GeoArch

Report 2015/08

Geophysical survey at Caerau, Cardiff [ST135750]

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Geophysical survey at Wick Road, St Brides Major, Vale of Glamorgan

Dr T.P. Young

Abstract

Geophysical surveys were undertaken across the NE section of Caerau hill, including a largely unsurveyed section of the hilltop field, the small fields around St Mary's Church, the ringwork and the slopes below the church to the east.

The key outcomes were firstly the recognition of magnetic anomalies potentially indicating a destroyed outer defence to the Iron Age hillfort on the slopes east of the church and secondly some featuring within the ringwork that provides some tentative hints of structures.

Contents

Methods

Survey rationale and background

The survey area (centred on [ST135750]) included areas to the north of existing 'TimeTeam' survey of the hillfort interior (Brennan 2013; Davis & Sharples 2013) and extends over parts of the hillfort interior, the 'ringwork', and downslope outside the hillfort defences to the NE.

According to published British Geological Survey mapping, the site lies mainly on the Triassic Blue Anchor Formation, with the lower slopes probably reach down into early levels of the Mercia Mudstone Group. The site lies outside the mapped extent of boulder clays, but spoil alongside ditches suggest that deposits rich in Coal Measures sandstone pebbles do occur in this area.

The survey was commissioned by Dr O. Davis of Cardiff University. The survey was, largely, intended simply as a research exercise, but the resistivity part of the project also acted as a public engagement exercise.

The site was surveyed on 19th March 2015, with the main survey undertaken on the 20th (with the ground resistivity undertaken by school groups) and the 21st (with the ground resistivity as part of a public event) March, and with the areas around the church completed on 1st April.

In all cases where a high degree of certainty on the presence/absence of archaeological features is required, or a high level of interpretation of those features, then additional investigations, usually including intrusive testing through trial excavation, may be required. Geophysical survey results should not be relied on, on their own, to provide unambiguous interpretations.

Survey layout

Surveys were laid-out using a Trimble survey grade RTK GPS system. The GPS base-stations from 2014 were all damaged or unlocatable (although subsequently station stn14-8 at E=313528.978, N=175055.759 and z=72.583 was relocated immediately NE of the NE churchyard entrance).

A new base-station (stn15) was therefore created in the 'car park' area adjacent to the church. GPS data were logged by the Trimble 4700 base receiver for a period of 30 minutes on the morning of 19th March 2015. The base station logged data were converted to RINEX format (using Trimble's '*RinexConvert*' utility) and were (together with RINEX files from the five closest OS passive net stations) backdated using the '*RinexDates'* utility to permit baseline processing in '*Trimble Geomatics Office'* (TGO). The OS data also required stripping from 10 to 7 included data types to ensure compatibility with TGO, using '*Teqc'*. The data files were then post-processed to give a location for the base-station accurate to within a few millimetres.

The corrected location was determined as E=313480.071, N=175024.309, z=74.527. The base-station was re-established with the adjusted coordinates and the survey area pegged to design locations at 'round-number' 20m intervals of National Grid using a Trimble 5800 rover. The grid pegs were positioned to within 40mm of the correct location reported by the GPS, which should mean they have a final accuracy to within approximately 50mm of National Grid.

The survey location with grid layout is shown in Figure 1.

Magnetic gradiometry

Magnetic gradiometry was undertaken with a Bartington Grad 601 Dual fluxgate gradiometer. Data were collected at 0.125m intervals on walked traverses 2m apart (giving effective traverse interval of 1.0m; single density). Grids were walked on South to North traverses.

Data were downloaded from the instrument, assembled and cleaned using DW Consulting's '*Terrasurveyor Lite v3*' software. The grids were assembled, the data clipped and the destriping function employed for data in which there was an imbalance between the two gradiometers. The raw data are illustrated in Figure 2.

The data were then exported from *Terrasurveyor* and interpolated to a 0.125m node-spacing using Golden Software's *Surfer* package to reduce pixilation where required. The interpolated and georeferenced data are illustrated in Figures 4-6.

Ground resistivity

The ground resistivity survey was undertaken with a Geoscan RM15 resistivity meter, operating a 'parallel twin electrode' configuration, employing three electrodes with 0.5m probe spacing on a PA5 frame, via an MPX15 multiplexer.

In this configuration, the adjacent mobile electrode pairs had a 0.5m spacing (giving the main component of the response from 0.5-0.7m depth), with 0.5m between centres, to give a 0.5m effective traverse interval. The outer probes therefore had a 1.0m spacing (giving the main component of the response from 1.0-1.5m depth), with a 1.0m traverse interval.

Data were collected as a series of three measurements (left 0.5m-, right 0.5m-, 1.0m-spaced). Data were collected with a 0.5m sample interval (i.e. the raw 0.5m-spaced data has 0.5 x 0.5m node spacing and the 1.0m-spaced data has a 0.5 x 1.0m node spacing). The grids were walked as a mixture of standard 20m grids and smaller 10m grids to accommodate the school groups. Grids were walked on South to North traverses.

Data were downloaded from the instrument and collated using Geoscan Research's '*Geoplot*' software. The left and right datasets at 0.5m mobile probe spacing were merged into a single composite. Minor grid matching was required to fit the first grid collected into the rest of the survey.

Data processing was limited to one pass of the 'despike' function in Geoplot, with radius set to 1 and a threshold of 3 std. dev. before replacement by the mean of adjacent points. Raw data at this stage are illustrated in Figure 3.

Data were then exported from Geoplot and imported to Golden Software's 'Surfer'. The data were gridded by kriging to a node-spacing of 0.125m for production of the final, less pixelated, image. The georeferenced interpolated data are illustrated in Figure 7 upper (0.5m-spaced data) and Figure 7 lower (1.0m-spaced data).

Additionally, the 0.5m-spaced data were given two passes of the high pass filter in Geoplot (with radius set to 10) to produce a dataset with less influence from the geomorphology. This dataset is illustrated in Figure 3b (0.5m-spaced data).

Results

Magnetic gradiometry

Data quality was generally good in the southern part of the survey but poor towards the north – the result of lack of suitable locations for zeroing the instrument and challenging, steep, uneven topography. The numbers in the following description refer to the numbered anomalies on Figures 8 and 9.

Dispersed ferrous debris were abundant across most of the site, except for the SE.

Two areas were particularly affected by modern building and associated occupation debris (Figure 8, grey tone). The central part of the surveyed area (1), to the SW of St Mary's Church, included the site of 20th century agricultural structures (pig styes?) and series of banks or tracks formed of slag and brick rubble. This approximately square area was too magnetically 'noisy' for detailed interpretation. Dispersed magnetic debris from this area also affected some adjacent areas. To the N of this, a slag bank (2) is particularly prominent ([313469, 175085] to [313465, 175070]), and appears to impound the pond. A small ditch, or overflow runs northwards from the pond and was imaged a slight linear anomaly ([313465, 175096] to [313470, 175087]; Figure 8, dark blue line).

