Rampion 2 Wind Farm

Category 6: Environmental Statement

Volume 4, Appendix 26.4: Hydrogeological Risk Assessment

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Executive Summary

This appendix has been produced to support the **Chapter 26: Water environment, Volume 2** of the ES (Document Reference: 6.2.26) of the Rampion 2 Environmental Statement. The Proposed Development comprises a cable route that crosses the geological transition between the Chalk Formations of the South Downs. There are a number of public and private water supply abstractions in the area, and this hydrogeological risk assessment (HRA) has been undertaken to assess any potentially significant effects on these receptors, with a particular emphasis on Southern Water (SW) public water supplies. The assessment considers potential effects for each phase of the Rampion 2 lifespan, namely the construction, operation and maintenance and decommissioning phases.

The HRA has been undertaken in consultation with SW and uses Environment Agency guidance to establish a detailed source / pathway / receptor conceptual model for the specific water resource receptors assessed. The conceptual understanding of the flow paths and catchment areas of receptors considers the published Environment Agency source protection zones of boreholes and associated pathways from available information. This area of the South Downs contains karstic features within the Chalk that may represent pathways of rapid groundwater flow, pathways and these are considered in the assessment. A range of design and good industry practices are included as embedded environmental measures to remove or minimise any environmental effects on the receptors as far as possible. The chapter concludes that there will be no significant residual effects from Rampion 2 upon the water resources following the implementation of standard and site-specific mitigation measures.

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1. Introduction

1.1 Overview

1.1.1 WSP (previously Wood Group UK Limited) has supported Rampion Extension Development Limited (RED) with water environment surveys and assessments as part of the EIA and the design change process for the Rampion 2 project. On 23 December 2021, a key stakeholder, Southern Water (SW), sent an email to WSP stating that "*going forwards we would expect to see a detailed hydrogeological assessment of the works, including consideration of the karst risk, and an understanding of groundwater levels (through monitoring) along the route of the connection through the Environment Agency (EA) SPZ1 and SPZ2, consideration of the seasonal variation in groundwater levels / groundwater catchment orientation, and avoiding undertaking construction when recharge / heavy rainfall is forecast*."

1.1.2 As a result of this request from SW, it was agreed with RED, in June 2022, to produce a hydrogeological risk assessment (HRA) in proximity of Warningcamp and New Down along the original Preliminary Environmental Information Report (PEIR) Assessment Boundary (RED, 2021). This was in recognition that construction activities including trenchless crossing (for example horizontal directional drilling (HDD)) were being proposed across public water supply Source Protection Zone (SPZ) 2s and on the edge of SPZ 1s. Furthermore, in August 2022, a decision was taken by RED to consider further additional onshore cable re-routes known as the Longer Alternative Cable Routes (LACR), namely LACR-01a,01b and 01c. These additional routes are in the vicinity of the Angmering and Patching / Clapham SW public water supplies and intersected SPZs 2 and 3 for these abstractions.

1.1.3 During a meeting with the Environment Agency and SW on 4 May 2022, onshore cable re-routes were discussed. Both stakeholders communicated concerns about potential karst features in this region that would need further special consideration. SW mapping indicates that karst features may be present in the vicinity of the re-routes. Therefore, due to the introduction of the additional re-routes (LACR-01a, 01b and 01c) and further requests from key stakeholders, a detailed HRA was carried out for several routes in the vicinity of the Angmering and Patching SW public water supplies.

1.1.4 The Warningcamp and New Down original PEIR route (RED, 2021) was removed in favour of LACR-01 following consultation (see **Chapter 3: Alternatives, Volume 2** of the ES (Document Reference: 6.2.3). The final onshore cable route evolved from the re-routes and is known as the proposed DCO Order Limits and is shown on **Figure 26.4.1**.

1.1.5 The proposed cabling and associated infrastructure may still pose a risk towards the underlying aquifer, the Angmering / Patching public water supplies and other water resources. These have therefore all been identified as potential receptors and require further detailed investigation. The HRA presented within this document is used to assess the risk to these receptors and to inform the final route design and suitable mitigation measures to be incorporated into the DCO Application.

1.2 Scope

Geographical scope and Study Area

1.2.1 The geographical scope for the HRA covers the proposed DCO Order Limits shown in **Figure 26.4.1**. The route across the South Downs runs from Lyminster and proceeds in an easterly direction under Decoy Lane, the A27 Arundel road and a Public Right of Way (PRoW) before reaching Hammerpot. The route then continues in an easterly direction, before turning north near Patching, up towards Michelgrove, where there is a steep-sided hillside which requires a trenchless crossing to the west of Michelgrove Park. The route turns north and then north-east towards Myrtle Grove Farm. It then passes across the south-western slopes of Blackpatch Hill before continuing north to Sullington Hill where it drops off the South Downs scarp, using trenchless crossing (for example HDD) to the north-east before continuing on towards Washington.

1.2.2 The Study Area for the HRA comprises a 250m buffer around the proposed DCO Order Limits and a 1km buffer around areas where HDD is proposed. The area considered is primarily across the South Downs, associated with the SPZs of the SW abstractions and the Chalk outcrop (and shallow subcrop), i.e., the area along the proposed route from just south of the A27 carriageway at Poling north-east to where the route comes off the South Downs to the west of Washington. Cable installation only require shallow ground intrusion, whilst HDD operations require significantly greater depths. Access tracks and associated works, although likely to be minor and limited to depths of less than a metre, are also included within the assessment.

1.2.3 The cable installation, activities within construction compound areas and particularly the use of HDD techniques on and / or within the Chalk outcrop present a hazard to groundwater resources and abstractions in terms of water quality. Any activities that can adversely affect groundwater must therefore be considered, including physical disturbance of the aquifer, and are included within the HRA. The focus is risk to groundwater quality since any works will be temporary and short lived and no long-term impacts on groundwater levels are anticipated.

Scoped out receptors and activities

1.2.4 The focus of the HRA is on water resource abstraction used for human supply only. The primary purpose of this report is to consider potential impacts on groundwater abstractions (as requested by SW and the Environment Agency – see **Section 1.1**), in order to inform the final conclusions of **Chapter 26: Water environment, Volume 2** of the ES (Document Reference: 6.2.26). Other receptors are not required to be considered in the HRA given that they are appropriately considered separately in the chapter. The following paragraphs provide further detail on which receptors have been scoped out from the HRA.

1.2.5 Although these groundwater resources abstract from aquifer groundwater bodies the assessment of potential effects on groundwater aquifers (Principal and Secondary) are instead considered within the **Chapter 26: Water environment, Volume 2** of the ES (Document Reference: 6.2.26). Similarly, **Chapter 26: Water environment, Volume 2** of the ES (Document Reference: 6.2.26) considers conservation sites and surface water features such as Chalk streams, springs (unless a water resource used for abstraction) and lakes / ponds. As such all of these receptors are outside of the scope of the HRA to avoid any unnecessary duplication in the assessment.

1.2.6 In addition to this any potential impacts to the surface water environment, such as surface water abstractions or surface water bodies are not considered within the scope since they are covered by **Chapter 26: Water environment, Volume 2** of the ES (Document Reference: 6.2.26). Potential impacts on the Water Framework Directive (WFD) status of groundwater and surface water bodies and conservation sites have also not been considered within the HRA since these aspects are dealt within the **Chapter 26: Water environment, Volume 2** of the ES (Document Reference: 6.2.26).

1.2.7 Construction access is via access tracks that have been defined as construction; construction & operational; light construction; light construction / operational and operational (access points on **Figure 26.4.1**) based on the scale of upgrading works to be undertaken on the routes. Light construction / operational and operational access tracks require no or minimal works and are considered to not represent a source of contamination or other disruption, and so have not been included within the HRA.

1.2.8 The Warningcamp SW abstraction has been scoped out from the assessment due to the re-routing of the proposed DCO Order Limits being almost 3km east of the borehole locations. There is an access track proposed from the existing highway in the vicinity along an existing track (Access 25), but any works along this route are likely to be minimal and this is not considered in the assessment.

1.2.9 In addition, the SW Stanhope Lodge / Stanhope Lodge Worthing abstraction has been scoped out from the assessment since only access tracks (Access 28) exist within the SPZ 3 of this abstraction, with the nearest proposed DCO Order Limits boundary occurring over 6km to the north of the boreholes.

1.2.10 The unsaturated zone across the South Downs, i.e., above the water table, is of significant thickness and therefore it is unlikely works will interact directly with groundwater. As such, the influence on the aquifer, where the unsaturated zone is thick, in terms of quantity from dewatering of the trenched excavations are not considered. The impacts of dewatering and drilling activities on groundwater levels for deeper excavations for HDD works where the water table may be encountered have been considered within the assessment.

1.2.11 The effects of less permeable access track / temporary construction compound bases in reducing infiltration and recharge to the aquifer are also not considered within the assessment since they are considered within **Chapter 26: Water environment, Volume 2** of the ES (Document Reference: 6.2.26) and are not significant compared to the overall recharge to the aquifer. In addition, the mobilising of contamination from areas of poor land quality is not considered within this HRA since this is dealt within the **Chapter 26: Water environment, Volume 2** of the ES (Document Reference: 6.2.26).

1.3 Site Visit

1.3.1 Site visits were undertaken on the 7, 8 and 9 November 2022, 7 December 2022 and 16 May 2023 to inform the baseline description and conceptual understanding of route areas with the following aims:

- to establish an appreciation for the topography within which the contamination source and potential receptors are located;
- to visit and assess hydrogeological and hydrological features, for example watercourses, surface water features and dry river valleys, springs, stream sinks, dissolution and other karst features;
- to survey the area for surface karstic features and other depressions, measuring and recording dimensions and shape and establishing the likely flow regime; and
- to visit any accessible Chalk pits and/or outcrops to assess Chalk geology, lithology, structure and dip as well as assessing superficial deposits.

1.3.2 The site visit observations are presented within **Annex A**.

1.4 Key assumptions / limitations

1.4.1 Key assumptions and limitations of the HRA include the following;

- Although the Chalk aquifer of the South Down has been the subject of many previous regional studies, a local site-specific study of the areas of interest has not been undertaken before. As such, the conceptual model presented here should be updated as more information becomes available. SW has also indicated that it would prefer not to see any intrusive site investigations at the time of writing, which would otherwise have added to current understanding;
- No digital geological modelling or software was used whilst undertaking the risk assessment;
- There is no inclusion of project ground investigation data, including geophysical data[1], which were not available at the time of writing; and
- Access to SW data was with its approval and of necessity limited in nature:
  - No information regarding the Clapham production borehole and the Angmering, Patching (No. 1, 2 and 3) and Clapham observation boreholes has been made available; and
  - The exact National Grid References (NGRs) of boreholes have not been supplied by SW and so location data have been collected from other

[1] Geophysical non-intrusive resistivity and electromagnetic works were undertaken along route LACR-01 in May 2023.

sources and are estimates only. Information supplied by SW included reports which outlined indicative locations of abstraction boreholes. The SPZs have been derived from modelling. This is determined through applying Environment Agency groundwater flow models run at the location of abstractions, inputting parameters such as flow direction, geology type, rainfall and hydrological boundaries (Environment Agency, 2023).

1.5 Consultation

1.5.1 Relevant stakeholder consultation with respect to this HRA is provided in **Table 1-1**.

Table 1-1 Relevant Stakeholder Consultation

Stakeholder Consultation	Date(s)	Summary of Stakeholder Consultation
Environment Agency review of the PEIR (RED, 2021)	July 2021	The Environment Agency provided the following concluding comments in relation to Chapter 27: Water Environment for the PEIR (RED, 2021): "*Given that the route and substation are not located in any highly sensitive location with respect to groundwater, we agree that the measures and approaches as outlined are sufficient*." This has been noted. A range of embedded environmental measures have been provided as part of this detailed HRA. The Environment Agency also stated more specifically: "*We welcome confirmation that no infrastructure and construction activities will take place inside the SPZ 1 for the named (public water supply) sources. We would welcome the confirmation regarding limiting higher risk activities inside the SPZ 2. Please also note that there are default 50m SPZ 1 around private water supplies used for potable purposes. A default 250m SPZ 2 would also generally be implemented around these sources*." As detailed in C-137 in **Section 5.2** of this document, there will be no groundworks within any SPZ 1s and the only temporary construction activities within discrete areas of the Warningcamp SPZ 1 will be light temporary construction access utilising existing farm tracks near Hill Barn (Access 25). This activity will not involve any ground disturbance. There are also no activities within any default SPZ 1 for PWSs. Activities in SPZ 2 have also been limited along sections of the

Stakeholder Consultation	Date(s)	Summary of Stakeholder Consultation
		onshore cable corridor. C-137 provides a statement confirming what activities will be outside of the SPZs.
Southern Water	E-mail sent 23 December 2021[2]	The email predominantly comprised a discussion of technical hydrogeological issues associated with the SW Warningcamp public licensed groundwater abstraction asset. However, SW states that it "*would strongly object to any route that passes through the EA SPZ 1 …... We would consider this to unnecessarily increase the risk of either a contamination incident or through the generation of turbidity from ground disturbance, impacting on Southern Waters ability to operate its public licensed groundwater abstraction and its legal obligation to supply customers with wholesome water*." Further SW states that it "*will always try to take a pragmatic approach with these kind of schemes weighing up the potential risk with the needs of the developer. We accept that this would be a conservative approach, however, we would not want to set an unnecessary precedent of accepting potentially contaminative construction works directly through an EA SPZ 1.*" SW also states that an extensive karstic mapping project of the Brighton and Worthing Chalk Blocks was undertaken in 2018, which highlighted an extensive area of karst development to the east of the River Arun in the area of Warningcamp and Angmering. SW raises it expectation "*to see a detailed hydrogeological risk assessment of the works, including consideration of the karst risk, and an understanding of groundwater levels (through monitoring) along the route of the connection through the EA SPZ 1 and SPZ 2 with consideration of the seasonal variation in groundwater levels / groundwater catchment orientation, and avoiding undertaking construction when recharge / heavy rainfall is forecast*".
Environment Agency and Southern Water Consultation Meetings	21 December 2021, 5 May 2022, and 14	During each meeting, the latest route options were shared with the Environment Agency and SW to obtain feedback from their groundwater specialists. During the first two meetings SW expressed that it would object to any proposals which crossed the

[2] Personal communication with Richard Gamble (Senior Catchment Hydrogeology Specialist) of SW on the 23 December 2021.

Stakeholder Consultation	Date(s)	Summary of Stakeholder Consultation
	September 2022	SPZ1 of its Warningcamp and Patching public water supplies. The Environment Agency also expressed that its least preferred onshore cable route in the Warningcamp Hill valley was the one that traversed along the bottom of the valley. SW also shared information from its catchment conceptualisation work which indicated that the source of the Warningcamp supply came from the east and north east of the associated SPZ. SW has also shared information on the location of potential karst features. Following each meeting the views and data from the Environment Agency and SW have been taken into account in the design of the Proposed Development. On the 14 September 2022 the stakeholders also welcomed each of the embedded environmental measures being put forward including the inclusion of a HRA as part of the ES.
Environment Agency Expert Topic Group (ETG) attendance	23 November 2022	The scope of the HRA was presented to the Environment Agency in terms of the Study Area and methodologies. The Environment Agency noted that it was overall in agreement with the proposals.
Southern Water review of the scope of the Hydrogeological Risk Assessment	23 November 2022	SW could not attend the ETG meeting but reviewed slides in relation to the scope for the HRA for SW groundwater abstractions. SW also reported that in general they looked acceptable.
Environment Agency review of Preliminary Supplementary Information Report	29 November 2022	The Environment Agency provided the following comments: "*In general, we are satisfied with the contents of the Supplementary Information Report. Having had targeted topic meetings we are confident that our position has been represented*"; and with regards to groundwater: "*In relation to modifications to the potential route at LACR-01 and LACR-02 and MR-04, we welcome the confirmation no ground disturbance / groundworks will take place within the Source Protection Zone (SPZ) 1. The only activities in SPZ 1 will be use of access track and "stringing out" of Horizontal Directional Drilling crossings only. We welcome the confirmation that there will be non–hazardous drilling fluid types and techniques to manage risks of drilling fluid breakout. We would also*

Stakeholder Consultation	Date(s)	Summary of Stakeholder Consultation
		support a watching brief for solution features, pre–construction Ground Investigation to identify sensitive areas and ground conditions and avoidance of features (swelling clays, transition zones, preferential pathways for breakouts)." These comments have been incorporated into embedded environmental measures, namely C227, C234 – drilling fluid breakout management; C235 – cable installation design for HDD; C236, C241, C245 – no use of environmentally hazardous drilling fluids; C246, C250, C251 – watching brief for solution features (C-252). These are presented in **Section 5.2** of this report.

1.6 Report Structure

1.6.1 Section 2 provides an introduction to the principles of groundwater protection in England and a summary of relevant legislation, policy and guidance in **Section 2**. **Section 3** gives a description of the regional and local hydrogeological environment, including details of the SW supply boreholes of interest. A conceptual hydrogeological site model is then developed within **Section 4,** in terms of potential contamination sources, pathways and receptors. This is facilitated by conceptual cross sections for the SW boreholes considered for assessment, where consideration is given to the following:

- receptors and groundwater catchment areas, particularly in relation to the SW abstraction SPZs;
- hydrogeology and groundwater levels along areas of the proposed DCO Order Limits, including karstic features; and
- seasonal variation in groundwater levels / groundwater catchment orientation.

1.6.2 The methodology of the groundwater risk assessment is presented within **Section 5.2** and the assessment is undertaken in **Section 5**. Embedded measures and other additional mitigation for minimising impacts on the identified hydrogeological receptors are also described and any residual risks on receptors identified. Final conclusions are presented in **Section 6**.

1.6.3 As mentioned earlier, the site visit observations are presented within **Annex A**.

2. Principles and regulations of groundwater protection

2.1 Principles of Groundwater Protection

2.1.1 The approach to protecting groundwater in England is set out in The Environment Agency's Approach to Groundwater Protection (Environment Agency, 2017). The priority is to protect groundwater and water supplies intended for human consumption, as well as to ensure protection of the quality of groundwater that supports ecosystems. This is achieved by preventing hazardous substances and limiting non-hazardous pollutants from entering groundwater and by identifying the sensitivity of groundwater, i.e. within principal and secondary aquifers that can provide significant quantities of drinking water, and its vulnerability.

2.1.2 Sensitive groundwater locations have protection zones applied for areas where pollution on or below the land may present a risk to groundwater. These include drinking water protected areas (DrWPAs) and source protection zones (SPZs). The Environment Agency applies a general level of protection for all drinking water sources through the use of SPZs. In addition, private water supplies (PWSs) provide water to homes, businesses or services, commonly in rural areas, and are regulated by local authorities. All PWSs used for human consumption or food production purposes have an SPZ 1 designation with a default radius of 50m and a default catchment radius area of 250m.

2.1.3 The installation of underground cables for the Proposed Development may impact groundwater resources through the risk of contamination during construction affecting groundwater quality. Depending on the potential severity of the hazard, the Environment Agency may object (through planning or permitting controls) to such activities in certain areas. Where works and infrastructure is close to sensitive receptors, the Environment Agency is likely to adopt the precautionary principle as even where the likelihood is not high, the consequences may be serious or irreversible.

2.2 Legislative and Regulatory Framework

2.2.1 This section identifies the legislation, policy and other documentation that has informed the HRA. Further information on policies relevant to the EIA and their status is provided in **Chapter 2: Policy and legislative context, Volume 2** of the ES (Document Reference 6.2.2) and **Chapter 26: Water environment, Volume 2** of the ES (Document Reference 6.2.26).

2.2.2 National legislation relevant to the protection of groundwater is given in **Table 2-1**.

Table 2-1 Relevant National Legislation

Legislation	Relevance to protection of groundwater
Overarching National Policy Statement (NPS) for Energy EN-1 **Department of Energy and Climate Change (DECC) (2011)**	EN-1 states that "*Where the project is likely to have effects on the water environment, the applicant should undertake an assessment of the existing status of, and impacts of the proposed project on, water quality, water resources and physical characteristics of the water environment as part of the ES or equivalent. The ES should in particular describe:* • *existing water resources affected by the proposed project and the impacts of the proposed project on water resources, noting any relevant existing abstraction rates, proposed new abstraction rates and proposed changes to abstraction rates (including any impact on or use of mains supplies and reference to Catchment Abstraction Management Strategies); and…* • *any impacts of the proposed project on water bodies or protected areas under the Water Framework Directive and source protection zones (SPZs) around potable groundwater abstractions*."
Draft Overarching NPS for Energy EN-1 **Department for Energy Security and Net Zero (DESNZ)) (2023)**	EN-1 states that where a "*project is likely to have effects on the water environment, the applicant should undertake an assessment of the existing status of, and impacts of the proposed project on, water quality, water resources and physical characteristics of the water environment, and how this might change due to the impact of climate change on rainfall patterns and consequently water availability across the water environment, as part of the ES or equivalent*". This is to include "*any impacts of the proposed project on water bodies or protected areas under the Water Framework Directive and source protection zones (SPZs) around potable groundwater abstractions*".
Draft National Policy Statement for Water Resources Infrastructure **Department of Environment, Food and Rural Affairs (Defra) (2019)**	The section on Water Quality and Resources links directly with Environment Agency guidance that explains the legal requirements associated with groundwater activities. In this respect the National Policy Statement for Water Resources Infrastructure requires activities to adhere to the principles of the Environment Agency approach to groundwater protection.
Core guidance for the Environmental	This aims to provide comprehensive help for those operating, regulating or interested in 'regulated facilities' covered by these

Legislation	Relevance to protection of groundwater
Permitting (England and Wales) regulations (EPR) 2016 (SI 2016 No 1154) **Defra (2020)**	regulations (EPR). Such facilities could potentially harm the environment or human health, and EPR requires their operators to obtain a permit or to register some activities, which would otherwise require permits, as 'exempt facilities'. Under EPR it is a criminal offence to "*cause or knowingly permit*" groundwater to become polluted. Penalties include fines, imprisonment or both. Relevant to the proposed cabling and associated works include the following: • Schedule 8 – Part B installations and Part B mobile plant (regulation 8(1)(b)); • Schedule 21 – water discharge activities (regulation 8(1)(f)); and • Schedule 22 – groundwater activities (regulation 8(1)(g))
Water Resources Act 1991	See further details in **Section 2.3**.
Water Framework Directive (2000/60/EC)	See further details in **Section 2.7**.

2.2.3 In addition to national legislation, SW operates in accordance with a number of key guidance policies. These are detailed further in **Section 2.4**.

2.3 Key Legislation

2.3.1 The Water Resources Act 1991 (UK Government (1991)), Water Act 2003 (UK Government, 2003) and Environmental Permitting (England and Wales) Regulations 2016 (UK Government, 2016) are key legislation relevant to the Water Environment. The Water Resources Act 1991 states that it is an offence to cause or knowingly permit polluting, noxious, poisonous or any solid waste matter to enter controlled waters. The Act was revised by the Water Act 2003, which sets out regulatory controls for water abstraction, water impoundment and protection of water resources. Provisions for the regulation of water discharges to controlled waters are set out in the Environmental Permitting (England and Wales) Regulations 2016 and have replaced provisions in the earlier Acts mentioned here.

2.3.2 These Acts and Regulations set out the permitting and compliance framework which will regulate all site emissions, water abstractions and discharges with the potential to interact with the water environment. Important to the Proposed Development is the requirement to obtain a licence for dewatering of engineering works and to ensure that any impact on the environment can be mitigated.

2.4 Key Guidance

2.4.1 The Environment Agency is the main regulator with respect to environmental permitting. It is also a statutory consultee for the purpose of the Planning Act 2008.

The Environment Agency's approach to groundwater protection (Environment Agency, 2018) contains position statements which provide information about its approach to managing and protecting groundwater. They detail how the Environment Agency delivers government policy for groundwater and adopts a risk-based approach where legislation allows. Many of the approaches set out in the position statements are not statutory but may be referenced in statutory guidance and legislation. The most relevant of these policies with respect to the Proposed Development are summarised below:

- **B1: Initial screening tools**: The Environment Agency will use SPZs as an initial screening tool to identify "*areas where it would object in principle to certain potentially polluting activities, or other activities that could damage groundwater*" and / or areas "*where additional controls or restrictions on activities may be needed to protect water intended for human consumption*";
- **N7: Hydrogeological risk assessment:** "*Developers proposing schemes that present a hazard to groundwater resources, quality or abstractions must provide an acceptable hydrogeological risk assessment (HRA) to the Environment Agency and the planning authority. Any activities that can adversely affect groundwater must be considered, including physical disturbance of the aquifer. If the HRA identifies unacceptable risks then the developer must provide appropriate mitigation. If this is not done or is not possible the Environment Agency will recommend that the planning permission is conditioned, or it will object to the proposal*";
- **N8: Physical disturbance of aquifers in SPZ1:** "*Within SPZ1, the Environment Agency will normally object in principle to any planning application for a development that may physically disturb an aquifer*"; and
- **N11: Protection of resources and the environment from changes to aquifer conditions:** "*For any proposal that would physically disturb aquifers, lower groundwater levels, or impede or intercept groundwater flow, the Environment Agency will seek to achieve equivalent protection for water resources and the related groundwater-dependent environment as if the effect were caused by a licensable abstraction*".

2.4.2 Hence, on the basis of these policies the Environment Agency require a HRA and suitable mitigation for the proposed cabling works.

2.4.3 SW operates in accordance with a number of key policies. Relevant policies with respect to the cable routing include the following:

- Biodiversity: the company has *"signed up to the protection of Chalk streams to stop their decline, as well as to restore their health and ecological status"* (Southern Water, 2023); and
- Environment: the company aims to conform to its *"compliance obligations by meeting or exceeding the environmental requirements of legislation, regulation and our adopted standards"*; *"prevent pollution, eliminate serious pollution incidents and contain the environmental impact"* of its activities; and be *"a good and trusted neighbour and be a steward for the environment"* wherever it operates (Southern Water, 2023).

2.4.4 There is little in these policies that have direct relevance to the cabling proposals presented within this HRA. However, the approval of a DCO will be challenged by Southern Water (SW) and other abstractors if they consider that the yield and / or water quality of abstractions are at risk from the proposed works. For example, SW has a duty to provide good quality water to its customers, and an objection from such an organisation is likely to be taken very seriously.

2.4.5 Water companies, such as SW, use SPZs to protect their groundwater abstraction sources, see **Section 2.6**.

2.5 Aquifer Status

2.5.1 The designation of an aquifer reflects the importance of the aquifer in terms of groundwater as a drinking water supply resource and also its role in supporting surface water flows and wetland ecosystems (British Geological Survey (BGS), 2022). Principal and Secondary aquifers may provide significant quantities of drinking water and water for business needs. They may also support rivers, lakes and wetlands and other groundwater dependent ecosystems.

2.5.2 Aquifers are divided into two different types: superficial (permeable, unconsolidated (loose) deposits, e.g. sands and gravel) and bedrock (solid, permeable formations, e.g. sandstone, chalk and limestone). The designations (in order of importance) are as follows: Principal, Secondary A, Secondary B, Secondary undifferentiated and unproductive strata.

2.5.3 The Defra (2023) Multi-Agency Geographic Information for the Countryside (MAGIC) web application Aquifer Designation Map was used to identify aquifer designations with the Study Area. The Chalk is the major aquifer of southern and eastern England and occupies much of the Study Area and is designated as a 'Principal' aquifer. The Lambeth Group bedrock is present to the south of the Study Area and is a designated as 'Secondary A' aquifer.

2.5.4 With regards to superficial deposits, the Defra (2023) MAGIC Aquifer Designation map indicates the head deposits designated as 'Secondary undifferentiated' and occasionally alluvium, within the lower dry valleys, are designated as 'Secondary A' aquifer.

2.6 Source Protection Zones

2.6.1 The Environment Agency has defined SPZs to protect groundwater abstraction sources (wells, boreholes and springs). SPZs indicate those areas where groundwater supplies are at risk from potentially polluting activities and accidental releases of pollutants. SPZs are primarily a policy tool used to control activities close to public water supplies. They also provide the basis for catchment management work such as safeguard zones. SPZs are not statutory and are mainly for guidance but they do relate to distances and zones defined in legislation where certain activities may be restricted.

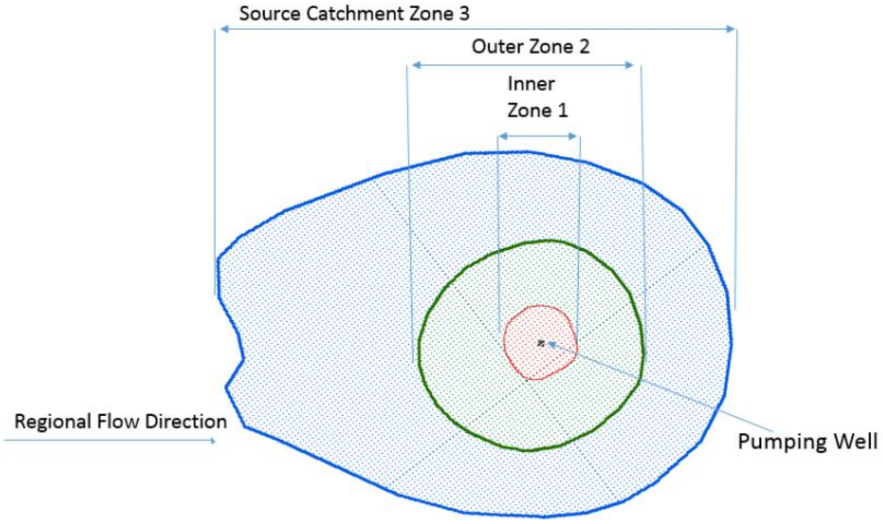
2.6.2 The Environment Agency first published SPZ methodology guidance in August 1996 (Environment Agency, 1996). An updated document "Groundwater Source Protection Zones – Review of Methods" was published in August 2009 (Environment Agency, 2009). The most recent guidance published in March 2019

"Manual for the production of Groundwater Source Protection Zones" (Environment Agency, 2019) updates the methodology for defining groundwater SPZ's.

2.6.3 SPZs typically comprise three main zones (**Graphic 26.4.1**). The first two zones are based on the travel time of potential pollutants through the saturated zone, whilst SPZ 3 represents the recharge area:

- Inner 'SPZ 1' – defined as the 50-day travel time of pollutant to source and has a 50m default minimum radius. This zone is usually located adjacent to the abstraction, although in karst terrain it can extend some distance away due to rapid transport pathways. The Environment Agency's Approach to Groundwater Protection (2018) sets the tightest control of activities in this zone;
- Outer 'SPZ 2' – is defined as the 400-day travel time of pollutant to source with a 250 or 500m minimum radius around the source depending on the amount of water abstracted;
- Total catchment 'SPZ 3' –the area around a supply source within which all the groundwater ends up at the abstraction point. This is the area from where the recharge water is being taken and can extend some distance from the abstraction.

Graphic 26.4.1 Schematic Representation of SPZ (from Environment Agency, 2019)



2.6.4 There are a number of SPZs identified which the Proposed Development may intersect. This includes a number SPZs of public water supplies as well as PWSs. Further details of identified SPZs are provided later in this document.

2.7 Safeguard Zone / Drinking Water Protection Areas

2.7.1 The Environment Agency may use SPZs as the basis for safeguard zones (SgZs) (European Commission, 2007). These are used at sources at risk of groundwater pollution resulting in a deterioration in the quality of water abstracted leading to a likely increase in treatment needed to supply good quality water used for human consumption (Environment Agency, 2019).

2.7.2 SgZs are established around public water supplies where additional pollution control measures are needed. The Water Framework Directive (2000/60/EC) requires that DrWPAs are identified (WFD Article 7.1) and that they are given the necessary protection (WFD Article 7.3) with the aim of avoiding deterioration in their quality, in order to reduce the level of treatment required in the production of drinking water (Environment Agency, 2021).

2.7.3 The geometry of groundwater SgZs are based on groundwater SPZs, usually SPZ 1 and SPZ 2, and use additional assessment to identify areas which may or may not coincide with the SPZ, for example where additional measures are required to ensure that abstraction waters meet Article 7.3 of the WFD (Environment Agency, 2021).

2.7.4 All groundwater bodies in England are designated as DrWPAs. This aims to protect groundwater from over-abstraction and to prevent deterioration in groundwater quality that could increase the treatment of drinking water.

2.7.5 The Defra (2023) MAGIC Map shows that SPZ 1 and the majority of the SPZ 2 of the Patching groundwater abstraction source are designated as drinking water SgZs[3].

[3] It should be noted that the SPZ for the Angmering abstraction is not designated as a SgZ.

3. Hydrogeological Environment

3.1 Site Setting

3.1.1 The Study Area (**Figure 26.4.1**) is in West Sussex to the east of Arundel, north of the A27 dual carriageway and west of the A280 at Clapham. The Study Area extends along a section of the onshore cable route for approximately 7km to the north-east, into the South Downs, and is generally aligned with the SPZs in the area. The area is rural and land use is predominantly arable and improved grassland (UK Centre for Ecology & Hydrology (UKCEH) Land Cover Map 2015 dataset). Woods and arable land are found at lower elevations and on the tops of valleys in the south of the Study Area, whereas the higher ground of the South Downs to the north is largely farmland with less woodland.

3.2 Topography and Drainage

3.2.1 The ground elevation across the Study Area (**Figure 26.4.2**) ranges from approximately 5mAOD south-west of Hammerpot, south of the A27 carriageway, to approximately 205mAOD at Sullington Hill within the South Downs in the north of the Study Area. In the south of the Study Area the topography generally consists of gently sloping ground with dry valleys rising from the south to Barpham Hill (142mAOD), with a steeper south-eastern valley flank controlled by the Chalk scarp slope. This valley trends south-east to north-west from the A280 carriageway to Michelgrove and Lower Barpham. Other smaller valleys are found in the area, generally trending north to south, for example at Angmering Farm. North of this in the South Downs are steeper valleys, generally trending north to south, and better-defined hills, for example at Harrow Hill and Blackpatch Hill between which the proposed DCO Order Limits route passes.

3.2.2 Valleys within the Study Area are predominantly dry valleys typical of the Chalk karstic landscape of the South Downs. Drainage is only observed at the very lowest elevations, just north and south of the A27 carriageway in the south of the Study Area, where it is developed on the less permeable Paleogene deposits. Surface water features, such as streams and ponds, can be found in this area. Spring lines also develop along an east to west trending line, just north of the carriageway, due to topographic and hydrogeological controls.

3.2.3 Two Chalk streams in the area are recognised. One starts at Shelden Lane within Fox Rough and flows to the west before disappearing and then reappearing as a spring at Hammerpot. It then flows under the A27 towards the south-west into a series of ponds before flowing into the Black Ditch. The other Chalk stream is located approximately 1.5km south of the Warningcamp Hill valley, starting within open ground north of Sailor's Copse, and flowing to the west towards Warningcamp and then into the River Arun.

3.2.4 Most Chalk springs are located on particular lithological horizons (Allen et al., 1997) which are susceptible to the development of conduits along inception horizons (**Section 3.4.9**). There are also seasonal springs, as well as perennial springs, called "bournes" or "winterbournes" linked to dry valleys within the area.

However, within the Brighton and Worthing Chalk Blocks, it is considered that due to the lack of perennial surface watercourses, so-called 'sinking' streams are mostly absent.

3.2.5 There is a spring at Hammerpot which is approximately 20m to the south of the proposed DCO Order Limits route and the trenchless crossing (for a crossing of a PRoW). The spring is a source to a Chalk stream which was identified by the South Downs National Park Authority (SDNPA) as being a priority feature, although it occurs within the Lambeth Group geology and head superficial deposits. This Chalk stream is part of the Black Ditch WFD water body catchment.

3.3 Geology

3.3.1 **Table 3-1** shows the general stratigraphic sequence for Southern Sussex (AMEC, 2016). The BGS mapping (1996) shows the Cretaceous White Chalk outcropping over much of the Study Area (**Figure 26.4.3**), particularly the Tarrant and Spetisbury Chalk Members of the Culver Chalk Formation of the Upper Chalk, which forms the down dip slope at lower elevations of the South Downs, in the south of the Study Area. These comprise soft white chalks with large flint bands. Marl bands are generally absent, leading to the formations possessing orthogonal fracture sets with high overall aquifer potential characteristic of the Worthing Chalk Block. Flow and dissolution horizons are likely to have developed along and above the major flint bands within these areas.

3.3.2 The bedrock at the higher elevations, in the north of the Study Area, comprises the Newhaven Chalk, Seaford Chalk and the Lewes Nodular Chalk. These are all of Upper Cretaceous age and within the White Chalk Subgroup. The Newhaven Chalk Formation is soft to medium hard smooth white chalk with numerous marl seams and flint bands, the Seaford Chalk Formation is firm white chalk with large nodular and tabular flints, and with marls in the lower part and the Lewes Nodular Chalk Formation is hard to very hard nodular chalks with interbedded soft chalk and marls.

Table 3-1 General Stratigraphic Sequence for Southern Sussex

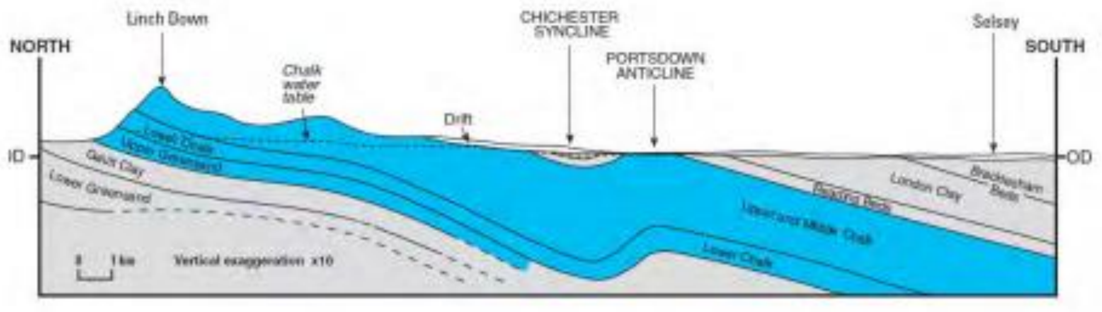
Era	Group		Formation		Approximate Thickness (m)
Palaeogene	-		London Clay		90
	Lambeth		Woolwich & Reading (Undifferentiated)		30
Cretaceous	Chalk Group	White Chalk	Culver Chalk	Spetisbury Chalk Member	<65
				Tarrant Chalk Member	35-45
			Newhaven Chalk		40-76
			Seaford Chalk		50-80
			Lewes Nodular Chalk		35-80
			New Pit Chalk		25-55
			Holywell Nodular Chalk		20-35
		Grey Chalk	Zig Zag Chalk		20-80
			West Melbury Marly Chalk		10-40
	-		Upper Greensand		25
	-		Gault		105

3.3.3 In the south of the Study Area the Chalk is overlain by Palaeogene deposits. These include the London Clay Group with the Lambeth Group at the base of the Palaeogene, the latter comprising the Woolwich and Reading Formations. These are fluvio-deltaic and shallow marine interbedded sands, gravels, clays and silts. At the boundary of the Chalk and Palaeogene the contact is unconformable and sharp or often undulating which represents a long period of uplift, structural flexuring and erosion. The Reading Formation generally behaves as an aquiclude and confines groundwater in the Chalk aquifer.

3.3.4 Rapid recharge may be associated with the Palaeogene cover, as the low permeability soils associated with this can concentrate runoff into the Chalk aquifer via surface and near-surface dissolution features within the Chalk and associated collapse features within the overlying Paleogene. These features are typically found along the boundary of the Upper Chalk with the overlying Palaeogene sediments. The dissolution features can be a few metres deep and tens of metres across and are generally lined with clay derived from the insoluble remains of the Chalk (BGS, 2013).

3.3.5 The Chalk in the region lies on the southern limb of the Weald-Artois anticlinorium. The Chalk forms the higher elevated topography of the South Downs to the north of the Study Area between Warningcamp and Washington in West Sussex. The general regional shallow dip (approximately 6 degrees) is to the south, from the primary Chalk escarpment which forms the high South Downs towards the coastal plain and the English Channel (AMEC, 2016). There are a number of east-west folds across the South Downs, most significantly the Chichester Syncline, and this geological structure has a marked impact on the hydrogeology and hydrogeochemistry of the region (**Graphic 26.4.2**). Palaeogene sediments infilling the syncline confine the Chalk in this area (Jones and Robins, 1999), such as the Lambeth Group/ London Clay which forms the younger formations infilling the syncline.

Graphic 26.4.2 Generalised Regional Geological Section Through Chichester and Across the Manhood Peninsula (BGS, 1999)



3.3.6 Superficial deposits are present across much of the Study Area (**Figure 26.4.4**), although absent on the lower elevations, such that just north of the A27 carriageway the Spetisbury Chalk and Lambeth Group are exposed, whilst on the higher elevations of the South Downs and steep valley sides the Chalk bedrock is exposed.

3.3.7 Clay-with-flints are present variably on hilltop interfluves across the South Downs and generally comprise reddish brown clays or sandy clays with abundant flint gravel and cobble sized flints (BGS, 2019). Clay-with-flints across the Study Area occurs on a large ’V‘ shaped interfluve with the apex at Upper Barpham and across upper ground to the south-east south of Michelgrove Park where it crosses the proposed DCO Order Limits. The deposits stop at approximately the 50mAOD contour on gently sloping topography. The contact with the underlying Chalk is often highly irregular owing to dissolution, and Clay-with-flints deposits are often encountered infilling solution pipes and karst features in the Chalk (AMEC, 2016).

3.3.8 Head deposits typically form narrow bands in dry valley bottoms (**Figure 26.4.4**) and are composed of varying proportions of clays, silts, sands and flint gravels. They were formed by periglacial solifluction of a weathered upper mantle of the Chalk during Pleistocene glacial periods. The thickness, extent and composition of head deposits are variable depending on the nature of the upslope material.

3.4 Hydrogeology

3.4.1 The 1:625,000 scale Hydrogeological map of England and Wales (BGS, 2022) indicates that the White Chalk Subgroup is a highly productive Principal aquifer. The Chalk is a dual porosity media with a high matrix porosity and low primary permeability, but with significant flow taking place within solution-enhanced fractures. Such fractures are typically best developed in shallow horizons and dominantly in the zones of modern and past water-table fluctuations (Allen et al., 1997). Extremely rapid flow may occur through these karstic features when enlarged into cavities and conduits within the Chalk by dissolution. Tracer tests from stream sinks often demonstrate flow rates of several km per day and connectivity to abstractions.

3.4.2 Across the South Downs and in the north of the Study Area, between Wepham Down and Sullington Hill Chalk, groundwater levels range between 50mAOD and 70mAOD (50 metres below ground level (mbgl) and 135mbgl respectively), with groundwater flowing in a southern and south-western direction towards Clapham, Patching and Angmering. Generally, water levels in the Chalk reflects the topography, with the shallowest water levels beneath valleys and the greatest variation in water levels observed, and thickest unsaturated zones, observed towards the interfluves (Jones and Robins, 1999). The depth of the unsaturated zone may therefore vary greatly from 0-20m beneath valleys to up to 100m in within the interfluves.

3.4.3 An area of shallow groundwater exists where the Chalk meets the Lambeth Group to the south of the Angmering SPZ. Information from an Environment Agency observation borehole log at Hammerpot Old Barn indicates that between June 2002 and March 2022 the average recorded groundwater level was around 7mAOD and the maximum recorded groundwater level was approximately 12.9mAOD, the latter being within several metres of the ground surface around that location (15mAOD).

3.4.4 Superficial deposits that overlie the Chalk aquifer vary in permeability but are generally thin across the Study Areas and are likely to offer relatively little storage as aquifers themselves and/or reduce recharge into the Chalk aquifer below. The exception to this are the Clay-with-flints superficial deposits that are known to affect infiltration into the Chalk due to their low permeability. In the South Downs where the Clay-with-flints outcrops, it is typically less than 5m thick (and likely to be even less within the Study Area) and is therefore not likely to have a large impact on infiltration to the Chalk aquifer in this area (Jones and Robins, 1999).

3.4.5 Regionally groundwater flow is from north to south, across the South Downs, reflecting the dip of the Chalk in the area (**Figure 26.4.3**). However, the Chichester Syncline restricts southward-flowing groundwater and diverts it to the east, and the Palaeogene sediments infilling the syncline confine the Chalk groundwater in this area and act as a barrier to groundwater flowing south to the sea. Locally groundwater flow is controlled by topography, i.e. dry valley routes, and / or permeability variations and enhancement due to karstic development. Local groundwater flow patterns will also vary seasonally as relative groundwater levels and pathway patterns change.

3.4.6 Previous mention has been made of the Chalk in the Study Area being karstic. Within the Chalk of the South Downs, karst features occur where there is drainage underground through cavities enlarged by dissolution processes (BGS, 2017). These features often include dolines, stream sinks, dry valleys and springs. Surface karst features are potential entry points for pollutants to enter the ground and rapidly travel along karst flow paths though the unsaturated zone, and where connected with the aquifer and exploited by potable abstraction points these may provide high risk pathways for pollutants to rapidly reach these supplies.

3.4.7 Dolines, sometimes known as sinkholes, are a characteristic surface expression of karst forming a closed depression with a cone or bowl shape and are generally circular or elliptical in plan. These form by the gradual dissolution of Chalk, usually below superficial deposits (particularly beneath the Clay-with-flints deposits) and / or soils with subsequent collapse of superficial deposits above (e.g., Waltham and Fookes, 2003).

3.4.8 Stream sinks, also known as swallow holes, are occasionally observed in the Chalk (Maurice, 2009), and whilst dolines can occur without water flowing into them, a sinking stream or swallow hole 'swallows' water at the point at which a stream disappears from the surface to flow underground. These may or may not be associated with a surface depression. They can occur in isolation or in groups and are often recognisable as hollows along a stream channel in Chalk areas (Maurice et al., 2011). Stream sinks are often associated with the fringe of the Palaeogene sediments lying over the Chalk due to the increase in the acidity of runoff water.

3.4.9 In karst aquifers springs can form the outlets for the subsurface solutional networks, and their locations provide important information on the locations and controls on these networks. Most Chalk springs are located on particular lithological horizons (Allen et al., 1997) which are susceptible to the inception of conduit development. Inception horizons occur along marly layers and / or tabular flint layers or any other impermeable bedding plane structure. These are areas where groundwater is impeded increasing dissolution times and hence creating conduits, etc.

3.4.10 Dry valleys can form in response to the subsurface dissolution enlargement of fractures to form fissures and conduits resulting in rapid infiltration and the capture of surface flow into the subsurface. The incision of Chalk dry valleys may have occurred by a combination of periglacial and karst processes (Baxter et al., 2008) but are representative of subsurface Chalk aquifer flow.

3.4.11 Despite this, the density of dissolution surface karst features within the South Downs regions is low compared to some other areas of southern England (Edmunds and Walton, 1983), with a density of 5 to 10 solution features per $100km^2$ for this area. This observation was confirmed by the WSP site walkover in which very few karst features were observed.

3.4.12 SW is investigating the possible sources and pathways of groundwater pollution, specifically from nitrate and solvents. SW has therefore undertaken investigations using Lidar analysis combined with site survey verification of identified depressions to map karstic features. This Brighton and Worthing Chalk Block Karst Mapping study covered the area north of Hammerpot and the identified features have helped inform the design evolution process accordingly[4].

3.5 Aquifer Properties

3.5.1 Transmissivity and storage values in the Chalk of the South Downs show a large variation, with transmissivities ranging between 16 to $9500m^2\ d^{-1}$ and storage coefficients ranging from 2×10^{-4} to 0.032. The aquifer properties within the Chalk generally reflect the topography, in that there is a general pattern of high transmissivity and storage coefficient observed within the valleys and lower transmissivity and storage on intervening interfluves. Transmissivity is therefore highest in the main valleys, sometimes in excess of $1000m^2d^{-1}$, whereas below the interfluves it may reduce to less than $20m^2d^{-1}$. Smaller dry valleys tend to exhibit intermediate values and the yields are generally poor.

3.5.2 This topographic pattern could have developed for a number of reasons (Adams et al., 1999):

- erosion along valleys reduces effective stress which can lead to the opening of horizontal fractures;
- the concentration of groundwater flow towards valleys as discharge areas and mixing of groundwaters near the points of discharge which have different chemical compositions (result in significant volumes of aggressive groundwaters that are undersaturated with respect to calcite. These factors combine to enhance Chalk dissolution, ultimately creating larger diameter conduits (the major fractures were probably initiated during the late Pleistocene when, due to lower sea levels, hydraulic gradients, and hence rates of groundwater flux, were greater); and
- periglaciation could also have contributed towards the enhanced permeability along valleys. Repeated freezing and thawing within the active layer would have broken down the top few metres to provide a mantle of weathered Chalk

[4] Due to confidentiality the results of the SW karstic survey results can not be shared in the public domain, however the details of the Rampion 2 HRA walkover carried out by WSP are detailed in **Annex A**.

which could easily be eroded; within the valleys, repeated freeze–thaw may have opened up fractures to a depth of 20 to 30m.

3.5.3 In addition, many valleys follow lines of structural weakness with a higher frequency of fractures. Many of the dry valleys are linear, consistently trending in a limited number of directions, and the frequency and regular spacing of the valleys (lineaments) indicates a relationship to significant fracture lines. Also, major structural features, such as the Chichester Syncline, have affected transmissivity by focusing groundwater in three discharge areas, namely the Fishbourne springs, the Bedhampton springs, and at Arundel, and producing local zones of high transmissivity.

