11.0 A GROUND AND GROUNDWATER PROTECTION

A1 Chapter Alterations

A1.1 This chapter of the ES Addendum updates the ES with respect to the following:

- **A revised drilling and casing programme;**
- **Minor revisions to the expected geological sequence;**
- **Additional information concerning drilling muds;**
- **Review of parameters set out in Table 4.1 and updates made as required;**
- **Replacement Figures 11.1A, 11.2A, 11.3A, 11.5A and 11.6A; and**
- **Clarification of terminology used throughout the ES. In particular, references to the lateral well have been changed to horizontal to reflect the terminology used in Chapter 4A.**

Introduction

11.1 This chapter of the ES assesses the likely significant effects of the Proposed Development in terms of ground and groundwater protection and is supported by **Appendix 11.1**.

11.2 The chapter describes the assessment methodology; the baseline conditions currently existing at the ~~Assessment~~ **Application** Site and surroundings; the likely significant environmental effects; the mitigation measures required to prevent, reduce or offset any significant adverse effects; and the likely residual effects after these measures have been employed.

11.3 This chapter has been prepared by Hydrock Consultants.

Legislation and Policy Context

European Policy

Water Framework Directive (Ref.11.1)

11.4 Historically, groundwater protection was ensured by implementation of the Groundwater Directive (80/68/EEC) which differentiated between List I and List II substances. Entry of List I substances to groundwater was required to be prevented entirely and List II discouraged but allowed if a permit applied.

11.5 This Directive, which in UK was implemented via the 1998 Groundwater Regulations, is set to be repealed in 2013 through implementation of the Water Framework Directive (2000/60/EC) which includes a Daughter Directive (2006/118/EC) that provides similar controls as the original Groundwater Directive.

11.6 The notion of List I and List II substances has been replaced by that of 'hazardous' and 'non-hazardous' substances, the emission of which, to groundwater, is to be prevented or limited.

11.7 The Water Framework Directive commits EU member states to achieve good qualitative and quantitative status of all water bodies by 2015. Under the Directive, management units for groundwater referred to as Groundwater Bodies are defined, with a requirement to classify them as 'Good' or 'Poor' depending quality attributable to human intervention. Control regimes are to apply to ensure that quality does not deteriorate.

11.8 According to the Environment Agency website neither groundwater in the superficial deposits that underlie the site nor groundwater in the bedrock is classified as a groundwater body. This position is in keeping with the low water resources value of both units as described in Section ~~11.38~~ **11.41** below.

National Policy

Water Resources Act, 1991 (Ref. 11.3)

11.9 Under the Water Resources Act of 1991, "causing or knowingly permitting" poisonous or noxious matter to enter controlled waters is a criminal offence. More recently, the

concept of 'significance' has been introduced into the application of legislation relating land contamination to the pollution of controlled waters.

DCLG, National Planning Policy Framework, 2012 (Ref. 11.2)

11.10 The 2012 National Planning Policy Framework **(NPPF)** requires that development plans should minimise pollution and other adverse effects on the local and natural environment. Pollution is defined as 'anything that affects the quality of land, ...water or soils'.

Planning Practice Guidance for Onshore Oil and Gas (2013)

11.10a The Planning Practice Guidance for Onshore Oil and Gas ("Onshore Guidance") was published by DCLG in July 2013. The Onshore Guidance makes clear that the Environment Agency (EA) is the key regulator with regards to the protection of water resources including groundwater aquifers, and that the planning authority can leave the issue of identifying and mitigating risks to aquifers to the EA.

Planning Practice Guidance (2014)

11.10b The Planning Practice Guidance (PPG) was published by DCLG in March 2014 and sets out revised and updated practice guidance alongside the NPPF. Further to the Onshore Guidance, the PPG also makes clear that the planning authority should consider if the proposal is an acceptable land use rather than focusing on control processes. Whilst control processes and permitting should be left to regulatory agencies, the guidance does identify the potential for contamination of land as being an environmental issue that planning authorities should address, and that issue is the focus of this chapter.

Local Policy

West Sussex County Council Minerals Local Plan, 2003 (Ref. 11.4)

11.11 This document sets out the County Council's vision, objectives and strategy for mineral land-use planning in West Sussex and provides a detailed policy framework for determining mineral planning applications.

11.12 At 6.13 of the Plan there is a general requirement to produce an Environmental Statement within which the significant environmental effects of the development are to be assessed. The document also includes a brief description of the geology and hydrogeology, noting that the deeper geology (1500m-2100m depth) may contain hydrocarbons.

11.13 Policies 15 and 16 of the Plan relate to the protection of the water environment. Policy 15 concerns effects on groundwater levels (and consequential effects on surface waters) and Policy 16 concerns protection of water quality. Whilst the principles are applicable to the Proposed Development, the policy is written with sand and gravel workings in mind.

Chichester District Council Local Plan, 1999 (Ref. 11.5)

11.14 The Chichester Local Plan is the document that currently guides development in the district. A stated objective of the plan is to secure the protection and enhancement of the natural physical environment.

11.15 There is limited local policy on groundwater protection with Policy RE27 “Protection of Surface and Groundwater Resources” having not been saved in the Local Plan. However, Policy BE5 which deals with business, industry and warehousing in the rural area states that new proposals should not “generate unacceptable levels of soil, water or air pollution”.

Local Governance

11.16 In addition to the above policy statements it is expected that CDC's Contaminated Land Officer (the CLO) and the Environment Agency will be consultees to the application as part of the planning process.

11.17 The Environment Agency will require assurance that the proposed works will not cause Pollution of Controlled Waters, be they either surface waters or groundwater. Similarly, the CLO will need to be assured that the works will not result in land contamination and there is a clear and obvious link between these two issues. Specific conditions may be included in the permission to ensure that appropriate action is taken.

Assessment Methodology

General

11.18 In the context of an assessment of effects on controlled waters, the area under consideration is the ~~Assessment~~ **Application** Site (as defined in **Chapter 3**). Primarily it is proposed to drill a vertical well at the location indicated with the well terminating at a point directly beneath the start position at the surface (**Figure 11.1A**).

11.19 However as explained in **Chapter 4A** (Project Description) there is a contingency proposal to drill a ~~lateral~~ **horizontal** well at the same location, in which case, a ~~lateral~~ **horizontal** hole will be formed, **starting** at approximately **884** ~~515~~ m depth and will progress in a ~~north~~ **south** westerly direction (**225**~~50~~^{o}) for a distance of **2500** ~~5000~~ ft. (**762** ~~1524~~ m). This ~~lateral~~ **horizontal** hole will mostly be ~~formed~~ in the Upper Kimmeridge Limestone (reference **Table 11.1**). At its point of termination (**Figure 11.1A**) the horizontal ~~lateral~~ well will be approximately **1310** ~~400~~m below ground level. The ~~lateral~~ **horizontal** well configuration is shown in **Figure 11.2A** in a geological context.

11.20 Drilling of the ~~lateral~~ **horizontal** well will not commence until the vertical well below the point of deviation has been plugged and abandoned in accordance with O&G UK Guidelines.

11.21 The assessment process is one of acquiring published and unpublished information pertaining to the geology, hydrology, and hydrogeology of the ~~Assessment~~ **Application** Site and then using it to formulate a conceptual model of current conditions. All aspects of the drilling works, both surface and subsurface, are then reviewed and their potential impact on existing conditions is assessed. Where significant and/or adverse change is anticipated, appropriate mitigation measures are described.

11.22 Additional issues to consider are the water-related effect on any protected areas that are potentially affected by activities at **the** ~~Assessment~~ **Application** Site.

Conceptual Model

11.23 The formulation of a Conceptual Model is a key part of the standard way of assessing the effects of a proposed development on controlled waters and any protected sites that depend on such waters.