To the south of St Mary's, an area adjacent to the demolished Church Cottage, was also very magnetically noisy, possibly due both to its original use and the spread of debris from the house site (3). The northern part of this field shows low negative magnetic anomalies against a relatively clean background. These include examples aligned SW – NE (e.g. [313548, 175049] to [313529, 175025]), but also faint In the south of the field, indistinct alignments within the noisy areas in the same two directions are also visible (particularly on the coarser scale plot, Figure 6).

The interior of the hillfort is crossed by a ferrous pipe (4) passing between the site of the former agricultural structures and a brick-built tank on the northern slopes (from [313421, 175063] to [313456, 175056]).

This field shows a strong agricultural (ploughing) lineation oriented SW-NE (5). In the NE of the survey area downslope (NW-SE) lineations (6) are also probably agricultural. In the SE of the survey, minor slope-parallel lineations (7) may be associated with soil creep or with the underlying geology.

Below the springs on the steep slope were a variety of features visible in the magnetic data, including a strong positive magnetic anomaly (8) associated with a stream course, which showed numerous fragments of ceramic drain on the surface.

A minor positive arcuate anomaly in the same area is of uncertain origin, but may also be associated with drainage (9). A short length of somewhat similar downslope-directed narrow positive anomaly (10) is also of uncertain origin.

To the NW of the survey, close to the N lip of the hilltop, a mainly negative magnetic anomaly ([313425, 175072] to [313447, 175079] corresponds to a small, lynchet-like feature (11). This appears to be a continuation of the plough-margin feature that encircles much of the hilltop.

Magnetic anomalies of archaeological origin were seen in the SW of the area, where a small area showed similar characteristics to the remainder of the hillfort interior surveyed previously. Within this area the most prominent feature was an arc ([313420, 175040] to [313446, 175015]) of a linear, positive magnetic anomaly, with a slightly irregular course, an amplitude of 4-5nT and a width of 1.5-1.7m (12). The anomaly probably continues southwards beyond its clear expression, but its N-S direction means the destriping routine in *Terrasurveyor* may have filtered it out.

To the north of this a narrow positive linear anomaly apparently has a straight course, ([313421, 175055] to [313441, 175038]) but is partly obscured by ferrous debris (13).

The main hillfort rampart was well imaged immediately to the west of the ringwork, where it forms a strong topographic feature ([313480, 175102] to [313509, 175105]), although it is unclear to what extent the intensity of the anomaly (+8nT to -10nT) is a product of the topography (14).

On the east side of the survey area the magnetic data show an anomaly (15) corresponding to the outer face of the inner rampart ([313529, 175002] to [313553, 175035]). It not clear how much of this anomaly reflects the influence of the dark soil, rich in modern debris that has spilled, or been tipped, over the edge of the field above.

A prominent linear positive anomaly (16) runs along a line well-down the slope of the field, with barely noticeable surface expression ([313542, 175000] to [313592, 175080]). The anomaly is weak (peak amplitude of approximately 3nT) and is approximately 4m wide. Downslope of the northern end of this anomaly an irregularly shaped positive anomaly (17) may simply be disturbed ground associated with seepage from the spring, but might include an additional component outside the line of (16).

At the southern end of the east part of the surface a slightly stronger (<3.7nT), but narrower (less than 2m) linear positive anomaly (18) runs obliquely to the feature describes above ([313537, 175000] to [313549, 175027]).

Ground Resistivity

Data quality was generally good, requiring only minor spike removal, however there was significant striping due to imbalance between the two sets of probes on the frame at 0.5m spacing. The numbers in the following description refer to the numbered anomalies on Figures 10 and 11.

To the N, S and W the survey limits coincide approximately with the crest of the rampart of the ringwork. To the E, the survey was prevented from reaching the crest by vegetation. To the SW the survey was continued through the entrance and across the adjacent sections of bank.

There is a complex pattern of resistivity variation across the ringwork. The pattern is very similar in the survey conducted with 0.5m mobile probe spacing and that with 1.0m spacing, but there are some slight differences.

On the N and NE sides the resistivity is low on the bank, whereas to the NW and S the resistivity of the bank is higher than much of the internal area and in both these areas the featuring of the resistivity cross-cuts the topographic bank. The entrance passage shows very low resistivity with a central positive anomaly, suggesting the detail may be controlled by modern wheel ruts.

The survey with 0.5m-spaced mobile probes shows a distinct ‘T’-shaped narrow positive anomaly to the S side of the entrance, several irregular areas of elevated resistivity and several marked ‘steps’ in the resistivity. The background to the finer-scale featuring appears to possess a NW-SE grain. The survey with 1.0m-spaced mobile electrodes shows a similar overall pattern, although the narrow positive anomalies are less marked and the NW-SE trends are more marked.

The survey with 1.0m-spaced mobile electrodes shows a decrease in resistivity (area ‘i’) on the rear face of the bank on either side of the entrance (‘a’ and ‘b’), suggesting a straight inner face to the original defences in this area, approximately parallel to the straight outer margin of the bank. Such a linear arrangement (rather than the apparently curved plan of the remainder of the circuit) would facilitate defence of the gateway and the siting of any gate-tower.

Within the interior of the ringwork there are several other anomalies and lineations that are approximately co-axial with the suggested alignment of the frontal defences. These include:

- a rectangular area of slightly lowered resistivity (and a possible marginal narrow anomaly with lowered resistivity) to the NE (‘c’).
- a small area of elevated resistivity in the centre of the enclosure (‘d’), which again appears to have a marginal low-resistivity anomaly.
- a narrow positive linear resistivity anomaly parallel to the rear of the bank E of the entrance (‘e’).
- a zone of extremely elevated resistivity in the SE of the enclosure, which appears to have a narrow marginal anomaly of reduced resistivity (‘f’).
- a zone of elevated resistivity in the NW of the enclosure, bounded to the SE by a NE-SW zone of reduced resistivity (‘g’).

In addition to these, there is a prominent narrow positive resistivity anomaly directed ENE from the inner end of the E side of the entrance passageway (‘h’).

Interpretation

Magnetic gradiometry

The magnetic survey clarified the location and nature of the NE corner of the large Roman period enclosure (Figures 8/9, 12). Davis & Sharples (2013) discussed the nature of this enclosure in the context of the discovery that towards the SE corner it was bounded not by a ditch, but apparently by large pits. The present survey shows it as a slightly irregular feature, but it appears continuous, apart from its absence on the expected course in the southernmost 20m of the survey area. Unfortunately, it is not clear if this is a genuine absence, or whether its location along the walked traverse has meant it has been processed out of the dataset by the destriping algorithm.

The survey also located the NE termination of the lynchet-like feature, interpreted as the margin of post-medieval cultivation along the northern side of the fields (Figure 8/9, 11).

To the east side of the hill, the magnetic survey has located major anomalies that coincide with the potential location for any outer defences, comparable with those on the other sides of the hillfort. There is almost no surface expression oif the new feature (Figures 8/9, 16), and the anomaly is only approximately 4m wide, but nonetheless an interpretation as an external defence (a ditch or terrace) would appear more likely than as a lynchet. Equally interesting in this area is the anomaly apparently indicating another ditch (Figures 8/9, 18) between the two lines of defences. It is unclear if this too is defensive (perhaps as a strengthening of the defences near to the eastern gateway into the hillfort), or whether it is an entirely separate feature.

