



GEOPHYSICAL SURVEY

LAND TO THE SOUTH OF
HORNSEA LEISURE PARK

EAST RIDING OF YORKSHIRE

prepared for

Savills

on behalf of

Shorewood Leisure

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Grid Ref TA 19975 49122

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LAND TO THE SOUTH OF HORNSEA LEISURE PARK, HORNSEA, EAST RIDING OF YORKSHIRE

GEOPHYSICAL SURVEY REPORT

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LAND TO THE SOUTH OF HORNSEA LEISURE PARK, HORNSEA, EAST RIDING OF
YORKSHIRE
GEOPHYSICAL SURVEY REPORT

Summary

Northern Archaeological Associates Ltd was commissioned by Savills on behalf of Shorewood Leisure to undertake a geophysical survey on land to the south of Hornsea Leisure Park, Hornsea East Riding of Yorkshire (NGR: TA 19975 49122). The work was undertaken in support of a planning application for the proposed extension of the existing Hornsea Leisure Park.

The proposed development area comprises approximately 11.93ha of amenity grassland and former agricultural land divided into two areas. The first is a 5.25ha site located within the north western corner of the leisure park (PDA A) and the second is a 6.68ha site (PDA B) located immediately south of the park. Situated directly south of PDA B is a Scheduled Monument (NMLE: 1423379), described as 'East Field crop mark site centred 300m SSE of Northorpe, interpreted as a Neolithic henge later reused as a Bronze Age ringwork'. This is a roughly circular cropmark, approximately 50m in diameter set within a later coaxial field system.

The geophysical survey was conducted across PDA B on the 15th and 16th July 2019. PDA A had previously been surveyed as part of an earlier scheme of archaeological investigations by NAA in advance of the construction of a new access road and balancing pond to the north of the leisure park.

Results in the field to the south-east of the leisure park (Field A) were inconclusive, and identified a number of amorphous anomalies of an unknown origin; whilst the results in the field to the south-west (Field B) identified several curvilinear, rectilinear and amorphous anomalies that plausibly relate to buried archaeological features of a possible prehistoric date. A linear anomaly running on a north-west to south-east alignment corresponds with a former stream recorded on the 1809 Enclosure map, and a linear trend possibly relates to a field boundary, or a headland. A field boundary is shown in this location on 19th century Ordnance Survey maps. Otherwise, anomalies identified within the survey area were generally considered to be caused by either modern or agricultural activity.

In summary, the geophysical survey in PDA B has identified a moderate potential for the presence of archaeological material on the west side of the site. The date and nature of these features remain unknown, but based tentatively on their form and that they appear to lie beneath the medieval ridge and furrow, it is considered likely that these are prehistoric in origin. This accords with the cropmark evidence of a possible Bronze Age field system in the adjacent field to the

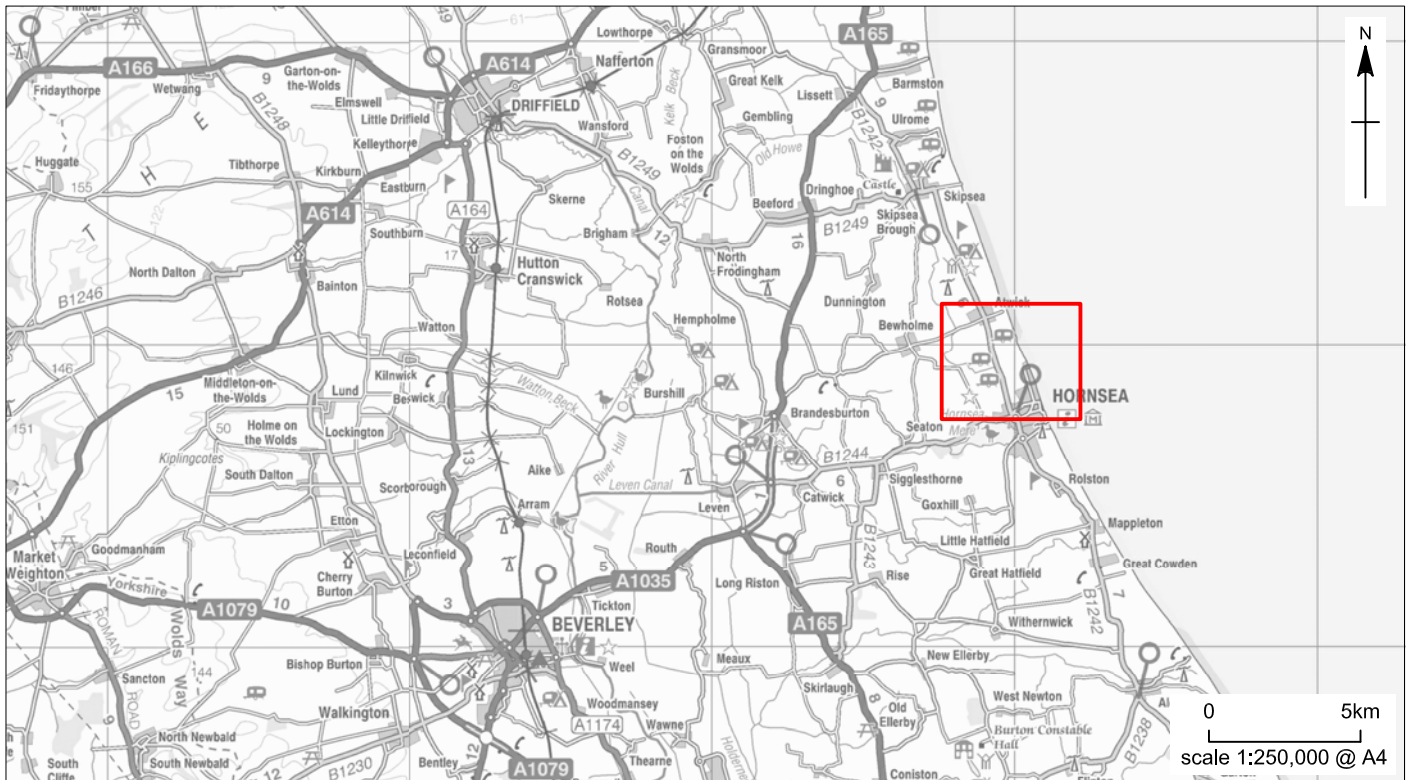
south. However, currently there is little to suggest that any features relating directly to the Neolithic henge monument continue north into PDA B, although this cannot be confirmed without further archaeological investigation.

The earlier geophysical survey in PDA A showed no evidence of the prehistoric field system continuing north beyond the present leisure park. Similarly, no evidence of prehistoric activity was identified during the 2015 excavations, although these were very limited in scope. In the western part of the site the survey identified a number of linear anomalies interpreted as possibly in-filled ditches relating to the medieval settlement of Northorpe. Excavation confirmed the presence of several ditches or gullies associated with one or more garths at the northern end of the deserted medieval village. Pottery from these features date occupation of the site to the 12th through to the 14th century.

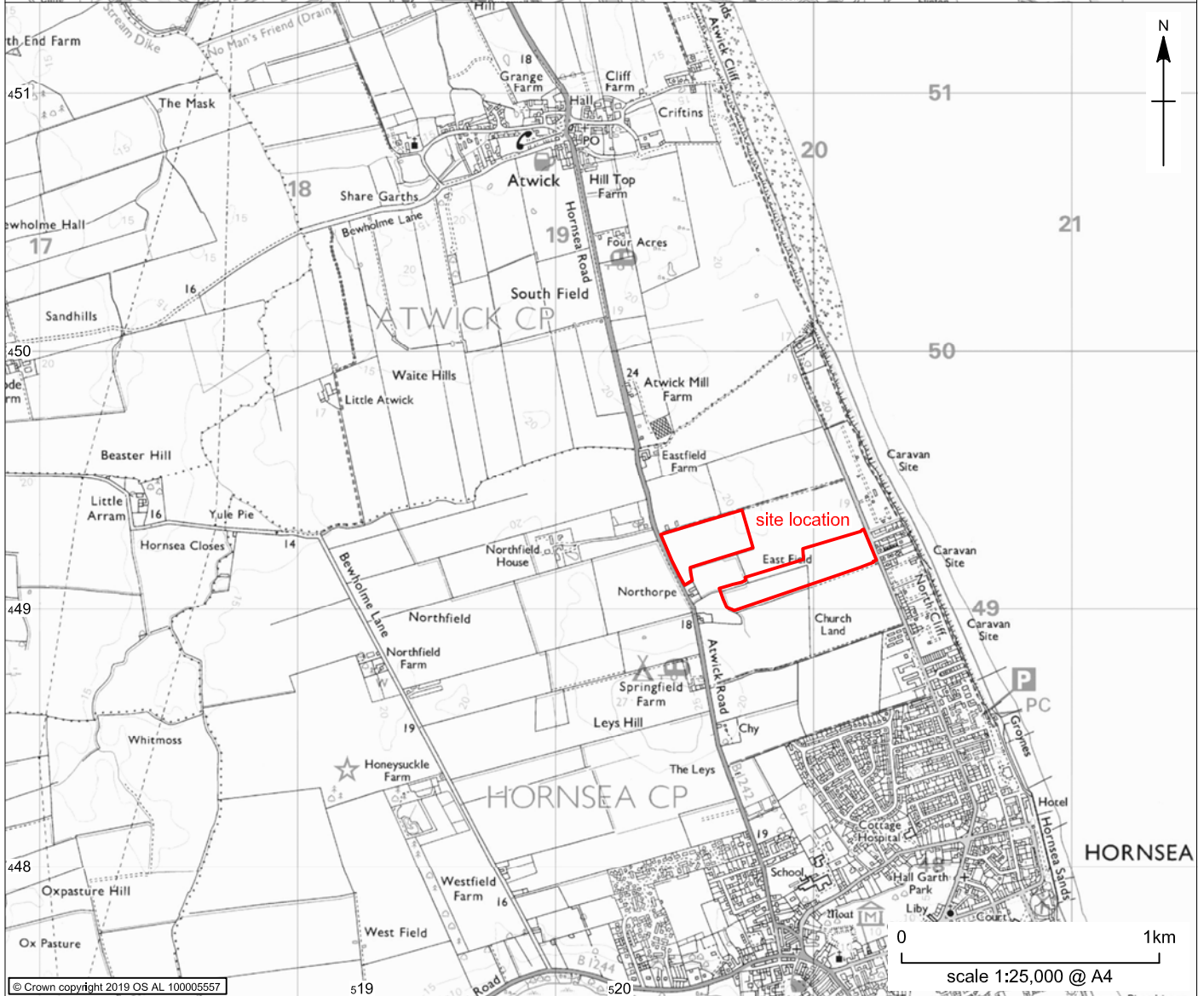
Based on the results of both phases of geophysical survey, it is likely that the Humber Archaeology Partnership (advisers to the East Riding of Yorkshire Council) and Historic England will require a phase of archaeological trial trenching to ascertain the nature, form, date and preservation of any potential archaeological remains. It is recommended that the evaluation is focused initially in the south-west field of PDA B, extending to the other areas as/if required. The results of the trenching will in turn inform a statement of heritage significance and impact assessment to evaluate any risk to the archaeology arising from the proposed expansion.

