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Booth Ventures Waste (Midlands) Ltd

Report No. 5430-BLP-R-003-02
August 2023

Sandown Quarry Landfill

Environmental Permit Application – ESID

BOOTH VENTURES

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1 Introduction

1.1 Report Context

This report outlines the Environmental Setting and Installation Design (ESID) for the Sandown Quarry Landfill (operator Booth Ventures Waste (Midlands) Ltd) and defines the technical standards to be employed at the facility. This ESID supports the permit application for the site and summarises the proposed engineering for the associated void infill. In addition, the report details the proposed measures to be employed to ensure the filling of the void does not have a detrimental impact on the surrounding environment.

The information provides a basis for relevant risk assessment and established baseline conditions. This ESID report develops the Conceptual Site Model (CSM) for the landfill, and hence characterises the source term, potential pathways and receptors for the subsequent environmental risk assessments and follows the appropriate Environment Agency template[1].

1.2 Proposed Development - Overview

Booth Ventures Waste (Midlands) Ltd (company number 12508267, the proposed site Operator) intend to infill and restore the quarry void at Sandown Quarry. The site referenced within this application is "*Sandown Quarry Landfill*". The mineral reserve extraction (from ~90mAOD currently to a terminal depth of 75mAOD) is expected to be completed by / during summer 2023 and is not part of the application submission. On completion of the mineral reserve removal, Booth Ventures Waste (Midlands) Ltd will operate the site under a lease agreement with the landowner Wienerberger UK (company number 05299520).

The proposals are as follows:

- Installation of a suitable engineered barrier (where applicable);
- Landfilling using low pollution potential materials (Qualifying Materials), inert and non-hazardous wastes;
- Processing / recovery of aggregates as required;
- Restoration of the site to similar levels to the surrounding ground, with a gentle slope for surface water management; and
- Landscaping of the site to a suitable restored surface.

Infilling

This site is currently an active quarry for the extraction of marl / mudstone (from the Etruria Formation) to produce bricks. Upon completion of quarrying activities, the operator proposes restoration of the void by landfilling with non-hazardous wastes.

Applications seeking consent for Planning Permission (submitted to the Local Planning Authority) and Environmental Permit (the later being the subject of this application) are twin tracked for

[1] https://www.gov.uk/government/publications/esid-report-template

efficiency. The infilling scheme (Environmental Permitting Regulations 2016, Schedule 1, Chapter 5 Waste Management, Section 5.2, Part A(1) (a) "Disposal of Waste in a Landfill") proposes to utilise a supply of excavation waste materials associated with excavation and construction works to restore the quarry. Site activities will accord with "Landfilling", designated D5 and "restoration", designated R5 and R10 as outlined in Annex I and II of the Waste Framework Directive (Directive 2008/98/EC). The infill material will comprise only of wastes which are considered suitable, and which are specified by Her Majesty's Revenue and Customs (HMRC) in The Landfill Tax (Qualifying Material) Order 2011 (as amended) (i.e. Qualifying Materials (QMs)[2].

The design of the infilling scheme and restoration profile will be completed to a level coincident with surrounding perimeter ground levels. The scheme accounts for long term surface water management and additionally aims to enhance the local ecology by providing further habitat generation on the margin of the 'Swan Pool' and 'Swag' Sites of Scientific Interest (SSSI).

On-Site Processing

In support of the restoration operations and to support sustainability, imported wastes with a recoverable component will be processed to recover aggregates in accordance with the quality protocol approved by the Environment Agency[3]. It is anticipated that approximately 5% of the wastes imported will be suitable for processing (crushing and/or screening).

Suitable wastes, selected from the imported wastes, will be stockpiled on a hardstanding pad (aggregate over lower permeability soil) located within the base of the void (eastern area) prior to treatment. When sufficient recoverable wastes have been stockpiled treatment will be undertaken periodically for short periods utilising mobile plant under the landfill permit. Recovered aggregate will either be used on site (e.g. for creation of roads and hardstanding areas) or exported and used in accordance with quality protocol (e.g. pipe bedding and highway sub base). The recovery of aggregates from imported wastes will cease when the final restoration of the quarry void is completed. Residual material from the crushing and/or screening activity will be deposited within the landfill void.

1.3 Supporting Documentation

Drawings

A number of drawings illustrate relevant aspects of the application that accord with Environment Agency Guidance, these drawings are numbered as:

- ESID 1 Location
- ESID 2 Environmental Site Setting
- ESID 3 Cultural and Natural Heritage
- ESID 4 Site Layout and Waste Deposition (Permit / Installation Boundary)
- ESID 5A Installation Phasing (Year 0 – after year 6)

[2] The Landfill Tax (Qualifying Material) Order 2011 (as amended) - https://www.legislation.gov.uk/uksi/2011/1017/contents/made
[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/296499/LIT_8709_c60600.pdf

- ESID 5B Installation Phasing (Year 9 – after year 18)
- ESID 5C Installation Phasing – Cross Sections
- ESID 5D Installation Phasing (Cross-sections including Canal)
- ESID 6 Proposed Restoration
- ESID 7A Leachate Management
- ESID 7B Leachate Management
- ESID 8 Site Investigation Locations
- ESID 9 Local and Regional Geology
- ESID 10 Regional Hydrogeology
- ESID 11 Geological / Hydrogeological Cross Sections
- ESID 12 Monitoring
- ESID 13 Surface Water Management – General Arrangement (Appendix J of Report 07200-100) – Rev 4

Assessment

This Environmental Setting and Installation Design report provides supporting information for the following and associated assessments:

- 5430-BLP-R-004-02 Environmental Risk Assessment (H1)
- 5430-BLP-R-005-02 Waste Acceptance Criteria (WAC)
- 5430-BLP-R-006-02 Hydrogeological Risk Assessment (HRA)
- 5430-BLP-R-007-02 Gas Risk Assessment (GRA)
- 5430-BLP-R-008-02 Stability Assessment (SRA) and supplementary report 5430/R/016/01
- 5430-BLP-R-009-02 Emissions Monitoring and Financial Provision Report
- Surface Water Management Plan (07200/SWMP/R02 – 7 Engineering Consultancy) – October 2022 (Appendix D of this ESID)
- Surface Water Management Plan Addendum (07200/SWMP/R02 – 7 Engineering Consultancy) – July 2023 (Appendix D of this ESID)

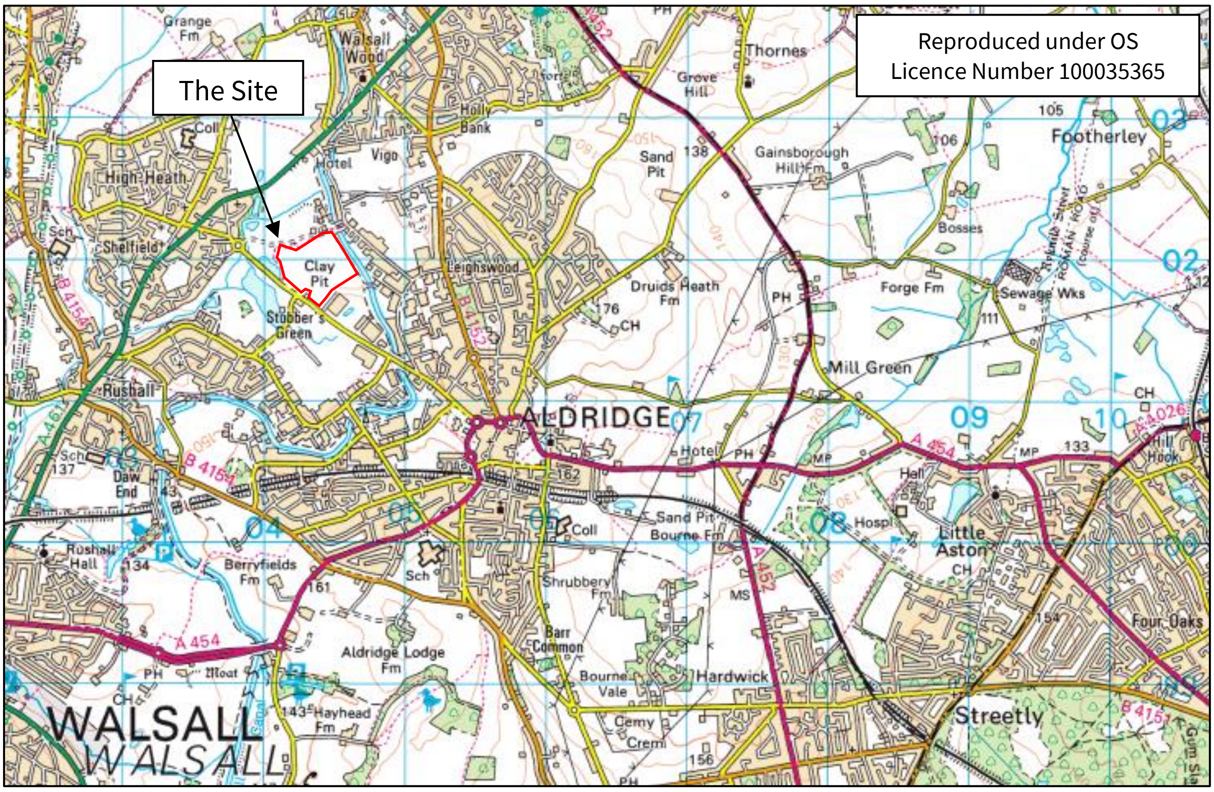
A GroundSure report is provided at Appendix B that includes historic mapping, monitoring data is provided at Appendix B and site investigations / drilling logs are provided at Appendix C.

1.4 Site Location and Surrounding Land Use

Sandown Quarry is located approximately 4km to the northeast of Walsall, 1.7km northwest of the town of Aldridge at National Grid Reference (NGR) SK 04386 01960 (Figure 1, see also drawing ESID 1).

The site is currently an active quarry operated by Weinerberger UK, extracting marl and mudstone for the brick manufacturing industry.

Figure 1 Site Location



Additional quarry sites are located within the immediate area (some of which are operational) extracting the same natural resource (e.g. Ibstock's Atlas Quarry to the south and Aldridge Site to the east, drawing ESID 2). The Aldridge Brickworks are also depicted on Figure 2.

Many of the historical sites have been infilled and restored by landfilling, e.g. sites located 300m to the west, 20m to the north, 430m to the southeast, 220m east, 195m northeast of the proposed permit boundary (see drawing ESID 2). Environmental information relating to these nearby sites pertinent to this application (considered relevant to the production of report 5430-BLP-R-003-02) have been obtained through a freedom of information request to the Environment Agency (reference 254021, date received 30th March 2022).

The current operations at the Sandown Quarry occupy the central and northern end of the site, the mineral processing operations, kilns, workshop and offices occupy the south and south-eastern end of the facility (Figure 2). Current excavation depths within the quarry are ~90mAOD, accumulation of rainwater in the base of the void collects during wet periods of the year, this water is removed to the on-site surface water settlement pond in the north-western corner. The water is directed to a drain in accordance with a current discharge consent which then passively flows through a network of drains to the west, towards the Swag SSSI (Figure 3).

The perimeter of the site is at ~130mAOD to the east and southeast in the area of the brickwork's storage yard rising to ~133mAOD in the north-western corner near to the current surface water settlement pond (Figure 3 and drawing reference ESID 4).

Figure 2 Aerial Overview of Sandown Quarry

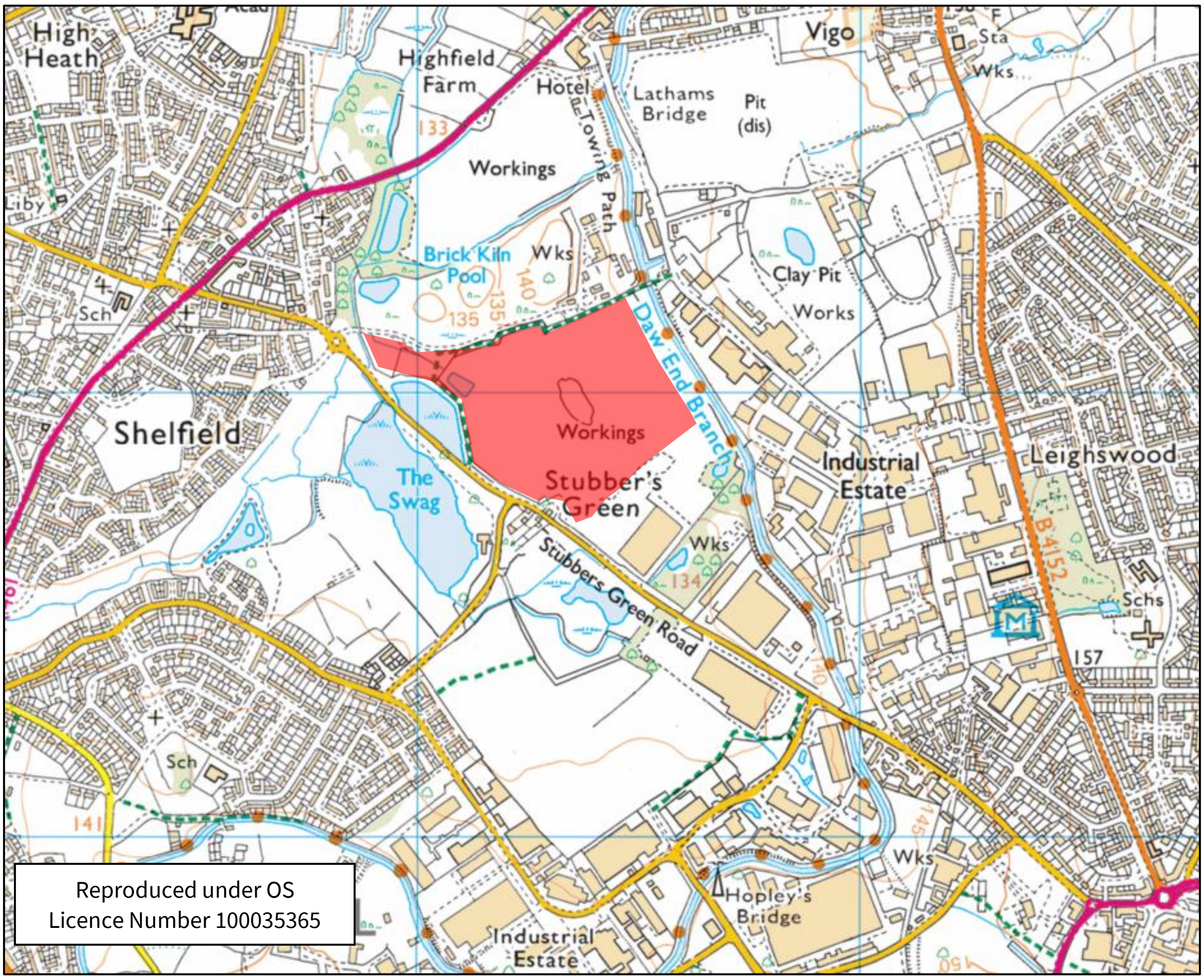
Moving north-easterly, ground levels increase to ~137mAOD, a level consistent with the edge of the current void along its eastern boundary however there are areas of low permeability "cast back" materials present (interburden / overburden surplus to brick manufacture) within the intervening land between the eastern boundary of the void and the Daw End Canal which is adjacent to the site perimeter (Figure 3). These areas increase in height up to ~144mAOD.

Locally, the highest ground is at ~175 - 180mAOD to the east in the residential area of Leighswood, falling to the west and northwest to 125mAOD associated with the lower lying areas of the Ford Brook tributaries (west of High Heath, Figure 1, Figure 4) that flow to the River Tame which is located 6.7km to the southwest beyond the Walsall Ring Road (Broadway) and the M6.

The local topographical context is illustrated on the shaded relief contour map (Figure 4), cross referencing the topography with the geological setting (further detail provided in Section 3.4, Section 3.5) it is apparent that the high areas of land to the east relate to the outcrop of the Chester

Formation strata (Triassic). The site itself is located within the Carboniferous (older) Etruria Formation strata.

Figure 3 Site Location - Detail



Indicative permit area and boundary shown for context, proposed permit boundary is detailed on ESID 4.

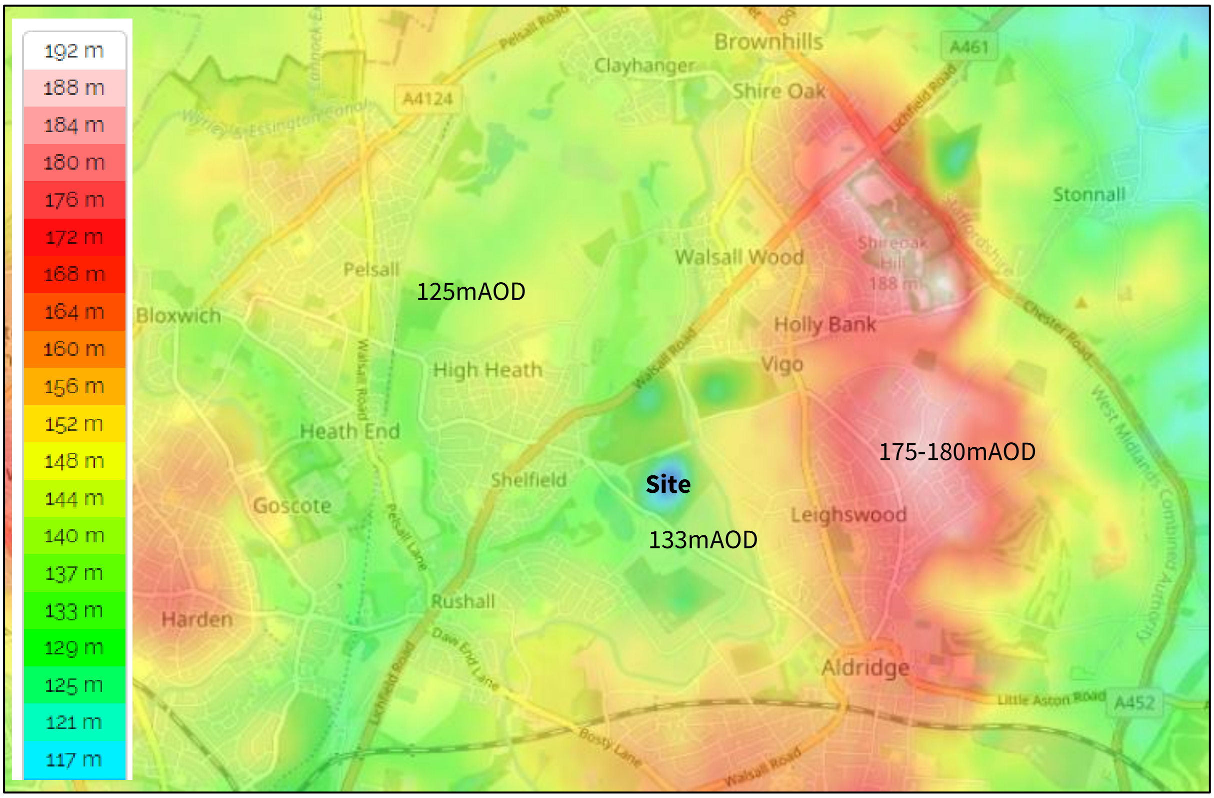
As noted above in regard to land on the eastern perimeter, extensive placement of 'non-mineral resource' material has also taken place in other areas of the current quarry void periphery. Aerial images available on-line indicate placement between 2000 and 2007 particularly the areas to the south and southwest, progressing along the western boundary towards the location of the surface water settlement pond (Figure 2).

1.5 Local Amenity Receptors

A sensitive receptor review has been undertaken within a 1.5km screening distance, receptors are identified in ESID 2 and Table 1. An Environment Agency 'Nature and Heritage Conservation Screening Report' (ref: EPR/LB3107UP/A001) was requested and received in March 2021 which identified Local Wildlife Sites (LWS) referred to as Dumblederry Lane, Anchor Brook Valley, Daw End Brach Canal and Stubbers Green within 200m of the Site.

The LWS sites have been included on the accompanying Sensitive Receptor Location Plan (Drawing ESID 3) and are also referenced in Table 1. The Screening Report identified protected species to the east associated with the Canal, namely Floating-leaved Water Plantain and various protected habitats such as Deciduous Woodland / Fens / Coastal or Floodplain grazing.

Figure 4 Shade Relief Contour Map



Higher topographical areas relate to the outcrop of the Chester Formation strata.

The report also highlighted that there are no Special Areas of Conservation (SAC), Special Protection Areas (SPA), RAMSAR sites, National Nature Reserve (NNR) or Local Naturel Reserves (LNR) located near the Site. The Screening Report is attached as Appendix A within the associated H1 Environmental Risk Assessment (report 5430-BLP-R-004-02).

Sites of Special Scientific Interest (SSSI) are located within the screening distance, namely the Jockey Fields SSSI, Swan Pool and the Swag SSSI and Stubbers Green Bog (drawing ESID 2).

