METROLINK

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A25.7

Geophysical Report - Phase 4 Lissenhall and Naul Road

Lissenhall Little, Balheary Demesne and Cloghran, MetroLink, Phase IV, Dublin

Archaeological Geophysical Survey

Detection Licence No. 18R0196

Survey undertaken for
Jacobs Engineering
on behalf of
Transport Infrastructure Ireland

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EARTHSOUND geophysics

EAG 418

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Table of Contents

Summary of Results

Between the 1st and 10th March 2021, a series of geophysical surveys were undertaken in advance of the proposed MetroLink. The work was commissioned by Jacobs Engineering on behalf of Transport Infrastructure Ireland. Three sites were surveyed within Lissenhall Lttle, Balheary Demesne and Cloghran Townlands as they represented Sites of Archaeological Interest along the proposed MetroLink route. The surveys undertaken in this report represent the 4th phase of survey undertaken in advance of Metrolink. Magnetometer surveys were undertaken at a sample resolution of 0.5m x 0.25m. A percentage of electromagnetic surveys were also undertaken on all sites over anomalies detected within the magnetometer data at a sample resolution of 0.5m x 0.25m. The surveys were conducted upon a bedrock geology consisting of Limestone and Shale, beneath tills and gravels. The survey area at Lissenhall 1b comprised a number of harvested crop fields. Lissenhall 1c comprised pasture parkland, while Cloghran was a pasture field.

At Lissenhall 1B an apparent diverse archaeological landscape has been revealed. The presence of enclosure DU011-131---- was confirmed through the geophysics, while suggesting that additional internal divisions may be present. A ring-ditch associated with RMP DU011-130---- was also confirmed, this monument had previously identified through aerial photography and previous Metro North test excavations. Surrounding this monument a series of pits and ditches were detected which suggest the presence of associated remains. Three further archaeological enclosures were identified, including a large multi-ditched enclosure in the northeast corner which has been cut by a pipeline.

Further potential archaeological activity was detected through a large number of possible pits. The majority of these are situated surrounding the large multi-ditched enclosure and across the northwest portion of the survey area. A number of possible enclosure ditches, sub-divisions and interconnecting ditches were detected within the vicinity which hint at a large multi-phased archaeological landscape.

The surveys undertaken within Balheary Demesne were heavily impacted by pipes and magnetic disturbance; however a number of features were detected which could be archaeological in origin or associated with the construction of the parkland. Magnetic disturbance and a pipe also impacted on the surveys at Cloghran where a number of agricultural boundaries, potential archaeological features and pits were detected.

Statement of Indemnity

A geophysical survey is a scientific procedure that produces observations of results which are influenced by specific variables. The results and subsequent interpretation of the geophysical survey presented here should not be treated as an absolute representation of the underlying archaeological features, but as a hypothesis that must be proved or disproved. ***Direct investigations are recommended to confirm the findings of this report.*** *Verification can only be provided via intrusive means, such as Test Trench excavations.*

1 Introduction

1.1 Brief Description of the Proposed Development

Earthsound Geophysics Ltd. were commissioned by Jacobs Engineering on behalf of Transport Infrastructure Ireland to carry out geophysical surveys at three pre-selected areas along the proposed MetroLink scheme, Dublin. The techniques to be used on each site were pre-determined by Transport Infrastructure Ireland. Previous surveys have been undertaken by this company in advance of Metrolink and this report represents the 4th phase of work. The surveys undertaken in 2019 were located on the southern boundary of the present survey area (Gimson & Garner 2019 and shown in Figures 5, 6, 9 & 10).

1.2 Aims of the Survey

Transport Infrastructure Ireland required a series of archaeological geophysical surveys at a number of pre-selected areas along the route of MetroLink, Dublin. The survey was carried out in accordance with the brief prepared by Jacobs Engineering, using a combination of Magnetic Gradiometer and EM Apparent Electrical Resistivity.

The purpose of these surveys were to ascertain, identify and map the presence of any previously unrecorded and buried archaeological structures and/or features. The results of the geophysical survey may be followed by a programme of invasive archaeological test trenching and will inform the archaeological strategy for the proposed scheme. From these results, it will be possible to identify the effects of the MetroLink project on archaeology in the surrounding environment.

1.3 Description of the Survey Area

All the survey areas are located on a bedrock geology of Limestone and Shale, overlain by tills and gravels. All these soils and geologies are weakly magnetic and may create limited magnetic contrast within the magnetometer data. The use of apparent electrical resistivity surveys will help to mitigate against these influences on the magnetometer surveys. The climatic conditions for the surveys were mixed with periods of heavy rain and overcast weather. The weather is unlikely to have had an impact on the results obtained as the EMI apparent electrical resistivity surveys map contrasts at depth rather than at the surface.

1.4 Archaeological Background and Statutory Protections

There are no known monuments located within Lissenhall 1C and Cloghran. Lissenhall 1B contains two known monuments, Ring ditch DU011-130---- & Enclosure DU011-131----. In addition the geophysical surveys undertaken by this company in 2019 on adjacent land in Lissenhall revealed the presence of an enclosure (Gimson & Garner 2019). A portion of the northern field had been subjected to archaeological test trenching (Channing 2009) this trenching revealed the presence of ring-ditch DU011-130---- and a nearby cremation pit. The test trenches are not visible within the data collected for this report and therefore have not impacted the results.

The National Monuments Acts (1930-2014) prohibit the unauthorised use of detecting devices on archaeological sites as well as unauthorised searches for archaeological objects using such devices. All elements of the survey were carried out in accordance with a written method statement and an application for a detection licence from the Department of Housing, Local Government and Heritage to carry out the work. The Detection Licence was issued to Heather Gimson, Licence number 18R0196.

1.5 Health and Safety requirements

A health and safety statement was submitted to Jacobs Engineering/TII prior to the commencement of work.

2 Methodology

Fieldwork was carried out between the 1st and 10th March 2021 by C. Hogan and U. Garner of Earthsound Geophysics.

Magnetometer surveys were carried out using a LEA MAX Förster gradiometer system. A total of 13.59 hectares of magnetometer surveys were conducted.

Apparent EMI Electrical Resistivity data were collected using a GF Instruments CMD Mini-Explorer. The survey areas covered a total of 8.1 hectares.

The Magnetometer surveys and EMI Electrical Resistivity surveys were undertaken gridlessly with each data point logged using a Trimble RTK GPS VRS Now system.

All these techniques have been used in commercial and research archaeological projects for many years and are considered the most appropriate techniques for a detailed investigation of the underlying archaeology (Aspinall *et al*. 2008, Clark 1996, Scollar *et al.* 1990, Gaffney & Gater 2003).

Where possible, the use of multiple geophysical techniques allows a greater confidence to be placed in the interpretation of detected anomalies, which is especially useful on small sites such as this. Their combined application can be used to determine the geometry, compositional material and the extent of an archaeological target.

2.1 Magnetometer Survey

Instrument	Eastern Atlas LEA MAX^{1505} System
Components	LEA D2, 10-channel digitiser
Data Acquisition Resolution	0.5m x 0.1m
Sensors	8 x Förster FEREX® 4.032 CON650 fluxgate gradiometers
Platform	LEA MAX^{1505} System cart
Data Acquisition Method	Gridless, using a Trimble RTK GPS VRS Now system to an accuracy of 5cm
Sensitivity	<0.1 nT
Data Logger	Panasonic Toughbook CF-H2 Field computer
Calibration	According to manufacturers guidelines (Pilz & Goossens 2015)
Data Processing	Ealdec: Profile decoding Ealmat.m: Normalisation, drift correction Surfer 8: Data Gridding (0.5m x 0.25m), using the Kriging Gridding Method
Graphical Display / Dynamic Range	Greyscale -2nT (white) to 2nT (black)

2.2 Electromagnetic Induction Survey

EMI Measurement	Apparent Electrical Resistivity (ER_a)
Instrument	GF Instruments CMD-MiniExplorer
Data Acquisition Resolution	0.5m x 0.2s
Coil Configuration	Vertical Coplanar Coil configuration (VPC) or 'half-depth', effective depth range: 0.25m, 0.5m, 0.9m
Platform	SparrowHawk-1000 cart system, sensor positioned 10cm above the ground
Data Acquisition Method	Continuous mode, Gridless, using a Trimble RTK GPS VRS Now system to an accuracy of 5cm
Measuring Range	ER_a: 1000mS/m, resolution 0.1mS/m
Data Logger	CMD Control Unit
Calibration	According to manufacturers guidelines (GF Instruments 2010)
Data Processing	CMD Data Transfer: conversion to Apparent Electrical Resistivity (ER_a) from Apparent Electrical Conductivity (Quadrature) Process-it: Drift correction using a moving filter, Despike, Low Pass Gaussian Filter, Interpolation
Graphical Display / Dynamic Range	Greyscale -7mS/m (black) to 7mS/m (white)

2.3 Reporting, Mapping & Archiving

The geophysical survey and report follow the recommendations outlined by relevant best practice guidance documents as a minimum standard (Bonsall *et al*. 2014; David *et al*. 2008; Gaffney *et al*. 2002, Schmidt *et al*. 2015). Ordnance Survey of Ireland mapping was supplied by Jacobs Engineering. Geophysical data, the figures presented here and the text have been archived following the recommendations of the Archaeology Data Service (Schmidt & Ernenwein 2011).

3 Results & Discussion

The interpretation figures should not be looked at in isolation but in conjunction with the relevant discussion section and with the information contained in the Appendices. Features are highlighted in the interpretation diagrams and are described and interpreted within the text.

3.1 Lissenhall 1B

Method of Assessment:		**Magnetometer**							**Site:**	**Lissenhall Little**	
Site Description:		Slightly undulating harvested crop field which was overgrown with some weeds.									
Figure No.:		3, 4, 7 & 8									
No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
M101	Multiple linear magnetic anomalies	Multiple locations	✓						The linear and parallel nature of these ditches suggests that they are likely to be associated with relict agricultural boundaries; none of the features appear on any historic OS map.	✓	
M102	Arcing highly magnetic anomaly	718530.378,749070.875	✓	✓					This enclosure ditch probably contains burnt remains and may contain an entranceway to the west. Measuring 24m in diameter the enclosure appears to contain a number of possible pits within its centre.	✓	
M103	Three isolated responses and nearby arcing magnetic anomalies	718566.816,749057.987 Multiple locations	✓		✓				Three possible pits which run in a linear formation across the northeast corner of the field. Adjacent to these are two arcing possible cut features, 20m and 18m in length which may be archaeological in origin.	✓	
M104	Linear and curvilinear magnetic anomaly	718548.877,749066.392	✓		✓				These possible cut features, 17m and 11m in length may be related to M102 or may be agricultural in origin.	✓	
M105	Two isolated responses	718483.288,749049.582			✓				Two possible pits	✓	
M106	Arcing negative magnetic response	718587.559,749023.807			✓		✓	✓	Arcing possible stone feature, 24m in length and possible enclosing an area 13m in diameter. This feature could be archaeological in origin and appears to have been cut by a relict field boundary. Alternatively the anomaly could be geological in origin or associated with magnetic interference.	✓	
M107	Three linear magnetic anomalies	718522.416,749006.206 Multiple locations	✓		✓				Three possible ditches which run parallel to each other. These anomalies may be agricultural or archaeological in origin.	✓	

