Appendix 17.3B –Geophysical Survey Report

GEOPHYSICAL SURVEY REPORT

Project

ARCHAEOLOGICAL MAGNETIC GRADIOMETRY SURVEY

Location

Kellystown, County Dublin

Client

Courtney Deery Heritage Consultancy

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NMS Detection Licence: 23R0523
February 2025
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GEOPHYSICAL SURVEY REPORT

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Archaeological Magnetic Gradiometry Survey

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Kellystown, County Dublin

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Courtney Deery Heritage Consultancy

Archaeological consultant: T Young MA PhD FGS FSA
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Reviewer: S Hughes PhD BSc FGS
Job Reference: 9275
Date: February 2025

Revisions

Version	Status	Date	Author	Reviewer	Description of Changes
1.0	Draft	13/02/2025	JR Mertes	C Bird	Draft for review
2.0	Final	14/02/2025	JR Mertes	S Hughes	Final draft

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1 EXECUTIVE SUMMARY

A magnetic gradiometry survey was conducted at Kellystown, County Dublin in January 2025, examining a proposed residential development site. The survey was carried out by TerraDat under NMS license 23R0523, using a Sensys Magneto MXV3 system mounted on an ATV, following up on previous surveys from 2023 and 2024.

The site is a greenfield environment within Kellystown townland, centered at ITM coordinates [705891, 737727]. It is bordered by railway tracks to the north (between Clonsilla and Coolmine stations), with St. Mochtas FC approximately 30m to the southeast. The site measures approximately 3 hectares and contains no known Sites and Monuments Records (SMR) within or near its boundary.

The survey data quality was generally good, despite some minor "tank tracking" effects from cart movement and occasional gaps due to obstacles. The site exhibits a wide spread of ferrous material, likely attributed to magnetic mineral-bearing clasts within the glacial till, and several pit-like features that probably represent tree-boles. However, an archaeological origin cannot be ruled out.

Only one feature (Site 1) was identified as potentially archaeologically significant. This feature consists of a broad circular ditch approximately 10 meters in diameter, bisected by the western field boundary. It includes what appears to be an external bank with an internal ditch and shows evidence of highly magnetic fill in its southeastern quadrant, suggesting possible occupation activity. A strong dipolar response at the centre could indicate either ferrous material or burning.

2 INTRODUCTION

2.1 This report describes a geophysical survey conducted within Kellystown Townland, Co. Dublin. Two previous phases of survey work were conducted in 2023 and 2024 (ref TD report numbers 8858, 8712). The proposed development site (PDS) is being considered for residential-led development. A high-resolution magnetic gradiometry survey covering all accessible parts of the survey area was conducted to identify features that may be of archaeological significance.

2.2 The geophysical survey was conducted under an extension to Licence No. 23R0523, issued by the National Monuments Service.

2.3 Site description

2.3.1 The PDS is a greenfield environment within Kellystown townland. The site is centred on Irish Transverse Mercator (ITM) grid coordinates [705891, 737727] and is bordered to the north by the railway, halfway between Clonsilla and Coolmine stations. St. Mochtas FC is approximately ~30 m to the SE. The site measures ~3 ha. Plate 1 shows the site location, and Plate 2 shows the extent of the survey area in detail.

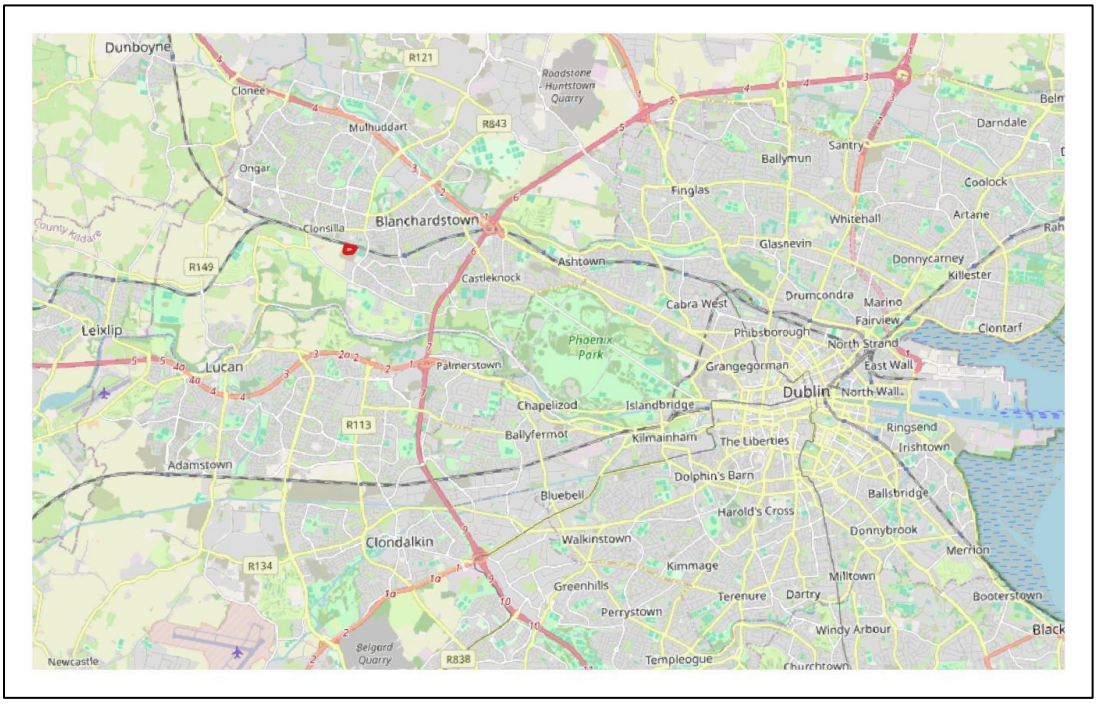


Plate 1: *Site location*

Plate 2: *Detail of the survey area and nearby SMRs*

2.4 Geological setting

2.4.1 The Geological Survey Ireland (GSI) maps the survey area as almost entirely underlain by glacial till derived from limestones (Plate 3, left). The bedrock geology consists of calcareous shale, limestone conglomerate of the Tober Colleen Formation and some dark limestone and shale of the Lucan Formation in the eastern extents of the survey area (Plate 3, right).