11.24 The conceptual model for this ~~Assessment~~ **Application** Site is presented below in the form of a source-pathway-receptor 'pollution linkage' relationship to identify linkages that may be considered to be plausible. Further consideration may subsequently show them not to connect so as to form a 'significant' pollution linkage, that is, one that causes pollution of controlled waters.

11.25 The principal potential sources of contamination are:

- materials stored at the surface in the well site area;
- substances present in the drilling mud used in the drilling process;
- hydrocarbons and other contaminants present in formations encountered; and
- hydrocarbons stored on site in the event that the borehole is productive.

11.26 The potential pathways are:

- leakage of substances stored at the surface and their downward migration to contaminate groundwater in water bearing horizons;
- as above, directly via entry into the drilled borehole;
- the release of contaminants to surface water via contaminated runoff; and
- the upward escape of hydrocarbons or other contaminants to contaminate aquifers present above their point of origin:
    - during drilling;
    - during a potential production phase; and
    - post-abandonment.

11.27 The principal receptors are:

- groundwater resources in underlying aquifers;
- the off-site surface water system; and
- surface waters in hydraulic continuity with either of the above aquifers.

Baseline Conditions

Site History

11.28 The historical maps showing the Application Site area are included at **Appendix 11.1.** The land has never been other than undeveloped farmland since the earliest Ordnance Survey map of 1876.

Hydrology and Drainage

11.29 The northern boundary of the ~~Assessment~~ **Application** Site is located approximately 50m south of Boxal Brook, which flows south-eastwards to join the River Kird at Skiff Copse. The intervening land slopes generally northwards towards the river.

11.30 Under the Water Framework Directive the Environment Agency does not classify Boxal Brook but notes the River Kird as being of Poor Ecological Quality ecologically. The chemical quality of the River Kird is unclassified.

Protected Sites

11.31 The site is in a Nitrate Vulnerable Zone and there are protected sites less than 1km from the ~~Assessment~~ **Application** Site. The protected sites are woodland, collectively known as The Mens, which include SSSI and Special Areas of Conservation.

Geology

Geological Setting

11.32 The ~~Assessment~~ **Application** Site is located on the southern side of the Weald Basin. The geological conditions are illustrated on **Figure 11.3A**, which has been compiled from the British Geological Survey (BGS) 1:50,000 sheet 301 (Haslemere) and 317/332 (Chichester and Bognor) (Ref 11.7). Local geological information is provided in the Geology section of the *Envirocheck* report presented at **Appendix 11.1.**

11.33 In summary, it is an area where Lower Cretaceous Wealden Beds dip southwards towards the South Downs where they become overlain by younger Lower Greensand and Chalk sequences. Arun Terrace Deposits are present in patches to the south and south-east of the ~~Assessment~~ **Application** Site with 'Arun Terrace Deposits 3 Member' mapped as underlying the extreme south east corner of the ~~Assessment~~ **Application** Site itself. Also, there is a thin strip of alluvium associated with Boxhall Brook, which is mapped as extending as far as the northern boundary of the ~~Assessment~~ **Application** Site. The Wealden Beds are underlain by a progressively older sequence of Mesozoic and Palaeozoic strata.

Stratigraphy

11.34 The geological sequence to be penetrated by the proposed borehole is shown in **Table 11.1** below.

Table 11.1: Proposed Development - Expected Geological Sequence

Unit Name and Age			Estimated Drilled Depth to top of Formations Shown		Unit Thickness Penetrated	
			ft	m (rounded)	ft	m (rounded)
Lower Cretaceous (Wealden Beds)		Weald Clay	0	0	998	304
	Hastings Beds	Upper Tunbridge Wells Sand	998	304	450	137
		Grinstead Clay	1448	441	90	27
		Lower Tunbridge Wells Sand	1538	469	100	30
		Wadhurst Clay	1638	499	250	76
		Ashdown Beds	1888	575	450	137
Upper Jurassic		Upper Purbeck Beds	2338	713	260	79
		Middle Purbeck Beds	2598	792	285	87
		Lower Purbeck Beds	2883	879	420	128
		Purbeck Anhydrite	3303	1007	85	26
		Portland Beds	3388	1033	255	78
		Upper Kimmeridge Clay	3643	1110	562	171
		Upper Kimmeridge Limestone	4205	1282	275	84
		Middle Kimmeridge Clay	4305	1312	100	30
		Lower Kimmeridge Limestone	4480	1366	1398	426
		Corallian Beds	5878	1792	300	91
		Oxford Clay	6178	1883	430	131
Middle Jurassic		Kellaways Beds	6608	2014	45	14
		Cornbrash	6653	2028	60	18
		Great Oolite	6713	2046	150	46
		Fullers Earth	6863	2092	93	28
		Inferior Oolite	6956	2120	350	107
Lower Jurassic		Upper Lias	7306	2227	650	198
		Middle Lias	7956	2425	149	45
		Lower Lias				
		Total Depth	8105	2470	-	-

11.35 Available geological mapping shows Weald Clay to be underlying the ~~Assessment~~ **Application** Site and surrounding area with no superficial cover other than in the south east corner of the site where Arun Terrace Deposits may be present.

11.36 The Upper Tunbridge Wells Sand formation lies below the Weald Clay but does not crop out in this area, doing so some 10-12 km to the north-west.

11.37 BGS Sheet 318/333 (Brighton and Worthing) differentiates the Wealden Beds stratigraphy in more detail and by reference to this map and the BGS Lexicon it is possible to define the stratigraphy more precisely (Ref 11.8).

11.38 The key features are that the Tunbridge Wells Sand Formation is separated into Upper and Lower parts by the Grinstead Clay. The Lower Tunbridge Wells Sand is then underlain by the Wadhurst Clay Formation and the Ashdown Formation, the latter overlying the Purbeck Beds. Beds between the Upper Tunbridge Wells Sands and the Ashdown Beds are collectively known as the Hastings Beds, and these, combined with the Weald Clay, are referred to as the Wealden Beds.

Lithology

11.39 The lithological characteristics of the individual units are summarised in **Table 11.2**. The information presented is taken from regional geological mapping referenced above and associated reports.

11.40 The Weald Clay formation contains minor and sometimes discontinuous bands of sandstone, the location of which, in relation to the drill site, is evident on the Solid Geology map of the Envirocheck report at **Appendix 11.1**. The ~~Assessment~~ **Application** Site is located just south one of the sandstone units, which is mapped as being evident in the Boxal Brook cutting.

Structure

11.41 The geological structure is illustrated by the section shown on **Figure 11.4**. The shallower rock sequence represented by the Wealden Beds dips gently southwards to pass beneath the South Downs.

Locally, the Weald Clay is subject to minor faulting to the north-west and north-east of the Application Site. This faulting affects the minor sandstone units that form part of the Weald Clay sequence.