Disclaimer

The results of geophysical survey may not reveal all potential archaeology and do not provide a comprehensive map of the sub-surface, but only responses relative to the environment. Geological, agricultural and modern responses may mask archaeological features. Short-lived features may not give strong responses. Only clear features have been interpreted and discussed in this report.



0 5km
scale 1:250,000 @ A4



0 1km
scale 1:25,000 @ A4

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Hornsea Leisures Park: site location

Figure 1

1.0 INTRODUCTION

- 1.1 Northern Archaeological Associates Ltd (NAA) was commissioned by Savills on behalf of Shorewood Leisure on behalf of Shorewood Leisure to undertake a geophysical survey on land to the south of Hornsea Leisure Park, Hornsea, East Riding of Yorkshire (NGR: TA 19975 49122). This was required to assess the potential for buried archaeological remains in support of a planning application for the proposed extension of the existing Hornsea Leisure Park, HU18 1EL.
- 1.2 The proposed development area (hereafter PDA) comprises approximately 11.93ha of amenity grassland and former agricultural land located 1.6km north of Hornsea (Fig. 1). There are two areas of proposed expansion (Fig. 2). The first is a 5.25ha site located within the north western corner of the leisure park, on land between Atwick Road and the existing car park (hereafter PDA A). The second is a 6.68ha site (hereafter PDA B), located immediately south of the park.
- 1.3 The current phase of geophysical survey relates only to PDA B and was conducted on the 15th and 16th July 2019. PDA A had previously been surveyed as part of an earlier scheme of archaeological investigation completed by NAA in advance of the construction of a new access road and balancing pond (Planning Ref: DC/12/03979/PLF) (NAA 2012; 2013; 2015). The results of both phases of geophysical survey will be considered together in the final sections of this report.

2.0 LOCATION, TOPOGRAPHY AND GEOLOGY

Location

- 2.1 PDA B comprises approximately 6.68ha of land to the south of Hornsea Leisure Park, which is located approximately 1.6km to the north of the centre of Hornsea, in the East Riding of Yorkshire (Fig. 1). The geophysical survey targeted two fields, currently set aside to pasture (Fig. 3).
- 2.2 The site is bordered to the north by Hornsea Leisure Park, Northorpe Farm to the west, Cliffe Road and residential estates lining the seaside to the east, and agricultural land to the south.

Topography

- 2.3 The site is set on a gentle east facing slope. Within the PDA itself the ground was fairly

level. The highest part of the site was recorded at c.17m above Ordnance Datum (aOD); whilst the lowest part lies at c.16m aOD.

Geology and soils

- 2.4 The solid geology consists of sandstone of the Rowe Chalk Formation, and superficial deposits largely comprise Devensian till (British Geological Survey 2019).
- 2.5 The soils are mapped as Holderness Association (Soil Survey of England and Wales 1983). Holderness Association is largely composed of slowly permeable fine loamy and moderately permeable coarse loamy soils on chalky till and glaciofluvial drift (Jarvis *et al.* 1984, 273).

Previous Works

- 2.6 Between 2012 and 2015, NAA completed a series of archaeological investigations in advance of the construction of a new access road and balancing pond in PDA A. The site had previously been identified by Humber Archaeology Partnership (HAP), advisers to the East Riding of Yorkshire Council (ERYC), as of archaeological interest in relation to prehistoric and medieval activity. NAA were commissioned by Shorewood Leisure to undertake an archaeological appraisal of the site (NAA Report 12/119). This concluded that the proposed works could have an impact on potentially locally important prehistoric, Roman and medieval remains.
- 2.7 Subsequent to the appraisal, a scheme of archaeological mitigations works was agreed with HAP in advance of the development. This constituted a geophysical survey in the first instance, followed by 'strip, map and record' excavation along the course of the proposed road and area of the balancing pond.
- 2.8 Phase Site Investigations were commissioned by NAA to undertake the geophysical survey in December 2012 (Phase 2013 ARC/929/341). The survey identified a number of linear anomalies within the western part of PDA A, interpreted as land divisions associated with the deserted medieval village of Northorpe. No anomalies indicative of prehistoric remains were identified.
- 2.9 Strip, map and record, excavations were conducted by NAA in February and March 2013 (NAA Report 15/25). Soil stripping of the road corridor and the balancing pond to the south exposed the remains of nine ditches or gullies, together with a single pit, in the western part of the site. The remains comprised both medieval and post medieval

features. Remains of post-medieval ridge and furrow agriculture were also found to the east. The medieval remains were interpreted as boundary features associated with one or more plots of land (garths) at the northern end of the deserted medieval village. Pottery from these were dated to between the 12th and 14th centuries, the absence of any later finds from the area possibly marking the end of occupation at this end of the village.

- 2.10 No previous archaeological work has been conducted within the boundary of PDA B.

Designations

- 2.11 Located immediately south of PDA B is a Scheduled Monument (NMLE: 1423379), described as 'East Field crop mark site centred 300m SSE of Northorpe, interpreted as a Neolithic henge later reused as a Bronze Age ringwork'. The site was first designated on in April 2015, after the previous works associated with PDA A had been completed. The features is described as a roughly circular cropmark, approximately 50m in diameter, interpreted as a henge monument dating to the Late Neolithic (2800 -2000BC) (Fig. 4).



Figure 4: cropmarks visible on aerial photograph. Interpreted as the remains of a Neolithic henge and later Bronze Age ringwork and field system. Taken by Historic England's Aerial Reconnaissance team (NML entry).

- 2.12 The boundary of the scheduled area runs along the hedge dividing PDA B from the site and, as such, a section 42 agreement was not required prior to survey. The proposed

strategy was, however, discussed and agreed in advance with the Historic England Inspector of Ancient Monument, Dr Keith Emerick. It clearly states within the listing that there is a potential for remains to continue south of the currently designated area.

3.0 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

3.1 The following is a summary of the archaeological and historical background to place the geophysical survey results within the broader context. It is based on the earlier archaeological desk-based appraisal prepared by NAA in 2012 (NAA Report 12/119).

Prehistoric to Roman

3.2 The potential Neolithic henge monument to the south of PDA B appears to comprise a triple-ditched enclosure, approximately 6 to 8 metres in diameter, with a break on the south-east side forming an entrance (Historic England NMLE 1423379). At the centre of the enclosure is a roughly circular feature, measuring approximately 15m in diameter, which may be a related ritual building or structure.

3.3 The henge sits within a later Bronze Age co-axial field system running on a south-east to north-west alignment along a slight ridge. Two large rectangular fields, defined by substantial boundary ditches, run across the scheduled area, with the henge monument located centrally within the northernmost plot. The northern boundary of this plot deviates to accommodate the line of the henge, suggesting that the Neolithic structure was extant in some form when the field system was first set out. This indicates that the henge was re-purposed as a ringwork enclosure in the Late Bronze Age (1000 – 750BC), potentially indicating a continuity of use through to the early Iron Age.