The survey also showed linear anomalies in the field SE of St Mary’s Church (Figures 8/9, 3). These appear to be present not only in the northern section of the field, but also in the area of much magnetic noise in the southern part of the field, interpreted as recent debris. In places towards the south of the field these narrow negative magnetic anomalies form rectilinear patterns similar to the anomalies that might be produced by a stone building. Given their distribution across the field, they are more likely to represent plough disturbance of the strongly magnetic/magnetically susceptible material. It would appear likely that this area may have been ‘improved’, perhaps following the dumping of building debris in the south and/or removal of the field boundary mapped by the 1st edition OS showing a routeway passing around the churchyard to the SE (i.e. lying within this field ,but no longer visible).

Ground Resistivity

The interpretation of the resistivity data is complicated by the multiphase history of this area. The ringwork is likely to have variously incorporated and replaced aspects of the Iron Age defensive architecture, coupled with which the geological context of this marginal hilltop location may also be complex. None of the anomalies is interpretable in a straightforward manner – so any attempt to interpret them is highly speculative.

Narrow negative resistivity anomalies might have a geological origin; they are commonly seen above prominent cracks of various sorts (faults, joints, bedding…) in bedrock or even of superficial modern origin (e.g. wheelruts or plough furrows). It is possible, however, that they are of archaeological origin, being narrow cut features (gullies, timber slots or even closely-spaced postholes).

The interpretation of the bank includes what appears to be a straight section either side of the gate (‘a’ and ‘b’). The variable resistivity of the zones to NW and SE of this straight section (including ‘f’ and ‘g’) is problematic, but may possibly relate to the nature of any surviving underlying Iron Age rampart remnant. The contrast with the low resistivity bank to the N and NE may indicate a different origin for the bank on that side – perhaps even overlying the outer face/ditch of the Iron Age defences. The low resistivity zone ‘I’ may represent the wedge of sediment accumulated against and inside the original inner face of the bank.

The area ‘c’ is very subtly-defined, but is just possibly suggestive of the footprint of a timber building– perhaps of appropriate size (c. 18.5m x 6.5m) for a hall or large barn. The possible marginal anomalies appear discontinuous, so may possibly indicate postholes. If area ‘c’ does represent a building, then positive anomaly ‘d’ lies almost central to the SW side – and might therefore potentially be a porch or base of a staircase to a first floor door. If area ‘c’ is not a structure, but merely a coincidence of other anomalies, then anomaly ‘d’ is isolated and almost exactly central to the ringwork. In this case an alternative interpretation, such as perhaps stonework around a well, needs to be sought.

The prominent positive anomalies ‘e’ and ‘h’ are very well imaged on the 0.5m-spaced data, suggesting they are shallow features. It is possible that ‘h’ is associated with the margin of the zone of vehicular access to the ringwork in recent times, but an archaeological origin would appear more likely. It is not aligned with the other potential features, but does appear to link the entrance with the S corner of area ‘c’. As a high resistivity anomaly, a wall footing might be a potential interpretation, but a stone drain would be equally plausible. It may also be noteworthy that anomaly ‘h’ is approximately aligned towards the northern margin of the churchyard (on the 1st edition OS; Figure 10) before its northern extension in the early 20th century – thus ‘h’ might be associated with an original (or at least pre-late 19th century) direction of access that passed to the north of the churchyard, rather than south as in the late 19th century, or through the churchyard as at present. Anomaly ‘e’ is difficult to interpret for it extends from the interior of the ringwork well into the line of the topographic bank. If a wall, then it might indicate the rear of a tower, but the lack of other sides make this unlikely. The angular relationship between ‘h’ and ‘e’ make it not impossible that they bound two sides of a structure, but if so the plan is not rectilinear and the other two sides are not identifiable.

Conclusions

The key results of the project were:

- to locate a probable line of outer defences as part of the Iron Age circuit

- to locate a ditch of unknown age and significance cutting those outer defences at the southern edge of the survey

- further evidence for the nature of the Roman ‘large enclosure’, including its NE angle, around which the ditch, though irregular, appears more continuous than appeared on the earlier survey.

- to identify a probable straight section of the ringwork defences, on either side of the entrance

- to suggest, albeit very tentatively, the location of a possible timber building on the NE side of the ringwork interior

- to locate some additional features, some possibly of stone, of unknown significance within the ringwork

References

BRENNAN, N. 2013. Caerau, South Wales, Evaluation and Assessment of Results. Wessex Archaeology Unpublished report 85201.01.

DAVIS, O. & SHARPLES, N. 2013. *Excavations at Caerau Hillfort, Cardiff, South Wales, 2013, an interim report*. Cardiff Studies in Archaeology, Specialist report No. 34.

YOUNG, T.P. 2012. Geophysical survey at Caerau Hillfort, Cardiff [ST133750]. GeoArch Report 2012/07, 9pp.

Captions

Figure 1: Location of survey area and grid layout (base mapping © Crown copyright and database rights 2015 Ordnance Survey), with staked grid locations indicated by circles.

Figure 2. Raw (but destriped) magnetic gradiometer data as a bitmapped images from Terrasurveyor. North to top, grid squares are 20m.

(a) survey in ringwork interior, greyscale -12nT (black) to +12nT (white).

(b) survey on NE slopes, greyscale -12nT (black) to +12nT (white).

(c) survey of hilltop areas, greyscale -30nT (black) to +30nT (white).

(d) survey of hilltop areas, greyscale -4nT (black) to +4nT (white).

Figure 3. Raw ground resistivity survey of ringwork as bitmapped images from Geoplot:

(a) 0.5m-spaced data, with a greyscale 27 ohm measured resistance (black) to 80 ohm (white).

(b) 0.5m-spaced data, after high pass filtering, with greyscale -10 ohm measured resistance (black) to +10 ohm (white).

(c) 1.0m-spaced data with greyscale 25 ohm measured resistance (black) to 35 ohm (white).

For (a) and (c) the images to the right show the central swathe 10m wide undertaken with the school groups.

Figure 4. Interpolated magnetic gradiometer survey displayed on OS basemap (base mapping © Crown copyright and database rights 2015 Ordnance Survey), greyscale -30nT (black) to +30nT (white).

Figure 5. Interpolated magnetic gradiometer survey displayed on OS basemap (base mapping © Crown copyright and database rights 2015 Ordnance Survey), greyscale -12nT (black) to +12nT (white).

Figure 6. Interpolated magnetic gradiometer survey displayed on OS basemap (base mapping © Crown copyright and database rights 2015 Ordnance Survey), greyscale -4nT (black) to +4nT (white).

Figure 7. Comparison of the two ground resistivity datasets (base mapping © Crown copyright and database rights 2015 Ordnance Survey):

(upper) 0.5m-spaced data, with a greyscale 34 ohm measured resistance (black) to 60 ohm (white).

(lower) 1.0m-spaced data, with a greyscale 28 ohm measured resistance (black) to 35 ohm (white).

Figure 8. Summary interpretation of magnetic gradiometer survey. For explanation see text.

