

**HYDROGEOLOGICAL AND
HYDROLOGICAL ASSESSMENT FOR
PROPOSED MINERAL EXTRACTION AT
BOURBLES FARM**

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GENERAL NOTES

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1 INTRODUCTION

1.1 Background

The Bourbles Farm site is located immediately east of the town of Preesall, on the North Fylde coast of Lancashire. It is located 3 km inland from the River Wyre estuary. The Application Area currently comprises 22.3 hectares (ha) of agricultural land and several fishing lakes. A 13.1 ha area has been identified for the extraction of sand and gravel. Mineral extraction will be undertaken on a campaign basis. Within Phase A and Phases 2 to 4 the mineral is situated below the watertable and dewatering will therefore be required to permit safe and efficient working. The mineral from Phase 1 will be worked wet. The mineral will be processed on-site. Progressive restoration will be undertaken using overburden and imported inert materials.

Hafren Water has been commissioned to undertake a hydrogeological and hydrological assessment in support of the Planning Application, the results of which are provided herein.

1.2 Location

The Application Area is accessed from Lancaster Road, 250 m from the A588 (Head Dyke Lane). This site is located at National Grid Reference (NGR) SD 37782 47617. The location of the Application Area is shown on *Drawing 3133/HIA/01*.

1.3 Scope of assessment

The objectives of the investigation are as below:

- Determination of baseline conditions of the water environment at the site and its environs
- Identification of potential impacts of the proposed development
- Assessment of the magnitude and significance of potential impacts
- Derivation of appropriate mitigation measures for any identified potential impacts

1.4 Data sources

The characteristics of the water environment have been investigated with the use of existing published data and reports, assessment of site data and experience of other sites in broadly similar settings. The data sources used in the investigation are listed below:

British Geological Survey (BGS)

- 1:50,000 scale geological map for Blackpool, Solid and Drift, Sheet 66, and digital on-line mapping
- Geological borehole logs

British Mining

- Preesall Salt Mines: V. Landless, *The Northern Mine Research Society UK, British Mining No 11*, pp 38 -43, 1979

Environment Agency

- Licensed and de-regulated abstractions
- Rainfall data
- Groundwater monitoring data
- Landfill sites

UKSO mapping

- National Soil Inventory (NSI) soil chemistry maps

Wyre Council

- Private water supply data

Lancashire County Council

- Local minerals and waste plan

Greenfield Environmental Ltd

- Site plans
- Mineral investigation borehole logs
- Grainsize analysis
- Groundwater monitoring data

1.5 Methodology

Baseline conditions of the water environment have been defined by the collation and analysis of existing data and field observations obtained during a site visit (16th September 2021). The potential effects of the proposed development upon the extant water environment have been assessed by reference to the baseline data and a series of matrices (*Appendix 3133/HIA/A1*). This ensures a rigorous and consistent approach to the assessment of potential impacts. Mitigation measures have been proposed, where appropriate.

2 BASELINE CONDITIONS

2.1 Current and historical site use

The Application Area ('the site') currently comprises grazed and arable agricultural land and three fishing lakes. Limited areas of mineral have historically been extracted to create the fishing lakes. The surrounding area is characterised by small villages and mixed agricultural land use.

2.2 Landform

The Application Area lies in an extensive area of very low relief on the Fylde coastal plain, located between 5-10 metres Above Ordnance Datum (mAOD). A series of small, raised areas (drumlins) are located to the west of the site, with the highest local elevation of 25 mAOD recorded near Preesall, 1.8 km to the southwest of the site.

The Application Area is situated on a slightly raised area with a break in slope at the northern and southern site boundaries, approximately demarked on the OS maps by the 5 mAOD contour line. Within the site boundary spot heights are recorded between 4.8–6.7 mAOD. The gently undulating topography generally declines towards the northern and southern site boundaries.

2.3 Hydrology

2.3.1 Rainfall

Monthly total rainfall data were obtained from the Environment Agency for the Fleetwood Gauging Station, located 4.6 km southwest of the site. The gauging station is located at a similar elevation to the Application Area and data is available from 1997–2022. The average annual rainfall for this period was 890 mm and the monthly average is shown in *Table 3133/HIA/T1*.

3133/HIA/T1: Average rainfall (1997 – 2022)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	79.7	69.9	54.8	44.0	51.3	61.1	68.8	83.1	84.2	103.3	93.9	96.1

2.3.2 Watercourses

Watercourses within the vicinity of the site are shown on *Drawing 3133/HIA/02*.

Drainage is dominated by ditches and dykes, the largest of which is Wheel Foot Watercourse and Cocker's Dyke (Drain), located 650 m northwest and 950 m north of the site respectively.

Both watercourses drain north-northwestwards, with their outlets controlled by floodgates on the coastline. The closest 'Main Rivers' to the site are unnamed field drains located 50 m to the north of the site and Wheel Foot Watercourse.

The site is located across the catchment divide between the River Wyre and the River Lune. Field drains located to the west and south of the site flow directly to the estuary of the River Wyre, located 3 km to the west of the site. Field drains to the north of the site are within the catchment of the River Lune, but flow 1.5 km northwards, towards the coast.

Conditions within the field drains change seasonally. Many drains were observed to be dry during the site visit in September 2021. Conversely, at the time of the mineral investigation in March 2021, during very wet weather conditions, Greenfield Environmental reported flooding of the field drains. An exception was the field drain that borders the eastern site boundary, which did not appear to flood. This eastern boundary drain continues northwards, discharging into Cocker's Dyke.

2.3.3 Waterbodies

Three fishing lakes are located within the site boundary (P1–P3 on *Drawing 3133/HIA/02*) and are located at elevations of 5.2–5.3 mAOD (Lidar, 2017 data). A visual inspection conducted during the site visit in September 2021 indicated that these waterbodies are unlined. The sidewalls within the waterbodies are partially supported by retaining metal structures.

A fourth fishing lake (P4 on *Drawing 3133/HIA/02*) is located directly adjacent to the west of the site and understood to be constructed within made ground. The water level was recorded at 5.15 mAOD (Lidar, 2017 data).

Numerous waterbodies are shown on the 1:25,000-scale OS map within 2 km of the site. Several of the waterbodies to the west are relict features, associated with the Preesall Salt Works. Four large waterbodies (P5 to P8) indicate large areas of subsidence associated with collapsed salt caverns created by historical mining. Waterbody P8 is noted as an active area of mine subsidence (see Section 2.7).

2.4 Surface water abstractions

Within a 2 km radius of the site, no private surface water abstractions are recorded by Wyre Council, and no licensed surface water abstractions have been advised by the Environment Agency.

2.5 Consented discharges

Five consented discharges are recorded by the EA within a 2 km radius of the site, as shown on *Drawing 3133/HIA/02*. The EA has not confirmed whether these are discharges to surface water or groundwater. All of the discharges are located to the south of the site and are associated with either the sewerage network (operated by water companies), a discharge from a domestic property or from a holiday park/campsite.

2.6 Sites of ecological and conservation interest

2.6.1 Statutory sites

Two sites of international importance (SAC, SPA or RAMSAR) occur within 2 km of the site boundary (*Drawing 3133/HIA/03*). Morecambe Bay Ramsar site (reference UK11045) is located within 2 km to the north, and 3 km to the west of the site, following the coastline and the banks of the River Wyre Estuary. The Morecambe Bay Special Area of Conservation (SAC reference UK0013027) also follows the coastline to the north of the site.

The coastline and the banks of the River Wyre Estuary are designated as the Wyre Estuary Sites of Special Scientific Interest (SSSI). This is an area of intertidal estuarine flats and ungrazed saltmarsh, which has been designated for ecological reasons due to the habitat it provides for birdlife and rare flora.

There are no Local or National Nature Reserves within 2 km of the site boundary.

2.6.2 Non-statutory sites

There are no non-statutory Local Wildlife Sites (LWS) within 2 km of the Application Area boundary. The closest LWS is Barnaby's Sands and Burrow Marsh, located 3.2 km to the southwest of the site. These are both included within the Wyre Estuary SSSI.

2.7 Landfill sites

2.7.1 Historical landfill sites

Environment Agency data indicates the existence of three historical landfill sites within 2 km of the site boundary. The sites are shown on *Drawing 3133/HIA/04* and their details are recorded in *Table 3133/HIA/T2*. Willow Grove Landfill and Sandy Lane Tip are located 625 m and 770 m to the northwest of the site, and Bonds Farm landfill is located 1.4 km to the northeast.

3133/HIA/T2: Historical landfill sites					
Map ID	Site Name	WRC N°	Licence holder	Active years	Materials
HL1	Willow Grove	2300/0146	Wyre Borough Council	1960 - 1974	Inert, industrial and household (chemical and domestic wastes)
HL2	Sandy Lane Tip	-	Preesall Urban District Council	1960 - 1974	No information
HL3	Bonds Farm	2300/0147	Wyre Borough Council	1972 - 1974	Household

2.7.2 Permitted landfill sites

According to Environment Agency data, there are no permitted (active) landfill sites within 2 km of the site boundary.

An area which currently contains a waterbody, located 1.4 km to the southwest of the Application Area, is recorded as a permitted landfill (*Drawing 3133/HIA/04*). However, it is not a landfill, but an area of salt mine subsidence. A summary of the information provided under the current 'landfill' licence for the site is listed in *Table 3133/HIA/T3*.

3133/HIA/T3: Active landfill sites				
Map ID	Site Name	Licence N°	Licence holder	Status
PL1	I C I Mine Subsidence	EA/EPR/DB3338AU/T001	Biffin Limited	Closure

2.8 Geology

2.8.1 Bedrock

Bedrock strata in the vicinity of the site are shown on *Drawing 3133/HIA/05*. The stratigraphical sequence, geological descriptions and local proven thickness are summarised in *Table 3133/HIA/T4*. The bedrock formations in the vicinity of the site are completely concealed by superficial deposits. The site is underlain by sandstones of the Sherwood Sandstone Group. The Mercia Mudstone outcrops as a fault bounded area to the south of the site, and to the west as a fault bounded synclinal structure beneath the River Wyre estuary.

2.8.2 Superficial deposits

Superficial deposits in the vicinity of the site are shown on *Drawing 3133/HIA/05*. An elongate deposit of raised storm beach sand and gravel, extending inland from the coastline, comprises

the economic mineral. Blown sand and marine beach deposits are mapped to the north, along the coastline. Tidal Flat deposits comprising of clay and silt, with some areas of coarser material, surround the site to the east, south and west.

Based on the interpretation included in BGS Map Sheet 66, the storm beach sand and gravels and the tidal flats are directly underlain by older glacial till deposits. The Till outcrops at surface to the west of the site. Drumlin features are visible to the west of the site, which BGS records indicate to be formed of Boulder Clay, with cores of glacial sand.

3133/HIA/T4: Regional stratigraphy				
	Group	Formation		Lithology ^A
Superficial Deposits	-		Peat	-
			Marine beach deposits	Sand
			Blown sand	Sand
			Tidal flat deposits	Clay and silt
			Raised storm beach deposits	Sand and gravel
			Glaciofluvial deposits	Sand and gravel
			Diamicton (Till)	Boulder Clay
Bedrock	Mercia Mudstones	Sidmouth Mudstone Formation	Breckells Mudstone	200 m of reddish brown mudstone with gypsum nodules and halite veins
			Kirkham Mudstone	Sequence of red-brown and grey-green mudstones with frequent thin siltstone beds. Near the River Wyre Estuary, the Preesall Salts divide this mudstone unit into two parts -an upper 120 m thick unit and lower 110 m thick unit
			Preesall Halite Member (Preesall Salt)	Halite with thin beds of reddish brown and dark greenish grey mudstone, which has a local recorded thickness of up to 185 m
			Singleton Mudstone	137–310 m of red-brown mudstone containing gypsum veins. Thin salt beds lie near the top (Mythop Salt deposit) and base (Rossall Salt deposit) of the Formation
		Tarporley Siltstone Formation	-	20–35 m of interbedded mudstone siltstone and sandstone bands

3133/HIA/T4: Regional stratigraphy				
	Group	Formation		Lithology ^A
		(Hambleton Mudstone)		
	Sherwood Sandstone (SSG)	-	-	150 m Yellow, red and brown Sandstone, pebbly at top of the sequence
^A BGS notes on Map sheet 66 and BGS Lexicon				

2.8.3 Local geology

Mineral investigation was conducted at the site by Baxter Construction in February 2018 and by Greenfield Environmental Limited in March 2021. Three deep boreholes were drilled in 2018, and a further twenty-six shallow boreholes in 2021; the records are provided in *Appendix 3133/HIA/A2*.

Soil overburden was recorded across the site with an average thickness of 0.5 m. Limited areas of 2–3 m thick peaty soils, silt and peat were recorded in the southern and western site areas, outside of the proposed mineral extraction area.

The economic mineral is described as sand and gravel, often with cobbles near the surface. The deposit varies in silt content and colour (grey, brown and yellow) across the site, and becomes sandier with depth. A peaty silty clay lens, 0.2–0.3 m in thickness, is present in the centre of the site, dividing the economic mineral at this location into two units.

The economic mineral pinches out to the north, south and east. The thickness of the mineral proven in 2018 was between 3.8–9.25 m, with an average of 6.9 m. Further investigation in 2021 proved that it was between 0.8–5.9 m, with an average thickness of 2.7 m. The mineral thickness varies across the site but is generally closer to ground level and thinner in the northeast of the site, becoming deeper and thicker within the western site block (Phase 1).

Mineral investigation drilling indicates that the economic mineral is entirely underlain by Tidal Flats, with Till present at depth. This differs from the interpretation shown on BGS Map Sheet 66. The Tidal Flat deposits are described as a sandy silt, with occasional organic content, shell fragments and rare silty sand beds. The Tidal Flats were proven from 3.0–10.9 m in thickness, with an average of 5 m.

The Till deposits are described as a soft, sandy, silty clay, with occasional lenses of silt, sand and plant remains and shell fragments. The full thickness of the Till was not proven at the site,

however a maximum thickness of 6.2 m was recorded. Records for BGS borehole SD34NE99 indicate a Till thickness of 9.1 m and describe it as hard Boulder Clay.

2.8.4 Local areas of made ground

Wyre Council has identified an area of land adjacent to the west of the site which has been restored using unknown fill material. No information regarding this area or the imported material is available.

Logs for mineral investigation boreholes BH21-18 indicate that this made ground is 3.9 m thick. The geological log describes this material as "*black, angular, coarse grained glassy grit/made ground, with occasional lumps of slag <40 mm*". It was recorded to be underlain by 0.2 m of mixed gravel and made ground, with sandy silt at depth. It can therefore be inferred that the full thickness of sand and gravel has been removed within this area.

2.9 Hydrogeology

2.9.1 Aquifer designations

The Sherwood Sandstone Group is classed by the Environment Agency as a Principal Aquifer and is a regionally important groundwater resource for industrial use and public water supply.

The Tarporley Siltstone and mudstones of the Sidmouth Mudstone Formation are defined as Secondary 'B' Aquifers. These are predominantly lower permeability units. The Halite deposits are registered as unproductive strata, due to their crystalline nature.

The marine sand, blown sand, raised storm beach and the glaciofluvial deposits are classed as Secondary 'A' Aquifers. These are, by definition, permeable layers capable of supporting water supplies at a local rather than strategic scale. The Till deposits have been classed as a Secondary Undifferentiated Aquifer, where it has not been possible to attribute either aquifer category 'A' or 'B' to a rock type. Lastly, the Tidal Flats and Peat deposits are classed by the Environment Agency as non-aquifers, however Peat deposits usually store limited volumes of groundwater.

2.9.2 Aquifer status

The whole of the Sherwood Sandstone catchment is designated as an outer source protection zone (SPZIII). The closest groundwater source protected by a SPZ Zone I and II is located >10 km to the east of the site. Environment Agency data indicates that the Sandstone aquifer is generally over-abstracted.

The site is not located within a Drinking Water Safeguard Zone or Nitrate Vulnerable Zone (NVZ) for groundwater or surface water.

2.9.3 Aquifer properties

Site-specific hydraulic conductivities have been estimated from particle size distribution (PSD) conducted on the 2018 and 2021 mineral investigations. The analysis was conducted using the Excel based tool 'HydrogeoSieveXL' which identifies the most appropriate method of analysis from a list of 15 formulas based on the particle size distribution; the results are provided in *Appendix 3133/HIA/A3* and summarised in *Table 3133/HIA/T5*. The range in values reflects the mixed deposit encountered at the site, comprising silt, sand, gravel and cobbles.

Based on the above information a range of hydraulic conductivity values from 4 to 400 m/d, with a best estimate of 40 m/d, is considered representative of the site.

3133/HIA/T5: Hydraulic conductivity from PSD analysis		
Sample grading	2018 borehole PSD analysis	2021 borehole PSD analysis
Coarsest	12,106.0 m/d	627.6 m/d
Finest	4.6 m/d	14.0 m/d
Median	320.8 m/d	

2.9.4 Springs

There are no springs within 2 km of the site shown on the 1:25,000-scale OS map.

2.9.5 Groundwater abstractions

Within a 2 km radius of the site, no private groundwater abstractions have been noted by Wyre Council, and no licensed groundwater abstractions have been noted by the Environment Agency.

The locations of wells noted on the OS maps are shown on *Drawing 3133/HIA/02*. After the collapse of the Preesall Salt Mines, salt continued to be extracted from brine wells until the 1980s. These brine wells are labelled on the OS map, located 1.5–2.5 km to the west of the site. Within 2 km of the site, two wells are noted near Shaw's Lane, located 1.5 km to the east, and a single well was noted 1.1 km west of the site. None of these wells have been noted as active private abstraction by the local authority.

2.9.6 Groundwater levels

Sand and gravel

Groundwater strike data was recorded during drilling in March 2021. Water strikes were recorded between 0.6–2.3 m below ground level (mbgl), within the top of the sand and gravel deposits. A groundwater strike was recorded within the made ground at 5.46 mAOD, similar to the adjacent boreholes situated within the sand and gravel. This infers that the made ground is permeable and may be in hydraulic continuity with groundwater.

Groundwater level data is provided as *Appendix 3133/HIA/A4*.

Four groundwater monitoring boreholes (BF21-3, BF21-13, BF21-14 and BF21-16) are installed around the Application Area (*Drawing 3133/HIA/A4.1*) which monitor the sand, gravel, and basal silt deposits. Groundwater level monitoring was conducted on six occasions between March 2021 and January 2023 and a groundwater hydrograph of the resultant data is presented in *Appendix 3133/HIA/A4 (Drawing 3133/HIA/A4.2)*. Groundwater levels range between 0.33–2.01 mbgl. Groundwater elevations are between 4.25–5.61 mAOD and decline generally eastwards by approximately 0.3–0.55 m. The groundwater flow is mainly eastwards, varying occasionally towards the northeast or southeast. In March 2021, when the surrounding field drains were flooded, a westerly groundwater flow direction was observed. This implies that the thin sand deposit is draining radially into the peripheral field drains, and that the groundwater levels are controlled by the water level within the surrounding field drains. Initial data indicates that winter rainfall causes increases in groundwater levels of between 0.5–1.0 m.

Groundwater level data indicates saturated sand, gravel and silt to be present across the site. The range of saturated thickness of sand and gravel across Phase A and Phases 2 to 4 is between 0.6–3.1 m. A greater thickness of economic mineral is present within Phase 1; as groundwater level monitoring data is not available for Phase 1, a maximum saturated sand and gravel thickness of 5 m can be inferred using the groundwater strike data from borehole BH 21-21.

Sandstone

Water strike and rest groundwater level data for the sandstone bedrock has been obtained from BGS borehole reference SD34NE96, which is located 1.7 km southeast of the site. The borehole log records 21.34 m of Boulder Clay, underlain by red clay and sand (weathered sandstone), with sandstone and clay beds at depth. The groundwater strike was recorded

within the weathered sandstone at -17.07 mAOD. A rest water level of 1.21 mAOD was recorded at the end of drilling, implying that the sandstone comprises a confined aquifer.

The Environment Agency provided historical groundwater level monitoring data for three sandstone boreholes, which is summarised in *Table 3133/HIA/T6* below. Water strike data is not available from the BGS borehole logs. However, the log for borehole SD34NE97, at the Pilling Moss monitoring location, records the top of the sandstone at 27.43 mbgl (-21.72 mAOD), and the monitoring data records a rest water level between 3.8–5.13 mAOD. If it is assumed that water was encountered at the level of the sandstone, then this rest water level also implies the groundwater within it was confined.