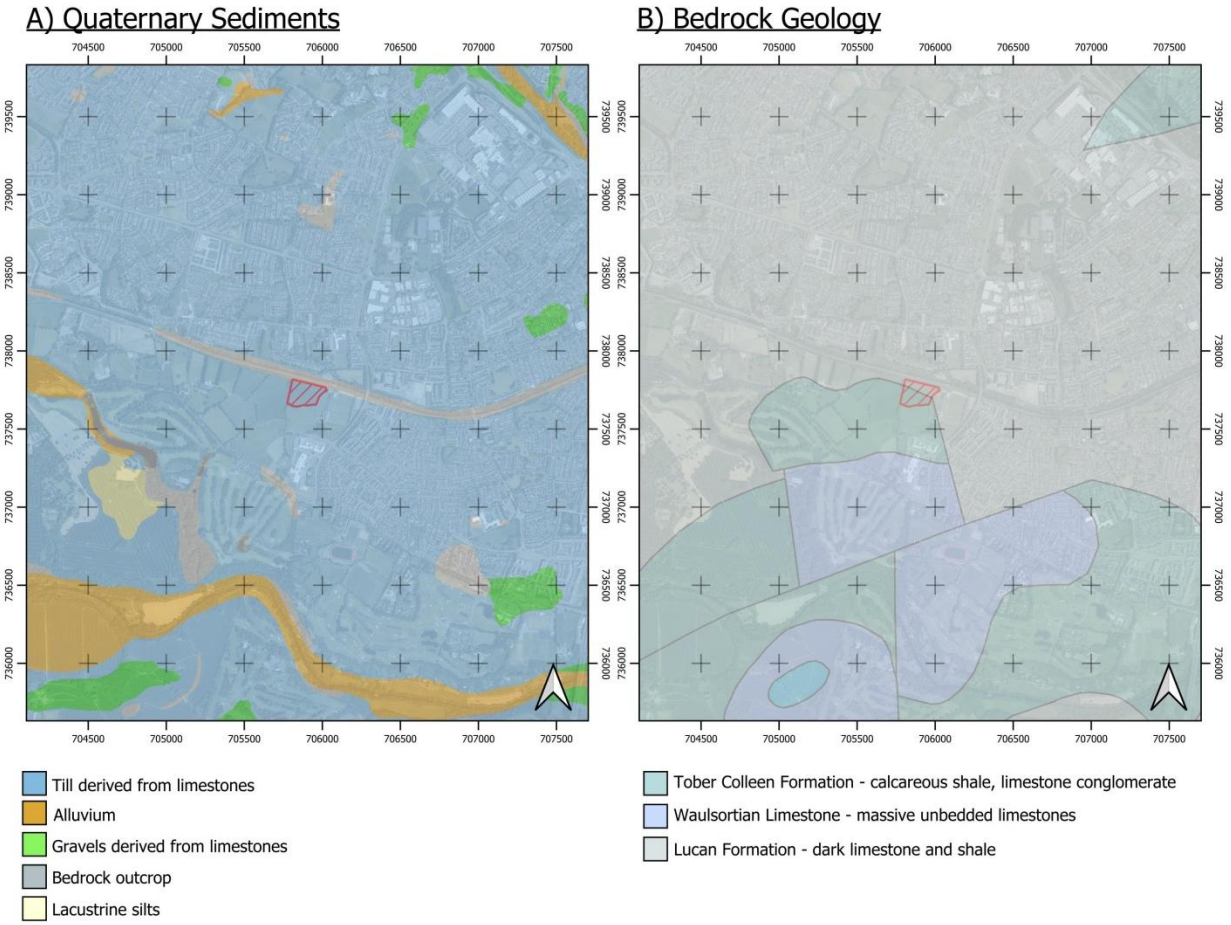


Plate 3: *Superficial geology (A) and solid geology (B) of the site and surrounding area*

2.5 Administrative and archaeological setting

The PDS is a greenfield environment entirely located in Kellystown Townland. No Sites and Monuments Records (SMR) are within or near the site boundary.

2.6 Survey objectives

The primary objective of the geophysical survey is to locate and describe any detectable archaeological features present. The survey will provide context and insight as a standalone document and facilitate any subsequent fieldwork phase by indicating the detected features' location, character, extent, and potential significance.

The geophysical survey results will inform any subsequent archaeological assessment and the design layout. Therefore, it is being conducted before the other archaeological evaluations.

2.7 Quality control

The geophysical data were collected per standard operating procedures outlined by the instrument manufacturer and TerraDat company policy. All services and reports are undertaken to the highest standards to BS 5930:2015 (site investigation) and meet the standard required by The Chartered Institute for Archaeologists' Standard and Guidance for Archaeological Geophysical Survey (2014).

On completion of the survey, the data were downloaded from the survey instrument onto a computer and backed up appropriately. The acquired data set was initially checked for errors that may be caused by instrument noise, low batteries, positional discrepancies, etc., and any field notes were either written up or incorporated in the initial data processing stage. The data set was then processed using standard processing routines. Once processed, the resulting plots are subject to peer review to ensure the integrity of the interpretation. Our quality control standards are BS EN ISO 9001:2015 certified.

3 SURVEY DESCRIPTION

The survey was conducted using magnetic gradiometry. The results are presented as interpreted data plans indicating the location and physical characteristics of identified anomalous features together with a text description.

3.1 Topographic survey/grid layout

The *SENSYS MAGNETO MXV3* data acquisition is controlled by proprietary software *MONMX,* which provides a real-time graphical display of ground coverage based on the RTK GPS positioning system mounted on the trailer. Survey traverses are acquired to provide as little overlap between traverses as possible while minimising any gaps between the traverses. Survey traverses are driven as straight as is reasonably practicable until the entire field is covered, after which 'headland' files are acquired at the field edges to ensure maximum coverage.

