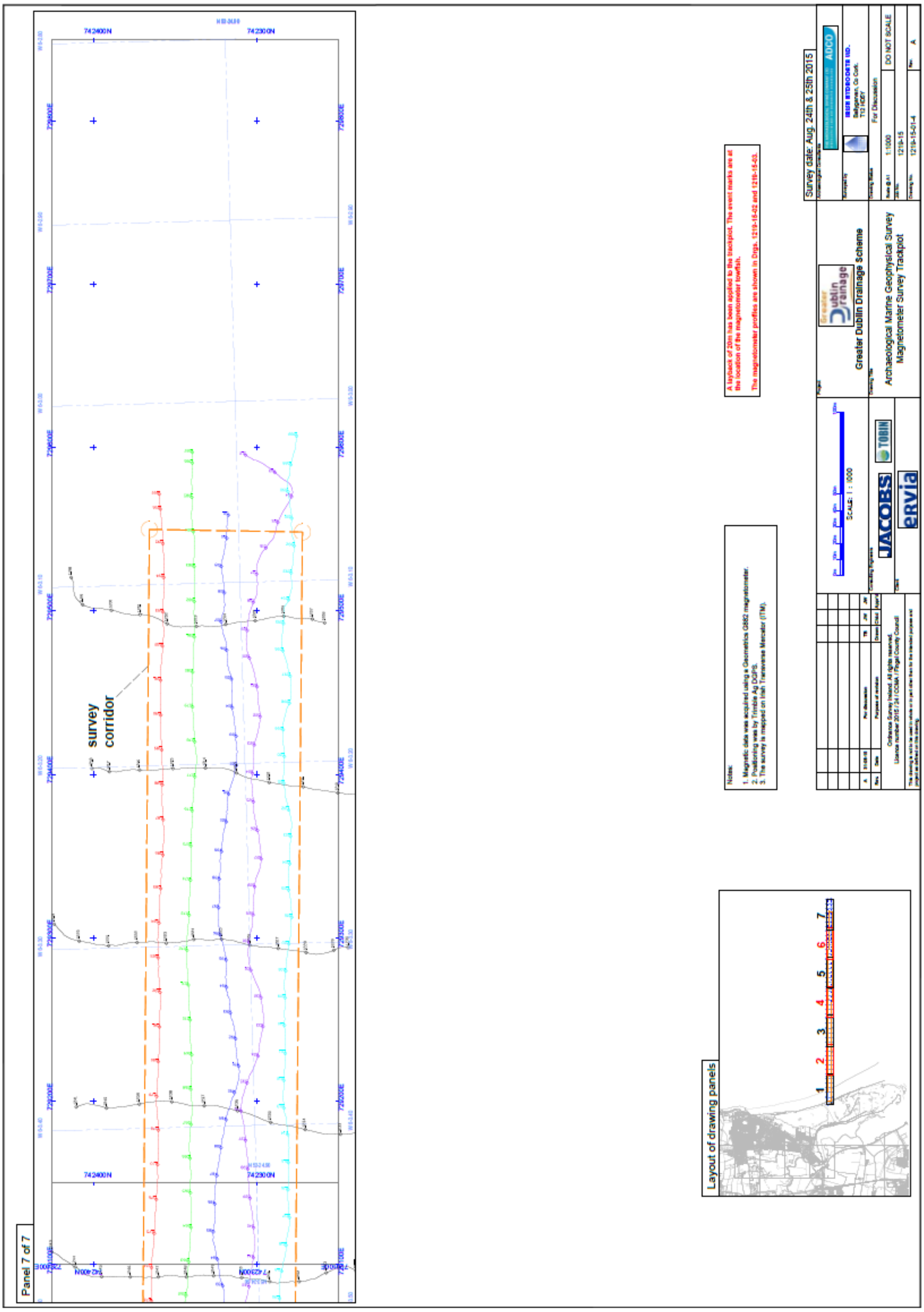


Fig. 6.4d Magnetometer and sub-bottom survey trackplot – Sheet 4 of 4

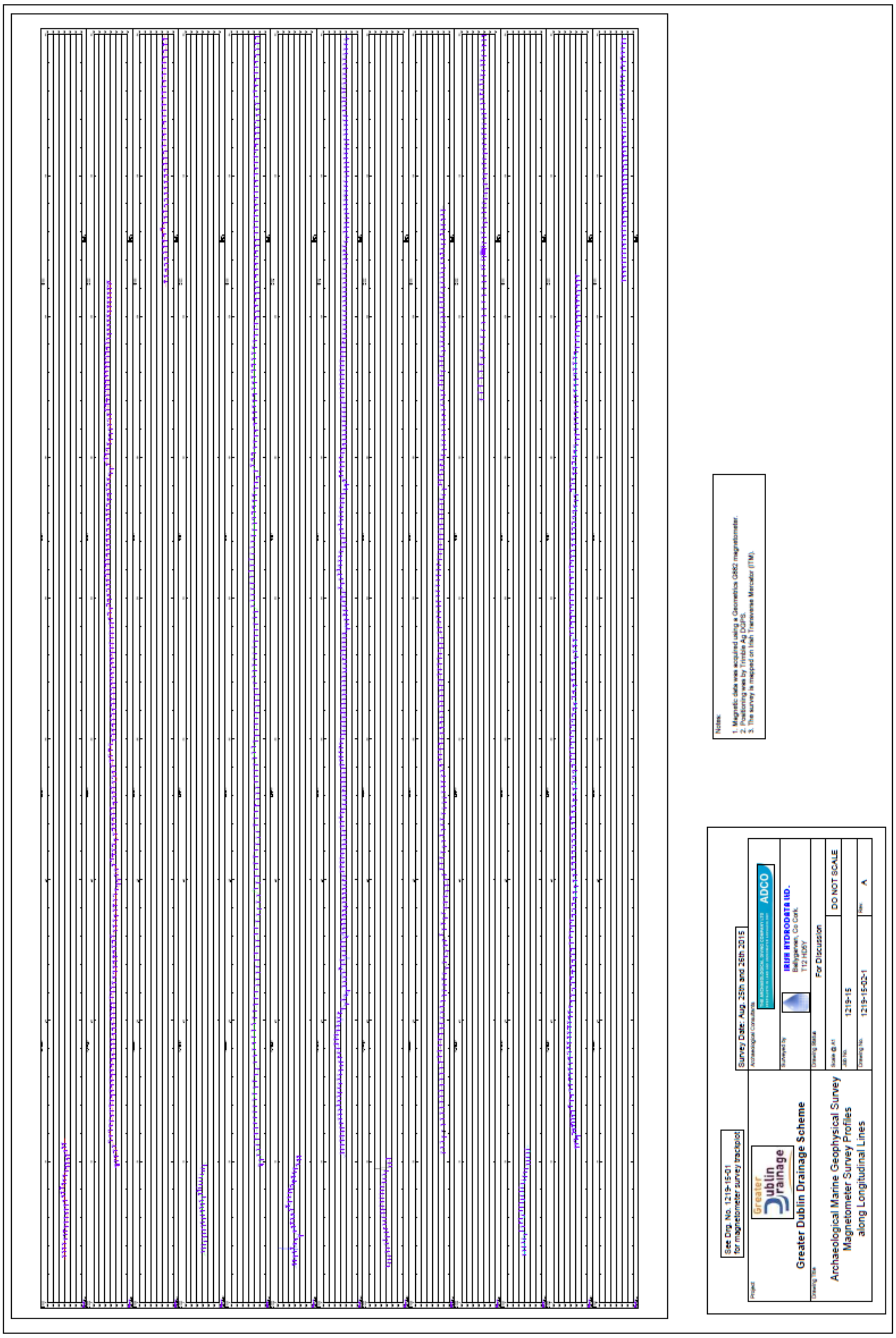


Fig. 6.5   Magnetometer profiles along longitudinal lines

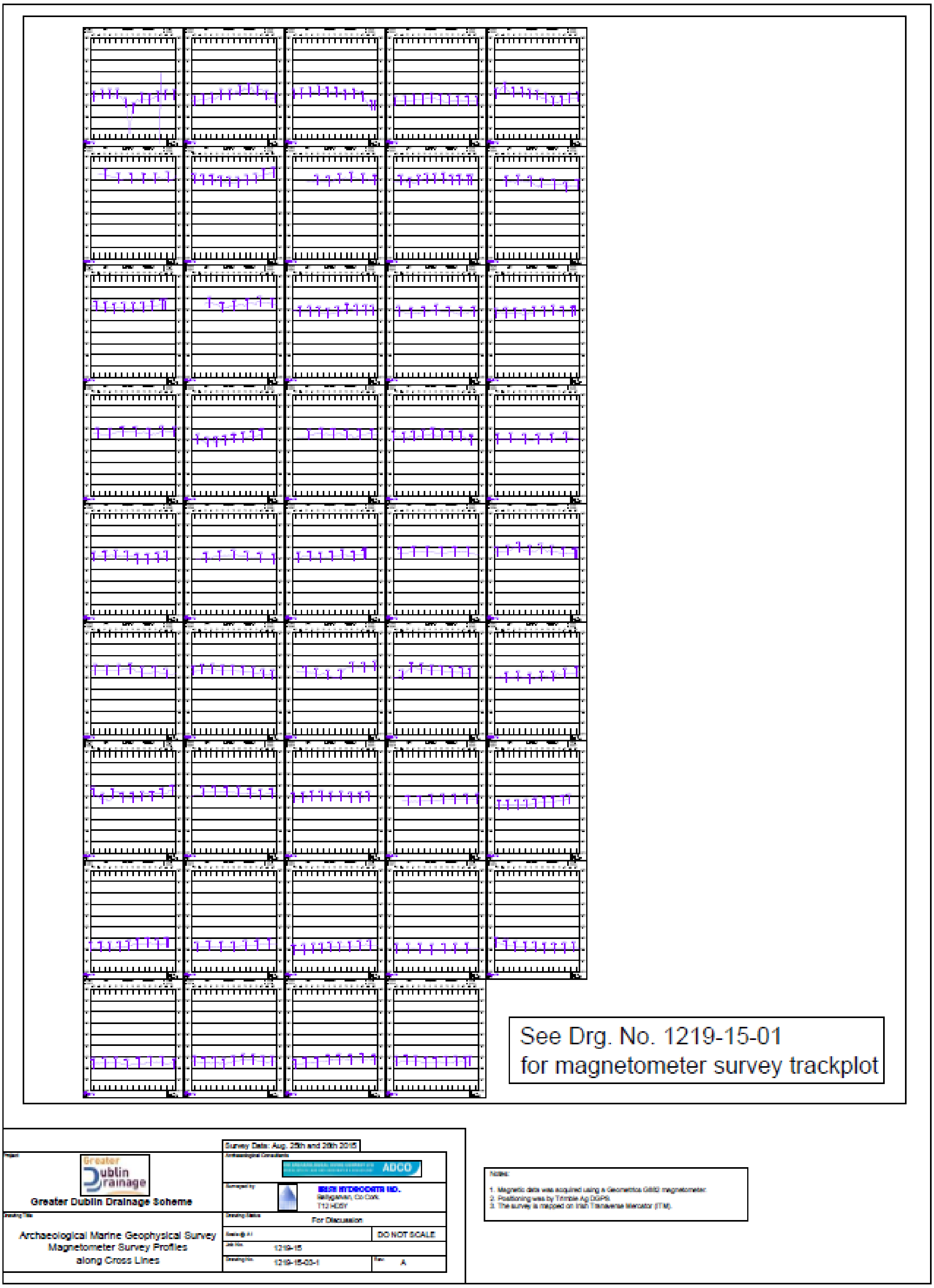


Fig. 6.6 Magnetometer profiles along cross lines

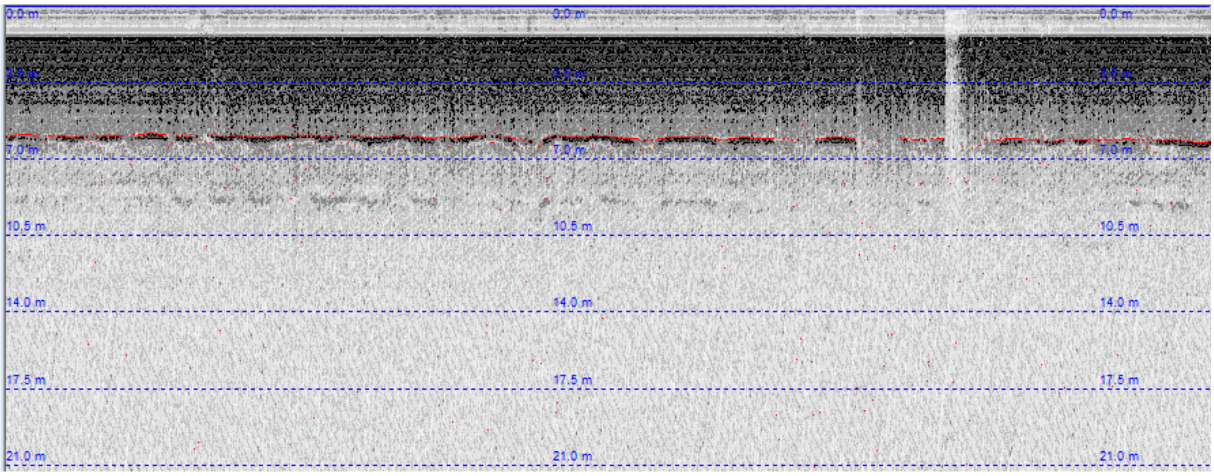


Fig. 6.7 Sub-bottom record - Example

7.0 SUMMARY

The survey was carried out during the period August 24th to 26th 2015.

Preliminary post-processing was carried out with bathymetric charts and survey trackplots produced. All raw survey data along with the charts and trackplots were assembled and provided to ADCO for archaeological assessment.

An MMO was present during the survey at all times. The MMO report was provided to ADCO and also directly to DAHG.

APPENDIX A

EQUIPMENT DATA SHEETS

AgGPS 132

Combination DGPS receiver with The Choice technology

Standard features
- 12 Channel DGPS receiver
- Submeter differential accuracy
- Positioning based on high performance GPS engine design
- Internal L-Band satellite differential receiver
- Internal MSK Beacon receiver
- Internal WAAS/EGNOS receiver
- Two programmable RS-232 ports