3.4 The cropmarks are clearly visible extending to the east, west and south of the henge but are not immediately apparent to the north, within the PDA. Notably, no prehistoric evidence was found during the earlier excavations to the north in PDA A, although these were fairly limited in nature (NAA Report 15/25). It is possible that any prehistoric remains have been truncated by later ploughing, evidence of which is visible in the field immediately west of PDA B. However, the preservation of prehistoric material beneath medieval ridge and furrow cannot be ruled out.

3.5 Henge monuments of this type frequently form part of an extensive, multi-period ritual landscape, often covering a wide area. Nine kilometres south-west of the leisure park, a well-preserved henge site, first identified from aerial photographs, has recently been

excavated at Little Catwick Quarry (NGR TA 132 465) (Yorkshire Post, Friday 29 December 2017). This may suggest an extensive prehistoric ritual landscape extending across the coastal zone. Similar sites have been found at Thornborough in North Yorkshire (NMLE 1004912), where ten potential henges have been recorded, each located within a 10km radius of one another. Research at Thornborough has also identified Neolithic activity suggestive of camp sites surrounded the henges at a distance of between 500m to 1km away. However, there is little evidence of any such occupation activity taking place immediately around the henges (NMLE: 1423379).

- 3.6 Parallels to the site from within the East Riding would include the Wolds site of Paddock Hill, near Thwing (NGR TA 030 707) (Humber HER 3939), where a multiple-ditched circular feature, identified as a later Neolithic henge, was re-used in the Bronze Age as a defended settlement and enlarged and re-defined during the Anglo-Saxon period. However, at over 120m diameter, Paddock Hill is considerably larger than the East Field enclosure.
- 3.7 There are no other recorded prehistoric/Roman finds within the vicinity of the application area, although there are records of early prehistoric artefacts being found within the wider vicinity. These include a number of flints artefacts, including arrowheads and scrapers, collected by the Morfitt family in the area between Atwick and Hornsea (Harrison 2005, 33–5), and two bone harpoon points of Mesolithic date recorded as found in the Hornsea area (*ibid.*, 28–42).
- 3.8 Iron Age and Roman activity within the area is sparse, comprising principally pottery sherds and metalwork found by the Morfitts', together with the recovery of several complete Roman greyware pots eroding from the cliff at Atwick. Of possible note are two Iron Age coins found on the beach near Hornsea and a probable Iron Age chariot burial which was excavated within the town (Harrison 2005, 53–9).

Early Medieval

- 3.9 Little evidence of early medieval activity has been recorded in the area. During construction of the Hydro Hotel in Hornsea, a 6th-century Anglo-Saxon cemetery (Humber HER 3547) was identified, and a bone comb of a similar date found on the beach, presumably washed out of the cliff (Humber HER 3548).

Medieval

- 3.10 The former medieval hamlet of Northorpe (Humber HER 8893) lay on the east side of the Atwick Road. The first specific documentary reference to the settlement occurs in 1198. Prior to this the township of *Torp* (Thorpe) was recorded in the 1086 Domesday survey, but it is uncertain whether this refers to Northorpe or Southorpe. In 1377 the poll-tax register lists seven tax payers at Northorpe compared to 28 tenants at Southorpe and 264 at Hornsea, indicating a small hamlet of limited size on the outskirts of the township.
- 3.11 Some indication of the extent and layout of the hamlet can be inferred from the 1809 enclosure map (ERALS IA/82). This shows a series of small irregularly shaped plots (numbered 157 to 164) set along and slightly back-from the Atwick Road (Fig. 6), with a series of large rectangular fields adjoining to the east. The layout of the medieval settlement and associated field system therefore appears to have been preserved in the early-19th century enclosure landscape. The small, irregular plots shown on the map are likely to represent the fossilised boundaries of a series of medieval garths that would have formed the focus for the settlement, and the rectangular fields the fossilised boundaries of the former medieval strip fields.



Figure 5: medieval ridge and furrow visible on east side of Northorpe Farm and Cottage.

- 3.12 The 2012 geophysical survey of PDA A identified several rectilinear anomalies interpreted as enclosure boundaries. Subsequent archaeological excavation in 2015 confirmed this interpretation, producing evidence of a series of medieval garths and post-medieval agriculture. Traces of ridge and furrow cultivation can still be seen on aerial photographic coverage of the area, extending from the Atwick Road into the eastern part of PDA B. This suggests that the field has been under periodic arable cultivation from at least the medieval period onwards.
- 3.13 The strip fields formed the 'East Field' of the Hornsea townfield system. The adjacent North Field (later West Field) on the opposite side of the Atwick Road is also shown on early historic maps of the area. The East Field extended all the way to the cliff edge, as shown on the 1809 enclosure map, with small strips of land visible along the cliff top. Documentary evidence records that there has been a considerable amount of land erosion into the sea over time, with allegedly 240 yards (219 metres) lost between 1547 and 1609 and a further 100 - 200 acres lost by 1637 (VCH 2002).

Post medieval

- 3.14 There are no documentary references to Northorpe after the 17th century, when the settlement seems to have been largely abandoned. Notably, there are no buildings shown on the 1809 enclosure map, although Poulson writes that locals recall 'stones being dug up...which seemed to be part of buildings' in the early 19th century (1840, 340). The land does, however, appear to have remained under the ownership of a number of different individuals prior to enclosure. PDA A is recorded as belonging to Moses Lawson, and PDA B to W. Stork (Fig. 6).
- 3.15 By the publication of the 1852 First Edition 6-inch Ordnance Survey (OS) map, most of the garths had disappear in a phase of post-enclosure field rationalisation. Only two plots survived, both immediately east of PDA B (numbers 159 and 160 on the enclosure map). The northernmost plot (159) belonged to W. Stork and that to the south (160) to the church. This was part of a large block of land that included the field with the cropmark henge. Marked as 'Church Land' on later OS maps this was probably Glebe land, the proceeds from any crop going either to the maintenance of the parish priest or the poor. There is no indication that there was ever a church or chapel associated with Northorpe.

3.16 Northorpe Farm was constructed sometime between 1852 and the publication of the Second Edition OS map in 1890. This was a courtyard farm in the High Victorian tradition. A smaller farmstead – Northorpe Cottage - was built to the south. The associated field layout remained little altered over the following years until the leisure park was established in the 1970s. The 1971 OS map (not reproduced), shows an electricity substation constructed in the south-east corner of PDA B (NGR TA 20239 49185). Situated on the west side of Cliff Road, close to the west end of Nutana Avenue.

4.0 AIMS AND OBJECTIVES

4.1 The aim of the geophysical survey was to map and record potential buried features located within PDA B. Through analysis of the results, NAA aimed to provide a detailed interpretation to enable an assessment of archaeological potential and inform future mitigation strategies.

4.2 The objectives of the survey were to:

- undertake a geophysical survey across areas deemed suitable for data collection;
- attempt to identify and record any sub-surface remains within the survey boundary;
- characterise the nature of identified anomalies, and where possible suggest the nature of feature they potentially relate to;
- assess the archaeological significance of identified anomalies;
- identify possible concentrations of past activity in order to inform the requirement for any further archaeological investigation at the site; and
- produce a detailed report that includes illustrated results of the geophysical survey.

5.0 METHODOLOGY

5.1 The geophysical survey was undertaken as a gradiometer survey using the Bartington Grad601-2 dual magnetic gradiometer system with data logger. The readings were recorded at a resolution of 0.01nT and data was collected with a traverse interval of 1m and a sample interval of 0.25m. All recorded survey data was collected with reference to a site survey grid comprised of individual 30m x 30m squares. The grid was established using Real Time Kinematic (RTK) differential GPS equipment and marked out using non-metallic survey markers. All grid nodes were set out with a positional

accuracy of at least 0.1m as per current guidelines (ClfA 2014, Schmidt *et al.* 2015) and could be relocated on the ground by a third party. The base lines used to create the survey grids are shown on Figure 3 and further details are available in Appendix A.

- 5.2 The processing was undertaken using Geoplot 3.0 software and consisted of standard processing procedures. Details of processing steps applied to collected data are given in Appendix B.
- 5.3 On the greyscale plot (Figs. 6 and 8), positive readings are shown as increasingly darker areas and negative readings are shown as increasingly lighter areas. The XY-trace plot demonstrates the readings as offsets from a central line (Fig. 8).
- 5.4 Interpretation of identified anomalies is generally achieved through analysis of anomaly patterning and increases in magnetic response and is often aided through examining supporting information (including, but not limited to, historic maps, LiDAR survey data, and aerial photographs). The interpreted data uses colour coding to highlight specific readings in the survey area (Fig. 10).
- 5.5 Appendix C details the terminology and characterisation of anomalies used for interpreting data.

Surface conditions and other mitigating factors

- 5.6 PDA B is a linear block of land to the south of the existing Leisure Park. Orientated east to west, it is divided into two fields; Field A to the east and Field B to the west (Fig. 3). At the time of survey both fields contained low-lying pasture but Google Earth aerial photographic imagery shows the area has been ploughed fairly recently.
- 5.7 Areas along the perimeter of the site contained high vegetation, and so could not be surveyed. Attempts were made to avoid areas affected by above-ground features that were likely to have a high magnetic susceptibility, such as metal fencing and gates, to minimise the potential for their magnetic responses to impinge on the survey results and mask potential buried features.