3.2 Magnetic survey

Magnetic surveys exploit the subtle deviation in the Earth's magnetic field caused by objects/materials of variable magnetic properties in the subsurface. These properties include ferromagnetism, remanent magnetism, and magnetic susceptibility. In an archaeological setting, these tend to be buried ferrous objects, burnt materials, or the disturbance or accumulation of naturally occurring ferrous minerals within the soil. The recorded data value is the magnetic gradient (the difference in the magnetic field strength recorded by two vertically separated fluxgate magnetometers).

A plan image showing the variation in the magnetic gradient of the site survey area is produced. Based on the recorded magnetic variation, it is possible to identify buried archaeological features such as walls, hearths, kilns, ditches, and pits.

3.2.1 Magnetic survey - field activity

The magnetic gradiometry data were acquired using a multi-sensor array (8 fluxgate gradiometer probes installed at 0.5m sensor separation) mounted on a specialist modular (*Sensys Magneto MXV3*; Plate 4). Network-corrected RTK GPS provides real-time GPS positioning. The trailer is towed across the survey area behind an ATV (Plate 4) at speeds of <15 km/h. This system allows for the acquisition of 0.5m horizontal resolution gradiometry data within a 3.5m wide swathe. The data were acquired at a rate of 200Hz, nominally providing data at 0.025m intervals along each traverse. This approach enhances resolution (double that of a conventional hand-held instrument in both x and y directions) and acquisition rate; However, a trade-off can be a poorer signal-to-noise ratio.

Plate 4: *John Deer Gator and Sensys Magneto MXV3 (Library photo).*

3.2.2 Magnetic survey - data processing

The gradiometry data were acquired using *SENSYS* proprietary software *MONMX*, which produces a data file for each acquired survey line. These files are compiled in *DLMGPS*, which associates each gradiometry data point with a GPS coordinate, calculated based on the location of each sensor within the array, thus creating a single swathe of gradiometry data up to 3.5m wide. The software applies a constant median filter to normalise the data within each swathe; the data are then exported as raw ASCII files.

The ASCII files output from *DLMGPS* were further processed using TerraDat proprietary software *MagMerge* (Plate 5) to remove any poor-quality data (sensor drop-outs/data spikes, etc/overlapping data.) and apply 50Hz and rolling median filters. The 50Hz filter removes artefacts principally associated with electrical power lines, while the median filter equalises the

background data across the swathes within a dataset, removing any apparent striping between them. Plate 6 shows an example of raw data alongside filtered data. Table 1 details the processing steps that are applied to the ASCII data;