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Figure No.:	3, 4, 7 & 8									
No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
M108	Circular highly magnetic anomaly	718513.56,748981.221	✓	✓					Ring-ditch, 11.7m in diameter which appears to contain burnt remains. A number of segments to this ditch were detected in the geophysics suggesting that the ditch may comprise of multiple cuts or deposits. This anomaly corresponds to RMP DU011-130----. To the north eight possible pits were detected, while further possible pits were detected to the south of the ring-ditch. In archaeological investigations of RMP DU011-130---- a cremation pit was detected. It is possible that these pits represent similar features.	✓	
M109	Arcing magnetic anomaly	718521.535,748961.273	✓		✓				Arcing possible cut feature, 24m in length which may be associated with M108 or M113	✓	
M110	Series of isolated magnetic responses	Multiple locations			✓		✓		Numerous possible pits which were detected in the northwestern portion of the field. These anomalies have a raised magnetism suggesting that they might contain burnt or fired remains and are likely to be archaeological in origin, however a geological or agricultural explanation cannot be totally ruled out.	✓	
M111	Arcing magnetic anomalies	Multiple locations	✓		✓				Numerous possible cut features, measuring between 40m and 8m in length. These anomalies are likely to be archaeological in origin and could be associated with M110, a geological explanation cannot be totally ruled out however as some of the anomalies appear in the resistivity data it indicates that they are physical features within the soil.	✓	
M112	Area of magnetic enhancement and arcing magnetic anomaly	718478.357,748985.571 Multiple locations	✓		✓				The arcing magnetic anomaly 42m in length could represent an archaeological ditch, possibly associated with M111, however this ditch appears substantially larger. Surrounding this a large area of magnetic enhancement was detected, covering an area 40m x 32m. This enhancement may be agricultural in origin or could indicate the presence of archaeological remains possibly ploughed out.	✓	

Method of Assessment:	**Magnetometer**								**Site:**	**Lissenhall Little**
Site Description:	Slightly undulating harvested crop field which was overgrown with some weeds.									
Figure No.:	3, 4, 7 & 8									
No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
M113	Curvilinear magnetic anomaly	718497.104,748947.66	✓		✓				Curvilinear possible ditch or cut feature, 62m in length which appears to intersect with ring-ditch M108. This anomaly could be archaeological or agricultural in origin.	✓	
M114	Area of enhancement	718508.898,748949.954			✓		✓		Area of enhancement that could be agricultural in origin or may indicate the presence of archaeological remains possibly ploughed out.	✓	
M115	Two interconnecting curvilinear magnetic anomalies	718535.126,748930.123	✓		✓				Two ditches or cut features, 53m and 40m in length which may be agricultural or archaeological in origin and possibly cross a number of other anomalies (M116 & M119)	✓	
M116	Area of enhancement containing a series isolated responses	718535.962,748947.178 Multiple locations			✓		✓		Area of enhancement which is suggestive of archaeological remains and appears to coincide with a number of possible pits and a possible cut feature. The presence of these anomalies could indicate the location of an archaeological site. This anomaly may have been cut by the test trenching which was undertaken in 2009 (Channing 2009) but no archaeological remains were recorded, possibly suggesting that the feature sits within the plough zone.	✓	
M117	Arcing magnetic anomaly containing a series isolated responses and an area of magnetic enhancement	718555.612,748960.18 Multiple locations	✓		✓				Sub-circular possible ditch, 19m in diameter which appears to enclose a number of possible pits. A zone of magnetic enhancement was detected within the area which may be associated with the ploughing of this feature or other archaeological remains surrounding it.	✓	
M118	Arcing magnetic anomaly	718576.995,748960.369	✓		✓				Possible ditch or cut feature, 18m in length which could be archaeological in origin and may be associated with M117 or M119.	✓	
M119	Three isolated responses and two arcing anomalies	718562.09,748934.125 Multiple locations	✓		✓				Two arcing possible ditches or cut features and three possible pits. These anomalies could be archaeological in origin.	✓	
M120	Linear magnetic anomaly	718577.617,748978.024	✓		✓				Linear possible ditch which may be agricultural in origin and may be associated with the adjacent boundary M101.	✓	
M121	Arcing magnetic anomaly	718477.843,748854.872	✓		✓				Arcing possible ditch or cut feature, 25m in length. This anomaly could be archaeological, agricultural or geological in origin.	✓	

Method of Assessment:	**Magnetometer**								**Site:**	**Lissenhall Little**
Site Description:	Slightly undulating harvested crop field which was overgrown with some weeds.									
Figure No.:	3, 4, 7 & 8									
No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
M122	Sub-circular magnetic anomaly	718469.701,748824.803	✓		✓				Sub-circular possible ditch, 50m in length and possibly enclosing an area 28m in diameter. Within this possible enclosure ditch a further arcing ditch was detected, 18m in length. These features may be archaeological in origin.	✓	
M123	Series of isolated responses and curvilinear anomalies	718502.583,748826.962 Multiple locations	✓		✓				A zone of possible pits and small cut features. The presence of these anomalies is suggestive of archaeological remains, possibly associated with M122, M124 & M125.	✓	
M124	Sub-rectangular magnetic anomaly dissected by a series of isolated responses	718511.6,748842.193	✓		✓				Sub-rectangular possible ditch, enclosing an area 6m x7m. This ditch appears to have been dissected by or contains seven possible pits. One additional pit was detected at the centre of the anomaly, while a further arcing possible ditch, 9m in length leads west.	✓	
M125	Series of curvilinear anomalies	718518.909,748818.72 Multiple locations	✓		✓				Series of possible ditches or cut features which appear to form a roughly rectangular series of divisions covering an area 30m by 15m. These anomalies could be archaeological in origin and may be associated with one feature or multiple.	✓	
M126	Series of interconnecting linear magnetic anomalies	718478.953,748806.135 Multiple locations	✓		✓				Series of interconnecting ditches which could be agricultural in origin. They however, appear to terminate to the southwest in a small arcing ditch, 13m in length and therefore may have an archaeological origin.	✓	
M127	Series of arcing magnetic anomalies and two isolated responses	718509.691,748767.035 Multiple locations	✓		✓				Series of possible ditches or cut features which appear to form an oval possible enclosure ditch, 23m in diameter which contains internal features and two possible pits. The location of the possible pits might suggest that they represent entrance features.	✓	
M128	Four isolated responses	Multiple locations			✓				Four possible pits which may be associated with M127 or M130.	✓	
M129	Linear magnetic anomaly	718495.349,748743.309	✓		✓				Linear ditch which may be agricultural in origin.	✓	
M130	Arcing highly magnetic anomaly	718514.92,748734.649	✓		✓				Arcing enclosure ditch which is associated with RMP DU011-131----. The enclosure ditch may contain burnt remains and measures at least 18m in diameter. The presence of magnetic disturbance to the south has masked the true extent of the feature.	✓	

Method of Assessment:	**Magnetometer**								**Site:**	**Lissenhall Little**
Site Description:	Slightly undulating harvested crop field which was overgrown with some weeds.									
Figure No.:	3, 4, 7 & 8									
No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
M131	Right-angled magnetic anomaly	718518.208,748727.076	✓		✓				Possible ditch or bounding feature which appears to be associated with the magnetic disturbance. The presence of multiple ferrous responses suggests that this feature may be relatively modern in origin, possibly associated with deposition.	✓	
M132	Two arcing magnetic anomalies	718677.27,748758.603, 718675.183,748738.788	✓		✓				Two arcing possible ditches or cut features which might be associated with archaeological remains, 20m in diameter.	✓	
M133	Arcing highly magnetic anomaly	718630.196,748774.253	✓	✓					Arcing ditch which contains burnt remain. This anomaly has similar geophysical characteristics to M102 & M130 and represents an archaeological enclosure, 33m in diameter. Two possible pits were detected within this enclosure.	✓	
M134	Series of isolated magnetic responses	718638.279,748798.156 Multiple locations			✓			✓	Six possible pits. These anomalies are relatively weak and therefore could be archaeological, agricultural or geological in origin.	✓	
M135	Four linear magnetic anomalies	718623.696,748839.722 Multiple locations	✓		✓				Four sections of linear ditch which appear to form a rough X shape. It is possible that these anomalies represent relict agricultural boundaries.	✓	
M136	Two magnetic anomalies	718599.393,748845.661 Multiple locations	✓		✓				Two possible ditches or cut features, 12m & 15m in length. These anomalies could be archaeological or agricultural in origin.	✓	
M137	Arcing magnetic anomaly	718608.789,748876.987	✓		✓				Arcing possible ditch, 16m in length. This anomaly could be archaeological, agricultural or geological in origin.	✓	
M138	Arcing magnetic anomaly	718638.182,748853.696	✓		✓				Arcing possible ditch, 47m in length which could be archaeological in origin and may be associated with M139.	✓	
M139	Series of arcing magnetic anomalies	718648.712,748882	✓		✓				Series of arcing possible ditches. The majority of these appear to interconnect and may represent archaeological remains, possibly associated with M138.	✓	
M140	Three areas of enhancement	Multiple locations			✓		✓		Three zones of raised magnetism which could be suggestive of ploughed out features either archaeological or agricultural in origin.	✓	
M141	Right-angled magnetic anomaly	718682.543,748830.235	✓		✓				Possible ditch, 26m in length which may represent an agricultural boundary.	✓	

Method of Assessment:	**Magnetometer**								**Site:**	**Lissenhall Little**
Site Description:	Slightly undulating harvested crop field which was overgrown with some weeds.									
Figure No.:	3, 4, 7 & 8									
No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
M142	Isolated area of high magnetism	718704.701,748827.264			✓		✓		Area of possible burnt remains measuring 7m in length which might be associated with archaeological or agricultural processes.	✓	
M143	Two interconnecting magnetic anomalies	718744.083,748815.71	✓		✓				Two possible ditches or cut features which may interconnect. Measuring 18m & 25m in length these anomalies could be agricultural or archaeological.	✓	
M144	Curvilinear magnetic anomaly	718714.183,748830.002 Multiple locations	✓		✓				Possible boundary ditch which was detected in four sections. This feature covers an area 193m long and may represent an agricultural boundary or be archaeological in origin. The southern portion of the anomaly suggests that the feature may contain a double ditch, while the northern section may be associated with an archaeological enclosure.	✓	
M145	Series of curvilinear magnetic anomalies	718725.339,748871.86 Multiple locations	✓		✓				Possible ditches or cut features which measure between 21m and 5m in length. These anomalies are suggestive of archaeological remains and are likely to be associated with M146.	✓	
M146	Series of isolated responses	718718.693,748877.957 Multiple locations			✓				Series of possible pits which are located within the southern portion of M148 and surrounding M145. These pits are likely to be archaeological in origin.	✓	
M147	Series of magnetic zones and a curvilinear magnetic anomaly	718694.525,748873.188 Multiple locations			✓				Four of magnetic zones were detected which appear to run in a curvilinear formation. These anomalies could present closely spaced pits or be associated with a ditch cut. It is likely that they are archaeological in origin and are probably associated with M145 & M146. The features terminate at an arcing possible ditch, 14m in length which is similar in composition to M145 and is likely to be archaeological.	✓	
M148	Series of highly magnetic anomalies	718739.018,748899.226 Multiple locations	✓	✓					Series of enclosure ditches covering an area 67m in width. This enclosure has been cut by a pipeline and the features are likely to extend closer to the pipe but have been obscured within the survey by the pipes magnetic interference. The anomalies indicate the presence of multiple internal divisions within the enclosure and possible ditch re-cuts.	✓	

Method of Assessment:	**Magnetometer**								**Site:**	**Lissenhall Little**
Site Description:	Slightly undulating harvested crop field which was overgrown with some weeds.									
Figure No.:	3, 4, 7 & 8									
No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
M149	Series of linear magnetic anomalies	718776.069,748906.989 Multiple locations	✓		✓				Possible ditches or internal divisions associated with enclosure M148. The presence of two wider magnetic anomalies to the south may represent archaeological deposits or ploughed out ditch fills.	✓	
M150	Series of linear magnetic anomalies	718759.748,748941.532 Multiple locations	✓		✓				Three linear ditches which are very similar in composition to M149 and could represent the continuation of internal divisions associated with enclosure M148.	✓	
M151	Series of isolated responses	718762.337,748945.898 Multiple locations			✓				Series of possible pits which are likely to be archaeological in origin and could be associated with enclosure M148.	✓	
M152	Series of magnetic zones	718769.456,748964.497 Multiple locations			✓				Five wider magnetic zones which could represent archaeological deposits, ploughed out ditch fills or agricultural features.	✓	
M153	Series of isolated responses	718796.638,748953.984 Multiple locations			✓				Four possible pits. These anomalies may be archaeological or agricultural in origin.	✓	
M154	Series of highly magnetic isolated responses	718790.651,748948.486 Multiple locations			✓		✓		Four highly magnetic pits or fired deposits. These anomalies may represent industrial activity or the site of relatively modern burning or deeply buried metallic deposits.	✓	
	Multiple linear and curvilinear magnetic trends	Multiple locations			✓		✓		Possible archaeological, agricultural or geological features.	✓	
	Linear highly magnetic anomaly	Multiple locations						✓	A modern services pipe running across the centre of the survey area.	✓	
	Areas of strongly magnetic responses	Multiple locations				✓		✓	Modern disturbance such as fencing materials, dumping against field boundaries, buried metal objects, pipes.		

