highways england

A303 Stonehenge
Amesbury to Berwick Down

Written Scheme of Investigation for Archaeological Geophysical Survey

Phase 1

November 2016

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Foreword

This document comprises a Written Scheme of Investigation (WSI) outlining the initial strategy and methodology by which Wessex Archaeology will implement the programme of geophysical works over eight survey areas in association with the A303 from Amesbury to Berwick Down improvement scheme. The work was commissioned by Arup Atkins Joint Venture, on behalf of Highways England, to inform the PCF Stage 2 Options Assessment Phase for the A303 improvement scheme.

1 Introduction

1.1 Project background

1.1.1 Wessex Archaeology has been commissioned by Arup Atkins Joint Venture (AAJV), to carry out geophysical surveys over eight survey areas along the route of the A303 (hereafter "the Scheme") (**Figure 1**). The surveys form part of an ongoing programme of archaeological works being undertaken along the A303 from Amesbury to Berwick Down to inform the PCF Stage 2 Options Assessment Phase for the A303 improvement scheme.

1.2 Scope of Document

1.2.1 This specification sets out the initial strategy and methodology by which Wessex Archaeology will implement the programme of geophysical works. This specification is designed following the project requirements as provided in Archaeological Geophysical Survey Design Brief [1].

1.2.2 In format and content this document conforms with current best practice and to the guidance outlined by the following:

- *Management of Research Projects in the Historic Environment* [2];
- *Standards and guidance for archaeological geophysical survey* [3];
- *Historic England's Guidelines Geophysical Survey in Archaeological Field Evaluation* [4]; and
- *Thesauri* [5].

1.2.3 This document will be submitted to and approved by Historic England and the Wiltshire Council Archaeological Service (WCAS) acting on behalf of the Local Planning Authority Wiltshire Council (WC) and to the National Trust Archaeologist (Stonehenge & Avebury WHS relating to National Trust lands) by AAJV prior to fieldwork commencing.

2 Site Description

2.1 Location, topography and geology

2.1.1 The Scheme is located between Amesbury and Berwick Down with the individual survey areas located to the north and south of the A303. The eight survey areas have been provided to Wessex Archaeology as provided in **Table 2-1**.

Table 2-1 Survey areas

Survey Area	OS National Grid Reference	Area (ha)
SW1	SU 10872 41293	45.5
SW2	SU 10159 40708	18.3
SW3	SU 09412 40989	69.2
SW4	SU 06978 40693	22.3
SE1	SU 14214 41855	18.9
NE1	SU 15587 42248	5.1
NE2	SU 14359 42202	43.1
NW4	SU 07387 41087	5.4

SW1	SU 10872 41293	45.5
SW2	SU 10159 40708	18.3
SW3	SU 09412 40989	69.2
SW4	SU 06978 40693	22.3

2.1.2 The bedrock geology of the route is mapped as chalk of the white chalk subgroup formed in the upper cretaceous period with no recorded superficial deposits within the survey areas [6].

2.1.3 The areas to be surveyed are mostly flat high-land, with some gradient changes due to the River Avon, but in general the Scheme falls from approximately 110 m aOD at the western extent down to the eastern extent at 90 m aOD.

2.2 Archaeological and historical background

2.2.1 The archaeological context has been presented in brief within the *Archaeological Geophysical Survey Design Brief* [1] which examined the potential for the survival of buried archaeological remains within the development area and surrounding landscape.

2.2.2 Four of the survey sites are situated within the Stonehenge, Avebury and Associated Sites World Heritage Site (WHS) (SW2 SW1 SE1 and NE2) whilst the remaining four (SW4, NW4, SW3 and NE1) are situated outside of the boundary. All of the survey areas are however located within a landscape containing nationally and regionally important multi-period archaeology. A high density of archaeological features, potentially of national and international significance in terms of their contribution to the Stonehenge, Avebury and Associated Sites World Heritage Site's 'Outstanding Universal Value' (OUV), were identified by the Historic England National Mapping Programme project the Stonehenge World Heritage Site Mapping Project [7] surrounding the current A303 and as such much of the data on known archaeological remains from this area is derived from aerial sources.

2.2.3 The Stonehenge, Avebury and Associated Sites World Heritage Site is internationally important for its complexes of outstanding prehistoric monuments [8]. The 26 square kilometres of the WHS encompasses Stonehenge, Avebury and a range of Neolithic and Bronze Age ceremonial and funerary monuments and associated sites that survive exceptionally well in the surrounding landscape. The area was a focus for ceremonial and funerary activity throughout the Neolithic and Bronze Age and there is a general potential across the Stonehenge WHS for the discovery of previously unrecorded archaeological remains relating to the prehistoric and later activity. Extensive surveys in association with the A303 Stonehenge Improvements have demonstrated the potential for archaeological remains (i.e. [9] [10] [11] [12]).