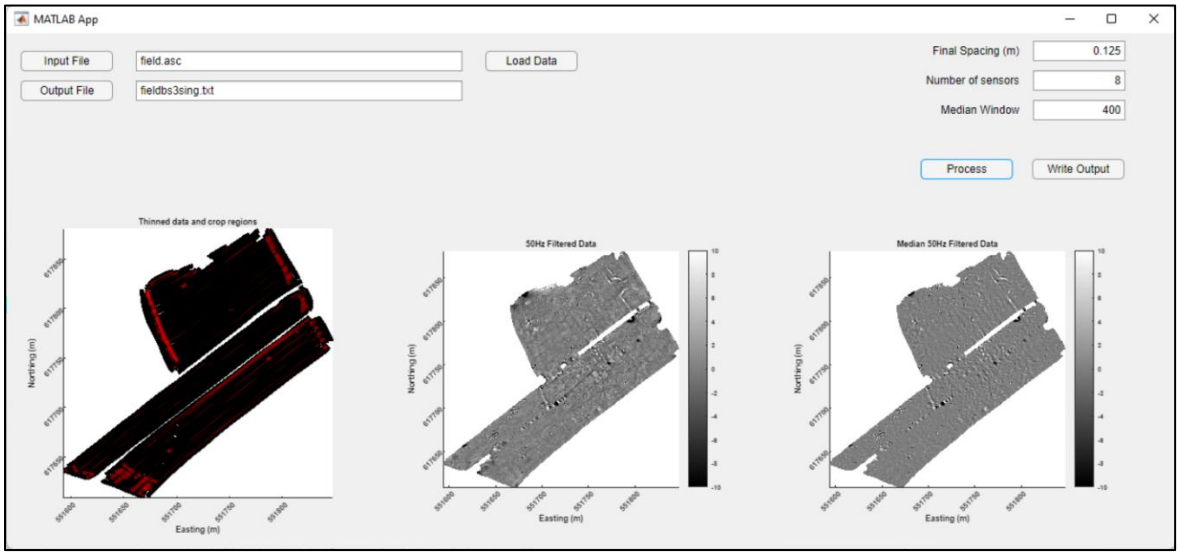


Plate 5: *TerraDat proprietary software MagMerge*

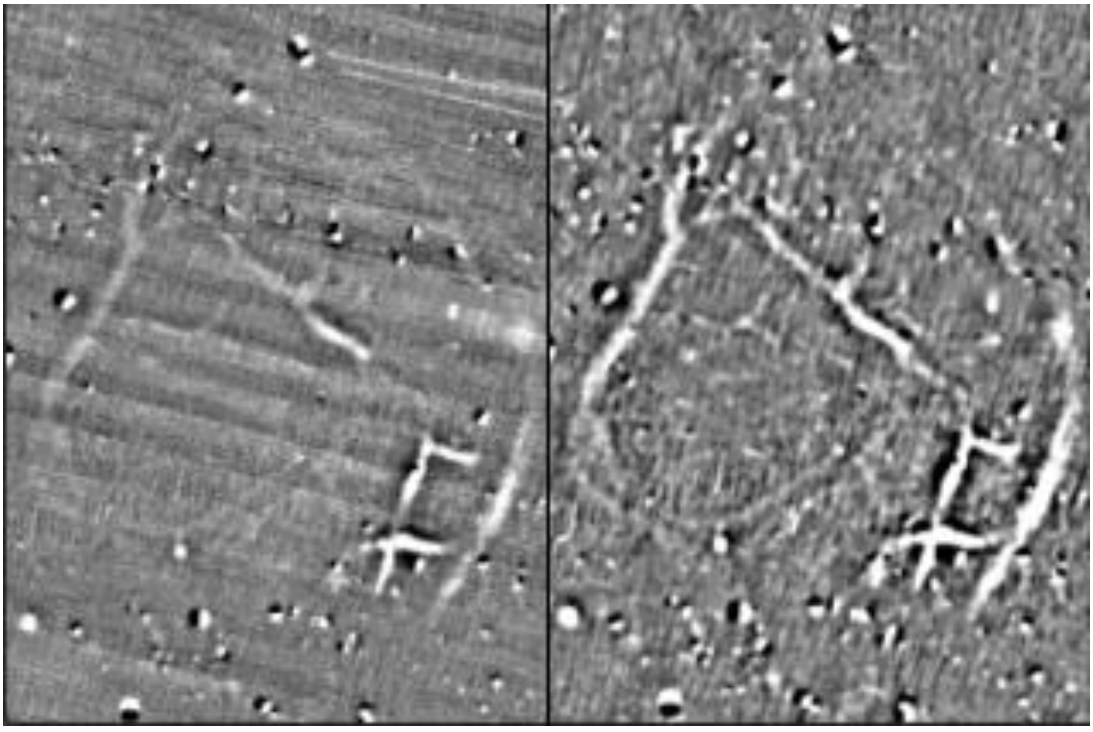


Plate 6: *Raw data (left) and filtered data (right)*

Processing Step	Description
Raw data input	Raw data (.asc) file is imported, and X,Y,Z,gradient,Time_stamp,sensor columns are retained. All other columns are removed.
Truncate Time_Stamp	Alphanumeric Time_stamp variable is truncated to the last digits (e.g. L1_20221007-095821_GZ.prm becomes 95821) to create unique IDs for

	each line.
Create line_number	Variable 'line_number' (i.e. 1 to #lines) is created by identifying all unique 'Time_stamp' values.
Rolling median	The median filter is calculated per line, per sensor, on values within -/+20nT and removed from the gradient to create a new 'GM' column. The rolling median filter has a window length of 400 data points centred on the input value. Therefore, the first and last 200 data points do not have sufficient information to calculate the median. In these cases, the first calculated value is applied back to the start of the line, and the last calculated value is filled forward to the end of the line. In practical terms, the median window length is equivalent to 10m of data acquisition.
Filter 50Hz Noise	50Hz noise from electrical utilities is removed through wavelet analysis, signal decomposition, and a 50Hz Bandstop filter. Both methods yield similar results. Multiple combinations of median and 50Hz filters are created (i.e. G50, G50M, G50BS and G50BSM) for comparison.
Calculate Mean Spacing	Mean along-track spacing is calculated.
Thin data	Data are thinned to specified output resolution using the calculated mean spacing
Crop overlapping data	Calculate bounding polygons around each line of data. Remove data located within reverse-ordered overlapping polygons.
Display Data	Plot thinned data and cropped areas, plot 50Hz filtered data, plot median filtered data.
Write output file	Write output file containing thinned data with X,Y,Z, gradient,Time_stamp,sensor,Gm,G50,G50M,linenum,G50BS,G50BSM.
Write output GPS	Write output X,Y,Z gps file using centre (actual GPS) data.

***Table 1**: Processing steps applied to the raw magnetic gradiometry data.*

The magnetic gradiometry data is output as raw and filtered 'XYZ' files in .CSV format. The height data from the GPS is also output as an approximately 3m x 0.125m resolution DTM of the Site. These files are gridded in Oasis Montaj, using minimum curvature gridding and a grid cell size of 0.125m. Once the data is gridded and an appropriate colour scale applied, the data is exported as high-resolution GeoTiff images (900 DPI) before being imported into the open-

source GIS software qGIS. Features of interest are then digitised to produce summary archaeological interpretation plans. These are integrated with the DTM to allow consideration of any identified archaeological features within the site's topography. Final figures are created in CorelDraw.

4 RESULTS AND DISCUSSION

The final processed data quality is good. There is an issue with the persistence of subtle 'tank-tracking' (narrow longitudinal oscillations in background values between +/-1 nT) due to the slight bobbing motion of the cart.

The data are presented as a series of grey-scaled plots exhibiting variations in the intensity of the magnetic gradient across the survey area. Both raw and processed magnetic data are used for the archaeological interpretation; therefore, both data types are presented in the figures. The figures are presented at 1:2500.

Anomalous geophysical features of interest have been digitised and presented as summary interpretation plots; Plate 7 presents a key to be used in conjunction with these plots.

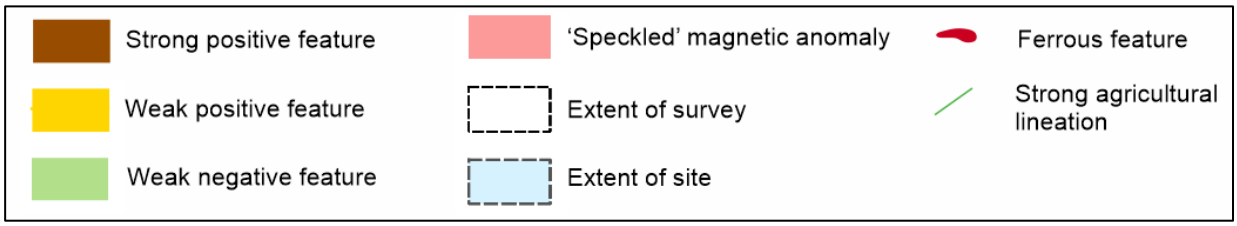


***Plate 7**: Key to be used in conjunction with the interpretive plots*

4.1 Magnetic gradiometry

Magnetic gradiometry (measurement of the vertical gradient of the Earth's magnetic field, using two sensors, one positioned above the other typically at 1.0m separation) developed

from magnetometry (measurement of the Earth's magnetic field strength, using a single sensor) to free magnetic surveys from the constraint of requiring base-station measurements to compensate for diurnal variation in field strength.