The Jockey Fields SSSI (Neutral Grassland) to the north of the A461 is recorded as being "*unfavourable / declining*" as a result of a sewage spill in 2016 "*hence damaged through gross eutrophication*". The Swan Pool and the Swag SSSI (the boundary of Swan Pool SSSI extends into the boundary of Sandown Quarry) are recorded as fen, marsh and swamp which are "*unfavourable / no change*".

The Natural England Website details "*Much of the reed swamp at Swan Pool has been lost to scrub encroachment and reedswamp at the Swag to horse grazing over last few decades. More recent ornithological advice is to work with landowners to restore the reedswamps and see what happens. Scrub control at Swan Pool will require a long-term programme taking into account existing wildlife interest such as other bird species and invertebrates, whereas a fence is required at the Swag to* *prevent grazing animals from eating off any emerging reedswamp growth. A stable water level is also required*". It is also noted that swallows on autumn passage no longer use the site.

Table 1 Sensitive Receptor Review

Receptor No.	Receptor	Receptor Type	Approx. Distance from Site Boundary (m)	Direction from Site
1	Residential properties on Stubbers Green Road	Residential	20	SW
2	Residential properties on New Street	Residential	125	NW
3	Residential properties on Swan Pool Grove	Residential	130	W
4	Residential properties on Brook Meadow Road	Residential	150	W
5	Residential properties on Woodhaven	Residential	180	W
6	Residential properties on Broadheath Drive	Residential	240	W
7	Residential properties on Woodbridge Close	Residential	210	NNW
8	Ormiston Shelfield Community Academy	School	850	SE
9	St John's CE Primary School	School	1230	NNE
10	Leighswood Primary School	School	960	ESE
11	St Francis Catholic Primary School	School	520	WNW
12	Greenfield Primary School	School	870	W
13	Radleys Primary School	School	900	SW
14	Greenfields Allotments	Recreation	670	N
15	Aldridge Sailing Club	Recreation	200	SW
16	Open parkland around The Swag	Recreation	40	W
17	Recreation Ground	Recreation	450	W
18	Sandown Brickworks	Industrial/Commercial	40	S
19	Empire Industrial Estate	Industrial/Commercial	80	E
20	Veolia Empire Work (waste treatment)	Industrial/Commercial	15	N
21	Highfields South Landfill Site	Industrial/Commercial	250	N
22	Vigo Utopia Landfill Site	Industrial/Commercial	210	NNE
23	Linley Lodge Industrial Estate	Industrial/Commercial	590	SSW
24	Mercian Weldcraft Factory	Industrial/Commercial	280	SSE
25	Ibstock Brick Atlas brickworks	Industrial/Commercial	430	SSE
26	Ibstock Brick Atlas open quarry	Industrial/Commercial	410	S
27	Daw End Branch	Canal	15	E
28	Swan Pool	Pond	10	W
29	The Swag	Lake	75	W
30	Unnamed pond	Pond	90	NNW
31	Brick Kiln Pool	Pond	200	N
32	Unnamed pond	Pond	220	S
33	Unnamed pond	Pond	500	WSW
34	Unnamed pond	Pond	210	SSE
35	Unnamed pond	Pond	330	NE
36	On-site Drain – Highfield South	Site Drainage	320	N
37	Unnamed drain	watercourse	5	W

Receptor No.	Receptor	Receptor Type	Approx. Distance from Site Boundary (m)	Direction from Site
38	Unnamed drain	watercourse	20	NW
39	Unnamed drain	watercourse	300	W
40	Unnamed drain	watercourse	200	NNW
41	Unnamed drain	watercourse	50	S
42	Swan Pool and The Swag SSSI	SSSI	0	W
43	Stubbers Green Bog SSSI	SSSI	50	S
44	Jockey Fields SSSI	SSSI	340	N
45	Daw End Railway Cutting SSSI	SSSI	1250	SSW
46	Dumblederry Lane LWS	LWS	220	SW
47	Anchor Brook Valley LWS	LWS	70	S
48	Daw End Branch Canal LWS	LWS	15	E
49	Stubbers Green LWS	LWS	15	W
50	Stubbers Green Road	Road	20	W
51	Barns Lane	Road	50	SW
52	Unnamed access road to Veolia Site	Road	20	ENE
53	Empire Close	Road	140	E

See drawings ESID 2, ESID 3. Sensitive Receptors do not include former / historic landfill sites.

All aspects of the site's restoration are covered in the Planning Application submission to the local planning authority LPA. The proposals contained herein, i.e. infilling the void to a suitable restored landform is considered beneficial long-term for ecological regeneration and includes enlargement of the current on-site settlement pond.

The Stubbers Green Bog SSSI (fen, marsh and swamp) to the southeast is recorded as "*unfavourable / declining*" and requires scrub and tree management. Additionally, a review of designated sites within an increased distance 2km of the site has been undertaken through a review of the www.magic.gov.uk site and there are none identified as present within the screened area. The nearest designated site is a Special Area of Conservation (SAC) is located 3.4km to the northwest, the Cannock Extension Canal. Designation is based on lowland habitat supporting floating water-plantain *Luronium natans* at the eastern limit of the plant's natural distribution in England.

A full review of sensitive receptors within 1.5 km are summarised and listed in Table 1, as stated above the locations are depicted on drawing ESID 2 and Drawing ESID 3.

2 Source Term Characterisation

2.1 The Development of the Installation

The Sandown Quarry is located within a natural "geological barrier" of significant lateral and vertical thicknesses. As such, the granting of an Environmental Permit is considered acceptable (paragraph 1 of Annex 1 of the Landfill Directive 'the Directive' 99/31/EC[4] as the location of the landfill is such that it would not pose a serious environmental risk.

The proposed non-hazardous site is not located within a groundwater Source Protection Zone (SPZ), or below water table (where the strata provides an important contribution to river flow or sensitive surface water receptors), within or on a major aquifer or within a SPZ, zone II or III [5,6]. Further details are provided in Section 3.8.

The landfill will be developed on the principle of containment, site access is restricted to the public and is fully fenced with lockable gates. As stated in the Regulatory Guidance Series No LFD1[6], containment engineering for the purposes of groundwater protection cannot be undertaken in isolation from gas management. Gas generation is addressed further in report 5430-BLP-R-007-02.

LFD1 goes on to state that in assessing the landfill engineering proposals, there must be:

- compliance with the LFD, Annex 1 engineering requirements;
- no likelihood of unacceptable discharge / emission over the entire lifecycle of the landfill (i.e. Landfill Directive and Groundwater Directive compliant); and,
- structural / physical stability over the entire lifecycle of the landfill.

Stability aspects are addressed in report 5430-BLP-R-008-02 and supplementary report (5430/R/016/01, May 2023).

As such, the engineering standards (based on technical assessment within this application) are Directive compliant by the provision of:

- An *in-situ* basal "natural" geological barrier of low permeability marl (Etruria Formation strata), the requirements for a geological barrier are set out in paragraph 3.2 of Annex I to the Directive.
- Emplacement of engineered site-won marl ("artificial" geological barrier) to complement the existing "natural" geological barrier where the natural strata is exposed in the sidewall faces of the final quarry exposure (i.e. areas not covered over with cast back materials).
- Removal of the requirement for an "Artificial Sealing Liner". The Hydrogeological Risk Assessment (5430-BLP-R-006-02) has indicated there is no requirement for leachate collection, hence there is no requirement for the inclusion of an Artificial Sealing Liner (ASL) in addition to the geological barrier (paragraph 3.3 of Annex I to the Directive).

The example given in LFD1 outlines that "*where a landfill is located on a significant depth of consistently low permeability stratum (such as clay) which could provide a bottom sealing system. In these cases the addition of an artificial sealing liner to provide additional bottom sealing would provide a negligible contribution to the protection of soil and water and so may not be required*".

[4] Landfill Directive (99/31/EC) - Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste
[5] Environmental Permitting Guidance, The Landfill Directive. For the Environmental Permitting (England and Wales) Regulations 2010, Updated March 2010. Version 3.1, DEFRA
[6] Environmental Permitting Regulations (England and Wales) 2010. Regulatory Guidance Series, No LFD 1 Understanding the Landfill Directive. Environment Agency

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Although "water bearing" layers or lenses are present within the Etruria Formation, site investigations have demonstrated there is no persistent / lateral connection between identified layers, as such the formation does not represent a groundwater receptor as defined by the Water Framework Directive (WFD) (further details are provided in Section 3). Conversely, irrespective to the potential "yield" thresholds used for sustainable abstraction purposes, the conceptualisation detailed herein (based on site specific detail, local knowledge and literature-based research) indicates there is no connectivity between the Etruria Marl (water bearing lenses) and baseflow fed surface water systems.

The *in-situ* marl will provide a natural low permeability basal barrier to negate any vertical seepages / any migration of liquid from the waste out of the landfill. The thickness of the "natural" geological barrier beneath the base of the site is >5m (site investigation detail provided at Appendix C), historic information indicates a thickness of ~82m prior to water bearing Coal Measures strata (see information at Section 3.5.2). As such, there is no requirement to further engineer a liner on the site base.

The proposed engineered "artificial" geological barrier (sidewall liner) will form a low permeability seal of 500mm minimum thickness, at a permeability no greater than $1x10^{-8}$ m/s in areas of site where the Etruria Formation is exposed in the sidewall faces of the final quarry exposure. The thickness accords with the minimum requirement outlined in the DEFRA guidance document[5] and paragraph 3.2 of Annex I to the Directive (landfill for non-hazardous wastes). The geological barrier in these areas is hence a combination of both natural and artificial.

Many of the former quarry sidewalls around the site perimeter are sufficiently covered to protect the natural strata at the site boundary, the extensive placement "cast back" materials historically has resulted in significant lateral thicknesses of material between the infill and the *in-situ* Etruria Formation strata, further detail provided in Section 4.1. The use of this material is commercially unviable based on aesthetics, when fired the appearance does not meet the required standards / colour.

The waste infill will be composed solely of Qualifying Materials, which will have low leachate and landfill gas producing capacity and are essentially inert. The void space will be filled up to existing ground levels, with a slightly raised profile / gradient engineered to facilitate surface water management.

The environmental protection measures included within the design of the landfill e.g. cell lining systems and capping systems will be designed in accordance with the Landfill Directive and as such are considered to represent best practice environmental protection (leachate management is not required).

The infilling materials, which by their very nature once compacted, capped and restored will not require active management. The surrounding geological and hydrogeological systems are not considered at risk based on the information reviewed to date (further details provided in the relevant assessment documents). On completion of the filling a cap will be placed commensurate to the requirements for an artificial geological barrier (i.e. a minimum 500m thickness with a permeability no greater than $1x10^{-8}$ m/s).

2.2 Site History and Local Historical Development

A Groundsure Enviro-Geo Insight report[7] is included at Appendix B, the historical maps contained therein show that in 1883 the land locally was predominantly agricultural with areas of Coal Mining and Clay extraction. Historical land use from 1883 to present is tabulated below in Table 2.

Table 2 Historical Land Use

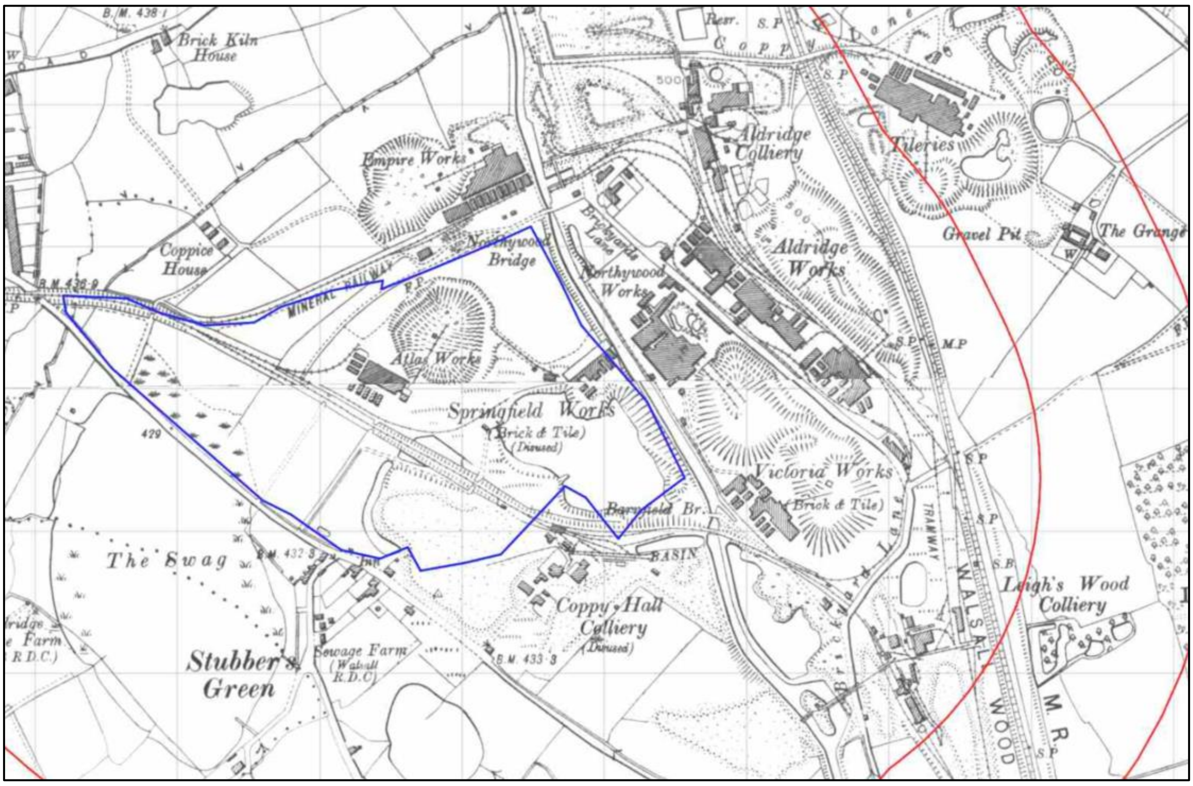
Date	Land Use	Reference
1883 - 1888	London North-western Railway identified bisecting the site, Stubber's Green Brick Works is present on site (north of the railway), Stubber's Green Colliery south of the railway. A pond located in the north-centre of site, the canal is present to the east. Leigh's Colliery and the Victoria works identified to the southeast, Aldridge Colliery to the northeast, settlement of Stubber's Green to the south. Unnamed brickworks are present to the north and Railway to the east (Walsall Wood Branch), beyond the canal.	County Series 1:10,560
1901	Extension of two works within the site, Springfield works at old Stubbers Green works, and Atlas works in centre-west of site. Stubbers Green colliery now referred to as Coppy Hall Colliery. Empire works to the north of Site and Northywood works east of the canal (referred to as the Birmingham Canal Navigation), residential properties increasing at Shelfield to the northwest. Numerous hamlets and small farm properties located nearby. Expansion of the Victoria works to the east (beyond the canal). Small area of marshland recorded near to the current location of the Swag.	County Series 1:10,560
1915 - 1921	Atlas works expansion on site in addition to the Empire works, Springfield works and Coppy Hall Colliery now disused, the bisecting railway still present through the centre of the site. The Swag now present, Sewage farm (Walsall R.D.C) southeast of Barns Lane.	County Series 1:10,560
1938	No significant change at site or local area. Increase in houses at Shelfield and Walsall Wood to the northeast.	County Series 1:10,560
1954 - 1956	Atlas works continue to develop, Empire works expansion to the north, Aldrige works to the east (beyond the canal) and development of Utopia works to the northeast. Swan pool now present in Site boundary. Sewage works development west of Stubber's Green and the Swag.	County Series 1:10,560
1972 - 1973	Bisecting railway now dismantled, further residential development in Shelfield and Rushall (southwest of Site). Single works at site, pits occupying north-eastern quarter of site. Walsall Wood Railway Branch dismantled to the east.	Ordinance Survey 1:10,000
1980 - 1982	No significant on-site change, more pools and pits in former Empire Works to north (e.g. Brick Kiln Pool). Development of an Industrial Estate in between the canal and Leighswood to the east. Walsall Wood Railway Branch developed into the route of the B4152.	Ordinance Survey 1:10,000
1990 - 1992	On-site Atlas brick works now gone, most of site is a single clay pit. Neighbouring former Empire works to the north is now a completed landfill, further expansion in Shelfield to the west of site and Leighswood to the East including the Leighswood Industrial Estate.	Ordinance Survey 1:10,000
2001 -2010	No significant changes / development.	Ordinance Survey 1:10,000
2022	No significant changes / development.	Ordinance Survey 1:10,000

The site area has expanded predominantly in regard to brick and tile manufacture between the late 19th Century and 1950's. Clay (marl) extraction predates the publication of the 1883 map however extraction continues locally at some sites including at Sandown Quarry.

[7] Groundsure (February 2022), Enviro+Geo Insight – Sandown Quarry Landfill. Report reference GS-8507932

In tandem with the brickwork expansion was the local increase in residential housing, not only on account of the brick industry but also to supply labour for the Coal Mining Industry. As recognised in Table 2, numerous collieries are located within the local area, Coppy Hall immediately adjacent to the south of the site, Aldridge to the northeast and Leigh's Wood to the southeast (Figure 5).

Figure 5 Location of Nearby Brickworks and Collieries



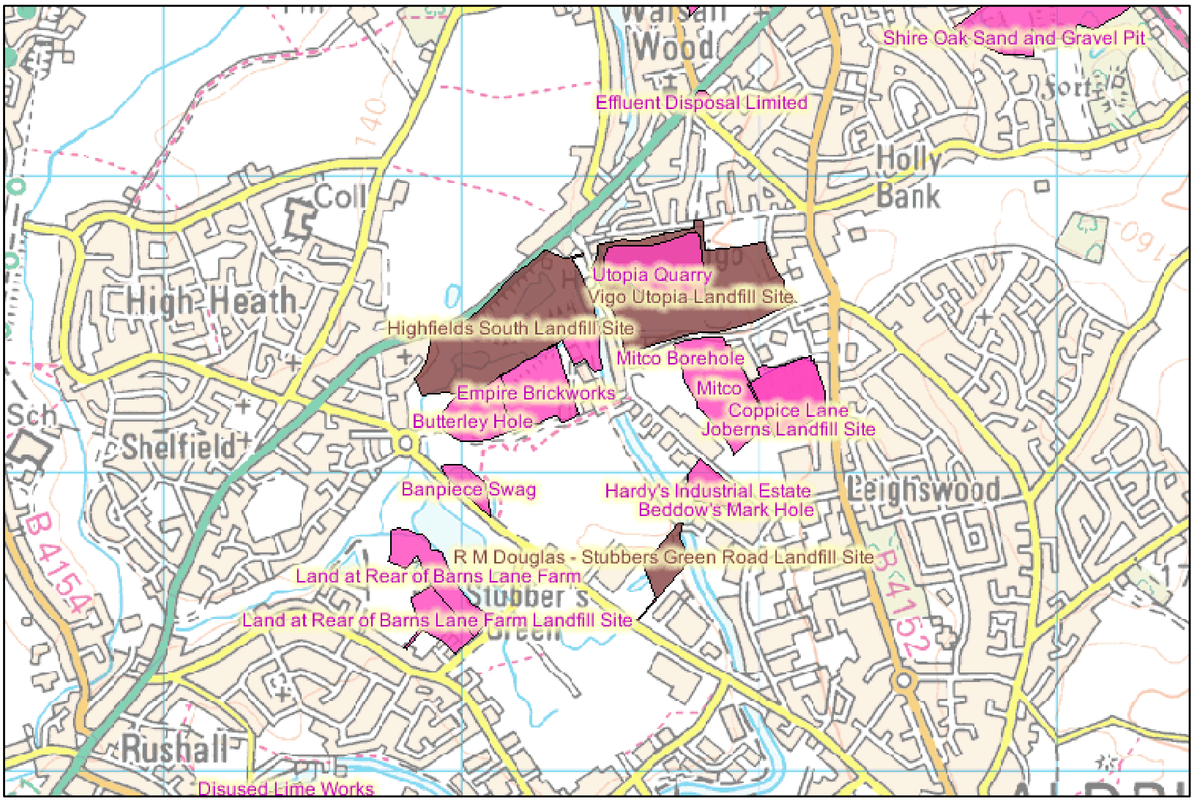
Extract from the 1915 – 1920 County Series 6" Map (part of Appendix B), blue line – approximate area of Sandown Quarry.

As noted in Section 1.3, subsequent to the removal of the brick making mineral reserves in some of the workings noted in Table 2 and Figure 5, these former quarry voids have been backfilled with wastes (Figure 6).

Additionally, the Groundsure report at Appendix B identifies that there are:

- 4 active, or recently closed sites recorded within 500m of Sandown Quarry (under EA regulation)
- 3 historic sites within 500m (BGS records)
- 4 historic sites within 500m (LA mapping)
- 13 historic sites within 500m (EA records)
- 17 historical waste sites (LPA records)
- 27 licensed waste sites (EA records)
- 17 waste exemptions (exempt from needing a permit)

Figure 6 Location of Nearby Landfills



Brown infill denotes authorised landfill, pink denotes "historic landfill"

As such, the potential for adverse environmental effects in the local area and alteration of baseline conditions (groundwater, surface water, soils) is significant. Much of the local surface cover (soils and superficial strata) and underlying natural geological strata (bedrock) have been removed. Further detail is provided in Section 3.5.