- CAN bus J1939 compatible
- 1 PPS output
- Up to10 Hz positioning
- Outputs GPS position in either NMEA or TSIP data messages
- AgRemote configuration software for the PC
- Magnetic antenna mount
- AgGPS 170 Field Computer compatible
- AgGPS EZ-Map compatible
- 2 line, 16 character liquid crystal display
- 4 button keypad

Options
- Parallel Swathing Option
- EVEREST multipath reduction

Physical characteristics

AgGPS 132 housing

Size . . . . . 14.5 cm W × 5.1 cm H × 19.5 cm D (5.7" W × 2.0" H × 7.7" D)
Weight. . . . . 0.76 kg (1.68 lb)
Power . . . . . 7 W (max), 10 to 32 V DC
Operating temperature. . . . . –20 °C to +65 °C
Storage temperature . . . . . –30 °C to +85 °C
Humidity . . . . . 100% condensing, unit fully sealed
Casing . . . . . Dust proof, waterproof, shock resistant
Compliance . . . . . FCC Class B, CE

Combined antenna

Size . . . . . 15.5 cm D × 14 cm H (6.1" D × 5.5" H)
Weight. . . . . 55 kg (1.2 lb)
Operating temp . . . . . –30 °C to +65 °C
Storage temp . . . . . –40 °C to +85 °C
Humidity . . . . . 100% condensing, unit fully sealed
Casing . . . . . Dust proof, waterproof, shock resistant

Specifications subject to change without notice.