The identified magnetic anomalies (i.e. areas with a magnetic gradient that deviates from that of the typical site background) may be due to the influence of one of three main magnetic properties: ferromagnetism (that exhibited by a magnetic object of ferrous metal), remanent magnetism (a permanent sympathetic magnetic field acquired during the cooling of a hot object, commonly seen in both fixed archaeological features such as hearths, as well as portable materials, (such as ceramic building material [CBM]) and most importantly of all, magnetic susceptibility ([MS], a measure of the temporary sympathetic magnetic field generated by a body in an ambient field). Typically, weathering elevates the magnetic susceptibility, so soils have a higher MS than their parent rock. Anthropogenic processes (particularly heating) may also enhance MS. Thus, the fills of archaeological cut features typically show a higher magnetic susceptibility than the substrate into which they are cut (and thus appear as positive anomalies). There are exceptions to this sense of susceptibility contrast – for instance, where a cut feature is filled by stone with low magnetic susceptibility. For structures built of stone, there is typically a stronger contrast between the lower MS stonework and higher MS occupation deposits (meaning that stone walls, drains, etc., will usually show negative magnetic anomalies).

Ferrous materials will usually strongly influence the magnetic gradient but of a limited spatial extent. These anomalies typically show strong negative and positive components (so a small iron object appears as a black/white dot on the plots). Accumulations of iron objects may generate a speckled appearance – typical, for instance, of the sites of former wire fences. The remanent magnetic fields of CBM may also produce speckled textures – brick rubble will appear similar to a spread of ferrous debris but with lower magnitude 'spikes'.

5 RESULTS

The site exhibits a wide spread of isolated ferrous features, likely attributed to magnetic mineral-bearing clasts within the glacial till. Several pit-like features are present, probably representing tree-boles, though an archaeological origin cannot be ruled out.

An east-west trending series of data gaps and high-amplitude responses crosses the centre of the site, corresponding to the location of fence posts.

Only one feature has been identified as having potential archaeological significance.

Site 1 comprises a broad annular feature bisected by the western field boundary. The primary element is a circular ditch approximately 10 meters in diameter, with a width varying from 2.5 meters in the south to 2 meters in the north. The southeastern quadrant exhibits a very high amplitude response zone, suggesting a highly magnetic fill associated with occupation activity beyond the survey area.

An external negative anomaly, approximately 2 meters wide, encircles the feature, possibly indicating an external bank with an internal ditch. A strong dipolar response is present at the centre of the feature, which may indicate either ferrous material or evidence of burning.

Disclaimer

This report represents an opinionated interpretation of the geophysical data. It is intended to guide follow-up invasive investigation. Features that do not produce measurable geophysical anomalies or are hidden by other features may remain undetected. Geophysical surveys complement invasive/destructive methods and provide a tool for investigating the subsurface; they do not produce data that can be taken to represent all of the ground conditions found within the surveyed area. Areas that have not been surveyed due to obstructed access or any other reason are excluded from the interpretation.

Appendices

Appendix A: Glossary

A

Aerial imagery: Photographs taken from aircraft or satellites used for archaeological prospection

Alluvial deposits: Sediments deposited by flowing water, typically consisting of sand, silt, and gravel

Anomaly: A deviation from the expected or background reading in geophysical data

Anthropogenic: Caused or produced by human activities

Archaeological Magnetic Gradiometry: A geophysical survey technique that measures variations in the Earth's magnetic field to detect buried archaeological features

Artifact (archaeological): Any object made, modified, or used by humans

B

Background signal: The typical or average geophysical reading for an area

Baseline: Reference measurement used to calibrate survey results

Bedrock: Solid rock beneath surface materials

Bronze Age: Archaeological period (circa 2500-500 BCE)

BS EN ISO 9001:2015: International standard for quality management systems

Buffer zone: Area surrounding a feature where effects may still be detected

C

CBM (Ceramic Building Materials): Archaeological term for human-made clay items like bricks, tiles, etc.

Cut feature: An archaeological feature that has been dug into the ground, such as a ditch or pit

Coordinates (ITM): Ireland's official coordinate system for mapping and spatial referencing

D

Data acquisition: Process of collecting geophysical measurements

Data processing: Methods used to clean and enhance raw survey data

Diurnal variations: Daily changes in the Earth's magnetic field

DTM (Digital Terrain Model): Digital representation of ground surface topography

Deep ploughing: Agricultural practice that disturbs soil at greater depths than conventional ploughing

E

Engineered ground: Soil that has been artificially modified or disturbed

Erratics: Rock fragments transported by glacial ice

F

Feature: Any distinct archaeological or geological formation

Ferromagnetism: Strong form of magnetism associated with iron and similar materials

Field boundary: Physical division between different areas of land

Fluxgate gradiometer: Device used to measure magnetic field gradients

Formation: A fundamental unit in stratigraphy representing a distinct layer of rock

G

Geological setting: Description of the types, ages, and arrangements of rocks in an area

GIS (Geographic Information System): Software for analysing spatial data

Glacio-fluvial: Related to meltwater streams from glaciers

GPS (Global Positioning System): Satellite-based navigation system

Gradiometry: Measurement of the rate of change of a field with distance

Grid layout: Systematic arrangement of survey areas

GSI: Geological Survey of Ireland

H

Halo effect: Magnetic distortion extending beyond the physical boundaries of a feature

Head deposits: Weathered material moved downslope by gravity

Heritage asset: Any element of the historic environment with archaeological significance