Most relevant to the site and the immediate environmental site setting is the presence of landfill sites (and possible associated impacts) adjacent to the site boundary.

The "Banpiece Swag" is recorded as being present adjacent to the western site boundary, this area of former waste deposition is now in the location of the Swan Pool SSSI. The 'Butterley Hole' / Empire Brickworks Sites are located adjacent to the northerly facing site boundary with the 'Douglas, Stubber's Green Road' Site to the southeast. Multiple sites are located to the east and northeast beyond the Daw End Canal and eastern site perimeter.

The potential effects of these site are discussed further in Section 3.7.2.

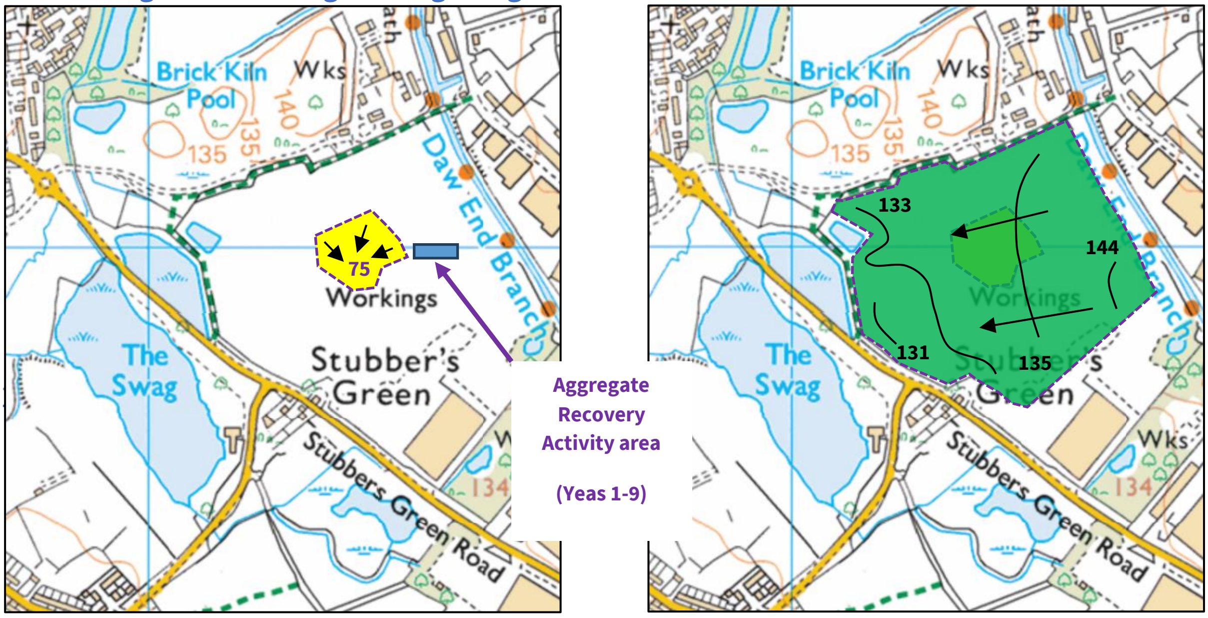
2.3 Proposed Development

Infilling restoration will utilise excavation and construction waste to create a landform that will maximise future use for the operator / landowner. The area of infilling is contained within the low permeability Etruria Formation strata, the proposed permit / installation boundary detailed on Drawing ESID 4. The edges of the voids are variably covered by trees and vegetation that have naturally regenerated providing an established visual barrier to operations.

The site will utilise the void after the final extraction of winnable mineral resource is complete (anticipated during the summer of 2023), the sidewall slopes (engineered liner) and basal liner (in-situ geological barrier) have undergone an assessment of stability and basal heave respectively (see report reference 5430-BLP-R-008-02, Plough Geotechnical Ltd). The excavation of the brick marl reserve will continue down to a terminal depth of 75mAOD (Figure 7, drawing ESID 5A).

The basal footprint is designed a single "cell" (drawing ESID 5A) at ~1.3ha, sidewall degrading / slippage in advance of sidewall engineering preparation will be continually monitored. If slippages are noted, the areas will be remediated accordingly in advance of infilling.

Figure 7 Engineering Design Schematic



Base (mAOD) & direction of fall

Restoration Surface (mAOD) & direction of fall

Although water ingress into the void was not observed during the site visit (April 2022), any areas that experience water seepages during the development of the site will instigate appropriate monitoring. The judgement of significance (in terms of hydraulic failure) will be undertaken and if required, engineering measures would be considered accordingly for collection / removal through the process of engineering and infilling.

The site design and conceptualisation are based on natural containment and enhanced (where necessary) with "engineered containment". Potential effects on the adjacent superficial strata, made ground around the site periphery, the lower sidewall *in-situ* bedrock strata and underlying bedrock strata (all potential water bearing systems) have been assessed accordingly (5430-BLP-R-006-02). In addition to the hydrogeological receptors, the Daw End Canal, the Swag and Swan Pool hydrological receptors are considered accordingly.

Where required, the "exposed faces" (sidewall) of the natural geological barrier will be enhanced with re-worked Etruria Formation strata to the specification of 500 mm of engineered clay to a maximum permeability of $1x10^{-8}$ m/s.

The Stability Assessment (report 5430-BLP-R-008-02, Plough Geotechnical Ltd) confirms that based on the expected geometry of the void that construction of the proposed landfill will be stable and there is no expectation of basal heave as a result of pore-water pressures. Factors of safety for *in-situ* exposed faces are acceptable.

The site will only allow for wastes considered suitable for quarry restoration. HM Revenue and Customs (HMRC) made specific allowance for quarry restoration identifying a very limited list of suitable wastes in accordance with The Landfill Tax (Qualifying Material) Order 2011 (as amended)[2].

These Qualifying Material (QM) wastes are primarily inert and non-hazardous waste with low pollution potential.

Nature of Qualifying Materials

The proposed wastes will consist of excavation, construction/demolition wastes and similar industrial wastes that have a low-level pollution potential.

The qualifying materials include wastes in the following groups:

- Group 1 Rocks and soils
- Group 2 Ceramics or concrete materials
- Group 3 Minerals, processed or prepared
- Group 4 Furnace slags
- Group 5 Ash

Of these, the majority of the materials to be landfilled are expected to be:

- Soil (including mixed clays, silts and sands);
- Stones; and
- Concrete based construction materials from development schemes

Therefore, it is not expected that the waste will generate landfill gas or that active management of landfill gas will be required. Such a restriction will also prevent the generation of the primary soluble landfill leachate pollutant (i.e. ammonium) as well as the organic degradation by-products, namely hydrolysis products such as the phenols and the hazardous substances such as BTEX compounds.

The proposed wastes will have a negligible pollution potential; thus, the void is highly likely to rapidly stabilise to a state where the permitted area could be surrendered upon or shortly after cessation of disposal activities (anticipated 10 years from commencement of closure). Hence, final surrender is likely to be undertaken far in advance of the adjacent biodegradable putrescible waste landfills, e.g. Butterley Hole Landfill, Highfields South Landfill and Vigo Utopia to the north east.

Waste Characterisation

The infill material may be sourced from excavated mineral and aggregates or similar suitable excavated waste materials and recovered aggregates. This will be enforced by rigorous waste pre-acceptance procedures ensuring only suitable wastes as listed in the European Waste Catalogue (EWC) may be used. The waste material is considered to be of a low polluting potential.

Only wastes that meet the requirements of the Landfill Tax (Qualifying Material) Order 2011 (as amended) (QMO) will be accepted for disposal with due regard to the advice given in HMRC Notice LFT1[8]. During the Level 1 characterisation check all waste proposed to be accepted will be compared to the EWC code for the permitted wastes above and to the appropriate description given in the QMO. Waste will only be accepted if it appears in both lists.

During Level 1 characterisation all available data will be assessed to confirm that the correct non-hazardous EWC code has been allocated by the waste producer. Comparison will be made with limiting factors specified in Environment Agency guidance WM3[9].

Only wastes confirmed as non-hazardous in accordance with the WM3 guidance and that meet the requirements of QMO and that achieve acceptance criteria imposed by paragraph 2.1.1 of the Annex to Council Decision 2003/33/EC[10] will be accepted without the need to review supporting analytical data. All other wastes will only be accepted following comparison of the analytical composition data against the limits imposed by WM3 and this document. All such records will be retained in accordance with the obligations imposed by the Duty of Care and for auditing purposes by HMRC for the operational life of the site. Waste acceptance is detailed in report 5430-BLP-R-005-02.

Waste Inputs

An engineered design (based on the final proposed operational extraction requirement) has defined the overall volumes of the void with associated 1:3 slopes. The infill volume is calculated at 3.1Mm^3 (equivalent to 6.2M tonnes). The infilling is anticipated to have a duration of 20 years although material availability may alter the initial assumptions. Input rates averaged over the expected infilling period would equate to 310,000t/y, however, to account for any surplus or additional waste infill availability and only 260 working days in a calendar year, a permitted maximum of 700,000t/y is proposed within the application. Installation phasing will progress in accordance with drawings ESID 5A, 5B, 5C and 5D.

Restoration will meet the objectives of the associated / current planning application; selected materials will be utilised to assist in surface water control (ESID 6). A typical thickness of 1m of restoration soils is proposed over the cap for achieving the desired restoration profile. ~153,000m^3 is required for a final 1m surface layer over the site (area of 15.3ha), which equates to ~306,000t. A permitted maximum limit of 306,000 t/y is proposed within the application (to account for import of all restoration soil in the final year of operation required).

2.5 Installation Engineering

Paragraph 1.2 of Annex I to the Landfill Directive states that a landfill can only be authorised if it does not pose serious environmental risk. Paragraph 3.1 provides that a combination of either

[8] https://www.gov.uk/government/publications/excise-notice-lft1-a-general-guide-to-landfill-tax/excise-notice-lft1-a-general-guide-to-landfill-tax
[9] Guidance on the classification and assessment of waste (1st Edition v1.2.GB) Technical Guidance WM3
[10] 2003/33/EC: Council Decision of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC

geological barrier and a bottom liner or a geological barrier and top liner must always be in place in order to protect soil, groundwater and surface water. Paragraphs 3.2 and 3.3 provide technical detail on what these requirements entail, whilst paragraph 3.4 allows for a reduction in what is required under paragraph 3.2 and 3.3.

Paragraph 2 states that appropriate measures for water control and leachate management shall be taken with respect to the collection of leachate. However, the third point in this paragraph says that if an assessment of the location of the landfill and the waste to be accepted shows that the landfill poses no potential hazard to the environment, the measures to collect contaminated water and leachate may be dis-applied. Paragraph 2 therefore indicates that in addition to landfills for inert waste, leachate collection may not be required at landfills for selected non-hazardous waste.

The Environment Agency provides guidance[6] on 'Understanding the Landfill Directive Version 2 (March 2010)'. The guidance indicates that the design of a landfill site should be based on site specific risk assessments. It indicates that a particular element of design criteria of the Annex I may be removed where demonstrated as unnecessary by appropriate risk assessment.

The conceptual site design within this document conform to the requirements of the following:

- Landfill Directive (99/31/EC)[4];
- The Environmental Permitting (England and Wales) Regulations 2016 (as amended) (2016 Regulations)[11];
- The Environment Agency's Landfill Engineering guidance documents – Sector Technical Guidance (LFE series)[12];

Infilling will be undertaken in accordance with Section 5.2, Part A(1) (a) of The Environmental Permitting (England and Wales) Regulations 2016 "Disposal of waste in a Landfill".

Annex 1 of the Landfill Directive outlines the design requirements needed to achieve a successful permit application. The Landfill Directive requires all landfills to have a geological barrier and the Environment Agency have further qualified the directive such that a geological barrier must:

- Extend across the entirety of the base and side walls of the landfill;
- Provide a barrier to contaminant emissions; and
- Provide sufficient attenuation to prevent pollution to soil and groundwater.

In summary, the design of the site includes a 'natural' geological barrier of *in-situ'* Etruria Formation strata (marl) across the base of the site, the proven thickness is greater than 5m with a permeability of $<1x10^{-9}$m/s (this exceeds the minimum Directive requirement for a 'mineral layer' of thickness and permeability requirements of 1m, k = $1x10^{-9}$m/s). See further supporting information contained

[11] SI 2016 No. 1154 - The Environmental Permitting (England and Wales) Regulations 2016
NOTE: The Environmental Permitting (England and Wales) Regulations 2016 ("the 2016 Regulations") consolidate and replace the Environmental Permitting (England and Wales) Regulations 2010 (S.I. 2010/675) ("the 2010 Regulations"), which have been amended 15 times to date. The 2016 Regulations set out an environmental permitting and compliance regime that applies to various activities and industries

[12] https://www.gov.uk/government/collections/environmental-permitting-landfill-sector-technical-guidance

herein (e.g. “basal succession, Section 3.5.2 and Appendix C). As such there is no requirement for additional engineering on the base of the site.

A re-engineered Etruria Formation ‘artificial’ geological barrier (AGB) will be placed across the sidewalls adjacent to the presence of any exposed *in-situ* strata (to mitigate against any “permeable” lenses or layers exposed within the sidewall), see additional discussion in the supporting Hydrogeological Risk Assessment. The Directive states that the artificially established geological barrier should be no less than 0.5 m thick (Annex I, Paragraph 3.2).

A 500mm minimum thickness AGB, at a permeability no greater than $1x10^{-8}$m/s is proposed to provide a combined geological barrier for lateral containment. Engineering requirements for the construction of an AGB are outlined in Environment Agency guidance ‘How to comply with your environmental permit, Landfill (EPR 5.02)’ – Now Withdrawn (21st April 2021) and replaced with on-line guidance[13].

For steeper sections of the side slope any re-worked marl will be placed in lifts commensurate to the rising waste fill deposits to ensure stability. Where there are already placed, extensive thicknesses of cast back materials (interburden / overburden) overlying the natural strata, there will be no requirement for further addition of an engineered AGB. The lateral thicknesses of this material to the site perimeter are extensive (see Section 4.1). If areas of more “granular” based material are encountered in advance of engineering, they may also be processed / removed and backfilled with a suitable (lower permeability) replacement relocated from elsewhere on site. Assessment for additional lining will be undertaken if these materials are encountered.

Due to the nature of the waste to be deposited (and the associated potential source term) it has been demonstrated through the Hydrogeological Risk Assessment (report reference 5430-BLP-R-006-02) that leachate collection is not required. As there is no requirement to collect leachate within the site, it is considered that there is no requirement to install an artificial sealing liner (ASL). Environment Agency guidance[6] describes the ASL is part of the leachate collection and sealing system mostly met by the inclusion of geomembrane.

This engineering approach is widely used across similar sites with identical infilling schemes, as per previous applications undertaken previously by TerraConsult (now ByrneLooby). As the site only contains a single cell, there are no requirements for internal bunds and infilling operations will be “below ground level” throughout the majority of the development.

A separate “Waste Recovery Plan” has been issued to the Environment Agency (May 2022, reference 5430-BLP-R-00010-01) which covers the associated road construction to access the base of the void (area depicted on drawing ESID4). A Bespoke Waste Recovery Permit submission will be made in due course. The volume of material required is 35,000m^3 (suitable inert waste, appropriate for use and stable as per the associated assessment). The access road becomes sacrificial within the landfill infilling scheme and will be progressively covered as per the phased progression detailed on drawing ESID 5A, 5B and 5C.

On issue of the Environmental Permit for the infilling, a detailed CQA design, construction and method statement will be submitted to the Environment Agency for approval. The mineral liner

[13] https://www.gov.uk/guidance/landfill-operators-environmental-permits

(AGB) will be placed in accordance with the Environment Agency guidance LFE4 – Earthworks in Landfill Engineering[14] and will be subject to independent third party CQA. Based on the identification of receptors detailed herein and derivation of the sites conceptual site model (underpinned by a source – pathway – receptor framework) it is therefore considered that the proposed engineering design of Sandown Quarry Landfill is compliant with the requirements of the Landfill Directive.

2.6 Engineering Properties

The hydraulic conductivities for the placed and engineered Etruria Formation Marl (test data for the engineered clay from other nearby landfill sites, obtained through freedom of information request) demonstrated that the compacted marl can attain a hydraulic conductivity of 2.7×10^{-11} – 9.9×10^{-10}m/s (site A) and between 1.4×10^{-11} – 2.4×10^{-10}m/s (site B).

2.7 Groundwater Management System

The hydraulic nature of the Etruria Formation strata (overview in the Minor Properties Aquifer manual[15]) has indicated that water abstractions are not recorded locally, or in other areas of the UK. Although more permeable, water bearing layers or lenses can be recorded within the Formation, they are not observed as being laterally extensive, they are essentially “encapsulated” / static water systems with no ability for lateral flow.

Additionally, extraction of the mineral resource and open void (through decades of operation) has indicated that significant groundwater management has not been required. When observed historically, minor seepages / weeps from exposed faces are reported to relate to prolonged seasonal events and have not been deemed significant. Dewatering has not been necessary to remove the mudstone / marl for the ongoing brick production.

As such there are no requirements for basal underdrainage or sidewall collection drains (ring main or spur drains with risers) based on current site knowledge.

Any water ingress observed as part of the final void preparation would be characterised in terms of “significance” (only within the terms of hydraulic failure), assessment and appropriate control measures would be considered / recommended as part of an updated stability assessment.

It is noted however that the site investigations (Appendix C) within the current base of the void reported two sandstone layers (an upper layer between 87.10 – 85.84mAOD and lower layer 83.98 – 82.10mAOD), a monitoring installation was not installed (as the area will be excavated further) however the open hole did fill with water to a level coincident with the standing water in the base of the adjacent void.

It is unknown if these layers are capable of transmitting significant volumes of water to the base of the excavation, or if the back cast material at the surface (in this location) allowed for ponding / standing water to decant directly into the open void.

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[14] LFE4 - Earthworks in landfill engineering, Design, construction and quality assurance of earthworks in landfill engineering. Environment Agency

[15] The physical properties of minor aquifers in England and Wales. British Geological Survey Technical Report, WD/00/4. 234pp. Environment Agency R&D Publication 68 (Jones et al. 2000)

Once these layers are removed during final brick reserve extraction, the potential continuation to the southeast can be further ascertained, any ingress can be monitored and incorporated into the CQA plan for the landfill engineering design.

2.8 Leachate / Infill pore-water Management and Monitoring

It has been demonstrated by the Hydrogeological Risk Assessment and through experienced gained at other similar sites that by controlling the nature of the waste inputs, leachate collection will not be necessary.

However, if present, leachate monitoring will be undertaken utilising a single monitoring chamber connected to basal drains (drawing ESID 7A, 7B).

This will further assist in establishing source term characteristics of the infill (leachable pore-water quality) and accords with overarching agreed principles applied to similar infill schemes for other operators that have been recently accepted and permitted.

2.8.1 Waste infill Characteristics - Overview

The wastes proposed consist of excavation, construction and demolition wastes and potentially some similar industrial wastes that are inert or non-hazardous with low levels of contamination to be confirmed by waste pre-acceptance procedures. It is anticipated that the majority of wastes will be either:

- excavated soil and stones including clays and silts; or
- similar materials resulting from the treatment of mixed construction, demolition and excavation wastes.

Experience has shown that such materials tend to have a relatively high silt and clay content and as a result following placement achieve low vertical permeability.

As the site is not yet operational; there are no samples of the waste available. However, ByrneLooby has been provided laboratory test results of four samples from another site (not operated by Booth Ventures Waste (Midlands) Ltd) permitted to accept non-hazardous Qualifying Material. The four samples all show well-graded particle size distributions (PSD's) with vertical permeability values reported in the range $1x10^{-10}$ to $3x10^{-10}$ m/s from laboratory testing in a 100 mm diameter triaxial cell.

Environment Agency guidance on hydrogeological risk assessments for landfill[16] (www.gov.uk) states that when determining an appropriate leachate source-term the following information should be considered in order of preference:

- Actual leachate composition from similar sites;
- Waste leaching data on the potential wastes; and
- Literature values.

Further details regarding the source term for the qualifying material infill is presented in the report referenced 5430-BLP-R-006-02 and waste acceptance report 5430-BLP-R-005-02. The potential

[16] https://www.gov.uk/guidance/landfill-operators-environmental-permits/what-to-include-in-your-hydrogeological-risk-assessment

leachate source term for the infill has significantly less polluting potential than non-hazardous bio-degradable waste sites (i.e. that contained within the adjacent sites to the north and northeast) already consented.

