A66 Northern Trans-Pennine Project
TR010062

3.4 Environmental Statement Appendix 8.7 Geochemical Survey Report

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Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

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Infrastructure Planning

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The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

A66 Northern Trans-Pennine Project Development Consent Order 202x

3.4 ENVIRONMENTAL STATEMENT APPENDIX 8.7 GEOCHEMICAL SURVEY REPORT

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8.7 Geochemical Survey Report

Geochemical and Magnetic Susceptibility Survey A66 NTP

Temple Sowerby to Appleby, Cumbria

ARS Report N°: 2022/47

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A66 NTP
Geochemical and Magnetic Susceptibility Survey
Temple Sowerby to Appleby

ARS LTD REPORT 2022/47

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EXECUTIVE SUMMARY

Project Name:	A66 NTP Geochemical and magnetic susceptibility survey, Cumbria
Hard Geology:	Sandstone and conglomerate
Superficial Geology:	Diamicton till and alluvium
Soil Type:	Slowly permeable to free draining, slightly acidic, loamy and clayey soils
NGR:	NY653239
Date of Fieldwork:	7/2/2022 to 9/3/2022
Date of Report:	1/4/2022

Geochemical and magnetic susceptibility survey was undertaken along the Temple Sowerby to Appleby section of the A66 NTP upgrade corridor. Variation in soil geochemistry and magnetic susceptibility were assessed in order to identify enhancements that may be of archaeological significance within the survey area.

The survey was undertaken between 2/7/2022 and 3/9/2022 in accordance with a written scheme of works agreed with Story Contracting and Amey/Arup.

The survey covered 11 separate field packages and identified areas of enhancement that may be of archaeological significance, some of which coincide with known sites recorded in the Cumbria Historic Environment Record. The survey also defined areas where archaeological potential is considered to be low based on an absence of chemical and magnetic enhancement among in these areas.

CONTENTS

LIST OF FIGURES

1 Introduction

1.1 Project and Planning Background

1.1.1 This report has been prepared by Archaeological Research Services Ltd (ARS Ltd) on behalf of Story Contracting. It details a scheme of geochemical and magnetic susceptibility survey works for the A66 Northern Trans-Pennine project between Temple Sowerby and Appleby-in Westmorland (NGR NY 653233).

1.1.2 The client commissioned a survey to test for the presence/absence of heritage assets within the survey area (Figure 1).

1.2 Survey area Location and Description

1.2.1 The survey area is defined in red on Figure 1 (see page 3). The survey area centres on the village of Kirkby Thore, Cumbria. The survey area is bounded to the north-west by Temple Sowerby, to the south-east by Appleby-in Westmorland and is centred on NGR NY 653233. The survey area encompasses a total area of ~135ha. Following a rescope of the survey area on the 2nd March 2022, the survey areas was reduced to 67.4 ha. The total area surveyed was 72.3ha.

1.2.2 The survey area covers the foothills of the Northern Pennines along the north side of the Eden Valley at approximately 116m AOD. Land use in the survey area is predominantly given over to pasture, with limited cultivation of crops such as barley and sugar beet.

1.3 Geology and Soils

1.3.1 The bedrock geology of the survey area comprises sandstone and conglomerate of the Permian Rocks Group formed approximately 251 to 299 million years ago. The area has been subjected to fluvial processes with extensive superficial deposits of Diamicton Till, which covers the majority of the survey area, alongside alluvial deposits made up of clay, silt, sand and gravel adjacent to the River Eden (BGS 2022).

1.3.2 Soils within the survey area are classified as slowly permeable to free draining, slightly acidic, loamy and clayey soils (Soilscape, 2022). The area has a strong history of mineral extraction. Located on the periphery of the Northern Pennine Orefield, historic lead and copper mines are located in the vicinity and a gypsum works currently operates north of Kirkby Thore.

1.4 Archaeological and Historical Background

Prehistoric

1.4.1 Palaeolithic sites and materials have not been previously identified within the survey area with the nearest evidence for activity being on the Cumbrian and Durham coasts. Significant Mesolithic activity has been documented at Brampton Flint Working Site, Long Marton which is in close proximity to the survey area. Evidence for Neolithic activity has not been identified in the proximity to the survey area aside from limited stray finds. The absence of evidence for Neolithic sites in the Eden Valley is clear and the discovery of sites relating to the period would be a significant addition to regional knowledge. Evidence for Bronze Age sites within the A66 Corridor is more pronounced and has been revealed through the excavation of features relating to settlement at Temple Sowerby and in the funerary monuments at Long Marton. Brandcrook Hill Sub-Circular Enclosure, Long Marton, is visible as a cropmark within the survey area and highlights the potential for identifying Iron Age settlement.

Roman

1.4.2 The most prominent evidence for Roman activity is a Roman road which linked the Roman forts and settlements of Cumbria with the Roman forts and settlements of North Yorkshire, and passed through the vicus associated with the Fort of Bravoniacum. Construction is believed to have commenced during the reigns of either a Flavian Emperor or Emperor Trajan. Roman camps and other military sites have been identified along the extent of the road, examples of which include the Redlands Bank Camp, Crackenthorpe and the Eden View Temporary Roman Camp, Kirkby Thore. In addition to these sites, Iron Age/Roman settlements have been identified at Bolton rectangular enclosure and Redlands Bank Farmstead, Crackenthorpe, a Romano-British enclosed settlement.

Medieval

1.4.3 There are several medieval villages surrounding the survey area including Bolton, Brampton and Crackenthorpe. Consequently, evidence of medieval field systems can be expected in the vicinity. A number of dykes have been identified in the survey area that may represent defensive works from the medieval period including Whirly Lum Ridge Earthworks.

Post Medieval

1.4.4 There is evidence for post medieval activity throughout the area. A number of quarries provide evidence of industry and are visible at Hungriggs Quarries, Long Marton and Stamp Hill Quarries, Long Marton. A disused railway likely follows part of the Roman road (Between Temple Sowerby and Appleby in Westmorland). The railway transects the survey area southeast of Kirkby Thore.

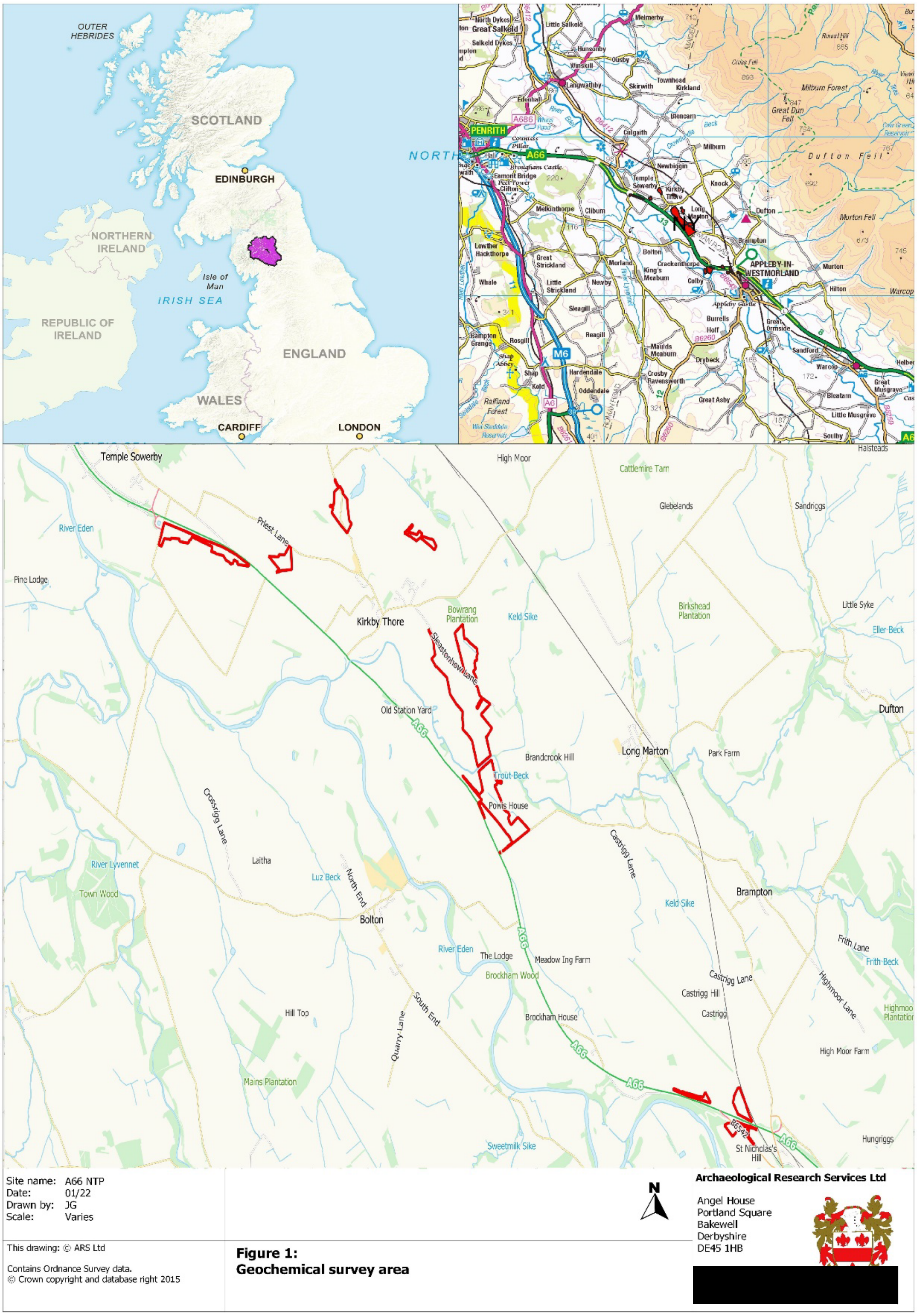

Figure 1. Site location

2 Aims and Objectives

2.1 Project Aim

2.1.1 This project aims to test the presence of significant archaeological deposits across the survey area using an integrated survey technique that employs systematic in-situ geochemical (GC) and magnetic susceptibility (MS) survey to quantify soil variability. Quantified variation in soil chemistry and magnetism will be used to attribute archaeological significance to areas within the survey area.

2.2 Project Objectives

2.2.1 The aim of the project was achieved through the following objectives:

- To undertake a systematic GC survey at 20m intervals on a grid across the survey area.
- To undertake a systematic MS survey at 20m intervals on a grid across the survey area.
- To process multi-variate data and to produce maps that best represent soil variation across the survey area.
- To analyse soil variation as determined by GC/MS and to attribute archaeological significance to any structured variation and apparent blank areas.
- To delimit and characterise any surviving archaeological remains within the survey area

3 Method Statement

3.1 Coverage

3.1.1 The survey area covers 67.4 ha and is shown in Figure 1. The survey area is divided in to three areas (1-3).

- Area 1: North-west of Kirkby Thore
- Area 2: South-east of Kirkby Thore
- Area 3: North-west of Appleby-in-Westmorland

3.2 Professional Standards

3.2.1 The archaeological fieldwork was undertaken in accordance with the Chartered Institute for Archaeologists (CIfA) *Code of Conduct* (2019).

3.2.2 All staff employed on the project were suitably qualified and experienced for their respective roles. All staff were briefed on the work required by this specification and were required to read both this WSI and the survey area Risk Assessment.

3.3 General Methodology

3.3.1 The survey is an integrated approach that combines geochemical analysis and magnetic susceptibility.

3.3.2 Geochemical survey is a sensitive technique that can detect subtle variability in soil chemistry brought about by a range of human activities. It can detect chemical enhancements in soil as a result of activities such as burning, craftwork, middening, habitation, burial, manuring, animal processing and industrial activities.

3.3.3 Trace elements may relate to anthropogenic processes and/or local geology/lithology (Wilson et al. 2009) (Table 1).

Origin	**Elements**	**Comments**	**References**
Geology/Lithology	Na, Al, Ti, Sc, Zr, Nb, Cd, Cs, Hg	Na, K -soil mobility	Khan *et al.* 2013 Effect of slope position on physico-chemical properties of eroded soil. soil and Environment. 31. 22-28.
Anthropogenic	P, Mg, Ca, Cu, Zn, Ni, Mn, Sr, Pb, Sn, K, S, Ba	P, calcium -middens, burials, livestock, food processing[1]. P, Mg-Wood burning[2]. Cu, Pb, zinc (Main anthropogenic indicators) + Cr, Mg, Mn, Ni, P, Se, Sn, Sr and Zn[3] (Cu, Pb, Mn-at elevated levels >300ppm craft working i.e. metallurgy[4])	[1] Lutz, 1951; Parsons, 1962; Cook and Heitzer, 1965 [2] Heidenreich and Navratil, 1973 [3] Bethell and Carver, 1987; Ottaway and Matthews, 1988 [4] Pyatt *et al.* 1999; Pyatt *et al.* 2002, Davies *et al.* 1988; Wilson *et al*. 2009
Uncertain	V, Rb, Al, Cl, As	Local geological system dependency	Wilson *et al*. 2009

Table 1 Origins of key trace elements in geochemical analysis.

3.3.4 Studies undertaken by Dungworth (2014) and Aston *et al.* (1998) have addressed the relationship between elemental variation and depth on archaeological sites concluding that there are strong correlations between surface and sub-surface analyses. The high sensitivity of HH-pXRF (hand held portable x-ray fluorescence) instrumentation and its ability to detect trace elements at very low levels (ppm) means that chemical signatures across a site can be established from non-invasive surface analyses. For each sampling point determinations were made using an Olympus Vanta HH-pXRF.

3.3.5 Magnetic susceptibility survey relies on the detection of magnetic enhancement brought about by a range of past human activities such as habitation, use of hearths, and craft production. This relationship between human activities and the increased magnetic susceptibility is well established and has been used extensively for archaeological prospection and the spatial characterisation of excavated contexts.

3.3.6 Human activities such as fire use and the concentration of processed materials are responsible for the conversion of residual iron oxides (Fe_2O_3-hematite) to accumulated forms of magnetic and feri-magnetic iron oxides (magnetite Fe_3O_4, and maghaemite γ-Fe_2O_3). In addition, residual iron oxides may also be reduced to magnetic oxides by the anaerobic metabolism of bacteria present in decomposing organic deposits such as middens and pit fills.

3.3.7 Magnetic susceptibility survey detects the tendency of a soil to become magnetised by an applied magnetic field. When mapped it is an effective technique for locating areas that have been subjected to heat or other processes that give rise to the magnetic enhancement of iron oxides. It is also an effective means for differentiating between varied soil types and can be used to map geological variability.

3.3.8 Magnetic susceptibility offers advantages over magnetic gradiometer surveys for the detection certain types of site, specifically sites that are present as shallow spreads in or near to top soil e.g. early medieval sites with burnt timber buildings. This ability for magnetic susceptibility to detect sites of this kind is due to the measurement of absolute susceptibility in contrast to gradiometer surveys which measure small differences in the earth's magnetic field between two sensors. Sites present as thin spreads will not register sufficiently on gradiometer surveys due to the thin deposits not deflecting the earth's magnetic field.

3.4 Methodology for geochemical survey

3.4.1 The survey will undertake multi-elemental analysis of up to 34 elements including Mg, Al, Si, K, Ca, S, P, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, W, Zn, Hg, As, Pb, Bi, Se, Th, U, Rb, Sr, Y, Zr, Nb, Mo, Ag, Cd, Sn, and Sb.

3.4.2 Geochemical analysis of the surface was undertaken on an area of topsoil cleared of loose vegetation and soil crumb (~0.1x0.1m). Sample points are located at 20m intervals on a systematic grid. The total number of data points collected was ~25-27/ha.

3.4.3 Analysis was undertaken using an Olympus Vanta VRM instrument deployed in geochem mode. Two filters were used that permitted the analysis of heavy metals and light elements including phosphorus. Accuracy and precision were determined through the repeated analysis of in-house standards and certified reference materials.

3.4.4 Geochemical survey personnel were suitably trained, qualified and experienced to undertake the work. The analyst used the instrument in hand-held mode and it was positioned in intimate contact with the prepared soil surface for the duration of the sampling period.

3.4.5 Sampling locations on the 20m systematic grid were accurately positioned using a GNSS field controller (GPS) connected to Leica Smartnet to receive corrections resulting in a typical accuracy of better than 0.1m. Systematic sampling across a site grid is a routine method that offers an effective way to ensure site coverage and even distribution of sampling locations.

3.5 Methodology for magnetic susceptibility survey

3.5.1 Magnetic susceptibility survey was carried out with reference to EAC Guidelines for the Use of Geophysics in Archaeology (Schmidt et al.https://www.europae-archaeologiae-consilium.org/eac-guidelines).

3.5.2 Magnetic susceptibility survey was undertaken across a survey grid corresponding with that used for the geochemical survey. The survey targeted predefined sampling locations accurately located using a Leica GNSS field controller (GPS) connected to Leica Smartnet providing a location accuracy of typically 0.1m or better.

3.5.3 Before magnetic susceptibility determination, the area to be analysed was prepared to facilitate good contact with the field coil sensor. Preparation involved the removal of vegetation over an area no greater than (~0.1x0.1m) in line with that prepared for geochemical survey. The area was lightly troweled to prepare a level analytical surface.

3.5.4 Magnetic susceptibility was be determined in-situ using a Terraplus KT-10 portable field instrument. Readings were taken with an integrated field coil sensor and recorded as ‘volume specific magnetic susceptibility’ with the volume being uniformly defined by the coil.

3.5.5 The instrument will be brought into firm contact with the analysis area following a free air determination. Results will be represented as graduated variance plots and incorporated in a GIS.

3.5.6 Magnetic Susceptibility survey personnel will be suitably trained, qualified and experienced to undertake the work.

4 Results

4.1 Outline of chemical variation maps

4.1.1 Survey data is mapped using a variable colour ramp to illustrate variation across individual fields and across field packages when fields are in close proximity. The limits of the colour ramp correlates with the max-min range of elemental results by field and allows for the maximum discrimination of variation across the survey area.

4.1.2 While this method is ideal for illustrating variability within a single field (or field package where individual fields are mapped together) and highlights the areas with the highest potential for locating archaeological deposits, it is not intended for absolute comparative analysis across packages as the colour ramps are optimised for individual fields.

4.1.3 This method results in fields with low variability showing comparable colour differentiation to fields with more pronounced and structured anomalies, although the structure of this colour differentiation will contrast strongly between fields with low variability (i.e. close to background levels) and fields with structured anomalies. Each field should therefore be assessed in light of the concentration range expressed in the legend.

Area 1: North-west of Kirkby Thore

4.2 Field Package 1 (FP1)

4.2.1 A total of 185 sampling points were analysed across FP1 for both geochemical and magnetic susceptibility survey. The fields in FP1 were used for crop production and pasture. The A66 forms the northern boundary to this package.

Magnetic Susceptibility

4.2.2 The results of the magnetic susceptibility survey are shown in Figure 3. Magnetic susceptibility ranged from 0.066 – 0.567 SI units. The susceptibility of the soils was low to moderate with evidence of spatially distributed enhancements in the region of 0.3 – 0.567 SI units within the central and north western edge of FP1 compared to lower levels of approximately 0.1 SI units in the eastern and north-western extent of the field.

Geochemical Survey

Phosphorus (P)

4.2.3 Figure 4 shows the variability of phosphorus across FP1. Phosphorus ranged from ~ 540 to 2700 ppm indicating a wide distribution of values across this field. The British Geological Survey (BGS) indicates the average background value of phosphorus is in the region of 700-800 ppm which tends towards the lower end of the range for UK soils and highlights that approximately 25% of returned values show elevated levels of phosphorus.

4.2.4 The spatial distribution shows a structured concentration in in the north-western corner of FP1 which diminishes towards the south-eastern limit of the field.

4.2.5 The trend of higher values to the north-western extent of the field package shows a degree of correlation with magnetic susceptibility although there are also contrasts.

Copper (Cu)

4.2.6 Figure 5 shows copper variability and spatial distribution across FP1. Copper ranged from ~8 to 37 ppm. The BGS indicates the average background value of copper in the region is approximately 8-12 ppm which can be used to see higher survey values as being enhanced levels of copper.

4.2.7 In contrast to results for phosphorus, copper shows lower levels in the north-west and higher values towards the east. There is some correlation in the spatial distribution of enhanced copper values and magnetic susceptibility in the central eastern section of the field package.

Zinc (Zn)

4.2.8 Figure 6 depicts the zinc variability across FP1. Zinc ranged from 27-64 ppm indicating a range of levels with spatially patterned enhancement in areas. The BGS indicates the average background value of zinc is in the region of 45-55 ppm which suggests negligible levels of enhancement.

4.2.9 The distribution of zinc variation does not demonstrate any structured or patterned anomalies.

Lead (Pb)

4.2.10 Figure 7 shows the lead variability across FP1. Lead ranged from 6-25 ppm. The BGS indicates the average background value of lead is in the region of 65 – 120 ppm. The lower range detected in the survey is typical for pXRF surface survey.

4.2.11 There is a degree of correlation between copper and lead especially in the central area of the survey.

Calcium (Ca)

4.2.12 Figure 8 depicts the calcium variability across FP1. Calcium ranged from 1333 – 17984 ppm. It is worth noting that this range is skewed by a single outlier with a value of 17984 ppm. With the exclusion of this value, the range is better reflected as 1333 – 5684 ppm.

The BGS indicates the average value of calcium for this region is 2800 – 4200 ppm suggesting a degree of enhancement in the survey data.

4.2.13 The spatial distribution of calcium shows a cluster above the BGS average in the eastern extent in FP1.

Areas of Enhancement/Anomalies

4.2.14 Following field by field analysis, the data set for the project was assessed to highlight zones of significant geochemical and magnetic enhancement. These zones of enhancement are depicted as colour-coded, numbered polygons (Figures 9, 16, 23, 30, 38, 39, 46, 53, 61, 68, 75 and 82). These zones can also indicate anomalous areas of the dataset where there is an apparent absence of enhancement. Comparison of zones of enhancement and the geophysical survey (magnetometry provided courtesy of Headland Archaeology), help contextualise results within the survey area and highlight regions of potential archaeological or geological significance.

4.2.15 The elemental concentration and magnetic susceptibility ranges for each significant zone of enhancement (polygon) are outlined in Table 1.

4.2.16 There is enhancement in phosphorus, copper and calcium within Field Package 1. As depicted in Figure 9, Field Package 1 runs adjacent to the A66. The Historic Environment Record lists various archaeological sites/features in close proximity to Field Package 1 including a potential rectangular enclosure visible as a cropmark to the immediate south (SMRNO: 5130), a Bronze Age settlement to the northwest and a Roman standing monument (milestone) to the north.

4.2.17 The elevation of phosphorus noted to the west of the field package (polygon 1 Figure 9) seems to correlate strongly with existing field boundaries within the extent of the survey and on this basis it is considered unlikely that it relates to archaeological deposits.

4.2.18 The zone of enhancement shown as Polygon 3 (Figure 9) in FP1 relates to calcium. Like phosphorus, enhanced calcium can indicate anthropogenic activity including middening, food processing and manuring. The zone of enhanced calcium marginally overlaps with an area of copper enhancement, Polygon 2. The proximity of copper and calcium anomalies may indicate anthropogenic activity but the limited extent of the survey makes unambiguous interpretation difficult.

4.3 Field Package 2 (FP2)

4.3.1 A total of 73 sampling points were analysed across FP2 for both geochemical and magnetic susceptibility survey. The northern field of FP2 was devoted to both crop production (sugar beet) and pasture whereas the southern and eastern fields were solely used for pastoral purposes at the time of survey.

Magnetic Susceptibility

4.3.2 The results of the magnetic susceptibility survey are shown in Figure 10. Magnetic susceptibility ranged from 0.129 – 1.365 SI units. This range demonstrates significant levels of enhancement. The spatial distribution of the magnetic susceptibility data indicates higher readings across the northern extent of FP2.

Geochemical Survey

Phosphorus (P)

4.3.3 Figure 11 shows phosphorus variability across Field Package 2. Phosphorus ranged from below limits of detection to 2394 ppm. The BGS indicates the average background value of phosphorus ranges from 700-800 ppm which suggests that there are areas of distinct phosphorus enhancement in FP2.

4.3.4 The spatial distribution of phosphorus enhanced values are situated in the southeastern extent of FP2, accounting for >50% of surveyed points. The spatial distribution of phosphorus does not correlate with the magnetic susceptibility or other surveyed elements.

Copper (Cu)

4.3.5 Figure 12 shows copper variability across FP2. Copper ranged from below limits of detection to 25 ppm. The BGS indicates the average background value of copper ranges from 8 – 12 ppm in this region suggesting that the copper data shows some level of enhancement.

4.3.6 The spatial distribution of copper across FP2 exhibits slightly elevated enhancements clustered in the central/eastern extent.

Zinc (Zn)

4.3.7 Figure 13 shows zinc variability across FP2. Zinc ranged from below limits of detection to 62 ppm. The BGS indicates the average background value of zinc ranges from 45 – 55ppm in this region.

4.3.8 The spatial distribution of zinc demonstrates a discrete focal point of enhancement within the centre of FP2. The remaining points lie within the BGS average value range.

Lead (Pb)

4.3.9 Figure 14 shows lead variability across FP2. Lead ranged from below limits of detection to 45 ppm. The BGS average value of lead ranges from 65 – 120 ppm.

4.3.10 The spatial distribution of lead shows higher concentrations along the western extent of FP2, and lower levels across the south-eastern corner.

Calcium (Ca)

4.3.11 Figure 15 shows calcium variability across FP2. Calcium ranged from below limits of detection to 5600 ppm. The BGS average background value of calcium ranges from 2800 – 4200 ppm in this region.

4.3.12 The spatial distribution of calcium shows no defined or structured anomaly.

Areas of Enhancement/Anomalies

4.3.13 The structure of anomalies in the data for magnetic susceptibility, phosphorus, copper and lead (see Figure 16) seem to closely align with field boundaries within the extent of the survey area.

4.3.14 Polygon 4 (Figure 16) outlining the elevated readings for Phosphorus correlate strongly with the modern field boundary suggesting a non-archaeological origin to this signature.

4.3.15 Polygon 5 (Figure 16) highlights the extent of enhanced magnetic susceptibility and again aligns closely with modern field boundaries.

4.3.16 Polygon 6 (Figure 16) shows elevated lead values again aligning with modern field boundaries and also correlating with elevated copper values (polygon 7).

4.3.17 While there is structured anomalies in many of the survey datasets they seem strongly correlated with modern field boundaries at least within the limits of the survey scope. On this basis they are probably not to be associated with archaeological deposits and more related to differential soil management and agricultural practice.

4.3.18 Although there are no HER records associated with the field, magnetometer survey has identified linear features within the field package. As these are on a different alignment to the modern field boundaries, it is unlikely the anomalies identified by this survey are associated with these earlier features.

4.4 Field Package 3 (FP3)

4.4.1 A total of 174 sampling points were analysed in FP3 for both geochemical and magnetic susceptibility survey. FP3 is bisected by a winding road running north-south.

Magnetic Susceptibility

4.4.2 Figure 17 shows the variability of magnetic susceptibility survey in FP3. Magnetic susceptibility ranged from 0.023 to 1.099 SI units. However, this range is skewed by an outlier of 1.099 SI units, situated in the south-eastern corner of FP3. Excluding this point, the range is better reflected as 0.023 to 0.75 SI units. These readings demonstrate low to moderate magnetic susceptibility across FP3.

4.4.3 There is a notable enhancement in the field to the east of the road with lower values found almost exclusively to the west of the road.

Geochemical Survey

Phosphorus (P)

4.4.4 Figure 18 shows the variability of phosphorus in FP3. The phosphorus values ranged from below limits of detection to 2561 ppm. The BGS average background values for this region range from 700-800 ppm.

4.4.5 Spatial distribution of phosphorus also demonstrated strong correlation with field boundaries to the east of the road with enhanced values exceeding 1600 ppm. However, at the northwestern extent of FP3 and extending to its northern edge, there are a cluster of phosphorus enhanced values > 1800 ppm that does not appear to correlate with field boundaries.

Copper (Cu)

4.4.6 Figure 19 shows the variability in copper across FP3. Copper values ranged from below limits of detection to 28 ppm. The BGS average background values for this region range from 8-12 ppm.

4.4.7 The spatial distribution of enhanced copper shows correlation with modern field boundaries but there is also some subtlety within the datasets (see below).

4.4.8 Copper correlates with high magnetic susceptibility values to some degree and specifically in the southeastern extent of FP3.

Zinc (Zn)

4.4.9 Figure 20 shows the variability of zinc in FP3. The zinc values ranged from below limits of detection to 100 ppm. The BGS average background value in this region range from 45 to 55 ppm.

4.4.10 There is no clear pattern to enhanced zinc values although there is a broad trend of higher values to the north-west and lower values to the south-east. There is a weak correlation with modern field boundaries.

Lead (Pb)

4.4.11 Figure 21 shows the variability of lead in FP3. The lead values ranged from below limits of detection to 48 ppm. The BGS average background value of lead in this region ranges from 65 to 120 ppm with the returned values of the survey showing a typical response in comparison to BGS values.

4.4.12 The spatial distribution of lead shows a strong correlation with field boundaries with the north-eastern field showing low values and the south-eastern area showing enhanced levels.

Calcium (Ca)

4.4.13 Figure 22 shows the variability of calcium in FP3. The calcium values ranged from below limits of detection to 38,675 ppm. The maximum reading of 38,675 ppm is an outlier. When removed, the range of calcium values in FP3 is more accurately reflected as below limits of detection to 8701 ppm. The BGS average background value in this region range from 2800 to 4200 ppm. A small minority of calcium values show elevated values above the BGS background.

4.4.14 The spatial distribution of the elevated calcium values are situated along the western boundary of the road.

Areas of Enhancement/Anomalies

4.4.15 Within FP3, there were spatially defined anomalies in the datasets for magnetic susceptibility, phosphorus and calcium. Figure 23 shows that the limits of these anomalies are defined by the road that bisects the field package.

4.4.16 Polygons 8 and 9 (Figure 23) refer to zones of enhancement of phosphorus in the northern corner (near Halefield Farm House) and south-eastern extent of FP3 respectively. Polygon 9 correlates strongly with modern field boundaries and it is unlikely that it relates to archaeological deposits. Polygon 8 is limited in its extent and may related to archaeological deposits but the lack of structure suggests that these are unlikely to be significant.

4.4.17 Polygon 10 (Figure 23) demarcates a small area associated with elevated magnetic susceptibility within a wider field of elevated results. In light of elevated susceptibility values being returned across the field in contrast to the rest of the field package it is unlikely that these values relate to significant archaeological deposits.

4.4.18 Polygon 11 outlines an area of higher calcium values. This area coincides with a palaeochannel clearly visible in Google Earth imagery. These elevated values should therefore be understood as being the result of natural erosion and depositional processes acting on local limestone or gypsum deposits which were transported by fluvial action.

4.5 Field Package 4 (FP4)

4.5.1 A total of 75 sampling points were analysed in FP4 for both geochemical and magnetic susceptibility survey.

Magnetic Susceptibility

4.5.2 Figure 24 shows the variability of magnetic susceptibility survey in FP4. Magnetic susceptibility ranged from 0.024 to 0.252 SI units. These readings demonstrate low magnetic susceptibility across FP4. The spatial distribution of magnetic susceptibility exhibits higher readings in the western extent of FP4.

Geochemical Survey

Phosphorus (P)

4.5.3 Figure 25 shows the variability of Phosphorus across FP4. The phosphorus values ranged from below limits of detection to 1440 ppm. The BGS average background value for this region ranged from 700-800 ppm. Over 50% of the recorded phosphorus values lie above the BGS background average indicating enhancement of phosphorus within FP4.

4.5.4 The spatial distribution of enhanced phosphorus values are concentrated along the south-western extent of the survey area spanning two agricultural fields.