Table 11.2: Lithological Descriptions

Stratigraphic Unit	Lithological Description
Weald Clay	Pale to dark grey clay or mudstone, locally with subordinate lenticular sandstone and limestone layers.
Upper Tunbridge Wells Sand	Interbedded siltstone, silty mudstone and sandstone.
Grinstead Clay	Principally shale and mudstone.
Lower Tunbridge Wells Sand	Coarse-grained quartzose sandstone overlying interbedded siltstone and sandstone, becoming increasingly argillaceous with depth.
Wadhurst Clay	Brick red, brown, or grey-green claystone.
Ashdown Beds	Fine-grained silty sandstone and mudstone (claystone)
Upper Purbeck Beds	Calcareous claystones, grading to silty claystone.
Middle Purbeck Beds	White to light grey limestone.
Lower Purbeck Beds	Interbedded limestone and claystone.
Purbeck Anhydrite	White to translucent anhydrite.
Portland Sandstone	Firm to moderately hard fine grained sandstone or siltstone.
Kimmeridge **Formation** ~~Clay~~	Thick sequence of moderately calcareous and silty claystone with thin limestone stringers.
Corallian Beds	Argillaceous limestone grading to calcareous claystone, interbedded with siltstone, sandstone and thin limestone stringers.
Oxford Clay	Thick claystone with stringers of limestone.
Kellaways Beds	Thick sequence of fine-grained sandstones which are locally glauconitic.
Cornbrash	Shelly micritic limestone and minor claystone.
Great Oolite (including Forest Marble)	Oolitic limestone with argillaceous laminations, grading to calcareous claystone.
Fullers Earth	Calcareous claystone with thin argillaceous limestones.
Inferior Oolite	Shelly limestone, calcareous mudstone and sandy limestone.
Upper Lias	Calcareous mudstone and shale.
Middle Lias	Micaceous mudstone grading upwards into siltstone, sandstone and limestone.
Lower Lias	Alternating shale, mudstone and limestone.
Triassic	Mercia Mudstone overlying Sherwood Sandstone and the Rhaetic.
Palaeozoic	Not known.

Hydrogeology

The Aquifer System

11.42 The stratigraphy and lithology summarised in **Tables 11.1** and **11.2** results in the aquifer system presented in **Table 11.3** below. The Aquifer Designations accord with the latest Environment Agency Groundwater Protection Policy (GP3). Under the Water Framework Directive, groundwater in the Weald Clay is unclassified chemically or quantitatively, which is indicative of its general status as unproductive strata.

11.43 The geological structure is such that the proposed exploratory borehole:

- will not encounter the Upper Tunbridge Wells Sand until a drilled depth of approximately 304 m depth has been reached; but
- may penetrate the Secondary Aquifers formed by the sandstone and limestone lenses within the Weald Clay.

Groundwater Levels and Flow

11.44 There are no data on groundwater levels and flow in the area. However it may be inferred from an assessment of geological mapping, lithological data, topography and drainage that:

- the Weald Clay materials directly beneath the drill site are likely to be characterised by a low overall permeability with little deep infiltration of rainfall and shallow down-slope interflow only;
- groundwater in the superficial deposits and in the Secondary Aquifer sandstones in the Weald Clay:
    1. is locally recharged and unconfined at outcrop with subsequent down-dip flow into a confined zone;
    2. is characterised by a low overall throughput of water;
- groundwater in the deeper Secondary Aquifers, starting with the Upper Tunbridge Wells Sand:

3. will be recharged on the outcrop area, which is some 10-12 km to the north east and beyond;
4. will flow southwards according to the regional dip of the strata; and
5. has no practical connection with groundwater beneath the site or through which the proposed hydrocarbon exploratory borehole will penetrate.

11.45 Regarding the southerly groundwater flow in the deeper Secondary Aquifers, the actual depth of the aquifers beneath the drill site may be such that there is little actual groundwater movement in that area. Hydrochemical processes may then be such that the groundwater is of poor quality.

Table 11.3: The Aquifer System

Stratigraphic Unit	**Aquifer Designation**	**Inferred or Recorded Aquifer Characteristics**
Weald Clay Formation	Mostly unproductive strata but includes minor sandstones and limestone which are given Secondary A status (formerly designated a minor aquifer of low vulnerability)	Sandstone inferred to have moderate primary and secondary porosity and permeability with resource value constrained by limited lateral extent.
Upper Tunbridge Wells Sand	Secondary A	Recorded as sandstone and siltstone. Presumed in parts to have moderate to high primary and secondary porosity and permeability.
Grinstead Clay	Unproductive strata	
Lower Tunbridge Wells Sands	Secondary A	Recorded as sandstone and siltstone. Presumed in parts to have moderate to high primary and secondary porosity and permeability.
Wadhurst Clay	Mostly unproductive strata but includes minor sandstones and limestone which are given Secondary A status	Sandstone inferred to have moderate primary and secondary porosity and permeability with resource value constrained by limited lateral extent.
Ashdown Beds	Sands and sandstone layers are given Secondary A status	Sandstone inferred to have moderate primary and secondary porosity and permeability with resource value constrained by limited lateral extent.
Purbeck Beds	Formations below this depth (i.e. > 700m begl) are generally not recognised as aquifers in this region, being too deep to exploit and likely	Mostly low permeability argillaceous formations not used as aquifers.
Purbeck Anhydrite		
Portland Sandstone		
Kimmeridge ~~Clay~~ **Formation**		
Corallian Beds		
Oxford Clay		

Stratigraphic Unit	Aquifer Designation	Inferred or Recorded Aquifer Characteristics
Kellaways Beds	to contain poor quality groundwater	
Cornbrash		
Great Oolite		A Principal Aquifer outside of this region, whose aquifer properties are mainly dependent on extensive secondary porosity and permeability which is unlikely to be extensively developed at the depth at which it occurs below the Wisborough Green area (> 2100m begl).
Fullers Earth		Mostly low permeability argillaceous formations not used as aquifers.
Inferior Oolite		
Upper Lias		
Middle Lias		
Lower Lias		

Groundwater Utilisation

11.46 Data contained in the Envirocheck Report at **Appendix 11.1** indicate there to be no licensed groundwater abstractions within 2km of the ~~Assessment~~ **Application** Site boundary. However, the BGS Geoindex (Ref 11.9) shows a 30m+ deep borehole to be present at Sparrs Farm, some 600m north-east of the Application ~~site~~ **Site**. The borehole is either disused or is an unlicensed private water supply. Water Well locations are shown on **Figure 11.6A**.

Groundwater Vulnerability

11.47 The Groundwater Vulnerability Map for the area (Sheet 45, West Sussex and Surrey) indicates the entire ~~Assessment~~ **Application** Site to be underlain by a Minor Aquifer of High Vulnerability (Ref 11.10). The more recent aquifer designation system locates the site on Unproductive Strata which accords better with the geological mapping.

Likely Significant Effects

11.48 Potential effects have been assessed sequentially in accordance with the Significance Matrix table presented earlier (**Table 2.2**) and in relation to the proposed phasing of the Proposed Development.

Phase 1: Construction (of the access road and well site)

11.49 Compared to baseline conditions, these works will slightly reduce soil moisture due to reduced recharge and interception of runoff and/or interflow from upstream.

11.50 However considering the small size of the ~~Assessment~~ **Application** Site in relation to the overall catchment area, the effects in terms of either groundwater quantity or quality are expected to be negligible.

11.50a These works also involve the setting of 30" diameter casing at a depth of 20ft during construction of the cellar, and will involve lowering the casing into a hole formed by a mechanical excavator. This casing will them be cemented in place. The effects of this work in terms of either groundwater quantity or quality are expected to be negligible.

Phase 1 (other activities)

11.50b Other Phase 1 activities comprise the mobilisation of a Conductor Setting rig, and the drilling of a 26" diameter hole through the 30" diameter casing, to a depth of up to 200ft. A 20" diameter conductor pipe will then be installed into the hole and cemented in place. The 26" diameter borehole will be drilled using a drilling mud made up of fresh water and bentonite. On completion, the rig will be demobilised.

11.50c A potential effect of drilling the 26" hole is contamination of shallow aquifers during drilling, followed by the onward migration of that contamination to water wells or surface waters. This potential effect, which is limited by low ground permeability

conditions, is direct, short term, but local only, and therefore the scale of the effect is Low and the significance is negligible.

Phase 2: Main Rig Mobilisation and drilling (Vertical and Horizontal)

Land Contamination at the drill site and release of contaminated runoff

11.51 This is a potentially adverse effect involving uncontrolled surface release (i.e. spillages) of contaminative substances used in connection with the drilling works (chemical additives, lubricants etc.), however caused. This process potentially leads to ground contamination, groundwater contamination, and surface water contamination following the off-site migration of run-off from rainfall.