I

Inlier: Older rocks surrounded by younger ones

Interference: Unwanted signals that affect survey readings

Interpretive plot: Visual representation of processed survey data

L

LiDAR: Light Detection and Ranging; remote sensing method using laser light

Lineation: Linear pattern or feature in survey data

Lithology: Physical characteristics of rocks

M

Magnetic gradient: Change in magnetic field strength between two points

Magnetic susceptibility: Measure of how magnetisable a material is

Magnetometry: Study and measurement of magnetic fields

Medieval: Historical period (circa 1100-1500 CE)

Minimum curvature gridding: Mathematical method for interpolating data points

N

Neolithic: Archaeological period (circa 4000-2500 BCE)

Network-corrected RTK GPS: High-precision GPS system with real-time corrections

nT (nanoTesla): Unit of magnetic field strength

Negative anomaly: Reading lower than background values

O

OSI (Ordnance Survey Ireland): Irish national mapping agency

Overlay: Superimposition of different data layers

P

PDS (Proposed Development Site): Area being considered for development

Penannular: Ring-shaped with a gap or opening

Post-medieval: Historical period after 1500 CE

Positive anomaly: Reading higher than background values

R

Raw data: Unprocessed survey measurements

Remanent magnetism: Permanent magnetisation remaining in materials

Resolution: Level of detail in survey data

RTK (Real-Time Kinematic): High-precision satellite navigation technique

S

Signal-to-noise ratio: Measure of desired signal strength compared to background noise

Sites and Monuments Record: Ireland's official system for cataloguing archaeological sites

Stratigraphy: Study of rock layers and layering

Superficial deposits: Geological materials lying on bedrock

Survey traverse: Path followed during data collection

T

Tank-tracking: Pattern of parallel linear anomalies caused by survey vehicle

Topography: Physical features of land surface

Traverse: Linear path followed during survey

U

Utilities: Modern service infrastructure (pipes, cables, etc.)

V

Viewshed: Area visible from a specific location

Visual interpretation: Analysis of survey results by expert examination

W

Wavelet analysis: Mathematical method for processing survey data

Appendix B: Feature Description Table

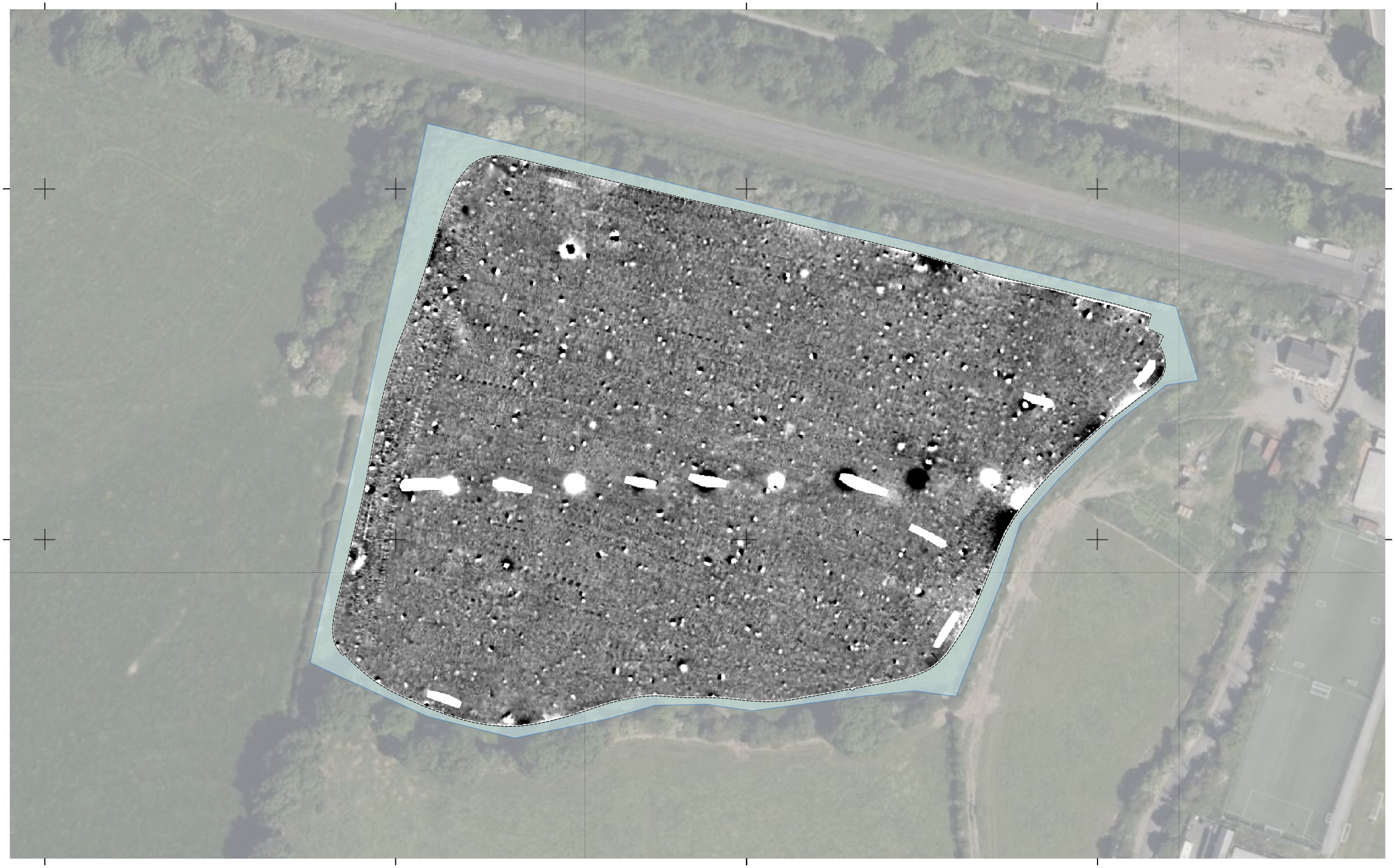
Feature Type	Symbol Description	Archaeological Interpretation
MAGNETIC SIGNATURES		
Strong positive feature	Brown fill	Typically indicates thermoremanent features (hearths, kilns, furnaces), filled pits with organic/burnt material
Weak positive feature	Yellow fill	Often represents shallow cut features (ditches, pits, postholes), plowed-out archaeological deposits
Weak negative feature	Light green fill	Usually indicates banks, walls, stone features, or soil displacement
'Speckled' magnetic anomaly	Pink/salmon fill	Areas of magnetic disturbance from modern debris, burned material scatter
SURVEY BOUNDARIES		
Extent of survey	Black dashed line	Defines total area covered by geophysical survey
Extent of Site	Light blue dashed line	Indicates site boundary
ARCHAEOLOGICAL FEATURES		
Archaeological Site	Red outline	Area of archaeological interest based on survey evidence
Sites and monuments record	Red diamond	Known archaeological sites recorded in official databases
Possible archaeology	Black curved/shaded line	Potential archaeological features
HISTORICAL LANDSCAPE FEATURES		
Old field boundary	Brown dashed line	Former field boundaries from historical Ordnance Survey maps
Feature on historical AP	Dotted line	Features visible in aerial photographs
ACCESS INFORMATION		
Inaccessible area	Cross-hatched area	Areas where survey was not possible
ADDITIONAL FEATURES		
Ferrous feature	Red fill	Modern metal objects, pipes, cables, historic metalwork
LIRM	Light blue fill	Lightning Induced Remanent Magnetisation
Geology	Grey fill/text	Natural variations in bedrock or superficial geology
Agricultural lineation	Green line	Regular plough marks
Probable field drain	Blue line	Subsurface agricultural drainage systems
Pylon	Pink circle	Modern electrical infrastructure