Method of Assessment:	**Resistivity**								**Site:**	**Lissenhall Little**
Site Description:	Slightly undulating harvested crop field which was overgrown with some weeds.									
Figure No.:	5, 6, 9 & 10									
No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
R155	Arcing low resistivity anomaly	718543.093,749069.964	✓	✓					Arcing enclosure ditch, 29m in diameter, which was also detected in the magnetometer data M102.	✓	
R156	Arcing low resistivity anomaly	718492.843,749065.452	✓		✓				Arcing ditch, 44m in length which may be archaeological or agricultural in origin and possibly interlinks with R157	✓	
R157	Linear high resistivity anomaly	718482.802,749053.286			✓				Linear stone or compact earth feature, 29m in length which may represent a former agricultural boundary and could be associated with R160.	✓	
R158	Curvilinear low resistivity anomaly	718559.867,749060.908	✓		✓				Possible ditch or cut feature, 14m in length. This anomaly could be archaeological or agricultural in origin and may extend into R161.	✓	
R159	Series of isolated low resistivity anomalies	Multiple locations			✓				Small zones of disturbed or waterlogged soil which were detected in the northern portion of the survey area. These anomalies could represent archaeology, agricultural deposits or be associated with natural waterlogging.	✓	
R160	Right-angled high resistivity anomaly	718544.777,749045.366			✓				Right-angled stone or compact earth feature, 57m in length. This anomaly may represent a relict field boundary and may interlink with R161. It may represent a continuation of R157.	✓	
R161	Curvilinear low resistivity anomaly	718547.87,749030.793	✓		✓				Ditch or cut feature, 42m in length which may extend into R158. This anomaly could be archaeological or agricultural in origin.	✓	
R162	Series of isolated low resistivity anomalies	Multiple locations			✓				Linear zones of disturbed or waterlogged soil which were detected close to the eastern field boundary. These anomalies could represent archaeology but are more likely to be agricultural in origin or be associated with natural waterlogging.	✓	
R163	Area of low resistivity	718563.96,748994.291	✓		✓				Area of disturbed soil, 23m in length which could be archaeological in origin; however it is situated next to a relict field boundary and therefore could be archaeological in origin.	✓	
R164	Series of linear low resistivity anomalies	Multiple locations	✓						These ditches represent relict field boundaries and were detected in the magnetometer data.	✓	
R165	Circular low resistivity anomaly	718506.821,748987.028	✓	✓					Two sections of a circular ring-ditch, 13m in diameter. This anomaly was detected in the magnetometer data M108 and relates to RMP DU011-130----.	✓	

Method of Assessment:	**Resistivity**								**Site:**	**Lissenhall Little**
Site Description:	Slightly undulating harvested crop field which was overgrown with some weeds.									
Figure No.:	5, 6, 9 & 10									
No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
R166	Series of curvilinear and arcing low resistivity anomalies	718530.206,749008.795 Multiple locations	✓		✓				Series of possible ditches or cut features, between 22m & 15m in length which are suggestive of archaeological features. These anomalies are located within the vicinity of ring-ditch R165 and a series of pits. They may also be related to M111 & R180.	✓	
R167	Series of isolated low resistivity responses	Multiple locations			✓				Five possible pits located within the vicinity of ring-ditch R165. These anomalies are likely to be archaeological in origin.	✓	
R168	Isolated high resistivity response	718512.732,748954.694			✓		✓		Possible stone capped pit, near surface stone or compact archaeological deposit. The anomaly is located within the vicinity of R167 and ring-ditch R165 and therefore could be archaeological in origin.	✓	
R169	Four isolated high resistivity responses	Multiple locations			✓		✓		Possible stone capped pit, near surface stone or compact archaeological deposit which are located close to the pipeline which crosses the survey area.	✓	
R170	Three curvilinear low resistivity anomalies	Multiple locations	✓		✓				Possible ditches or cut features, between 33m & 22m in length, which may be archaeological or agricultural in origin.	✓	
R171	Two zones of low resistivity	718557.059,748959.817, 718571.278,748964.444			✓		✓		These areas of disturbed soil could be archaeological, agricultural or geological in origin, however they appear to coincide with anomaly M117 within the magnetometer data (a possible enclosure ditch and pits) and therefore an archaeological explanation for anomaly R171 is more likely.	✓	
R172	Three isolated high resistivity responses	718574.584,748968.741 Multiple locations			✓		✓		Possible stone capped pit, near surface stone or compact archaeological deposit which are located close to M117 and R171 and therefore may be related.	✓	
R173	Linear low resistivity anomaly	718493.571,748950.231	✓		✓				Linear possible ditch, 52m in length, which appears to probably run into ring-ditch R165. This anomaly could represent an archaeological or agricultural boundary.	✓	
R174	Linear low resistivity anomaly	718483.981,748968.741	✓		✓				Linear possible ditch, 140m in length which is likely to be agricultural in origin.	✓	
R175	Curvilinear low resistivity anomaly	718483.751,749029.101	✓		✓				Curvilinear possible ditch or cut feature, 24m in length. This anomaly could be agricultural in origin or associated with R166.	✓	

Method of Assessment:	**Resistivity**								**Site:**	**Lissenhall Little**
Site Description:	Slightly undulating harvested crop field which was overgrown with some weeds.									
Figure No.:	5, 6, 9 & 10									
No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
R176	Linear low resistivity anomaly	718439.219,749001.385	✓		✓				Ditch or cut feature, 57m in length which is likely to be agricultural in origin, possibly associated with the adjacent relict field boundary (R164) detected in both techniques.	✓	
R177	Linear low resistivity anomaly	718412.227,748999.113	✓		✓				Ditch or cut feature, 12m in length which could be archaeological, agricultural or geological in origin.	✓	
R178	Series of low resistivity anomalies	718417.39,748963.022 Multiple locations			✓		✓		Possible dug features that could be archaeological in origin. Alternatively these anomalies could relate to disturbed agricultural ground or waterlogged soils.	✓	
R179	Series of low resistivity isolated responses	718440.498,748953.815 Multiple locations			✓				Series of possible pits located in the northwestern half of the survey area. These pits are located in an area identified as containing many pits in the magnetometer data (M110) and a number of the anomalies appear to coincide	✓	
R180	Series of curvilinear low resistivity anomalies	718465.217,748966.027 Multiple locations	✓		✓				Possible ditches or cut feature, between 9m & 22m in length which are suggestive of archaeological remains. These anomalies are likely to be associated with M111 in the magnetometer data.	✓	
R181	Series of linear low resistivity anomalies	718465.426,748844.666 Multiple locations	✓		✓				Possible ditches or cut features which are likely to interlink and form a series of relict boundaries possibly agricultural in origin.	✓	
R182	Series of isolated low resistivity responses	718468.301,748822.584 Multiple locations			✓				Possible pits which are likely to be archaeological in origin. The northern of these anomalies form a roughly sub-circular formation which coincides with M122 a possible enclosure ditch.	✓	
R183	Linear area of low resistivity	718484.379,748825.885	✓		✓				This anomaly could represent a series of closely spaced pits, a ploughed out ditch or archaeological deposit. Measuring 19m in length it has a slightly arcing profile.		
R184	Linear low resistivity anomaly	718516.391,748763.259	✓		✓				Ditch or cut feature, 54m in length which is likely to represent a relict agricultural boundary.	✓	
R185	Linear low resistivity anomaly	718474.678,748742.289	✓		✓				Ditch or cut feature, 38m in length which is likely to represent a relict agricultural boundary.	✓	

Method of Assessment:	**Resistivity**								**Site:**	**Lissenhall Little**
Site Description:	Slightly undulating harvested crop field which was overgrown with some weeds.									
Figure No.:	5, 6, 9 & 10									
No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
R186	Zone of low resistivity	718480.363,748754.289			✓		✓		Area of disturbed or waterlogged soil, 28m x 17m. This anomaly could be archaeological, agricultural or geological in origin.	✓	
R187	Zone of high resistivity	718500.836,748740.207			✓		✓		Area of stony or compact soil, 26m x 10m. This anomaly could be archaeological, agricultural or geological in origin.	✓	
R188	Arcing low resistivity anomaly	718516.61,748735.177	✓	✓					Arcing enclosure ditch, 18m in diameter which matches the location of M130 and RMP DU011-131. The presence of a possible internal ditch, 12m in length, suggests that the monument might contain internal features or divisions.	✓	
R189	Arcing low resistivity anomaly	718633.545,748766.189	✓		✓				Arcing ditch or cut feature, 24m in length. This anomaly is in the vicinity of enclosure M133 and could be related.	✓	
R190	Four isolated low resistivity responses	718625.49,748771.89 Multiple locations			✓				Four possible pits which may be associated with enclosure M133.	✓	
R191	Zone of low resistivity	718647.641,748784.631			✓		✓		Area of disturbed or waterlogged soil, 13m x 8m, which could be archaeological, agricultural or geological in origin.	✓	
R192	Linear low resistivity anomaly	718622.858,748860.26	✓		✓				Possible ditch or cut feature which was detected on the edge of the survey area and therefore could be archaeological, agricultural or geological	✓	
R193	Three zones of low resistivity	Multiple locations			✓		✓		Zones of disturbed or waterlogged soil which could be archaeological, agricultural or geological. However their location close to or within possible archaeological remains detected in the magnetometer data, suggests that they are more likely to be archaeological in origin.	✓	
R194	Arcing low resistivity anomaly	718671.858,748860.595	✓		✓				Arcing ditch or cut feature, 25m in length which could represent a boundary feature enclosing anomalies R195.	✓	
R195	Series of curvilinear and arcing high resistivity anomalies	718685.954,748869.313 Multiple locations			✓				Compact earth or stone features which may be archaeological in origin. Measuring between 8m & 32m in length these features could be associated with M156, M156 & M147.	✓	

Method of Assessment:	**Resistivity**								**Site:**	**Lissenhall Little**
Site Description:	Slightly undulating harvested crop field which was overgrown with some weeds.									
Figure No.:	5, 6, 9 & 10									
No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
R196	Multiple low resistivity anomalies and isolated responses	Multiple locations	✓		✓				Series of possible ditches or cut features and pits which are likely to be archaeological in origin. These anomalies are located within the vicinity of M146 and close to enclosure M148.	✓	
R197	Three areas of low resistivity	718730.993,748906.353 Multiple locations			✓				Three large dug or disturbed ground features which coincide with a portion of enclosure ditch M148. The presence of three individual features within the resistivity data may indicate that this ditch is made up of individual deposits rather than one contiguous feature.	✓	
R198	Four areas of high resistivity	Multiple locations			✓		✓		Area of stony or compact soil, which could be archaeological, agricultural or geological in origin. Their location within a zone identified as archaeological prospective in the magnetometer data suggests that they are most likely archaeological in origin.	✓	
R199	Series of linear and arcing low resistivity anomalies	Multiple locations	✓		✓				Series of possible ditches or cut features which were detected within the vicinity of enclosure M148, both north and south of the modern pipeline. It is probable that these dug features represent internal and external divisions associated with the enclosure.		
R200	Series of isolated low resistivity responses	Multiple locations	✓		✓				Six possible pits which are likely to be associated with R199 as well as M150 & M151. It is likely that these pits are archaeological in origin.		
	Multiple parallel linear trends	Multiple locations						✓	Possible cultivation furrows, running in SW-NE direction, parallel to modern field boundary.		
	Linear areas of low resistivity	Multiple locations						✓	Pipeline which crosses the survey area.		