3.5.4 Superimposed upon the general topographical distribution are other effects which sometimes result in high permeability and karstic behaviour. Lithology has a marked effect on fracturing, and hence on aquifer properties. For example, soft Chalks tend to have less well-developed fractures and aquifer properties are consequently poorer. Solution features appear to be more common within the Upper Chalk (softer White Chalk) than the Middle and Lower Chalk (harder Grey Chalk) (Edmonds and Walton, 1983).

3.5.5 There is also a strong litho-stratigraphical control on the development of solution-enhanced fissures and conduits in the Chalk formations with most developed at the inception horizons of hardgrounds, marls and flint layers (Allen et al., 1997; Maurice et al., 2021). The Upper Chalk or White Chalk formations include many potential inception horizons (hardbands) increasing the probability of dissolution resulting in karst feature formation.

3.5.6 The presence of hardgrounds, particularly when near the surface, can significantly increase the permeability of the Chalk. Hardgrounds probably fracture more cleanly than other Chalks due to their greater hardness (Allen et al., 1997). Marls enable enhanced dissolution due to their low permeability and the consequent focusing of flow in adjacent strata. Similarly, flint layers may also form barriers to flow (especially tabular flints), concentrating flow above or below them.

3.5.7 The importance of hardbands as inception horizons, which are often laterally continuous over large distances, means that there is a strong bedding control on the development of Chalk permeability with flows concentrated along the dip and strike of bedding partings (Farrant et al., 2022). Vertical and conjugate fractures transfer groundwater downwards between bedding plane horizons. The focusing of flow on inception horizons can lead to a layered system in the Chalk with vertical hydraulic discontinuities within sequences (Karapanos et al., 2021). Inception horizons are also associated with the formation of spring discharges (Soley et al., 2012) and can control the spatial and temporal variation flow of winterbourne streams (Allen et al., 1997; Farrant, 2021).

3.5.8 Vertical profiles of permeability have been interpreted from flow logs and together with packer test results indicate that:

- permeability measured throughout a sequence in a borehole is about an order of magnitude greater than the matrix permeability;
- only a few large fractures are necessary to give the high transmissivity indicated by pumping tests;

- zones that have very high permeabilities correspond to fracture horizons;
- the most important flow horizons are almost invariably concentrated near the top of the Chalk, with less flow from depths greater than 50m below the surface of the Chalk; and
- the presence of hardgrounds, flints and marls can significantly increase dissolution of the Chalk adjacent to these features.

3.6 Groundwater Abstractions

PWSs

3.6.1 PWSs within the Study Area are listed in **Table 3-2** and shown within **Figure 26.4.5**. The table includes an assessment on whether each supply requires further consideration within this HRA and provides the rationale for this decision.

3.6.2 There is some borehole information available for the vicinity of certain of these PWSs. Data from the BGS GeoIndex for a borehole called Green Lodge Angmering drilled in 1910 to a depth of 60.96mbgl (located at around 18mAOD between builds at Green Lodge, north of the A27 carriageway) is in the vicinity of the Angmering Park Stud Farm PWS borehole shown within **Table 3-2** (uncertain if it is the same borehole although the BGS record says it was disused in 1959). This borehole gives useful data for the thickness of the Paleogene in the area, with the drift and Reading Formation described as mottled and yellow clay with flints 16.15m thick above Chalk with flints. The rest water levels recorded at the time were at 13.4mbgl.

3.6.3 There are also two BGS boreholes in the vicinity of “The Decoy” PWS and again it is uncertain which if any pertain to the currently abstracted borehole. The Decoy Cottage Angmering borehole was drilled to 51.51mbgl possibly prior to 1895, and a rest water level recorded at approximately 8mbgl. Drift (described as 6m thick of “valley gravel”) and over 50m of London Clay and Reading Formation exist in the area above the Chalk aquifer. The Manor Farm Poling borehole is located 30m to the north-west and was drilled to 60.96mbgl in 1980. Rest groundwater level was measured at 8.23mbgl and geology recorded as blue / grey clay down to 28.35mbgl above Chalk and flint. This borehole was cased to 38.1mbgl prior to undergoing a pumping test where abstraction must be from the Chalk aquifer. Both boreholes in the vicinity of “The Decoy” are at approximately 10mAOD.

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Table 3-2 Private Water Supplies Within the Study Area

ID*	Supply name	NGR	Supply type	Regs	Use	Daily usage (m^3/day)	Conceptual reason for further assessment within HRA
P4	The Decoy	TQ 058053	Borehole	Exempt	Single Domestic - Exempt	Unknown	**Screened In.** A groundwater abstraction 150m south-west of the proposed DCO Order Limits. Although the borehole and infrastructure is located on the Lambeth Group geology the PWS is down hydraulic gradient of proposed HDD works. Low permeability layers above the Chalk aquifer are likely to be of a significant thickness but uncertain at the HDD locations.
P5	Suzy Smith Racing / Angmering Park Estate	TQ 066074	Borehole	Unknown	Supplies approximately 50 residential properties on the Angmering / North Park Estate and other properties in Arundel	Unknown	**Screened In.** Groundwater abstraction 500m west of the proposed DCO Order Limits and within the same geology (Chalk). Although beyond a 250m buffer from the proposed DCO Order Limits it is down hydraulic gradient and within a shallow valley named the *Buckman*s on Ordnance Survey mapping, where the route crosses and where there is Clay-with-flints superficial deposits.

ID*	Supply name	NGR	Supply type	Regs	Use	Daily usage (m^3/day)	Conceptual reason for further assessment within HRA
P7	Upper Barpham	TQ 067089	Borehole	Reg 10	Small supplies, including small shared supplies and those to single dwellings only (Reg 10)	Unknown	**Screened Out.** Groundwater abstraction within the Chalk on Clay-with-flints but approximately 600m west of and up hydraulic gradient of the proposed DCO Order Limits.
P8	Turners Dairies	TQ 090084	Public Supply	Reg 8		Unknown	**Screened Out.** Groundwater abstraction within the Chalk but approximately 970m south-east of the Proposed DCO Order Limits route. It is approximately 275m north-east of the access road upon which upgrading works are planned on Michelgrove Lane (Access-26). However, these works are minor and the PWS is up hydraulic gradient of the access road. It is approximately 970m away from a section of open cut associated with the temporary construction corridor.
P9	Long Furlong Barn	TQ 095075	Borehole	Reg 9	Large supplies and those used as part of a commercial or public activity (including some	Unknown	**Screened Out.** Groundwater abstraction within the Chalk and approximately 1.5km from Proposed DCO Order Limits and 410m from the nearest site access road (Access-26), Michelgrove Lane,

ID*	Supply name	NGR	Supply type	Regs	Use	Daily usage (m^3/day)	Conceptual reason for further assessment within HRA
					supplies to tenanted single dwellings) (Reg 9)		which will involve minor upgrades during construction. Screened out based of distance from any significant works and location up hydraulic gradient from the nearest works proposed on the access road.
P10	The Chantry Mere	TQ 092128	Groundwater		Domestic-Potable	8	**Screened In.** A groundwater abstraction within 50m of a site access on an existing road (Chantry Lane) (Access-30). Although it is within the Upper Greensand Formation and 800m north of the proposed DCO Order Limits and HDD infrastructure, it is down hydraulic gradient of this proposed works.
P19	East Cottage	TQ 090086	Borehole	Reg 10	Small supplies, including small shared supplies and those to single dwellings only (Reg 10)	N/A	**Screened In.** Likely groundwater abstraction just over 300m to the south-east of the Proposed DCO Order Limits.
P20	Green Pastures	TQ 091083		Reg 8	N/A	N/A	**Screened In.** Likely groundwater abstraction within 160m of a site access on an existing road (extension to Longfurlong Lane)

ID*	Supply name	NGR	Supply type	Regs	Use	Daily usage (m^3/day)	Conceptual reason for further assessment within HRA
							(Access-27) and 600m south-east of the proposed DCO Order Limits.
P21	Myrtlegrove Cottage Stables	TQ 089085	Borehole	Reg 8	N/A	N/A	**Screened In.** Likely groundwater abstraction just under 300m to the south-east of the proposed DCO Order Limits.
P22	The Martins	TQ 090084	Borehole	Reg 8	N/A	N/A	**Screened In.** Likely groundwater abstraction just approximately 370m to the south-east of the proposed DCO Order Limits.
P23	Myrtlegrove Cottage	TQ 081100	Borehole	Reg 8	N/A	N/A	**Screened Out.** Located 900m and hydraulically upgradient of the proposed DCO Order Limits.
P24	Michelgrove	TQ 081083	Borehole	Unknown	N/A	N/A	**Screened In.** A groundwater supply within 250m of minor road upgrade works along Michelgrove Lane and within a valley and 340m downgradient of a trenchless crossing (TC-12).

* ID given within the ES Water Chapter baseline section

Public Water Supply

3.6.4 The SW public water supply boreholes within the Study Area are listed within **Table 3-3** and shown within **Figure 26.4.5**.

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Table 3-3 Southern Water Public Water Supply Boreholes

Source	Catchment	National Grid Reference (NGR)	Depth	Casing depths
Angmering Borehole 1	Angmering	TQ 058070	123m below the headworks flange	39.6m below the headworks flange
Angmering Borehole 2	Angmering	TQ 067067	125.3m below the lining flange	33.81m below the lining flange
Angmering Observation Borehole	Angmering	TQ 058069	N/A	N/A
Clapham	Clapham	TQ 090063	N/A	N/A
Clapham Borehole	Clapham	TQ 091063	N/A	N/A
Patching Well 1	Patching	TQ 092073	149m (bgl)	36.2m (bgl)
Patching Well 2	Patching	TQ 091074	152.5m (500ft)+	36.2m (below flange plate)
Patching Observation Boreholes 1, 2, 3	Patching	N/A	N/A	N/A

Note:*NGRs are estimates and have not been confirmed with SW as data was not available.+ Based on information provided by the BGS Borehole Database and / or SW Company Records

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3.6.5 The Angmering abstraction boreholes comprise Boreholes No. 1 and No. 2 (**Table 3-3**) and are located on the northern edge of Hammerpot Copse and 250m south-west of Wepham Hall respectively. Angmering Borehole No. 1 is over 700m to the south-east of Borehole No. 2. It is believed that there is an observation borehole (Angmering 2 Observation Well) located at the Angmering Borehole No. 2 site, although there is no available data for this borehole and the two boreholes distance apart is uncertain. The Angmering boreholes were drilled in 1971 and are shown on **Figure 26.4.5**.

3.6.6 The Angmering Park Borehole No. 1 (named Angmering Main on geophysical reports) is approximately 1.5km north-west of Hammerpot, and is drilled to 123m below the headworks flange (set as datum) with casing set at 39.6m. Geophysical logging of the production borehole, undertaken in May 1995 probably due to inspection and turbidity issues, has indicated that there are possible zones of inflow and / or outflow between 46 and 60m, 75 and 92m and at 102m below datum (Southern Science, 1995). Caliper logs identified major fissuring from 46 to 58m and at 56m, 78m, 83m and 100m below datum and temperature increase was observed from a depth of 75m.

3.6.7 The CCTV survey for Angmering Park Borehole No. 1 also identified possible casing failures at 9.6m, 17.4m and 25m below datum. The rest water level at the time of logging was at 37.3m below datum at No. 1 (recorded in 1995) and 29.15m below datum at No. 2 (recorded in 2017).

3.6.8 Angmering Park Borehole No. 2 (named Angmering Borehole 2 on geophysical reports) is located approximately 820m north-west of Hammerpot and is drilled to 125.3m below the lining flange (set as datum) with plain steel lining between 0 and 33.81m below datum and the remaining length of the borehole unlined. Geophysical logging of the production borehole undertaken in February 2017 has indicated that there is a large area of washout / breakout, with minor fissured areas observed in the unlined borehole to around 44.86m below datum. Flowmeter logs recorded inflow at around 37m below datum and caliper logs identified additional fissures at 48.73 and 73.15m below datum.

3.6.9 A CCTV survey conducted in May 1995 identified that the fluid column was turbid for its entire length. This survey also identified a series of flint bands between 45 and 54m below datum and well-developed fissures at 54.2, 54.3 and 56m below datum, as well as a well-defined vertical fissure at 58m below datum.

3.6.10 The Patching source comprises Boreholes No. 1 and No. 2 (**Table 3-3**). These are both located within the pumping station at Sleepy Hollow, just off the A280 Highway. There are also three observation boreholes surrounding the Patching site although there is no data available for these boreholes. There is an adit which intersects Borehole No. 1 at 44 to 46m depth and is assumed to also intersect Borehole No. 2. The distance between the two boreholes is uncertain but may be in the order of 50m.

3.6.11 A CCTV and geophysics log for Patching Borehole No.1 from October 1995 by SWS recorded a rest water level at the time of the survey at 36.9mbgl which coincides with the depth of the plain casing of the well at 36.2m (Southern Science Ltd, 1995). The geophysics survey noted that the majority of flow was from the intersecting adit, and some additional minor flow was reported between depth of 40 to 120m. Impeller flow logs observed possible flow zones at 41mbgl, between

60 and 74mbgl, and at 88mbgl, 98mbgl and 127mbgl. Substantial fluid seepage above the rest water level was noted at the base of the casing of the well and orientated to the north at the time of the survey.

3.6.12 The CCTV and geophysical log observed pump chaffing between 50 to 63m depth, indicating the pump is installed at around this level in borehole No.1. The conclusion of the October 1995 SWS report suggested that the pump should not be lowered below 50m depth. Fluid seepage at the base of the casing was observed approximately from a northernly direction.

3.6.13 A CCTV inspection and geophysical logging were carried out in the Patching Borehole No. 2 in February 2016. The rest water level at the time of the survey was recorded at 30.1mbgl (European Geophysical Services Ltd, 2016). The Chalk was generally homogeneous, “clean” with occasional fissured horizons. Initially the Chalk was heavily stained with possible iron deposits although this cleared at around 39mbgl. The adit was noted between 45 – 46.4m depth and is thought to connect with Borehole No. 1 to the west. The adit appeared to be in a good condition and structurally sound at this time. Flow points into the borehole were identified at depths around 45m, 86m and 92m. Flow rates were estimated to be around 4.5l/s from around 86 - 92m, increasing to around 6 l/s at 70m up to the adit at 45m.

3.7 Water Quality

3.7.1 The BGS hydrogeological report ‘The Chalk aquifer of the South Downs’ (Jones and Robins, 1999) provides the baseline groundwater quality for the South Downs aquifer. The Chalk groundwater is generally of good quality apart from the local effects of coastal saline intrusion and the threat of pollution, typically from fertilisers and pesticides used for agriculture. Nitrate concentrations are above the expected baseline and indicate some leaching from agricultural land. Intrusion of saline water can be of concern mainly at the near-surface but typically good quality groundwater is present below the intruding saline water which should not extend into the Study Area.

3.7.2 The chemical analyses of groundwaters from boreholes in the vicinity of the Study Area (**Graphic 26.4.3**) of the South Downs aquifer is shown in **Table 3-4**. Jones and Robins (1999) report that generally the groundwaters across the South Downs are aerobic as indicated by high dissolved oxygen concentrations, there is little degradation of nitrate, and iron (Fe) and manganese (Mn) concentrations are low. The magnesium / calcium (Mg / Ca) ratio is close to that of the Chalk sediment, implying relatively short residence times, as do the low concentrations. Beneath the Chichester Syncline, waters tend to be anaerobic causing loss of nitrate, and increasing concentration of most metals. The strontium / chloride (Sr / Cl) ratio for most of the waters indicates residence times in the order of decades, with the exception of beneath the Chichester Syncline. This is backed up by isotopic evidence, which suggests that most of the exploited groundwater in the area is modern, although one sample from the confined Chalk beneath the Chichester Syncline had a lighter isotopic composition and indicates a probable palaeowater geochemical signature.

Graphic 26.4.3 Borehole Location Map for Water Quality Data (Source: Jones and Robins, 1999)

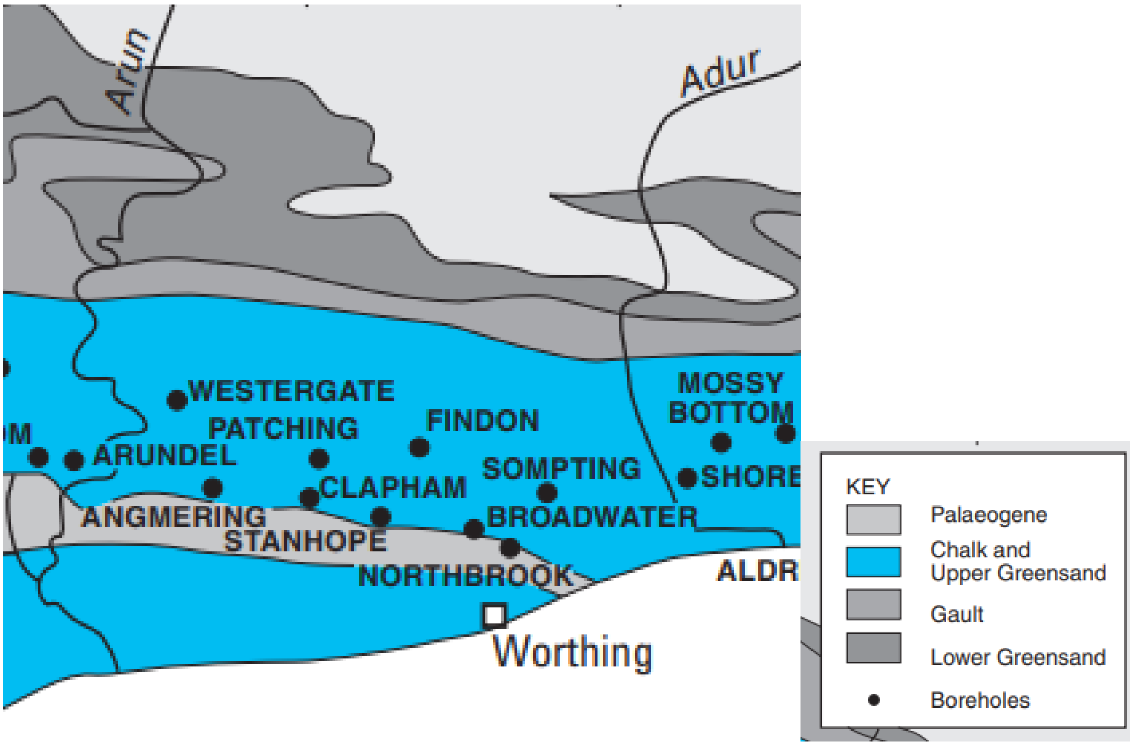

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Table 3-4 Chemical Analyses of Groundwater from the South Downs, mg/l unless otherwise specified (Jones and Robins, 1999)

Location	Temp	pH	O2	SEC (μS cm-1)	Na	K	Ca	Mg	HCO3-fld	SO4	Cl	NO3-N	Si	Sr	Ba	Li	Rb	B
Westergate	11.6	6.57	8.9	757.00	18.3	1.60	118.46	4.07	314.00	17.6	35.9	10	3.88	0.334	23.6	0.99	0.73	27.30
Patcham	11.5	6.86	9.4	580.00	12.5	0.92	84.34	2.07	215.00	11.8	24.3	4.5	3.23	0.212	17.7	1.17	0.86	13.80
Arundel	13.2	6.77	8.6	512.00	11.6	0.70	89.56	1.81	249.00	6.1	22.1	3	3.51	0.203	12.7	0.53	0.46	9.60
Burpham	10.5	6.97	7.2	636.00	12.3	1.07	89.03	2.01	241.00	8	22.9	4.8	4.26	0.204	11.5	0.67	0.55	13.40
Angmering	11.4	6.9	5.1	755.00	19.4	1.62	83.9	3.56	328.00	11.2	34.0	4.9	4.33	0.263	16	1.4		
Clapham	11.5	6.89	8.8	698.00	18.9	1.54	105.33	2.62	265.00	11.3	33.7	5.1	5.12	0.284	15.7	5.46	0.92	21.60
Patching	11.9	6.83	9.5	705.00	12.7	1.27	70.16	2.37	257.00	7.4	23.4	6	5.71	0.241	58.1	1.88		42.40
Findon	12.8	7	6	695.00	13.9	1.72	99.49	2.56	250.00	9.6	26.1	5.9	3.19	0.311	21.8	1.27	1.27	21.80
Sompting	11.1	6.92	7.3	639.00	18.5	1.34	99.81	2.80	233.00	18.2	32.9	6.6	4.63	0.222	20.9	0.75	0.64	25.80
Broadwater	11.1	7.04	0	775.00	14.4	1.76	100.87	2.50	244.00	17	27.0	40.9	3.82	0.243	1746.1	0.99	1.14	28.60

Location	Fe (total)	Mn	Cu	Ni	Zn	Pb	F	Br	I	pCO2 x atmos	SI (calcite)
Westergate	-0.1	-0.5	4.84	5.95	28.86	0.91	0.10	110.00	7.7	66.3	-0.12
Patcham	2.3	0.1	1.19	3.84	3.98	0.33	0.09	82.00	3.9	23.5	-0.11
Arundel	2.6	-0.2	3.83	5.16	4.97	1.10	0.09	71.00	3.9	34.2	-0.08
Burpham	4.6	-0.3	4.33	4.81	17.32	0.66	0.09	81.00	4.0	20.1	0.06
Angmering	-0.1	-0.1	1.32		3.97		0.09	120.00	6.4	32.5	0.10
Clapham	54.6	0.4	4.49	5.68	15.60	0.70	0.10	110.00	4.8	26.8	0.09
Patching	3.8	0.6	0.60	4.46	1.81		0.08	78.00	4.6	30.3	-0.13
Findon	2.3	-0.1	1.60	5.51	3.81	0.50	0.10	100.00	4.4	20.0	0.18
Sompting	4.7	0.4	5.30	6.98	3.84	1.06	0.09	140.00	5.1	21.9	0.04
Broadwater	4.2	0.2	2.57	7.68	18.79	2.06	0.09	110.00	5.5	17.3	0.17

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4. Conceptual Hydrogeological Site Model

4.1 Project Description / Proposed Works

4.1.1 The project description is provided in **Chapter 4: The Proposed Development, Volume 2** of the ES (Document Reference: 6.2.4). The ES considers the effects that could result from construction from across a specific 40m onshore temporary construction corridor within the larger (approximately 60-80m) proposed DCO Order Limits. The width of the onshore cable corridor for surface open trenching is therefore up to 40m (widened in locations where there is a technical necessity, such as at trenchless crossing sites).

4.1.2 Construction activities are also described in detail within **Chapter 4: The Proposed Development, Volume 2** of the ES (Document Reference: 6.2.4). Cable trenches will be excavated and backfilled, with a target excavation depth of on average 1.2m to install the cable circuit. Access tracks will also be constructed to facilitate the movement of construction vehicles and plant. The works will also require a number of temporary site compounds, which will also require topsoil stripping to provide a suitable area. Temporary construction compound areas will include storage of material / waste and equipment, and welfare facilities.

4.1.3 Trenchless crossings will be used through any sensitive locations and / or because of logistical requirements, with associated compounds for this work. For trenchless crossings, excavation depths will be much deeper, up to 25mbgl. At watercourses the pre-fabricated concrete duct protection blocks will be buried well at a depth of approximately 1m below the watercourse.

4.2 Potential Sources of Impact

4.2.1 There is the potential for spillage or leakage of fuels, lubricants or other chemicals during construction during the cable laydown at compounds and during the movement of construction vehicles and plant. HDD works pose the greatest risk to receptors given that they involve drilling to greater depths, sometimes within the Chalk aquifer in places. Details of the HDD proposed works are given within **Chapter 4: The Proposed Development, Volume 2** of the ES (Document Reference: 6.2.4). At HDD sites there is the potential for the breakout and leakage of bentonite and drilling fluids into the subsurface and/or the increase in turbidity within groundwater, with a subsequent decrease in receiving water quality.

4.2.2 In general, Chalk groundwater abstractions within the South Downs are known to be at risk from potentially polluting activities (including agriculture pathogenic microorganisms, such as coliform and cryptosporidium), transport infrastructure and industry within their catchments. Care should be taken therefore during works not to mobilise contaminants in areas such as these, i.e., within land drains, sewer system, soakaways etc. The abstractions are also known to be prone to elevated natural turbidity.

4.3 Potential Pathways

4.3.1 Potential pathways include surface karst features, such as stream sinks and hydrogeologically active stream sinks and dolines which provide a potential mechanism for pollutants and sediments to enter the Chalk aquifer directly. In addition to surface karst features, there is the potential for vertical / horizontal (often along bedding planes and inception horizons) solution-enhanced fissures within the Chalk which have no surface expression to also facilitate rapid transport of pollutants and sediments through the unsaturated zone (Farrant et al., 2021; Maurice et al., submitted). For example, turbidity ‘spikes’ occur following heavy rainfall or site disturbance due to the widespread presence of high permeability fissuring in both the unsaturated (above water table) and saturated Chalk.

4.3.2 Karst aquifer catchments can be particularly difficult to assess for example where large springs and abstractions are fed by many different conduit and fissure networks which can extend several kilometres, and with the additional complexity of numerous flowpaths and substantial changes in catchment areas under seasonal high and low water levels (Maurice et al., submitted).

4.4 Potential Receptors

4.4.1 The list of water resource receptors (public water supplies and PWSs) associated with the Study Area are given in **Table 4-1** and shown within **Figure 26.4.5**.

Table 4-1 Water Resources Receptor List

Receptor	Rationale
Southern Water Boreholes	
Angmering Borehole No. 1 and No. 2	Regionally important SW public groundwater supply (and associated catchment / SPZ).
Patching Boreholes No. 1 and No. 2	
Clapham Borehole	
PWSs	
The Decoy (P4)	Unlicensed (assumed potable) groundwater PWS abstractions.
Suzy Smith Racing / Angmering Park Estate (P5)	
The Chantry Mere (P10)	
East Cottage (P19)	
Green Pastures (P20)	
Myrtlegrove Cottage Stables (P21)	
The Martins (P22)	

Receptor	Rationale
Michelgrove (P24)	

4.5 Conceptual model

4.5.1 This section presents the conceptual model of the hydrogeological understanding of each of the areas of interest in terms of a source / pathway / receptor model. The SW boreholes whose SPZs are intersected by the proposed DCO Order Limits are the main focus of concern since these represent potential areas in which pathways may most likely exist. The discussion is supported by conceptual cross sections (**Graphics 26.4.4 – 26.4.5**).

Angmering Public Water Supply Area

4.5.2 The Angmering public water supply comprises two boreholes (Borehole No. 1 and No. 2). The proposed DCO Order Limits is located approximately 500m east of Borehole No. 2 at its closest point (**Figure 26.4.5**). The proposed DCO Order Limits route crosses SPZ 2 and SPZ 3 of the Angmering boreholes, as the route moves northwards, for 1240m of the route in SPZ 2 and 725m within SPZ 3 (up to the HDD compound HDD TC-12a).

4.5.3 Angmering Borehole No. 2 is on ground that slopes gently to the south, aligned with the shallow (five degrees) regional Chalk dip. At this location there is no superficial deposits overlying the Chalk aquifer, and only thin soils exist. Angmering Borehole No. 1 is located approximately 900m north-east of Borehole No. 2 within a shallow valley on ground rising to the north. The borehole is located on the edge of head deposits overlying the bedrock of Spetisbury Chalk Member strata.

4.5.4 To the south of the boreholes is the Chichester Syncline, and London Clay overlies the Lambeth Group within the centre of the syncline (**Graphic 26.4.4b**). The proposed DCO Order Limits route passes over the Lambeth Group on either side of the A27 carriageway. North of the A27 the proposed DCO Order Limits route moves onto the Spetisbury Chalk Member (approximately 500m to the south-east of Borehole No. 2) as the route passes directly to the north. Within the Study Area (close to the proposed DCO Order Limits route) the lithology of the Lambeth Group varies spatially and with depth. Within boreholes logs to the south of the SW Angmering boreholes it is described as having thick layers of clay (10 - 30m), with this clay mottled in some areas and in others interbedded with marl. Additionally, there is flint within some of the marl and clay bands and thin layers (around 2m thickness) of sand and coarse gravel.

4.5.5 Head deposits exist over the syncline, but none are present overlying the Chalk over much of the catchment, apart from running up the valleys to and from the Angmering Park Stud Farm. These are predominantly dry valleys although there is a pond water feature at the Stud Farm which flows to a sink possibly indicating the head is impermeable to a certain extent. The Suzy Smith Racing / Angmering Park Estate (P5) PWS is located to the north of this area where a valley branches into two.

4.5.6 Recharge in this area will largely be directly into the Chalk aquifer and the source is therefore vulnerable to pollution through rapid fissure flow to the boreholes, albeit a thick unsaturated zone exists across much of the area. The closest Clay-with-flints outcrops is 500-800m north of Borehole No. 2, on higher ground. There is some evidence (from SW surveys) of karst features running along the centre lines of dry valleys to the south of Angmering Park, and although this is in line with conceptual understanding of karst development within the Chalk, this could not be confirmed in the field.

4.5.7 A swallow hole has been observed approximately 200m south of the Chalk / Lambeth Group outcrop some 600m south of Borehole No. 2. This is possibly part of a line of swallow holes developed along the Lambeth outcrop in this area. The swallow hole at “The Lions” was observed during the site visit in November 2022 (**Annex A**). This was a large swallow hole 5m by 5m and 1.5m deep. A ditch with water flowing west-south-west along a woodland edge was feeding water into the swallow hole at approximately 0.2l/s. Small depressions were also found in the area and there appeared to be an east to west line of karst features at this location.

4.5.8 The development of karstic features along the edge of the Palaeogene deposits due to acidic runoff effects is well documented. It is assumed that the general flow of groundwater is down through the unsaturated zone until an interception horizon is encountered, with unsaturated / groundwater flow predominantly to the south / south-west in the direction of dip.

4.5.9 A spring is shown on OS mapping at just north of Hammerpot. A ditch between the PRoW and private property was observed but was not flowing at the time of the site visit, but no spring was observed at this location. The apparent spring occurs along a valley on the Lambeth Group, broadly trending north-east to south-west. To the east along the valley and up hydraulic gradient are located ditches within Fox Rough, indicated to be the origin of a Chalk stream. This water feature ends at a large swallow hole south of Swillage Barn, aligned to drainage and a footpath in the area . This was visited during the November 2022 site survey and consists of a large feature, 40m by 8m and 3m deep. The feature runs along the line of a man-made ditch and along the border of field and footpath (**Annex A**). Drainage mapping produced by Arun District Council (ADC) indicates that a soakaway has been installed within the swallow hole in response to flooding in the area. To the west of the valley line and down hydraulic gradient is a series of ponds located 50-100m south of proposed DCO Order Limits route where the route is south of the A27, along the route of the Chalk stream previously identified.

4.5.10 Rest groundwater levels within the Angmering public water supply Borehole No. 2 are at approximately 1mAOD (**Graphic 26.4.4**), and a groundwater level just above 0mAOD on the upper slopes of the Chalk hills appears consistent with historical boreholes in this area. This suggests the presence of a thick unsaturated zone, even prior to the pumping drawdown in the area from the Angmering abstraction boreholes. The casing within the Angmering Park Borehole No. 2 was set at 33.81m depth (below reference) with inflow recorded at around 37m and fissures occurring predominantly below 48m depth. This indicates likely pathways into the borehole, above and below the drawdown.

4.5.11 The sinking and reappearance of watercourses within dry Chalk valleys is commonly observed and flow is dependent on the groundwater levels within the Chalk and often seasonally controlled. In this area along the valley within the Lambeth Group the relationship between the water levels within the Chalk and possible perched water tables within the Lambeth beneath head deposits may be more complex. However, vertical upward hydraulic gradients and flow from the Chalk into the Lambeth and to the Chalk stream is indicated within the valley.

4.5.12 It is noticeable in the surrounding area that springs / water features appear to occur along a line that is approximately 500m south of the Chalk / Lambeth Group boundary and may indicate the area in which vertical hydraulic gradients are reversed from sinking to rising. Alternatively, the Lambeth may become more impermeable in this area and the Chalk becomes increasing confined to the south.

4.5.13 The Hammerpot observation borehole, approximately 0.5km to the south-east of the Angmering public water supply Borehole No. 2 was investigated as a result of anomalous borehole water quality conductivity profiles in September 1986 and October 1991 (BGS, 1999). The logged profile for fluid conductivities ranged from 680 to 850µS cm^{-1} down to 62m depth, below which conductivity reduced. Water sampling also showed an unusual water chemistry enriched in dissolved salts and it was concluded that these logs represented a localised and periodic condition, and possibly related to the confined conditions at this site.

4.5.14 The spring at Hammerpot is approximately 40m from the proposed DCO Order Limits route at is closest point and approximately 70m south of HDD compound TC-11. This is shown on cross-section A-A' (**Graphic 26.4.4**), with groundwater from the Chalk aquifer having been interpreted as being drawn upwards through the Lambeth Group and head deposits and re-emerging at surface. This spring forms part of a Chalk stream, which runs north-east to south-west through the area, sinking and reappearing at several points and representing a line of hydrogeological significance.

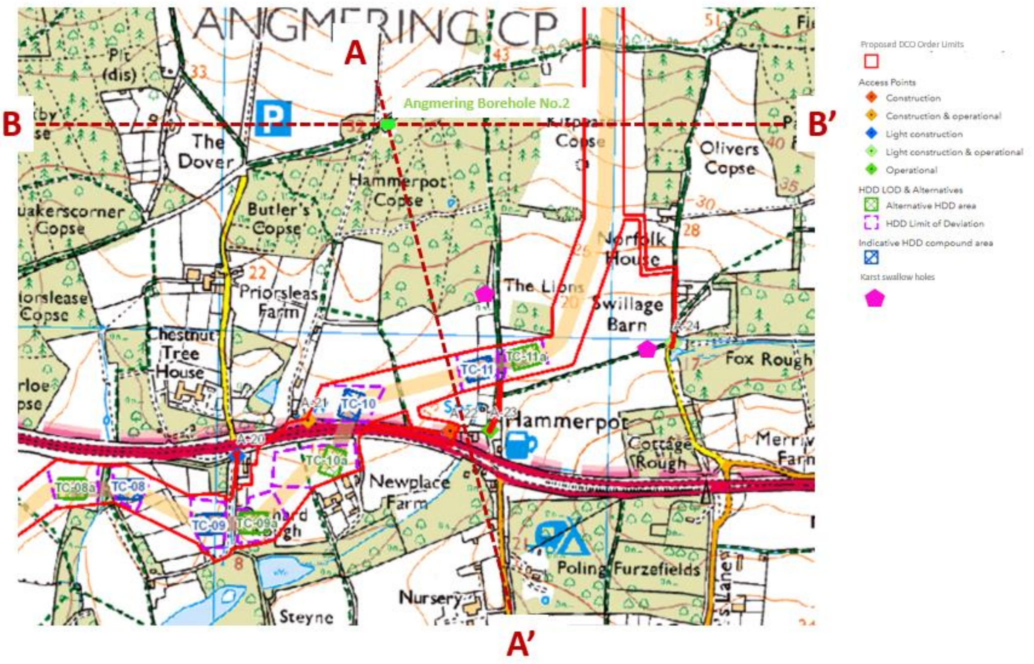
4.5.15 The Decoy (P4) PWS near the A27 is outside of the SPZs but close to the proposed DCO Order Limits route, including HDD compounds. Assuming a zone of influence of 250 m, there is the potential for the PWS to be affected by drilling for these compounds. It is recommended that drilling for the HDD does not go below the base of the Lambeth Group to minimise impacts to the Chalk aquifer. However, it is not known what strata the PWS is abstracting from.

4.5.16 In terms of potential sources of impact (**Graphic 26.4.4b**) associated with the proposed DCO Order Limits route in this area, these are summarised as follows:

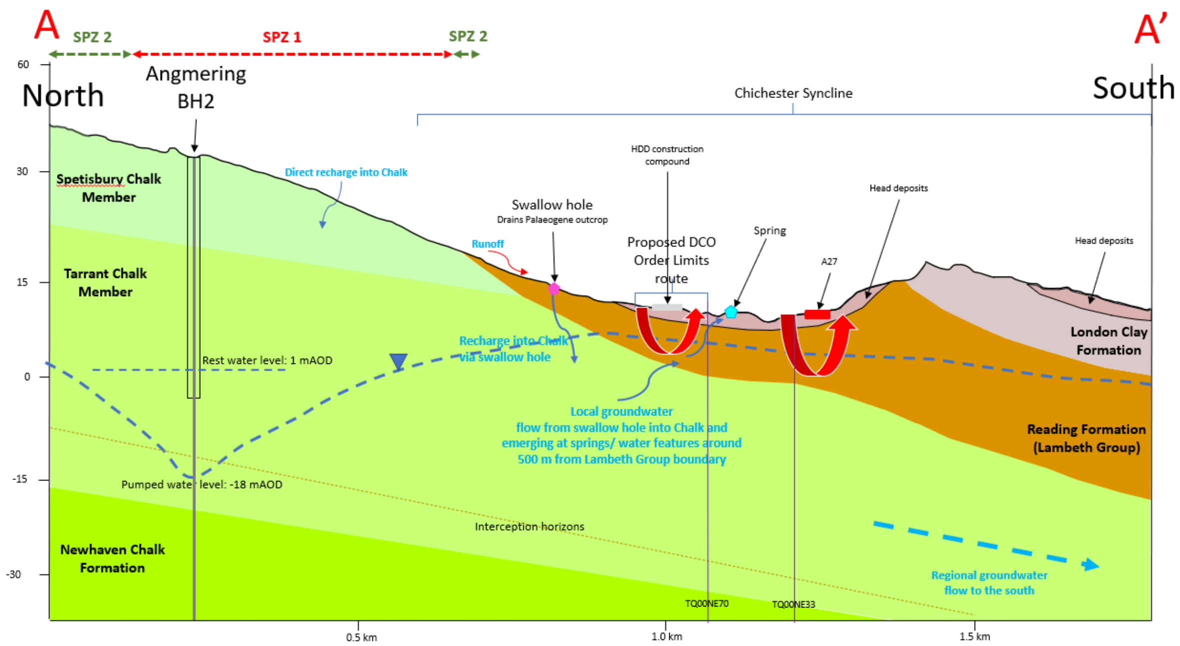
- the proposed HDD beneath the A27 within the vicinity of the Decoy (P4) PWS in this area; and
- the proposed cable excavation within SPZ2 of the Angmering public boreholes (specifically Borehole No. 2), at its closest point approximately 600m to the east of the borehole.

4.5.17 Although the route is more than 250 m from Angmering Borehole No. 2 it is uncertain whether it is outside of its zone of influence, such that there is a potential pathway along interception horizons within the Chalk. These will outcrop at the surface further to the north of the borehole and further to the north along the proposed DCO Order Limits in the area.

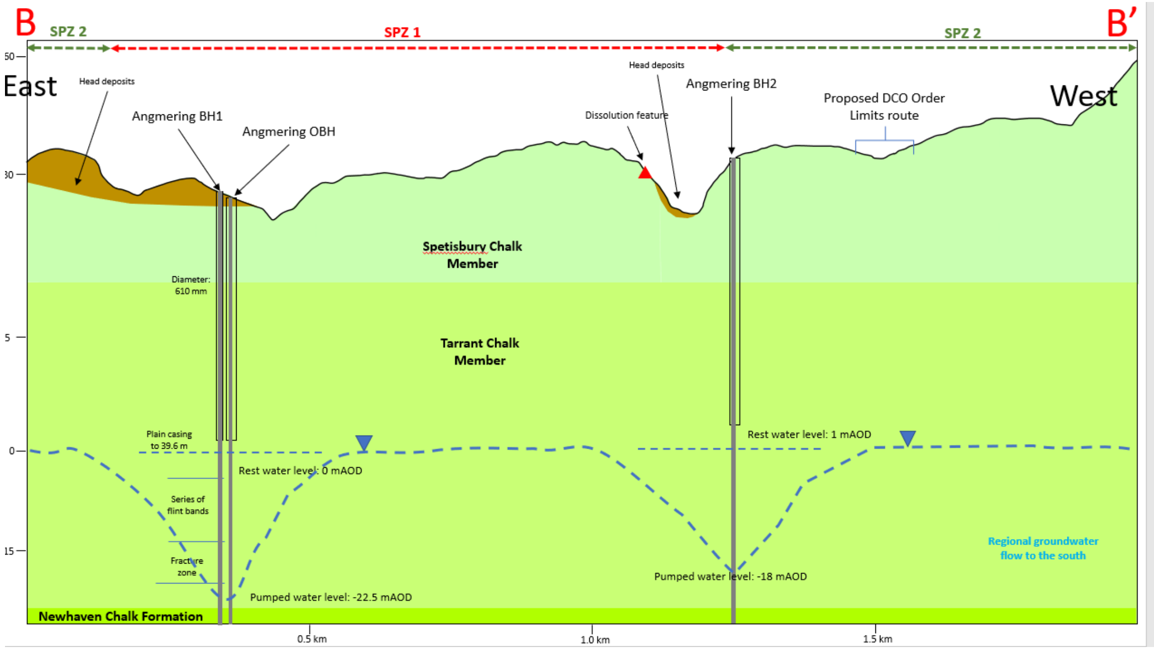
Graphic 26.4.4a Angmering Borehole No.2 Conceptual Section Location Map



Graphic 26.4.4b Conceptual Section A-A'



Graphic 26.4.4c Conceptual Section B-B’



Patching / Clapham Public Water Supply Area

4.5.18 The proposed DCO Order Limits route is located approximately 1.3km to the north of the Patching Boreholes No. 1 and No. 2 (**Figure 26.4.5**), whilst the access track (Access-26) along which upgrading works are proposed are only 50m away at its closest point. Both boreholes lie on relatively flat ground, sloping gently to the east, and are located at the head of a north to south orientated valley (Longfurlong) along which the A280 carriageway passes. The valley divides into two north of the boreholes trending to the east towards Longfurlong Barn (route of the A280) and to the north-west (access track route) forming noticeably steep southern aspects to the valley sides.

4.5.19 The topography rises gently to higher ground in the north (Blackpatch Hill 169mAOD). Proposed construction activities along the proposed DCO Order Limits route are located on this higher ground and are up-hydraulic gradient of the boreholes. The proposed DCO Order Limits route crosses the SPZ 2 1.4km north-west of the Patching boreholes, whilst the access track south-west of the boreholes lie within their SPZ 1, as well as the SPZ 1 of the Clapham public water supply abstraction.

4.5.20 The Clapham borehole is almost 1km south to the south of the Patching boreholes at a lower elevation within the Longfurlong valley. This valley forms a significant break within the southern South Downs dip slope Chalk, along which the A280 carriageway passes. This valley is likely a significant hydrogeology feature and groundwater flow pathway, within which the Patching and Clapham boreholes have been placed.

4.5.21 The Patching Boreholes No. 1 and 2 are within the Chalk showing a dip towards the south, in line with the regional five degrees dip in the area. At this location, to the west of the boreholes, a narrow (80m wide) band of superficial head deposits overlie the Chalk aquifer within the base of the valley.

4.5.22 The Longfurlong valley exposes the Tarrant Chalk Member further to the south (**Graphic 26.4.5b**). The Newhaven and Seaford Chalk Formations outcrop to the north, across which the proposed DCO Order Limits route passes. There are no HDD operations proposed in this part of the proposed DCO Order Limits. To the south of the Clapham borehole is the Chichester Syncline and the London Clay overlies the Lambeth Group within the centre of the syncline.

4.5.23 Recharge in this area will therefore largely be directly into the Chalk aquifer and with there being no superficial deposits and only thin soils, the public water supply (Patching and Clapham) boreholes are therefore vulnerable to pollution through rapid fissure flow to the receptors, albeit a thick unsaturated zone exists across much of the area. There is a small patch of Clay-with-flints on the top of Blackpatch Hill. The SW karst survey was not undertaken in the area north of the Patching boreholes and during the site visit (**Annex A**) no karst features were identified. Karst dissolution features and swallow holes were identified south of Clapham, associated with the Palaeogene fringe, but they are a considerable distance from the main proposed DCO Order Limits route and are not considered further.

4.5.24 The valleys across the area are dry with no water features observed. The Longfurlong valley is also dry with a small pond and observed head and alluvial deposits 230m south-west of Clapham, with the larger Patching pond south of this. These water features occur at the Chalk / Paleogene boundary.

4.5.25 Seasonal maximum groundwater levels within the Patching public water supply borehole No. 2 are between -28mAOD and -9mAOD for maximum winter and minimum summer levels respectively (Plate 5b). This borehole exhibits 10 - 35m seasonal fluctuations in groundwater levels. Hydrogeological mapping shows a ‘cone of depression’ around the Patching boreholes and groundwater levels rising slowly to the north beneath the Chalk hills, to around 15mAOD beneath Blackpatch Hill (at a ground elevation of 169mAOD). Groundwater levels were identified by BGS’s three test bores in the area in 1952, one of which appears to match with the location of the Turners Dairies (P8) PWS, where at a ground elevation of 157mAOD groundwater rest levels of approximately 12.5 mAOD were observed. Flow into the Patching borehole No. 1 has been noted from the north (below the base of the casing) within the unsaturated zone and from various depths within the saturated zone.

4.5.26 Dry Chalk valleys are potential groundwater flow paths and trend north-east to south-west from the south-western aspect of Blackpatch Hill towards Michelgrove and into the valley north of the Patching boreholes. The dominant flow will be along the two major valleys north-east and east of the Patching boreholes. Additional evidence for this is that the groundwater contours appear to steepen along these routes as the valleys turn northward. The SW Patching water supply SPZ 1 is orientated along the north-west valley only, which may be misleading since the boreholes are considered likely to take some or a significant amount of water from the eastern direction as well. The SPZ 2 then extends up along dry valley routes north of Myrtlegrove, between Harrow Hill, and these too are also likely to act as flow pathways. A natural hydraulic divide of higher ground appears to exist south-east to north-west, along the ridge from Patching Hill through Michelgrove to Barpham Hill, and is represented by a gap between the SPZs of the SW Patching and Angmering sources.

4.5.27 The PWSs of East Cottage (P19), Green Pastures (P20), Myrtlegrove Cottage Stables (P21) and The Martins (P22) lie in a cluster at Myrtle Grove Farm, 250m south-east of the proposed DCO Order Limits route. These PWSs are located within a small valley that runs to the north-east towards the top of Blackpatch Hill. An access track runs across the valley head towards the top of the hill. The proposed DCO Order Limits route runs to the north within another separate dry valley to the north-west. Details of these boreholes are unknown and it is not clear how deep or what strata the PWSs are abstracting from.

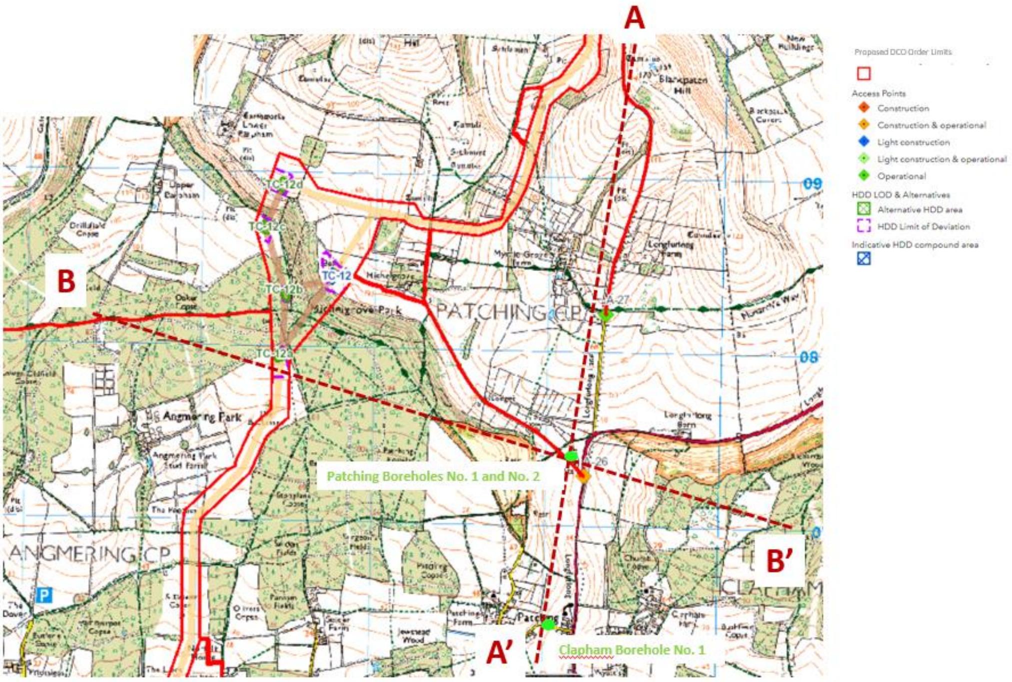
4.5.28 The Michelgrove (P24) PWS is located at Michelgrove, 250m east of the proposed DCO Order Limits route. The PWS is also 360m east of a proposed HDD compound TC-12 and both the route and the compound are located within the same valley that descends to the south-east.

4.5.29 The Chantry Mere (P10) PWS is a spring source, located on head superficial deposits and the Upper Greensand Formation at the base of the Chalk scarp in the north of the South Downs and approximately 820 m north of the proposed DCO Order Limits route and HDD compound TC-15b. A valley lies to the south-west of the PWS and this is the flow path through the Chalk to the spring. An access track drops down the slope to The Chantry along the eastern edge of the valley.