6.0 RESULTS

Field A

- 6.1 Several amorphous anomalies were identified in the middle of Field A of an unknown

origin (**A1**). These anomalies do not correspond with features recorded on either historic maps or modern aerial photographs and are composed of incomplete patterning and variable increases in magnetic response. Consequently, it is not possible to ascertain whether they denote infilled features, modern activity or belong to geological or pedological changes in the sub-strata.

- 6.2 During the second half of the 20th century an electricity substation is recorded on Ordnance Survey maps in the south-west corner of Field A. It is probable that the bipolar anomaly (**A2**) in the south-east of the field is related to this modern activity.
- 6.3 There is an area of magnetic disturbance in the north of Field A that is considered likely to be caused by geological or pedological changes in the substrata. Several trends have been identified within areas of the geological disturbance that may be suggestive of infilled features, but interpretation is very tentative, and it is equally plausible that they are instead caused by natural deposits with linear forms.

Field B

- 6.4 A fragmented series of linear anomalies (**B1**) run on a north-west to south-east orientation that correspond with the location of a stream, shown on the 1809 Enclosure map (Fig. 6).
- 6.5 Several linear and curvilinear anomalies (**B2 – B3**) have been identified within the centre of Field B. **B2** forms a linear anomaly that runs on a north-northeast to south-southwest orientation, **B3** possibly has a curvilinear form and in part runs parallel to the west of **B2**, and **B4** run on a north-south orientation to the east of **B2**. It is considered plausible that these anomalies denote infilled features relating to former human activity, such as ditches. However, given the inconsistent increases in magnetic values of these anomalies, their fragmented form, and nearby magnetic disturbance, it is uncertain if they are all part of the same phase of activity.
- 6.6 A curvilinear anomaly was identified in the west of Field B that has a large amorphous anomaly in its centre (**B5a**). Although tentative, it is plausible that these anomalies relate to the same activity and are indicative of a feature with an outer curvilinear ditch and either a large pit or area of burning at its centre. Several fragmented linear and rectilinear anomalies (**B5b**) lie to the west of (**B5a**) that possibly also denote infilled features, but poor patterning has resulted in a tentative interpretation.

6.7 A linear trend (**B6**) composed of weak increases in magnetic value has been identified in the centre of Area B that possibly either denotes a former field boundary, or a headland located to its east. A north to south field boundary is recorded on the 1852 OS (not reproduced) in this location, crossing the field north to south.

6.8 Regularly spaced linear anomalies at broad intervals on an east-west alignment in Field B are considered likely to relate to ridge and furrow.

General anomalies across the whole site

6.9 There are numerous weak isolated anomalies with an amorphous form of an unknown origin across the survey area. Those with a coherent patterning or broader form were identified within the interpretation (positive response—unknown origin). Given that several anomalies have been postulated as having an archaeological origin, it is plausible that some of the amorphous anomalies relate to either infilled features, such as pits or areas of burning. Conversely, given the lack of supporting information, conclusive interpretation is difficult, and a tentative interpretation applies, as it is equally plausible that they instead denote modern material in the topsoil, or geological or pedological changes in the substrata.

6.10 There are several weak and diffuse linear trends. These fail to produce the necessary patterning or increases in magnetic response in order to be interpreted fully, and as a consequence, their origin is unknown.

6.11 There are two possible alignments of regularly spaced linear anomalies that are considered likely to relate to agricultural activity. Generally, these anomalies comprise weak increases in magnetic response and so detailed interpretation is uncertain. Although tentative, it is possible that narrowly spaced anomalies on an east-west orientation belong to modern ploughing, whilst anomalies with a broader spacing on a north-south orientation denote land drains

6.12 Several isolated bipolar responses have been identified. These are considered to be modern and caused by highly magnetic material, such as ferrous objects.

6.13 Dipolar anomalies are often likely to relate to ferrous or modern objects buried in the topsoil and so have not been identified in the interpretation plots.

- 6.14 High concentrations of dipolar anomalies, likely to be caused by modern magnetic debris in the topsoil, have been distinguished as 'Areas of Increased Magnetic Response'. Strong responses caused by above-ground features external to the survey area, such as metal fencing and gates, have been characterised as external interference.
- 6.15 There is a high level of magnetic disturbance across the site that is considered likely to relate to geological or pedological changes in the substrata. Broad responses displaying an amorphous form with clear increases in magnetic value were identified. However, their interpretation is tentative, especially where their patterning corresponds with the orientation of agricultural activity, or they have a more coherent linear or rectilinear forms. In these instances, it is possible that anomalies are instead either related to agricultural activity or infilled features.

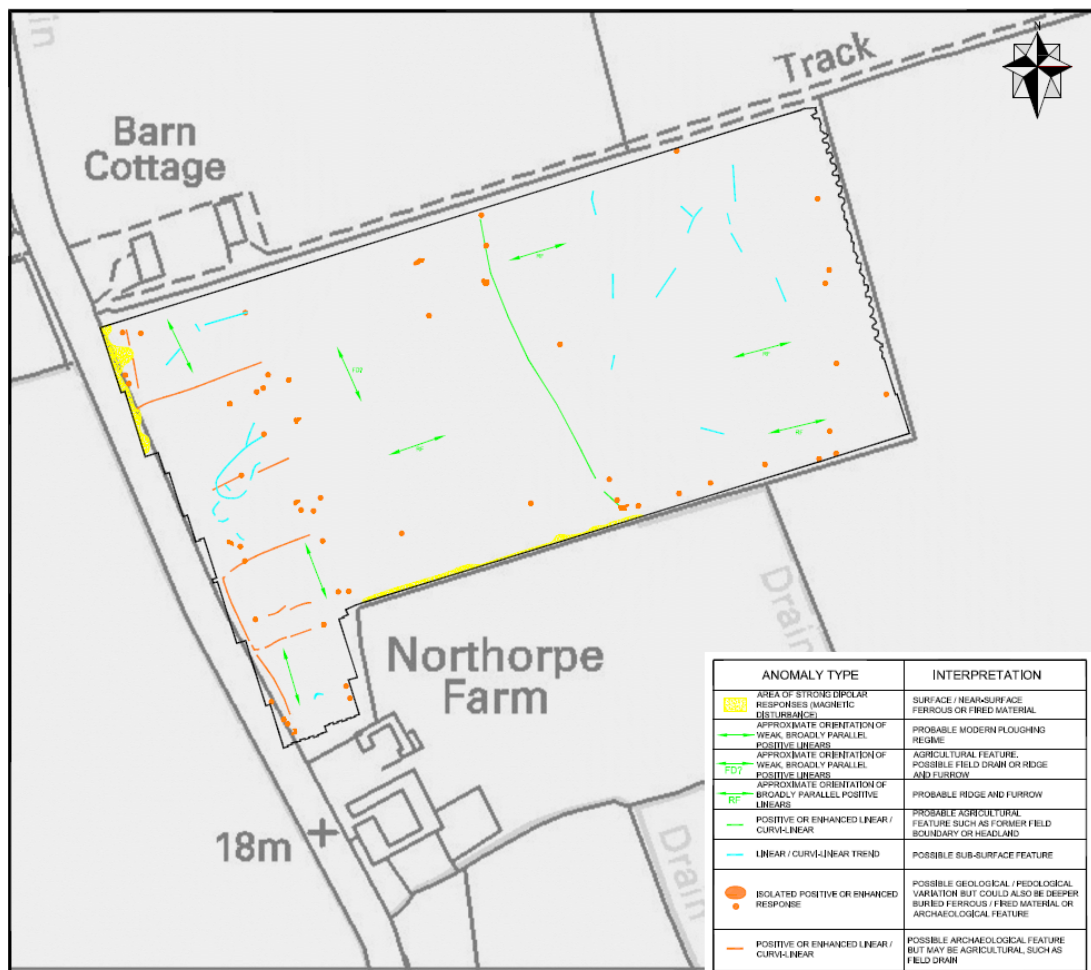


Figure 11: interpretative results from 2013 geophysical survey of PDA A.

Results of the earlier geophysical survey of PDA A

- 6.16 The earlier geophysical survey was commissioned by NAA from Phase Site

Investigations Ltd. It was conducted using a combination of a Bartington Grad601-02 magnetic gradiometer and magnetometer array cart system (MACS). Data for the Bartington component was collected at 1 m by 0.25 m intervals over a series of 30 m grids (Phase 2013 ARC/929/341).

- 6.17 The results of the survey showed a high level of disturbance across PDA A, leading to rather inconclusive results (Fig. 8). A number of trends were present but were weak or irregular. It is possible that the linear anomalies and trends observed relate to buried infilled archaeological features associated with the medieval hamlet of Northorpe (Fig. 11). Notably, the linear responses conform with the garth plots shown on the 1809 Enclosure map. However, given their fragmented form and the modern activity in this area, it is equally plausible that they are either of a modern or agricultural nature.
- 6.18 The results also identified several isolated bipolar and dipolar anomalies that are likely to relate to modern activity and ferrous materials in the topsoil.