Mapping options
- The AgGPS 132 receiver is fully expandable to meet your changing needs
- Add a Pocket PC and AgGPS EZ-Map for mapping and industry-standard record-keeping options such as coverage mapping and feature/boundary mapping
- Add an AgGPS 170 field computer for the ultimate field information management solution, with enhanced guidance, field mapping, flow control, flow monitoring, variable rate management, and soil sampling capabilities

Performance characteristics

General. . . . . 12 channel L1 code phase receiver
Maximum update rate . . . . . 10 Hz
Position accuracy
Static (year-to-year). . . . . submeter differential
Dynamic (pass-to-pass). . . . . 4–12 inch (10–30 cm) RMS 15 min pass-to-pass accuracy
Time to first fix . . . . . <30 seconds, typical
NMEA messages . . . . . GGA, GGL, GRS, GST, VTG, RMC, GSA, GSV, XTE, ZDA, ALM, MSS
Communication Ports . . . . . 2 × RS-232, 2 × J1939 (CAN 2.0B)

Ordering information
1. *AgGPS 132 DGPS/Satellite/Beacon/WAAS/EGNOS receiver system w/30945 cable: Order 33300-00*
2. *AgGPS 132 DGPS/Satellite/Beacon/WAAS/EGNOS receiver system w/no antenna: Order 33300-02*

Recommended AgGPS 132 system configurations
1. *AgGPS 132 used with customer supplied Precision Agriculture Equipment: Order 33300-00*
2. *AgGPS 132 with AgGPS PSO for guidance and logging: Order 33300-00 and 34623-00*
3. *AgGPS 132 with AgGPS EZ-Map for mapping and logging (requires user supplied Pocket PC): Order 33300-00 and 46657-00-ENG*
4. *AgGPS 132 with AgGPS 170 Field Computer for guidance, mapping, logging, sampling, variable rate application: Order 33300-00, 38381-00, and 34623-00*

Notes:
Any of these configurations can easily be upgraded to DGPS Autopilot™.
At least 5 satellites, PDOP ≤6, SNR ≥6, elev mask = 8 using WAAS or L-Band (OmniSTAR or Thales) differential correction services. WAAS is a free service available in the US, L-Band services require a subscription.
Trimble Navigation Limited is not responsible for the operation or failure of operation of GPS satellites or the availability of GPS satellite signals.

Water Level Specifications (all models)

Model	Range**	Factory Calibrated Range (0 to 40°C; 32 to 104°F)	Water Level Accuracy (Typical Error)***	Resolution	Burst Pressure**
U20-001-04 U20-001-04-Ti	0-4 m (0-13 ft) 0-145 kPa (0-21 psia)	69 to 145 kPa (10-21 psia)	±0.3 cm (0.01 ft) (±0.075% FS)	0.14 cm (0.005 ft)	310 kPa (45 psia) 18 m (60 ft) depth
U20-001-01 U20-001-01-Ti	0-9 m (0-30 ft) 0-207 kPa (0-30 psia)	69 to 207 kPa (10-30 psia)	±0.5 cm (0.015 ft) (±0.05% FS)	0.21 cm (0.007 ft)	310 kPa (45 psia) 18 m (60 ft) depth
U20-001-02	0-30 m (0-100 ft) 0-400 kPa (0-58 psia)	69 to 400 kPa (10-58 psia)	±1.5 cm (0.05 ft) (±0.05% FS)	0.41 cm (0.013 ft)	500 kPa (72.5 psia) 40.8 m (134 ft) depth
U20-001-03	0-76 m (0-250 ft) 0-850 kPa (0-123 psia)	69 to 850 kPa (10-123 psia)	±3.8 cm (0.125 ft) (±0.05% FS)	0.87 cm (0.028 ft)	1200 kPa (174 psia) 112 m (368 ft) depth


Bottom Line to Precision Sounding
9.12
10.98
320M
ECHOSOUNDER
KNUDSEN
ENGINEERING LIMITED
Hydrographic Survey
Pre and Post Dredge Operations
Single / Dual Frequency, 3.5 to 250 kHz
Compact, Rugged Design
Automatic or Manual Control
High Resolution, 32 Greyscale Printer
Software Flexibility Ensures Product Longevity
Interface - GPS, Heave, Datalogger, SCSI, Windows®

The 320M Marine Echosounder was developed to meet demanding requirements of field work. Its low maintenance modular construction, together with advanced features and easy configuration, make the 320M the most flexible sounder available.

Using either the high or low frequency channel, or both simultaneously, the 320M produces a high resolution record accurately depicting bottom profiles and sediment layers with 32 shades of grey. The thermal printer uses easily loaded 21.6cm (8.5") plastic film for permanent, high-quality records. The annotated depth grid is printed with reverse shading for clarity.

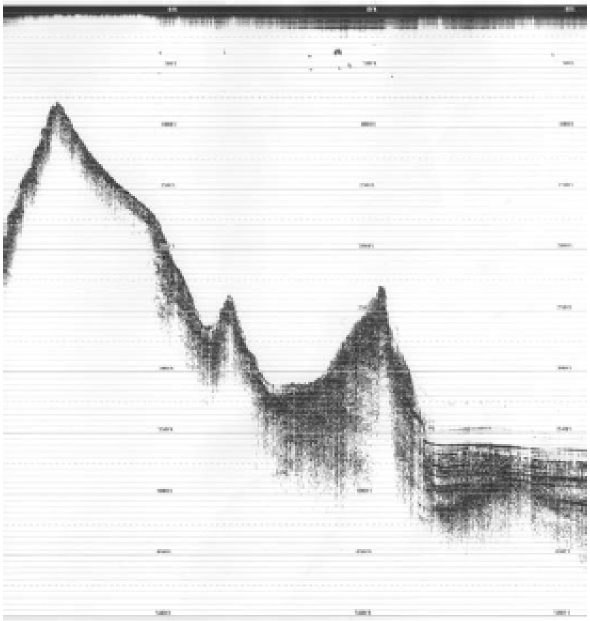
Digitized water depth is shown on two large 4-digit LCD displays, visible in direct sunlight and backlit for night operation. Serial RS232 depth data is continuously available in NMEA format as well as user-defined string formats, and in operator-selectable time and position tagged formats.

An LCD menu display with simple 2-button control provides access to parameters such as sound velocity, draft, TX blanking, serial port assignment, time and date setting, and many more, as well as a variety of self-test, communication and configuration features. All settings are retained in non-volatile memory and recalled on power-up.

Three RS232 ports support communication with personal computers, NMEA input and output devices, GPS receivers, sound velocity sensors, heave sensors, remote depth displays and survey data loggers.

The standard 320M firmware includes drivers for all the devices above and can be field upgraded where firmware can be downloaded through a serial port into "flash" program memory.

In addition to traditional "hands-on" operation, an optional upgrade allows the 320M to be operated remotely through the built in SCSI interface and Windows application software.



Technical Specifications *(subject to change without notice)*:

Main Ranges:

Metres, Feet or Fathoms	Scale
10	1 : 50
20	1 : 100
50	1 : 250
100	1 : 500
200	1 : 1000
500	1 : 2500
1000	1 : 5000
2000	1 :10000
5000 (available via SCSI and serial only)	

Phased Ranges: Multiple 50% overlapped phases of each range (20% overlap optional), manual or automatic selection.

Paper Speed: 7 settings.

Frequencies: 3.5 kHz to 250 kHz. Standard frequencies include - LF 12, 24, 26, 28, 30, 33, 38, 40, 41, or 50 kHz, - HF 100, 120, 150, 200, 208, or 210 kHz.

Depth Display: Two LCD (backlit) 4-digit displays for high and low frequency.

Power: 4 selectable levels for each frequency, maximum 1,000 watts RMS into 50 ohms.

Resolution: 1 cm (0-99.99), 1 dm (100-999.9), 1 m (>1000)
1/100 ft (0-99.99), 1/10 ft (100-999.9), 1 ft (>1000)
1/100 fm (0-99.99), 1/10 fm (100-999.9), 1 fm (>1000)

Record width: 20 cm Paper width: 21.6 cm (8.5").