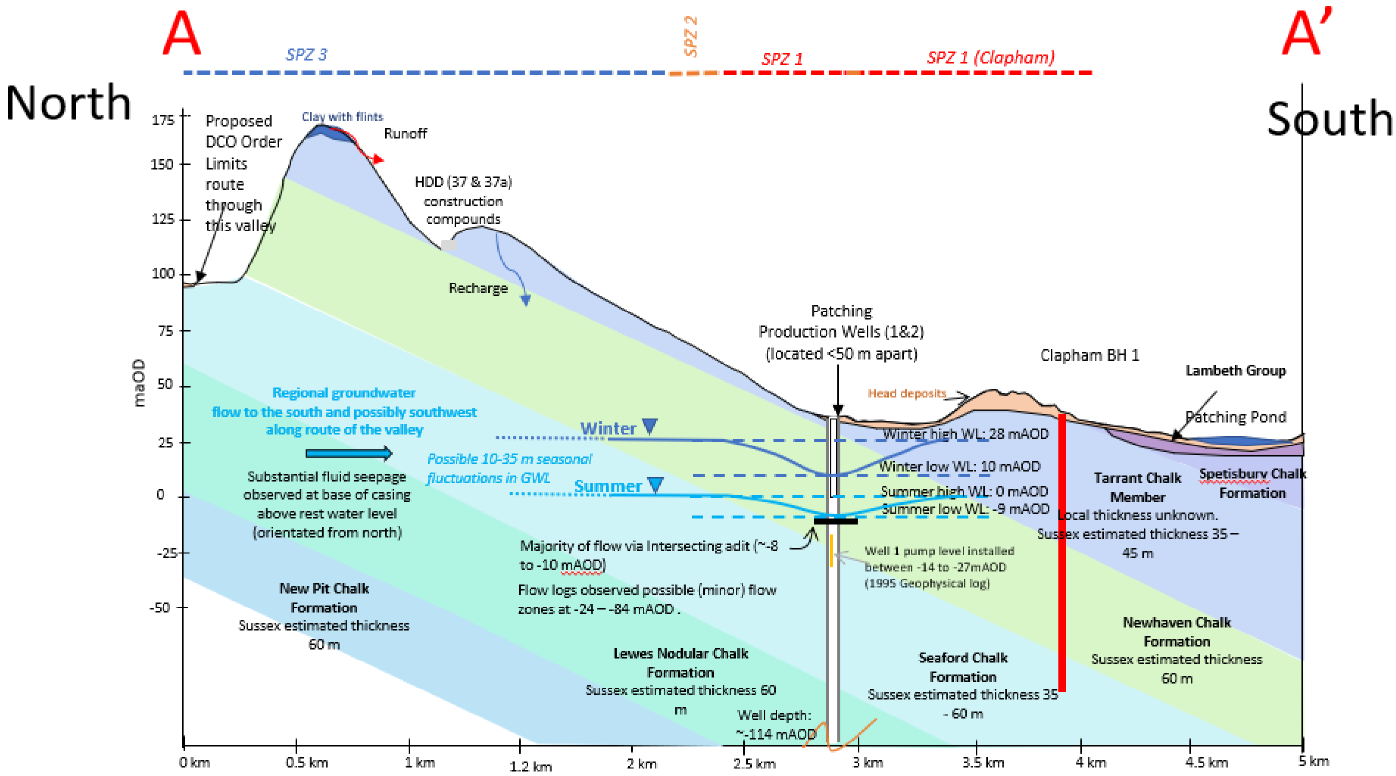
4.5.30 In terms of potential sources of impact (**Graphic 26.4.5a**) associated with the proposed DCO Order Limits route in this area, these are summarised as follows:

- access track works in close proximity to the Patching boreholes;
- the proposed cable excavation and HDD 250m to the west of the Michelgrove (P24) PWS;
- the proposed cable excavation and HDD to the south of the Chantry Mere (P10) PWS spring; and
- access track works to the north-east of the following PWSs: East Cottage (P19), Green Pastures (P20), Myrtlegrove Cottage Stables (P21) and The Martins (P22).

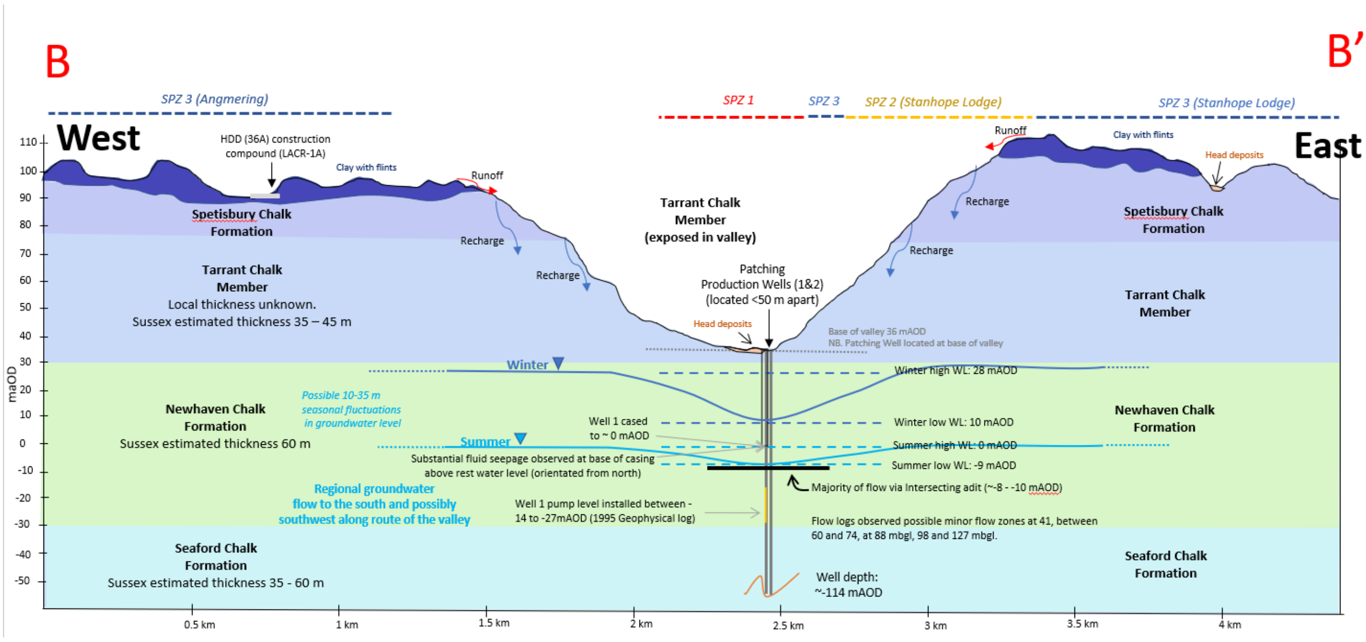
Graphic 26.4.5a Patching Borehole No.2 Conceptual Section Location Map



Graphic 26.4.5b Conceptual Section A-A'



Graphic 26.4.5c Conceptual Section B-B’



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5. Hydrogeological Risk Assessment

5.1 Approach

5.1.1 The approach adopted follows the Government guidelines for a HRA report (Environment Agency and Defra, 2018) with conceptual source – pathway - receptor linkages identified. At this stage the information used is largely desk-based data drawing on records provided by the Environment Agency and SW but supported by site visits. The emphasis of this groundwater risk assessment is placed on the protection of groundwater public water and PWS abstractions. Other groundwater-related receptors are addressed within the **Chapter 26: Water environment, Volume 2** of the ES (Document Reference: 6.2.26).

5.1.2 The ES and this accompanying HRA identifies all the potential risk linkages and also the best practice techniques to mitigate the groundwater risks. SW has been involved in discussions regarding the Proposed Development in order to help mitigate these risks.

5.1.3 As identified in **Section 2.7** above the presence of SPZs in the vicinity of the Rampion cable route influences the assessment as follows:

- SPZ 1: Potentially polluting activities are not permitted in a SPZ 1. The Proposed Development does not identify any new potentially polluting activities in these areas;
- SPZ2: the Environment Agency will only agree to proposals for infrastructure developments where they do not have the potential to cause pollution or harmful disturbance to groundwater flow or where these risks can be reduced to an acceptable level. In order to reduce any risks the Environment Agency expects best available techniques (BAT) to be applied. All activities have been identified within SPZ 2s and have been assessed on this basis; and
- The SPZs represent the total catchment area of an abstraction source and any dewatering within this area has the potential to impact the quantity of supply to the receptor.

5.1.4 All PWSs used for human consumption or food production purposes have an SPZ 1 designation with a default radius of 50m and a 250m capture zone. However, on screening PWSs (**Table 3-2**) each specific hydrogeological regime at each supply has been considered separately due to the pathways that may exist within the Chalk environment that may allow the rapid transport of pollutants.

5.1.5 The following assessment therefore considers potential activities within SPZ1s and SPZ 2s and it is assumed that construction activities within SPZ 3 do not propose a risk given that embedded mitigation and best practice will be applied to all works. PWSs have been assessed based on their own particular hydrogeological setting and source – pathway - receptor model.

5.2 Methodology

Hazard Identification

5.2.1 Hazard (source of risk) identification has been undertaken for the current cable route to evaluate whether the development (with appropriate mitigation measures) is acceptable in terms of the risk to the receptors. The main mechanisms that could result in a release of contaminants to the groundwater for instance are from the leak of fuel, lubricants and other chemicals during proposed cable installation. In addition, the potential for breakout and leakage of bentonite during HDD trenchless crossing activities remains a hazard, particularly within the Chalk bedrock where karstic conditions may exist. Sediments can also be disturbed and released during cable route excavation, laydown and access track upgrading works. Dewatering of excavations is another source of risk, albeit related to groundwater quantity rather than quality.

Potential Risk Pathways

5.2.2 The main contaminant and sediment risk pathway is from the surface to the natural Chalk system by vertical flow in the unsaturated zone and lateral flow in the saturated zone. The thin soils present and exposed Chalk do not retain pollutants and sediments such that downward flow can occur into the unsaturated zone and ultimately to the water table.

5.2.3 The Chalk is a dual porosity system which means that although it has many rapid pathways (fissures) available for contaminants and sediments to travel along, the bulk of the water present is within the matrix. Matrix porewater has the potential to attenuate dissolved contaminants. In the saturated zone contaminants can move very rapidly and across long distances through fissures (karstic flow) and more slowly within the matrix by diffusion. The presence of extensive fissuring also provides the pathway for the transmission of excavation dewatering impacts.

5.2.4 Additional risk pathways can be created by the proposed works. For instance, incorrectly constructed and sealed deep HDD site investigation or water level monitoring boreholes may result in additional vertical pathways within the unsaturated zone that can intersect existing fractures and karstic features.

Risk Register

5.2.5 The risk register considers the on-site sources and pathways that have potential to cause effects during construction. These are listed in **Table 5-1**.

Table 5-1 Construction Activities, Potential Sources and Potential Effects

Activity	Potential Source	Potential effect
Construction phase		
Cable laying with machinery and refuelling	Spillage or leakage of fuels, lubricants or other	Potential for accidental contamination and

Activity	Potential Source	Potential effect
	chemicals and / or disturbance and subsequent release of sediments during cable laydown and installation.	sediments to enter groundwater and then the abstractions.
HDD works	Spillage or leakage of fuels, lubricants or other chemicals during drilling. This includes the potential for breakout and leakage of bentonite during trenchless crossing. Also disturbance and subsequent release of sediments.	Potential for accidental contamination and sediments to enter groundwater and then the abstractions.
Dewatering and drilling activities	Dewatering of the trenched excavations for cabling and during HDD.	Decline in groundwater levels which then affects abstraction yields.
Access track upgrading works	Spillage or leakage of fuels, lubricants or other chemicals during upgrading works from equipment / vehicles. Also disturbance and subsequent release of sediments.	Potential for accidental contamination and sediments to enter groundwater and then the abstractions.
Operation and maintenance phase		
Isolated cable repairs	Spillage or leakage of fuels and chemicals from vehicles onsite or during any repairs.	Potential for accidental contamination entering groundwater and then the abstractions.
Sub-surface structures and infills	The diversion of sub-surface land drainage flow pathways due to the permanent presence of limited below ground concrete lined joint bays, backfilled material around cable circuits and below ground cable structures and impermeable surfaces.	Decline in groundwater levels which then affects abstraction yields.
Decommissioning phase		

Activity	Potential Source	Potential effect
Isolated decommissioning works	Spillage or leakage of fuels and chemicals from vehicles onsite.	Potential for accidental contamination entering groundwater and then the abstractions.
Subsurface structures and infills	The diversion of sub-surface land drainage flow pathways due to the residual sub-surface structures and infills.	Decline in groundwater levels which then affects abstraction yields.

5.2.6 For each source, the risk assessment presented below considers the hazard (e.g. event causing a release of a contaminated substance or a dewatering effect to the environment), the magnitude and likelihood of the effect and its consequence (e.g. pollution or reduction in groundwater level at a receptor), before and after mitigation. Where the overall risk is identified as high or above then the proposed works are considered to represent an unacceptable risk unless further mitigation measures can be implemented.

5.2.7 The vulnerability of receptors is greatest where surface karst features allow point recharge and rapid unsaturated zone flow through stream sinks, dolines, losing rivers, vertical solution-enhanced fissures, and soakaways, and the underlying Chalk aquifer is characterised by solution-enhanced fissures and conduits and accompanying rapid saturated groundwater flow. In addition, vulnerability to groundwater is dependent upon the thickness and permeability of superficial deposits as well as the thickness of the unsaturated zone which reduces the likelihood of a pathway between the source and the receptor.

Mitigation Measures

5.2.8 As part of the Rampion 2 design process, a number of embedded environmental measures have been adopted to reduce the potential for impacts on water environment. These embedded environmental measures have evolved over the development process as the design progressed and in response to consultation.

5.2.9 These embedded environmental measures also include those that have been identified as good or standard practice and include actions that will be undertaken to meet existing legislation requirements. As there is a commitment to implementing these embedded environmental measures, and also to various standard sectoral practices and procedures, they are considered inherently part of the design of Rampion 2 and are set out in **Table 26-20** of **Chapter 26: Water environment, Volume 2** of the ES (Document Reference: 6.2.26). This sets out the relevant embedded environmental measures[5] within the design and how these affect the water environment assessment. Those with specific relevance to the HRA are summarised in the following paragraphs.

5.2.10 **C137** - All proposed onshore infrastructure and construction activities will be sited outside of the inner Source Protection Zone 1 (SPZ1) for the Southern Water public water supplies. The only exceptions to this will be for light 4 X 4 construction access route which crosses part of Warningcamp SPZ1 and the installation of several minor passing places within the Patching SPZ1. Access routes will utilise existing tracks, roads, farm entrances etc as far as practicable, and where necessary no-dig solutions (e.g. aluminium trackway) and other site specific measures (e.g. C-250 and C-251) would also be utilised. There will be no storage of hazardous materials including chemicals, oils and fuels within any SPZ..

5.2.11 **C227** - Techniques will be employed by the contractor to manage the risk of drilling fluid breakout or losses into the deposits or strata surrounding the HDD bore. Drilling fluids will be used to seal permeable deposits or strata. The naturally occurring bentonite clay will be used as the base for the drilling fluid, which will line the bore wall, preventing fluid loss and near-surface groundwater ingress.

5.2.12 **C234** - Techniques will be employed by the contractor to manage the risk of drilling fluid breakout or losses into the deposits or strata surrounding trenchless crossings (including HDD bores). The risk of breakouts can be mitigated by adopting good drilling practices, including the following:

1. Experienced drillers;
2. Standard process and procedures for drilling, data collection and communication;
3. Appropriate drill fluid monitoring (fluid properties, volume/flow and downhole pressure);
4. Development of a breakout response plan, so that equipment and trained personnel are in place for rapid response; and
5. Acquisition of rights-of-way or easements for at least the first 60m from both the entry and exit holes so that no access-related delays are incurred in response to any breakouts.

5.2.13 **C235** - Best practice techniques and methodologies will be undertaken during the implementation of HDD works. The HDD works are to be undertaken in accordance with Pipeline Design for Installation of HDD (Manual of Practice) by ASCE Oct 2014 or similar.

5.2.14 **C236** - For trenchless crossings detailed pre-drilling planning of methods and processes will be undertaken. The extensive pre-drill planning will include the completion of potential sub-surface structures along the alignment, environmental

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[5] Measures specifically for water resources pertinent to this assessment include: C-5, C-7, C-8, C-19, C-25, C-28, C-29, C-74, C-76, C-78, C-123, C-124, C-137, C-141, C-142, C-149, C-150, C-151, C-153, C-227, C-234, C-235, C-236, C-241, C-245, C-246, C-250, C-251, and C-253.

due diligence of the sites of the entry and exit holes, a geotechnical investigation along the proposed alignment to determine geological conditions with an emphasis on identifying sensitive areas and problematic ground conditions, and the analytical analysis of fluid pressures versus depth of cover to determine adequate depths of cover to minimise breakouts.

5.2.15 **C241** - During HDD activities, the drilling fluid engineer will carefully monitor the fluid usage in the recycling system and will quickly identify if fluid is being lost into the strata. If fluid loss is identified there are a number of measures that can be taken to seal the bore, including the following:

- Modifying the drilling fluid properties to increase the effectiveness of the bentonite clay filter cake that lines the wall of the borehole;
- Standard process and procedures in place for drilling, data collection and communication;
- Appropriate drill fluid monitoring (fluid properties, fluid volume and flow, and downhole annular pressure);
- Addition of stop-loss materials to bridge and seal larger voids in the soil; and
- Modifying the mud weight (drilling fluid density) to either balance or counter the groundwater pressure depending on ground conditions.

5.2.16 **C245** - Environmentally hazardous drilling fluids, or those containing groundwater hazardous substances, will not be used during trenchless crossings (including HDD).

5.2.17 **C246** - A watching brief will be carried out by the appointed Contractor and their Environmental Clerk of Works to monitor the drilling of the trenchless crossing (TC-11) and the excavation of trenches along a targeted part of the cable route which is in closest proximity to karstic solution features between Hammerpot and 'The Buckmans' (C12a) (Chainage 9.3km to 11.7 km). The watching brief will be carried out to identify sensitive areas and ground conditions (swelling clays, transition zones, preferential pathways for breakouts) in order to provide any evidence of karstic solution features within the cable corridor at this location. In the event that any solution features are identified then micro-siting of the route would be carried out to avoid such features.

5.2.18 **C-250** - The construction of the passing place upgrades along Michelgrove Lane will be programmed for Spring – Autumn (April – November) when groundwater levels in this area are typically lower.

5.2.19 **C-251** - Prior to the commencement of the construction of the passing places along Michelgrove Lane, these works areas will be visually checked by a qualified environmental advisor to confirm that there are no karst solution features.

5.2.20 **C253** - A water quality monitoring programme will be carried out at PWSs in proximity of the Order Limits, for instance at Brookbarn Farm, Suzy Smith Racing / Angmering Park Estate and Michelgrove for an appropriate period prior to during and post construction of the cable route. Further details of the monitoring regime will be discussed and agreed with Arun District Council at the post-DCO stage.

Risk Matrix

5.2.21 The risk matrix combines the likelihood of a hazard event occurring with the consequence of the event to derive an overall risk (negligible, low, medium, high and severe). The likelihood and consequence categories are summarised in **Table 5-2** and **Table 5-3** respectively and the combined risk table is set out in **Table 5-4**. Individual hazards are then assessed using this risk matrix.

5.2.22 The likelihood of an event is ranked using criteria in relation to catchment risk assessments used in the water industry and with individual water companies. The consequences used are in the context of the public water supply borehole sources which have been identified as the key receptors during this assessment. Consequences are also assessed in terms of the effect on the PWSs and the effect on these sources to continue to supply drinking water.

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Table 5-2 Likelihood Criteria

	Likelihood					
	1	**2**	**3**	**4**	**5**	**6**
	Remote	**Highly Unlikely**	**Unlikely**	**Possible**	**Likely**	**Highly Likely**
Historical	Unheard of in the water industry	Has occurred once or twice in the water industry	Has occurred many times in the industry	Has been experienced once or twice by a water company	Has occurred frequently in a water company's experience	Has occurred frequently at a particular location
Frequency: (Continuous Operation)	Once every 10,000 - 100,000 years atlocation	Once every 1,000 - 10,000 years at location	Once every 100 - 1,000 years at location	Once every 10 - 100 years at location	Once every 1 - 10 years at location	More than once a year at location or continuously
Probability: (Single Activity)	1 in 100,000 - 1,000,000	1 in 10,000 - 100,000	1 in 1,000 - 10,000	1 in 100 - 1,000	1 in 10 - 100	> 1 in 10

Table 5-3 Environmental Consequences of an Event

	Consequence	Description
A	Catastrophic	Large scale impact. Results in large scale exceedance of drinking water standards in abstraction with the need to shut down supply or implement additional treatment. Long term / permanent impact.
B	Massive	Large scale impact. Results in major exceedance of drinking water standards in abstraction with the need to shut down supply or implement additional treatment. Long term (years / decades) impact.
C	Major	Large scale impact. Results in major deterioration of water quality, and consistent exceedance of drinking water standards. Long term (months / years) impact.
D	Moderate	Moderate scale impact. Results in deterioration in water quality and exceedance of some drinking water standards. Potable abstractions need monitoring and may need to be taken out of supply. Medium term (weeks / months) impact.
E	Minor	Minor scale impact. Results in minor deterioration in water quality with low risk to groundwater abstractions. Medium term (weeks / months) impact.
F	Slight	Limited impact. Little or no deterioration in water quality. Short term (days / weeks) impact.

5.2.23 The combination of likelihood and consequences leads to a qualitative assessment of the overall risk that is categorised from negligible to severe.

Table 5-4 Risk Matrix

		Likelihood					
		Remote	Highly Unlikely	Unlikely	Possible	Likely Highly	Likely
Consequence	Catastrophic	Low	Medium	High	High	Severe	Severe
	Massive	Low	Medium	Medium	High	High	Severe
	Major	Negligible	Low	Medium	Medium	High	High
	Moderate	Negligible	Low	Low	Medium	Medium	High
	Minor	Negligible	Negligible	Negligible	Low	Medium	Medium
	Slight	Negligible	Negligible	Negligible	Negligible	Low	Medium

Results

5.2.24 The risk assessment results are given in **Table 5-5** to **Table 5-11** based on risks to public water supplies and PWSs. The risk assessment for each receptor is discussed below.

Public Water Supply

Angmering Public Water Supply: Construction Phase

5.2.25 Along the proposed DCO Order Limits and cable route all higher risk activities of HDD are located down hydraulic gradient of the Angmering public water supply SPZ. This abstraction's SPZ is primarily up dip to the north and the capture zone of the Angmering boreholes does not reach as far south as the HDD areas (**Figure 26.4.5**). In addition, HDD areas along the proposed DCO Order Limits route north and south of the A27 carriageway lie on superficial deposits and thick Palaeogene Lambeth deposits. These HDD crossings will be installed to shallow depths which prevents interaction within the Chalk Primary aquifer. It is unlikely any hydraulic pathways to the receptor exist in the south of the route, particularly south of the A27 highway.

5.2.26 Karst features are present and represent a line of swallow holes at the Chalk / Lambeth Formation boundary from a line running south-east of "The Lions" area to Swillage Barn and lie on the edge of the Angmering public water supply SPZ 2.

The highest risk area, where karstic features and pathways may exist, is therefore where the proposed DCO Order Limits turns north towards Kitpease Copse and enters the SPZ 2. Geophysical investigation surveys were carried out between 16 May and 22 May 2023 within this area running along the proposed DCO Order Limits route most at risk. The detailed results from the Electrical Resistivity Tomography (ERT) and Electromagnetic Conductivity (EM) geophysical surveys within this area are presented in **Annex B** for further information. Two trial survey areas were surveyed on known swallow holes / sink holes prior to running the main survey and used to develop the geophysical model for the main survey across the DCO area of interest. The main survey consisted of ERT and EM at the trenchless crossing just north of Hammerpot and EM across an extensive area across fields to the east and north across fields and sloping ground up to Kitpease Copse.

5.2.27 In summary, the main survey EM results displayed a large-scale trend in values with relatively high apparent conductivity values in the south and relatively low conductivity values in the north. This was interpreted to be consistent with the geological conditions, i.e., a shallowing of depth to Chalk bedrock (from approximately 10m depth) to the north beneath the Lambeth Group. Localised variations in conductivity trends were identified within the data which could relate to possible dissolution / collapse features[6] of relative low apparent conductivity (blue hatch on the *Anomaly Location Plan* in **Annex B**). These results will be taken into account during the detailed design of the temporary construction corridor in order to further minimise the likelihood of encountering possible solution features within this area. A watching brief for karstic pathway features will also be applied to excavation works in this area.

5.2.28 In the area along the proposed DCO Order Limits route to the north of the “The Lions” groundwater level depths will vary. The Chalk in this area is unconfined, making it highly vulnerable to surface contamination. It is also known to be highly karstic. However, during the excavation and cable laying the likelihood of encountering karstic pathways is low, as the unsaturated zone is thick, i.e. > 30m, and the natural pathway along down dip inception horizons is to the south. Given the understanding of the hydrogeology in the area and the shallow nature of the intrusive works within the recharge area, an *Unlikely* likelihood applies to the excavation and cable laying risk, with a *Moderate* consequence and *Low* risk. With additional mitigation controls a **Highly Unlikely** likelihood has been applied, giving a *Low* residual risk.

5.2.29 HDD works north of Hammerpot that pass beneath a PRoW are expected to be relatively shallow works within the Lambeth Formation. The HDD is located down hydraulic gradient of the Angmering public water supply SPZ. Although significant pathways into the Chalk aquifer are not expected, the results from the geophysical investigation surveys (in **Annex B**) and the watching brief for karstic pathway features will be fully taken into account during the micro-siting of the trenchless crossing works. A *Highly Unlikely* likelihood has been applied, and any consequences will be *Moderate*, giving a *Low* risk of accidental contamination and

[6] It must be emphasised that geophysical methods can only identify areas of subsurface areas that have variations in geophysical properties. The interpretation of the cause of such anomalies is inevitably based on assumptions utilising the best information available.

sediment entering the groundwater. However, mitigation will be applied during the proposed works on the proposed DCO Order Limits route and HDD leading to a *Remote* likelihood leading to a **Negligible** residual risk.

5.2.30 Given that HDD and cable installation activities are only temporary in duration and unlikely to comprise significant volumes of dewatering, there is unlikely to be a significant impact on aquifer water levels. The HDDs are down hydraulic gradient of the Angmering public water supply boreholes and associated SPZs. A decline in groundwater levels due to HDD works is therefore *Highly Unlikely*, with *Slight* consequence and *Negligible* risk*.* Given the hydrogeological conceptual understanding of the area and the scale of the works and mitigation controls to be applied, the likelihood is revised to *Remote,* with **Negligible** residual risk.

Angmering Public Water Supply: Operation and Maintenance / Decommissioning Phases

5.2.31 Given that ground conditions along the cable route will have been established during construction, the interception of significant pathways to receptors during cable repairs has a reduced likelihood during these later phases. In addition, the extent of work activities and the use of fuels are reduced, giving a *Highly Unlikely* likelihood, a *Minor* consequence and a *Negligible* risk from activities associated with cable repairs. With mitigations in place the likelihood will be reduced to *Remote* giving a **Negligible** residual risk.

5.2.32 During decommissioning works the proposed cable will be left in situ. Any isolated decommissioning works would have a *Remote* likelihood of pollution from leaks and spills and any consequences will be *Slight*, giving an overall **Negligible** residual risk.

5.2.33 Subsurface barriers to flow are usually not considered given that the onshore cable corridor is within the unsaturated zone and in well drained soils. The exception to this is across lower ground in the area with a coverage of head deposits, but with drainage mitigation applied a *Highly Unlikely* likelihood has been applied and any consequences to groundwater flow will be *Slight* and the risk *Negligible.* With mitigations in place the likelihood will be reduced to *Remote* giving a **Negligible** residual risk.

Patching / Clapham Public Water Supplies: Construction Phase

5.2.34 Since the Clapham public water supply is directly down hydraulic gradient of the Patching public water supply the two receptors have been considered together in the risk assessment. Although there is little information on the Clapham borehole it is sourcing groundwater from the same catchment as the Patching boreholes, albeit slightly higher within the Chalk Formation. The close proximity of these boreholes and presumably reasonable yield is a demonstration of the significant flow paths that exist through the Longfurlong valley.

5.2.35 The proposed DCO Order Limits and cable route are located up hydraulic gradient of the water supplies within their SPZ 2s and a significant distance (approximately 1.5km) away. No higher risk HDD activities are planned in the area, although minor upgrade works along Michelgrove Lane are planned within the SPZ 1 and in close proximity to the Patching boreholes.

5.2.36 Although no karst features have been identified in the area, flow pathways are likely located along the valleys. The SPZ 1s and 2s are orientated along the valleys and up geological dip, whilst SPZ 3s are located on the interfluves. The area most at risk is where the proposed DCO Order Limits route crosses and runs up the valley, north-west of Myrtle Grove Farm. A watching brief for karstic pathway features will be applied to excavation works in this area.

5.2.37 Even if karstic pathways exist in the SPZ2 along the proposed DCO Order Limits the likelihood of encountering them during the excavation and cable laying is low as the unsaturated zone is thick, i.e. > 40m. Given the current understanding of the hydrogeology in the area, the shallow nature of the excavation and cable laying works within the recharge area and the distance from the receptors a *Highly Unlikely* likelihood applies to risks associated with accidental contamination and sediment entering the groundwater, with a *Slight* consequence and *Negligible* risk. With additional mitigation controls a *Remote* likelihood is more appropriate, resulting in an overall **Negligible** residual risk.

5.2.38 Given that the activity of upgrade works along Michelgrove Lane are not significant excavations and only temporary in duration, there is unlikely to be a significant impact on the aquifer. Although the works are within SPZ 1, they are down hydraulic gradient of the water supply boreholes and located on head deposits, which depending on thickness may offer a degree of protection to the aquifer below. A watching brief for karstic pathway features will be applied to excavation works along Longfurlong Lane and Michelgrove Lane in this area. In the unlikely event that features are identified then micro-siting will be carried out to avoid any features. In addition, the construction of the passing place upgrades along Longfurlong Lane and Michelgrove Lane will be programmed for spring – autumn (March – November) when groundwater levels in this area are typically lower. A *Highly Unlikely* likelihood applies to risks associated with accidental contamination and sediment entering the groundwater, with a *Slight* consequence and *Negligible* risk. With additional mitigation controls a *Remote* likelihood has been applied, giving a **Negligible** residual risk.

Patching / Clapham Public Water Supplies: Operation and Maintenance / Decommissioning Phases

5.2.39 Given that ground conditions along the cable route will have been established during construction, the interception of significant pathways to receptors during cable repairs has a reduced likelihood. In addition, the extent of work activities and the use of fuels are reduced, giving a *Highly Unlikely* likelihood, a *Slight* consequence and a *Negligible* risk from activities associated with cable repairs. With mitigations in place the likelihood will be reduced to *Remote* giving a **Negligible** residual risk.

5.2.40 Subsurface barriers to flow are not considered given that the cable route is within the unsaturated zone and in well drained soils. During decommissioning works the proposed cable will be left in situ. Any isolated decommissioning works would have a *Remote* likelihood of pollution from leaks and spills and any consequences will be *Slight*, giving an overall **Negligible** residual risk.

PWSs

The Decoy (P4): Construction Phase

5.2.41 The groundwater abstraction is within 250m and down hydraulic gradient / down dip of the proposed DCO Order Limits and HDD works. However, the borehole is located on the Lambeth Group geology and low permeability layers above the Chalk aquifer, although uncertain at this time[7], are likely to be of a significant thickness at the HDD locations. The cable laying works will be within the Lambeth Group strata and a *Remote* likelihood and a consequence of S*light* have been assumed both pre- and post-mitigation, giving a **Negligible** risk.

5.2.42 Associated HDD works are beneath a small watercourse feature and design depths are not expected to be significant. With additional mitigation during dewatering and excavation activities including HDD design controls the likelihood of the HDD works affecting groundwater quality and groundwater levels can be reduced from *Highly Unlikely* to *Remote*, and any consequences will be *Slight*, giving a **Negligible** residual risk.

Suzy Smith Racing / Angmering Park Estate (P5): Construction Phase

5.2.43 This groundwater PWS abstraction is 500m west of the proposed DCO Order Limits and down hydraulic gradient. HDD works are proposed, approximately 750m to the north-east of the PWS on the edge of the SPZ 3. There is a potential groundwater flow pathway along the valley from the Buckmans and also Clay-with-flints superficial deposits in the vicinity of the proposed DCO Order Limits, and potential karst features associated with these deposits, although none were observed during the site visit.

5.2.44 Even so, with mitigation applied during cable laying the likelihood of pollution and the mobilisation of sediment can be reduced from *Unlikely* to *Highly Unlikely*, and a *Moderate* consequence from activities gives a *Low* risk for the PWS. A watching brief for karstic pathway features will be applied to excavation works in this area along the proposed DCO Order Limits route.

5.2.45 There is uncertainty on the location of the Suzy Smith Racing / Angmering Park Estate PWS borehole, and it may be positioned to the north of the valley line on higher ground at Angmering Park Stud Farm. Even so, it is down hydraulic gradient and down dip of the proposed HDD works. With this taken into account as well as uncertainties regarding the supply a conservative approach has been taken and a likelihood of *Unlikely* and a consequence of *Moderate* have been assumed, giving a *Low* risk A watching brief for karstic pathway features will be applied to excavation works in this area. With the associated uncertainties, in addition to the distance of works from the PWS and with additional mitigation controls, including HDD design controls, will lower the likelihood to *Highly Unlikely*, but residual risk remains **Low**.

[7] Calculations using likely dip (5 degrees) of the Chalk / Lambeth boundary and the distance from the known Decoy BGS borehole infer a possible Lambeth Group / London Clay thickness of around 20m thickness.

5.2.46 Given the distance of the PWS, down hydraulic gradient of the HDD works any affect on groundwater levels have a *Remote* likelihood, and any consequences will be *Slight*, giving a **Negligible** residual risk.

The Chantry Mere (P10): Construction Phase

5.2.47 The Chantry Mere (P10) PWS is a spring source at the base of the Chalk scarp in the north of the South Downs and is a significant distance (820m) north of the proposed DCO Order Limits route and HDD area.

5.2.48 The proposed DCO Order Limits route and HDD, although on high ground, are down dip of the PWS and away from the valley to the south-west of Chantry Mere which is the likely groundwater flow route to the spring source. As such, with additional mitigation controls during road upgrades, cable laying excavations and works associated with HDD, the likelihood can be reduced from *Highly Unlikely* to *Remote*, and any consequences will be *Slight*, giving a **Negligible** residual risk.

5.2.49 An access track upon which minor upgrading works are planned lies about 50m to the east of the PWS. The PWS is situated on head superficial deposits and the Upper Greensand Formation which will offer protection to the source. Given the minimal work activities and the mitigation applied the likelihood can be reduced from *Highly Unlikely to Remote,* and a *Slight* consequence from activities associated with works is anticipated to present a **Negligible** residual risk.

5.2.50 With additional mitigation during dewatering and excavation activities including HDD design controls the likelihood of the HDD works affecting groundwater levels are *Remote*, and any consequences will be *Slight*, giving a **Negligible** residual risk.

East Cottage (P19), Green Pastures (P20), Myrtlegrove Cottage Stables (P21) and The Martins (P22): Construction Phase

5.2.51 These PWSs lie in a cluster at Myrtle Grove Farm, over 250m south-east of the proposed DCO Order Limits route. An access track upon which minor works are planned is located to the east of the PWSs, but only the Green Pastures (P20) 250m buffer intersects with the track. Given the minimal activities of work involved along the access track (no exaction works along the route are planned) and mitigation applied the likelihood can be reduced from *Highly Unlikely* to *Remote*, and that any consequences would be *Slight*, a **Negligible** residual risk has been applied for all the PWSs in this area.

5.2.52 The access track runs across the valley head towards the top of the hill, 900m from the PWS cluster. The groundwater flow pathway is likely down dip and along this dry valley route and a watching brief for karstic flow pathways will be in place for this area if excavations are undertaken. The proposed DCO Order Limits run to the west of this, within a separate dry valley and there is a possible hydraulic divide between the two. In addition, the unsaturated zone beneath the proposed DCO Order Limits is likely to be significant, up to 50m. With mitigation applied the likelihood of risk associated from pollution and sediment mobilisation during cable laying can be reduced from *Highly Unlikely* to *Remote*, and a *Slight* consequence from activities associated with works along the proposed DCO Order Limits route is anticipated, giving a **Negligible** residual risk for all the PWSs in this area.

Michelgrove (P24): Construction Phase

5.2.53 This PWS is located at Michelgrove and is approximately 250m east of the proposed DCO Order Limits route (360m east of a proposed HDD) and within the vicinity of access tracks to the south and east. The PWS is located within the same valley and down hydraulic gradient of the proposed DCO Order Limits route and HDD.

5.2.54 Prior to the commencement of the construction of the passing places along Longfurlong Lane and Michelgrove Lane access track, these works areas will be visually checked to confirm that there is no karst solution features. In the unlikely event that features are identified then micro-siting will be carried out to avoid any features. In addition, the construction of the passing place upgrades along Longfurlong Lane and Michelgrove Lane will be programmed for spring – autumn (March – November) when groundwater levels in this area are typically lower.

5.2.55 The access tracks are down hydraulic gradient of the PWS and given the minimal associated works and the mitigation to be applied the likelihood can be reduced from *Highly Unlikely* to *Remote* and a *Moderate* consequence from works are anticipated, giving a **Negligible** residual risk.

5.2.56 Given the thickness of the unsaturated zone beneath the proposed DCO Order Limits route which is likely to be significant and the distance of works to the PWS receptor, with mitigation applied the likelihood of risk associated from pollution and sediment mobilisation during cable laying can be reduced from *Highly Unlikely* to *Remote*, and a *Moderate* consequence from activities associated with works along the proposed DCO Order Limits route is anticipated, giving a **Negligible** residual risk for all the PWSs in this area.

5.2.57 With additional mitigation during dewatering and excavation activities including HDD design controls the likelihood of the HDD works affecting groundwater levels are *Remote*, and any consequences will be *Slight*, giving a **Negligible** residual risk.

5.2.58 In addition, the proposed DCO Order Limits route and HDD are located within the valley along which the main groundwater flow pathway may exist, albeit approximately 270m apart. The unsaturated zone is significant in the area (up to 40m thick) and the dip of the Chalk is to the south which may direct groundwater pathways more towards the south, and away from the PWS. Although the distance of the HDD works from the PWS is significant, with the associated uncertainties, an *Unlikely* likelihood has been applied, and any consequences will be *Moderate*, giving a *Low* risk. Although, mitigation will be applied during the proposed works on the DCO Order Limits route and HDD leading to a *Highly Unlikely* likelihood leading to a **Low** residual risk, additional monitoring and conditions are recommended during construction at this receptor. The Applicants propose to implement a water quality and levels monitoring regime at the well, and a temporary portable water supply tied into the well will be provided for the duration of the HDD activities.

All PWSs: Operation and Maintenance / Decommissioning Phases

5.2.59 Given that ground conditions along the cable route will have been established during construction, the interception of significant pathways to receptors has a reduced likelihood. In addition, the extent of work activities, and the use of fuels are reduced and with operation mitigation in place likelihood of pollution from leaks and spills has *a Remote* likelihood and with a *Slight* consequence from activities associated with cable repairs gives a **Negligible** residual risk.

5.2.60 Subsurface barriers to flow are generally not considered given that the cable route is within the unsaturated zone and in well drained soils. The exception to this is across lower ground in the area with a coverage of head deposits, but given the depth of the proposed cable and with drainage mitigation in place a *Remote* likelihood has been applied for both the operation and maintenance and decommissioning phases. For sub-surface barriers to flow and recharge any consequences will be *Slight*, giving an overall **Negligible** residual risk.

5.2.61 During decommissioning works the proposed cable will be left in situ. Any isolated decommissioning works would have a *Remote* likelihood of pollution from leaks and spills and any consequences will be *Slight*, giving an overall **Negligible** residual risk.

Table 5-5 Determination of Hydrogeological Risks – Angmering Public Water Supply

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
Construction phase								
Cable laying with machinery and refuelling	Spillage or leakage of fuels, lubricants or other chemicals, disturbance and release of sediment during cable laydown and installation.	Potential for accidental contamination and sediments entering groundwater and then the abstraction.	Unlikely	Moderate	Low	**Overall Design** C-18, C-29, C-74, C-78, C-137, C-138 **Construction General** – C-7 *Materials Management Plan (MMP) and Defra 2009 Code of Construction Practice (CoCP)*, C-19, C-25 *(CDM Regs),* C-28, C-129, C-140, C-141 **Construction Water and Silt**	Highly Unlikely	Low

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						<u>Management</u> – C-77 **<u>Construction Pollution Prevention</u>** – C-8, C-76 *Pollution Prevention Plans (PPPs)*, C-142, C-149, C-150, C-151, C-153 *Operations and Maintenance Plan and Pollution Incident Control Plan (PICP),* C-167, C-227, C-234 *Drilling Fluid Breakout Management*, C-235 *Pipeline Design for Installation of Horizontal Directional Drilling,* C-236,		

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						C-241, C-245, C-246, and C-251		
HDD works	Spillage or leakage of fuels, lubricants or other chemicals during drilling. This includes the potential for breakout and leakage of bentonite during trenchless crossing. Also disturbance and subsequent release of sediments.	Potential for accidental contamination and sediments entering groundwater and then the abstraction.	Highly Unlikely	Moderate	Low	**Overall Design** C-18, C-29, C-74, C-78, C-137, C-138 **Construction General** – C-7 *MMP and Defra 2009 CoCP*, C-19, C-25 *(CDM Regs)*, C-28, C-129, C-140, C-141 **Construction Water and Silt Management** – C-77 **Construction Pollution Prevention** – C-8, C-76 *PPPs*, C-142, C-149, C-150, C-151,	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						C-153 *Operations and Maintenance PICP,* C-167, C-227, C-234 *Drilling Fluid Breakout Management*, C-235 *Pipeline Design for Installation of Horizontal Directional Drilling,* C-236, C-241, C-245, C-246, and C-251		
Dewatering and drilling activities	Dewatering of the trenched excavations for cabling and during HDD.	Decline in groundwater levels which then affects abstraction yield.	Highly Unlikely	Slight	Negligible	**Overall Design** C-18, C-29, C-74, C-78, C-137, C-138, C-206 *HRA,* C-226 *Pre-construction GI* **Construction General** – C-7 *MMP and Defra*	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						2009 CoCP, C-19, C-25 *(CDM Regs),* C-28, C-129, C-140, C-141 **Construction Water and Silt Management** – C-77 **Construction Pollution Prevention** – C-8, C-76 *PPPs*, C-142, C-149, C-150, C-151, C-153 *Operations and Maintenance Plan and PICP,* C-167, C-227, C-234 *Drilling Fluid Breakout Management*, C-235 *Pipeline Design for Installation of Horizontal*		

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						Directional Drilling, C-236, C-241, C-245, C-246, and C-251		
Operation and maintenance phase								
Isolated cable repairs	Spillage or leakage of fuels and chemicals from vehicles onsite or during any repairs.	Potential for accidental contamination entering groundwater and then the abstraction.	Highly Unlikely	Minor	Negligible	**Post DCO Arrangements**	Remote	Negligible
Sub-surface structures and infills	The diversion of sub-surface land drainage flow pathways due to the permanent presence of limited below ground concrete lined joint bays, backfilled material around cable circuits and below ground cable structures and	Decline in groundwater levels which then affects abstraction yield.	Highly Unlikely	Slight	Negligible	**Overall Design** C-19	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
	impermeable surfaces.							
Decommissioning phase								
Isolated decommissioning works	Spillage or leakage of fuels and chemicals from vehicles onsite.	Potential for accidental contamination entering groundwater and then the abstraction.	Highly Unlikely	Slight	Negligible	**Post DCO Arrangements**	Remote	Negligible
Sub-surface structures and infills	The diversion of sub-surface land drainage flow pathways due to residual sub-surface structures and infills.	Decline in groundwater levels which then affects abstraction yield.	Highly Unlikely	Slight	Negligible	**Overall Design** C-19	Remote	Negligible

Table 5-6 Determination of Hydrogeological Risks – Patching / Clapham Public Water Supply

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
Construction phase								

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
Cable laying with machinery and refuelling **Minor upgrading works on access track**	Spillage or leakage of fuels, lubricants or other chemicals, disturbance and release of sediment during cable laydown and installation.	Potential for accidental contamination and sediments entering the groundwater and then the abstraction.	Highly Unlikely	Slight	Negligible	**Overall Design** – C-18, C-29, C-74, C-78, C-137, C-138 **Construction General** – C-7 *MMP and Defra 2009 CoCP*, C-19, C-25 *(CDM Regs),* C-28, C-129, C-140, C-141 **Construction Water and Silt Management** – C-77 **Construction Pollution Prevention** – C-8, C-76 *PPPs*, C-142, C-149, C-150, C-151, C-153 *Operations and Maintenance Plan and PICP,*	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						C-167, C-227, C-234 *Drilling Fluid Breakout Management*, C-235 *Pipeline Design for Installation of Horizontal Directional Drilling,* C-236, C-241, C-245, C-250 and C-251		
Operation and maintenance phase								
Isolated cable repairs	Spillage or leakage of fuels and chemicals from vehicles onsite or during any repairs.	Potential for accidental contamination entering groundwater and then the abstraction.	Highly Unlikely	Slight	Negligible	**Post DCO Arrangements**	Remote	Negligible
Decommissioning phase								

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
Isolated decommissioning works	Spillage or leakage of fuels and chemicals from vehicles onsite.	Potential for accidental contamination entering groundwater and then the abstraction.	Remote	Slight	Negligible	**Post DCO Arrangements**	Remote	Negligible

Table 5-7 Determination of Hydrogeological Risks – The Decoy (P4) PWS

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
Construction phase								
Cable laying with machinery and refuelling	Spillage or leakage of fuels, lubricants or other chemicals, disturbance and release of sediment during cable laydown and installation.	Potential for accidental contamination and sediments entering groundwater and then the abstraction.	Remote	Slight	Negligible	**Overall Design** – C-18, C-29, C-74, C-78, C-137, C-138 **Construction General** – C-7 *MMP and Defra 2009 CoCP*, C-19, C-25 *(CDM Regs)*, C-28, C-129, C-140, C-141 **Construction Water and Silt Management** C-77 **Construction Pollution Prevention** –	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						C-8, C-76 *PPPs*, C-142, C-149, C-150, C-151, C-153 *Operations and Maintenance Plan and PICP*, C-167, C-227, C-234 *Drilling Fluid Breakout Management*, C-235 *Pipeline Design for Installation of Horizontal Directional Drilling,* C-236, C-241, C-245 and C-251		
HDD works	Spillage or leakage of fuels, lubricants or other chemicals during drilling This	Potential for accidental contamination and sediments entering groundwater	Highly Unlikely	Slight	Negligible	**Overall Design** C-18, C-29, C-74, C-78, C-137, C-138 **Construction General** – C-7	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
	includes the potential for breakout and leakage of bentonite during trenchless crossing. Also disturbance and subsequent release of sediments.	and then the abstraction.				*MMP and Defra 2009 CoCP*, C-19, C-25 *(CDM Regs),* C-28, C-129, C-140, C-141 **Construction Water and Silt Management** C-77 **Construction Pollution Prevention** – C-8, C-76 *PPPs*, C-142, C-149, C-150, C-151, C-153 *Operations and Maintenance Plan and PICP*, C-167, C-227, C-234 *Drilling Fluid Breakout Management*, C-235 *Pipeline*		

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						Design for Installation of Horizontal Directional Drilling, C-236, C241, C-245 and C-251		
Dewatering and drilling activities	Dewatering of the trenched excavations for cabling and during HDD.	Decline in groundwater levels which then affects abstraction yield.	Highly Unlikely	Slight	Negligible	**Overall Design** C-18, C-29, C-74, C-78, C-137, C-138 **Construction General** – C-7 *MMP and Defra 2009 CoCP*, C-19, C-25 *(CDM Regs),* C-28, C-129, C-140, C-141 **Construction Water and Silt Management** C-77	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						Construction Pollution Prevention – C-8, C-76 *PPPs*, C-142, C-149, C-150, C-151, C-153 *Operations and Maintenance Plan and PICP,* C-167, C-227, C-234 *Drilling Fluid Breakout Management*, C-235 *Pipeline Design for Installation of Horizontal Directional Drilling,* C-236, C-241, C-245 and C-251		
Operation and maintenance phase								
Isolated cable repairs	Spillage or leakage of fuels and	Potential for accidental contamination	Remote	Slight	Negligible	**Post DCO Arrangements**	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
	chemicals from vehicles onsite or during any repairs.	entering groundwater and then the abstraction.						
Sub-surface structures and infills	The diversion of sub-surface land drainage flow pathways due to the permanent presence of limited below ground concrete lined joint bays, backfilled material around cable circuits and below ground cable structures and	Decline in groundwater levels which then affects abstraction yield.	Remote	Slight	Negligible	**Overall Design** C-19	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
	impermeable surfaces.							
Decommissioning phase								
Isolated decommissioning works	Spillage or leakage of fuels and chemicals from vehicles onsite.	Potential for accidental contamination entering groundwater and then the abstraction.	Remote	Slight	Negligible	**Post DCO Arrangements**	Remote	Negligible

Table 5-8 Determination of Hydrogeological Risks – Suzy Smith Racing / Angmering Park Estate (P5)