Figure 9. Summary interpretation of magnetic gradiometer survey, displayed on OS base mapping, for details see text (base mapping © Crown copyright and database rights 2015 Ordnance Survey).

Figure 10. Summary interpretation of ground resistivity survey. For explanation see text. Pecked lines indicate approximate extent of earthwork features, grey linework shows late 19th century extent of church yard and St Mary's Church.

Figure 11. Summary interpretation of ground resistivity survey, displayed on OS base mapping, for details see text (base mapping © Crown copyright and database rights 2015 Ordnance Survey).

Figure 1

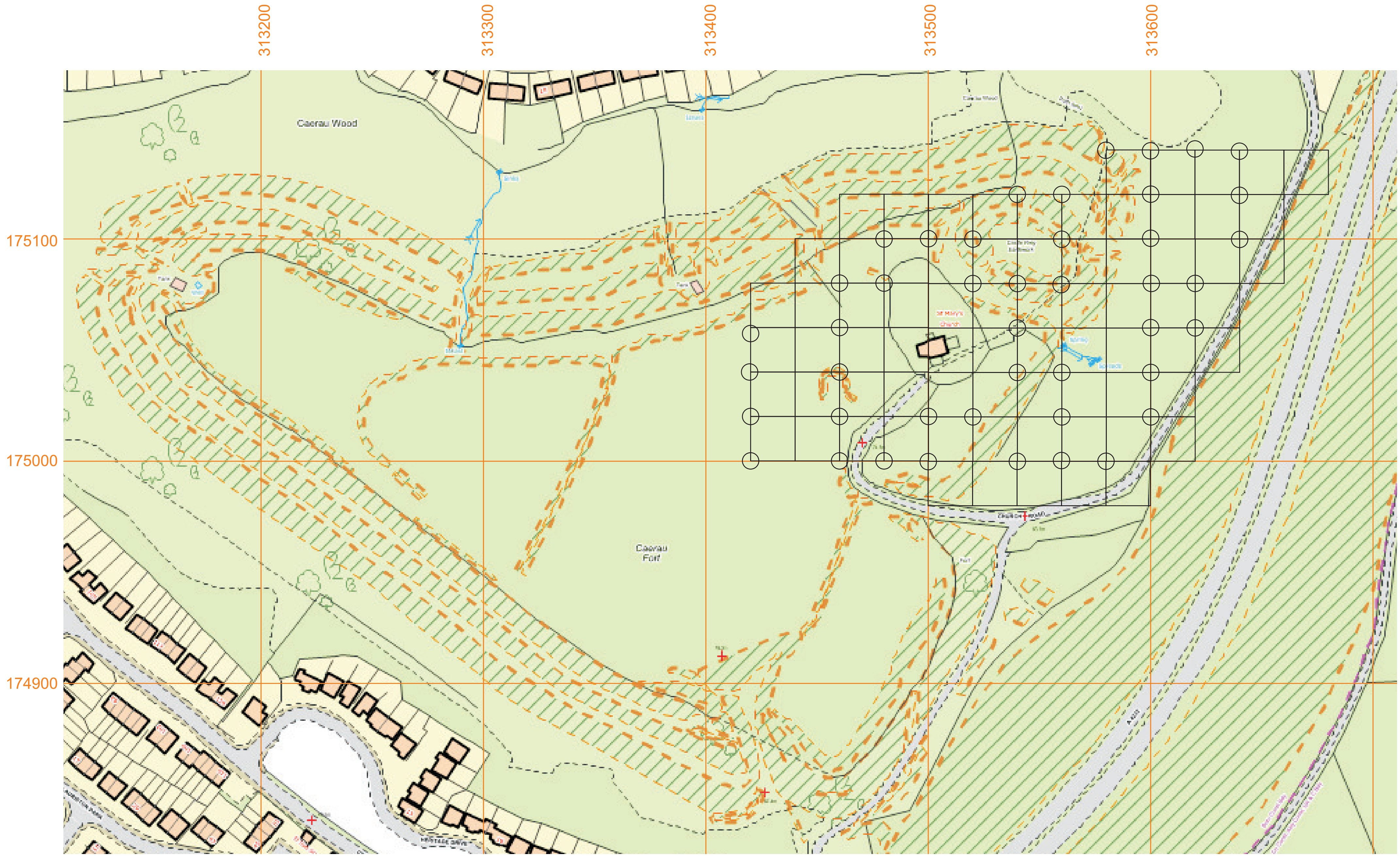

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Figure 2

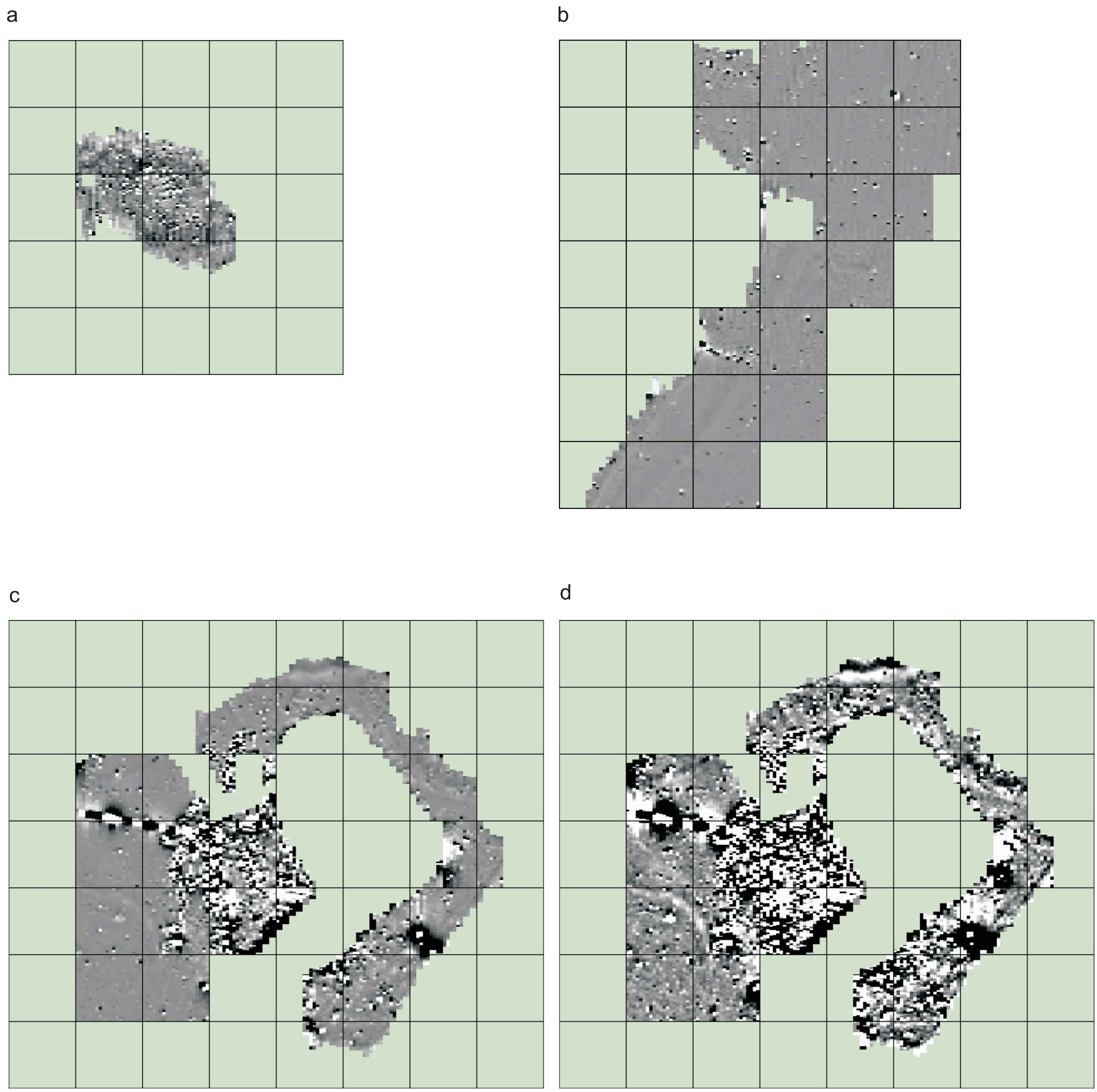

Figure 3

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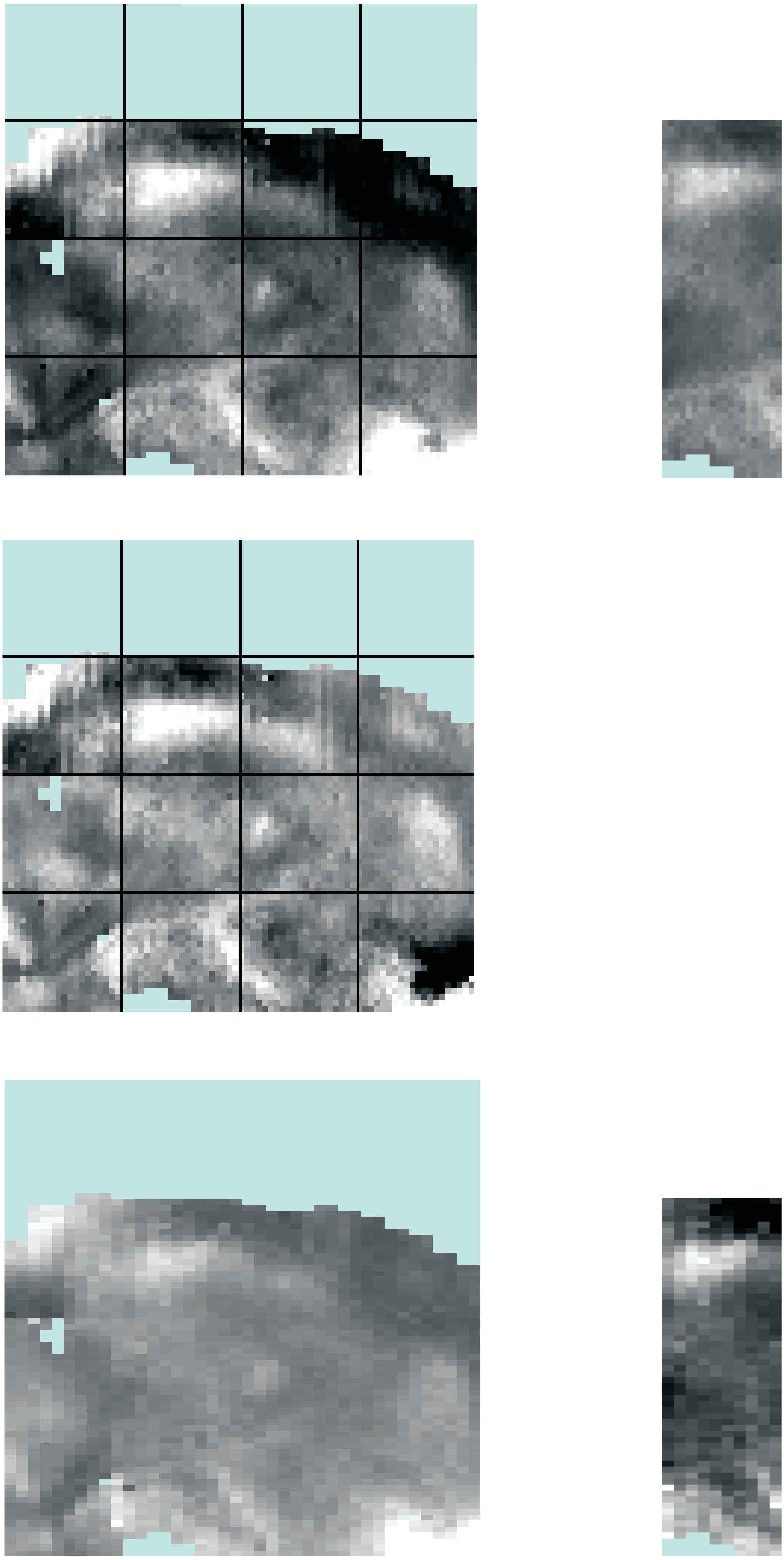

Figure 4


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Figure 5

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St Mary's
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Figure 6