3133/HIA/T6: Sandstone groundwater levels (EA monitoring boreholes)								
Reference	Location	NGR (SD) Distance/ Direction	BGS borehole	Depth	Data available	N° of readings	Groundwater levels	
							mbgl	mAOD
SD34_52	I.C.I. B	37500 46400 1 km S	SD34NE129	27.74	Nov 1972 – Apr 1973	8	0.02– 0.54	4.34– 4.86 ^A
SD44_28A	I.C.I. A	40390 48340 2.2 km NE	SD44NW12	21.64	Nov 1972 – Apr 1973	9	1.1– 2.55	3.45– 4.9 ^B
SD34_17B	Pilling Moss N° 9 Water Well	39690 45950 1.9 km SE	SD34NE97	130.45	Nov 1972 – Jun 1981	10	0.18– 1.51	3.8– 5.13
^A Ground level estimated from BGS borehole log ^B Ground level estimated from OS map								

2.10 Conceptual hydrogeology

Based on the baseline assessment a hydrogeological conceptual model for the site has been developed, which is used in the risk assessment.

The economic mineral is a sand and gravel unit classified by the Environment Agency as a Secondary 'A' Aquifer. An area of made ground is present to the west of the site of unknown source or content. It is considered likely that the full thickness of sand and gravel has been removed from this area.

The sand and gravel deposits beneath the site extend to an average depth of 3.9 mbgl, however are deeper and thicker within Phase 1, and are partially saturated across the site. Groundwater egress from the economic mineral is considered to be radial, draining to the surrounding land drains. These drains flow northwards and ultimately discharge to the Cocker's Dyke Drain or Wheel Foot Watercourse. Flow to the sea from these drains is controlled by flood gates located at the coast, operated by the Environment Agency.

Several waterbodies (P1 to P3) are located within the site. They have formed within areas of previous mineral extraction and are therefore anticipated to be in hydraulic continuity with groundwater within the sand and gravel. Another waterbody (P4) is located between the eastern and western site areas, within an area of made ground. Groundwater strike data indicates that the made ground is permeable, and that hydraulic connection between groundwater within the sand and gravel, made ground and waterbody P4 exists.

The economic deposit is underlain by Tidal Flats (silt) and glacial Till (soft to hard silty clay). A maximum Tidal Flats thickness of 10.9 m was recorded within the site, which are defined by the EA as a non-aquifer. Locally, a maximum Till thickness of 9.1 m has been proven. These combined deposits form the base of the local active hydrogeological system.

The Sherwood Sandstone Formation bedrock beneath the site is classified by the Environment Agency as a Principal Aquifer. Regionally, the bedrock is completely concealed beneath glacial deposits, which have been recorded at over 20 m in thickness. Local groundwater data from the sandstone indicates that the aquifer is confined. The superficial aquifer is therefore hydraulically isolated from the sandstone bedrock.

The Mercia Mudstone, which outcrops to the west and southwest of the site, forms the local lateral boundary to the sandstone aquifer, hydraulically isolating it from historical salt mining activities to the west.

3 THE PROPOSED DEVELOPMENT

3.1 Operational phase

The proposed operational site layout is provided as *Appendix 3133/HIA/A5*. The site has a total area of 22.3 ha with sand and gravel extraction proposed across approximately 13.1 ha. Mineral extraction will be undertaken in five phases; Phase A within the plant site and mineral extraction Phases 1 to 4. A gas pipeline and water main cross the site, and consequently Phase 3 will be worked as two separate void areas (Phase 3-A and Phase 3-B) to account for the 'stand-off' zones required for each pipeline.

Mineral will be extracted on a campaign basis over a 5-year period. Mineral extraction beneath the plant site will be undertaken as Phase A to create an area suitable for mineral processing. Removal of the plant infrastructure will be undertaken as Phase 5. Mineral extraction Phases A and Phases 1 to 4 are between 1 and 3.7 ha in size.

Overburden will be stored temporarily in bunds around the edge of each Phase and will be used subsequently for site restoration. Imported inert material suitable for use in the restoration of each phase will also be stockpiled on-site. Mineral will be processed on-site and stockpiled adjacent to the plant site prior to export.

A new haul road will be created to transport mineral from Phase 1 to the plant site, with low screening bunds created along its edges. The site would be accessed from Lancaster Road to the south, via a new access road. Sections of the plant and stocking area and quarry entrance road will be temporarily raised, by approximately 1 m above existing ground levels to 5 mAOD, using permeable granular material for the duration of site operations. The plant site, including mineral extraction area Phase A, is 2.2 ha in size.

3.2 Restoration

The proposed restoration scheme for the site is provided as *Appendix 3133/HIA/A5*. It will be restored progressively on a campaign basis using overburden and interburden sourced on-site, and suitable imported inert material. The final restoration and landscaping is anticipated to be completed over approximately 1.5 years. The total lifetime of the site is therefore 6 to 7 years. Waterbody P1, used as a silt lagoon during mineral extraction and therefore infilled during site operation, will be restored to woodland. New fishing lakes will be created within Phases 1 to 4.

The remainder of the site will be returned to original ground levels for agricultural and equestrian use. The plant site will be restored to original ground elevation levels and be utilised

as a caravan and holiday park (this change of use will be assessed under a separate Planning Application).

3.3 Water management

3.3.1 Operational water management

Mineral extraction from Phase 1, above the groundwater table, will be undertaken in a single cut during the summer months. Mineral below the groundwater table will be worked wet with no dewatering.

The full mineral thickness from Phases A, 2, 3 and 4 will be extracted under dry working conditions, which will necessitate active dewatering. To reduce the dewatering requirement, the site will be worked on a campaign basis, during the drier months. Water from dewatering and from run-off generated within the plant site will be allowed to settle in a sump and discharged to the on-site waterbodies. Excess water, which cannot be managed on-site, will be discharged to the adjacent field drain network. These field drains flow northwards and ultimately discharge to the Cocker's Dyke Drain or Wheel Foot Watercourse. Flow to the sea from these drains is controlled by flood gates located at the coast, operated by the Environment Agency.

A water supply is not required for mineral processing. Water from a freshwater lagoon adjacent to the plant site will be used to provide dust suppression and to supply a wheel wash. Settled clean water will be recirculated from the silt lagoon to the freshwater lagoon, and the system will be periodically topped up using water from dewatering as required.

Silt from the Tidal Flats would be extracted wet, using a long-reach excavator and, together with the underlying clay, this material would be used to line the sides of the quarry void to reduce groundwater ingress. This will significantly reduce the dewatering requirement and impact upon the surrounding water environment.

3.3.2 Dewatering requirement

Dewatering to facilitate mineral extraction will be required in Phases A, 2, 3 and 4. A range of hydraulic conductivity values from 4 to 400 m/d have been considered to assess volumes of ingress, with a best estimate of 40 m/d. The mineral is partially saturated, with maximum saturated thicknesses of 3.1 m in the east of the site area (Phases A, 2, 3 and 4). The estimate of dewatering requirement has been made using the largest area likely to be open at one time, Phase 3-B, which has an area of 3.7 ha (average dimensions 160 x 230 m). Groundwater ingress calculations are included in *Appendix 3133/HIA/A6*.

The radius of influence of watertable drawdown, caused by dewatering, has been estimated to be 200 m from the active working void.

The estimated volume of groundwater inflows and incident rainfall is summarised below. For steady-state inflows from the sand and gravel, the maximum groundwater inflow rates, based on a hydraulic conductivity of 40 m/d, are estimated to be 1,250 m³/d (14.5 l/s) for a required drawdown of 3.1 m within Phase 3-B.

The removal of incident rainfall from the active quarry void will also be required. Volumes of incident rainfall provided in *Table 3133/HIA/T7* have been calculated using average rainfall data taken from the Fleetwood rain gauge.

3133/HIA/T7: Incident rainfall				
Area	Range (m ³ /day)	Average (m ³ /day)	Flow range (l/s)	Average Flow (l/s)
Phase 3-B (3.7 ha)	54 – 123	89.7	0.6 – 1.4	1.0

The maximum combined dewatering requirement occurs during extraction of Phase 3-B at 1,372.3 m³/d (15.9 l/s).

Progressive restoration will be undertaken on a campaign basis, therefore each Phase is unlikely to exist as completely open void space at any one time. This would reduce the area requiring dewatering, and therefore the actual dewatering requirements are likely to be lower than those presented above. The above calculations represent a worst-case scenario.

Pumping off-site is only permitted up to the combined greenfield run-off rate for the operational phase and the plant site area, which has been detailed in the accompanying FRA (FRA, Hafren Water, June 2023). Off-site discharge will need to take cognisance of tide levels in Morecombe Bay so that existing flooding issues along receiving watercourses due to 'tide locking' are not exacerbated. The quarry will be signed up to receive local flood alerts and will not discharge off-site when notified by the EA during times of flooding.

Water from dewatering will be required for dust suppression and to supply an on-site wheel wash, therefore reducing the total volume of water required to be discharged off-site.

3.3.3 Water management post-restoration

Following completion of restoration, surface run-off from the restored quarry will revert to pre-development conditions and any subsequent water management will be passive. Surface water run-off will enter the existing field drain network.

4 ASSESSMENT OF IMPACTS

4.1 Methodology

An assessment of the potential effects of the proposed development on the water environment within the site and its surrounds has been undertaken.

Potential impacts to the baseline and current conditions have been assessed. Short-term (operational) and long-term (post-restoration) phases of site development have been considered. The potential for unplanned incidents, such as spillage of hazardous substances, have also been taken into account. The following factors were considered:

- Magnitude of the impact
- Spatial extent of the impact
- Frequency of the impacts
- Timescale over which the impact may occur
- Cumulative impacts
- Sensitivity of the receiving environment

Mitigation measures and residual impacts have been considered as part of the assessment. The method of assessment is detailed in *Appendix 3133/HIA/A1* together with the matrices used to provide a robust method of assessment.

4.2 Baseline sensitivity

The characteristics of the baseline water environment are used to form a basis from which the impact assessment can be undertaken. Details of how the baseline catchment sensitivity is assessed are provided in *Table 3133/HIA/A1.1 of Appendix 3133/HIA/A1*.

Baseline sensitivities for various features surrounding the site are given in *Table 3133/HIA/T8*.

3133/HIA/T8: Baseline sensitivity		
Catchment	Sensitivity	Reasons
SURFACE WATER		
Waterbodies P2, P3, P4 (P1 to be removed)	Low	The adjacent waterbodies are not connected to the surrounding field drains. The waterbodies are used for fishing and are unlined. Waterbody P1 will be used as a silt settlement lagoon as part of the operational water management scheme. This waterbody will be infilled with silt and will be restored to woodland area. It is assumed that any fish will be removed prior to the start of site operation

3133/HIA/T8: Baseline sensitivity		
Catchment	Sensitivity	Reasons
		There is a hydraulic connection of the surface waterbodies with groundwater within the sand and gravel deposit. These waterbodies are considered to be of low sensitivity and are owned by the same landholder as the site
Rivers Wyre & Lune/ Field ditches	Low	The surface water run-off and groundwater issues from the economic mineral drain from within the site into the surrounding field drains. The site is located across the catchment divide between the Rivers Wyre and Lune. The drains are part of extensive regional catchments supporting these watercourses As the drainage from within the Application Area is negligible within the scale of these catchments, they are considered of low sensitivity
GROUNDWATER		
Superficial Aquifer (economic mineral)	Low	The site is located across a raised storm beach deposit, comprising sand and gravel, classified by the Environment Agency as a Secondary 'A' Aquifer. The aquifer drains to the surrounding field drains and is considered to be in hydraulic continuity with adjacent waterbodies No local private or licensed supplies have been identified. The sensitivity is therefore classed as Low
Bedrock Aquifer Surrounding site	Medium	Underlying sandstone bedrock is designated as a Principal Aquifer and provides a major resource for public water supply. The aquifer is completely concealed by regional Till deposits and is under confined conditions, hydraulically separate from the overlying sand and gravel deposits The site lies within the total catchment Source Protection Zone. The closest groundwater source protected by a SPZ Zone I and II is located >10 km to the east of the site Despite the regional significance of this aquifer, locally it is confined and not hydraulically linked to the economic mineral. In addition, no local or licensed abstractions have been identified. The sensitivity is therefore classed as Medium
CONSERVATION SITES		
River Wyre Estuary/ Morecambe Bay Ramsar & SPA Wyre Estuary SSSI	Medium	The protected sites are over 1.5 km downstream of the site and are supported by drainage from several regional scale catchments. Although these sites are highly sensitive, drainage contributions from the Application Area are negligible within the scale of their catchments. The sensitivity is therefore classed as Medium

The subsequent overall sensitivity of the groundwater environment surrounding the site is assessed as '**Low**' for the superficial aquifer, and as '**Medium**' for the bedrock Principal Aquifer. The sensitivity of the surface water environment is assessed as '**Medium**' for the downstream surface water-supported conservation sites, and '**Low**' for the on-site waterbodies, field drains and rivers.

4.3 Potential impacts during mineral extraction

To permit dry and safe working conditions for mineral extraction, the full thickness of overburden and mineral will need to be dewatered within Phase A and Phases 2–4. Mineral below the groundwater level within Phase 1 will be worked wet, with no dewatering required. Mineral extraction and dewatering is proposed to be undertaken on a campaign basis when conditions are dry and groundwater levels are low. Progressive restoration will reduce the open void area requiring dewatering, and therefore reduce the dewatering requirement.

4.3.1 Surface water flow

The drawdown of groundwater levels, caused by dewatering, may reduce the volume of groundwater egressing to the local field drains. However, the drainage from within the Application Area under greenfield conditions is negligible. The field drains will continue to receive surface water run-off and drainage from the surrounding catchment.

The field drains are within the River Wyre and the River Lune regional-scale catchments. These rivers are located outside of the estimated radius of influence of dewatering.

To reduce the dewatering requirement, the site will be worked on a campaign basis during the drier months of the year. Any potential impact will therefore be limited to the period of dewatering only. A proportion of dewatering will be discharged to the surrounding field drain network, thereby mitigating any derogation of flow.

The proposed water management scheme will ensure that the magnitude of impact to the adjacent field drains resulting from dewatering is 'Negligible'. With a 'Low' sensitivity catchment, the significance of effect is therefore 'None'.

4.3.2 Surface water levels

The on-site waterbodies are owned by the same landholder as the site and are considered to be in hydraulic connection with the surrounding superficial aquifer. Therefore, drawdown of groundwater levels, caused by dewatering, may impact their water levels.

To reduce the dewatering requirement, the site will be worked on a campaign basis during the drier months of the year.

Dewatering, and hence any associated potential impacts, will be time-limited, occurring over the lifetime of the quarry only. A proportion of settled water will be discharged to the waterbodies, thereby mitigating any decline in surface water levels.

If required, the underlying clay can be used to line sections of the void walls to reduce groundwater ingress and thus reduce the dewatering requirements. This mitigation will minimise the radius of influence of dewatering, including minimising any potential impact to the adjacent waterbodies.

Considering the proposed mitigation measures outlined above, the potential magnitude of impact on surface water levels within the adjacent waterbodies from dewatering is therefore considered to be 'Negligible'. With a 'Low' sensitivity catchment, the significance of effect is therefore 'None'.

4.3.3 Groundwater levels

Dewatering within Phase A and Phases 2-4 will have localised impact on groundwater levels in the superficial deposits. Dewatering will take place on a campaign basis and any impact is anticipated to be time-limited and restricted to within the radius of influence surrounding the actively dewatered phase. A proportion of dewatering will be discharged to the on-site waterbodies to infiltrate to ground, thereby mitigating any derogation in levels.

Mineral below the groundwater level within Phase 1 will be worked wet without dewatering, therefore there will be no change in groundwater-levels around this working area.

The sensitivity of the superficial groundwater catchment is considered to be 'Low' with the magnitude of impact 'Negligible'. The significance of effect is therefore 'None'.

The superficial aquifer is hydraulically isolated from the Sandstone Aquifer at depth by the Tidal Flats and glacial Till deposits. Therefore, the Principal Aquifer will not be impacted by the proposed dewatering activity.

The sensitivity of the bedrock groundwater catchment is assessed as 'Medium' with the magnitude of impact 'Negligible'. The significance of effect is therefore 'Minor'.

4.3.4 Groundwater flow

The groundwater flow direction within the superficial deposits under current conditions is radial at the periphery of the deposit. Groundwater issues from the sand and gravel egress into the surrounding field drains or support the on-site waterbodies. During dewatering, the local groundwater flow direction within the superficial deposits may be temporarily modified, with flow directed towards the location of dewatering.

Dewatering will take place on a campaign basis and any impact is anticipated to be time-limited and restricted to being within the estimated radius of influence of the actively dewatered phase. A proportion of dewatering will be discharged to the on-site waterbodies to infiltrate back to ground, or off-site to the field-drain network, thereby mitigating any derogation due to the temporary change in groundwater flow direction.

The proposed water management scheme at the site will ensure that the magnitude of impact from dewatering to groundwater flow is 'Negligible'. The sensitivity of the superficial groundwater catchment is assessed to be 'Low', and the significance of effect is therefore 'None'.

4.3.5 Designated sites of ecological interest

The River Wyre Estuary/Morecambe Bay Ramsar & SPA and Wyre Estuary SSSI are located over 1.5 km downstream of the site. These sites are supported by drainage from extensive regional scale surface water catchments up and downstream of the site. The drainage from within the Application Area under greenfield conditions is negligible in relation to the scale of these catchments.

During site operation, the field drains will continue to receive surface water run-off and drainage from the surrounding catchment. A proportion of dewatering from the proposed quarry will be discharged to the surrounding field drain network. All of the protected environmental sites are located outside of the predicted radius of influence of dewatering.

Because all the designated sites are outside of the radius of influence and are supported by extensive surface water catchments, they are considered to have a magnitude of impact from dewatering of 'Negligible'. With a sensitivity of 'Medium', the significance of effect is therefore 'Minor'.

4.3.6 Water quality

Settled water derived from dewatering will be discharged to the adjacent waterbodies and field drains. Potential exists for adverse impact on surface water quality from suspended solids

and chemical contamination, principally from the accidental release of hydrocarbons (fuels and lubricants).

Suspended solids

Water from dewatering will be settled within a sump in the quarry void, prior to being discharged to the on-site waterbodies or off-site. This will ensure that there is sufficient settlement provision to remove suspended solids from the discharged water.

The proposed water management scheme will ensure that the magnitude of impact on surface water quality will be 'Negligible'. For the superficial aquifer, on-site waterbodies, surrounding field drains, with a 'Low' sensitivity catchment, the significance of effect is therefore 'None'.

Chemical contamination

There is a risk of small-scale accidental release of chemicals or hydrocarbons from mobile plant within the quarry.

All fuel and chemicals will be contained within a bunded storage area on hardstanding. Frequent inspections of mobile plant and fuel tanks will be conducted, and spill kits carried on all vehicles.

In the unlikely event of an accidental release of chemicals or hydrocarbons contaminants could enter the water management system if not immediately or fully contained. Spill kits will be provided on-site. Therefore, in the unlikely event of an incident, contaminants will be contained and disposed of at a suitable facility and in accordance with best practice. The immediate termination of pumping and use of a shut-off valve, to be installed on the discharge pipe, will enable the temporary suspension of discharge flow until clean-up is achieved.

The residual risk to groundwater within the superficial aquifer, on-site waterbodies and field drains is therefore assessed to be 'Negligible'.

The Principal Aquifer is hydraulically isolated from the superficial aquifer and therefore will not be impacted by an accidental release of chemicals or hydrocarbons at ground level.

With the proposed mitigation measures in place, the potential impact on surface water quality due to chemical contamination is therefore considered to be 'Negligible'. For the superficial aquifer, on-site waterbodies and surrounding field drains, with a 'Low' sensitivity catchment, the significance of effect is therefore 'None'.

The sensitivity of the Principal Aquifer is considered to be 'Medium'. With the proposed mitigation measures implemented, the magnitude of impact is considered to be 'Negligible' and the significance of potential impact is classed as 'Minor'.

Further 'Best practice' mitigation measures are discussed in Section 6.

4.4 Potential impacts following restoration

The site will be progressively restored using inert fill, back to original ground level, with the creation of several waterbodies. Waterbody P1 will be infilled with silt and restored to woodland.

4.4.1 Surface water run-off

As the site will be restored to pre-existing ground levels, surface water run-off will continue as per the pre-development situation. Surface water run-off will enter the existing field drain network.

Considering the above information, the post-restoration surface water regime will ultimately remain unaltered from the pre-development scenario. The sensitivity of receptors is assessed as 'Low', with a 'Negligible' magnitude of impact. The significance of effect is therefore 'None'.

4.4.2 Groundwater levels and flow

Following the completion of restoration, dewatering will cease and groundwater levels will recover.

The areas restored using imported inert materials are considered likely to have lower hydraulic conductivity than the sand and gravel, and therefore have the potential to act as an impediment to groundwater flow. However, areas of sand and gravel aquifer will remain around the proposed mineral extraction areas. Groundwater flow paths may be partially diverted around the restored areas, however the ultimate flow direction towards the edge of the deposit, will remain unchanged from the pre-development scenario.