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
Construction phase								
Cable laying with machinery and refuelling	Spillage or leakage of fuels, lubricants or other chemicals, disturbance and release of sediment during cable laydown and installation.	Potential for accidental contamination and sediments entering groundwater and then the abstraction.	Unlikely	Moderate	Low	**Overall Design** – C-18, C-29, C-74, C-78, C-137, C-138 **Construction General** – C-7 *MMP and Defra 2009 CoCP*, C-19, C-25 *(CDM Regs)*, C-28, C-129, C-140, C-141 **Construction Water and Silt Management** C-77 **Construction Pollution Prevention** – C-8, C-76	Highly Unlikely	Low

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						PPPs, C-142, C-149, C-150, C-151, C-153 *Operations and Maintenance Plan and PICP*, C-167, C-227, C-234 *Drilling Fluid Breakout Management*, C-235 *Pipeline Design for Installation of Horizontal Directional Drilling*, C-236, C-241, C-245, C-251 and C-253		
HDD works	Spillage or leakage of fuels, lubricants or other chemicals during drilling This	Potential for accidental contamination and sediments entering groundwater	Unlikely	Moderate	Low	**Overall Design** – C-18, C-29, C-74, C-78, C-137, C-138 **Construction General**	Highly Unlikely	Low

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
	includes the potential for breakout and leakage of bentonite during trenchless crossing. Also disturbance and subsequent release of sediments.	and then the abstraction.				C-7 *MMP and Defra 2009 CoCP*, C-19, C-25 *(CDM Regs)*, C-28, C-129, C-140, C-141 **<u>Construction Water and Silt Management</u>** C-77 **<u>Construction Pollution Prevention</u>** – C-8, C-76 *PPPs*, C-142, C-149, C-150, C-151, C-153 *Operations and Maintenance Plan and PICP*, C-167, C-227, C-234 *Drilling Fluid Breakout Management*, C-235 *Pipeline*		

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						Design for Installation of Horizontal Directional Drilling, C-236, C-241, C-245 and C-251		
Dewatering and drilling activities	Dewatering of the trenched excavations for cabling and during HDD.	Decline in groundwater levels which then affects abstraction yield.	Remote	Slight	Negligible	**Overall Design** C-18, C-29, C-74, C-78, C-137, C-138 **Construction General** – C-7 *MMP and Defra 2009 CoCP*, C-19, C-25 *(CDM Regs),* C-28, C-129, C-140, C-141 **Construction Water and Silt Management** – C-77	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						Construction Pollution Prevention C-8, C-76 *PPPs*, C-142, C-149, C-150, C-151, C-153 *Operations and Maintenance Plan and PICP,* C-167, C-227, C-234 *Drilling Fluid Breakout Management*, C-235 *Pipeline Design for Installation of Horizontal Directional Drilling,* C-236, C-241, C-245, C-251 and C-253.		
Operation and maintenance phase								
Isolated cable repairs	Spillage or leakage of	Potential for accidental	Remote	Slight	Negligible	**Post DCO Arrangements**	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
	fuels and chemicals from vehicles onsite or during any repairs.	contamination entering groundwater and then the abstraction.						
Decommissioning phase								
Isolated decommissioning works	Spillage or leakage of fuels and chemicals from vehicles onsite.	Potential for accidental contamination entering groundwater and then the abstraction.	Remote	Slight	Negligible	**Post DCO Arrangements**	Remote	Negligible

Table 5-9 Determination of Hydrogeological Risks – The Chantry Mere (P10)

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
Construction phase								

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
Cable laying with machinery and refuelling **Minor upgrading works on access track**	Spillage or leakage of fuels, lubricants or other chemicals, disturbance and release of sediment during cable laydown and installation.	Potential for accidental contamination and sediments entering groundwater and then the abstraction	Highly Unlikely	Slight	Negligible	**Overall Design** – C-18, C-29, C-74, C-78, C-137, C-138 **Construction General** – C-7 *MMP and Defra 2009 CoCP*, C-19, C-25 *(CDM Regs)*, C-28, C-129, C-140, C-141 **Construction Water and Silt Management** C-77 **Construction Pollution Prevention** – C-8, C-76 *PPPs*, C-142, C-149, C-150, C-151, C-153 *Operations and*	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						Maintenance Plan and PICP, C-167, C-227, C-234 *Drilling Fluid Breakout Management*, C-235 *Pipeline Design for Installation of Horizontal Directional Drilling,* C-236, C-241, C-245 and C-251		
HDD works	Spillage or leakage of fuels, lubricants or other chemicals during drilling This includes the potential for breakout and leakage of bentonite during	Potential for accidental contamination and sediments entering groundwater and then the abstraction.	Highly Unlikely	Slight	Negligible	**Overall Design** – C-18, C-29, C-74, C-78, C137, C-138 **Construction General** – C-7 *MMP and Defra 2009 CoCP*, C-19, C-25 *(CDM Regs),* C-28,	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
	trenchless crossing. Also disturbance and subsequent release of sediments.					C-129, C-140, C-141 **<u>Construction Water and Silt Management</u>** C-77 **<u>Construction Pollution Prevention</u>** – C-8, C-76 *PPPs*, C-142, C-149, C-150, C-151, C-153 *Operations and Maintenance Plan and PICP,* C-167, C-227, C-234 *Drilling Fluid Breakout Management*, C-235 *Pipeline Design for Installation of Horizontal Directional Drilling,* C-236,		

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						C-241, C-245 and C-251		
Dewatering and drilling activities	Dewatering of the trenched excavations for cabling and during HDD.	Decline in groundwater levels which then affects abstraction yield.	Remote	Slight	Negligible	**Overall Design** – C-18, C-29, C-74, C-78, C-137, C-138 **Construction General** – C-7 *MMP and Defra 2009 CoCP*, C-19, C25 *(CDM Regs)*, C-28, C-129, C-140, C-141 **Construction Water and Silt Management** C-77 **Construction Pollution Prevention** – C-8, C-76 *PPPs*, C-142, C-149, C-150,	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						C-151, C-153 *Operations and Maintenance Plan and PICP,* C-167, C-227, C-234 *Drilling Fluid Breakout Management*, C-235 *Pipeline Design for Installation of Horizontal Directional Drilling,* C-236, C-241, C-245 and C-251		
Operation and maintenance phase								
Isolated cable repairs	Spillage or leakage of fuels and chemicals from vehicles onsite or during any repairs.	Potential for accidental contamination entering groundwater and then the abstraction.	Remote	Slight	Negligible	**Post DCO Arrangements**	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
Subsurface structures and infills	The diversion of sub-surface land drainage flow pathways due to the permanent presence of limited below ground concrete lined joint bays, backfilled material around cable circuits and below ground cable structures and impermeable surfaces.	Decline in groundwater levels which then affects abstraction yield.	Remote	Slight	Negligible	**Overall Design** C-19	Remote	Negligible
Decommissioning phase								

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
Isolated decommissioning works	Spillage or leakage of fuels and chemicals from vehicles onsite.	Potential for accidental contamination entering groundwater and then the abstraction.	Remote	Slight	Negligible	**Post DCO Arrangements**	Remote	Negligible

Table 5-10 Determination of Hydrogeological Risks – East Cottage (P19), Green Pastures (P20), Myrtlegrove Cottage Stables (P21) and The Martins (P22)

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
Construction phase								
Cable laying with machinery and refuelling **Minor upgrading works on access track**	Spillage or leakage of fuels, lubricants or other chemicals, disturbance and release of sediment during cable	Potential for accidental contamination and sediments entering groundwater and then the abstraction.	Highly Unlikely	Slight	Negligible	**Overall Design** – C-18, C-29, C-74, C-78, C-137, C-138 **Construction General** – C-7 *MMP and Defra 2009 CoCP*, C-19, C-25 *(CDM*	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
	laydown and installation.					*Regs),* C-28, C-129, C-140, C-141 **<u>Construction Water and Silt Management</u>** C-77 **<u>Construction Pollution Prevention</u>** – C-8, C-76 *PPPs*, C-142, C-149, C-150, C-151, C-153 *Operations and Maintenance Plan and PICP,* C-167, C-227, C-234 *Drilling Fluid Breakout Management*, C-235 *Pipeline Design for Installation of Horizontal Directional*		

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						Drilling, C-236, C-241, C-245 and C-251		
Operation and maintenance phase								
Isolated cable repairs	Spillage or leakage of fuels and chemicals from vehicles onsite or during any repairs.	Potential for accidental contamination entering groundwater and then the abstraction.	Remote	Slight	Negligible	**Post DCO Arrangements**	Remote	Negligible
Decommissioning phase								
Isolated decommissioning works	Spillage or leakage of fuels and chemicals from vehicles onsite.	Potential for accidental contamination entering groundwater and then the abstraction.	Remote	Slight	Negligible	**Post DCO Arrangements**	Remote	Negligible

Table 5-11 Determination of Hydrogeological Risks – Michelgrove (P24)

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
Construction phase								
Cable laying with machinery and refuelling **Minor upgrading works on access track**	Spillage or leakage of fuels, lubricants or other chemicals, disturbance and release of sediment during construction during cable laydown and installation.	Potential for accidental contamination and sediments entering groundwater and then the abstraction.	Highly Unlikely	Moderate	Low	**Overall Design** C-18, C-29, C-74, C-78, C-137, C-138 **Construction General** C-7 *MMP and Defra 2009 CoCP*, C-19, C-25 *(CDM Regs),* C-28, C-129, C-140, C-141 **Construction Water and Silt Management** C-77 **Construction Pollution Prevention** C-8, C-76 *PPPs*, C-142, C-149, C-150, C-151, C-153 *Operations and Maintenance Plan and PICP,* C-167, C-227, C-234--*Breakout Management*, C-235	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						Pipeline Design for Installation of Horizontal Directional Drilling, C-236, C-241, C-245, C-251 and C-253		
HDD works	Spillage or leakage of fuels, lubricants or other chemicals during drilling This includes the potential for breakout and leakage of bentonite during trenchless crossing. Also disturbance and subsequent release of sediments.	Potential for accidental contamination and sediments entering groundwater and then the abstraction.	Unlikely	Moderate	Low	**Overall Design** – C-18, C-29, C-74, C-78, C-137, C-138 **Construction General** – C-7 *MMP and Defra 2009 CoCP*, C-19, C-25 *(CDM Regs),* C-28, C-129, C-140, C-141 **Construction Water and Silt Management** C-77 **Construction Pollution Prevention** C-8, C-76 *PPPs*, C-142, C-149, C-150, C-151, C-153 *Operations and Maintenance Plan and PICP,* C-167, C-227, C-234 *Drilling Fluid Breakout*	Highly Unlikely	Low

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						Management, C-235 *Pipeline Design for Installation of Horizontal Directional Drilling,* C-236, C-241, C-245, C-251 and C-253		
Dewatering and drilling activities	Dewatering of the trenched excavations for cabling and during HDD.	Decline in groundwater levels which then affects abstraction yield.	Remote	Slight	Negligible	**Overall Design** C-18, C-29, C-74, C-78, C-137, C-138 **Construction General** C-7 *MMP and Defra 2009 CoCP*, C-19, C-25 *(CDM Regs),* C-28, C-129, C-140, C-141 **Construction Water and Silt Management** C-77 **Construction Pollution Prevention** – C-8, C-76 *PPPs*, C-142, C-149, C-150, C-151, C-153 *Operations and Maintenance Plan and PICP,* C-167, C-227, C-234 *Drilling*	Remote	Negligible

Activity	Potential Source	Potential effect	Likelihood	Consequence	Risk	Mitigation	Revised Likelihood	Residual Risk
						Fluid Breakout Management, C-235 *Pipeline Design for Installation of Horizontal Directional Drilling,* C-236, C-241, C-245, C-251 and C-253		
Operation and maintenance phase								
Isolated cable repairs	Spillage or leakage of fuels and chemicals from vehicles onsite or during any repairs.	Potential for accidental contamination entering groundwater and then the abstraction.	Remote	Slight	Negligible	**Post DCO Arrangements**	Remote	Negligible
Decommissioning phase								
Isolated decommissioning works	Spillage or leakage of fuels and chemicals from vehicles onsite.	Potential for accidental contamination entering groundwater and then the abstraction.	Remote	Slight	Negligible	**Post DCO Arrangements**	Remote	Negligible

6. Conclusions

6.1.1 The Study Area is located upon the Chalk of the South Downs, located within areas of known karst features which influence groundwater flow pathways. Rapid transport flow and dewatering pathways can increase risk and these have been considered during the assessment. The HRA first summarises the geology, hydrogeology and water resource features of interest in the Study Area. This information is then used to develop conceptual site models.

6.1.2 The risk assessment uses potential hazards from an activity list during construction, operation and decommissioning. Pathways are identified based on the conceptual models for specific screened in abstraction receptors within the Study Area, utilising conceptual cross sections and SPZs for public water supplies. The risk assessment assumes that no new potentially polluting activities will occur in the SPZ 1s and the hazards assessed are all assessed as potentially occurring in SPZ 2s and SPZ 3s. Mitigation has been taken from the **Chapter 26: Water environment, Volume 2** of the ES (Document Reference: 6.2.26), with receptor site-specific mitigation applied where applicable.

6.1.3 The HRA has identified the hazards of the proposed works, i.e. that could result in a release of contaminants or dewatering effects to the environment, the consequence of the releases and the likelihood of the event occurring. A number of significant hazard events have been identified and for each an appropriate set of mitigation measures (safeguards) have been proposed such that the residual risk is concluded to be low or negligible. The risk assessment has determined that no degradation of water supplies is likely to result from the proposed works.

6.1.4 **Table 6-1** gives a summary of the assessment results of risks identified as **Low** with specific mitigation applied.

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Table 6-1 Assessment Summary Table

Receptor	Activity	Final Likelihood	Consequence	Residual Risk	Specific Mitigation
Angmering Public Water Supply	Cable laying with machinery and refuelling	Highly Unlikely	Moderate	**Low**	Geophysical investigation surveys are planned within this area running along the proposed DCO Order Limits route most at risk in this area. A watching brief for karstic pathway features will be applied to excavation works most at risk in this area.
Suzy Smith Racing / Angmering Park Estate (P5) PWS	Cable laying with machinery and refuelling / HDD operations	Highly Unlikely	Moderate	**Low**	Watching brief to visually checked to confirm that there is no karst solution features present during cable excavations across “The Buckmans” valley head location. Additional monitoring is recommended at the borehole during construction.
Michelgrove (P24) PWS	HDD operations	Highly Unlikely	Moderate	**Low**	Works programmed for spring – autumn (March – November). Watching brief to visually checked to confirm that there is no karst solution features present. Additional monitoring is recommended at the borehole during construction and HDD works.

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7. Glossary of terms and abbreviations

Term (acronym)	Definition
Above Ordnance Datum (AOD)	Ordnance Datum is the vertical datum used by the Ordnance Survey as the basis for deriving the height of ground level on maps. Topography may be described using the level in comparison to ‘above’ ordnance datum.
BAT	Best Available Technology
BGS	British Geological Survey
DCO Application	An application for consent under the Planning Act 2008 to undertake a Nationally Significant Infrastructure Project made to the Planning Inspectorate who will consider the application and make a recommendation to the Secretary of State, who will decide on whether development consent should be granted for the Proposed Development.
DECC	(Former) Department of Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
DrWPAs	Drinking water protected areas
Environment Agency	A non-departmental public body, with responsibilities relating to the protection and enhancement of the environment in England.
Environmental Impact Assessment (EIA)	The process of evaluating the likely significant environmental effects of a proposed project or development over and above the existing circumstances (or ‘baseline’).
Environmental Statement (ES)	The written output presenting the full findings of the Environmental Impact Assessment.
EPR	Environmental Permitting Regulations
HDD	A trenchless crossing engineering technique using a drill steered underground without the requirement for open trenches. This technique is often employed when crossing

Term (acronym)	Definition
	environmentally sensitive areas, major water courses and highways. This method is able to carry out the underground installation of pipes and cables with minimal surface disruption.
HRA	Hydrogeological Risk Assessment
MAGIC	An online, map-based library of data sources maintained by Defra.
NGR	National Grid Reference
NPS	National Policy Statement
Planning Act 2008	The legislative framework for the process of approving major new infrastructure projects.
Preliminary Environmental Information Report (PEIR)	The written output of the Environmental Impact Assessment undertaken to date for the Proposed Development. It is developed to support Statutory Consultation and presents the preliminary findings of the assessment to allow an informed view to be developed of the Proposed Development, the assessment approach that has been undertaken, and the preliminary conclusions on the likely significant effects of the Proposed Development and environmental measures proposed.
PRoW	Public Right of Way
PWS	Private water supply
RED	Rampion Extension Development Limited (the Applicant)
SDNPA	South Downs National Park Authority
SgZs	Safeguard Zones
SPZ	Source protection zone
SW	Southern Water

Term (acronym)	Definition
SWS	Southern Water Services
UKCEH	UK Centre for Hydrology and Ecology
Water Framework Directive (WFD)	A substantial piece of EU water legislation that came into force in 2000, with the overarching objective to get all water bodies in Europe to attain Good or High Ecological Status. River Basin Management Plans have been created which set out measures and potential mitigation to ensure that water bodies in England and Wales achieve 'Good Ecological Status'.

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Figures

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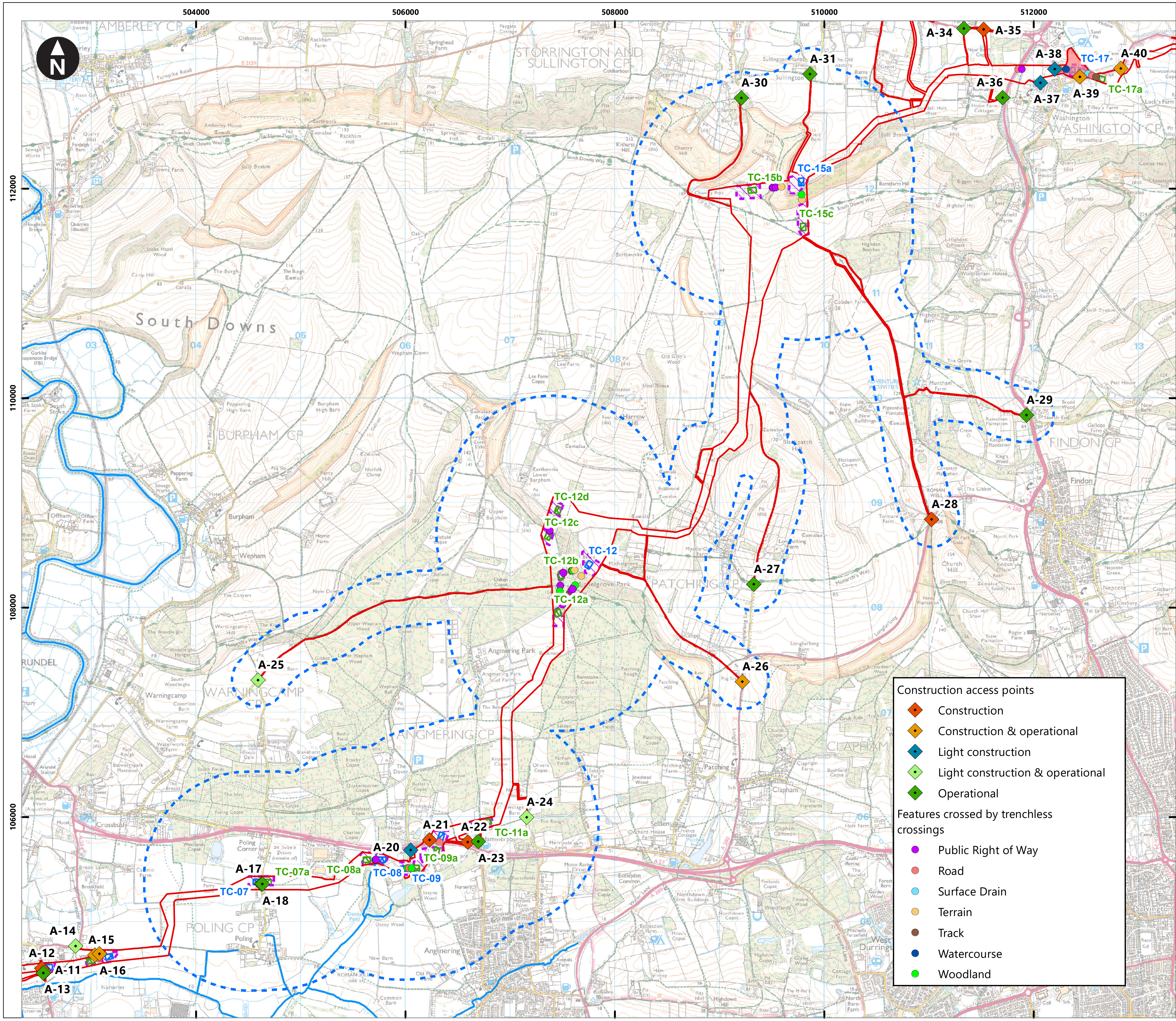
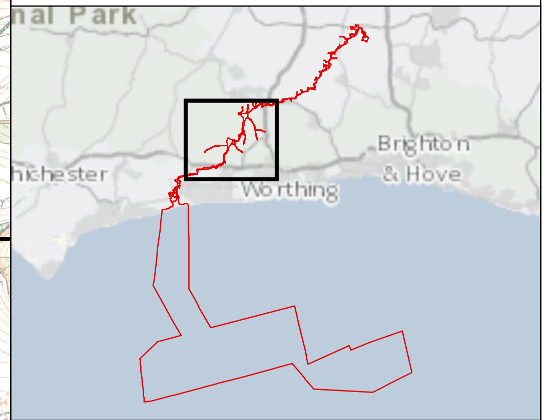


Key

- Proposed DCO Order Limits
- HRA Study Area
- Temporary construction compounds
- Trenchless Crossing (TC) compounds
- Trenchless Crossing (TC) compound alternatives
- Trenchless Crossing (TC) limits of deviation
- Main Rivers

The Study Area for the HRA comprises a 250m buffer around the proposed DCO Order Limits and a 1km buffer around areas where HDD is proposed.



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British National Grid Transverse Mercator

Rampion Extension Development

Rampion 2 Offshore Wind Farm

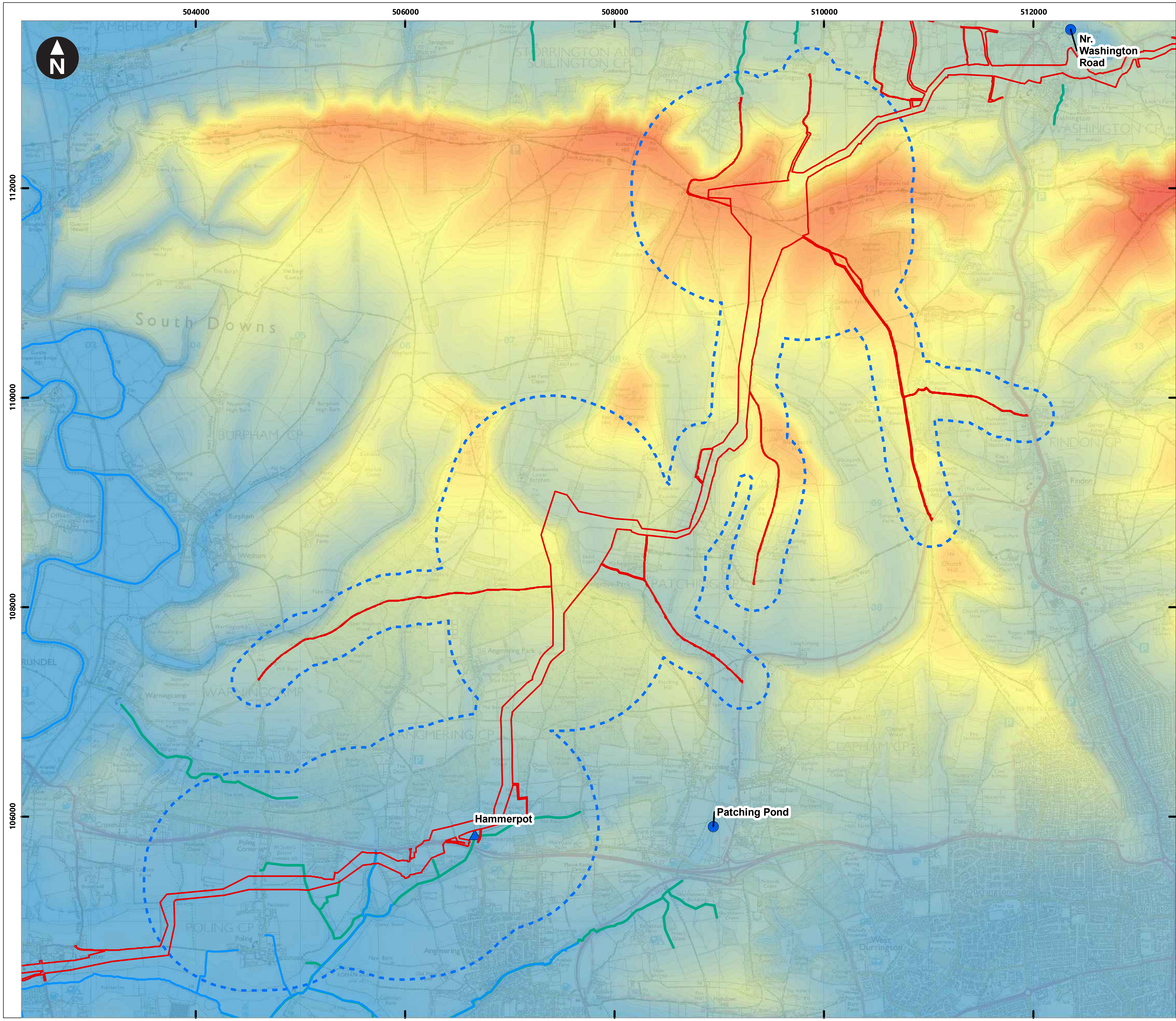
Figure 26.4.1 Site location

Hydrogeological Risk Assessment

Environmental Assessment

System Identifier:	Version:
42285-WSPE-ES-ON-FG-OY-1364	1.0

Company:	Drawn By:	Chk/Aprvd:	Drawn Date:	Status:
WSP	COLLJ	AMYJO	01/08/2023	Final



Key

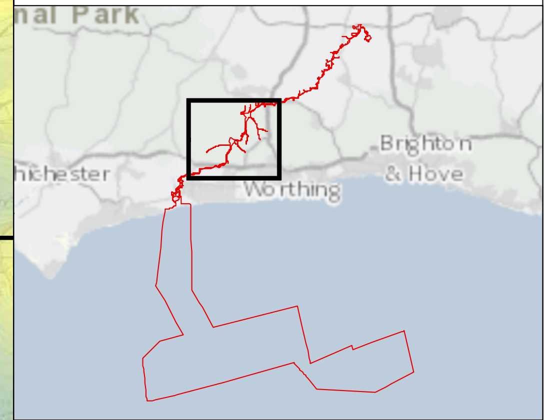
- Proposed DCO Order Limits
- HRA Study Area
- Main Rivers
- Springs
- Ponds
- Chalk streams

LiDAR (2m resolution) DTM elevation (m)

High :

Low :

The Study Area for the HRA comprises a 250m buffer around the proposed DCO Order Limits and a 1km buffer around areas where HDD is proposed.



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British National Grid Transverse Mercator

Rampion Extension Development

Rampion 2 WIND FARM

Rampion 2 Offshore Wind Farm

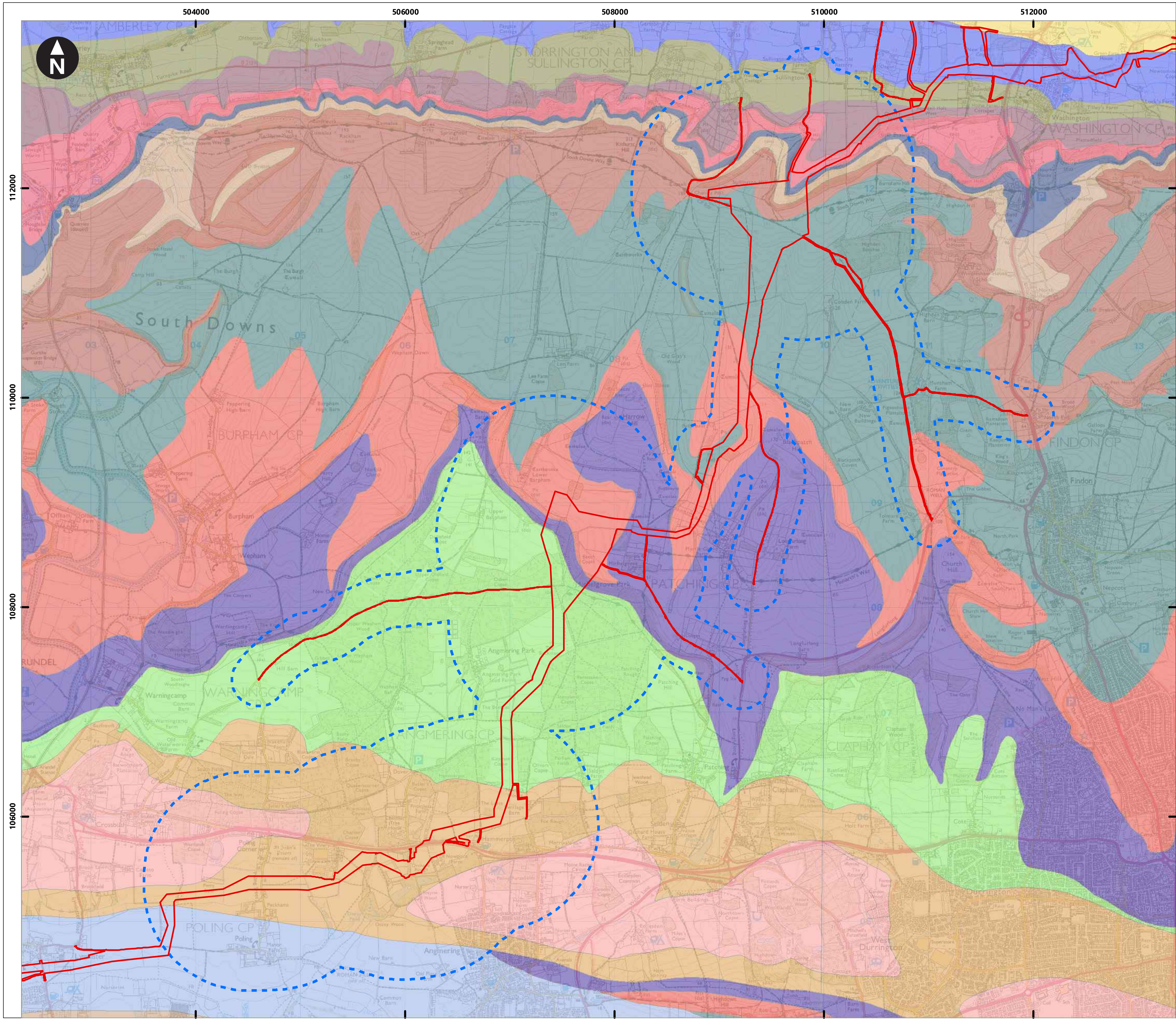
Figure 26.4.2 Topography and drainage

Hydrogeological Risk Assessment

Environmental Assessment

System Identifier:	Version:
42285-WSPE-ES-ON-FG-OY-1291	1.0

Company:	Drawn By:	Chk/Aprvd:	Drawn Date:	Status:
WSP	COLLJ	AMYJO	18/07/2023	Final



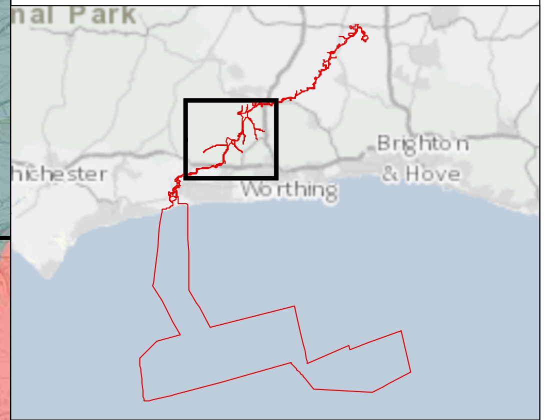
Key

- Proposed DCO Order Limits
- HRA Study Area

Bedrock Geology (BGS, 50k)

- Folkstone Formation
- Gault Formation
- Holywell Nodular Chalk Formation
- Lambeth Group
- Lewes Nodular Chalk Formation
- Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation, Culver Chalk Formation and Portsdown Chalk Formation (Undifferentiated)
- London Clay Formation
- New Pit Chalk Formation
- Newhaven Chalk Formation
- Seaford Chalk Formation
- Spetisbury Chalk Member
- Tarrant Chalk Member
- Upper Greensand Formation
- West Melbury Marly Chalk Formation
- Zig Zag Chalk Formation

The Study Area for the HRA comprises a 250m buffer around the proposed DCO Order Limits and a 1km buffer around areas where HDD is proposed.



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British National Grid Transverse Mercator

Rampion Extension Development

Rampion 2 WIND FARM

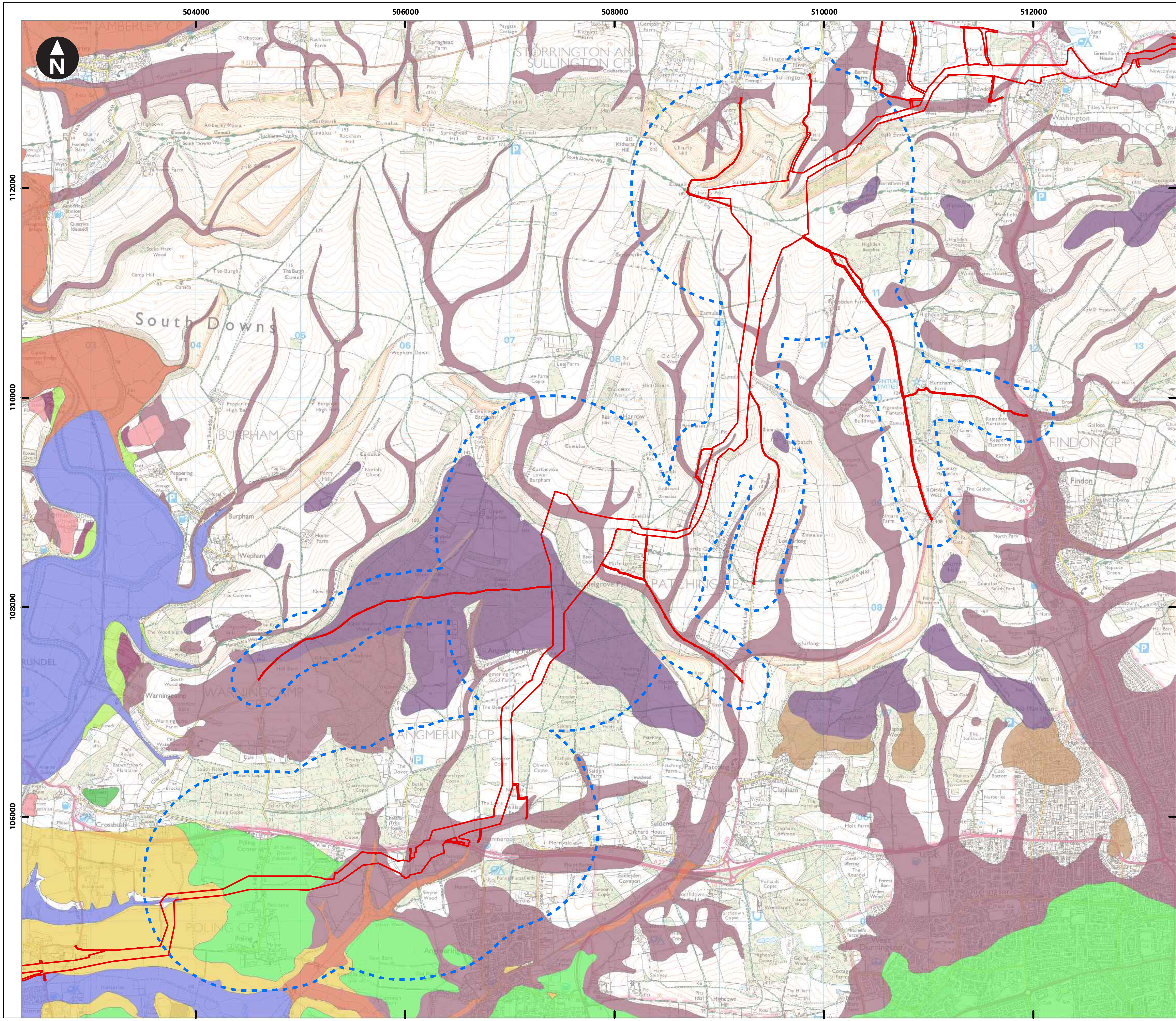
Rampion 2 Offshore Wind Farm

Figure 26.4.3 Solid Geology (1:50000)

Hydrogeological Risk Assessment

Environmental Assessment

System Identifier:				Version:
42285-WSPE-ES-ON-FG-OY-5581				1.0
Company: WSP	Drawn By: COLLJ	Chk/Aprvd: AMYJO	Drawn Date: 18/07/2023	Status: Final



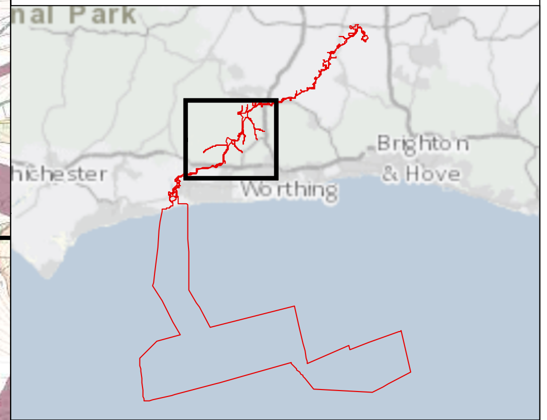
Key

- Proposed DCO Order Limits
- HRA Study Area

Superficial Geology (BGS, 50k)

- Alluvium
- Arun Terrace Deposits, 2 Member
- Arun Terrace Deposits, 3 Member
- Arun Terrace Deposits, 4 Member
- Clay-With-Flints Formation
- Head
- Head, 1
- Raised Beach Deposits, 1
- Raised Marine Deposits
- Raised Storm Beach Deposits, 2
- River Terrace Deposits (Undifferentiated)

The Study Area for the HRA comprises a 250m buffer around the proposed DCO Order Limits and a 1km buffer around areas where HDD is proposed.



Kilometres

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1:35,000

British National Grid Transverse Mercator

Rampion Extension Development

Rampion 2 WIND FARM

Rampion 2 Offshore Wind Farm

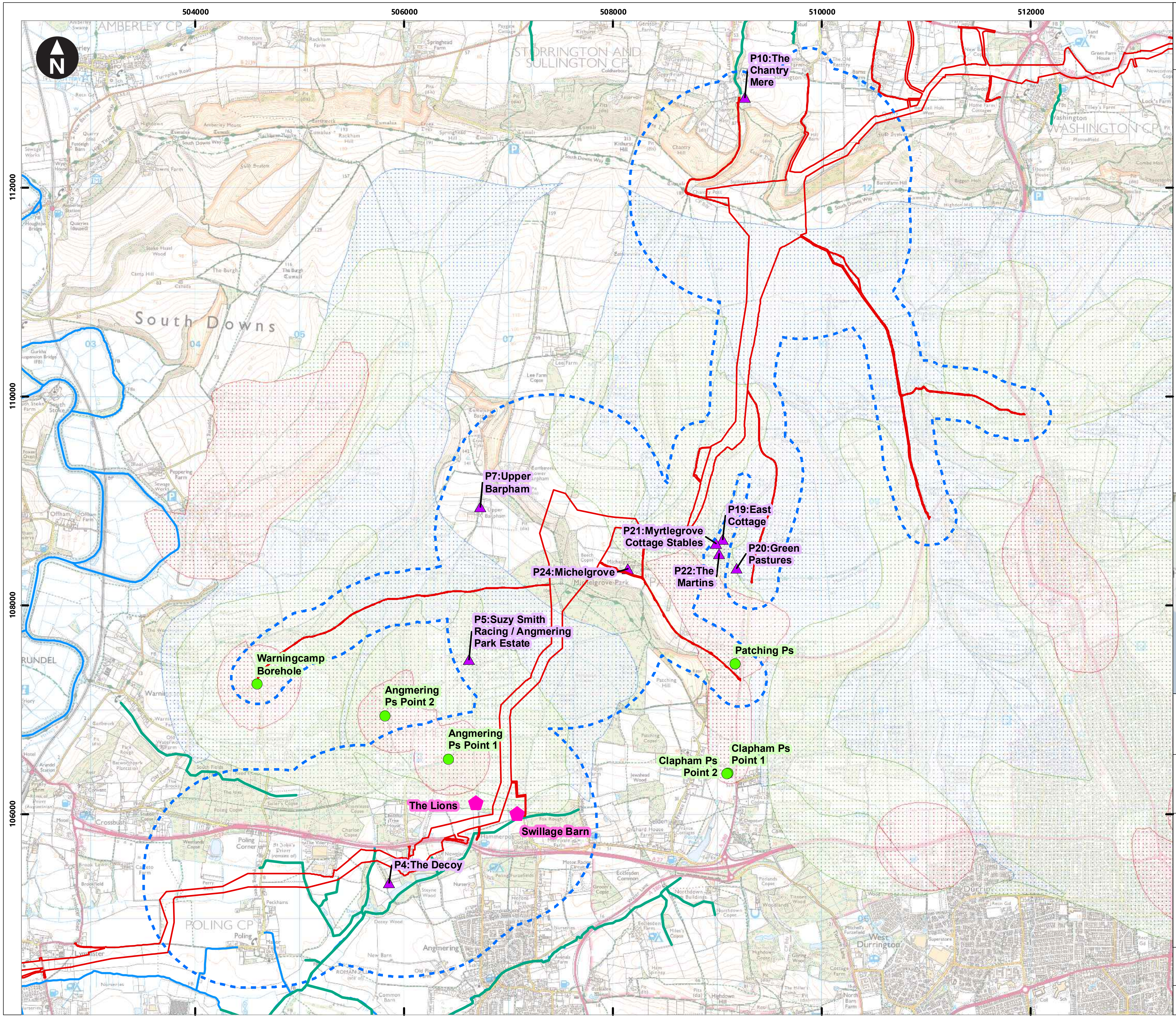
Figure 26.4.4 Superficial Geology (1:50000)

Hydrogeological Risk Assessment

Environmental Assessment

System Identifier:	Version:
42285-WSPE-ES-ON-FG-OY-2804	1.0

Company:	Drawn By:	Chk/Aprvd:	Drawn Date:	Status:
WSP	COLLJ	AMYJO	18/07/2023	Final



Key

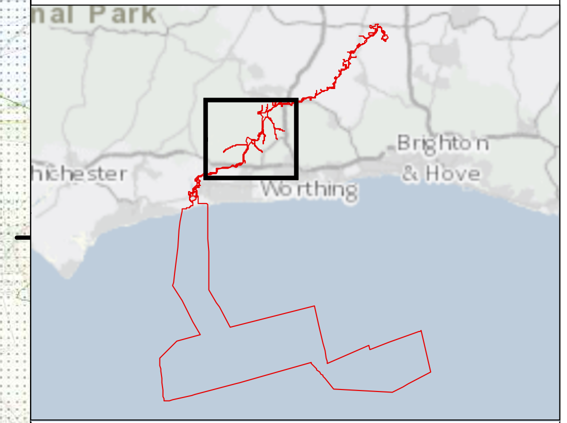
- Proposed DCO Order Limits
- HRA Study Area
- Licensed Abstractions
- Private Water Supplies
- Chalk streams
- Main Rivers

Source Protection Zones

- 1
- 2
- 3

Swallow Holes

- Found



Kilometres

0 0.175 0.35 0.7 1.05 1.4

1:35,000

British National Grid Transverse Mercator

Rampion Extension Development

Rampion 2 WIND FARM

Rampion 2 Offshore Wind Farm

Figure 26.4.5 Hydrogeological features and potential receptors

Hydrogeological Risk Assessment

Environmental Assessment

System Identifier:	Version:
42285-WSPE-ES-ON-FG-OY-5395	1.0

Company:	Drawn By:	Chk/Aprvd:	Drawn Date:	Status:
WSP	COLLJ	AMYJO	18/07/2023	Final

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Annex A
Hydrogeology Site Visit Notes

Overview

Site visits were undertaken on 07, 08 and 09 November 2022, on the 07 December 2022 and on 16 May 2023 to inform the baseline description and conceptual understanding of the Study Area and area of interest. The locations visited are shown within **Figure 26.4.1** - Site location of the Hydrogeological Risk Assessment (HRA) Appendix.

In the area of interest visited during the site visit the Lambeth Formation forms low lying land to the north of the A27 and the topography rises gently to the north onto the Chalk of the South Downs. The boundary between these formations was not observed but the topography is likely to be geological strata dip controlled indicating the shallow dip to southwest (5 degrees) as indicated on geological mapping. On the Lambeth it was noticeable that there is more drainage/ surface water (flowing water in ditches and ponds, etc.) and there seems to be a zone approximately 500m from the chalk/ Lambeth boundary where this wetter environment on the Lambeth starts – i.e., springs and surface water features. This could be where the thickness/ lithology of the Lambeth reduces permeability significantly and where the karst influence of the Chalk below is diminished.

The land surrounding the Warningcamp borehole (visited whilst the route in this area was still an option) gently slopes to the northeast, again a likely feature of the shallow dip of the geological strata. The proposed cable crossing point, at the time, at Warningcamp is a steeper valley with flat valley bottom. Infilling sediments are head superficial deposits within the area of the crossing which appear to form thicker deposits along the north western side of the valley. Lower down the valley the flat "flood plain" widens and superficial deposits are raised marine deposits. The valley was walked down gradient and the area where the water table intersected the surface identified by water in ditches which was clear in places and of good quality (reeds growing etc.). This occurred just above 0m AOD and where manmade drainage has been put in place across a wider flat valley bottom within raised marine deposits.

Exposed chalk was only seen at a few localities (chalk pits and tracks) during the site visit and although difficult to determine they seem to confirm a shallow dip to the southwest across the area. Head and clay with flints were interpreted as being very thin which may explain the frequent breaking through of chalk pits into chalk on the hill tops (interfluves). Chalk (Spitsbury Chalk Member) contained some nodular and thin tabular flints, but no karstic dissolution features were seen. Most accumulations of clay with flints cover the hill tops across the northern part of the area. Head deposits form the base of the valleys sometimes forming raised berms/ areas sometimes on one side of the valley base (i.e., at Warningcamp). Distinguishing between the clay with flints and head was difficult since they seemed to be very similar in nature.

A lot of chalk pits were found (most of the lidar identified depressions) on chalk often on the upper valley slope and also on the top of valley slopes where larger chalk pits had punctured through the clay with flints/ head to access the chalk. Chalk pits were often large and slumped in with no or rarely any chalk exposed. They were usually identified as having poorly defined entrances.

Few karst (dolines/ dissolution features) were identified and only one confirmed case of karst was made. This was a swallow hole with water (a flow of 1l/s) sinking into a depression on the Lambeth at the "*Lions*" just north of Hammerpot. The sink was a depression 5m by 5m and 1.5m deep and took water from a ditch running along a woodland edge in a southwest south direction. Other depressions were identified within the area, for example a doline 3m in diameter, 0.5m deep and located only 50m to the west of the swallow hole. This area was deemed worthy of geophysical analysis, albeit on Lambeth deposits.

Karst is often found on the clay with flints deposits within southern England, because of their effects to increase the acidity of recharge waters. However, this does not seem to be the case in this area and no small circular funnel shaped depressions, typical of doline features, were identified on this deposit. This is either because the survey team did not happen across them (unlikely given the land coverage walked) and/ or the Lidar analysis undertaken by Southern Water (SW) was not at a sensitivity (2 to 10m diameter depressions typical of doline karst) to identify features to target or possibly the clay with flints is too thin in this area for karst to develop. No karst was identified on bare chalk outcrop areas either. Even where the SW dataset identified dissolution features (defined as found and/or not visited by SW) nothing was found. This could be because of the time lapse since their survey and features had been infilled or ploughed out within fields.

Some contamination in the form of dumping was observed, such as plastics etc, but being away from busy roads large scale dumping and pollution risks were largely absent from much of the area.