2.8.2 Leachate Chemistry

As referred to above, a leachate source term for the waste types proposed in this application will not contain a putrescible component to the waste stream. Consequently, the significant ammoniacal-N and dissolved organic matter (as represented by the COD) as well as other soluble salts will not be present as readily degradable organic matter and soluble salts are specifically excluded from the list of wastes described as QMs. Given that the proposed waste types are unlikely to contain a degradable organic content, elevated ammoniacal-N and BOD is not expected to be associated with the site. Similarly, solvents, refined petroleum fuels or other chemical sources will be excluded.

Further detail relating to the source term chemistry for similar sites (based on an identical waste inventory) is provided in the supporting Hydrogeological Risk Assessment (report 5430-BLP-R-006-02) with an outline / overview provided in report 5430-BLP-R-005-02 for completeness.

2.8.3 Requirements for Basal Drainage and Leachate Management

As detailed above, there are no requirements for a basal drainage layer at the site (above the geological barrier) as based on risk assessment there is no requirement to collect, manage or remove leachate.

When overall drainage behaviour has been assessed in similar applications for the infilled wastes, it is the 'large-scale' or mass permeability that controls drainage behaviour. The mass permeability of compacted well graded materials will tend toward the median or mean of the range of permeability that might be expected if individual loads were tested.

The action of tipping, dozing and compaction results in mixing of loads and means that even multiple loads of slightly higher or lower permeability do not have a significant effect on the mass permeability of the waste material. Therefore, the mass permeability of the placed waste to be of the order of 10^{-8} to 10^{-9} m/s (equivalent to the Landfill Directive requirements for geological barriers).

Drainage measures would have negligible drainage effect in such very low permeability, well-graded soils. This is recognised in UK construction industry guidance CIRIA Report C750 Groundwater Control – Design and Practice, 2nd Edition (Preene et al., 2016 [17]) where Figure 1.10 of that report states that below a permeability of approximately 10^{-7} m/s '*Dewatering may not be feasible and may not be necessary'*. The 'may not be feasible' comment reflects the poor drainage behaviour discussed above. The 'may not be necessary' comment reflects the fact that very low permeability soils are often hardly affected by destabilising effects of groundwater flow that can occur in more permeable soils.

[17] Preene, M. Roberts, T.O.L. and Powrie (2016). Groundwater Control – Design and Practice, 2nd Edition. Construction Industry Research and Information Association, CIRIA Report C750, London.

A combination of compaction during placement and the subsequent loading will result in variable permeability within the waste mass and is considered likely to be generally low to very low depending on the clay content in the waste soil.

However, it is considered unlikely that the soil fill will exhibit uniformly the same hydraulic properties[18,19] with the soil likely to be anisotropic with reduced vertical porosity/permeability. Consequently, it is considered highly likely that layers of soil will have varied composition and similarly variable permeability and porosity. The transit of liquid vertically downwards through this soil fill will therefore be limited by the soil layers of the lowest permeability. The location of such layers may vary throughout the fill and thus it is considered probable that the vertical transit of incidental rainfall to the base of the site will be minor compared to the lateral flow in the upper layers of saturated soils.

This lateral movement of liquid within fill is well recognised[20,21] and the effects of even limited quantities of soil have been identified by the Environment Agency whose guidance on the use of daily cover on biodegradable wastes states: *"You will need to consider the permeability of you chosen landfill cover material. Unless the material is known to degrade rapidly once buried, you must avoid a build-up of layers within the waste body. This is to prevent perched leachate within the site and impede the removal of landfill gas or leachate. You must remove any low permeability materials you've used for landfill cover before applying the next layer."* Effectively the proposed waste mass will consist of many layers of soil fill, many of which will be a low permeability material.

Any extraction of liquid from a basal drainage layer is limited by the rate of liquid ingress to the layer. Initially as the soils at the base of the site consolidate and excess pore pressure dissipates liquid may enter the drainage layer, however any vertical flow to the drainage layer will be limited by the low permeability of the soils above.

Therefore, if the drainage layer is 'pumped dry' the impact of this on the liquid content of the soils above will in all likelihood be much localised. It is considered improbable that all liquid within the significant thickness of overlying soils can be removed or that the upper level of saturated soil could be lowered by extraction of liquid at the base of the site. However, based on these details above and in accordance with information submitted previously in regard to similar applications (and approved by the Agency), the operator intends to include discretionary spine drains within the site design.

Imported stone (or similar applicable material) will be utilised to surround the spine drains. An extended leachate pad area will be included within the design to allow for retro installation of a secondary well of required.

Water / direct run-off from the waste materials during waste placement is outlined in Section 2.10.

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[18] Ahuja LR et al , 1981, A Theoretical Analysis of Interflow of Water Through Surface Soil Horizons with Implications for Movement of Chemicals in Field Runoff, Water Resources Research Vol 17, No 1 pp65-71.
[19] Ahuja LR & Ross JD, 1983, Effect of Subsoil Conductivity and thickness on Interflow Pathways, Rates and Source Areas for Chemicals in a Sloping Layered Soil With Seepage Face, J. of Hydrology, 64, 189-204.
[20] Hall DGM et al, 1977, Soil Survey Technical Monograph No.9, Water Retention, Porosity and Density of Field Soils, Harpenden.
[21] White RE, 1987, Introduction to the Principles and Practice of Soil Science, Blackwell, ISBN 0-632-01606-x

2.8.4 Requirements for Water Balance

Under the conditions of infilling the Sandown Quarry void, and previous understanding in regard to accumulation of water in low-permeability waste (detailed above), a water balance is not required and hence is not included in the supporting HRA (5430-BLP-R-006-02).

Based on the conceptual understanding of the site, it is expected that the water balance would be controlled by the following characteristics:

- very limited groundwater inflow (due to the engineered lining system of the site and extremely low permeability of the surrounding and underlying Etruria Formation Marl).
- permeable layers are encapsulated within the "bulk" marl / mudstone
- very limited potential for the placed waste to generate 'leachate' (i.e. mobile water) due to the low permeability (10^{-8} to 10^{-9} m/s) and the fine-grained nature of the waste.
- due to the nature of the waste materials, that the majority of the water falling onto the waste during placement will become run-off and, subject to water quality, will be pumped as part of surface water management (Section 2.10). Over the operational period of the site very little water is anticipated to soak into the waste and contribute to 'leachate' production, also referred to as a "soil mass porewater". However, water will be encouraged to drain / infiltrate to the waste mass where possible during infilling.
- limited infiltration in the longer term as the overall site run-off (when infilling and restoration is complete), is to be conveyed to the existing discharge point as part of the Surface Water management system (Appendix D).

2.8.5 Leachate Monitoring

During the initial stage of filling, it is anticipated that the low permeability of the restoration fill will limit the available liquid within the fill. Nevertheless, it is proposed to construct one monitoring point from which liquid samples (leachable pore-water) may be taken. The design of the monitoring point and location are illustrated on drawings ESID 7A / 7B. The monitoring point will be constructed so that it can be built up as filling progresses. The chamber will be surrounded by fines free selective fill to provide initial support and protection and to encourage the collection of liquid (if generated).

The monitoring point will be provided with a gas monitoring tap to allow for the monitoring of landfill gas. Additionally, spine drains will be installed within the cell directed to the leachate monitoring point. Details of these and the monitoring point is shown on the Engineering Detail drawing ESID 7B. A target pad will be installed adjacent to the monitoring point in case of the requirement for a future replacement chamber (see also Section 2.8.3).

2.9 Landfill Gas Management and Monitoring Infrastructure

It has been identified within similar applications and the associated accompanying Landfill Gas Risk Assessment (5430-BLP-R-007-02) that the production of landfill gas will be negligible due to the non-biodegradable nature of the permitted waste types.

2.9.1 Landfill Gas Generation

Section 7.4.5 of the Agency's LFTGN03[22] discusses the role of microbial populations contained within the predominantly low permeability, soil rich wastes and cover materials oxidising a proportion of the methane generated within the waste mass. With the negligible amount of methane predicted to be generated, it is considered that this methane oxidation will have a significant role in the management and control of any landfill gas generated at Site. LFTGN03 states that this biological methane oxidation is considered and appropriate method for controlling landfill gas on low gassing sites. Further details are provided in report 5430-BLP-R-007-02.

2.9.2 Landfill Gas Monitoring

As referred to in Section 2.8.5, a gas monitoring tap will be installed to the leachate well to allow for monitoring purposes. In addition, following the completion of infilling, in waste landfill gas monitoring points will be installed in accordance the requirements of Environment Agency landfill surrender guidance (EPR 5.02) (installed at a frequency of 2 per hectare), the restored area is measure at ~15.5ha.

2.10 Surface Water Management System – Infilling Phase

During the filling process, water collected within the active void (cell base), or subsequent phase areas will be treated as leachate, contained and removed accordingly. This will be addressed operationally in the construction of temporary bunds and appropriate waste grading so that rainfall derived run-off can be contained and tested.

If testing indicates the water is clean, it will be pumped to the existing surface water settlement pond and discharged in accordance with the current consent (T/08/35782/T 01, dated 24/02/2003). If required operationally, a temporary additional storage pond to the north / northwest of the site would be considered to assist in water management.

This secondary containment pond could store water for monitoring purposes, and dependant on water quality criteria could be pumped to the existing surface water settlement pond for discharge. Monitoring undertaken would ensure that the current discharge consent limits are not exceeded (consent provided at Appendix D). Current background surface water baselining data collection is ongoing, see Section 3.9).

As all operation are below perimeter ground level (until approximately year 18), any water usage for dust suppression, site activities within the engineered area or wheel wash use will not affect public amenity, i.e. users of the Canal or public right of way (dashed green line on Figure 3).

2.11 Capping System

On completion of the filling a cap will be placed (selected low-permeability materials) to limit infiltration.

A final capping layer will be installed over the site as filling is completed, the cap is designed to:

- Prevent the waste from being disturbed;

[22] Guidance on the Management of landfill gas, LFTGN03

- Control water infiltration;
- Be stable to erosion;
- Be resistant to penetration by roots; and
- Be able to tolerate the long-term strains caused by differential settlement.

2.12 Sub-Cap Seepage Collection

The supporting HRA has demonstrated that leachate collection is not required.

Although the matrix conductivity of the infill is expected to be low and the potential to transmit high rates of flow limited, the soil infill is expected to act as the pore saturation limiting layer therefore the upper layers of the soil infill will become readily saturated and infiltration will be diverted across the lowest point of the surface. As the proposed wastes have a low leaching potential and there will be limited contact with the wastes, it is anticipated that this run-off water could be discharged directly to the environment under a schedule consistent with that of clean surface water at the site.

At Sandown, the only feasible direct linkage to Swan Pool is via overland flow on the western boundary. As such, and with respect to the potential for leachate porewater levels to reach such a height that they are able to bypass the engineered containment and flow overland to the surrounding ground surface or into surface waters (considered extremely unlikely due to the physical constraints of the site and waste properties) it is proposed to install a collection drainage channel around the exterior top edge of the waste fill (western perimeter) in accordance with the restoration profile, but only if required.

The source term should be monitored as outlined within the Emissions and Monitoring Plan (report 5430-BLP-R-09-02) from the in-waste monitoring point, and subsequently crossed checked against the assumptions contained with the HRA (report 5430-BLP-R-006-02). If, through the collection of the pore-water / leachate source term data there are any environmental concerns, or a significant deviation from the assumed source term is noted then a collection drain could be considered. The design (including collection chamber) would be approved via a submission of a CQA plan, it is unlikely that this will be required until at least year 12-15 (ESID 5B). Simple intrusive investigations at that time would ascertain if the waste infill is saturated, or as expected water has been expelled during burial / compaction with only limited volumes present as isolated pockets within the waste profile.

2.13 Restoration and Aftercare

The final infilling will involve a design height which allows for surface water to flow passively to the surface water settlement pond (Figure 7, drawing ESID 6 and ESID 13). The infilling of the void will provide final restoration contours for the site to be commensurate with the surrounding land surface (as far as is reasonably practical).

The restored surface, 15.5Ha (high point of 144mAOD in the southeast corner of site will convey rainfall run-off towards the northwest corner of the site boundary to the enlarged surface water management / settlement pond (total area of ~1.3Ha). The cap slope gradient is calculated at 1:30, surface water drainage will utilise the two current discharge points as required.

Restoration will meet the objectives of the current planning application, a typical thickness of 1m of restoration soils is proposed over the cap, ~153,000m^3 is required for a final 1m surface layer over the site, which equates to a total of ~306,000t. The soils will be seeded with grass to prevent erosion and provide a low maintenance surface. The grass cover will be encouraged as part of the restoration to minimise maintenance at the site. There are no specified phases in regard restoration scheme, restoration will be completed as soon as practicably possible on completion of infilling.

2.14 Surface Water Management System – Post Infilling / Restoration Phase

On final completion of infilling and restoration (ESID 5C, ESID 6), all surface water flow will be conveyed to the discharge point (outlet A) as previously undertaken with consent T/08/35782/T/D (drawing 07200 - 100, Rev 4). Monitoring point SW3 will become the future discharge point monitoring location. Limits and volumes that require amendment during the twin tracked Planning Application will be undertaken with the “local flood authority” to accommodate the modelled rates outlined within the SWMP (Appendix D). If modifications are required to the ditch system that feeds to the Vigo Brook, these will be undertaken in conjunction with the local council and if required a “ordinary water consent” will be obtained.

The majority of flow will be to the enlarged surface water settlement pond, through the current ditch system and hence through the discharge point “outlet A”. A summary from the Surface Water Management Plan and addendum (see Appendix D) is provided in Section 3.9.

2.15 Post Closure Controls

Completion criteria (when the waste is physically and chemically stable) will be determined based on the collection of monitoring data, future risk assessment i.e. the periodic 6yr HRA submissions (in addition to future Gas Risk Assessment) will delineate when the operator can apply to surrender the permit. The conceptualisation of how the containment systems will operate throughout the life cycle of the proposed development is presented within Table 3.

Table 3 Management Measures and Technical Controls Throughout the Landfill Life Cycle

Landfill Phase	Leachate Management	Gas Management	Containment System		Landfill Cap
			Geological Barrier	Engineered Clay	
Operational	No requirement for management, no specified leachate limits required. Periodic monitoring undertaken for establishing surrender point	No requirement for management, no specified leachate limits required. Periodic monitoring undertaken for establishing surrender point	Operates as designed	Operates as designed	N/A
Post Closure & Aftercare Period	Periodic monitoring undertaken for establishing surrender point, some degradation/ clogging of the drainage system	Periodic monitoring undertaken for establishing surrender point, some degradation/ well clogging of the monitoring system	Operates as designed	Operates as designed	Operates as designed
Site Completion	None	None	Operates as designed	Operates as designed	Operates as designed
Post Site Completion	None	None	Operates as designed	Operates as designed	Operates as designed

The proposed aftercare will include ecological enhancement for the benefit of the adjacent Swan Pool SSSI. Further details are provided in the planning application submission to the LPA. Monitoring of pore-water (leachate), gas and surface water on site will continue until permit surrender (monitoring locations for the site are depicted on drawing ESID 12). Post closure checks will be undertaken to review periodically the on-site management systems, and to check for subsidence or differential settlement.

2.16 On Site Processing

The aggregate recovery operation will be undertaken at the base of the void initially on a hardcore pad as illustrated on drawing ESID 4. As operations progress, and the infilling commences in accordance with the "broad" outline phase infilling scheme depicted on drawings ESID 5A and 5B, there will be a requirement to move the processing area accordingly.

The pad will be placed on lower permeability soils which will direct surface water run-off into the quarry void, where the water will either be directed to the current surface water pond. Only selected waste types will be suitable for the recovery of aggregates. These wastes are specified in Appendix C of the quality protocol and can be summarised as:

- Waste gravel and crushed rocks other than those mentioned in 01 04 07 (EWC 01 04 08)
- Waste sand and clays (EWC 01 04 09)
- Glass packaging (EWC 15 01 07) / Glass (EWC 19 12 05 / 20 01 02)
- Concrete (EWC 17 01 01)
- Bricks (EWC 17 01 02)
- Tiles and ceramics (EWC 17 01 03)
- Mixtures of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06 (EWC 17 01 07)
- Glass (EWC 17 02 02)
- Bituminous mixtures other than those mentioned in 17 03 01 (EWC 17 03 02)
- Soils and stones other than those mentioned in 17 05 03 (17 05 04)
- Dredging spoil other than those mentioned in 17 05 05 (17 05 06)
- Track ballast other than those mentioned in 17 09 01, 17 09 02 and 17 09 03 (17 09 04)
- Mineral (for example sand and stones) 19 12 09
- Garden and park waste (including cemetery waste) – soil and stones (20 02 02)

Suitable wastes will be diverted from the disposal in the landfill and stockpiled until a sufficient quantity is available for the deployment of mobile plant to crush and /or screen the wastes. The most suitable wastes will be those which contain large amounts of stone, brick and concrete and are consequently the least susceptible to generation of wind-blown dust when stockpiled.

Assuming 5% of annual inputs to the site area is suitable for recovery approximately 35,000 tonnes of waste will be treated per year. All recovered aggregate will meet the end of waste criteria detailed in the quality protocol. The recovered aggregate may be utilised on site or exported for use in off-site construction projects. The any waste from the treatment process will be used in the engineered landfill void subject to appropriate classification in accordance with WM3 and achieving the appropriate standards as dictated by any necessary testing to confirm status as QM as dictated by HMRC.

3 Pathway and Receptor Characterisation

3.1 Climate

Information contained on the Met Office website[23] provides details for the local area. Key statistical information is presented below in Table 4 and Table 5.

Table 4 Coleshill Climate Statistics (1991 – 2020)

Month	Max Temp °C	Min Temp °C	Rainfall (mm)
January	7.3	1.7	63.3
February	7.9	1.7	46.9
March	10.5	2.9	46.6
April	13.5	4.3	48.1
May	16.6	6.5	53.8
June	19.6	7.1	64.9
July	22.0	10.0	52.9
August	21.5	12.0	66.2
September	18.6	10.0	58.1
October	14.2	7.3	72.8
November	10.2	4.2	69.6
December	7.6	1.9	64.7
Annual	*14.1*	*6.3*	*708.2*

3.2 Rainfall

Table 4 presents the 30-year statistical averages for the area, covering the date period 1991-2020. The data is taken from the Coleshill Climate Station, altitude 96m above mean sea level, 20km southeast of site, annual rainfall (708mm/yr) is marginally greater than that detailed in MAFF 1976 (695mm/yr). The Coleshill annual rainfall is ~100mm less than the 1991-2020 annual total for the Midlands District (0). The climate and drainage reference manual indicates that drainage is only possible when the soil is at “field capacity” or wetter, hence only during the wetter periods of the year will there be excess rainfall beyond the requirement for plant uptake or losses through evaporation.

For the relevant area[24] (agro-climatic area 20), the end of field capacity (later quartile) is May and return to field capacity (earlier quartile) is October, the median excess rain is 230mm out of an annual mean rainfall of 695mm.

[23] https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcqf99dn5
[24] MAFF Climate and Drainage Report 34, 1976 HMSO

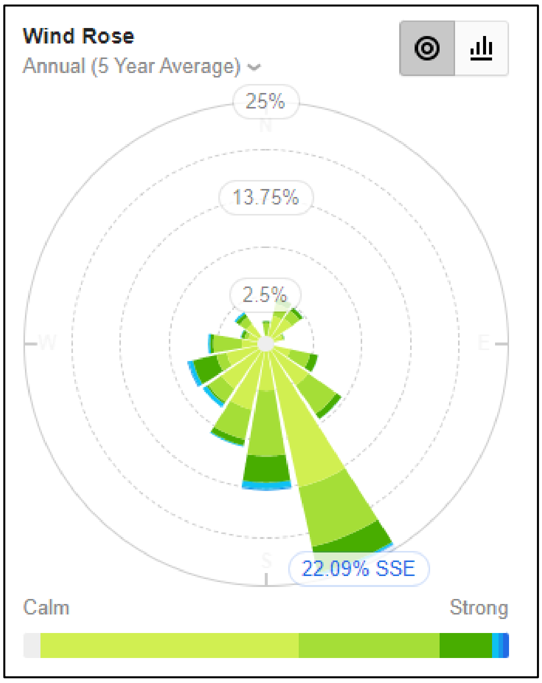
Table 5 Climate Statistics - Midlands District (1991 – 2020)

Month	Max. temp (°C)	Min. temp (°C)	Days of air frost (days)	Sunshine (hours)	Rainfall (mm)	Days of rainfall >= 1 mm (days)	Monthly mean wind speed at 10m (knots)
January	7.01	1.35	10.82	53.52	73.01	12.72	8.95
February	7.66	1.32	10.13	75.97	59.18	10.75	8.99
March	10.10	2.50	6.70	114.40	54.46	10.24	8.81
April	13.12	4.11	3.22	156.29	55.08	10.16	7.94
May	16.30	6.79	0.55	191.89	58.38	9.88	7.51
June	19.15	9.66	0.01	179.81	64.86	10.02	6.95
July	21.35	11.64	0.00	191.82	65.47	10.27	6.72
August	20.90	11.56	0.00	174.43	70.52	10.81	6.73
September	18.09	9.46	0.00	135.85	64.54	10.00	6.94
October	13.93	6.83	1.27	99.43	81.58	12.02	7.65
November	9.92	3.81	4.90	61.83	80.51	13.21	7.91
December	7.35	1.62	10.40	50.16	82.30	13.06	8.35
Annual	*13.77*	*5.91*	*47.99*	*1485.40*	*809.89*	*133.14*	*7.78*

3.3 Wind

A wind rose is presented below in Figure 8, this data shows a statistical representation of data obtained between 2015 and 2020. Predominant wind direction is from the south-southeast at ~22%.