Considering the above information, the post-restoration groundwater regime will ultimately remain unaltered from the greenfield scenario. The sensitivity of receptors is considered to be 'Medium', with a 'Negligible' magnitude of impact. The significance of effect is therefore 'Minor'.

4.4.3 Water quality

Any risk of contamination from either suspended solids or hydrocarbons from mobile plant during restoration will remain as per the operational phase. Following completion of the restoration, this risk will be removed.

There is a potential risk of accidentally including contaminated materials ('rogue loads') in the imported inert material used for on-site restoration. However, the requisite Environmental Permit (EP) will stipulate stringent waste acceptance procedures and criteria. The waste stream will also be controlled via conditions imposed within the Environmental Permit.

Considering the above information with regards to water quality, the sensitivity of the surface water and groundwater receptors will therefore remain unaltered from the operational phase, and the magnitude and significance of post-operational impacts will be reduced as the risk are removed.

5 WATER FRAMEWORK DIRECTIVE ASSESSMENT

5.1 Introduction

The Water Framework Directive (WFD) (2000/60/EC) was implemented in England and Wales by The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003. The WFD requires that all European countries manage the water environment to consistent standards, which include:

- Prevent deterioration in the status of aquatic ecosystems, protect and improve the ecological condition of waters
- Aim to achieve at least 'Good' status for all waterbodies by 2015. Where this is not possible, and subject to the criteria set out in the Directive, aim to achieve 'Good' status by 2021 or 2027
- Meet the requirements of Water Framework Directive Protected Areas
- Promote sustainable use of water as a natural resource
- Conserve habitats and species that directly depend on water
- Reduce or phase out the release of individual pollutants or groups of pollutants that present a significant threat to the aquatic environment
- Progressively reduce the pollution of groundwater and prevent or limit the entry of pollutants
- Contribute to mitigating the effects of floods and droughts

An assessment of the application is required to ensure that there are no impacts to the current or future status of the relevant waterbodies.

5.2 Location

The groundwater body associated with the underlying bedrock Sandstone Aquifer is the Fylde Permo-Triassic Sandstone Aquifer (GB41201G100500). The 2019 classification is 'Poor' for quantitative status and 'Good' for chemical status.

There is no WFD aquifer status available for the superficial aquifer, therefore there are no associated ecological or chemical criteria to be formally assessed.

The site lies within the surface water catchments of both the River Wyre and the River Lune, however it is not located within a designated surface water WFD waterbody, and therefore has no associated ecological or chemical criteria to be formally assessed.

5.3 Assessment

5.3.1 Quantitative status

Dewatering on a campaign basis will be undertaken to permit dry and safe working conditions for mineral extraction in Phase A and Phases 2-4. Dewatering may cause groundwater levels to be temporarily lowered around the active mineral extraction phase. Water from dewatering will be returned to the superficial aquifer via the on-site waterbodies and to the surface water catchment via the adjacent field drain network.

The economic mineral, the superficial aquifer, is underlain by Tidal Flats and glacial Till deposits that hydraulically isolate and confine the Sandstone Aquifer, which is located at depth beneath the site. Therefore, the Principal Aquifer will not be impacted by the proposed dewatering.

Following completion of the restoration, dewatering will cease and groundwater levels will rebound. Groundwater flow and surface water run-off will continue as per the current, pre-development situation.

There is no WFD aquifer status for the superficial aquifer or for the local surface water catchment. However, considering the above, the proposals will have no impact on the quantitative status of the local surface water or groundwater catchment.

5.3.2 Qualitative status

Water from dewatering will settle temporarily within a sump in the quarry void, prior to being discharged. This will ensure that there is sufficient settlement to remove suspended solids from the discharge. There is potential for impact to the local qualitative status of surface water and groundwater due to the accidental release of hydrocarbons during the operational phase. Control measures will be in place to mitigate against any impacts. Further best practice techniques are outlined in Section 6 below.

Materials to be imported into the site for engineering and restoration purposes will be wholly inert. Groundwater quality may be impacted if non-inert materials are inadvertently imported to the site. However, this will be mitigated by rigorous Waste Acceptance Criteria and Procedures, to be addressed during the application for an Environmental Permit. It is considered that the proposals will have no impact on the qualitative status of the groundwater.

There is no WFD aquifer status for the superficial aquifer or for the local surface water catchment. However, considering the above, the proposals will have no impact on the quality of the local surface water or groundwater.

6 MITIGATION MEASURES AND RESIDUAL IMPACTS

6.1 General

Impacts associated with the proposed development are discussed in Section 4 above. Where an adverse impact has been identified, mitigation measures are proposed below and the residual impact re-assessed.

6.2 Hydrocarbon spills

The potential risk of hydrocarbons entering groundwater would be mitigated against by the following measures:

- a) Any storage of fuel on-site should be outside the quarry void on hardstanding and in a bunded area. Any fuel or chemicals stored are to be held in double-skinned tanks with minimum 110% bund capacity
- b) All site equipment should be regularly checked for fuel and oil leakages
- c) Written procedures will be in place for responding to an accidental spill of hydrocarbons, which will minimise the risk to the environment
- d) Spill kits will be available for use on-site in the unlikely event that a spillage occurs
- e) In the unlikely event that hydrocarbons enter the water management system, discharge from site will temporarily be suspended until clean-up is completed

With these measures in place, the magnitude of impact will be '*Negligible*', with a significance of '*Minor*'.

7 CUMULATIVE IMPACTS

Cumulative impacts are those which result from changes caused by past, present or future foreseeable actions and can be defined under two categories:

No other active or proposed quarry developments have been identified within the local area. Therefore there will be no cumulative impacts from the development of Bourbles Farm Quarry.

8 SUMMARY AND CONCLUSIONS

The Bourbles Farm site is located immediately east of the town of Preesall, on the North Fylde coast of Lancashire, located 3 km inland from the River Wyre estuary. The Application Area currently comprises 22.3 ha of agricultural land and several fishing lakes. A 13.1 ha area has been identified for the extraction of sand and gravel.

Mineral extraction will be undertaken on a campaign basis in five phases and mineral will be processed on-site. The economic mineral is situated partially below the watertable. Mineral below groundwater level in Phase 1 will be worked wet, however dewatering will be required to permit safe and efficient mineral extraction from Phase A and Phases 2-4. Dewatering water will be settled within the quarry void and then discharged to both the on-site waterbodies and the adjacent field drain network. Any potential localised impacts on surface water or groundwater levels or flows will be mitigated by the discharge of water from dewatering.

Progressive restoration of the site will be undertaken using overburden and interburden from the site, as well as imported inert materials. Following completion of restoration, surface run-off from the restored site will revert to greenfield conditions and active water management will not be required. Surface water run-off will passively enter the existing field drain network.

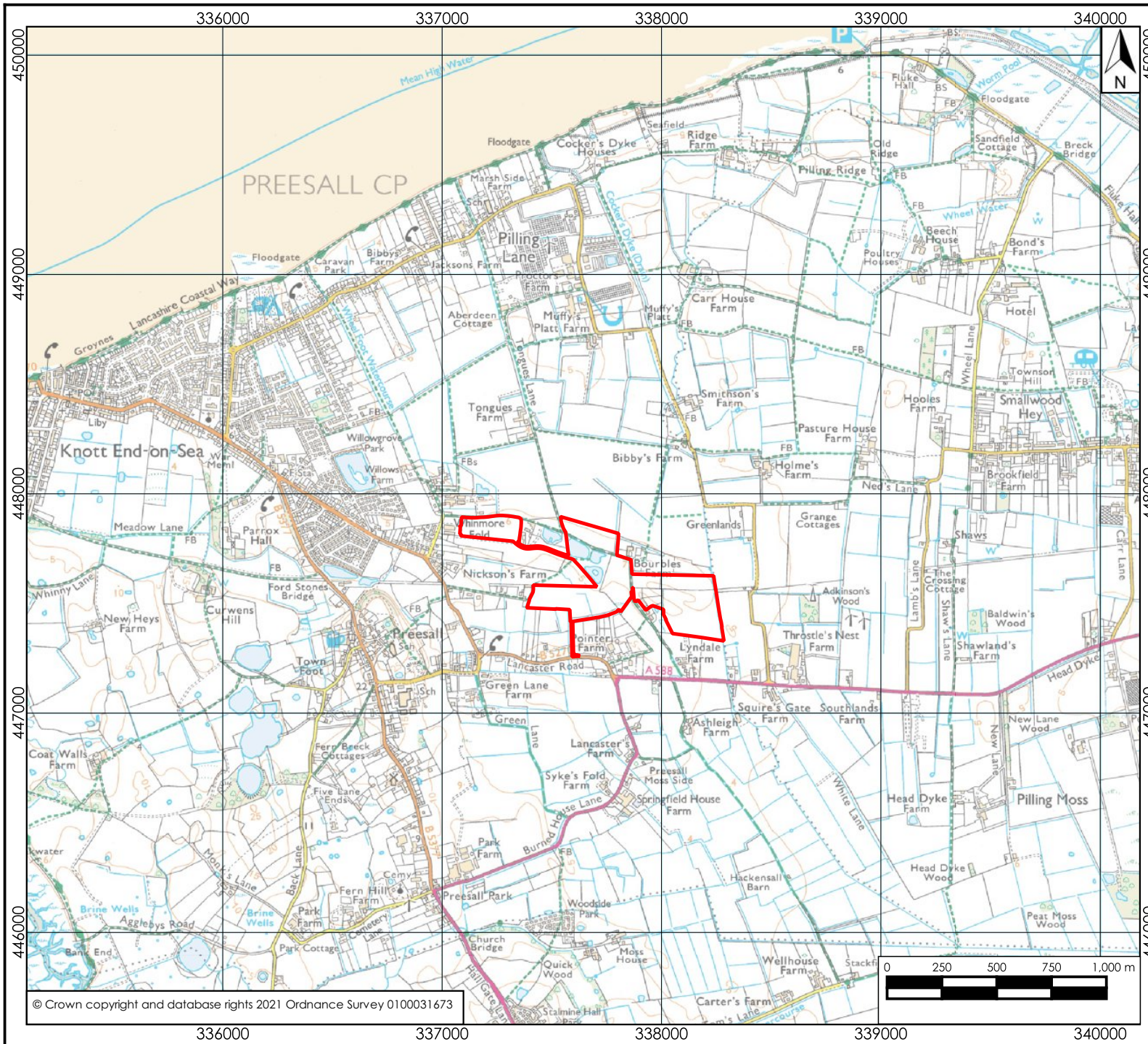
The bedrock beneath the site is the Sherwood Sandstone Formation, which is classified by the Environment Agency as a Principal Aquifer. Regionally, the bedrock is completely concealed beneath glacial deposits, which are up to 20 m thick. Local groundwater data from the sandstone aquifer indicates that this is confined. The superficial aquifer which forms the economic mineral is therefore hydraulically isolated from the sandstone bedrock at depth.

No local private or licensed supplies from the superficial or bedrock aquifer have been identified.

The River Wyre Estuary and the coastline, located 2 km to the north of the site, are both located within the Morecambe Bay Ramsar site and Special Area of Conservation, and the Wyre Estuary Site of Special Scientific Interest. These protected sites are supported by drainage from several regional scale catchments.

No residual and cumulative impacts from the proposed development on the local surface water or groundwater catchments have been identified.

DRAWINGS



Key
 Site Boundary

Scale correct at A4

Client The Baxter Group

Title Site Location

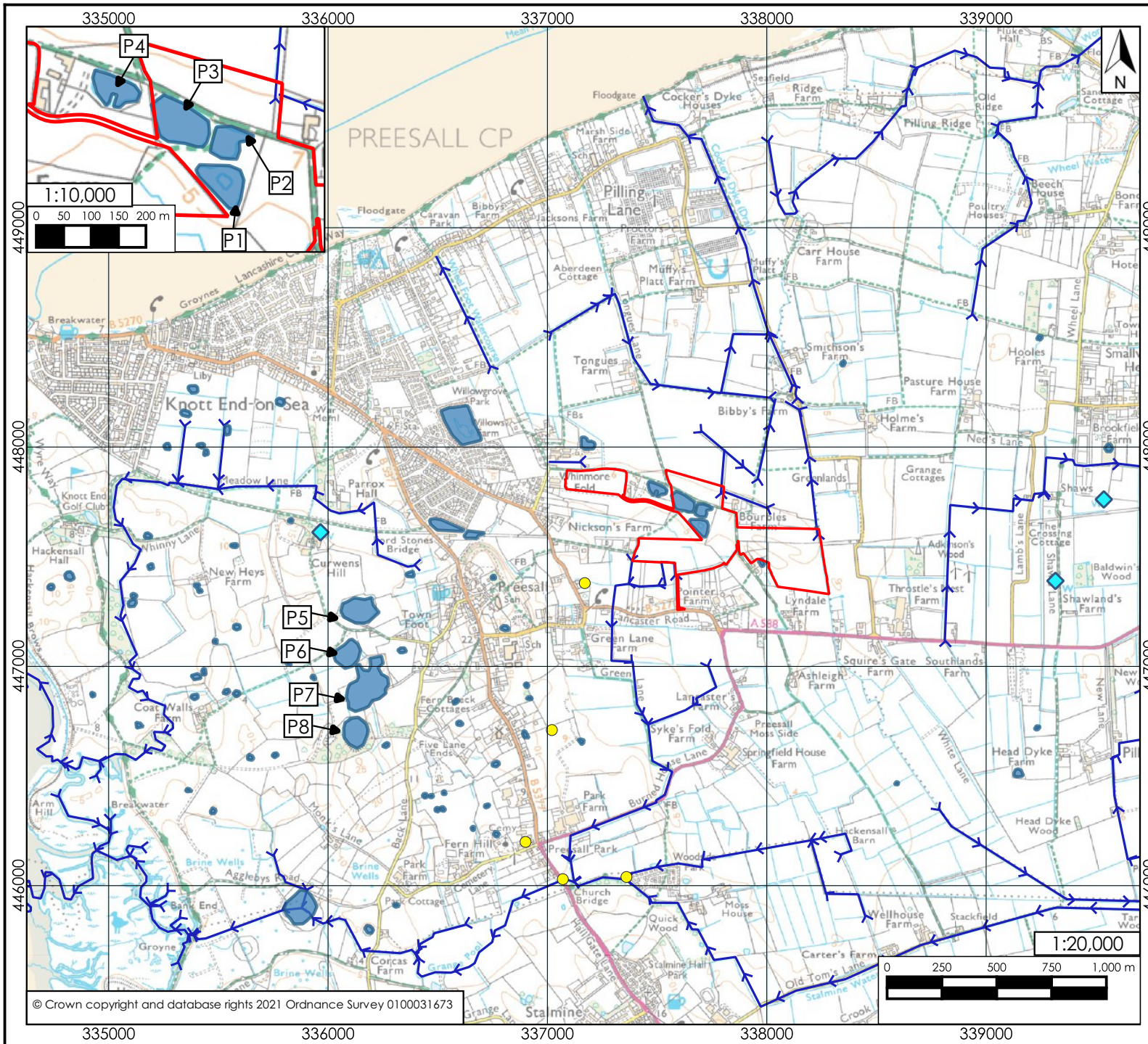
Project Bourbles Farm Quarry

Drawing 3133/HIA/01 Version 1

Date March 23 Scale 1:25,000

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Key

- Site Boundary
- Waterbody
- > Watercourse
- ◆ OS Well
- Consented Discharge

Scale correct at A4

Client The Baxter Group

Title Water Features

Project Bourbles Farm Quarry

Drawing 3133/HIA/02	Version 1
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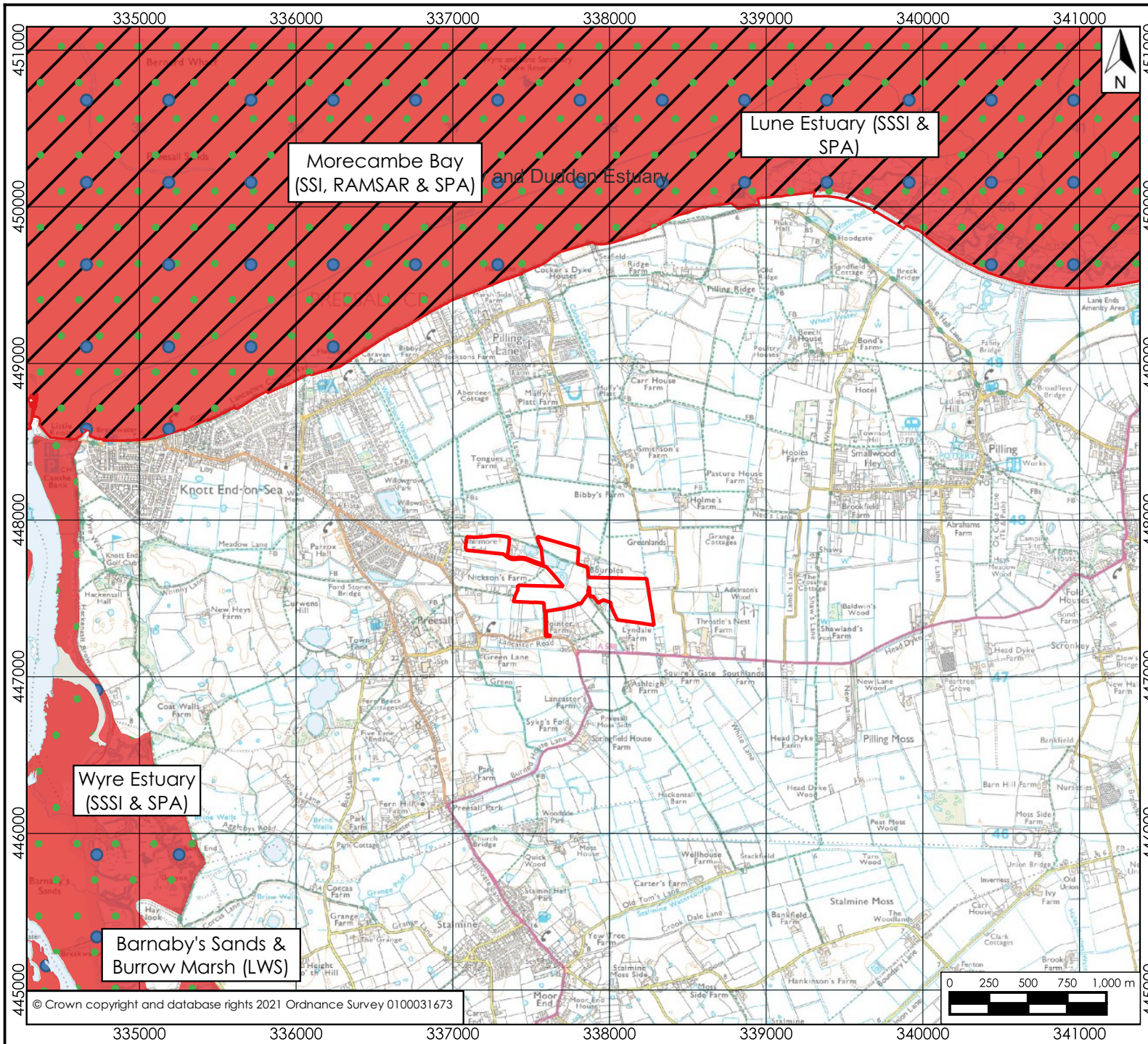
Date March 23	Scale See Maps
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Key

- Site Boundary
- Ecological Features**
- SSSI
- RAMSAR
- SAC
- SPA

Scale correct at A4

Client	The Baxter Group
Title	Sites of Ecological Interest
Project	Bourbles Farm Quarry