Field Notes

Monday 07 November 2022

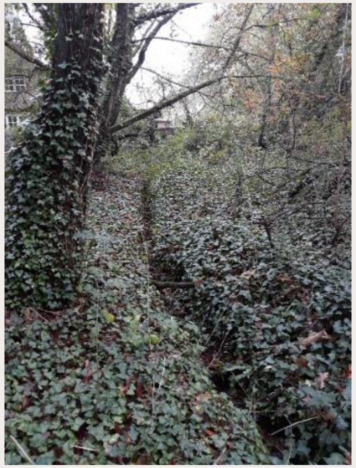
Weather: Cloudy, 12ºC, heavy rain in the morning, light wind, dry in the afternoon

Location: Hammerpot north of the A27

Table A-1 Monday 07 November 2022 survey locations

Activity	Date	Time	Field Stop Number	Notes	Photos
Surface water feature identified	Monday 07 November 2022	11:50	Stop 1	Location: Selden Lane from south at Arundel Road travelling north. NGR TQ 077058. On the Lambeth Group geology valley, downwards slope with ditches and ponding at bottom of hill, including an approx. 30m long pond water feature.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Karst feature – SW found swallow hole	Monday 07 November 2022	12:30	Stop 2	Location: South of Norfolk House and Swillage Barn. TQ 070059. Two possible swallow holes; one not found as in private property but could not see anything in the area. Second possible swallow hole is further west along border of field and footpath. This was a large feature 40m by 8m and 3m deep, although the base could not be seen due to dense vegetation. The feature runs along line of ditch to the west but it is unlikely the larger feature identified as a swallow holes is man-made. This is within the base the valley on Lambeth geology.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Spring identified on OS mapping	Monday 07 November 2022	14:26	Stop 3	Location: Hammerpot off Arundel Road, travelling south to north. TQ 066057. Ditch between the Public Right of Way (PRoW) and private property, 0.3m wide and with water 0.2m deep which was not flowing at the time of the visit. No obvious spring was identified. Slightly north there is a cable HDD crossing east to west across the PRoW and possibly through an extended garden with horses.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Karst feature – SW found swallow hole	Monday 07 November 2022	14:50	Stop 4	Location: travelled north, west of "*The Lions*". TQ 066061. Karst features were found in this area. A large swallow hole 5m by 5m and 1.5m deep. A ditch with water flowing west south west along woodland edge was feeding water into the swallow hole. The swallow hole was visibly takes in flowing water from the ditch at 0.2 l/s. The bottom of feature is flat, slightly modified on one side and dry. A smaller depression was found 10m to the east. Also 50m to the west there is a doline feature, 3m diameter, 0.5m deep, rounded, rounded, curved bottom with hazel trees growing. There is a ditch 7m to the south which was full of water at the time of the visit whilst the doline whose depth was greater than the ditch was dry. These features are on relatively flat ground, slopping from west and north. There appears to be an	 

Activity	Date	Time	Field Stop Number	Notes	Photos
				east to west line of karst features in this area.	
SW small Lidar depression	Monday 07 November 2022	15:15	Stop 5	Location: east of Hammerpot Copse TQ 066063 Likely a large chalk pit 30m by 60m, 7m deep. This feature is on edge of Chalk/ Lambeth geological boundary. Pine trees found growing within the center (about 30 years old). There is no exposed chalk and it has sloping sides with a shallower entrance slope to the south.	
SW not accessed dissolution feature	Monday 07 November 2022	15:28	Stop 6	Location: East of Hammerpot Copse. TQ 067064. Within woodland and on the boundary with a field. Dissolution feature labelled as not accessed. We were able to	

Activity	Date	Time	Field Stop Number	Notes	Photos
				access the location during the survey but no karst features were found in the area. No photograph was taken at this area.	
Small depression	Monday 07 November 2022	15:38	Stop 7	Location: On PRoW, north of Hammerpot Copse. TQ 066065. Just within woodland to the side of the path. A shallow depression, 10 m by 15 m, 1 m deep, possible doline.	
Checlk pit on OS mapping	Monday 07 November 2022	15:44	Stop 8	Location: Northern PRoW exit at Hammerpot Copse, leading up to Angmering Estate. TQ 066067. This is a large chalk pit, 50m by 60m, 8m deep and badger set digging has exposed chalk debris.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Topographic feature	Monday 07 November 2022	15:49	Stop 9	Location: looking west along PRoW up to Angmering Estate. TQ 06690 06865. A view of a dry chalk valley	
Depression identified during survey	Monday 07 November 2022	15:53	Stop 10	Location: In woodland prior to Angmering Estate. TQ 066068. A large chalk pit, 50m by 60m, 10m deep.	
Depression identified during survey	Monday 07 November 2022	16:02	Stop 11	Location: In woodland prior to Angmering Estate. TQ 067071. Large chalk pit, 6m depth, with some flint bands visible in the exposed chalk.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Depression identified during survey	Monday 07 November 2022	16:21	Stop 12	Location: Northern woodland of Hammerpot Copse. TQ 065065. A large chalk pit, 100m by 30m by 7m, with an exposed chalk face to the east.	
SW Lidar depression of undetermined size	Monday 07 November 2022	16:35	Stop 13	Location: Boarder of Butlers Copse and Priorsleas Farm. TQ 062061. A SW Lidar depression which is shallow, 1.5m deep and elongated 6m by 30m. It is uncertain but it is likely to be a pit with no drainage into it. It is dry with rubbish, metal drum, plastics and also some chalk debris. On superficial head and on boundary of Spetisbury Chalk and Lambeth.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Surface water feature identified and private water supply well	Monday 07 November 2022	16:42	Stop 14	Location: South of Priorsleas Farm near the A27. TQ 061058. A pond located on the Lambeth Group geology. A nearby private water supply and well, marked on OS mapping was not found.	

Tuesday 08 November 2022

Weather: Cloudy, 12ºC to 14ºC warm – occasional rain in the morning, light wind, drier in the afternoon with some blue sky

Location: Warningcamp Area

Table A-2 Tuesday 8 November 2022 survey locations

Activity	Date	Time	Field Stop Number	Notes	Photos
Surface water feature identified	Tuesday 08 November 2022	09:43	Stop 1	Location: East side of Clay Lane. TQ 039065. A pond located on the boundary of the Lambeth Group geology and Spetisbury Chalk. Bottom of the valley, south of the main Warningcamp area. The water is brown and highly sedimented after heavy rains.	

Activity	Date	Time	Field Stop Number	Notes	Photos
SW not accessed dissolution feature	Tuesday 08 November 2022	09:55	Stop 2	Location: Old Waterworks Farm. TQ 038066. SW dissolution feature identified that was labelled as not accessed. We are able to access the location during the survey but nothing found. It is within a field and could have been filled in.	
Topographic survey	Tuesday 08 November 2022	10:07	Stop 3	Location: West side of Clay Lane. TQ 040069. The survey view is looking west towards cable route along Warningcamp Farm, Arundel seen in the distance.	
SW not accessed dissolution feature	Tuesday 08 November 2022	10:13	Stop 4	Location: In strip of Woodland at Warningcamp. TQ 041069. Dissolution feature identified that was labelled as not accessed. We are able to access the location during the survey but nothing found. Location is within	

Activity	Date	Time	Field Stop Number	Notes	Photos
				thin strip of woodland, with fields surrounding – no photo was taken.	
SW Warnincamp abstraction borehole	Tuesday 08 November 2022	10:27	Stop 5	Location: Warningcamp, at corner of Blakehurst Lane. TQ 046072. SWS Warningcamp abstraction borehole, was gated off but in clear site of flat ground.	
SW Warnincamp observation borehole	Tuesday 08 November 2022	10:30	Stop 6	Location: Warningcamp, at corner of Blakehurst Lane. TQ 046072. The SWS Warningcamp abstraction borehole, this was found in a small area behind an area for car parking, very nearby the abstraction borehole (15 meters to the northeast). The label on the borehole indicates it is the property of Affinity Water, but it must SWS owned.	

Activity	Date	Time	Field Stop Number	Notes	Photos
SW identified chalk pit of undetermined size	Tuesday 08 November 2022	10:55	Stop 7	Location: Top of valley at Monarchs Way. TQ 046076. Large chalk pit found, some exposed chalk with modular and thin tabular flint up to 5cm. Dip difficult to determine but it has a low angle to south west. Flint with more variable dip angles. This outcrop is on then boundary of Tarrant chalk and Spetisbury Chalk group.	
Inspection of chalk face of chalk pit	Tuesday 08 November 2022	11:05	Stop 8	Location: Top of valley at Monarchs Way. TQ 045075. Chalk alongside of large chalk pit. Dip confirms shallow 6 degrees between south and west. Thin 1 cm tabular and modular chalk, fossils present (echinoid). Again on the boundary of Tarrant chalk and Spetisbury Chalk.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Topographic survey	Tuesday 08 November 2022	11:20	Stop 9	Location: base of Warningcamp Valley. TQ 042076. Looking towards the valley crossing point in southwest direction, 20m flat width across bottom of valley, on Tarrant chalk with berm of head deposit to the northwest side of valley. Steep sided valley at approximately 45 degrees, with approximately 50 mAOD height at top of valley.	
HDD location survey	Tuesday 08 November 2022	11:25	Stop 10	Location: base of Warningcamp Valley. TQ 041075. At the direct travel route of the indicative cable route corridor with HDD compounds at the top of each side of the valley, alternative HDD compound is found at the bottom of the valley. Note of overhead electrical cables potentially crossing the same route as cable. Left image looks northwest, right image looks southeast.	 

Activity	Date	Time	Field Stop Number	Notes	Photos
Surface water feature identified	Tuesday 08 November 2022	11:35	Stop 11	Location: base of Warningcamp Valley, on corner of woodland. TQ 040074. Pond located in a depression at the base of the valley. Water is dark in colour and silty after heavy rain. It is approximately 5m by 6m, and 1m deep. Clayey soils, uncertain if water table or perched water. The valley bottom flat widens to 30m travelling west.	
Exposed chalk face	Tuesday 08 November 2022	11:42	Stop 12	Location: Raised platform along PRoW at south base of Warningcamp Valley. TQ 040074. A track along a raised platform exposes chalk face on one side. Thin 0.2m sub soil, weathered chalk 1m, and then clayey, putty like and crumbly white chalk no flint seen. There had been recent forestry works along the footpath.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Ditches/ streams identified on map	Tuesday 08 November 2022	11:57	Stop 13	Location: base of Warningcamp Valley on far west side. TQ 036074. We found a man-made ditch which is at the base of the valley and runs from one side of the valley to the other to then turn at a right angle along the valley route and down gradient. Likely water table, full of deep water, 3m wide in places, reeds seen, clear water. Geology is of superficial layer of raised marine deposits in the area It suggests water table at this elevation/ location.	 
SW LiDAR feature	Tuesday 08 November 2022	12:14	Stop 14	Location: The Woodleighs, north of Warningcamp Valley. TQ 039077. Identified Lidar feature could not be found. Could be under the dense vegetation.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Depression identified	Tuesday 08 November 2022	12:41	Stop 15	Location: at top of Warningcamp Valley on south side on edge of field. TQ 043074. Depression identified on the edge of field. This was not previously identified during SW Lidar analysis. It is 20m in diameter, 1.5m deep. Water ponding in path but not in main depression. It has smooth sides and is on the edge of head superficial deposit and is likely a chalk pit.	
SW LiDAR feature	Tuesday 08 November 2022	13:48	Stop 16	Location: Oldfield Copse woodland. TQ 058080. Depression identified, fenced off but visible on side of path. 5m diameter, circular, slightly funnelled shape,1.5m deep, 0.2m of water at bottom. Closed depression, no drainage. Possible doline on chalk.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Depression identified	Tuesday 08 November 2022	13:50	Stop 17	Location: Oldfield Copse woodland. TQ 058080. Pit found close to road, this was not previously identified by SW Lidar. Dimensions are 15m by 25m, 2.5m deep, oval shape, possible ramp to northeast, likely chalk pit.	
SW LiDAR feature	Tuesday 08 November 2022	13:54	Stop 18	Location: Oldfield Copse woodland. TQ 058080. Lidar feature identified by SW but not found. It could have been slightly mis-mapped and instead by the above feature.	
SW LiDAR feature	Tuesday 08 November 2022	14:02	Stop 19	Location: Upper Wepham Wood. TQ 057079. Site identified by LiDAR data, found to be chalk pit with dimensions 40m by 30m, and 4.5m deep, obvious entrance ramp to the south, oval shape. Vehicle entrance tracks visible	

Activity	Date	Time	Field Stop Number	Notes	Photos
				on road side. No superficial geology in the area.	
Depression identified	Tuesday 08 November 2022	14:10	Stop 20	Location: Upper Wepham Wood. TQ 057078. A small depression within woodland. It is likely a small doline, 5m by 7m, shallow 1m deep. Enclosed circular depression, on the Spetisbury Chalk member.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Depressions identified	Tuesday 08 November 2022	14:15	Stop 21	Location: Upper Wepham Wood. TQ 057077 Two depressions were found just next to each other, first is 5m diameter and 0.75m deep, circular closed and shallow. The second Larger feature is 10m to south. Oval shaped, closed but possible ramp to south, 10m by 25m, and 1.5m deep. They could also be chalk pits due to ramp. On the edge of head chalk boundary possibly indicating pit.	
SW LiDAR feature	Tuesday 08 November 2022	14:25	Stop 22	Location: Lower Oldfield Copse. TQ 058075. Large chalk pit identified by LiDAR data. Two separate levels. 50m by 35m, and 6m deep, irregular shape with possible two faces east and west, infilled with beech trees that are approximately 50 years old. Found on head deposits.	

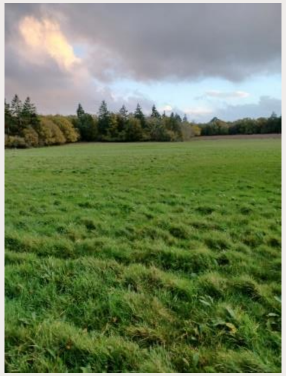
Activity	Date	Time	Field Stop Number	Notes	Photos
SW LiDAR feature	Tuesday 08 November 2022	14:34	Stop 23	Location: Upper Wepham Wood. TQ 056076. Chalk pit found on the head boundary. 50m by 40m, and 7m deep. Oval shaped. Possible ramp to the east. Not close to any paths.	
SW LiDAR feature	Tuesday 08 November 2022	14:39	Stop 24	Location: Upper Wepham Wood. TQ 055077. Chalk pit found with dimensions 25m by 30m, and 2.5m deep. Just on the Chalk/ head boundary. Oval shaped with one steep slightly rectangular face. Next to path indicating likely chalk pit.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Chalk pit	Tuesday 08 November 2022	14:49	Stop 25	Location: Upper Wepham Wood. TQ 052078. Chalk pit found as identified through OS mapping. It has two levels with dimensions of 40m by 30m and 6m deep. Steep on one side. Within chalk on side of valley. It has an entrance on lower valley slope to the west and irregular in shape.	
Chalk pit	Tuesday 08 November 2022	14:56	Stop 26	Location: Upper Wepham Wood. TQ 053079. Chalk pit found as identified from OS mapping. It has dimensions of 15m by 10m and 3.5m deep and is oval shaped and on side of valley. Lower entrance level downslope of the valley and a steep slope on one side.	

Activity	Date	Time	Field Stop Number	Notes	Photos
SW LiDAR feature	Tuesday 08 November 2022	15:05	Stop 27	Location: Tenantry Copse. TQ 055081. LiDAR feature identified, when inspected it was found to be a chalk pit. Irregular in shape with one upper level, 40m by 30m in size, and 5m deep. It has a sloped entrance on east side towards path.	
Depression identified	Tuesday 08 November 2022	15:28	Stop 28	Location: Gibbet Piece. TQ 051074. Depression identified within woodland and it is likely to be a chalk pit. Dimensions are 10m by 25m, and 2m deep, oval shaped with shallow depression, but no obvious ramp and next to path. Located on superficial head deposit,	

Activity	Date	Time	Field Stop Number	Notes	Photos
SW LiDAR feature	Tuesday 08 November 2022	15:36	Stop 29	Location: Gibbet Piece. TQ 052072. A LiDAR depression was found and although it is slightly fenced off it remains visible. It is large in size at 30m by 40m and 5m deep and oval shaped, with a possible entrance to west and is likely a chalk pit on head deposits.	
SW dissolution feature – not accessed	Tuesday 08 November 2022	15:40	Stop 30	Location: Gibbet Piece. TQ 051072. Dissolution feature highlighted from the OS mapping. However, from an inspection of the surrounding area no dissolution feature was found. It is located in the boundary of woodland and field with sheep.	

Activity	Date	Time	Field Stop Number	Notes	Photos
SW LiDAR feature	Tuesday 08 November 2022	15:48	Stop 31	Location: Gibbet Piece. TQ 054071. Aa large chalk pit with dimensions 60m by 50m and 10m deep. Irregular in shape with numerous centres. Possible entrance to the east, near path and found on head deposit.	
SW LiDAR feature	Tuesday 08 November 2022	16:05	Stop 32	Location: Woodland next to Blakehurst Farm. TQ 049068. Feature picked up by SW LiDAR data, but it is in a small section of woodland that is fenced over and densely vegetated so it is not clear what might be in there. But it is likely a large chalk pit. No dissolution features were visible.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Dissolution feature – not accessed	Tuesday 08 November 2022	16:12	Stop 33	Location: Blakehurst Copse. TQ 050067. A field with a dissolution feature identified by SW as visible. But it is fenced off at the time of the survey so not directly accessible. There is possibly a depression in the field, but it is too far away and not clear.	
Large chalk pit – not accessed	Tuesday 08 November 2022	16:21	Stop 34	Location: Bushey Field. TQ 052068. Large chalk pit found that had previously not been accessed. It is more than 100m in diameter, with numerous levels and steep faces on some sides. It is within a woodland area with dense vegetation within the pit.	

Wednesday 09 November 2022

Weather: 13ºC to 15ºC warm, light wind, dry with some blue sky and high cloud

Location: Angmering Park and Patching

Table A-3 Wednesday 9 November 2022 survey locations

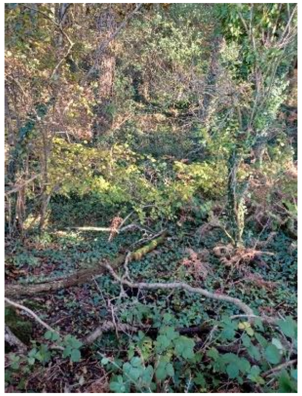
Activity	Date	Time	Field Stop Number	Notes	Photos
Topographic survey	Wednesday 09 November 2022	09:50	Stop 1	Location: Michelgrove Lane – north west end. TQ 083082. View looking northwest along the valley.	
SW chalk pit identified	Wednesday 09 November 2022	09:57	Stop 2	Location: Michelgrove Park, on valley side facing northeast. TQ 082079. A large chalk pit on eastern side of valley with dimensions of 30m by 25m. it is alongside a track and there is exposed	

Activity	Date	Time	Field Stop Number	Notes	Photos
				chalk, but the dip of strata is not visible.	
SW chalk pit identified	Wednesday 09 November 2022	10:04	Stop 3	Location: Top of valley at Patching Rough. TQ 082077. A large chalk pit found, 80m by 40m, and 8m deep with two centres. It has an irregular shape and there is no chalk exposed.	
SW LiDAR feature	Wednesday 09 November 2022	10:10	Stop 4	Location: Patching Rough. TQ 081078. SW LiDAR feature identified site found and it is likely to be a chalk pit. Although rounded it has possible entrance to north east. On clay with flints and chalk boundary and is 30m in diameter and 3.5m deep.	

Activity	Date	Time	Field Stop Number	Notes	Photos
SW LiDAR feature	Wednesday 09 November 2022	10:20	Stop 5	Location: Patching Rough. TQ 081076. SW LiDAR feature identified site found and it is likely to be a chalk pit with flints present. Steep to the north, possible entrance to south west with very large tracks. It is oval shaped, with dimensions of 30m by 25m, and 3.5m deep with some chalk debris observed.	
Swallow hole – not accessed	Wednesday 09 November 2022	10:34	Stop 6	Location: Patching Rough. TQ 079076. A swallow hole identified from SW data, but when area inspected only flat ground within the woodland was observed. No drainage or sink feature appear to exist.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Depression found	Wednesday 09 November 2022	10:38	Stop 7	Location: Patching Rough. TQ 079076. A small depression on ground, not identified from the SW LiDAR analysis. Dimensions of the feature are 5m by 5m and 0.5m deep. It is next to a track and possibly a pit on chalk with flints deposits.	
SW large LiDAR depression	Wednesday 09 November 2022	10:47	Stop 8	Location: North of Barnstake Copse. TQ 077075. A depression found and is likely a chalk pit. It is rectangular in shape and regular, with high berms in middle running northeast to southwest with dimensions of 35m by 50m and 5m deep.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Topographic survey, distant view of dissolution feature	Wednesday 09 November 2022	10:53	Stop 9	Location: Boundary of Angmering Park and woodlands. TQ 076075. View north west to area of dissolution feature within the field.	
SW dissolution feature	Wednesday 09 November 2022	11:05	Stop 10	Location: Angmering Park, within the field. TQ 074076. A dissolution feature identified within SW data, but upon inspection of the area no evidence of a dissolution feature was found, only a patch of bare ground with less crops and a possible slight scoop on north edge of valley, but no clear indications of a dissolution feature.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Topographic survey	Wednesday 09 November 2022	11:11	Stop 11	Location: Angmering Park, within the field. TQ 073076. View downslope towards valley facing west.	
Depression found	Wednesday 09 November 2022	11:23	Stop 12	Location: Boundary of Angmering Park and woodlands. TQ 076077. A possible chalk pit found, on the edge of a field. The dimensions are 35m by 25m, and 6.5m deep, oval shaped and just within woodland with dense vegetation inside, it is located just to the north of valley, on top of the valley. It is a closed depression, shallower on southern side where there is also a track.	

Activity	Date	Time	Field Stop Number	Notes	Photos
SW small chalk pit	Wednesday 09 November 2022	11:28	Stop 13	Location: Boundary of Angmering Park and woodlands. TQ 075078. An elongated feature, 8m wide, 35m long, 2 m deep, by a track regular in shape and likely a pit.	
Topographic survey	Wednesday 09 November 2022	11:38	Stop 14	Location: Boundary of Angmering Park and woodlands. TQ 072079. Looking south towards field from the pathway in the woodland.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Three SW LiDAR features	Wednesday 09 November 2022	11:44	Stop 15	Location: Oaken Copse, north of Angmering Park. TQ 070078. Although three LiDAR features were identified, only found two large chalk pits in a line were found. Both were oval in shape, 6m deep, large up to 30m by 40m, with some chalk exposed.	
Topographic survey	Wednesday 09 November 2022	12:50	Stop 16	Location: Longfurlong Farm. TQ 095093. A view looking southwest downslope of the valley at a crossing area.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Topographic survey	Wednesday 09 November 2022	12:54	Stop 17	Location: Longfurlong Farm. TQ 094094. View looking southeast near a crossing area.	
Topographic survey	Wednesday 09 November 2022	13:06	Stop 18	Location: top of Blackpatch Hill. TQ 096095. View looking south at the HDD area.	

Activity	Date	Time	Field Stop Number	Notes	Photos
SW small LiDAR feature	Wednesday 09 November 2022	13:06	Stop 19	Location: top of Blackpatch Hill. TQ 096095. At this LiDAR depression a man-made feature was found 2 with a very regular circular berm, 25m in diameter and 1 m high. This was at high point of hill at 175m AOD.	

Panoramic view looking southwest, from the top of the artificial berm.

Activity	Date	Time	Field Stop Number	Notes	Photos
SW LiDAR feature	Wednesday 09 November 2022	13:21	Stop 20	Location: Longfurlong Farm. TQ 094091. A chalk pit found as an identified LiDAR feature. It is a scoop in the hillside, rectangular shape with dimensions 20m by 25m, and 4m depth with no exposed chalk .	

Wednesday 07 December 2022

Weather: Partly cloudy, 3ºC, dry all day, not windy

Location: Hammerpot north of the A27

Table A-4 Wednesday 7 December 2022 survey locations

Activity	Date	Time	Field Stop Number	Notes	Photos
	Wednesday 07 December 2022	09:24	Stop 1	Location: Hammerpot. TQ 067057. Ditch with flowing water, travels around the properties and fields. Slowly flowing water.	 

Activity	Date	Time	Field Stop Number	Notes	Photos
Topographic survey	Wednesday 07 December 2022	09:33	Stop 2	Location: north of Hammerpot along PRoW. TQ 067059. Location of HDD cable crossing. Looking on to the west side of the PRoW.	
Swallow re-visited	Wednesday 07 December 2022	09:43	Stop 3	Location: West of The Lions. TQ 065060. Swallow hole visited for a second time. However due to the dry weather conditions this day, there was not a visible flow in the ditch. More leafy debris present. Horses are in the field immediately adjacent.	  

Activity	Date	Time	Field Stop Number	Notes	Photos
Doline re-visited	Wednesday 07 December 2022	09:44	Stop 4	Location: West of The Lions. TQ 066060. Doline identified, appears exactly the same as previous visit.	
Topographic survey	Wednesday 07 December 2022	09:52	Stop 5	Location: North of Hammerpot. TQ 065060. Looking south towards the HDD crossing on the west side of the PRoW. Looking at same area as stop 2 but from the north.	
Topographic survey	Wednesday 07 December 2022	10:04	Stop 6	Location: North of Hammerpot. TQ 067060. Looking south towards the HDD crossing on the east side of the PRoW.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Water feature identified	Wednesday 07 December 2022	10:07	Stop 7	Location: In the woodland at The Lions. TQ 067060. Water feature found in the woodland area. It is rectangular shape with dimensions of 5m by 30m.There are reeds and other vegetation in the water, the water is mostly brown and sedimented. It is on the Lambeth bedrock on the boundary of a head deposit. The soils are very soft and light brown to red in colour.	  
Topographic survey	Wednesday 07 December 2022	10:21	Stop 8	Location: On the edge of the woodland and field at The Lions. TQ 068060. Looking east across the red line boundary.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Topographic survey	Wednesday 07 December 2022	10:24	Stop 9	Location: In the field at The Lions. TQ 069060. Looking north along the red line boundary.	
Possible swallow hole re-visited	Wednesday 07 December 2022	10:30	Stop 10	Location: in field, next to PRoW at The Lions. TQ 070059. Possible swallow, the same condition as when previously visited.	 

Activity	Date	Time	Field Stop Number	Notes	Photos
Possible swallow hole re-visited	Wednesday 07 December 2022	10:37	Stop 11	Location: in field, next to PRoW at The Lions. TQ 070059. Possible swallow, the same condition as when previously visited.	 
Surface water feature re-visited	Wednesday 07 December 2022	10:43	Stop 12	Location: along the road to the west of Fox Rough. TQ 071059. Surface water feature visited again, brown sedimented waters. Abundance of bird life present. Protected habitat.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Flowing water	Wednesday 07 December 2022	10:50	Stop 13	Location: In Fox Rough campsite. TQ 072059. Clear flowing water travelling west to east. On head deposit.	
Surface and subsurface feature from mapping	Wednesday 07 December 2022	11:03	Stop 14	Location: In Fox Rough campsite. TQ 073060. Clear flowing water travelling west to east. There is a pipe coming from the northeast pointing into the stream but currently no output. Children's play area nearby, swing in picture.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Possible swallow hole	Wednesday 07 December 2022	11:14	Stop 15	Location: In Fox Rough campsite. TQ 072059. Possible swallow hole, in large pit which is at the end of the stream/ditch pictured in previous stops. There is a small pool and the water stops flowing, possibly due to a swallow hole. Pit is 40m by 20m and 8 m deep, it is flat on one end where the water from the stream comes from. There is a platform on the top of the southern edge – suggests this could have been filled with water in the past. Videos available upon request.	 

Activity	Date	Time	Field Stop Number	Notes	Photos
Surface water feature identified	Wednesday 07 December 2022	11:17	Stop 16	Location: Fox Rough. TQ 071059. The same pond as in stop 12 but from the opposing side. The pond drains into the pit where the swallow hole, however it does not reach as far as up to the swallow hole.	 
Topographic survey	Wednesday 07 December 2022	11:40	Stop 17	Location: The Lions, in the field. TQ 069062. Looking south along red line boundary, opposite direction of stop 9.	
LiDAR feature investigated	Wednesday 07 December 2022	11:44	Stop 18	Location: woodland between Kitpease Copse and The Lions. TQ 069063. Large chalk put found. Approximately 15m by 30m and 4m deep. On boundary of Lambeth and Spetisbury Chalk.	

Activity	Date	Time	Field Stop Number	Notes	Photos
				Elongated shape, with dense vegetation throughout.	
LiDAR feature investigated	Wednesday 07 December 2022	11:46	Stop 19	Location: woodland between Kitpease Copse and The Lions. TQ 068063. Second smaller chalk put found next to larger one at stop 19. Dimensions are 5m by 7m and 2m deep.	
Topographic survey	Wednesday 07 December 2022	11:50	Stop 20	Location: Kitpease Copse. TQ 069063. Looking north along red line boundary.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Dissolution feature on mapping	Wednesday 07 December 2022	11:54	Stop 21	Location: Kitpease Copse. TQ 069064. Dissolution feature had been identified by SWS mapping work. Upon visiting the area no feature had been found. It could have possibly been filled in.	
Topographic survey	Wednesday 07 December 2022	13:46	Stop 22	Location: Kitpease Copse. TQ 069064. Looking south along red line boundary. Faces in the direction of stop 20.	
Topographic survey	Wednesday 07 December 2022	13:48	Stop 23	Location PRoW between Angmering and Kitpease Copse. TQ 069067. Cable passes through the footpath with no crossing.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Topographic survey	Wednesday 07 December 2022	13:52	Stop 24	Location: Angmering, between The Beeches and Kitpease Copse. TQ 069067. Looking north along red line boundary.	
Walking near red line boundary	Wednesday 07 December 2022	14:00	Stop 25	Location: boundary of field and woodland at Angmering. TQ 071068. Existing infrastructure found. Approximately 100m east of red line boundary.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Survey	Wednesday 07 December 2022	14:03	Stop 26	Location: The Beeches. TQ 070069. Along path with tracks on the east of the red line boundary.	
Topographic survey	Wednesday 07 December 2022	14:06	Stop 27	Location: The Beeches. TQ 070070. Looking west across red line boundary. Picture is taken over a fence into well maintained field, it looks like it used to keep horses.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Topographic survey	Wednesday 07 December 2022	14:11	Stop 28	Location: The Beeches. TQ 070070. Looking northeast along red line boundary. In the corner of the field there is a waste pile of hay.	 
Topographic survey	Wednesday 07 December 2022	14:20	Stop 29	Location: Angmering Park Stud Farm. TQ 070074. South side of valley, looking northeast towards dissolution feature that was previously visited in November but nothing was found.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Dissolution feature identified from mapping	Wednesday 07 December 2022	14:37	Stop 30	Location: Angmering Park Stud Farm. TQ 069074. In small section of wooded area, a possible chalk pit with dimensions of 8m by 12m and 2m deep. It is on the side of the valley so much steeper on the south side and a natural entrance on the north. In the middle of the pit there was a slightly raised chalk area, in the middle of the there was a hole that was considered to be an animal borrow, although the surveyor was not certain.	
Topographic survey	Wednesday 07 December 2022	14:48	Stop 31	Location: Angmering Park Stud Farm. TQ 072073. Looking northeast along red line boundary.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Chalk pit found	Wednesday 07 December 2022	15:02	Stop 32	Location: In woodland near Selden Fields. TQ 072069. Large chalk pit found with dimensions of 25m by 20m and 5m deep. It is sloped on the southwest side displaying a natural entrance. There is a raised platform in the middle with three dips surrounding.	
Chalk pit on mapping	Wednesday 07 December 2022	15:12	Stop 33	Location Olivers Copse. TQ 072066. In a field with crops, a chalk put was identified through mapping. However when visited nothing could be seen, possibly there is a dip in the ground where it might have been filled in.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Chalk pit found	Wednesday 07 December 2022	15:17	Stop 34	Location Parham Fields. TQ 073065. Chalk pit found with dimensions of 10m by 15m and 3m deep. In woodland on side of path with no chalk visible.	
Surface water feature found	Wednesday 07 December 2022	15:21	Stop 35	Location Parham Fields. TQ 075064. Small surface water feature found in woodland on the side near a field. It has a circular shape and has dimensions of 5m by 7m. The dissolution feature identified from the mapping could not be found nearby.	

Activity	Date	Time	Field Stop Number	Notes	Photos
Survey	Wednesday 07 December 2022	15:23	Stop 36	Location Parham Fields. TQ 075064. Thin pipe found in an east to west direction. Unclear what it is used for.	
Dissolution feature on mapping	Wednesday 07 December 2022	15:40	Stop 37	Location Olivers Copse. TQ 072063. The mapping identified a dissolution feature in the field, however upon inspection no such feature could be identified. It is in a field so could have been filled in.	

Tuesday 16 May 2023

Weather: Partly cloudy, warm, 17^{o}C, dry all day, light windy, sunny

Location: Michelgrove Lane, north of the A280

Table A-5 Tuesday 16 May 2023 survey locations

Activity	Date	Time	Field Stop Number	Notes	Photos
Survey	Tuesday 16 May 2023	17:00	Stop 1	Location: Michelgrove Lane, (Access-26), outside of SW Patching public water supply. TQ 091073. Location of upgrading works along the Michelgrove Lane looking northwest and southeast.	 

Activity	Date	Time	Field Stop Number	Notes	Photos
Survey	Tuesday 16 May 2023	17:20	Stop 2	Location: Michelgrove Lane, (Access-26), 100 m south of Michelgrove PWS looking west towards HDD compound TC-12. TQ 081083.	

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Annex B
Geophysical Investigation Report

Littlehampton to Bolney cable route

Report | Geophysical Investigation

223150 01 | 9 June 2023

Final

WSP

Document Control

Document Information

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01	9 June 2023	Final	First issue	AD	BB	DK

Project Team

Initials	Name	Role
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Executive Summary

This report documents a geophysical investigation using electrical resistivity tomography (ERT) and electromagnetic conductivity (EM) at the site of a proposed cable route near Littlehampton.

The specific objective of the geophysical investigation was to identify potential risk areas within the study area that might pose difficult ground conditions for the planned cable route works. Such risk areas may relate to dissolution/karst features within the near surface chalk geology.

The survey was carried out between 16th May and 22nd May 2023 using an Syscal Terra ERT system and a CMD Explorer EM instrument.

Initial trial surveys were undertaken at two suspected existing sink hole features (The Lions sink hole on 16th May and Swillage Barn sink hole on 17th May).

The ERT results at the Lions sink hole location indicated significant variation in the interpreted boundary between the Lambeth group layer and the chalk bedrock at the location of the suspected sink hole.

The ERT results at the Swillage barn site indicated an anomalously high resistivity zone within the Lambeth group sediments at the location of the suspected sink hole. This was also apparent in the EM survey results at this location which showed an area of low conductivity (high resistivity) in the same location.

The main survey ERT lines/EM survey area followed on from the two trial investigations. The main survey data were interpreted for similar features as identified in the two trial investigations.

The main survey ERT survey comprised 3 parallel profile lines, each 225 m in length, in an approximate east-west orientation. The ERT data was considered to be of good quality with very low contact resistances between the electrodes and the ground surface. Modelled resistivity data generally displayed low r.m.s. errors less than 1.3%.

The main survey EM area was approximately 90,000 sqm (9 Ha) in size. The data quality was considered to be good with the instrument drift between days very low.

The main survey ERT results indicated a relatively uniform and consistent 2-layer ground model with an upper layer of relatively low resistivity interpreted to be the Lambeth group sediments above a relatively high resistivity layer interpreted to be the chalk bedrock. The depth of this interpreted boundary was approximately 11 m bgl (6 m elevation) at the western end of the ERT lines and shallowed slightly to approximately 7 m bgl (10 m elevation) in the eastern end of the survey lines.

The EM results indicated a strong regional trend in apparent conductivity values across the survey area which ranged from relatively high in the southern portion to relatively low in the northern portion of the site. This trend would be consistent with a gradual shallowing of the chalk bedrock (with relatively low conductivity) to the north which was understood to be the geological setting.

Within this large north-south trend in values, regions of relatively low and relatively high apparent conductivity were identified which may indicate localised variations in the subsurface structure/composition.

The regions of relatively low conductivity (high resistivity) could be related to possible zones where there has been migration of a less conductive material into the Lambeth layer. This was considered to be a potential explanation for the feature identified in both the ERT and EM data at the Swillage barn suspected sink hole location. Other possible causes of a low conductivity anomaly could be a localised area where the chalk bedrock is closer to the ground surface or a localised compositional change within the Lambeth/chalk layers.

The areas of relatively high apparent conductivity could be related to regions where the chalk bedrock is locally deeper or could relate to a localised compositional change within the Lambeth/chalk layers.

It must be emphasised that geophysical methods can only identify areas yielding results that are different, i.e. anomalous to the site norm. The interpretation of the cause of such anomalies is inevitably based on assumptions utilising the best information available on the historic use/geology of the site. Positive identification of these anomalies can only be made through using visual or intrusive investigation techniques.

Contents

Appendices

Figures in the Main Text

Tables in the Main Text

Abbreviations

BGL	Below ground level
ERT	Electrical resistivity tomography
EM	Electromagnetic conductivity
GPS	Global Positioning System
OS	Ordnance Survey
RTK	Real-time kinetic
QC	Quality control

1. Introduction

1.1 General

This report documents a geophysical investigation using electrical resistivity tomography (ERT) and electromagnetic conductivity (EM) carried out along a proposed corridor section of a cable route near Littlehampton for WSP.

1.2 Objective

The specific objective of the geophysical investigation was to identify potential risk areas within the study area that might pose difficult ground conditions for the planned cable route works. Such risk areas may relate to dissolution/karst features within the near surface chalk geology.

1.3 Site Work

The geophysical investigation was carried out between 16th and 22nd May 2023. Two trial investigations were conducted at the suspected locations of sink hole features prior to the commencement of the main survey.

1.4 Terms of Reference

This investigation employed geophysical methods and therefore the majority of the findings presented here are the result of the measurement and interpretation of electrical signals. As such any results derived from the geophysical investigation should be taken in the context of and in reference to the complete ground investigation. Reasonable skill and care were taken to ensure that the results are accurate and reliable, including reference where appropriate to published data from this and/or other sites. However, as with other indirect methods there is a possibility of localised inconsistencies and inaccuracies within the results.

This final report supersedes any previous reports, whether written or oral and completes the work currently commissioned by WSP.

1.5 Service Constraints

Appendix A (Service Constraints) outlines the limitations of this report in terms of a range of considerations including, but not limited to, its purpose, its scope, the data on which it is based, its use by Third Parties, possible future changes in design procedures and possible changes in the conditions at the site with time. Appendix A represents a clear exposition of the constraints, which apply to all reports issued by Fugro. It should be noted that the Service Constraints do not in any way supersede the terms and conditions of the contract between Fugro and the Client.

2. Background Information & Survey Rationale

2.1 General

We understand that as part of the planning application process for an onshore cable route there is a requirement for information relating to the possible presence of cavities and solution features at a site near Littlehampton.

The underlying geology is predominantly chalk and there is some existing evidence of underground karst fissuring in areas where the chalk has contact with superficial deposits (chalk with flints) and Lambeth Group.

The area required for the investigation is shown in Figure 2.1 below:

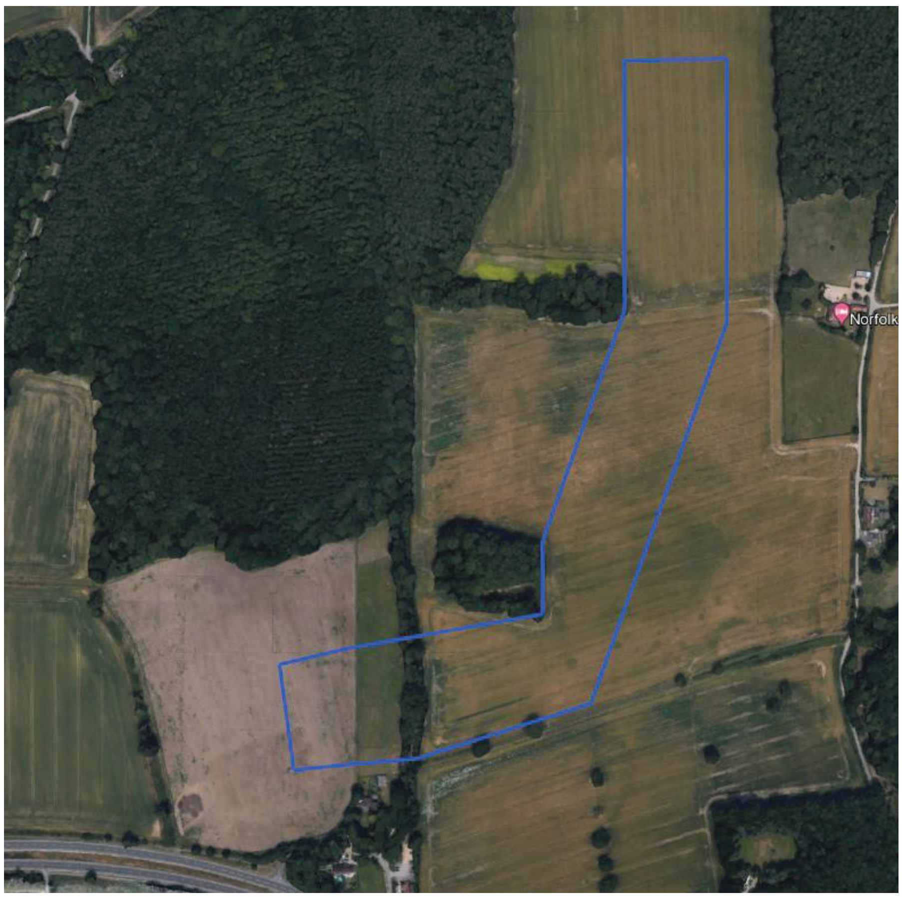


Figure 2.1 Area required for investigation

2.2 Site Information

The site comprised open and relatively flat farmland which was mostly crop fields. There were a few small horse paddocks and a public right of way crossing the survey area as well.

The parts of the site that comprised the survey area are presented on drawing no. 223150-D01.

2.3 Geology

The site geology was understood to comprise superficial deposits of the Lambeth Group overlying chalk bedrock. The chalk bedrock was understood to be located at approximately 10 m below ground level in the southern portion of the site and come closer to the surface towards the north.

2.4 Survey Methods

The investigation was carried out using a combination of the following geophysical methods:

- Electrical resistivity tomography (ERT)
- Electromagnetic conductivity (EM)

2.5 Rationale

Detection of chalk dissolution features can be achieved where there is a measurable contrast in physical properties between the target body and the surrounding material, in this case electrical properties. A solution feature with an increased water or clayey fill content will represent a low resistivity/high conductivity anomaly in relation to unweathered chalk. An air-filled maintained void would represent a high resistivity/low conductivity anomaly in relation to surrounding chalk material.

By mapping these variations in resistivity (ERT) and conductivity (EM) the spatial position of risk areas can be identified.

These data can then be used to plan and target follow up intrusive investigation (using for example gamma CPT, boreholes etc) to further characterise the risk feature.

3. Electrical Resistivity Tomography

3.1 Theory

Electrical Resistivity Tomography (ERT) is often employed as a stratigraphic profiling tool but may also be used to detect and map discrete or lateral variations within the ground structure e.g. landfill boundaries, mine workings or voids, solution features, contamination. The technique measures variations in the electrical properties resistivity) of ground materials. Where a layered ground structure is present with significant contrasts in electrical properties, ERT data can be interpreted to provide stratigraphic/geological cross-sections. ERT data can effectively provide a link between discrete intrusive information (BH's, CPT's etc) to give a more complete understanding of the ground structure.

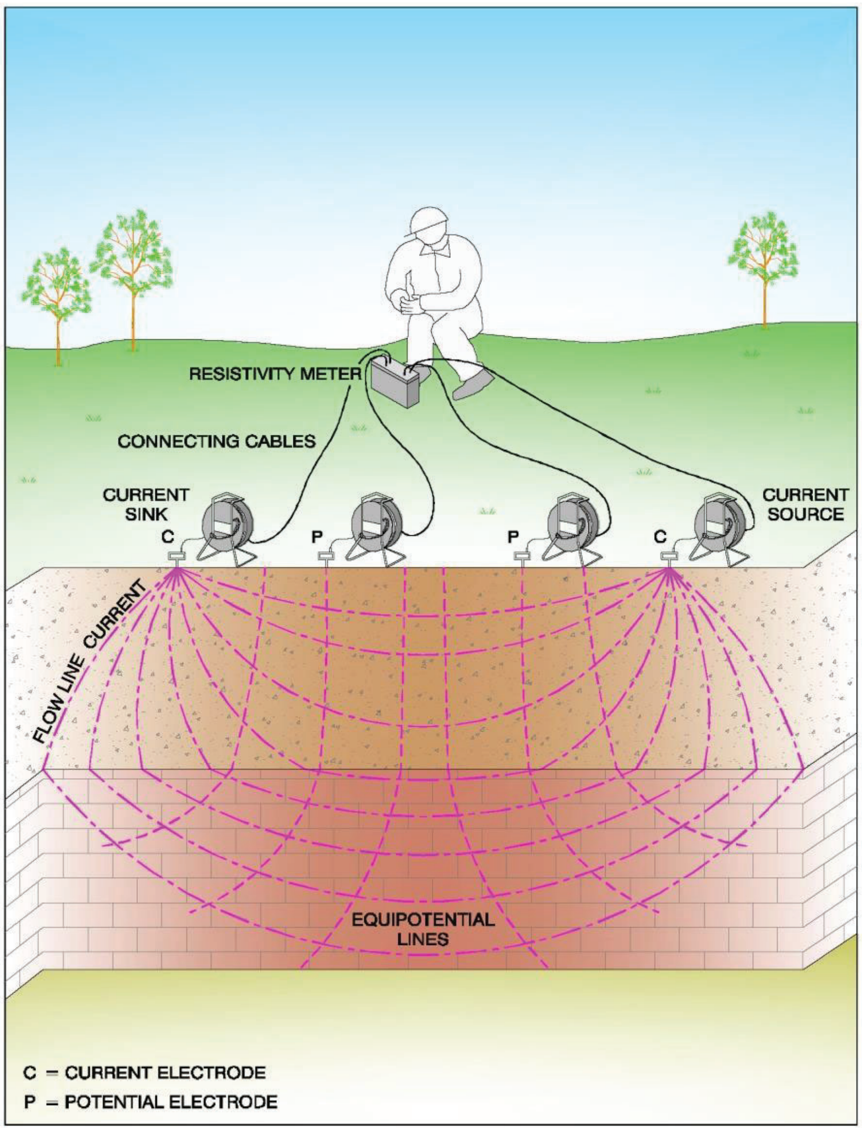


Figure 3.1: Schematic illustration of electrical resistivity survey spread

Apparent electrical resistivity distribution of the subsurface can be measured using an array of four electrodes. By injecting a DC or very low frequency AC current (I) between a pair of electrodes and measuring the resulting potential difference (V) with a second pair of electrodes, it is possible to calculate the apparent resistivity using a derivation of Ohms law (R=V/I). This approach is known as galvanic resistivity, as schematic of which is presented in Figure 3.1 above.

Electrodes are normally co-linear and geometrically spaced. An electric current is then injected via an electrode pair and the resulting potential difference is measured at a pair of potential electrodes. Depth penetration is primarily a function of electrode spacing, therefore by increasing the separation of the electrodes, readings can be taken at greater depths. Numerous electrode array types can be employed depending upon site and target considerations, e.g. Wenner, dipole-dipole, Wenner-Schlumberger.

For electrical resistivity tomography investigations, multi-electrode acquisition systems are commonly employed. Numerous electrodes are deployed and connected to the system via multi-core cables. The system automatically selects various different combinations of electrodes, eventually creating a vertical cross-section of apparent resistivity values for the subsurface beneath the electrode array.

Ground resistivity depends on several factors; primarily a function of porosity resistivity can also vary due to variations in material (matrix) chemical composition, grain size and shape and pore fluid characteristics.

Different soil and rock types can have different resistivity characteristics (see table below). Generally, soils will exhibit lower apparent resistivity than competent rocks. Clayey and peaty soils are typically described by lower apparent resistivity than, for example, sandy or gravelly soils. The presence of loosely compacted material or voids above the water table can result in an increase in apparent resistivity values (as a function of increased air-filled porosity). Tabulated below are some resistivity values of common geological materials (adapted from Reynolds, 1997: p.422-423).

Table 3.1: Typical resistivity values for common geological materials

Soil/Rock Type	Nominal Resistivity [ohm.m]
Top soil	250 – 1700
Clay (very dry)	50 – 150
Quaternary / recent sands	50 – 100
Gravel (dry)	1400
Gravel (saturated)	100
Dry sandy soil	80 – 1050
Sandy clay / clayey sand	20 – 215
Sand and gravel	30 – 225

Soil/Rock Type	Nominal Resistivity [ohm.m]
Sandstone	$1 – 7.4x10^8$
Alluvium and sand	10 - 800
Conglomerate	$2 x 10^3 – 10^4$
Consolidated shale	20 –2000
Limestone	$50 – 5x10^7$

With reference to the above table it is apparent that characterising geological materials from resistivity values alone is prone to ambiguity. Such ambiguity can be refined through calibration with other geophysical or intrusive information.

3.2 Survey Methodology

The ERT survey was collected along 2 survey lines at both the Lions and Swillage Barn trial sites. The position of the survey lines at the Lions trial site are provided on drawing 223150-D02. The position of the survey lines at the Swillage Barn trial site are provided on drawing 223150-D05.

The main phase ERT survey comprised a total of 3 survey lines each 225 m in length. The positions of the main area survey lines have been provided on drawing 223150-D01 and in more detail on drawing 223150-D09.

The start and end coordinates of all lines have been summarised in Table 3.2 below. The coordinate system used on this project was OSGB (1936).

Table 3.2: ERT Survey line details

Line ID	Start Coordinates		End Coordinates		Length [m]
	Easting	Northing	Easting	Northing	
Lions Trial Line 1	506602.85	106074.56	506700.07	106080.61	97.5
Lions Trial Line 2	506666.40	106049.96	506662.74	106113.74	65
Swillage Barn Trial Line 1	506998.90	105946.50	507124.25	105987.89	132.5
Swillage Barn Trial Line 2	507007.29	105902.13	506988.74	105987.44	87.5
Line 1A	506605.72	105924.53	506824.72	105957.31	225
Line 1B	506603.54	105914.33	506822.77	105945.09	225
Line 1C	506605.37	105903.68	506825.05	105934.30	225

Data were acquired using an Iris Syscal Terra multichannel acquisition system. Key survey parameters defined for this survey are summarised in Table 3.3 below:

Table 3.3: ERT survey acquisition parameters/equipment

Parameter	Description
Equipment	Syscal Terra
Array Type	Wenner-Schlumberger
Max number of electrodes	72
Min electrode spacing	2.5 m
On time	0.5 sec
Off time	0.1 sec
Cycles	3
Depth of investigation	20 m

Survey lines were initially set out at the required positions. Steel electrodes were inserted into the ground at a constant minimum electrode separation (defined in the table above). Electrodes were connected to multicore cable using crocodile clips. Each multicore cable was in turn connected to the Syscal Terra control unit.