2.2.4 A brief description of the known archaeological resource within the individual survey sites is given below.

SW1

2.2.5 This area is located within the WHS and contains a number of extant Neolithic and Bronze Age monuments, including eight Scheduled Monuments, all of which are associated with the ceremonial and funerary landscape of prehistoric

monuments that surrounds Stonehenge. This includes the early-Neolithic Wilsford Down Long Barrow, a group of seven Bronze Age bowl barrows and a pond barrow on Wilsford Down, two bowl barrows and a long barrow on Normanton Down and three bowl barrows and a Bronze Age pond barrow containing a deep shaft used as a site for ritual deposition on Normanton Gorse.

2.2.6 Other archaeological features of this area include the fragmentary remains of a field system visible as cropmarks on aerial photographs and other cropmarks including linear features and a large curving ditch. Such features are of unknown date but some are likely to be prehistoric possibly representing agricultural activity within the later prehistoric periods.

SW2

2.2.7 Located in close proximity to SW1 this area is also within the WHS and contains extant Neolithic and Bronze Age monuments. The area contains three Scheduled Monuments including a mostly levelled small Neolithic henge monument, a Bronze Age bowl barrow and part of a linear boundary following the area's north-east boundary that is likely to date from the later Bronze Age or Iron Age. Other archaeological features include the ploughed down remains of prehistoric field systems likely to be related to those present in SW1, ploughed down remains of medieval ridge and furrow earthworks, cropmarks related to 20th century military training and a post-medieval dew pond.

SW3

2.2.8 This area is located outside of the WHS but also contains archaeological remains dating from the Neolithic and Bronze Age that are associated with the ceremonial landscape surrounding Stonehenge. The area contains a single Scheduled Monument, a Bronze Age bowl barrow. A milestone lies on the roadside of the A360 that marks the eastern boundary of the area that is Grade II Listed. Like much of the locality there is evidence in the form of cropmarks for the fragmentary remains of a probably prehistoric or Romano-British field system. There is also evidence for plough levelled medieval ridge and furrow. Cropmarks have also been identified that relate to seven possible ring ditches representing the buried remains of ploughed down Bronze Age barrows.

2.2.9 Other cropmarks have been identified of a possible Romano-British settlement on Oatlands Hill, consisting of a series of ditched enclosures containing compounds pits and ditches set around a linear trackway that continues to the west. Modern archaeological remains are also known in the form of a former World War Two airfield at Oatlands Hill. The airfield contained three airstrips and four hangers. Buried remains of the airfield are likely to be present.

SW4

2.2.10 This area is located outside of the WHS and does not contain any remains related to the prehistoric landscape at Stonehenge. The area consists of a post-medieval field to the west of the village of Winterbourne Stoke. Based on available sources (http://www.heritagegateway.org.uk/gateway/), the area contains no known archaeological remains although there is evidence for prehistoric settlement enclosures (visible as cropmarks) from the hill summit to the immediate north. As such the area may contain related archaeological remains such as the buried infilled ditches of a field system or other settlement remains.

SE1

2.2.11 This area is located within the heart of the WHS and contains extant Neolithic and Bronze Age monuments related to the Stonehenge landscape and is highly likely to contain buried archaeological remains from these periods. The area contains four Scheduled Monuments consisting of five Bronze Age bowl barrows of which three are in a group. The Stonehenge Avenue, a processional way directly associated with the monument passes through the area from north-west to south-east. Various archaeological features are known from cropmark evidence including a possible Neolithic long barrow located to the east of the avenue and at least three ring ditches related to plough levelled Bronze Age barrows. Modern features include a Second World War Type 22 pill box.

NE1

2.2.12 This small area consists of part of a field situated to the north of the town of Amesbury and to the east of Countess Farm. It is located outside of the WHS but is in relatively close proximity to other elements of the prehistoric ceremonial landscape at Stonehenge. Test pitting within the area in 1993 recorded a buried flint scatter thought to relate to Neolithic settlement close to the River Avon, which lies to the south. Other related Neolithic settlement remains may occur within this area. Aside from the flints other archaeological remains have consisted of metal detector find of a Roman harness and nail cleaner.

NE2

2.2.13 This area is also located within the heart of the WHS and contains extant Neolithic and Bronze Age monuments related to the Stonehenge landscape and is highly likely to contain buried archaeological remains from these periods. This area contains eleven Scheduled Monuments all of which are Bronze Age barrows and include sixteen extant monuments some of which are in groups. The area also contains a section of the Stonehenge Avenue which cross the western end of the area. Probable prehistoric cropmark features include an enigmatic three sided ditched feature and nine ring ditches representing plough levelled Bronze Age barrows including a double bell-barrow. Many of the ring ditches form a line cutting across the area from east to west.