7.0 DISCUSSION

- 7.1 Generally, the results across PDA B contain a high level of magnetic disturbance including broad amorphous anomalies, which is plausibly caused by geological or pedological changes within the substrata.
- 7.2 Several amorphous anomalies were identified in Field A, to the south-east of the current leisure park. A lack of supporting information coupled with inconsistent increases in magnetic values and poor patterning, has meant that the origin of these anomalies is uncertain, and it is not possible to ascertain if they denote buried archaeological features, modern activity or geological or pedological changes in the substrata.
- 7.3 The results in Field B to the south-west of the park were slightly more coherent, and several linear and curvilinear anomalies have been identified that potentially relate to infilled features associated with former phases of human habitation. A stream present on the 1809 Enclosure map appears as a well-formed linear anomaly running through the centre of the field. Further linear, curvilinear and amorphous anomalies were identified, but lacked the necessary shape and increases in magnetic values for detailed interpretation. Although tentative, the series of linear anomalies within the centre of the field might relate to ditches associated with a continuation of the Bronze Age field system observed within the scheduled area to the south. The two curvilinear anomalies

(**B3**, **B5a**) are of particular interest in this respect and may be indicative of ring ditches or gullies. Notably, the ridge and furrow appears to run over both features. Given the width of the lands, and their curve, the cultivation is likely to be medieval in date. This would indicate that the anomalies identified during the survey are likely to pre-date the 11th century. However, it should be noted that this interpretation is very tentative and further investigation is required to confirm these postulations.

7.4 Other linear anomalies, as well as trends, were identified, but were composed of weak increases in magnetic response or poor patterning. Consequently, their origin is unknown, and it is uncertain if they are of an archaeological nature or are related to agricultural or modern activity.

7.5 Several linear anomalies were identified within the survey results that are interpreted as being of an agricultural nature such as a possible field boundary or headland (**B6**), and ridge and furrow in Field B. Narrowly spaced linear anomalies were also identified in Field A that possibly related to modern ploughing, as well as broader spaced anomalies that potentially were related to land drains.

7.6 The results of the survey in PDA A were less conclusive, although several positive linear anomalies were identified on the west of the site, adjacent to the Atwick Road. These were relatively strong and are possibly evidence of infilled ditches associated with medieval settlement of Northorpe.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 The geophysical survey in PDA B has identified a low to moderate potential for the presence of archaeology on the south-east side of the site (Field A) and a moderate potential on the south-west side (Field B). The date and nature of these features remain unknown, but based tentatively on their form, and that they appears to lie beneath the medieval ridge and furrow, it is considered they are likely to be prehistoric in origin. This accords with the cropmark evidence of a possible Bronze Age field system observed in the adjacent field to the south (Figs. 4 and 9). Such material is likely to be of high to low significance depending on the nature, form and preservation of the archaeological remains.

8.2 There is little to suggest that any features relating directly to the Neolithic henge monument continue north into PDA B, although this cannot be confirmed without

further archaeological investigation.

- 8.3 Further evidence of prehistoric activity may also be masked by the medieval ridge and furrow recorded on the west side of the site. Earlier ploughing can result in a considerable build-up of redeposited soil serving to preserve archaeological material beneath, although there may be a degree of truncation. The survey did identify anomalies beneath the cultivation (e.g. B3 and B5a-b) but the presence of further evidence cannot be ruled out.
- 8.4 The geophysical survey in area PDA A was less conclusive but appeared to show no evidence of the prehistoric field system continuing north beyond the present leisure park. Similarly, no evidence of prehistoric activity was identified during the 2015 excavations, although these were very limited in scope.
- 8.5 In the western part of the site, a number of linear anomalies have been interpreted as possibly in-filled ditches relating to the hamlet of Northorpe. Excavation confirmed the presence of several ditches or gullies, interpreted as boundary features associated with one or more plots or garths at the northern end of the settlement. Pottery from these features dated from the 12th through to the 14th century. As such, there is a high potential for the survival of archaeological deposits and features relating to the medieval period on the west site of PDA A. This material is considered to be of moderate to low significance depending on the nature, form and preservation of the archaeological remains.
- 8.6 Based on the results of the geophysical survey it is likely that HAP and Historic England will require a phase of archaeological trial trenching to ascertain the nature, form, date and preservation of any potential archaeological remains across the PDA. The requirement is likely to comprise:
- Targeted trial trenching of the anomalies identified in PDA B, suitable to inform an understanding of the archaeology but not compromise future investigation or preservation in-situ, as warranted.
 - Targeted trial trenching, as above, of the anomalies identified on the west side of PDA A. Given that there has already been a degree of excavation in this area only limited trenching would be required to establishing the extent of the surviving archaeology and any variation in preservation across this side of the PDA.

- A percentage sample across the site to determine the presence or absence of archaeological remains and, where present their nature, date, form and preservation. In particular, the area of medieval ridge and furrow on the west side of PDA B should be evaluated to determine the potential survival of prehistoric material beneath the later cultivation.
- 8.7 Currently plans for the expansion works are in the early stages, predicated on the results of initial assessments. Therefore, a phased approach to the trial trenching is recommended for consideration. This would begin with trenching in Field B in PDA B, after which discussion would be held with all parties. Then moving on to Field A and finally PDA A, as required. This might be sequentially, as part of the same episode of fieldwork, or in separate stages. In this way the viability of the development can be evaluated with limited risk to the client and the archaeology. The proposed development is for the erection of a series of temporary dwellings (static caravans) across both areas, with potential ground impacts arising from levelling, the laying of hard standing, installation of roads, services, foul drainage, SUDS and landscaping.
- 8.8 The results of the trial trenching will be used to inform an assessment of significance and Heritage Impact Assessment (HIA). The latter will consider any potential risks to significance, or setting, arising from the planned expansion of the leisure park, and in discussion with HAP and Historic England propose an appropriate mitigation strategy.

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APPENDIX A

TECHNICAL INFORMATION

GRADIOMETER SURVEY

Magnetic surveys measure distortions in the earth's magnetic field caused by small magnetic fields associated with buried features (Gaffney and Gater 2003, 36) that have either remanent or induced magnetic properties (Aspinal *et al.* 2008, 21–26). Human activity and inhabitation often alters the magnetic properties of materials (Aspinal *et al.* 2008, 21) resulting in the ability for numerous archaeological features to be detected through magnetic surveys. Intensive burning or heating can result in materials attaining a thermoremanent magnetisation; examples of which include kilns, ovens, heaths and brick structures (Aspinal *et al.* 2008, 27; Gaffney and Gater 2003, 37). When topsoil rich with iron oxides, fills a man-made depression in the subsoil, it creates an infilled feature, such as a pit or ditch, with a higher magnetic susceptibility compared to the surrounding soil (Aspinal *et al.* 2008, 37–41; Gaffney and Gater 2003, 22–26). Magnetic surveys can also detect features with a lower magnetic susceptibility than the surrounding soil, an example of which is a stone wall.

LIMITATIONS

Poor results can be due to several factors including short lived archaeological occupation/use or sites with minimal cut or built features. Results can also be limited in areas with soils naturally deficient in iron compounds or in areas with soils overlying naturally magnetic geology, which will produce strong responses masking archaeological features.

Overlying layers, such as demolition rubble or layers of made ground, can hide any earlier archaeological features. The presence of above ground structures and underground services containing ferrous material can distort or mask nearby features.

Particularly uneven or steep ground can increase the processing required, or distort results beyond the capabilities of processing. It is also possible in areas containing dramatic topographical changes that natural weathering, such as hillwash, often in combination with intensive modern ploughing, will reduced the topsoil on slopes and towards the peaks of hills and possibly destroy or truncate potential archaeological features. Conversely features at the bottom of slopes may be covered by a greater layer of topsoil, and so if buried features are present, they appear faint within the results, if at all.

Over processing of data can also obscure or remove features, especially if there are on the same orientation as the direction of data collection. Consequently, where possible, attempts are made to ensure data is not collected on the same orientation as known potential features and that data quality is sufficient to minimise the required data processing.

INSTRUMENTATION

The data was collected using handheld Bartington Grad 601-2 fluxgate gradiometers. The Bartington 601-2 is a single axis, vertical component fluxgate gradiometer comprising a data logger battery cassette and two sensors. The sensors are Grad-01-1000L cylindrical gradiometer sensors mounted on a rigid carrying frame; each sensor contains two fluxgate magnetometers with 1m vertical separation.

The difference in the magnetic field between the two fluxgates in each sensor is measured in nanoTesla (nT). NAA gradiometer data is recorded with a range of ± 100 nT, which equates to a resolution of 0.01nT. It should be noted that the actual resolution is limited to 0.03nT as a consequence of internal instrumental noise (Bartington Instruments Ltd n.d., 23). The gradiometer records two lines of data on each traverse, the grids are walked in a zig-zag pattern amounting to 15 traverses. The gradiometers are calibrated at the start of every day and recalibrated whenever necessary.