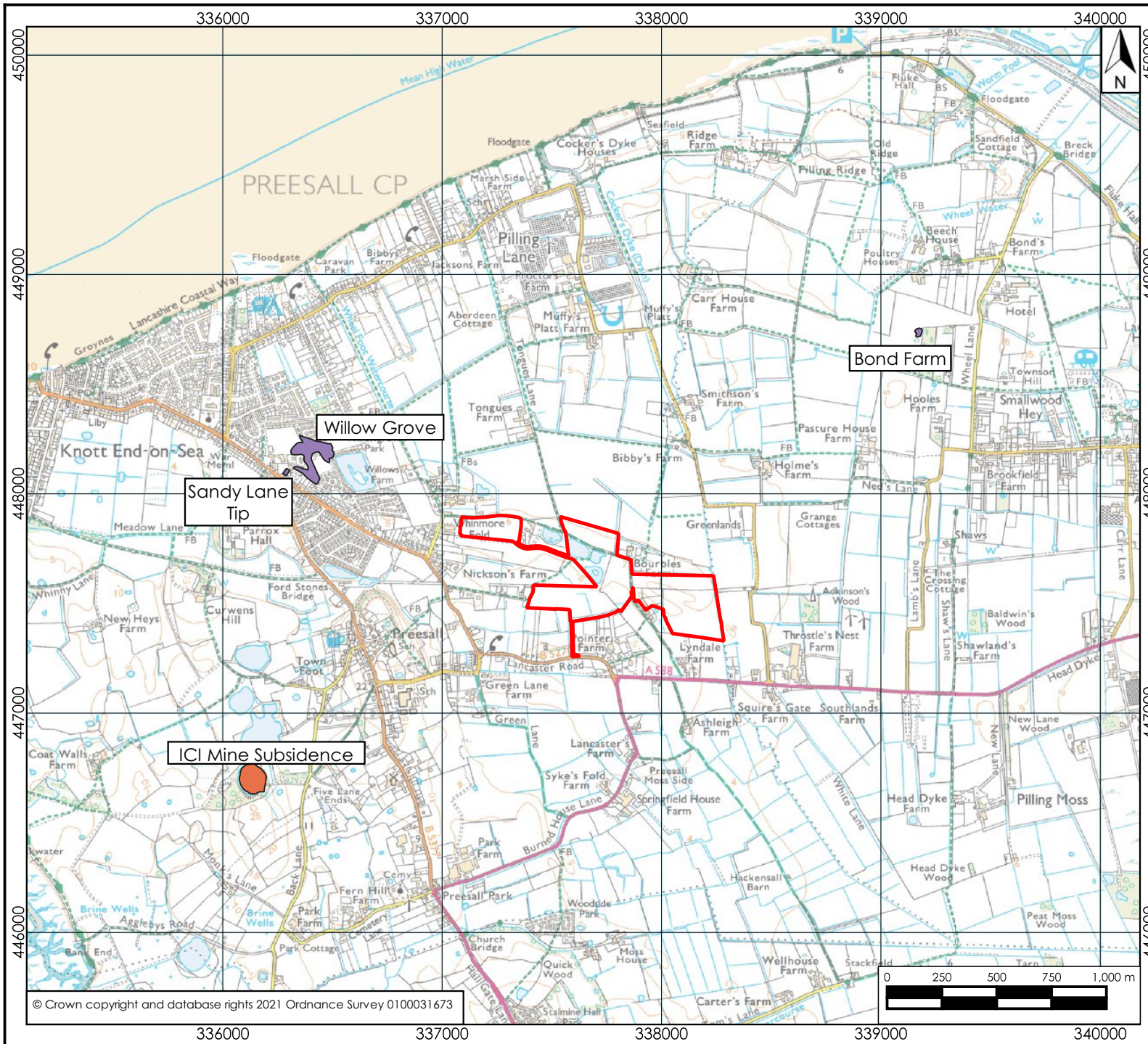
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Key

- Site Boundary
- Authorised landfills
- Historical landfills

Scale correct at A4

Client The Baxter Group

Title Landfill Sites

Project Bourbles Farm Quarry

Drawing 3133/HIA/04	Version 1
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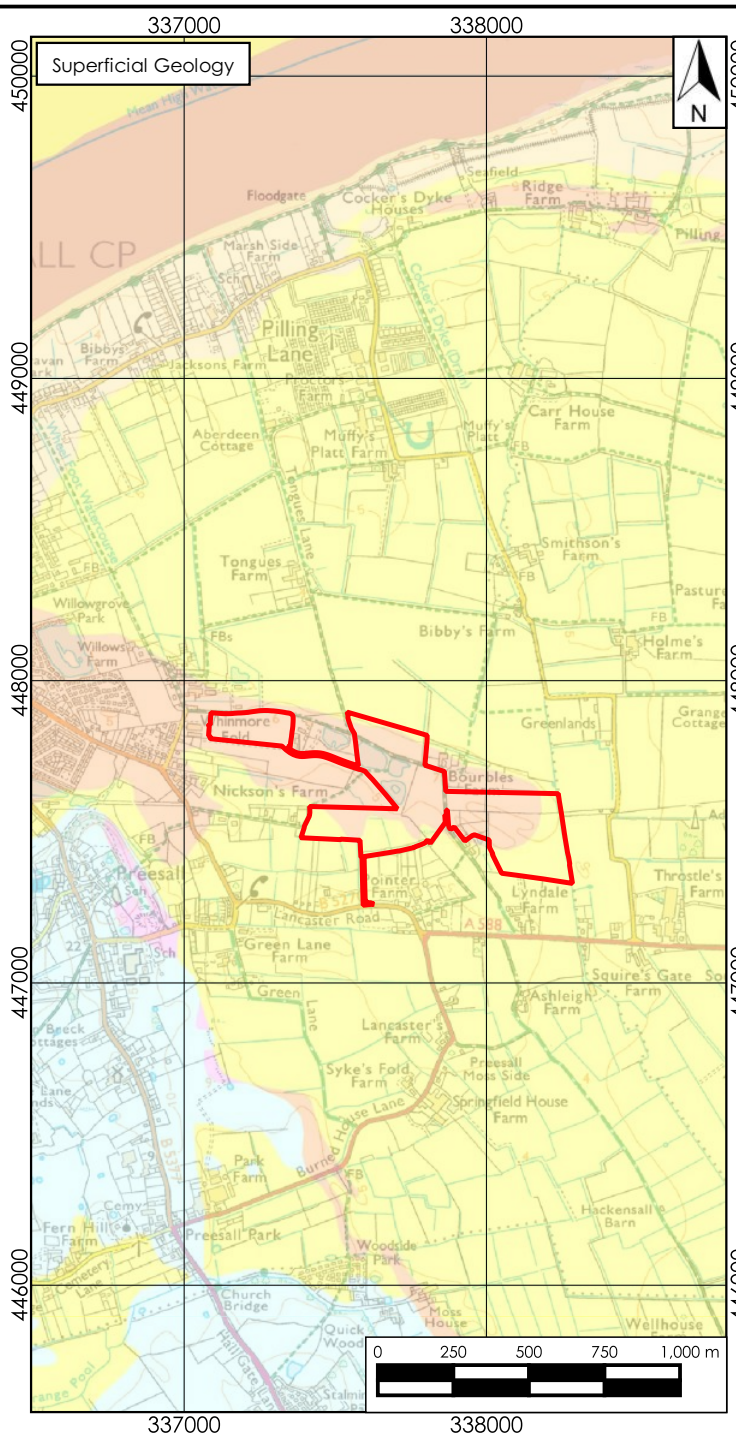
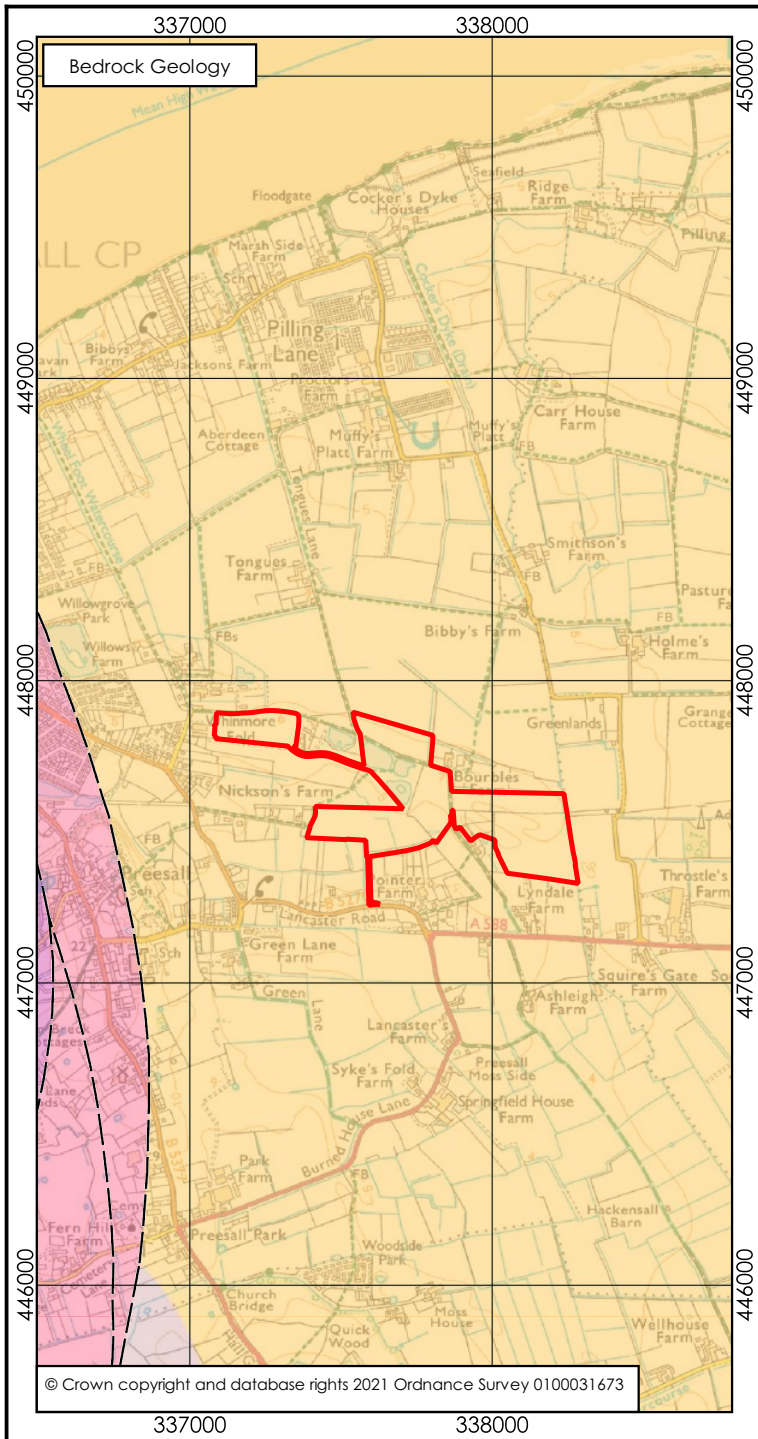
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Legend

- Site Boundary
- Fault Trace
- Bedrock Geology**
- Sherwood Sandstone Group
- Sidmouth Mudstone Formation
- Preesall Halite Member
- Superficial Deposits**
- Blown Sand
- Marine Beach Deposits - Sand
- Raised Storm Beach Deposits
- Tidal Flat Deposits

Scale correct at A4

Client The Baxter Group

Title Geology

Project Bourbles Farm Quarry

Drawing 3133/HIA/05 Version 1

Date March 23 Scale 1:25,000

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APPENDIX 3133/HIA/A1

Assessment methodology

Method of assessment

The method of assessment of hydrological and aquatic effects has involved:

- Characterisation of the baseline environment
- Determination of the sensitivity of key catchments and watercourses
- Evaluation of the significance of predicted effects taking account of the magnitude of effects (before and after mitigation)
- Evaluation of the sensitivity of the baseline environment affected

A rigorous and consistent approach to the assessment has been adopted using matrices to help classify sensitivity of the resource and determine the scale and significance of effects.

Baseline sensitivity

The characterisation of the baseline water environment has involved the review of data and identification of sensitivities. The characterisation of catchment sensitivities has been guided by the matrix presented in *Table 3133/HIA/A1.1* which lists indicative criteria.

The criteria for sensitivity are based approximately on hierarchy of factors relating to the quality of the aquatic environment. The criteria have been used to guide the analysis of the sensitivity of the baseline hydrological, hydrogeological and water quality environment.

Table 3133/HIA/A1.1: Catchment sensitivity classification		
Sensitivity category	Sensitivity criteria	
	Adjacent to Application Area	Downstream/in catchment
High sensitivity	SSSI or Aquatic Natura 2000 site Wetland/watercourse habitat of particular ecological importance Highly vulnerable groundwater Significant peat deposits on sloping ground	Aquatic Natura 2000 site or SSSI immediately downstream/ adjacent to site
Medium sensitivity	Wetland watercourse habitat of particular ecological importance Moderately vulnerable groundwater Significant peat deposits	Aquatic Natura 2000 site or SSSI further downstream of the catchment. Sensitive locally designated site of ecological interest
Low sensitivity	Low vulnerability groundwater Superficial peat deposits	
Not sensitive	No aquatic habitats or watercourses present No significant groundwater present	

Impact prediction and evaluation

The prediction and assessment of effects on hydrology, hydrogeology and other aquatic resources has been undertaken using a series of tables to document the various potential impacts from aspects of the proposed project. Impacts have been predicted for the proposed development based on the guideline criteria for impact magnitudes set out in *Table 3133/HIA/A1.2*.

Table 3133/HIA/A1.2: Impact magnitude	
Impact magnitude	Guideline criteria
High	Total loss of, or alteration to, key features of the baseline resource such that post-development characteristics or quality would be fundamentally and irreversibly changed, eg watercourse realignment
Medium	Total loss of, or alteration to, key features of the baseline resource such that post-development characteristics or quality would be partially changed, eg in-stream permanent bridge works
Low	Small changes to the baseline resource which are detectable but the underlying characteristics or quality of the baseline situation would be similar to pre-development conditions, eg culverting of very small watercourses
Negligible	A very slight change from baseline conditions, which is barely distinguishable and approximates to the 'no change' situation, eg short-term compaction from plant movements

Using these criteria a series of generic impacts have been predicted for the proposed development. Residual effects have been predicted taking into account site-specific mitigation.

The significance of the predicted effects has been assessed in relation to the sensitivities of the baseline resource. A matrix of significance was developed to provide a consistent framework for evaluation and is presented in *Table 3133/HIA/A1.3*. Guideline criteria for the various categories of effect are included in *Table 3133/HIA/A1.4*.

Table 3133/HIA/A1.3: Significance matrix				
Magnitude	Sensitivity			
	High	Medium	Low	Negligible
High	Major	Major	Moderate	Minor
Medium	Major	Moderate	Minor	Minor
Low	Moderate	Minor	Minor	None
Negligible	Minor	Minor	None	None

Table 3133/HIA/A1.4: Significance of effects categories		
Significance	Definition	Guideline criteria
None	No detectable change to the environment	No effects on drainage patterns, surface and groundwater quality or aquatic habitat

Table 3133/HIA/A1.4: Significance of effects categories		
Significance	Definition	Guideline criteria
Minor	A small but detectable change to the environment	Localised changes in drainage patterns or groundwater flows, or changes resulting in minor and reversible effects on surface and groundwater quality or aquatic habitats
Moderate	A larger, but non-fundamental change to the environment	Changes in water quality or quantity affecting part of a catchment or groundwaters of moderate vulnerability, or changes resulting in loss of conservation value to aquatic habitats or designated areas
Major	A fundamental change to the environment	Changes in water quality or quantity affecting widespread catchments or groundwater reserves of strategic significance, or changes resulting in substantial loss of conservation value to aquatic habitats and designations

In the above classification, fundamental changes are those which are permanent, detrimental and would result in widespread change to the baseline environment.

The matrices used to guide the assessment have been applied with a degree of flexibility since the evaluation of effects would always be subject to particular location-specific characteristics which need to be taken into account. For this reason, the evaluation of impact significance, in particular, would not always correlate exactly with the cells in the relevant matrix where professional judgement and knowledge of local conditions may result in a slightly different interpretation of the impact concerned. Cumulative effects have been taken into account through prediction and evaluation of effects at a catchment-wide level.

APPENDIX 3133/HIA/A2

Borehole logs



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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-01	
Dates start 08-03-21 finish 08-03-21	Ground Level (mAOD) 5.529	Co-Ordinates (British National Grid) E 337615.928 N 447834.685		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.50		(0.50) 5.03	Gravelly sandy SOIL (Drillers log)				
1.30		(0.80) 4.23	SAND & GRAVEL Dark grey becoming dark brown with depth, CLAYEY, COBBLEY, mostly medium (with some fine and coarse) grained SAND. Gravel <100mm, most 70mm.		0.40-1.30	B1	
		(4.20)	BASAL SILT / CLAY Light grey, soft, SANDY SILT/CLAY. End of Hole		1.30-1.90	B2	
5.50		0.03			1.90-5.00	B3	

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All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

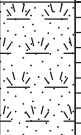
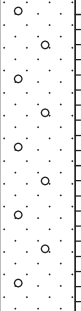

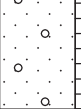

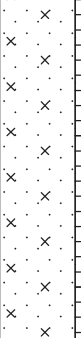
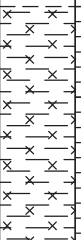

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-02	
Dates start 08-03-21 finish 08-03-21	Ground Level (mAOD) 6.001	Co-Ordinates (British National Grid) E 337693.336 N 447810.057		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.40		(0.40) 5.60	Dark stoney sandy SOIL (Driller's log)				
1.30		(1.50) 4.70	SAND & GRAVEL Grey / dark brown, SILTY, well sorted medium (with occasional coarse) SAND & GRAVEL. Occasional cobbles. Gravel max is ~80mm, most ~30mm, gravel is rounded quartzite and occasional pink granite clasts... ... Becoming wet below 1.3m. Gravel <200mm, most is 20-30mm. Gravel is rounded to subrounded, hard clasts of red and grey quartzite, red coarse sandstone and black mafic igneous material.		0.40-1.30	B1	
1.90		4.10			1.30-1.90	B2	4 : 45 : 51
5.00		1.00	BASAL SILT Grey, wet, soft (very fine) SANDY SILT, occasional gravel in top 1m with some organic black peat...		1.90-5.00	B3	
8.40		(6.50)	...Becoming SILT and very fine grained SAND below 5.0m. Some black organic particles and rootlets. Not mineral.		5.00-6.00	B4	
8.40		-2.40			6.00-8.40	B5	
10.00		(1.60)	BASAL CLAY Grey, soft SILTY CLAY with white shells / shell fragments. End of Hole		8.40-10.00	B6	
10.00		-4.00					

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All dimensions in metres Scale 1:50	Contractor Metcalf Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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

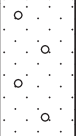
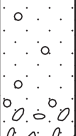



Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-04	
Dates start 09-03-21 finish 09-03-21	Ground Level (mAOD) 6.287	Co-Ordinates (British National Grid) E 337818.975 N 447627.972		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.90		(0.90) 5.39	Dark sandy SOIL with occasional gravel. (Drillers log)				
0.90-2.40		(2.10) 3.29	SAND & GRAVEL Dark reddish brown, SILTY, GRAVELLY, fine to medium (with some coarse) SAND with occasional cobbles. Gravel <75mm, most is 20-30mm. Gravel is rounded to subrounded with occasional flat shape...		0.90-2.40	B1	
2.40-3.00		(0.20) 3.09	Bluish, light grey with orange/brown, silty, soft CLAY with organic fragments.		2.40-3.00	B2	3 : 78 : 19
3.20-4.00		(0.80) 2.29	Light yellowish brown, SILTY, GRAVELLY, medium to coarse (with some fine) SAND, occasional cobbles. Gravel is subrounded to rounded, =60mm, most ~20mm.		3.20-4.00	B3	
4.00-6.00		0.29	BASAL SILT Greenish grey, (very fine) SANDY, organic soft SILT with occasional shell fragments (=1mm)...		4.00-6.00	B4	53 : 47 : 0
6.00-8.40		(4.40)	...Becoming VERY SILTY, very fine SAND below 6.0m.		6.00-8.40	B5	
8.40-9.50		(1.60)	BASAL CLAY Light grey, very soft, SILTY CLAY with many shell fragments (=3mm) (End of Hole)		8.40-9.50	B6	
10.00		-3.71					

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All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-05	
Dates start 10-03-21 finish 10-03-21	Ground Level (mAOD) 6.652	Co-Ordinates (British National Grid) E 337813.68 N 447689.801		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.35		(0.35) 6.30	Sandy SOIL with occasional gravel. (Driller's log)				
1.30		5.35	SAND & GRAVEL Light brown, slightly silty, very well sorted, medium grained SAND with occasional cobbles (50-90mm) and rare soft grey silty lumps (=15mm). Dry with pungent aroma and contaminated with duck excrement...		0.35-1.30	B1	
2.80		(3.55) 3.85	...Becoming GRAVELLY below 1.3m. SILTY GRAVELLY medium to coarse (with some fine) grained SAND with occasional cobbles. Gravel <60mm, most ~20mm, rounded - subrounded, red and grey quartzite, mafic igneous and pink granite clasts...		1.30-2.80	B2	2 : 54 : 44
3.90		2.75	...Becoming very gravelly below 2.8m. Light yellowish brown, SILTY, medium to coarse SAND AND GRAVEL. Gravel <~100mm, most is ~10-20mm, subrounded pink granite, mafic igneous and quartzite clasts. Many shell fragments (=1mm)		2.80-3.90	B3	
5.90		0.75	BASAL SILT Grey, very fine SANDY SILT with some black organics...		3.90-5.90	B4	
8.50		(4.60) -1.85	... With shell fragments below 5.9m.				
9.50		(1.00) -2.85	BASAL CLAY Grey, soft, slightly SANDY, SILTY CLAY End of Hole				