Sound Velocity: 1300 - 1700 m/s Resolution: 1 m/s
4265 - 5577 ft/s Resolution: 1 ft/s
710 - 929 fm/s Resolution: 1 fm/s

Clock Internal battery backed time and date clock.

Draft: 0 - 100 m Resolution: 1 cm
0 - 328.08 ft Resolution: 0.01 ft
0 - 54.68 fm Resolution: 0.01 fm

Annotation: Internal: date, time, GPS position.
External: from RS 232 port.

Pulse Length: Automatically selected, with operator override.

Printer: Self-test, manual or automatic contrast, high resolution of 1600 pixels per line in a 32 step grey scale, LED status indicators, paper advance control.

Gain Controls: AGC, TVG and manual receive gain for each frequency.

TX Blanking: 0 - 300 m. Resolution: 0.1 m
0 - 984.3 ft. Resolution: 0.1 ft
0 - 164.0 fm Resolution: 0.1 fm

Serial Ports: Three RS 232 ports, 300-38,400 baud, optional RS 422.

SCSI Port: Standard. (Advanced Windows application software optional.)
Note: Contact manufacturer for PC requirements.

Heave: TSS and Seatex compatible.

Position: Compatible with all popular GPS receivers.

Power Supply: 9 to 36 VDC, 60 watts maximum. (12 or 24VDC nominal)
85 - 240 VAC adaptor available.

Installation: Bulkhead or 19" rack mountable. Includes custom Hardigg case.

Dimensions: W 432 x H 355 x D 241 mm. (16.5" x 14" x 9.5")

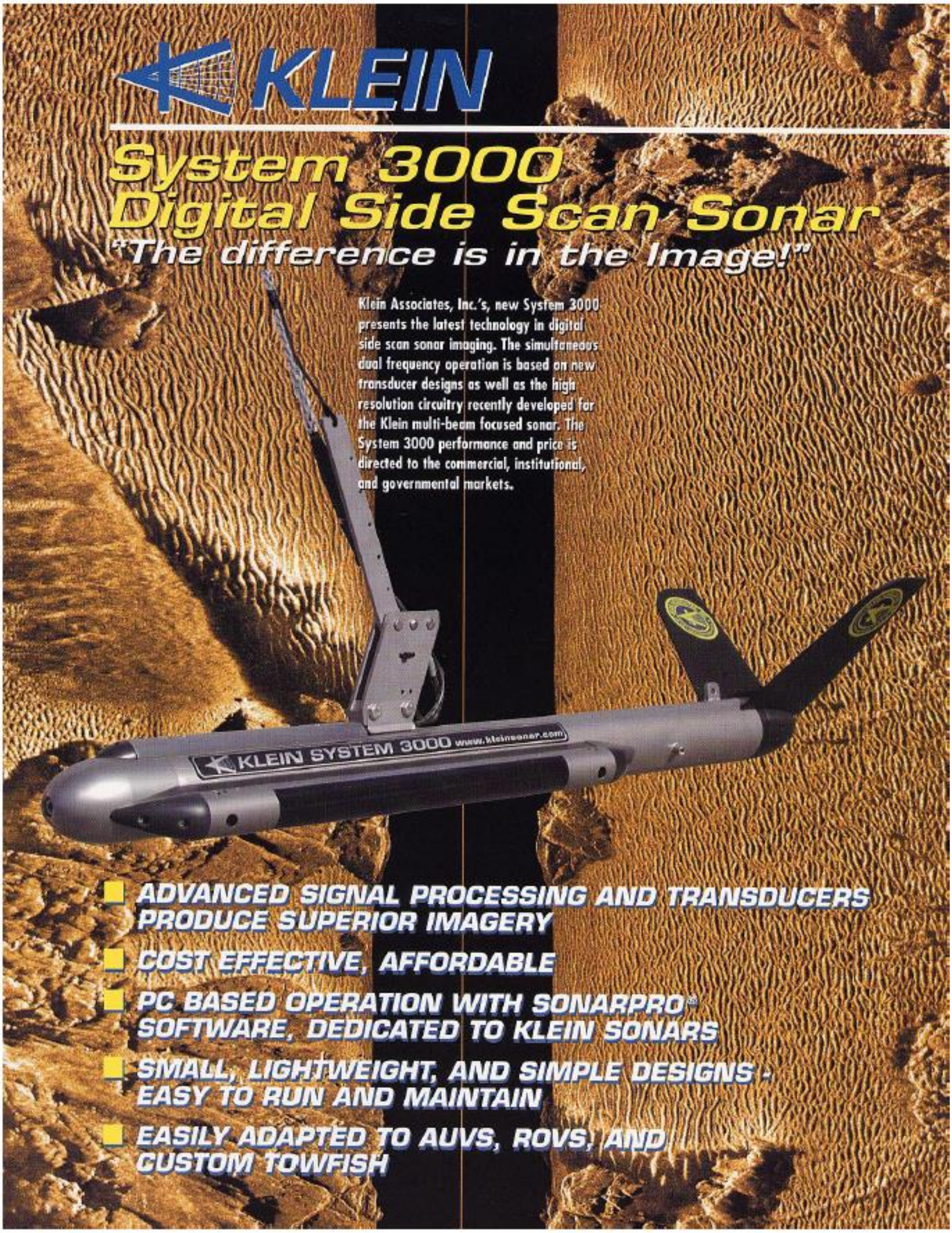
Weight: 19 kg. (40 lb)

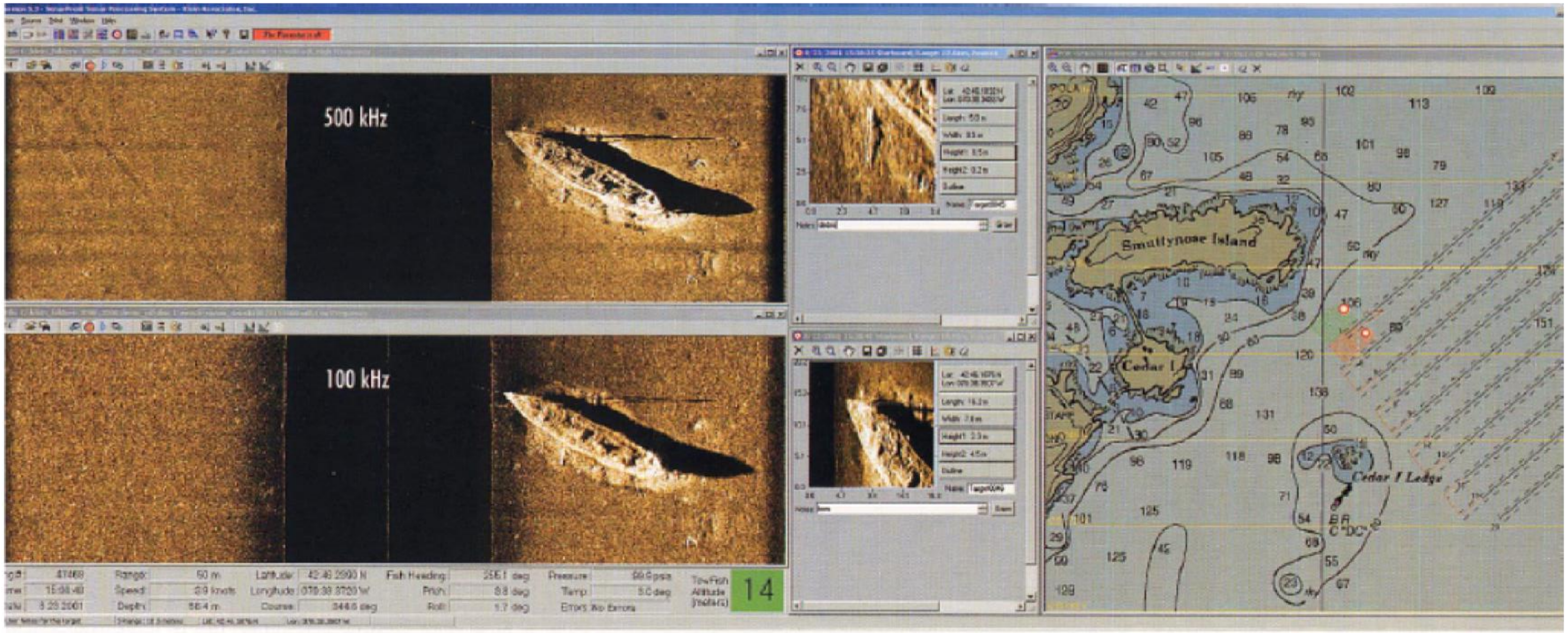
Units: Metres, Feet or Fathoms

Options:
- Windows SCSI Application Software
- Custom stand
- Single frequency (upgradeable to dual frequency)
- Transducer multiplexer
- Transducers (many are available)
- Transducer 'over the side' mounting brackets
- Rackmount brackets
- Remote Display
- On-site training/installation