3.2 Balheary Demesne

Method of Assessment:		**Magnetometer**							**Site:**	**Balheary Demesne**
Site Description:		Flat parkland which contained short grass. The area was partially planted by trees and contained a pipeline and pathway.								
Figure No.:		11 & 12								
No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
	Areas of strongly magnetic responses	Multiple locations				✓		✓	Modern disturbance such as fencing materials, dumping against field boundaries, buried metal objects, footpaths.		
	Highly magnetic linear	Multiple locations						✓	Pipelines		

Method of Assessment:	**Resistivity**								**Site:**	**Balheary Demesne**
Site Description:	Flat parkland which contained short grass. The area was partially planted by trees and contained a pipeline and pathway.									
Figure No.:	13 & 14									
No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
R201	Arcing low resistivity anomaly	718581.926,748224.681							Arcing possible ditch, 32m in length which may be archaeological, agricultural or associated with the parkland construction.	✓	
R202	Isolated high resistivity response	718591.148,748180.535							Area of compact earth or stone, 5m in diameter which may be archaeological, agricultural or associated with the parkland construction	✓	
R203	Arcing low resistivity anomaly	718589.692,748172.854							Arcing possible ditch 10m in length which could be archaeological or agricultural in origin.	✓	
R204	Area of low resistivity	718597.938,748179.728							Area of disturbed or wet ground, 10m in diameter which may be archaeological, agricultural or associated with the parkland construction. It could also be associated with anomalies R203 and R205.	✓	
R205	Series of curvilinear low resistivity anomalies	718603.282,748188.458							Series of curvilinear possible ditches covering an area 13m x 4m. These anomalies could be archaeological in origin.	✓	
R206	Zone of high resistivity	718613.955,748203.823							Linear zone of compact earth or stone deposit, 10m in width, which is likely to be geological or associated with the composition of the parkland construction.	✓	
R207	Area of low resistivity	718626.737,748192.342							Area of disturbed or wet ground, 11m x 4m, which may be archaeological, agricultural or associated with the parkland construction.	✓	
R208	Two curvilinear low resistivity anomalies	718625.771,748208.51							Two possible ditches or cut features, 7m and 10m in length which may be archaeological, agricultural or associated with the parkland construction.	✓	
R209	Curvilinear low anomaly	718636.612,748192.339							Possible ditch or cut feature, 19m in length which forms a rough 'Z-shape'. This anomaly could be archaeological, agricultural or associated with the parkland construction.	✓	

3.3 Cloghran

Method of Assessment:	**Magnetometer**								**Site:**	**Cloghran**
Site Description:	Pasture field situated on a gentle north facing slope, which contained thick short to medium height grass.									
Figure No.:	15 & 16									
No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
M301	Linear magnetic anomaly	717548.699,744301.504	✓		✓				Possible ditch, 25m in length which could be archaeological or agricultural in origin.	✓	
M302	Linear magnetic anomaly	717567.507,744289.358	✓		✓				Possible ditch, 49m in length which could be archaeological or agricultural in origin.		
M303	Two interconnecting curvilinear magnetic anomalies	717567.507,744289.358	✓		✓				Two possible ditches, covering a length of 84m. These anomalies could represent archaeological or agricultural.	✓	
M304	Two interconnecting curvilinear magnetic anomalies	717665.894,744321.511	✓		✓				Two possible ditches which cross near the centre. Measuring 25m and 18m in length these anomalies could be agricultural or archaeological.	✓	
M305	Linear magnetic anomaly	717673.345,744301.505	✓		✓				Two sections of a linear ditch which is likely to represent a former field boundary or field division.	✓	
M306	Arcing magnetic anomaly	717638.494,744269.725	✓		✓				Arcing possible ditch, 17m in length which could be archaeological.	✓	
M307	Two interconnecting linear anomalies	717625.253,744259.388	✓		✓				Two interconnecting ditches which run parallel and at right-angles to M305 and therefore are likely to be associated and agricultural in origin.	✓	
M308	Linear magnetic anomaly	717687.228,744202.308	✓		✓				Linear possible ditch, 60m in length which is probably agricultural.	✓	
	Multiple linear and curvilinear magnetic trends	Multiple locations			✓		✓		Possibly associated with archaeology, agricultural or geology.	✓	
	Areas of strongly magnetic responses	Multiple locations				✓		✓	Modern disturbance such as, dumping, buried metal objects. It appears that the field has been used for modern dumping or soil deposition– may be masking underlying archaeological remains		
	Highly magnetic linear	717628.159, 744305.579						✓	Pipeline		

Method of Assessment:	**Resistivity**	**Site:**	**Cloghran**
Site Description:	Pasture field situated on a gentle north facing slope, which contained thick short to medium height grass.		
Figure No.:	17 & 18		

No.	Form of Anomaly	ITM (E,N)	Possible Source(s) of Anomaly						Comment	Recommendation	
			Ditch	**Archaeology**	**? Archaeology**	Ferrous	Geology / Soils	Interference / Modern		Test Excavation	Geophysical Survey
R309	Series of low resistivity linears	Multiple locations	✓		✓				Series of possible ditches, these could be agricultural in origin or associated with the soil dumping identified in the magnetometer data.	✓	
R310	Low resistivity linear	717535.868,744326.054	✓		✓				Possible ditch, 31m in length which is likely to be agricultural.	✓	
R311	Series of isolated low resistivity responses	Multiple locations			✓		✓		Series of possible pits which were detected across the survey area. Ranging in size from 14m to 2m in width these anomalies could be archaeological, agricultural or associated with the soil dumping	✓	
R312	Arcing high resistivity anomaly	717602.703,744322.498			✓		✓		Possible compact earth feature, 33m in length which could be archaeological, agricultural or associated with the soil dumping	✓	
R313	Two interconnecting low resistivity linears	717634.882,744251.06	✓		✓				Two interconnecting ditches which are likely to be agricultural in origin.	✓	
R314	Two arcing low resistivity anomalies	717671.703,744268.997, 717661.183,744268.378	✓		✓				Arcing ditch, 25m in diameter which possibly encloses a smaller ditch 17m in length. These features could represent archaeology.	✓	
R315	Arcing low resistivity anomaly	717657.625,744292.191	✓		✓				Ditch which measures 84m in length. This feature has an arcing terminus at the eastern end and runs east with two parallel tails, 11m apart.	✓	
R316	Low resistivity linear	717664.187,744316.138	✓		✓				Possible ditch, 54m in length this possibly terminates at R314.	✓	
R317	Two arcing high resistivity anomalies	717704.193,744334.095, 717719.664,744315.076			✓		✓		Two sections of arcing stone or compact earth feature, possibly enclosing an area 28m x 19m. This anomaly could be archaeological, agricultural or associated with the soil dumping.	✓	
R318	Low resistivity linear	717716.569,744304.097	✓		✓				Possible ditch, 28m in length	✓	
R319	Two arcing low resistivity anomalies	717700.789,744294.665, 717684.699,744305.798	✓		✓				Two sections of arcing ditch which represent the same anomaly. Measuring 27m x 20m this anomaly could be archaeological.	✓	
R320	Curvilinear low resistivity anomaly	717675.262,744285.696	✓		✓				Possible ditch, 31m in length	✓	
R321	Arcing low resistivity anomaly	717680.522,744236.679	✓		✓				Arcing possible ditch, 49m in length which could be archaeological or associated with soil dumping.	✓	
R322	Low resistivity linear	717664.123,744226.938							Possible agricultural ditch which matches the location of M305.	✓	

4 Conclusion

4.1 Summary of Results

At Lissenhall 1B an apparent diverse archaeological landscape has been revealed. The presence of enclosure DU011-131---- was confirmed through the geophysics, while suggesting that additional internal divisions may be present. A ring-ditch associated with RMP DU011-130---- was also confirmed, this monument had previously identified through aerial photography and previous Metro North test excavations. Surrounding this monument a series of pits and ditches were detected which suggest the presence of associated remains. Three further archaeological enclosures were identified, including a large multi-ditched enclosure in the northeast corner which has been cut by a pipeline.

Further potential archaeological activity was detected through a large number of possible pits. The majority of these are situated surrounding the large multi-ditched enclosure and across the northwest portion of the survey area. A number of possible enclosure ditches, sub-divisions and interconnecting ditches were detected within the vicinity which hint at a large multi-phased archaeological landscape.

The surveys undertaken within Balheary Demesne were heavily impacted by pipes and magnetic disturbance; however a number of features were detected which could be archaeological in origin or associated with the construction of the parkland. Magnetic disturbance and a pipe also impacted on the surveys at Cloghran where a number of agricultural boundaries, potential archaeological features and pits were detected.

4.2 Dissemination

The results of this survey were submitted to Jacobs Engineering/TII. Additional copies will be distributed in accordance with the Consent to use a Detection Device (see Appendix 2).

5 Acknowledgements

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7 Figures

Technical Appendix

Appendix 1: Anomaly Classifications

Magnetometer

Magnetometer surveys are undertaken using magnetic gradiometers which measure the magnetic content of the underlying soils. Measurements are gained using sensors which calculate the difference between the geological / pedological background and anthropogenic remains associated with archaeological activity.

Positive Magnetic Anomalies
Burnt features, particularly kilns, but also hearths, furnaces and burnt (specifically 'burnt', not 'heated') mounds of stone will create a strongly magnetic anomaly due to thermoremanence. Cut features, such as pits, ditches or wooden postholes will create anomalies that will vary in shape and magnetic intensity depending on which material they were backfilled by (Fassbinder 2015). For cut features backfilled (or 'refilled') by

- magnetically enhanced topsoil – the refill will generate a positive magnetic anomaly
- homogeneous topsoil – the refill will generate an anomaly proportional to the size and volume of the archaeological feature.

The magnetic anomaly shape and intensity will also be determined by concentrations of pottery, ash or burned material, solid rocks or other material.

Negative Magnetic Anomalies
Negative magnetic anomalies have a number of causes (Fassbinder 2015):

- The material remains of the archaeological feature may have a lower magnetic susceptibility (MS) than the adjacent topsoil. In some cases the MS of a ditch may appear as both a positive and negative anomaly, reflecting the variable MS of the refill material. Some stone foundations can also appear as weakly magnetic or negative magnetic anomalies.
- If a cut feature is immediately refilled by the same material e.g. a grave cut excavated before a funeral is (almost) immediately refilled by the human body and the same (unaltered) sediment that was excavated before.
- Geochemical processes (see Fassbinder 2015) can alter the magnetic response, e.g. an archaeological feature identified by a positive anomaly can convert to a negative anomaly due to the combination of stagnant moisture and a changing groundwater table.

