Site Condition Report

Wressle Wellsite

Wressle-1

Hydrocarbon Production and Short Duration Well Operations, including Sidetrack and Radial Drilling, Near Wellbore Treatments and Proppant Squeeze Operations

3rd June 2016

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1. INTRODUCTION

Egdon Resources U.K. Limited (Egdon Resources) is a subsidiary of Egdon Resources PLC, which was formed in 1997 and was awarded its first licence in 1998 and gained its first operated licence in 2000. Under the Petroleum Licensing system this permits the licence holder to '*search and bore for and get petroleum within the licence boundary'* subject to the granting of planning permission, in accordance with the Town and Country Planning Act 1990. Egdon is an international petroleum exploration, development and production company with operations in the United Kingdom and France. The United Kingdom operations are conducted through Egdon Resources U.K. Limited and are directed from the registered office in Hampshire.

Egdon Resources is engaged in the exploration and production of petroleum onshore United Kingdom and holds 25% in the Petroleum Exploration and Development Licence 180 (PEDL 180) with the remaining interest held by Europa Oil and Gas (33.34%), Celtique (33.33%) and Union Jack Oil (8.33%). Within PEDL 180, Egdon Resources, as the operator, have successfully drilled and tested the Wressle-1 exploratory borehole.

The purpose of this report is to record the condition of the site prior to and in support of an environmental permit variation (EPR/AB3609XX) being submitted to the Environment Agency under the Environmental Permitting (England and Wales) Regulations 2010, as amended (EPR 2010).

2. SCOPE

This Site Condition Report is applicable to the Wressle wellsite and all hydrocarbon production operations and short duration well operation permitted therein, in accordance with environmental permits and planning consent, both currently being sought in parallel by Egdon Resources.

It is applicable to Egdon Resources, its contractors and subcontractors and can be used in support of applications to the Environment Agency under EPR 2010, where there is a requirement to provide a Site Condition Report.

It has been provided as a record of the site condition prior to commencing hydrocarbon production and short duration well operations, which may include sidetrack drilling, radial drilling, near wellbore treatments and proppant squeeze operations. It will continue to be updated as the operations progress and will be used to identify any changes to the environment as a result of the permitting operation when surrendering the environmental permit.

3. DEFINITIONS

Active Area:	The area of the wellsite designated for the drilling operation which has a perimeter drainage ditch and is lined with an environmental membrane.
BGL:	Below Ground Level
BGS:	British Geological Survey
DEFRA:	Department for Environment, Food & Rural Affairs
EPR 2010:	Environmental Permitting (England and Wales) Regulations 2010, as amended
Km:	Kilometre (1000 metres)
LWS:	Local Wildlife Site
m:	Metres
mm:	millimetres
mg/l	Milligram per Litre
Non Active:	The area of the wellsite designated for the siting of office accommodation, welfare facilities and parking
PEDL:	Petroleum Exploration and Development Licence
PWS:	Private Water Supplies
SSSI:	Special Site of Scientific Interest
TDS:	Total Dissolved Solids
TVD:	True Vertical Depth
URS:	A specialist consultancy who undertook a Site Condition Report for the initial permit application (URS now known as AECOM)
VOCs:	Volatile Organic Compounds

4. WELLSITE DETAILS

The location of the Wressle wellsite, within which production of hydrocarbons from the Ashover Grit formation and other formations will be undertaken, is as follows:

Wressle-1
Lodge Farm
Clapp Gate
Broughton and Appleby
DN15 0DB

National Grid Ref: Easting: 496772
Northing: 411102

Site Area: 1.27 hectares.

The site surface boundary is detailed in green on the site plans included within ER- EPRA-W1-SP-004.

5. SITE CONDITION PRIOR TO PERMIT ISSUE

The following section provides a detailed report on the current condition of the Wressle wellsite, the point at which an application to vary the existing Wreesle environmental permit is submitted to the Environment Agency. The permit variation application seeks to enable additional activities, over and above those currently authorised, namely a groundwater activity, a non-hazardous mining waste facility and installation operation for the loading, unloading, handling or storage of crude oil.

5.1 Sources of Information

This site condition report has been compiled using a range of information sources, including:

- The Wressle-1 Site Condition Report, URS 2013
- The Wressle-1 Flood Risk Assessment, R Elliott Associates 2013;
- The Wressle Hydrogeological Risk Assessment, Envireau Water 2016;
- British Geological Survey;
- The Environment Agency;
- LandIS Soilscapes website; and
- MAGIC.

5.2 Wellsite Location

The Wressle wellsite is located within an agricultural field approximately 350m east of Sadler's Lodge Farm and is bound to the north by the Ella Beck surface watercourse with agricultural land beyond and to the west by agricultural land with a wood approximately 70m to the west.

The nearest residential property to the wellsite is North Cottage, located approximately 530m to the east. Decoy Cottage is located approximately 580m to the south of the wellsite.

A site location plan has been provided within ER-EPRA-W1-SP-004.

5.3 Land Use

The Wressle wellsite is located within an agricultural field, which forms part of a much larger agricultural holding.

Prior to its construction in spring to 2014, the land upon which the Wressle wellsite was constructed had been used for arable farming, however, since its construction, the wellsite has been used for hydrocarbon exploration, including drilling of the Wressle-1 exploratory borehole in 2014 and the subsequent testing of the well in 2015.

5.4 Environmental Setting

The Wressle wellsite is not located within a statutory or non-statutory designated area.

An Ecology assessment undertaken in support of the 2013 Planning Application to North Lincolnshire Council identified statutory and non-statutory designations as being of relevance to the proposed Wressle wellsite.

The MAGIC online search identified two statutory designated sites within a 2km radius of the site boundary. These are the Broughton Far Wood, and Broughton Alder Wood; these are both Sites of Special Scientific Interest (SSSI). Broughton Far Wood is located approximately 700m to the west of the site boundary, and Broughton Alder Wood is located approximately 1.3km west of the site boundary.

The Lincolnshire Environmental Records Centre (LERC) identified twelve non-statutory sites within 2km of the site boundary. These are summarised in Table 5.1 below.

Name	Designation	Location and Distance from Wellsite
Broughton East Wood	Local Wildlife Site (LWS)	SE 965099, located 800m to the south west of the Site
Broughton Far Wood	Local Wildlife Site (LWS)	SE958104, located 1km to the west of the Site
Broughton West Wood	Local Wildlife Site (LWS)	SE950090, located 1.7km to the south west of the Site
Clapgate Pit	Lincolnshire Wildlife Trust (LWT) Reserve	SE961108, located 700m to the west of the Site
Far Wood Farm Meadow	Local Wildlife Site (LWS)	SE959099, located 1.2km to the south west of the Site
Haverholme Common	Site of Nature Conservation Interest (SNCI)	SE951121, located 1.4km to the north west of the Site.
Heron Holt	No citation as yet	Located 1.3km to the south west of the Site
Kebb Wood	Local Wildlife Site (LWS)	SE958123, located 1.3km to the north west of the Site
New River Ancholme	Local Wildlife Site (LWS)	SE982115, located 1.5km to the east of the Site
Rowland Plantation	Local Wildlife Site (LWS)	SE959115, located 270m to the north of the Site
Spring Wood	Site of Nature Conservation Interest (SNCI)	SE953112, located 1.3km to the west of the Site.
Weir Dyke	Local Wildlife Site (LWS)	SE981120, located 1.6km to the north east of the Site

Table 5.1: Non-Statutory Designated Sites

5.5 Geological Setting

The geological setting has been characterised using British Geological Survey (BGS) Map Sheet 89 (Brigg); records from the BGS's database of water wells and boreholes; and geological data obtained by Egdon Resources during the construction of the Wressle-1 well.

The geological map suggests that superficial deposits at the wellsite consist of blown sands. Peat and alluvium deposits are present to the east of the wellsite. The total thickness of superficial deposits is expected to be approximately 5m, as suggested by interpretation of BGS records for nearby water wells in the area.

The bedrock geology in the vicinity of the wellsite is characterised by Jurassic age strata. The wellsite is underlain by the Kellaways Formation (Ancholme Group) which is in turn underlain by the Cornbrash Formation and the Blisworth Clay, Blisworth Limestone & Rutland Formations of the Great Oolite Group. Beneath this, the Inferior Oolite Group is present and consists of the Lincolnshire Limestone Formation, the Grantham Formation and the Northampton Sand Formation. The Inferior Oolite Group outcrops approximately 500m west of the wellsite. The Northampton Sand Formation lies unconformably on mudstones of the Lias Group.

The Jurassic age strata are underlain by the Penarth and Mercia Mudstone Groups, and the Sherwood Sandstone Group of Triassic age, which are in turn underlain by Permian and Carboniferous age bedrock.

The expected geology at the wellsite is summarised in Table 3. The expected depth and thicknesses of the Jurassic formations have been estimated based on BGS 1:50,000 scale mapping, whilst the expected depth and thicknesses of the deeper strata is based on geological data obtained by Egdon Resources during the construction of the Wressle-1 well.

Age	Group	Formation	Description	Approx. Expected Thickness (m)	Approx. Depth to Base of Strata (mbgl)
Quaternary	Superficial Deposits		Blown sands / peat / alluvium deposits (clay and sand)	5	5
	Ancholme Group	Kellaways Formation	Mudstone, grey, silici-silty or silici-sandy	5	10
	Great Oolite Group	Cornbrash Formations	Limestone, bluish grey to olive or yellowish brown when weathered	2	12
		Blisworth Clay, Blisworth Limestone & Rutland Formations (formerly Upper Estuarine Series)	Clay, sandstone and limestone	13	25
	Inferior Oolite Group	Lincolnshire Limestone Formation	Limestone	25	57
		Grantham Formation	Mudstone, sandy mudstone and argillaceous siltstone-sandstone	2	
		Northampton Sand Formation	Sandy ironstone with lenses of mudstone or limestone	5	
Lower Jurassic	Lias Group	Whitby Mudstone	Fossiliferous mudstone and	143	200

Age	Group	Formation	Description	Approx. Expected Thickness (m)	Approx. Depth to Base of Strata (mbgl)
		Formation	siltstone.		
		Marlstone Rock Formation	Sandy, shell fragmental and ooidal ferruginous limestone interbedded with ferruginous calcareous sandstone		
		Dyrham Formation	Silty sandy mudstone		
		Charmouth Mudstone Formation	Dark grey shale and mudstone, argillaceous limestone or ironstone nodules		
		Scunthorpe Mudstone Formation	Calcareous and silty mudstone with thin beds of argillaceous limestone and calcareous siltstone		
Triassic	Penarth and Mercia Mudstone Groups		Mudstone with siltstone and evaporite	250	450
	Sherwood Sandstone Group		Sandstone with occasional beds of mudstone and siltstone	360	810
Permian	Zechstein Group		Mudstone and limestone with evaporite	325	1135
Carboniferous	Westphalian Group / Millstone Grit Group (including the Ashover Grit)/ Carboniferous Limestone Group		Sandstone, mudstone and coals measures	>600	>1735

Table 5.2: Expected Geological Sequence

The bedrock strata dip at a shallow angle towards the east.

The Brigg Fault, located 1km west of the wellsite, trends in a northwest-southeast direction over a distance of 10km and downthrows the strata to the east by approximately 50m.

There are two smaller faults located 450m and 900m northeast of the wellsite; trending in a northwest-southeast direction and downthrowing strata to the west.

5.6 Hydrogeological Setting

The aquifer potential at the wellsite has been assessed using literature published by the BGS in the Major and Minor Aquifer databases.

The superficial deposits in the vicinity of the wellsite are predominantly comprised of alluviums, blown sand or sand and gravel. These deposits may contain shallow groundwater and could be targeted to provide small yields for domestic use. A shallow superficial deposits groundwater system up to approximately 5m is therefore expected to be present at the site.

The Kellaways Formation comprises low permeability mudstone and is considered essentially Unproductive.

However, the Kellaways Sands (typically 2m to 4m thick) at the base of the formation may contain small quantities of groundwater.

The underlying formations that make up the Great Oolite Group comprise mudstone, sandstone and limestone bedrock. The most productive layers are the Cornbrash Formation and the Blisworth Limestone Formation which are classified by the Environment Agency as Secondary aquifers. However, in this area the Cornbrash Formation is unlikely to contain significant quantities of groundwater due to its limited thickness and separation from the underlying Blisworth Limestone Formation by the Blisworth Clay Formation.

The underlying Lincolnshire Limestone Formation is classified by the Environment Agency as a Principal aquifer. The Lincolnshire Limestone can be divided into two sub-units, the Upper Lincolnshire Limestone and the Lower Lincolnshire Limestone. The Upper Lincolnshire Limestone has a variable thickness but is dominantly a coarse, shelly cross-bedded oolite. The Lower Lincolnshire Limestone is a mainly fine-grained, micritic and peloidal limestone.

The Lincolnshire Limestone Formation outcrops approximately 250m west of the wellsite. The limestone dips to the east and thins from more than 30m in thickness at outcrop to less than 20m in thickness in the east where it is confined by the overlying mudstone and clays of the Upper Estuarine Series and becomes increasingly artesian in nature. An interpretation of data from the BGS water wells database by Envireau Water suggests groundwater heads in the Lincolnshire Limestone at the Wressle wellsite will be close to or above ground level (artesian conditions). Where the Grantham Formation is thin, the Lincolnshire Limestone is often in hydraulic continuity with the underlying Northampton Sand Formation. There is also potential for a small amount of flow between the Lincolnshire Limestone and overlying Blisworth Limestone through the Rutland Formation.

Groundwater movement through the limestone is almost entirely by fracture flow along well developed bedding plane fractures and joints. Groundwater flow in the Lincolnshire Limestone is eastwards downdip from the outcrop to the confined area. The Brigg Fault is likely to restrict groundwater flow as it downthrows the Lincolnshire Limestone to the east by approximately 50m. The main recharge to the limestone aquifer is via rainfall. Spring lines occur along the top and the base of the Lincolnshire Limestone. Seasonal variations in the rest water levels in the Lincolnshire Limestone are typically in order of 10m to 15m due to the rapid response time of the aquifer to recharge. The groundwater is of good chemical quality, generally hard near the outcrop, softening in an easterly direction under cover of the permeable clay but the quality eventually deteriorates with increasing depths and distance to the outcrop.

Groundwater in the Northampton Sand Formation is a combination of matrix and fracture flow. The Northampton Sand Formation form a reliable aquifer at shallow depths (less than 10m) beneath the ground surface. Springs occur at the junction of the sands with the underlying Whitby Mudstone (e.g. near Far Wood Farm). Water from the Northampton Sand Formation is generally of good quality but hard.

The Marlstone Rock Formation, which outcrops approximately 2.8km west of the wellsite, is the most important secondary aquifer in the Middle Lias with groundwater contained in, and transported through, a regionally developed fissure system. Both weathered and un-weathered Marlstone Rock are very fine grained with low matrix permeability; flow is therefore predominant along fissure with possibly small or non-existent matrix-flow. The Marlstone Rock is assumed to be in hydraulic continuity with the underlying Dyrham Formation siltstone. The water quality is generally good but hard and often ferruginous.

In the East Midlands Shelf, the permeable parts of the Scunthorpe Mudstone Formation are the thin limestone bands and calcareous sandy belt present towards the top. Yields are generally low. Groundwater quality is generally hard and often poor in the Scunthorpe Mudstone Formation; possibly saline or containing hydrogen sulphide from decomposing pyrite in the shales.

The Penarth Group is classed as Unproductive strata and the Mercia Mudstone Group Secondary aquifer will also act as Unproductive strata at this location due to its depth. The base of the Mercia Mudstone is located

at approximately 450m below ground level. It provides a hydraulic break between the groundwater systems that have a resource value and deeper water bearing systems in the deeper Triassic, Permian and Carboniferous strata that are likely to contain formation water with limited or no resource value. As documented by a geothermal investigation in the area, the Triassic Sherwood Sandstone at this location contains formation water with an elevated salinity (TDS estimated to be around 7,500mg/L). Water bearing formations in the underlying Permian and Carboniferous bedrock are likely to contain saline water and hydrocarbons.

A Hydrogeological Risk Assessment has been undertaken in support of the Wressle-1 permit variation application and is provided as Appendix 2.

5.7 Surface Water Feature

Surface water features within 2km of the Wressle wellsite have been identified from 1:25,000 Ordnance Survey mapping. The locations of the major surface water features are presented on Figure 5.1 and their details are summarised in Table 5.3.

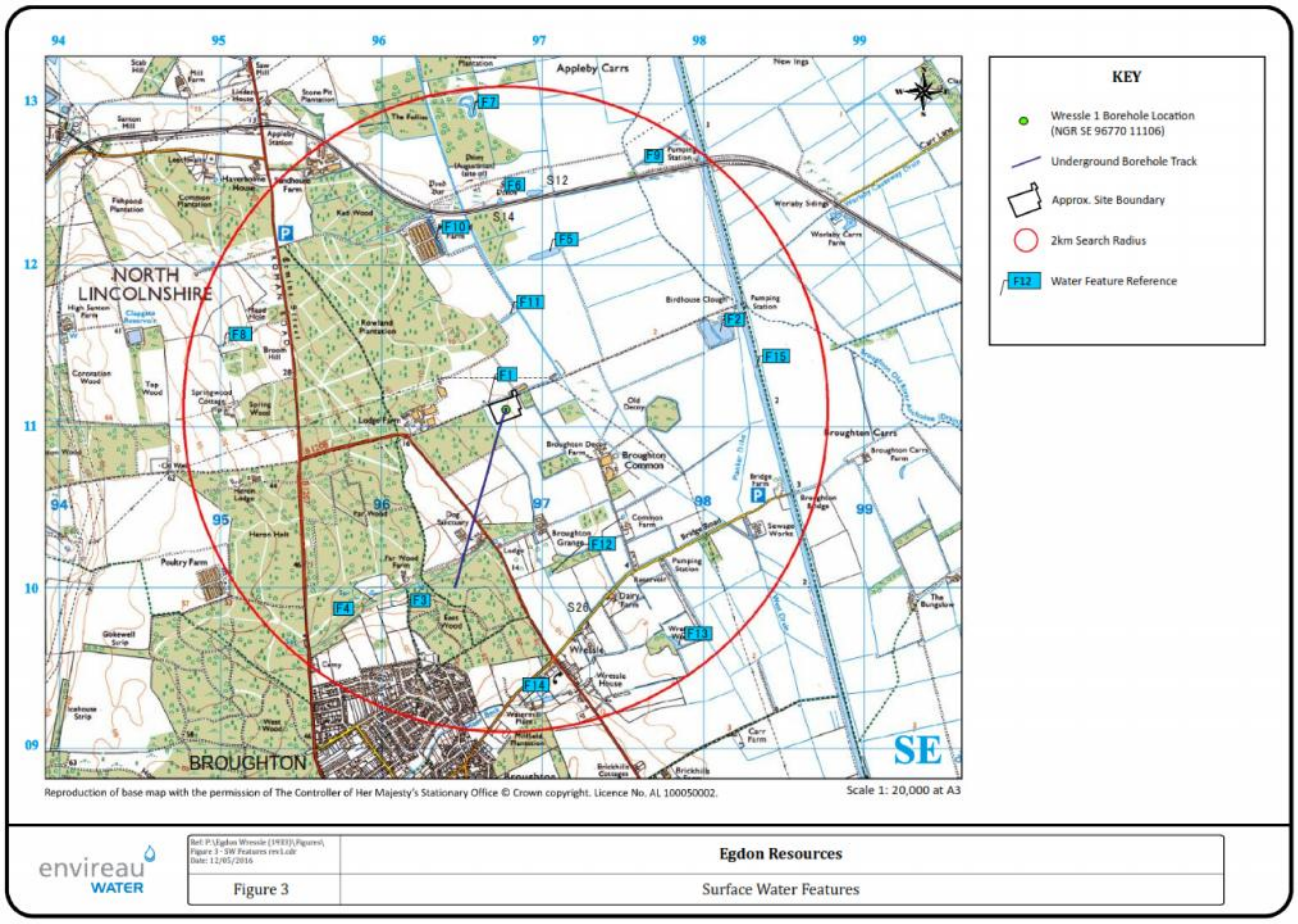

Figure 5.1: Surface Water Features

Reference on Figure 5.1	Feature	Description	Approx. Distance from Wellsite(km)
F1	Ella Beck + West Drain	"Main River". Circumventing the site, running southwards on the western side and eastwards on the northern side and then northwards into River Humber.	0.06
F2	Large Pond	Large Pond at near Birdhouse Clough	1.32
F3	Small Pond	Stream and ponds system south of Far Wood Farm	1.28
F4	Springs	Springs west of Far Wood Farm	1.47
F5	Large Pond	Large Pond	0.97
F6	Small Pond	Small Fish Ponds at the Priory	1.42
F7	Large Pond	Large Pond at The Follies	1.91
F8	Small Pond	Small Pond at Broom Hill	1.84
F9	Small Pond	Small Ponds at Appleby Carrs Pumping Station	2
F10	Small Pond	Small Pond at Kebwood Farm	1.04
F11	Small Pond	Small Pond east of Rowland Plantation	0.59
F12	Small Pond	Small Ponds near Broughton Grange and Common Farm	1.0
F13	Small Pond	Small Pond at Wressle Wood	1.8
F14	Moor Beck	Running eastward and joining Ella Beck, associated pond near Watermill Place	1.91
F15	New River	Bunded river, running northward to River Humber	1.58

Reference on Figure 5.1	Feature	Description	Approx. Distance from Wellsite(km)
	Ancholme		
N/A	Field Drains	Various field drains and dykes within the 2km radius	N/A

Table 5.3: Surface Water Features

5.8 Protected Water Rights

Protected water rights within a 2km radius of the Wressle wellsite have been identified and are presented on Figure 5.2, which is presented as Figure 5 within the Wressle-1 Hydrogeological Risk Assessment.