11.52 The potentially adverse effect would be direct, short term, but local only, and therefore the Scale of the Effect is Low. The potential magnitude of the effect is considered to be medium because of downstream water pollution impacts and the overall significance is therefore moderate/minor.

Contamination of aquifers during drilling

11.53 This is a potentially adverse effect caused by the release of drilling fluids into aquifers during drilling and their onward migration to water wells and surface waters. The effect is direct and short to medium term because of the slow sub-surface migration of contaminants.

11.54 **Figure 11.5A** is a diagram showing the well construction details. Drilling as far as the Upper ~~Purbeck~~ **Kimmeridge Clay** will be accomplished using a ~~fresh~~ **water-based mud (WBM) system with non-hazardous (as defined under the Water Framework Directive) additives**. On completion of drilling to this depth the well will be cased and cemented, thus preventing contact between formations above the Upper **Kimmeridge Clay** ~~Purbeck~~ (i.e. the potential aquifers) and subsequent drilling fluids or production hydrocarbons.

11.55 As the contingent **horizontal** ~~lateral~~ hole drilling all takes place below the Upper Purbeck, such drilling imparts no additional risk to the potential aquifers above this depth.

11.56 Hydrogeological conditions are such that the anticipated Scale of the Effect of either the vertical well or the **horizontal** ~~lateral~~ hole contingency are Low and the magnitude of the effect is also Low. The overall significance is therefore Minor.

Accidental Release of contaminants into the borehole during drilling

11.57 This is a potentially adverse effect similar to the above caused by the spillage and release of chemicals (in storage at the site) into the aquifer during drilling, and their onward migration to water wells and surface waters. The effect is direct and short to medium term because of the slow sub-surface migration of contaminants.

11.58 Again, hydrogeological conditions are such that the anticipated Scale of the Effect is Low and the magnitude of the effect is also Low. The overall significance is therefore Minor.

Phase 3 ~~a/b~~: Testing ~~(gas and oil)~~

11.59 There are no additional significant effects associated with Phase 3 that are not evaluated under Phases 1 and 2 activities mentioned above. The effect of stored chemicals for use in drilling fluids is replaced by the temporary storage of hydrocarbons, the effect which is evaluated below.

Land Contamination at the drill site and release of contaminated runoff

11.60 The potential for land contamination at the drill site and release of contaminated runoff at this stage is mainly associated with the temporary storage of hydrocarbons extracted from the borehole. This is a potentially adverse effect which could lead to ground

contamination, groundwater contamination, and surface water contamination following the off-site migration of run-off from rainfall.

11.61 The effect would be direct, short term, but local only, and therefore the Scale of the Effect is Low. Because of the potential surface water impact and the potential onward connection to watercourses of more significance, the Magnitude of the Effect is assessed as Medium so the overall significance is Moderate/Minor.

~~*Phase 3a:*~~*Extended* ***Well*** *Testing* ~~*(gas and oil)*~~

11.62 In the event that the initial short term testing provides encouraging results, Celtique may decide to run an Extended Well Test (EWT) which could run for up to 26 weeks. In respect of potential risk to controlled waters it may be noted that such a proposal would incorporate:

- Storage tanks for produced oil and formation water but contained within in a bunded area;
- An oil/water/gas separator for the separation of the produced well stream also contained within the bunded area;
- Transfer pumps to transfer fluids between the storage tanks and also to road tankers for export.

11.63 In practice there are no additional significant effects associated with the extended testing proposals that are not evaluated under Phases 1 and 2 activities mentioned above, where the effect of stored chemicals for use in drilling fluids is replaced by the temporary storage of hydrocarbons for a more extended period.

11.64 The potential for land contamination is an adverse effect which could lead to ground contamination, groundwater contamination, and surface water contamination following the off-site migration of run-off from rainfall.

11.65 The effect would be direct, still relatively short term, and local only, and therefore the Scale of the Effect is Low. Because of the potential surface water impact and the potential onward connection to watercourses of more significance, the Magnitude of the Effect is assessed as Medium so the overall significance is Moderate/Minor.

Phase 4a: Restoration

Contamination of aquifers following abandonment

11.66 At whatever stage the borehole is abandoned, the potential exists for upward migration of saline waters and hydrocarbons etc. into aquifers. This is a potentially long-term adverse effect.

11.67 Despite the hydrogeological conditions, in theory, if the escape of these contaminants continued uninterrupted, widespread contaminant migration is a possibility such that the anticipated Scale of the Effect may be regarded as Medium. However, the lack of a reliance on groundwater is such that the magnitude of effect criterion is no more than Medium. The overall significance is therefore assessed as Moderate.

Phase 4b: Retention

11.68 In the event of retention of the well site as hydrocarbon production and storage facility, some of the adverse effects mentioned in respect of Phases 1-3 would be maintained in the long term and one new effect will arise. The retained effects and the additional effects are as follows:

Land Contamination at the drill site and release of contaminated runoff

11.69 The potential for land contamination at the drill site and release of contaminated runoff is now mainly associated with the long-term storage of hydrocarbons extracted from the borehole. This is a potentially adverse effect which potentially leads to ground

contamination, groundwater contamination, and surface water contamination following the off-site migration of run-off from rainfall.

11.70 The effect would be direct, long-term, but local only, and therefore the Scale of the Effect is Low. Because of the potential surface water impact and the potential onward connection to watercourses of more significance, the Magnitude of the Effect is assessed as Medium so the overall significance is Moderate/Minor.

Mitigation Measures

Phase 1: Construction (of the access road and well site)

11.71 There are no significant effects during Phase 1 **(Construction of the access road and well site)** that require mitigation.

Phase 1 (other activities)

11.72 In respect of the sandstones in the Wealden Beds that are locally exploited there is an inherently low likelihood of this process occurring to any extent because they are thin, frequently discontinuous, and relatively low permeability. Also the drilling of the 26" borehole to 200ft (60m) will be accomplished using a mix of fresh water and bentonite, neither of which are considered Hazardous in the context of the Water Framework Directive.

Phase 2: Main Rig Mobilisation and drilling (Vertical and Horizontal)

Land Contamination at the drill site and release of contaminated runoff

11.73 As part of site preparation, all parts of it will be underlain by a High Density Polyethylene (HDPE) liner placed on compacted and levelled 6F2 foundation material.

11.74 In addition, all drilling fluid additives will be stored is a designated bunded area. These arrangements restrict the likelihood of spillages and leaks occurring prevent them contaminating the natural ground present beneath the drill site.

11.75 The site boundaries are a ditch system that that leads to a Class 2 Interceptor so that only uncontaminated run-off water is released from the drill site area. These mitigation measures, such as the size of the interceptor, are to be finalised as part of detailed design.

Contamination of aquifers during drilling

11.76 A possible effect of the drilling is migration of the drilling fluids into the rock formations through which the borehole penetrates. In respect of the sandstones in the Wealden Beds that are locally exploited there is an inherently low likelihood of this process occurring to any extent because they are thin, frequently discontinuous, and relatively low permeability. However, deeper geological units such as limestones in the Jurassic strata may have a higher permeability.

11.77 Several factors are incorporated into the design (i.e. the drilling works specification) mitigate this risk, the principal ones being:

- use of a water-based drilling mud with ~~toxic~~ **non-hazardous** additives **when drilling through potential aquifers (i.e. all formations down as far as the Upper Kimmeridge Clay);**

- control of the mud-balance such that lost circulation and invasion of the formations penetrated is minimal; and

- the very short-term exposure of the formation to the drilling mud, given that the hole is quickly cased after drilling.