Figures

705700 705800 705900 706000

737800

737700



705700 705800 **705900** **706000**

N

Extent of site

Inaccessible area

Magnetic Gradient (nT)

-4 4

Title:
Raw magnetic gradiometry data presented at +/-4 nT

Project:
KELLYSTOWN

TERRA DAT
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Email: web@terradat.co.uk

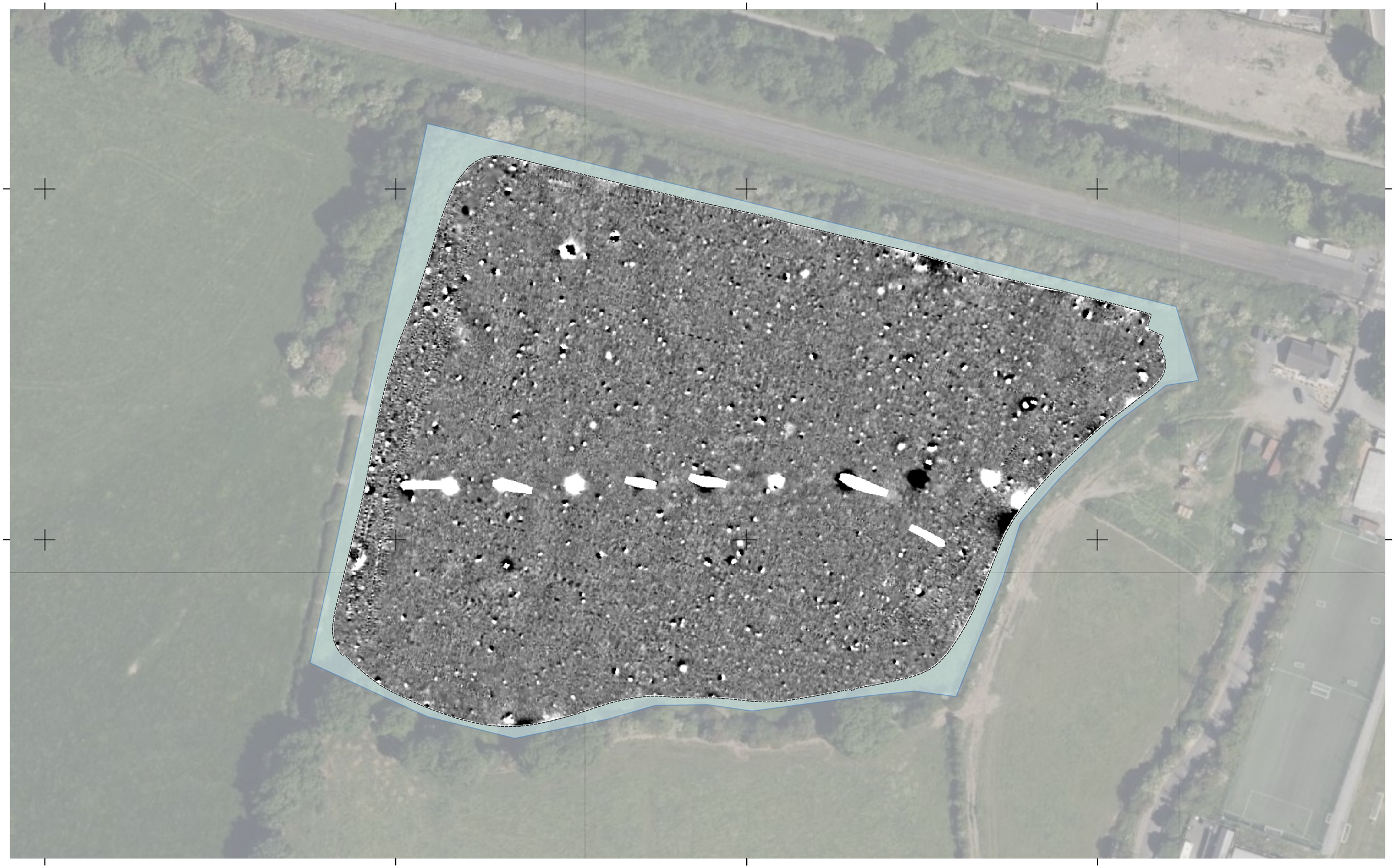
Scale: 1:1000 at A3
Drawn by/Ref: JRM/9275/1
Date: 10/02/2025