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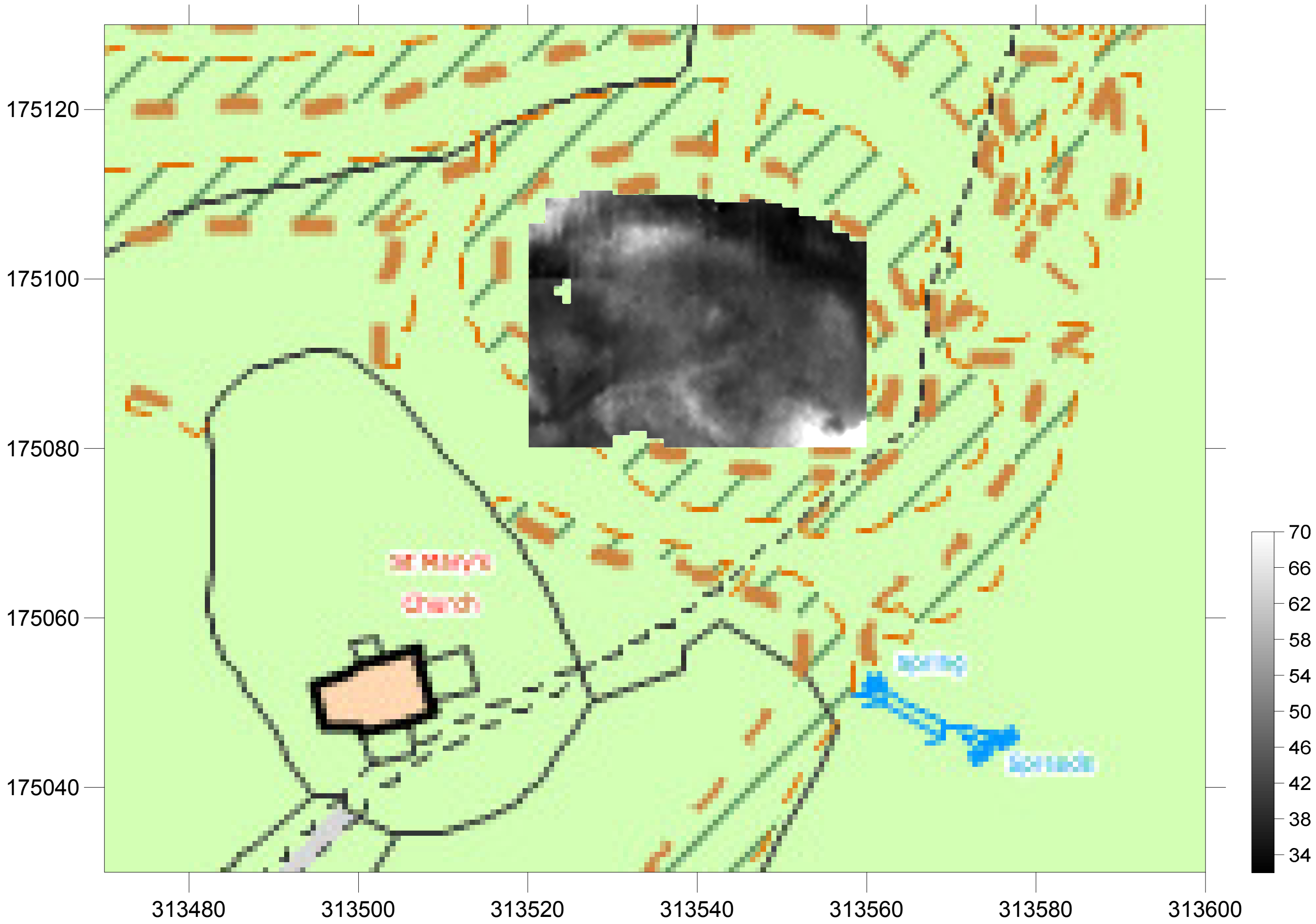
Figure 7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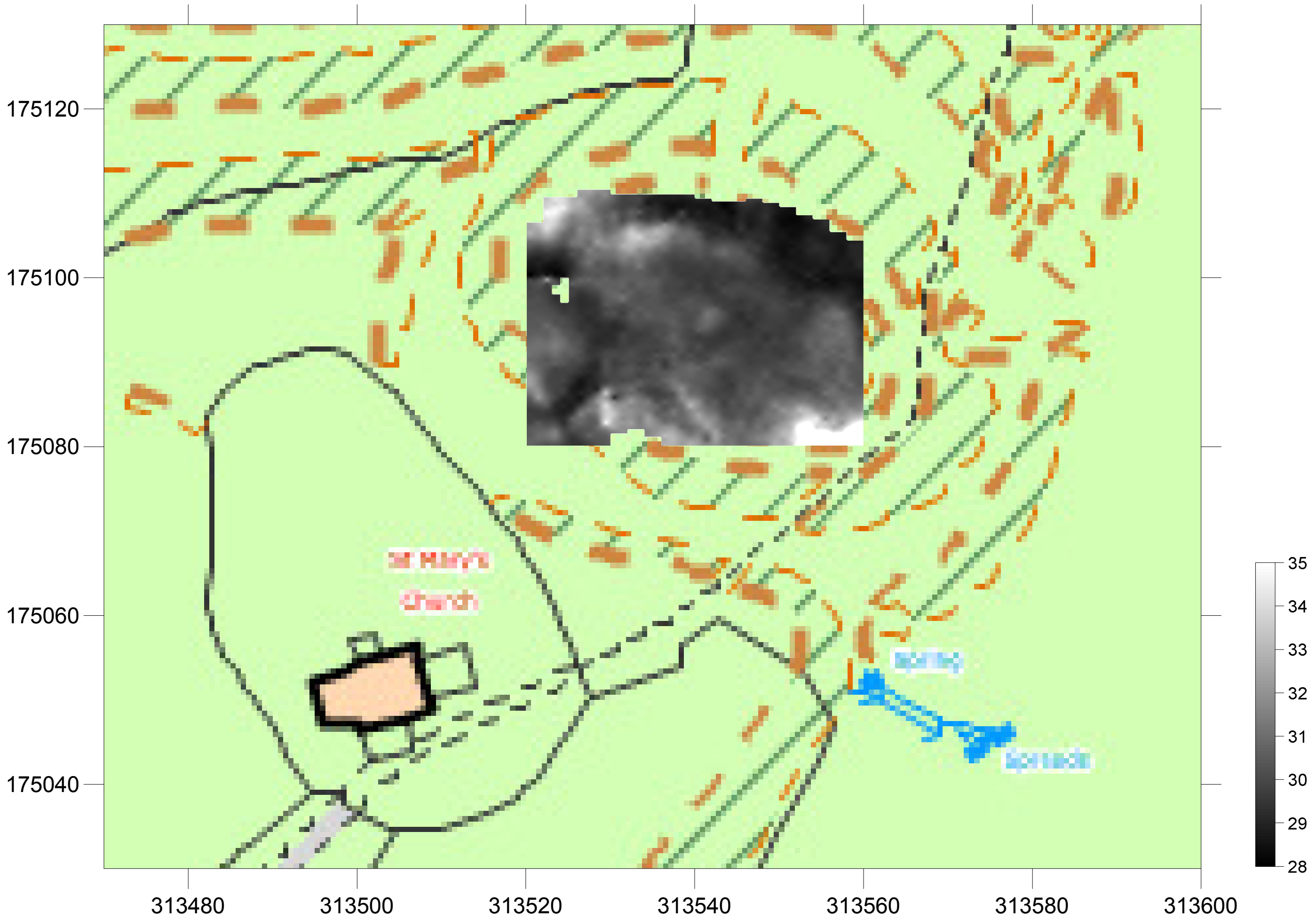
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Figure 8