Prior to commencement of data acquisition, a number of quality control checks were carried out to ensure that contact resistances at each electrode were at satisfactory levels. Generally, the contact resistances were very low (below 500 Ohm.m) for the ground conditions encountered on this site.

Data acquisition was controlled automatically based upon specific protocol files designed specifically to meet the survey objectives. Resistivity data was stored digitally on the system internal memory.

Coordinates of survey lines and electrodes were recorded using RTK GPS equipment to an accuracy of +/- 0.1 m.

Upon completion of data acquisition, raw data were downloaded to a field PC in binary format and converted to ASCII to allow initial field QC and further office-based processing.

3.3 Data Processing

Field data were downloaded using Iris Instruments Prosys II software package. Data were then filtered to remove any spurious values before being exported in an ASCII format compatible with the Geotomo RES2DINV program.

Topographic information was incorporated into each survey line dataset to allow appropriate elevation correction to be applied during processing.

Data were further reviewed with the RESDINV software and where necessary further manual editing of questionable data points was completed by a geophysicist. Data were then subject to a robust inversion process to produce a best fit model of the subsurface resistivity distribution. The r.m.s. errors between the modelled data and the measured data were below 1.3% which was considered to be very good.

Final model resistivity data were exported and contoured using Geosoft Oasis Montaj. Colour contour scales were selected to best represent the data distribution across the site. Contour scales were kept consistent between lines to enable direct comparison.

Final resistivity sections are presented on drawing 223150-D03A and drawing 223150-D03B for the Lions sink hole trial Line 1 and Line 2.

Final resistivity sections are presented on drawing 223150-D06A and drawing 223150-D06B for the Swillage Barn sink hole trial Line 1 and Line 2.

Final resistivity sections are presented on drawing 223150-D10A, drawing 223150-D10B and drawing 223150-D10C for the main survey Line 1A, Line 1B and Line 1C.

4. Frequency Domain Electromagnetics

4.1 Theory

Frequency domain electromagnetic measurements are often carried out to provide rapid, reconnaissance surveys across large physical areas. The technique is sensitive to both changes in ground conductivity and metallic objects within the ground (e.g. an increase in clay content, solution features, leachate/contamination, services, landfill material etc). Surface positions of such buried targets can therefore be identified for further intrusive or remediation work.

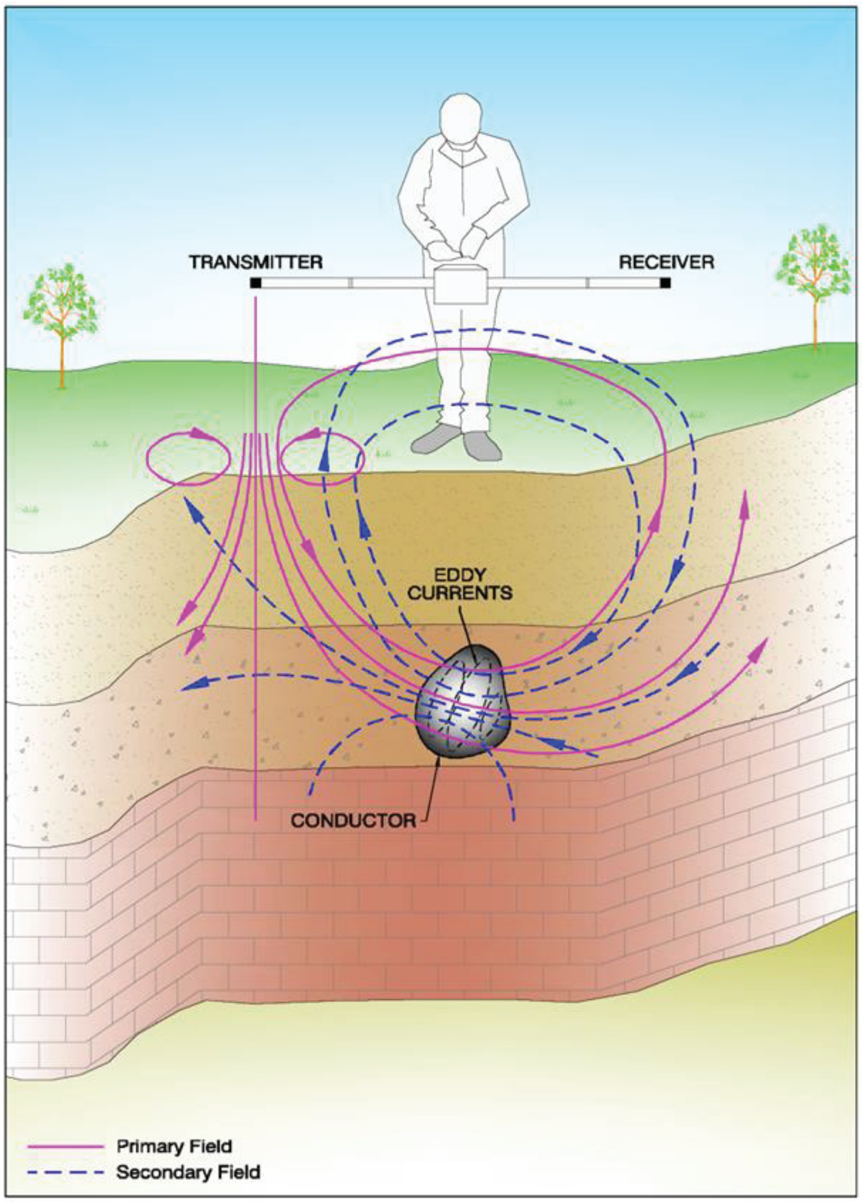


Figure 4.1: Schematic illustration of the frequency domain electromagnetic technique

A primary electromagnetic field is generated at the surface by a low voltage alternating current within a dipole transmitter. When the primary field interacts with conductive materials within the subsurface, eddy currents are generated. These eddy currents in turn generate their own (secondary) electromagnetic field, the strength of which is proportional to the bulk average conductivity of the subsurface. The resultant electromagnetic field is recorded at the surface by a dipole receiver, from which the secondary magnetic field can be deduced. A schematic of the technique is presented on Figure 4.1.

The instrument records the quadrature response of the electromagnetic field, which is directly related to the average bulk conductivity of the subsurface. This is usually recorded in milli-Siemens per metre (mS/m).

Measurements may be taken in both horizontal and vertical dipole mode. The depth of investigation for each mode is approximately 0.75 and 1.5 times the dipole separation respectively. Different designs of EM instruments may be used to provide alternative depths of penetration. The CMD Explorer utilises 3 different coil separations to provide 3 different depth measurements of approximately 2.2, 4.4 and 6.6 m below ground level.

Changes in the electrical properties of the subsurface mass, e.g. presence of man-made structures or geological features generally give rise to a contrast in the ground electrical conductivity which can be measured by the electromagnetic instruments.

Data is normally filtered to remove erroneous noise and plotted as profiles or contour plots, from which the extent of anomalous features can be identified.

4.2 Survey Methodology

The EM survey for the Lions sink hole trial was carried out across an area measuring approximately 1200 sqm. The position of the survey area is provided on drawing 223150-D02. The EM survey for the Swillage Barn sink hole trial was carried out across an area measuring approximately 1200 sqm. The position of the survey area is provided on drawing 223150-D05. The EM survey for the main survey was carried out across an area measuring approximately 90, 000 sqm (9 hectares). The position of the survey area is provided on drawing 223150-D01.

Data were acquired using a CMD Explorer meter. Key survey parameters defined for this survey are summarised in Table 4.1.

Table 4.1: CMD survey acquisition parameters/equipment

Parameter	Description
Meter	CMD Explorer
Dipole mode	Horizontal
Approx depth penetration	2.2 m, 4.4 m, 6.6 m bgl
Line orientation	Parallel
Line spacing	2 m

Parameter	Description
Positioning mode	dGPS
Measurement interval	<0.2 m

An initial local reference grid was established on site covering the required survey area. The EM system was set up according to manufacturer instructions and nulled at a designated base station.

Prior to commencement of data acquisition, a number of quality control checks were carried out to assess equipment function.

Data acquisition commenced and concluded with a series of measurements at the designated site base station. This control data was used to assess and correct for any time dependant instrument drift. Base station data was acquired at the start and end of each survey day to ensure that site wide data could be corrected relative to the same measurement datum.

Data were saved digitally on a dedicated data logger to enable office based post-processing.

Coordinates of all measurement stations were recorded using dGPS equipment to an accuracy of +/- 0.1 m.

4.3 Data Processing

Raw data were imported into Oasis Montaj software for post processing.

Post processing steps included:

- Incorporation of positional information
- Coordinate transform to project coordinate system
- Minimum curvature contouring
- Presentation at appropriate colour scales

Post processed contour sections showing site variations in conductivity were overlain onto a base plan to allow identification and annotation of anomalous features.

Final conductivity contour sections are presented on drawings 223150-D04A, 223150-D04B and 223150-D04C for the 2.2 m, 4.4 m and 6.6 m depth measurements at the Lions sink hole trial location.

Final conductivity contour sections are presented on drawings 223150-D07A, 223150-D07B and 223150-D07C for the 2.2 m, 4.4 m and 6.6 m depth measurements at the Swillage Barn sink hole trial location.

Final conductivity contour sections are presented on drawings 223150-D11A, 223150-D11B and 223150-D11C for the 2.2 m, 4.4 m and 6.6 m depth measurements for the main survey area.

5. Findings and interpretation

5.1 Trial survey results – Lions sink hole location

The trial survey at the Lions comprised of two perpendicular ERT lines. The main ERT line (Lions ERT Line 1) was orientated approximately west to east and positioned to cross a large surface depression understood to be associated with a possible sink hole (at 64 m line chainage) and a second smaller surface depression at 22 m line chainage. A second ERT line (Lions ERT Line 2) was orientated south to north across the larger surface depression which was located at 32 m line chainage.

The trial results at the Lions sink hole location indicated that there was significant variation in the interpreted depth of the Lambeth/chalk interface which may be indicative of weathering of the upper part of the chalk. This variation appeared to be spatially coincident with the surface 'known' position of two sink holes.

For example, on Lions ERT Line 1 (drawing no. 223150-D03A) the interface was at a shallow depth of a few metres (~15 m elevation) between 5 m and 18 m line chainage and between 65 m and 90 m line chainage. There was a notable step down of the Lambeth/chalk interface to ~8-10 m elevation between 18 and 65 m line chainage from the suspected location of a small sink hole at 22 m line chainage and the position of the larger sink hole at 64 m line chainage. This might indicate that the weathering of the chalk is laterally more extensive between the surface expression of the sink hole at ~64 m line chainage and the suspected location of a second sink hole at 22 m line chainage.

The variation of the Lambeth/chalk interface was less evident on Lions ERT line 2 (drawing no. 223150-D03B) which may indicate that the variation of the interface is orientated between the two suspected sink holes in an approximate east-west orientation.

Due to the location of the suspected sink hole at the Lions site adjacent to a forest, it was only possible to deploy the electromagnetic conductivity method in the adjacent open field located away from the suspected sink hole. The surveyed area in this field measured approximately 1200 sqm. The 2.2 m bgl depth measurement displayed a range of apparent conductivity values which varied between 24 mS/m and 40 mS/m (drawing no. 223150-D04A), the 4.4 m bgl depth measurement displayed a range of apparent conductivity values which varied between 30 mS/m and 55 mS/m (drawing no. 223150-D04B) and the 6.6 m bgl depth measurement displayed a range of apparent conductivity values which varied between 40 mS/m and 60 mS/m (drawing no. 223150-D04C).

In general, the higher conductivity values for all three depth measurements were located towards the north-east corner of the field where the measurements were affected by a metal fence. No discernible relationship between the possible sink hole and the electromagnetic conductivity data due to the location of the feature outside of the survey area and the influence of the metal fence at this test site.

5.2 Trial survey results – Swillage barn sink hole location

The suspected location of the sink hole at Swillage barn was located in a large inaccessible ditch surrounded by dense vegetation and the survey had to be focussed around the edges of the ditch.

The ERT trial at the Swillage barn sink hole location comprised two lines with ERT line 1 orientated west to east parallel to the ditch. Swillage barn ERT line 2 was orientated perpendicular to line 1 in a south to north orientation and positioned at the only possible location where the ditch could be crossed. The electromagnetic conductivity survey covered an area of approximately 2500 sqm located either side of the ditch. The location of the survey area and lines at the Swillage barn site are shown on drawing no. 223150-D05.

The results of the ERT trial at this location indicated the general distribution of the modelled resistivity values was similar to those observed at the Lions sink hole with relatively low values (less than ~40 Ohm.m) interpreted to represent the Lambeth group above relatively higher values (greater than ~40 Ohm.m) interpreted to be the chalk bedrock. This interface was relatively consistent at the Swillage barn location at a depth of approximately 8 m to 13 m below ground level (10 m to 5 m elevation) with no sharp elevation change as observed at the Lions location.

Swillage barn ERT line 1 (drawing no. 223150-D06A) displayed a zone of relatively high modelled resistivity values (between ~15 and 30 Ohm.m) within the interpreted Lambeth sediments layer between 55 m and 85 m line chainage which was approximately adjacent to the suspected sink hole feature. This region of relatively high modelled resistivity values within the Lambeth group may indicate a zone of more resistive material which has entered the Lambeth group sediments possibly from movement associated with the sink hole feature. Located above the Lambeth layer (between line chainage 20 m and 120 m) there was a region of high modelled resistivity values (greater than ~30 Ohm.m) at the near surface. This has been interpretated as shallow sediments above the Lambeth layer and may be the material which has possibly migrated into the Lambeth layer around the location of the sink hole.

Swillage barn ERT line 2 (drawing no. 223150-D06B) displayed a similar distribution of modelled resistivity values as the first line with the interpreted Lambeth/chalk interface gradually varying between 12 m depth (5 m elevation) in the south to 7 m depth (10 m elevation) in the north. Several regions of high resistivity to the top of the Lambeth group were also observed. There was no such region of high resistivity within the Lambeth group most likely as this line was located away from the suspected sink hole feature.

The electromagnetic conductivity survey at the Swillage barn location covered an area of approximately 2500 sqm either side of the ditch (drawing no. 223150-D05). The access for the survey was restricted by the location of the ditch and dense vegetation around the ditch. The 2.2 m bgl depth measurement displayed a range of apparent conductivity values which varied between 18 mS/m and 34 mS/m (drawing no. 223150-D07A), the 4.4 m bgl depth measurement displayed a range of apparent conductivity values which varied between 20 mS/m and 60 mS/m (drawing no. 223150-D07B) and the 6.6 m bgl depth measurement displayed a range of apparent conductivity values which varied between 24 mS/m and 60 mS/m (drawing no. 223150-D07C).

The distribution of the apparent conductivity values indicated a significant region of low values centred at approximate coordinates (507064, 105970) which was understood to be close to where the suspected sink hole was located. This region of low apparent conductivity was coincident with the high resistivity zone identified on Swillage barn ERT line 1 between 55 m and 85 m line chainage. The location of these feature was added to an anomaly location plan for the trial area (drawing no. 223150-D08).

5.3 Main survey results - ERT

The interpretation of the main ERT survey lines (ERT line 1A, line 1B and line 1C) was based upon the features observed on the resistivity sections at the locations of two suspected sink hole features. For the Lions sink hole this was a localised abrupt variation in the Lambeth/chalk bedrock interface and for the Swillage Barn sink hole this was a zone of relatively more resistive material in the Lambeth group layer.

The ERT results for the main survey area are presented on drawing no. 223150-D10A for Line 1A, drawing no. 223150-D10B for Line 1B and drawing no. 223150-D10C for Line 1C. The upper panel of the drawing shows the modelled resistivity results and the lower panel shows the interpreted geological cross section from the results.

The ERT values for the three main survey lines ranged between approximately 2 Ohm.m and 80 Ohm.m. The distribution of modelled resistivity values generally displayed a two-layer geological model. There was an upper layer of relatively low resistivity/high conductivity material (with modelled resistivity values less than ~40 Ohm.m but mostly in the range of 5 to 15 Ohm.m with relatively higher values in the near surface) which has been considered most likely to be associated with Lambeth group sands/clays. Underlying this low resistivity layer was a relatively high resistivity/low conductivity layer (modelled resistivity values greater than ~40 Ohm.m) which is most likely associated with the chalk bedrock.

The main survey ERT sections generally displayed a gradual increase in the elevation of the chalk bedrock in an easterly orientation along the direction of the three survey lines. To the western end of the survey lines, at 0 m line chainage, the interpreted boundary between the Lambeth group and the chalk was at approximately 6 m elevation (~11 m below ground level). To the eastern end of the survey lines (225 m line chainage) the elevation of the interpreted interface was located at approximately 10 m elevation (~7 m below ground level).

In the near surface, there were very localised and relatively thin areas of high resistivity on top of the Lambeth group. These were located between 90 m and 117 m and at 124 m chainage along Line 1A, between 88 m and 113 m, between 136 m and 142 m and between 157 m and 172 m chainage along Line 1B and between 149 m and 156 m and at 64 m, 163 m, 172 m and 179 m chainage along Line 1C. These areas were only approximately 2 m in thickness and the variation between the adjacent resistivity lines suggested they could be related to small/localised variations in the shallow deposits/topsoil.

Between 137 m and 153 m chainage on Line 1A a zone of relatively high modelled resistivity values was observed in the interpreted Lambeth layer (values between ~15 and 20 Ohm.m). This was also spatially coincident with a region of relatively low conductivity identified in the electromagnetic conductivity investigation.

5.4 Main survey results - EM

The electromagnetic conductivity survey for the main area of investigation comprised a total area of approximately 90,000 sqm (9 Ha), with a corridor width of 100 m centred on the proposed cable route.

The 2.2 m bgl depth measurement displayed a range of apparent conductivity values which varied between 10 mS/m and 50 mS/m (drawing no. 223150-D11A), the 4.4 m bgl depth measurement displayed a range of apparent conductivity values which varied between 12 mS/m and 70 mS/m (drawing no. 223150-D11B) and the 6.6 m bgl depth measurement displayed a range of apparent conductivity values which varied between 14 mS/m and 90 mS/m (drawing no. 223150-D11C).

There was a dominant trend in the distribution of apparent conductivity values across the main survey area which varied from relatively high values in the southern portion of the area to relatively low values in the northern part of the survey area. It was understood that the chalk bedrock was generally shallower in the northern part of the site. The trend of high conductivity in the south to relatively low in the north would be consistent with the expected shallowing chalk in the north. Chalk typically displays relatively low apparent conductivity (relatively high resistivity) and where the bedrock is close to the surface, relatively lower measured apparent conductivity values would be expected. This trend was observed for all three depth measurements.

The interpretation of the electromagnetic conductivity results for anomalies possibly related to solution features was based upon the relatively low apparent conductivity anomaly observed at the location of the Swillage barn sink hole. Localised regions of relatively low apparent conductivity were visually identified from the 3 different depth measurements across the main survey area. The larger scale trend in apparent conductivity values associated with the depth variation in the chalk bedrock provided a complication to the interpretation. To aid the visual interpretation of the EM results, a linear trend pattern was removed from the 6.6 m depth conductivity measurements. The trend which was removed from the data has been shown (drawing no. 223150-D11D). The results with the trend removed has been shown in drawing no. 223150-D11E. This trend-removed (residual) data was used in conjunction with the original data for the 2.2, 4.4 and 6.6 m depth apparent conductivity data to identify localised anomalous regions within the electromagnetic conductivity data which could possibly indicate the presence of solution features.

The interpreted anomaly location plan has been shown on drawing no. 223150-D12. Regions of relatively low apparent conductivity were identified which could be related to possible solution features as shown in the trial investigation at Swillage barn. In addition to these low conductivity features, areas of anomalously high apparent conductivity were also highlighted.

The regions of relatively low conductivity (high resistivity) could be related to possible zones where there has been migration of a less conductive material into the Lambeth layer. This was considered to be a potential explanation for the feature identified in both the ERT and EM data at the Swillage barn suspected sink hole location. Other possible causes of a low conductivity anomaly could be a localised area where the chalk bedrock is closer to the ground surface or a localised compositional change within the Lambeth/chalk layers.

The areas of relatively high apparent conductivity could be related to regions where the chalk bedrock is locally deeper or could relate to a localised compositional change within the Lambeth/chalk layers i.e. increased clay or moisture content.

The location of the anomalies identified in the electromagnetic conductivity survey have been summarised in Table 5.1 below:

Table 5.1: EM anomaly summary table

Easting	Northing	Description
506700	105855	Relative conductivity Low
506875	105940	Relative conductivity Low
506590	105942	Relative conductivity Low
506750	105970	Relative conductivity Low
506885	106135	Relative conductivity Low
506982	106274	Relative conductivity Low
506949	106332	Relative conductivity Low
506932	106410	Relative conductivity Low
506997	106448	Relative conductivity Low
506672	105897	Relative conductivity High
506844	105997	Relative conductivity High
507024	106357	Relative conductivity High
506970	106416	Relative conductivity High
507000	106549	Relative conductivity High

6. Summary & Conclusions

6.1 General

This report documents a geophysical investigation using electrical resistivity tomography (ERT) and electromagnetic conductivity (EM) carried out along a proposed corridor section of a cable route near Littlehampton.

The specific objective of the geophysical investigation was to identify potential risk areas within the study area that might pose difficult ground conditions for the planned cable route works. Such risk areas may relate to dissolution/karst features within the near surface chalk geology.

The geophysical investigation was carried out between 16th and 22nd May 2023. Two trial investigations were conducted at the suspected locations of sink hole features prior to the commencement of the main survey.

6.2 Summary

Both the ERT and EM methods were trialled at the location of two different suspected sink hole features prior to the commencement of the main survey phase.

The main survey comprised a total of 3 ERT profile lines, each 225 m in length which were centred on a public right of way under which the cable would have to be tunnelled. The main survey EM area measured approximately 90, 000 sqm and was conducted within a 100 m corridor width of a section of the proposed cable route.

The data collected were considered to be of good quality. The contact resistances between the electrodes and the ground for the ERT survey were very low (less than 500 Ohm.m). Instrument drift was very low between days for the EM survey.

Data were acquired and processed following protocols described in this report. The final processed ERT data and respective interpretation are summarised on drawing no. 223150-D10A for Line 1A, drawing no. 223150-D10B for Line 1B and drawing no. 223150-D10C for Line 1C. The final processed EM data are presented on drawing no. 223150-D11A for the 2.2 m bgl depth measurement, drawing no. 223150-D11B for the 4.4 m bgl depth measurement and drawing no. 223150-D11C for the 6.6 m bgl depth measurement.

The interpreted anomaly location plan for the main survey area has been presented on drawing no. 223150-D12.

6.3 Conclusion

The ERT trial investigation at the Lions location identified a significant increase in the depth of the interpreted chalk bedrock between the main suspected sink hole feature and a smaller surface depression.

The trial investigation at the Swillage barn location identified an anomalous zone of relatively high resistivity within the interpreted Lambeth group layer adjacent to the position of the suspected sink hole. This corresponded to a significant region of relatively high conductivity in the EM survey.

The main survey followed on from the two trial investigations and comprised three ERT profile lines, each 225 m in length and an area of EM measuring approximately 90,000 sqm (9 Ha). The interpretation of the ERT and EM data was based upon features identified in the trial investigation as well as to identify any other anomalous regions within the data.

The three ERT profile lines displayed a distribution of modelled resistivity values which generally displayed a two-layer geological model. There was an upper layer of relatively low resistivity/high conductivity material which has been considered most likely to be associated with Lambeth group sands/clays. Underlying this low resistivity layer was a relatively high resistivity/low conductivity layer which is most likely associated with the chalk bedrock.

In general, the interpreted Lambeth/chalk boundary gradually increased in elevation in an easterly orientation along the three survey lines from 6 m elevation (~11 m below ground level) to 10 m elevation (~7 m below ground level). In addition to the two main layers, there were also thin zones of relatively high resistivity located at or near the ground surface which were thought to represent shallow deposits on top of the Lambeth group.

This two-layer model was relatively uniform and consistent along the length of all three ERT profile lines. Between 137 m and 153 m line chainage on ERT Line 1A a zone of relatively high modelled resistivity values was observed within the interpreted Lambeth layer. This was similar to the feature identified on the resistivity section at the Swillage barn suspected sink hole location.

The main survey electromagnetic conductivity results displayed a large-scale trend in values across the site for the three different instrument depth measurements with relatively high apparent conductivity in the south and relatively low conductivity in the north. This was interpreted to be consistent with the shallowing of the chalk bedrock to the north. Localised variations in this trend were visually identified from the data which could relate to possible sink hole features.

As identified in the EM results for the trial survey at Swillage barn, the majority of the anomalous regions identified were areas of relatively low apparent conductivity. One area was spatially coincident with the zone of relatively high resistivity observed on ERT Line 1A.

Several areas of relatively high apparent conductivity were also identified. Potential causes of the regions could be a localised increase in the thickness of the relatively more conductive Lambeth layer or a localised variation in the ground composition.

It must be emphasised that geophysical methods can only identify areas yielding results that are different, i.e. anomalous to the site norm. The interpretation of the cause of such anomalies is inevitably based on assumptions utilising the best information available on the historic use/geology of the site. Positive identification of these anomalies can only be made through using visual or intrusive investigation techniques.

7. References

Reynolds, J. M. (1997) *An Introduction to Applied and Environmental Geophysics*. Chichester, John Wiley & Sons

Appendix A

Service Constraints

A.1 Service Constraints

i. This report and the assessment carried out in connection with the report (together the "Services") were compiled and carried out by Fugro GeoServices Limited (Fugro) for WSP (the "Client") in accordance with the terms of a contract between Fugro and the Client. The Services were performed by Fugro with the skill and care ordinarily exercised by a reasonable specialist at the time the Services were performed. Further, and in particular, the Services were performed by Fugro taking into account the limits of the scope of works required by the Client, the time scale involved and the resources, including financial and manpower resources, agreed between Fugro and the Client.

ii. Other than that expressly contained in paragraph 1 above, Fugro provides no other representation or warranty whether express or implied, in relation to the Services.

iii. The Services were performed by Fugro exclusively for the purposes of the Client. Fugro is not aware of any interest of or reliance by any party other than the Client in or on the Services. Unless expressly provided in writing, Fugro does not authorise, consent or condone any party other than the Client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and Fugro disclaims any liability to such party. Any such party would be advised to seek independent advice from a competent specialist and / or lawyer.

iv. It is Fugro's understanding that this report is to be used for the purpose described in Section 1 - "Introduction" of this report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, and/or should the Client's proposed development or use of the site change (including in particular any change in any design and/or specification relating to the proposed use or development of the site), this report may no longer be valid or appropriate and any further use of or reliance upon the report in those circumstances by the Client without Fugro's review and advice shall be at the Client's sole and own risk. Should Fugro be requested, and Fugro agree, to review the report after the date hereof, Fugro shall be entitled to additional payment at the then existing rates or such other terms as may be agreed between Fugro and the Client.

v. The passage of time may result in changes (whether man-made or otherwise) in site conditions and changes in regulatory or other legal provisions, technology, methods of analysis, or economic conditions which could render the report inaccurate or unreliable. The information, recommendations and conclusions contained in this report should not be relied upon if any such changes have taken place or after a period of 2 years from the date of this report or such other period as maybe expressly stated in the report, without the written agreement of Fugro. In the absence of such written agreement of Fugro, reliance on the report after any such changes have occurred or after the period of 2 years has expired shall be at the Client's own and sole risk. Should Fugro agree to review the report after the period of 2 years has expired, Fugro shall be entitled to additional payment at the then existing rates or such other terms as may be agreed between Fugro and the Client.

vi. The observations, recommendations and conclusions in this report are based solely upon the Services, which were provided pursuant to the contract between the Client and Fugro. Fugro has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the Client and Fugro. Fugro is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services.

vii. Where the Services have involved Fugro's interpretation and/or other use of any information (including documentation or materials, analysis, recommendations and conclusions) provided by third parties (including independent testing and/or information services or laboratories) or the Client and upon which Fugro was reasonably entitled to rely or involved Fugro's observations of existing physical conditions of any site involved in the Services, then the Services clearly are limited by the accuracy of such information and the observations which were reasonably possible of the said site. Unless otherwise stated, Fugro was not authorised and did not attempt to independently verify the accuracy or completeness of such information, received from the Client or third parties during the performance of the Services. Fugro is not liable for any inaccuracies (including any incompleteness) in the said information, the discovery of which inaccuracies required the doing of any act including the gathering of any information which it was not reasonably possible for Fugro to do including the doing of any independent investigation of the information provided to Fugro save as otherwise provided in the terms of the contract between the Client and Fugro.

Appendix B

Drawings

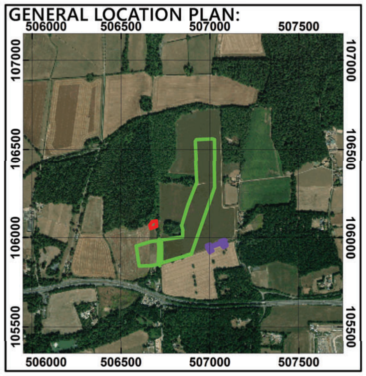
B.1 List of Drawings

223150-D01	-	GENERAL LOCATION PLAN SHOWING POSITION OF GEOPHYSCAL SURVEYS
223150-D02	-	LOCATION PLAN SHOWING POSITION OF GEOPHYSCAL SURVEY – LIONS SINK HOLE TRIAL
223150-D03A	-	MODELLED AND INTERPRETED SECTION – LIONS ERT LINE 1
223150-D03B	-	MODELLED AND INTERPRETED SECTION – LIONS ERT LINE 2
223150-D04A	-	LIONS TRIAL AREA EM RESULTS – APPROX. DEPTH 2.2 m
223150-D04B	-	LIONS TRIAL AREA EM RESULTS – APPROX. DEPTH 4.4 m
223150-D04C	-	LIONS TRIAL AREA EM RESULTS – APPROX. DEPTH 6.6 m
223150-D05	-	LOCATION PLAN SHOWING POSITION OF GEOPHYSCAL SURVEY – SWILLAGE BARN SINK HOLE TRIAL
223150-D06A	-	MODELLED AND INTERPRETED SECTION – SWILLAGE BARN ERT LINE 1
223150-D06B	-	MODELLED AND INTERPRETED SECTION – SWILLAGE BARN ERT LINE 2
223150-D07A	-	SWILLAGE BARN TRIAL AREA EM RESULTS – APPROX. DEPTH 2.2 m
223150-D07B	-	SWILLAGE BARN TRIAL AREA EM RESULTS – APPROX. DEPTH 4.4 m
223150-D07C	-	SWILLAGE BARN TRIAL AREA EM RESULTS – APPROX. DEPTH 6.6 m
223150-D08	-	SWILLAGE BARN SINK HOLE TRIAL ANOMALY LOCATION PLAN
223150-D09	-	LOCATION PLAN SHOWING POSITION OF ERT LINES – MAIN SURVEY AREA
223150-D10A	-	MODELLED AND INTERPRETED SECTION – ERT LINE 1A
223150-D10B	-	MODELLED AND INTERPRETED SECTION – ERT LINE 1B
223150-D10C	-	MODELLED AND INTERPRETED SECTION – ERT LINE 1C
223150-D11A	-	MAIN SURVEY AREA EM RESULTS – APPROX. DEPTH 2.2 m
223150-D11B	-	MAIN SURVEY AREA EM RESULTS – APPROX. DEPTH 4.4 m
223150-D11C	-	MAIN SURVEY AREA EM RESULTS – APPROX. DEPTH 6.6 m

223150-D11D	-	MAIN SURVEY AREA EM RESULTS – APPROX. DEPTH 6.6 m REGIONAL TREND
223150-D11E	-	MAIN SURVEY AREA EM RESULTS – APPROX. DEPTH 6.6 m RESIDUAL RESULTS
223150-D12	-	MAIN SURVEY AREA ANOMALY LOCATION PLAN

223150-D01 - GENERAL LOCATION PLAN SHOWING POSITION OF GEOPHYSICAL SURVEYS

GENERAL LOCATION PLAN:



LEGEND:

ERT LINE POSITION

EM SURVEY AREAS

Lions sink hole Trial Area

Swillage Barn sink hole Trial Area

Main Survey Area

SCALE GENERAL LOCATION:

Scale 1:20000

500 0 500 1000

metres

OSGB 1936 / British National Grid

SCALE:

Scale 1:2500

50 0 50 100

metres

OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Elevation datum relative to m (OD)

CLIENT:

WSP

PROJECT:

LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY

TITLE:

GENERAL LOCATION PLAN SHOWING POSITION OF GEOPHYSICAL SURVEYS

PROJECT NO.: 223150		DRAWING NO.: 223150-D01	
ISSUE REFERENCE: 01		DATE: 07/06/2023	
INTERP. BY: AD	DATE: 07/06/2023	DRAWN BY: AD	DATE: 07/06/2023
CHECKED BY: BB	DATE: 07/06/2023	APPROVED BY: DK	DATE: 07/06/2023
DRAWING SCALE: 1:2500			
PLOTTED DRAWING SIZE: A2 (594 x 420 mm)			

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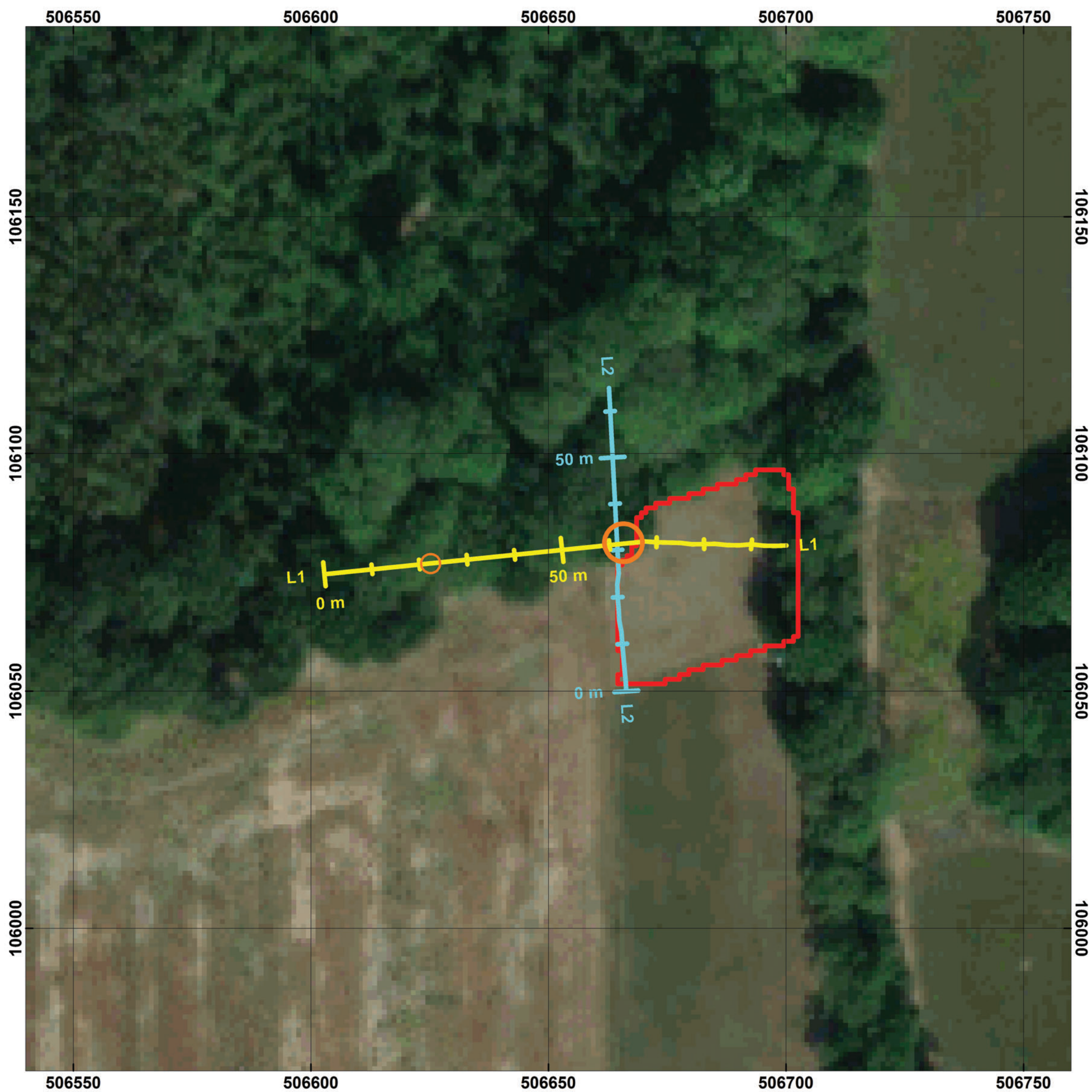
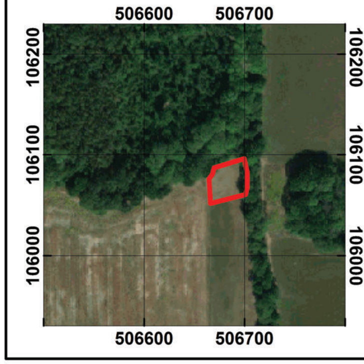
Fugro House, Hithercroft Road
Wallingford, Oxfordshire, OX10 9RB
Tel: +44 (0)870 4021 400

223150-D02 - LOCATION PLAN SHOWING POSITION OF GEOPHYSICAL SURVEY - LIONS SINK HOLE TRIAL



GENERAL LOCATION PLAN:



LEGEND:

- LIONS ERT LINE 1
- LIONS ERT LINE 2
- EM SURVEY AREA

SUSPECTED SINK HOLE LOCATION

- MAIN FEATURE
- SMALLER FEATURE

SCALE GENERAL LOCATION:

Scale 1:5000

100 0 100 200

metres

OSGB 1936 / British National Grid

SCALE:

Scale 1:1000

20 0 20 40

metres

OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT:	WSP		
PROJECT:	LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY		
TITLE:	LOCATION PLAN SHOWING POSITION OF GEOPHYSICAL SURVEY LIONS SINK HOLE TRIAL		
PROJECT NO.: 223150		DRAWING NO.: 223150-D02	
ISSUE REFERENCE: 01		DATE: 06/06/2023	
INTERP. BY: AD	DATE: 06/06/2023	DRAWN BY: AD	DATE: 06/06/2023
CHECKED BY: BB	DATE: 06/06/2023	APPROVED BY: DK	DATE: 06/06/2023
DRAWING SCALE: 1:1000		FUGRO	
PLOTTED DRAWING SIZE: A3 (420mm x 297mm)			

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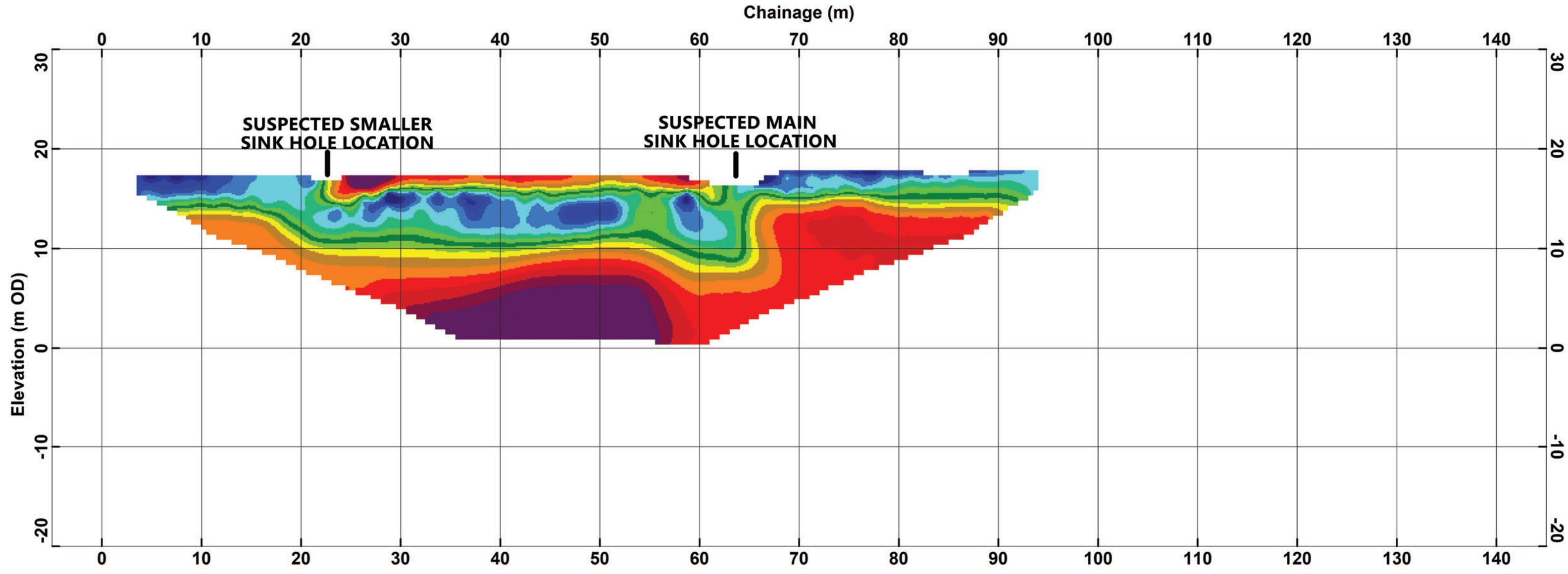
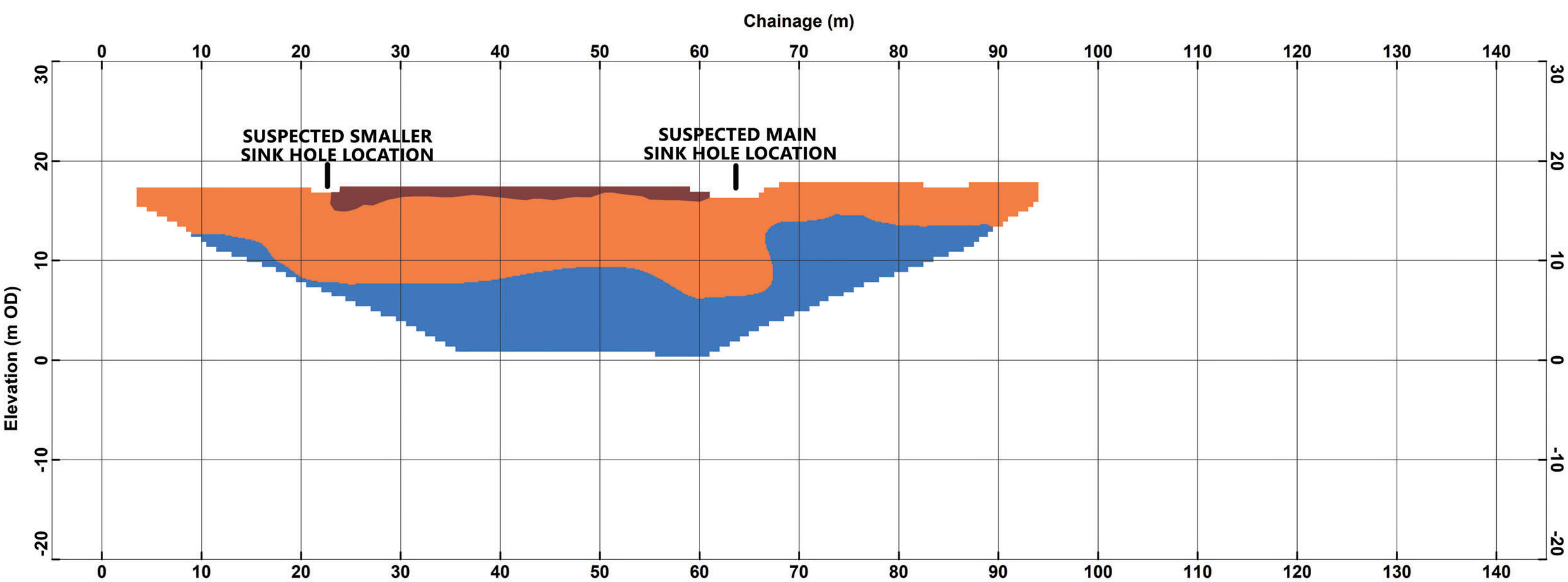
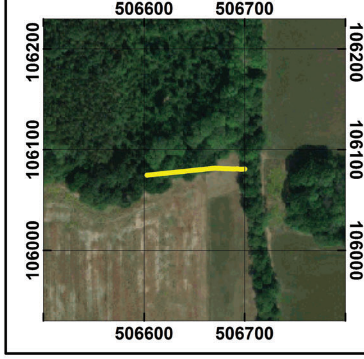
LIONS SINK HOLE TRIAL - ERT LINE 1 MODELLED SECTION



LIONS SINK HOLE TRIAL - ERT LINE 1 INTERPRETED SECTION



GENERAL LOCATION PLAN:



LEGEND:

LIONS ERT LINE 1

5 6 7 9 10 15 21 31 45 64

Modelled Resistivity
Ohm.m

INTERPRETATION

- **Relatively high resistivity zone - Shallow sediments**
- **Relatively low resistivity layer - Lambeth Group**
- **Relatively high resistivity zone**
- **Relatively high resistivity layer - Chalk bedrock**

SCALE GENERAL LOCATION:
Scale 1:5000
100 0 100 200
metres
OSGB 1936 / British National Grid

SCALE:
Scale 1:500
10 0 10 20
metres

NOTES:
1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT:	WSP		
PROJECT:	LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY		
TITLE:	MODELLED AND INTERPRETED SECTION LIONS ERT LINE 1		
PROJECT NO.: 223150		DRAWING NO.: 223150-D03A	
ISSUE REFERENCE: 01		DATE: 06/06/2023	
INTERP. BY: AD	DATE: 06/06/2023	DRAWN BY: AD	DATE: 06/06/2023
CHECKED BY: BB	DATE: 06/06/2023	APPROVED BY: DK	DATE: 06/06/2023
DRAWING SCALE: 1:500			
PLOTTED DRAWING SIZE: A3 (420mm x 297mm)			

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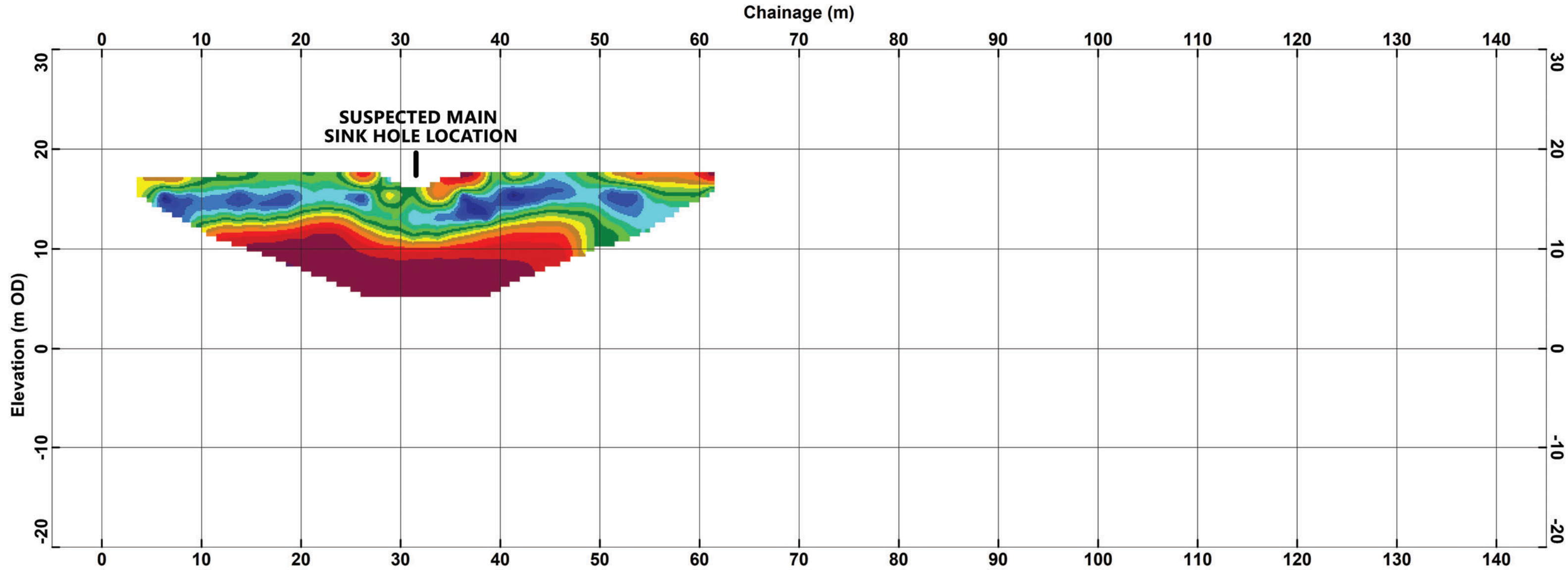
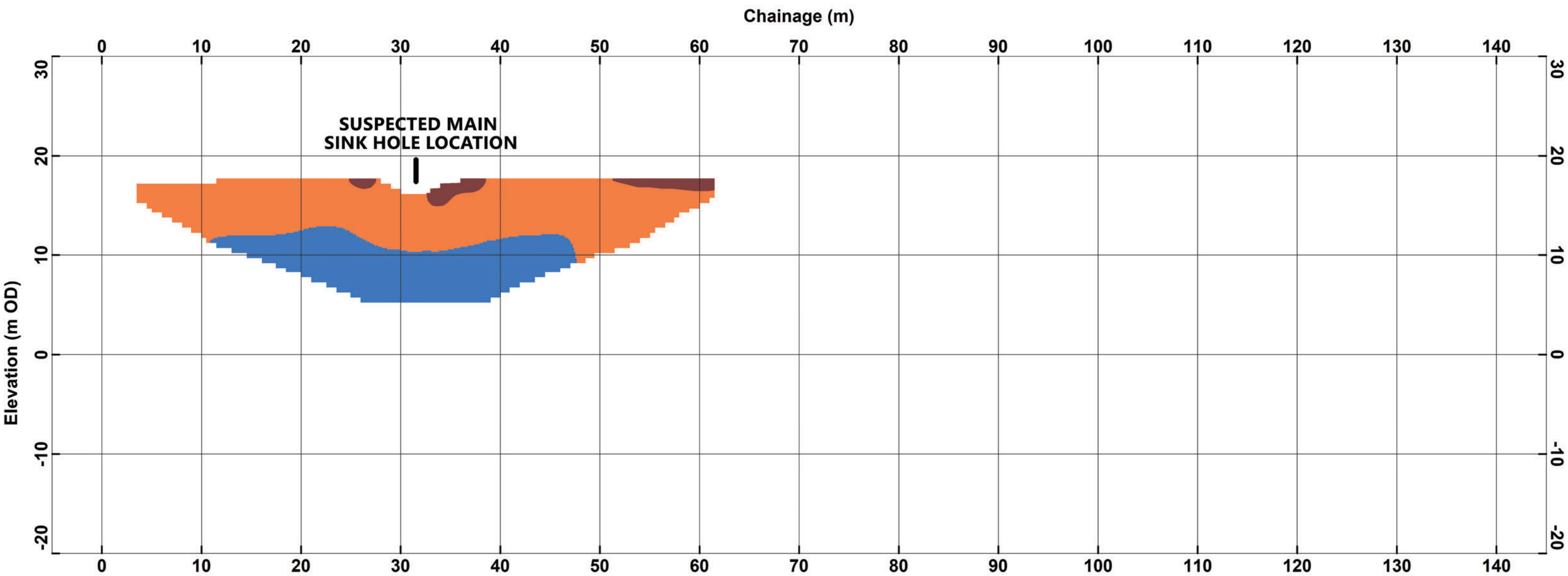
Fugro House, Hithercroft Road
Wallingford, Oxfordshire. OX10 9RB
Tel: +44 (0)870 4021 400