SURVEY DETAILS

Table A1: Survey summary

	Survey
Grid size	30m x 30m
Traverse interval	1m
Reading interval	0.25m
Direction of 1st traverse	N
Number of Grids	208
Area covered	5.79ha
Date(s) of fieldwork	15th and 16th July 2019

Table A2: Baseline co-ordinates (baseline is shown on Fig. 3)

Grid point (gp) A	Grid point (gp) B
NGR: 519899.1453 449136.8517	NGR: 519959.1453 449136.8517

Table A3: Site information and conditions

Item	Detail
Geology	Rowe Chalk Formation
Superficial deposits	Majority: Devensian till Devensian till
Soils	Holderness Association
Topography	Highest: 16m aOD Lowest: 17m aOD
Land use / condition	Pasture
Weather / conditions prior to and during survey	Sunny

APPENDIX B

DATA PROCESSING INFORMATION

Gradiometer survey data is downloaded using the Bartington Grad 601 software and the processing was undertaken using Geoplot 3.0 software.

Table B1: Commonly applied techniques

Process	Effect
Zero mean traverse	Removes stripping which can occur as a consequence of using multi sensor arrays or a 'zigzag' data collection method by setting the mean reading for each traverse to zero.
Destagger	Removes stagger in the data introduced through inconsistency data collection pace and often exacerbated through the 'zig-zag' methodology.
Clip	Clips data above or below a set value to potentially enhance potential weaker anomalies.
Despike	Removes random spikes or high readings to reduce the appearance of dominant readings, often created by modern ferrous objects that can distort the results.
Low pass filter	Removes low frequency waves or broad anomalies such as those caused by strong or large gradual variations in the soil's magnetic susceptibility often caused by geological or natural changes in the substrata.
Interpolation	Used to smooth or reduce the blocky appearance of data by improving the spatial density and balance the quantity of data points in the X and Y directions.

Table B2: Processing steps

Minimal Processing	Increased Processing
<ul style="list-style-type: none"> • Zero mean traverse +5/-5 • Destagger: <p>Area A</p> <ul style="list-style-type: none"> - All grids; 1 <p>Area B</p> <ul style="list-style-type: none"> - Grid 7: -1 - Grids, 8, 10, 13, 14, 15, 16, 19, 20, 21, 22, 26, 27, 28, 32, 35, 38, 40, 41, 45, 46, 47, 48, 51, 52, 53, 54, 57, 58, 59, 64, 65 and 66: 1 - Grids 1, 33, 34, 39, 60: 2 - Grids 14, 2 and 22: -1 - Grid 2 and 9: 3 	<ul style="list-style-type: none"> • Low Pass Filter • Interpolate Y, Expand - Linear, x2

APPENDIX C

DATA VISUALISATION INFORMATION

FIGURES

The data was used to produce a series of images to demonstrate the results of surveys these are detailed below:

- Greyscale/Colourscale Plot: this visualised the results as a shaded drawing with highest readings showing as black, running through different shades to lowest showing as white.
- XY-trace Plot: this creates a line drawing showing the peaks and troughs of the readings as vertical offset from a centreline.
- Interpreted Plot: through detailed analysis, anomalies have been interpreted and possible features identified. Interpretation drawings are used to show potential features and in particular to reinforce and clarify the written interpretation of the data. Anomalies have been characterised using the terminology detailed in the following section, and have been assigned colour coding outlined in keys found on the relevant figures associated with this report.

MAGNETIC ANOMALIES AND TERMINOLOGY

Table C1: Lexicon of terminology

Terminology	Detail
Anomaly	Any outstanding high or low readings forming a particular shape or covering a specific area with the survey results.
Feature	A man-made or naturally created object or material that has been detected through investigation works and has sufficient characteristics or supporting evidence for positive identification.
Magnetic susceptibility	The ability of a buried feature to be magnetically induced when a magnetic field is applied
Magnetic response	<p>The strength of the changes in magnetic values caused by a buried feature with either a greater or lesser ability to be magnetised compared with the soil around it.</p> <p>Anomalies are considered to either have strong / weak or positive / negative responses.</p> <p>The strength of magnetic response (along with patterning) can be essential in determining the nature of an anomaly, but it should be noted that the size or strength of the magnetic response does not correlate with the size of the buried feature.</p>
Patterning of an anomaly	The shape or form of an individual anomaly
Thermoremanence	The affect caused when a material has been magnetically altered through a process of heating. Thermoremanent magnetisation occurs when an object or material is heated passed the Curie Point and acquires a permanent magnetisation that is associated with the magnetic field that they cooled within (Gaffney and Gater 2003:37)

Different anomalies can represent different features created by human, agricultural or modern activity, or natural pedological or geological changes in the substrata.

Anomalies interpreted with a 'greater' categorisation are considered more likely to be of the interpreted characterisation; whereas a more tentative interpretation is applied to those with a 'lesser' categorisation as a consequence of weaker increases in magnetic response or the anomalies incomplete patterning or irregular form.

The strength and size of anomalies can vary depending on the magnetic properties of the feature, the magnetic susceptibility of the soil, the depth to which the feature is buried, and the state of preservation.

Table C2: Characterisation of anomalies

Characterisation	Detail
Archaeology	
Linear anomaly	<p>Linear anomalies with a positive or negative magnetic responses, and composed of a patterning or shape that is suggestive of a buried archaeological feature. These are often indicative of structural remains or infilled features such as ditches.</p> <p>The strength of anomaly signal can be suggestive of the properties of the feature. Negative linear anomalies represent upstanding or infilled features that are less magnetically susceptible than background readings, for example structures or ditches composed of a non-igneous stone material. Bipolar linear anomalies considered to be of an archaeological nature are indicative of material with a high magnetic susceptibility, such as a brick wall.</p>
Unknown	
Positive amorphous response	<p>Isolated anomalies or anomalies with an amorphous form.</p> <p>Unless associated with conclusively identified archaeological remains, such as linear anomalies, absolute identification of positive responses can be problematic as it is often not possible to decipher if they are of an archaeological, modern or agricultural origin. Consequently, isolated positive responses are not shown within the interpretation unless composed of a broad form or belonging to a series of isolated positive responses.</p>
Trends	<p>Weak and diffuse anomalies with an uncertain origin are denoted by trends. It is possible that these belong to archaeological features, but given their weak signatures or incomplete patterning it is equally plausible that they relate to agricultural features or natural soil formations.</p>
Agriculture	
Field boundary	<p>Isolated linear anomalies that are likely to be indicative of former land divisions. A more conclusive interpretation is given to linear anomalies that correspond with the location of field boundaries recorded on historic maps, Aerial photos or LiDAR coverage of the site.</p>
Ridge and furrow?	<p>Broadly spaced linear anomalies that are possibly indicative of earlier forms of agriculture, such as ridge and furrow. These often correspond with the location of earthworks visible on the ground or identified on aerial photos or LiDAR survey coverage.</p>

Characterisation	Detail
Agriculture?	Regularly spaced linear anomalies that are likely to be of an agricultural nature. However, the lack of supporting information, weak responses, or non-uniform distribution means that it is unclear as to the nature or origin of the agricultural process they are caused by.
Modern	
Bipolar response (modern)	Positive anomalies with associated negative 'halo' (bipolar) denote features with a strong magnetic response are likely to be of a modern origin. Isolated bipolar responses of a modern nature are likely to relate to buried ferrous material or objects, such as metallic agricultural debris. If a trend is noted in the alignment or spacing of isolated bipolar responses, it is possible that they are indicative of ferrous fittings or connectors used on buried non-magnetic buried utilities.
Area of increased magnetic response	Areas of increased magnetic response denote areas of disturbance containing a high concentration of dipolar and / or bipolar responses. These are generally considered to be caused by modern debris in the top soil, although it is possible that the disturbance is in part also caused by isolated archaeological material or geological or pedological changes in the substrata.
External interference	Areas of magnetic disturbance, often along the edges of survey areas are caused by standing metal structures such as fencing and buildings.