Figure 8 Walsall Wind Direction Distribution % (2015 – 2020)[25]



[25] https://wind.willyweather.co.uk/wm/west-midlands/walsall.html

3.4 Geological Succession - Overview

The surrounding geological sequence[26] comprises:

Superficial Strata:

- Alluvium – to the west, minor coverage within the channels / tributaries of the Ford Brook
- Glacio-fluvial deposits – limited coverage in the area of Swan Pool and to the west, beyond Stubbers Green Road
- Till – all perimeters of the site (it is noted that this cannot be an accurate reflection of actual site coverage – the deposits have been removed to allow extraction of the underlying bedrock)

The underlying geological sequence comprises:
Bedrock Strata:

- Etruria Formation – Mudstone / Sandstone / Conglomerate – Carboniferous (at Site)
- Aveley Member – Mudstone and Sandstone – Carboniferous (east of site and north)
- Middle Coal Measures – Mudstone / Siltstone / Sandstone – Carboniferous (south of site)
- Lower Coal Measures – Mudstone / Siltstone / Sandstone – Carboniferous (west of site)

3.4.1 Regional Context and Literature Based Accounts

The site is located within "marine / alluvial plain facies clay" bedrock known as the Etruria Formation formerly referred to as the Etruria Group or Etruria Marl[27]. The BGS description is a "*red, purple, brown, ochreous, green, grey and commonly mottled mudstone, with lenticular sandstones and conglomerates referred to as 'espleys'.*" The sandstones (if present) are discontinuous and form "wedges" within the marl. Current nomenclature has been used in documenting the local stratigraphic succession and relationship to the site.

The Etruria Formation forms part (lower) of the Warwickshire Group Strata. Glover et al. 1993[28] state that it is generally accepted that the 'Westphalian C' Etruria Formation records the northwards progradation of 'redbed' alluvial sedimentation over grey, coal-bearing fluvio-deltaic sediments of the Westphalian A to C Coal Measures (references contained therein).

In the Staffordshire area, the Etruria Formation crops out within a fault bounded inlier (Upper Carboniferous), surrounded and locally overlain (i.e. to the east) by Triassic Strata (Chester Formation), see ESID 9. The Etruria Formation is referred to as a condensed sequence deposited on the southern margin of the Pennine Basin during a period of widespread, thermally induced subsidence which succeeded an initial Dinantian to Namurian rifting phase[28].

The Etruria Formation alluvial sedimentation event is predominantly 'red beds' of massive, silty mudstone[27]. Haematite concretions, sphaerosiderite ($FeCO_3$), siderite and carbonaceous muds are

[26] https://mapapps.bgs.ac.uk/geologyofbritain/home.html
[27] Origin of red beds in a moist tropical climate (Etruria Formation, Upper Carboniferous, UK) B. M. Besly and P. Turner Geological Society, London, Special Publications, 11, 131-147, 1 January 1983
[28] Etruria Formation (Westphalian C) palaeoenvironments and volcanicity on the southern margins of the Pennine Basin, South Staffordshire, England. Journal of the Geological Society, London, vol 150, 1993, pp. 737-750. Glover, B.W, Powell, J.H, Waters, C.N.

reported in addition to thin green coloured sandstones and conglomeratic lenses. The red colour is postulated to be derived from either dehydration of detrital ferric oxide soon after deposition or oxidation of ferrous iron associated with organic material[27]. Previously referred to as the Etruria Marl, marl is further defined in a mineralogical sense as "*a fine-grained, deep-sea sediment comprising abundant clay with a variable but significant content of carbonate*". XRF and XRD analysis indicates "*a high kaolinite content, some illite and ordererd illite/smectite and hematite which is expected from the purple-red colour of the bulk sample. Less common is the chlorite content, which is untypical of samples of this formation in Staffordshire. Note, however that clays and quartz are the only silicates present apart from traces of feldspar*"[29].

Continuation of the geological succession (Coal Measures overlain by Etruria Formation) continues to the southwest (Cradley Heath area), northwest (Cannock) and into Shropshire and North Wales (Wrexham area).

3.5 Geological Succession – Local Area and Site Detail

3.5.1 Superficial Geology and Near Surface Cover (Soils & Back cast material)

Superficial Strata

A review of the British Geological Survey (BGS) website indicates that Glacial Till and glacio-fluvial deposits are reported at the periphery of the site. Local superficial strata are depicted on Figure 9. Borehole logs available on-line indicate locally however, where present (and prior to any subsequent removal) they can attain thicknesses in the 1.5 – 8.2m thickness range (Figure 10).

As stated in Section 3.4 however, these deposits have been removed at site as a result of the mineral resource extraction that underlies the superficial strata. This is confirmed by the 2022 Site Investigation (SI) works (Appendix C, Factual Ground Investigation Report, reference C10259-FGIR, June 2022), the April 2022 boreholes are numbered BH22-01, BH22-02S/D (shallow and deep) and BH22-04S/D (Figure 11). The decommissioned site investigation borehole on the western boundary (south of the surface water settlement pond, BH22-03) did not encounter the presence of superficial strata.

There are no logs are available for the previously installed boreholes identified at site, these monitoring locations are depicted by orange symbols on Figure 11.

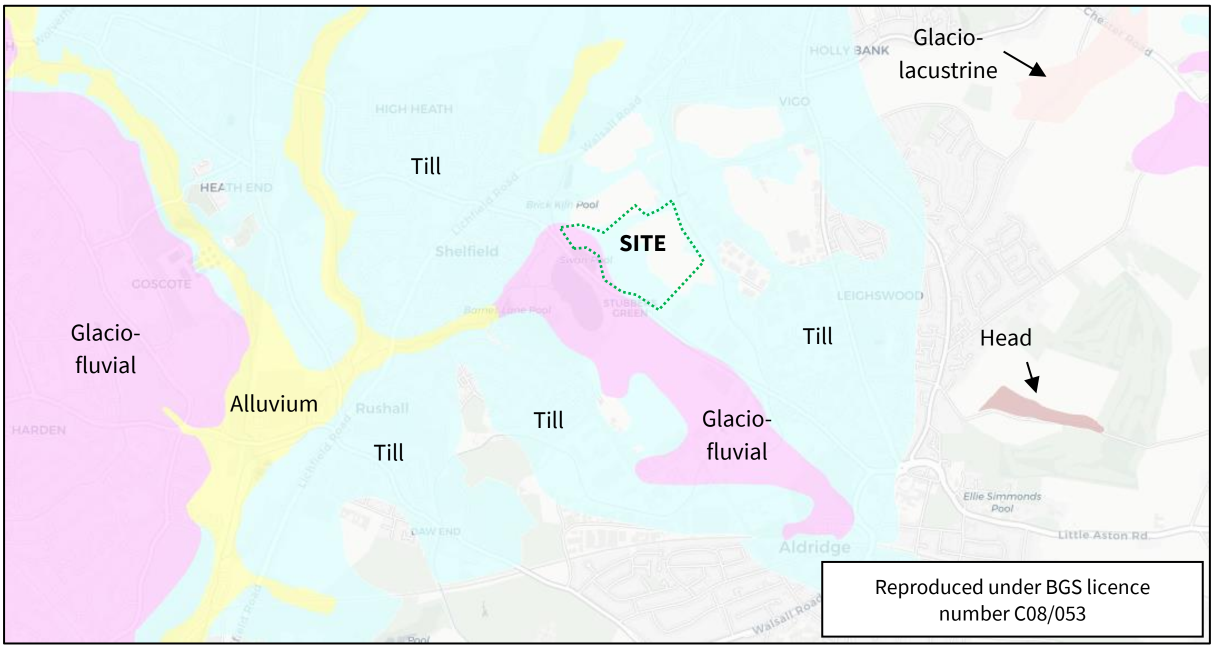
As such, there are no confirmed superficial strata at site boundary. It is additionally recognised however that BGS mapping indicates that there are extensive areas of land to the east and south (beyond the Leighswood and Aldridge residential area) with no coverage of superficial strata.

Soils

Soils are not present at the site, locally they are defined by the UKSO (UK Soil Observatory) as loamy / sandy sustaining wet meadows habitat[30] and are "slowly permeable", seasonally / naturally wet[31] with base rich loamy and clayey soil.

[29] https://www.xrayminerals.co.uk/en/when-is-a-marl-not-a-marl/
[30] http://mapapps2.bgs.ac.uk/ukso/home.html
[31] http://www.landis.org.uk/soilscapes/

Figure 9 Local Superficial Strata



White areas denote no superficial deposits present, i.e. "no coverage"

Back Cast Material

The coverage of the commercially unviable material is extensive around the site perimeter; this material is clearly evident on historic aerial photography (e.g. as depicted in Figure 11) particularly along the southern and western void batters with further extensive coverage along the eastern and north eastern boundary.

To the east of the proposed infilling scheme (borehole log reference BH22-01, Appendix C) 24m of back cast material is recorded, to the north 15m (borehole log reference BH22-02D), to the south / southwest 25.5m (borehole log reference BH22-04D) with 10.6m on the west perimeter location (geotechnical test position, borehole log reference BH22-03).

6.9m of back cast material was recorded in the base of pit (borehole log reference BH22-05), locations are depicted on Figure 11. Lateral thicknesses are extensive, a review is provided in Section 4.1.

The description of the back cast / made ground on the western perimeter is reported as predominantly stiff, brown, fine to medium gravelly sandy CLAY, brown fine to coarse gravelly silty CLAY, red brown coarse sandy SILT / CLAY.

Minor pockets of sandier material were noted along with sandstone fragment, where recorded however they were encapsulated by CLAY dominated material, referred to, based on geotechnical testing as "low plasticity clay" (Appendix 3 in the Factual Ground Investigation Report, reference C10259-FGIR, June 2022, Appendix C to this document).

Figure 10 BGS Borehole Review and Associated Geological / Stratigraphic Detail

SK00SW220 Basic lithology	From (mAOD)	To (mAOD)	Thickness (m)
Drift	130.51	126.55	3.96
Mudstone	126.55	124.11	2.44
Sandstone	124.11	123.8	0.31
Mudstone	123.8	116.49	7.31
Sandstone	116.49	115.45	1.04
Mudstone	115.45	113.54	1.91
Sandstone	113.54	111.76	1.78
Mudstone	111.76	109.94	1.82
Sandstone	109.94	109.48	0.46
Mudstone	109.48	105.31	4.17
Conglomerate (espley)	105.31	104.4	0.91
Mudstone	104.4	98.51	5.89
Sandstone	98.51	97.77	0.74
Mudstone	97.77	96.65	1.12
Sandstone	96.65	96.37	0.28
Mudstone	96.37	96.07	0.3
Sandstone	96.07	95.56	0.51
Mudstone	95.56	95.36	0.2
Conglomerate (espley)	95.36	93.73	1.63
Mudstone	93.73	86.92	6.81
Conglomerate (espley)	86.92	86.64	0.28
Mudstone	86.64	84.38	2.26
Conglomerate (espley)	84.38	84.21	0.17
Mudstone	84.21	83.11	1.1
Sandstone	83.11	82.99	0.12
Mudstone	82.99	78.82	4.17
Conglomerate (espley)	78.82	78.08	0.74
Mudstone	78.08	74.63	3.45
Conglomerate (espley)	74.63	73.54	1.09
Mudstone	73.54	68.94	4.6

SK00SW221 Basic lithology	From (mAOD)	To (mAOD)	Thickness (m)
Drift	130.85	124.15	6.70
Mudstone	124.15	123.23	0.92
Sandstone (espley)	123.23	122.60	0.63
Mudstone	122.60	122.27	0.33
Conglomerate (espley)	122.27	121.91	0.36
Mudstone	121.91	121.73	0.18
Sandstone (espley)	121.73	121.43	0.30
Mudstone	121.43	114.85	6.58
Sandstone	114.85	113.81	1.04
Mudstone	113.81	113.38	0.43
Sandstone	113.38	113.27	0.11
Mudstone	113.27	112.97	0.30
Conglomerate (espley)	112.97	112.31	0.66
Mudstone	112.31	112.11	0.20
Sandstone	112.11	111.95	0.16
Mudstone	111.95	108.68	3.27
Sandstone	108.68	107.91	0.77
Mudstone	107.91	100.07	7.84

SK00SW222 Basic lithology	From (mAOD)	To (mAOD)	Thickness (m)
Drift	111.14	109.47	1.67
Mudstone	109.47	108.75	0.72
Sandstone	108.75	108.58	0.17
Mudstone	108.58	108.40	0.18
Sandstone	108.40	108.32	0.08
Mudstone	108.32	107.48	0.84
Sandstone	107.48	106.72	0.76
Mudstone	106.72	106.65	0.07
Sandstone	106.65	106.32	0.33
Mudstone	106.32	105.73	0.59
Conglomerate (espley)	105.73	104.39	1.34
Mudstone	104.39	102.79	1.60
Conglomerate (espley)	102.79	101.19	1.60
Mudstone	101.19	90.06	11.13
Sandstone (espley)	90.06	89.98	0.08
Mudstone	89.98	82.75	7.23
Sandstone	82.75	81.73	1.02
Mudstone	81.73	81.12	0.61
Sandstone	81.12	80.71	0.41
Mudstone	80.71	80.66	0.05

SK00SW341 Basic lithology	From (mAOD)	To (mAOD)	Thickness (m)
Drift	141.23	135.37	5.86
Mudstone	135.37	131.63	3.74
Sandstone (espley)	131.63	129.98	1.65
Mudstone	129.98	126.43	3.55
Sandstone (espley)	126.43	123.43	3.00
Mudstone	123.43	121.88	1.55
Sandstone (espley)	121.88	120.68	1.20
Mudstone	120.68	113.73	6.95
Sandstone	113.73	110.83	2.90
Sandstone (espley)	110.83	110.13	0.70
Sandstone	110.13	104.43	5.70
Mudstone	104.43	101.83	2.60

SK00SW236 Basic lithology	From (mAOD)	To (mAOD)	Thickness (m)
Drift	133.00	125.38	7.62
Mudstone	125.38	111.05	14.33
Sandstone	111.05	109.07	1.98
Mudstone	109.07	105.57	3.50
Sandstone	105.57	105.26	0.31
Mudstone	105.26	102.52	2.74

SK00SW235 Basic lithology	From (mAOD)	To (mAOD)	Thickness (m)
Drift	133.50	125.27	8.23
Mudstone	125.27	118.26	7.01
Sandstone	118.26	116.74	1.52
Mudstone	116.74	115.21	1.53
Sandstone	115.21	108.51	6.70
Mudstone	108.51	103.02	5.49

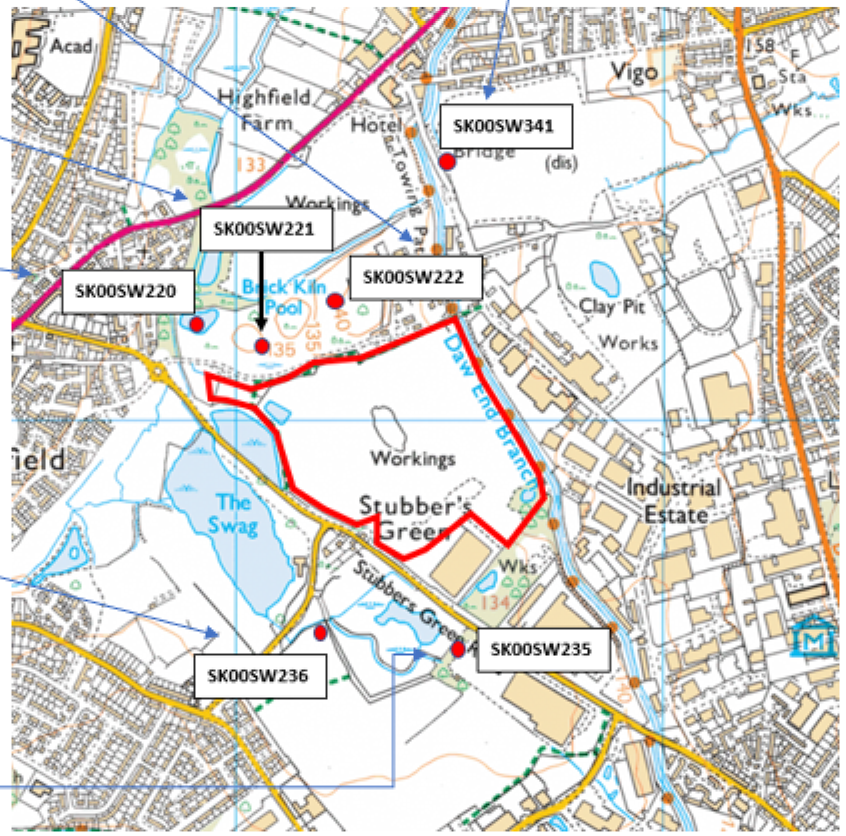
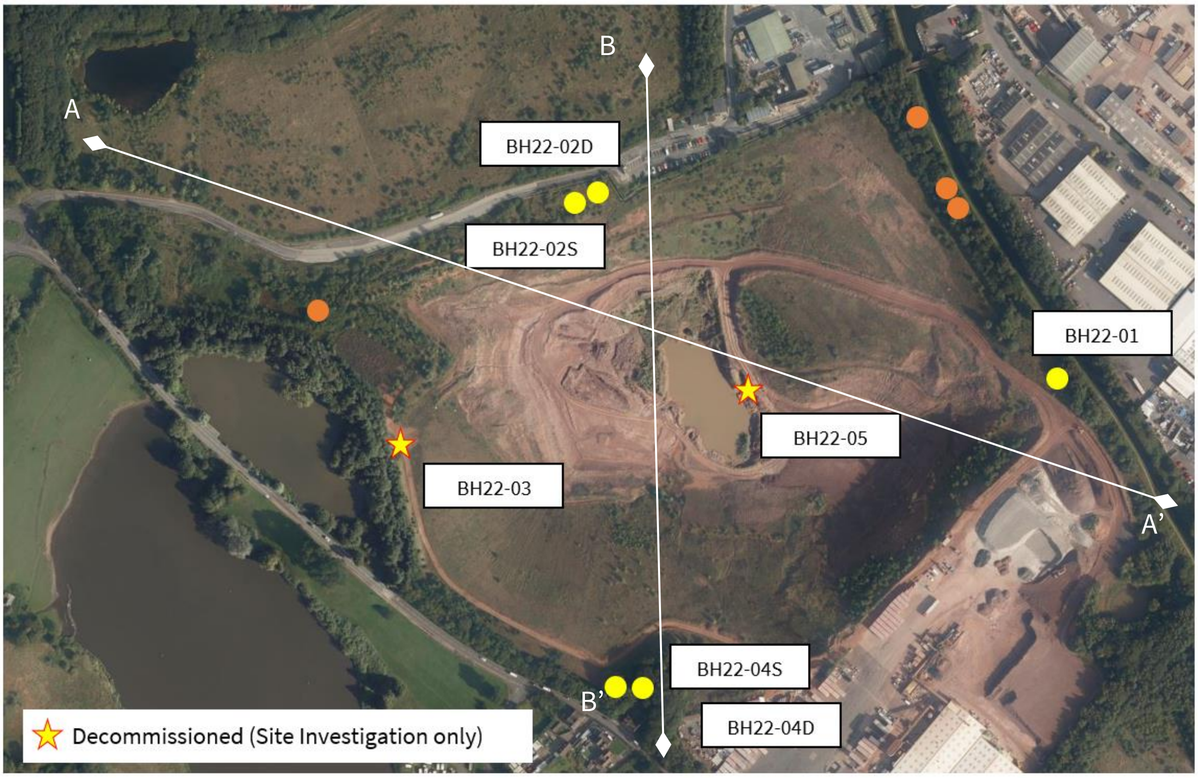


Figure 11 Location of 2022 SI Boreholes and existing on-site monitoring installations



Yellow symbol – 2022 SI and Monitoring Installation (ESID 8), orange symbol – existing monitoring installations. A-A' and B-B' are section lines represented on Figure 18. Hydrogeological Cross Sections are provided on drawing ESID 11.

3.5.2 Bedrock Geology

Stratigraphy

Rocks of the Silurian, Upper Carboniferous and Triassic are all present locally. To the west, bedrock exposure is poor, a summary of the local strata is presented below, the bedrock geology is presented on Figure 12, see also ESID 9.