4.5.5 Phosphorus shows a structured spatial distribution that does not correlate with other elements (see below).

Copper (Cu)

4.5.6 Figure 26 shows the variability of copper across FP4. Copper values ranged from below limits of detection to 19 ppm. The BGS average background value in this region ranges between 8 to 12 ppm.

4.5.7 The spatial distribution of copper shows no clear pattern. There are no observable correlations between the distribution of copper compared with other elements or magnetic susceptibility.

Zinc (Zn)

4.5.8 Figure 27 shows the variability of zinc across FP4. The zinc values ranged from below limits of detection to 60 ppm. The BGS average background value of zinc in this region is 45 to 55 ppm.

4.5.9 Again, there is no clearly defined spatial patterning observed in the zinc dataset. There are no observable correlations between the distribution of zinc compared with other elements or magnetic susceptibility.

Lead (Pb)

4.5.10 Figure 28 shows the variability of lead across FP4. The lead values ranged from below limits of detection to 24 ppm. The BGS average background value of lead in this region is 65 to 120 ppm.

4.5.11 The levels of lead are low with no clearly defined anomaly present. There are no observable correlations between the distribution of lead compared with other elements or magnetic susceptibility.

Calcium (Ca)

4.5.12 Figure 29 shows the variability of calcium across FP4. The calcium values ranged from below limits of detection to 3710 ppm. The BGS average background value of calcium in this region ranges from 2800 to 4200 ppm.

4.5.13 The spatial distribution of calcium shows a concentration of higher values along the south-western boundary of the field to the north-west but it is poorly defined There are no observable correlations between the distribution of calcium compared with other elements or magnetic susceptibility.

Areas of Enhancement/Anomalies

4.5.14 Within FP 4 (Figure 30) there were no significant elemental or magnetic susceptibility enhancements. According to HER, there are earthworks (SMRNO:16995) and a cropmark (SMRNO:16992) 140m to the north and 130m to the south-east respectively. However, the geochemical results do not indicate the presence of any significant archaeological deposits within the survey area

Area 2: South-east of Kirkby Thore

4.6 Field Package 5 (FP5)

4.6.1 A total of 427 sampling points were analysed in FP5 for both geochemical and magnetic susceptibility survey. Land access permissions meant that all sampling points were not accessible meaning that a significant area was descoped. The limited extend of the survey area presents challenges to interpreting the datasets.

Magnetic Susceptibility

4.6.2 Figure 32 shows the variability of magnetic susceptibility survey in FP5. Magnetic susceptibility ranged from 0.038 to 1.289 SI units. These readings demonstrate low to high magnetic susceptibility across FP5. High values are clearly visible in the northern extent (adjacent to Sleastonhow Lane) with values >0.5 SI units.

4.6.3 Magnetic susceptibility is lower in the southern extent of the package with some structure, reminiscent of geological variation, in the central area of the field package.

Geochemical Survey

Phosphorus (P)

4.6.4 Figure 33 shows the variability of phosphorus across FP5. The phosphorus values ranged from below limits of detection to 2211 ppm. The BGS average background value for this region ranged from 800-900 ppm

4.6.5 The spatial distribution of phosphorus shows enhanced values are concentrated at the northern extent of FP5, adjacent to Sleastonhow Lane with a strong correlations evident between phosphorus and magnetic susceptibility.

4.6.6 Variation in phosphorus in the eastern fields appears to correlate with field boundaries within the extent of the survey while the western anomaly appears to be distict.

Copper (Cu)

4.6.7 Figure 34 shows the variability of copper across FP5. The copper values ranged from below the limit of detection to 42 ppm. The BGS average background value for this region ranged from 12 – 15 ppm.

4.6.8 The spatial distribution of copper across FP5 exhibits enhancement situated in the northern extent (adjacent to Sleastonhow Lane), along the western edge of scoped area and immediately north of Trout Beck.

Zinc (Zn)

4.6.9 Figure 35 shows the variability of zinc across FP5. The zinc values ranged from below the limit of detection to 267 ppm. The BGS average background value of zinc for this region ranged from 43 to 49 ppm.

4.6.10 The distribution of elevated zinc levels respect field boundaries within the limit of the survey and suggest that the pattern is the result of recent agricultural processes..

Lead (Pb)

4.6.11 Figure 36 shows the variability of lead across FP5. The lead values ranged from below the limit of detection to 1144 ppm. The BGS average background value of lead for this region ranges from 38 to 55 ppm.

4.6.12 These are very high levels of lead along the edges of Trout Beck and points towards a activities associated with lead minerals.

Calcium (Ca)

4.6.13 Figure 37 shows the variability of calcium across FP5. The calcium values ranged from 7 to 4880 ppm. The BGS average background value of calcium for this region ranges from 2100 to 2200 ppm.

The spatial distribution of calcium mirrors phosphorus, copper and magnetic susceptibility. Higher values are present as a concentration in the north-west extent of the package with lower values associated with the area to the south.

Areas of Enhancement/Anomalies

4.6.14 Across FP5, there are eight zones of enhancement for phosphorus, copper, zinc, lead and magnetic susceptibility. As depicted in Figures 38 and 39, FP5 extends across several fields, due north of the A66. The survey was not continuous as is punctuated by surveyed areas which frustrates attempts to examine geochemical variation across the area. The survey area is therefore discussed as northern and southern areas.

4.6.15 Elevated magnetic susceptibility, copper and phosphorus values coincide as areas of structured enhancement at the northern extent of FP5. These directly coincide with an enclosure visible as a cropmark in the northern extent of the field (SMRNO: 6004) and are likely to be associated with the site.

4.6.16 Discrete areas of copper enhancement are shown by polygons 16 and 17 and may be associated with areas of activity given the concentration of known archaeological sites evidenced in the HER.

4.6.17 Enhancement of zinc, copper and lead are present at the south-eastern extent of FP5, along the northern bank of Trout Beck. It should be noted that elevated lead and zinc values extend across to the south side of the watercourse. Lead values in the Trout Beck area are significant and are the highest measured during the survey. At these levels activities associated with mineral processing should be considered. However, given the proximity of Trout Beck and in light of the known mineralisation in the wider area the enhancement may be due to natural processes. However, it is difficult to account for the distribution based on known geology and on balance it is likely that this area is the enhanced by anthropogenic processes associated with lead processing.

4.7 Field Package 7 (FP7)

4.7.1 A total of 477 sampling points were analysed in FP7 for both geochemical and magnetic susceptibility survey.

Magnetic Susceptibility

4.7.2 Figure 40 shows the variability of magnetic susceptibility survey in FP7. Magnetic susceptibility ranged from 0.0 to 1.059 SI units. The maximum of the range is skewed by two anomalous high magnetic susceptibility readings of 0.802 and 1.059 SI units. Excluding these values, the range is better reported as 0.0 to 0.359 SI units. Generally, the magnetic susceptibility readings demonstrate low magnetic susceptibility across FP7. Spatial distribution of higher magnetic susceptibility readings cluster to the immediate north-west of Powis House Farm, and the eastern and northern extents of FP7.

Geochemical Survey

Phosphorus (P)

4.7.3 Figure 41 shows the variability of phosphorus in FP7. The phosphorus values range from below limits of detection to 6660 ppm. The BGS average background value in this region ranges from 800 to 900 ppm.

4.7.4 The highest values concentrated to the north of Powis House Farm and at the northern extent of FP7. These clusters lie in close proximity to Trout Beck. With the exception of these high clusters, the areas north, north-east and north-west are primarily within or below the BGS background phosphorus levels.

4.7.5 To the south and east of Powis House Farm, phosphorus values typically range between 500 to 1200 ppm. There is a cluster of highly enhanced phosphorus values (>6600 ppm) to the immediate east of Powis House Farm, also in close proximity to Trout Beck (see discussion in section 4.7.14).

Copper (Cu)

4.7.6 Figure 42 shows the variability of copper in FP7. The copper values range from below limits of detection to 25 ppm. The BGS average background value in this region ranges from 12 to 15 ppm.

4.7.7 Towards the northern extent of FP7 lies a cluster of moderately enhanced copper values. These enhanced values are situated in close proximity to Trout Beck. Elsewhere there is little structure to the dataset.

Zinc (Zn)

4.7.8 Figure 43 shows the variability of zinc in FP7. The zinc values range from 21 to 301 ppm. The BGS average background value in this region ranges from 43 to 49 ppm.

4.7.9 The spatial distribution of zinc shows a clear concentration of higher values in the north-west of the survey area in close proximity to the Trout Beck.

4.7.10 The southern and eastern extents of FP7 are predominantly aligned with the BGS background average, although there are small concentrations of elevated readings but these are unlikely to be significant archaeological deposits.

Lead (Pb)

4.7.11 Figure 44 shows the variability of lead in FP7. The lead values range from 5 to 2731 ppm. The BGS average background value in this region ranges from 38 to 55 ppm.

4.7.12 The spatial distribution of lead is very heavily structured and shows a discrete and very well defined anomaly in the north-west of the survey area. At these concentrations it is likely that the anomaly is associated with lead mineralisation and the correlation with zinc should be unsurprising due to the close association of lead and zinc mineralisation.

4.7.13 The cluster of significant enhancement (>500 ppm) is situated in the far northern extent of FP7. The southern and eastern extents of FP7 are predominantly BGS background average or below.

Calcium (Ca)

4.7.14 Figure 45 shows the variability of calcium in FP7. The calcium values range from 110 to 4075 ppm. The BGS average background value in this region ranges from 2100 to 2200 ppm.

4.7.15 The pattern of spatial distribution of calcium is inverted when compared to magnetic susceptibility and zinc and lead. Extending to the south and east of Powis House Farm, the field is densely populated by clusters of low and high enhancement. In contrast the areas to the immediate and far northern and western extent typically exhibit insignificant or background levels of calcium.

Areas of Enhancement/Anomalies

4.7.16 As depicted in Figure 46, FP7 covers a large area of multiple fields bounded by the A66 and Trout Beck. Within FP7, there are five zones of enhancement of lead, zinc and phosphorus, all situated to the immediate south of Trout Beck. The sites located in proximity to FP7 include a scheduled Roman camp (listing entry: 107189) and Roman road (SMRNO: 1809), ridge and furrow earthworks (SMRNO: 6008) to the east and an enclosure visible as a cropmark (SMRNO: 6002) across Trout Beck to the immediate northeast of the field package.

4.7.17 The largest zone of enhancement (polygon 21) accounts for lead and encompasses the remaining zones of enhancement of zinc and phosphorus. In this zone, the concentration of lead values are significantly enhanced for the region surrounding Kirkby Thore. The significant lead enhancement is mirrored across Trout Beck by polygon 20 in FP5. High concentrations of lead are often considered a key anthropogenic indicator. However, given the proximity of Trout Beck, these zones of enhancement may be naturally accounted for by the action of fluvial/alluvial processes. Furthermore, high concentrations of lead may be attributed to a discrete natural deposit of lead. All factors considered, there is potential for anthropogenic activity within this zone.

4.7.18 Within the zone of significantly enhanced lead, there are two distinct zones of zinc enhancement – bordering the banks of Trout Beck and another smaller zone to the south (polygons 22 and 24 respectively, Figure 46). Much like lead, zinc is associated with metallurgic industry and other craftworking methods. The coinciding presence of enhanced zinc and lead provides a stronger indication of potential anthropogenic activity within this region.

4.7.19 Polygons 23 and 25 (Figure 46) refer to zones of enhancement of phosphorus in the northern corner FP7 (to the south of Trout Beck). Anthropogenic activity is linked to enhanced phosphorus as it relates to the accumulation of organic waste resulting from middening, manuring of from the disposal of food waste. The proximity of known HER sites (specifically cropmark SMRNO: 6002) and the presence of enhanced phosphorus in conjunction with zinc and lead, support the possibility of archaeological features being present in this area of FP7.

4.8 Field Package 16 (F16)

4.8.1 A total of 125 sampling points were analysed in FP16 for both geochemical and magnetic susceptibility survey.

Magnetic Susceptibility

Figure 47 shows the variability of magnetic susceptibility survey in FP16. Magnetic susceptibility ranged from 0.014 to 0.412 SI units. Generally, the magnetic susceptibility readings demonstrate low magnetic susceptibility across FP16. Geochemical Survey

Phosphorus (P)

4.8.2 Figure 48 shows the variability of phosphorus across FP 16. The phosphorus values ranged from below limits of detection to 1133 ppm. The BGS average background value for this region ranged from 800 to 900 ppm.

4.8.3 The spatial distribution of phosphorus mirrors magnetic susceptibility, a low-level enhancement (>900 ppm) cluster toward the southern and northern extents with a large area of lower readings (600< ppm) spanning the central to eastern edge.

4.8.4 The variability across the dataset appears to correlate with an area of earth moving and disturbance.

Copper (Cu)

4.8.5 Figure 49 shows the variability of copper across FP16. The copper values ranged from 3 to 21 ppm. The BGS average background value in this region for copper ranges from 12-15 ppm.

4.8.6 The spatial distribution of copper mirrors magnetic susceptibility, however to a lesser extent than phosphorus. Clusters of low level enhancement of copper occur at the southern and northern extents of FP16 and these contrast which what appears as a depleted zone in the centre of the survey area.

Zinc (Zn)

4.8.7 Figure 50 shows the variability of zinc across FP16. The zinc values ranged from 14 to 60ppm. The BGS average background value in this region for zinc ranges from 43-59 ppm.

4.8.8 The spatial distribution of zinc again follows the pattern described above for other elements where the central area is depleted and relatively higher values occur on the periphery of the survey area.

4.8.9 Clusters of high zinc concentrations (>38 ppm) occur at the southern and northern extents of FP16. These clusters are divided by a central strip extending to the eastern edge of lower concentrations of zinc, typically falling below 23 ppm.

Lead (Pb)

4.8.10 Figure 51 shows the variability of lead across FP16. The spatial pattern for lead again follows that described above but as a particularly stark pattern. Lead values ranged from below limits of detection to 28 ppm. The BGS average background value of lead in this region ranges from 38-55 ppm.

4.8.11 The spatial distribution of lead mirrors the patterning shown for other elements (phosphorus, copper, zinc and magnetic susceptibility).

Calcium (Ca)

4.8.12 Figure 52 shows the variability of calcium across FP16. The calcium values ranged from 681 to 33,755 ppm. The maximum value of this range is heavily skewed by one anomalous value (33,755ppm). Excluding this value, the range of calcium is better represented as 681 to 9456ppm. The BGS average background value in this region ranged from 2100 to 2200 ppm.

4.8.13 In contrast to the other elements discussed above, the spatial distribution of calcium shows an inverted pattern with an enhanced region in the centre of the survey area and lower values returned on the peripheries of the survey area.

Areas of Enhancement/Anomalies

4.8.14 Field package FP16 shows a peculiar geochemical patterning where there is a discrete central zone which shows depletion for all elements with the exception of calcium which shows a relative enhancement in the same area. It is most likely that this pattern is associated with recent earth moving and landscaping activities which may have involved the bulk import/export of soil materials.

4.8.15 This field package is situated to the north of Sleastonhow Lane, and due northeast of the northern extent of FP5. Given its proximity to FP5, FP16 lies in the vicinity of the a cropmark (SMRNO: 6004) but there is nothing to indicate any association with the geochemical results..

Area 3: North-west of Appleby-in-Westmorland

4.9 Field Package 10 (F10)

4.9.1 A total of 86 sampling points were analysed in Field 10 for both geochemical and magnetic susceptibility survey.

Magnetic Susceptibility

4.9.2 Figure 55 shows the variability of magnetic susceptibility survey in FP 10. Magnetic susceptibility ranged from 0.004 to 0.654 SI units. Maximum range value is skewed by two values >0.49 SI units. A more accurate range of magnetic susceptibility is 0.004 to 0.22 SI units (with the exclusion of these two points). Generally, the magnetic susceptibility readings demonstrate low magnetic susceptibility across FP10. Concerning spatial distribution, the data exhibits a shifting concentration gradient (low to high) from the northern corner to the elongated southern edge respectively.

Geochemical Survey

Phosphorus (P)

4.9.3 Figure 56 shows the variability of phosphorus in FP10. The phosphorus values ranged from below limits of detection to 1085 ppm. The BGS average background value of phosphorus in this region ranges from 800 to 900 ppm. Therefore, there are points of low-level enhancement of phosphorus in FP10.

4.9.4 Spatial distribution of phosphorus exhibits no observable pattern with the exception of an east-west line of higher concentrations of phosphorus (some enhanced) which align with a pre-existing fence line. There are no discernible correlations between the distribution of phosphorus compared with other elements or magnetic susceptibility.

Copper (Cu)

4.9.5 Figure 57 shows the variability of copper in FP10. The copper values ranged from below limits of detection to 45 ppm. The BGS average background value of copper in this region ranges from 10-12 ppm. The maximum range value is offset by a single anomalous significantly enhanced copper reading. Excluding this value, a more representative range is below limits of detection to 19 ppm. Considering the BGS, there is evidence of low enhancement of copper (plus the significant enhancement outlined above, located on the south-western extremity of FP10).

4.9.6 Spatial distribution of enhanced copper values situated in the southwestern corner/strip. Radiating north-east from this corner, the copper values progressively lower in concentration to align with BGS background levels or less. This pattern of distribution is common between lead and zinc.

Zinc (Zn)

4.9.7 Figure 58 shows the variability of zinc in FP10. The zinc values ranged from below limits of detection to 71 ppm. The BGS average background value of zinc in this region ranges from 40 to 42 ppm. Only a handful of values demonstrate low to moderate enhancement of zinc with the majority of the dataset falling within or below the BGS average.

4.9.8 The spatial distribution of zinc exhibits higher concentration (including enhanced values) clustering along the south-western edge/strip; closely situated to the disused railway line and A66. Extending north-east from this cluster, the readings progressively decrease in zinc concentrations. There is some degree of overlap concerning the spatial distributions of zinc and magnetic susceptibility.

Lead (Pb)

4.9.9 Figure 59 shows the variability of lead in FP10. The lead values ranged from below limits of detection to 31 ppm. The BGS average background value of lead in this region ranges from 50 to 52 ppm. As recorded values fall below the BGS average, there are no areas of significant lead enhancement within FP10.

4.9.10 The spatial distribution of lead exhibits higher concentration (including enhanced values) clustering along the south-western edge/strip; closely situated to the disused railway line and A66. Extending north-east from this cluster, the readings progressively decrease in lead concentrations. The spatial distributions of zinc, lead and copper values all exhibit similar patterns.

Calcium (Ca)

4.9.11 Figure 60 shows the variability of calcium in FP10. The calcium values ranged from below limits of detection to 4030 ppm. The BGS average background value for calcium in this region ranges from 2400 to 2700 ppm. With the exclusion of one anomalous enhanced reading of 4030 ppm of Ca, the majority recorded values fall within or below the BGS average.

4.9.12 The single enhanced calcium value of Field 10 is situated along the south-western border. The spatial distribution of remaining values demonstrates no observable pattern.

Areas of Enhancement/Anomalies

4.9.13 Within FP10 (Figure 61) there were no significant elemental or magnetic susceptibility enhancements. According to HER, there are earthworks and a cropmark to the northwest (SMRNO: 4210) and west (SMRNO: 6700), and a Roman road to the north (SMRNO: 1809). However, this particular field package presented no discernable enhancement in regards to geochemistry and magnetic susceptibility.

4.10 Field Package 11 (F11)

4.10.1 A total of 66 sampling points were analysed in FP11 for both geochemical and magnetic susceptibility survey.

Magnetic Susceptibility

4.10.2 Figure 62 shows the variability of magnetic susceptibility survey in FP11. Magnetic susceptibility ranged from 0.05 to 0.765 SI units. Generally, the magnetic susceptibility readings demonstrate low magnetic susceptibility across FP11. The maximum reading (0.765 SI units) was recorded in the southern corner. The spatial distribution of magnetic susceptibility exhibits no observable pattern.

Geochemical Survey

Phosphorus (P)

4.10.3 Figure 63 shows the variability of phosphorus across FP11. The phosphorus values ranged from 392 to 1231 ppm. The BGS average background value of phosphorus in this region ranges from 800 to 900 ppm. A small number of phosphorus values exhibit low-level enhancement (n=3, >1000ppm) whereas the remaining dataset align with the BGS background average of lower concentrations of phosphorus.

4.10.4 Generally, the spatial distribution of phosphorus exhibits an increasing concentration gradient from the northwest corner extending to the southeast edge of FP11. The patterns of spatial distribution of phosphorus does not correlate with any other elements or magnetic susceptibility.

Copper (Cu)

4.10.5 Figure 64 shows the variability of copper across FP11. The copper values ranged from 6 to 24 ppm. The BGS average background value of copper in this region ranges from 10 to 12 ppm. Approximately 75% of the values exhibit low to moderate enhancement from the background average.

4.10.6 Generally, the pattern of spatial distribution of low to moderate enhanced copper are more concentrated along the northern and north-western borders of FP11; and progressively decreases radiating away from these borders. There is no discernible correlation between spatial distributions of copper and other elements or magnetic susceptibility.

Zinc (Zn)

4.10.7 Figure 65 shows the variability of zinc across FP11. The zinc values ranged from 39 to 54 ppm. The BGS average background value of zinc in this region ranges from 40 to 42 ppm. Approximately 50% of the values for zinc demonstrate low level enhancement (>43 ppm).

4.10.8 Generally, the spatial distribution of enhanced values populate the northern and north-western borders of FP11. However, there are clusters of enhanced values scattered throughout the field with no discernible pattern.

Lead (Pb)

4.10.9 Figure 66 shows the variability of lead across FP11. The lead values ranged from 17 to 45 ppm. The BGS average background value of lead in this region ranges from 50 to 52 ppm. As recorded values fall below the BGS average, there are no areas of significant lead enhancement within FP11.

4.10.10 Higher concentrations of lead typically populate the north corner and north-eastern border and progressively decrease radiating away from these areas in FP11. This pattern of distribution is not shared with other elements or magnetic susceptibility.

Calcium (Ca)

4.10.11 Figure 67 shows the variability of calcium across FP11. The calcium values ranged from 1052 to 2797 ppm. The BGS background average value of calcium in this region ranges from 2400 to 2700 ppm. The majority of recorded values fall within or below the BGS background average. There are two readings that exhibit enhancement albeit marginal.

4.10.12 The two enhanced calcium values are situated along the western border of FP11. There is no discernible pattern of spatial distribution of calcium.

Areas of Enhancement/Anomalies

4.10.13 Within FP11, there is one zone of copper enhancement situated in the northern extent and denoted by polygon 26 (Figure 68). According to HER, there are no sites of archaeological or historic significance in the immediate vicinity of FP11. Anthropogenic activities that give rise to copper enhancement typically coincide with waste materials derived from metabolic processes and craft working (non-ferrous metallurgy). Therefore, the enhanced copper zone/polygon may be indicative of potential anthropogenic activity in FP11.

4.11 Field Package 12 (FP12)

4.11.1 A total of 65 sampling points were analysed in Field 12 for both geochemical and magnetic susceptibility survey.

Magnetic Susceptibility

4.11.2 Figure 69 shows the variability of magnetic susceptibility survey in FP12. Magnetic susceptibility ranged from 0.026 to 0.091 SI units. Generally, the magnetic susceptibility readings demonstrate very low magnetic susceptibility across FP12. Generally, the spatial distribution of higher magnetic susceptibility readings populate the northern extent and along the periphery of FP12, however there are scattered high readings within the southern extent.

Geochemical Survey

Phosphorus (P)

4.11.3 Figure 70 shows the variability of phosphorus in FP12. The phosphorus values range from below limits of detection to 507 ppm. The BGS average background value in this region range from 800 to 900 ppm. As recorded values fall below the BGS average, there are no areas of significant phosphorus enhancement within FP12.

4.11.4 Higher concentrations of phosphorus cluster along the south-eastern, northern and western borders. The central regions typically exhibit low-level phosphorus values. There is some correlation/overlap between the phosphorus and copper spatial distributions.

Copper (Cu)

4.11.5 Figure 71 shows the variability of copper in FP12. The copper values range from below limits of detection to 12 ppm. The BGS average background value in this region range from 10 to 12 ppm. As recorded values fall below the BGS average, there are no areas of significant copper enhancement within FP12.

4.11.6 Generally, higher concentrations of copper appear to populate the borders at random of FP12. This pattern of spatial distribution of copper is similar to phosphorus.

Zinc (Zn)

4.11.7 Figure 72 shows the variability of zinc in FP12. The zinc values range from below limits of detection to 79 ppm. The BGS average background value in this region range from 40 to 42 ppm. Of the data readings, only two values exhibit moderate enhancement. These values are situated in the northern corner. The majority lie within or below the BGS range.

4.11.8 Generally, the enhanced and higher concentrations of zinc typically populate the northern extent and decrease toward the southern extent of FP12.

Lead (Pb)

4.11.9 Figure 73 shows the variability of lead in FP12. The lead values range from below limits of detection to 15 ppm. The BGS average background value in this region range from 50 to 52 ppm. As recorded values fall below the BGS average, there are no areas of significant lead enhancement within FP12.

4.11.10 Typically, higher concentrations of lead appear to populate the borders at random of FP12. This pattern of spatial distribution of lead is similar to phosphorus and copper.

Calcium (Ca)

4.11.11 Figure 74 shows the variability of calcium in FP12. The calcium values range from below limits of detection to 2510 ppm. The BGS average background value in this region range from 2400 to 2700 ppm. As recorded values fall below the BGS average, there are no areas of significant calcium enhancement within FP12.

4.11.12 Higher concentrations of calcium typically cluster along the western border of FP12. This pattern of spatial distribution does not correlate with other elements or magnetic susceptibility.

Areas of Enhancement/Anomalies

4.11.13 Within FP12 (Figure 75) there were no significant elemental or magnetic susceptibility enhancements. According to HER, FP12 is situated immediately south of a Roman road (SMRNO: 1809). However, this particular field package proved blank/anomalous in regards to geochemistry and magnetic susceptibility.

4.12 Field Package 13 (FP13)

4.12.1 A total of 49 sampling points were analysed in FP13 for both geochemical and magnetic susceptibility survey.

Magnetic Susceptibility

4.12.2 Figure 76 shows the variability of magnetic susceptibility survey in FP13. Magnetic susceptibility ranged from 0.076 to 0.998 SI units. Generally, the magnetic susceptibility readings demonstrate very low magnetic susceptibility across FP13 with the exception of an anomalous high reading of 0.998 SI units. Excluding this value the range is better reported as 0.076 to 0.267 SI units. Generally, the spatial distribution of higher magnetic susceptibility readings populate the southern extent of FP13.

Geochemical Survey

Phosphorus (P)

4.12.3 Figure 77 shows the variability of phosphorus in FP13. The phosphorus values range from below limits of detection to 1691 ppm. The BGS average background value in this region range from 800 to 900 ppm. Approximately 75% of the data exhibit low to moderate enhancement of phosphorus in FP13.

4.12.4 The higher moderately enhanced reading of phosphorus are clustered in an east-west strip spanning the breadth of FP13. However, there are discrete high enhanced values situated within the southern corner. Spatial distribution of phosphorus does not correlate with any other elements or magnetic susceptibility.

Copper (Cu)

4.12.5 Figure 78 shows the variability of copper in FP13. The copper values range from below limits of detection to 22 ppm. The BGS average background value in this region range from 10 to 12 ppm. Approximately 75% of the data exhibit low to moderate enhancement of copper in FP13.

4.12.6 The moderately enhanced values of copper typically populate the north-west corner of FP13. The south-eastern edge exhibits low, negligible concentrations of Cu. The patterns of spatial distribution of copper and lead demonstrate some correlation.

Zinc (Zn)

4.12.7 Figure 79 shows the variability of zinc in FP13. The zinc values range from below limits of detection to 91 ppm. The BGS average background value in this region ranges from 40 to 42 ppm. A small minority of points exhibit enhancement (>45ppm). The remaining majority lie within or below the BGS average.

4.12.8 Across FP13, there are discrete clusters of higher concentration of zinc with no discernible pattern between their distributions. Spatial distribution of zinc does not correlate with any other elements or magnetic susceptibility.

Lead (Pb)

4.12.9 Figure 80 shows the variability of lead in FP13. The lead values range from below limits of detection to 71 ppm. The BGS average background value in this region ranges from 50 to 52 ppm. Of the data readings, only one anomalous value exhibits moderate enhancement. The remaining majority lie within or below the BGS range.

4.12.10 The higher concentrations of lead are situated across the central and north-western extents of FP13. Spatial distribution of lead does not correlate with any other elements or magnetic susceptibility.

Calcium (Ca)

4.12.11 Figure 81 shows the variability of calcium in FP13. The calcium values range from 1813 to 3592 ppm. The BGS average background value in this region ranges from 2400 to 2700 ppm. Approximately 50% of the data exhibit low to moderate enhancement of calcium in FP13.

4.12.12 Concerning spatial distribution, in the north-eastern corner of FP13 cluster the high and enhanced calcium values. Radiating from this area, the concentration of calcium decreases to levels within or below the BGS average background value. Spatial distribution of calcium does not correlate with any other elements or magnetic susceptibility.

Areas of Enhancement/Anomalies

4.12.13 In Figure 82, there are two zones of enhancement of phosphorus and calcium present in FP13 (polygons 27 and 28 respectively). According to HER, FP13 is located near to a Roman road and Medieval ridge and furrow earthworks, due north and east respectively.

4.12.14 A small area of enhanced phosphorus values are evident within the northern extent of FP13 (polygon 27). Phosphorus enhancement is most commonly understood as relating to the accumulation of organic waste resulting from middening, manuring of from the disposal of food waste. The significant enhanced phosphorus values may be indicative of anthropogenic activity however, one must consider the aforementioned discussion regarding phosphorus and its limitations including post medieval agricultural industry.

4.12.15 The zone of enhanced calcium (polygon 28) situated in the northern extent of FP13 may indicate anthropogenic activity including middening, food processing and manuring. However, geophysical survey exhibited no overt indications of human activity or industry. Furthermore, the underlying geological landscape which is composed of calcium-rich deposits, must also be considered.

5 Discussion

5.1 Overview

5.1.1 Despite the limited area over which the survey was conducted, especially in light of areas descoped, the data returned from the survey has produced a valuable dataset. That dataset provides information regarding areas of potential archaeological significance as well as providing additional data to indicate areas of low archaeological potential. The datasets can allow areas to be more clearly categorised in terms of significance with a greater degree of confidence.

5.1.2 The survey has defined structured anomalies that in some instances correlate strongly with known archaeological sites documented in the HER. In other instances, structured anomalies hold the possibility of being newly identified features/areas of activity. In addition, areas where little enhancement or structure is noted the results can be considered as additional evidence of these areas having low archaeological potential and can be more confidently classified as 'blank areas'.

5.1.3 Where available the results of geophysics and any HER records have been considered alongside survey data. Together these combined datasets allow a comprehensive assessment of archaeological potential of the survey area with the various datasets complementing one another.

5.1.4 The field packages that can be considered to hold the greatest potential for archaeological significance include 1, 5 and 7. These field packages returned datasets that exhibited spatially structured enhancement above background. Importantly, these field packages showed structured variation across more than one variable with multiple elements and/or magnetic susceptibility showing various degrees of correlation. Where such structured variation is correlated with HER records or geophysical results it is highlighted in the text.

5.1.5 Elevated copper values align with a structured enhancement of lead in Field Package 1. These are closely associated with a rectangular enclosure (SMRNO: 5130) visible as cropmark 80m to the south and the roman road to the immediate north-east. This area of enhancement has the potential to be associated with Roman activity in the area. The elevated area of phosphorus to the west of the package is unlikely to relate to archaeological activity on the basis of its strong correlation with field boundaries.