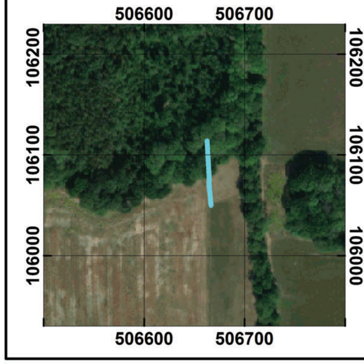
LIONS SINK HOLE TRIAL - ERT LINE 2 MODELLED SECTION



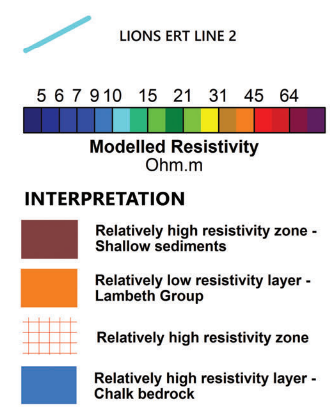
LIONS SINK HOLE TRIAL - ERT LINE 2 INTERPRETED SECTION



GENERAL LOCATION PLAN:



LEGEND:



SCALE GENERAL LOCATION:

Scale 1:5000

100 0 100 200

metres

OSGB 1936 / British National Grid

SCALE:

Scale 1:500

10 0 10 20

metres

NOTES:

1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT: WSP			
PROJECT: LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY			
TITLE: MODELLED AND INTERPRETED SECTION LIONS ERT LINE 2			
PROJECT NO.: 223150		DRAWING NO.: 223150-D03B	
ISSUE REFERENCE: 01		DATE: 06/06/2023	
INTERP. BY: AD	DATE: 06/06/2023	DRAWN BY: AD	DATE: 06/06/2023
CHECKED BY: BB	DATE: 06/06/2023	APPROVED BY: DK	DATE: 06/06/2023
DRAWING SCALE: 1:500			
PLOTTED DRAWING SIZE: A3 (420mm x 297mm)			

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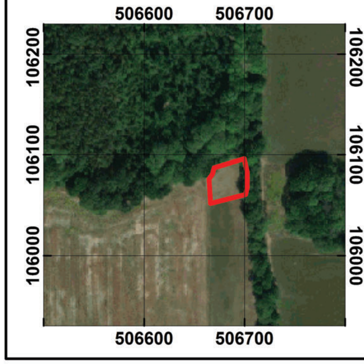
Wallingford, Oxfordshire. OX10 9RB
Tel: +44 (0)870 4021 400

223150-D04A - LIONS TRIAL AREA EM RESULTS - APPROX. DEPTH 2.2 m

GENERAL LOCATION PLAN:

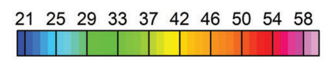


LEGEND:

LIONS ERT LINE 1

LIONS ERT LINE 2

EM SURVEY AREA



Apparent Conductivity
mS/m

SCALE GENERAL LOCATION:

Scale 1:5000

100 0 100 200

metres

OSGB 1936 / British National Grid

SCALE:

Scale 1:1000

20 0 20 40

metres

OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT: WSP			
PROJECT: LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY			
TITLE: LIONS TRIAL AREA EM RESULTS APPROX. DEPTH 2.2 m			
PROJECT NO.: 223150		DRAWING NO.: 223150-D04A	
ISSUE REFERENCE: 01		DATE: 06/06/2023	
INTERP. BY: AD	DATE: 06/06/2023	DRAWN BY: AD	DATE: 06/06/2023
CHECKED BY: BB	DATE: 06/06/2023	APPROVED BY: DK	DATE: 06/06/2023
DRAWING SCALE: 1:1000			
PLOTTED DRAWING SIZE: A3 (420mm x 297mm)			

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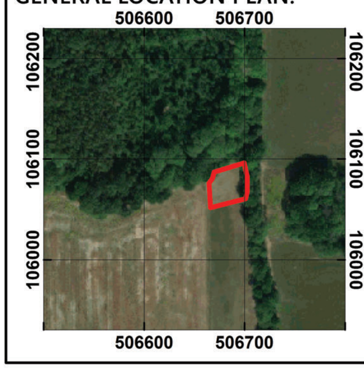
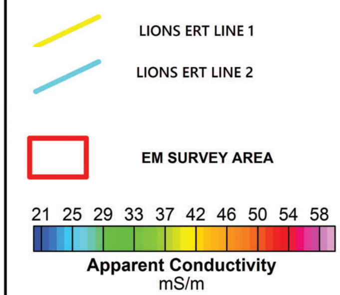
Wallingford, Oxfordshire. OX10 9RB
Tel: +44 (0)870 4021 400

223150-D04B - LIONS TRIAL AREA EM RESULTS - APPROX. DEPTH 4.4 m

GENERAL LOCATION PLAN:



LEGEND:



SCALE GENERAL LOCATION:
Scale 1:5000
100 0 100 200
metres
OSGB 1936 / British National Grid

SCALE:
Scale 1:1000
20 0 20 40
metres
OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT:	WSP
PROJECT:	LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY
TITLE:	LIONS TRIAL AREA EM RESULTS APPROX. DEPTH 4.4 m

PROJECT NO.:	223150			DRAWING NO.:	223150-D04B		
ISSUE REFERENCE:	01			DATE:	06/06/2023		
INTERP. BY:	AD	DATE:	06/06/2023	DRAWN BY:	AD	DATE:	06/06/2023
CHECKED BY:	BB	DATE:	06/06/2023	APPROVED BY:	DK	DATE:	06/06/2023
DRAWING SCALE:	1:1000						
PLOTTED DRAWING SIZE:	A3 (420mm x 297mm)						

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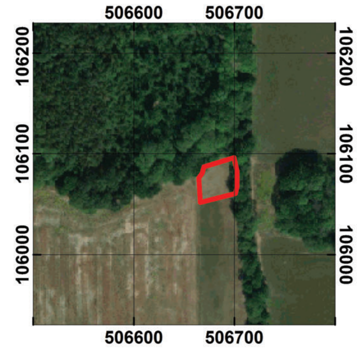
Fugro House, Hithercroft Road
Wallingford, Oxfordshire. OX10 9RB
Tel: +44 (0)870 4021 400

223150-D04C - LIONS TRIAL AREA EM RESULTS - APPROX. DEPTH 6.6 m

GENERAL LOCATION PLAN:



LEGEND:

LIONS ERT LINE 1

LIONS ERT LINE 2

EM SURVEY AREA

21 25 29 33 37 42 46 50 54 58

Apparent Conductivity
mS/m

SCALE GENERAL LOCATION:
Scale 1:5000
100 0 100 200
metres
OSGB 1936 / British National Grid

SCALE:
Scale 1:1000
20 0 20 40
metres
OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT:	WSP		
PROJECT:	LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY		
TITLE:	LIONS TRIAL AREA EM RESULTS APPROX. DEPTH 6.6 m		
PROJECT NO.: 223150		DRAWING NO.: 223150-D04C	
ISSUE REFERENCE: 01		DATE: 06/06/2023	
INTERP. BY: AD	DATE: 06/06/2023	DRAWN BY: AD	DATE: 06/06/2023
CHECKED BY: BB	DATE: 06/06/2023	APPROVED BY: DK	DATE: 06/06/2023
DRAWING SCALE: 1:1000			
PLOTTED DRAWING SIZE: A3 (420mm x 297mm)			

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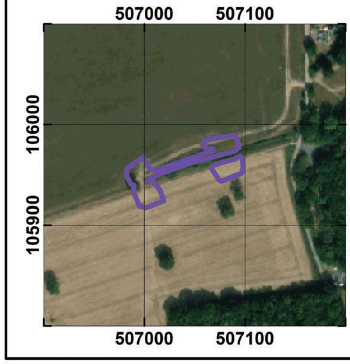
Wallingford, Oxfordshire. OX10 9RB
Tel: +44 (0)870 4021 400

223150-D05 - LOCATION PLAN SHOWING POSITION OF GEOPHYSICAL SURVEY - SWILLAGE BARN SINK HOLE TRIAL

GENERAL LOCATION PLAN:



LEGEND:

SWILLAGE BARN ERT LINE 1

SWILLAGE BARN ERT LINE 2

EM SURVEY AREA

APPROXIMATE LOCATION OF SUSPECTED SINK HOLE

SCALE GENERAL LOCATION:
Scale 1:5000
100 0 100 200
metres
OSGB 1936 / British National Grid

SCALE:
Scale 1:1000
20 0 20 40
metres
OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT: WSP			
PROJECT: LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY			
TITLE: LOCATION PLAN SHOWING POSITION OF GEOPHYSICAL SURVEY SWILLAGE BARN SINK HOLE TRIAL			
PROJECT NO.: 223150		DRAWING NO.: 223150-D05	
ISSUE REFERENCE: 01		DATE: 06/06/2023	
INTERP. BY: AD	DATE: 06/06/2023	DRAWN BY: AD	DATE: 06/06/2023
CHECKED BY: BB	DATE: 06/06/2023	APPROVED BY: DK	DATE: 06/06/2023
DRAWING SCALE: 1:1000			
PLOTTED DRAWING SIZE: A3 (420mm x 297mm)			

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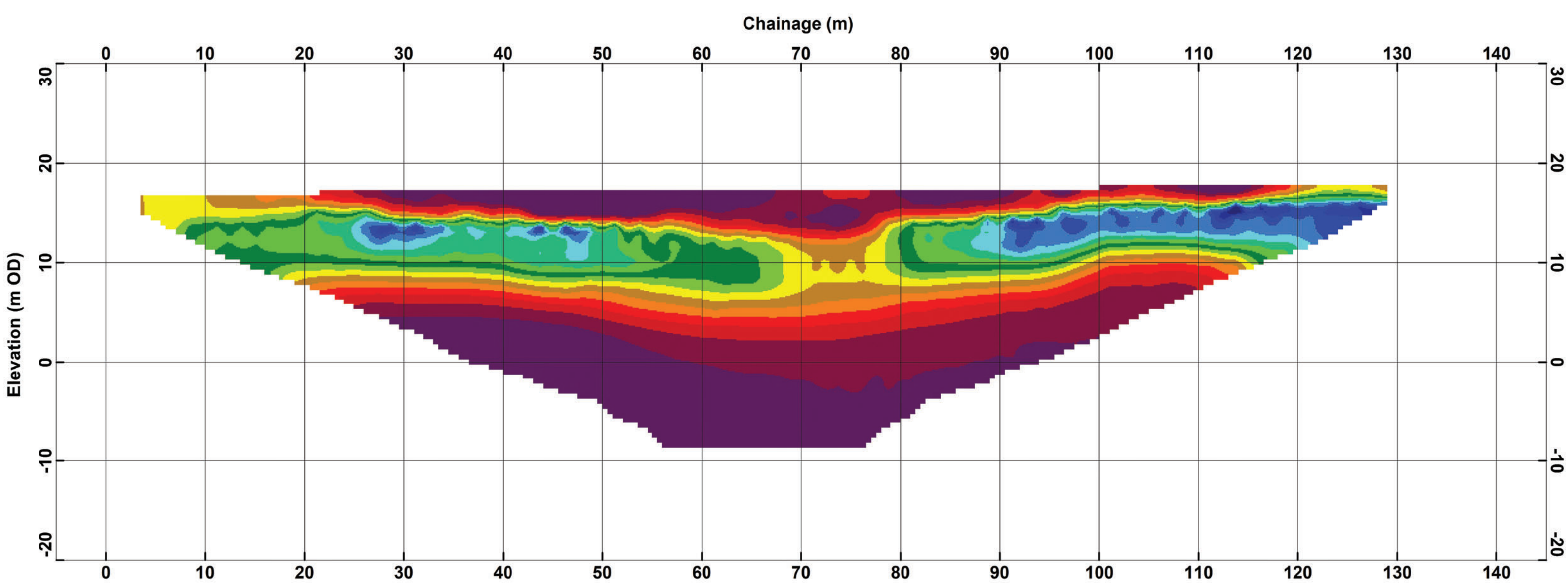
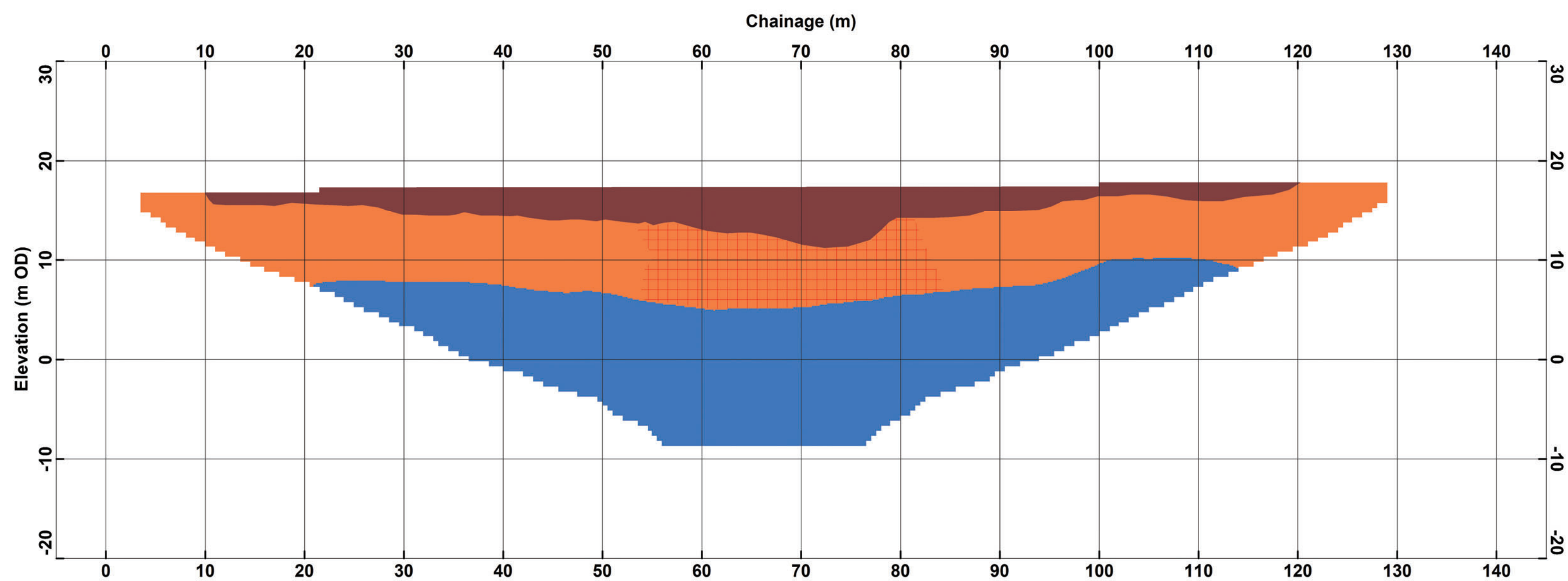
Wallingford, Oxfordshire. OX10 9RB
Tel: +44 (0)870 4021 400

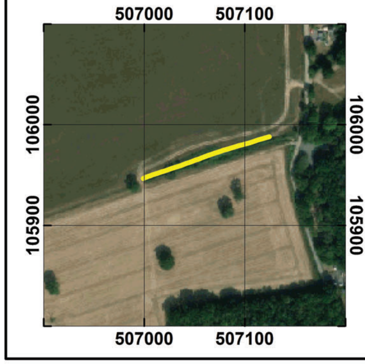
SWILLAGE BARN SINK HOLE TRIAL - ERT LINE 1 MODELLED SECTION



SWILLAGE BARN SINK HOLE TRIAL - ERT LINE 1 INTERPRETED SECTION

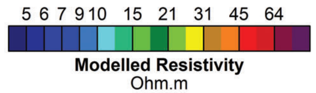


GENERAL LOCATION PLAN:



LEGEND:

SWILLAGE BARN ERT LINE 1



INTERPRETATION

- Relatively high resistivity zone - Shallow sediments
- Relatively low resistivity layer - Lambeth Group
- Relatively high resistivity zone
- Relatively high resistivity layer - Chalk bedrock

SCALE GENERAL LOCATION:
Scale 1:5000
100 0 100 200
metres
OSGB 1936 / British National Grid

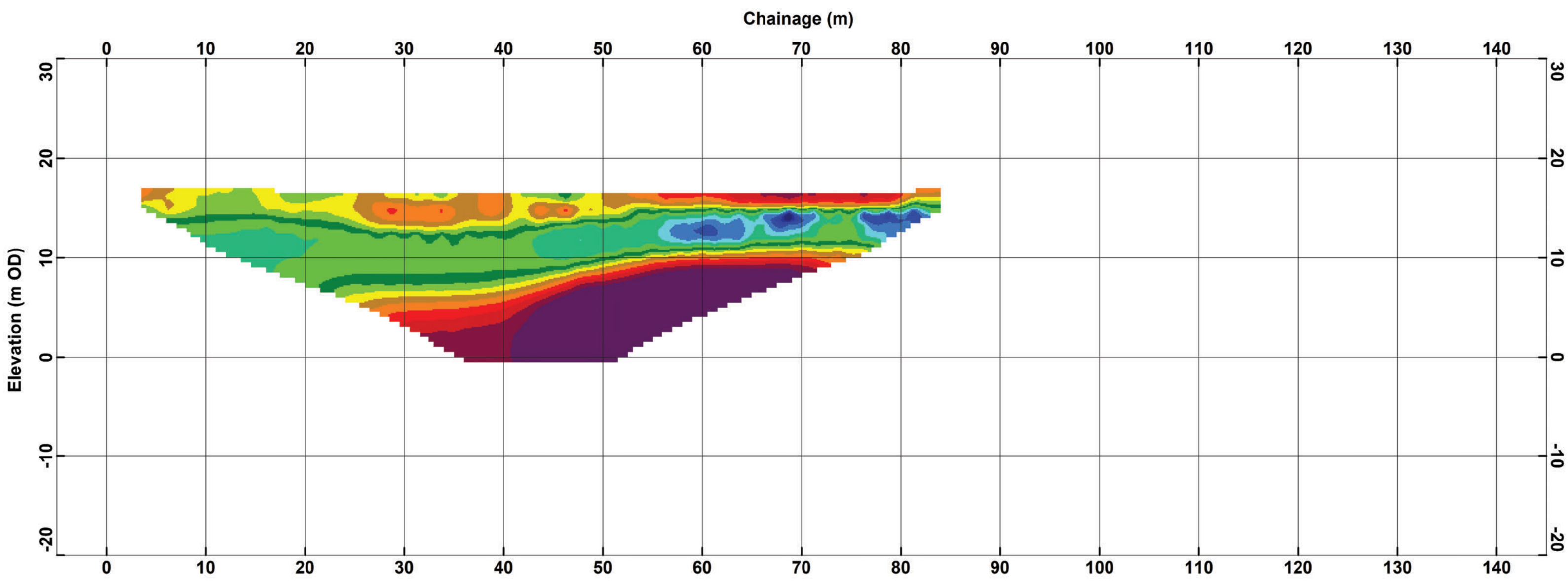
SCALE:
Scale 1:500
10 0 10 20
metres

NOTES:

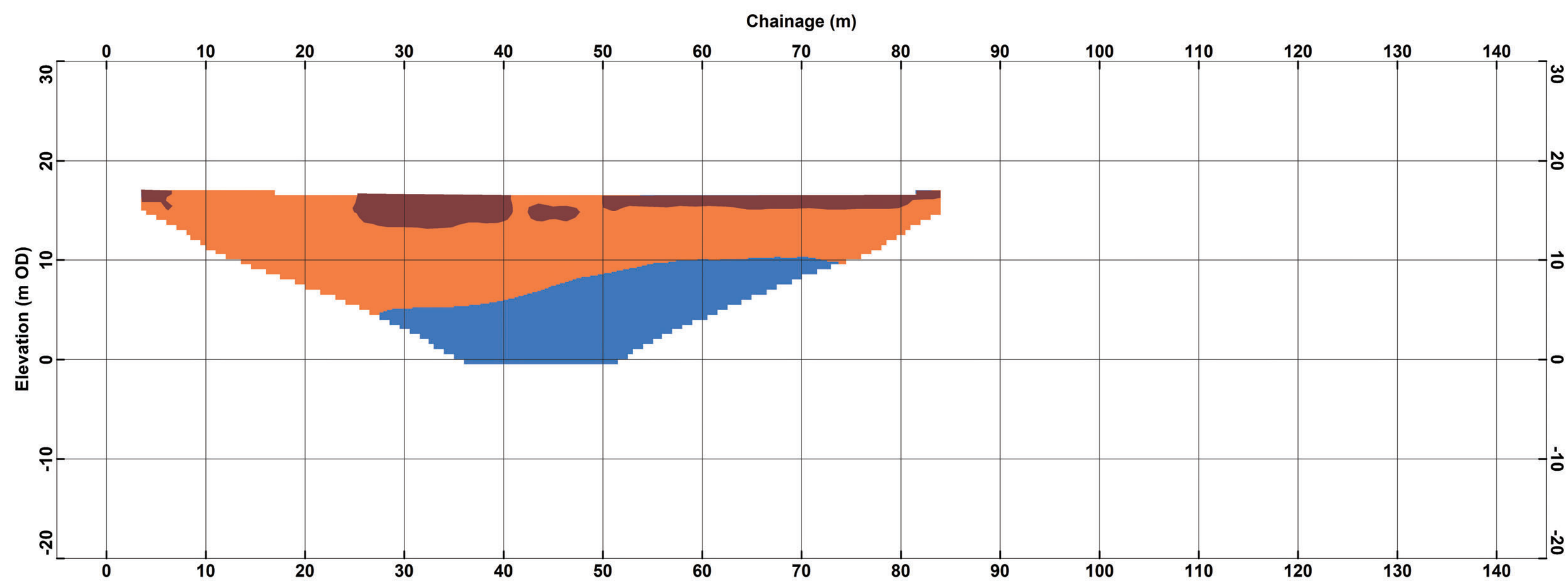
1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT:	WSP		
PROJECT:	LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY		
TITLE:	MODELLED AND INTERPRETED SECTION SWILLAGE BARN ERT LINE 1		
PROJECT NO.: 223150		DRAWING NO.: 223150-D06A	
ISSUE REFERENCE: 01		DATE: 06/06/2023	
INTERP. BY: AD	DATE: 06/06/2023	DRAWN BY: AD	DATE: 06/06/2023
CHECKED BY: BB	DATE: 06/06/2023	APPROVED BY: DK	DATE: 06/06/2023
DRAWING SCALE: 1:500			
PLOTTED DRAWING SIZE: A3 (420mm x 297mm)			
FUGRO GEOSERVICES LIMITED Fugro House, Hithercroft Road Wallingford, Oxfordshire. OX10 9RB Tel: +44 (0)870 4021 400			

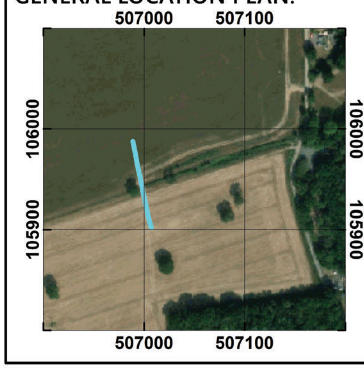
SWILLAGE BARN SINK HOLE TRIAL - ERT LINE 2 MODELLED SECTION



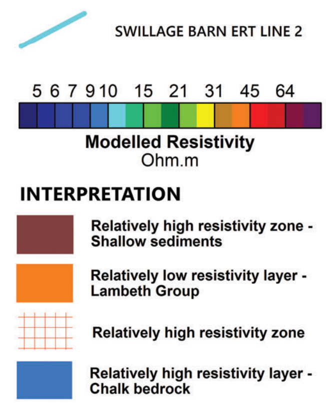
SWILLAGE BARN SINK HOLE TRIAL - ERT LINE 2 INTERPRETED SECTION



GENERAL LOCATION PLAN:



LEGEND:



SCALE GENERAL LOCATION:
Scale 1:5000
100 0 100 200
metres
OSGB 1936 / British National Grid

SCALE:
Scale 1:500
10 0 10 20
metres

NOTES:
1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT:	WSP		
PROJECT:	LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY		
TITLE:	MODELLED AND INTERPRETED SECTION SWILLAGE BARN ERT LINE 2		
PROJECT NO.: 223150		DRAWING NO.: 223150-D06B	
ISSUE REFERENCE: 01		DATE: 06/06/2023	
INTERP. BY: AD	DATE: 06/06/2023	DRAWN BY: AD	DATE: 06/06/2023
CHECKED BY: BB	DATE: 06/06/2023	APPROVED BY: DK	DATE: 06/06/2023
DRAWING SCALE: 1:500			
PLOTTED DRAWING SIZE: A3 (420mm x 297mm)			

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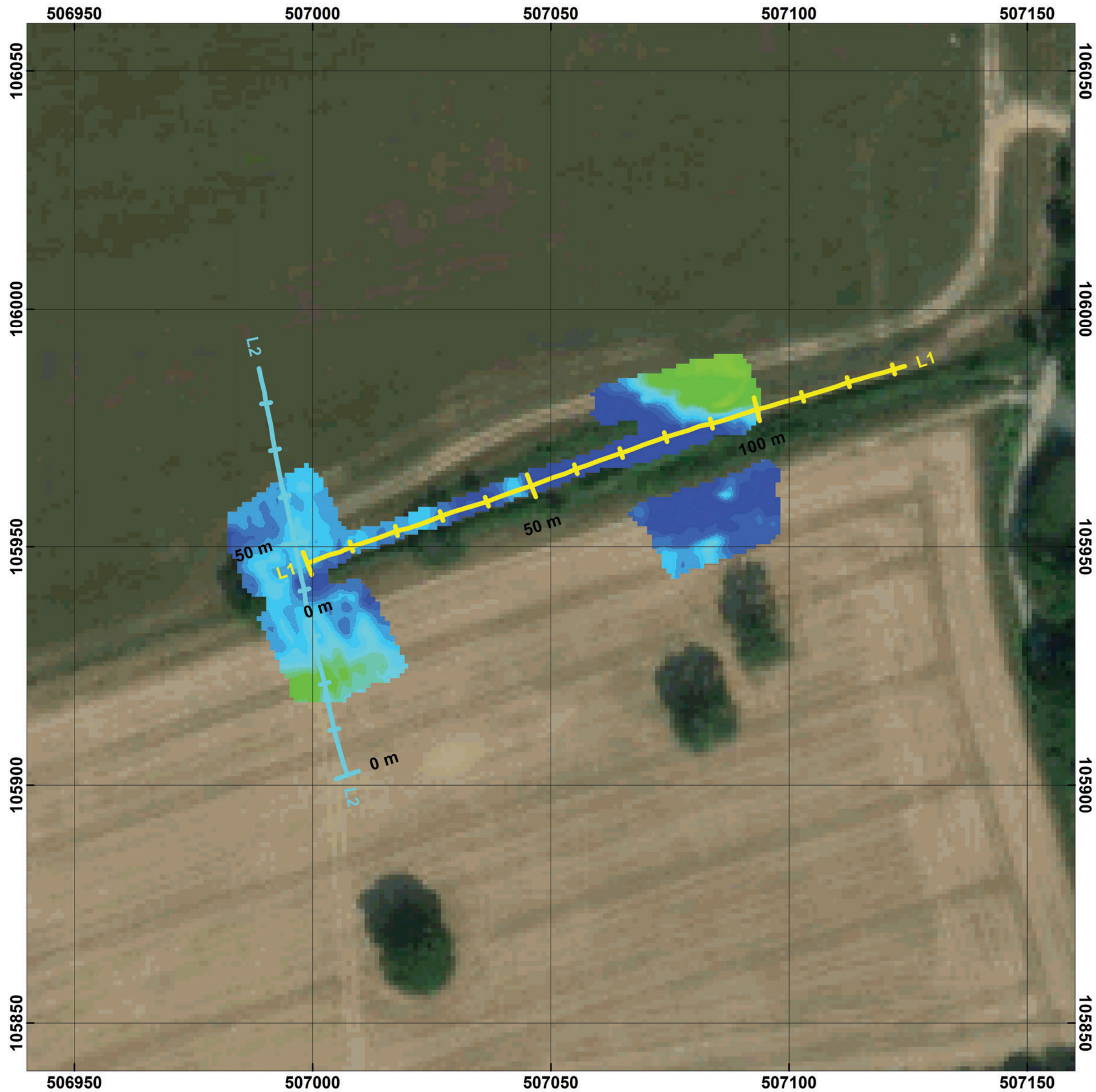
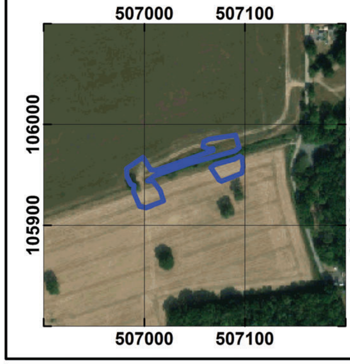
Tel: +44 (0)870 4021 400

223150-D07A - SWILLAGE BARN TRIAL AREA EM RESULTS - APPROX. DEPTH 2.2 m



GENERAL LOCATION PLAN:



LEGEND:

SWILLAGE BARN ERT LINE 1

SWILLAGE BARN ERT LINE 2

EM SURVEY AREA

21 25 29 33 37 42 46 50 54 58

Apparent Conductivity
mS/m

SCALE GENERAL LOCATION:
Scale 1:5000
100 0 100 200
metres
OSGB 1936 / British National Grid

SCALE:
Scale 1:1000
20 0 20 40
metres
OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT:	WSP		
PROJECT:	LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY		
TITLE:	SWILLAGE BARN TRIAL AREA EM RESULTS APPROX. DEPTH 2.2 m		
PROJECT NO.: 223150		DRAWING NO.: 223150-D07A	
ISSUE REFERENCE: 01		DATE: 06/06/2023	
INTERP. BY: AD	DATE: 06/06/2023	DRAWN BY: AD	DATE: 06/06/2023
CHECKED BY: BB	DATE: 06/06/2023	APPROVED BY: DK	DATE: 06/06/2023
DRAWING SCALE: 1:1000			
PLOTTED DRAWING SIZE: A3 (420mm x 297mm)			

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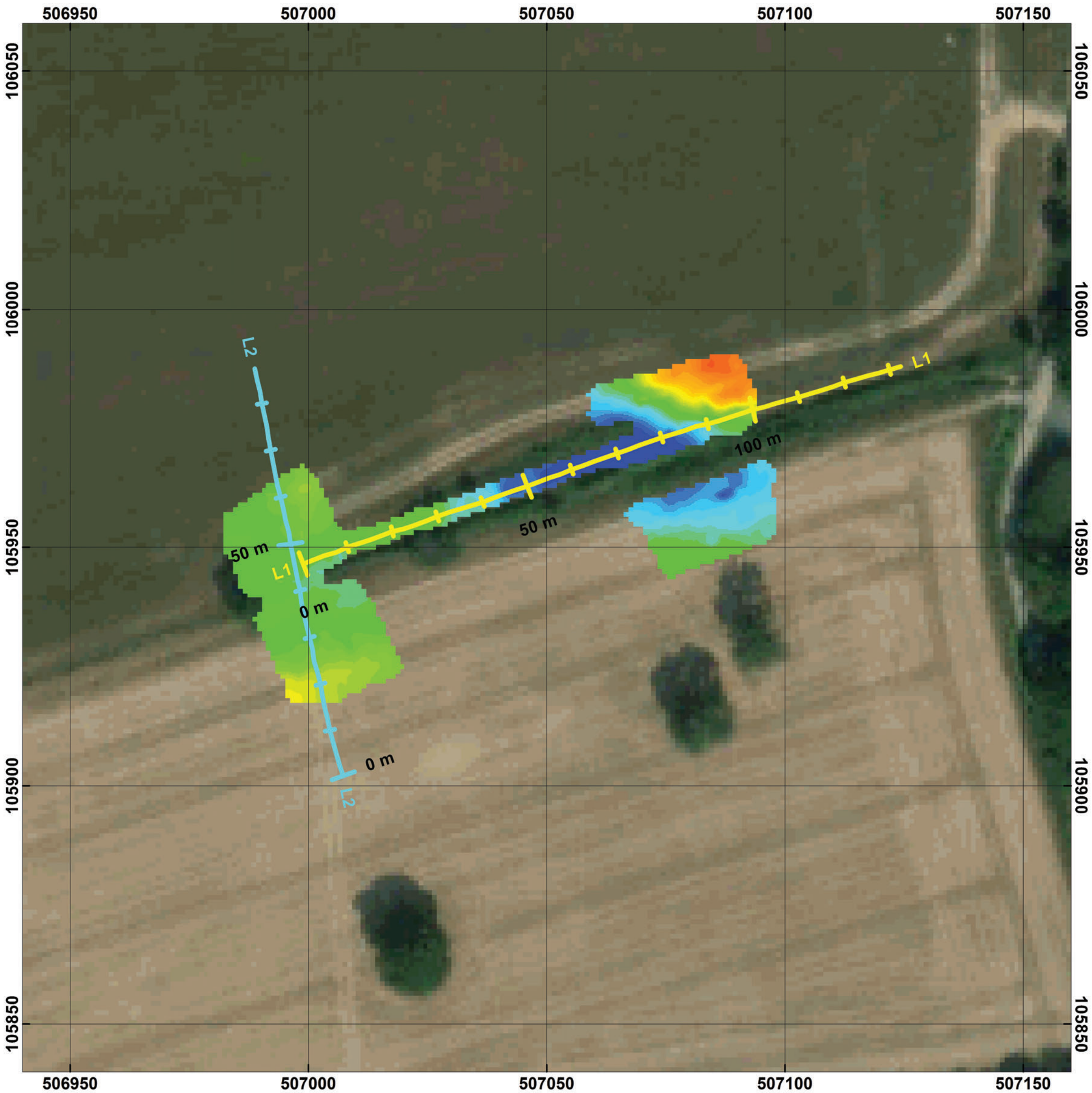
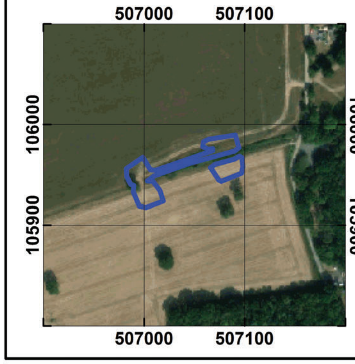
Tel: +44 (0)870 4021 400

223150-D07B - SWILLAGE BARN TRIAL AREA EM RESULTS - APPROX. DEPTH 4.4 m



GENERAL LOCATION PLAN:



LEGEND:

SWILLAGE BARN ERT LINE 1

SWILLAGE BARN ERT LINE 2

EM SURVEY AREA

21 25 29 33 37 42 46 50 54 58

Apparent Conductivity
mS/m

SCALE GENERAL LOCATION:
Scale 1:5000
100 0 100 200
metres
OSGB 1936 / British National Grid

SCALE:
Scale 1:1000
20 0 20 40
metres
OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT:	WSP		
PROJECT:	LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY		
TITLE:	SWILLAGE BARN TRIAL AREA EM RESULTS APPROX. DEPTH 4.4 m		
PROJECT NO.: 223150		DRAWING NO.: 223150-D07B	
ISSUE REFERENCE: 01		DATE: 06/06/2023	
INTERP. BY: AD	DATE: 06/06/2023	DRAWN BY: AD	DATE: 06/06/2023
CHECKED BY: BB	DATE: 06/06/2023	APPROVED BY: DK	DATE: 06/06/2023
DRAWING SCALE: 1:1000			
PLOTTED DRAWING SIZE: A3 (420mm x 297mm)			

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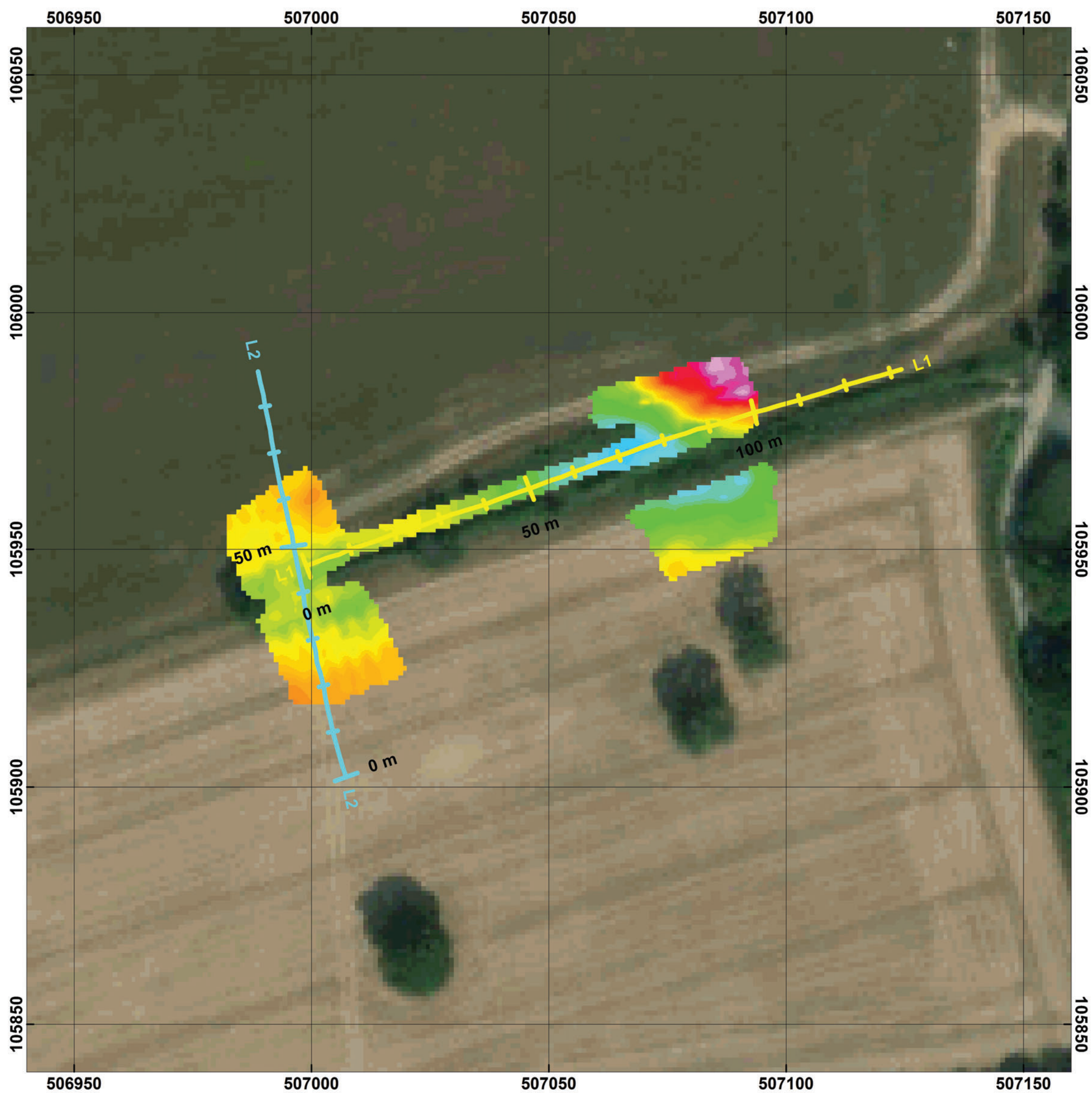
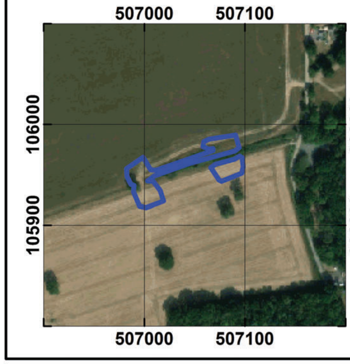
Wallingford, Oxfordshire. OX10 9RB
Tel: +44 (0)870 4021 400

223150-D07C - SWILLAGE BARN TRIAL AREA EM RESULTS - APPROX. DEPTH 6.6 m



GENERAL LOCATION PLAN:



LEGEND:

SWILLAGE BARN ERT LINE 1

SWILLAGE BARN ERT LINE 2

EM SURVEY AREA

21 25 29 33 37 42 46 50 54 58

Apparent Conductivity
mS/m

SCALE GENERAL LOCATION:
Scale 1:5000
100 0 100 200
metres
OSGB 1936 / British National Grid

SCALE:
Scale 1:1000
20 0 20 40
metres
OSGB 1936 / British National Grid

NOTES:
1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT:	WSP		
PROJECT:	LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY		
TITLE:	SWILLAGE BARN TRIAL AREA EM RESULTS APPROX. DEPTH 6.6 m		
PROJECT NO.: 223150		DRAWING NO.: 223150-D07C	
ISSUE REFERENCE: 01		DATE: 06/06/2023	
INTERP. BY: AD	DATE: 06/06/2023	DRAWN BY: AD	DATE: 06/06/2023
CHECKED BY: BB	DATE: 06/06/2023	APPROVED BY: DK	DATE: 06/06/2023
DRAWING SCALE: 1:1000			
PLOTTED DRAWING SIZE: A3 (420mm x 297mm)			

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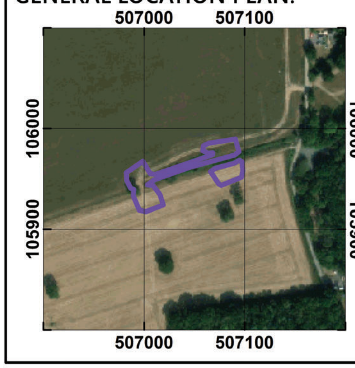
Wallingford, Oxfordshire. OX10 9RB
Tel: +44 (0)870 4021 400

223150-D08 - SWILLAGE BARN SINK HOLE TRIAL ANOMALY LOCATION PLAN

GENERAL LOCATION PLAN:



LEGEND:

- EM SURVEY AREA
- APPROXIMATE LOCATION OF SUSPECTED SINK HOLE
- EM - RELATIVELY LOW CONDUCTIVITY ANOMALY
- ERT - RELATIVELY HIGH RESISTIVITY ANOMALY IN LAMBETH GROUP

SCALE GENERAL LOCATION:
Scale 1:5000
100 0 100 200
metres
OSGB 1936 / British National Grid

SCALE:
Scale 1:1000
20 0 20 40
metres
OSGB 1936 / British National Grid

NOTES:
1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT:	WSP		
PROJECT:	LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY		
TITLE:	SWILLAGE BARN SINK HOLE TRIAL ANOMALY LOCATION PLAN		
PROJECT NO.: 223150		DRAWING NO.: 223150-D08	
ISSUE REFERENCE: 01		DATE: 06/06/2023	
INTERP. BY: AD	DATE: 06/06/2023	DRAWN BY: AD	DATE: 06/06/2023
CHECKED BY: BB	DATE: 06/06/2023	APPROVED BY: DK	DATE: 06/06/2023
DRAWING SCALE: 1:1000			
PLOTTED DRAWING SIZE: A3 (420mm x 297mm)			

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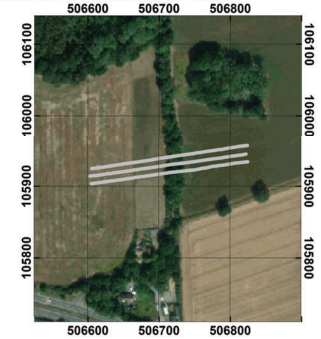
Wallingford, Oxfordshire. OX10 9RB
Tel: +44 (0)870 4021 400

223150-D09 - LOCATION PLAN SHOWING POSITION OF ERT LINES - MAIN SURVEY

GENERAL LOCATION PLAN:



LEGEND:

- ERT LINE 1A
- ERT LINE 1B
- ERT LINE 1C

SCALE GENERAL LOCATION:

Scale 1:5000

100 0 100 200

metres

OSGB 1936 / British National Grid

SCALE:

Scale 1:500

10 0 10 20

metres

OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Elevation datum relative to m (OD)

CLIENT:

WSP

PROJECT:

LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY

TITLE:

LOCATION PLAN SHOWING POSITION OF ERT LINES - MAIN SURVEY

PROJECT NO.: 223150		DRAWING NO.: 223150-D09	
ISSUE REFERENCE: 01		DATE: 07/06/2023	
INTERP. BY: AD	DATE: 07/06/2023	DRAWN BY: AD	DATE: 07/06/2023
CHECKED BY: BB	DATE: 07/06/2023	APPROVED BY: DK	DATE: 07/06/2023
DRAWING SCALE: 1:500			
PLOTTED DRAWING SIZE: A2 (594 x 420 mm)			