East of Site

- Wlildmoor Sandstone Member – Sandstone (east, 2.9km northeast);
- Chester Formation – Sandstone & Conglomerate (east >1.6km east and southeast);
- Alveley Member – Mudstone / Sandstone (east >0.8km);

<u>Site</u>

- Etruria Formation – Mudstone / Sandstone / Conglomerate (fully contained)

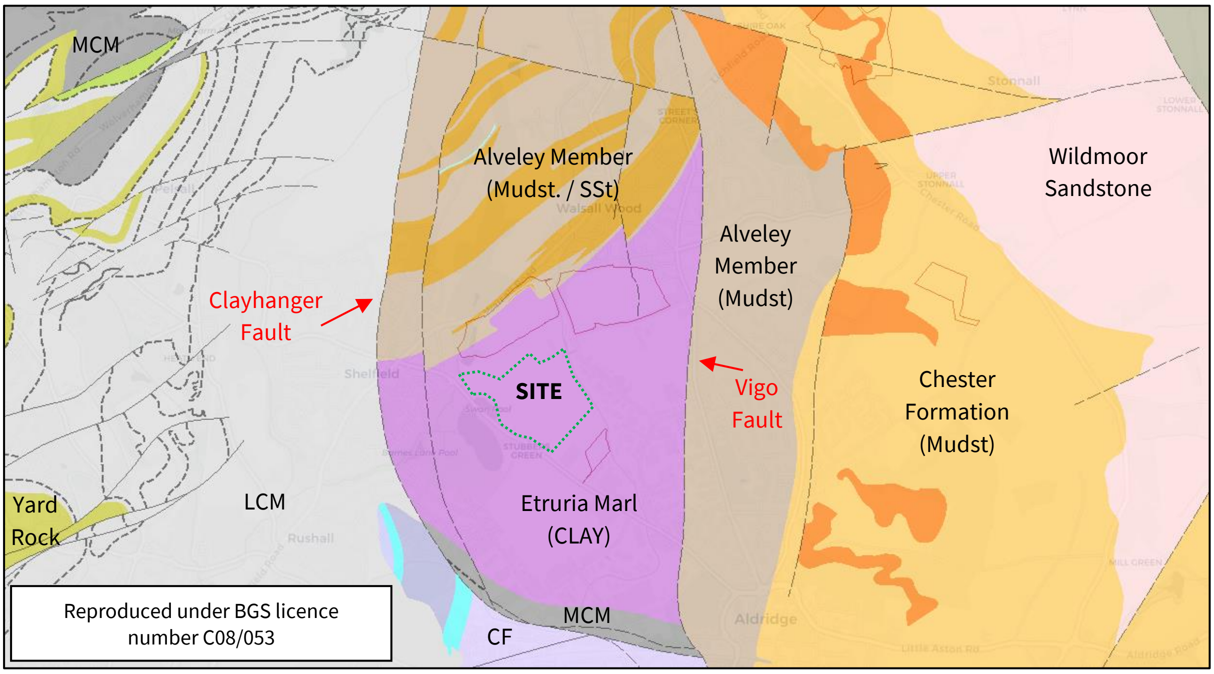
West of Site

- Pennine Lower Coal Measures Formation – Mudstone / siltstone / sandstone (west 0.8km), Middle Coal Measures beyond;
- Yard Rock – Sandstone (2.9km southwest);

South of Site

- Middle Coal Measures & Coalbrooke Formation – Mudstone (1.1km south)

Figure 12 Local Bedrock Geology

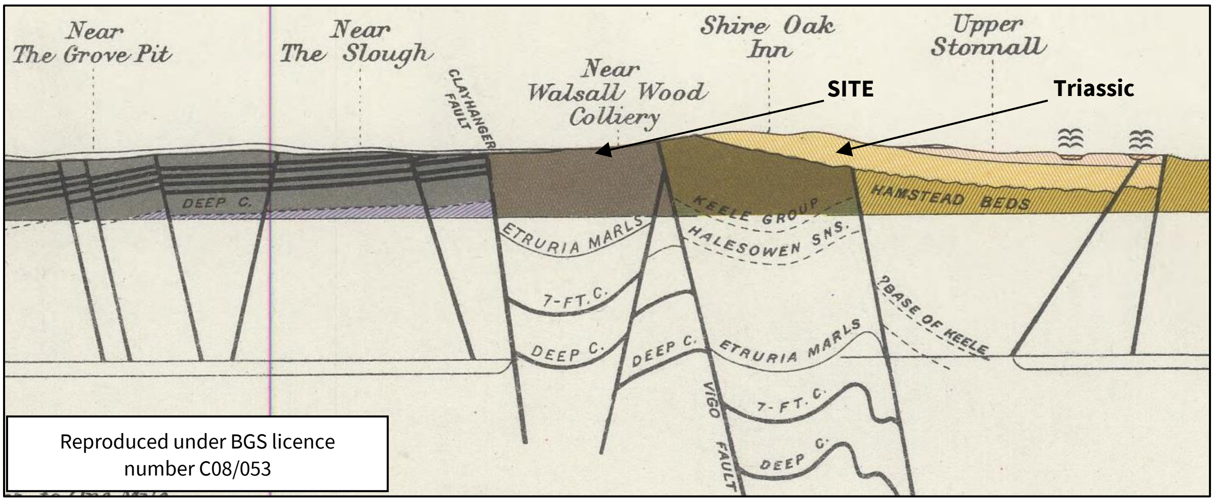


MCM – Middle Coal Measures (Carboniferous); LCM – Lower Coal Measures (Carboniferous); CF – Coalbrookdale Formation (Silurian); Aveley Member (Carboniferous); Chester Formation and Wildmoor Sandstone (Triassic).

The Etruria Formation and Alveley Member are part of the Carboniferous Warwickshire Group. The unit forms the base of the "Barren Measures" above the more production Coal Measures strata. There are younger Triassic sequences (Chester Formation and Wildmoor Member) to the east. The Coalbrookdale Formation to the south forms part of the older Silurian Wenlock strata.

To the west, the Yard Rock is part of the Lower Carboniferous Coal Measures Formation. The cross section provided at Figure 13 provides lithological and structural relationship context. The site is contained within a faulted block (Clayhanger Fault ~0.7km to the west and Vigo Fault ~0.6km to the east) which separate the Etruria Formation from the Coal Measures strata to the west, and Alveley Member to the east.

Figure 13 Geological Cross-section (Extract from BGS Sheet 154)



The Alveley Member was formerly referred to as the Keele Group (Figure 13) and is described by the BGS as *"comprises mainly homogeneous silty clay, which is, however, very silty and micaceous at some levels. There are regular discontinuous layers of claystone concretions. Thin beds or partings of clayey silt, very fine-grained sand or glauconitic clay are present at some levels".*

A review of the quarry geological exposure has indicated that majority of the exposed bedrock strata is a fine-grained red mudstone / marl of the Etruria Formation (Figure 14), as noted in Section 3.5.1, Figure 14 and Figure 15 illustrate the areas of cast back material placed around the quarry margins. BGS mapping indicates shallow dips of 3 or 4° north within the Warwickshire Group at the Site (BGS sheet 154 Litchfield, 1970 version), a 13cm thick exposure of compact sandstone was observed in the northern exposed quarry face (Figure 16), a shallow dip of ~8° was measured, strike 070°.

These observations are consistent with historic literature accounts and recent SI information (locations detailed on Figure 11 and ESID 8, SI information provided at Appendix C). Espleys (of a conglomeratic nature) were not observed in the quarry exposure and where present, the sandstone layers did not appear to be laterally extensive (although some faces were obscured by slope degradation of the clay / mudstone material above and below. The predominant lithology within the Formation identified within the exposed quarry faces is described as a "fine grained" mudstone / marl consistent with literature accounts.

Basal Succession

The core recovered sequence from the site investigation borehole BH22-05 (location in the base of the void, Figure 11) has demonstrated that below the proposed base of site i.e. below 75mAOD the basal barrier is comprised of "mudstone" down to 69.4mAOD.

Figure 14 View Northwest of Sandown Quarry

Figure 15 View South of Sandown Quarry

Interburden / Overburden are predominantly low permeability reject materials not suitable for brick production.

Figure 16 Sandstone Layer at Sandown Quarry (northern face exposure)

Occasional “gravelly clay bands” were observed at thicknesses less than 15cm below 75mAOD, discontinuities when observed tended to be infilled with “clay”. No water strikes were notable on drilling albeit water subsequently accumulated in the hole once left open. This may have been accountable as a result of the nearby standing water, 6.88m of made ground at surface (in the base of the quarry void) or may have been derived from the two sandstone layers in the upper section of the borehole (*note: these layers will be removed as a result of deepening the current quarry void down to 75mAOD*).

With respect to further details for the bedrock sequence underneath the proposed base of site, at Stubbers Green, the two shafts of the Coppy Hall Colliery recorded at least 210ft of ‘Red Marl’ (~64m), hence the base of the Etruria Formation could be at ~67mAOD (assuming a former ground height of 131mAOD). Although the local memoir[32] historic account of 1919 notes the Etruria “Red Marl” extends to a depth of ~210ft (~64m); equivalent to a depth of ~67mAOD, it is noted that the interbedded sequence extends lower, “*as such the exact thickness is uncertain*”. The accounts from other nearby collieries suggest the depth is significantly lower than the depth reported in the 1919 memoir (c.f. Figure 17).

Further detail however provided in the BGS Aldridge – Brownhills Geological Report[33] suggests that the diachronous contact boundary between the ‘Red Beds’ (Etruria Formation, Westphalian C strata) and the underlying ‘Grey Beds’ (Coal Measures, Westphalian C) could be substantially deeper at ~-10mOD (Figure 17). The base (lowermost horizon) of the ‘Red Beds’ appears to become progressively deeper to the south[33]. As such, the substantial depth to Coal Measures strata at site is confirmed by the nearby Aldridge Colliery drilling log (depth of ~426m) where the ‘Red Beds’ are absent below depths of 405ft from surface[34], equivalent to 125m (thus providing a base of formation at ~20mAOD). The summarised detail contained therein within Appendix 2, (site reference number 34) indicates a base of Etruria to be 152.4m from surface (equivalent to -7mOD) as depicted on Figure 17.

The marl / mudstone is structureless and unbedded[33] as observed at site and within the cores recovered from the 2022 investigations (as described form borehole BH22-05). A summary account of the geological framework at site is presented in Table 6, a schematic representation of the site geology and local context is provided in Figure 18.

Sidewall succession

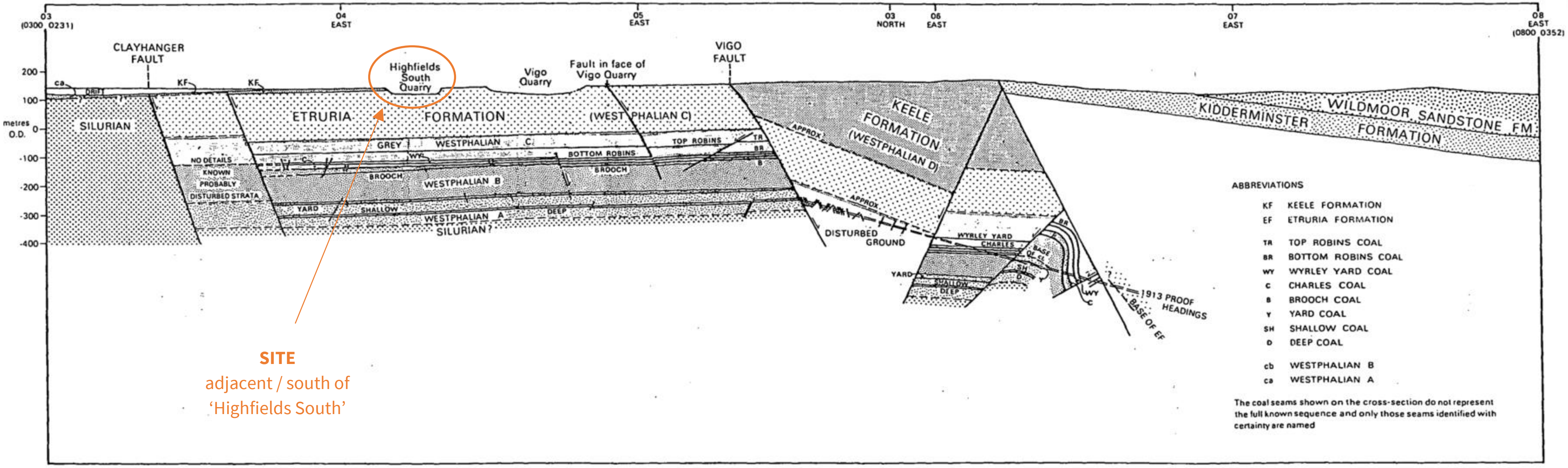
The sandstones within the sequence, when present, vary from fine to coarse grained. The impersistent nature of these coarse units are observed on the BGS borehole log review detailed in Figure 10, even accounting for a dip angle of some 3 - 10°, there are no clear correlations or connection of layers trending from south to north, consistent with dip direction recorded on BGS mapping (of approximately northwards). Sandstone layers range typically between 0.1 and 2m in thickness, a 6.7m thick layer was recorded in the southwest (at SK00SW235) and a 5.7m thick layer to the north-east (at SK00SW341).

[32] The geology of the country around Lichfield, including the northern parts of the South Staffordshire and Warwickshire Coalfields. Explanation of sheet 154 (with contributions by JB Hill, T Eastwood and J Pringle), 1919 (Ref DF154), HMSO London

[33] Geological Reports for DoE. Land Use Planning, Aldridge – Brownhills SK00SW and SK00SE, part of 1:50 000 sheet 154 (Litchfield), Wilson, A.A, Lowe, D.J, Price, D and Langford, R.L. 1984.

[34] http://scans.bgs.ac.uk/sobi_scans/boreholes/189458/images/10243438.html (page 7 of 16)

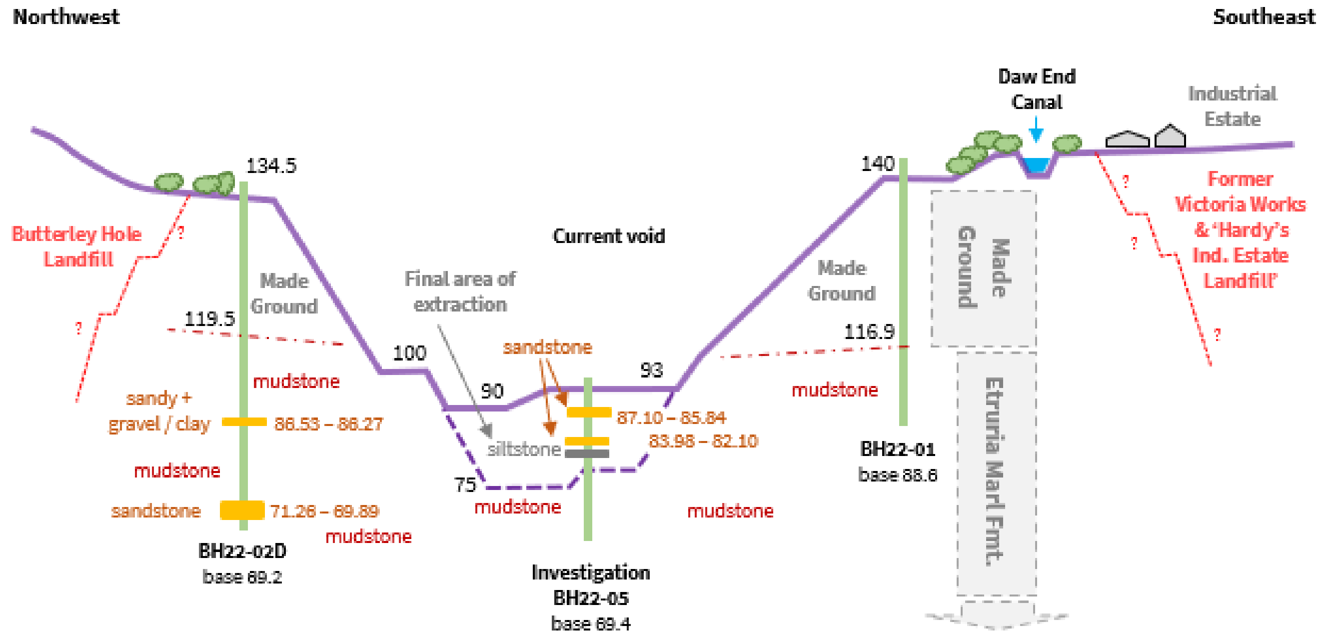
Figure 17 Horizontal Section through the Aldridge Colliery Workings

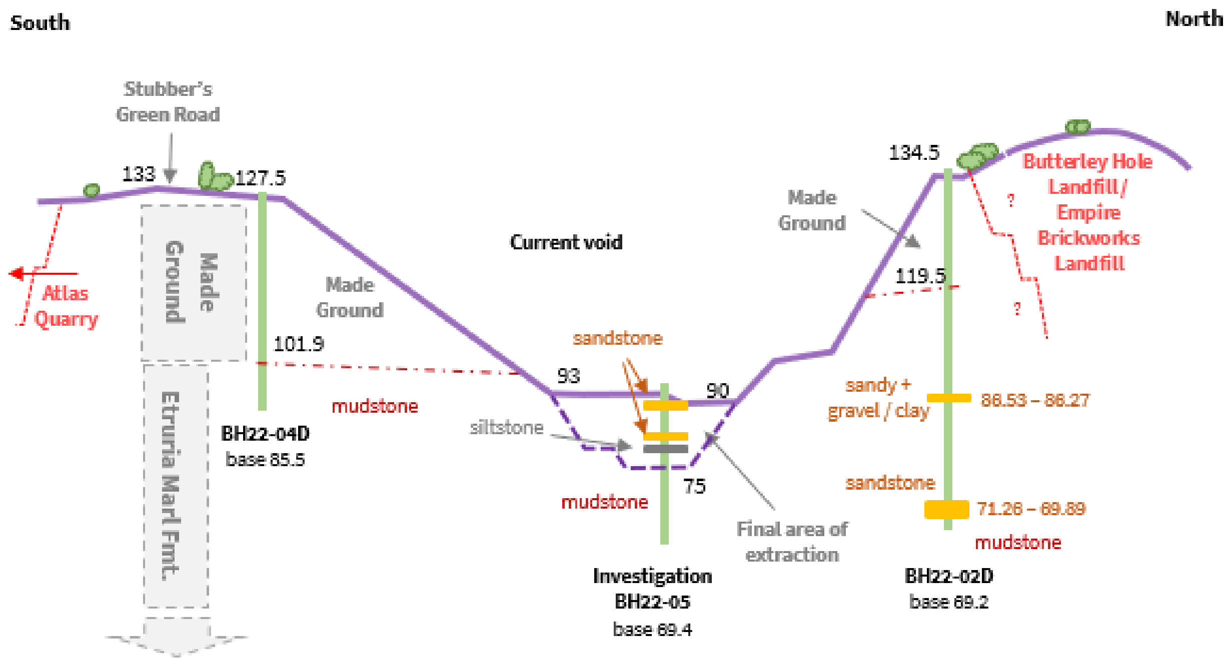


Extract from Wilson et al. 1984.

The section line details the extensive lateral and vertical thickness of the natural geological barrier. As such, there is no underlying Hydrogeological receptor at site.

Figure 18 Schematic Geological & Local Site Context at Sandown Quarry





Upper section line A-A', lower section line B-B' as represented on Figure 11.

The 6.7m thick sandstone at BGS borehole log SK00SW235, Figure 10 (115.2mAOD to 108.5mAOD) was only reported at a thickness of 1.98m at SK00SW236 (~111mAOD to 109mAOD) which confirms the lateral variance in thickness both laterally (along strike) and in a “down-dip” direction. The separation distance between the locations is only 328m. At this elevation, the sandstone unit would “daylight” in the sidewall of the quarry void (if not obscured by cast-back material placement).

However, the potential linkages towards the site from the south / southeast do not appear to be continual along the strike direction of the stratigraphic sequence observed in the quarry (070°).

The sandstone layer observed at SK00SW236 between 111 and 109mAOD (southwest of the site) was not encountered in the drilling observations at BH22-01, i.e. between the made ground / bedrock interface at 116.9mAOD (from ~109mAOD) down to the end of hole (eoh) at 88.6mAO or at BH22-04D (eoh at 85.47mAOD).