5.1.6 Significant enhancement of magnetic susceptibility, copper and phosphorus are aligned at the northern extent of Field Package 5. These coincide with an enclosure identified as a cropmark in historic aerial photographs. The levels of copper enhancement identified are in line with those expected for settlement activities as opposed to metallurgical activity. Elevated levels of phosphorus are often associated with high levels of organic material such as might be expected in areas used for middening, food processing and/or animal corralling. Enhancement of these elements alongside significantly elevated magnetic susceptibility values are indicative of settlement activity in this area.

5.1.7 Enhanced phosphorous, copper, zinc and lead values are associated with Trout Beck in the south-eastern extent of Field Package 5 and the north-western extent of Field Package 7. Levels of lead enhancement in Field package 7 (up to 2700 ppm) are such that they are most likely associated with mineral extraction or metallurgical activity or perhaps a mineralised lead deposit. While copper values are elevated, it is not sufficient to be indicative of copper-based metallurgical activity. The origin of this geochemical signature should be explored further.

5.1.8 Field packages showing no significant enhancement or spatial structure in terms of geochemical and magnetic susceptibility survey include Field Package 4, 10 and 12. These field packages are considered to have very low archaeological potential based on the results of this survey and the lack of features identified through geophysical and aerial survey of these fields.

5.1.9 The potential archaeological significance of each field package is presented below in Table 1 alongside information detailing accessibility and whether this impacted survey.

Field package	XY	Archaeological significance	Notes

1	NY620261	Medium	Accessible and surveyed
2	NY628262	Low	Accessible and surveyed
3	NY634265	Low	Accessible and surveyed
4	NY642263	Low	Accessible and surveyed
5	NY644249	High	Partially accessible and surveyed
7	NY652237	Medium	Accessible and surveyed
16	NY648252	Low	Accessible and surveyed
10	NY674218	Low	Accessible and surveyed
11	NY676214	Low	Accessible and surveyed
12	NY677216	Low	Accessible and surveyed
13	NY677214	Low	Accessible and surveyed

Table 1. Table detailing field packages, location and archaeological significance

5.1.10 The survey has succeeded in the characterising the variability in geochemistry and magnetic susceptibility across the survey area. Areas of low and high archaeological potential have been identified on the basis of spatial patterning of multiple elements.

5.1.11 Structured spatial variation in geochemical datasets is best identified across extensive survey areas. The areas descoped from the survey due to land access issues reduce the extent of the survey and therefore increase the interpretative challenge with the survey data. Nonetheless, it is clear that the data secured holds certain potential to add our understanding of the archaeological significance of the survey area.

5.1.12 In summary, there are few areas that can be recommended for further archaeological investigation. Areas that warrant further investigation are FPs 1,5 and 7 with area 5 and 7 having the higher potential. Conversely, the other Field Packages produced no indication of having a high archaeological potential and on that basis can be considered as ‘blank areas’ or areas of low archaeological potential.

5.1.13 Issues regarding land accession account for areas not surveyed within the scoped area. Specifically, this includes areas within field packages 5 and 16. An area at the south-eastern extent of field package 16 was inaccessible because of the presence of cattle in the field. Part of field package 5 were inaccessible as a result of the presence of electric fencing crossing partitioning the fields within the package. The survey covered all areas that could be accessed in these field packages.

6 Publicity, Confidentiality and Copyright

6.1.1 Any publicity will be handled by the client.

6.1.2 ARS Ltd will retain the copyright of all documentary, photographic and video material under the Copyright, Designs and Patent Act (1988).

7 Statement of Indemnity

7.1.1 All statements and opinions contained within this report arising from the works undertaken are offered in good faith and compiled according to professional standards. No responsibility can be accepted by the author/s of the report for any errors of fact or opinion resulting from data supplied by any third party, or for loss or other consequence arising from decisions or actions made upon the basis of facts or opinions expressed in any such report(s), howsoever such facts and opinions may have been derived.

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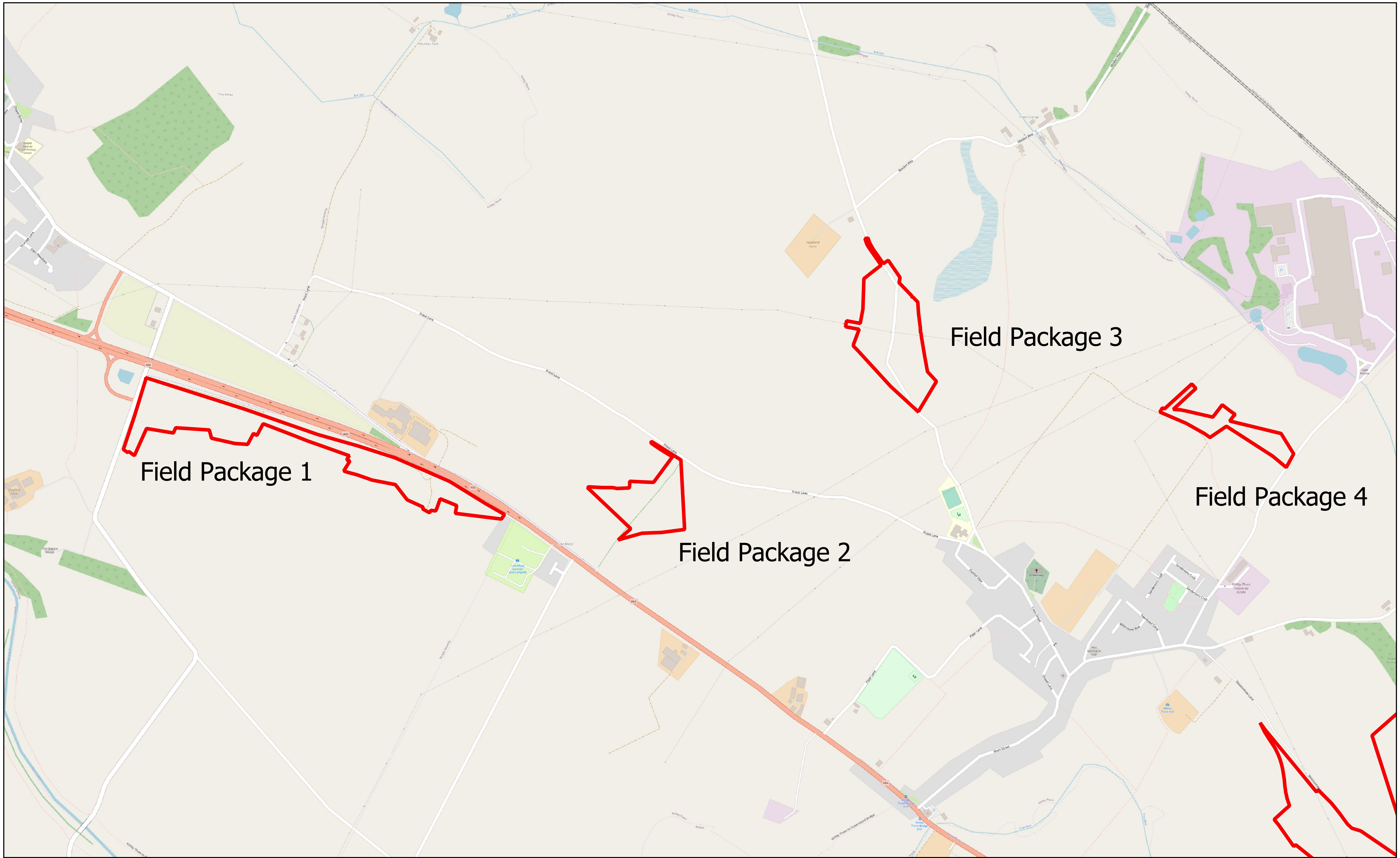


Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

A66_Geochemical_Survey_Areas_(re_scoped)

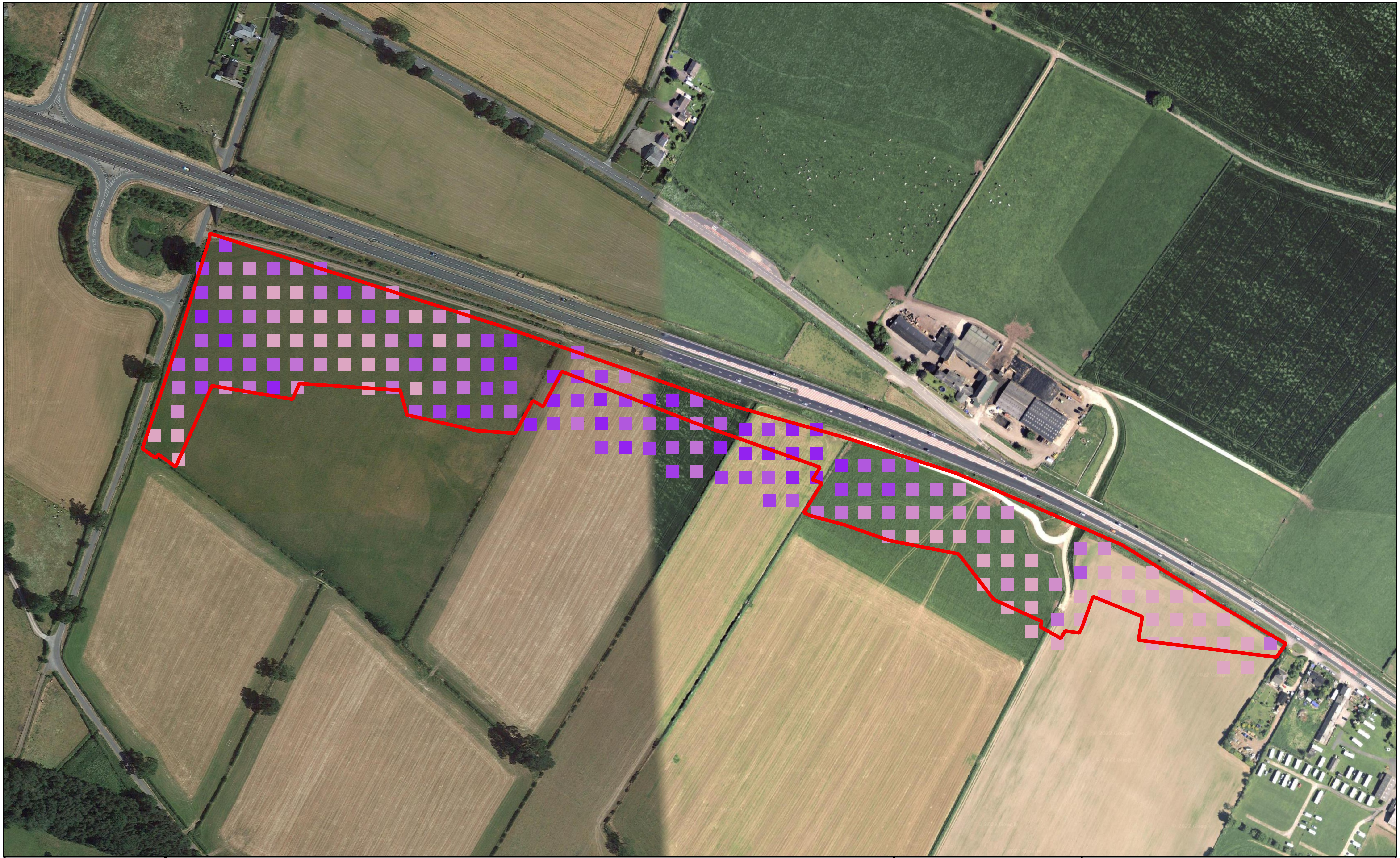
A66 Geochemical Survey

Figure 2: Geochemical Survey Areas - Area 1

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 100 200 300 400 m

Date: 29/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Magnetic Susceptibility SI

- 0.066 - 0.097
- 0.097 - 0.12
- 0.12 - 0.165
- 0.165 - 0.217
- 0.217 - 0.28
- 0.28 - 0.328
- 0.328 - 0.567

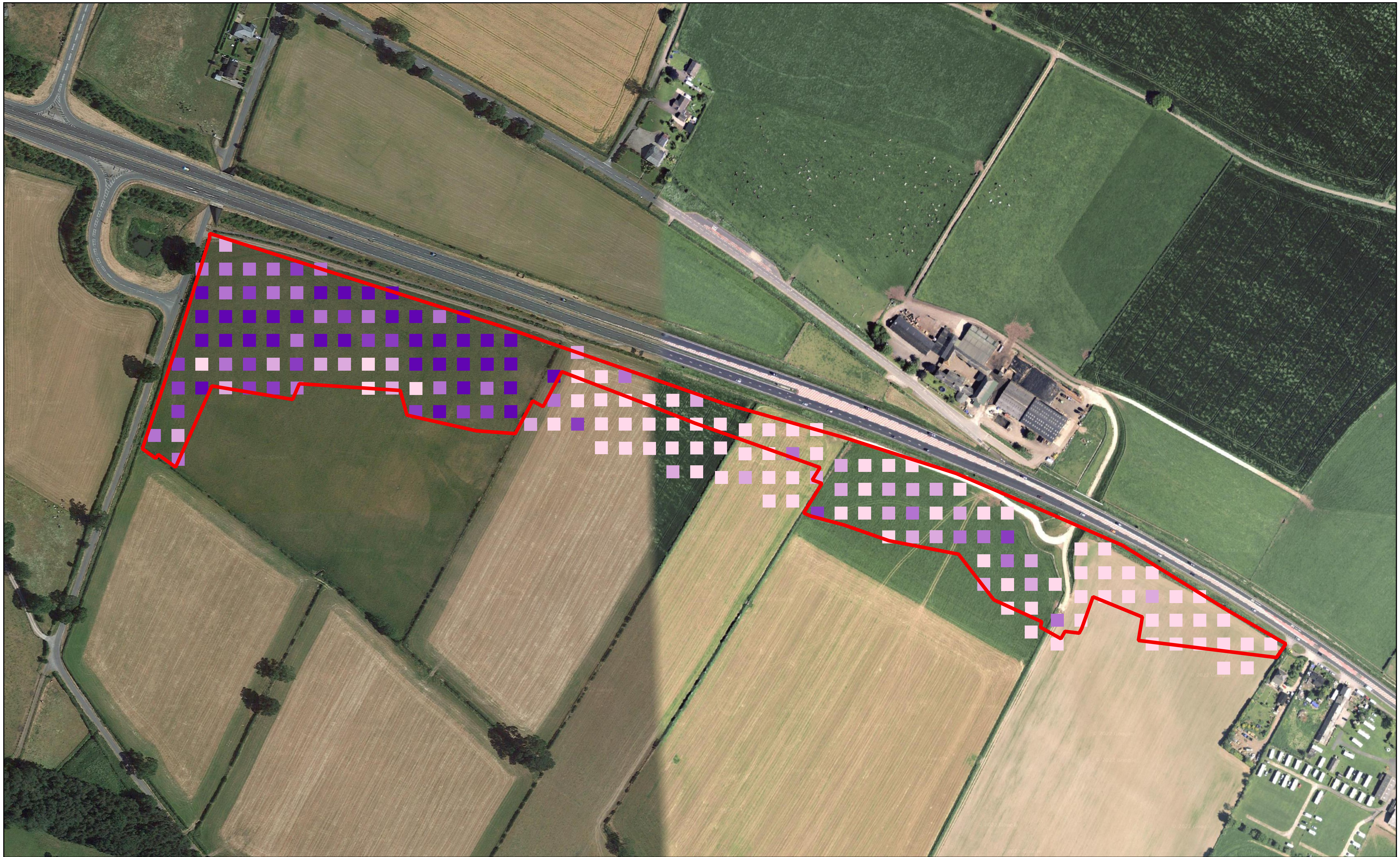
A66 Geochemical Survey

Figure 3: Variation of Magnetic Susceptibility across Field Package 1

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Phosphorus (P) ppm

- 542 - 797
- 797 - 947
- 947 - 1075
- 1075 - 1288
- 1288 - 1506
- 1506 - 1712
- 1712 - 2674

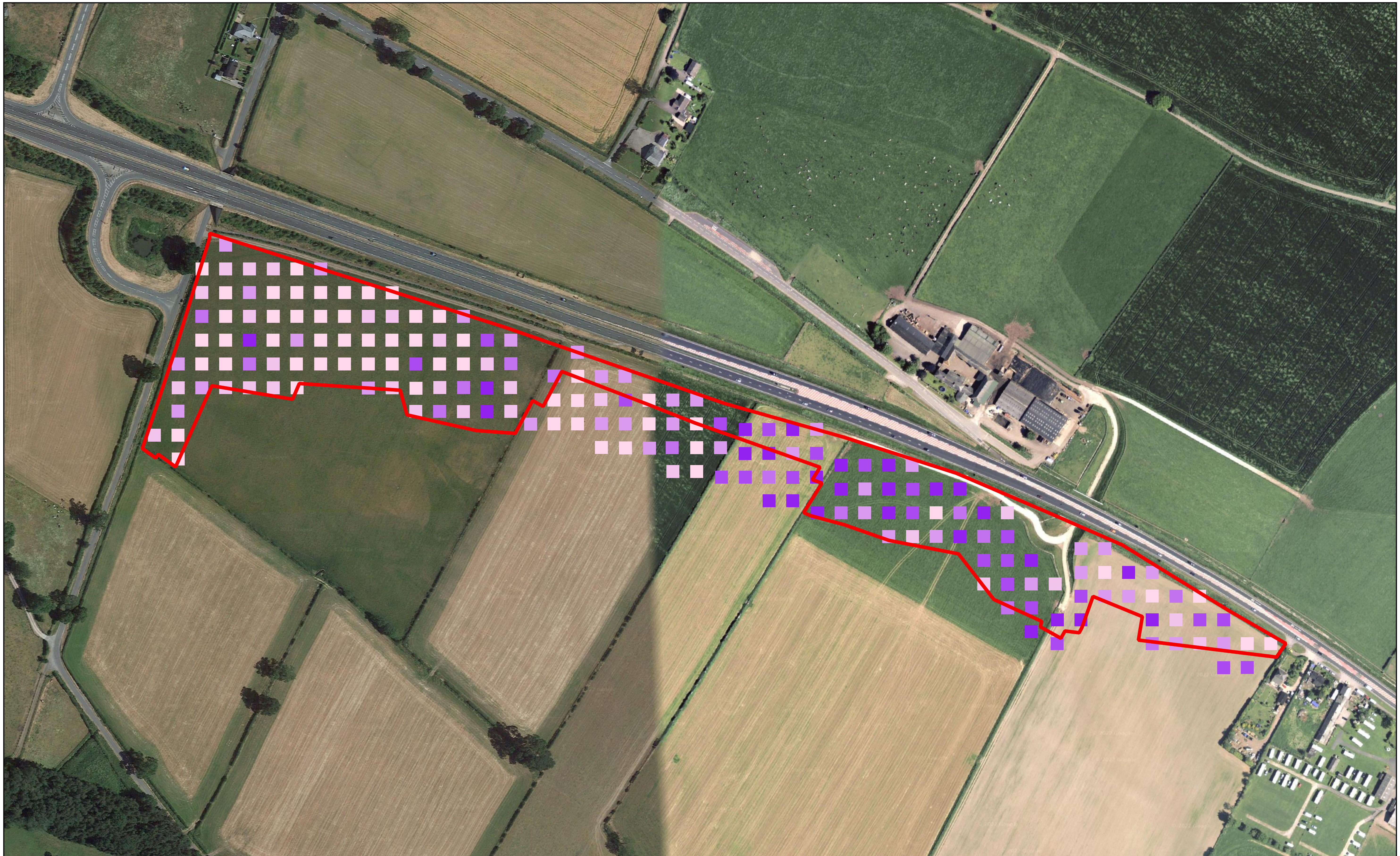
A66 Geochemical Survey

Figure 4: Variation of Phosphorus across Field Package 1

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Copper (Cu) ppm

- 8 - 12
- 12 - 13
- 13 - 15
- 15 - 17
- 17 - 18
- 18 - 21
- 21 - 37

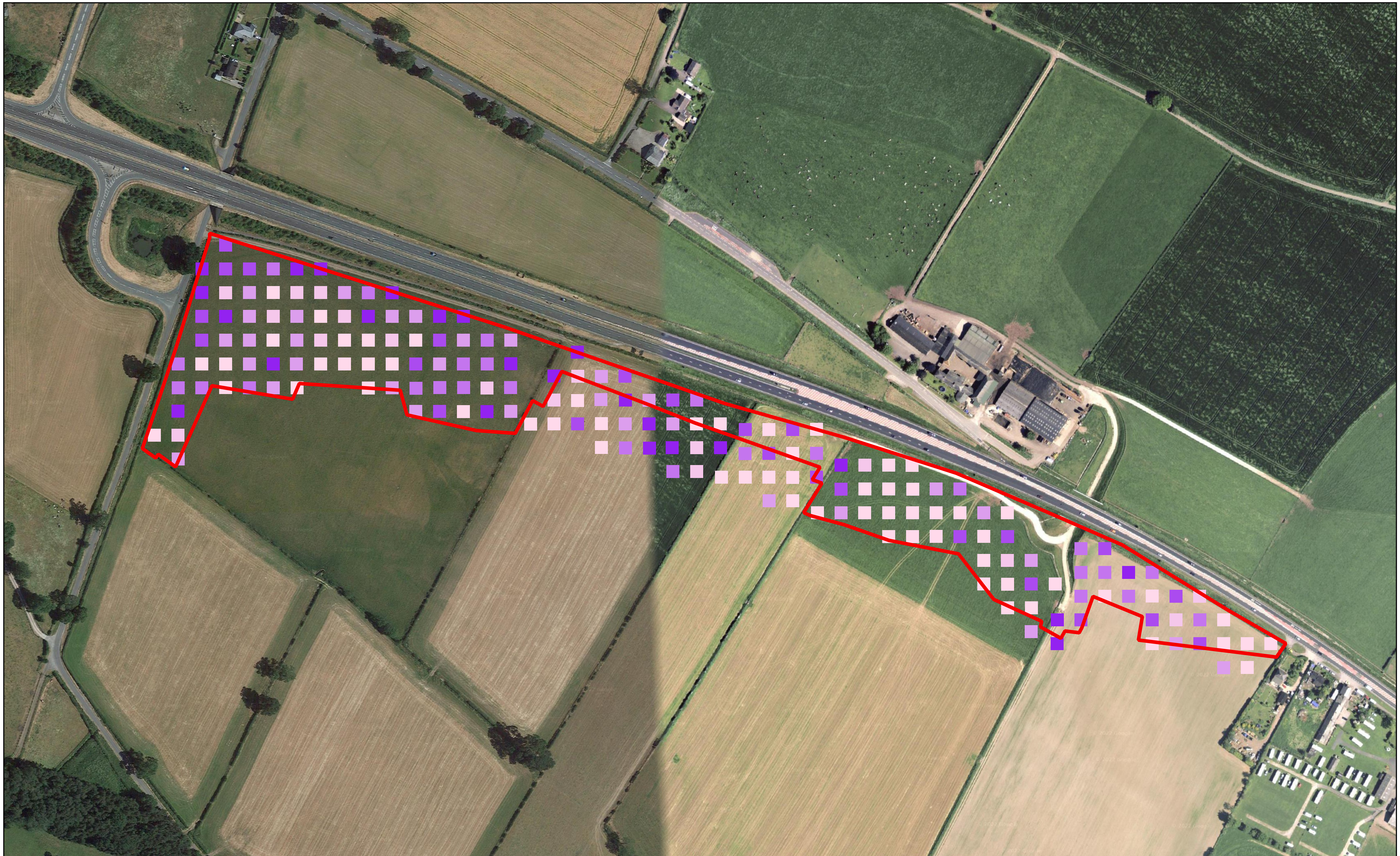
A66 Geochemical Survey

Figure 5: Variation of Copper across Field Package 1

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Zinc (Zn) ppm

- 27 - 34
- 34 - 36
- 36 - 37.9
- 37.9 - 39
- 39 - 41
- 41 - 44
- 44 - 62

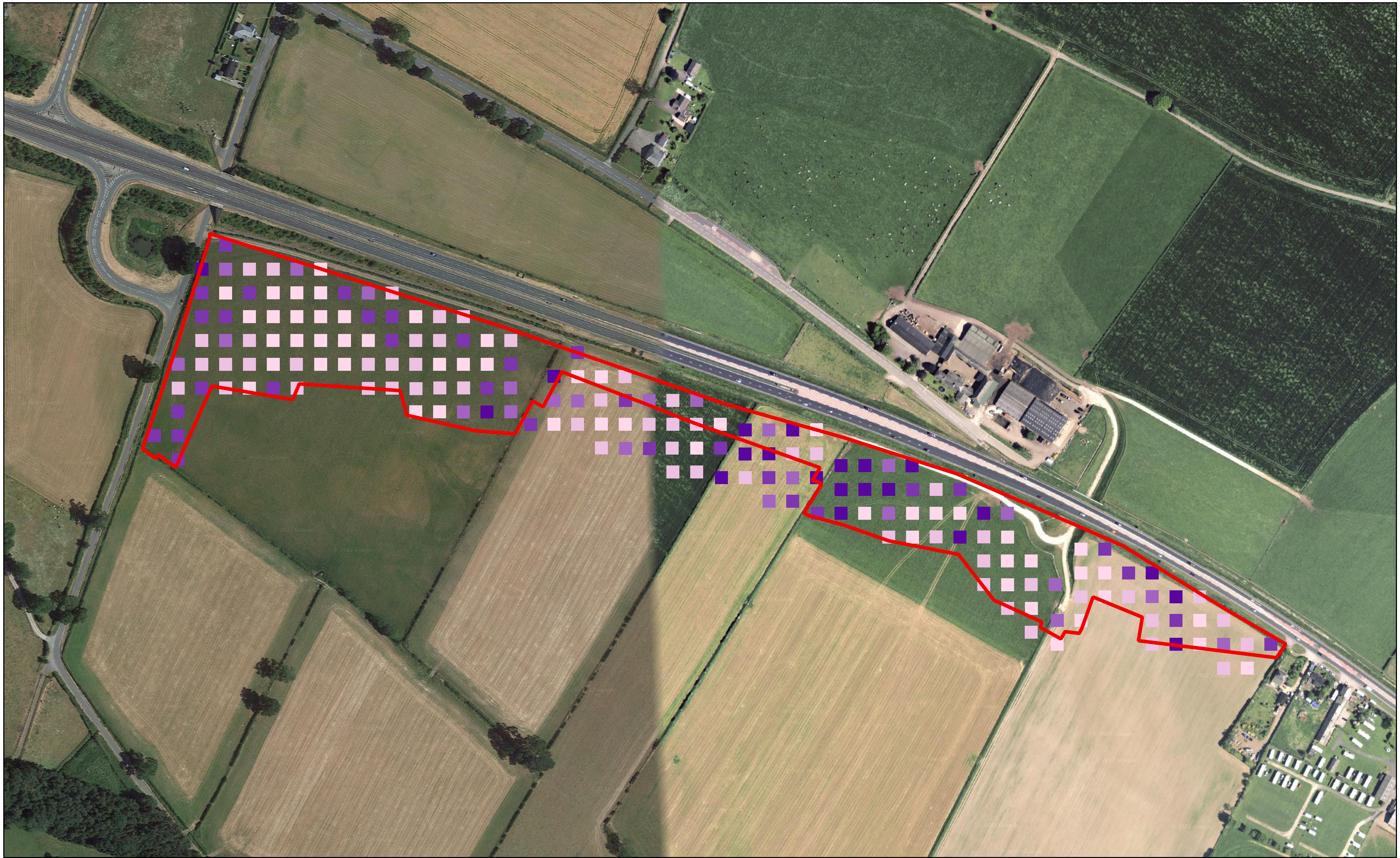
A66 Geochemical Survey

Figure 6: Variation of Zinc across Field Package 1

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Lead (Pb) ppm

- 6 - 10
- 10 - 11.6
- 11.6 - 13
- 13 - 14.4
- 14.4 - 16
- 16 - 25

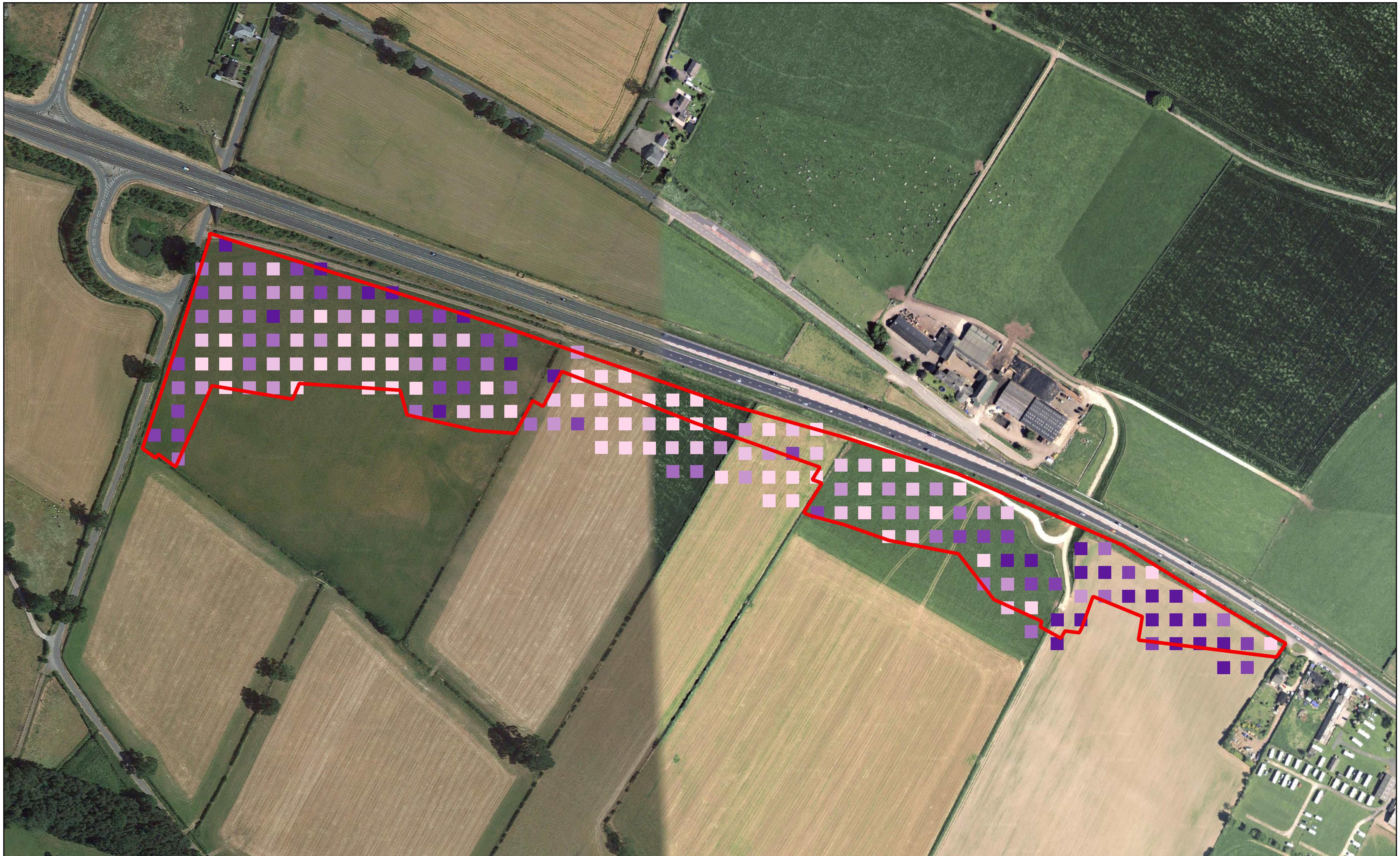
A66 Geochemical Survey

Figure 7: Variation of Lead across Field Package 1

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Calcium (Ca) ppm

- 1333 - 2060
- 2060 - 2316
- 2316 - 2476
- 2476 - 2696
- 2696 - 2892
- 2892 - 3262
- 3262 - 17984