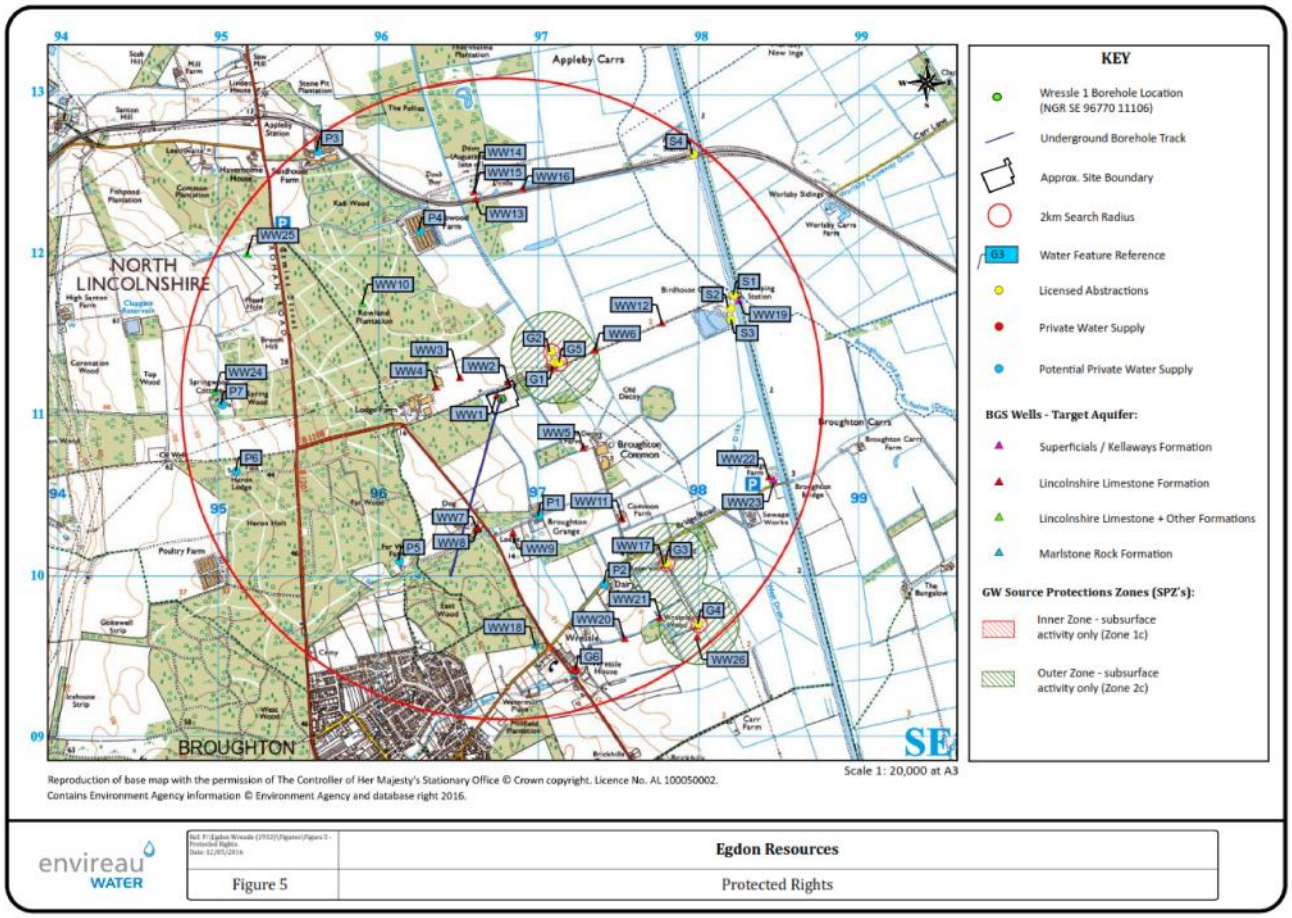

Figure 5.2: Protected Water Rights within a 2km Radius of the Wellsite

5.8.2 Licence and Other Abstractions

Based on a search of the Environment Agency abstraction licence database, there is one licensed groundwater abstraction and three licensed surface water abstractions within the 2km radius. The location of the licensed abstractions are shown within Figure 5.1 and the licence details are summarised in Table 5.4.

Some of the licences cover multiple sources of abstraction. The licensed groundwater abstraction includes three sources (the Clapgate and Birdhouse Clough sources) all located 0.4km east of the wellsite; and two sources (the Bridge Road sources) located 1.5km and 1.9km southeast of the wellsite respectively.

Source No. on Figure 5.1	Location	Source	Licence #	Easting	Northing	Distance from Wellsite (km)
G1	Clapgate	Groundwater	4/29/07/* G/0020	497100	411330	0.4
G2	North of Birdhouse Clough Pumping Station	Groundwater		497080	411400	0.4
G3	Near Bridge Road Pumping Station	Groundwater		497800	410080	1.5
G4	South of Bridge Road Pumping Station	Groundwater		498000	409700	1.9
G5	Near Birdhouse Clough Pumping Station	Groundwater		497130	411330	0.4
S1	River Ancholme, Appleby	River	4/29/05/* S/0020	498220	411750	1.6
S2	Planker Dyke	River	4/29/07/* S/0037	498200	411670	1.5
S3	Planker Dyke	River		498200	411600	1.5
S4	New River Ancholme LB Worlaby	River	4/29/05/* S/0010	497970	412630	1.9

Table 5.4: Licensed Abstractions

5.8.3 BGS Boreholes and Wells

A search of the BGS water wells online database has been undertaken, which has identified 32 water well records within the 2km search radius. However, the BGS data is indicative of water wells that have been historically present but may not necessarily be present or accessible now.

The majority of the records relate to water wells targeting the Lincolnshire Limestone Formation or the Marlstone Rock Formation. A few shallow wells target the Kellaways Formation. The closest water well record (WW1) is located on the wellsite close to the Ella Beck and targets the Lincolnshire Limestone Formation, however this well was not located during the construction of the wellsite. The deepest water well (WW10) is 122m deep and is located some 1.1km northwest of the wellsite at Rowlands Plantation and targets a number of formations including the Lincolnshire Limestone Formation and the Marlstone Rock Formation.

The well records are summarised in Appendix A within the Wressle-1 Hydrogeological Risk Assessment and their locations are presented within Figure 5.2.

5.8.4 Private Water Supplies

A search of North Lincolnshire Council's register of Private Water Supplies (PWS) has been undertaken. The Council has confirmed that they have one PWS recorded within the 2km search radius. The location of the registered PWS is presented within Figure 5.2 and summarised in Table 5.5.

Source No. on Figure 5.1	Location	Likely Target Aquifer	Easting	Northing	Distance from Wellsite (km)
G6	Stone Cottages, Brigg Road, Wressle, Brigg DN20 0BT	Marlstone Rock Formation	497232	409412	1.7km

Table 5.5: Registered Private Water Supplies

It is recognised that the local authority's PWS register may be incomplete and that unrecorded supplies may exist at outlying properties. Based on the local geology, any unrecorded supplies in the vicinity of the wellsite would be most likely to target the Superficial Deposits or the Lincolnshire Limestone Formation.

The BGS water wells identified in Section 5.8.3 all have the potential to be used as PWS. In addition, a review of the 1:25,000 scale Ordnance Survey mapping data has identified seven other properties within the 2km radius where PWS could potentially be present. The location of the potential PWS are presented on Figure 5.2 and summarised in Table 5.6.

Ref No. on Figure 5.1	Location	Easting	Northing	Distance from Wellsite (km)
P1	Broughton Grange	49700	41038	0.8
P2	Dairy Farm	49743	40997	1.3

Ref No. on Figure 5.1	Location	Easting	Northing	Distance from Wellsite (km)
P3	Sandhouse Farm	49563	41263	1.9
P4	Kebwood Farm	49626	41214	1.2
P5	Far Wood Farm	49614	41006	1.2
P6	Heron Lodge	49522	41067	1.6
P7	Springwood Cottage	49503	41109	1.7

Table 5.6: Potential Private Water Supplies

5.9 Surface Water and Drainage

The nearest surface water feature to the Wressle wellsite is Ella Beck, located immediately adjacent to the northern perimeter of the wellsite and approximately 60m distance from the western perimeter of the wellsite. Ella Beck is not classified by the Environment Agency with regards to ecological and chemical quality. An unnamed land/field drain is also present approximately 45m east of the wellsite, adjacent to the southern extent of the wooded area.

The nearest Environment Agency assessed watercourse is the River Ancholme, located approximately 1.58km east of the wellsite and is designated as being of poor ecological quality and failing with regard to chemical quality. The ecological and chemical quality of the River Ancholme is not anticipated by the Environment Agency to change.

The Wressle wellsite is located in a Flood Risk Zone 1 (annual flood probability of less than 0.1%), with the access road partly lying in Zone 2 and 3(ii) (annual flood probability of 0.1% to 1% and greater than 1% respectively).

A Flood Risk Assessment for the wellsite was prepared by R Elliott Associates Ltd in January 2013 and the wellsite was constructed following the recommended mitigation measures to reduce the risk of flooding.

5.10 Soils

There are two soil types at the Wressle wellsite, taken from the LandIS Soilscapes website, developed by Cranfield University and accessed on 12/05/2016. The western part of the wellsite is classified as ‘freely draining very acid sandy and loamy soils’ and the eastern part of the wellsite is classified as ‘freely draining lime-rich loamy soils’.

No detailed soil sampling and/or analysis was undertaken prior to site construction.

5.11 Air Quality

In considering the overall impact of the flaring activity on local air quality, it is necessary to consider the existing levels of pollutants within the area of interest. Background air quality data for the area around the Wressle wellsite were obtained from DEFRA. Using the latest data DEFRA, the background levels of nitrogen dioxide (NO_2) and carbon monoxide (CO) were established. Table 5.7 below provides a summary of the estimated background concentrations of NO_2 and CO.

Pollutant	**Concentration**
Nitrogen Dioxide (2014)	12.95 µg m^3
Carbon Monoxide (2010)	0.22 µg m^3

Table 5.7: Summary of background concentrations for Wressle

As part of the Wressle-1 well testing phase air quality monitoring was undertaken to establish baseline results prior to the undertaking of flaring activities. These results have been provided within Appendix 6 of this Site Condition Report, together with results from air quality monitoring conducted during flaring operation.

All storage tanks onsite require the ability to vent, in order to allow the displacement and replacement of air as the tanks are filled and offloaded respectively. The storage tanks onsite will be connected via a vent line manifold to a single release point located within the north east corner of the active area of the wellsite.

5.12 Wellsite Construction

The Wressle wellsite was constructed by excavating topsoil and relocating it to the northern and western boundary of the wellsite. The topsoil which is stored onsite for subsequent wellsite restoration, forms part of the bund, which provides partial screening of the wellsite. The subsoil was then ‘cut to fill’, a method of removing subsoil from higher areas of the wellsite and relocating it within the lower areas of the wellsite to create a level plateau.

Once the wellsite was level a ditch was excavated around the perimeter of the active area of the wellsite. The perimeter ditch forms part of the wellsite containment, collecting and storing surface run-off water.

Following excavation of the perimeter ditch, the active area of the wellsite was overlaid with a LOTRAK geotextile membrane and covered with 50mm sand with a Bentomat membrane which is a geosynthetic clay liner (GCL) specifically designed for landfill, surface water impoundments and secondary containment. The membrane is self-sealing if punctured, with high climatic and chemical resistance. Additional sand and LOTRAK were then placed over the membrane with a layer of 300mm Type 3 stone completing the wellsite active area surface. A typical cross section of the wellsite construction is presented as Figure 5.3.

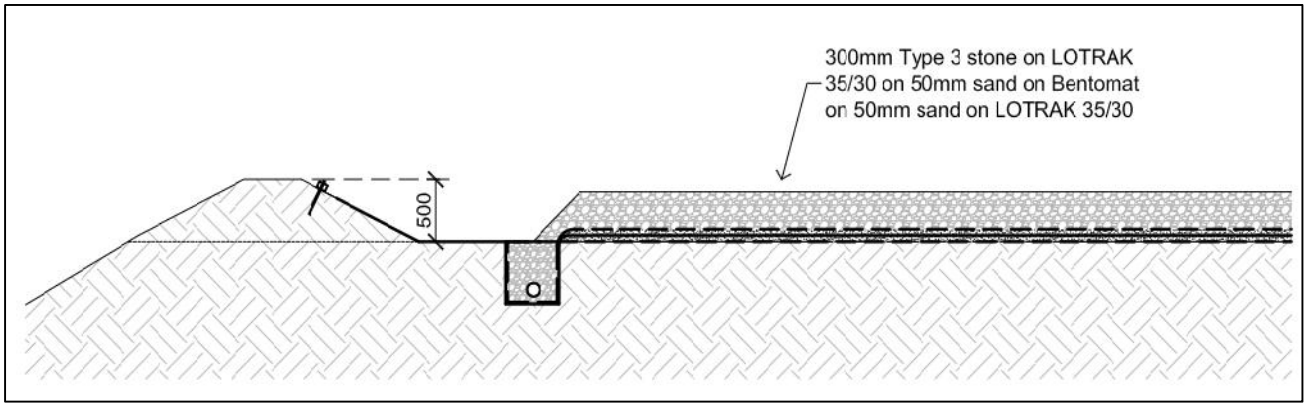

Figure 5.3: Typical Ditch Construction in Fill

The active area of the wellsite was constructed with stone compacted on top of an impermeable membrane protected by geotextiles. The active area of the wellsite will be surrounded by a drain, comprising a lined trench with a porous pipe laid in the bottom and backfilled with coarse 75-50mm rejects as shown. As part of the production phase, the drainage pipe will connect to a surface water interceptor to enable the discharge of clean surface water.

Stone aggregate was used for the surface of both the active and non-active areas of the wellsite.

A drilling cellar was constructed within the centre of the active area of the wellsite and forms a containment area within which the well was drilled, whilst also housing the wellhead. The cellar comprises a reinforced concrete chamber sunk into the ground with the top surface, level with the main site platform. An initial section of large diameter casing was built into its base to provide a starting point for the drilling operations. The drilling cellar was constructed around the large diameter casings using precast concrete rings encased in a concrete jacket surround. The impermeable membrane was incorporated into the cellar construction to maintain environmental integrity of the active area of the wellsite.

A concrete drilling pad was constructed at surface, immediately surrounding the drilling cellar. The concrete pad was sized and constructed to take the ground loading of the drilling rig and subsequent equipment.

5.12.1 Permanent Containment Bunding

The construction of a permanent masonry containment bund, within which oil storage tanks will be positioned is proposed and will be installed prior to hydrocarbon production.

A permanent tanker loading area with containment is also proposed.

Surface water collected within the permanent containment bund and permanent tanker loading area within wellsite will be collected and stored temporarily on site for subsequent offsite treatment and disposal at an Environment Agency permitting waste treatment facility. The containment bunds will be fitted with automated sump pumps, which will transfer the water to temporary holding tanks, which may be fitted with high level alarms.

5.12.2 Groundwater Quality Monitoring Boreholes

An outline scheme of monitoring has been prepared in support of the Wressle-1 permit variation application and, once implemented, will demonstrate the effectiveness of mitigation measure.

The outline scheme of monitoring provides for the drilling of four (4) monitoring boreholes, three (3) shallow boreholes up to depth of approximately 5m to target the shallow water systems and one (1) deeper borehole to a depth of up to 50m to target the Lincolnshire Limestone formation.

The monitoring boreholes will be located outwith the active area of the wellsite and protected by concrete base surround.

5.13 Wellsite Drainage

The Wressle wellsite has been constructed such that it provides a complete containment for operations that take place therein. The wellsite was constructed using a Bentomat impermeable membrane, which lines the active area of the wellsite including the perimeter ditches. The purpose of the impermeable membrane is to capture any surface run-off liquids such as rainwater, but also capture any spillages incurred onsite and contain them within the site perimeter ditches, ensuring environmental harm is averted and any spillages can be rectified onsite. A schematic showing the impermeable membrane is provided as Figure 5.3.

Connected to the perimeter ditch will be an oil interceptor which is to be installed during wellsite remedial works. The purpose of the interceptor is to enable the discharge of clean surface run-off water from the site during hydrocarbon production. Prior to installation, the existing containment ditch will be assessed to ensure it retains integrity, if it is evident that the performance of the Bentomat impermeable membrane has been compromised, remedial work will be undertaken to reinstate integrity prior to operations commencing onsite.

An isolation valve will be located at the discharge point from the site perimeter, upstream from the interceptor. A flow valve will also be present downstream from the interceptor to provide additional means of isolation.

The discharge of surface water during short duration well operations, such as sidetrack drilling, radial drilling and proppant squeeze, where temporary equipment on site increases the potential for a minor spill to occur, will be restricted. During short duration well operations, surface run-off water will be contained onsite for subsequent offsite treatment and disposal at an Environment Agency permitting waste treatment facility.

Surface water collected within the permanent containment bund and permanent tanker loading area within wellsite will be collected and stored temporarily on site for subsequent offsite treatment and disposal at an Environment Agency permitting waste treatment facility.

5.14 Wressle-1 Well Construction

The existing Wressle-1 well was constructed in August 2014 to a total depth 2,236mMDBGL, which represents a true vertical depth (TVD) of 1,810mBGL. The well is deviated and a schematic showing the construction concept is provided as Figure 5.4. All measurements below are expressed in metres TVD referenced to ground level and have been interpreted from the well construction data provided by Egdon Resources.

The well has been constructed as follows:

- 334mm (13 3/8”) diameter conductor casing installed to a depth of 61m TVD into the Lias Group;
- 241mm (9 5/8”) diameter intermediate casing to a depth of 445m TVD into the Mercia Mudstone Group just above the top of the Sherwood Sandstone Group;
- 175mm (7”) diameter production casing to a depth of 847m TVD into the Permian strata;
- 127mm (5”) diameter ‘production liner’ installed from 771m to 1810m TVD into the Carboniferous Limestone Group. The production liner is the term given to a production casing string that does not extend to the top of the wellbore.

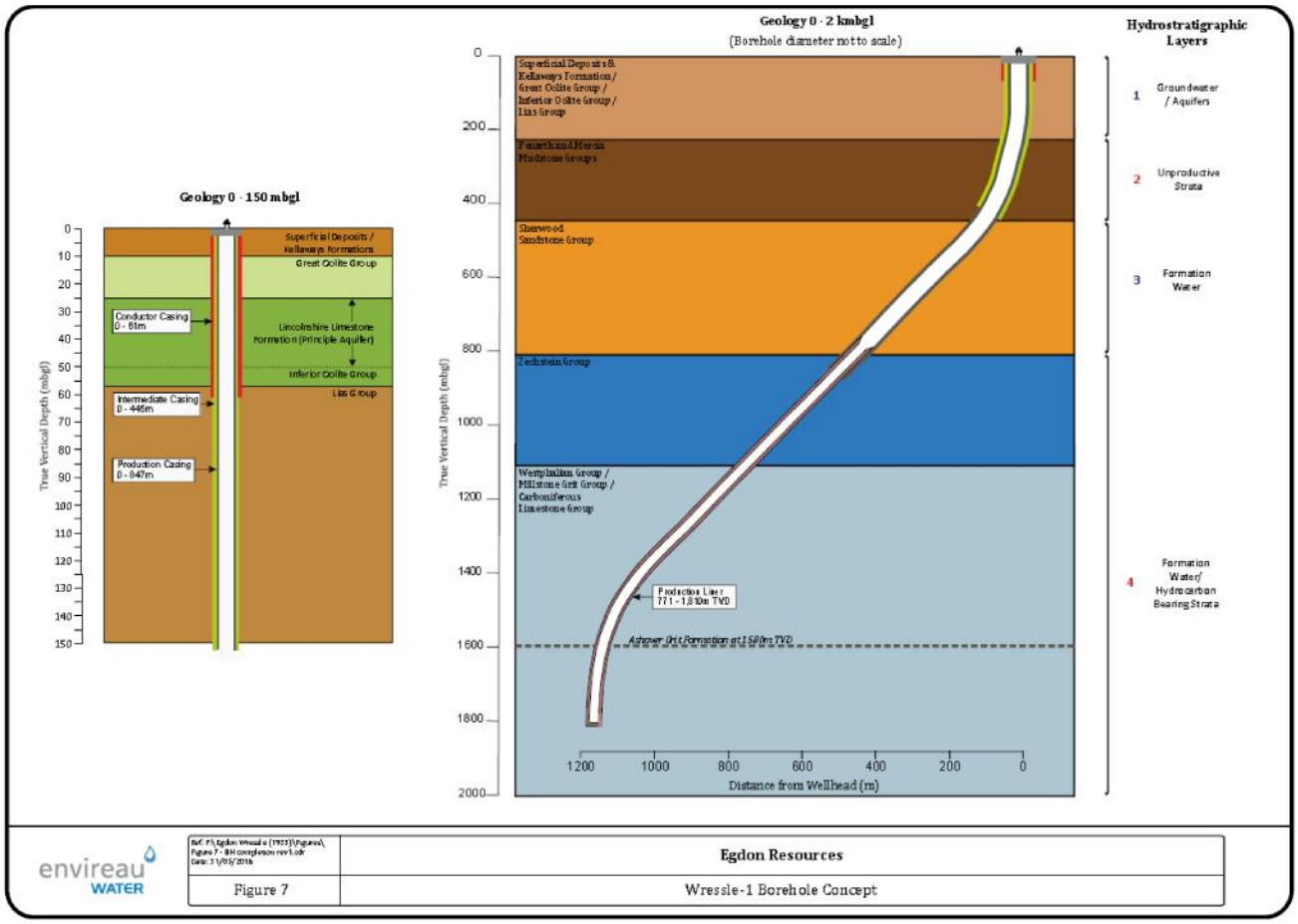

Figure 5.4: Conceptual Model

As illustrated on Figure 5.4, construction has been carried out to prevent vertical migration of fluids between the different hydrostratigraphic units; with each casing string cemented and pressure tested on completion. The casing strings provide a permanent physical barrier between useful groundwater with a resource value that is present in the top ~200m of strata and used for potable and other supplies (Layer 1), and the brackish or saline and hydrocarbon rich formation waters present in the Triassic Sherwood Sandstone Group and Permian / Carboniferous strata (Layers 3 & 4) respectively; present beneath the Mercia Mudstone Group (Layer 2) at depths in excess of 450m. The low permeability and thickness of Layer 2 prevents upward or downward vertical migration between these layers.

The Wressle-1 well has been constructed in accordance with the Offshore Wells (Design and Construction etc.) Regulations 1996 (DCR) and contains three cemented casings that provide barriers within the system to ensure well integrity, and prevent gas and fluids migrating between different hydrostratigraphic units.

The Wressle-1 well encounter hydrocarbons in a number of target formations, which were subsequently tested between January to March 2015 to determine whether any of the formations had commercial production potential. This and subsequent testing between June to August 2015, showed that the three formations, the Ashover Grit, Wingfield Flags and Penistone Flags had the potential for commercial development. It is planned to initially develop the carboniferous Ashover Grit Formation (present at a depth of 1580mTVD).

Well engineering works within the production zone of the Wressle-1 well are now required to develop the wellsite for commercial oil production.

5.15 Historic Land Use

Historical maps dated back as far as 1886 consistently identify the land at which the wellsite sits upon as being an area of undeveloped land, considered likely to be of agricultural use given the presence of farm buildings in close proximity to the land most notably Sadler's Lodge Farm which was present on all historical maps.

Data obtained from the initial Site Condition Report identifies the land to be generally undeveloped. Agricultural land was located to the north, south and east of the site, whilst woodland comprised areas of land to west. Other potentially significant historic land uses within 1km of the site include a pumping station located 350m east of the site.

Following a review of the historical maps it has been considered that there is a low likelihood that the soil and/or groundwater may have been affected by contamination. However, the possibility does exist that the soil and groundwater may have been affected by fertiliser and farm chemical usage both onsite and in the immediate vicinity.

5.16 Pollution Incidents and Contamination

A review of the Environment Agency website shows there are no historic landfill site sites within 2km of the Wressle wellsite.

One pollution incident to controlled water was recorded within 1km of the wellsite. An unnamed operator discharged an unspecified pollutant into a river/stream 650m east of the wellsite. The incident was designated Category 3 – Minor Incident.

6. PERMITTED ACTIVITIES

The permitted activities to be conducted at the Wressle wellsite will include the following:

- a Mining Waste Operation, as defined by the Mining Waste Directive and Schedule 20 of the Environmental Permitting (England and Wales) Regulations 2010, as amended, relating to the management of extractive waste;
- a Radioactive Substances activity under the Environmental Permitting (England and Wales) Regulations 2010, as amended, relating to the accumulation and disposal of radioactive waste;
- a Mining Waste Facility, as defined by the Mining Waste Directive and Schedule 20 of the Environmental Permitting (England and Wales) Regulations 2010, as amended, for the disposal of proppant fluid retained with the formation;
- a precautionary approach to conduct a groundwater activity, as defined by the Groundwater Directive and Schedule 22 of the Environmental Permitting (England and Wales) Regulations 2010, as amended, for the undertaking of a groundwater activity; and
- an Industrial Emissions activity, as defined by the Industrial Emissions Directive and Part 2 Schedule 1.2 of the Environmental Permitting (England and Wales) Regulations 2010, as amended, relating to the loading, unloading, handling and storage of crude oil.