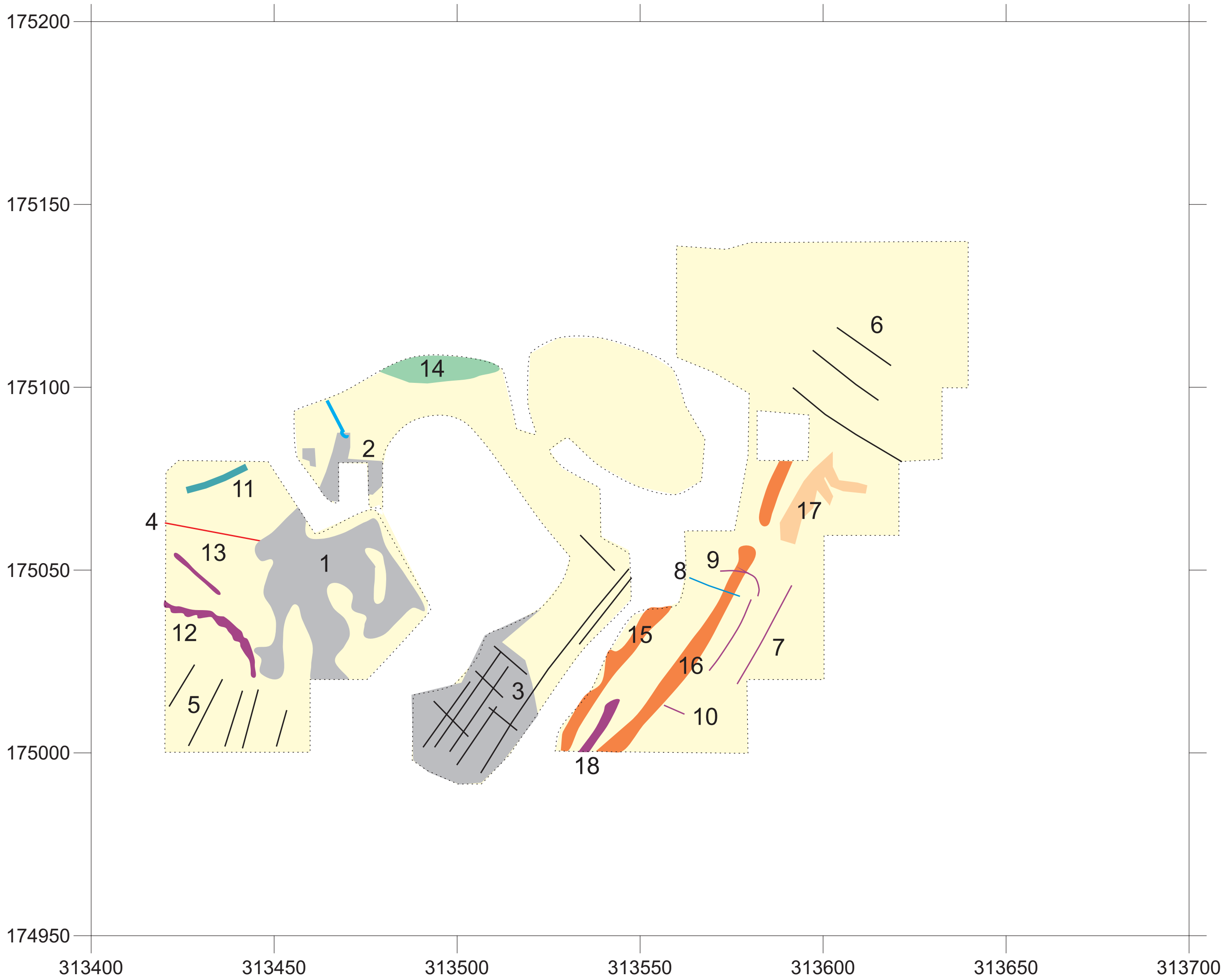
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Figure 9