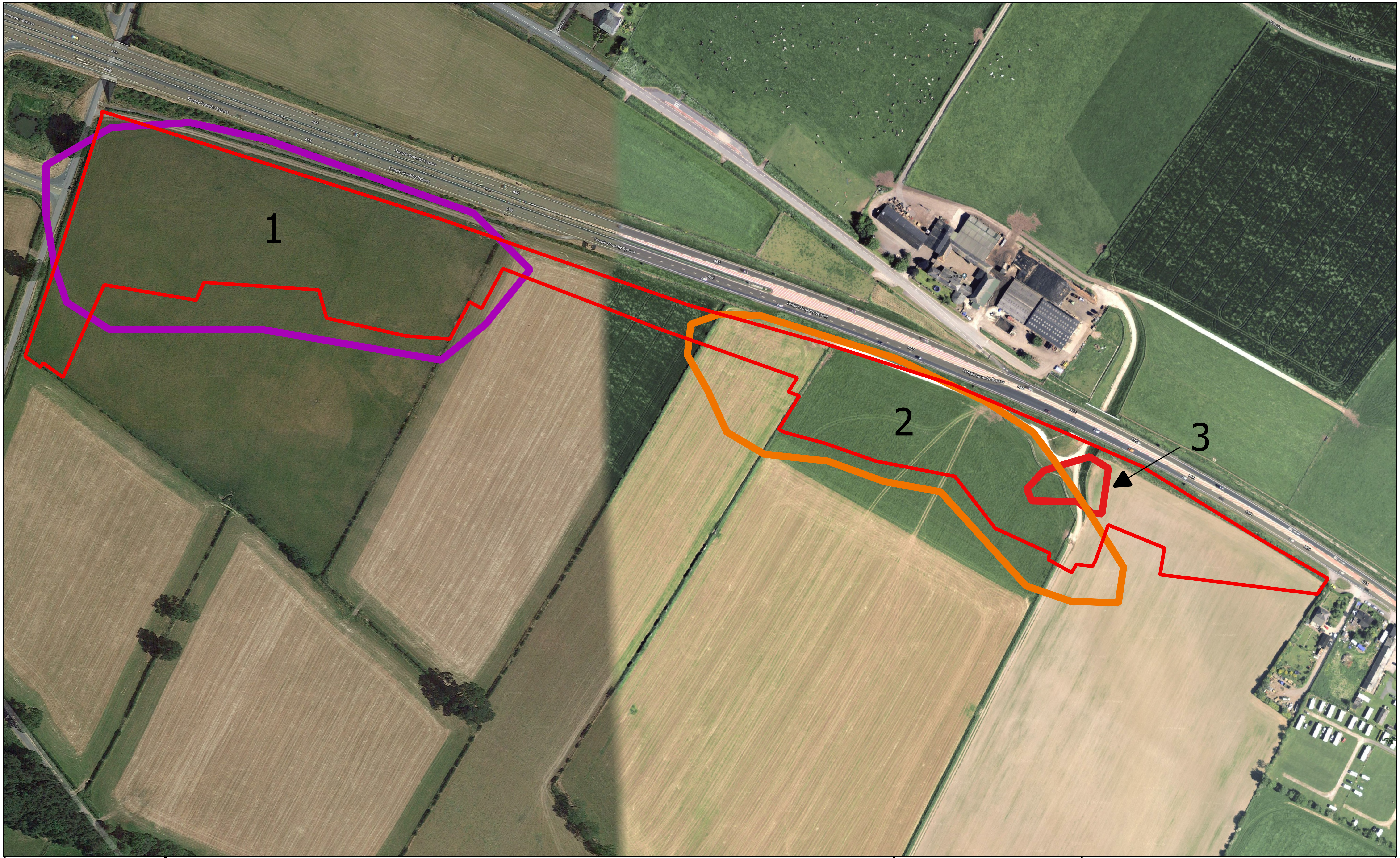
A66 Geochemical Survey

Figure 8: Variation of Calcium across Field Package 1

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

Zones of Enhancement

Calcium (Ca) Copper (Cu) Phosphorus (P)

A66 Geochemical Survey

Figure 9: Interpreted Zones of Enhancement across Field Package 1

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 30/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Magnetic Susceptibility SI

- 0.129 - 0.235
- 0.235 - 0.402
- 0.402 - 0.468
- 0.468 - 0.578
- 0.578 - 0.722
- 0.722 - 0.878
- 0.878 - 1.365

A66 Geochemical Survey

Figure 10: Variation of Magnetic Susceptibility across Field Package 2

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Phosphorus (P) ppm

- 0 - 713
- 713 - 898
- 898 - 1004
- 1004 - 1275
- 1275 - 1583
- 1583 - 1857
- 1857 - 2395

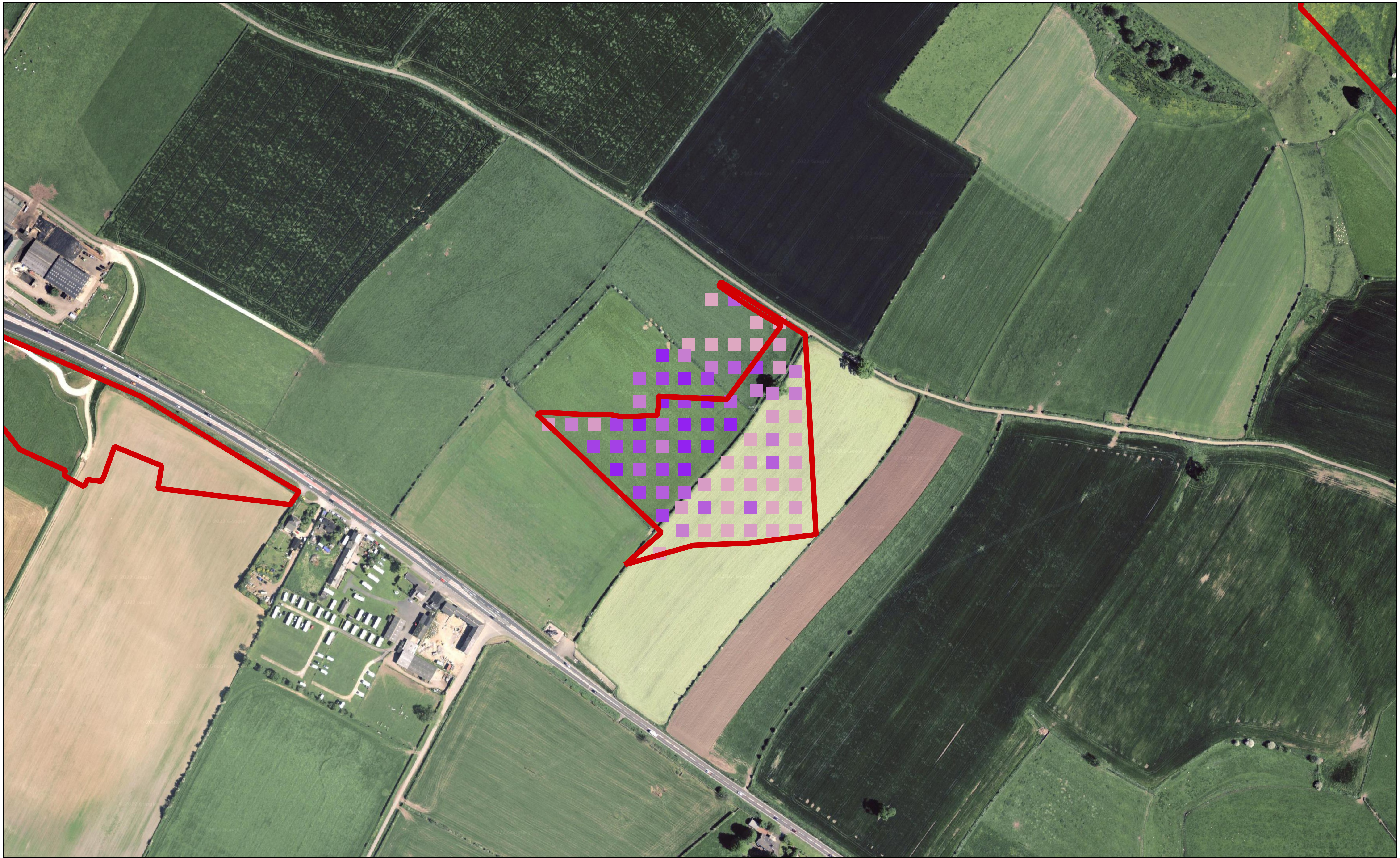
A66 Geochemical Survey

Figure 11: Variation of Phosphorus across Field Package 2

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Copper (Cu) ppm

- 0 - 11.9
- 11.9 - 13.4
- 13.4 - 15.3
- 15.3 - 17.3
- 17.3 - 18.4
- 18.4 - 20.9
- 20.9 - 25.5

A66 Geochemical Survey

Figure 12: Variation of Copper across Field Package 2

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Zinc (Zn) ppm

- 0 - 38
- 38 - 41.1
- 41.1 - 43
- 43 - 45.2
- 45.2 - 47.4
- 47.4 - 51.3
- 51.3 - 62.8

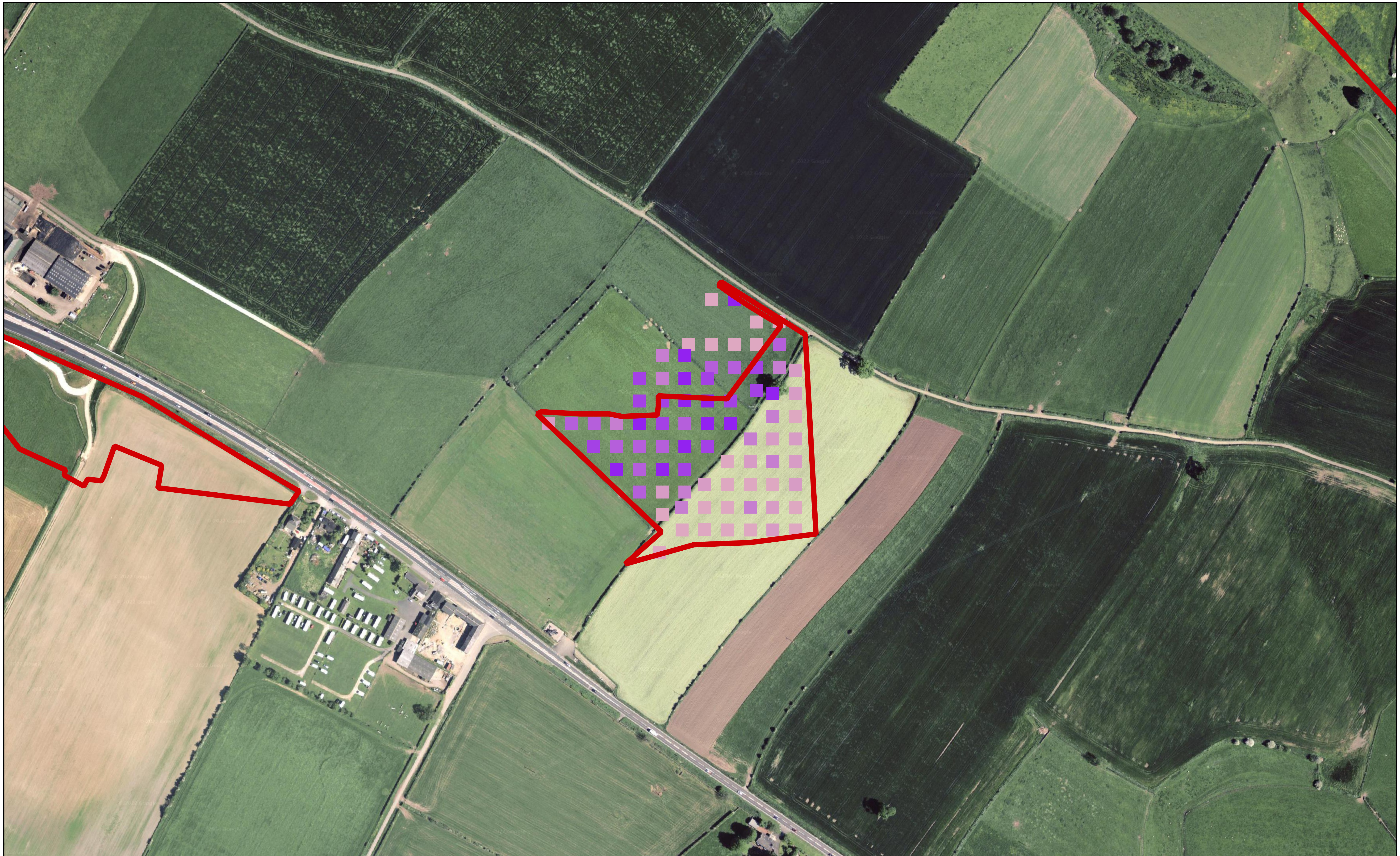
A66 Geochemical Survey

Figure 13: Variation of Zinc across Field Package 2

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Lead (Pb) ppm

- 0 - 18.8
- 18.8 - 22.3
- 22.3 - 25.7
- 25.7 - 28.7
- 28.7 - 30.6
- 30.6 - 33.9
- 33.9 - 45.3

A66 Geochemical Survey

Figure 14: Variation of Lead across Field Package 2

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Calcium (Ca) ppm

- 0 - 2034
- 2034 - 2321
- 2321 - 2514
- 2514 - 2689
- 2689 - 2986
- 2986 - 3186
- 3186 - 5601

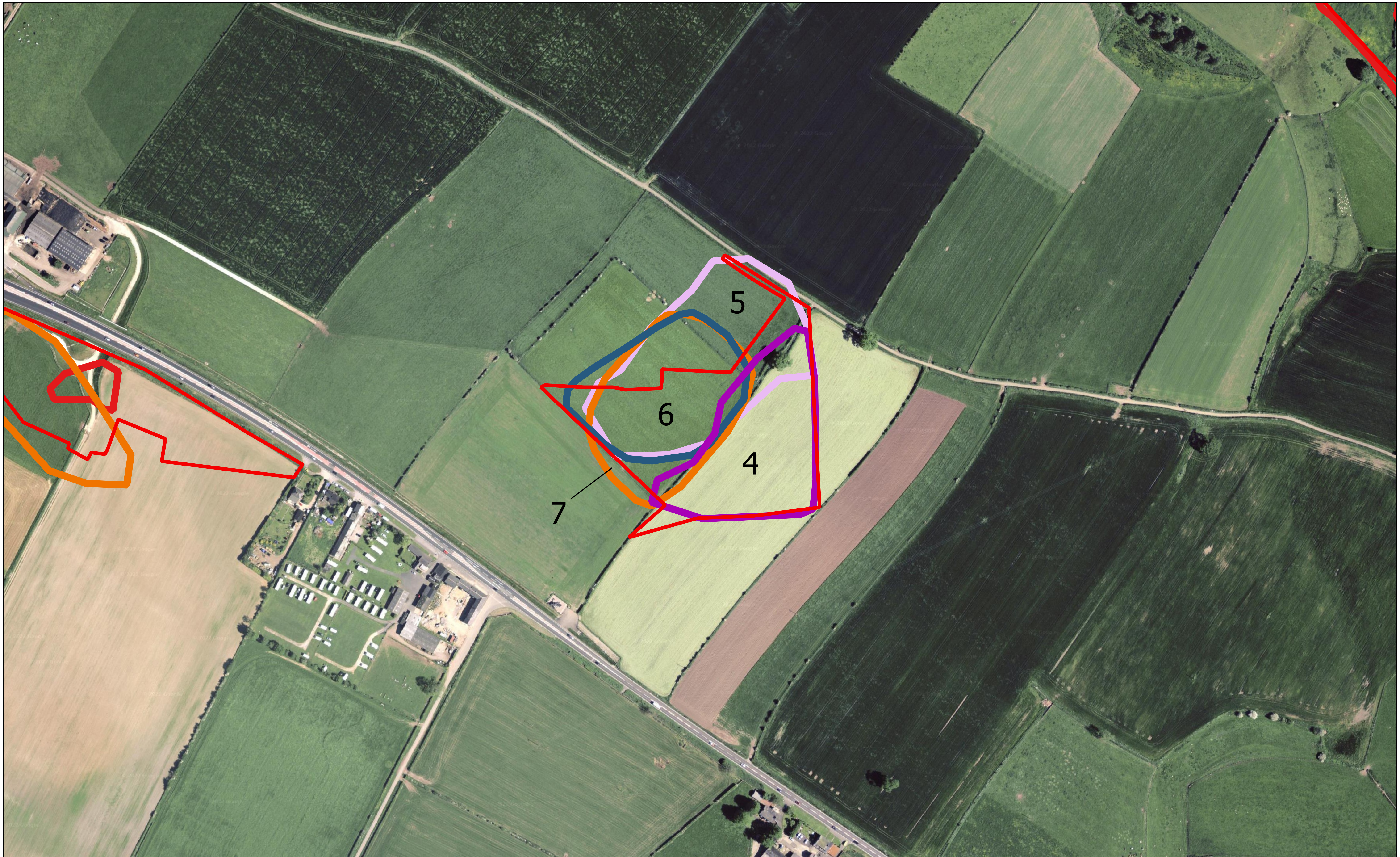
A66 Geochemical Survey

Figure 15: Variation of Calcium across Field Package 2

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Zones of Enhancement

Calcium (Ca) | Copper (Cu) | Magnetic Susceptibility (SI) | Phosphorus (P) | Lead (Pb)

A66 Geochemical Survey

Figure 16: Interpreted Zones of Enhancement across Field Package 2

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Magnetic Susceptibility SI

- 0.023 - 0.053
- 0.053 - 0.063
- 0.063 - 0.075
- 0.075 - 0.096
- 0.096 - 0.143
- 0.143 - 0.266
- 0.266 - 1.099
- 0.7279 - 0.7445
- 0.7445 - 1.099

A66 Geochemical Survey

Figure 17: Variation of Magnetic Susceptibility across Field Package 3

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Phosphorus (P) ppm

- 0 - 797
- 797 - 1100
- 1100 - 1293
- 1293 - 1507
- 1507 - 1767
- 1767 - 2091
- 2091 - 2561

A66 Geochemical Survey

Figure 18: Variation of Phosphorus across Field Package 3

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Copper (Cu) ppm

- 0 - 10.59
- 10.59 - 12.27
- 12.27 - 13.5
- 13.5 - 14.34
- 14.34 - 15.8
- 15.8 - 17.5
- 17.5 - 28

A66 Geochemical Survey

Figure 19: Variation of Copper across Field Package 9

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Zinc (Zn) ppm

- 0 - 37.3
- 37.3 - 39.9
- 39.9 - 42.3
- 42.3 - 44.7
- 44.7 - 47.5
- 47.5 - 51.2
- 51.2 - 100.8

A66 Geochemical Survey

Figure 20: Variation of Zinc across Field Package 3

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Lead (Pb) ppm

- 0 - 9.3
- 9.3 - 10.8
- 10.8 - 12.8
- 12.8 - 15
- 15 - 17.7
- 17.7 - 20.6
- 20.6 - 48.8

A66 Geochemical Survey

Figure 21: Variation of Lead across Field Package 3

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Calcium (Ca) ppm

- 0 - 2331
- 2331 - 2674
- 2674 - 2923
- 2923 - 3075
- 3075 - 3327
- 3327 - 3853
- 3853 - 38676

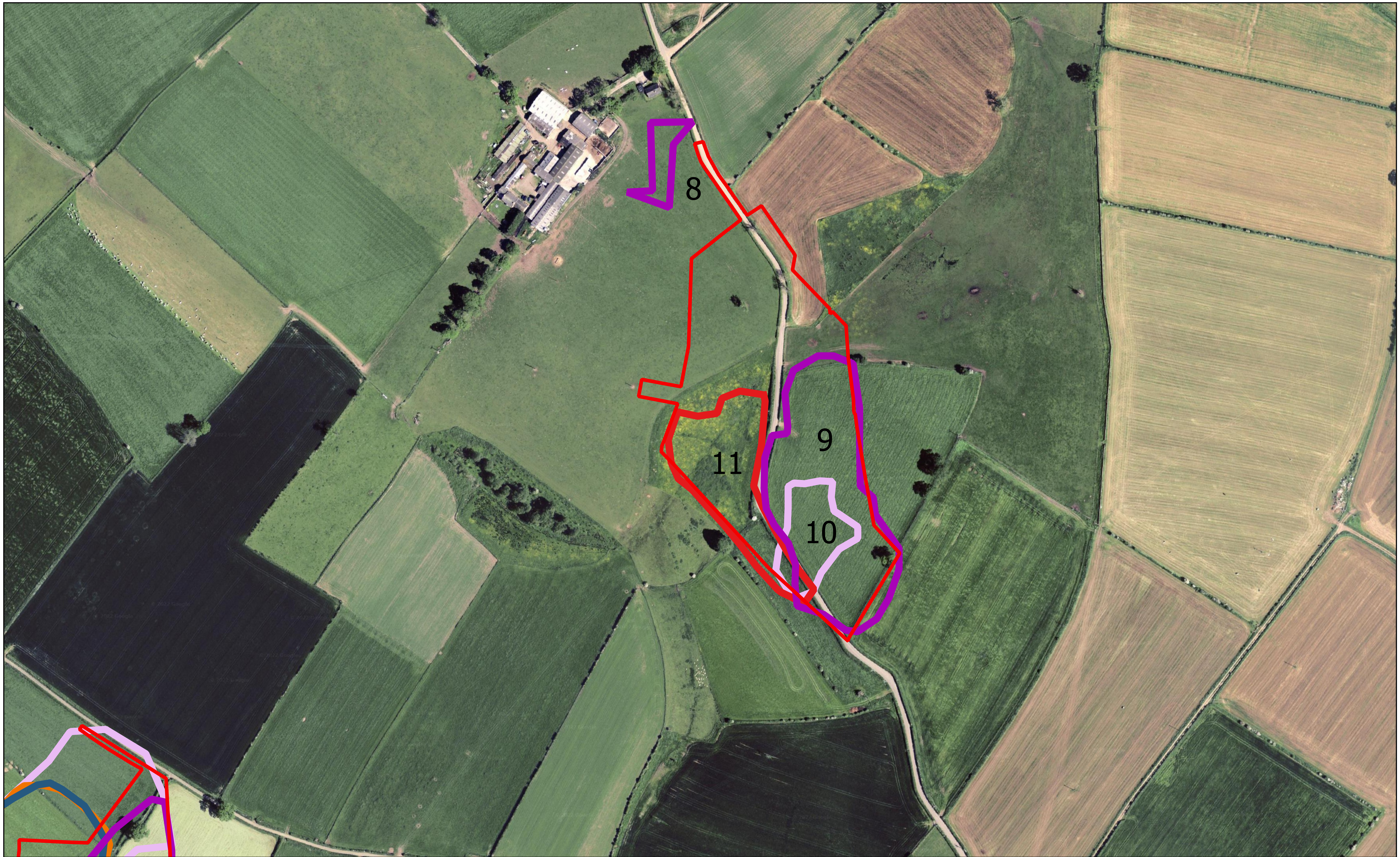
A66 Geochemical Survey

Figure 22: Variation of Calcium across Field Package 3

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 28/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Zones of Enhancement

Calcium (Ca) Copper (Cu) Magnetic Susceptibility (SI) Phosphorus (P) Lead (Pb)

A66 Geochemical Survey

Figure 23: Interpreted Zones of Enhancement across Field Package 3

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt

Scale: As indicated

Legend

Magnetic Susceptibility SI

- 0.024 - 0.05
- 0.05 - 0.058
- 0.058 - 0.0677
- 0.0677 - 0.0806
- 0.0806 - 0.0916
- 0.0916 - 0.1066
- 0.1066 - 0.252

A66 Geochemical Survey

Figure 24: Variation of Magnetic Susceptibility across Field Package 4

ARCHAEOLOGICAL RESEARCH SERVICES LTD

Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt

Scale: As indicated

Legend

Phosphorus (P) ppm

- 0 - 446
- 446 - 565
- 565 - 709
- 709 - 869
- 869 - 954
- 954 - 1076
- 1076 - 1440

A66 Geochemical Survey

Figure 25: Variation of Phosphorus across Field Package 4

ARCHAEOLOGICAL RESEARCH SERVICES LTD

Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt

Scale: As indicated

Legend

Copper (Cu) ppm

- 0 - 11.74
- 11.74 - 12.9
- 12.9 - 13.6
- 13.6 - 14.3
- 14.3 - 15
- 15 - 16.93
- 16.93 - 19.8

A66 Geochemical Survey

Figure 26: Variation of Copper across Field Package 4

ARCHAEOLOGICAL RESEARCH SERVICES LTD

Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Zinc (Zn) ppm

- 0 - 39.4
- 39.4 - 40.9
- 40.9 - 42.7
- 42.7 - 44.4
- 44.4 - 46.2
- 46.2 - 48.3
- 48.3 - 60.1

A66 Geochemical Survey

Figure 27: Variation of Zinc across Field Package 4

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Lead (Pb) ppm

8.40 - 10.74
13.09 - 15.43
15.43 - 17.77
17.77 - 20.11
20.11 - 22.46
22.46 - 24.80

A66 Geochemical Survey

Figure 28: Variation of Lead across Field Package 4

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

Calcium (Ca) ppm

- 0 - 2084
- 2084 - 2222
- 2222 - 2400
- 2400 - 2493
- 2493 - 2693
- 2693 - 2843
- 2843 - 3711

A66 Geochemical Survey

Figure 29: Variation of Calcium across Field Package 4

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: D. Hunt
Scale: As indicated

Legend

No areas of enhancement

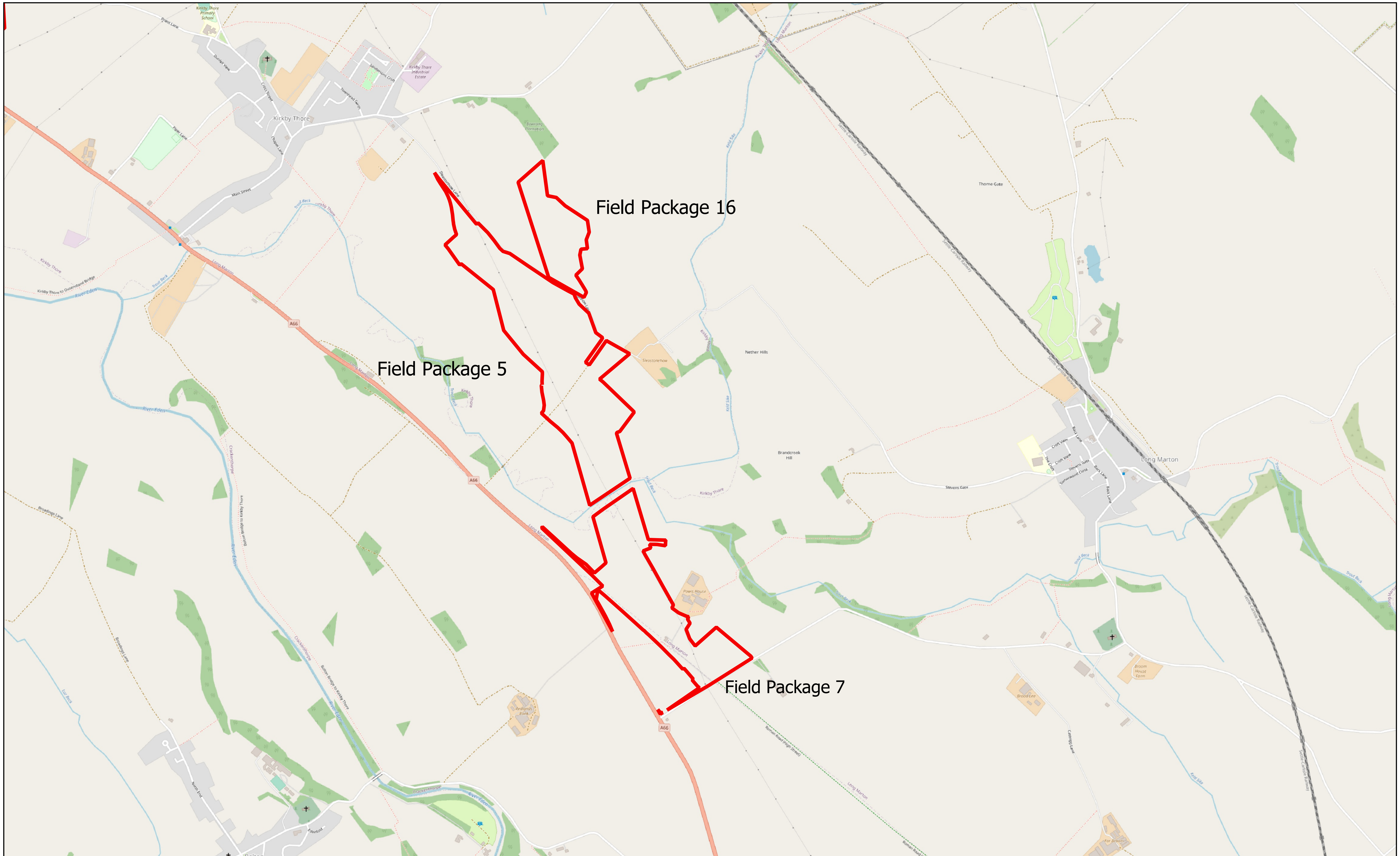
A66 Geochemical Survey

Figure 30: Interpreted Zones of Enhancement across Field Package 4

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

A66_Geochemical_Survey_Areas_(re_scoped)

A66 Geochemical Survey

Figure 31: Geochemical Survey Areas - Area 2

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 100 200 300 400 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Magnetic Susceptibility SI

- 0.042 - 0.11
- 0.11 - 0.125
- 0.125 - 0.145
- 0.145 - 0.17
- 0.17 - 0.204
- 0.204 - 0.295
- 0.295 - 1.289

A66 Geochemical Survey

Figure 32: Variation of Magnetic Susceptibility across Field Package 5

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 100 200 300 400 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

Phosphorus (P) ppm

- 0 - 231
- 231 - 403
- 403 - 619
- 619 - 1087
- 1087 - 1317
- 1317 - 1641
- 1641 - 2211

A66 Geochemical Survey

Figure 33: Variation of Phosphorus across Field Package 5

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 100 200 300 400 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Copper (Cu) ppm

- 0.7 - 13.6
- 13.6 - 15.6
- 15.6 - 17.5
- 17.5 - 18.7
- 18.7 - 20.9
- 20.9 - 24.3
- 24.3 - 42.6

A66 Geochemical Survey

Figure 34: Variation of Copper across Field Package 5

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 100 200 300 400 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Zinc (Zn) ppm

- 0.7 - 35
- 35 - 37.6
- 37.6 - 39.8
- 39.8 - 42.7
- 42.7 - 45.7
- 45.7 - 61.7
- 61.7 - 267.4

A66 Geochemical Survey

Figure 35: Variation of Zinc across Field Package 5

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 100 200 300 400 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

Lead (Pb) ppm

- 0.7 - 1.7
- 1.7 - 14.8
- 14.8 - 18.6
- 18.6 - 21.8
- 21.8 - 25.8
- 25.8 - 30.5
- 30.5 - 98.9
- 98.9 - 1144.2

A66 Geochemical Survey

Figure 36: Variation of Lead across Field Package 5

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 100 200 300 400 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

Calcium (Ca) ppm

- 0 - 2019
- 2019 - 2400
- 2400 - 2615
- 2615 - 2973
- 2973 - 3268
- 3268 - 3661
- 3661 - 4881