2.2.14 The area also contains cropmarks of levelled medieval ridge and furrow earthworks, the cropmark of a former 18th century road from Amesbury to Market Lavington and buried remains (known from cropmarks) of a post-medieval landscaped park that include an avenue and ornamental gardens associated with Amesbury Abbey. Also present are three clumps of trees planted in the 19th century in remembrance of the 1798 Battle of the Nile, several other lie to the south at Park Farm, the clumps representing ships that fought in the battle.

NW4

2.2.15 This area consists of a triangular post-medieval field located to the north-west of the village of Winterbourne Stoke in close proximity to SW4. Based on available sources (http://www.heritagegateway.org.uk/gateway/) the field contains no known archaeological remains although it is located in close proximity to known prehistoric settlement enclosures and to the remains of a plough levelled Bronze Age barrow located in the field to the north. As such there is considered to be a fairly high probability of related remains occurring within this area. A Grade II Listed milestone is located on the roadside of the A303 on the southern boundary of this area.

3 Aims and objectives

3.1 Project Aims and Objectives

3.1.1 With due regard to the Chartered Institute for Archaeologist's *Standard and guidance for archaeological geophysical survey* [3], the principle aim of an archaeological geophysical survey is to determine, as far as is reasonably possible, the nature of the detectable archaeological resource within a specified area using appropriate methods and practices, and in compliance with the *Code of Conduct* and other relevant by-laws of the CIfA.

3.1.2 The aim of this archaeological investigation is to gather information to inform the design proposals and wider environmental disciplines for the selection of the final route options.

3.1.3 The project specific objectives for this geophysical survey are defined by AAJV as follows:

- To determine the presence/absence of potentially significant archaeology within the WHS and wider proposed assessment corridors;
- Define the extent and character of any features within each survey site; and
- Produce an interpretive report on the findings of the survey to inform the options screening process.

4 Methodology

4.1 Access

4.1.1 The AAJV will make all access arrangements for the works, Wessex Archaeology will not deal directly with any landowners etc. unless instructed to do so by AAJV.

4.1.2 All Section 42 licences and National Trust Research Agreements will be obtained by AAJV and provided to Wessex Archaeology prior to mobilisation.

4.2 Record photographs

4.2.1 Wessex Archaeology will take sufficient dated colour photographs of all areas, including access routes, to provide a record of the original condition, and the condition on completion of all fieldwork.

4.3 Monitoring

4.3.1 Historic England, WCAS and the National Trust Archaeologist (Stonehenge & Avebury WHS within National Trust land) will be notified prior to commencement of work being undertaken by AAJV, unless otherwise agreed.

4.3.2 The work will be monitored by Historic England and/or WCAS and the National Trust Archaeologist (Stonehenge & Avebury WHS within National Trust land). The fieldwork and post-fieldwork will be monitored by Historic England and/or WCAS and the National Trust Archaeologist (Stonehenge & Avebury WHS within National Trust land) and all reasonable access will be provided to the works. Any changes in the agreed Written Scheme of Investigation will be discussed and agreed with Historic England, WCAS and the National Trust Archaeologist (Stonehenge & Avebury WHS within National Trust land) before implementation.

4.4 Survey specification

4.4.1 The navigation display on cart-based system provides real-time positioning enabling full site coverage without the need to set up individual grid nodes across the survey areas. However, in order to ensure survey accuracy, the boundaries of the survey extent will be established using a GPS.

4.4.2 Stakeout data will be prepared in British National Grid coordinates prior to survey using AutoCAD, and survey data will be georeferenced accordingly. Individual survey nodes will be established as grids at 30m x 30 m intervals for the hand-held gradiometer and ground penetrating radar (GPR) surveys, and as site boundaries for the cart-based surveys using a Leica Viva RTK GNSS instrument, which is precise to approximately 0.02 m and therefore exceeds Historic England recommendations [4].

4.4.3 The surveyed areas will be tied into the National Grid using GPS survey equipment to enable the surveyed area to be independently relocated by a third party. A selection of grid points will be re-occupied after the data has been acquired and checked to confirm the accuracy of the stake out location and that no disturbance has occurred.

4.4.4 Digital mapping and archaeological information gathered during previous work will be used to support the interpretation of the geophysical data.

4.4.5 An interpretation of the geophysical anomalies will also be presented identifying likely and possible archaeological features along with linear trends and areas of increased magnetic response.

4.4.6 Further details of the geophysical and survey equipment, methods, processing and interpretation are described in **Appendix A**, **B** and **C**.