7. NON-PERMITTED ACTIVITIES

A number of non-permitted activities will be conducted at the Wressle wellsite during hydrocarbon production and short duration well operations, including but not limited to:

- Production of hydrocarbons, including oil and associated natural gas used to generate electricity;
- Well maintenance and surveys not generating extractive wastes;
- Installation of groundwater monitoring boreholes;
- Well monitoring;
- Equipment maintenance and repairs;
- Extractive waste processes; and
- Storage and disposal of non-hazardous and hazardous waste not directly associated with the permitted activities.

For clarity a permit subject to the Mining Waste Directive covers the management of extracted waste and not the extraction process.

8. PREVIOUS MONITORING

Monitoring has been undertaken at the Wressle wellsite with respect to air quality and surface water, during previous well operations. Monitoring results have been document and are provide as appendices to this Site Condition Report, as follows:

- Appendix 4 – Surface Water Monitoring;
- Appendix 5 – Radioactive Substances Monitoring; and
- Appendix 6 – Air Quality Monitoring.

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APPENDIX 1 – SITE LOCATION MAPS

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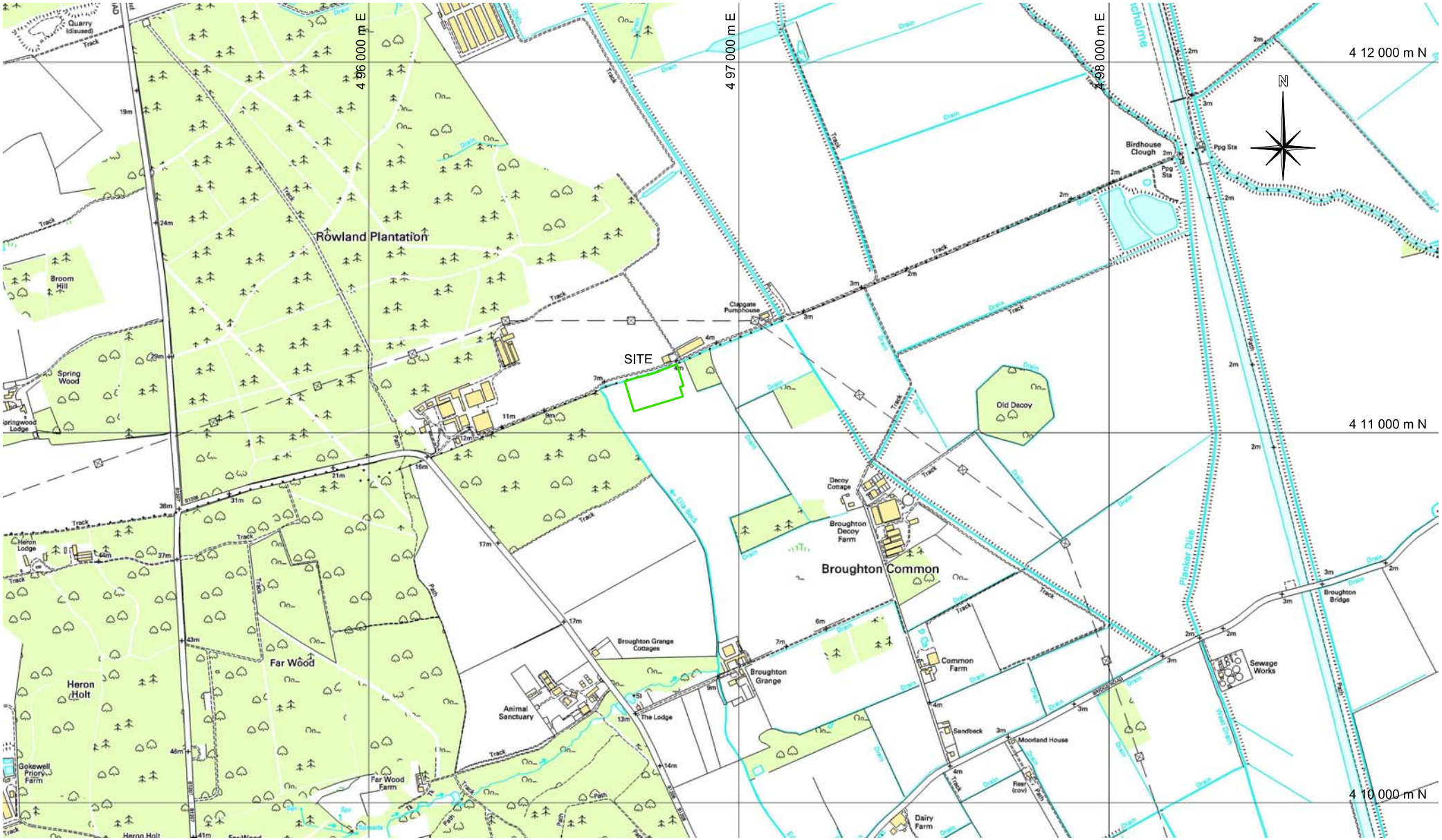

Site Location Plan

Scale 1:10,000

0 100m 200m

R Elliott Associates Ltd
CONSULTING STRUCTURAL & CIVIL ENGINEERS
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SO41 6EB

Client	Egdon Resources UK Ltd Wressle Brigg Lincolnshire
Job Title	Wressle Site
Drawn By	AJNE
Date	February 2013
Sheet Size	A3
Drawing Title	Site Location Plan (1:10,000)
Drawing Number	3334 EA 01
Revision	

Site of Application

Scale 1:2500

0 25m 50m

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Client	Egdon Resources UK Ltd Wressle Brigg Lincolnshire
Job Title	Wressle Site
Drawn By	AJNE
Date	February 2013
Sheet Size	A3
Drawing Title	Site of Application (1:2,500)
Drawing Number	3334 EA 02
Revision	

APPENDIX 2 – HYDROGEOLOGICAL RISK ASSESSMENT

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HYDROGEOLOGICAL RISK ASSESSMENT AND OUTLINE SCHEME OF MONITORING

WRESSLE-1 WELL, WRESSLE WELLSITE, NORTH LINCOLNSHIRE

For

Egdon Resources plc
The Wheat House
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Odiham
Hampshire
RG29 1LP

By

Envireau Water
Aske Stables
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Tel: 01748 889 268
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Ref: P:\Egdon Wressle (1933)\Reporting\Egdon Wressle HRA r3.4.docx
June 2016

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FIGURES

TABLES

APPENDICES

Revision	Details	Completed by	Date	Checked by	Date
REV01	1st Draft	AB	18/11/2015	PH	20/11/2015
REV02	2nd Draft	AB	27/04/2016	PH	03/01/2016
REV03	Final	PH	02/06/2016	JD	02/06/2016

HYDROGEOLOGICAL RISK ASSESSMENT AND OUTLINE SCHEME OF MONITORING

WRESSLE-1 WELL, WRESSLE WELLSITE, NORTH LINCOLNSHIRE

1 INTRODUCTION

Egdon Resources plc ("Egdon Resources") constructed an oil exploration well (Wressle-1) on farmland at Lodge Farm, Wressle, North Lincolnshire in August 2014 to a total depth 2,236m measured depth (MD) below ground level (1,810m true vertical depth (TVD) below ground level).

To investigate the viability of the well for commercial production, test operations were conducted from January to March 2015 and an Extended Well Test (EWT) was conducted between June and September 2015. The tests were successful and Egdon Resources is now progressing a Field Development Plan (FDP) for commercial oil production from the wellsite, which will be submitted to the United Kingdom Oil and Gas Authority (OGA) for approval.

Development of the wellsite for commercial oil production will require civil engineering works at surface and well engineering works within the production zone of the Wressle-1 well.

1.1 Regulatory Framework

To produce oil commercially from the wellsite, Egdon Resources will require a mining waste permit from the Environment Agency and planning permission from Lincolnshire County Council. To fulfil the requirements of the planning and permitting process, Egdon Resources must prepare a Hydrogeological Risk Assessment (HRA) to demonstrate that the potential risks to the water environment have been adequately considered and that mitigation measures are put in place to reduce risks to an acceptable level, where necessary.

1.2 Report Objective

This report has been prepared by Envireau Water and presents a HRA for the proposed development and the mitigation measures that will be implemented to reduce hydrogeological risks at the Wressle wellsite, as well as an outline scheme for groundwater and surface water monitoring.

The report will be submitted to the Environment Agency in supporting of an application to vary an existing mining waste permit and can also be used to support applications to the Mineral Planning Authority under the Town and Country Planning Act 1990.

1.3 Report Context

This HRA has been conducted in accordance with the technical framework for groundwater risk assessment set out in Groundwater protection: Principles and practice (GP3) [Ref.1].

The HRA report includes:

1. A review of the baseline hydrology, geology and hydrogeology around the wellsite.
2. Identification of surface water and groundwater features in close proximity to the wellsite.
3. A conceptual hydrogeological model.
4. The proposed outline development plan and proposals for how water will be managed at the site during all phases of the development.
5. A HRA conducted in accordance with the technical framework for groundwater risk assessment set out in Groundwater protection: Principles and practice (GP3) [Ref.1] and the risk assessment methodology set out in DEFRA's Green Leaves III (GL III) [Ref. 2]; together with proposals to mitigate hydrogeological risk.
6. An outline scheme for groundwater and surface water monitoring; including provisional specifications for groundwater monitoring boreholes at the wellsite.

2 SITE SETTING

2.1 Location

The Wressle wellsite is located within the Ancholme Valley. The wellsite covers approximately 1.2 Ha of land and is located approximately 23km southwest of Kingston upon Hull, 7.5km east of the centre of Scunthorpe and 2km northeast of the centre of Broughton at NGR 496770 411106. The location of the wellsite is shown on Figure 1. The proposed layout of the wellsite is shown on Figure 2.

2.2 Topography

The wellsite is located in a low-lying area between Ella Beck and West Drain. Ella Beck forms the western and northern boundary of the application site. The ground level around the wellsite slopes gently to the east, dropping from 15mAOD at Lodge Farm to 5mAOD at the site; and 2mAOD at the New River Ancholme, east of the site.

2.3 Land Use

The Wressle wellsite is located in a rural location, with surrounding land predominantly used for agriculture. The closest residential dwelling is located approximately 450m west of the wellsite close to the B1208 road. The closest conurbation is Broughton; the outskirts of which are located approximately 1.7km southwest of the wellsite.

2.4 Soils

There are two soil types at the wellsite (taken from the LandIS Soilscapes website, developed by Cranfield University and accessed on 12/05/2016 [Ref. 3]). The western part of the wellsite is classified as 'freely draining very acid sandy and loamy soils' and the eastern part of the wellsite is classified as 'freely draining lime-rich loamy soils'.

3 HYDROLOGY

3.1 Hydrological Characterisation

The New River Ancholme is located approximately 2km east of the wellsite and flows north through the Ancholme Valley towards the River Humber. The river has been modified and is canalised from Bishopbridge in West Lindsey District to the River Humber mouth.

West Drain is a major drain in the vicinity of the site. It is located 400m east of the site and flows northerly for about 10km where it joins the New River Ancholme close to the mouth of River Humber.

The hydrological catchment descriptors relating to the wellsite, surrounding area and associated hydrological catchment have been derived from the Flood Estimation Handbook (FEH) CD-ROM 3 [Ref. 4] and are provided in Table 1.

Table 1 Hydrological Catchment Descriptors

Descriptor	Abbreviation	Value
Catchment Area	AREA	7.16km^2
Mean Altitude	ALTBAR	39mAOD
Mean direction of all drainage path slopes	ASPBAR	76^o
Base Flow Index associated with each HOST soil class	BFIHOST	0.797
Standard Percentage Runoff associated with each HOST soil class	SPRHOST	20.07%
Proportion of time when soil moisture deficit was equal to, or below, 6mm during 1961-90	PROPWET	0.26
Standard Average Annual Rainfall (1961 – 1990)	SAAR	637mm
Extent of urban and suburban land within catchment	URBEXT$_{2000}$	0.0791
Description of location of urban / suburban areas within catchment	URBLOC$_{2000}$	1.09
Concentration of catchment urbanisation (quantification of connectivity of urban and suburban areas)	URBCONC$_{2000}$	0.846

The standard average annual rainfall (SAAR) value is 637mm/annum, which is slightly less than the UK average but consistent with the region. The SPRHOST value indicates that the proportion of runoff within the catchment is 20%, which is a low value. This value is consistent with the natural soil type at the wellsite as detailed within Section 2.4. The BFIHOST value is 79.7%, which indicates that there is a large groundwater component in the river discharge. The urban extent registered in the year 2000 (URBEXT2000) is stated as 0.08, reflecting the rural nature of the catchment. The catchment descriptors are consistent with the site setting and known hydrogeological setting presented in Section 5.

3.2 Surface Water Features

Surface water features within 2km of the Wressle wellsite have been identified from 1:25,000 Ordnance Survey mapping. The locations of the major surface water features are presented on Figure 3 and their details are summarised in Table 2.

Table 2 Surface Water Features

Reference on Figure 3	Feature	Description	Approx. Distance from Wellsite(km)
F1	Ella Beck + West Drain	"Main River". Circumventing the site, running southwards on the western side and eastwards on the northern side and then northwards into River Humber.	0.06
F2	Large Pond	Large pond near Birdhouse Clough	1.32
F3	Small Pond	Stream and ponds system south of Far Wood Farm	1.28
F4	Springs	Springs west of Far Wood Farm	1.47
F5	Large Pond	Large pond	0.97
F6	Small Pond	Small fish ponds at the Priory	1.42
F7	Large Pond	Large pond at The Follies	1.91
F8	Small Pond	Small pond at Broom Hill	1.84
F9	Small Pond	Small ponds at Appleby Carrs Pumping Station	2
F10	Small Pond	Small pond at Kebwood Farm	1.04
F11	Small Pond	Small pond east of Rowland Plantation	0.59
F12	Small Pond	Small ponds near Broughton Grange and Common Farm	1.0
F13	Small Pond	Small pond at Wressle Wood	1.8
F14	Moor Beck	Beck flowing eastward and joining Ella Beck, associated pond near Watermill Place	1.91
F15	New River Ancholme	Bunded river, running northwards to River Humber	1.58
N/A	Field Drains	Various field drains and dykes within the 2km radius	N/A

Surface water at the Wressle wellsite will be managed during the development as outlined in Section 8 in order to prevent any surface water associated with the proposed development coming into contact with any of the above surface water features.

3.3 Flood Zones

The Wressle wellsite is located in a Flood Risk Zone 1 (annual flood probability of less than 0.1%), with the access road partly lying in Zone 2 and 3(ii) (annual flood probability of 0.1% to 1% and greater than 1% respectively).

A Flood Risk Assessment for the wellsite was prepared by R Elliott Associates Ltd in January 2013 [Ref. 5] and the wellsite was constructed following the recommended mitigation measures to reduce the risk of flooding.

The proposed development, which is described fully in Section 7, is to enable commercial oil production and will not involve any landforming that will alter the risk of flooding to or from the site.

4 GEOLOGY

The geological setting has been characterised using British Geological Survey (BGS) Map Sheet 89 (Brigg); records from the BGS's database of water wells and boreholes; and geological data obtained by Egdon Resources during the construction of the Wressle-1 well. Excerpts from the BGS geological map are presented on Figures 4a, 4b and 4c.

4.1 Superficial Deposits

The geological map suggests that superficial deposits at the wellsite consist of blown sands. Peat and alluvium deposits are present to the east of the wellsite. The total thickness of superficial deposits is expected to be approximately 5m, as suggested by Envireau Water's interpretation of BGS records for nearby water wells in the area.

4.2 Bedrock Geology

The bedrock geology in the vicinity of the wellsite is characterised by Jurassic age strata. The wellsite is underlain by the Kellaways Formation (Ancholme Group) which is in turn underlain the Cornbrash Formation and the Blisworth Clay, Blisworth Limestone & Rutland Formations of the Great Oolite Group. Beneath this, the Inferior Oolite Group is present and consists of the Lincolnshire Limestone Formation, the Grantham Formation and the Northampton Sand Formation. The Inferior Oolite Group outcrops approximately 500m west of the wellsite. The Northampton Sand Formation lies unconformably on mudstones of the Lias Group.

The Jurassic age strata are underlain by the Penarth and Mercia Mudstone Groups, and the Sherwood Sandstone Group of Triassic age, which are in turn underlain by Permian and Carboniferous age bedrock.

The expected geology at the wellsite is summarised in Table 3. The expected depth and thicknesses of the Jurassic formations have been estimated by Envireau Water based on BGS 1:50,000 scale mapping, whilst the expected depth and thicknesses of the deeper strata is based on geological data obtained by Egdon Resources during the construction of the Wressle-1 well.

Table 3 Expected Geological Sequence

Age	Group	Formation	Description	Approx. Expected Thickness (m)	Approx. Depth to Base of Strata (mbgl)
Quaternary	Superficial Deposits		Blown sands / peat / alluvium deposits (clay and sand)	5	5
Middle Jurassic	Ancholme Group	Kellaways Formation	Mudstone, grey, silici-silty or silici-sandy	5	10
	Great Oolite Group	Cornbrash Formation	Limestone, bluish grey to olive or yellowish brown when weathered	2	12
		Blisworth Clay, Blisworth Limestone & Rutland Formations (formerly Upper Estuarine Series)	Clay, sandstone and limestone	13	25

Age	Group	Formation	Description	Approx. Expected Thickness (m)	Approx. Depth to Base of Strata (mbgl)
	Inferior Oolite Group	Lincolnshire Limestone Formation	Limestone	25	57
		Grantham Formation	Mudstone, sandy mudstone and argillaceous siltstone-sandstone	2	
		Northampton Sand Formation	Sandy ironstone with lenses of mudstone or limestone	5	
Lower Jurassic	Lias Group	Whitby Mudstone Formation	Fossiliferous mudstone and siltstone.	181	238
		Marlstone Rock Formation	Sandy, shell fragmental and ooidal ferruginous limestone interbedded with ferruginous calcareous sandstone		
		Dyrham Formation	Silty sandy mudstone		
		Charmouth Mudstone Formation	Dark grey shale and mudstone, argillaceous limestone or ironstone nodules		
		Scunthorpe Mudstone Formation	Calcareous and silty mudstone with thin beds of argillaceous limestone and calcareous siltstone		
Triassic	Penarth and Mercia Mudstone Groups		Mudstone with siltstone and evaporite	240	478
	Sherwood Sandstone Group		Sandstone with occasional beds of mudstone and siltstone	337	815
Permian	Zechstein Group		Mudstone and limestone with evaporite	322	1137
Carboniferous	Westphalian Group / Millstone Grit Group (including the Ashover Grit)/ Carboniferous Limestone Group		Sandstone, mudstone and coals measures	>657	>1794

4.3 Structural Geology

The bedrock strata dip at a shallow angle towards the east.

The Brigg Fault, located 1km west of the wellsite, trends in a northwest-southeast direction over a distance of 10km and downthrows the strata to the east by approximately 50m.

There are two smaller faults located 450m and 900m northeast of the wellsite; trending in a northwest-southeast direction and downthrowing strata to the west.

5 HYDROGEOLOGY

5.1 Aquifer Potential

The aquifer potential at the wellsite has been assessed using literature published by the BGS in the Major and Minor Aquifer databases [Ref. 6 and 7].

5.1.1 Superficial Deposits

The superficial deposits in the vicinity of the wellsite are predominantly comprised of alluviums, blown sand or sand and gravel. These deposits may contain shallow groundwater and could be targeted to provide small yields for domestic use. A shallow superficial deposits groundwater system up to approximately 5m is therefore expected to be present at the site.

5.1.2 Ancholme Group

The Kellaways Formation comprises low permeability mudstone and is considered essentially Unproductive. However, the Kellaways Sands (typically 2 to 4m thick) at the base of the formation may contain small quantities of groundwater [Ref. 7, p114].

5.1.3 Great Oolite Group

The underlying formations that make up the Great Oolite Group comprise mudstone, sandstone and limestone bedrock. The most productive layers are the Cornbrash Formation and the Blisworth Limestone Formation which are classified by the Environment Agency as Secondary aquifers. However, in this area the Cornbrash Formation is unlikely to contain significant quantities of groundwater due to its limited thickness and separation from the underlying Blisworth Limestone Formation by the Blisworth Clay Formation.

5.1.4 Inferior Oolite Group

The underlying Lincolnshire Limestone Formation is classified by the Environment Agency as a Principal aquifer. The Lincolnshire Limestone can be divided into two sub-units, the Upper Lincolnshire Limestone and the Lower Lincolnshire Limestone. The Upper Lincolnshire Limestone has a variable thickness but is dominantly a coarse, shelly cross-bedded oolite. The Lower Lincolnshire Limestone is a mainly fine-grained, micritic and peloidal limestone [Ref. 6, p135].

The Lincolnshire Limestone Formation outcrops approximately 250m west of the wellsite. The limestone dips to the east and thins from more than 30m in thickness at outcrop to less than 20m in thickness in the east where it is confined by the overlying mudstone and clays of the Upper Estuarine Series and becomes increasingly artesian in nature [Ref. 8]. An interpretation of data from the BGS water wells database by Envireau Water suggests groundwater heads in the Lincolnshire Limestone at the Wressle wellsite will be close to or above ground level (artesian conditions). Where the Grantham Formation is thin, the Lincolnshire Limestone is often in hydraulic continuity with the underlying Northampton Sand Formation [Ref.8]. There is also potential for a small amount of flow between the Lincolnshire Limestone and overlying Blisworth Limestone through the Rutland Formation [Ref. 6].

Groundwater movement through the limestone is almost entirely by fracture flow along well developed bedding plane fractures and joints. Groundwater flow in the Lincolnshire Limestone is eastwards downdip from the outcrop to the confined area. The Brigg Fault is likely to restrict groundwater flow as it downthrows the Lincolnshire

Limestone to the east by approximately 50m. The main recharge to the limestone aquifer is via rainfall. Spring lines occur along the top and the base of the Lincolnshire Limestone. Seasonal variations in the rest water levels in the Lincolnshire Limestone are typically in order of 10 to 15m due to the rapid response time of the aquifer to recharge. The groundwater is of good chemical quality, generally hard near the outcrop, softening in an easterly direction under cover of the permeable clay but the quality eventually deteriorates with increasing depths and distance to the outcrop [Ref. 9].

Groundwater in the Northampton Sand Formation is a combination of matrix and fracture flow. The Northampton Sand Formation form a reliable aquifer at shallow depths (less than 10m) beneath the ground surface. Springs occur at the junction of the sands with the underlying Whitby Mudstone (e.g. near Far Wood Farm). Water from the Northampton Sand Formation is generally of good quality but hard. [Ref. 7].

5.1.5 Lias Group

The Marlstone Rock Formation, which outcrops approximately 2.8km west of the wellsite, is the most important secondary aquifer in the Middle Lias with groundwater contained in, and transported through, a regionally developed fissure system. Both weathered and un-weathered Marlstone Rock are very fine grained with low matrix permeability; flow is therefore predominant along fissure with possibly small or non-existent matrix-flow. The Marlstone Rock is assumed to be in hydraulic continuity with the underlying Dyrham Formation siltstone. The water quality is generally good but hard and often ferruginous [Ref.7].

In the East Midlands Shelf, the permeable parts of the Scunthorpe Mudstone Formation are the thin limestone bands and calcareous sandy belt present towards the top. Yields are generally low. Groundwater quality is generally hard and often poor in the Scunthorpe Mudstone Formation; possibly saline or containing hydrogen sulphide from decomposing pyrite in the shales.