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All dimensions in metres Scale 1:50	Contractor Metcalf Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-06	
Dates start 10-03-21 finish 10-03-21	Ground Level (mAOD) 6.18	Co-Ordinates (British National Grid) E 337732.982 N 447607.463		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.90		(0.90) 5.28	Dark sandy SOIL with occasional gravel. (Drillers log)				
2.40		(3.00) 3.78	SAND & GRAVEL Dark brown, SILTY medium to coarse (with some fine) SAND & GRAVEL with some cobbles. Gravel =70mm, most ~20mm. Gravel is subrounded to rounded... ... Some white shell fragments (=3mm) below 2.4m...		0.90-2.40	B1	1 : 49 : 50
3.90		(0.30) 2.28			2.40-3.90	B2	
4.20		(0.30) 1.98	SAND Light grey, Slightly Silty, fine to medium grained SAND with many shell fragments (=3mm).		3.90-4.20	B3	
6.20		(4.00) -0.02	BASAL SILT Grey, very fine SANDY SILT. ... becoming sandier with depth below 6.2m		4.20-6.20	B4	
8.20		(1.00) -2.02	BASAL CLAY Light grey, very soft, SILTY CLAY.		6.20-8.20	B5	
9.20		(1.00) -3.02	(End of Hole)		8.20-9.20	B6	

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All dimensions in metres Scale 1:50	Contractor Metcalf Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-07	
Dates start 11-03-21 finish 11-03-21	Ground Level (mAOD) 6.471	Co-Ordinates (British National Grid) E 337648.517 N 447688.164		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.40		(0.40) 6.07	Sandy stoney SOIL (Drillers log)				
1.80		4.67	SAND & GRAVEL Dark reddish brown, SILTY, Slightly Gravelly, well sorted mostly medium grained SAND with occasional cobbles. Gravel <80mm, most ~20mm, rounded with some flat clasts. Hard, red/grey quartzite and igneous clasts. Some organic staining of the sand...		0.40-1.30	B1	
2.80		(3.30) 3.67	...Becoming SILTY, medium - coarse (with some fine) grained SAND & GRAVEL below 1.8m. Gravel <40mm, most 10-20mm, rounded - subrounded clasts. No cobbles...		1.30-2.80	B2	
3.70		3.67	...Becoming SILTY, well sorted medium (with some fine and coarse) grained SAND & GRAVEL. Occasional cobbles (including a 150mm angular andesite cobble wedged in the drilling tool). Gravel <150mm, most ~20mm.		2.80-4.00	B3	1 : 50 : 49
4.00		(0.30) 2.47	SAND				
7.00		(3.00) -0.53	Greyish light brown, Slightly Silty, coarse (with some medium and fine) grained SAND. No gravel. BASAL SILT Light grey, SANDY (very fine grained) SILT with organic black flecks and rare shell fragments <2mm. (End of Hole)		4.00-5.80	B4	

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All dimensions in metres Scale 1:50	Contractor Metcalf Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-08	
Dates start 16-03-21 finish 16-03-21	Ground Level (mAOD) 4.952	Co-Ordinates (British National Grid) E 337507.853 N 447530.661		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.40		(0.40) 4.55	Clayey dark TOPSOIL (Drillers log)		0.40-1.50	B1	
1.50		3.45	BASAL CLAY Light brown with orange and light grey, very soft SILTY CLAY... ...Becoming light grey (very fine) SANDY SILTY CLAY below 1.5m. (End of Hole)				
5.00		(4.60) -0.05			1.50-5.00	B2	

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All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-09	
Dates start 15-03-21 finish 15-03-21	Ground Level (mAOD) 5.341	Co-Ordinates (British National Grid) E 337599.96 N 447535.259		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.70		(0.70) 4.64	Soft sandy dark SOIL (Drillers log)				
1.80		(1.10) 3.54	SAND & GRAVEL Dark reddish brown, SILTY, GRAVELLY, mostly medium (with much fine and some coarse) SAND. Less gravel than other holes (~25% gravel). No cobbles. Gravel <50mm, most ~10mm and ~40mm, subrounded hard igneous and quartzite clasts with 1 angular hard red quartzitic sandstone clast.		0.70-1.80	B1	4 : 63 : 33
5.50		(3.70) -0.16	BASAL CLAY Light grey, (very fine grained) Slightly Sandy, SILTY, very soft CLAY. No laminations visible. (End of Hole)		1.80-5.50	B2	

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All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-10	
Dates start 15-03-21 finish 15-03-21	Ground Level (mAOD) 5.558	Co-Ordinates (British National Grid) E 337632.437 N 447482.243		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.40		(0.40) 5.16	Dark sandy SOIL with odd stones (Drillers log)				
1.30		4.26	SAND & GRAVEL Light reddish brown, SILTY, GRAVELLY, well sorted medium (with occasional coarse and some fine) grained SAND. Gravel <60mm, most ~20mm, subrounded - rounded (rare elongated) hard igneous and quartzite clasts. No cobbles... ...Becoming Yellowish brown, wet, Slightly Silty, Slightly Gravelly, well sorted medium grained SAND below 1.3m. Gravel <60mm, most ~40mm, subrounded - rounded hard igneous and quartzite clasts (including a single clast of red porphyry). Little / no fine gravel. Some <2mm shell fragments in sand fraction.		0.40-1.30	B1	
2.80		(2.40) 2.76	SILTY SAND Light grey, VERY SILTY, fine - medium grained SAND with black organic flecks, some rootlets, abundant shell fragments and thin soft grey clay bands. Marginal quality, includes reworked basal material.		1.30-2.80	B2	3 : 77 : 20
4.00		(1.20) 1.56	BASAL SILT Light grey, soft SILT. No sand. (End of Hole)		2.80-4.00	B3	
6.50		(2.50) -0.94			4.00-6.50	B4	

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All dimensions in metres Scale 1:50	Contractor Metcalf Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-11	
Dates start 16-03-21 finish 16-03-21	Ground Level (mAOD) 5.065	Co-Ordinates (British National Grid) E 337711.567 N 447512.4		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
1.40		3.67	Soft dark slightly peaty SOIL and CLAY (Drillers log)				
2.50		2.57	OVERBURDEN SILT Grey / brown, GRAVELLY, SANDY, VERY ORGANIC SILT with many wood fibres and peat. Sand and gravel is same material as the mineral deposit, but mixed with fines. May be re-worked material from railway		1.40-2.50	B1	
3.50		1.57	SAND & GRAVEL Grey / brown, VERY SILTY SANDY GRAVEL with some organics (<5mm long wood fibres). Sand is fine - medium grained, gravel is subangular - rounded hard grey quartzite, mafic igneous and pink granite clasts. Good quality gravel, but siltier than other holes. May be edge of deposit		2.50-3.50	B2	13 : 39 : 49
6.00		-0.94	BASAL SILTY SAND Light grey, EXTREMELY SILTY very fine - fine grained SAND with much organic black flecks and occasional shell fragments. Poor quality. (End of Hole)		3.50-6.00	B3	

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All dimensions in metres Scale 1:50	Contractor Metcalf Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-12	
Dates start 16-03-21 finish 16-03-21	Ground Level (mAOD) 5.021	Co-Ordinates (British National Grid) E 337654.527 N 447594.765		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.50		(0.50) 4.52	Peaty clayey SOIL (Drillers log)				
2.30		(1.80) 2.72	OVERBURDEN SILT Grey with brown laminae, soft, (very fine) SANDY laminated SILT. No shells, some rootlets - not the same material as the Basal Silt		0.50-2.30	B1	
3.70		(1.40) 1.32	SAND & GRAVEL Light grey, SILTY, GRAVELLY, coarse (with some medium) grained SAND. Angular, well sorted sand. Gravel <40mm, most 10-15mm, subrounded - subangular hard quartzite and igneous clasts. Occasional shells up to 30mm (oysters)		2.30-3.70	B2	6 : 61 : 33
6.10		(2.40) -1.08	BASAL SANDY SILT Light grey, very fine grained SAND and SILT with many <1mm shell fragments and organic fibres. Marginal material. (End of Hole)		3.70-6.10	B3	

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All dimensions in metres Scale 1:50	Contractor Metcalf Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-15
Dates start 18-03-21 finish 18-03-21	Ground Level (mAOD) 6.33	Co-Ordinates (British National Grid) E 337965.792 N 447622.088	
Client Baxter Group			Sheet 1 of 1

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.50		(0.50) 5.83	Sandy SOIL (Drillers log)				
2.00		(2.60) 4.33	Brown, SILTY, (medium - coarse) SANDY COBBLEY GRAVEL. Gravel <50mm, most 10-20mm, rounded - subangular hard quartzitic clasts. Mainly grey quartzite....		0.50-2.00	B1	2 : 33 : 66
3.10		3.23	...Wet below 2m. Occasional <2mm shell fragments. One rounded clast of hard red quartzitic sandstone		2.00-3.10	B2	
6.00		(2.90) 0.33	Light grey (very fine) SANDY SILT with much black organics (End of Hole)		3.10-6.00	B3	

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All dimensions in metres Scale 1:50	Contractor Metcalf Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-17	
Dates start 17-03-21 finish 17-03-21	Ground Level (mAOD) 5.697	Co-Ordinates (British National Grid) E 338167.344 N 447608.353		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.80		(0.80) 4.90	Dark sandy SOIL with odd stones (Drillers log)				
2.70		(1.90) 3.00	SAND & GRAVEL Light brown, SILTY, medium (with some fine) grained SAND & GRAVEL. Gravel <40mm, most ~20mm, rounded - subangular clasts of hard quartzite and igneous material.		0.80-2.70	B1	5 : 69 : 47
5.30		(4.80) 0.40	BASAL SILT Light grey (very fine) SANDY SILT with some <2mm shell fragments...		2.70-5.30	B2	
7.50		-1.80	...Becoming SILT and SAND below 5.3m (End of Hole)		5.30-7.50	B3	

GF MINERAL_BH + WATER_BFP 2021 GINT PROJECT:GPJ_AGS_3_1.GDT 12/5/21

All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG


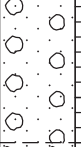
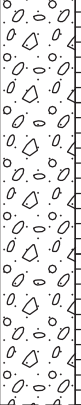
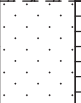
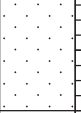

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-18	
Dates start 19-03-21 finish 19-03-21	Ground Level (mAOD) 6.355	Co-Ordinates (British National Grid) E 337462.021 N 447777.735		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.20		(0.20) 6.16	Stoney clay SOIL				
0.60		(0.40) 5.76	(Drillers log) Dark brown SANDY SILT TIPPED MATERIAL				
		(3.30)	Black, angular, coarse grained glassy GRIT / MADE GROUND. Occasional lumps of slag <40mm...				
3.90		2.46					
4.10		(0.20) 2.26	...Becoming GRAVELLY below 3.9m All clasts subrounded, ~20-50mm. 50% gravel, 50% tip. Marks base of deposit				
		(0.90)	BASAL SILT Light grey (very fine) SANDY SILT with occasional shell fragments				
5.00		1.36	(End of Hole)				

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All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-19	
Dates start 19-03-21 finish 19-03-21	Ground Level (mAOD) 6.597	Co-Ordinates (British National Grid) E 337294.513 N 447855.041		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.30		(0.30) 6.30	Sandy SOIL (Drillers log)				
1.30		(1.00) 5.30	SAND & GRAVEL Dark brown, SILTY, COBBLEY, Slightly Gravelly well sorted medium (with occasional fine and coarse) grained SAND. Gravel / cobbles rounded - subrounded, <120mm, most ~40mm hard mafic igneous and dark grey quartzite clasts...		0.30-1.30	B1	
4.00		(2.70) 2.60	.. Becoming brown / grey, Slightly Silty, medium - coarse (with some fine) grained SAND & GRAVEL with rare cobbles. Gravel <60mm, rounded - subangular hard mafic igneous and grey quartzite with occasional clasts of pink granite. Occasional <1mm shell fragments...		1.30-2.80	B2	2 : 53 : 46
4.30		(1.40) 2.30	SAND Medium - coarse grained SAND. Some shell fragments including 1 whole whelk		2.80-4.30	B3	
5.40		(1.40) 1.20	... Becoming light brown, Slightly Silty, medium - fine grained (becoming finer with depth) SAND with some shell fragments. Very rare coarse sand / fine gravel at top.		4.30-5.40	B4	9 : 92 : 0
7.00		(1.60) -0.40	BASAL SILT Grey, very fine SANDY SILT (End of Hole)		5.40-7.00	B5	

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All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-20
Dates start 20-03-21 finish 20-03-21	Ground Level (mAOD) 5.937	Co-Ordinates (British National Grid) E 337264.808 N 447796.553	
Client Baxter Group			Sheet 1 of 1

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.40		(0.40) 5.54	Sandy SOIL with some gravel (Drillers log)				
1.40		(1.00) 4.54	SAND & GRAVEL Dark reddish brown, organic stained, SILTY, Slightly Gravelly, COBBLEY, well sorted fine - medium grained SAND. Gravel <60mm, most 20-40mm, subrounded - subangular (some elongate clasts) of hard dark grey quartzite and mafic igneous material. 1 flat fissile clast of metamorphosed shale...		0.40-1.30	B1	
2.90		(3.00) 3.04	...Becoming more gravelly (GRAVELLY SAND) below 1.4m. Gravel becoming finer with depth, mostly 20mm...		1.30-2.90	B2	0 : 61 : 39
4.40		(1.54) 1.54	...Becoming light yellowish brown, less silty (Slightly Silty) below 2.9m. Gravel mostly 10-20mm.		2.90-4.40	B3	
5.00		(0.60) 0.94	SAND Light yellowish brown, Slightly Silty, very well sorted medium grained SAND. Very rare <10mm rounded gravel, some black soft organic flecks, frequent shell fragments <1mm.		4.40-5.00	B4	9 : 91 : 0
7.50		(2.50) -1.56	BASAL SILT Light grey, very fine SANDY SILT with frequent black organic flecks (End of Hole)		5.00-7.50	B5	

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All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-21	
Dates start 20-03-21 finish 20-03-21	Ground Level (mAOD) 6.096	Co-Ordinates (British National Grid) E 337153.83 N 447821.939		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.30		(0.30) 5.80	Sandy SOIL with some gravel				
1.40		(1.10) 4.70	(Drillers log) SAND & GRAVEL Light yellowish brown, Slightly Silty, Slightly Gravelly, COBBLEY, mostly medium (with some fine and coarse) grained SAND. Gravel is subrounded, <130mm mostly 20-40mm, hard quartzite and igneous clasts (including 1 cobble of white granite)...		0.30-1.40	B1	2 : 83 : 15
2.90		3.20	...Becoming brown/grey, SILTY, medium - coarse grained SAND & GRAVEL below 1.4m. Gravel <70mm, most ~10mm, rounded - subangular with some <3mm shell fragments...		1.40-2.90	B2	
4.40		(4.80) 1.70	...Becoming light brown below 2.9m. 1 hard red sandstone clast...		2.90-4.40	B3	1 : 59 : 40
6.20		1.70	... Becoming light yellowish brown, SILTY, GRAVELLY, fine - medium (with some coarse) grained SAND below 4.4m. Gravel <90mm, most 30mm, subrounded strong quartzite and igneous clasts. Rare oyster shells <50mm.		4.40-6.20	B4	
7.50		(1.30) -1.40	BASAL SILT Light grey, very fine SANDY SILT with some organic flecks and <3mm shell fragments (End of Hole)		6.20-7.50	B5	

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All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-22	
Dates start 20-03-21 finish 20-03-21	Ground Level (mAOD) 6.71	Co-Ordinates (British National Grid) E 337171.25 N 447868.298		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.30		(0.30) 6.41	Sandy SOIL				
1.40		(1.10) 5.31	(Drillers log) SAND & GRAVEL Light brown, Slightly Silty, Slightly Gravelly, COBBLEY, well sorted fine - medium grained SAND. Gravel <120mm, most ~20mm, rounded - subrounded with some flat clasts...		0.30-1.40	B1	1 : 52 : 47
3.00		3.71	...Becoming very dark brown, wet, SILTY, GRAVELLY, medium (occasional coarse) grained SAND below 1.4m. Gravel <50mm, most ~20mm, subrounded - subangular (occasionally flat) hard quartzite and igneous clasts...		1.40-3.00	B2	
4.50		(4.50) 2.21	...Increasing gravel content with depth - SAND & GRAVEL below 3.0m. Gravel <70mm, most ~20mm. Single red friable mudstone clast...		3.00-4.50	B3	
5.90		0.81	...Becoming light brown GRAVELLY medium SAND below 4.5m. Gravel <80mm, most 10-20mm. Occasional <1mm shell fragments		4.50-5.90	B4	3 : 70 : 27
7.50		(1.60) -0.79	BASAL SILTY CLAY Light grey, SANDY, SILTY organic CLAY with many shell fragments		5.90-7.50	B5	

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All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-23
Dates start 22-03-21 finish 22-03-21	Ground Level (mAOD) 5.733	Co-Ordinates (British National Grid) E 337093.608 N 447872.013	
Client Baxter Group			Sheet 1 of 1

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.20		(0.20) 5.53	Dark clayey stoney SOIL				
		(1.20)	(Drillers log) OVERBURDEN SILT Dark brown, SANDY, Slightly Gravelly SILT / SOIL. Dry.		0.20-1.40	B1	
1.40		4.33	OVERBURDEN PEAT		0.30-3.10	B1	
		(1.70)	Black SANDY, Slightly Gravelly, soft PEAT / SILT. Occasional wood pieces <100mm. Strong sulphurous smell.		1.40-3.10	B2	
3.10		2.63	SAND & GRAVEL				
		(2.10)	Brown / grey, SILTY, GRAVELLY, medium - fine (with some coarse) grained SAND with occasional cobbles. Gravel <70mm, rounded - subrounded with occasional flat clasts. Occasional <10mm shell fragments		3.10-5.20	B2	
5.20		0.53	BASAL SILT				
		(1.80)	Grey SILT / very fine SAND with organic particles and shell fragments (End of Hole)		5.20-7.00	B3	
7.00		-1.27					

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All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-24	
Dates start 23-03-21 finish 23-03-21	Ground Level (mAOD) 5.906	Co-Ordinates (British National Grid) E 338012.606 N 447695.859		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.50		(0.50) 5.41	Sandy Gravelly SOIL (Drillers log)				
2.20		(1.70) 3.71	SAND & GRAVEL Brown, SILTY, GRAVELLY, medium - coarse grained SAND. Gravel <40mm, most 10-20mm, rounded - subrounded hard grey and red quartzite and igneous clasts		0.50-2.20	B1	4 : 60 : 36
5.00		(2.80) 0.91	BASAL SILT Grey SILT / very fine SAND (End of Hole)		2.20-5.00	B2	

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All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-25	
Dates start 23-03-21 finish 23-03-21	Ground Level (mAOD) 5.813	Co-Ordinates (British National Grid) E 338115.694 N 447676.783		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.30		(0.30) 5.51	Gravelly sandy dark SOIL (Drillers log)		0.30-1.80	B1	3 : 70 : 27
		(1.50)	SAND & GRAVEL Light brown, SILTY, GRAVELLY, well sorted medium (with some coarse) grained SAND. Gravel <40mm, most 10-20mm				
1.80		4.01	BASAL SILT Grey SILT / very fine SAND with organic particles and shell fragments (End of Hole)		1.80-5.00	B2	
5.00		0.81					

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All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG

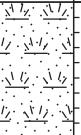

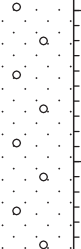



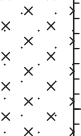
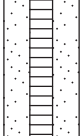
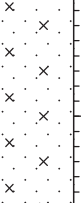
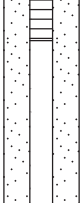
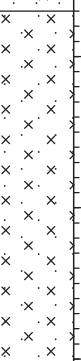
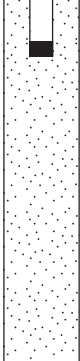

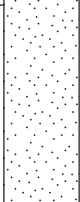
Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFP 21-26	
Dates start 23-03-21 finish 23-03-21	Ground Level (mAOD) 4.904	Co-Ordinates (British National Grid) E 338181.287 N 447649.402		
Client Baxter Group			Sheet 1 of 1	

STRATA				SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Water	Depth	Type No	Test Result (F:S:G)
0.30		(0.30) 4.60	Soft PEATY hard CLAYEY SOIL		0.30-1.60	B1	
		(1.30)	(Drillers log) OVERBURDEN CLAY Light grey with occasional light orange laminae, SILTY SANDY soft CLAY with rootlets. Laminated structure.				
1.60		3.30	BASAL SILT Wet, light grey, very fine grained SAND and SILT with frequent black organic flecks and shell fragments (End of Hole)		1.60-5.00	B2	
5.00		-0.10					