4.5 Gradiometer survey specification

4.5.1 The detailed gradiometer survey will be conducted using Bartington Grad-01-1000L gradiometers at 1 m intervals mounted on either a non-magnetic cart or on a hand-held frame with an effective sensitivity of 0.03 nT.

4.5.2 Data will be collected at 0.25 m intervals along transects spaced 1m apart, in accordance with Historic England guidelines [4]. Data will be collected in the zigzag method.

4.5.3 Data from the survey will be subject to minimal data correction processes. These would typically comprise a zero mean traverse function (±5 nT thresholds) to correct for variations in the calibration between the Bartington sensors used, and a de-step function to account for variations in traverse position due to varying ground cover and topography. These two steps are generally applied to all survey areas, with no further filtering or interpolation.

4.5.4 The data will be processed using commercially available and in-house software which allows greyscale and trace plots to be produced. Minimal processing will be applied to the data and typically includes bounded zero mean traverse and destagger functions.

4.6 Ground penetrating radar survey specification

4.6.1 The GPR survey will be conducted using a cart-mounted GPR system consisting principally of a shielded antenna and a control unit. The exact make and model of equipment is to be confirmed.

4.6.2 Data from the GPR survey will be subject to standard processing, typically including gain and wobble correction and navigational verification. Further processing such as migration, Hilbert transformation, band-pass and low-pass filtering may be undertaken where appropriate. Topographic data will be used to correct for the angular offsets caused by the variation in aspect of the terrain along the profile.

4.7 Preliminary schedule

4.7.1 The eight survey areas are anticipated to be subject to detailed gradiometer survey as shown in **Table 4-1**. Details of the GPR surveys will be discussed on receipt of confirmed survey locations.

4.7.2 The fieldwork will be undertaken Monday-Friday, with the usual working day starting at 08.00 and ending at 16.00.

Table 4-1 Preliminary gradiometer schedule

Survey Area	Area (ha)	Anticipated Method	Anticipated Duration	Anticipated Start Date
SW1	45.5	Cart	9 days	6/05/2016
SW2	18.3	Cart	4 days	2/05/2016
SW3	69.2	Cart	14 days	19/05/2016
SW4	22.3	Hand-Held	5 days	2/05/2016
SE1	18.9	Hand-Held	5 days	9/05/2016
NE1	5.1	Hand-Held	3 days	16/05/2016
NE2	43.1	Cart & Hand-Held	5 days	25/04/2016
NW4	5.4	Hand-Held	3 days	16/05/2016

4.7.3 The interpretive report will be submitted three weeks following demobilisation. The final report will be issued within two weeks of receipt of comments.

4.8 Health and Safety

4.8.1 Health and Safety considerations will be of paramount importance in conducting all fieldwork. Safe working practices will override archaeological considerations at all times.

4.8.2 All work will be carried out in accordance with the *Health and Safety at Work etc. Act* 1974 and the *Management of Health and Safety Regulations* 1992, and all other relevant Health and Safety legislation, regulations and codes of practice in force at the time.

4.8.3 Wessex Archaeology will supply a copy of their Health and Safety Policy and a Risk Assessment to AAJV before the commencement of any fieldwork. The Risk

Assessment will have been read and understood by all staff attending the Site before any groundwork commences.

4.8.4 Wessex Archaeology has both public liability (£10,000,000) and professional indemnity insurance (£5,000,000).

4.8.5 The geophysical survey team will be aware of safe working practices, safety equipment, emergency procedures and specific information relating to environmental conditions likely during fieldwork.

4.8.6 A risk of Unexploded Ordnance (UXO) has been identified within the Site, accordingly any suspect items discovered will immediately be reported to AAJV. Staff will not touch or move any suspect items and will take steps to clear the immediate area of staff and any other contractors or members of the public who may be present. Full details of the procedure to follow in relation to UXO will be contained in the Risk Assessment.

4.9 Reporting

4.9.1 Upon completion of the fieldwork results of the detailed geophysical surveys will be compiled into an illustrated report in Wessex Archaeology's house style describing the survey results and interpretation only.

4.9.2 The report will include the following elements:

- The name(s) of the investigators/contractors, title, date, report reference number and client details;
- A non-technical summary including the basis for the survey, its aims and results;
- Introduction including site location plan, site history, National Grid Reference, site description;
- An account of the background to the project and circumstances of work;
- The aims and objectives of the survey; and
- The methodology used.

4.9.3 The results of the survey will include:

- Plans at appropriate scales to include, raw data, greyscale plot, XY trace plot, interpretative plot. Each illustration will contain a scale bar and north arrow;
- A figure and text to demonstrate that the survey has been accurately geo-located;
- Detailed survey results and interpretation;
- Recommendations regarding further archaeological work necessary on site in advance of, or during, development where relevant;
- References to all primary and secondary sources consulted; and
- Appendices to include details of the geophysical and survey equipment, methods and processing undertaken and full definitions of the interpretation terms used in the report.