5.1.6 Triassic, Permian and Carboniferous Strata

The Penarth Group is classed as Unproductive strata and the Mercia Mudstone Group Secondary aquifer will also act as Unproductive strata at this location due to its depth. The base of the Mercia Mudstone is located at approximately 450m below ground level. It provides a hydraulic break between the groundwater systems that have a resource value and deeper water bearing systems in the deeper Triassic, Permian and Carboniferous strata that are likely to contain formation water with limited or no resource value. As documented by a geothermal investigation in the area [Ref. 10], the Triassic Sherwood Sandstone at this location contains formation water with an elevated salinity (TDS estimated to be around 7,500mg/L). Water bearing formations in the underlying Permian and Carboniferous bedrock are likely to contain saline water and hydrocarbons.

5.2 Protected Rights

Protected water rights within a 2km radius of the wellsite have been identified and are presented on Figure 5.

5.2.1 Licensed and Other Abstractions

Based on a search of the Environment Agency abstraction licence database, there is one licensed groundwater abstraction and three licensed surface water abstractions within the 2km radius. The location of the licensed abstractions are shown on Figure 5 and the licence details are summarised in Table 4.

Some of the licences cover multiple sources of abstraction. The licensed groundwater abstraction includes three sources (the Clapgate and Birdhouse Clough sources) all located 0.4km east of the wellsite; and two sources (the Bridge Road sources) located 1.5 and 1.9km southeast of the wellsite respectively.

Table 4 Licensed Abstractions

Source No. on Figure 5	Location	Source	Licence Number	Easting	Northing	Distance from Wellsite (km)
G1	Clapgate	Groundwater	4/29/07/*G/0020	497100	411330	0.4
G2	North of Birdhouse Clough Pumping Station	Groundwater		497080	411400	0.4
G3	Near Bridge Road Pumping Station	Groundwater		497800	410080	1.5
G4	South of Bridge Road Pumping Station	Groundwater		498000	409700	1.9
G5	Near Birdhouse Clough Pumping Station	Groundwater		497130	411330	0.4
S1	River Ancholme, Appleby	Surface Water (River)	4/29/05/*S/0020	498220	411750	1.6
S2	Planker Dyke	Surface Water (River)	4/29/07/*S/0037	498200	411670	1.5
S3	Planker Dyke	Surface Water (River)		498200	411600	1.5
S4	New River Ancholme LB Worlaby	Surface Water (River)	4/29/05/*S/0010	497970	412630	1.9

5.2.2 BGS Water Wells Database

A search of the BGS water wells online database has been undertaken, which has identified 32 water well records within the 2km search radius. However, the BGS data is indicative of water wells that have been historically present but may not necessarily be present or accessible now.

The majority of the records relate to water wells targeting the Lincolnshire Limestone Formation or the Marlstone Rock Formation. A few shallow wells target the Kellaways Formation. The closest water well record (WW1) is located on the wellsite close to the Ella Beck and targets the Lincolnshire Limestone Formation, however this well was not located during the construction of the wellsite. The deepest water well (WW10) is 122m deep and is located some 1.1km northwest of the wellsite at Rowlands Plantation and targets a number of formations including the Lincolnshire Limestone Formation and the Marlstone Rock Formation.

The well records are summarised in Appendix A and their locations are presented on Figure 5.

5.2.3 Private Water Supplies

A search of North Lincolnshire Council's register of Private Water Supplies (PWS) has been undertaken. The Council has confirmed that they have one PWS recorded within the 2km search radius. The location of the registered PWS is presented on Figure 5 and summarised in Table 5.

Table 5 Registered Private Water Supplies

Source No. on Figure 5	Location	Likely Target Aquifer	Easting	Northing	Distance from Wellsite (km)
G6	Stone Cottages, Brigg Road, Wressle, Brigg, DN20 0BT	Marlstone Rock Formation	497232	409412	1.7

It is recognised that the local authority's PWS register may be incomplete and that unrecorded supplies may exist at outlying properties. Based on the local geology, any unrecorded supplies in the vicinity of the wellsite would be most likely to target the Superficial Deposits or the Lincolnshire Limestone Formation.

The BGS water wells identified in Section 5.2.2 all have the potential to be used as PWS. In addition, a review of the 1:25,000 scale Ordnance Survey mapping data has identified seven other properties within the 2km radius where PWS could potentially be present. The location of the potential PWS are presented on Figure 5 and summarised in Table 6.

Table 6 Potential Private Water Supplies

Ref No. on Figure 5	Location	Easting	Northing	Distance from Wellsite (km)
P1	Broughton Grange	49700	41038	0.8
P2	Dairy Farm	49743	40997	1.3
P3	Sandhouse Farm	49563	41263	1.9
P4	Kebwood Farm	49626	41214	1.2
P5	Far Wood Farm	49614	41006	1.2
P6	Heron Lodge	49522	41067	1.6
P7	Springwood Cottage	49503	41109	1.7

5.3 Source Protection Zones

Source Protection Zones (SPZs) are used as a general level of protection for all drinking water sources, identifying those areas where the risk associated with groundwater contamination is greatest.

Data obtained from the Environment Agency indicates that the wellsite does not lie within a defined SPZ.

However, there are two SPZs relating to the licensed groundwater abstraction (Licence No. 4/29/07/*G/0020) at sources G1 to G5. The closest SPZ is east of the wellsite and relates to the Clapgate and Birdhouse Clough sources (G1, G2 & G5). The wellsite lies within 50m of the defined boundary of the outer zone of this SPZ. The second SPZ relates to the Bridge Road sources (G3 & G4); located southeast of the wellsite. The location of the Environment Agency defined SPZs are presented on Figure 5.

A default circular SPZ with a radius of 50m is applied to all other groundwater abstractions intended for human consumption. Based on the preceding desk based data review, there is potentially one water well (WW2) with a SPZ that could fall within 50m of the wellsite. WW2 is a historic water well constructed in the early 20th Century that appears to have been for exploration (ironstone mining) purposes.

5.4 Designated Sites

Natural England's MAgiC database indicates that there are two Sites of Special Scientific Interest (SSSI) within a 2km radius of the wellsite: the Broughton Far Wood SSSI and the Broughton Alder Wood SSSI. These sites are designated as SSSI due to their habitats of calcareous grassland and broadleaved, mixed and yew woodland. Both SSSI are not groundwater dependent and are located upgradient of the wellsite. The locations of the SSSI are presented on Figure 1.

There are no Special Areas of Conservation (SAC), Ramsar or other designated sites within a 2km radius of the wellsite.

5.5 Conceptual Hydrogeological Model

Based on the preceding data review, the conceptual hydrogeological model for the Wressle wellsite is illustrated on Figure 6 and can be summarised as follows:

- There are four hydrostratigraphic units – namely:
    - The Superficial Deposits, the Kellaways Formation, the Great Oolite Group, the Inferior Oolite Group and the Lias Group (Layer 1)
    - The Penarth and Mercia Mudstone Groups (Layer 2)
    - The Sherwood Sandstone Group (Layer 3)
    - The Permian and Carboniferous – the Zechstein Group, the Westphalian, Millstone Grit and Carboniferous Limestone Groups (Layer 4)
- The lateral variation in geology is controlled by dip and faulting.
- Recharge to the Sherwood Sandstone Group is limited to the outcrop and subcrop areas west of Scunthorpe. Recharge to the geology above the Lias Group occurs where the formations outcrop and subcrop across the Ancholme Valley.
- Hydraulic properties of the layers have been defined by literature search, but broadly:
    - Layer 1 can be taken as having useful hydraulic conductivity and storage.
    - Layer 2 is poorly permeable (very low hydraulic conductivity) and has limited useful storage.
    - Layer 3 has useful hydraulic conductivity and storage.
    - Layer 4 has limited hydraulic conductivity and storage, and poorly permeable clay and mudstone horizons at the top of the Permian effectively hydraulically separate the Permian (Layer 4) from the overlying Triassic water bearing formation.
- There is no vertical movement of water between the layers.
- Layer 1 comprises Principal and Secondary aquifers interbedded with Unproductive strata. Groundwater with a resource value is present in this layer.
- Layer 2 comprises approximately 250m of Unproductive strata and provides a vertical hydraulic break between useful groundwater in Layer 1 and formation waters contained in Layers 3 and 4.
- Layer 3 contains formation water with an elevated salinity and limited/no resource value.
- Layer 4 contains saline formation water, with no resource value. There is no active recharge to this layer.

6 EXISTING WELL

6.1 Regulatory Context

The Environment Agency regulates the environmental aspects of the onshore oil and gas industry in England through the Environmental Permitting Regulations (EPR) 2010.

The Health & Safety Executive (HSE) is the relevant regulator from a well integrity and site safety perspective and is responsible for overseeing that safe working practices are adopted by onshore operators as required under the Health and Safety at Work etc Act 1974, and regulations made under the Act. These specifically are:

- The Offshore Installations and Wells (Design and Construction, etc) Regulations 1996 (DCR), which apply to all wells drilled with a view to the extraction of petroleum, regardless of whether they are onshore or offshore. The regulations are primarily concerned with well integrity.
- The Borehole Site and Operations Regulations 1995 (BSOR), which apply to all onshore operations and are primarily concerned with the health and safety management of the wellsite.

There is a Memorandum of Understanding between the Environment Agency and the HSE [Ref. 11], to ensure effective coordination of the regulation of plant, processes and substances and measures to protect people and the environment, which are subject to regulation by both the Environment Agency and the HSE.

6.2 Wressle-1 Well Construction

The existing Wressle-1 well was constructed in August 2014 to a total measured depth (MD) of 2,236mbgl, which represents a true vertical depth (TVD) of 1,810mbgl. The well is deviated and a schematic showing the construction concept is provided on Figure 7. All measurements below are expressed in metres TVD referenced to ground level and have been interpreted from the well construction data provided by Egdon Resources.

The well has been constructed as follows:

- 334mm (13 $^{3}/_{8}$ ") diameter conductor casing installed to a depth of 61m TVD into the Lias Group.
- 241mm (9 $^{5}/_{8}$ ") diameter intermediate casing to a depth of 445m TVD into the Mercia Mudstone Group; just above the top of the Sherwood Sandstone Group.
- 175mm (7") diameter production casing to a depth of 847m TVD into the Permian strata.
- 114mm (4 ½ ") diameter 'production liner' installed from 771m to 1,810m TVD into the Carboniferous Limestone Group. The production liner is the term given to a production casing string that does not extend to the top of the wellbore.

As illustrated on Figure 7, construction has been carried out to prevent vertical migration of fluids between the different hydrostratigraphic units; with each casing string cemented and pressure tested on completion. The casing strings provide a permanent physical barrier between useful groundwater with a resource value that is present in the top ~200m of strata and used for potable and other supplies (Layer 1), and the brackish or saline and hydrocarbon rich formation waters present in the Triassic Sherwood Sandstone Group and Permian / Carboniferous strata (Layers 3 & 4) respectively; present beneath the Mercia Mudstone Group (Layer 2) at depths in excess of 450m. The low permeability and thickness of Layer 2 prevents upward or downward vertical migration between these layers.

The Wressle-1 well has been constructed in accordance with the DCR regulations and contains three cemented casings that provide barriers within the system to ensure well integrity, and prevent gas and fluids migrating between different hydrostratigraphic units.

6.3 Well Testing

Test operations conducted between January to March 2015, and between June to August 2015, showed that the three formations, the Ashover Grit, Wingfield Flags and Penistone Flags had the potential for commercial development. It is planned to initially develop the Carboniferous Ashover Grit Formation (present at a depth of 1580m TVD).

Civil engineering works at surface and well engineering works within the production zone of the Wressle-1 well are now required to develop the wellsite for commercial oil production.

7 PROPOSED DEVELOPMENT

Egdon Resources is progressing a Field Development Plan (FDP) for commercial oil production from the wellsite, based on conventional oil production from the Carboniferous Ashover Grit Formation.

In order to establish commercial oil production, one or more of the standard oilfield techniques described in the following sub sections may be used.

7.1 Drilling of a Sidetrack

A small sidetrack drilling operation may be undertaken to enhance oil flow from the Ashover Grit Formation. This will entail mobilisation of a drilling rig to the site to drill from the existing wellbore, just above the Ashover Grit Formation. The objective of the sidetrack would be to intersect the hydrocarbon reservoir and would comprise drilling a short length (c.25m) out from the existing casing. The drilling of the sidetrack will be undertaken using an oil based drilling fluid.

7.2 Radial Drilling

Egdon Resources may progress the option of radial-drilling two or more 'drain holes' into the Ashover Grit Formation. The drain holes would be achieved by drilling out of the existing casing using high-velocity fluid jets through a rotating nozzle, creating small lateral boreholes of 25 to 50mm in diameter, each up to 100m in length within the producing formation. Radial drilling would be undertaken using an oil based drilling fluid.

7.3 Wellbore Treatments

The plan requires the Wressle-1 well to undergo treatment in order to clean and rehabilitate it. The treatment will be in two phases, as follows:

Treatment Phase 1: Isolate the Ashover Grit Formation and carry out 'near well' treatment techniques to clean and rehabilitate the well; and to re-establish permeability in the Ashover Grit Formation close to the well (within approximately 10m).

Treatment Phase 2: Carry out a 'proppant squeeze' to enhance permeability within the formation; up to 40m from the well.

The treatments will improve the hydraulic efficiency of the well and the nearby surrounding formation; to enable oil to flow freely into the well for commercial production.

7.3.1 Treatment Phase 1: Near Well Treatments

A number of treatment techniques may be required to clean and rehabilitate the Wressle-1 well. All of the treatment techniques will remove deposits and debris that will have built up on the walls of the well and within the Ashover Grit Formation close to the well, since the initial drilling operation in 2014 and subsequent testing at the beginning of 2015.

The treatment techniques will utilise an injection line (formed from an open ended drill string) to allow treatment fluids to be pumped from surface to the target depth. Spent fluids and debris generated during the well treatment activities will be recovered from the well bore using reverse circulation.

Prior to carrying out any near well treatments, an engineering test will be undertaking to establish the natural fracture gradient of the formation. The engineering test, also known as a 'breakdown test', will determine the pressure at which the formation is likely to fracture, thus ensuring that any pressure applied to the formation during near well treatments does not exceed the natural fracture gradient of the formation.

The treatment techniques are described as follows:

1. **Acid Wash/Soak and Squeeze**. A low concentration (15%) acid solution, comprising of hydrochloric (HCl) and hydrofluoric (HF) acid solution will be pumped into the well at the required depth and circulated to remove carbonate deposits from the wall of the well and the throats of fractures. This process is termed an 'acid soak' or 'acid wash'. Once the well is clean, the acid solution will then be pumped into the well at the target depth and the well will be pressurised by pumping a low concentration (3-5%) ammonium chloride solution into the well to force or 'squeeze' the acid into the formation. The pressure applied will not exceed the fracture gradient of the target formation. The treatment is displaced with filtered diesel. The pressure will then be released to allow the injected fluids to be recovered from the well. The use of low concentration acid is analogous to the acidisation techniques used in the rehabilitation of public water supply and commercial water wells constructed within carbonate formations in the UK.

2. **Solvent Treatment**. Hydrocarbon based solvents (typically diesel) will be pumped into the well at the required depth and circulated to remove paraffin and asphaltene precipitates from the well and the near well formation. Solvents will also be pumped into the well and squeezed into the formation and then recovered, using the method described above for the acid squeeze.

3. **Nitrogen**. Liquefied nitrogen will be pumped into the well and squeezed into the formation, using the same method for the acid squeeze described above. As the liquefied nitrogen moves into the formation it turns to a gas and increases in volume; displacing debris from the formation into the well. Nitrogen can also be used with acid or other fluid treatments to energize the fluid, increasing fluid returns to surface.

4. **Hot washing**. Hot oil will be pumped into the well, circulated and recovered to dissolve or dislodge paraffin precipitates from the well.

On completion of each treatment, spent fluids and debris will be recovered from the well and disposed of to an Environment Agency approved waste disposal facility. While it is recognised that solvents and other hazardous/non-hazardous chemicals are being injected into the formation, the formation is hydrocarbon bearing and has 'no resource value'. In this case, Envireau Water considers the use of the above treatment techniques to be appropriate from both a technical and regulatory perspective.

7.3.2 Treatment Phase 2: Proppant Squeeze

A proppant squeeze may also be undertaken to further enhance the permeability of the formation close to the well. The proppant squeeze will initially involve pumping a low volume (c. 15 to 20m^3) of fluid into the well at the target depth to establish injectivity parameters. Once the injectivity parameters have been established, a low volume (c. 80 to 120 m^3) of fluid containing 20 to 30 tonnes of proppant (sand) will be pumped into the well at the target depth, and then pressurised to open up a single vertical fracture within the formation. On release of the pressure, the proppant will allow the fracture to remain open resulting in increased permeability and a greater ability for oil to flow from the formation. Modelling carried out by Egdon Resources (Appendix B) shows that the proppant squeeze will extend a lateral distance of approximately 40m from the wellbore and will extend up to 20m in height

above and below the perforations. The fracture created by the proppant squeeze will therefore remain within the Carboniferous Millstone Grit strata and will not extend into overlying formations.

7.4 Commercial Production

Once the near well treatments and/or proppant squeeze have been carried out, the Wressle-1 well will be ready to be brought into commercial production. Civil engineering works will be carried out at the wellsite including establishing a storage area for produced oil and water, and a 500KW electrical export facility. These facilities will be developed within special bunded areas and without causing damage to the integrity of the base of the wellsite.

8 WELLSITE CONSTRUCTION & WATER MANAGEMENT

8.1 Wellsite Construction

The construction of the Wressle-1 wellsite can be summarised as follows:

- The wellsite was constructed in 2014. A general arrangement diagram is presented in Figure 2.
- Earth banks/bunds are located around the boundaries of the wellsite.
- Covered filter drains are installed along the boundaries of the wellsite to collect surface runoff. The northern filter drain is connected to an oil-water separator (interceptor) after which water discharges into the Ella Beck to the north of the site.
- The earth banks/bunds and filter drains prevent overland flow to or from the wellsite.
- The base of the wellsite is formed from a low permeability clay liner ("Bentomat") above graded subsoil. The clay liner prevents surface water collecting at the wellsite infiltrating to ground. A 300mm thick layer of crushed stone is emplaced above the clay liner to provide a hardstanding area.
- Storage areas (produced water, oil, etc.) are bunded and surface water collecting in these areas is tankered away from the wellsite.

8.2 Existing Water Management

The Wressle wellsite utilises earth bunds and perimeter ditches/covered filter drains to manage surface water runoff. Water collecting at the wellsite is discharged to an existing small river (the Ella Beck) located along the northern boundary of the wellsite. Water collecting near any operational parts of the wellsite first passes through an oil-water separator (interceptor).

Runoff from the operational and storage tank bunded areas is contained and removed from the wellsite by tanker to an Environment Agency approved waste disposal facility.

The drainage system at the wellsite has been developed to allow discharge to the Ella Beck to occur as required, depending on storage capacity within the perimeter filter drains and the hardstanding areas of the wellsite, and rainfall events.

8.3 Proposed Water Management

Any plant, equipment and materials required to carry out the proposed treatment works will (where necessary) be bunded and any runoff contained and removed from the wellsite by tanker to an Environment Agency approved waste disposal facility.

All the storage tanks and gas/water separation facilities required for commercial production will be bunded and water removed by tanker to an Environment Agency approved waste disposal facility.

Surface water collecting across the remainder of the wellsite will be managed and discharged in the normal way.

The proposed water management strategy will ensure containment of any surface runoff from the areas of the wellsite where the treatment works are being carried out and that only clean, surface water runoff is discharged to the adjacent river.

9 HYDROGEOLOGICAL RISK ASSESSMENT

9.1 Assessment Methodology

A hydrogeological risk assessment (HRA) for the proposed treatment operations has been carried out in accordance with the Source-Pathway-Receptor (S-P-R) approach described in GL III [Ref. 2] and the methodology in the Environment Agency's H1 Environmental Risk Assessment framework – Annex J (Groundwater) [Ref. 12]. The basis of the risk assessment method is the selection of an appropriate level of detail for the assessment. Ref. 12 proposes three levels of details or Tiers from Tier 1 to Tier 3, where Tier 1 is qualitative and Tier 3 is highly quantitative. The selection of the appropriate tier requires an iterative approach based on an initial assessment and consideration of the outcome using a Tier 1 system. If that approach shows that the system is too complex or outcomes cannot be fully mitigated then a more detailed or quantitative approach would be warranted.

The construction and restoration of wellsites and the construction, testing and decommissioning of oil and gas wells is well understood, as is the geology and hydrogeology at the Wressle wellsite. Mitigation measures are clearly defined, tested and known to work. Therefore, a Tier 1 assessment is considered to be appropriate for the proposed development.

The assessment method, scoring and risk calculation is presented in Appendix C.

9.2 Hazard Identification

The data review has identified sensitive receptors that may be at risk from the proposed development. Table 7 presents the source-pathway-receptor linkage for the hazards during each of the development phases and shows that there are pollutant linkages (pathways) between potentially polluting activities and surface water and groundwater receptors, including:

- Surface water receptors comprising the field drains and becks in close proximity to the Wressle-1 wellsite.
- Groundwater receptors close to the wellsite with a resource value including:
    - Shallow, superficial deposits (Secondary aquifer)
    - Lincolnshire Limestone Formation (Principal aquifer)
    - Kellaways Formation, Great Oolite Group, Northampton Sand Formation and the Lower Lias Group (Secondary bedrock aquifers)
    - Private water supplies targeting the above
- Deeper water bearing formations beneath the Lias Group with limited or no resource value.

9.3 Risk Assessment

A risk assessment has been carried out based on the identified hazards in accordance with the methodology presented in Appendix C. A summary is presented in Table 8 and discussed in the subsections below.

9.3.1 Receptor Sensitivity

Receptor sensitivity has been assigned in accordance with Table C.1 in Appendix C.

The Ella beck is classed as a 'main' river and the surface water features have all been assessed as having a high sensitivity. No ecological status has been defined by the Environment Agency for the Ella Beck.

The most significant groundwater receptor at the wellsite is the Lincolnshire Limestone Formation (Principal aquifer), which is assessed as having a high sensitivity. The superficial deposits and Secondary bedrock aquifers from the Kellaways Formation, the Great Oolite Group, the Northampton Sand Formation and the Lower Lias Group are assessed as having a medium sensitivity. The deeper water bearing formations beneath the Lias Group are assessed as having a low sensitivity.

9.3.2 Magnitude of Impact

Magnitude of Impact has been assigned with reference to Table C.2 in Appendix C.

If the surface water features, the Principal Lincolnshire Limestone aquifer or any of the Secondary aquifers became contaminated during the proposed development, the magnitude of the impact would be classed as high, because there could be a major change to the water quality.

The magnitude of impact of contamination of the deeper water bearing formations is classed as very low because water from these formations is of poor quality, with limited or no resource value.

9.3.3 Significance of Effect

Significance of Effect has been assigned with reference to Table C.3 in Appendix C.

It follows that there are major effects to the surface water features and the Principal Lincolnshire Limestone aquifer, moderate effects to the Secondary aquifers and negligible effects to the deeper water bearing formations during the proposed development.

9.4 Likelihood of Occurrence

The Likelihood of Occurrence has been assigned with reference to Table C.4 in Appendix C.

During all phases of the proposed development, there is a moderate likelihood of leaching and/or spillage of produced water, hydrocarbons and chemical additives at the surface of the wellsite; and discharge to surface water or infiltration to shallow groundwater. However, the likelihood of infiltration from the surface of the wellsite to the Principal Lincolnshire Limestone aquifer and Secondary aquifer formations is low. This is due to the hydraulic break provided by the low permeability formations that overly the Lincolnshire Limestone and the presence of an upwards hydraulic gradient that prevents downwards movement of water.

The potential impacts relating to the sub-surface activities (well treatments) are unlikely to occur.

9.5 Risk Analysis

A qualitative risk analysis has been carried out in accordance with Table C.5 in Appendix C.