Printed in Canada
D10-01837 R10

10 Industrial Rd. Perth Ontario Canada K7H 3P2 Phone: (613) 267-1165 US: (315) 393-8861
Fax: (613) 267-7085 Homepage: http://knudsenengineering.com Email: info@knudsenengineering.com


KLEIN
System 3000
Digital Side Scan Sonar
"The difference is in the Image!"
Klein Associates, Inc.'s, new System 3000 presents the latest technology in digital side scan sonar imaging. The simultaneous dual frequency operation is based on new transducer designs as well as the high resolution circuitry recently developed for the Klein multi-beam focused sonar. The System 3000 performance and price is directed to the commercial, institutional, and governmental markets.
KLEIN SYSTEM 3000
ADVANCED SIGNAL PROCESSING AND TRANSDUCERS PRODUCE SUPERIOR IMAGERY
COST EFFECTIVE, AFFORDABLE
PC BASED OPERATION WITH SONARPRO® SOFTWARE, DEDICATED TO KLEIN SONARS
SMALL, LIGHTWEIGHT, AND SIMPLE DESIGNS - EASY TO RUN AND MAINTAIN
EASILY ADAPTED TO AUVS, ROVS, AND CUSTOM TOWFISH



SPECIFICATIONS

Towfish

Frequencies	100 kHz (125 kHz +/- 1% act.), 500 kHz (445 kHz, +/- 1% act.)
Transmission Pulse	Tone Burst, operator selectable from 25 to 400 µsecs.
	Independent pulses for each frequency
Beams	Horizontal - 1 deg. @ 100 kHz, 0.2 deg. @ 500 kHz
	Vertical - 40 deg.
Beam Tilt	5, 10, 15, 20, 25 degrees down, adjustable
Maximum Range	600 meters @ 100 kHz; 150 meters @ 500 kHz
Depth Rating	1,500 meters standard, options to 3km & 6km depths
Construction	Stainless Steel
Size	122 cm long, 8.9 cm diameter
Weight	29 kg in air
Standard Sensors	Roll, pitch, heading
Options	Magnetometer Interface, pressure, Acoustic Positioning Responder, and Responder Interface Kits

Transceiver Processor Unit (TPU)

Operating System	vxWorks® with custom application
Basic Hardware	19-inch rack or table mount, VME bus structure
Outputs	100 Base-Tx, Ethernet LAN
Navigation Input	NMEA 0183
Power	120 watts @ 120/240 VAC, 50/60 Hz

Klein Sonar Workstation

Basic Operating System	Windows NT® & 2000® or equiv.
Sonar Software	SonarPro®
Data Storage	Internal hard drive, optional devices available
Hardware	Industrial PC with technically advanced components

Tow Cables

Klein offers a selection of coaxial, Kevlar® reinforced, lightweight cables, double armored steel cables, and interfaces to fiber optic cables. All cables come fully terminated at the towfish end.

KLEIN

KLEIN ASSOCIATES, INC.
11 Klein Drive
Salem, N.H. 03079-1249, U.S.A.
Phone: (603) 893-6131
Fax: (603) 893-8807
E-mail: mail@kleinsonar.com
web site: www.kleinsonar.com

SonarPro® Software

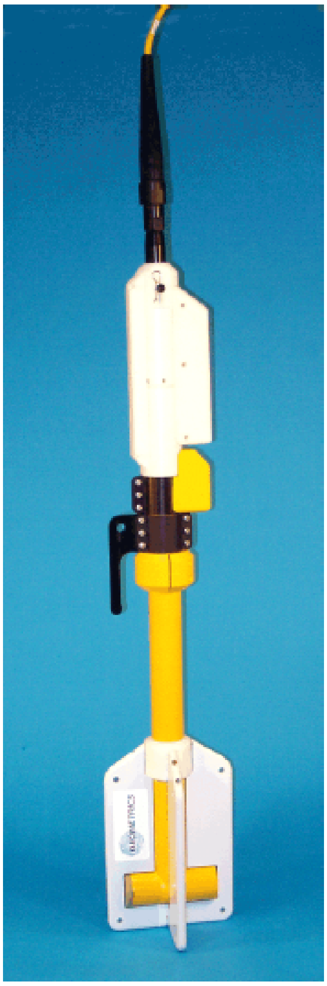
Custom developed software by users and for users of Klein side scan sonar systems operating on Windows NT® & 2000®. Field proven for many years on Klein's Multi-Beam Focused Sonar Series 5000 Systems and adapted to the System 3000 single-beam system. SonarPro® is a modular package combining ease of use with advanced sonar features.

Basic Modules	Main Program, Data Display, Information, Target Management, Navigation, Data Recording & Playing, and Sensor Display.
Multiple Display Windows	Permits multiple windows to view different features as well as targets in real time or in playback modes. Multi-Windows for sonar channels, navigation, sensors, status monitors, targets, etc.
Survey Design	Quick & easy survey set up with ability to change parameters, set tolerances, monitor actual coverage, and store settings.
Target Management	Independent windows permitting mensuration, logging, comparisons, filing, classification, positioning, time & survey target layers, and feature enhancements. Locates target in navigation window.
Sensor Window	Displays all sensors in several formats (includes some alarms) and responder set up to suit many frequencies and ping rates.
Networking	Permits multiple, real time processing workstations via a LAN including "master and slave" configurations.
"Wizards"	To help operator set up various manual and default parameters.

GEOMETRICS

G-882 MARINE MAGNETOMETER

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



G-882 with Weight Collar Depth Option & Altimeter

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

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

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

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

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

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

Typical Detection Range For Common Objects

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

MODEL G-882 CESIUM MARINE MAGNETOMETER SYSTEM SPECIFICATIONS

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

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE ***12/06***

GEOMETRICS INC. 2190 Fortune Drive, San Jose, California 95131, USA
Tel: 408-954-0522 – Fax: 408-954-0902 – Email: sales@geometrics.com

GEOMETRICS EUROPE 20 Eden Way, Pages Industrial Park, Leighton Buzzard LU7 4TZ, UK
Tel: 44-1525-383438 – Fax: 44-1525-382200 – Email: chris@georentals.co.uk

GEOMETRICS CHINA Laurel Technologies, Ste 1807-1810, Kun Tai Int'l Mansion, #12B, Chaowai St., Beijing 100020, China
Tel: 86-10-5879-0099 – Fax: 86-10-5879-0989 – Email: laurel@laureltech.com.cn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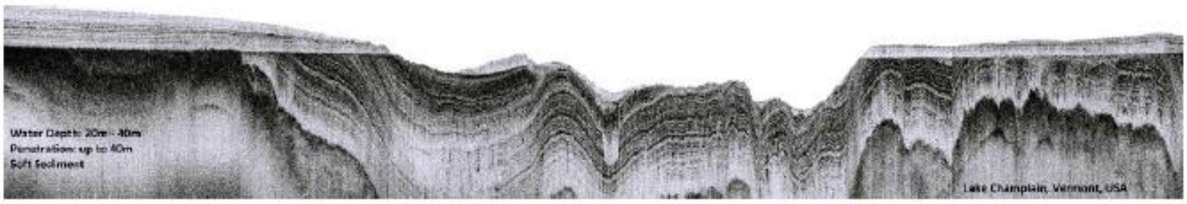
PINGER SBP