4.9.4 The report will be prepared within three weeks of completion of all fieldwork, and submitted to AAJV for approval. If required interim reporting can be completed following fieldwork, subject to variation.

4.9.5 Once approved, a digital report will be issued to AAJV. Digital copies of the raw data, report text, figures and electronic drawings will be made available upon

request. Additionally, hard copies of the report will be issued to AAJV, Historic England and to the Wiltshire Council HER (if required) and to the National Trust Archaeologist (Stonehenge & Avebury WHS) in their preferred format.

4.9.6 Wessex Archaeology shall retain full copyright of the client report under the Copyright, Designs and Patents Act 1988 with all rights reserved; excepting that it hereby provides an exclusive licence to AAJV for the use of the report by AAJV in all matters directly relating to the project as described in the specification.

4.10 Archiving

4.10.1 The information will be deposited within the relevant local authority where it can be freely copied for the purposes of archaeological research or Development Control within the planning process.

4.10.2 Details of the survey will be submitted online to the OASIS (Online Access to the Index of Archaeological Investigations) database within six months of the completion of all site work

4.10.3 An accession number, if required, will be sought prior to work commencing.

4.10.4 Material archived will include the raw data in Geoplot usable format.

4.10.5 If the requirements of this project change, a variation can be requested. The complete project archive will be prepared in accordance with Schmidt *et al*. (2001) *Geophysical Data in Archaeology: A Guide to Good Practice* (ADS) and those required by WSHER.

4.11 Project team

4.11.1 The project will be managed overall by Caroline Budd for Wessex Archaeology

4.11.2 The work will be undertaken by Wessex Archaeology's in-house geophysics team. Lucy Learmonth as Terrestrial Geophysics Manager will be responsible for the day to day running of the geophysical survey work from fieldwork through data processing, interpretation and reporting.

4.11.3 Dr Paul Baggaley as Director of GeoServices at Wessex Archaeology will be responsible for the work and Paul is, in turn, responsible to the Chief Executive. The Chief Executive, Chris Brayne, has ultimate responsibility for the maintenance of quality standards for all work within Wessex Archaeology.

4.11.4 Fieldwork will be undertaken by experienced members of the geophysics team and will comprise geophysicists from our Salisbury Office.

4.11.5 All nominated Wessex Archaeology staff are appropriately qualified and experienced for their project role. Wessex Archaeology reserves the right to vary project staff according to the operational demands of its overall programme. Career profiles can be provided on request.

4.12 Quality and Code of Practice

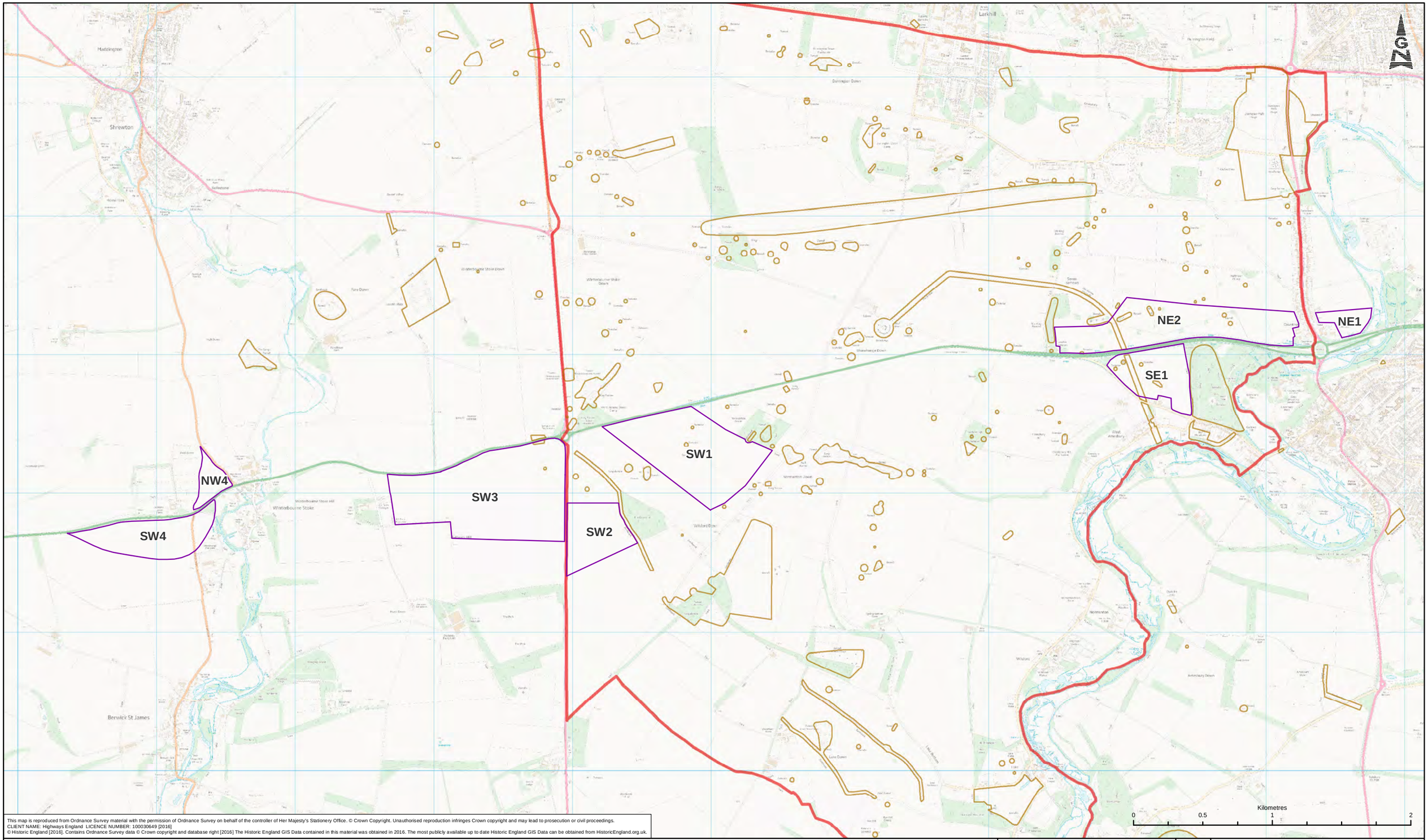
4.12.1 Wessex Archaeology is an archaeological organisation registered with the Chartered Institute for Archaeologists.