Dipolar Anomalies
A dipolar anomaly is a response to buried ferrous objects, often in the topsoil. Iron spikes generally are not removed in geophysical data; although often modern in origin (iron agricultural implements, rubbish), they can be indicative of archaeological material.

Absence of Anomalies
It is also possible that archaeological features exist that exhibit no magnetic contrast and hence cannot be identified by magnetometer survey.

Anomaly classification used to interpret Magnetometer data

After Gaffney & Gater (2003) and Gaffney *et al*. (2000).

A known archaeological feature type e.g. Ditch / Wall / Structure etc: An anomaly with a magnetic gradient that contrasts strongly with the surrounding sub-soil, where the presence of a type of archaeological feature is known from supporting evidence.

Archaeology: A linear, curvilinear or isolated anomaly with a magnetic gradient that contrasts strongly with the surrounding sub-soil, without any supporting evidence from another source.

- **Ditch / Wall:** A linear, curvilinear, annular or penannular anomaly with a magnetic gradient that contrasts strongly with the surrounding sub-soil. A positive polarity suggests a ditch; a negative polarity suggests a stone-filled ditch or wall.
- **Burnt Mound / Spread:** A horseshoe or ovoid shaped anomaly with a positive magnetic gradient that contrasts strongly with the surrounding sub-soil. An associated trough may be observed as a positive/negative anomaly, a hearth may also be expected nearby. Isolated responses in the vicinity could represent spreads of (or ploughed out) heat shattered stones.
- **Hearth:** A small isolated area (<2m diameter) of higher magnetic gradient than the surrounding sub-soil (typically >6nT).
- **Pit:** A small isolated area (>1-2m diameter) of moderate to high magnetic gradient, judged to be caused by a pit-type feature with a fill more magnetic than the surrounding soil.

Industrial: An isolated anomaly with a strong positive gradient (>30nT), judged not to be surface iron. This type of anomaly is typically caused by the remains of kilns or furnaces.

Magnetic Enhancement: A broad area of moderate positive magnetic gradient that contrasts with the surrounding sub-soil. May represent cultural noise associated with occupation or soil disturbance, judged to be of archaeological origin.

Ferrous: Dipolar anomalies indicating ferrous responses, judged to be in the near-surface.

Cultivation: Parallel linear responses of positive or negative polarity. Strong responses may indicate added magnetic material (e.g. burnt deposits) as fertiliser. Lower magnetic gradient anomalies 'beneath' the furrow overprint may be obscured. Higher magnetic gradient anomalies may be visualised *in situ* or ploughed out 'beneath' the furrow overprint.

Possible Archaeology: A linear, curvilinear or isolated anomaly with a magnetic gradient that contrasts weakly with the surrounding sub-soil, without any supporting evidence from another source. Such categories may represent possible archaeological or geological sources.

Modern Disturbance: Area where the ground has been disturbed in the recent past. Characterised by very large magnetic gradients and a high level of noise often accompanied by concentrations of dipolar, near-surface ferrous responses. This category also represents anomalies whose source may lie beyond the survey area, such as fencelines, vehicles or modern buildings.

Modern Pipe: Straight, linear anomaly with very large magnetic gradients alternating regularly between positive and negative polarity.

Previous Excavation: Area of uniform magnetic signal contained within a well-defined boundary in regions otherwise densely covered with archaeological anomalies.

Geology: Anomalies of possible geomorphological origin.

Electromagnetic Apparent Electrical Resistivity

Electromagnetic instruments transmit an alternating current which induces a primary and subsequently a secondary electromagnetic field which interacts with the underlying soils. One of the subsequent responses is the Apparent Electrical Conductivity of the soil, which are subsequently calculated via automated software to Apparent Electrical Resistivity (ER_a).

Anomaly classification used to interpret ER_a data

After Gaffney & Gater (2003) and Gaffney *et al*. (2000).

A known archaeological feature type e.g. Ditch / Wall / Structure etc: An anomaly with a ER_a that contrasts strongly with the surrounding sub-soil, where the presence of a type of archaeological feature is known from supporting evidence.

Archaeology: A linear, curvilinear or isolated anomaly with an ER_a that contrasts strongly with the surrounding sub-soil, without any supporting evidence from another source.

- **Ditch / Wall:** A discrete linear, curvilinear, annular or penannular anomaly with an ER_a that contrasts strongly with the surrounding sub-soil. A low ER_a suggests a ditch; a high ER_a suggests a stone-filled ditch or wall.
- **Mound of Stones:** A discrete horseshoe or ovoid shaped anomaly with a higher ER_a than the surrounding sub-soil.
- **Pit:** A small isolated area (>1-2m diameter) of ER_a that contrasts with the surrounding sub-soil, judged to be caused by a pit-type feature.
- **Cultivation:** Parallel linear responses of high or low ER_a.
- **Disturbed Soil:** A broad area of moderate ER_a change that contrasts with the surrounding sub-soil. May represent cultural noise associated with soil disturbance, judged to be of archaeological origin.

High ER_a Anomalies
Soils comprised of materials of a higher ER_a than the surrounding soil will exhibit anomalies of 'higher resistivity'. These are likely to include stone walls, masonry, rubble, cobbled or gravel surfaces, as well as near surface geology.

Low ER_a Anomalies
Soils that are comprised of materials of a lower ER_a than the surrounding soil will exhibit anomalies of 'lower resistivity'. These are likely to include ditches, drainage ditches and pits, as well as palaeochannels, drained soils, a high water table, deep topsoil, springs, boggy areas, areas adjacent to rivers and clay soils.

Modern Disturbance: Area where the ground has been disturbed in the recent past. Characterised by very large ER_a gradients and a high level of noise.

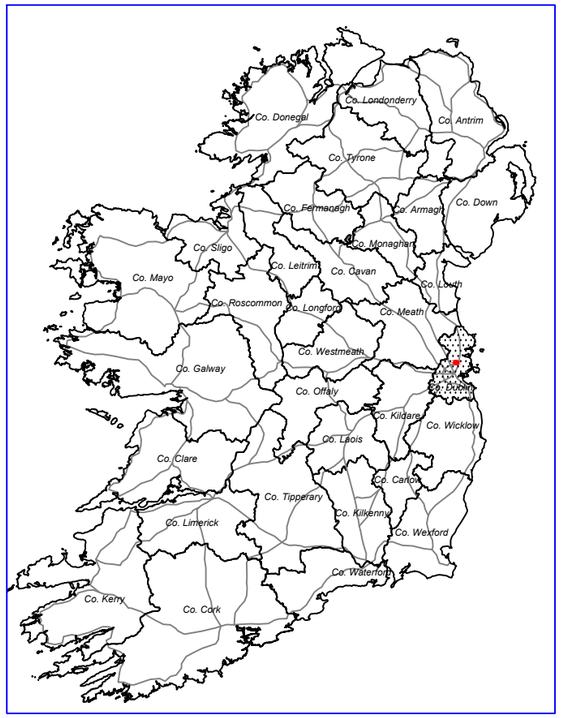
Modern Pipe: Straight, linear anomaly with an ER_a contrast.

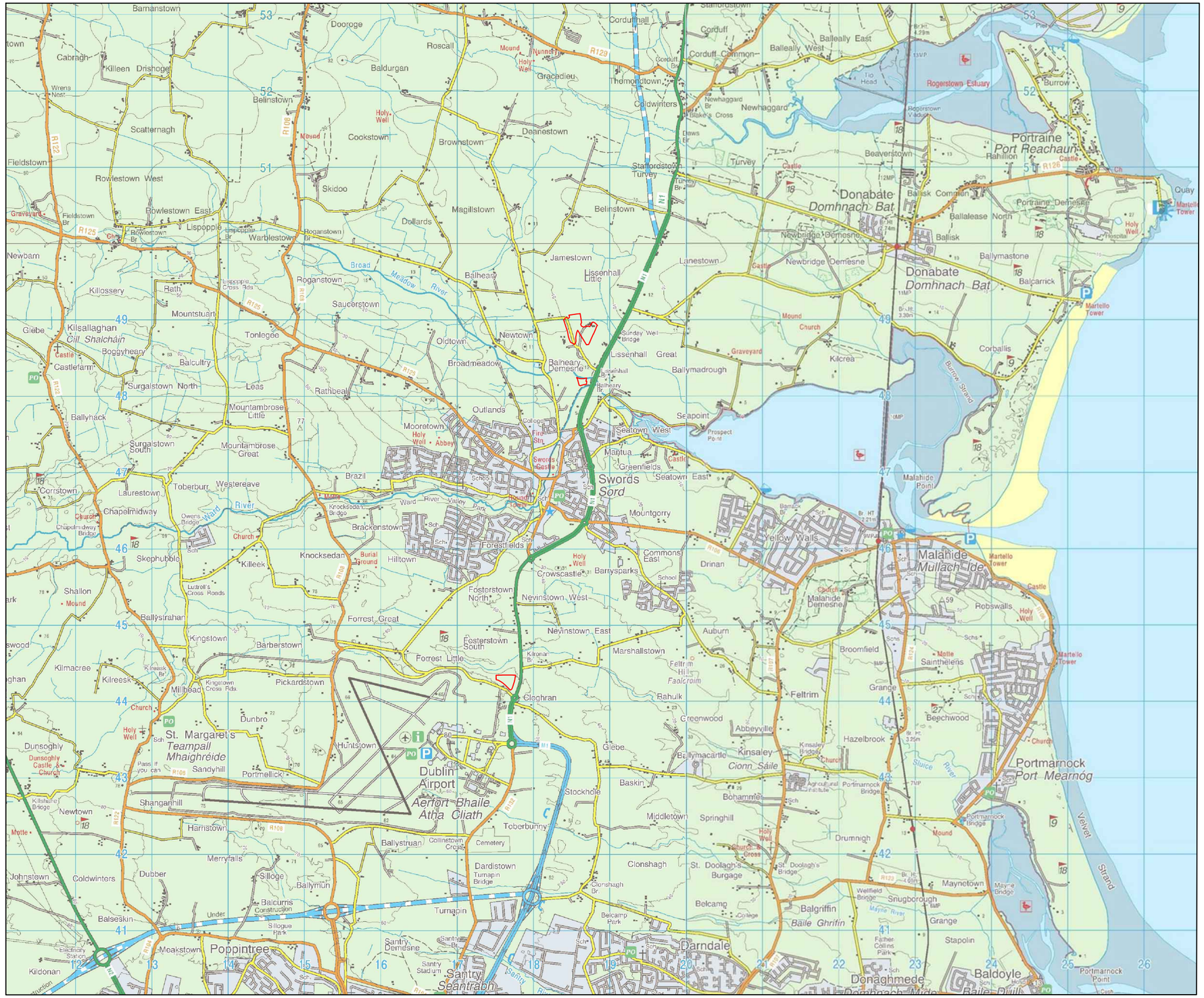
Geology: Anomalies of possible geomorphological origin.

Absence of Anomalies
It is also possible that archaeological features exist that exhibit no resistivity contrast and hence cannot be identified by Apparent Electrical Resistivity survey.