Accidental release of contaminants into the borehole during drilling

11.78 The HDPE membrane will be sealed around the concrete rings forming the well-head cellar, which will prevent ingress of contaminated surface water.

Phase 3 ~~a/b~~ Short Term and Extended <u>Well</u> Testing ~~(gas and oil)~~

Land Contamination at the drill site and release of contaminated runoff

11.79 The Phase 2 mitigation measures described above will continue into Phase 3 (for both gas and oil). The mitigation measures take into account the possibility of extended testing as described earlier.

Accidental release of contaminants into the borehole during testing

11.80 The Phase 2 mitigation measures described above applicable to drilling will continue into Phase 3 testing (for both gas and oil).

Phase 4a: Restoration

Contamination of aquifers following abandonment

11.81 Prior to abandonment the well will be fitted with cement plugs to prevent fluid movement between horizons. The theoretical risk of deterioration of the casing and screen, thereby linking the hydrocarbons to the aquifers, will be mitigated by using best practice-industry standards as follows:

- perforated casing sections in the production zones will be plugged with cement, thereby preventing the escape of residual hydrocarbons left in the reservoir (noting that, by that time, production will have removed most of the hydrocarbons present);

- the cement plugs and cement used in the casing will be placed in neutral pH environments, thereby minimising the risk of attack by acidisation;
- where necessary, sulphate-resistant cement will be used to minimise the risk of sulphate attack; and
- the steel casings will be protected:
    - externally by the cement lining; and
    - internally by creation of a pH neutral environment and the development of anaerobic conditions.

Phase 4b: Retention

11.82 The Phase 2 mitigation measures described above applicable to drilling will continue into Phase 4b: Retention (for both gas and oil), should such circumstances arise.

Residual Effects

11.83 In respect of the potentially adverse effects identified, following implementation of the proposed mitigation measures, no significant residual effects are anticipated, i.e. all will become negligible.

Cumulative Effects

11.84 Cumulative and interactive effects have been assessed in accordance with the EIA Methodology described in **Chapter 2**. There are no anticipated cumulative or interactive effects connected with ground or groundwater contamination once the mitigation measures have been implemented.

Summary

11.85 The Proposed Development is to be drilled through a geological sequence that is well-defined and understood. The inferred and recorded hydrogeological conditions accord

with groundwater licensing records to indicate that that there are no major aquifers present and no local reliance on groundwater for water supplies.

11.86 The risk of groundwater pollution is therefore inherently low but is reduced further by the incorporation of mitigation measures such as use of water-based, non-~~toxic~~ **Hazardous** drilling fluids ~~etc., which are industry standard~~ when drilling through potential aquifers. This risk assessment applies to **all aspects of the drilling, including the 26" diameter hole to 200ft depth, and in respect of the main phase of drilling, to** both the vertical well and the ~~lateral~~ **horizontal** contingent. Well abandonment proposals will ensure no such risk exists in the long-term.

11.87 The risk of local ground and surface water contamination will be removed by well-engineered site preparation, including the use of HDPE linings and the capture of all surface runoff via an interceptor ditch system. A summary of the effects, their significance and proposed mitigation is included below in **Table 11.4**.

Table 11.4: Wisborough Green Site: Table of Significance

Potential Effect	Nature of Effect (Permanent/ Temporary)	Significance (Major/Moderate/Minor) (Beneficial/Adverse/ Negligible)	Mitigation Measures	Geographical Importance*							Residual Effects (Major/Moderate/Minor) (Beneficial/Adverse/Negligible)
				I	UK	E	R	C	D	L	
Phase 1: Construction of Access Road and Well Site, including works associated with installation of surface casing and conductor casing											
Loss of soil moisture and reduced recharge	Temporary	Negligible	None required							✓	Negligible
Impairment of groundwater quality	Temporary	~~Negligible~~ **Minor**	None required							✓	Negligible
Contamination of aquifers during drilling to set conductor casing.	**Temporary**	**Negligible**	**Short duration of work on uncased shallow aquifers, mud balance control to reduce formation entry and use of non-toxic drilling fluids**							✓	**Negligible**
Phase 2: Mobilisation of the drill rig and drilling operations											
Land contamination at the drill site and release of contaminated run off (all potential sources)	Temporary	Moderate/Minor	Placement of HDPE line across site and creation of lined ditches leading to interceptor.							✓	Negligible
Consequential effect on protected areas	Temporary	Negligible	Arrangements as above plus distance to nearest protected area.							✓	Negligible
Contamination of aquifers during drilling.	Temporary	Minor	Short duration of work on uncased shallow aquifers, mud balance control to reduce formation entry and use of non-toxic drilling fluids							✓	Negligible
Accidental release of contaminants during drilling	Temporary	Minor	HDPE liner is sealed around well cellar preventing entry of spilled contaminants into the borehole							✓	Negligible
Phase 3~~a~~ Testing and evaluation (Oil and/or Gas)											
Land contamination at the drill site and release of contaminated run off (all potential sources)	Temporary	Moderate/Minor	Placement of HDPE liner across site and creation of lined ditches leading to interceptor.							✓	Negligible
~~**Phase 3b: Extended testing**~~											
~~Land contamination at the drill site and release of contaminated run off (all potential sources)~~	~~Temporary~~	~~Moderate/Minor~~	~~Placement of HDPE liner across site and creation of lined ditches leading to interceptor.~~							~~✓~~	~~Negligible~~
Phase 4a: Restoration											
Contamination of	Permanent	Moderate							✓		Negligible

aquifers following well abandonment			Sealing of well using cement plugs and use of corrosion-resistant materials.								
Phase 4b: Retention											
Contamination of controlled waters as a result of hydrocarbon spillages	Temporary	Moderate/Minor	Placement of HDPE line across site and creation of lined ditches leading to interceptor.							✓	Negligible

* **Geographical Importance**

I = International; UK = United Kingdom; E = England; R =Regional; C = County; D = District; L = Local

References (Ref)

11.1 European Parliament and Council. The Water Framework Directive. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000

11.2 Department for Communities and Local Government, 2012. National Planning Policy Framework

11.3 UK Statute Law Database. Water Resources Act, 1991. Official Text

11.4 West Sussex County Council, 2003. Minerals and Waste Policy. Minerals Local Plan

11.5 Chichester District Council 1999. Local Plan

11.6 Environment Agency/DEFRA, 2004. Contaminated Land Report (CLR) 11. Model Procedures for the Management of Land Contamination