4.12.2 Wessex Archaeology endorses the Code of Practice and the Code of Approved Practice for the Regulation of Contractual Arrangements in Field Archaeology of the Chartered Institute for Archaeologists.

4.12.3 All core staff would be of a standard approved by Wessex Archaeology, be employed in line with The Chartered Institute for Archaeologists Codes of Practice and be members of the Chartered Institute for Archaeologists or be appropriately qualified.

4.12.4 Wessex Archaeology is an ISO 9001:2008 accredited organisation (certificate number FS 606559), confirming the operation of a Quality Management System which complies with the requirements of the standard and covering its professional archaeological and heritage advice and services. The award of the ISO 9001 certificate, independently audited by the British Standards Institution (BSI), demonstrates Wessex Archaeology's commitment to providing quality heritage services to our clients. ISO (the International Organisation for Standardisation) is the most recognised standards body in the world, helping to drive excellence and continuous improvement within businesses.

5 Figures



Legend

- World Heritage Site
- Scheduled Monuments

Wiltshire Council Geophysical Survey WSI

NE1	51,290m²
NE2	430,990m²
NW4	54,020m²
SE1	189,410m²
SW1	455,450m²
SW2	183,250m²
SW3	691,590m²
SW4	222,560m²

Drawing Status	WORK IN PROGRESS
Suitability	S0
Project Title	A303 AMESBURY TO BERWICK DOWN
Client	highways england
Drawing Title	WILTSHIRE COUNCIL GEOPHYSICAL SURVEY AREAS
Designers	ARUP ATKINS
Scale	1:25,000
Designed	N/A
Drawn	SD
Checked	AH
Authorised	XXX
Original Size	A3
Date	15/04/16
Date	15/04/16
Date	15/04/16
Date	15/04/16
Drawing Number (Project | Originator | Volume)	HE551506 - AA - EHR
(Location | Type | Role | Number)	SWI - DR - YE - 000017
Revison	P01.1

Abbreviations List

AAJV	Arup Atkins Joint Venture
CIfA	Chartered Institute for Archaeologists
GPR	Ground Penetrating Radar
GPS	Global Positioning System
WCAS	Wiltshire Council Archaeological Service
WHS	World Heritage Site

References

[1] AAJV, A303 Amesbury to Berwick Down, Archaeological Geophysical Survey Design Brief, unpublished client brief, 2016.

[2] Historic England, Management of Research Projects in the Historic Environment: The MoRPHE Project Managers' Guide, 2015.

[3] CIfA, Standard and Guidance for archaeological geophysical survey, Chartered Institute for Archaeologists, 2014.

[4] English Heritage, Geophysical Survey in Archaeological Field Evaluation. Research and Professional Service Guideline No 1, 2nd edition, 2008.