It follows that the highest risk is to surface waters and shallow groundwater. The risks relating to sub-surface activities (well treatments) are low or very low.

9.5.1 Mitigation

The Wressle-1 well was constructed in 2014 in accordance with the DCR and BSOR regulations. The groundwater and water bearing formations present above the Carboniferous strata were cased, grouted and sealed before the well was progressed into the target hydrocarbon bearing formation. This prevents direct migration of hydrocarbons, any produced water and treatment fluids from the wellbore to the groundwater systems above the Mercia Mudstone Group.

The Wressle wellsite was constructed in accordance with best practice in wellsite construction and includes earth bunds and perimeter filter drains constructed around the boundary of the wellsite, to prevent overland flow and manage surface water runoff.

During the development, any plant, equipment and materials required to carry out the proposed treatment works will (where necessary) be bunded and any runoff contained and removed from the wellsite by tanker to an Environment Agency approved waste disposal facility.

All the storage tanks and gas/water separation facilities required for commercial production will be bunded and water removed by tanker to an Environment Agency approved waste disposal facility.

9.5.2 Residual Risk

As shown in Table 8, with the above mitigation measures in place, the likelihood of occurrence for all the identified hazards reduce to very unlikely. The residual risks associated with the identified hazards are therefore very low or none and are not significant.

Table 7 Source-Pathway-Receptor (S-P-R) Linkage

Phase	Hazard	Source (S)	Pathway (P)	Receptors (R)	S-P-R Linkage
Drilling Sidetrack; Radial Drilling	Hydrocarbon fuels and lubricants	Plant and equipment used to carry out the drilling	Spillage and discharge to surface water; infiltration to groundwater through the base of the wellsite	Surface water	Yes
				Shallow, superficial deposits (Secondary aquifer)	Yes
				Lincolnshire Limestone Formation (Principal aquifer)	No
				Secondary bedrock aquifers	No
				Deeper water bearing formations below the Lias	No
Treatment Phases	Hydrocarbon fuels and lubricants	Plant and equipment used to carry out the well treatment activities	Spillage and discharge to surface water; infiltration to groundwater through the base of the wellsite	Surface water	Yes
				Shallow, superficial deposits (Secondary aquifer)	Yes
				Lincolnshire Limestone Formation (Principal aquifer)	No
				Secondary bedrock aquifers	No
				Deeper water bearing formations below the Lias	No
	Well treatment fluids including acid, solvents, hydrocarbons and proppant; Produced water, natural gases and hydrocarbons from deep geological formations.	Well treatment fluids handled at surface	Spillage and discharge to surface water; infiltration to groundwater through the base of the wellsite	Surface water	Yes
				Shallow, superficial deposits (Secondary aquifer)	Yes
				Lincolnshire Limestone Formation (Principal aquifer)	No
				Secondary bedrock aquifers	No
				Deeper water bearing formations below the Lias	No
		Well treatment fluids pumped into the well and Ashover Grit Formation	Loss of well integrity leading to leakage	Surface water	Yes
				Shallow, superficial deposits (Secondary aquifer)	Yes
				Lincolnshire Limestone Formation (Principal aquifer)	Yes
				Secondary bedrock aquifers	Yes
				Deeper water bearing formations below the Lias	Yes
				Surface water	No
				Shallow, superficial deposits (Secondary aquifer)	No

Phase	Hazard	Source (S)	Pathway (P)	Receptors (R)	S-P-R Linkage
			Migration along natural faults and induced fractures	Lincolnshire Limestone Formation (Principal aquifer)	No
				Secondary bedrock aquifers	No
				Deeper water bearing formations below the Lias	No
			Vertical migration through the Millstone Grit Group	Surface water	No
				Shallow, superficial deposits (Secondary aquifer)	No
				Lincolnshire Limestone Formation (Principal aquifer)	No
				Secondary bedrock aquifers	No
				Deeper water bearing formations below the Lias	No
		Spent fluids recovered from the well after treatment activities	Spillage and discharge to surface water; infiltration to groundwater through the base of the wellsite	Surface water	Yes
				Shallow, superficial deposits (Secondary aquifer)	Yes
				Lincolnshire Limestone Formation (Principal aquifer)	No
				Secondary bedrock aquifers	No
				Deeper water bearing formations below the Lias	No
Commercial Production	Hydrocarbon fuels and lubricants	Plant and equipment used to prepare the wellsite for commercial production	Spillage and discharge to surface water; infiltration to groundwater through the base of the wellsite	Surface water	Yes
				Shallow, superficial deposits (Secondary aquifer)	Yes
				Lincolnshire Limestone Formation (Principal aquifer)	No
				Secondary bedrock aquifers	No
				Deeper water bearing formations below the Lias	No
	Hydrocarbon fuels	Commercial oil tanker movements	Spillage and discharge to surface water; infiltration to groundwater through the base of the wellsite	Surface water	Yes
				Shallow, superficial deposits (Secondary aquifer)	Yes
				Lincolnshire Limestone Formation (Principal aquifer)	No
				Secondary bedrock aquifers	No
				Deeper water bearing formations below the Lias	No

Phase	Hazard	Source (S)	Pathway (P)	Receptors (R)	S-P-R Linkage
	Produced water, natural gases and hydrocarbons from deep geological formations	Ashover Grit Formation	Loss of well integrity leading to leakage	Surface water	Yes
				Shallow, superficial deposits (Secondary aquifer)	Yes
				Lincolnshire Limestone Formation (Principal aquifer)	Yes
				Secondary bedrock aquifers	Yes
				Deeper water bearing formations below the Lias	Yes
			Migration along natural faults and induced fractures	Surface water	No
				Shallow, superficial deposits (Secondary aquifer)	No
				Lincolnshire Limestone Formation (Principal aquifer)	No
				Secondary bedrock aquifers	No
				Deeper water bearing formations below the Lias	No
			Vertical migration through the Millstone Grit Group	Surface water	No
				Shallow, superficial deposits (Secondary aquifer)	No
				Lincolnshire Limestone Formation (Principal aquifer)	No
				Secondary bedrock aquifers	No
				Deeper water bearing formations below the Lias	No

Table 8 Risk Assessment Summary

Phase	Hazard	Source (S)	Pathway (P)	Receptors (R)	Receptor Sensitivity	Magnitude of Impact	Significance of Effect	Likelihood of Occurrence	Risk Analysis	Mitigation	Likelihood of Occurrence after Mitigation	Residual Risk after Mitigation
Drilling Sidetrack; Radial Drilling	Hydrocarbon fuels and lubricants	Plant and equipment used to carry out the drilling	Spillage and discharge to surface water; infiltration to groundwater through the base of the wellsite	Surface water	High	High	Major	Moderate	**Medium**	Best practice in wellsite construction removes pathway, e.g. wellsite is underlain by impermeable membrane; contact water will be contained on site	Very Unlikely	**Very Low**
				Shallow, superficial deposits (Secondary aquifer)	Medium	High	Moderate	Moderate	**Low**		Very Unlikely	**None**
Treatment Phases	Hydrocarbon fuels and lubricants	Plant and equipment used to carry out the well treatment activities	Spillage and discharge to surface water; infiltration to groundwater through the base of the wellsite	Surface water	High	High	Major	Moderate	**Medium**	Best practice in wellsite construction removes pathway, e.g. wellsite is underlain by impermeable membrane; contact water will be contained on site	Very Unlikely	**Very Low**
				Shallow, superficial deposits (Secondary aquifer)	Medium	High	Moderate	Moderate	**Low**		Very Unlikely	**None**
	Well treatment fluids including acid, solvents, hydrocarbons and proppant; Produced water, natural gases and hydrocarbons from deep geological formations.	Well treatment fluids handled at surface	Spillage and discharge to surface water; infiltration to groundwater through the base of the wellsite	Surface water	High	High	Major	Moderate	**Medium**	Best practice in wellsite construction removes pathway, e.g. wellsite is underlain by impermeable membrane; contact water will be contained on site	Very Unlikely	**Very Low**
				Shallow, superficial deposits (Secondary aquifer)	Medium	High	Moderate	Moderate	**Low**		Very Unlikely	**None**
		Well treatment fluids pumped into the well and Ashover Grit Formation	Loss of well integrity leading to leakage	Surface water	High	High	Major	Unlikely	**Low**	Best practice in well construction removes pathway, e.g. surface casings provide multiple barriers between deep and shallow hydrogeological systems. Fracture created by proppant	Very Unlikely	**Very Low**
				Shallow, superficial deposits (Secondary aquifer)	Medium	High	Moderate	Unlikely	**Very Low**		Very Unlikely	**None**
				Lincolnshire Limestone Formation	High	High	Major	Unlikely	**Low**		Very Unlikely	**Very Low**

Phase	Hazard	Source (S)	Pathway (P)	Receptors (R)	Receptor Sensitivity	Magnitude of Impact	Significance of Effect	Likelihood of Occurrence	Risk Analysis	Mitigation	Likelihood of Occurrence after Mitigation	Residual Risk after Mitigation
				(Principal aquifer)						squeeze will be limited to Millstone Grit		
				Secondary bedrock aquifers	Medium	High	Moderate	Unlikely	**Very Low**		Very Unlikely	**None**
				Deeper water bearing formations below the Lias	Low	Very Low	Negligible	Unlikely	**None**		Very Unlikely	**None**
		Spent fluids recovered from the well after treatment activities	Spillage and discharge to surface water; infiltration to groundwater through the base of the wellsite	Surface water	Medium	High	Moderate	Moderate	**Low**	Best practice in wellsite construction removes pathway, e.g. wellsite is underlain by impermeable membrane; contact water will be contained on site	Very Unlikely	**None**
				Shallow, superficial deposits (Secondary aquifer)	Medium	High	Moderate	Moderate	**Low**		Very Unlikely	**None**
Commercial Production	Hydrocarbon fuels and lubricants	Plant and equipment used to prepare the wellsite for commercial production	Spillage and discharge to surface water; infiltration to groundwater through the base of the wellsite	Surface water	High	High	Major	Moderate	**Medium**	Best practice in wellsite construction removes pathway, e.g. wellsite is underlain by impermeable membrane; contact water will be contained on site	Very Unlikely	**Very Low**
				Shallow, superficial deposits (Secondary aquifer)	Medium	Low	Minor	Moderate	**Very Low**		Very Unlikely	**None**
	Hydrocarbon fuels	Commercial oil tanker movements	Spillage and discharge to surface water; infiltration to groundwater through the base of the wellsite	Surface water	High	High	Major	Moderate	**Medium**	Best practice in wellsite construction removes pathway, e.g. wellsite is underlain by impermeable membrane; contact water will be contained and disposed of by tanker	Very Unlikely	**Very Low**
				Shallow, superficial deposits (Secondary aquifer)	Medium	High	Moderate	Moderate	**Low**		Very Unlikely	**None**

Phase	Hazard	Source (S)	Pathway (P)	Receptors (R)	Receptor Sensitivity	Magnitude of Impact	Significance of Effect	Likelihood of Occurrence	Risk Analysis	Mitigation	Likelihood of Occurrence after Mitigation	Residual Risk after Mitigation
	Produced water, natural gases and hydrocarbons from deep geological formations	Ashover Grit Formation	Loss of well integrity leading to leakage	Surface water	High	High	Major	Unlikely	**Low**	Best practice in well construction removes pathway, e.g. surface casings provide multiple barriers between deep and shallow hydrogeological systems. Fracture created by proppant squeeze will be limited to Millstone Grit	Very Unlikely	**Very Low**
				Shallow, superficial deposits (Secondary aquifer)	Medium	High	Moderate	Unlikely	**Very Low**		Very Unlikely	**None**
				Lincolnshire Limestone Formation (Principal aquifer)	High	High	Major	Unlikely	**Low**		Very Unlikely	**Very Low**
				Secondary bedrock aquifers	Medium	High	Moderate	Unlikely	**Very Low**		Very Unlikely	**None**
				Deeper water bearing formations below the Lias	Low	Very Low	Negligible	Unlikely	**None**		Very Unlikely	**None**

10 OUTLINE SCHEME OF MONITORING

To demonstrate the effectiveness of the mitigation measures, an appropriate scheme of monitoring is required incorporating monitoring boreholes constructed at the wellsite and relevant off site surface water and groundwater features.

Based on the risk assessment in Section 9, the main risks from the development is to surface water and shallow groundwater features in close proximity of the site. However, it is also recognised that the site is underlain by a Principal aquifer of regional significance.

An outline scheme of monitoring has been developed taking account of the hydrogeological setting and the risk profile of the development. The final scheme will be subject to field verification of water features and will be agreed with the Environment Agency through the environmental permitting process; prior to development commencing. Monitoring will provide a groundwater quality baseline against which any changes in chemical and physical attributes during the development phases can be measured.

10.1 Water Monitoring Boreholes at the Wellsite

It is proposed to install three shallow boreholes up to a depth of approximately 5m to target the shallow groundwater system in the superficial deposits at the Wressle wellsite.

Provisional locations for the shallow boreholes are presented on Figure 8 and have been chosen based on the expected hydraulic gradient within the superficial deposits being towards the east; and taking account of physical site constraints. If on completion of the shallow boreholes the hydraulic gradient is not as expected, then a fourth shallow borehole may be constructed to achieve adequate triangulation of hydraulic heads.

It is also proposed to install a single, deeper borehole to a depth of up to approximately 50m, to target the Lincolnshire Limestone Formation beneath the site. The borehole will be located towards the east of the site (down hydraulic gradient) as shown on Figure 8.

The proposed construction of the monitoring boreholes is presented on Figure 9a and 9b. The monitoring boreholes will be constructed at a minimum 50mm finished diameter to allow the installation of a water sampling pump or bailer; and completed with headworks to facilitate head space gas sampling in the event it is required. The as-built construction details will be confirmed to the Environment Agency following completion.

10.2 Offsite Water Features

The desk based water features survey has identified a number of groundwater and surface water features within 2km of the Wressle wellsite. Subject to the consent of relevant landowners, all of the features identified will be verified in the field to ascertain their suitability for monitoring. Given the large number of water features that are potentially present, only the most relevant ones will be included within the final scheme. Features will be incorporated based on their proximity to the wellsite and to ensure sufficient spatial coverage of the different types of features around the wellsite.

10.3 Monitoring Parameters

The scheme of monitoring will comprise water sampling with field and laboratory analysis of the parameters listed in Table 9.

It is proposed that monitoring will be carried out monthly for at least three months before the development starts at the Wressle wellsite; to allow enough data to be collected to provide a water quality baseline. The data from the water sampling will be reviewed and discussed with the Environment Agency prior to the commencement of the well treatment and the scheme of monitoring may be adjusted from time-to-time based on the review of data.

Table 9 Analysis Parameters

Parameter	Field Analysis	Laboratory Analysis
pH	Y	Y
Temperature	Y	N
Electrical conductivity	Y	Y
Salinity	N	Y
Major/Minor ions[1]	N	Y
Petroleum Hydrocarbons, including dissolved methane[2]	N	Y
Treatment additives (To be defined by Egdon Resources)	N	Y
Water Level	Y	N

Notes: 1. Including Sodium, Potassium, Magnesium, Calcium, Chloride, Sulphate, Bicarbonate Alkalinity
2. Analysis for dissolved methane from suitable groundwater sources only

10.4 Monitoring Frequency

The frequency of monitoring will be agreed with the Environment Agency. At this stage, it is envisaged that baseline monitoring will be carried out monthly for at least three months before the development commences. A higher frequency of monitoring may be justified during some of the development phases.

10.5 Sampling Methodology

Water samples will be collected with reference to the British Standard for guidance on sampling of groundwaters (BS ISO 5667-11:2009, BS 6068-6.11:2009) [Ref. 13] and National Water Hygiene technical guidance [Ref. 14].

The exact sampling methodology for the wellsite monitoring boreholes will be dependent on the as built construction of the boreholes however, at this stage it is expected that a dedicated pneumatic bladder pump will be installed in each monitoring borehole to collect groundwater samples.

The use of bladder pumps is a low flow sampling technique and has been selected to ensure that water samples are as representative of the formation water chemistry as possible. A sampling pump may not be required in the wellsite monitoring borehole targeting the Lincolnshire Limestone if artesian conditions are encountered. Groundwater from borehole purging will be discharged to the wellsite drainage system.

Water samples from offsite monitoring locations will be obtained using bailers or existing pumps (where fitted).

10.6 Reporting

The data from the baseline monitoring will be reviewed and discussed with the Environment Agency prior to the commencement of the development. Data obtained during the development phase will be reviewed following each sampling round and will be reported at a frequency agreed with the Environment Agency. The scheme of monitoring will be regularly reviewed and a written report submitted to the Environment Agency for approval, detailing the review and containing any proposals for amendments to the scheme of monitoring.

11 SUMMARY & CONCLUSIONS

A hydrogeological risk assessment has been carried out in accordance with the methodology described in the Environment Agency's H1 Environmental Risk Assessment framework – Annex J (Groundwater).

The assessment demonstrates there are risks to surface water and groundwater receptors. These risks are reduced through mitigation measures, resulting in their being a very low or no overall residual risk of the proposed development. Consequently, residual risks are not significant.

Risks are mitigated by adopting the best practice approach to all phases of the proposed development, as described in the planning application.

An outline scheme of monitoring has been presented to demonstrate the effectiveness of the proposed mitigation measures. The scheme of monitoring will provide a robust water quality baseline against which any changes in chemical and physical attributes can be measured during and after the development.

Envireau Water
02/06/2016

12 REFERENCES

Ref. 1: Groundwater Protection: Principles and Practice (GP3), Version 1.1, Environment Agency, August 2013.

Ref. 2: Green Leaves III - Guidelines for Environmental Risk Assessment and Management: Green Leaves III. Revised Departmental Guidance Prepared by Defra and the Collaborative Centre of Excellence in Understanding and Managing Natural and Environmental Risks, Cranfield University November, 2011.

Ref. 3: Soilscapes (Cranfield University) Cranfield Soil and AgriFood Institute, October 2015. http://www.landis.org.uk/soilscapes/

Ref. 4: Flood Estimation Handbook (FEH) CD-ROM 3 (2010). Centre for Ecology and Hydrology, Wallingford.

Ref. 5: Assessment of Geology, Flood Risk and Pollution Control, prepared by R. Elliott Associates Ltd for Egdon Resources U.K. Ltd, January 2013.

Ref. 6: Allen, D. J., et al (1997). The physical properties of major aquifers in England and Wales. BGS Tech. Rep. WD/97/34. Environment Agency R&D publc. 8.

Ref. 7: H. K., et al. (2000). The physical properties of minor aquifers in England and Wales. BGS Tech. Rep. WD/00/04. Environment Agency R&D publc. 68.

Ref. 8: Griffiths, KJ, Shand, P, Marchant, P and Peach 2006. Baseline Report Series 23: The Lincolnshire Limestone, British Geological Survey Commissioned Report No. CR/06/060N

Ref. 9: Hydrogeological Map of North and East Lincolnshire, British Geological Survey, 1967

Ref. 10: Gale, I.N., et al. (1983). The post Carboniferous rocks of the East Yorkshire and Lincolnshire Basin, Investigation of the Geothermal Potential of the UK. British Geological Survey.

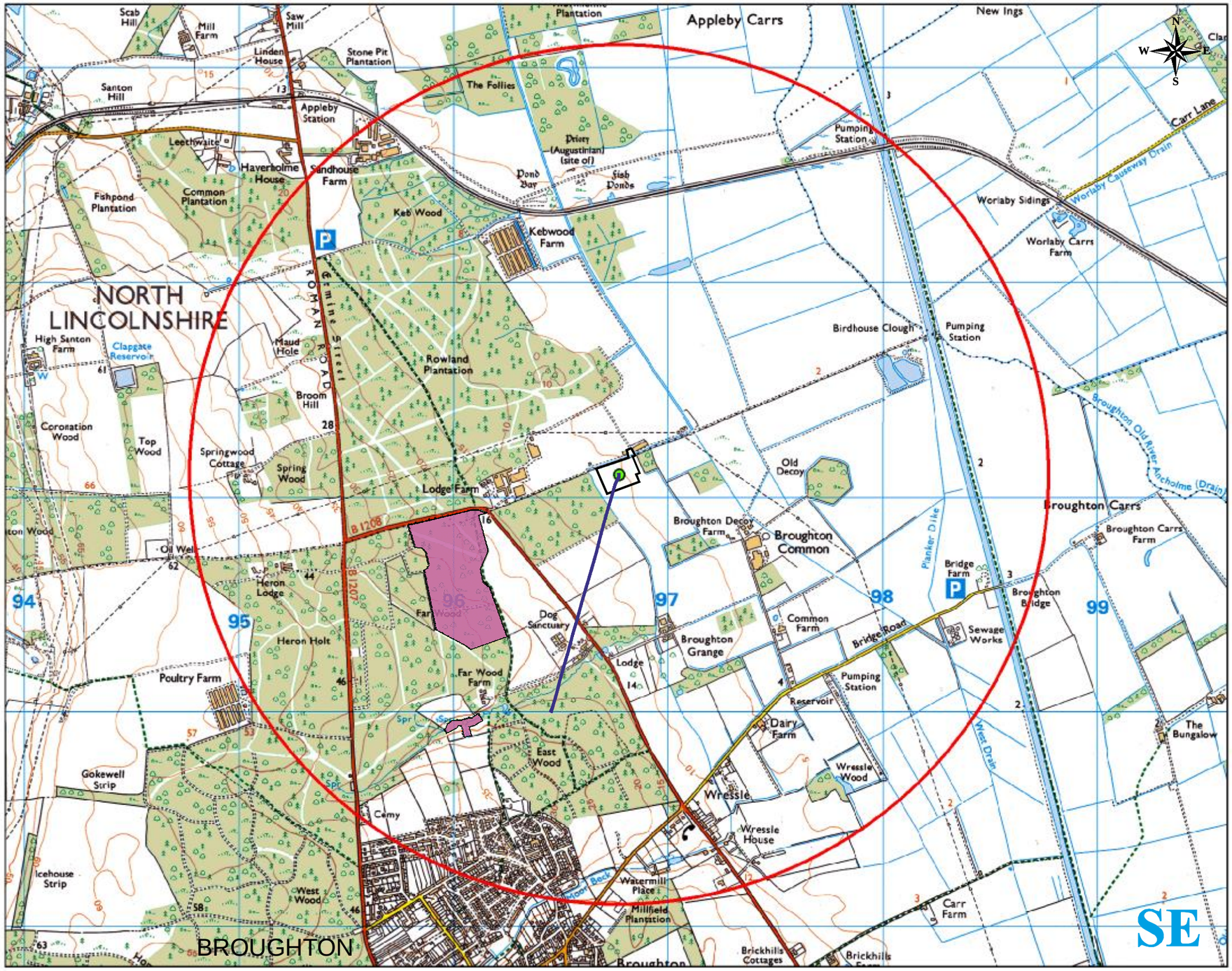
Ref. 11: Memorandum of Understanding between the Environment Agency and the Health and Safety Executive, July 2000.

Ref. 12: H1 Environmental Risk Assessment framework – Annex J (Groundwater). Environment Agency, 2010.

Ref. 13: Water quality - Sampling - Part 11: Guidance on sampling of groundwaters (BS ISO 5667-11:2009, BS 6068-6.11:2009).

Ref. 14: National Water Hygiene technical guidance. http://www.eusr.co.uk/directory/scheme/30095.