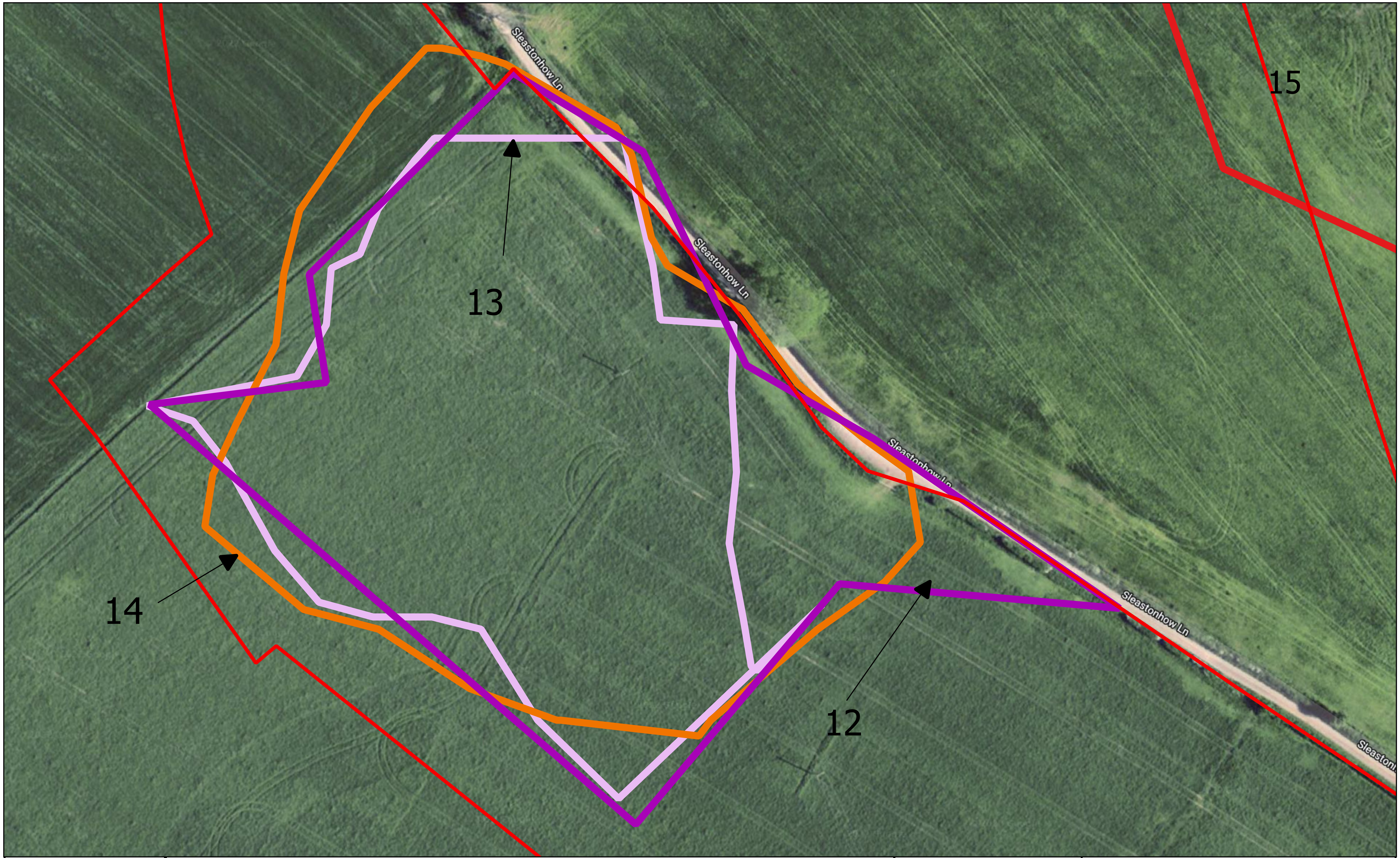
A66 Geochemical Survey

Figure 37: Variation of Calcium across Field Package 5

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 100 200 300 400 m

Date: 29/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Phosphorus (P) Copper (Cu) Magnetic Susceptibility (SI)

A66 Geochemical Survey

Figure 38: Interpreted Zones of Enhancement across Field Package 5 - Northern extent

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 10 20 30 40 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Zones of Enhancement

Copper (Cu) Lead (Pb) Zinc (Zn)

A66 Geochemical Survey

Figure 39: Interpreted Zones of Enhancement across Field Package 5 - Southern extent

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Magnetic Susceptibility SI

- 0 - 0.054
- 0.054 - 0.072
- 0.072 - 0.095
- 0.095 - 0.117
- 0.117 - 0.141
- 0.141 - 0.186
- 0.186 - 1.059

A66 Geochemical Survey

Figure 40: Variation of Magnetic Susceptibility across Field Package 7

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 50 100 150 200 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Phosphorus (P) ppm

- 1 - 127
- 127 - 212
- 212 - 362
- 362 - 485
- 485 - 648
- 648 - 1481
- 1481 - 6660

A66 Geochemical Survey

Figure 41: Variation of Phosphorus across Field Package 7

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 30/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Copper (Cu) ppm

- 0.67 - 7.7
- 7.7 - 8.9
- 8.9 - 9.8
- 9.8 - 10.7
- 10.7 - 11.8
- 11.8 - 13.4
- 13.4 - 24.6

A66 Geochemical Survey

Figure 42: Variation of Copper across Field Package 7

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 50 100 150 200 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Zinc (Zn) ppm

- 21.1 - 31.9
- 31.9 - 34.7
- 34.7 - 37.2
- 37.2 - 40.5
- 40.5 - 47.7
- 47.7 - 130.6
- 130.6 - 300.6

A66 Geochemical Survey

Figure 43: Variation of Zinc across Field Package 7

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 50 100 150 200 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

Lead (Pb) ppm

- 5.8 - 14.2
- 14.2 - 16.4
- 16.4 - 18.3
- 18.3 - 21.5
- 21.5 - 28.7
- 28.7 - 528
- 528 - 2731.9

A66 Geochemical Survey

Figure 44: Variation of Lead across Field Package 7

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 50 100 150 200 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

Calcium (Ca) ppm

- 110 - 1043
- 1043 - 1223
- 1223 - 1409
- 1409 - 1582
- 1582 - 1766
- 1766 - 2046
- 2046 - 4076

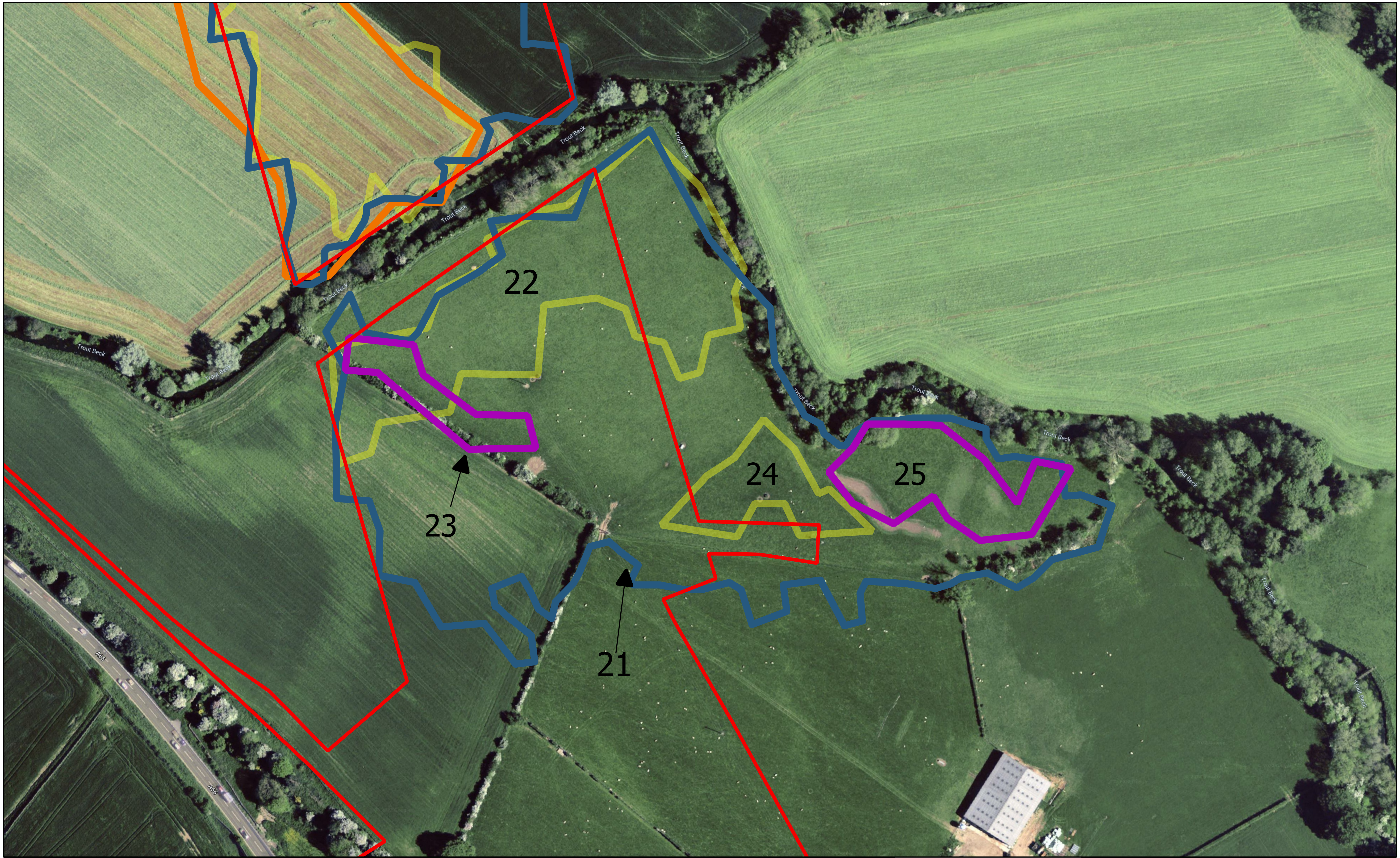
A66 Geochemical Survey

Figure 45: Variation of Calcium across Field Package 7

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 50 100 150 200 m

Date: 29/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Zones of Enhancement

Copper (Cu) Phosphorus (P) Lead (Pb) Zinc (Zn)

A66 Geochemical Survey

Figure 46: Interpreted Zones of Enhancement across Field Package 7

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Magnetic Susceptibility SI

- 0.014 - 0.034
- 0.034 - 0.049
- 0.049 - 0.065
- 0.065 - 0.098
- 0.098 - 0.132
- 0.132 - 0.179
- 0.179 - 0.412

A66 Geochemical Survey

Figure 47: Variation of Magnetic Susceptibility across Field Package 16

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Phosphorus (P) ppm

- 1 - 245
- 245 - 370
- 370 - 455
- 455 - 659
- 659 - 856
- 856 - 967
- 967 - 1134

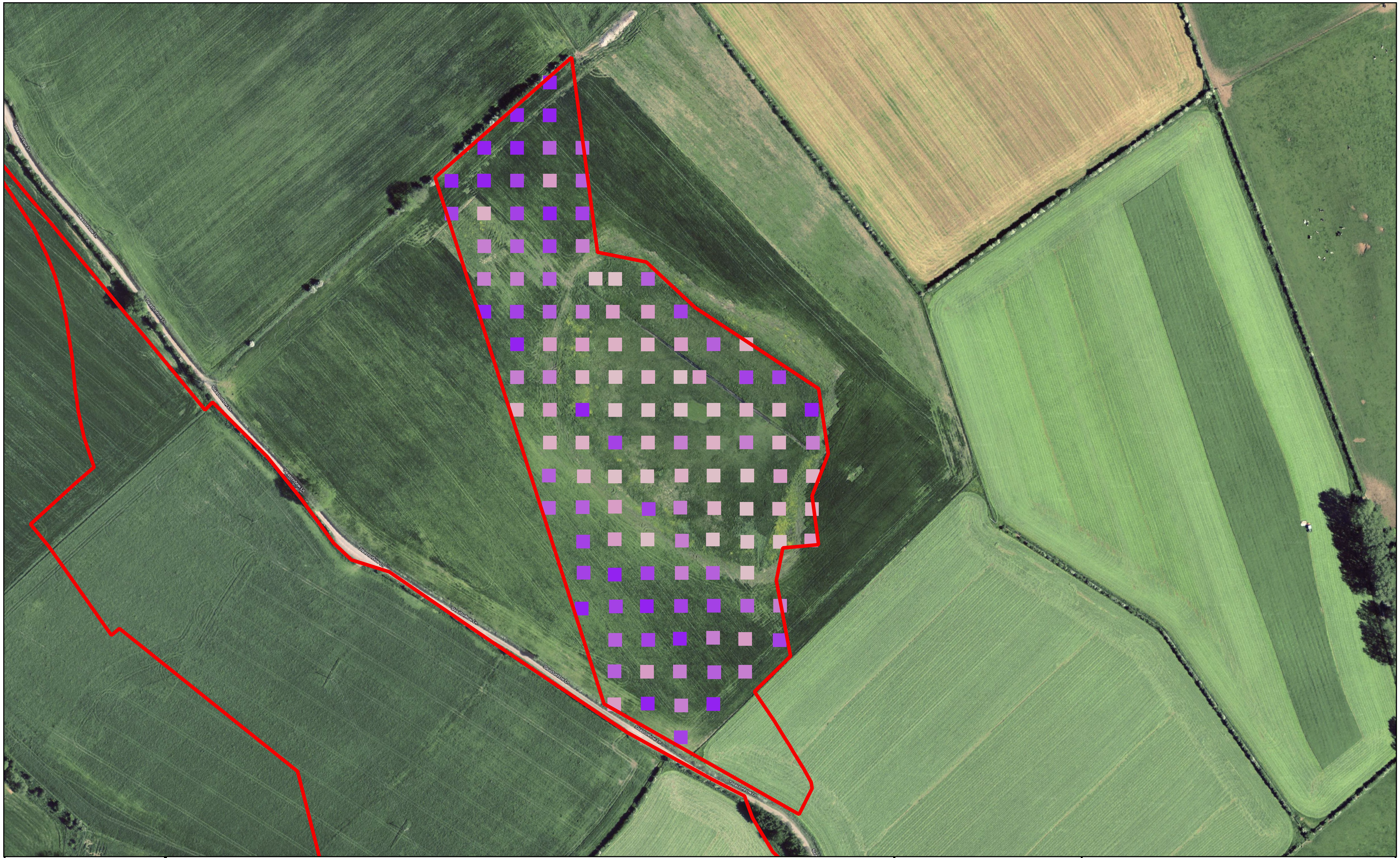
A66 Geochemical Survey

Figure 48: Variation of Phosphorus across Field Package 16

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Copper (Cu) ppm

3.6 - 9.3
9.3 - 11.4
11.4 - 12.5
12.5 - 13.6
13.6 - 15.4
15.4 - 16.8
16.8 - 20.9

A66 Geochemical Survey

Figure 49: Variation of Copper across Field Package 16

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Zinc (Zn) ppm

- 14.7 - 24.9 [18]
- 24.9 - 30.8 [18]
- 30.8 - 35.1 [19]
- 35.1 - 38.5 [17]
- 38.5 - 41.4 [19]
- 41.4 - 44.7 [17]
- 44.7 - 59.5 [18]

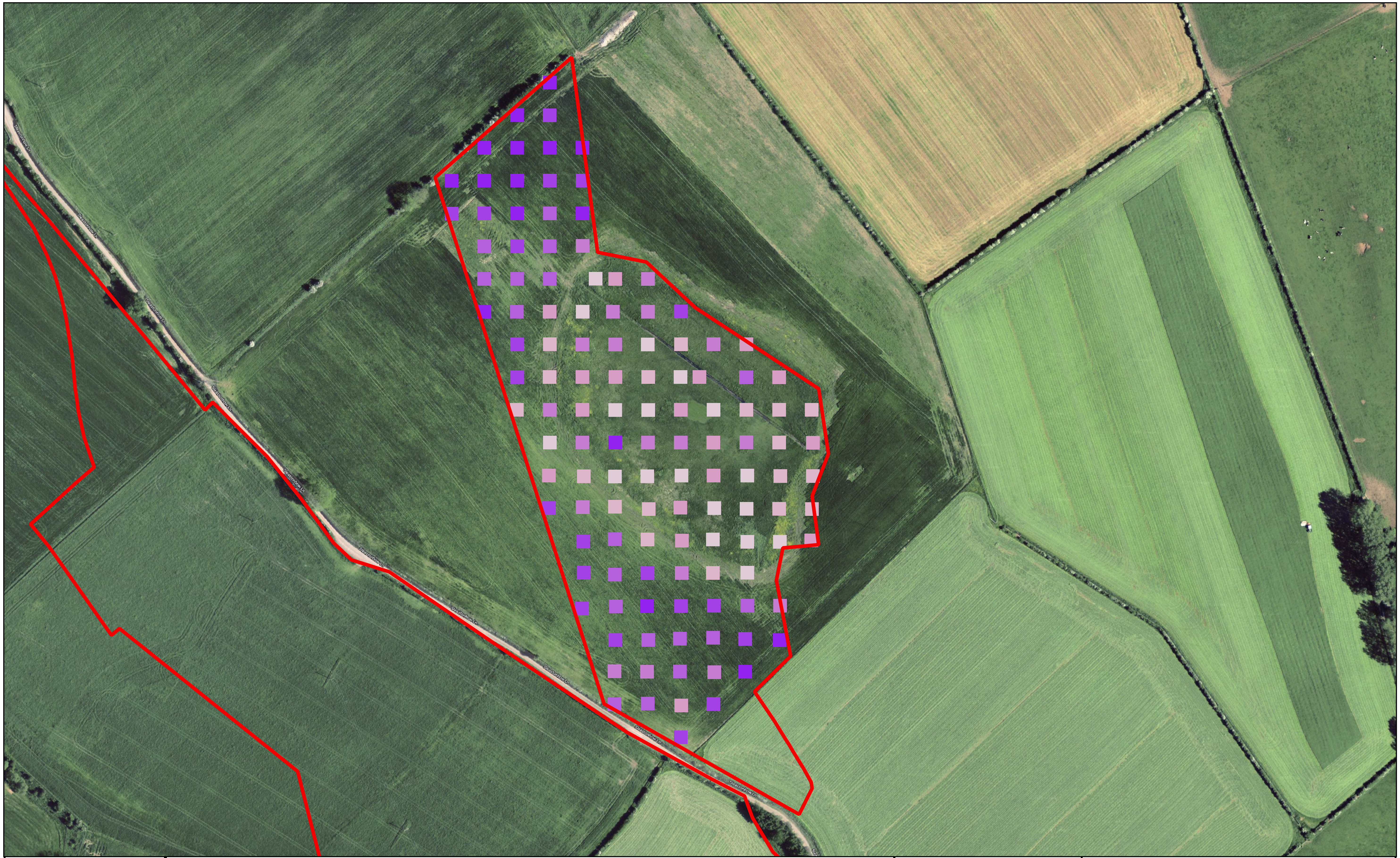
A66 Geochemical Survey

Figure 50: Variation of Zinc across Field Package 16

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

Lead (Pb) ppm

- 0.7 - 11.4
- 11.4 - 15.4
- 15.4 - 18.4
- 18.4 - 19.8
- 19.8 - 22.1
- 22.1 - 23.9
- 23.9 - 27.8

A66 Geochemical Survey

Figure 51: Variation of Lead across Field Package 16

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

Calcium (Ca) ppm

681 - 2640
2640 - 3308
3308 - 3825
3825 - 4251
4251 - 5230
5230 - 6765
6765 - 33755

A66 Geochemical Survey

Figure 52: Variation of Calcium across Field Package 16

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Zones of Enhancement

Calcium (Ca)

A66 Geochemical Survey

Figure 53: Interpreted Zones of Enhancement across Field Package 16

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

A66_Geochemical_Survey_Areas_(re_scoped)

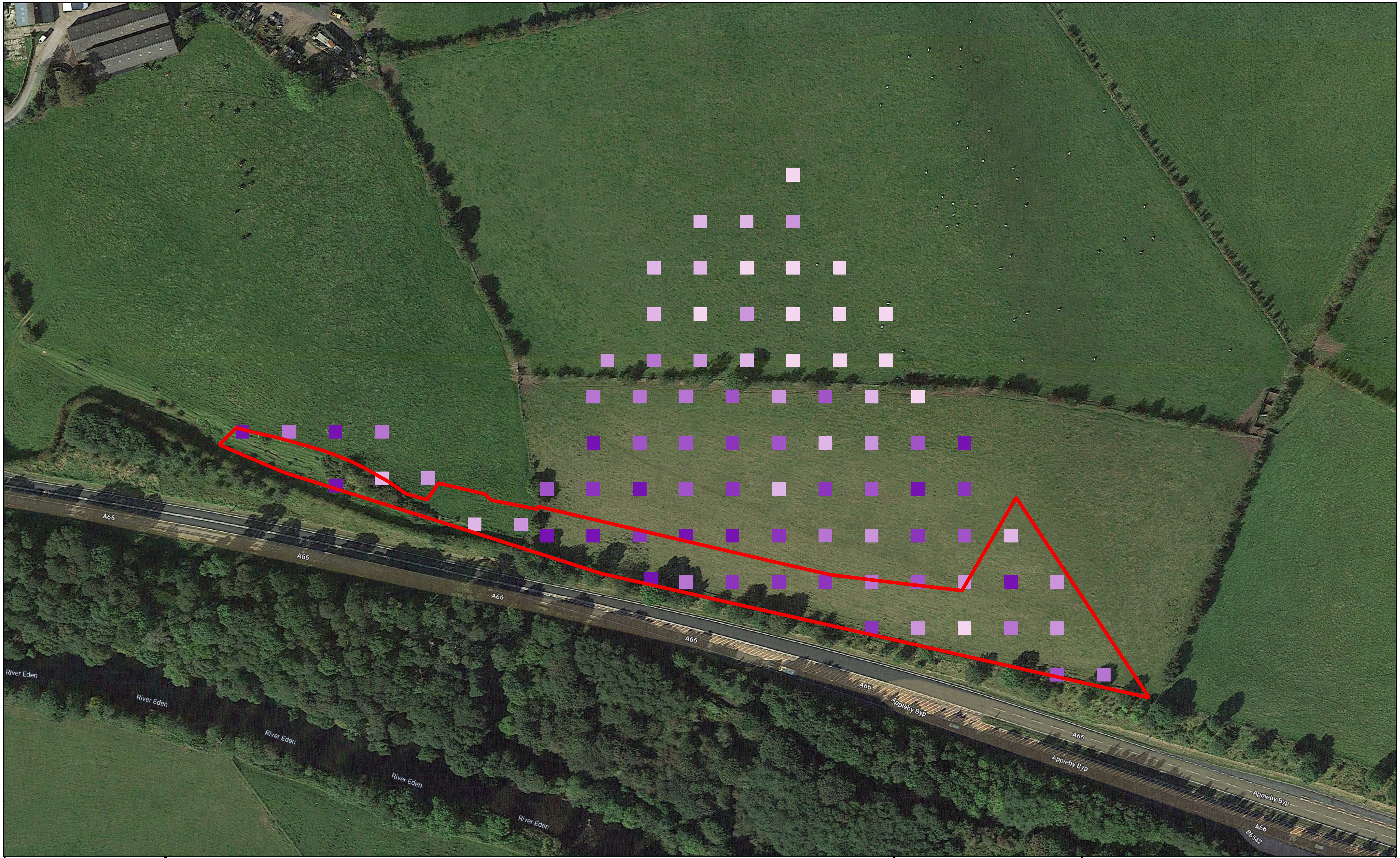
A66 Geochemical Survey

Figure 54: Geochemical Survey Areas - Area 3

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 50 100 150 200 m

Date: 29/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo

Scale: As indicated

Legend

Magnetic Susceptibility SI

- 0.004 - 0.0431
- 0.0431 - 0.0586
- 0.0586 - 0.068
- 0.068 - 0.0776
- 0.0776 - 0.0847
- 0.0847 - 0.0989
- 0.0989 - 0.654

A66 Geochemical Survey

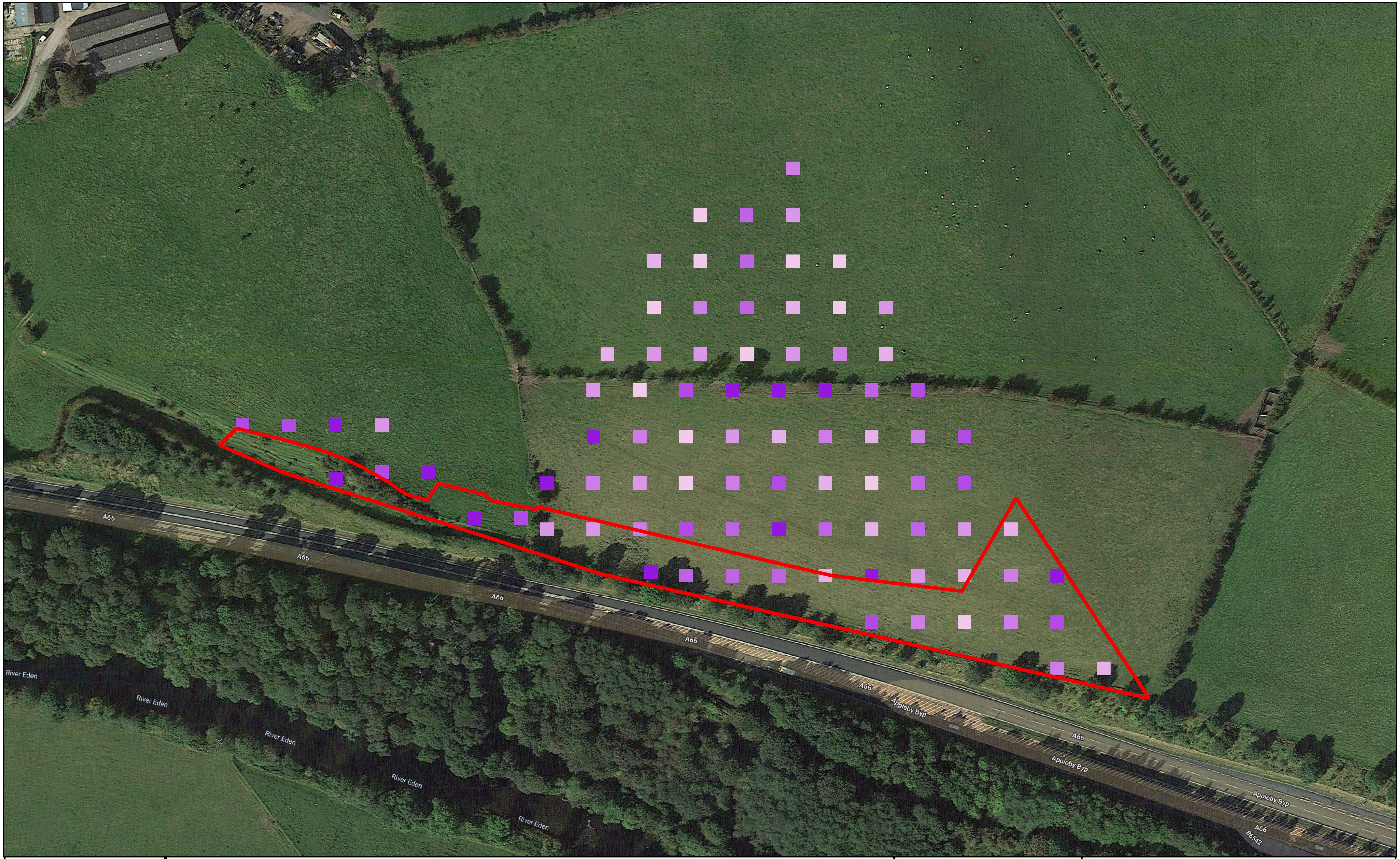
Figure 55: Variation of Magnetic Susceptibility across Field Package 10

ARCHAEOLOGICAL RESEARCH SERVICES LTD

Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Copper (Cu) ppm

0 - 4.96
4.96 - 6.66
6.66 - 7.4
7.4 - 8.4
8.4 - 9.54
9.54 - 11.21
11.21 - 45.7

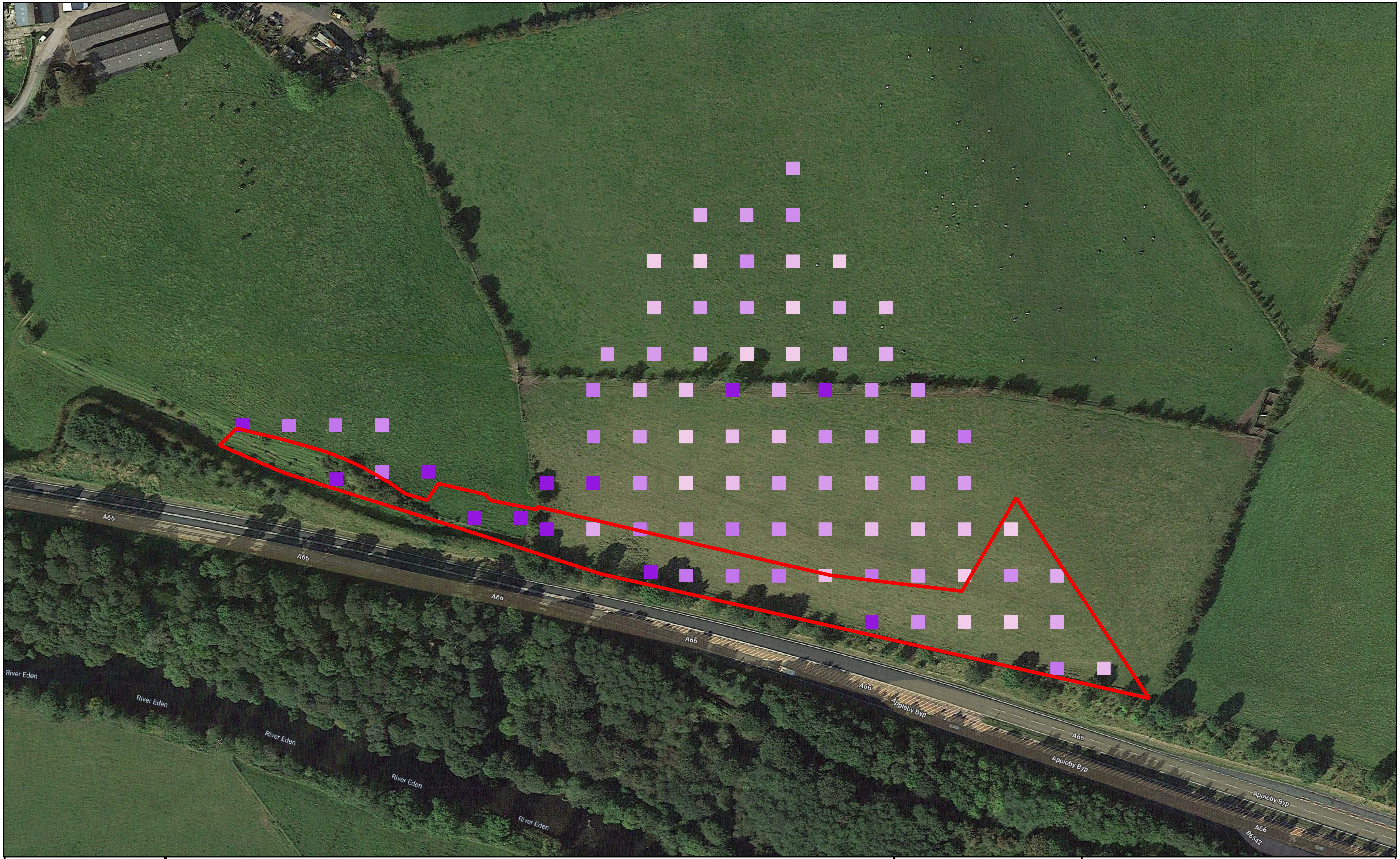
A66 Geochemical Survey

Figure 57: Variation of Copper across Field Package 10

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo

Scale: As indicated

Legend

Zinc (Zn) ppm

- 0 - 20.6 [12]
- 20.6 - 23.1 [12]
- 23.1 - 25.8 [12]
- 25.8 - 27.3 [14]
- 27.3 - 29.4 [11]
- 29.4 - 32.1 [13]
- 32.1 - 71.8 [12]