[5] Historic England, English heritage Thesauri, available at: http://thesaurus.english-heritage.org.uk/frequentuser.htm, 2013.

[6] British Geological Survey, Geology of Britain online viewer, available at: http://mapapps.bgs.ac.uk/geology ofbritain/home.html .

[7] Crutchley, S, Stonehenge World Heritage Site Mapping Project, English Heritage, 2002.

[8] Simmonds, S and Thomas, B, Stonehenge, Avebury and Associated Sites World Heritage Site. Management Plan 2015, Stonehenge and Avebury WHS Steering Committee, 2015.

[9] GSB, Report on Geophysical Survey: A303 Amesbury to Berwick Down, unpublished client report, Report No 92/3, 1992.

[10] GSB, Geophysical survey: A303 Stonehenge VII, unpublished report, Report No 2001/75, 2001a.

[11] GSB, Geophysical survey: A303 Stonehenge VI, unpublished client report, Report No 2001/82, 2001b.

[12] Wessex Archaeology, Stonehenge Archaeological Surveys. Archaeological Evaluation Reports, unpublished client report, 2003.

Appendices

Appendix A Magnetic survey equipment and data processing

A.1 Survey methods and equipment

A.1.1.1 The magnetic data for this project was acquired using a Bartington 601-2 dual magnetic gradiometer system. This instrument has two sensor assemblies fixed horizontally 1m apart allowing two traverses to be recorded simultaneously. Each sensor contains two fluxgate magnetometers arranged vertically with a 1m separation, and measures the difference between the vertical components of the total magnetic field within each sensor array. This arrangement of magnetometers suppresses any diurnal or low frequency effects.

A.1.1.2 The gradiometers have an effective resolution of 0.03nT over a ±100nT range, and measurements from each sensor are logged at intervals of 0.25m. All of the data are stored on an integrated data logger for subsequent post-processing and analysis.

A.1.1.3 Wessex Archaeology undertakes two types of magnetic surveys: scanning and detail. Both types depend upon the establishment of an accurate 20m or 30m site grid, which is achieved using a Leica Viva RTK GNSS instrument and then extended using tapes. The Leica Viva system receives corrections from a network of reference stations operated by the Ordnance Survey and Leica Geosystems, allowing positions to be determined with a precision of 0.02m in real-time and therefore exceed the level of accuracy recommended by Historic England [4] for geophysical surveys.

A.1.1.4 Scanning surveys consist of recording data at 0.25m intervals along transects spaced 10m apart, acquiring a minimum of 80 data points per transect. Due to the relatively coarse transect interval, scanning surveys should only be expected to detect extended regions of archaeological anomalies, when there is a greater likelihood of distinguishing such responses from the background magnetic field.

A.1.1.5 The detailed surveys consist of 20m x 20m or 30m x 30m grids, and data are collected at 0.25m intervals along traverses spaced 1m apart. These strategies give 1600 or 3600 measurements per 20m or 30m grid respectively, and are the recommended methodologies for archaeological surveys of this type [4].

A.1.1.6 Data may be collected with a higher sample density where complex archaeological anomalies are encountered, to aid the detection and characterisation of small and ephemeral features. Data may be collected at up to 0.125m intervals along traverses spaced up to 0.25m apart, resulting in a maximum of 28800 readings per 30m grid, exceeding that recommended by Historic England [4] for characterisation surveys.

A.2 Post-processing

A.2.1.1 The magnetic data collected during the detail survey are downloaded from the Bartington system for processing and analysis using both commercial and in-house software. This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

A.2.1.2 As the scanning data are not as closely distributed as with detailed survey, they are georeferenced using the GPS information and interpolated to highlight similar anomalies in adjacent transects. Directional trends may be removed before interpolation to produce more easily understood images.

A.2.1.3 Typical data and image processing steps may include:

- Destripe – Applying a zero mean traverse in order to remove differences caused by directional effects inherent in the magnetometer;
- Destagger – Shifting each traverse longitudinally by a number of readings. This corrects for operator errors and is used to enhance linear features;
- Despike – Filtering isolated data points that exceed the mean by a specified amount to reduce the appearance of dominant anomalous readings (generally only used for earth resistance data)

A.2.1.4 Typical displays of the data used during processing and analysis:

- XY Plot – Presents the data as a trace or graph line for each traverse. Each traverse is displaced down the image to produce a stacked profile effect. This type of image is useful as it shows the full range of individual anomalies.
- Greyscale – Presents the data in plan view using a greyscale to indicate the relative strength of the signal at each measurement point. These plots can be produced in colour to highlight certain features but generally greyscale plots are used during analysis of the data.