Appendix 2: Geophysical Archive

- Copies of the archive are held by Earthsound Archaeological Geophysics, at separate locations to ensure preservation against accidental damage or theft.
- The Client, Jacobs Engineering/TII, holds further copies of the report.
- A hard copy and a soft copy will be deposited with the Archaeological Licensing Section, National Monuments Service, Department of Housing, Local Government and Heritage, Room G50, Custom House, Dublin 1.
- A hard copy will be deposited with the National Museum of Ireland, Kildare Street, Dublin





Legend

Geophysical Survey Area

Site Location: MetroLink, Dublin - Phase IV

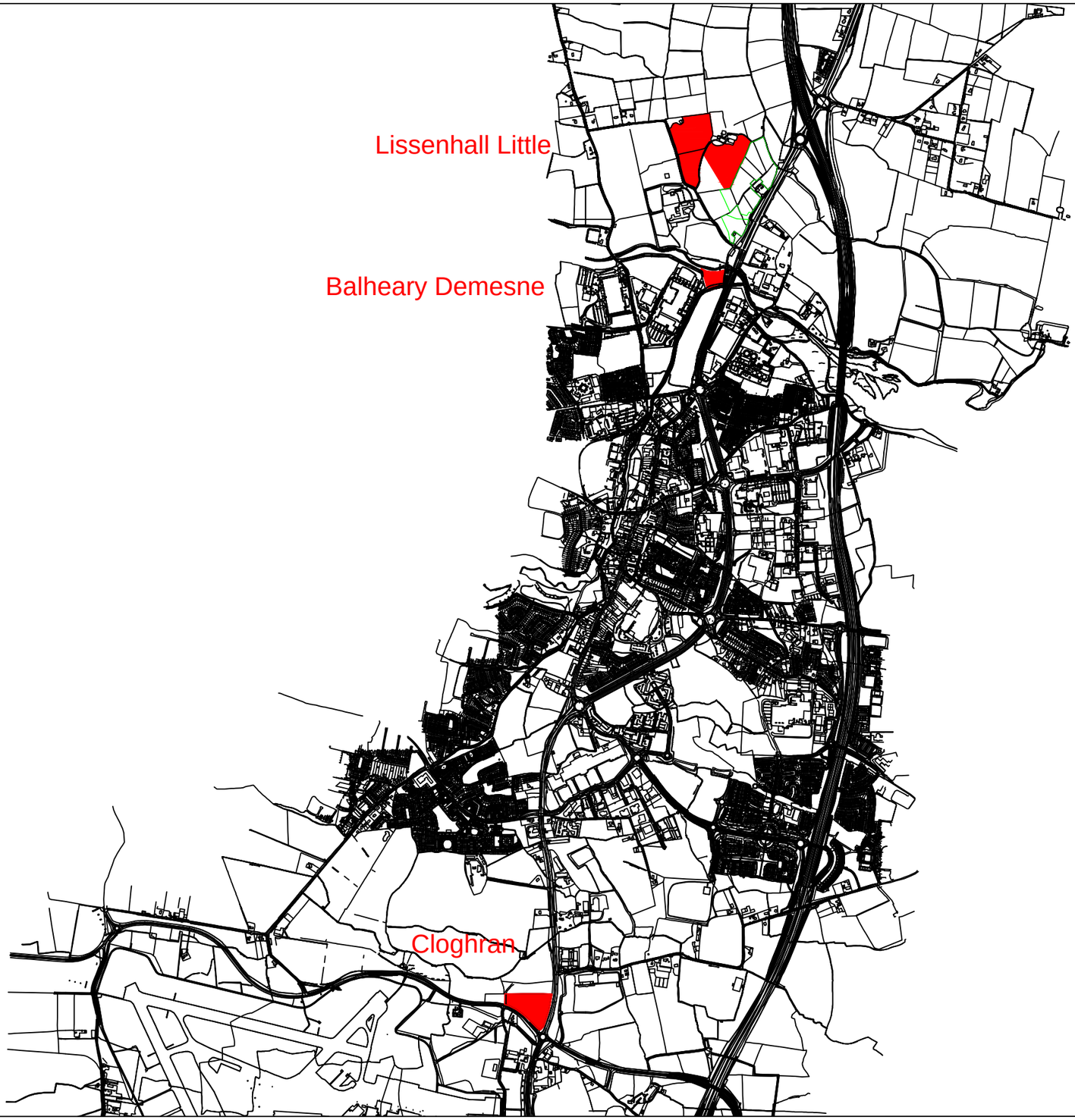
Client: Jacobs / TII

Drawing Courtesy of: OSI	Date: 03/03/21	Drawing No.: 20-076/01

0m 1km 2km

Figure No. 1: Location Map

EARTHSOUND geophysics



Legend

- Basemap
- Geophysical Survey Area
- Geophysical Survey Area undertaken in 2019 by this company for Metrolink

Site Location: MetroLink, Dublin - Phase IV

Client: Jacobs / TII

Drawing Courtesy of: OSI	Date: 03/03/21	Drawing No.: 20-076/02

0m 1000m 2000m

Figure No. 2: Detailed Location Map

EARTHSOUND geophysics

Legend

Basemap

nT

-2 0 2

Site Location: MetroLink, Dublin - Phase IV

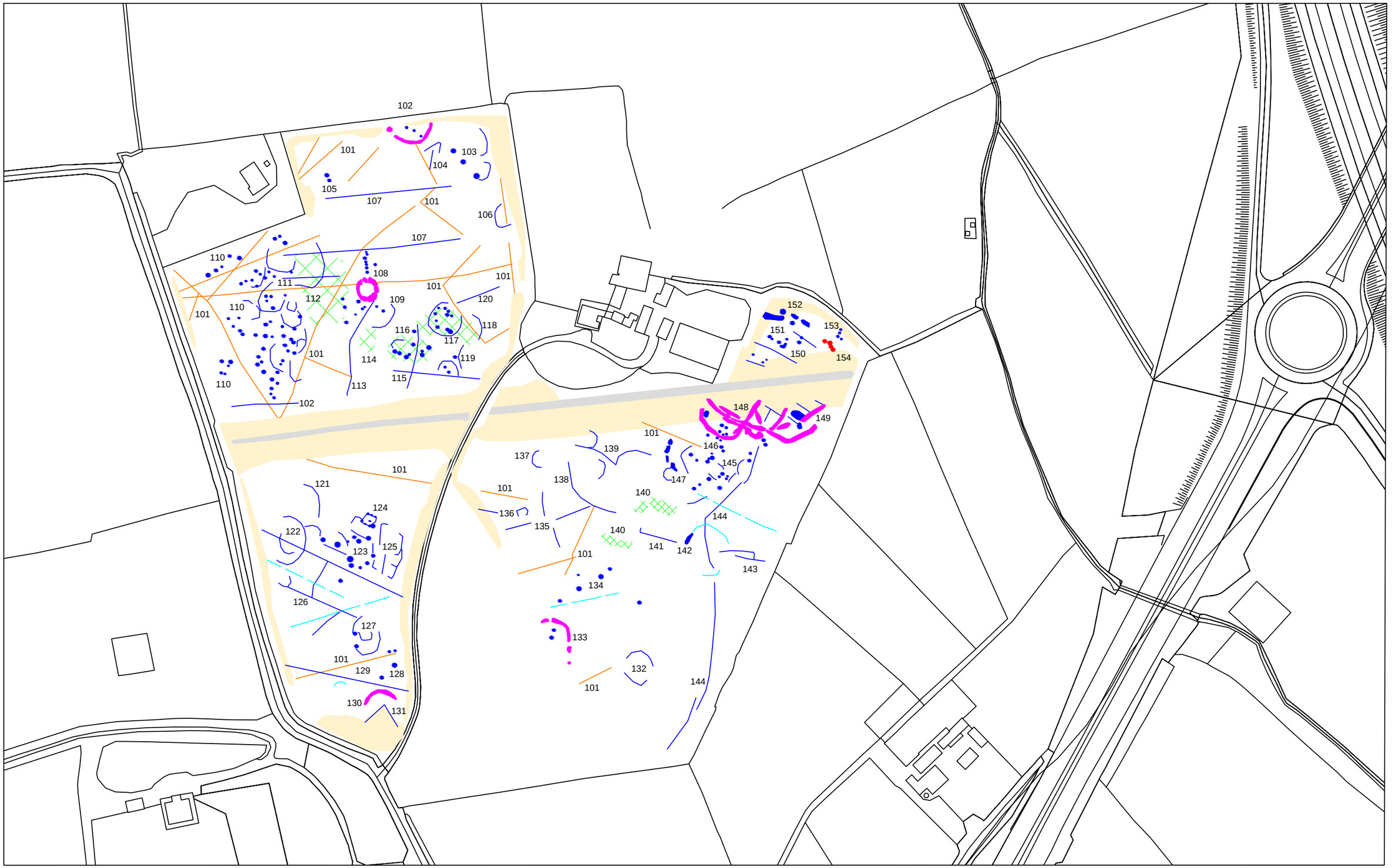
Client: Jacobs / TII

Drawing Courtesy of: OSI | Date: 03/03/21 | Drawing No.: 20-076/03

0m 100m 200m

Figure No. 3: Magnetometer Data: Lissenhall Little

EARTHSOUND geophysics



Legend

Basemap

- Archaeology
- Possible Archaeology
- Industrial
- Magnetic Enhancement
- Trend
- Probable Agricultural Boundary
- Modern Disturbance
- Modern Pipe

Site Location: MetroLink, Dublin - Phase IV

Client: Jacobs / TII

Drawing Courtesy of: OSI	Date: 25/03/21	Drawing No.: 20-076/04

0m 100m 200m

Figure No. 4: Magnetometer Interpretation: Lissenhall Little

EARTHSOUND geophysics

Legend

Basemap

mS/m

-7 0 7

Site Location: MetroLink, Dublin - Phase IV

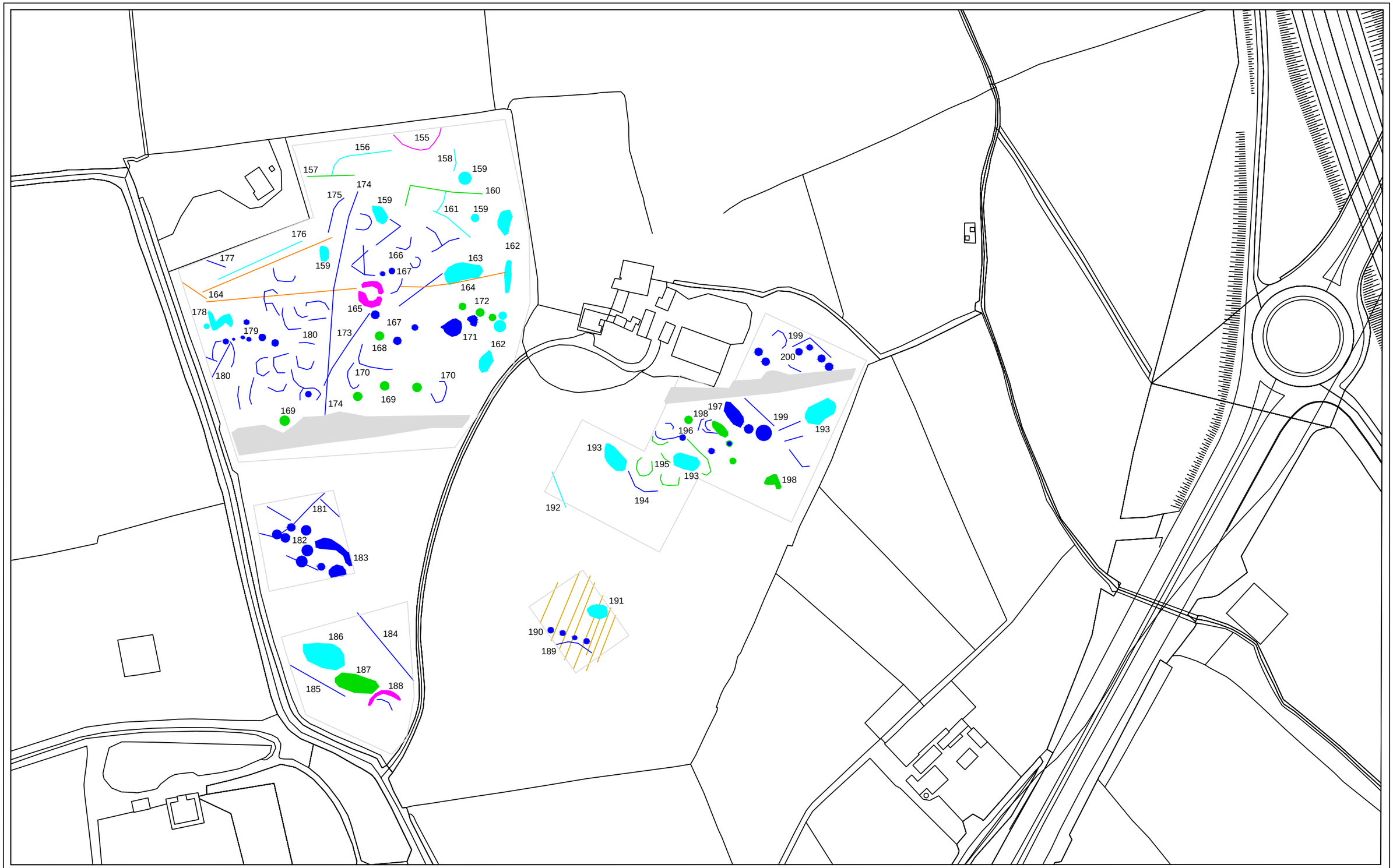
Client: Jacobs / TII

Drawing Courtesy of: OSI | Date: 03/03/21 | Drawing No.: 20-076/05

0m 100m 200m

Figure No. 5: Resistivity Data: Lissenhall Little

EARTHSOUND geophysics



Legend

- Basemap
- Survey Areas
- Archaeology
- Possible Archaeology
- Low Resistivity Anomaly
- High Resistivity Anomaly
- Probable Agricultural boundary
- Cultivation
- Modern Pipe