A66 Geochemical Survey

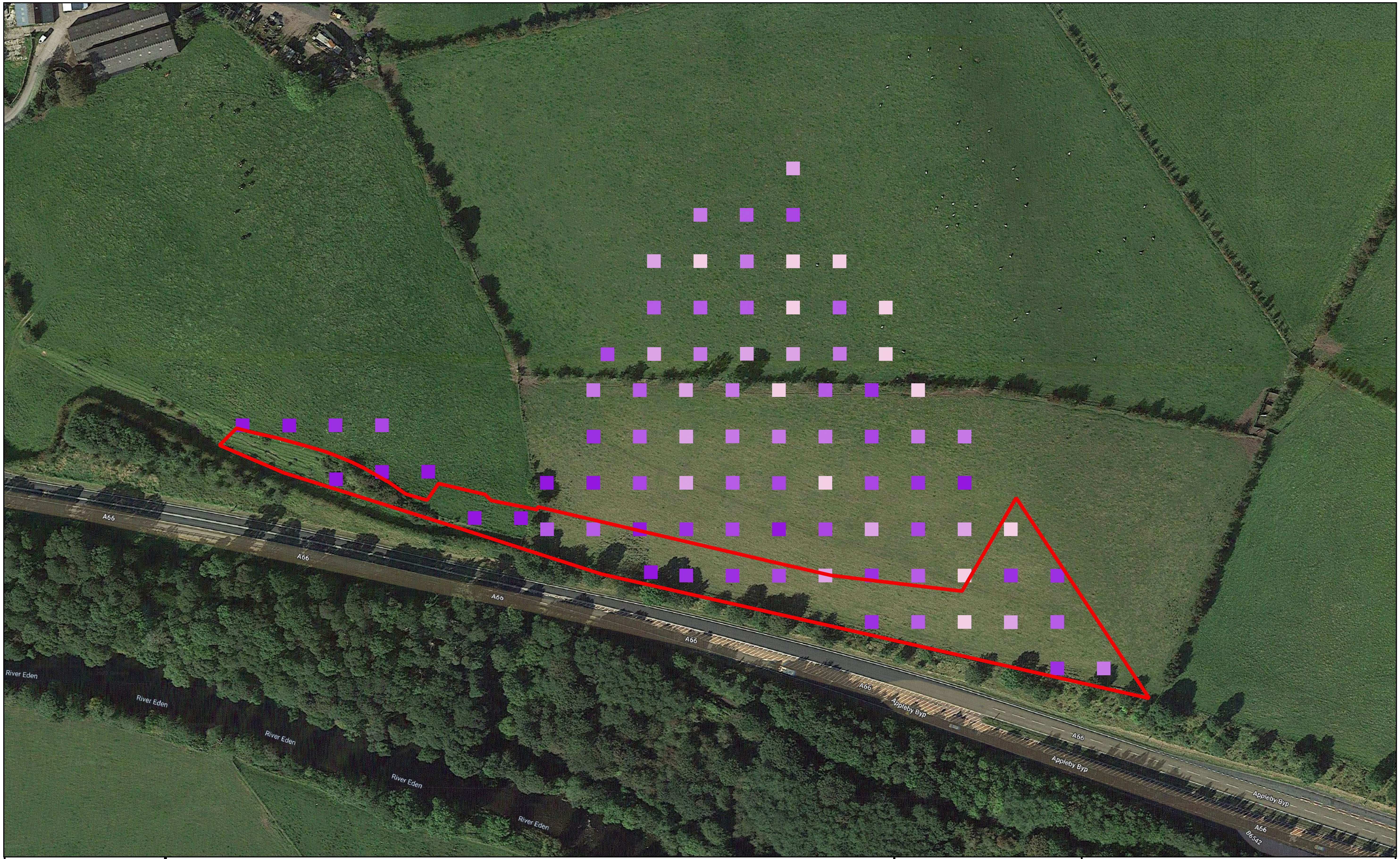
Figure 58: Variation of Zinc across Field Package 10

ARCHAEOLOGICAL RESEARCH SERVICES LTD

Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

Lead (Pb) ppm

- 0 - 5.43
- 5.43 - 6.56
- 6.56 - 8.39
- 8.39 - 9.3
- 9.3 - 10.83
- 10.83 - 12.67
- 12.67 - 31

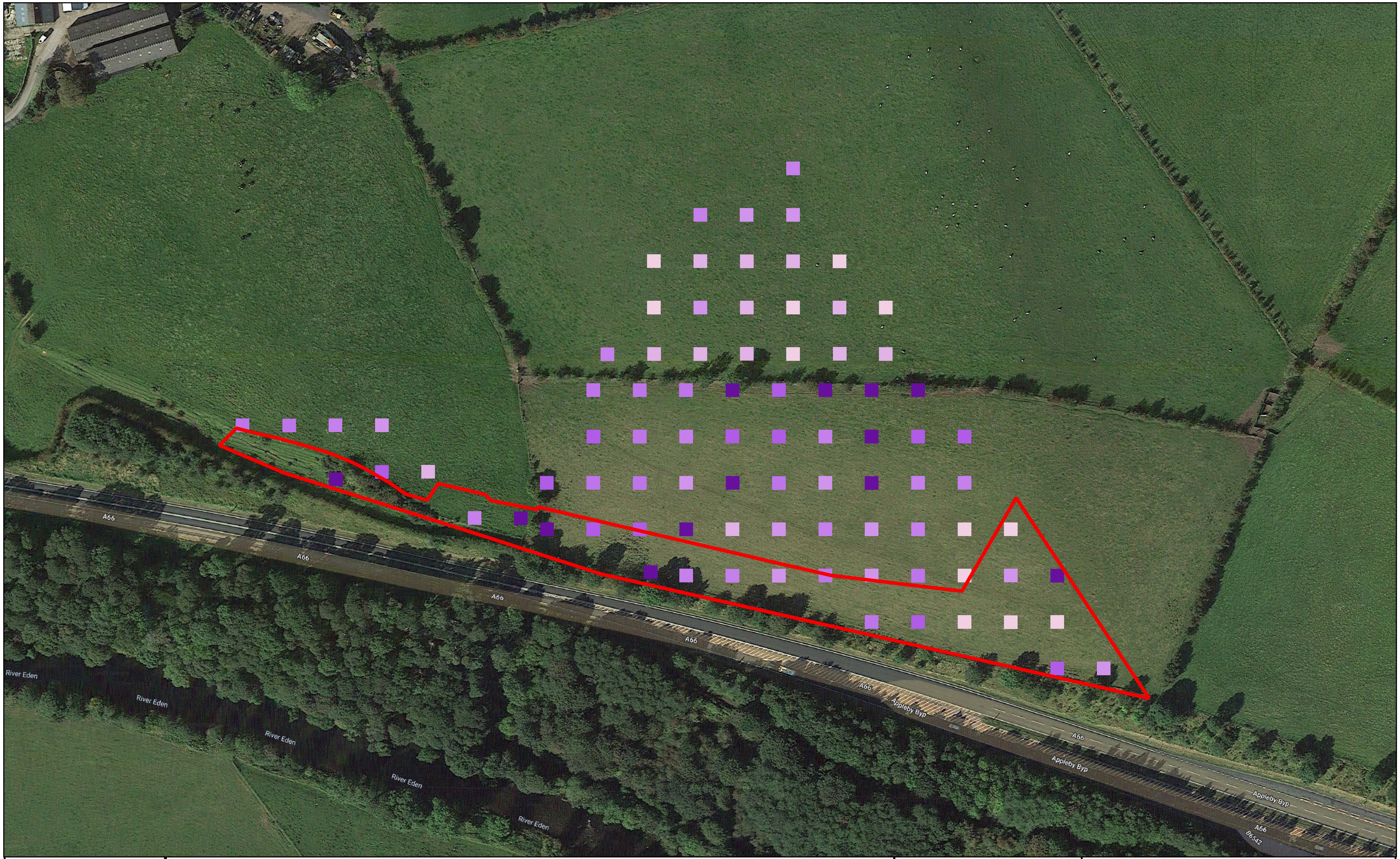
A66 Geochemical Survey

Figure 59: Variation of Lead across Field Package 10

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

Calcium (Ca) ppm

0 - 573
573 - 896
896 - 1131
1131 - 1240
1240 - 1391
1391 - 1666
1666 - 4030

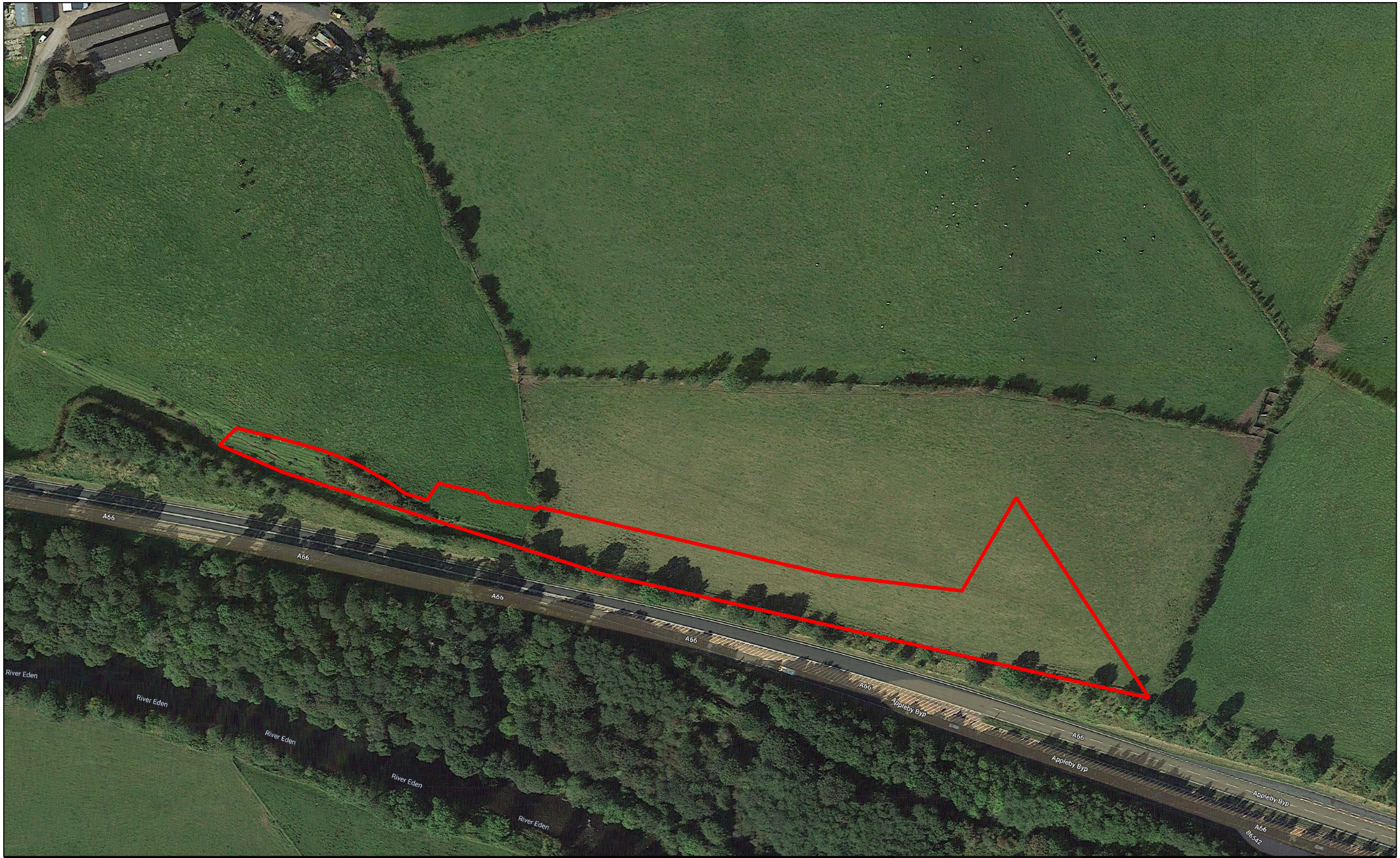
A66 Geochemical Survey

Figure 60: Variation of Calcium across Field Package 10

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo

Scale: As indicated

Legend

No areas of enhancement

A66 Geochemical Survey

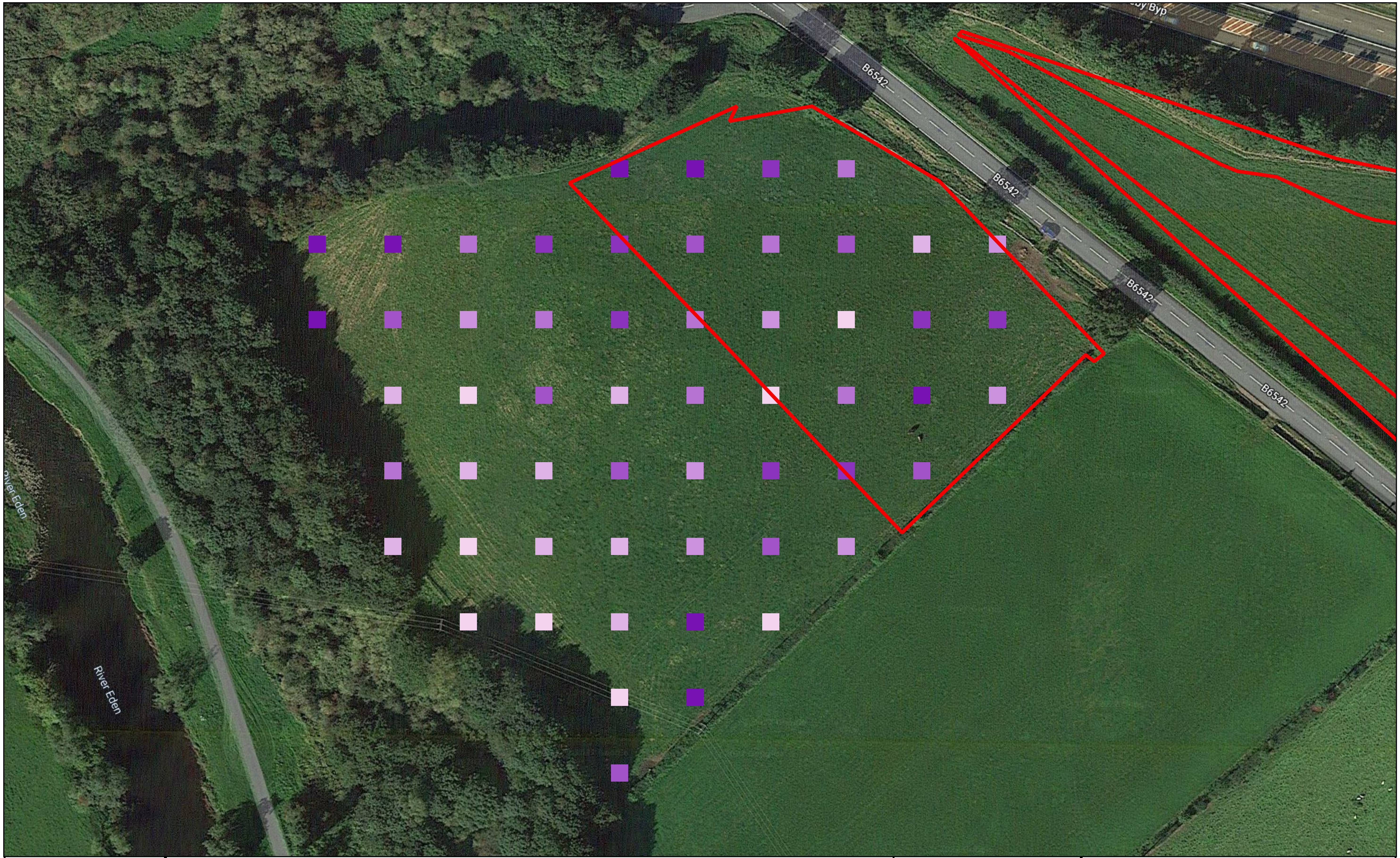
Figure 61: Interpreted Zones of Enhancement across Field Package 10

ARCHAEOLOGICAL RESEARCH SERVICES LTD

Digging with Purpose

0 25 50 75 100 m

Date: 29/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Magnetic Susceptibility SI

0.05 - 0.175 | 0.175 - 0.212 | 0.212 - 0.246 | 0.246 - 0.262 | 0.262 - 0.298 | 0.298 - 0.367 | 0.367 - 0.765

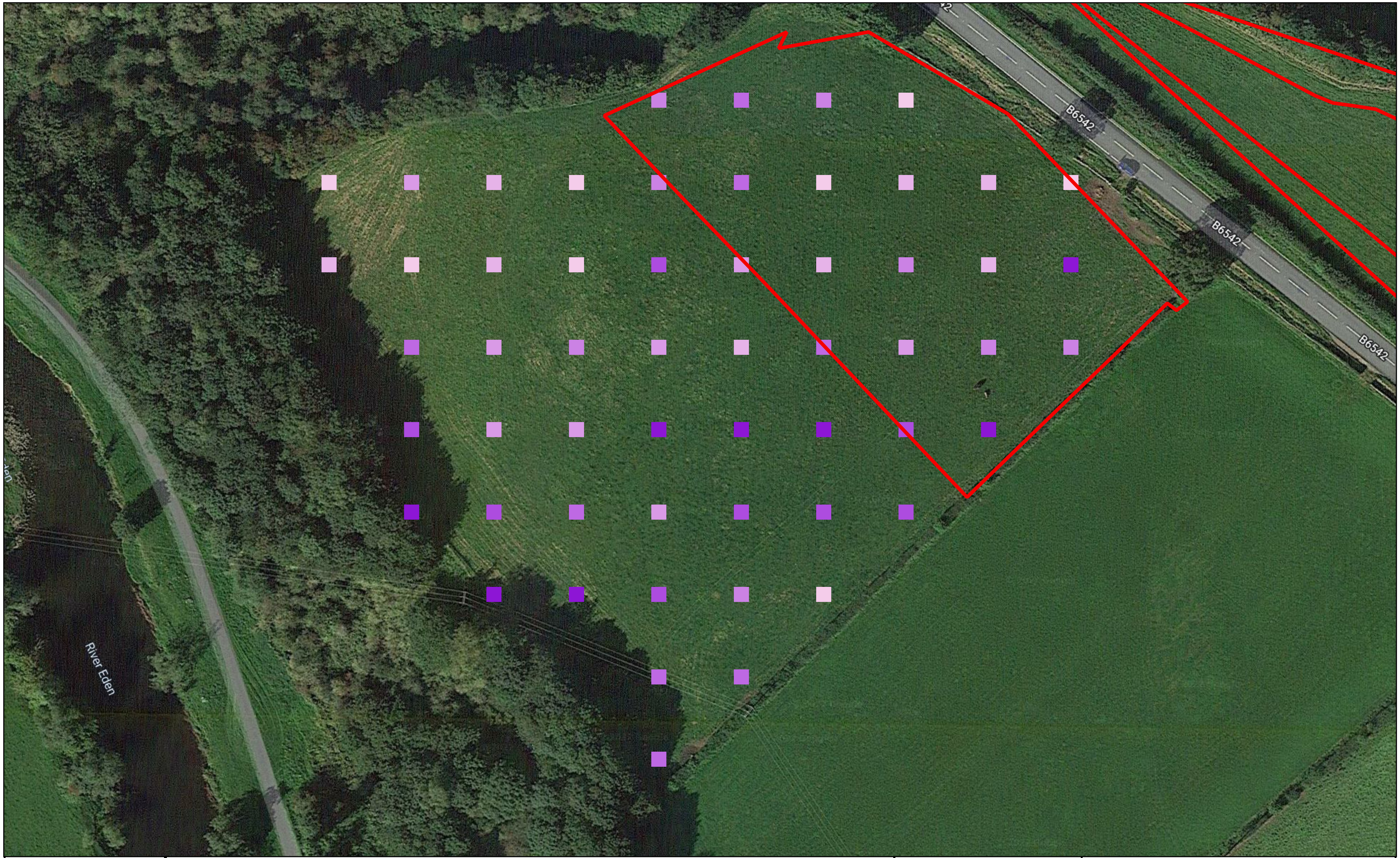
A66 Geochemical Survey

Figure 62: Variation of Magnetic Susceptibility across Field Package 11

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 10 20 30 40 50 m

Date: 29/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Phosphorus (P) ppm

- 393 - 488
- 488 - 545
- 545 - 573
- 573 - 592
- 592 - 671
- 671 - 799
- 799 - 1232

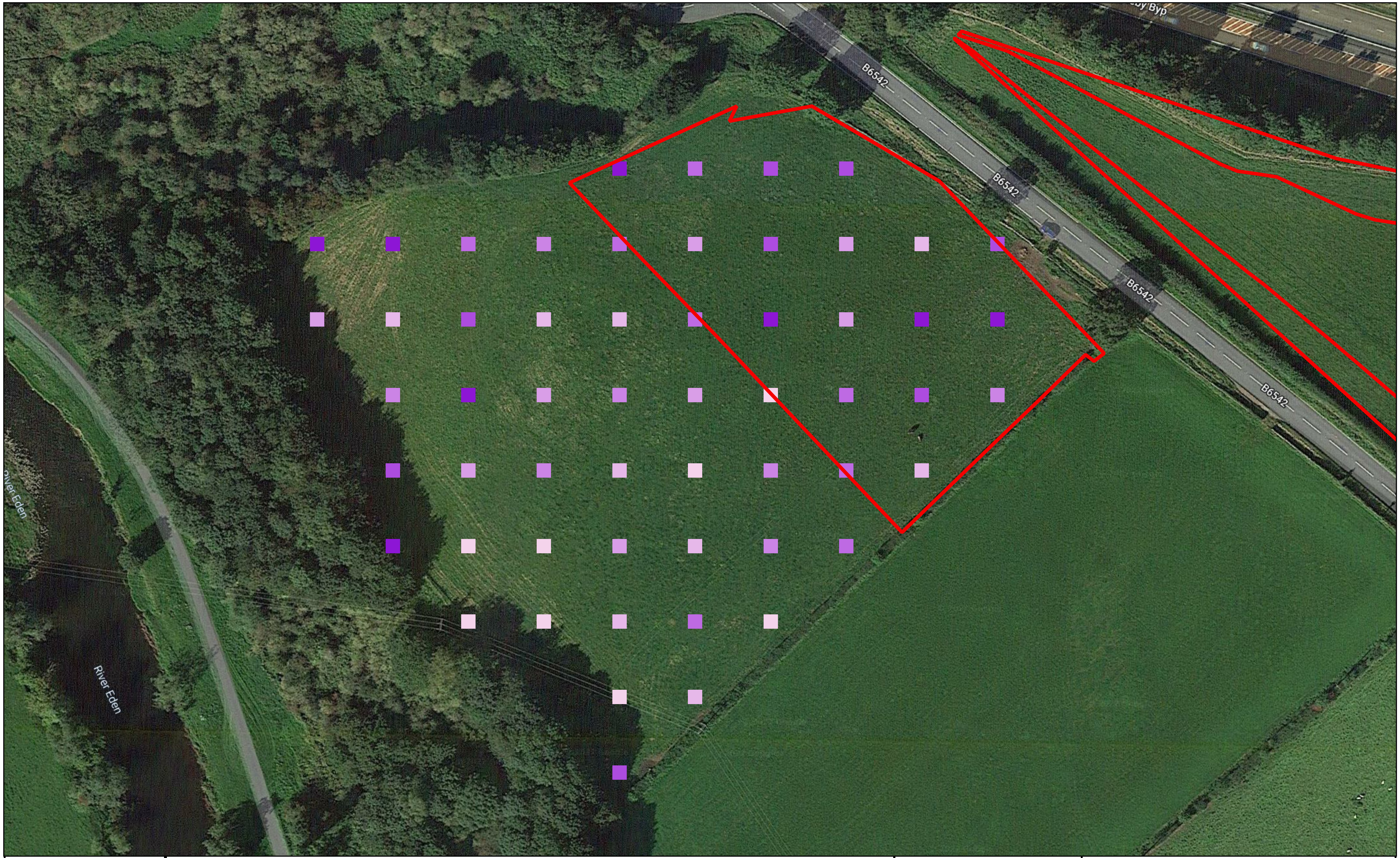
A66 Geochemical Survey

Figure 63: Variation of Phosphorus across Field Package 11

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 10 20 30 40 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Copper (Cu) ppm

6.7 - 14.09 | 14.09 - 15.2 | 15.2 - 16.1 | 16.1 - 17.69 | 17.69 - 18.83 | 18.83 - 20.3 | 20.3 - 24.5

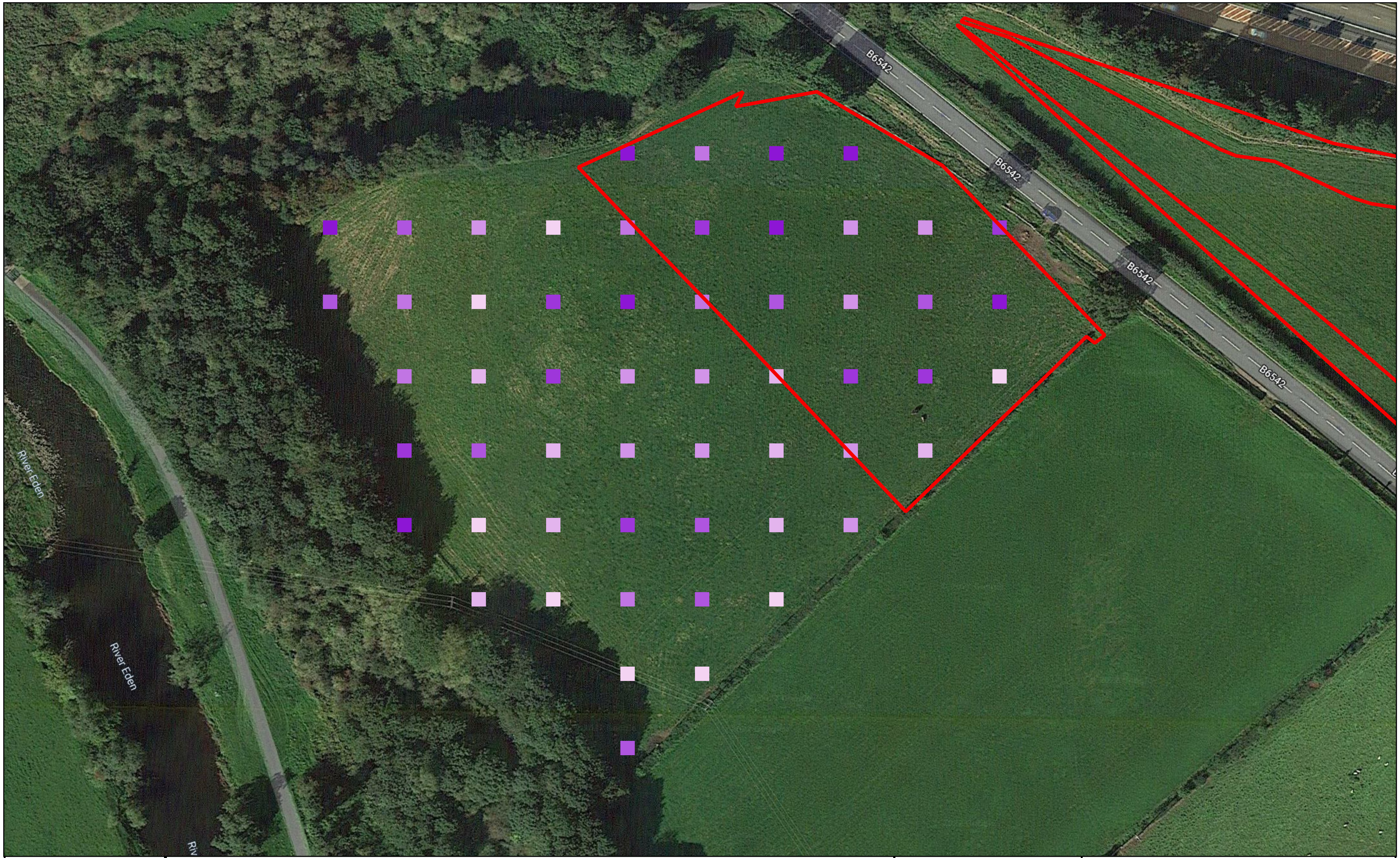
A66 Geochemical Survey

Figure 64: Variation of Copper across Field Package 11

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 10 20 30 40 50 m

Date: 29/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Zinc (Zn) ppm

- 29 - 37.7 [8]
- 37.7 - 39.9 [8]
- 39.9 - 42 [10]
- 42 - 43.4 [6]
- 43.4 - 45.8 [8]
- 45.8 - 49.2 [8]
- 49.2 - 54.4 [8]