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All dimensions in metres Scale 1:50	Contractor Metcalf Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFPW 21-03	
Dates start 09-03-21 finish 09-03-21	Ground Level (mAOD) 6.321	Co-Ordinates (British National Grid) E 337797.53 N 447754.825		
Client Baxter Group			Sheet 1 of 1	

STRATA				INSTALLATION	SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Legend	Water	Depth	Type No	Test Result (F:S:G)
0.90		(0.90) 5.42	Dark very sandy SOIL with occasional gravel. (Driller's log)					
2.60		(1.70) 3.72	SAND & GRAVEL Dark brown, very SILTY, GRAVELLY, mostly medium (with fine and some coarse) SAND with some cobbles. Gravel <75mm, most ~20-30mm. Gravel is subrounded to subangular, hard clasts of grey quartzite, pink granite and greenish black mafic igneous material. Rare, small (=2mm) shells / shell fragments.			0.90-2.60	B1	4 : 45 : 51
3.00		3.32	BASAL SILT Dark brown, SANDY, CLAYEY, slightly gravelly, SILT. Gravel is =10mm...			2.60-3.00	B2	
4.20		2.12	...Becoming grey, (very fine) SANDY SILT with occasional shell fragments (=2mm) below 3.0m...			3.00-4.20	B3	
5.70		0.62	... Becoming SILTY very fine SAND with occasional shell fragments below 4.2m. Very fine, not mineral...			4.20-5.70	B4	
8.10		-1.78	... Becoming greengish grey, (very fine) SANDY SILT with no shells below 5.7m			5.70-8.10	B5	
9.50		(1.40) -3.18	BASAL CLAY Light grey, very soft, SANDY SILTY CLAY with whole cockle shells (=20mm) and shell fragments (possibly drilling induced) End of Hole			8.10-9.50	B6	

GF MIN BH+STANDPIPE+WATER BIG DESC BFP 2021 GINT PROJECTGPI AGS3_1.GDT 12/5/21

All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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BOREHOLE LOG



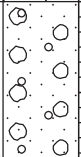

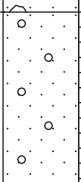
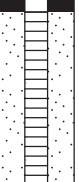



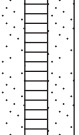
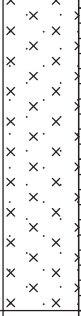
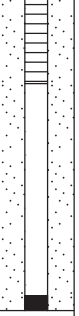
Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFPW 21-13	
Dates start 17-03-21 finish 17-03-21	Ground Level (mAOD) 5.641	Co-Ordinates (British National Grid) E 337589.893 N 447695.546		
Client Baxter Group			Sheet 1 of 1	

STRATA				INSTALLATION		SAMPLES & TESTS		
Depth	Legend	(Thickness) Reduced Level	Description	Legend	Water	Depth	Type No	Test Result (F:S:G)
0.90		(0.90) 4.74	Sandy SOIL with some gravel (Drillers log)					
2.40		(2.00) 3.24	SAND & GRAVEL Reddish brown, Slightly Silty, GRAVELLY, well sorted medium (with some fine) grained SAND. Less gravel than holes to north. No cobbles. Gravel <50mm, most ~20mm, subrounded - rounded clasts of hard grey quartzite and mafic igneous composition...			0.90-2.40	B1	2 : 76 : 22
2.90		(0.50) 2.74	...Becoming SANDY GRAVEL below 2.4m. Gravel <40mm, most 10-20mm. Very well sorted material			2.40-2.90	B2	
6.00		(3.10) -0.36	BASAL SILT Light grey, (very fine) SANDY soft SILT (End of Hole)			2.90-6.00	B3	

GF MIN BH+STANDPIPE+WATER BIG DESC BFP 2021 GINT PROJECTGPJ_AGS.3_1.GDT 12/5/21

All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
--	------------------------------------	---	---------------------

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFPW 21-14	
Dates start 18-03-21 finish 18-03-21	Ground Level (mAOD) 6.18	Co-Ordinates (British National Grid) E 337870.453 N 447612.598		
Client Baxter Group			Sheet 1 of 1	

STRATA				INSTALLATION	SAMPLES & TESTS			
Depth	Legend	(Thickness) Reduced Level	Description	Legend	Water	Depth	Type No	Test Result (F:S:G)
0.40		(0.40) 5.78	Sandy SOIL (Drillers log)					
1.50		4.68	SAND & GRAVEL Brown, SILTY, Slightly GRAVELLY, COBBLEY, well sorted medium (with some fine and coarse) grained SAND. Gravel <80mm, most ~40mm, all >30mm. No shells...			0.40-1.20	B1	
2.70		(2.30) 3.48	... Becoming dark brown and no cobbles below 1.5m. Gravel <40mm, most 10-20mm, rounded - subangular			1.20-2.70	B2	
3.00		(0.30) 3.18	Blueish grey, (fine - medium) SANDY PEATY soft SILT. Laminated, slight sulphurous smell					
3.90		(0.90) 2.28	Grey, SILTY, well sorted, fine - medium (with some coarse) grained SAND & GRAVEL. Gravel <30mm, rounded (more rounded than above) with rare subangular clasts, grey quartzite and andesite with occasional red hard quartzitic sandstone. No pink granite. Many shell fragments <2mm.			3.00-3.90	B3	6 : 47 : 47
6.00		(2.10) 0.18	Light grey (very fine) SANDY SILT with much black organics (End of Hole)			3.90-6.00	B4	

GF MIN BH+STANDPIPE+WATER BIG DESC BFP 2021 GINT PROJECTGPJ AGS3_1.GDT 12/5/21

All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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Greenfield Environmental Ltd
1-3 Commercial Road
Keyworth NG12 5JS

BOREHOLE LOG

Project Bourbles Farm 2021 Exploration Drilling			BOREHOLE No BFPW 21-16	
Dates start 18-03-21 finish 18-03-21	Ground Level (mAOD) 6.08	Co-Ordinates (British National Grid) E 338045.702 N 447641.51		
Client Baxter Group			Sheet 1 of 1	

STRATA				INSTALLATION		SAMPLES & TESTS		
Depth	Legend	(Thickness) Reduced Level	Description	Legend	Water	Depth	Type No	Test Result (F:S:G)
0.70		(0.70) 5.38	Very sandy SOIL (Drillers log)					
2.60		(1.90) 3.48	SAND & GRAVEL Dark brown, SILTY, well sorted medium - coarse grained SAND & GRAVEL with some cobbles. Gravel <50mm, most 10-20mm, rounded - subangular hard quartzite and igneous clasts. Occasional <5mm flat, laminated shell fragments (oysters).			0.70-2.60	B1	2 : 57 : 41
6.00		(3.40) 0.08	BASAL SILT Light grey (very fine) SANDY SILT with occasional <1mm shell fragments and much black organics (End of Hole)			2.60-6.00	B2	

GF MIN BH+STANDPIPE+WATER BIG DESC BFP 2021 GINT PROJECTGPJ AGS3_1.GDT 12/5/21

All dimensions in metres Scale 1:50	Contractor Metcalfe Bros	Method/ Plant Used Dando 150 (CP)	Logged By G Webb
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APPENDIX 3133/HIA/A3

Particle Size Analysis

Hydraulic conductivity calculated from PSD analysis using HydrogeoSieveXL

			0.063	0.125	0.25	0.5	1	2	4	6.3	8	10	14	20	25	40	80
BFP 21-2	B2	1.4-2.7m	1.4	2	3	30	65	67	68	69	69	69	69	71	72	73	82
BFPW 21-3	B1	0.9-2.6m	3.8	7	8	36	43	46	49	52	54	56	61	75	80	92	100
BFP 21-4	B2	2.4-3m	2.6	6	22	60	76	80	81	82	83	84	86	88	89	92	100
BFP 21-5	B2	1.3-2.8m	1.8	3	4	34	42	47	56	63	66	69	74	83	87	94	100
BFP 21-6	B1	0.9-2.4m	1	2	2	26	39	43	50	53	55	58	64	76	83	92	100
BFP 21-7	B3	2.8-4.0m	0.7	2	3	31	40	44	51	56	59	65	73	82	86	91	93
BFP 21-9	B1	0.7-1.8m	3.8	7	9	55	63	65	67	69	70	72	77	86	89	97	100
BFP 21-10	B2	1.4-2.7m	2.7	4	7	58	72	76	80	82	83	84	86	88	89	93	100
BFP 21-11	B2	2.5-3.5m	12.5	19	20	33	37	40	51	58	62	66	77	86	89	94	100
BFP 21-12	B2	2.3-3.7m	5.8	12	14	36	47	56	67	77	79	82	86	93	97	100	100
BFPW 21-13	B1	0.9-2.4m	2.1	3	3	46	69	73	78	79	80	82	85	89	90	97	100
BFPW 21-14	B3	3.0-3.9m	5.8	6	7	33	39	42	53	59	63	68	78	84	89	96	100
BFP 21-15	B1	0.5-2.0m	1.2	2	2	15	20	24	34	41	45	57	64	73	80	89	100
BFPW 21-16	B1	0.7-2.6m	1.9	3	3	24	39	48	59	65	68	71	77	84	88	98	100
BFP 21-17	B1	0.8-1.5m	4.9	9	10	38	56	64	74	77	79	80	83	87	91	100	100
BFP 21-19	B2	1.3-2.8m	1.5	2	2	17	33	42	54	58	60	64	71	83	88	97	100
BFP 21-19	B4	4.3-5.4m	8.5	18	23	86	99	100	100	100	100	100	100	100	100	100	100
BFP 21-20	B2	1.4-2.9m	0.1	1	2	35	46	52	61	65	68	71	75	86	89	95	100
BFP 21-20	B4	4.4-5.0m	9.4	10	12	73	95	98	100	100	100	100	100	100	100	100	100
BFP 21-21	B1	0.3-1.4m	1.9	2	4	71	83	84	85	85	85	85	86	87	87	88	88
BFP 21-21	B3	2.9-4.4m	0.9	2	4	33	42	51	60	67	71	73	76	82	87	91	94
BFP 21-22	B1	0.3-1.4m	1.4	5	7	27	40	46	53	59	62	65	71	81	85	96	100
BFP 21-22	B4	4.5-5.9m	2.8	5	7	53	64	67	73	76	77	78	81	87	88	93	100
BFP 21-24	B1	0.5-2.2m	3.9	6	8	41	50	55	64	69	71	74	78	88	91	96	100
BFP 21-25	B1	1.3-1.8m	3.4	4	5	33	58	68	73	74	75	76	78	80	84	92	100

		0.075	0.15	0.212	0.3	0.425	0.6	1.18	2.36	3.35	4	5	6.3	10	14	20	28	37.5	63	90
BH1	3.5-3.8m	1	1	1	2	8	14	19	22	28	31	33	36	44	50	57	66	72	82	100
BH1	5.0-5.5m	12	84	86	91	97	98	99	99	99	99	99	99	100	100	100	100	100	100	100
BH1	8.0-8.5m	17	75	78	81	86	88	89	89	90	90	90	91	92	93	93	95	100	100	100
BH2	0.5-1.0m	5	6	7	9	27	45	51	52	54	55	55	57	59	60	61	69	75	100	100
BH2	1.5-2.0m	1	1	1	2	5	8	11	12	16	18	19	22	26	30	34	40	50	60	100
BH3	0.5-1.0m	14	22	23	33	70	86	93	95	96	97	97	98	99	99	99	100	100	100	100
BH3	1.5-2.0m	7	8	9	18	47	60	66	67	70	71	72	75	81	85	87	91	100	100	100
BH3	3.5-4.0m	3	5	5	14	37	48	55	58	63	65	68	69	72	76	80	88	97	100	100

Sample	BFP 21-15 0.5-2.0m	B1	BFP 21-19 4.3-5.4m	B4	BH2 1.5-2.0m	BH1 8.0-8.5m
Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	cm/s	m/s	m/d
Hazen						
Hazen K [cm/s] = d ₁₀ (mm)						
Stichter	0.018416172	0.000184162	15.91157227			
Terzaghi	0.026375586	0.000263756	22.7885062			
Beyer				.537E-02	.537E-04	4.64
Saubertrei				.542E-02	.542E-04	4.68
Kruger				.358E-01	.358E-03	30.93
Kozeny-Carmen						
Zunker	0.423470701	0.004234707	365.8786858	.379E-01	.379E-03	32.73
Zamarin	0.517650709	0.005176507	447.2502123			
USBR						
Barr	0.019779449	0.000197794	17.08944402	.208E-02	.208E-04	1.80
Ayamani and Sen	3.352942834	0.033529428	2896.942608			
Chapuis						
Krumbein and Monk				.110E-01	.110E-03	9.52
geometric mean	0.139	0.001	119.673	0.010	0.00010	8.497
arithmetic mean	0.726	0.007	627.644	0.016	0.0002	14.049

Median	320.8	m/d
Mean	3188.1	m/d

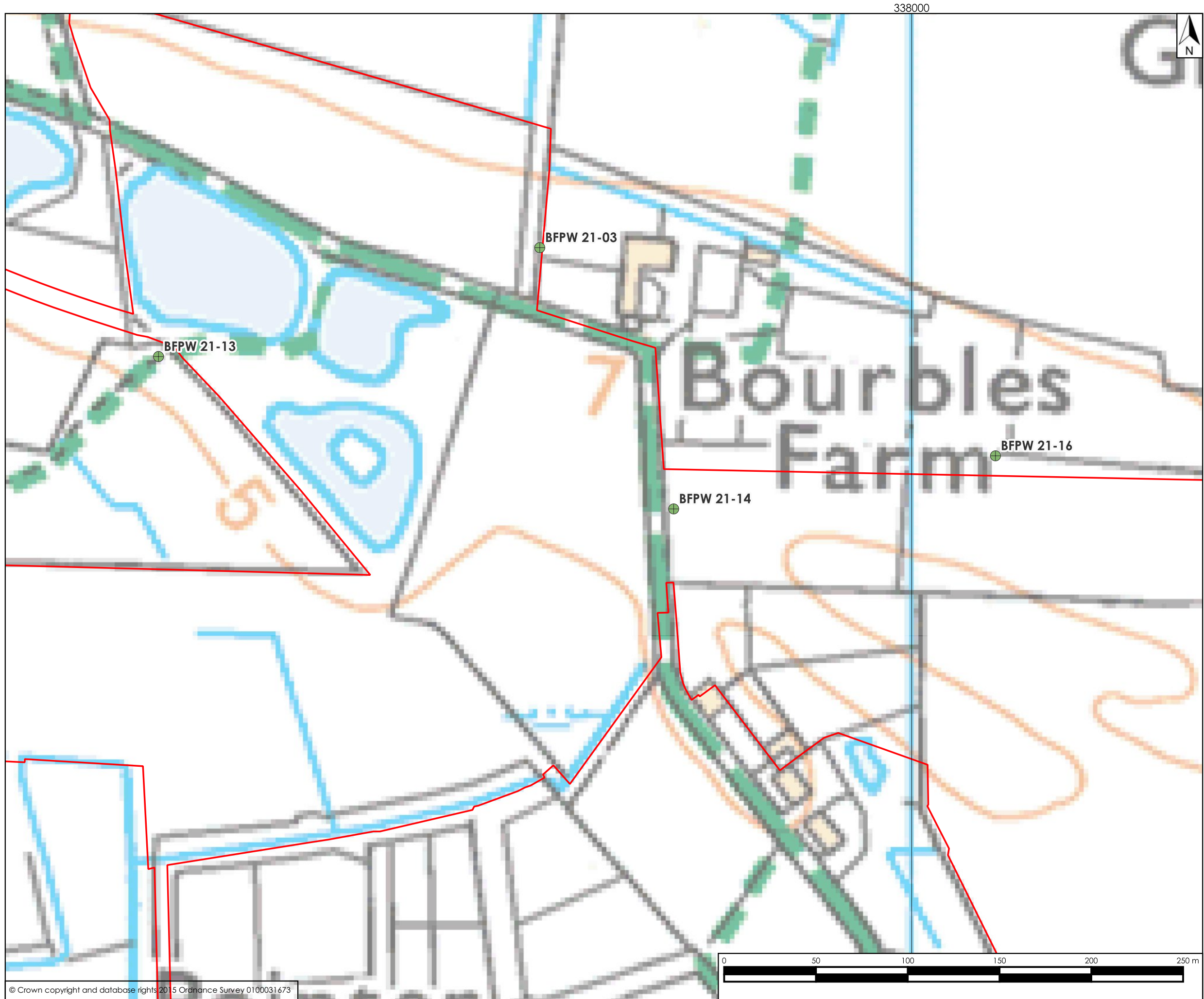
APPENDIX 3133/HIA/A4

Groundwater level data and hydrographs

Bourbles Farm
Groundwater Levels

Monitoring Borehole	BF21-3		BF21-13		BF21-14		BF21-16	
	Ground Level (mAOD) 6.321		Ground Level (mAOD) 5.938		Ground Level (mAOD) 6.180		Ground Level (mAOD) 6.080	
Date	Depth	Level	Depth	Level	Depth	Level	Depth	Level
15/03/21			0.8	5.14	0.8	5.38	0.9	5.18
02/06/21	1.82	4.50	1.32	4.62	1.69	4.49	1.73	4.35
16/09/21	2.01	4.31	1.30	4.64	1.84	4.34	1.83	4.25
01/02/22	1.51	4.81	1.05	4.89	1.28	4.90	1.25	4.83
06/10/22	1.85	4.47	1.35	4.59	2.01	4.17	1.69	4.39
31/01/2023	1.26	5.06	0.33	5.61	1.07	5.11	1.03	5.05
Min		4.31		4.59		4.17		4.25
Max		5.06		5.61		5.38		5.18
Mean		4.63		4.91		4.73		4.68

Exploration Borehole	BH21-22	BH21-21	BH21-20	BH21-19	BH21-18	BH21-17	BH21-16	BH21-15	BH21-14	BH21-13	BH21-12	BH21-11	BH21-10	BH21-9	BH21-8	BH21-7
Water Strike Depth on 15/03/21	1.1	1.2	1	1.2	0.9	0.9	0.9	0.7	0.8	0.8	2.3	0.6	1.2	0.9	No Strike	1.7



338000



- Legend
- Site Boundary
 - ⊕ Monitoring borehole locations

BFPW 21-03

BFPW 21-13

BFPW 21-14

BFPW 21-16

Bourbles Farm

Scale correct at A3

Client The Baxter Group

Title Groundwater Monitoring Locations

Project Borubles Farm Quarry

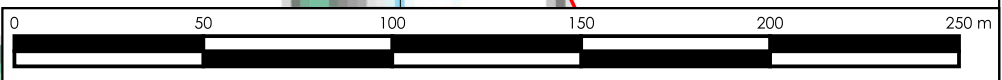
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Date March 2023	Scale 1:2,000
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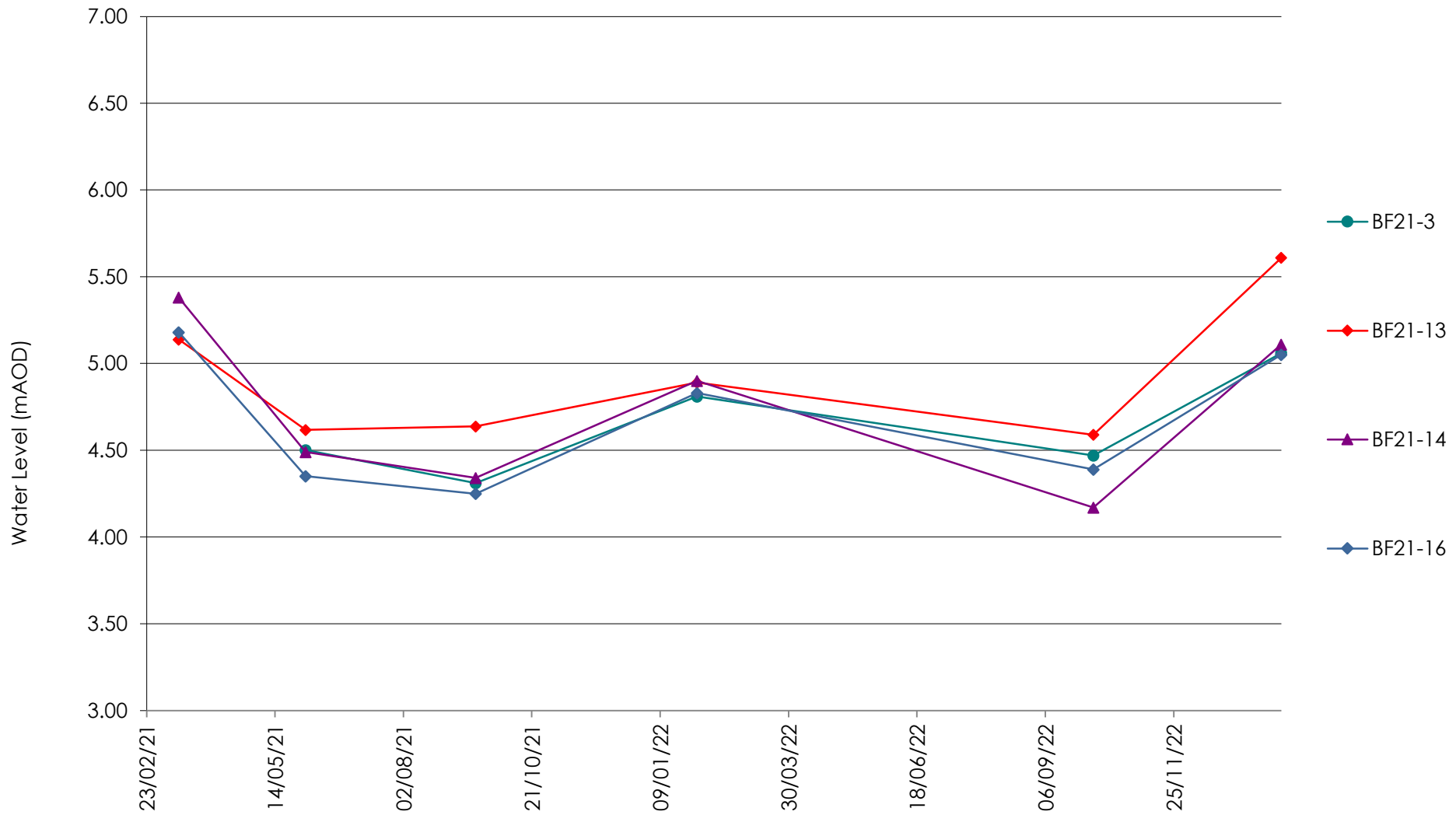
hafrenwater environmental water management