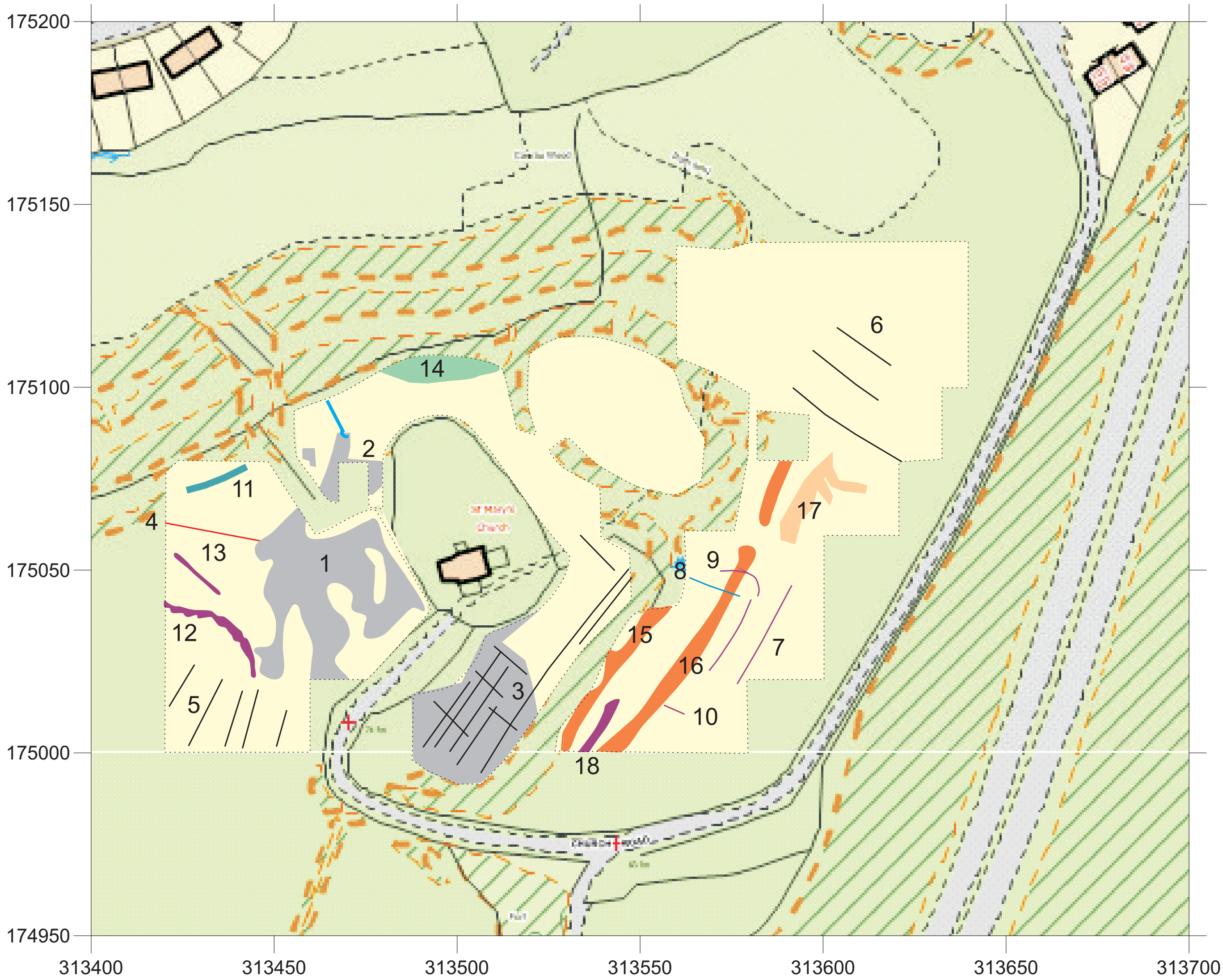

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Figure 10

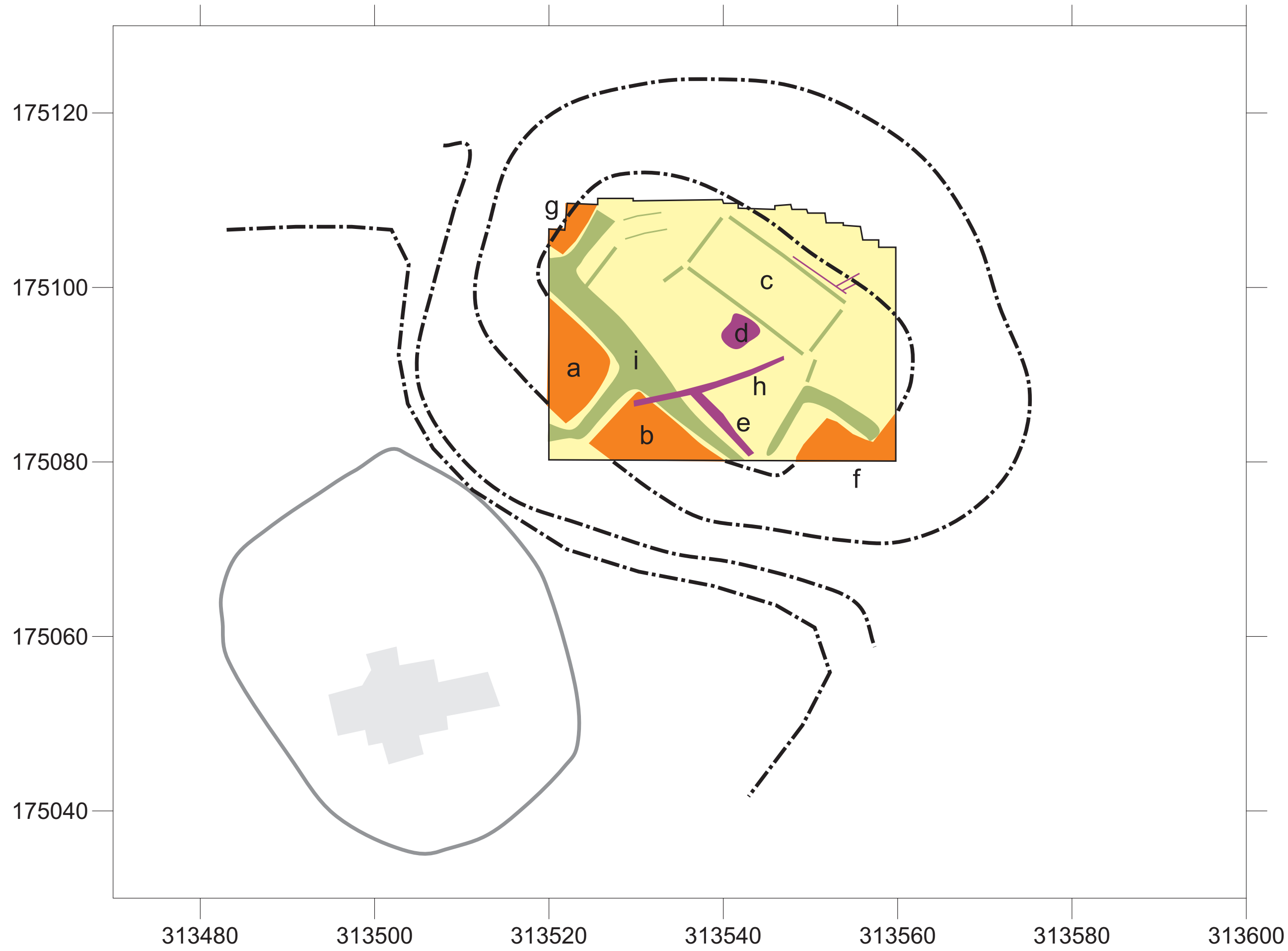

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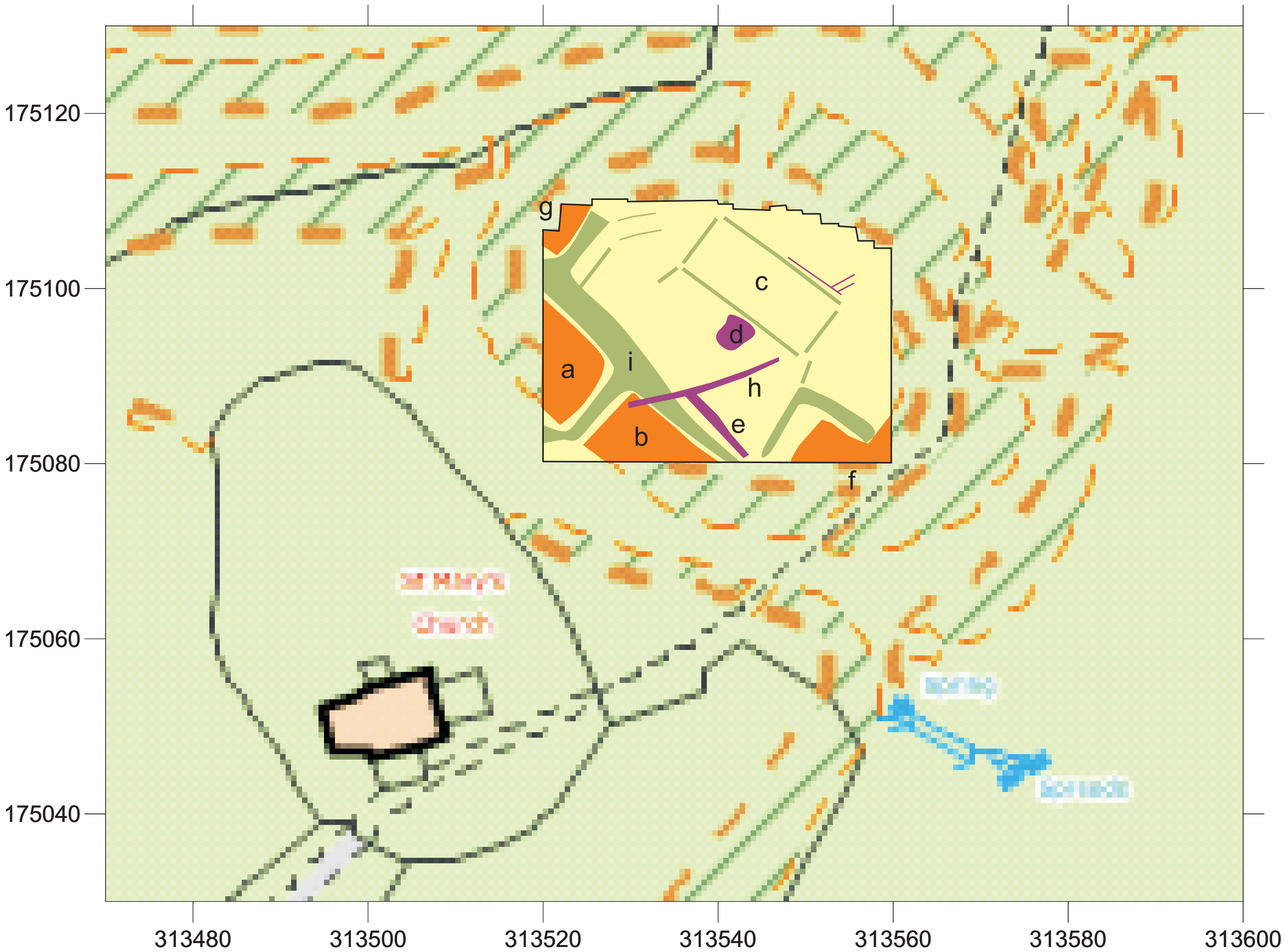
Figure 11



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St Mary's
Church

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