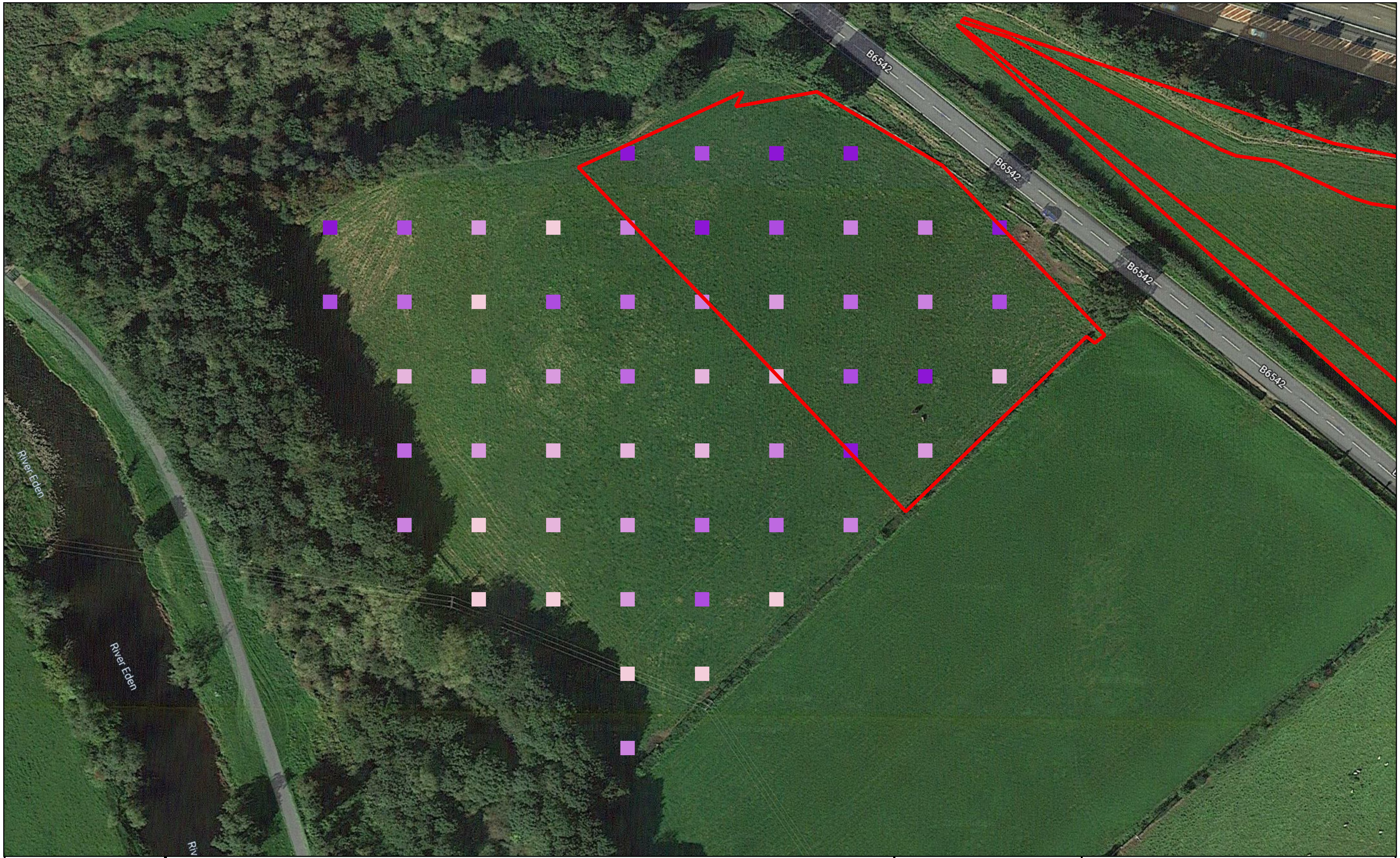
A66 Geochemical Survey

Figure 65: Variation of Zinc across Field Package 11

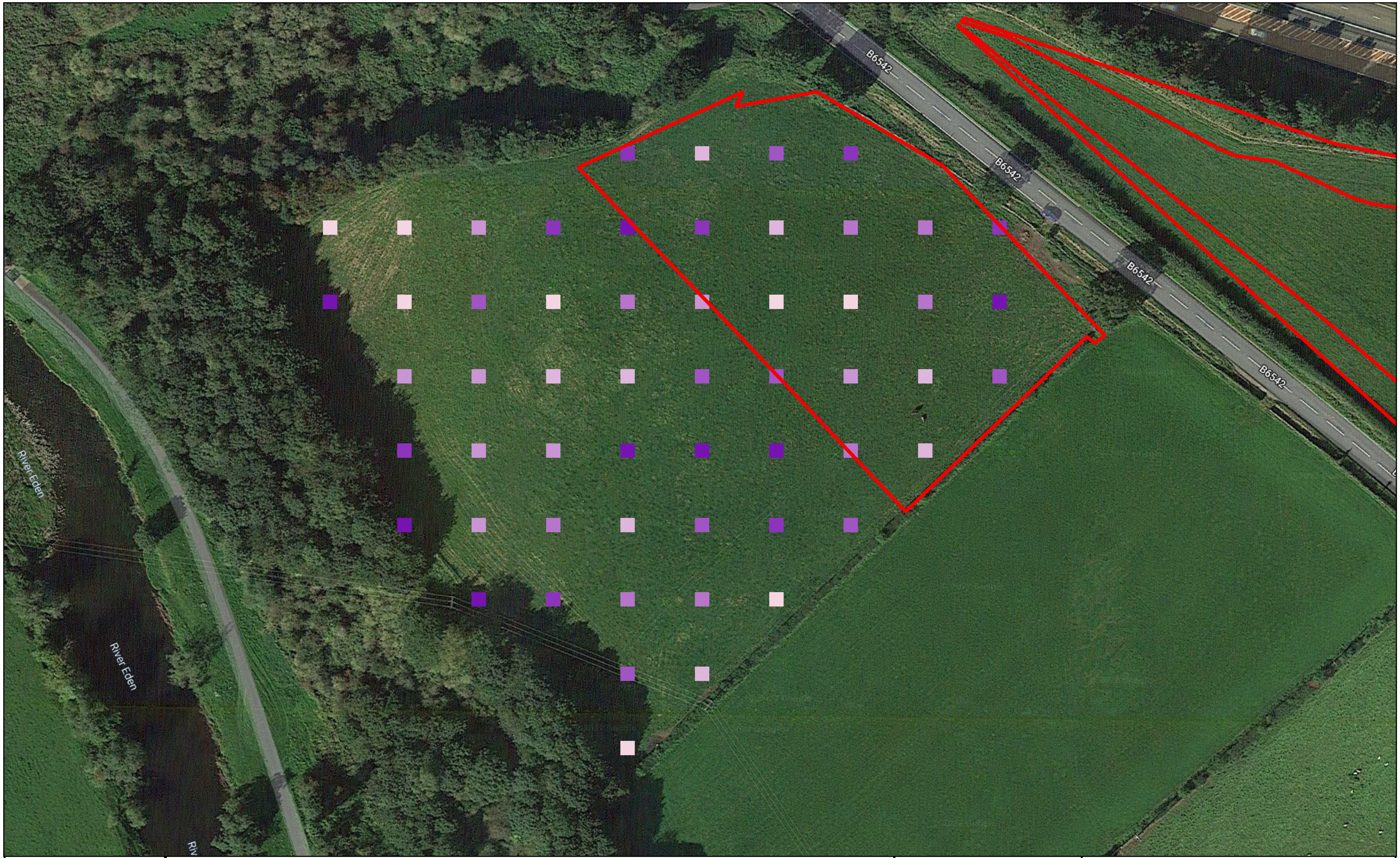
ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 10 20 30 40 m

Date: 30/03/2022



Project: A66 Geochemical Survey Site Name: Temple Sowerby to Appleby Drawn by: K.Pattillo Scale: As indicated	**Legend** Lead (Pb) ppm 17.6 - 22.1 · 22.1 - 27.5 · 27.5 - 29.9 · 29.9 - 31.1 · 31.1 - 34 · 34 - 39.7 · 39.7 - 45.3	**A66 Geochemical Survey** Figure 66: Variation of Lead across Field Package 11	ARCHAEOLOGICAL RESEARCH SERVICES LTD Digging with Purpose 0 10 20 30 40 m Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Calcium (Ca) ppm

1053 - 1433 | 1433 - 1508 | 1508 - 1541 | 1541 - 1655 | 1655 - 1736 | 1736 - 1933 | 1933 - 2798

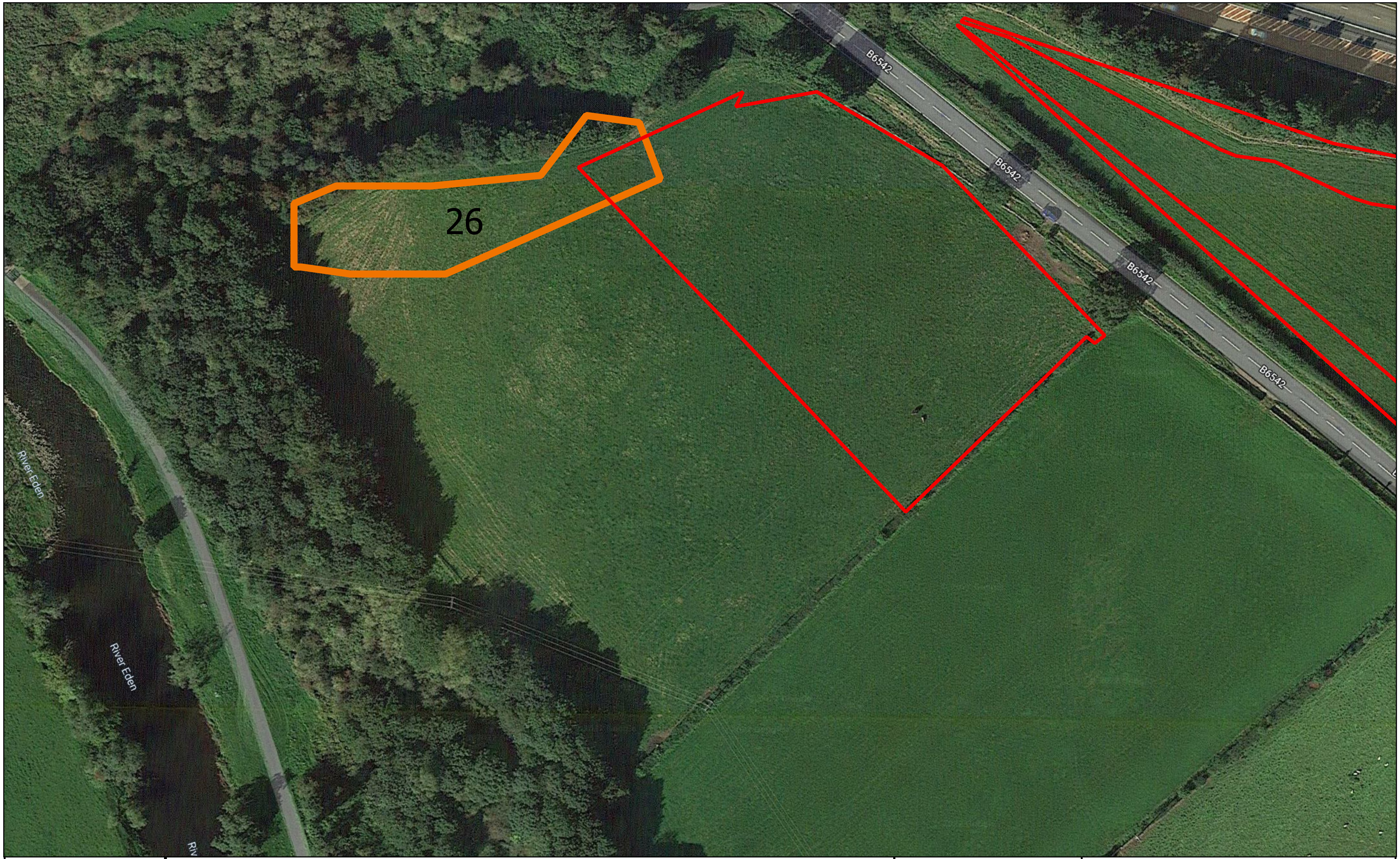
A66 Geochemical Survey

Figure 67: Variation of Calcium across Field Package 11

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 10 20 30 40 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

Zones of Enhancement

Copper (Cu)

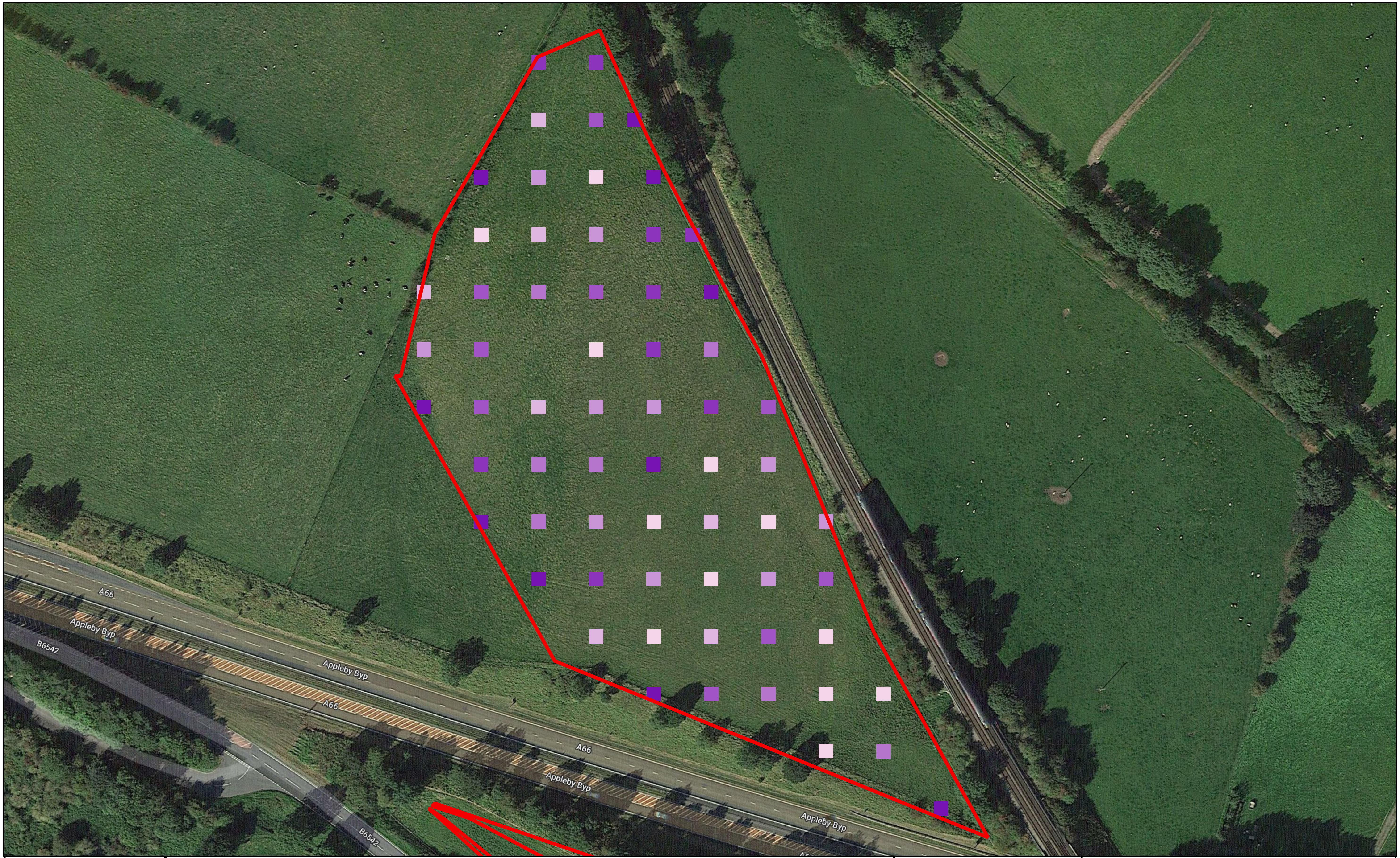
A66 Geochemical Survey

Figure 68: Interpreted Zones of Enhancement across Field Package 11

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 10 20 30 40 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

Magnetic Susceptibility SI

- 0.026 - 0.036
- 0.036 - 0.0406
- 0.0406 - 0.044
- 0.044 - 0.0486
- 0.0486 - 0.0537
- 0.0537 - 0.0619
- 0.0619 - 0.091

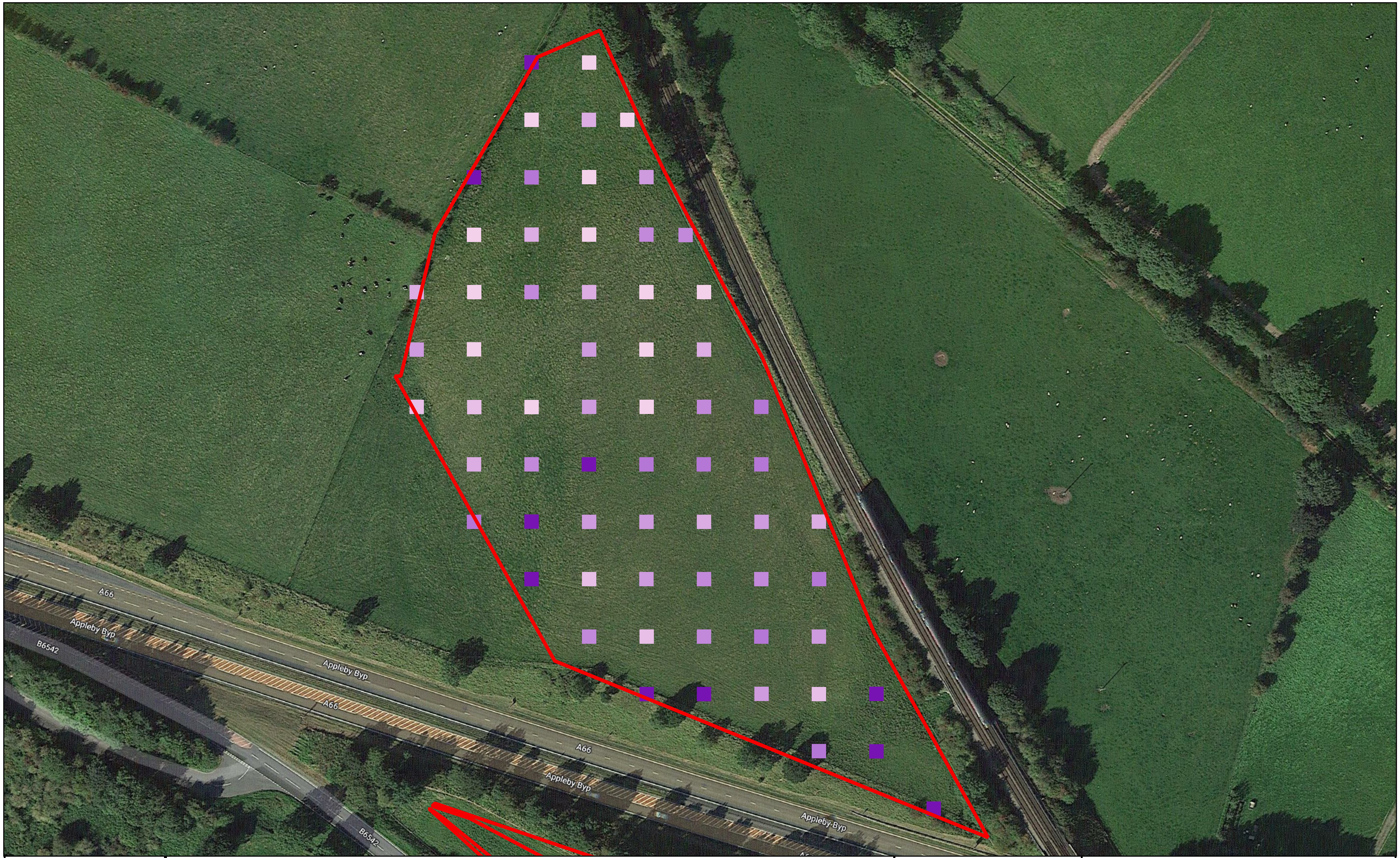
A66 Geochemical Survey

Figure 69: Variation of Magnetic Susceptibility across Field Package 12

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 20 40 60 80 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Phosphorus (P) ppm

0 - 0.67 | 0.67 - 49.51 | 49.51 - 82.36 | 82.36 - 104.91 | 104.91 - 139.34 | 139.34 - 183.44 | 183.44 - 507.1

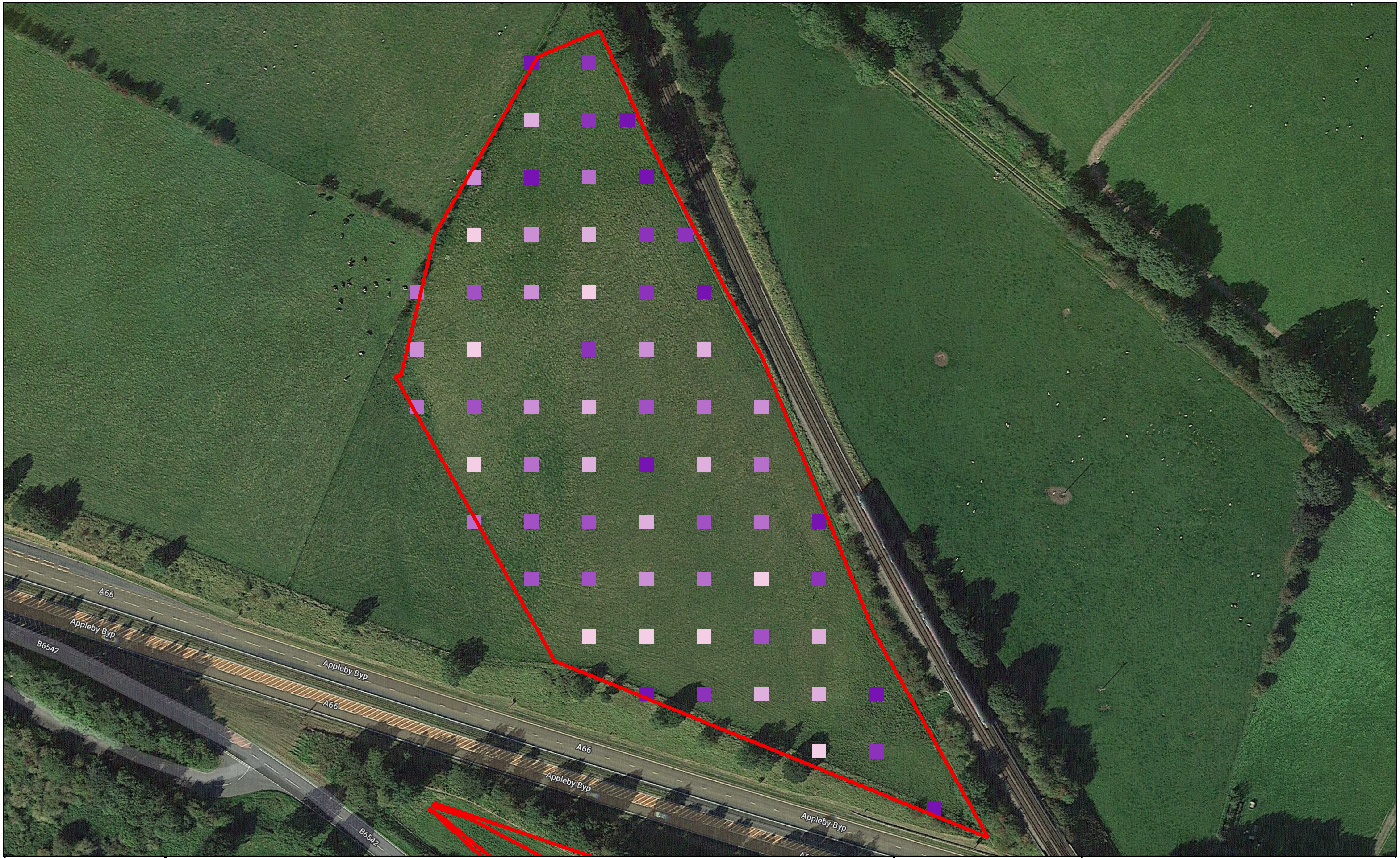
A66 Geochemical Survey

Figure 70: Variation of Phosphorus across Field Package 12

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 20 40 60 80 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo

Scale: As indicated

Legend

Copper (Cu) ppm

0 - 4.29 | 4.29 - 5 | 5 - 5.97 | 5.97 - 6.51 | 6.51 - 7.24 | 7.24 - 8.34 | 8.34 - 12

A66 Geochemical Survey

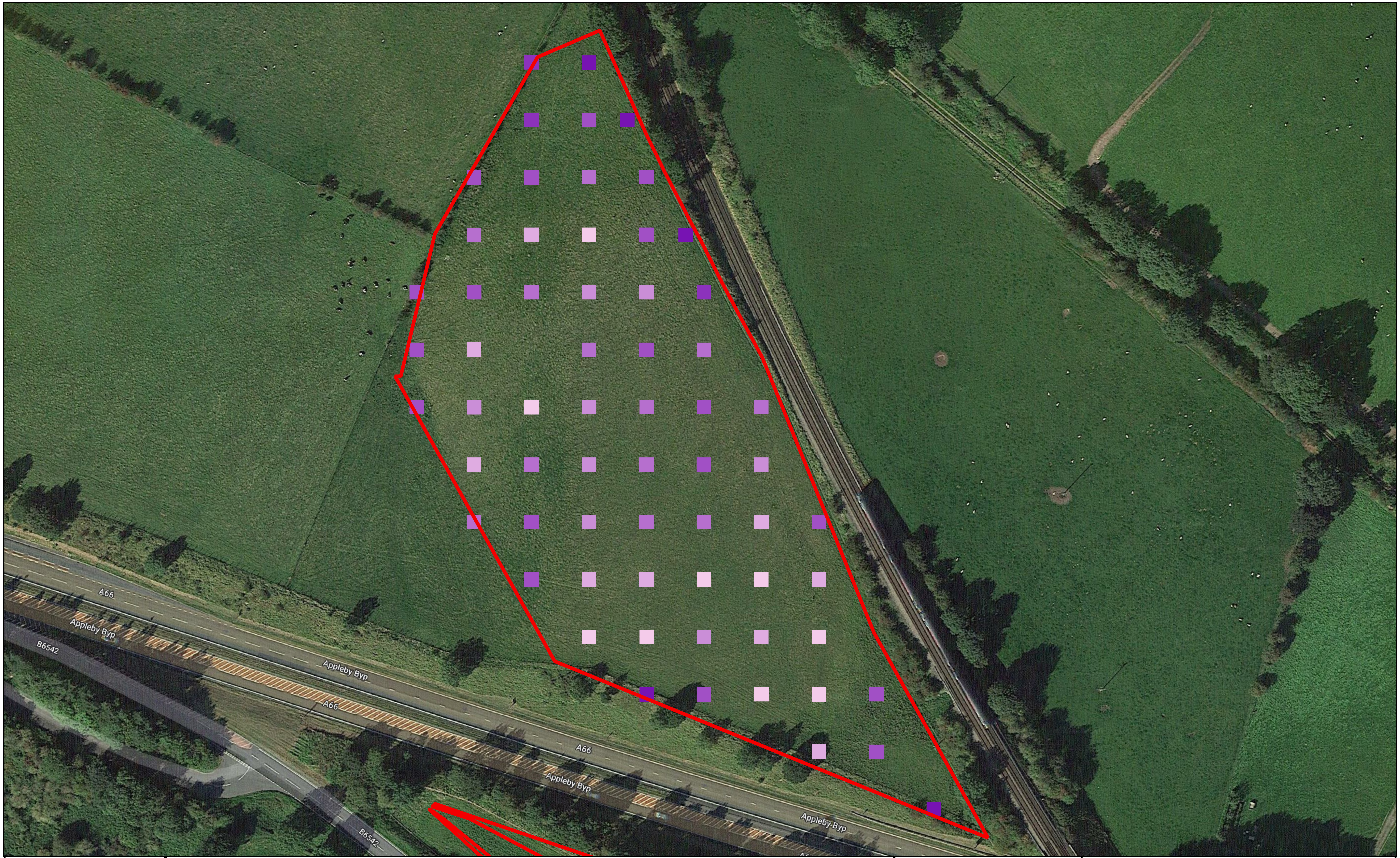
Figure 71: Variation of Copper across Field Package 12

ARCHAEOLOGICAL RESEARCH SERVICES LTD

Digging with Purpose

0 20 40 60 80 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Zinc (Zn) ppm

0 - 14.2 [9]
14.2 - 16.6 [9]
16.6 - 18.7 [9]
18.7 - 20.1 [12]
20.1 - 26.7 [18]
26.7 - 31.2 [3]
31.2 - 79.5 [5]

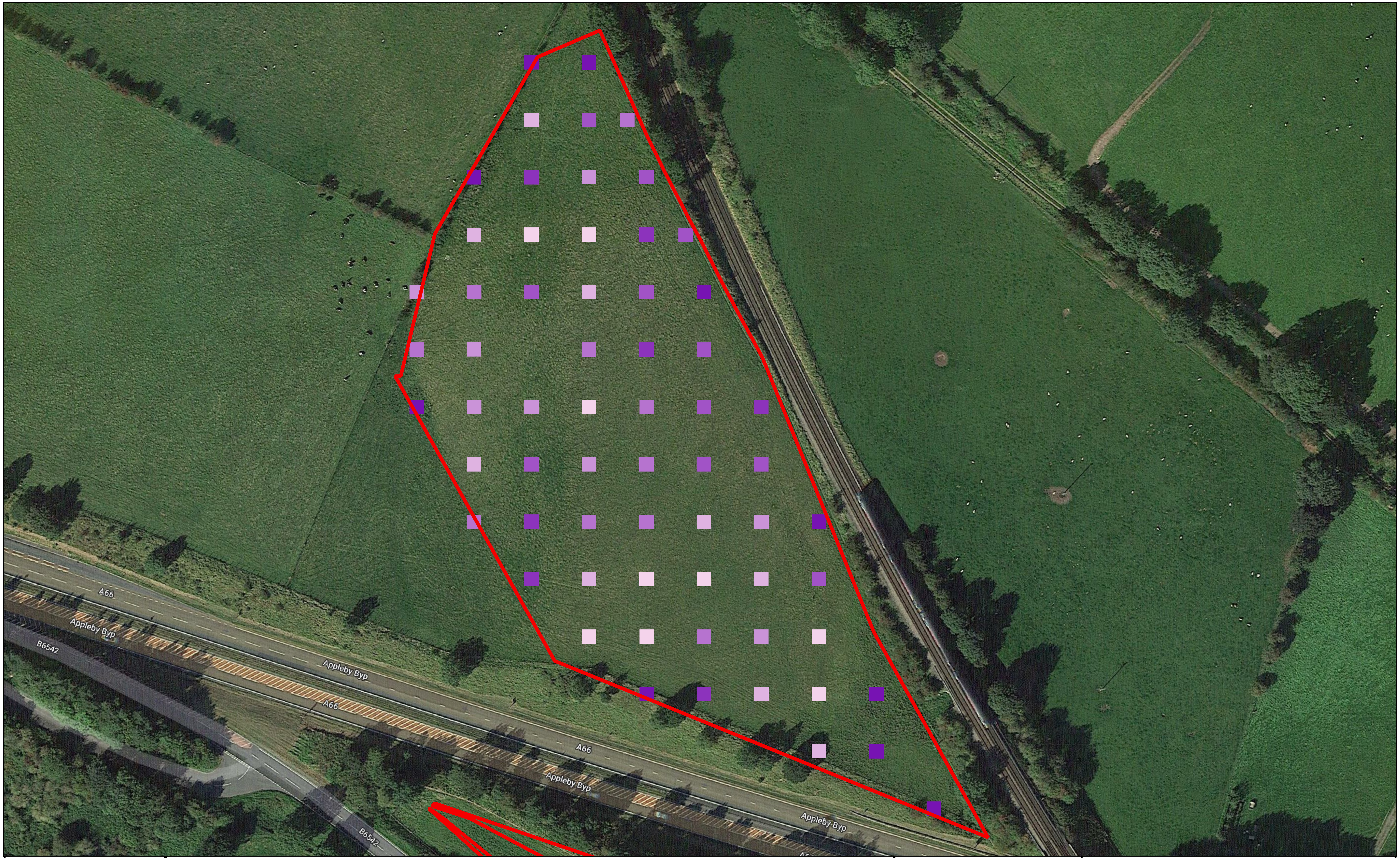
A66 Geochemical Survey

Figure 72: Variation of Zinc across Field Package 12

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 20 40 60 80 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

Lead (Pb) ppm

- 0 - 2.93
- 2.93 - 4.26
- 4.26 - 4.99
- 4.99 - 6.31
- 6.31 - 7
- 7 - 8.87
- 8.87 - 15.6