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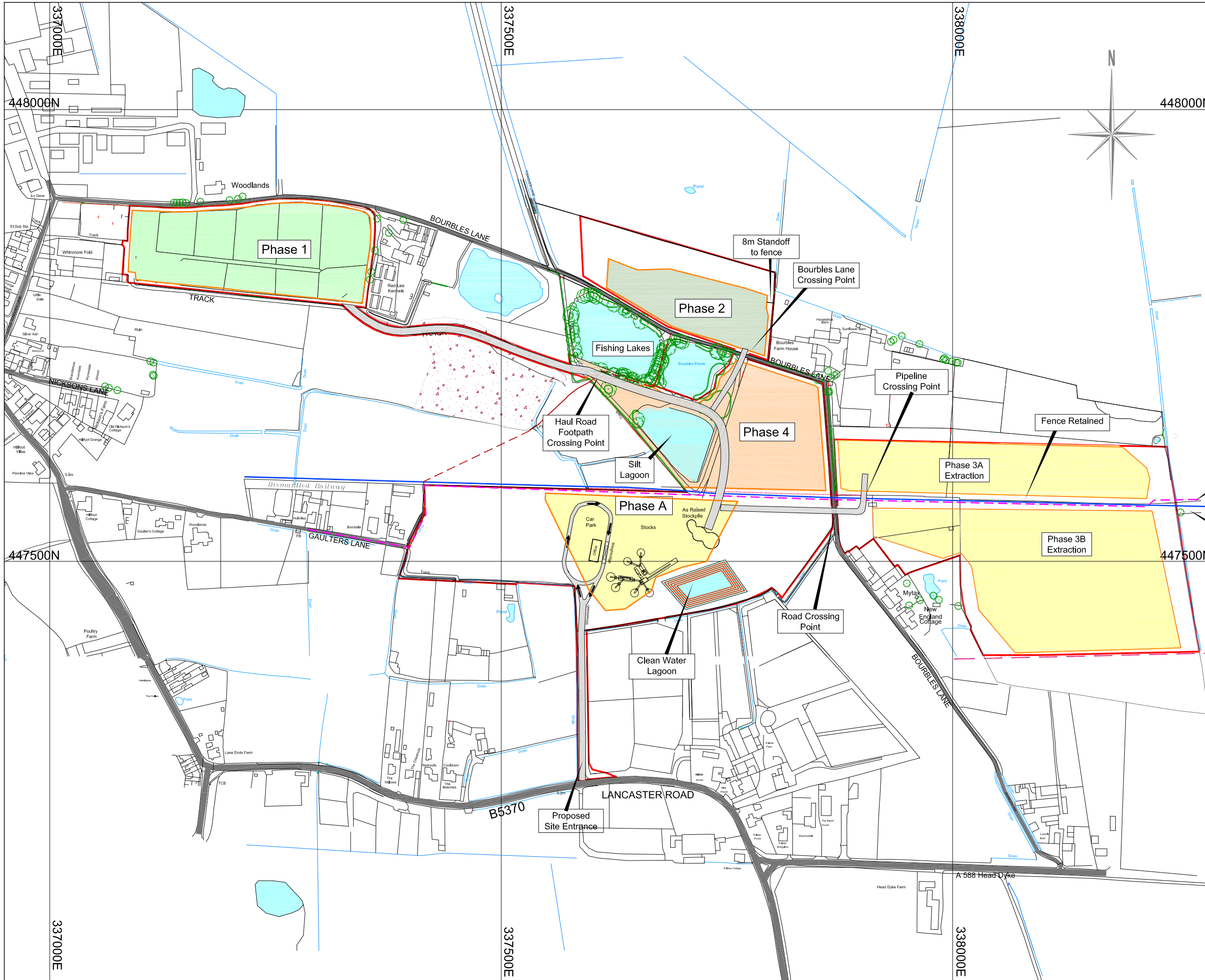


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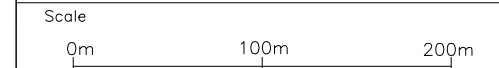
APPENDIX 3133/HIA/A5

Site phasing plans and restoration scheme



Key

- Application Area (20.69ha)
- Water
- Buried Gas Main
- Buried Water Main
- Overhead Electric



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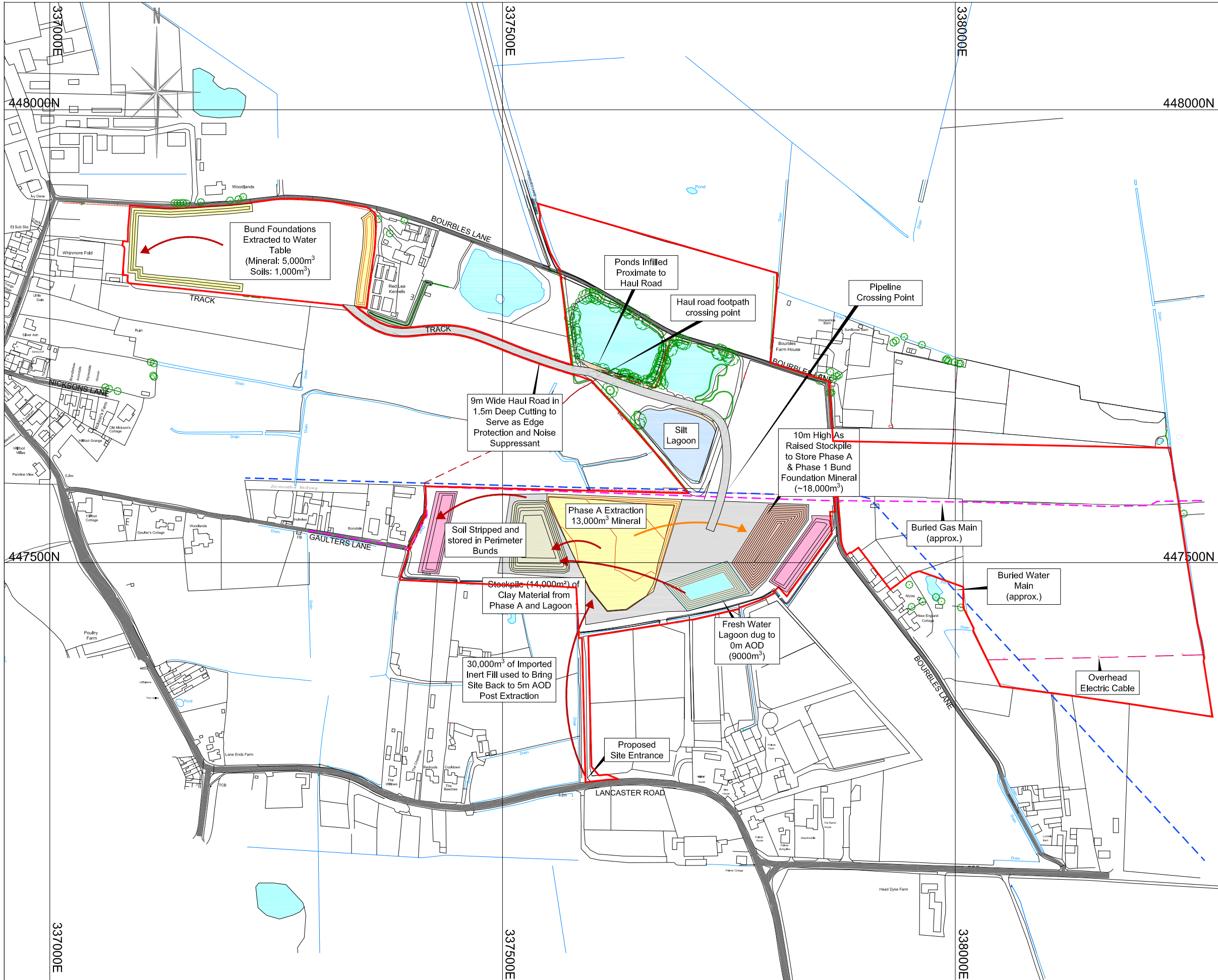
Site
Proposed Bourbles Quarry

Project
Planning Application

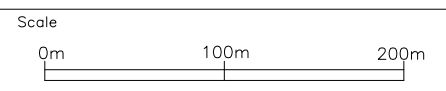
Plan
Application Areas
DRAFT May 2023

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 Drawn by: BGD





- Key**
- Application Area
 - Mineral Excavation
 - Plant Site
 - Clay Storage
 - Stockpiles
 - Water
 - Buried Gas Main
 - Buried Water Main
 - Bunds (3m high)
 - Soil / Overburden Movements
 - Mineral Movements
 - Direction of Working



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Site
Bourbles Farm

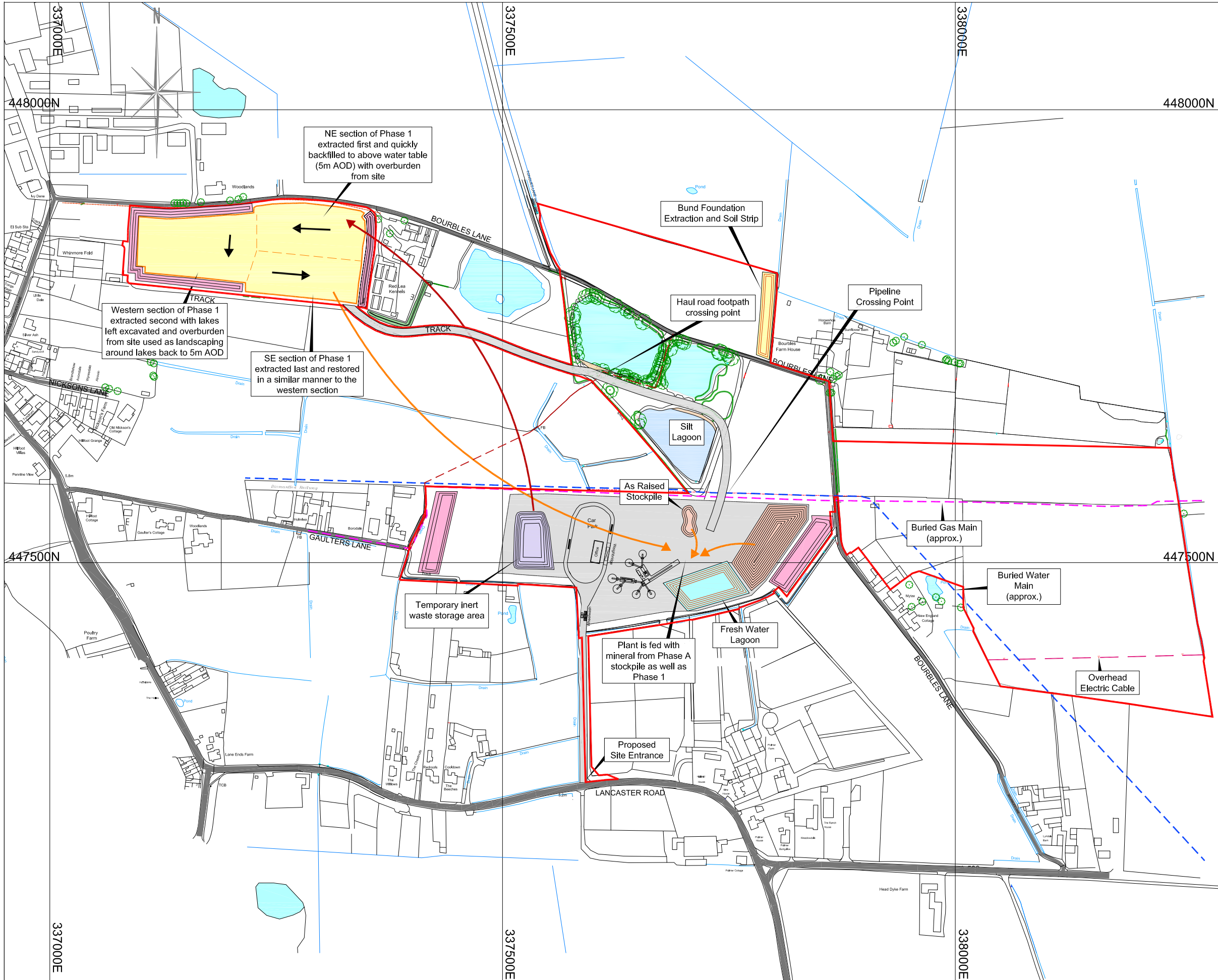
Project
Planning Application 2023

Plan
Phasing Plan- Phase A Extraction DRAFT

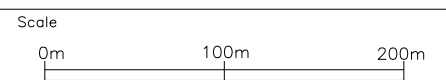
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 Drawn by: ISC



1 Commercial Road, Keyworth, Nottingham NG12 5JZ
 Email: admin@greenfieldenviro.co.uk
 Tel: 0115 937 2002



- Key**
- Application Area
 - Mineral Excavation
 - Plant Site
 - Stockpiles
 - Water
 - Temporary Inert Waste Storage
 - Buried Gas Main
 - Buried Water Main
 - Bunds (3m high)
 - Soil / Overburden Movements
 - Mineral Movements
 - Direction of Working



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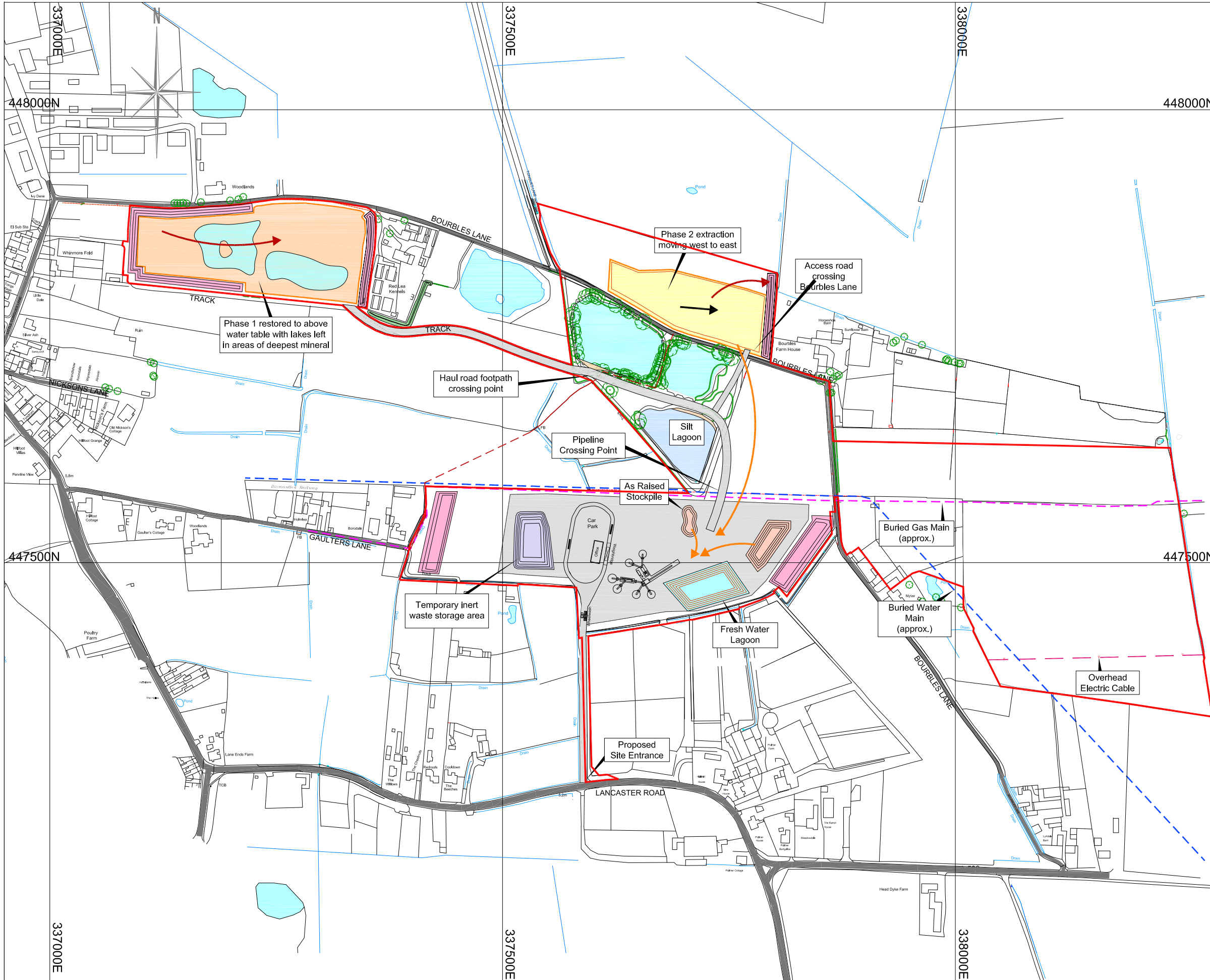
Site
 Bourbles Farm

Project
 Planning Application 2023

Plan
 Phasing Plan- Phase 1
 DRAFT

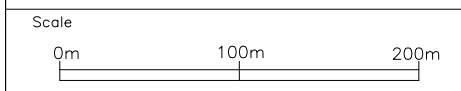
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Key

- Application Area
- Mineral Excavation
- Plant Site
- Partial Restoration
- Full Restoration
- Stockpiles
- Water
- Inert Material Storage Area
- Buried Gas Main
- Buried Water Main
- Bunds (3m high)
- Soil / Overburden Movements
- Mineral Movements
- Direction of Working