N

Site Location: MetroLink, Dublin - Phase IV

Client: Jacobs / TII

Drawing Courtesy of: OSI	Date: 25/03/21	Drawing No.: 20-076/06

0m 100m 200m

Figure No. 6: Resistivity Interpretation: Lissenhall Little

EARTHSOUND geophysics

Legend

- Basemap
- Geophysical Survey Area 2021
- Geophysical Survey Area 2019

nT

-2 0 2

Site Location: MetroLink, Dublin - Phase IV

Client: Jacobs / TII

Drawing Courtesy of: OSI	Date: 03/03/21	Drawing No.: 20-076/07

0m 150m 300m

Figure No. 7: Combined Earthsound Magnetometer Data at Lissenhall Little

EARTHSOUND geophysics

Legend

- Basemap
- Geophysical Survey Area 2021
- Geophysical Survey Area 2019
- Archaeology
- Possible Archaeology
- Industrial
- Magnetic Enhancement
- Trend
- Probable Agricultural Boundary
- Modern Disturbance
- Modern Pipe
- Cultivation Furrows

N

Site Location: MetroLink, Dublin - Phase IV

Client: Jacobs / TII

Drawing Courtesy of: OSI	Date: 25/03/21	Drawing No.: 20-076/08

0m 150m 300m

Figure No. 8: Combined Earthsound Magnetometer Interpretation at Lissenhall Little

EARTHSOUND geophysics

Legend

- Basemap
- Geophysical Survey Area 2021
- Geophysical Survey Area 2019

mS/m

Low — High

Site Location: MetroLink, Dublin - Phase IV

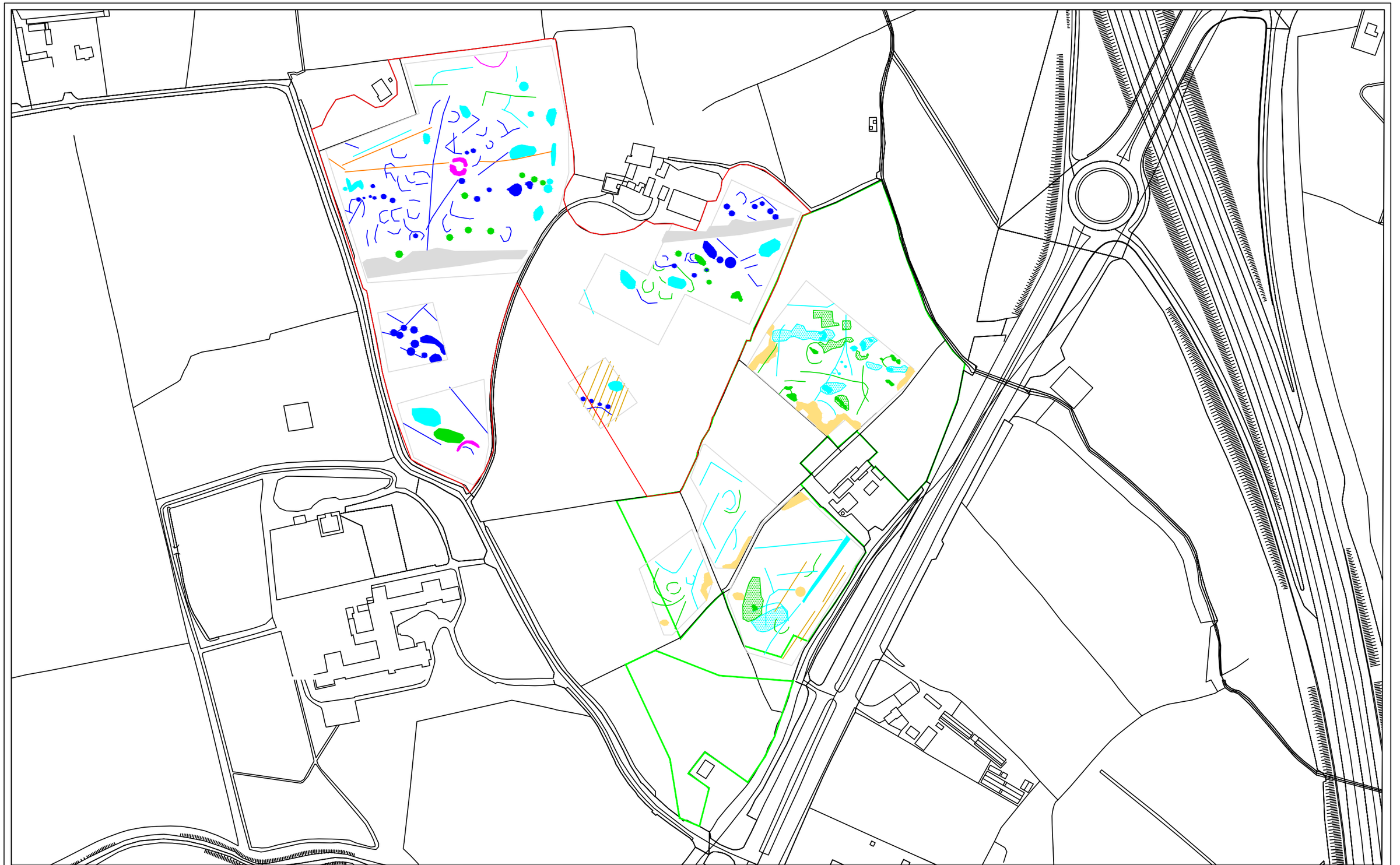
Client: Jacobs / TII

Drawing Courtesy of: OSI	Date: 03/03/21	Drawing No.: 20-076/09

0m — 150m — 300m

Figure No. 9: Combined Earthsound Resistivity Data at Lissenhall Little

EARTHSOUND geophysics



Legend

- Basemap
- Geophysical Survey Area 2021
- Geophysical Survey Area 2019
- Survey Areas
- Archaeology
- Possible Archaeology
- Low Resistivity Anomaly
- High Resistivity Anomaly
- Probable Agricultural boundary
- Cultivation
- Modern Pipe
- Modern Disturbance

N

Site Location: MetroLink, Dublin - Phase IV

Client: Jacobs / TII

Drawing Courtesy of: OSI	Date: 25/03/21	Drawing No.: 20-076/10

0m 150m 300m

Figure No. 10: Combined Earthsound Resistivity Interpretation at Lissenhall Little

EARTHSOUND geophysics

Legend

Basemap

nT

-2 0 2

Site Location: MetroLink, Dublin - Phase IV

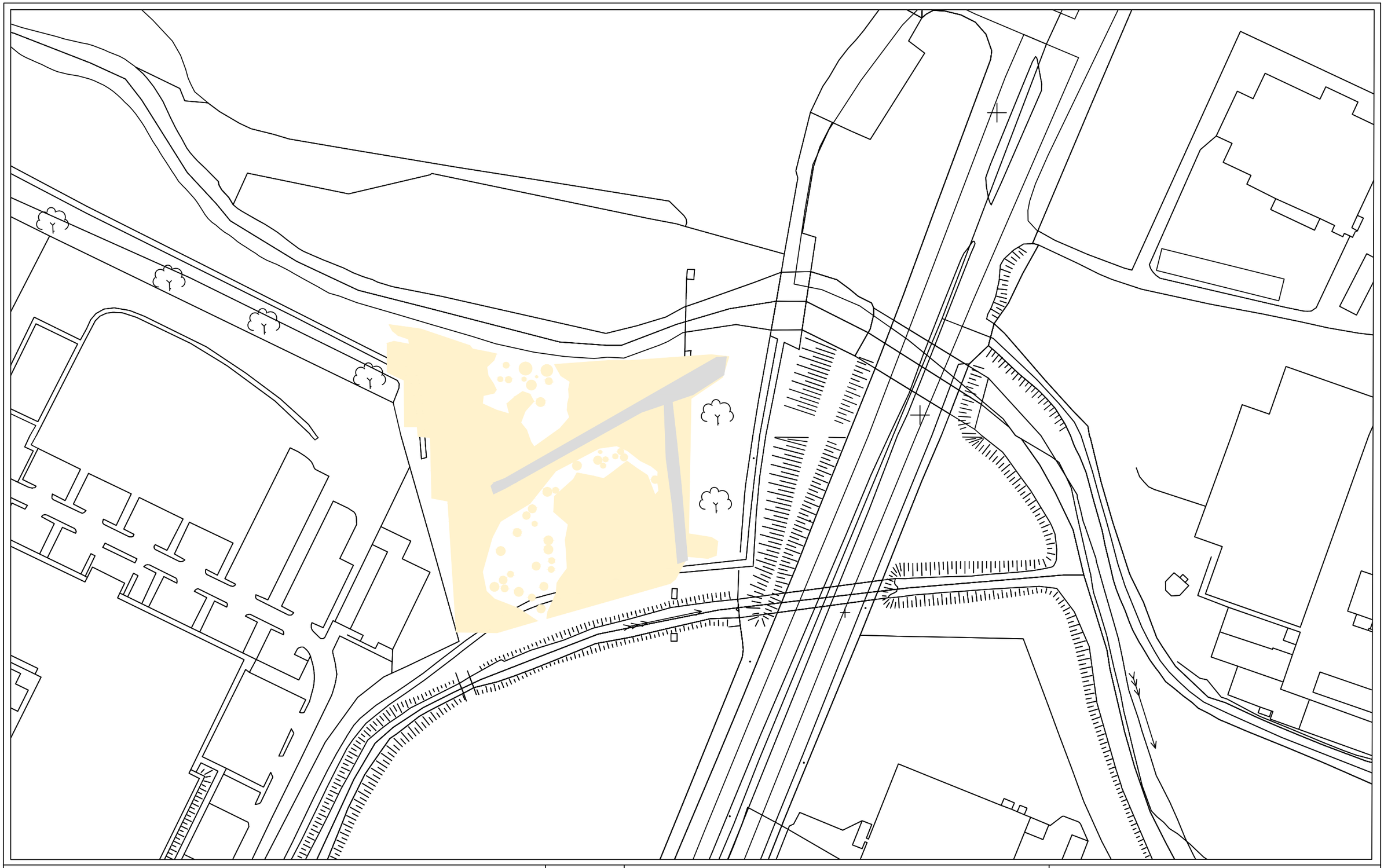
Client: Jacobs / TII

Drawing Courtesy of: OSI | Date: 15/03/21 | Drawing No.: 20-076/11

0m 50m 100m

Figure No. 11: Magnetometer Data: Balheary Demesmne

EARTHSOUND geophysics



Legend

Basemap

- Archaeology
- Possible Archaeology
- Industrial
- Magnetic Enhancement
- Trend
- Probable Agricultural Boundary
- Modern Disturbance
- Modern Pipe