Technical Specifications (subject to change without notice)	*Low Frequency Channel*		*High Frequency Channel*
	3.5kHz	15kHz	200kHz
Dry End - Echosounder			
Bandwidth	User configurable (up to 20kHz)		
Output Power	up to 2kW	up to 2kW	up to 1kW
Pulse Length (min / max)	62.5µs / 64 ms		62.5µs / 4 ms
Ping Repetition Rate (max)	20 Hz		
Gain	Manual, automatic (AGC), and time varied (TVG)		
Analog Gain	96dB programmable analog gain		
Time Varied Gain (TVG)	20logR, 40logR		
Zoom Display	Dynamic Window Positioning and Sizing		
Units	Meters, Feet, or Fathoms		
User Interface	Control using standard Windows PC		
Digital Data Formats	SEG-Y, XTF, KEB (Knudsen proprietary), ASCII		
Power Supply	24 Vdc		
Operating Temperature	0 - 50 degC		
Enclosure	Portable splashproof case		
Dimensions (length x width x height)	488mm (19.2") x 386mm (15.2") x 185mm (7.3")		
Weight	10.5kg (23lb)		
Wet End - Transducer			
Projector	KELA5701-3.5kHz	KEL291-15kHz	KEL491-200kHz
Impedance	100 Ohms	60 Ohms	60 Ohms
Peak Transmit Voltage Response	149dB	157.5dB	176dB
Receiver	KEL-Hydrophone		KEL491-200kHz
Beamwidth	30 deg @ 6kHz	12 deg @ 15kHz	9 deg @ 200kHz
Peak Receive Voltage Response	-197.2 dB re 1V/uPa		-191 dB re 1V/uPa
Dimensions (length x width x height)	864mm (34") x 514mm (20.25") x 381mm (15")		
Weight	21kg (46lb) - 15kHz Option		
	29kg (64lb) - 3.5kHz Option		
Cable Length	10m (33ft)		
Installation	Pole mount - over the side		

Fiberglass Fairing Assembly

Pinger Wet End shown as shipped



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10 Industrial Rd. Perth Ontario Canada K7H 3P2 Phone - Canada: (613) 267-1165 US: (315) 393-8861
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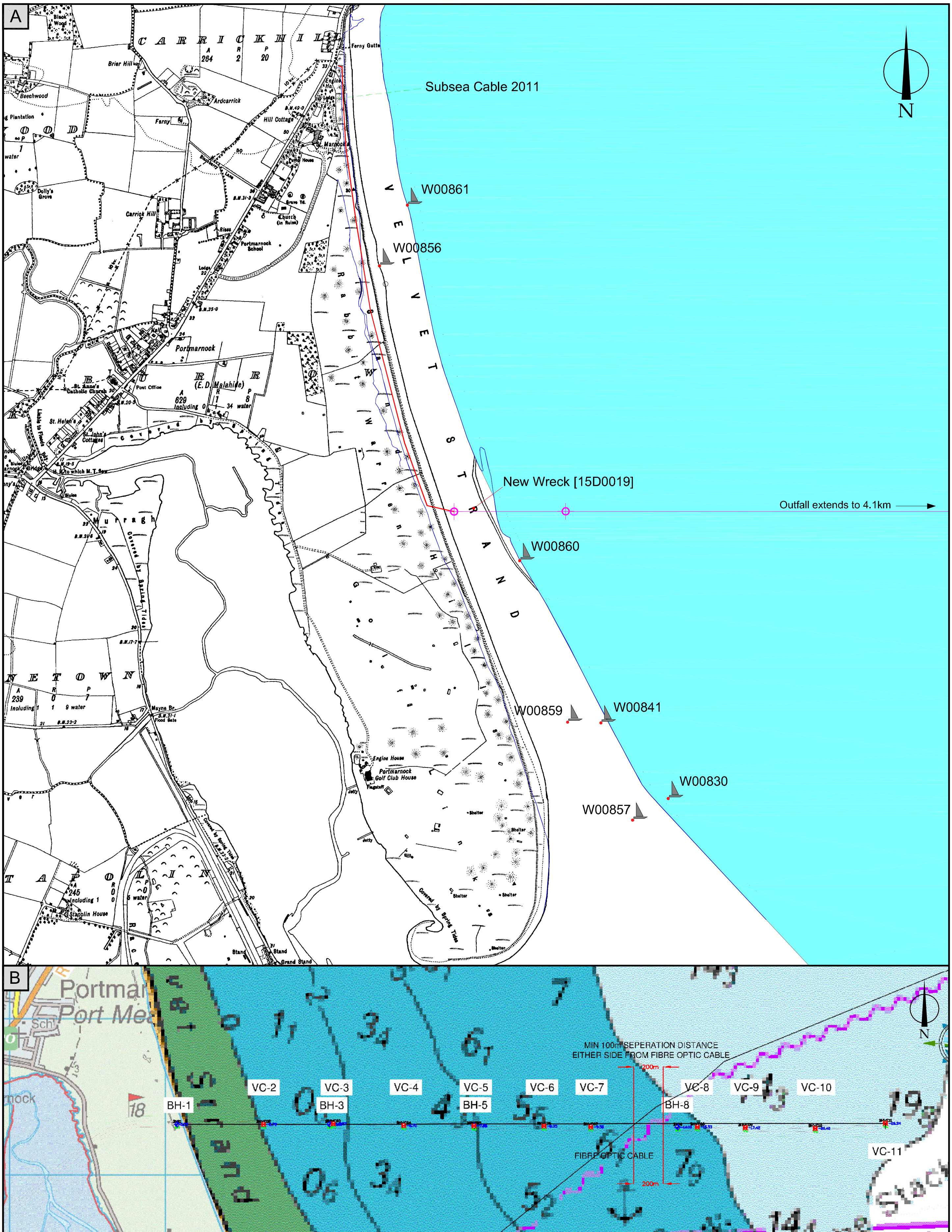
Figures and Plates, Main Report



Client
IAC Ltd./ Irish Water

Project
Greater Dublin Drainage Project, Velvet Strand

ADCO

A4

Notes

Source: OSi Historic Map Archive/ Project Dwg. 32102901-1055

- Proposed Haul Road
- Geological Testing Sites
- Subsea Cable Landfall
- Known Shipwreck Site
- Present day coastline