11.7 British Geological Survey 1:50,000 Geological Maps 301 (Haslemere) and 317/332 (Chichester and Bognor)

11.8 British Geological Survey 1:50,000 Geological Map 318/333 (Brighton and Worthing)

11.9 BGS (2013) Website Geoindex (water wells). **www.bgs.ac.uk** ~~www.bgs.au.uk~~

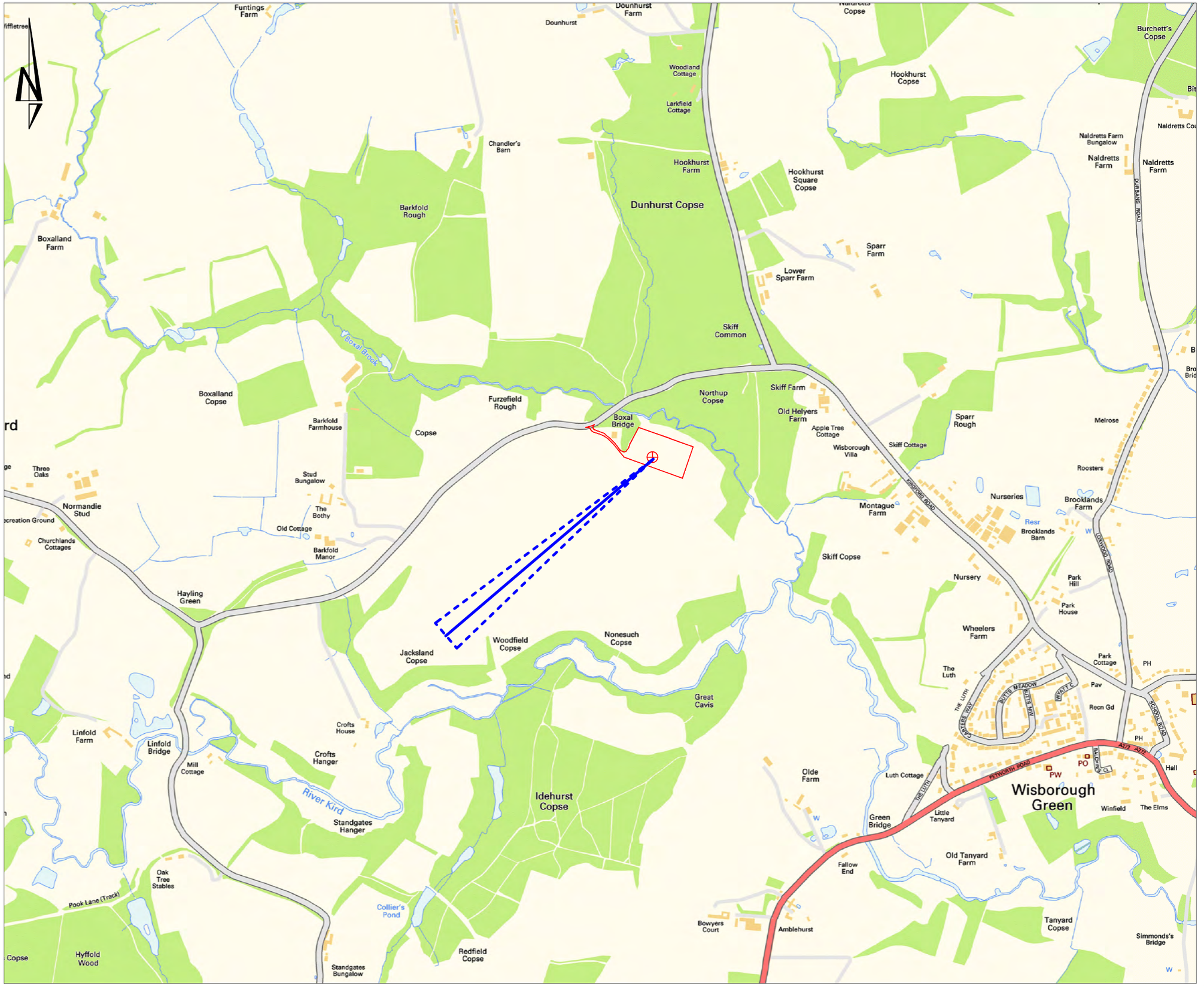
11.10 Environment Agency/BGS Groundwater Vulnerability Map Sheet 45, West Sussex and Surrey

11.11 Department for Communities and Local Government, Planning Practice Guidance for Onshore Oil and Gas, July 2013

11.12 Department for Communities and Local Government, Planning Practice Guidance, March 2014

FIGURE 11.1A

BOREHOLE LOCATION



Notes:

- Main Site Boundary
- Area Representing Potential Sub-surface Deviation (lateral drilling)
- Approximate Borehole Surface Location

Rev	Date	Description	Ckd	By
B	27/03/14	Amended sub-surface expression	EC	LW
A	21/08/13	Added in sub-surface expression	EC	LW

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Project
PROPOSED HYDROCARBON EXPLORATORY BOREHOLE (WISBOROUGH GREEN #1)

Title
Figure 11.1A: Borehole Location

Drawing Status
FINAL

Job No.
C/13054

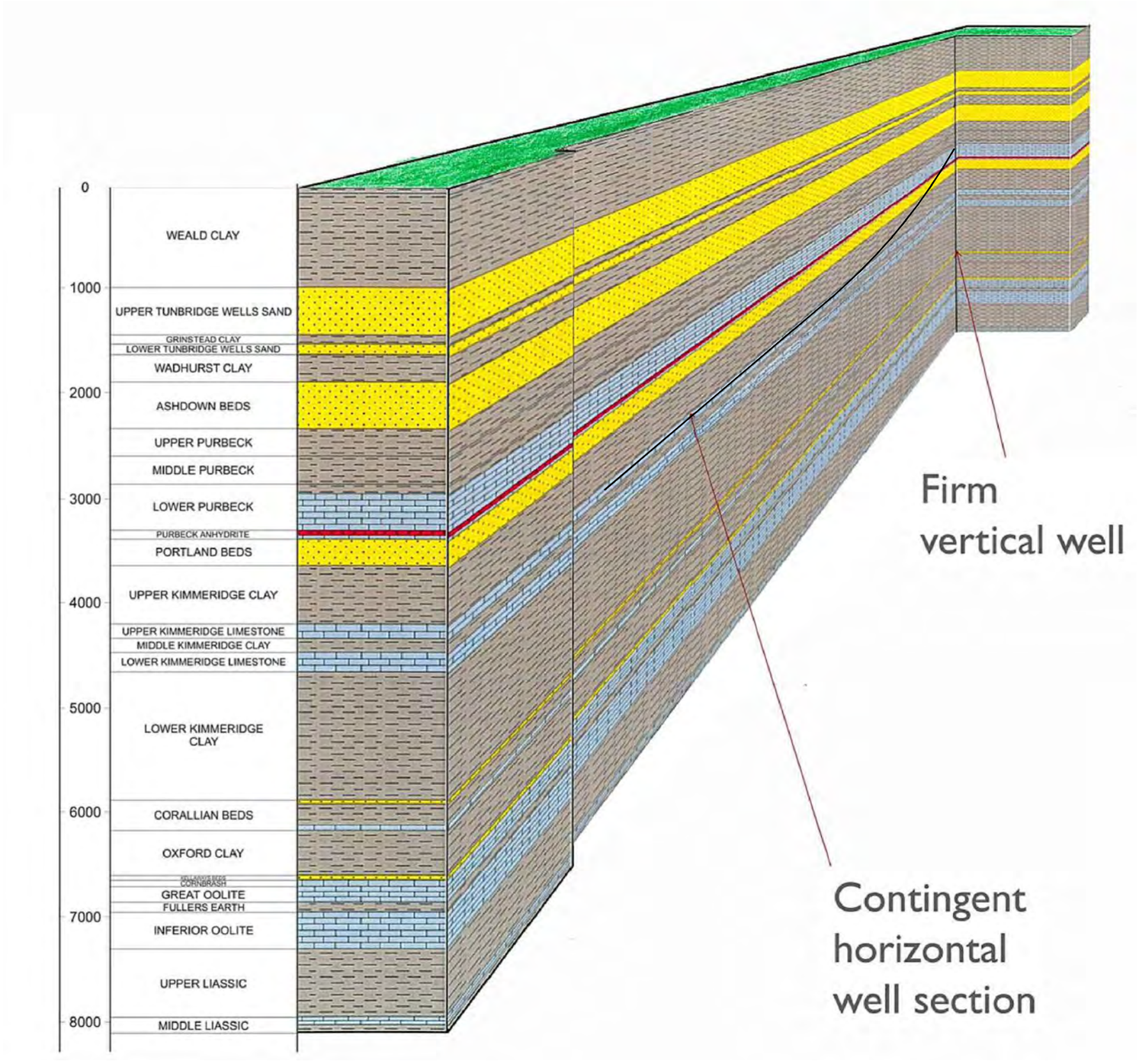
Drawn	Checked	Scale at A3	Date	Issue Date
LW	EC	1:5,000	22/03/13	22/03/13