FIGURES



KEY

- Wressle 1 Borehole Location (NGR SE 96770 11106)
- Underground Borehole Track
- Approx. Site Boundary
- 2km Search Radius
- Site of Special Scientific Interest (SSSI)

Scale 1: 20,000 at A3

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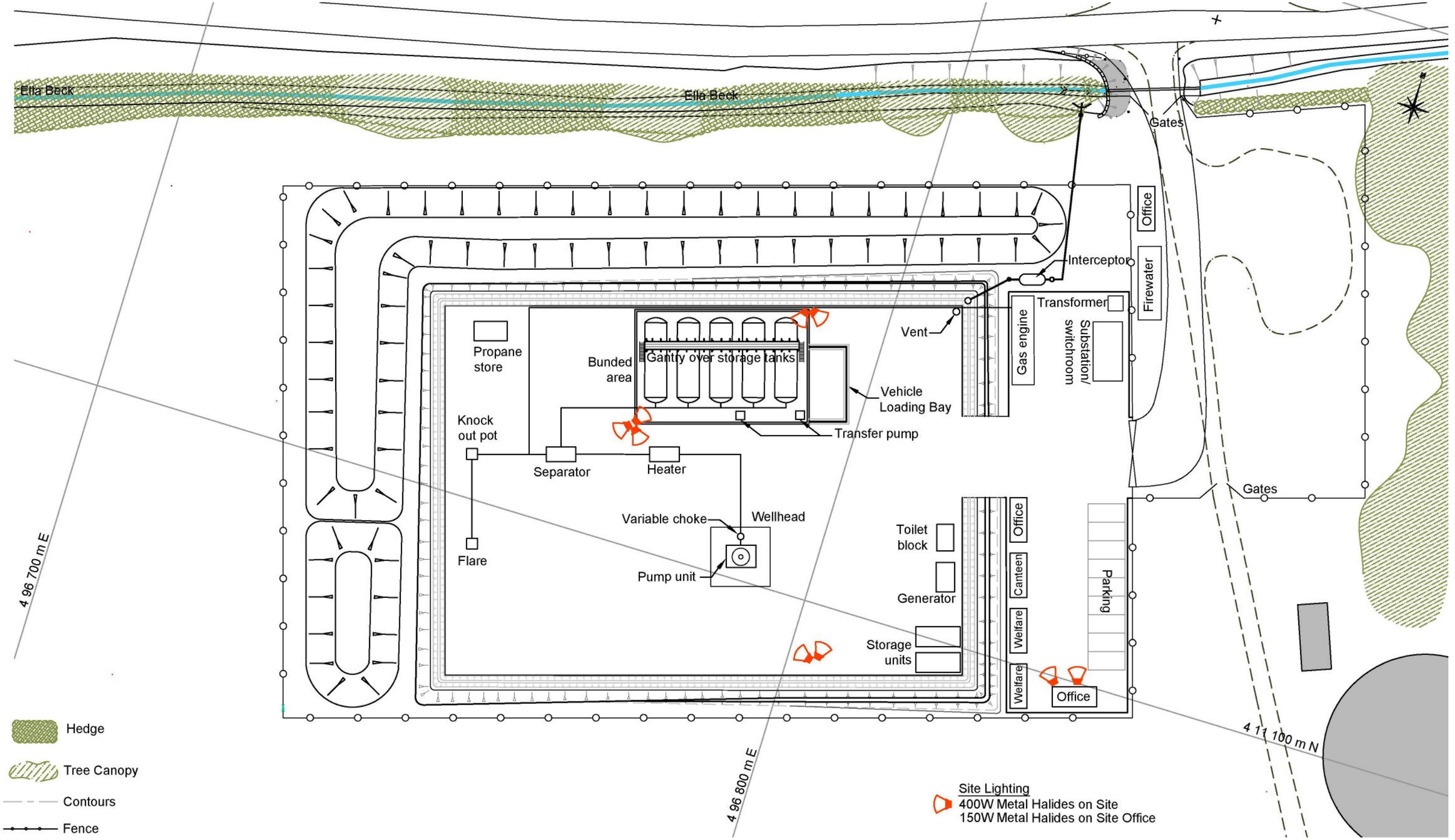
Ref: P:\Egdon Wressle (1933)\Figures\ Figure 1 - Location Map rev1.cdr Date: 12/05/2016	Egdon Resources
Figure 1	Site Location Map



Scale 1: 500 at A3

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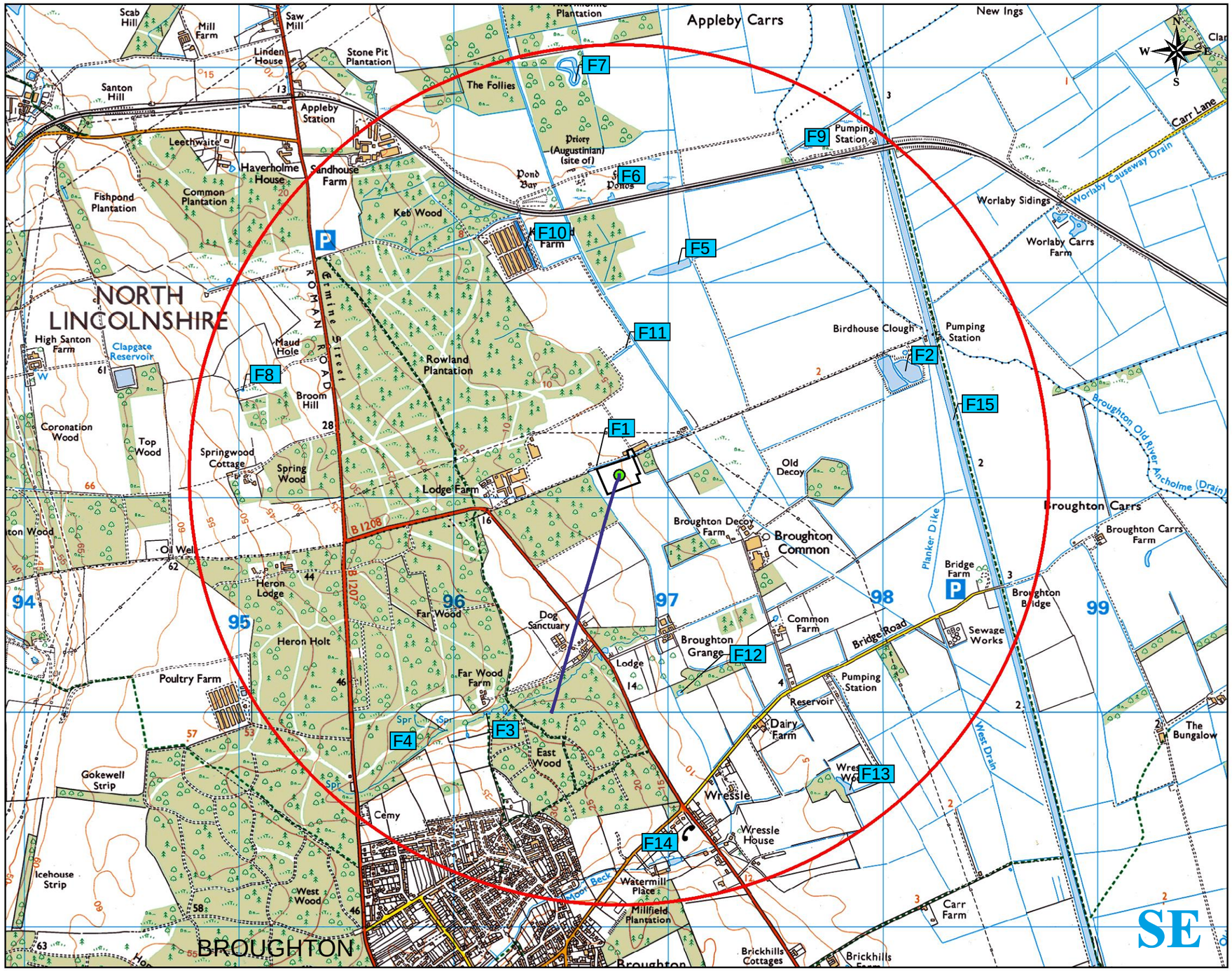
Ref: P:\Egdon Wressle (1933)\Figures\Figure 2 - Site Layout Date: 02/06/2016	Egdon Resources
Figure 2	Proposed Wellsite Layout Plan



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KEY

- Wressle 1 Borehole Location (NGR SE 96770 11106)
- Underground Borehole Track
- Approx. Site Boundary
- 2km Search Radius
- F12 Water Feature Reference

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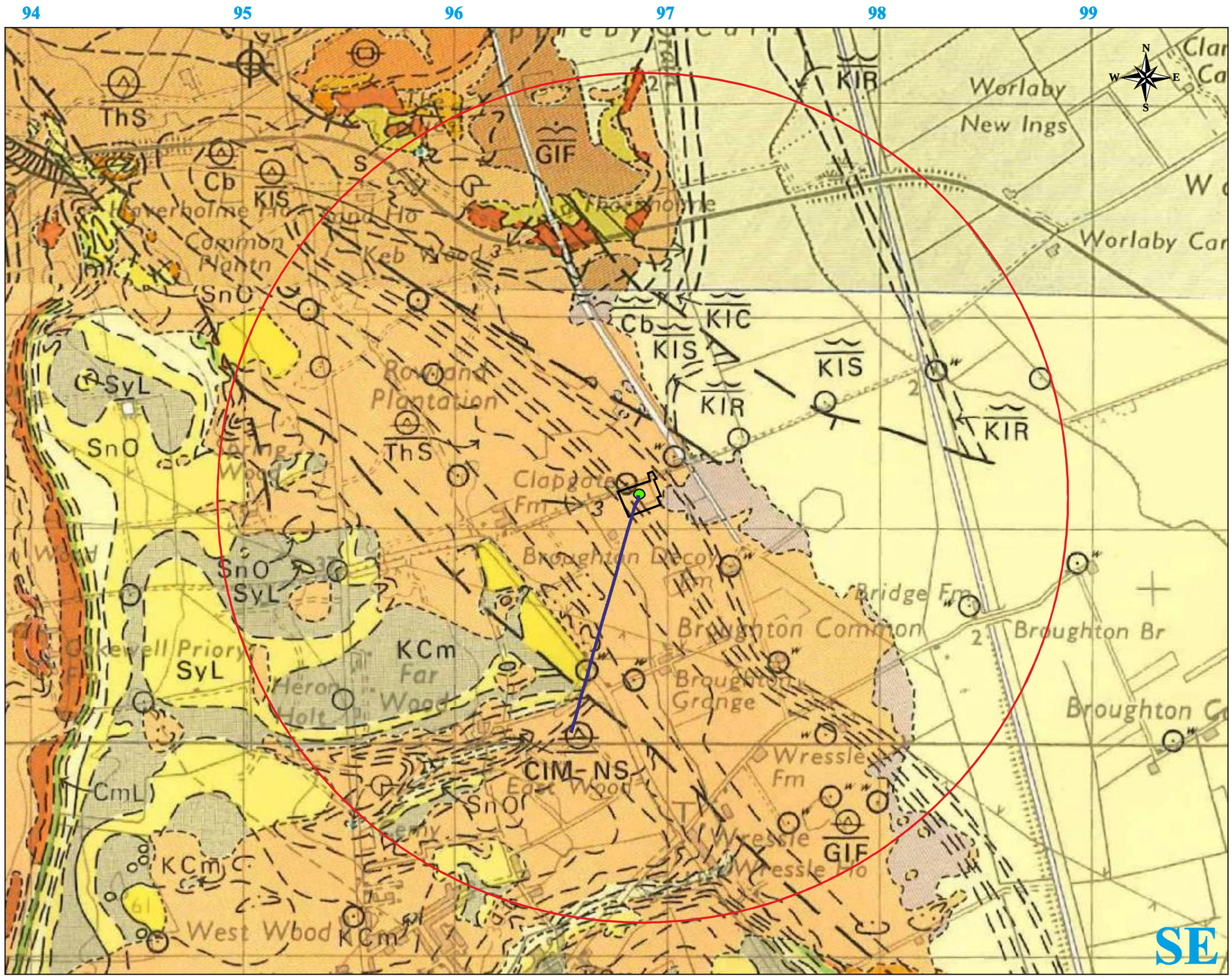
Ref: P:\Egdon Wressle (1933)\Figures\ Figure 3 - SW Features rev1.cdr Date: 12/05/2016	Egdon Resources
Figure 3	Surface Water Features



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KEY

- Wressle 1 Borehole Location (NGR SE 96770 11106)
- Approx. Site Boundary
- 2km Search Radius
- Underground Borehole Track

SUPERFICIAL GEOLOGY

QUATERNARY

- Landslip
- Warp (artificially induced alluvium)
- Marine or Estuarine Alluvium
- Peat
- Alluvium
- Dry Valley Deposits
- Calcareous Tufa
- Shell Marl
- Blown Sand
- First Terrace
- Terrace, undifferentiated
- Sand and Gravel — Vale of York Glacial Lake Deposits
- Silt and Clay — Vale of York Glacial Lake Deposits
- Head, including downwash
- Fluvio-glacial Sand and Gravel
- Glacial Sand and Gravel
- High-level Laminated Clay and Glacial Lake Deposits
- Till
- Interglacial Gravel Beach Deposits
- Interglacial Silt and Clay

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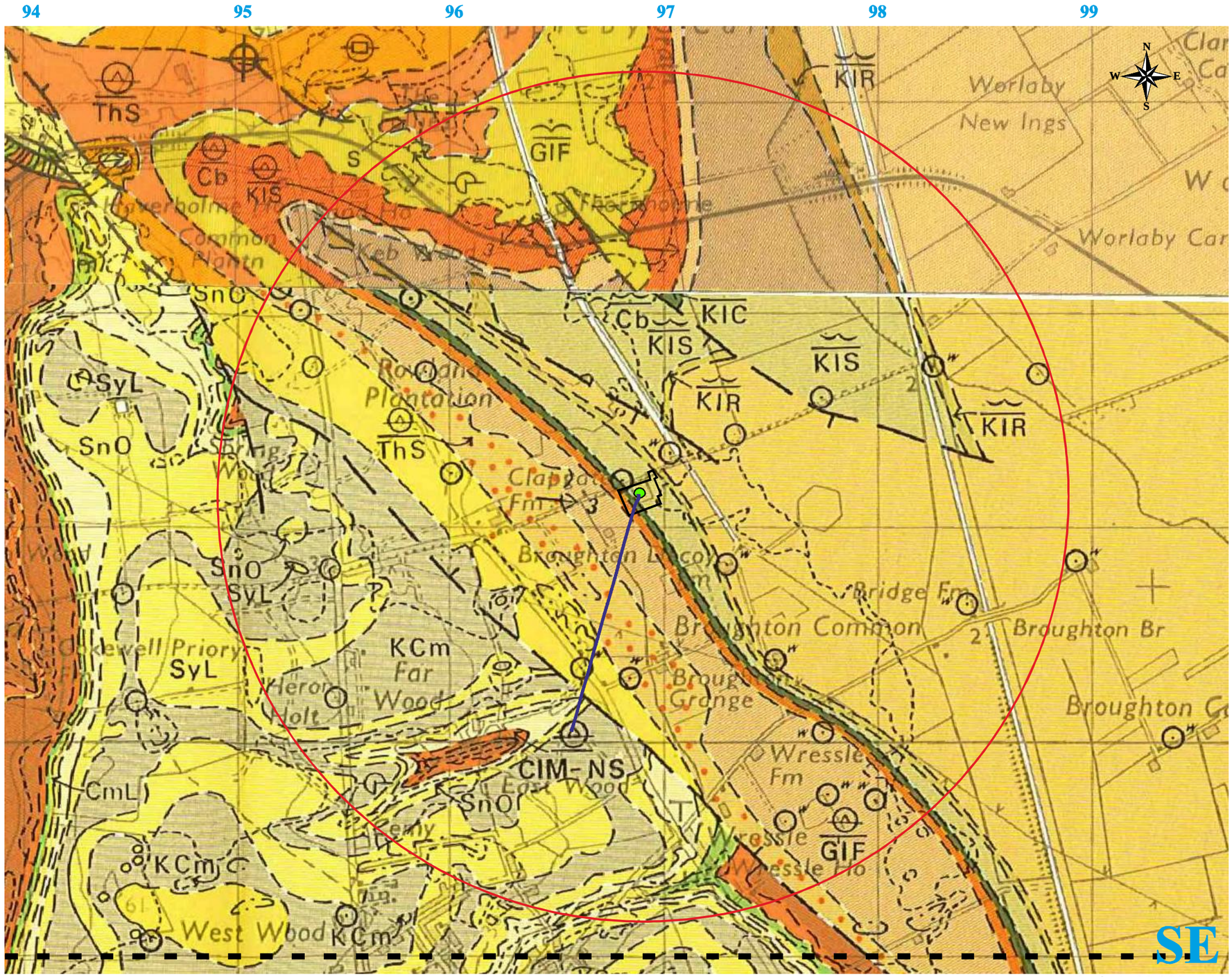
Ref: P:\Egdon Wressle (1933)\Figures\Figure 4a - Drift Geology Date: 12/05/2016	Egdon Resources
Figure 4a	Superficial Geology



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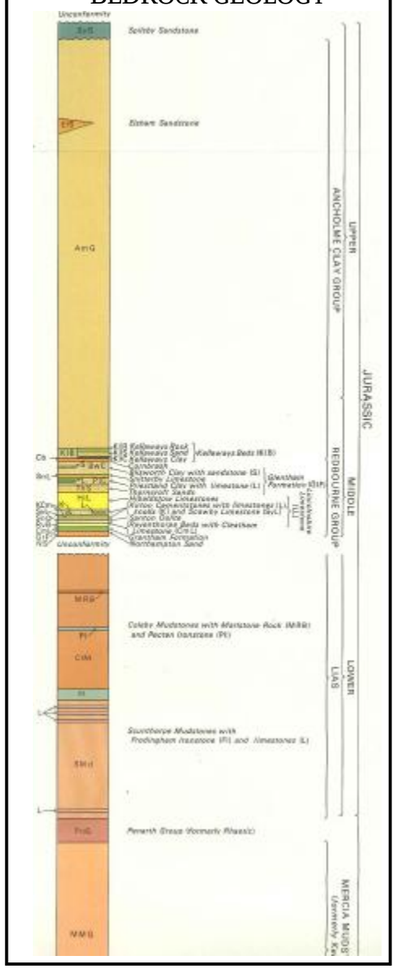
KEY

- Wressle 1 Borehole Location (NGR SE 96770 11106)
- Underground Borehole Track
- Approx. Site Boundary
- 2km Search Radius
- Line of Cross Section (see Figure 4c)

BEDROCK GEOLOGY



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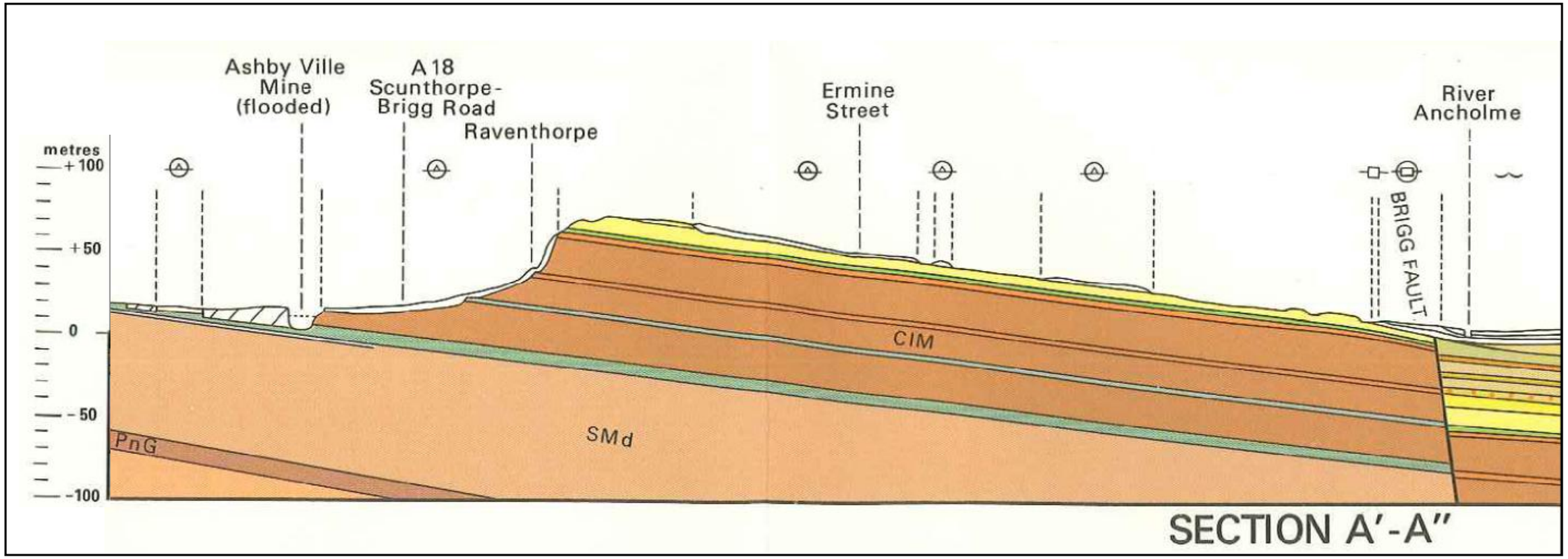
Ref: P:\Egdon Wressle (1933)\Figures\Figure 4b - Solid Geology Date: 12/05/2015	Egdon Resources
Figure 4b	Bedrock Geology



NOT TO SCALE

REFER TO FIGURE 4a AND 4b FOR KEY

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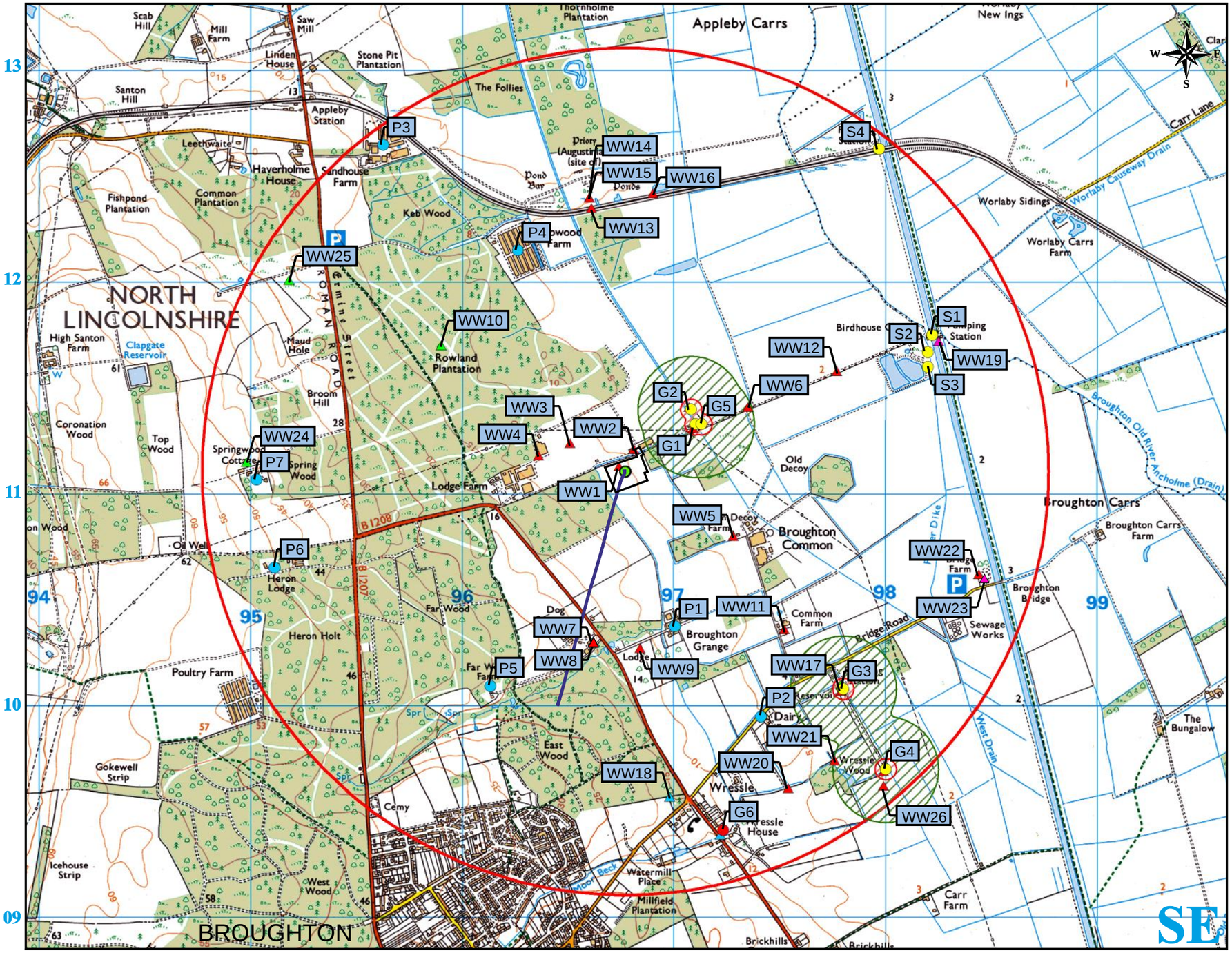
Ref: P:\Egdon Wressle (1933)\Figures\Figure 4c - Geology Sec Date: 12/05/2015	Egdon Resources
Figure 4c	Geological Cross Section