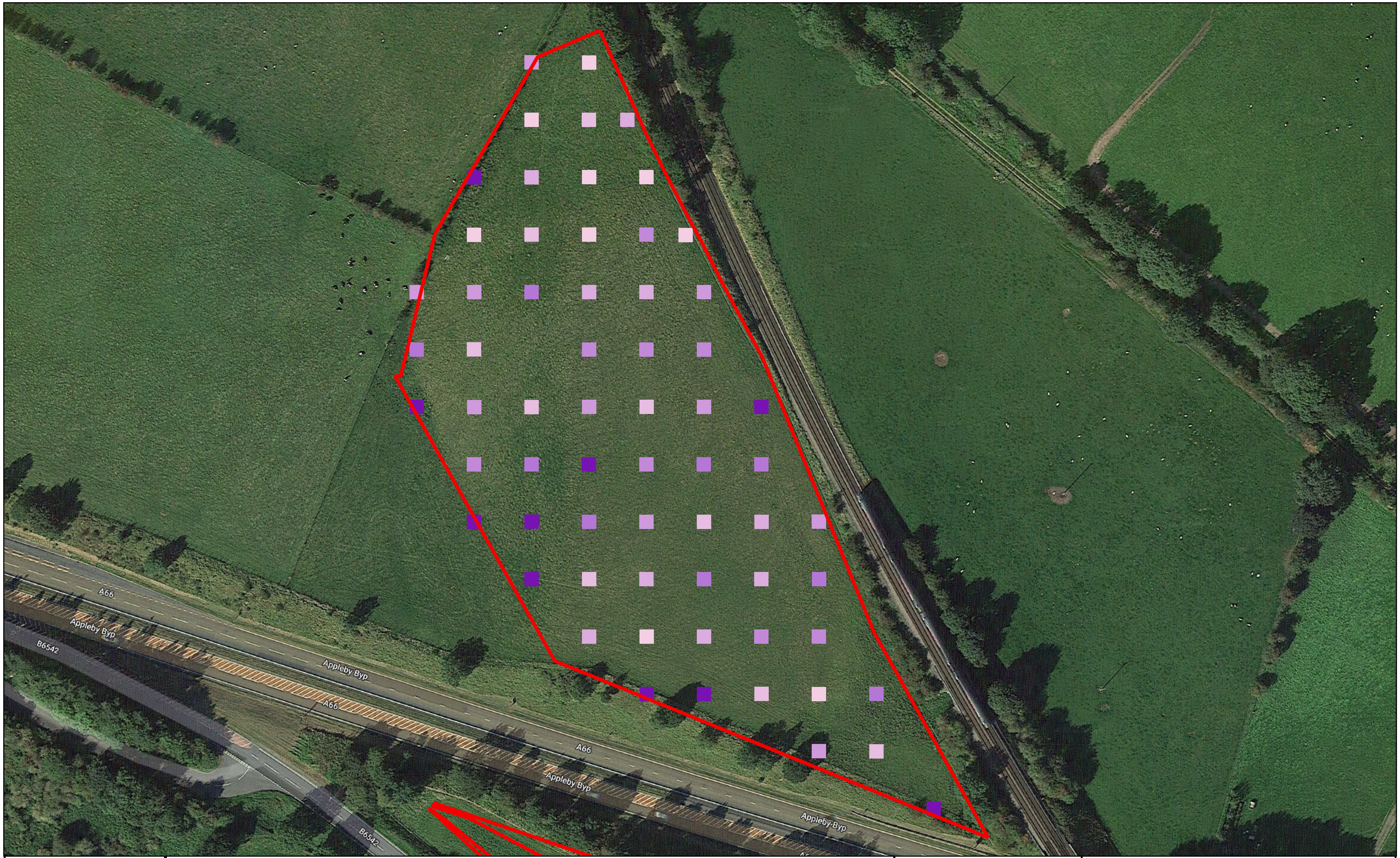
A66 Geochemical Survey

Figure 73: Variation of Lead across Field Package 12

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 20 40 60 80 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Calcium (Ca) ppm

0 - 960 | 960 - 1318 | 1318 - 1444 | 1444 - 1536 | 1536 - 1655 | 1655 - 1804 | 1804 - 2510

A66 Geochemical Survey

Figure 74: Variation of Calcium across Field Package 12

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 20 40 60 80 m

Date: 30/03/2022

Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

No areas of enhancement

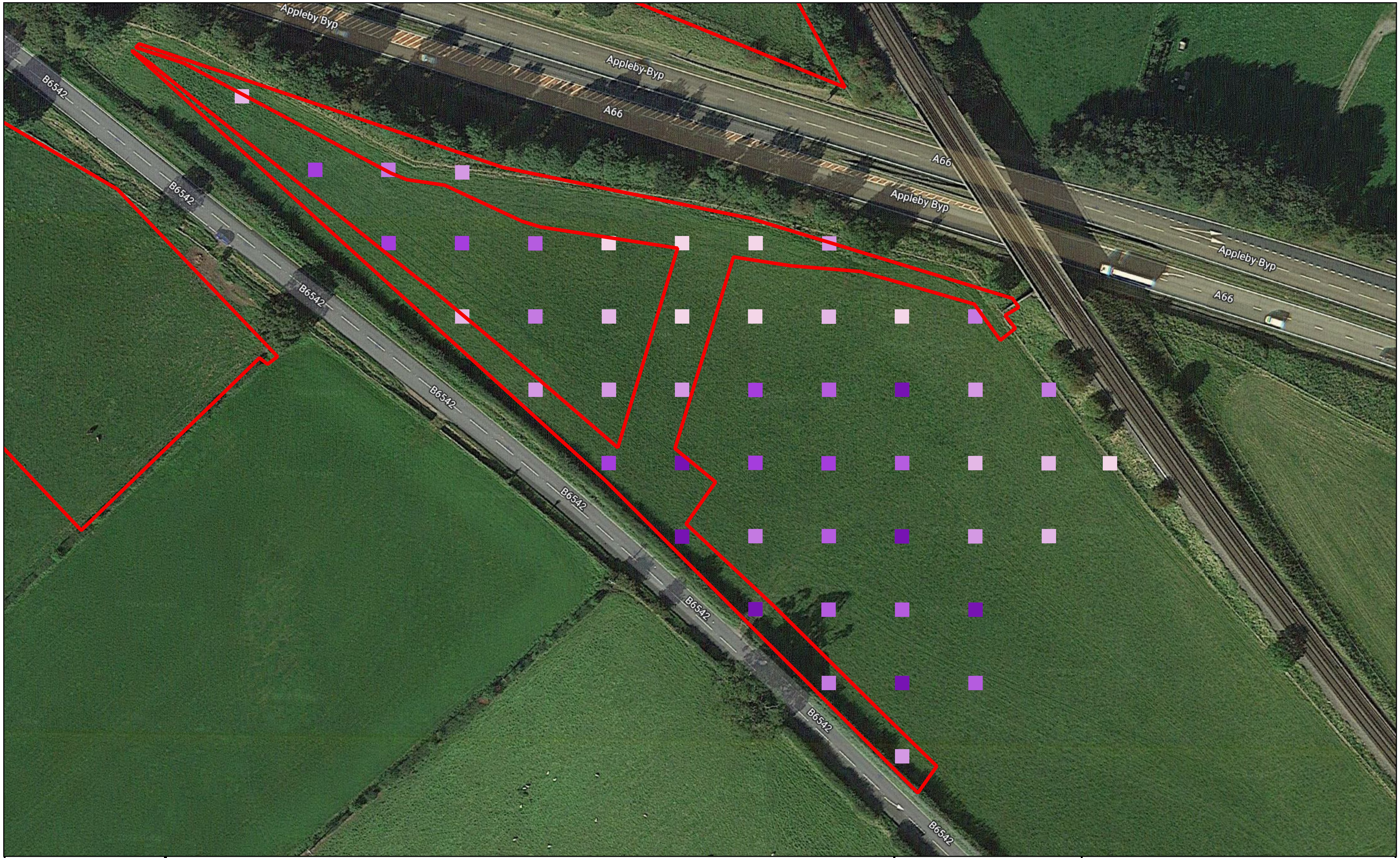
A66 Geochemical Survey

Figure 75: Interpreted Zones of Enhancement across Field Package 12

ARCHAEOLOGICAL RESEARCH SERVICES LTD
Digging with Purpose

0 20 40 60 80 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo

Scale: As indicated

Legend

Magnetic Susceptibility SI

- 0.076 - 0.1067
- 0.1067 - 0.1297
- 0.1297 - 0.142
- 0.142 - 0.1514
- 0.1514 - 0.1666
- 0.1666 - 0.1823
- 0.1823 - 0.998

A66 Geochemical Survey

Figure 76: Variation of Magnetic Susceptibility across Field Package 13

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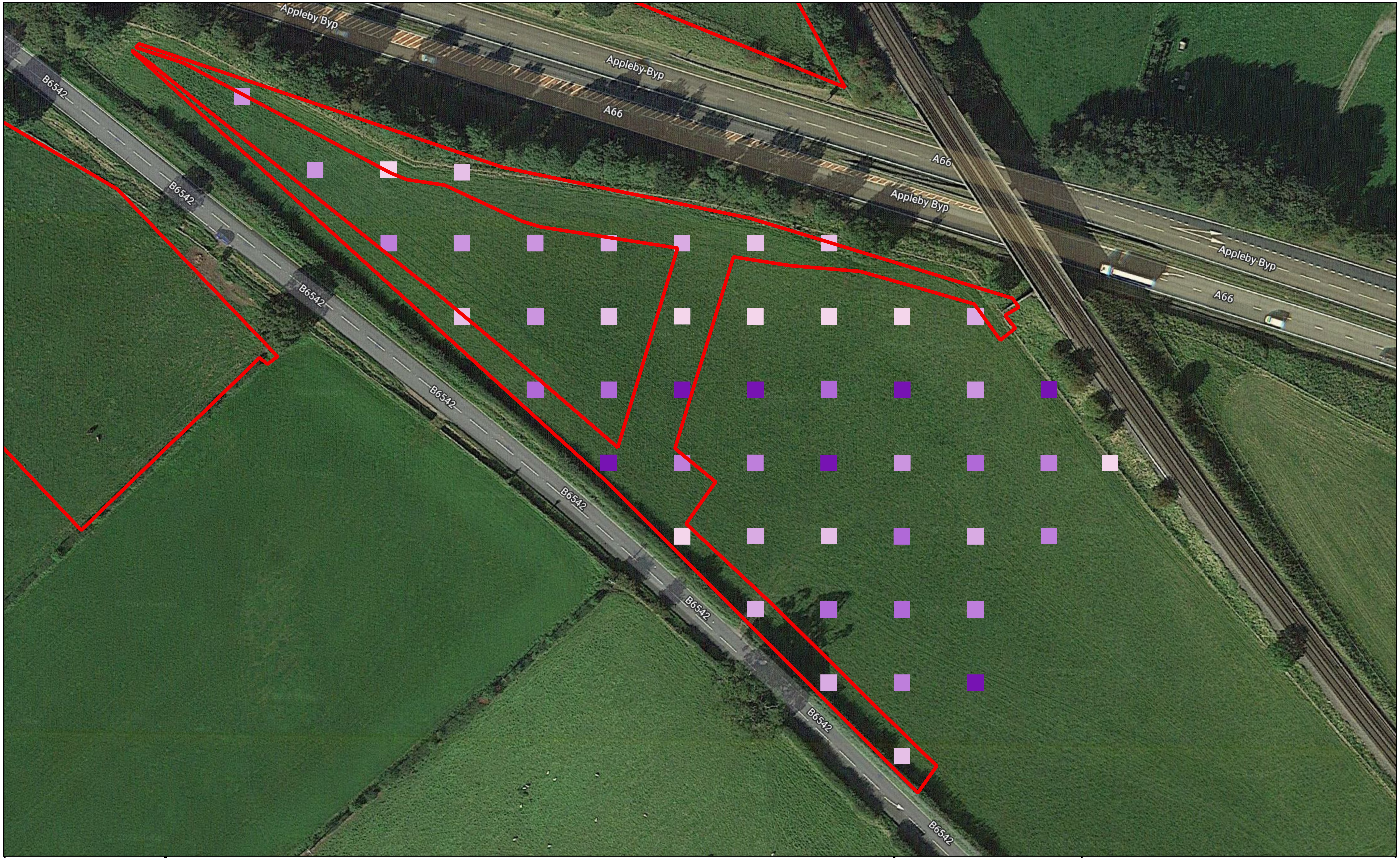
0 10 20 30 40 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Phosphorus (P) ppm

- 0 - 839
- 839 - 953
- 953 - 1154
- 1154 - 1214
- 1214 - 1349
- 1349 - 1464
- 1464 - 1692

A66 Geochemical Survey

Figure 77: Variation of Phosphorus across Field Package 13

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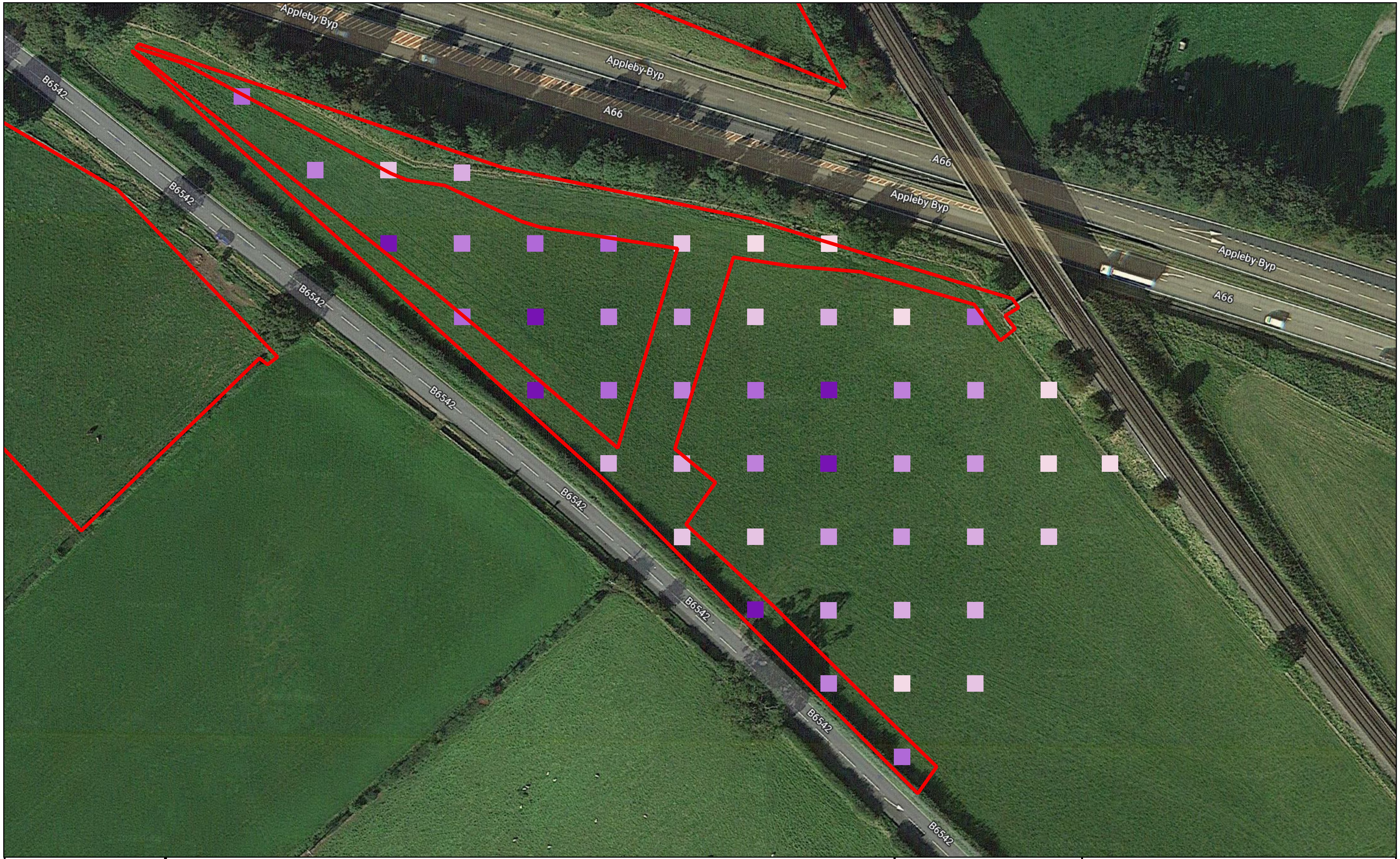
0 10 20 30 40 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

Copper (Cu) ppm

- 0 - 11.6
- 11.6 - 12.6
- 12.6 - 13.4
- 13.4 - 14.4
- 14.4 - 15.7
- 15.7 - 19
- 19 - 22.2

A66 Geochemical Survey

Figure 78: Variation of Copper across Field Package 13

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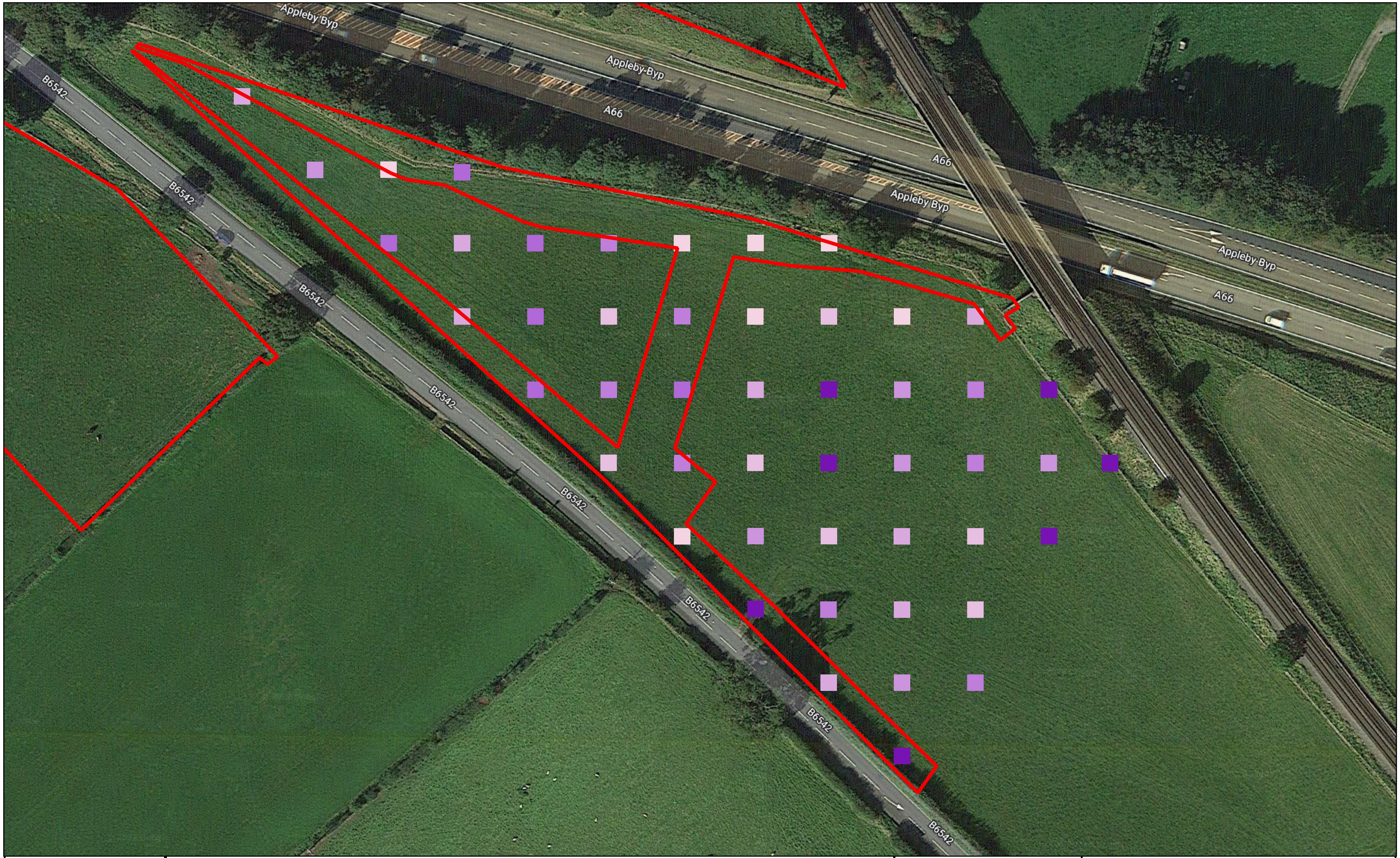
0 10 20 30 40 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Zinc (Zn) ppm

- 0 - 33.4 [7]
- 33.4 - 36.4 [7]
- 36.4 - 37.5 [8]
- 37.5 - 39.6 [6]
- 39.6 - 42.4 [8]
- 42.4 - 42.9 [6]
- 42.9 - 91.3 [7]

A66 Geochemical Survey

Figure 79: Variation of Zinc across Field Package 13

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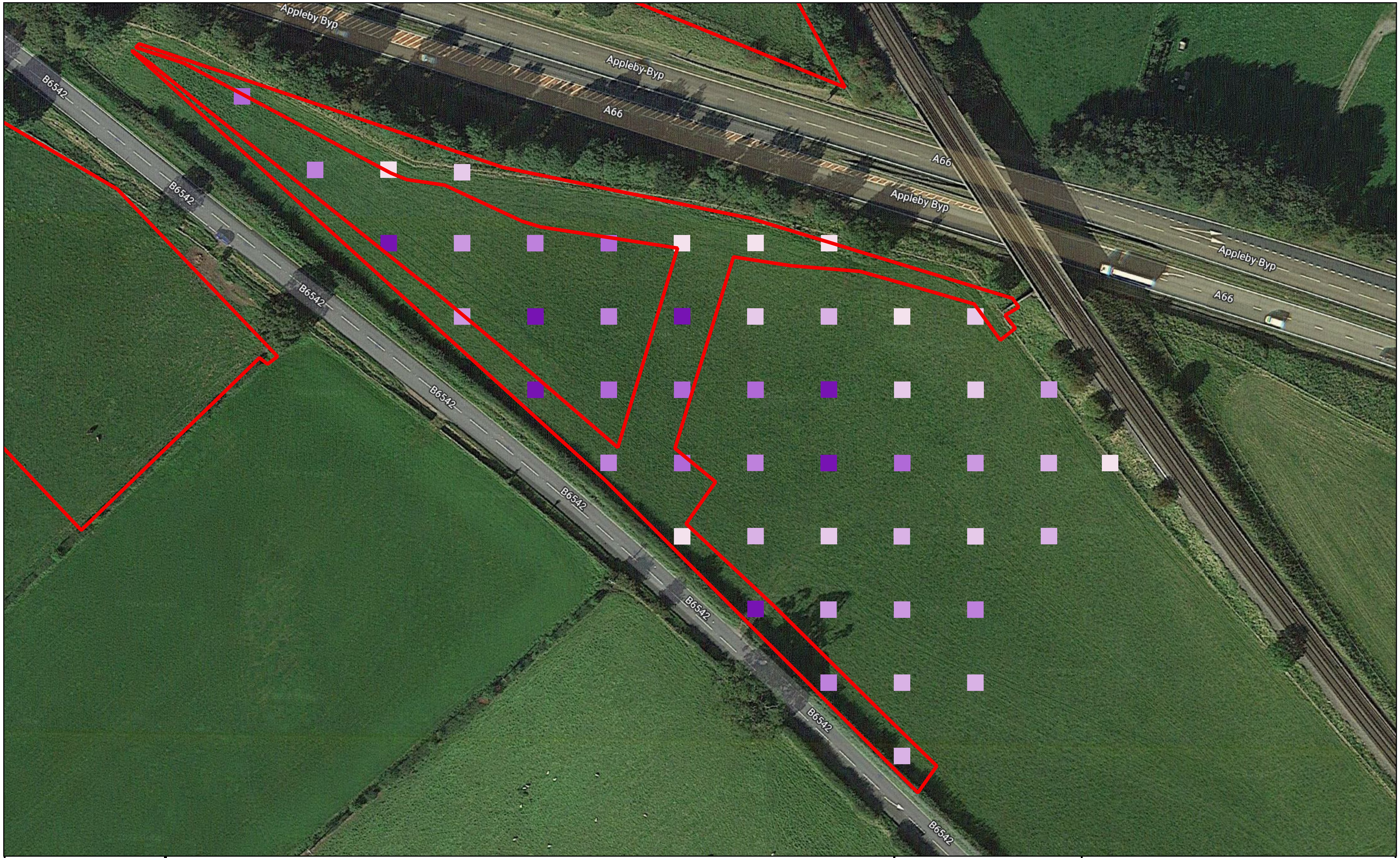
0 10 20 30 40 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo
Scale: As indicated

Legend

Lead (Pb) ppm

- 0 - 17.6
- 17.6 - 22.7
- 22.7 - 25.6
- 25.6 - 26.6
- 26.6 - 28.6
- 28.6 - 31.6
- 31.6 - 71.6

A66 Geochemical Survey

Figure 80: Variation of Lead across Field Package 13

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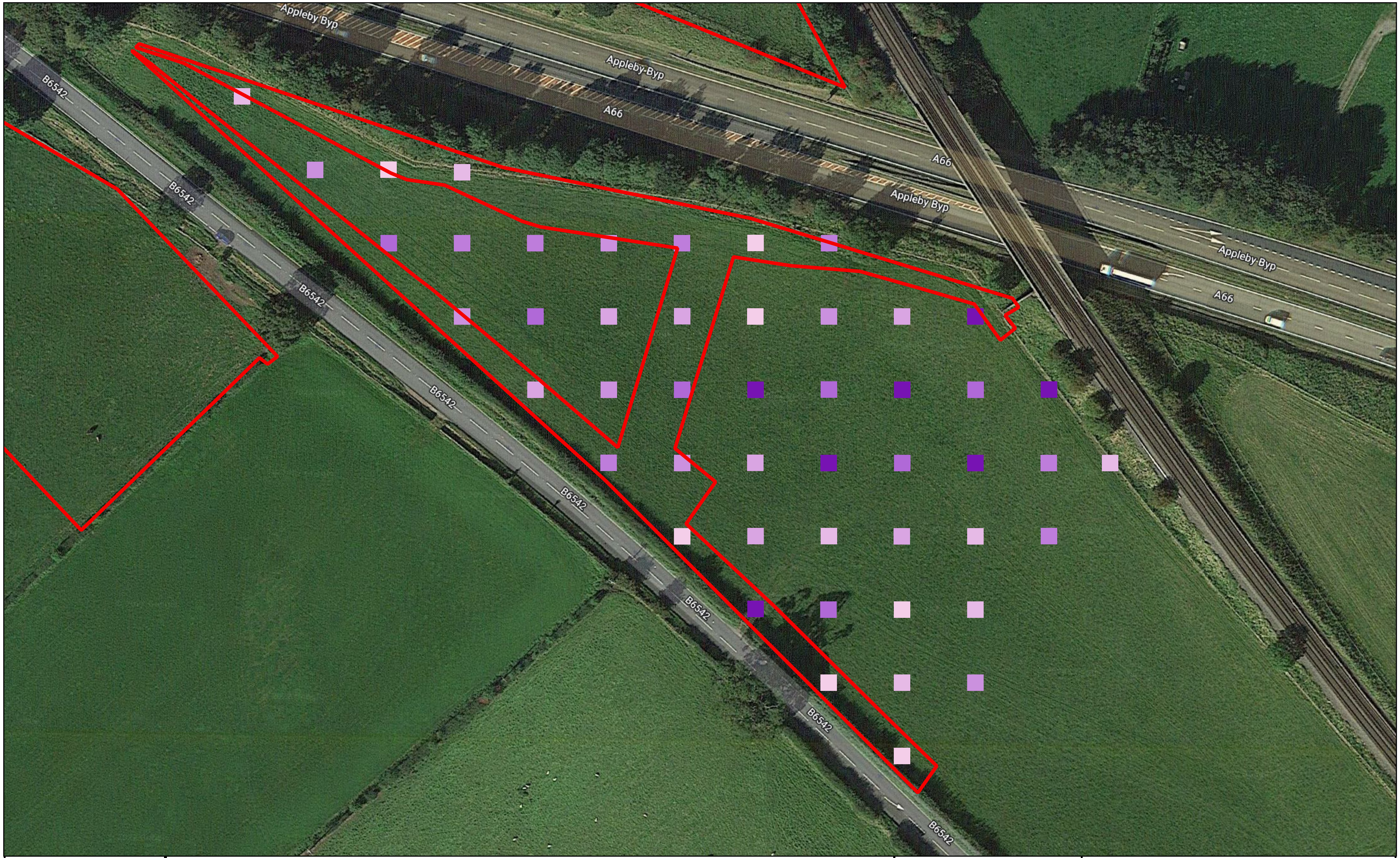
0 10 20 30 40 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K. Pattillo
Scale: As indicated

Legend

Calcium (Ca) ppm

- 0 - 2154
- 2154 - 2398
- 2398 - 2569
- 2569 - 2690
- 2690 - 2928
- 2928 - 3152
- 3152 - 3593

A66 Geochemical Survey

Figure 81: Variation of Calcium across Field Package 13

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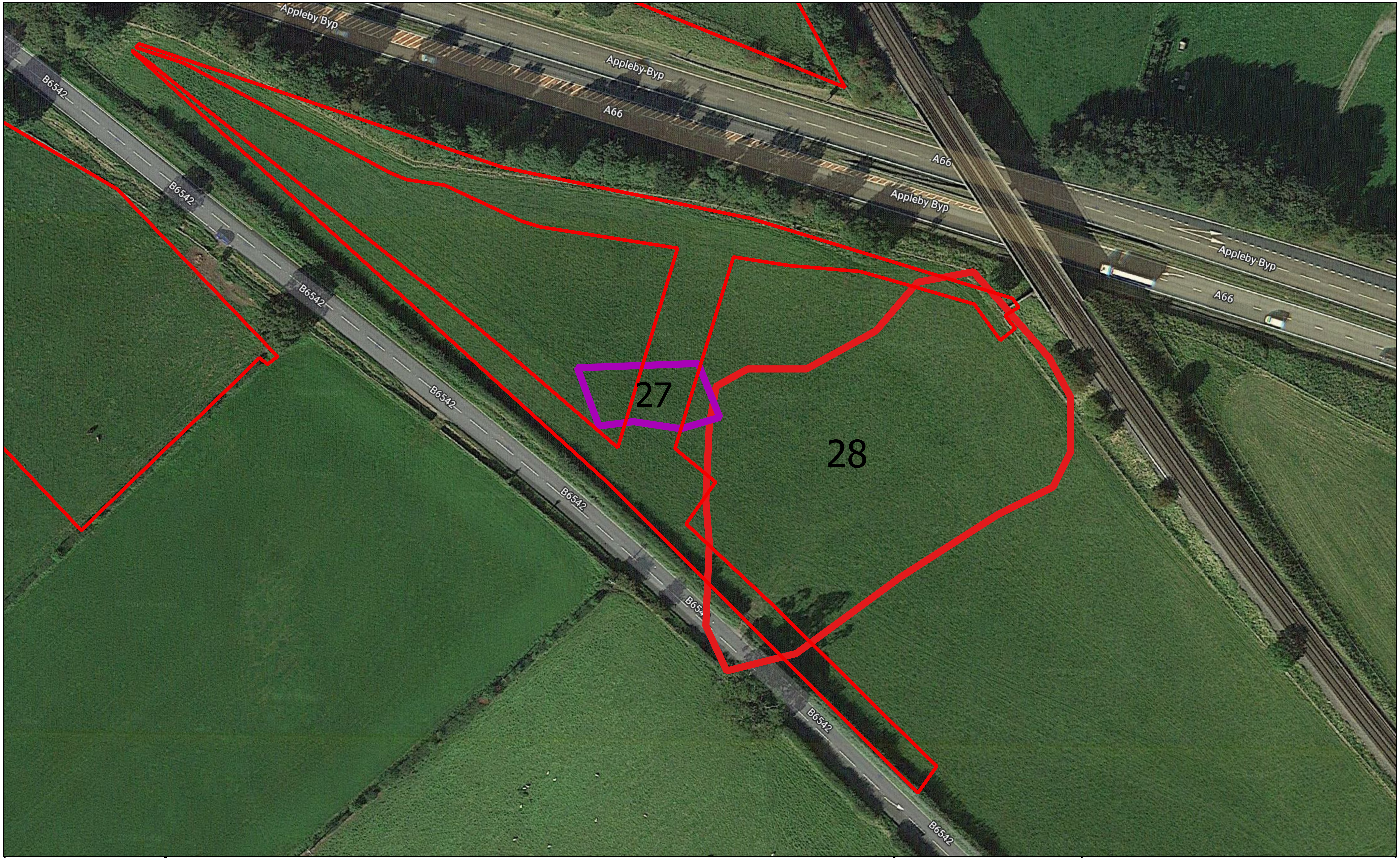
0 10 20 30 40 m

Date: 30/03/2022



Project: A66 Geochemical Survey

Site Name: Temple Sowerby to Appleby

Drawn by: K.Pattillo

Scale: As indicated

Legend

Zones of Enhancement

Calcium (Ca)

Phosphorus (P)

A66 Geochemical Survey

Figure 82: Interpreted Zones of Enhancement across Field Package 13

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0 10 20 30 40 m

Date: 30/03/2022