Drawing No.
C13054/02/001

Revision
B

FIGURE 11.2A

CONTINGENCY WELL



Notes:

Rev	Date	Description	Ckd	By
A	26/03/14	Amended Contingency Well	EC	LW

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Title
Figure 11.2A: Contingency Well

Drawing Status
FINAL

Job No.
C/13054

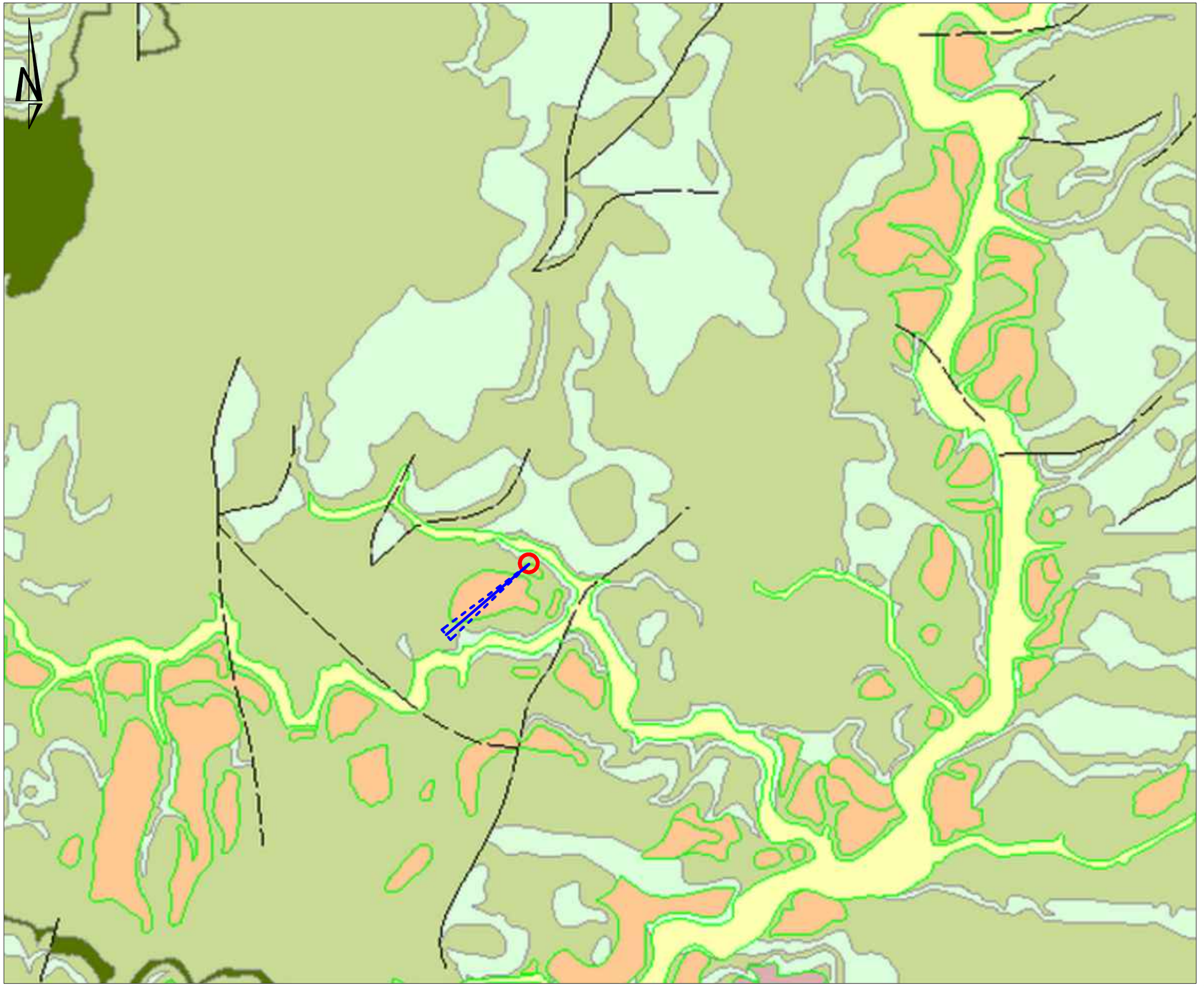
Drawn	Checked	Scale at A3	Date	Issue Date
LW	EC	NTS	22/03/13	22/03/13

Drawing No.
C13054/02/002

Revision
A

FIGURE 11.3A

GEOLOGICAL CONDITIONS



Notes:

Superficial deposits

- ALLUVIUM - CLAY, SILT, SAND AND GRAVEL
- ARUN TERRACE DEPOSITS, 1 MEMBER - SAND AND GRAVEL
- ARUN TERRACE DEPOSITS, 2 MEMBER - SAND AND GRAVEL
- ARUN TERRACE DEPOSITS, 3 MEMBER - SAND AND GRAVEL
- ARUN TERRACE DEPOSITS, 4 MEMBER - SAND AND GRAVEL
- ARUN TERRACE DEPOSITS, 5 MEMBER - SAND AND GRAVEL
- ARUN TERRACE DEPOSITS, 6 MEMBER - SAND AND GRAVEL
- RIVER TERRACE DEPOSITS, 2 TO 3 (ARUN) - SAND AND GRAVEL
- RIVER TERRACE DEPOSITS, 4 TO 5 (ARUN) - SAND AND GRAVEL
- HEAD - CLAY, SILT, SAND AND GRAVEL

Bedrock geology

- ATHERFIELD CLAY FORMATION - MUDSTONE
- HYTHE FORMATION - SANDSTONE
- WEALD CLAY FORMATION - CLAY-IRONSTONE
- WEALD CLAY FORMATION - LIMESTONE
- WEALD CLAY FORMATION - MUDSTONE
- WEALD CLAY FORMATION - SANDSTONE

Proposed Borehole Location

Area Representing Potential Sub-surface Deviation (lateral drilling)

Rev	Date	Description	Ckd	By
B	27/03/14	Amended sub-surface deviation	EC	LW
A	21/08/13	Added in sub-surface deviation	EC	LW

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Title
Figure 11.3A: Geological Conditions