KEY

- Wressle 1 Borehole Location (NGR SE 96770 11106)
- Underground Borehole Track
- Approx. Site Boundary
- 2km Search Radius
- # Water Feature Reference
- Licensed Abstractions
- Private Water Supply
- Potential Private Water Supply

BGS Wells - Target Aquifer:

- Superficials / Kellaways Formation
- Lincolnshire Limestone Formation
- Lincolnshire Limestone + Other Formations
- Marlstone Rock Formation

GW Source Protections Zones (SPZ's):

- Inner Zone - subsurface activity only (Zone 1c)
- Outer Zone - subsurface activity only (Zone 2c)

Scale 1: 20,000 at A3

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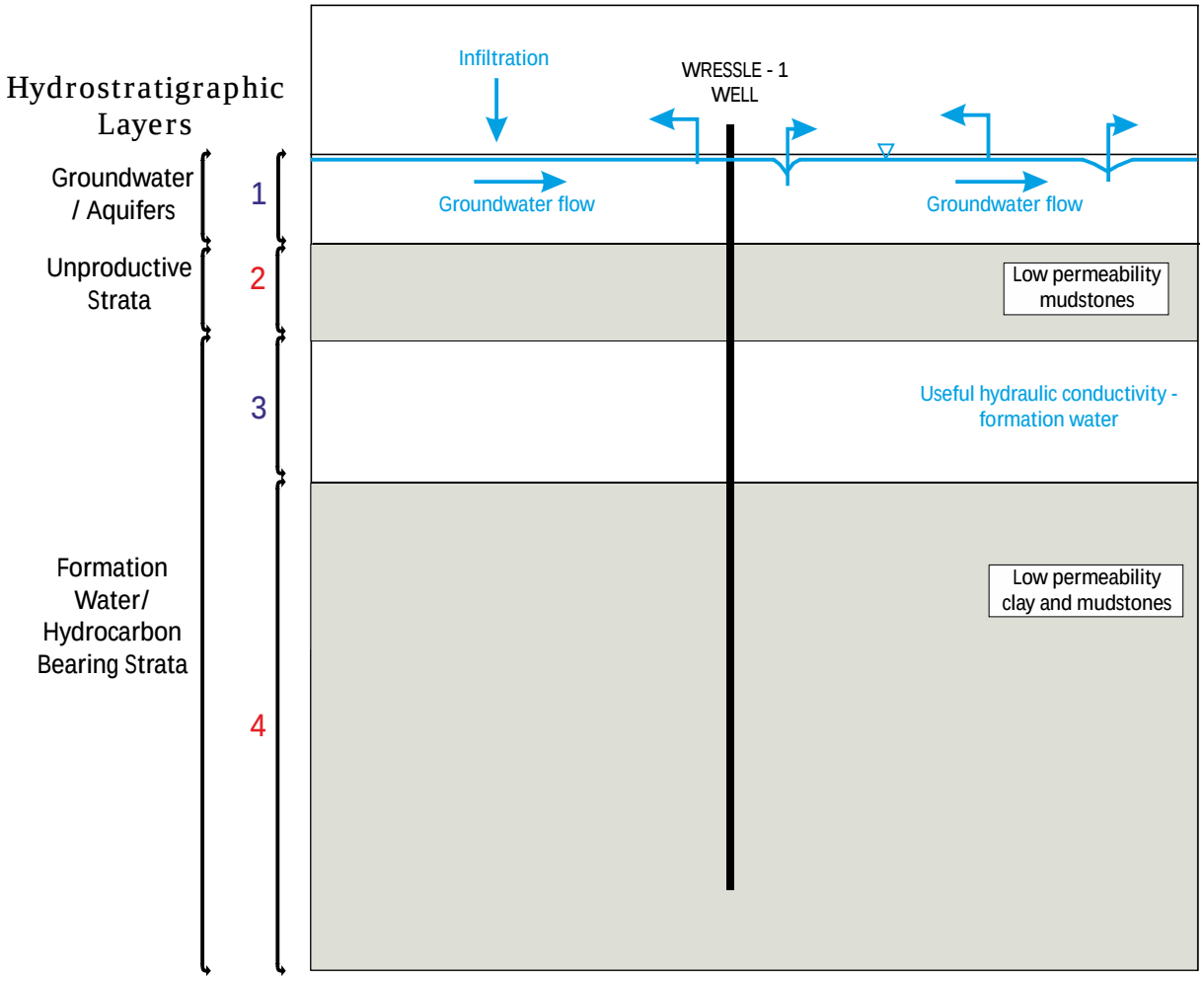
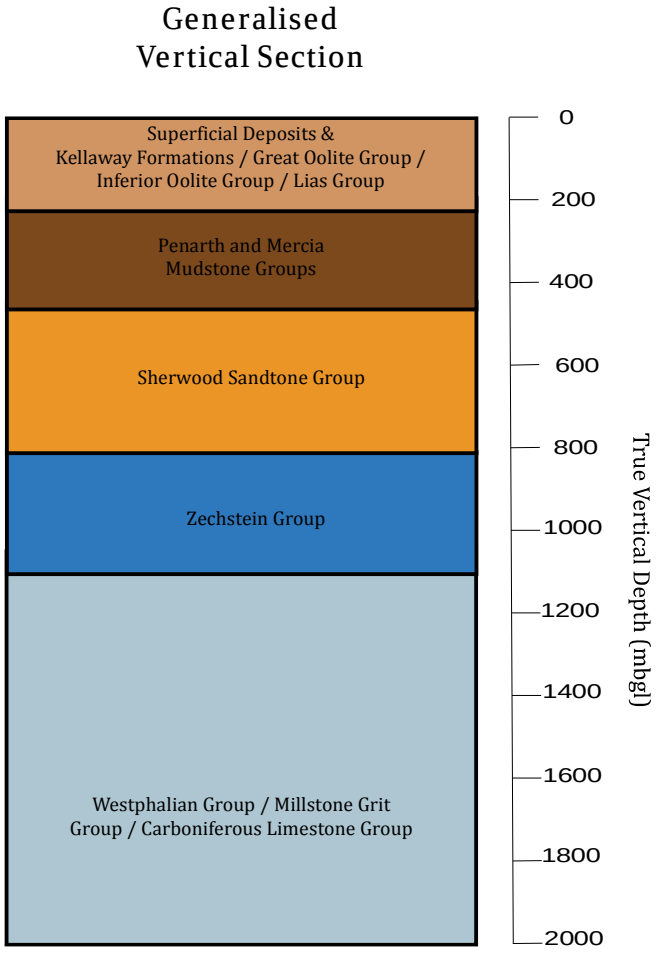
Ref: P:\Egdon Wressle (1933)\Figures\Figure 5 - Protected Rights Date: 12/05/2016	Egdon Resources
Figure 5	Protected Rights





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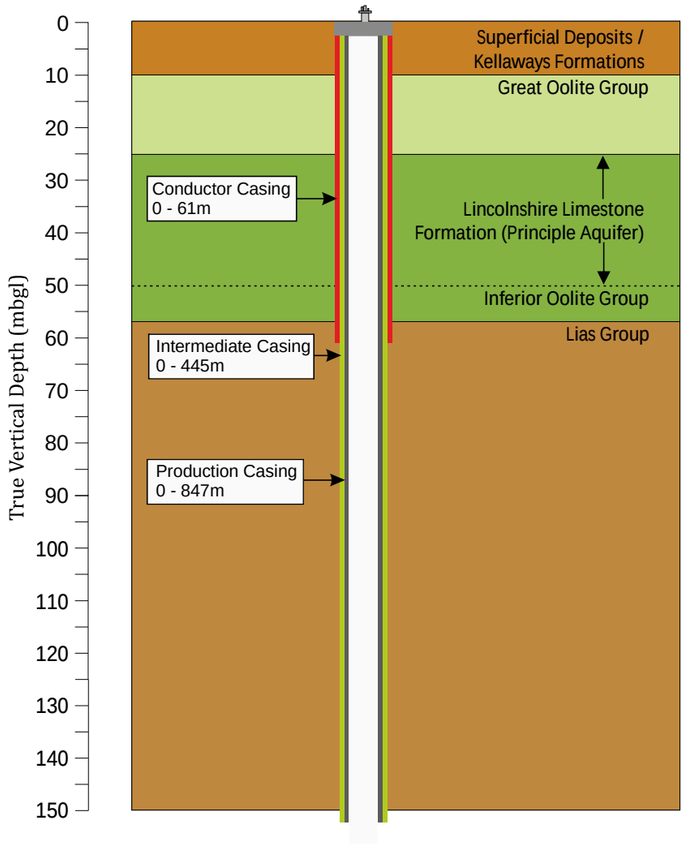
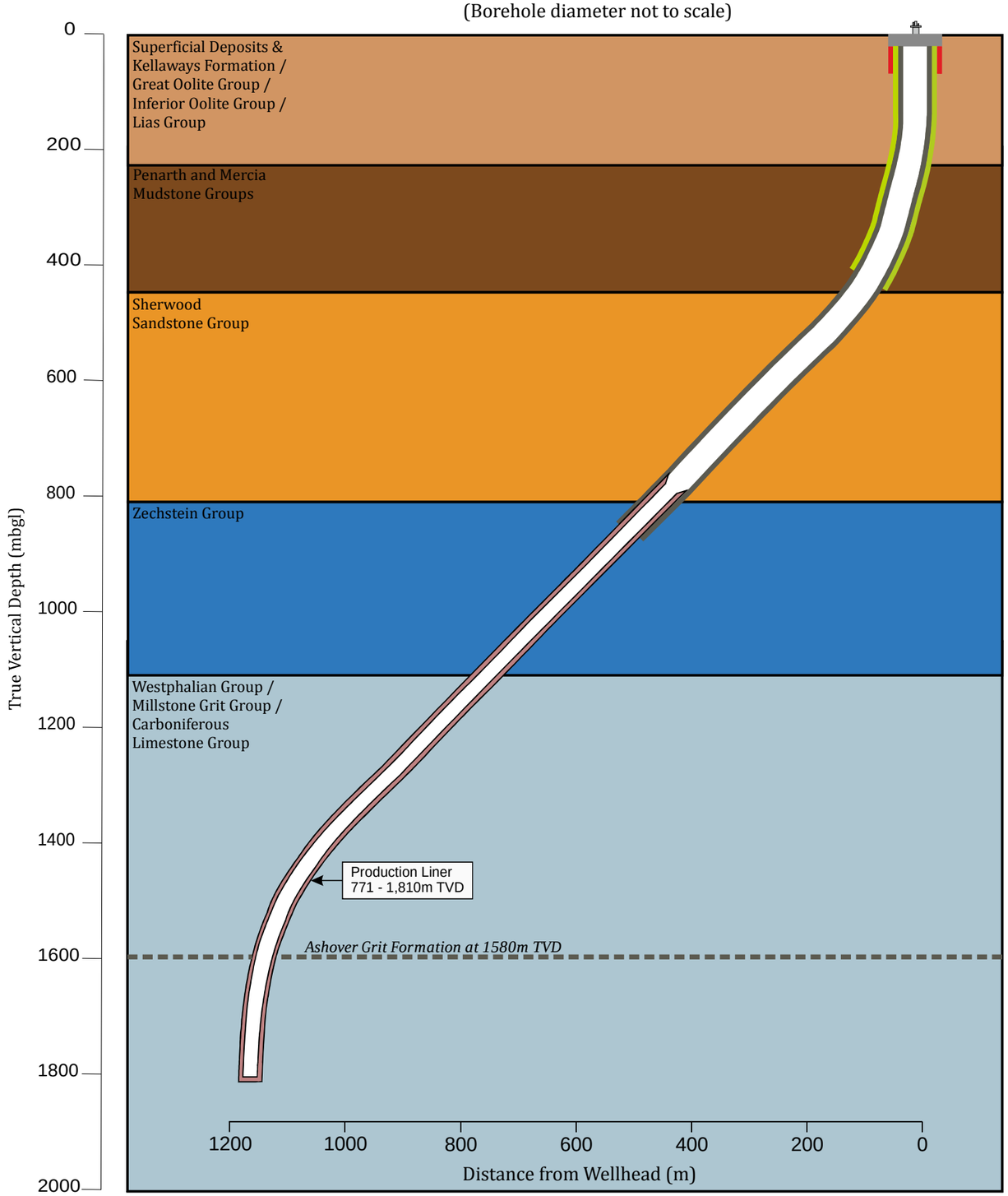
Ref: P:\Egdon Wressle (1933)\Figures\Figure 6 - Conceptual Model Date: 31/05/2016	Egdon Resources
Figure 6	Conceptual Hydrogeological Model

Geology 0 - 150 mbgl



Geology 0 - 2 kmbgl

(Borehole diameter not to scale)



Hydrostratigraphic Layers

1 Groundwater / Aquifers

2 Unproductive Strata

3 Formation Water

4 Formation Water/ Hydrocarbon Bearing Strata

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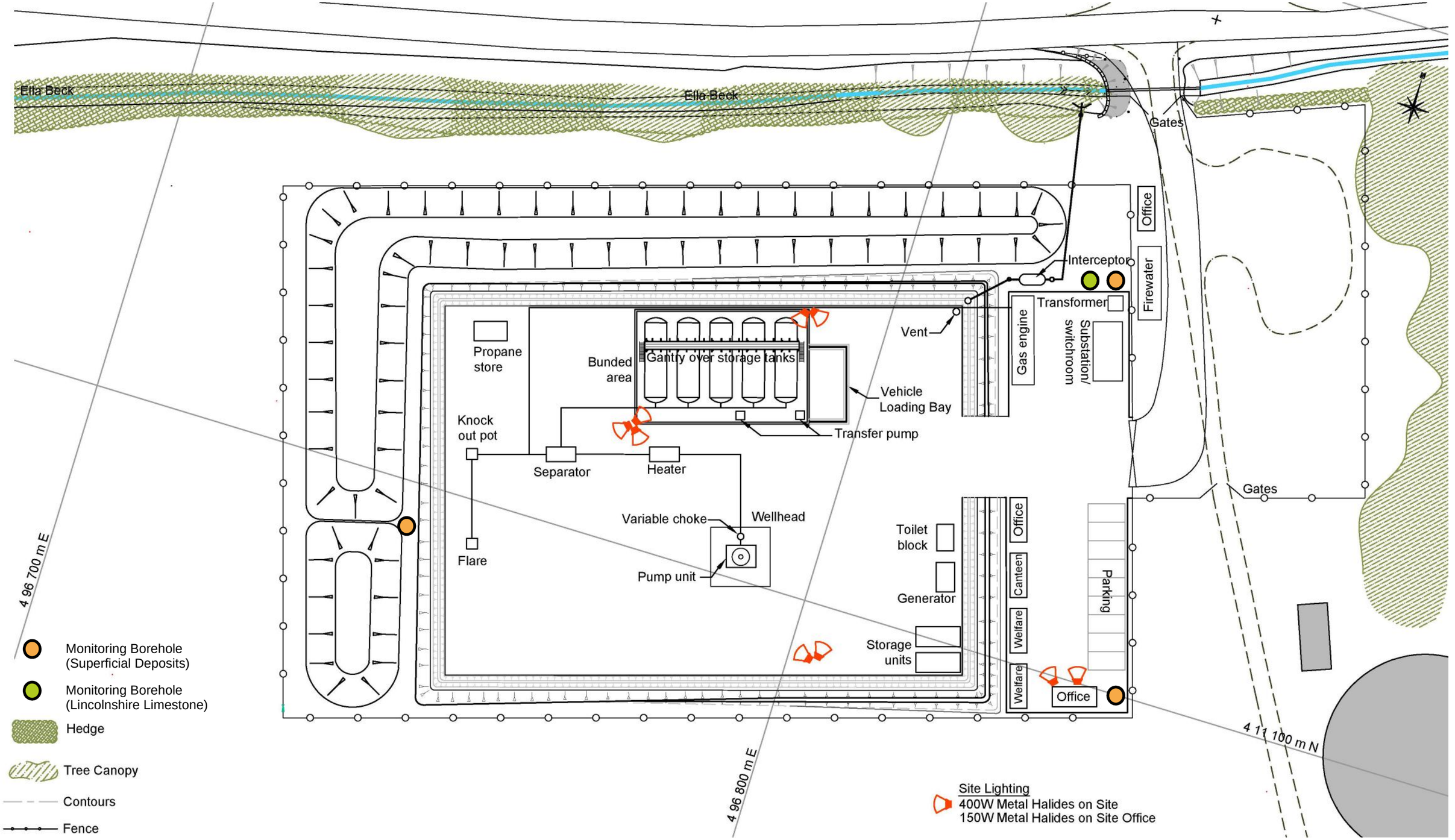
Ref: P:\Egdon Wressle (1933)\Figures\ Figure 7 - BH completion rev1.cdr Date: 31/05/2016	Egdon Resources
Figure 7	Wressle-1 Borehole Concept



Scale 1: 500 at A3

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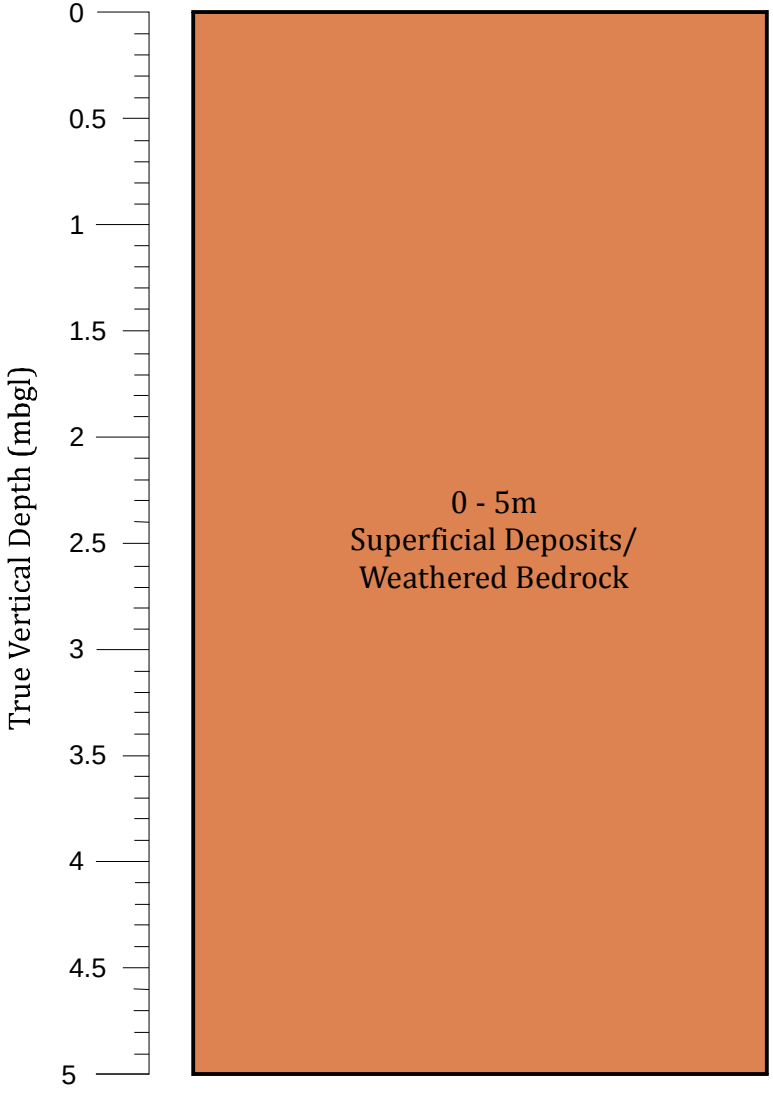
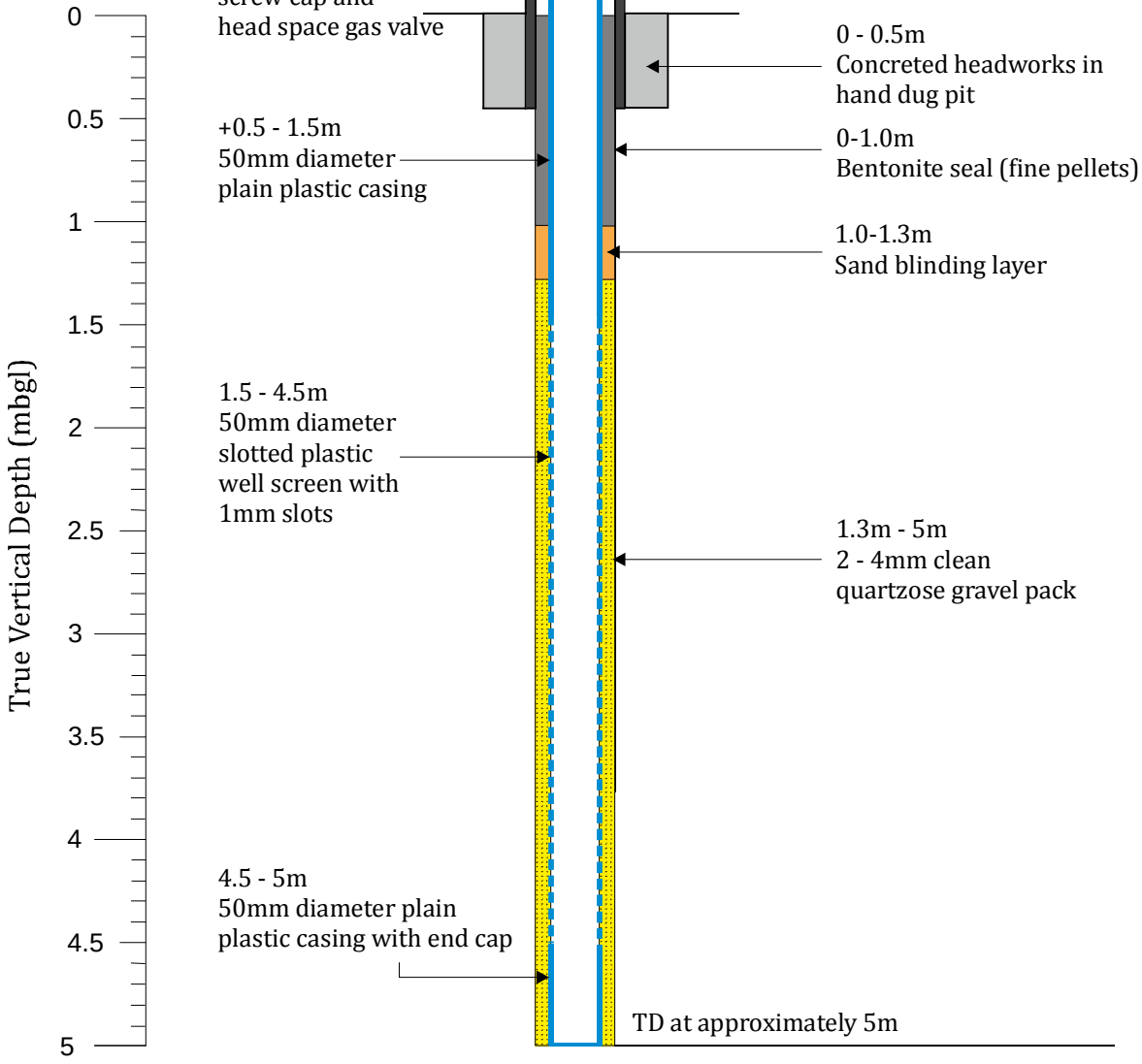
Ref: P:\Egdon Wressle (1933)\Figures\Figure 8 - Proposed MH Date: 02/06/2016	Egdon Resources
Figure 8	Proposed Monitoring Borehole Locations