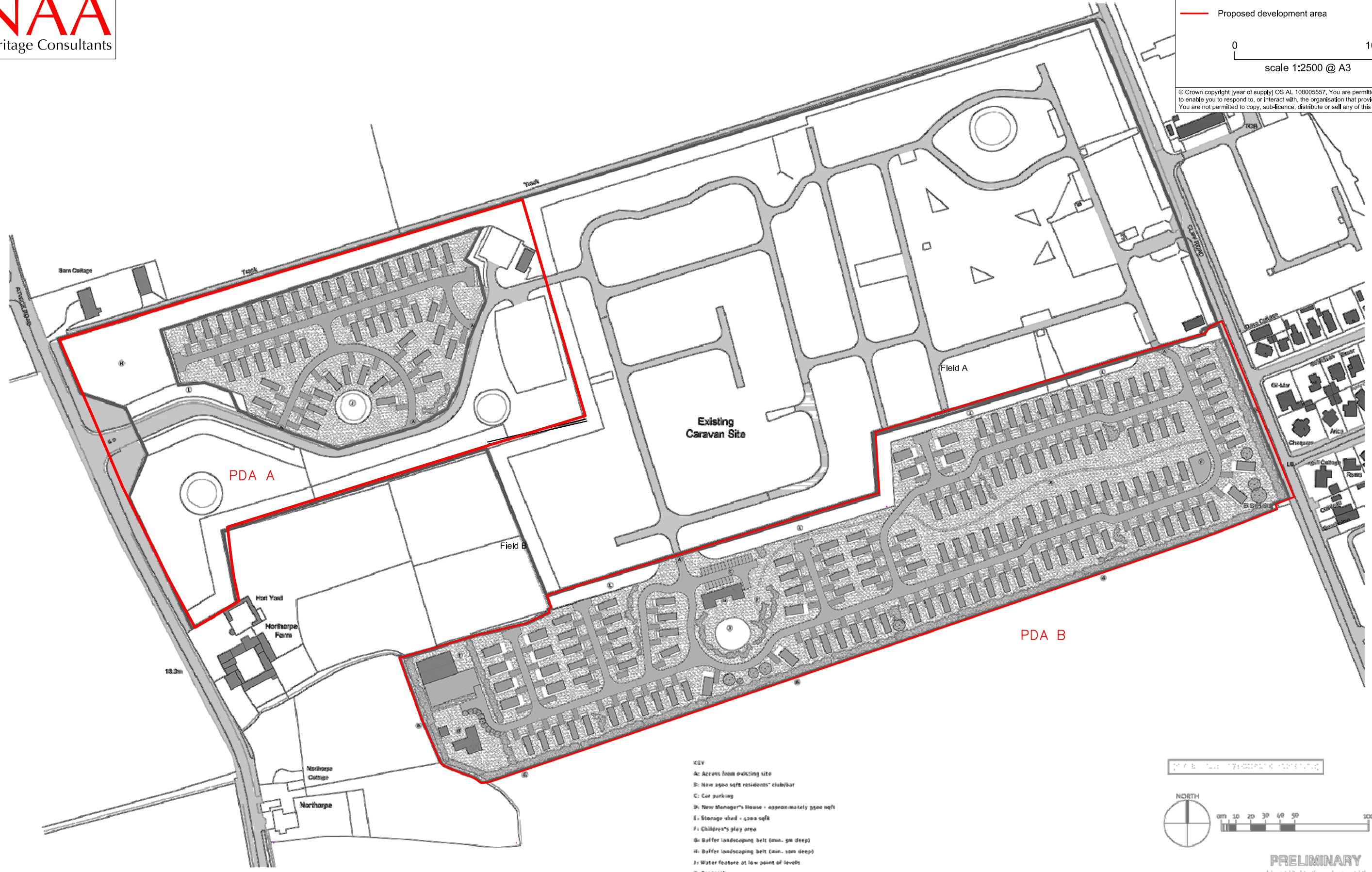
KEY

— Proposed development area

0 100 m

scale 1:2500 @ A3

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- KEY**
- A: Access from existing site
 - B: New 2500 sqft residents' club/bar
 - C: Car parking
 - D: New Manager's House - approximately 3500 sqft
 - E: Storage shed - 4200 sqft
 - F: Children's play area
 - G: Buffer landscaping belt (min. 3m deep)
 - H: Buffer landscaping belt (min. 35m deep)
 - J: Water feature at low point of levels
 - K: Footpath
 - L: Existing tree belt to remain

0 10 20 30 40 50 100

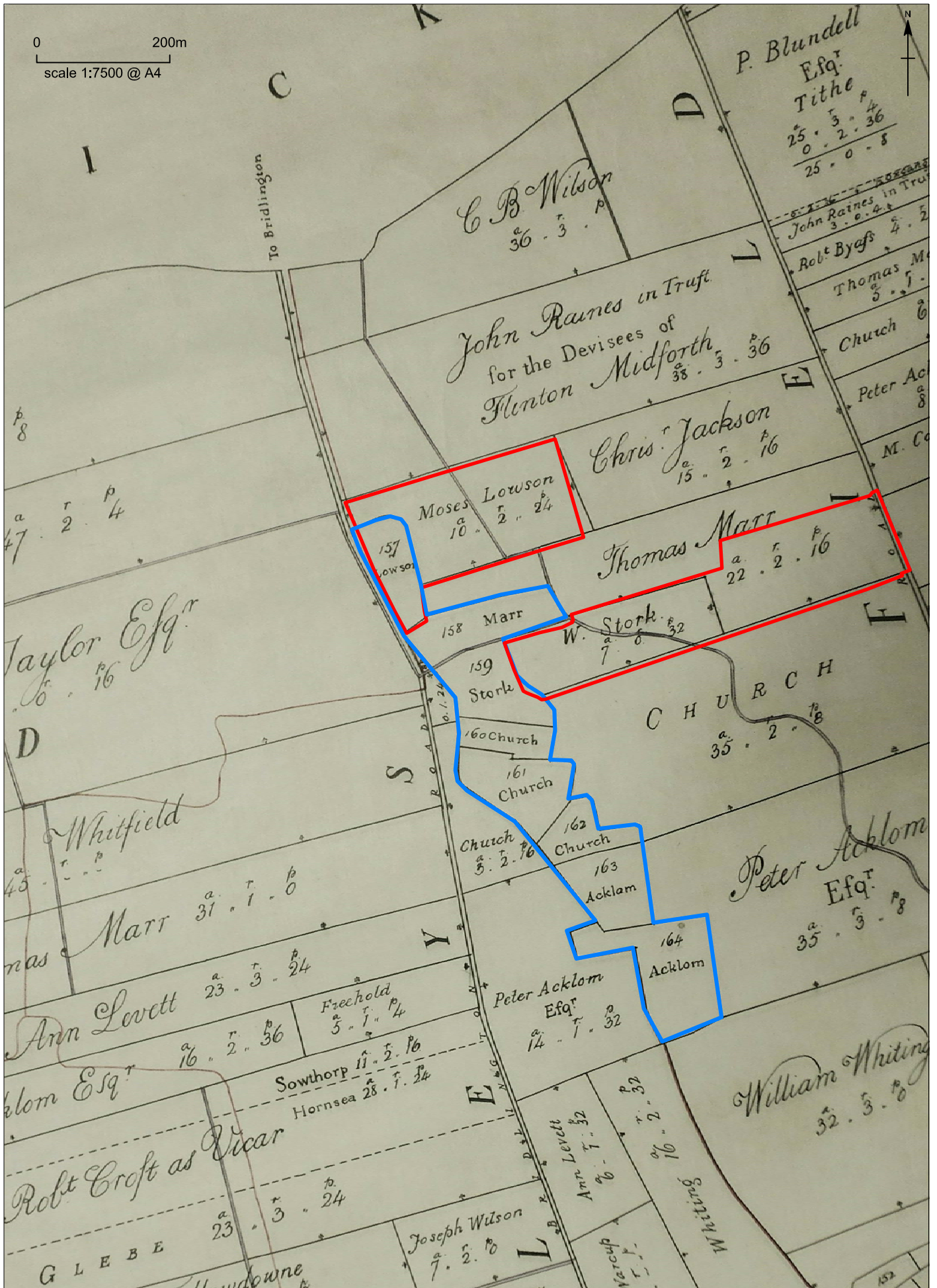
NORTH

PRELIMINARY
PLAN OF DEVELOPMENT

Rev.	Description	By	Date

Hornsea Leisure Park, Hornsea, East Riding of Yorkshire: locations of proposed development areas