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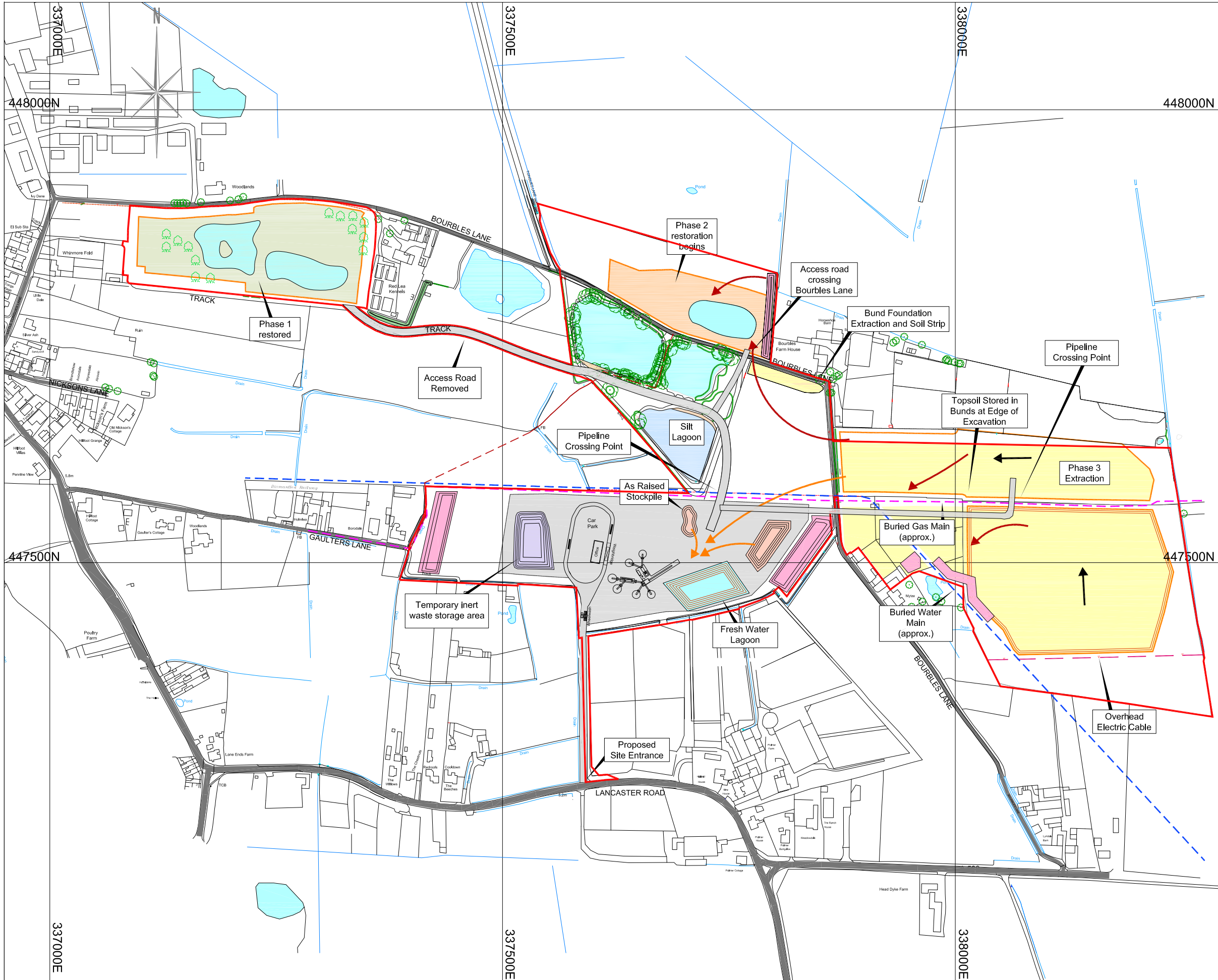
Site
 Bourbles Farm

Project
 Planning Application 2023

Plan
 Phasing Plan- Phase 2
 DRAFT

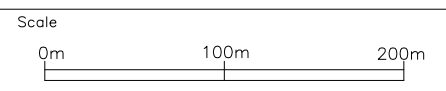
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Key

- Application Area
- Mineral Excavation
- Plant Site
- Partial Restoration
- Full Restoration
- Stockpiles
- Water
- Inert Material Storage Area
- Buried Gas Main
- Buried Water Main
- Bunds (3m high)
- Soil / Overburden Movements
- Mineral Movements
- Direction of Working



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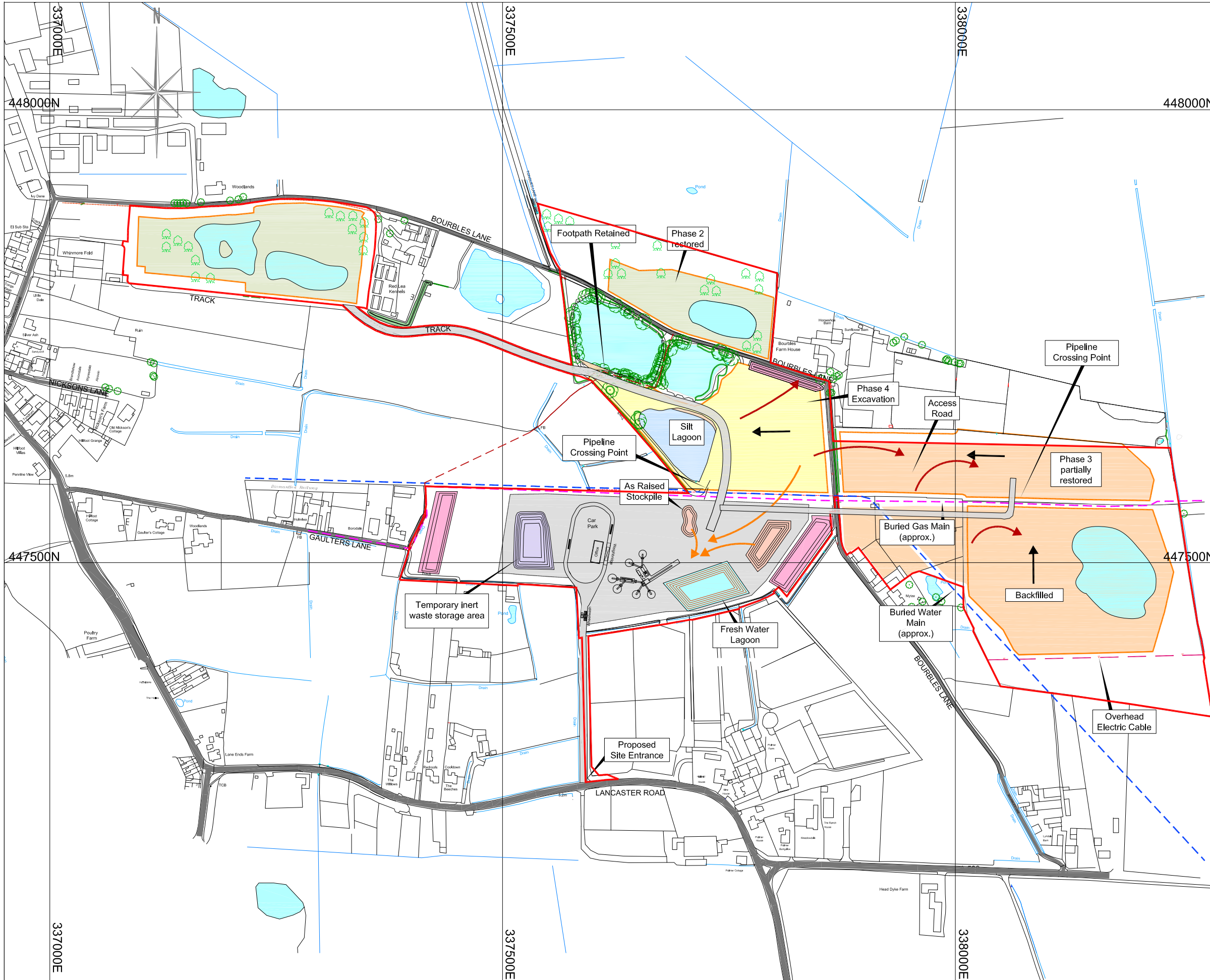
Site
 Bourbles Farm

Project
 Planning Application 2023

Plan
 Phasing Plan- Phase 3
 DRAFT

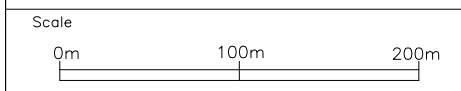
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Key

- Application Area
- Mineral Excavation
- Plant Site
- Partial Restoration
- Full Restoration
- Stockpiles
- Water
- Inert Material Storage Area
- Buried Gas Main
- Buried Water Main
- Bunds (3m high)
- Soil / Overburden Movements
- Mineral Movements
- Direction of Working



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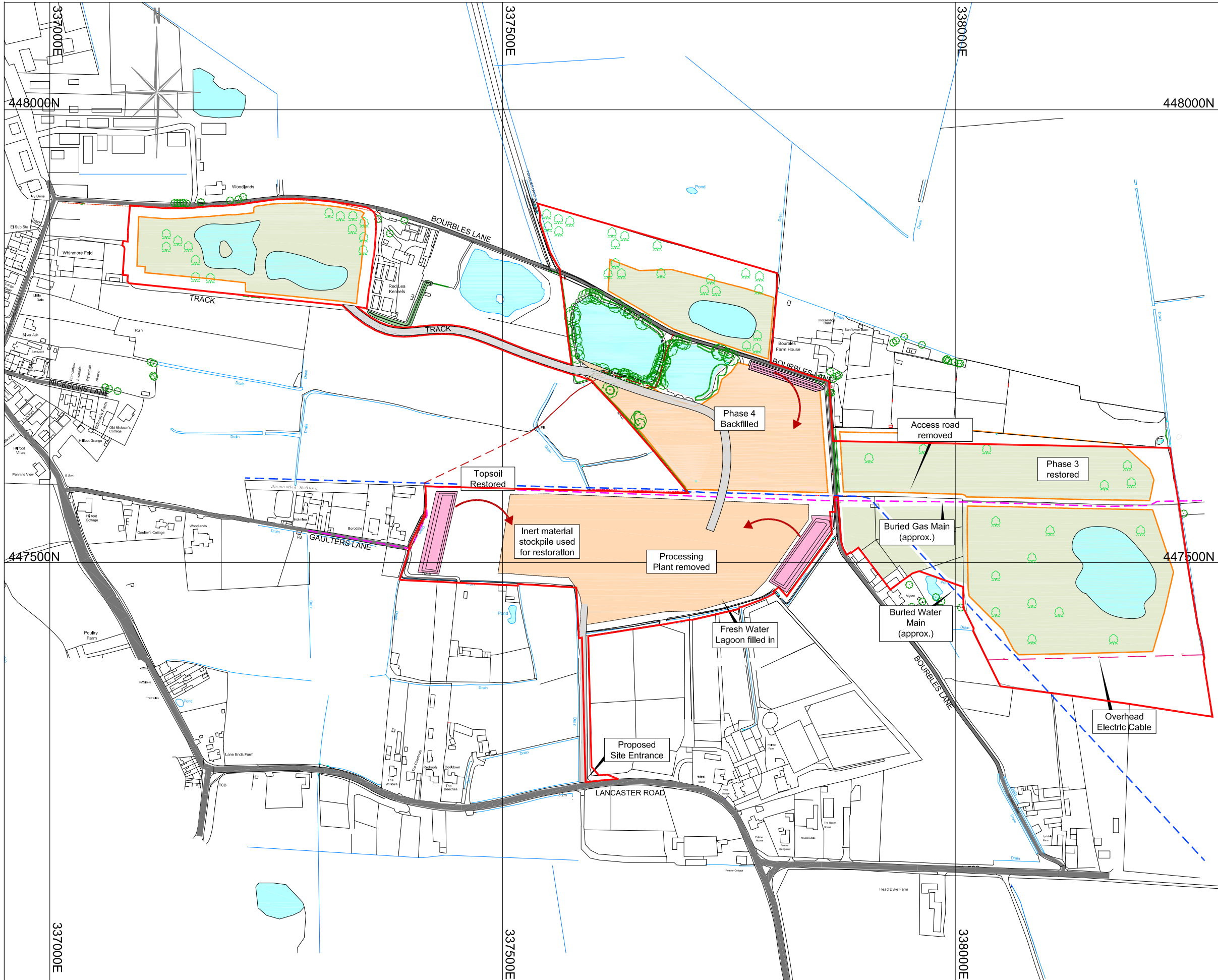
Site
 Bourbles Farm

Project
 Planning Application 2023

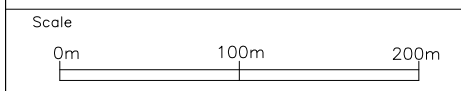
Plan
 Phasing Plan- Phase 4
 DRAFT

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 Drawn by: ISC





- Key**
- Application Area
 - Partial Restoration
 - Full Restoration
 - Water
 - Buried Gas Main
 - Buried Water Main
 - Bunds (3m high)
 - ↻ Soil / Overburden Movements
 - Direction of Working



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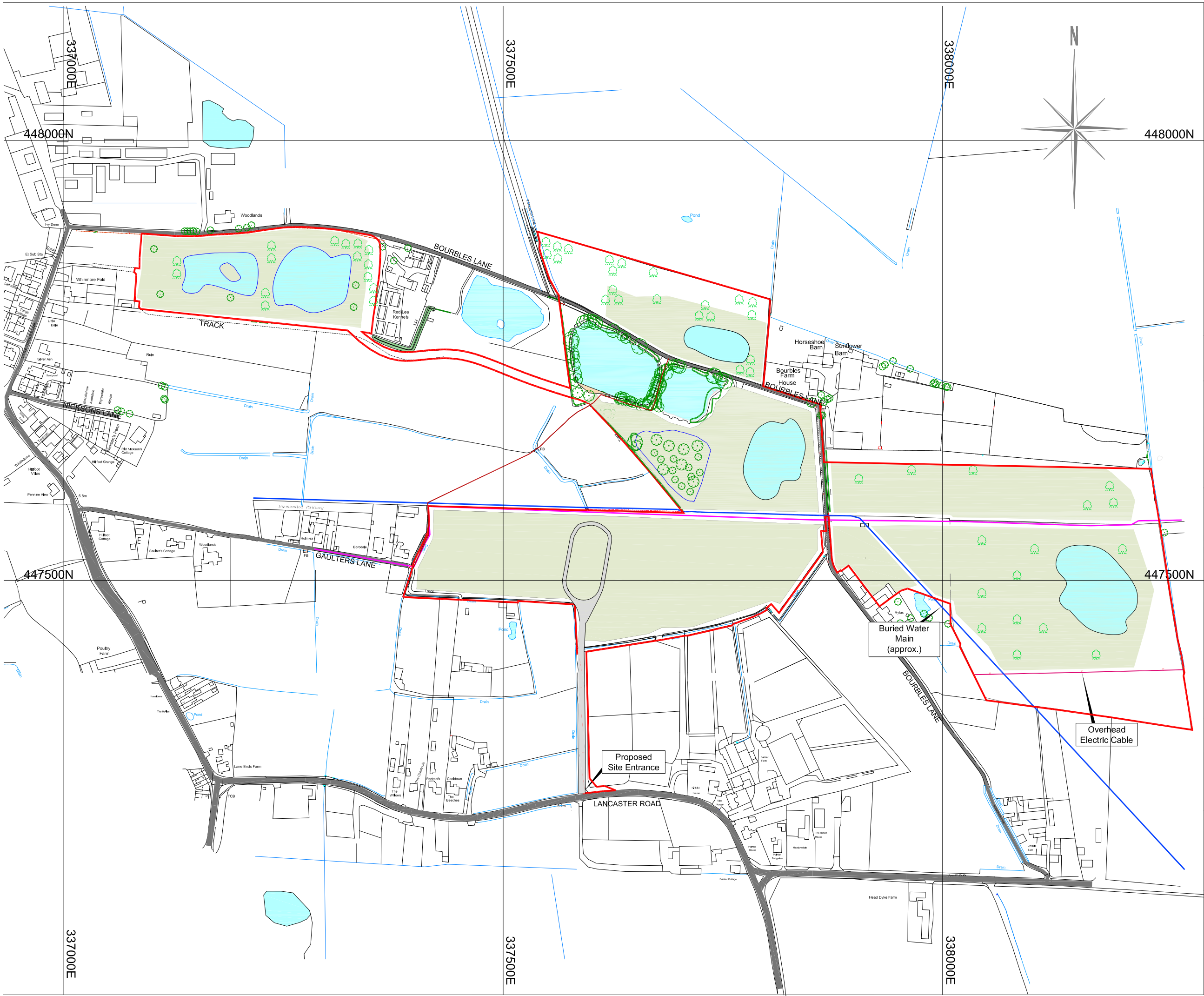
Site
 Bourbles Farm

Project
 Planning Application 2023

Plan
 Phasing Plan- Phase 5
 DRAFT

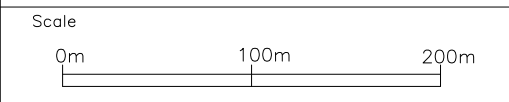
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 Date: 26/01/2023
 File: BFP Phase 5 DRAFT V1 JAN23.dwg
 Drawn by: ISC





Key

- Application Area
- Agricultural Restoration
- Water
- Buried Gas Main
- Buried Water Main



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Site
 Bourbles Farm

Project
 Planning Application 2023

Plan
 Restoration Plan v2
 DRAFT

Scale: 1:4000@A3
 Date: 09/03/2023
 File: BFP Restn Draft v2
 Drawn by: SJR



APPENDIX 3133/HIA/A6

Dewatering calculations

Calc sheet by:
Version number:
Date:

RM
1
30/05/2023



Hydraulic parameters

	<i>min</i>	<i>most likely</i>	<i>max</i>
Hydraulic conductivity, K (m/day)	4	40	400

Dupuit-Forcheimer formula for inflows

Initial saturated thickness, h_0 (m)	3.1		
Seepage face, h_s (m)	0.25		
Drawdown, Δh (m)	3.1		
Saturated thickness, h_w (m)	0.25		
Radius of working area choice	Rectangular	← select result from box 1	
Radius of working area, r_w (m)	124.1		
	<i>min</i>	<i>most likely</i>	<i>max</i>
Groundwater inflow, Q (m ³ /day)	291.3	1249.7	6636.5
Groundwater inflow, Q (L/s)	3.37	14.46	76.81

Box 1: CIRIA formula for effective radius of working area

Length (m)	230	
Width (m)	160	
	<i>Circular</i>	<i>Rectangular</i>
Effective radius (m)	108.2	124.1

Box 2: Sichardt formula for radius of influence

Sichardt factor, Cs	3000	(3000 for radial flow, 1500-2000 for linear flow)	
Drawdown (m)	3.1		
	<i>min</i>	<i>most likely</i>	<i>max</i>
Radius of influence, R_0 (m)	63.3	200.1	632.8

Total ingress (groundwater + rainfall)

Groundwater inflow choice	most likely	← select result from Their calcs	
Groundwater inflow (m ³ /day)	1249.7		
Runoff catchment (m ²)	36800		
	<i>min</i>	<i>most likely</i>	<i>max</i>
Fraction of rainfall forming runoff	60%	80%	100%
Fraction of rainfall choice	max	← select proportion from table above	

	Avg. rainfall per month (mm)	Runoff rate (m ³ /day)	Runoff rate (L/s)	Runoff + GW inflow (m ³ /day)	Runoff + GW inflow (L/s)
January	79.70	94.6	1.10	1344.3	15.56
February	69.90	91.9	1.06	1341.5	15.53
March	54.80	65.1	0.75	1314.7	15.22
April	44.00	54.0	0.62	1303.6	15.09
May	51.30	60.9	0.70	1310.6	15.17
June	61.10	74.9	0.87	1324.6	15.33
July	68.80	81.7	0.95	1331.3	15.41
August	83.10	98.6	1.14	1348.3	15.61
September	84.20	103.3	1.20	1352.9	15.66
October	103.30	122.6	1.42	1372.3	15.88
November	93.90	115.2	1.33	1364.8	15.80
December	96.10	114.1	1.32	1363.7	15.78
Annual average		89.7	1.0	1339.4	15.5
Annual maximum		122.6	1.4	1372.3	15.9

EXPLANATION OF CELL COLOURS

Yellow	Data entry
Green	Formulae
Blue	Select from list

EXPLANATION OF DUPUIT-FORCHEIMER FORMULA

Dupuit-Forscheimer is valid for unconfined flow (i.e. variable saturated thickness) CIRIA 2000: Eq 6.7. This is called the Theim-Dupuit equation by the Environment Agency 2007: box 3.2.

Where

$$Q = \pi k \left[\frac{(h_o^2 - h_w^2)}{\ln(r_o / r_w)} \right]$$

Q = groundwater ingress rate (m3/d)
 k = hydraulic conductivity (m/d)
 h0 = sat'd thickness before drawdown (m)
 hs = height of seepage face in workings (m)
 hw = sat'd aquifer thickness after drawdown + hs (m)
 rw = radius of working area (m)
 r0 = rw + radius of influence (m)

Effective radius of the working area estimate is based on CIRIA 2000: equation 6.5

EXPLANATION OF SICHARDT FORMULA

Cited as equation 6.8 in CIRIA 2000, and equation 3.4 by Cashman and Preene 2001.

Where

$$r = Ch \sqrt{k}$$

r = radius of influence (m)
 C = constant
 h = drawdown (m)
 k = hydraulic conductivity (m/s)
 rw = radius of working area (m)

REFERENCES

Cashman and Preene, 2001. Groundwater Lowering in Construction: A Practical Guide. Spon Press. (Superseded by Cashman and Preene, 2020. Groundwater Lowering in Construction: A Practical Guide to Dewatering (3rd edition). CRC Press)

CIRIA, 2000. Groundwater control - design and practice. Report C515 (Superseded by CIRIA, 2007. Groundwater control - design and practice (second edition). Report C750.)

Environment Agency, 2007. Hydrogeological impact appraisal for dewatering abstractions. Science Report SC040020/SR1