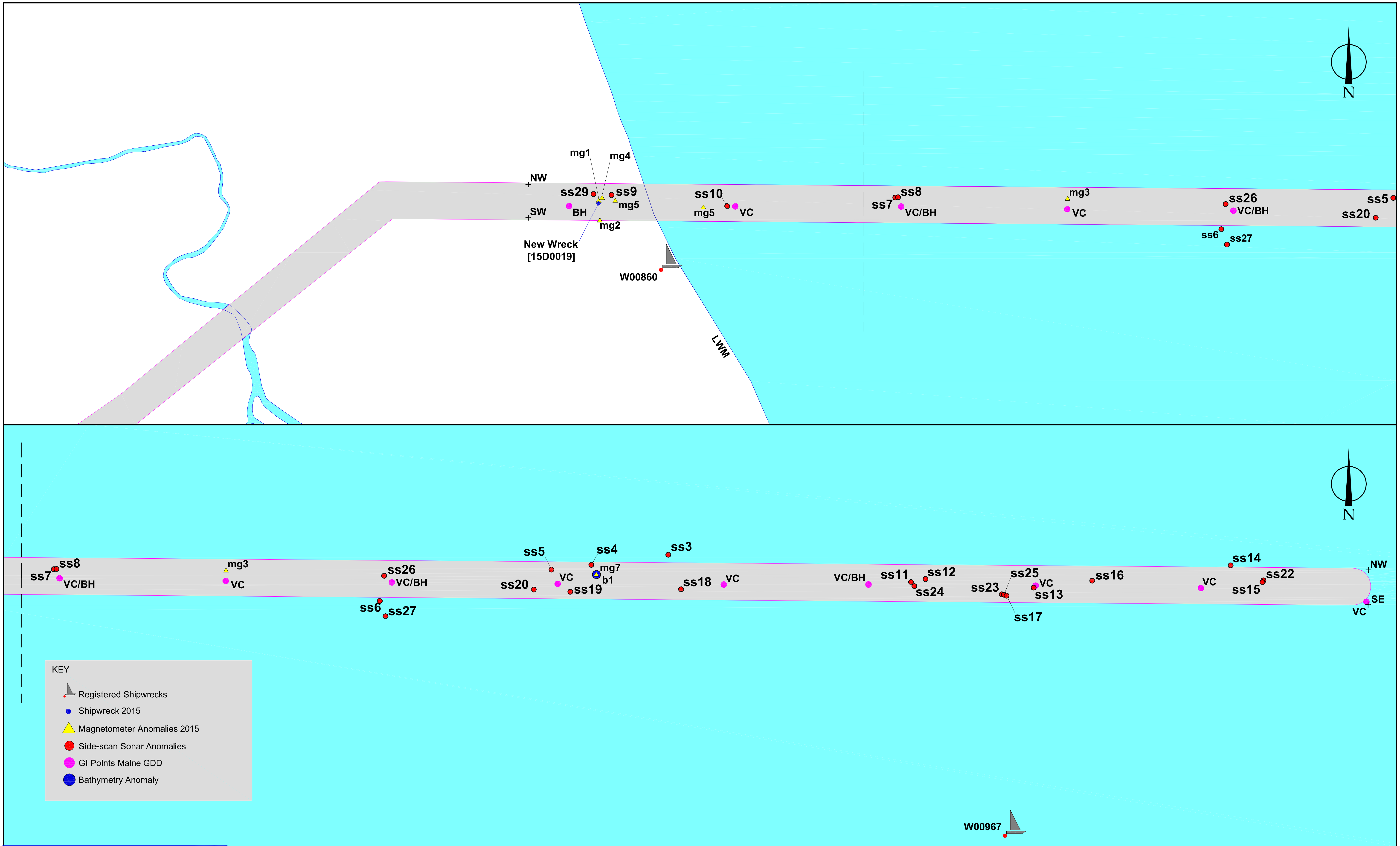
Title

Figure 1

A- Extract from OS (1912) 25" map with location of development, limit of present day coastline, and known shipwreck sites superimposed.

B- Extract from Project Drawing showing extent of outfall and location of Geotechnical Investigation.

Job/Exc No.	Compiled by	CAD reference	Date	Scale	Drawing No.
15R0092	R.Bangerter	GDD_Velvet	26.04.16	1:20,000/ 1:30,000	Figure 1



ADCO

Notes
Source: ArchGIS
LWM
Survey Corridor

A3

Job/Exc No.	Compiled by	CAD reference	Client	Title
15R0092	R.Bangerter	GDD_Velvet	IAC Ltd./ Irish Water	Figure 2- Location of Geophysical Anomalies and Geotechnical Investigation along extent of the Marine Outfall Survey Corridor [15R0092].
Date	**Scale**	**Drawing No.**	**Project**	
26.04.16	1:9500	Figure 2	Greater Dublin Drainage Project, Velvet Strand	

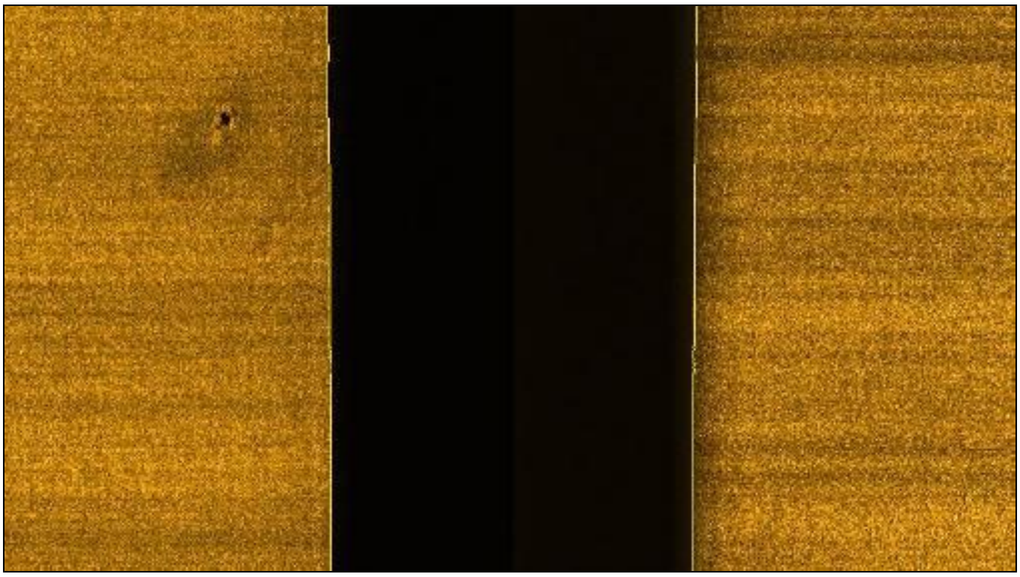


Plate 1: View looking at the side-scan sonar data trace, showing the featureless sandy surface that is typical of the area surveyed. The presence of anomalies is visible clearly in such environments, with the image including that of anomaly ss14 in the top left corner.

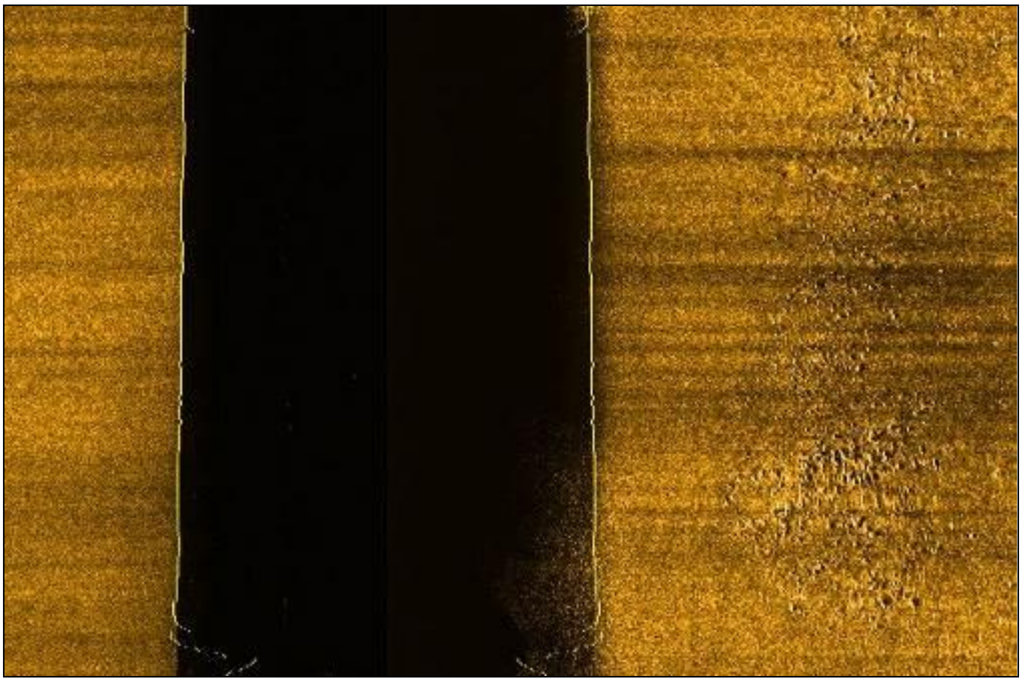


Plate 2: View looking at the side-scan sonar data trace, showing the one area of what appears to be cobbles on the seabed surface. It is identified as anomaly ss16. The viewer can see clearly individual stones forming a linear spread on the right side

of the screen, which contrasts with the clean sand surface on the left.