Drawing Status
FINAL

Job No.
C/13054

Drawn	Checked	Scale at A3	Date	Issue Date
LW	EC	1:25000	22/03/13	22/03/13

Drawing No.
C13054/02/003

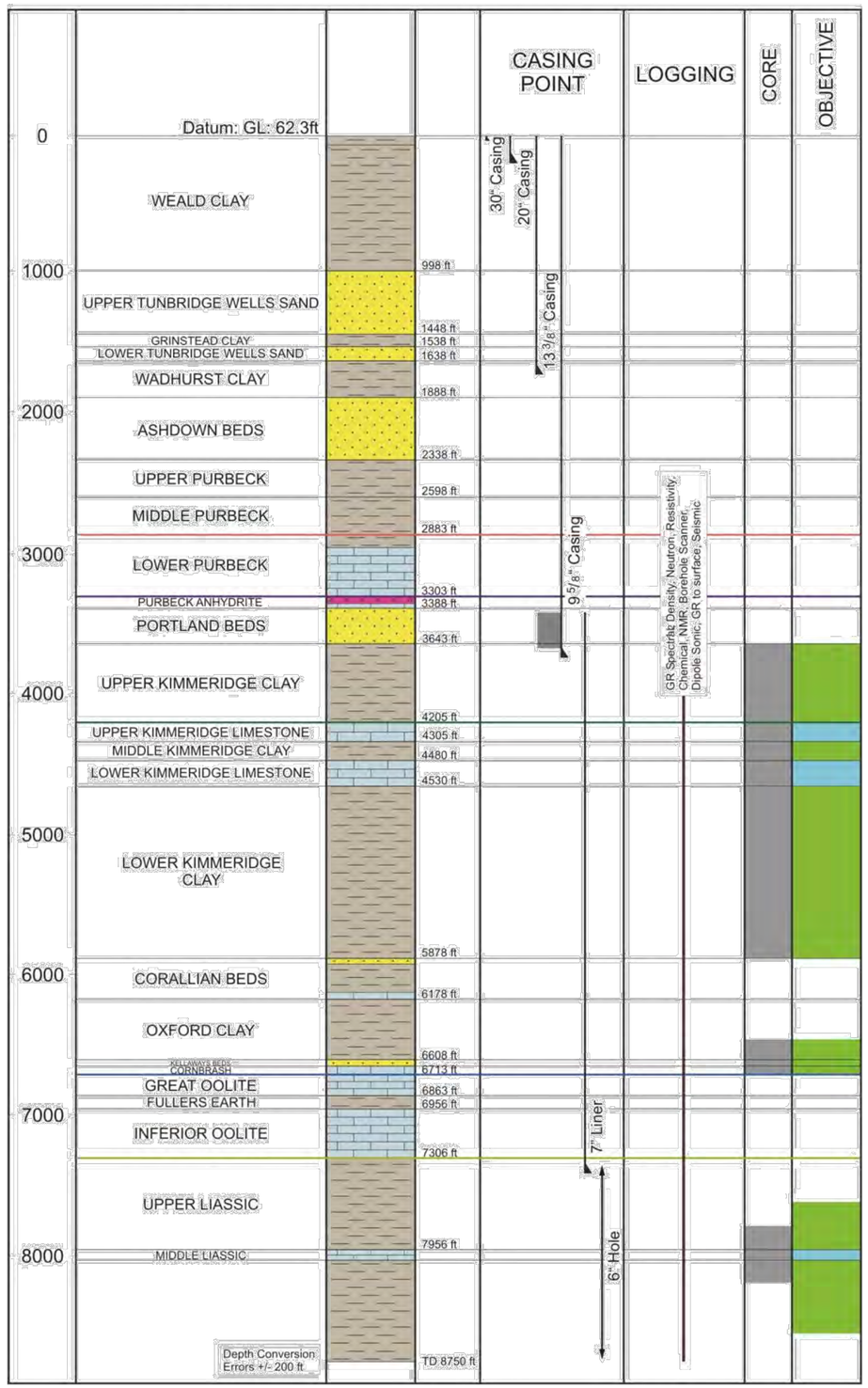
Revision
B

FIGURE 11.5A

BOREHOLE DIAGRAM

WISBOROUGH GREEN - 1

(Latitude: 51° 01' 50.616"N; Longitude: 0° 31' 21.522"W)



Notes:

Rev	Date	Description	Ckd	By
C	09/04/14	Amended well diagram	EC	LW
B	22/03/14	Amended well diagram	EC	LW
A	15/08/13	Amended well diagram	EC	LW

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Title
Figure 11.5A: Borehole Diagram

Drawing Status
FINAL

Job No.
C/13054

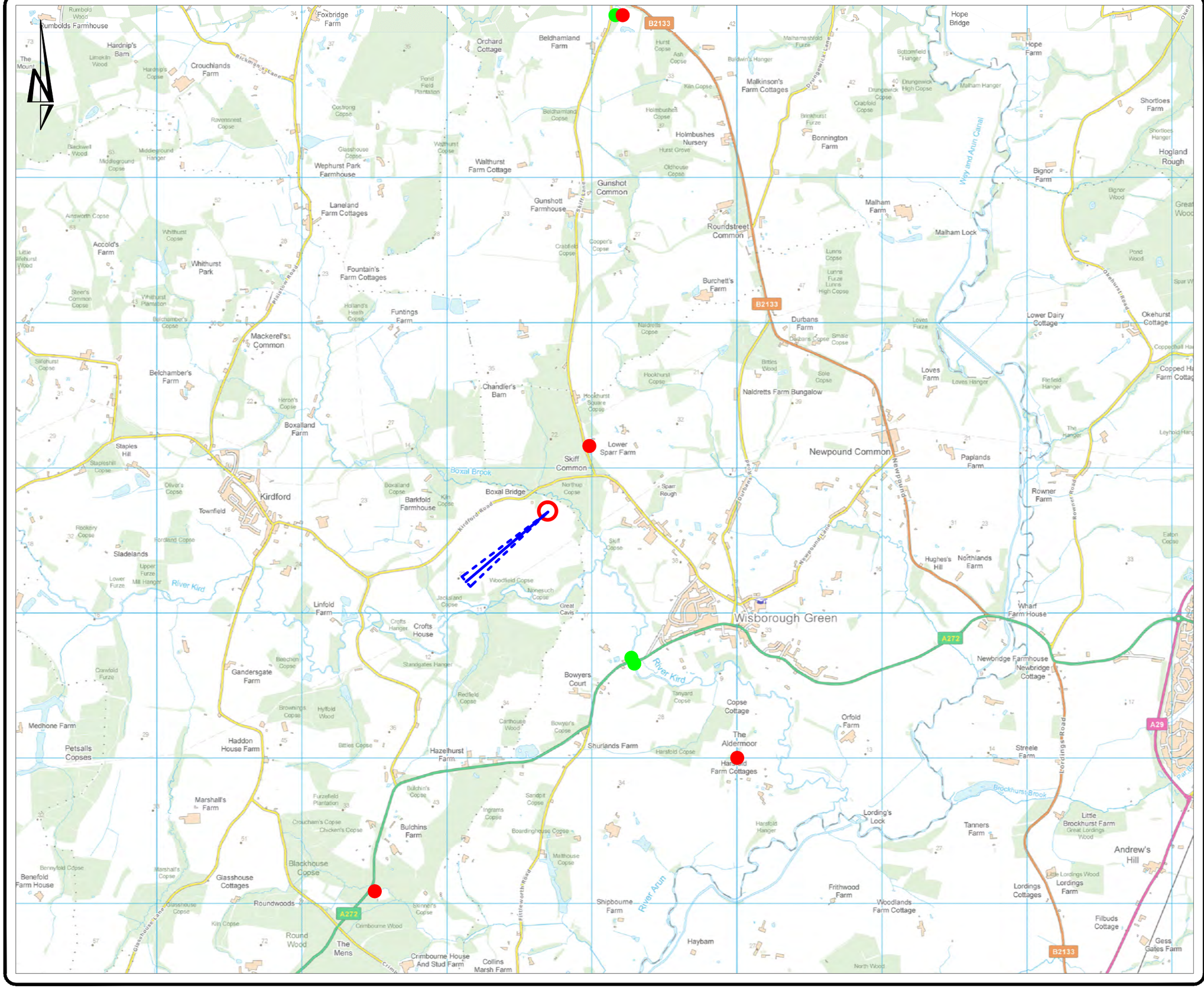
Drawn	Checked	Scale at A3	Date	Issue Date
LW	EC	NTS	22/03/13	22/03/13

Drawing No.
C13054/02/005

Revision
C

FIGURE 11.6A

LOCATION OF NEAREST WATER WELLS



Notes:

Key

- Proposed Borehole Location
- Area Representing Potential Sub-surface Deviation (lateral drilling)

Water wells (depth)

- Unknown
- 0-10m
- 10-30m
- 30-10m

Rev	Date	Description	Ckd	By
B	27/03/14	Amended sub-surface deviation	EC	LW
A	21/08/13	Added in sub-surface deviation	EC	LW

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Title: Figure 11.6A: Location of Nearest Water Wells

Drawing Status: FINAL

Job No.: C/13054

Drawn	Checked	Scale at A3	Date	Issue Date
LW	EC	1:25,000	22/03/13	22/03/13

Drawing No.: C13054/02/006

Revision: B