Table 6 Borehole Log Summary (2022 Investigation)

Reference	Datum Level mAOD	Drill depth m	Back cast material	Sandstone Espley Present	Conglomeratic Espley Present	Siltstone Present	Water strike observed during drilling (mAOD)
BH22-01	140.85	52.30	140.85-116.85	No	No	No	~133
BH22-02S	134.41	17.00	134.41-119.41	No	No	No	-
BH22-02D	134.53	65.30	134.53-119.53	Sandstone 71.26-69.89	Sandy / gravel clay (26cm) 86.53-86.27	No	-
BH22-03	130.49	15.00	130.49-119.89	No	No	No	-
BH22-04S	131.38	27.50	131.38-105.88	No	No	No	-
BH22-04D	127.47	42.00	127.47-101.97	No	No	No	-
BH22-05	94.40	25.00	94.40-87.52	Sandstone 87.10-85.84 83.98-82.10	gravel / clay (48cm) between 81.28 – 79.90	82.10-81.28	~87

Site Investigation locations **BH22-03** and **BH22-05** were decommissioned and backfilled will arisings (no installs), ESID 8. Datum levels taken from Factual Ground Investigation Report (June 2022) – Exploration Testing.

As such, this unit recorded in the BGS logs is either stratigraphically above the sandstone layers observed in BH22-05 (uppermost sandstone interval recorded between 87.10mAOD and 85.84mAOD) and is therefore potentially obscured behind the made ground interface above

101.97mAOD at BH22-04 or, conversely, this particular espley layer / lens has pinched out in the "down-dip" direction over a measured distance of ~ 170m.

The laterally and additionally "down-dip" discontinuous nature of the stratigraphic succession is most readily evidenced by observations such as the sandstone layer identified in the southerly exposed face to the north of the current void at 110mAOD (Figure 16), was not identified in the core recovered from BH22-02D to the north. At a dip angle (measured) of 8° the equivalent height at BH22-02D would be 99.7mAOD, at a shallower BGS reported dip angle of 3°, the relative height would be 106.1mAOD.

A stratigraphic correlation could be made (if there is a continuous connection) between the sandstone layer identified at BH22-05 at a height of 87.1mAOD (upper surface) and 71.2mAOD at BH22-02D with a dip angle of 4.4°. Once the final void extraction has taken place, this linkage can be verified, any such presence will be accounted for in the engineering requirements contained and proposed herein.

At the nearby Atlas Quarry to the south, three thin eslpey sandstone layers were observed, one layer up to 1.2m in thickness potentially at the base of the site[33], without further details on stratigraphic elevations it is not possible to comment further on these observations. As such, the evidence suggests that continuous (potentially water capable bearing layers) are not present at site. Even if, through a conservative approach, it is assumed that the observed significant sandstone bed is continuous from the south (i.e from BGS borehole SK00SW235 to SK00SW236 to BH22-05) there is no evidence to suggest that a sandstone of significant thickness continues to the north.

Structure

The spatial relationship between the various strata noted in section 3.5 is resultant of the site's location within a fault block in which the Etruria Marl is downthrown against the older Coal Measures to the west and younger deposits to the east. This block is also downthrown against the older Silurian deposits to the south and younger deposits to the north.

The following account is summarised form the BGS 1984 report[33]. Prior to the deposition of the Westphalian strata, pre-existing Silurian bedrock were faulted and had undergone gentle folding, dipping westwards at ~5°.

Post Carboniferous activity, with reactivation during the Triassic has resulted in numerous faults within the local area. Most notable are the Clayhanger Fault (a complex fault belt, location on Figure 12) located to the west and the Vigo Fault located to the east. The overall throw of the Clayhanger Fault belt is calculated at 300m in the south increasing to 630m in the north as a consequence of northward dipping strata on the downthrown side (fault orientation is predominantly north - south).

To the east, is the sub-parallel Vigo Fault, a normal fault with an easterly downthrow of ~200m. Both faults converge near to Aldridge with the Vigo Fault marking the easterly limit of the underlying coal working (Figure 17). During the site walkover, there was no visible evidence within the quarry exposure of minor faulting, although they are reported locally within the underlying Coal Measures strata.

3.6 Pathway Properties

Soils

The soils locally are <1m in thickness and are described as being cohesive and granular in an engineering sense[33]. There are no soils present at site and there are no linkages to soils at the site boundary.

Back Cast Material

As noted in Section 3.5.1, and Section 4.1 areas of made ground (cast back interburden and overburden are extensive in vertical (between ~10 and ~26m) and lateral thicknesses (between ~12 and ~135m).

Rising Head test results were obtained from site investigations in September 2022 at borehole location **BH22-04S** located within 25.5m of back cast material prior to encountering the in-situ Etruria Marl. A screen length of 23.72m was installed across this material overlying bedrock, water strikes were not observed during the investigation (Table 6). Dip to water at the start of the test was 16.39m (depth of well measured at 25.5m), recovering to 11.65m after 42 hours (full recovery).

- The results indicated a permeability of **4.7×10^{-10}m/s**.

Superficial Strata

Thickness locally ranges between 1.5m and 8.2m, they are predominantly glacial in origin and where recorded these deposits are lithologically variable (heterogeneous) and may contain organic matter, peat and organic clay. There are no known superficial deposits present at site and hence there are no linkages to superficial deposits at the site boundary.

Bedrock Strata

The thickness of the Etruria Formation has been proven to a depth equivalent to 69.4mAOD, (detail contained within the 2022 SI report, Appendix C), the lowermost 5m is a low permeability mudstone. Minor <15mm gravelly clay "occasional bands" are observed, discontinuities are typically less than 10mm and where reported are infilled with clay.

This *in-situ* natural geological barrier extends down to significant depths (e.g. Figure 17), laterally, this geological barrier extends to a distance of 370m to the northwest (to the Alveley Mudstone), 700m to the southwest, 720m to the east and 1.2km to the south. There are no published permeability data available for review however based on other clay strata used in the production of bricks it expected that permeabilities will be between 1×10^{-11}m/s to 1×10^{-9}m/s, between 1 and 2 orders of magnitude lower than that required for a mineral liner and an artificial geological barrier (AGB).

The Etruria Marl is effectively a dual property unit, a distinction that is not readily apparent from bulk permeability testing of the unit which returns an *in-situ* permeability of the formation to between 1.5x10^{-11}m/s and 2x10^{-5}m/s[35]. However, this upper range is considered to be due to the more permeable intermittent sandstone espleys where hydraulic conductivity ranges from 1.6x10^{-8}m/s to 1.7x10^{-5}m/s with an average hydraulic conductivity of 4x10^{-6}m/s, with the mudstone units at the lower (10^{-11}m/s) end of the range.

Additional 'Rising Head' test data obtained from site investigations in September 2022 for the existing site borehole now referenced as monitoring location BH3D and recently installed monitoring boreholes BH22-04D. All monitoring installations, both historic and recent are discussed further in Section 3.8.4.

BHP-03D (the deeper of a nested piezometer installation) with a depth of 72.38mbgl (response zone of 67m) had a pre-test dip to water level of 11.62mbgl recovering to 2.4mbgl after 17hrs (full recovery)

- The results indicated a permeability of **2.72 x 10-^{10}m/s**.

At **BH22-04D**, dip to water at the start of the test was 37.21mbgl (depth of well measured at 42mbgl), recovering to 11.90m after 39 hours (full recovery).

- The results indicated a permeability of **9.04 x 10^{-10}m/s**.

The in-situ permeability results of 2.72x10^{-10}m/s 9.04x10^{-10}m/s for the Etruria Formation is consistent with observations elsewhere relating to "mudstone dominant" sequences. Further discussion is provided in the HRA report 5430-BLP-R-006-02.

Man Made Subsurface Pathways

Services are not present around the site periphery (as determined during July 2022).

3.7 Areas of Worked Ground

3.7.1 Mining

Extensive mine workings however are located nearby, however these shafts / adits are almost exclusively located to the west of the site in association with coal mining activities and Coal Measures Strata outcrops[36] (Figure 19). Two Shafts are noted towards the southern boundary of the site (relating to Coppy Hall Colliery, Figure 5). The shafts are not within the proposed site area.

3.7.2 Landfilling

Landfilling in the local area is extensive, the presence of which is attributed to the low sensitivity of the hydrogeological systems (Section 3.8) and containment within a low permeability "*natural geological barrier*". Historic landfilling in the area is depicted on Figure 6. The GroundSure report (Appendix B) indicates that historic landfilling transgresses over the boundary of the Sandown Quarry site boundary (associated with planning applications dated in the early 1990's).

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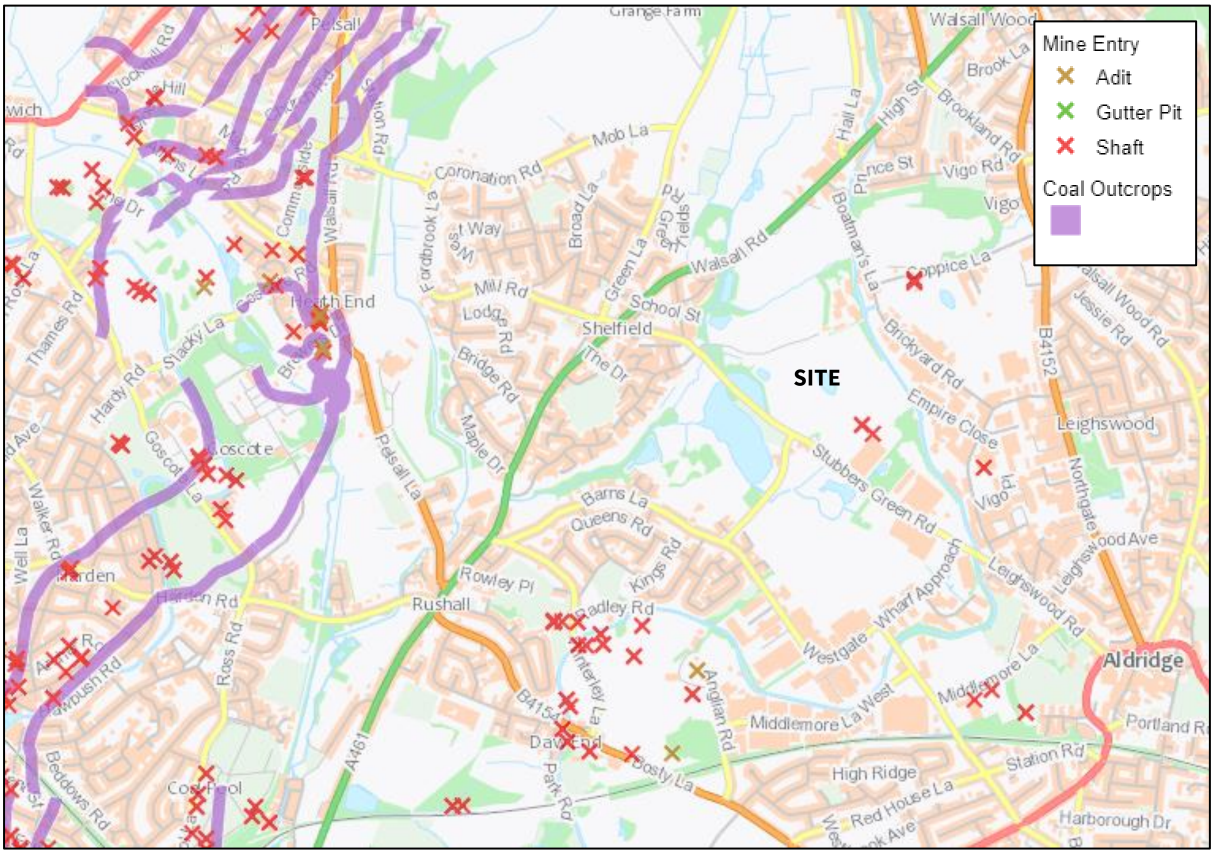
[35] SLR Consulting (2002) Vigo Hydrogeological Risk Assessment
[36] https://mapapps2.bgs.ac.uk/coalauthority/home.html

Figure 19 Coal Mine Access Areas & Local Outcrop



The nearest sites are located directly adjacent to the north boundary (Butterley Hole / Empire Brickworks) and northwest boundary to the site (Banpiece / Swag), hydraulically downgradient (Section 3.8.5 and additional discussion in the Hydrogeological Risk Assessment).

- Banpiece Swag – the Groundsure Report does not report any operator details, waste types or infilling dates.
  - *No details are available in regard to depth of waste or containment engineering however BGS records indicate "site no suitable for liquids or soluble solids"*
- The Butterley Hole Site (reference SL/324, 644/643) was operated by Polymeric Treatments Ltd, waste types included "special" and "liquid sludge" and infilling activities occurred between 1983 and 1988. The licence was surrendered in 1994.
- The Empire Brickworks Site (reference SL/50, SL51 644/77) was operated by Polymeric Treatments Ltd, waste types included "industrial", "special" and "liquid sludge" and infilling activities occurred between 1977 and 1994. The licence was surrendered in 1994.
  - *No details are available in regard to depth of waste or containment engineering.* It is understood that the Empire brickworks landfill was used to treat special chemical wastes using a "seal-o-safe" solidification technique prior to disposal within three deep lagoons.

To the south, “Douglas – Stubbers Green Road site” is referenced at a distance of ~200m from the site. The Douglas Stubbers Green Road site, with a licence issue date of May 1981 (RMD001, EA/EPR/UP3696FE/A001) is referenced as a landfill taking biodegradable waste and is hydraulically upgradient of Sandown Quarry (Section 3.8.5). Further details obtained on site CAR forms (Compliance Assessment Report) indicate landfilling had ceased by 1987, it is understood that there is no environmental monitoring undertaken. No details are available in regard to depth of waste or containment engineering, the available COPA licence of 1974 however indicates that biodegradable wastes (in addition to timber, plasterboard and asbestos were excluded, however this cannot be verified.

In addition to the significant number of sites referenced in Section 2.2, locally there are operational biodegradable sites where environmental monitoring is ongoing. Within 500m of the site are the Highfields South landfill EPR/NP3135SL (230m to the north) and Vigo Landfill EPR/BV2999IJ (420m to the northeast). The Highfield South site is directly to the north of the Butterley Hole and Empire sites.

Emissions from the Butterley Hole landfill site were previously identified as having had an impact on the pre-landfilling background water quality at Highfields South site (i.e. prior to the sidewall being engineered). As such, baseline groundwater quality locally (as part of existing sites with environmental permits) indicates that the quality of this porewater / groundwater (if associated with sandstone or eslpeys) is extremely poor and brackish (e.g. chloride, sodium and sulphate recent maximums of 340mg/l, 522mg/l and 1,100mg/l adjacent to Vigo Landfill, 1,400mg/l, 1,300mg/l and 820mg/l adjacent to Highfields South Landfill). All concentrations are significantly in excess of Drinking Water Standards (DWS) concentrations of 250mg/l (chloride and sulphate), 200mg/l (sodium) and indicate the porewater / groundwater is not potable (conceptually downgradient of the Sandown Quarry and proposed site).

At slightly greater distances from the site, it is understood that permission was granted in 1965 for the Walsall Wood Colliery (located ~1km northeast) to dispose of “toxic” wastes including acids, organically contaminated liquids and sewage sludge in Shaft 1 from 1966. Disposal ceased in 1976 when the mineshaft became blocked.

The treatment and disposal of these liquid wastes and sludges was then diverted from the Walsall Wood Colliery to the Mitco lagoon landfill (operated by Leigh) positioned immediately south of the Vigo Utopia site (320m to the east). The site was operated under Waste Disposal Licence SL 46. High level seepages associated with the Mitco lagoon landfill were reported along the southern edge of the Vigo Utopia Quarry void (within ~10m of the rim) which confirmed elevated chloride was present (>10,000mg/l).

Additionally, a borehole referred to as the “Mitco borehole” was sunk to a depth of ~425m at this site in an attempt to replace the blocked Walsall Wood Colliery mineshaft. This borehole was later used between 1977 and 1978 to dispose of liquid waste from the Mitco lagoon to the underground workings of the Aldridge Colliery under Waste Disposal Licence SL 226.

To the south-east of the Mitco Lagoon site is Joberns landfill (~400m southeast) which is also thought to have been managed by Leigh. This landfill is located ~100m south of Vigo Utopia landfill and it was reported by SLR in 2005 that *"the Environment Agency record Joberns landfill has no landfill gas control system and the site is known to be generating significant levels of landfill gas"* The site is thought to have been filled between 1969 and 1983 under Waste Disposal Licence SL 47 which has since been surrendered.

3.7.3 Industrial Uses and Pollution Incidents

There are 52 records of industrial land uses within 250m of site, these include tanks, chemical industries, an obsolete petrol station (220m to the north) and a consent for storage of cyanide (131m to the southeast at the Empire works).

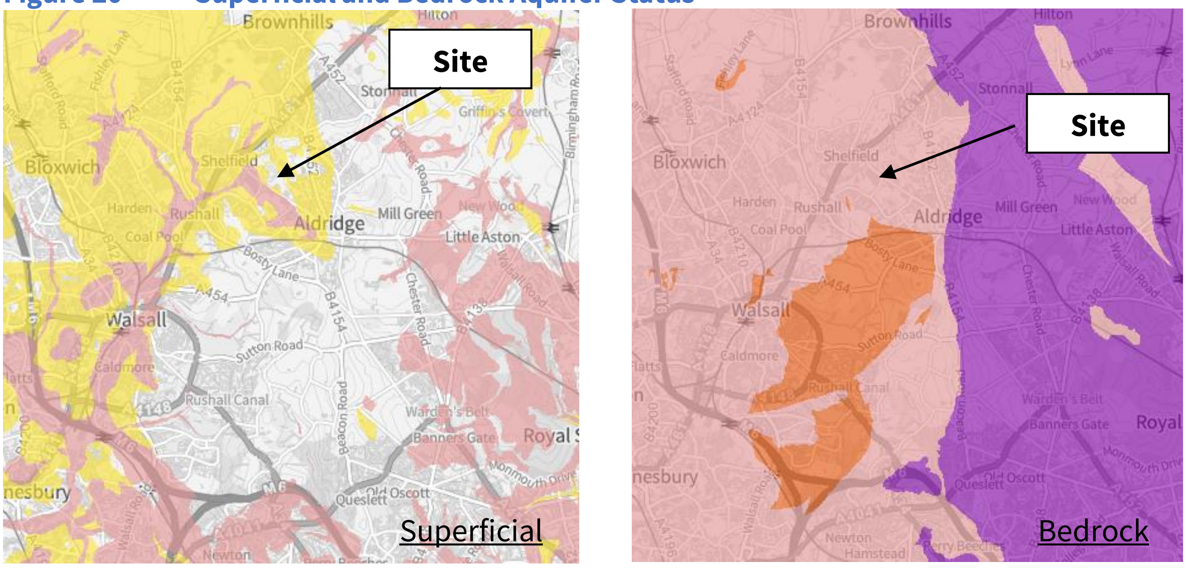
20 notifications for pollution incidents are recorded within 500m, since 2006 there has been 1 major and 2 significant incidences (a category 1 incident of which crude sewage was released 171m southwest, May 2020).

3.8 Hydrogeology / Groundwater

3.8.1 Aquifer Classification and Vulnerability

The glacial superficial deposits locally are designated by the Environment Agency as a Secondary (undifferentiated) aquifer (ESID 10, Figure 20). Superficial sediments are absent at site and therefore there is no lateral continuation to these deposits. Where present alluvium is designated as a Secondary A Aquifer.

Figure 20 Superficial and Bedrock Aquifer Status



Aquifer: Principal Secondary A Secondary B Secondary (undifferentiated) Unproductive

Made ground is present on site, this material (interburden / overburden) is not a receptor.

The Etruria Formation is characterised as a Secondary A aquifer (ESID 10, Figure 20) due to the presence of discontinuous higher permeability strata capable of supporting water supplies at a local rather than strategic scale. Water bearing capable sandstone layers are not connected (even over short distances) and are hydrogeologically separated as they are juxtaposed against low permeability mudstones or are encapsulated within the mudstone sequence. This is consistent with BGS information regarding the formation, literature accounts and site observations contained herein.

The site is not located in a groundwater Source Protection Zone (SPZ), the nearest is 1.5km to the east and is characterised as Total Catchment Zone 3. This SPZ is associated with the outcropping of the Triassic sandstone to the east which is considered a Principal Aquifer (ESID 10). This aquifer is stratigraphically above the Etruria Formation and topographically higher (separated by an angular unconformity), there is no hydraulic connection from site to this aquifer.

Groundwater vulnerability is considered “low”.

3.8.2 Hydraulic Properties

Literature Observations

Studies of the hydrogeological properties of the Etruria Formation are limited within available literature. There are no details locally and there are no hydraulic properties of either the made ground or the Etruria Formation at site, however the very nature of the bulk strata, defined as marl, mudstone (structureless) with very few discontinuities indicates that the permeability will be very low.

Elsewhere in the UK, the Etruria Formation (composed predominantly of impermeable argillaceous rocks and yields little or no water). Fractures in the ‘espley’ rocks, however, can yield moderate quantities of water suitable for small-scale agricultural or industrial requirements[15]. No observed groundwater seepages were observed during the site walkover in April 2022, the sandstone bed exposed was compact and cemented with no primary porosity evident. No seepages were observed through the jointed (both horizontal and vertical) layer.