Appendix B GPR equipment and data processing

B.1 Survey Methods and Equipment

B.1.1.1 The ground penetrating radar (GPR) data were collected using a cart-based shielded antennae with central frequencies suitable for the types of target being investigated. Lower frequency antennae are able to acquire data from deeper below the surface, whereas higher frequencies allow high resolution imaging of near-surface targets at the expense of deep penetration. The exact make and model of equipment varies.

B.1.1.2 The depth of penetration of GPR systems is determined by the central frequency of the antenna and the relative dielectric permittivity (RDP) of the material through which the GPR signal passes. In general, soils in floodplain settings may have a wide range of RDPs, although around 8 may be considered average, resulting in a maximum depth of penetration c. 2.5m with the GPR signal having a velocity of approximately 0.1m/ns.

B.1.1.3 The GPR beam is conical in shape, however, and whilst most of the energy is concentrated in the centre of the cone, the GPR signal illuminates a horizontal footprint which becomes wider with increasing depth. At the maximum depth of the antenna, it becomes impossible to resolve any feature smaller than the horizontal footprint for the corresponding depth. The size of the footprint is dependent upon central frequency, and its size increases as the central frequency decreases.

B.1.1.4 The vertical resolution is similarly dependent upon the central frequency; for the 300MHz antenna, features of the order of 0.05m may be resolved vertically. Antennae with lower frequencies can therefore penetrate more deeply but are less resolute in both horizontal and vertical directions. Choice of antenna frequency is guided largely by the anticipated depth to the target and the required resolution.

B.1.1.5 GPR data for detailed surveys are collected along traverses of varying length separated by 0.5m with cross lines collected running perpendicular to these traverses at wider separations. The data sampling resolution is governed by the data logger and a minimum separation of 0.05m between traces is collected for all surveys.

B.2 Post-Processing

B.2.1.1 The radar data collected during the detail survey are downloaded from the GPR system for processing and analysis using commercial software (GPR Slice). This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

B.2.1.2 Typical data and image processing steps may include:

- Gain – Amplifies GPR data based upon its position in the profile, which boosts the contrast between anomalies and background. A wobble correction is also applied during this step;

- Background Filter - is used to remove banding noises that are seen across the radargrams
- Bandpass – Removes GPR data lying outside a specified range, which removes high- and low-frequency noise.

B.2.1.3 Typical displays of the data used during processing and analysis:

- Timeslice – Presents the data as a series of successive plan views of the variation of reflector energy from the surface to the deepest recorded response. The variation in amplitude is represented using a colour scale with red indicating high amplitude and blue indicating low amplitude responses.
- Radargram – Presents each radar profile in a vertical view with distance along the profile expressed along the x axis and depth along the y axis. The amplitude variation is expressed using a greyscale.

Appendix C Geophysical interpretation

C.1.1.1 The interpretation methodology used by Wessex Archaeology separates the anomalies into four main categories: archaeological, modern, agricultural and uncertain origin/geological.

C.1.1.2 The archaeological category is used for features when the form, nature and pattern of the anomaly are indicative of archaeological material. Further sources of information such as aerial photographs may also have been incorporated in providing the final interpretation. This category is further sub-divided implying a decreasing level of confidence:

- Archaeology – used when there is a clear geophysical response and anthropogenic pattern.
- Possible archaeology – used for features which either which give a clear response but which form incomplete patterns or give a response but which form no discernible pattern or trend.

C.1.1.3 The modern category is used for anomalies that are presumed to be relatively modern in date:

- High Ampitude Response – used for responses caused by buried material. These anomalies are of unknown modern origin.
- Modern service – used for responses considered relating to cables and pipes; most are composed of ferrous/ceramic material although services made from non-magnetic material can sometimes be observed.

C.1.1.4 The agricultural category is used for the following:

- Former field boundaries – used for ditch sections that correspond to the position of boundaries marked on earlier mapping.
- Agricultural ditches – used for ditch sections that are aligned parallel to existing boundaries and former field boundaries that are not considered to be of archaeological significance.
- Ridge and furrow – used for broad and diffuse linear anomalies that are considered to indicate areas of former ridge and furrow.
- Ploughing – used for well-defined narrow linear responses, usually aligned parallel to existing field boundaries.
- Drainage – used to define the course of ceramic field drains that are visible in the data as a series of repeating bipolar (black and white) responses.

C.1.1.5 The uncertain origin/geological category is used for features when the form, nature and pattern of the anomaly are not sufficient to warrant a classification as an archaeological feature. This category is further sub-divided into:

- Trend – used for low amplitude or indistinct linear anomalies.
- Superficial geology – used for diffuse edged spreads considered to relate to shallow geological deposits. They can be distinguished as areas of positive, negative or broad bipolar (positive and negative) anomalies.

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Highways England creative job number BRS18_0124

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Highways England Company Limited registered in England and Wales number 09346363