N

Site Location: MetroLink, Dublin - Phase IV

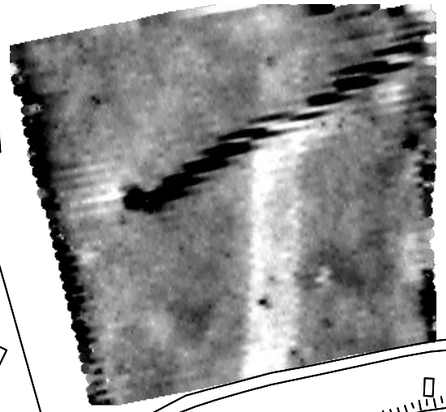
Client: Jacobs / TII

Drawing Courtesy of: OSI	Date: 23/03/21	Drawing No.: 20-076/12

0m 50m 100m

Figure No. 12: Magnetometer Interpretation: Balheary Demesne

EARTHSOUND geophysics



Legend

Basemap

mS/m

-7 0 7

Site Location: MetroLink, Dublin - Phase IV

Client: Jacobs / TII

Drawing Courtesy of: OSI | Date: 19/03/21 | Drawing No.: 20-076/13

0m 50m 100m

Figure No. 13: Resistivity Data: Balheary Demesne

EARTHSOUND geophysics

Legend

- Basemap
- Survey Area
- Archaeology
- Possible Archaeology
- Low Resistivity Anomaly
- High Resistivity Anomaly
- Probable Agricultural boundary
- Cultivation
- Modern Pipe

N

Site Location: MetroLink, Dublin - Phase IV

Client: Jacobs / TII

Drawing Courtesy of: OSI	Date: 22/03/21	Drawing No.: 20-076/14

0m 50m 100m

Figure No. 14: Resistivity Interpretation: Balheary Demesne

EARTHSOUND geophysics

Legend

Basemap

nT

-2 0 2

Site Location: MetroLink, Dublin - Phase IV

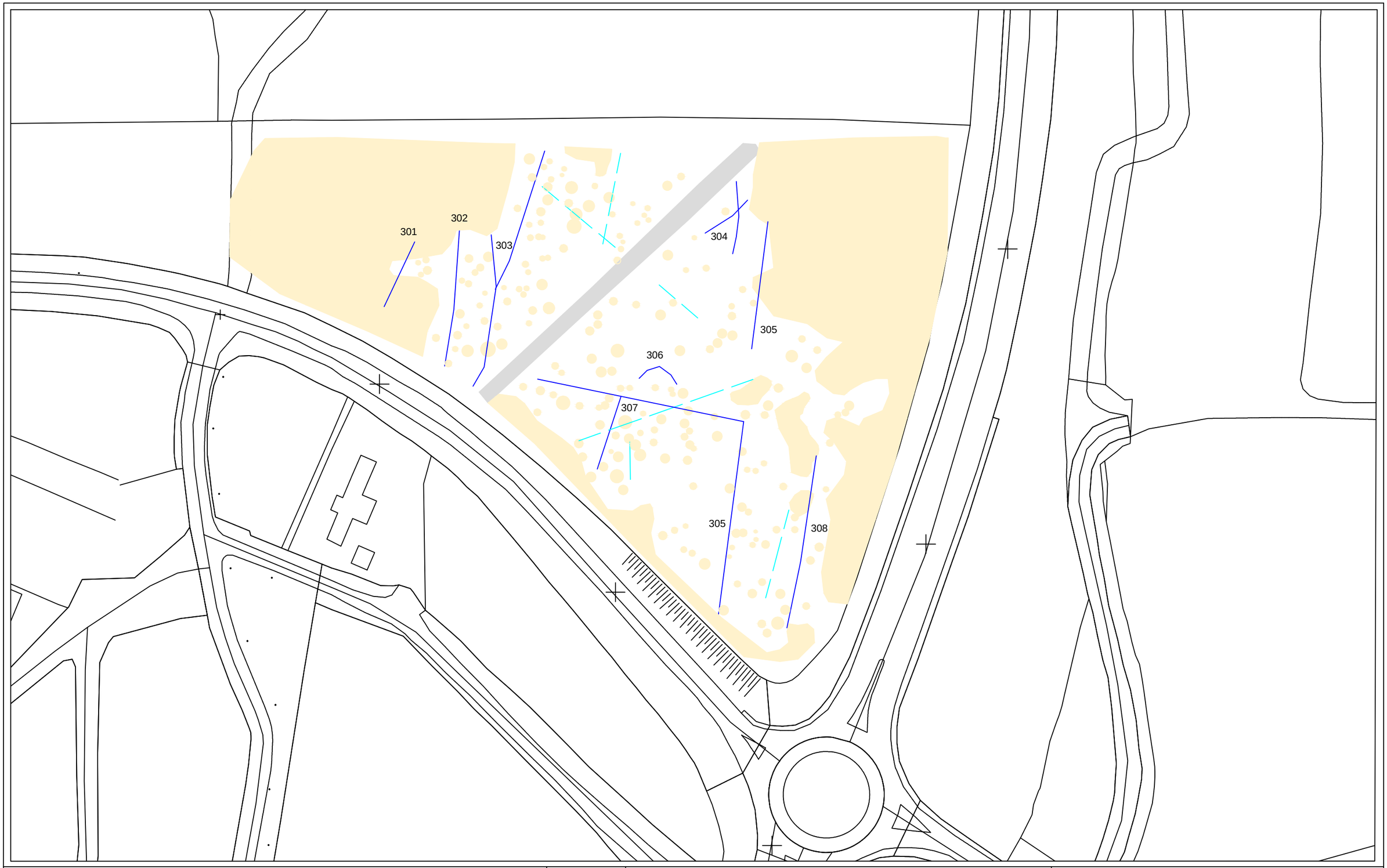
Client: Jacobs / TII

Drawing Courtesy of: OSI | Date: 15/03/21 | Drawing No.: 20-076/15

0m 50m 100m

Figure No. 15: Magnetometer Data: Cloghran

EARTHSOUND geophysics



Legend

Basemap

Archaeology
Possible Archaeology
Industrial
Magnetic Enhancement
Trend
Probable Agricultural Boundary
Modern Disturbance
Modern Pipe

N

Site Location: MetroLink, Dublin - Phase IV

Client: Jacobs / TII

Drawing Courtesy of: OSI	Date: 22/03/21	Drawing No.: 20-076/16

0m 50m 100m

Figure No. 16: Magnetometer Interpretation: Cloghran

EARTHSOUND geophysics

Legend

Basemap

mS/m

-7 0 7

Site Location: MetroLink, Dublin - Phase IV

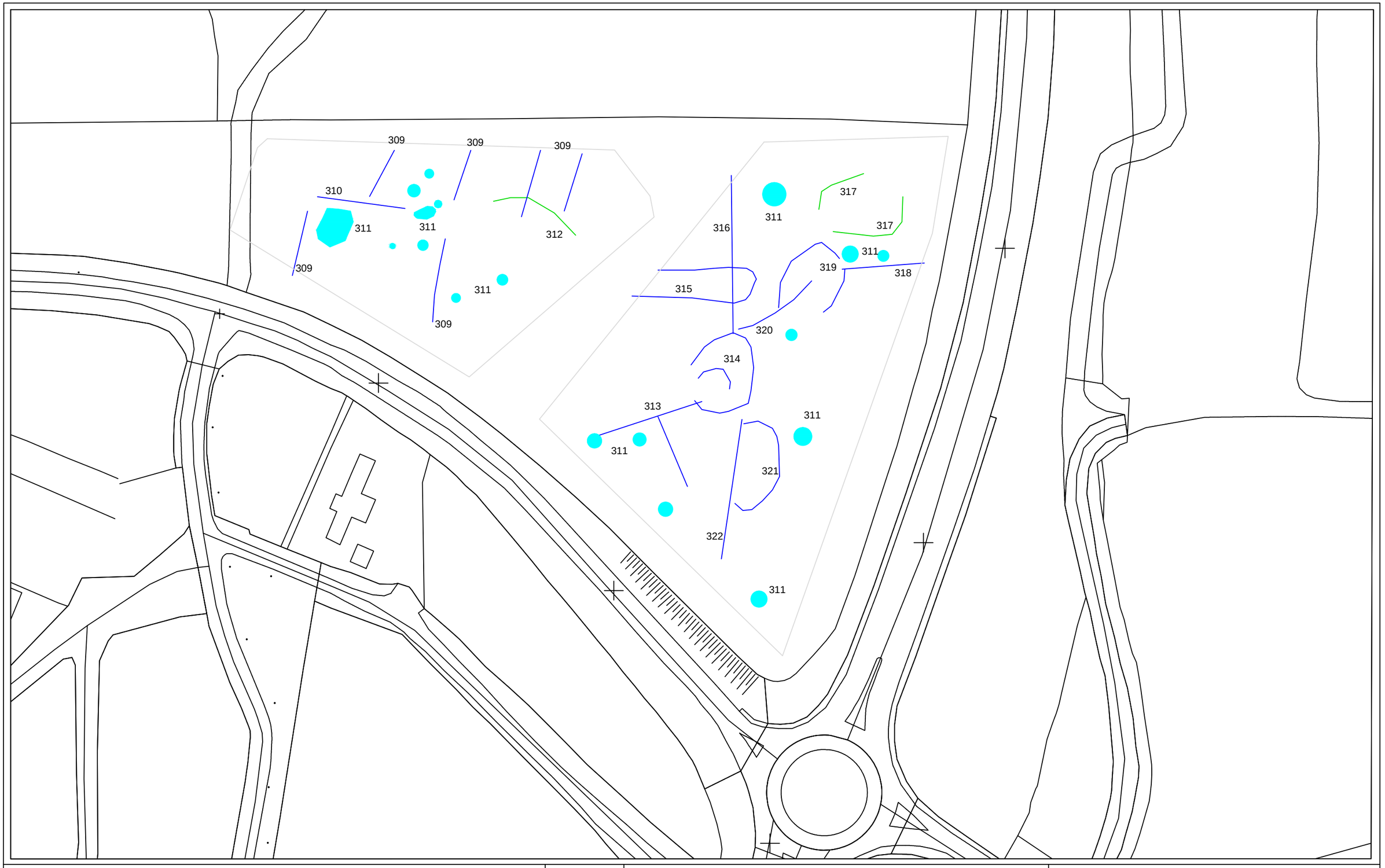
Client: Jacobs / TII

Drawing Courtesy of: OSI | Date: 19/03/21 | Drawing No.: 20-076/17

0m 50m 100m

Figure No. 17: Resistivity Data: Cloghran

EARTHSOUND geophysics



Legend

- Basemap
- Survey Areas
- Archaeology
- Possible Archaeology
- Low Resistivity Anomaly
- High Resistivity Anomaly
- Probable Agricultural boundary
- Cultivation
- Modern Pipe

N

Site Location: MetroLink, Dublin - Phase IV

Client: Jacobs / TII

Drawing Courtesy of: OSI	Date: 23/03/21	Drawing No.: 20-076/18

0m 50m 100m

Figure No. 18: Resistivity Interpretation: Cloghran

EARTHSOUND geophysics