Plate 3: View taken at Low Water in April 2015, looking South across the exposed tips of the framing timbers representing the location of the new wrecksite, 80m east of Borehole 1.

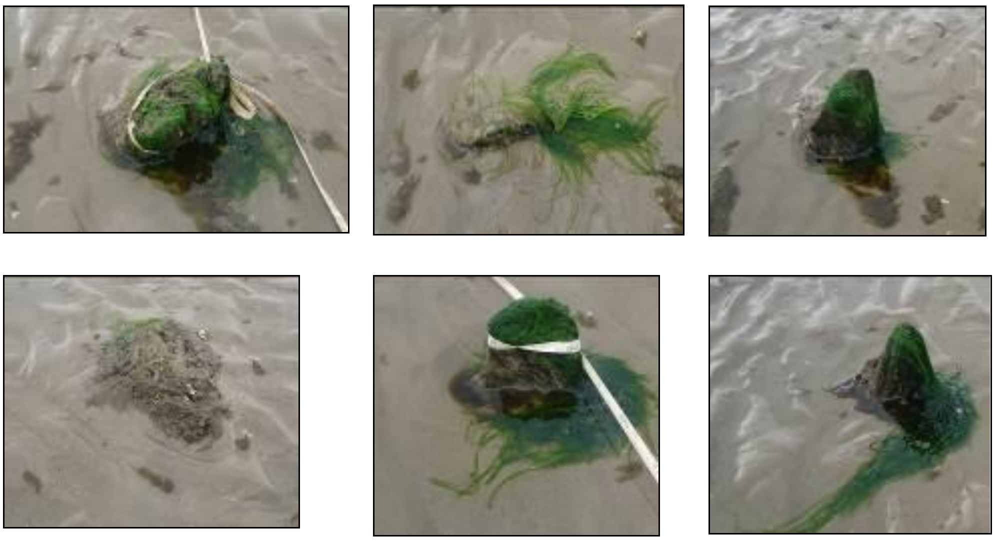


Plate 4: Close-up view taken in April 2015 of the six framing timbers that identify the new wrecksite, 80m east of Borehole 1. Clockwise from top follows the timbers from N to S, with the SW timber on the lower left.

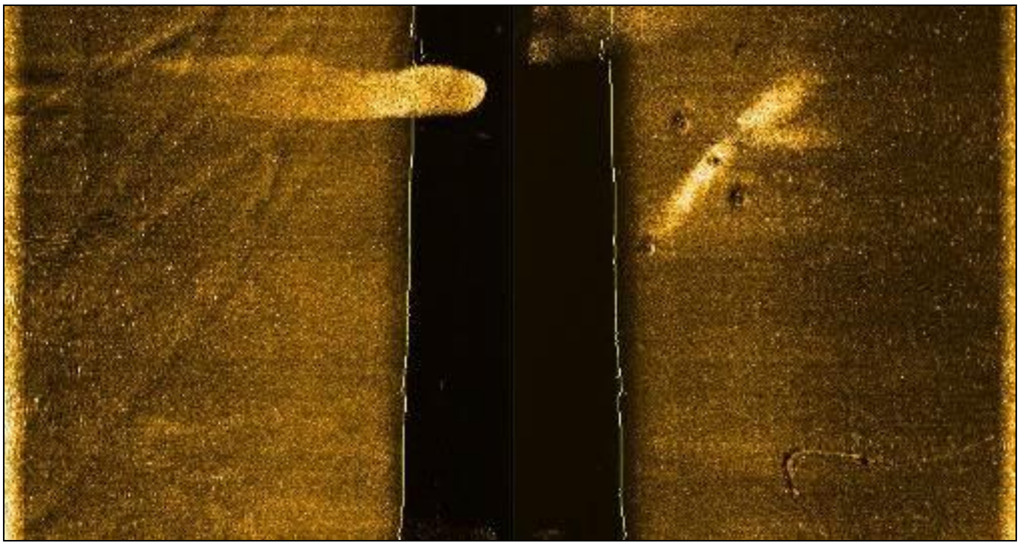


Plate 5: View looking at the side-scan sonar data trace where the seabed retains a series of features that are determined to be recent in origin. On the top right, a cluster of round-shaped anomalies form a sub-square shape. This features recurs elsewhere in the data sets, and appears to be the footprint for a spud barge that was on site immediately prior to the present survey. The linear feature in the bottom right is considered to be a dragmark associated with the barge's presence, where anchor cabling would have cut into the seabed surface and has left a temporary scar. The zig-zag lines in the top left are probably the remnants of trawl scars.

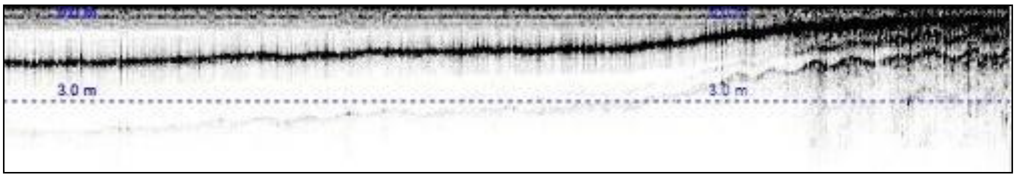
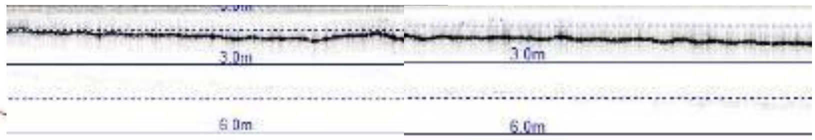
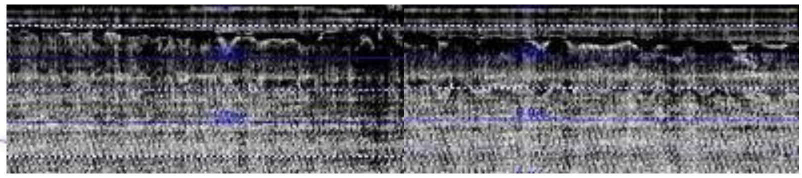


Plate 6: View of sub-bottom profile data trace, showing a perspective of the seabed's stratigraphy from close inshore (on the right side) and proceeding offshore (left side). The horizontal distance shown is approximately 70m. The vertical distance is indicated in the blue columns. The absence of any defined truncations and the absence of any hard reflectors in the section detail indicates a clean uninterrupted natural stratigraphy. The soft reflectors are associated with sand and soft silt.



E-W line at 09:00:40 N-S line at 09:21:08

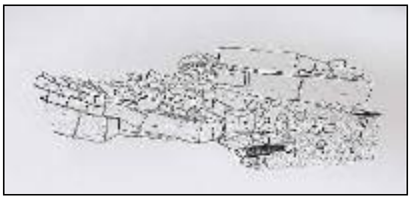


E-W line at 09:00:40 N-S line at 09:21:08

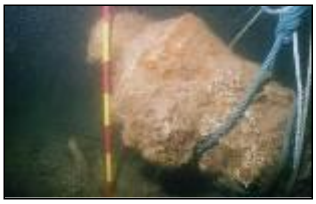
Plate 7: Detail from sub-bottom profile survey showing data traces from survey lines, 8m north and 3m east of the new wrecksite located on the intertidal foreshore. The data traces show the sub-bottom data cleaned (top) and raw (bottom).

Recording prehistoric logboat at Gormanston, Co. Meath GAS 2025 Irish Sea Interconnector

Underwater elevation of bridge pier collapsed in 1763. River Nore Flood Alleviation Scheme



Iron cannon on site of 17th-century timber wreck discovered during dredging programme Waterford Harbour



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