FIGURE 1

705700 705800 705900 706000

737800

737700



705700 705800 **705900** **706000**

N

Extent of site

Inaccessible area

Magnetic Gradient (nT)

-4 4

Title:
Processed magnetic gradiometry data presented at +/-4 nT

Project:
KELLYSTOWN

TERRA DAT
down to earth geophysics
Tel: +44 (0) 2920 700127
Web: www.terradat.co.uk
Email: web@terradat.co.uk

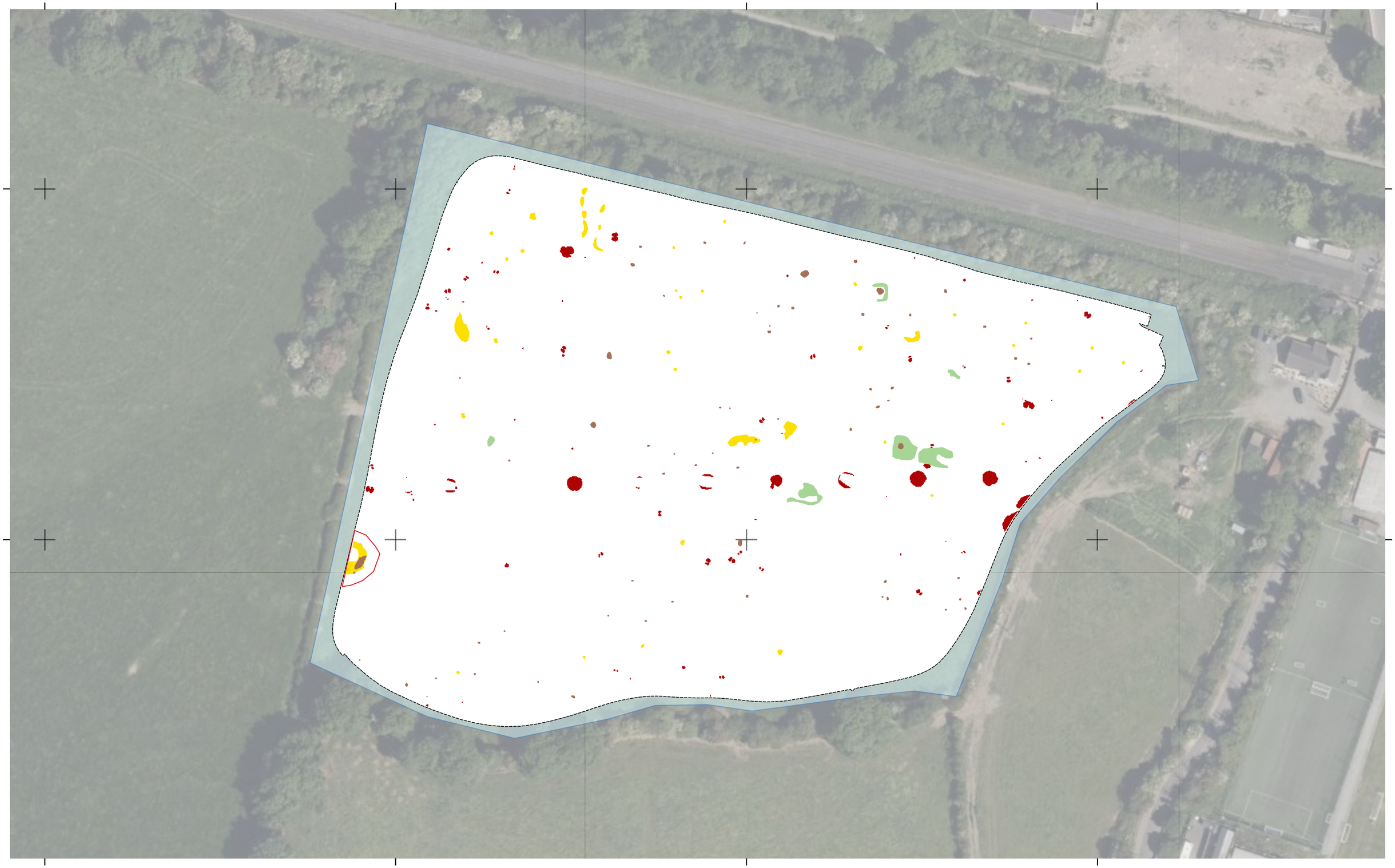
Scale: 1:1000 at A3
Drawn by/Ref: JRM/9275/2
Date: 10/02/2025

FIGURE 2

705700 705800 705900 706000

737800

737700



705700 705800 705900 706000

N

Strong positive feature

Weak positive feature

Weak negative feature

'Speckled' magnetic anomaly

Extent of survey

Extent of site

LIRM

Strong agricultural lineation

Sites of probable archaeology

Sites and monuments record

Ferrous feature

Title:

Summary archaeological interpretation

Project:

KELLYSTOWN

TERRA DAT
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Tel: +44 (0) 2920 700127
Web: www.terradat.co.uk
Email: web@terradat.co.uk

Scale: 1:1000 at A3

Drawn by/Ref: JRM/9275/3

Date: 10/02/2025

FIGURE 3

705700 705800 705900 706000

737800

737700

1

Elevation (m AOD)

63.1 67.5

N

Strong positive feature

Weak positive feature

Weak negative feature

'Speckled' magnetic anomaly

Extent of survey

xtent of site

LIRM

Strong agricultural lineation

Sites of probable archaeology

Sites and monuments record

Ferrous feature

Title:

Summary archaeological interpretation with topography

Project:

KELLYSTOWN

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Email: web@terradat.co.uk

Scale: 1:1000 at A3

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Date: 10/02/2025

FIGURE 4