EXPECTED GEOLOGY



BOREHOLE CONSTRUCTION DETAILS



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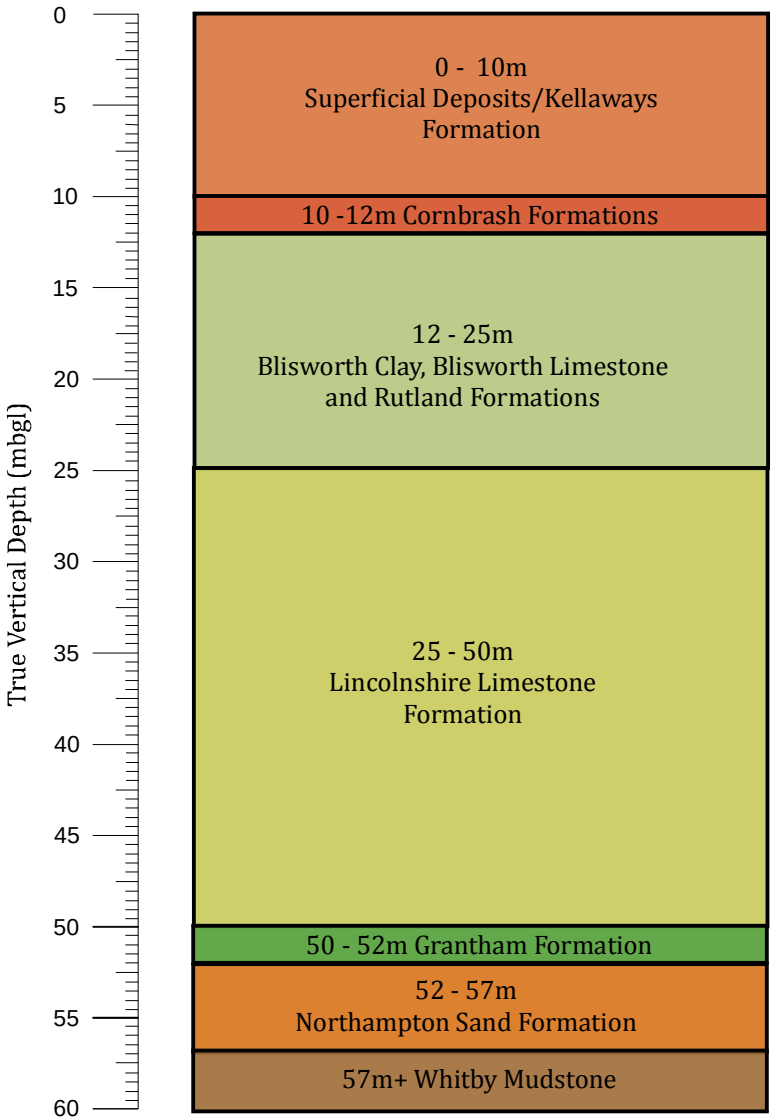
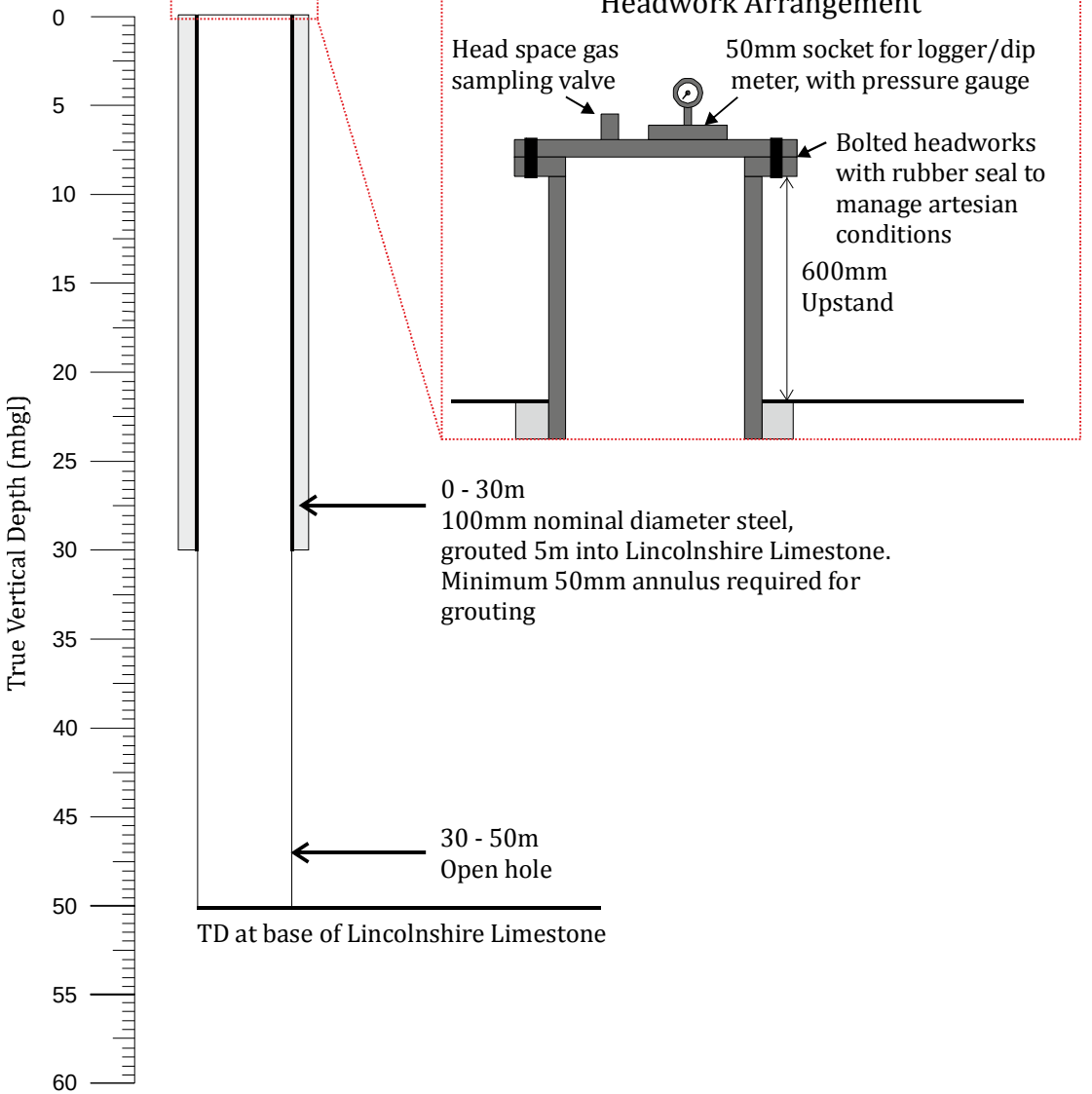
Ref: P:\Egdon Wressle (1933)\Figures\Figure 9a - MBH Date: 12/05/2015	Egdon Resources
Figure 9a	Proposed Shallow Monitoring Borehole Construction

EXPECTED GEOLOGY



BOREHOLE CONSTRUCTION DETAILS



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Ref: P:\Egdon Wressle (1933)\Figures\Figure 9b - MBH Date: 12/05/2015	Egdon Resources
Figure 9b	Proposed Limestone Monitoring Borehole Construction

APPENDIX A

BGS Water Well Database Records

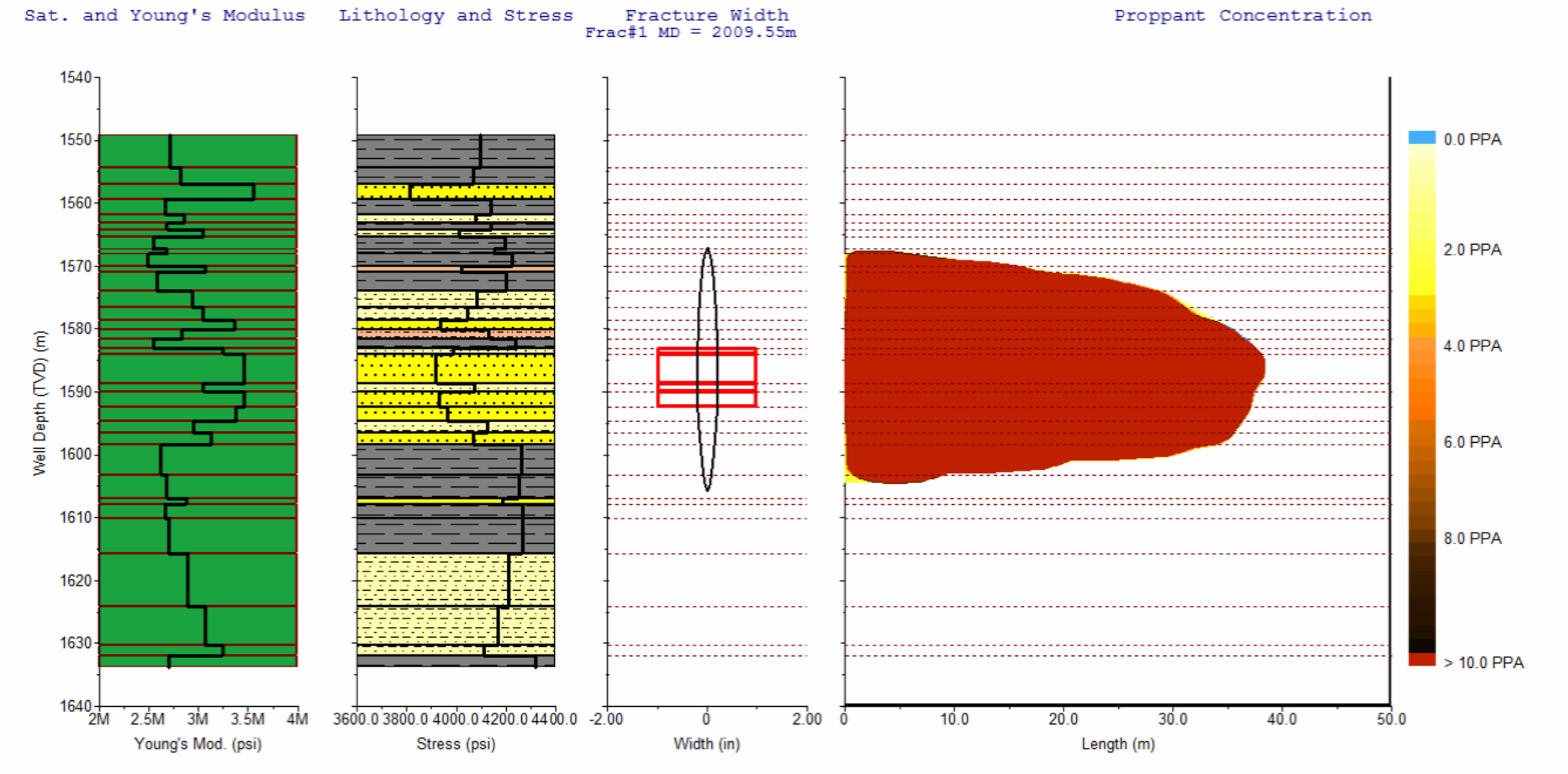
Ref No. on Figure 5	BGS Ref	Location	Likely Target Aquifer	Easting	Northing	Depth (m)	Distance from Wellsite (km)
WW1	SE91/80	CLAPGATES NO. 5	LINCOLNSHIRE LIMESTONE FORMATION	496740	411130	25	0.04
WW2	SE91/11	CLAPGATES NO. 6	LINCOLNSHIRE LIMESTONE FORMATION	496810	411210	35.7	0.11
WW3	SE91/87	LOW SANTON	LINCOLNSHIRE LIMESTONE FORMATION	496510	411240	18.3	0.29
G1	SE91/74	APPLEBY CARRS	LINCOLNSHIRE LIMESTONE FORMATION	497090	411310	55.8	0.38
G5	SE91/12	CLAPGATES NO. 8	LINCOLNSHIRE LIMESTONE FORMATION	497120	411330	55.8	0.42
WW4	SE91/79	CLAPGATES NO. 3	LINCOLNSHIRE LIMESTONE FORMATION	496360	411180	18.3	0.42
G2	SE91/4	CLAPGATE NO. 11	LINCOLNSHIRE LIMESTONE FORMATION	497070	411410	50.3	0.43
WW5	SE91/10	DECOY FARM	LINCOLNSHIRE LIMESTONE FORMATION	497280	410800	42.4	0.59
WW6	SE91/86	APPLEBY LODGE	LINCOLNSHIRE LIMESTONE FORMATION	497350	411410	54.3	0.65
WW7	SE91/15A	DOG SANCTUARY, WRESSLE	LINCOLNSHIRE LIMESTONE FORMATION	496620	410300	94.5	0.82
WW8	SE91/15B	DOG SANCTUARY, WRESSLE	NO AQUIFER / DRY	496620	410300	6.1	0.82
WW9	SE91/9	BROUGHTON GRANGE	LINCOLNSHIRE LIMESTONE FORMATION	496840	410270	35.7	0.84
WW10	SE91/26	ROWLANDS PLANTATION	LINCOLNSHIRE LIMESTONE FORMATION / OTHERS	495900	411700	122	1.05
WW11	SE91/7	DECOY HOUSE FARM, WRESSLE	LINCOLNSHIRE LIMESTONE FORMATION	497520	410360	42.4	1.06
WW12	SE91/85	CLAPGATE PUMPING STATION	LINCOLNSHIRE LIMESTONE FORMATION	497770	411580	78	1.11
WW13	SE91/58	THORNHOLME	LINCOLNSHIRE LIMESTONE FORMATION	496610	412350	46.6	1.25
WW14	SE91/57	THORNHOLME	LINCOLNSHIRE LIMESTONE FORMATION	496600	412400	46.9	1.31

Ref No. on Figure 5	BGS Ref	Location	Likely Target Aquifer	Easting	Northing	Depth (m)	Distance from Wellsite (km)
WW15	SE91/59	THORNHOLME	LINCOLNSHIRE LIMESTONE FORMATION	496600	412400	47.7	1.31
WW16	SE91/53	APPLEBY B/H NR. THORNHOLME	LINCOLNSHIRE LIMESTONE FORMATION	496900	412420	42.7	1.32
WW17	SE91/75	BROUGHTON	LINCOLNSHIRE LIMESTONE FORMATION / OTHERS	497790	410100	76.2	1.43
G3	SE91/8	WRESSLE	LINCOLNSHIRE LIMESTONE FORMATION	497790	410070	39.6	1.45
WW18	SE90/33	QUARRY AT CROSS ROADS NR. WRESSELL HOUSE	MARLSTONE ROCK FORMATION	496980	409570	61	1.55
WW19	SE91/89	ANCHOLME PUMPING STATION	KELLAWAYS FORMATION	498250	411720	16.5	1.60
WW20	SE90/34	W.OF WRESSELL WOOD	LINCOLNSHIRE LIMESTONE FORMATION	497540	409610	61	1.68
WW21	SE90/9	WRESSELL WOOD	LINCOLNSHIRE LIMESTONE FORMATION	497760	409740	45.7	1.69
WW22	SE91/5	BRIDGE FARM, BROUGHTON	LINCOLNSHIRE LIMESTONE FORMATION	498440	410620	69.2	1.74
G6	SE90/32	WRESSELL HOUSE BORE A	MARLSTONE ROCK FORMATION	497220	409390	58.8	1.77
WW23	SE91/81	BRIDGE FARM	SUPERFICIALS	498470	410590	16.8	1.78
WW24	SE91/78	SPRING WOOD LODGE	LINCOLNSHIRE LIMESTONE FORMATION / OTHERS	494980	411150	86	1.79
WW25	SE91/13	APPLEBY NO. 1	LINCOLNSHIRE LIMESTONE FORMATION / OTHERS	495180	412010	116.3	1.83
G4	SE90/57	E.OF WRESSELL WOOD	LINCOLNSHIRE LIMESTONE FORMATION	497990	409690	45.7	1.87
WW26	SE90/58	E.OF WRESSELL WOOD	LINCOLNSHIRE LIMESTONE FORMATION	497990	409620	39.6	1.92

APPENDIX B

Proppant Squeeze Modelling

PROPPANT SQUEEZE MODELLING RESULTS



APPENDIX C

Tier 1 Risk Assessment Methodology

Introduction

DEFRA's GL III [Ref. 1] contains generic guidelines for the assessment and management of environmental risks. GL III outlines a staged approach to risk assessment and the document is intended to guide regulatory staff in Government and its agencies, as well as those carrying out assessments, to reach a decision on managing environmental risk.

A hydrogeological risk assessment for the proposed development has been carried out in accordance with the Source-Pathway-Receptor (S-P-R) approach described in GL III [Ref. 1] and the methodology in the Environment Agency's H1 Environmental Risk Assessment framework – Annex J (Groundwater) [Ref. 2]. Where S-P-R linkages have been identified, the sensitivity of the receptor, magnitude of impact and significance of effect has been considered in order to assess potential risks.

Ref.2 describes a tiered approach to risk assessment, starting at Tier 1 and progressing to Tier 3. Tier 1 is essentially a qualitative approach and Tier 3 is highly quantitative approach. The choice of approach should be based on how complicated the system is, how high the risks are, and how easily and fully the risks can be mitigated. As such the selection process is iterative, and in complex systems there may be a mixture of approaches where simple, low risk sub-systems are assessed with a Tier 1 approach and more complex aspects with risks that cannot be fully mitigated may need a complex quantitative approach. The methodology described in this Appendix is for a Tier 1 assessment.

Receptor Sensitivity

The sensitivity of water resource receptors is based on their status and considered resource value, as described in Table C.1.

Table C.1 Receptor Sensitivity

Receptor Sensitivity	Description	Examples
Very High	Water resource with an importance and rarity at an international level with limited potential for substitution.	• A water resource making up a vital component of an SAC or SPA under the EC Habitats Directive • A water body achieving a status of 'High status or potential' under the WFD • Principal aquifer providing potable water to a large population • EC designated Salmonid fishery
High	Water resource with a high quality and rarity at a national or regional level and limited potential for substitution.	• A water resource designated or directly linked to a SSSI. • Principal aquifer providing potable water to a small population • A river designated as being of Good status or with a target of Good status or potential under the WFD • A water body used for national sporting events such as regattas or sailing events • EC designated Cyprinid fishery
Medium	Water resource with a high quality and rarity at a local scale; or Water resource with a medium quality and rarity at a regional or national scale.	• Secondary aquifer providing potable water to a small population • An aquifer providing abstraction water for agricultural and industrial use
Low	Water resource with a low quality and rarity at a local scale.	• A non 'main' river or stream or other water body without significant ecological habitat

Magnitude of Impact

The magnitude of a potential impact on a receptor depends on the nature and extent of the proposed development, and is independent of the sensitivity of the water resource, as described in Table C.2.

Table C.2 Magnitude of Impact

Magnitude of Impact	Description	Examples
High	Results in a major change to attributes.	• Loss of EU designated Salmonid fishery • Change in WFD classification of a water body. • Compromise employment source • Loss of flood storage/increased flood risk • Pollution of potable source of abstraction
Medium	Results in impact on integrity of attribute or loss of part of attribute.	• Loss / gain in productivity of a fishery. • Contribution / reduction of a significant proportion of the effluent in a receiving river, but insufficient to change its WFD classification • Reduction / increase in the economic value of the feature
Low	Results in minor impact to attributes.	• Measurable changes in attribute, but of limited size and/or proportion
Very Low	Results in an impact on attribute but of insignificant magnitude to affect use and/or integrity.	• Physical impact to a water resource, but no significant reduction/ increase in quality, productivity or biodiversity • No significant impact on the economic value of the feature • No increase in flood risk

Significance of Effect

The significance of the potential effect is derived by combining the assessments of both the sensitivity of the water resource and the magnitude of the impact in a simple matrix, as presented in Table C.3. Effects which are assessed to be major or moderate are considered to be significant, whilst those that are minor or negligible are not significant.

Table C.3 Significance of Effect

Receptor Sensitivity	Magnitude of Impact			
	High	**Medium**	**Low**	**Very Low**
Very High	Major	Major	Moderate	Moderate
High	Major	Moderate	Moderate	Minor
Medium	Moderate	Moderate	Minor	Negligible
Low	Moderate	Minor	Negligible	Negligible

Qualitative Likelihood

The qualitative likelihood of occurrence of a potential impact on a receptor is defined as described in Table C.4.

Table C.4 Qualitative Likelihood of Occurrence

Qualitative Likelihood of Occurrence	Description	Examples
Highly Likely	High probability of occurrence	• Spillage at a poorly maintained and operated facility • Uncontrolled activity in or on an aquifer, close to surface water • Uncontrolled known discharge
Likely	On balance could occur	• Controlled but un-mitigated activity • Complex process where failure of a part is likely to lead to release • Large area where 100% sealing cannot reasonably be expected
Moderate	Equally likely/unlikely	• Unmitigated, low risk • Controllable activity • Partially contained site
Unlikely	On balance wouldn't occur	• Mitigated higher risk • Simple, controllable activity • Underlain by poorly permeable strata • Existing contained site
Very Unlikely	Very low probability of occurrence	• Essentially no risk • Extreme set of circumstances required to generate low probability • Fully mitigated low or medium risk

Qualitative Risk Analysis

The residual qualitative risk is derived by combining the likelihood of occurrence and the significance of effect of a potential impact on a receptor in a simple matrix, as presented in Table C.5. Risks which are assessed to be very high, high or medium are considered to be significant, whilst those that are low, very low or none are not significant.

Table C.5 Qualitative Risk Analysis

Qualitative Likelihood of Occurrence	Significance of Effect			
	Major	**Moderate**	**Minor**	**Negligible**
Highly Likely	Very High	High	Medium	Low
Likely	High	Medium	Low	Very Low
Moderate	Medium	Low	Very Low	None
Unlikely	Low	Very Low	None	None
Very Unlikely	Very Low	None	None	None

References

Ref. 1: Green Leaves III - Guidelines for Environmental Risk Assessment and Management: Green Leaves III. Revised Departmental Guidance Prepared by Defra and the Collaborative Centre of Excellence in Understanding and Managing Natural and Environmental Risks, Cranfield University November, 2011.

Ref. 2: H1 Environmental Risk Assessment framework – Annex J (Groundwater). Environment Agency, 2010.

APPENDIX 3 – FLOOD RISK ASSESSMENT

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