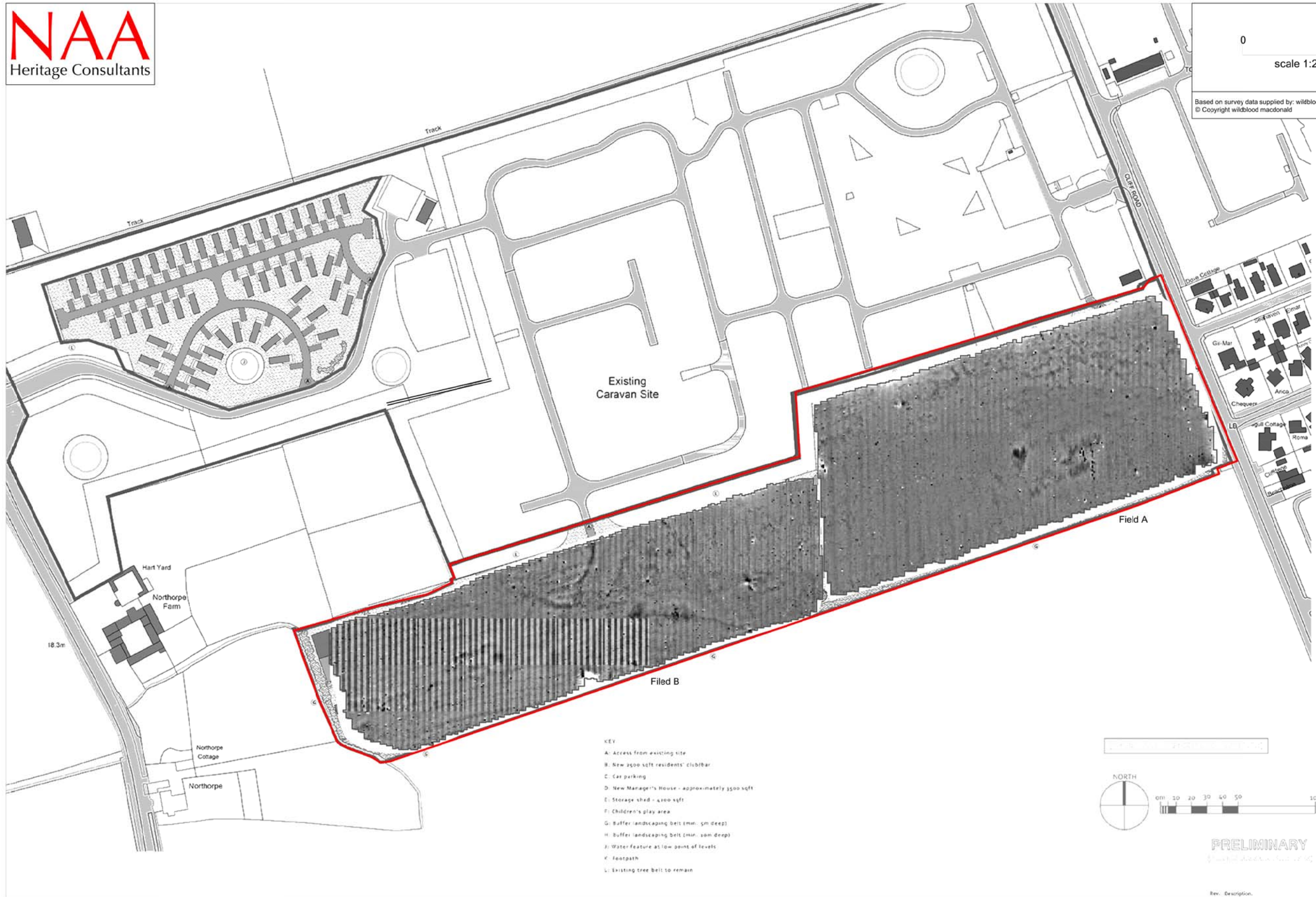
Hornsea Leisure Park: 1809 Enclosure map with village plots marked in blue

Figure 6

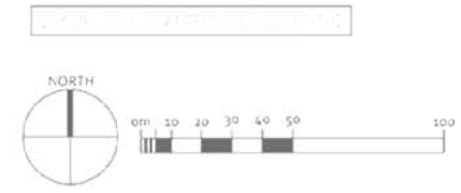
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Based on survey data supplied by: wildblood macdonald ref: 2587 (SK)12 survey date: February 2019
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9nT
-10nT
Palette: grey55.pt

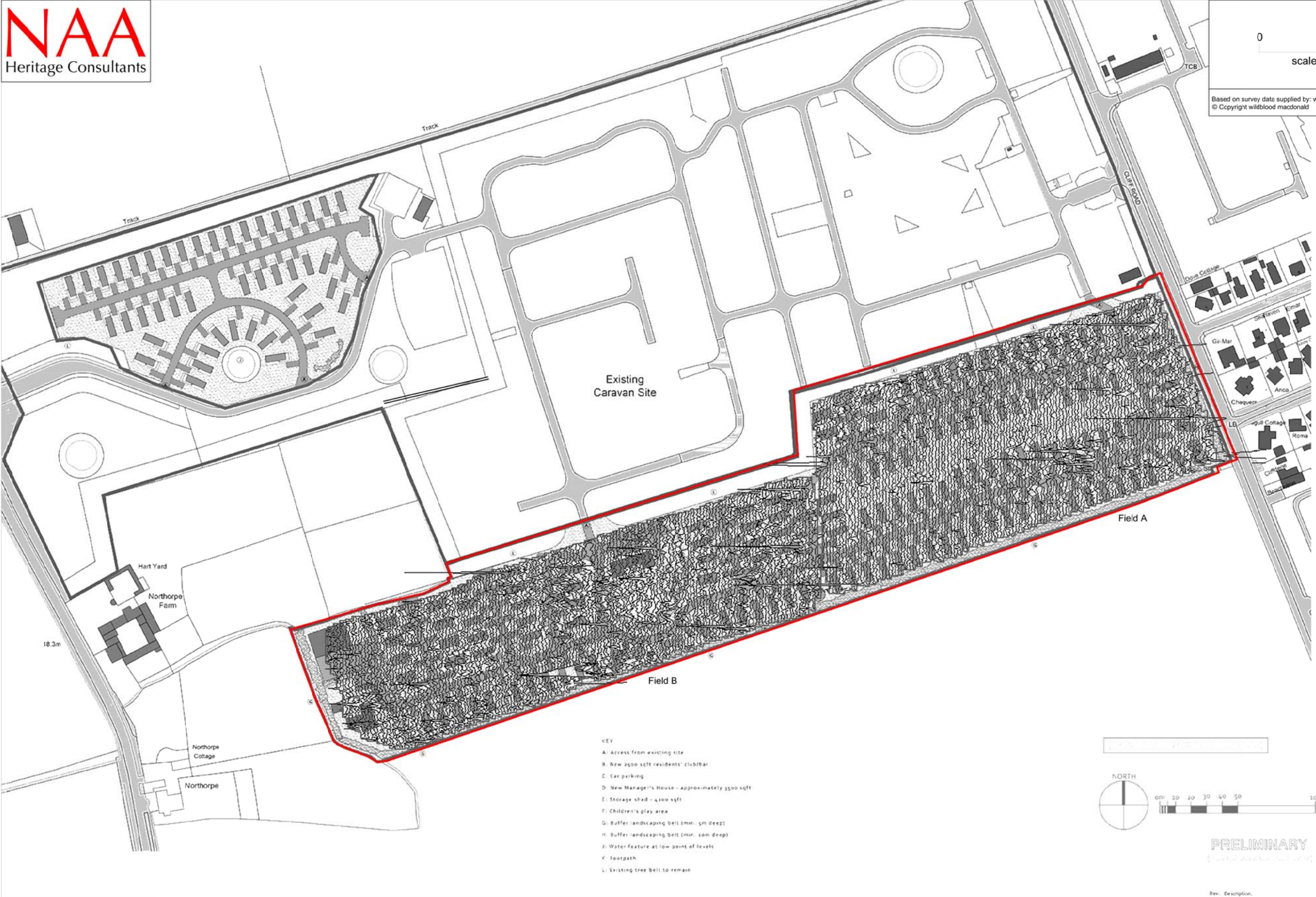


- KEY
- A: Access from existing site
 - B: New 2500 sqft residents' club/bar
 - C: Car parking
 - D: New Manager's House - approximately 3500 sqft
 - E: Storage shed - 400 sqft
 - F: Children's play area
 - G: Buffer/landscaping belt (min. 5m deep)
 - H: Buffer/landscaping belt (min. 30m deep)
 - J: Water feature at low point of levels
 - K: Footpath
 - L: Existing tree belt to remain

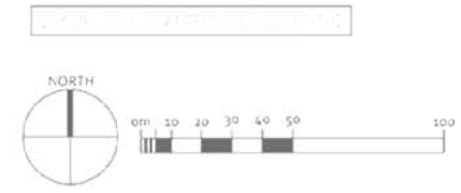


PRELIMINARY

Rev.	Description	By	Date
	Drawing Title		Scale @ size
	Sketch layout/Pre app		1:1250 @ A3
	Job No.	Dwg No.	Revision
	2587	(SK)12	
Date drawn	Status	Drawn by	Checked
Feb 2019	Sketch	KL	MB



- KEY
- A: Access from existing site
 - B: New 2500 sqft residents' club/bar
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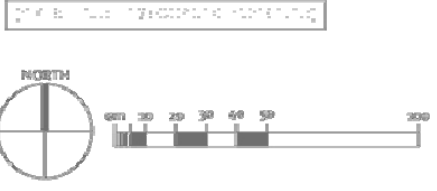
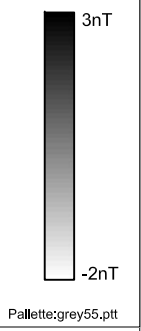


PRELIMINARY

Client	Shorewood Leisure Group	Rev. Description	By. Date
Project	Leisure development at Land at Hornsea Leisure Park	Drawing Title	Scale @ size
		Job No. Dwg No.	Revision
		2587 (SK)12	
Date drawn	Status	Drawn by	Checked
Feb 2019	Sketch	KL	MB



Based on survey data supplied by: wilblood macdonald ref: 2587 (SK)12 survey date: February 2019
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PRELIMINARY
(Subject to change)

Client	Site Description	Site Status
Sherwood Leisure Group	Sketch layout/Pre app	Site @ the time of survey
Project	Job No.	Project
Leisure development at Land at Hornsea Leisure Park	2587 (SK)12	2587
Work done	Date	Checked by
Feb 2019	Sketch	NL MB

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wilblood-macdonald.com

Based on geophysical survey data supplied by: Phase Site Investigations ref: ARC_929_341_01 survey date: 01/2013 © Copyright ***origiator***

AP by Historic England's Aerial Reconnaissance team

Hornsea Leisure Park, Hornsea, East Riding of Yorkshire: combined processed greyscale plots of gradiometer survey results and rectified image of cropmarks