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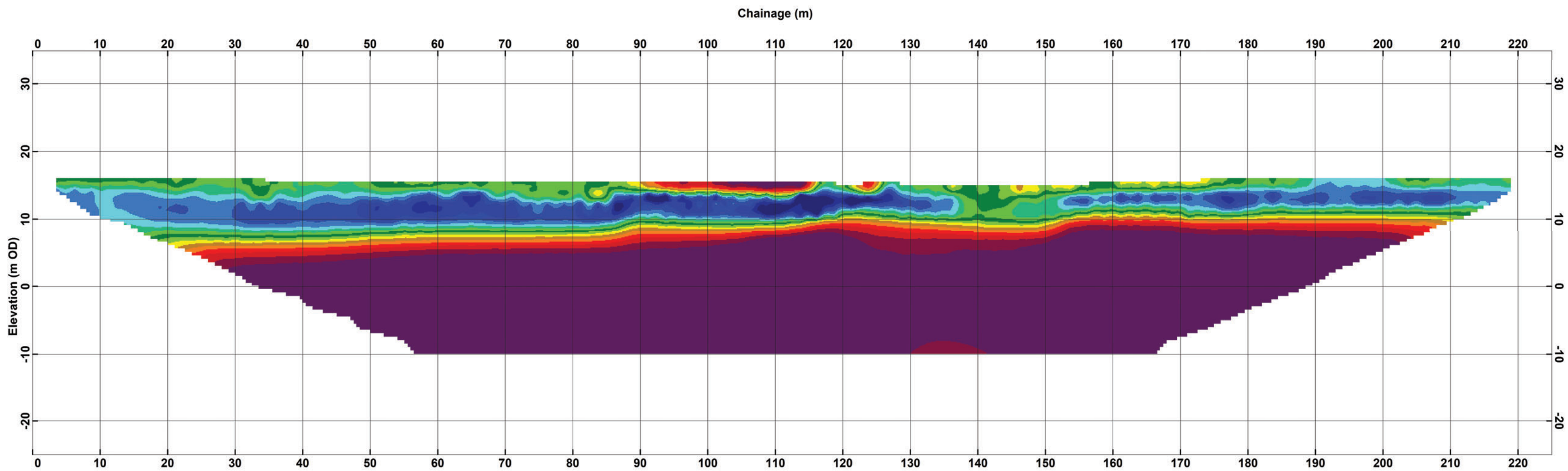
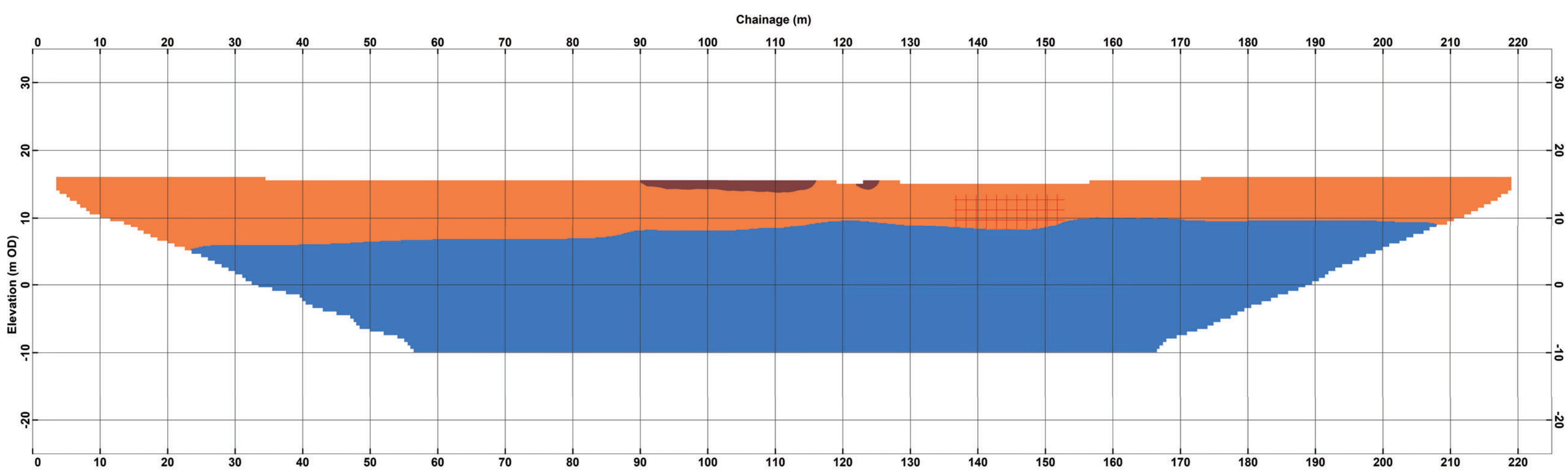
Wallingford, Oxfordshire. OX10 9RB
Tel: +44 (0)870 4021 400

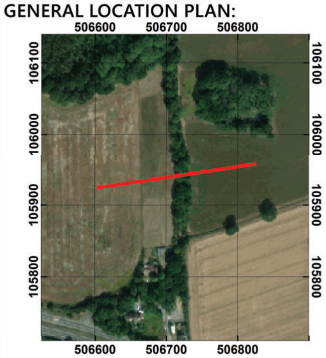
MODELLED SECTION - ERT LINE 1A



INTERPRETED SECTION - ERT LINE 1A



GENERAL LOCATION PLAN:



LEGEND:

ERT LINE 1A

5 6 7 9 10 15 21 31 45 64

Modelled Resistivity
Ohm.m

INTERPRETATION

- Relatively high resistivity zone - Shallow sediments
- Relatively low resistivity layer - Lambeth Group
- Relatively high resistivity zone
- Relatively high resistivity layer - Chalk bedrock

SCALE GENERAL LOCATION:

Scale 1:5000
100 0 100 200 300
metres
OSGB 1936 / British National Grid

SCALE:

Scale 1:500
10 0 10 20 30
metres
OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT: WSP

PROJECT: LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY

TITLE: MODELLED AND INTERPRETED SECTION ERT LINE 1A

PROJECT NO.: 223150		DRAWING NO.: 223150-D10A	
ISSUE REFERENCE: 01		DATE: 06/06/2023	
INTERP. BY: AD	DATE: 06/06/2023	DRAWN BY: AD	DATE: 06/06/2023
CHECKED BY: BB	DATE: 06/06/2023	APPROVED BY: DK	DATE: 06/06/2023
DRAWING SCALE: 1:500			
PLOTTED DRAWING SIZE: A2 (594 x 420 mm)			

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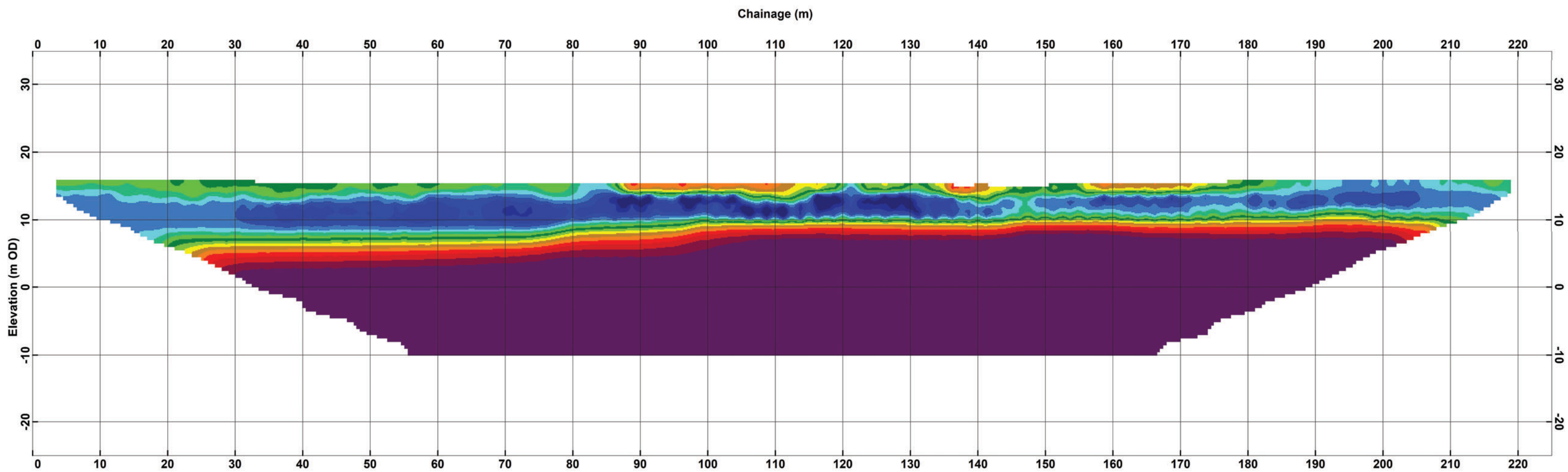
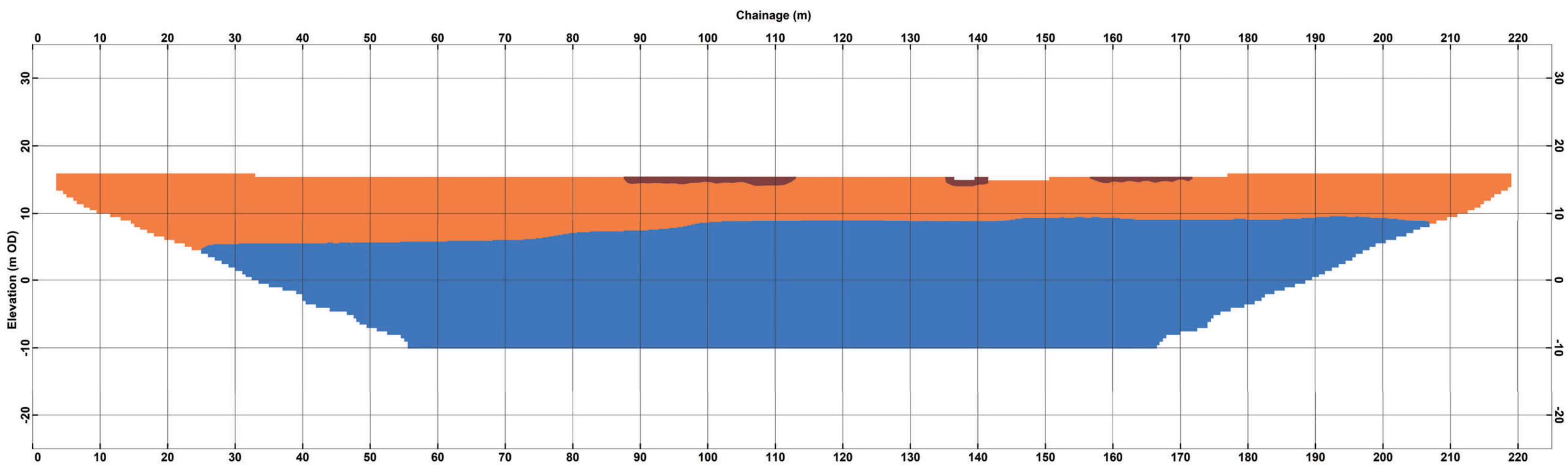
Wallingford, Oxfordshire, OX10 9RB
Tel: +44 (0)870 4021 400

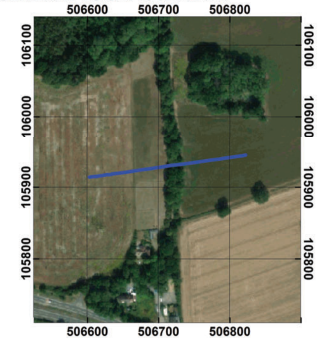
MODELLED SECTION - ERT LINE 1B



INTERPRETED SECTION - ERT LINE 1B



GENERAL LOCATION PLAN:



LEGEND:

ERT LINE 1B

INTERPRETATION

- Relatively high resistivity zone - Shallow sediments
- Relatively low resistivity layer - Lambeth Group
- Relatively high resistivity zone
- Relatively high resistivity layer - Chalk bedrock

SCALE GENERAL LOCATION:

Scale 1:5000

100 0 100 200 300

metres

OSGB 1936 / British National Grid

SCALE:

Scale 1:500

10 0 10 20 30

metres

OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT:

WSP

PROJECT:

LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY

TITLE:

MODELLED AND INTERPRETED SECTION ERT LINE 1B

PROJECT NO.: 223150		DRAWING NO.: 223150-D10B	
ISSUE REFERENCE: 01		DATE: 06/06/2023	
INTERP. BY: AD	DATE: 06/06/2023	DRAWN BY: AD	DATE: 06/06/2023
CHECKED BY: BB	DATE: 06/06/2023	APPROVED BY: DK	DATE: 06/06/2023
DRAWING SCALE: 1:500			
PLOTTED DRAWING SIZE: A2 (594 x 420 mm)			

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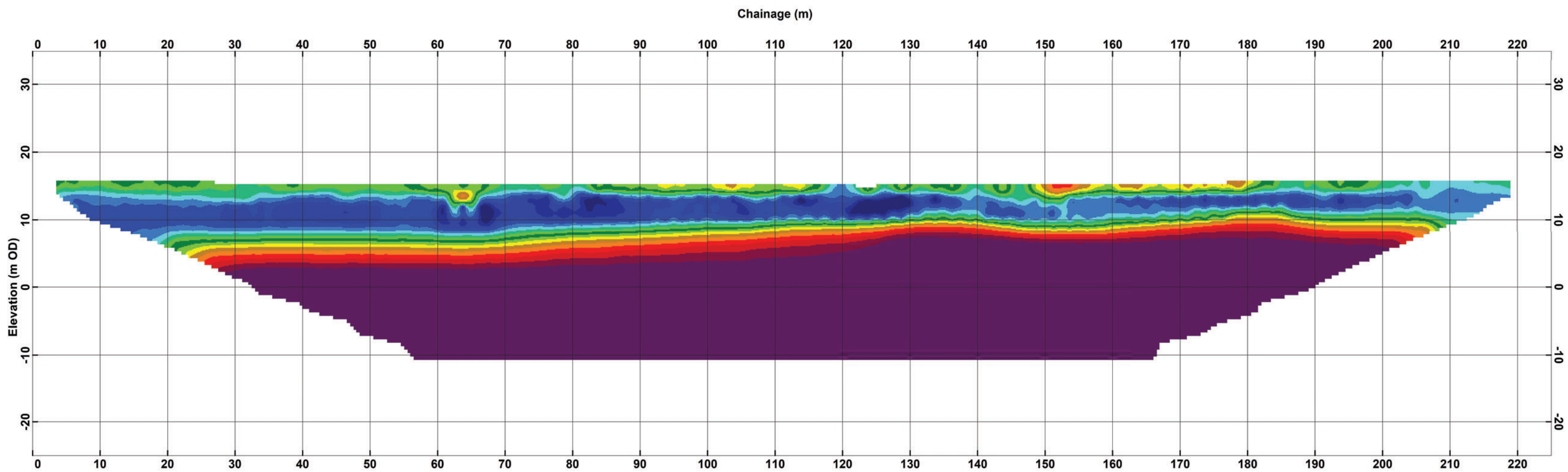
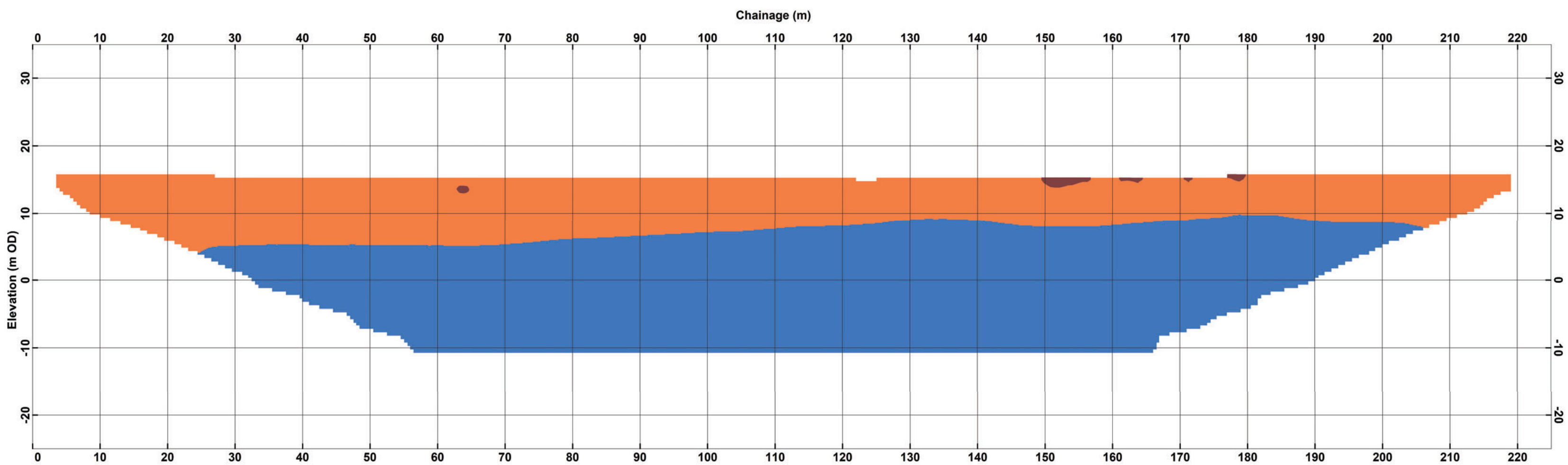
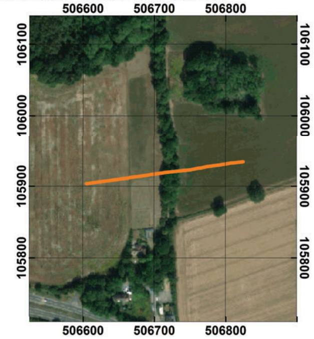
MODELLED SECTION - ERT LINE 1C



INTERPRETED SECTION - ERT LINE 1C



GENERAL LOCATION PLAN:



LEGEND:

ERT LINE 1C

5 6 7 9 10 15 21 31 45 64

Modelled Resistivity
Ohm.m

INTERPRETATION

- Relatively high resistivity zone - Shallow sediments
- Relatively low resistivity layer - Lambeth Group
- Relatively high resistivity zone
- Relatively high resistivity layer - Chalk bedrock

SCALE GENERAL LOCATION:

Scale 1:5000

100 0 100 200 300

metres

OSGB 1936 / British National Grid

SCALE:

Scale 1:500

10 0 10 20 30

metres

OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Datum relative to m (OD)

CLIENT: WSP			
PROJECT: LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY			
TITLE: MODELLED AND INTERPRETED SECTION ERT LINE 1C			
PROJECT NO.: 223150		DRAWING NO.: 223150-D10C	
ISSUE REFERENCE: 01		DATE: 06/06/2023	
INTERP. BY: AD	DATE: 06/06/2023	DRAWN BY: AD	DATE: 06/06/2023
CHECKED BY: BB	DATE: 06/06/2023	APPROVED BY: DK	DATE: 06/06/2023
DRAWING SCALE: 1:500			
PLOTTED DRAWING SIZE: A2 (594 x 420 mm)			

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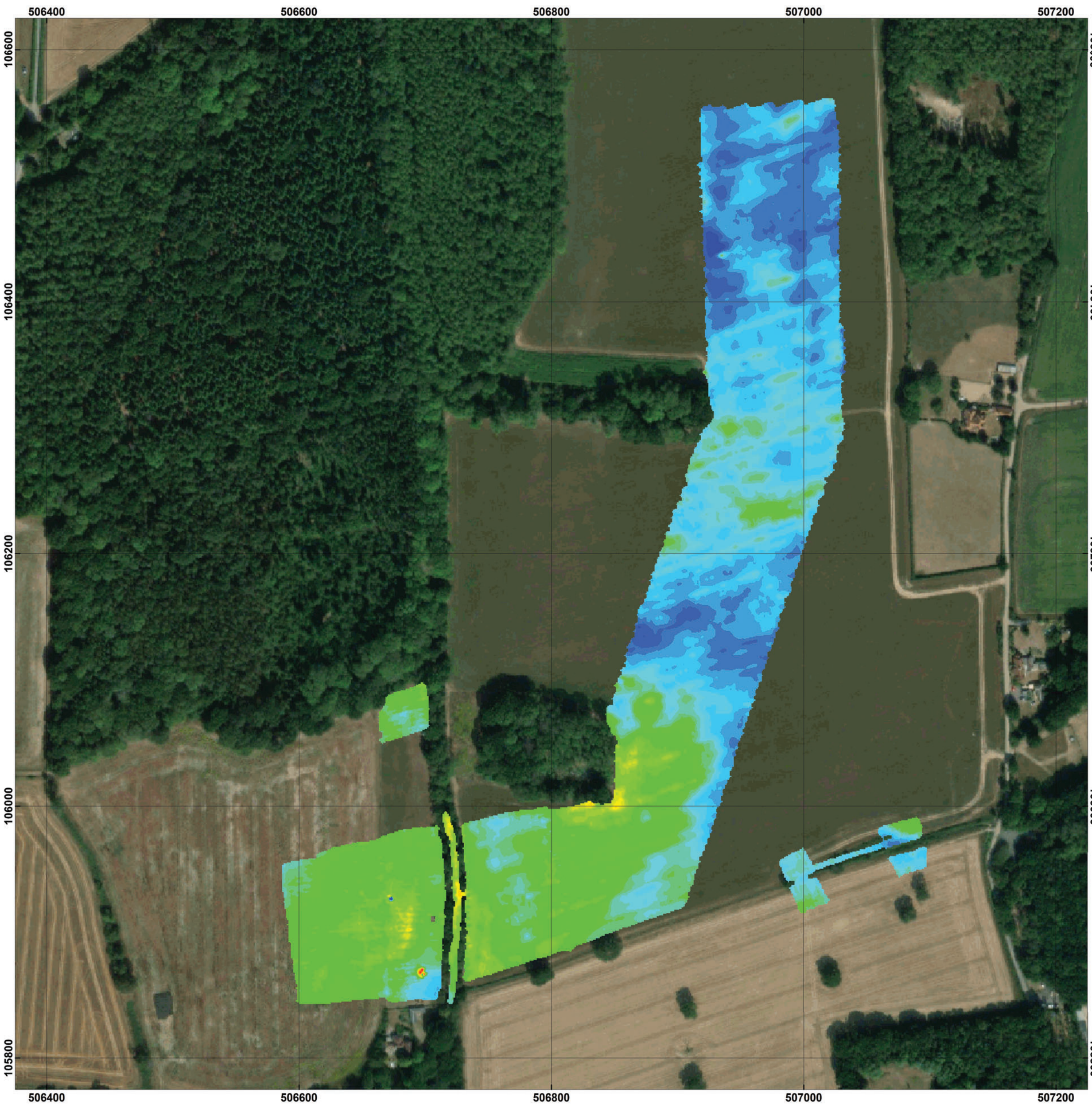
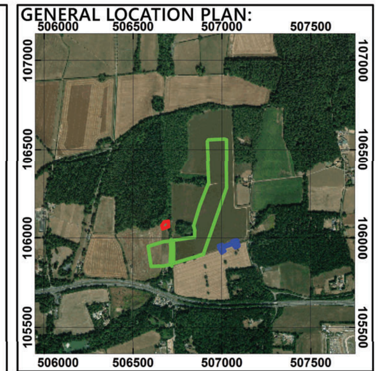
223150-D11A - MAIN SURVEY AREA EM RESULTS - APPROX. DEPTH 2.2 m



GENERAL LOCATION PLAN:



LEGEND:

12 18 24 31 37 43 49 55 61 67 74 80 86

Apparent Conductivity
mS/m

SCALE GENERAL LOCATION:

Scale 1:20000
500 0 500 1000
metres
OSGB 1936 / British National Grid

SCALE:

Scale 1:2500
50 0 50 100
metres
OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Elevation datum relative to m (OD)

CLIENT:
WSP

PROJECT:
LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY

TITLE:
MAIN SURVEY AREA EM RESULTS APPROX. DEPTH 2.2 m

PROJECT NO.: 223150		DRAWING NO.: 223150-D11A	
ISSUE REFERENCE: 01		DATE: 07/06/2023	
INTERP. BY: AD	DATE: 07/06/2023	DRAWN BY: AD	DATE: 07/06/2023
CHECKED BY: BB	DATE: 07/06/2023	APPROVED BY: DK	DATE: 07/06/2023
DRAWING SCALE: 1:2500			
PLOTTED DRAWING SIZE: A2 (594 x 420 mm)			

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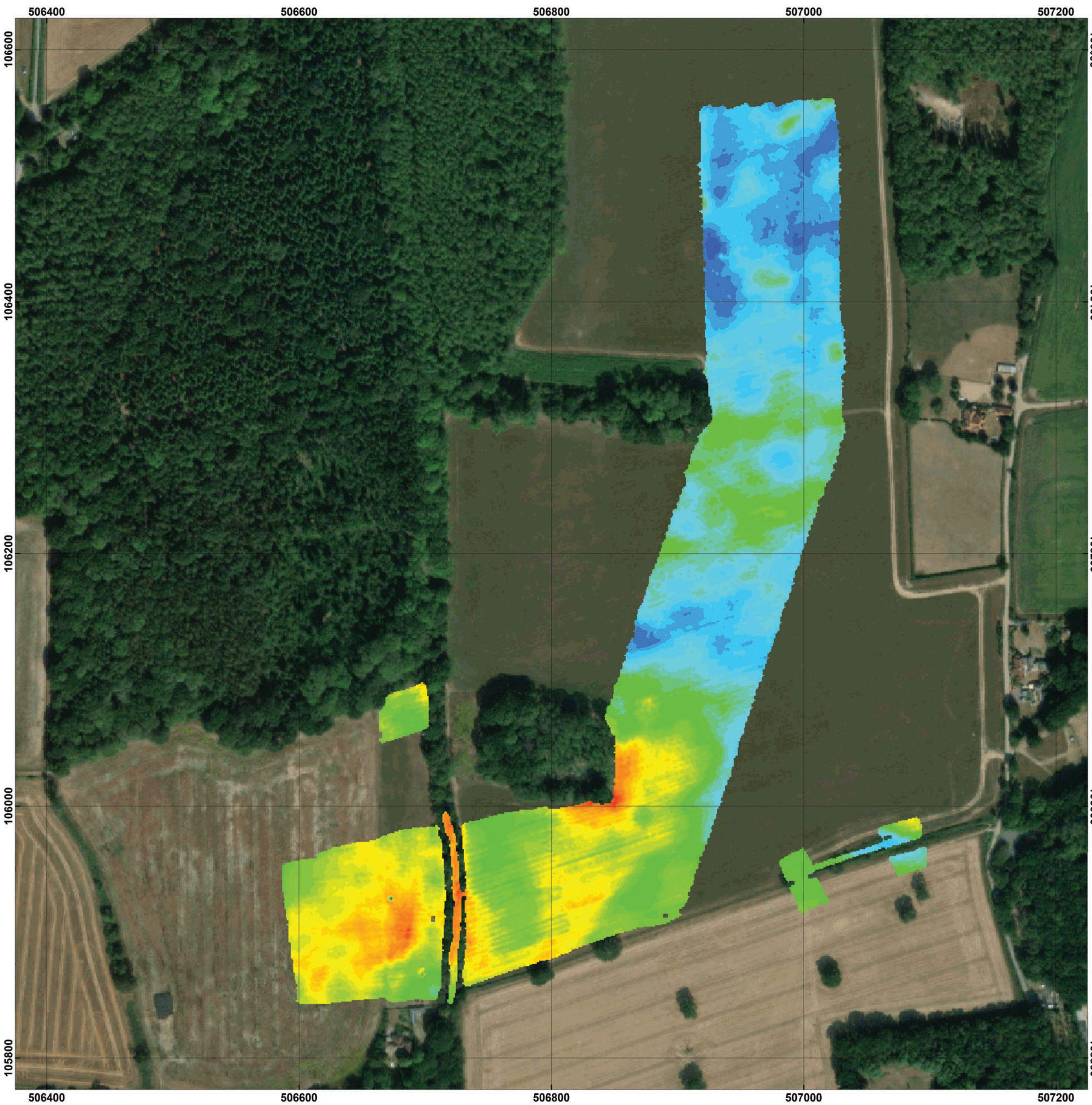
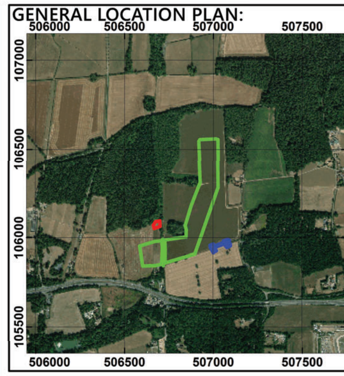
Wallingford, Oxfordshire. OX10 9RB
Tel: +44 (0)870 4021 400

223150-D11B - MAIN SURVEY AREA EM RESULTS - APPROX. DEPTH 4.4 m



GENERAL LOCATION PLAN:



LEGEND:

12 18 24 31 37 43 49 55 61 67 74 80 86

Apparent Conductivity
mS/m

SCALE GENERAL LOCATION:

Scale 1:20000
500 0 500 1000
metres
OSGB 1936 / British National Grid

SCALE:

Scale 1:2500
50 0 50 100
metres
OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Elevation datum relative to m (OD)

CLIENT: WSP			
PROJECT: LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY			
TITLE: MAIN SURVEY AREA EM RESULTS APPROX. DEPTH 4.4 m			
PROJECT NO.: 223150		DRAWING NO.: 223150-D11B	
ISSUE REFERENCE: 01		DATE: 07/06/2023	
INTERP. BY: AD	DATE: 07/06/2023	DRAWN BY: AD	DATE: 07/06/2023
CHECKED BY: BB	DATE: 07/06/2023	APPROVED BY: DK	DATE: 07/06/2023
DRAWING SCALE: 1:2500			
PLOTTED DRAWING SIZE: A2 (594 x 420 mm)			

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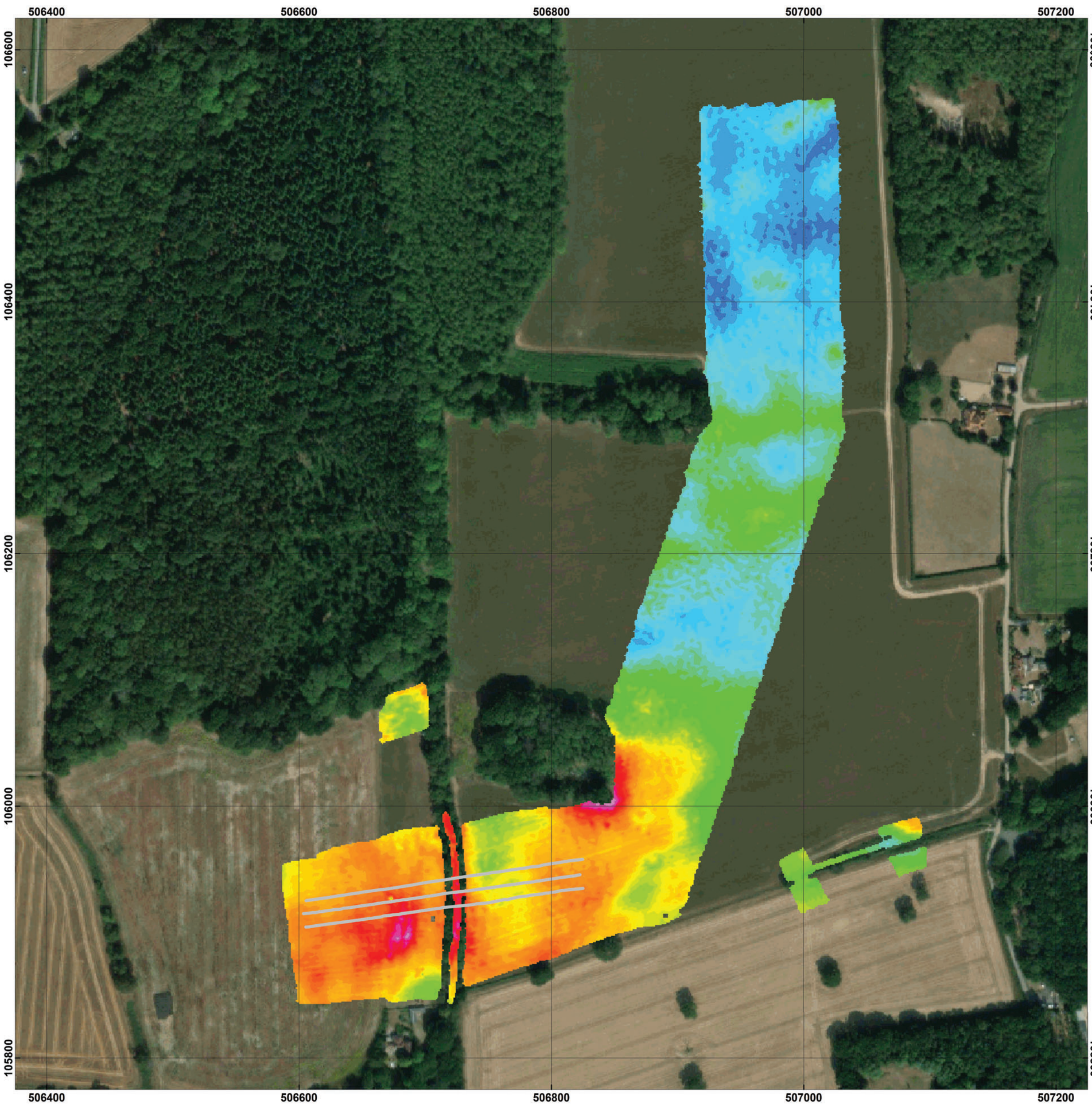
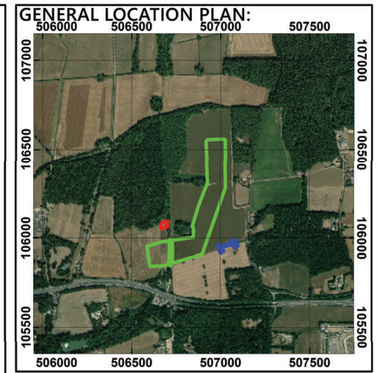
Tel: +44 (0)870 4021 400

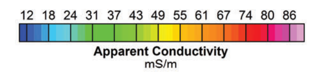
223150-D11C - MAIN SURVEY AREA EM RESULTS - APPROX. DEPTH 6.6 m



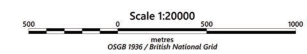
GENERAL LOCATION PLAN:



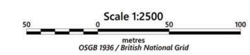
LEGEND:



SCALE GENERAL LOCATION:



SCALE:



NOTES:

1. Coordinates relative to OSGB
2. Elevation datum relative to m (OD)

CLIENT:

WSP

PROJECT:

LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY

TITLE:

MAIN SURVEY AREA EM RESULTS APPROX. DEPTH 6.6 m

PROJECT NO.: 223150		DRAWING NO.: 223150-D11C	
ISSUE REFERENCE: 01		DATE: 07/06/2023	
INTERP. BY: AD	DATE: 07/06/2023	DRAWN BY: AD	DATE: 07/06/2023
CHECKED BY: BB	DATE: 07/06/2023	APPROVED BY: DK	DATE: 07/06/2023
DRAWING SCALE: 1:2500			
PLOTTED DRAWING SIZE: A2 (594 x 420 mm)			

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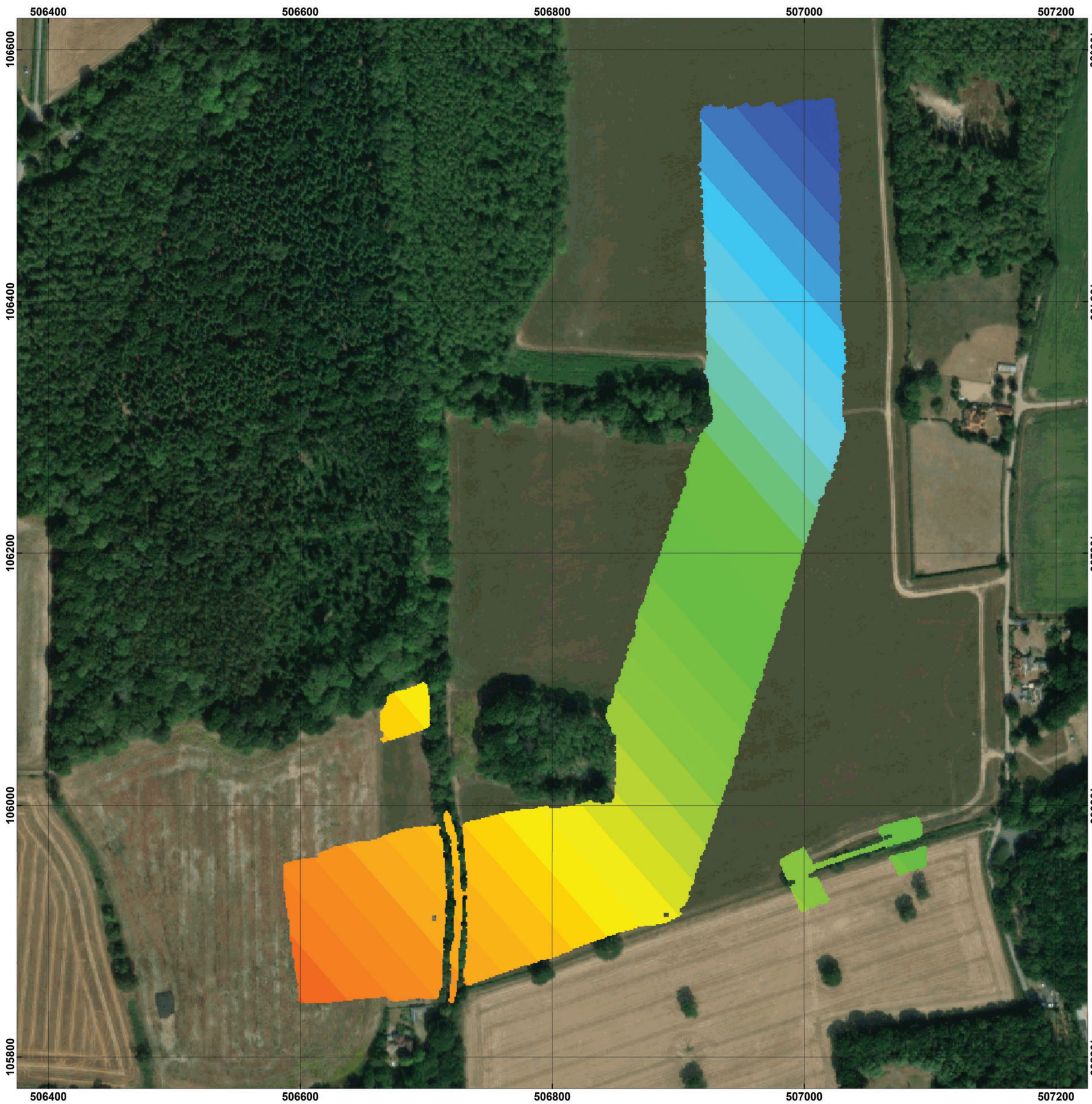
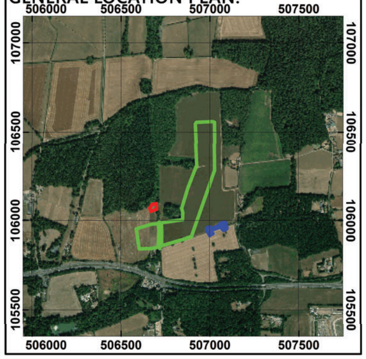
223150-D11D - MAIN SURVEY AREA EM RESULTS - APPROX. DEPTH 6.6 m - REGIONAL TREND



GENERAL LOCATION PLAN:



LEGEND:

12 18 24 31 37 43 49 55 61 67 74 80 86

Apparent Conductivity Trend
mS/m

SCALE GENERAL LOCATION:

Scale 1:20000

500 0 500 1000

metres

OSGB 1936 / British National Grid

SCALE:

Scale 1:2500

50 0 50 100

metres

OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Elevation datum relative to m (OD)

CLIENT: WSP

PROJECT: LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY

TITLE: MAIN SURVEY AREA EM APPROX. DEPTH 6.6 m REGIONAL TREND

PROJECT NO.:	223150		DRAWING NO.:	223150-D11D	
ISSUE REFERENCE:	01		DATE:	07/06/2023	
INTERP. BY:	AD	DATE: 07/06/2023	DRAWN BY:	AD	DATE: 07/06/2023
CHECKED BY:	BB	DATE: 07/06/2023	APPROVED BY:	DK	DATE: 07/06/2023
DRAWING SCALE:	1:2500				
PLOTTED DRAWING SIZE:	A2 (594 x 420 mm)				

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Wallingford, Oxfordshire, OX10 9RB
Tel: +44 (0)870 4021 400

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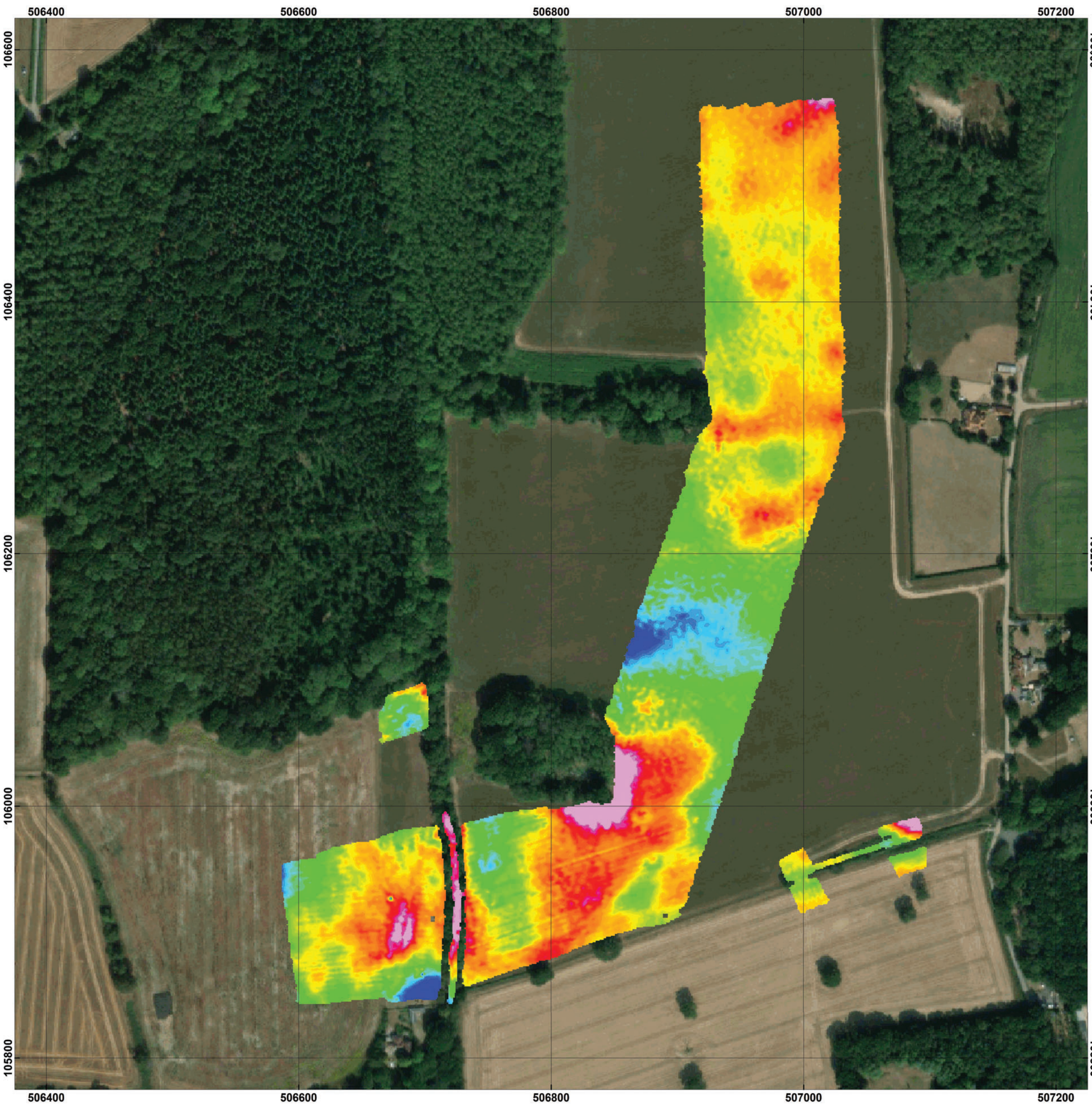
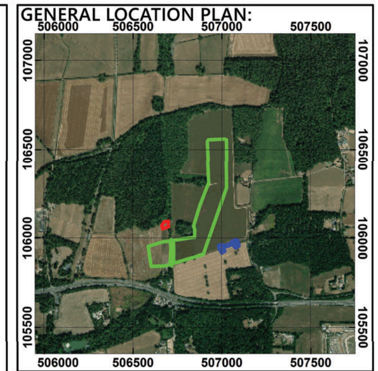
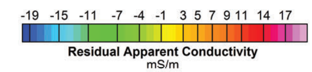
223150-D11E - MAIN SURVEY AREA EM RESULTS - APPROX. DEPTH 6.6 m RESIDUAL RESULTS



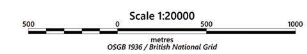
GENERAL LOCATION PLAN:



LEGEND:



SCALE GENERAL LOCATION:



SCALE:

NOTES:

1. Coordinates relative to OSGB
2. Elevation datum relative to m (OD)

CLIENT:

WSP

PROJECT:

LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY

TITLE:

MAIN SURVEY AREA EM APPROX. DEPTH 6.6 m RESIDUAL RESULTS

PROJECT NO.: 223150		DRAWING NO.: 223150-D11E	
ISSUE REFERENCE: 01		DATE: 07/06/2023	
INTERP. BY: AD	DATE: 07/06/2023	DRAWN BY: AD	DATE: 07/06/2023
CHECKED BY: BB	DATE: 07/06/2023	APPROVED BY: DK	DATE: 07/06/2023
DRAWING SCALE: 1:2500			
PLOTTED DRAWING SIZE: A2 (594 x 420 mm)			

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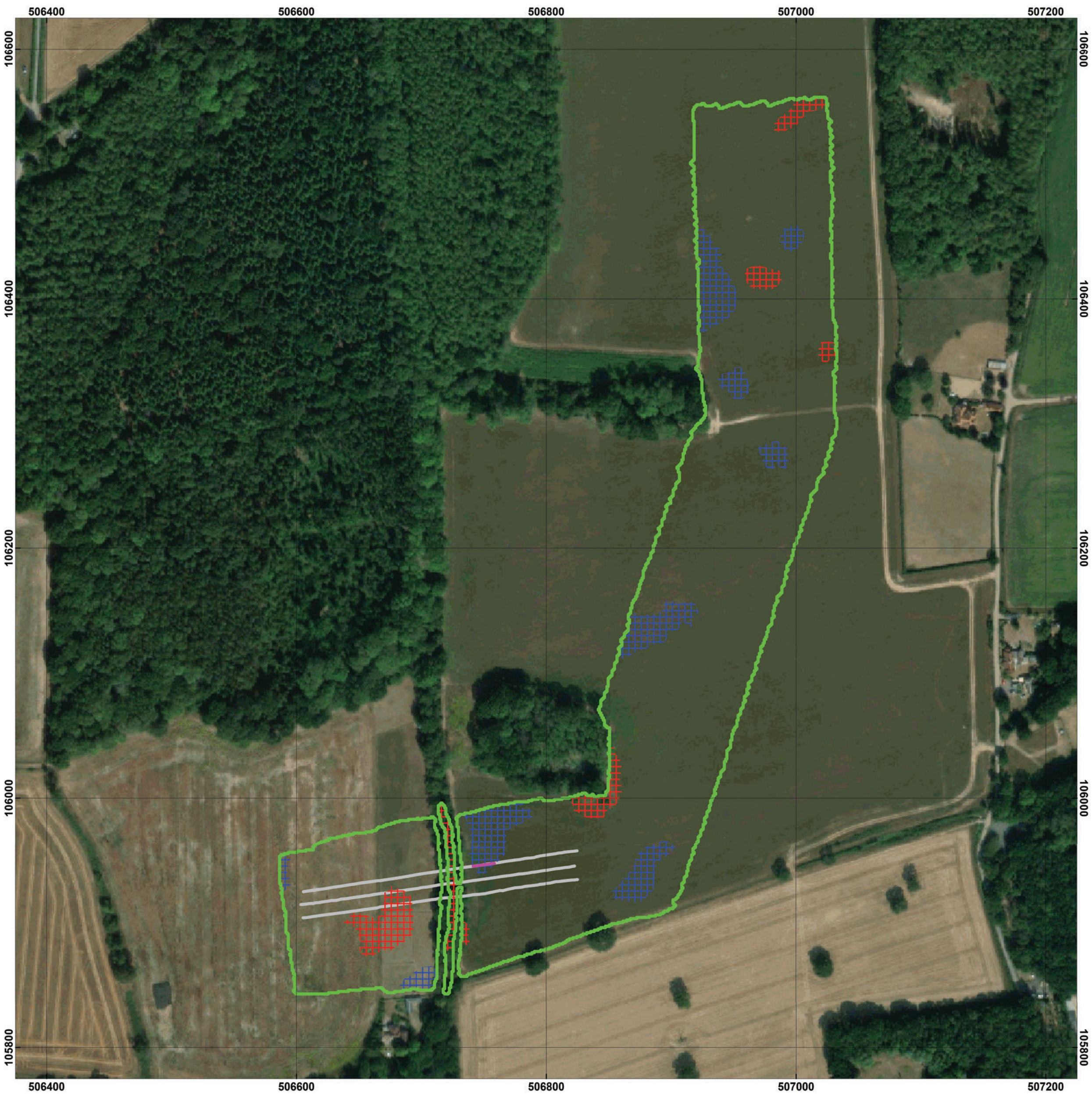
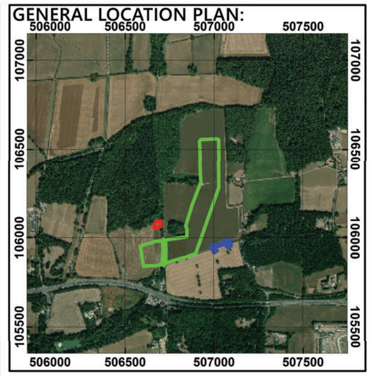
Wallingford, Oxfordshire. OX10 9RB
Tel: +44 (0)870 4021 400

223150-D12 - MAIN SURVEY AREA ANOMALY LOCATION PLAN



GENERAL LOCATION PLAN:



LEGEND:

- Main Survey Area
- Relative conductivity Low
- Relative conductivity High
- ERT anomaly - relatively high resistivity zone in Lambeth Group

SCALE GENERAL LOCATION:

Scale 1:20000

500 0 500 1000 metres

OSGB 1936 / British National Grid

SCALE:

Scale 1:2500

50 0 50 100 metres

OSGB 1936 / British National Grid

NOTES:

1. Coordinates relative to OSGB
2. Elevation datum relative to m (OD)

CLIENT:

WSP

PROJECT:

LITTLEHAMPTON TO BOLNEY CABLE ROUTE GEOPHYSICAL SURVEY

TITLE:

MAIN SURVEY AREA ANOMALY LOCATION PLAN

PROJECT NO.: 223150		DRAWING NO.: 223150-D12	
ISSUE REFERENCE: 01		DATE: 07/06/2023	
INTERP. BY: AD	DATE: 07/06/2023	DRAWN BY: AD	DATE: 07/06/2023
CHECKED BY: BB	DATE: 07/06/2023	APPROVED BY: DK	DATE: 07/06/2023
DRAWING SCALE: 1:2500			
PLOTTED DRAWING SIZE: A2 (594 x 420 mm)			

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Wallingford, Oxfordshire. OX10 9RB
Tel: +44 (0)870 4021 400

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Rampion 2
WIND FARM