Conglomeratic espley occurrences are noted in many of the nearby BGS borehole logs (Figure 10), albeit they are limited thicknesses, typically less than 1m when recorded. The on-site investigations did not identify conglomeratic layers greater than 47cm, isolated pockets were present up to 70mm in thickness (Appendix C) Conglomeratic layers are contained within thick mudstone sequences.

Site Observations – Etruria Marl

BHP-03D - The borehole was dipped prior to testing, dip to water was 2.35m (depth of well measured at 72.38m). The ID (internal diameter) was confirmed at 0.09m (9cm) hence a volume of 445l was present as a standing column of water within the borehole annulus. Steady state pumping was achieved after removing 63.5l (60mins), the pumping continued for a period of 6hrs, with a total volume of groundwater removed equalling 209l (steady state removal at ~24l/hr). Trial terminated due to insufficient site time available to site engineer.

- The results indicate a potential "maximum" yield of **1.5m^3/day** (falling to a sustained yield equivalent to 0.6m^3/day).

BH22-04D - The borehole was dipped prior to testing, dip to water was 7.92m (depth of well measured at 42m). The ID was confirmed at 0.07m (7cm) hence a volume of 130l was present as a standing column of water within the borehole annulus. Steady state pumping was not achieved, the pumping could not be sustained longer than 2hrs, 15 mins, with a total volume of groundwater removed equalling 149l. Trial terminated due to insufficient recharge to sustain low-flow pumping, clogging and siltation in tandem with a continual drop in water level.

- The results indicate a potential "maximum" yield of **1.7m^3/day** (incrementally falling to 0.8m^3/day after 3hrs)

Site Observations – Cast Back Material

BH22-04S - The borehole was dipped prior to testing, dip to water was 10.24m (depth of well measured at 27.5m). The ID was confirmed at 0.07m (7cm) hence a volume of 66l was present as a standing column of water within the borehole annulus. Steady state pumping was achieved after removing 50l (95 mins), the pumping continued for a period of 4hrs 35 mins, with a total volume of groundwater removed equalling 57l (steady state removal at ~1.2l/hr). Trial terminated due to insufficient site time available to site engineer.

- The results indicate a potential "maximum" yield of **0.8m^3/day** falling to a sustained yield equivalent of <0.01m^3/day after 1 hour).

A further test was undertaken at **BH22-01** that is screened over both the made ground and underlying Etruria Formation strata. During drilling installation, a water strike was observed about 7mbgl (approximate to ~133mAOD) which is within the upper part of the vertical profile of the cast back interburden / overburden materials (total depth of 24m). Current water levels (see Section 2.8.5) indicate that this water has evidently decanted into the monitoring point, now recording a water level coincident with the water strike which is interpreted as a localised "perched water" within the made ground. Conceptually, this is not related to the canal (based on the depth, see Drawing ESID 5D, canal level of ~143mAOD) and is evidently not sufficient in volume to supply a seepage of water into the open void. It is noted that the level of the access ramp into the current quarry is also at a level of ~135mAOD.

The pumping trial recorded a steady state removal of water at an approximate yield of 4.3m^3/day over a period of ~5 hrs (a total volume of 0.9m^3 was removed).

3.8.3 Groundwater Abstractions

There are no details for groundwater abstractions within 1km of the site (Appendix B). This is consistent with the expectations for the bedrock.

3.8.4 Groundwater Monitoring Installations

The site investigations of 2022 and requirement for ongoing environmental monitoring has resulted in the retainment of a singular monitoring point to the southeast of the site (BH22-01), and 2 pairs (shallow and deep) to the north (BH22-02S and BH22-02D) and southwest (BH22-04S and BH22-04D). Supporting information summarised in Table 7.

As stated in Section 3.5.1 and 3.5.2, BH22-03 and BH22-05 were decommissioned as they were only required for investigative purposes. The retained installations however have been amalgamated with pre-exiting monitoring points (located on Figure 11 as orange symbols) and have been renumbered for simplicity and future reference as depicted in Figure 21 below (ESID 12).

Through ongoing baseline data collection, it is recognised however at all proposed monitoring locations (existing and recently installed) indicate significantly slow recharge times that will not permit conventional purging of 3 well volumes prior to sampling. The observation are consistent with the permeability and yield determinations outlined in Section 3.6 and 3.8.2 above.

Figure 21 Site Monitoring Locations

Site monitoring locations utilised for "baseline" data collection. BHP- 03S and 03D are nested piezometers.

3.8.5 Groundwater Levels and Hydraulic Directions

Although borehole logs are not available for the pre-existing installations present at site, it is apparent that the shallow infrastructure (BHP-03S, BHP-06 and BHP-07, locations on Figure 21 and ESID 12) are monitoring either made ground or near surface superficial deposits (if present, this is considered unlikely based on the site investigation, local BGS mapping and material removal for brick marl extraction).

Table 7 Monitoring Location Summary

Reference	Purpose	Location Context relative to Site Infill	Monitored Horizon	Drilling Log – (Y/N) Casing – (Raised Flush)	Grid Reference	Ground Datum Level mAOD	Base datum [mAOD] & depth m
Site Investigations 2022							
BH22-01	GW Monitoring	Southeast	Made Ground/Etruria Fmt.	Yes Raised	E404638.99 N301972.32	140.86	[88.55] 52.30
BH22-02S	Gas & GW Monitoring	North	Made Ground	Yes Raised	E404257.44 N302144.26		[117.41] 17.00
BH22-02D	GW Monitoring	North	Etruria Fmt.	Yes Raised	E404267.52 N302142.63		[69.23] 65.30
BH22-04S	Gas & GW Monitoring	Southwest	Made Ground	Yes Raised	E404282.56 N301772.85	131.35	[103.88] 27.50
BH22-04D	GW Monitoring	Southwest	Etruria Fmt.	Yes Raised	E404288.79 N301772.65	131.49	[85.47] 42.00
Existing Infrastructure							
BHP-03S	Gas & GW Monitoring	Northwest	Made Ground	No Raised	E404059.79 N302033.25	131.64	[xxx] 5.68
BHP-03D	GW Monitoring	Northwest	Etruria Fmt.	No Raised	E404059.79 N302033.25	131.64	[xxx] 70.28
BHP-05	GW Monitoring	Northeast	Etruria Fmt.	No Flush	E404505.73 N302204.13	143.32	[xxx] 50.75
BHP-06	Gas & GW Monitoring	East	Made Ground	No Flush	E404538.94 N302141.33	141.65	[xxx] 3.99
BHP-07	Gas & GW Monitoring	East	Made Ground	No Flush	E404543.55 N302135.99	142.18	[xxx] 0.53

Previously present / existing infrastructure (referenced within this document as BHP-03, 05, 06, 07) – monitored horizon inferred based on 2022 SI results and depth of BH, locations presented on Figure 21 (ESID 12). Made Ground refers to cast back interburden / overburden materials.

It can be assumed however that BHP-03D (depth of ~70m) and BHP-05 (depth ~51m) are likely screened against the Etruria Formation Strata. It is unknown if the boreholes are additionally screened against overlying deposits.

In consideration that the majority of voids / quarries locally have been infilled with wastes (in addition to the inclusion of engineered sidewall barriers at some sites) it is recognised that any potential groundwater flow paths will have been further disrupted. The excavations in themselves have in fact disrupted any credible linkages of layers or lenses within the Etruria Formation.

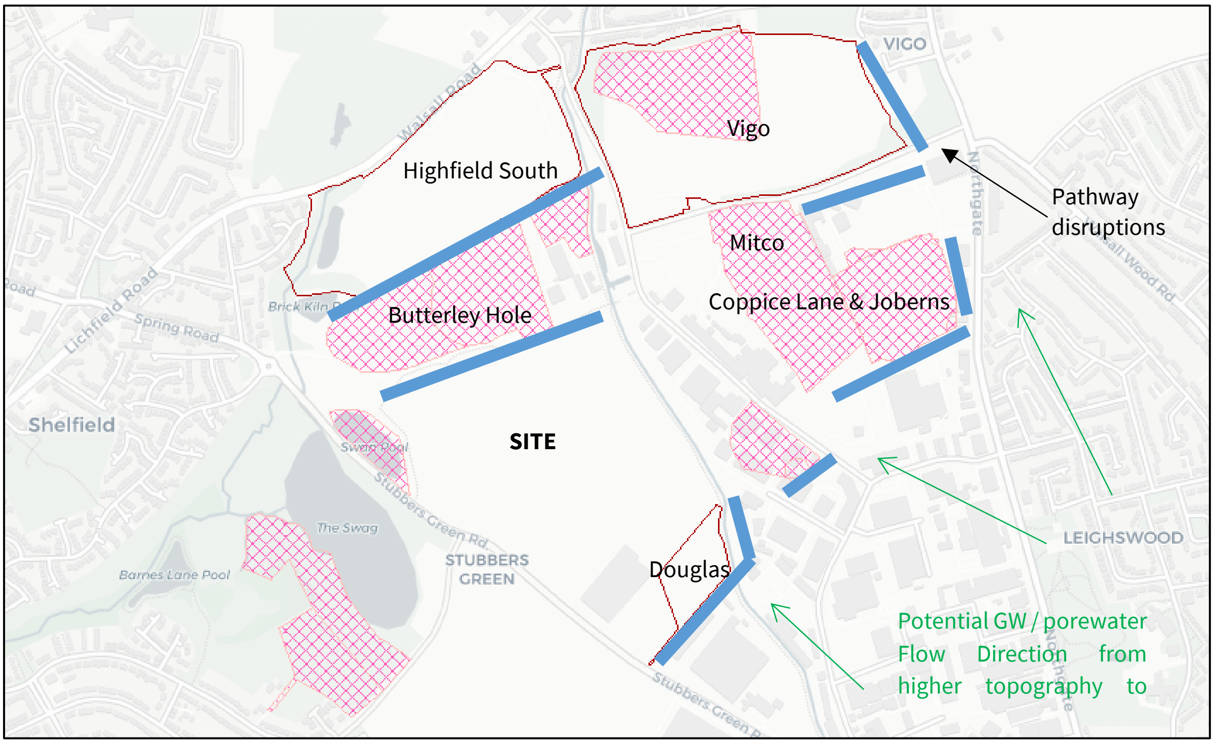
Conceptually, direct groundwater flows are assumed to follow a westerly or north-westerly direction (from higher topography to the east and southeast) which are interrupted by the disruption lines (depicted with blue lines in Figure 22) and hence any potential lateral linkages of sandstone layers / lenses or espleys are broken.

It may be expected is that monitoring at the periphery of any given site (including Sandown Quarry landfill), will potentially record a water mounding on the upgradient side with flow directions then diverted around the periphery. Water diversion may be a resultant effect from flow impedance by virtue of infilled wastes and engineered / enhanced geological barriers or disruption of water bearing layers, beds or lenses.

No significant water strikes were observed during drilling / investigation (Table 6), initial monitoring however has identified that water has accumulated within the monitoring installations (Table 8).

As noted in Section 3.8.4, purging for the necessity of sample collection has indicated very slow water recovery indicating both low permeability characteristics of the Etruria Formations and overlying made ground. The only monitoring location identified with a reasonable recharge / recovery rate is at BH22-02S (within the made ground adjacent to the Butterley Hole Landfill), location depicted below in Figure 22.

Figure 22 Location of Nearby Landfills & disruption of potential pathway linkages



The Sandown site (in addition to other excavations locally, i.e the Ibstock Atlas site to the south – not shown above) will have further disrupted flow directions within any laterally persistent layers, beds or lenses. Hatched notations denote "historic waste" areas.

Table 8 Water Level Summary (mAOD)

Monitoring Reference	Collar Datum	Initial Water Level				April 2022 – June 2023 Summary		
		April 2022	May 2022	June 2022	July 2022	Min. Water Level	Ave. Water Level	Max. Water Level
BH22-01	x	133.75	133.77	133.67	133.75	133.54	133.70	133.84
BH22-02S	x	133.05	132.99	133.11	133.11	132.78	133.06	133.88
BH22-02D	x	122.59	123.13	122.51	122.77	122.51	123.71	125.59
BH22-04S	x	125.02	124.86	124.66	124.11	121.11	123.91	125.02
BH22-04D	x	124.98	126.11	126.13	125.65	123.29	124.92	126.13
BHP-03S	x	130.27	129.49	129.56	129.22	129.29	129.67	130.27
BHP-03D	x	128.06	128.93	129.09	128.54	128.06	129.06	129.71
BHP-05	x	120.92	117.56	118.87	118.60	117.34	119.30	120.92
BHP-06	x	140.01	Dry	Dry	Dry	-	-	-
BHP-07	x	Dry	Dry	Dry	Dry	-	-	-

Drilling observations and core recovery has identified that the majority of the Etruria Formation is comprised of “marl” or mudstone at site. Sandstones and conglomerates are infrequent and are not laterally connected, where present they are thin layers (i.e. typically <1m, maximum of 1.37m – BH22-02D). As such, the water monitored within the monitoring installations are a combination water derived from thin, slightly more permeable layers within a 95% bulk matrix of low permeability mudstone.

ByrneLooby’s experience at other site locally (in combination with sites in the same strata in North Wales) and, additionally other sites hosted within geological barriers (mudstone and clay strata) indicates that pore-water can accumulate over time within monitoring installations. In all other observable cases the water levels recover to near surface levels and are usually indicative of local topography.

What can be stated at Sandown however is that if there is a consistent, hydraulically connected “water table” within the Etruria Formation (BH22-02D, BH22-04D and potentially BHP-03D, BHP-05) at the level of 119 mAOD to 129 mAOD (Table 8), the void would be full of water (current base of void level at ~90mAOD) and would require constant water management, this is not the case.

As such the term “groundwater” at Sandown in a hydrogeological context is a misnomer and a relatively static “porewater” may be more appropriate as evidenced by the water level and no evidential water ingress into the void. The water levels at BH22-02D and BH22-04D indicate confined, piezometric conditions for the Etruria Formation porewater, falling in a northerly direction consistent with geological dip (i.e. to the north). The inclusion of data from BHP-03D and BHP-05 does not provide evidence to support any consistent, conceptually down dip water linkages, limited water level variance indicates little / no seasonal effects consistent with the site setting, i.e. within a mudstone / clay barrier and no recharge to encapsulated water bearing layers.

The shallower installations (within the made ground) indicate either perched water (i.e. BH22-01) or water levels locally to the installation almost coincident with ground level, as such there are no flow directions observed within this material and water levels are lowest where the ground surface is lowest (i.e. BH22-04S).

3.8.6 Groundwater / Porewater Quality

Local Data

As noted in Section 3.7.2, water quality locally as been reported as being significantly variable and extremely poor at some monitoring location adjacent at other landfill sites. The poor and brackish groundwater / porewater (e.g. chloride, sodium and sulphate recent maximums of 340mg/l, 522mg/l and 1,100mg/l adjacent to Vigo Landfill, 1,400mg/l, 1,300mg/l and 820mg/l adjacent to Highfields South Landfill) indicate the water is not potable (conceptually downgradient and downdip of the site) and far in excess of DWS concentrations.

Recent ammoniacal-N concentrations adjacent to the Vigo Landfill site range between 0.9mg/l and 11mg/l (maximum) and 0.1mg/l and 3.1mg/l (average)[37], and adjacent to the Highfields South site range between 0.1mg/l and 100mg/l (maximum) and 0.2mg/l and 65.6mg/l (average)[38]. The greatest concentrations are attributed to the Butterley Hole site (adjacent to the northern boundary) at a borehole refenced as HSGW10.

Additionally, in regard to metals and metalloids there are elevated occurrences of nickel with a wider lateral distribution than the elevated arsenic concentrations observed. Nickel ranges between <0.001mg/l and 0.31mg/l (DWS of 0.02mg/l) with arsenic between 0.001mg/l and 0.07mg/l (DWS of 0.01mg/l).

According to the Hydrogelogical Risk Assessment Review in 2017, specific organic substances are only consistently identified along the Butterley Hole perimeter, with the highest concentrations present at HSGW10, with sequentially lower concentrations observed at HSGW05 and HSGW11. Organic substances are only reported as isolated substances in other locations and there are no associations with the phenolic or BTEX substances, which are the primary organic content within the Highfield South leachate. The organic substances identified at HSGW10 fall into four types, namely:

- the non-hazardous phenolic hydrolysis and primary breakdown products, of which methylphenol is the primary constituent;
- the BTEX substances of which toluene is the primary constituent;
- the pesticide diuron; and
- chlorinated solvents of which dichloroethane is the primary constituent.

The first two of the above type of substances are biodegradation products from organic matter, however, diuron and dichloroethane are anthropogenic and primary leachate constituents. Significantly diuron and dichloroethane are not present above leachate screening levels of 10µg/l

[37] Vigo Utopia Landfill Hydrogeological Risk Assessment Review, TerraConsult, June 2020 (Ref 10127-R15) – obtained through FOI Request to the Environment Agency.
[38] Highfield South Landfill Hydrogeological Risk Assessment Review, TerraConsult, January 2017 (Ref 10127-R02) – obtained through FOI Request to the Environment Agency.

within the Highfield South leachate, whilst toluene is an order of magnitude more concentrated in HSGW10 than within the site's leachate. Therefore, these substances cannot be associated with the Highfield South site.

Site Data

A summary of site data collected post March 2022 is summarised below in Table 9 (matrix substances) and Table 10 (metals), monitoring locations depicted on ESID 12 and Figure 21.

Table 9 Groundwater / Porewater Matrix Constituents (mg/l) April 2022 – June 2023

Borehole		EC µS/cm	NH_4-N	Chloride	Ca	Mg	Na	K	SO_4	Alk
Southeast Boundary										
BH22-01	Median	1,226	0.2	79	118	38	110	15	232	325
	85th %ile	1,342	0.4	90	132	43	153	16	244	360
	Max	1,390	0.4	92	135	47	174	20	265	378
Southwest Boundary										
BH22-04S	Median	2,220	0.2	278	162	108	199	11	481	366
	85th %ile	3,030	0.6	385	225	155	263	15	855	502
	Max	3,730	0.7	486	319	201	337	17	1,050	537
BH22-04D	Median	2,230	0.4	196	160	113	217	11	653	320
	85th %ile	3,280	0.7	235	262	181	267	14	1,126	489
	Max	3,370	0.8	425	323	233	313	14	1,350	593
East Boundary										
BHP-07	Median	830	1.6	98	51	1	112	11	92	187
	85th %ile	894	1.9	114	53	2	130	11	113	162
	Max	1,100	3.2	117	58	2	138	24	115	514
North Boundary										
BH22-02S	Median	28,063	141.7	10,658	557	197	4,170	588	561	778
	85th %ile	31,795	175.9	12,295	782	265	5,804	715	710	865
	Max	33,700	190.0	14,500	797	279	6,100	774	742	1,020
BH22-2D	Median	8,188	9.0	2,469	330	94	1,275	64	310	2,620
	85th %ile	10,895	12.8	3,303	347	101	1,865	81	361	428
	Max	11,200	13.0	3,420	362	103	1,950	87	391	564
Northwest Boundary										
BHP-03S	Median	1,725	0.8	237	135	51	168	7	253	302
	85th %ile	-	-	-	-	-	-	-	-	-
	Max	2,100	1.2	331	144	54	227	8	318	325
BHP-03D	Median	2,268	1.7	312	109	38	247	8	316	345
	85th %ile	3,180	2.6	513	156	56	526	12	454	373
	Max	3,330	3.4	550	166	56	586	14	486	402

DWS from 2016 No. 614, The Water Supply (Water Quality) Regulations 2016
http://www.legislation.gov.uk/uksi/2016/614/pdfs/uksi_20160614_en.pdf page 38.

Green shaded cells indicate where concentrations are in exceedance of MAC or typical water quality standards, Limits: EC (2500µS/cm); Chl (chloride) & SO_4 (250mg/l); Na (200mg/l); *Ammonium (units of measurement as mg/NH4/l) DWS 0.5mg/l guide value – (referenced standard for NH4-N 0.39mg/l); Alk – alkalinity (expressed as $CaCO_3$). No data for BHP-06 or BHP-07, only two samples from BHP-03S, 85%ile concentration not determined.

Table 10 Groundwater / Porewater Priority and Minor Metals / Metalloids Summary April 2022 – June 2023

		Cd	Cr	Cu	Ni	Zn	Pb	Hg	As
DWS (mg/l)		0.005	0.05	2	0.02	5	0.01	0.001	0.01
Southeast Boundary									
BH22-01	Median	0.0001	<0.001	<0.001	0.011	0.041	<0.001	<0.00003	<0.001
	85th %ile	0.0002	<0.001	<0.001	0.014	0.051	<0.001	<0.00003	<0.001
	Max	0.0003	<0.001	<0.001	0.016	0.066	<0.001	<0.00003	0.001
Southwest Boundary									
BH22-04S	Median	<0.00002	<0.001	<0.001	0.002	0.018	<0.001	<0.00003	0.003
	85th %ile	<0.00002	<0.001	<0.001	0.004	0.045	<0.001	<0.00003	0.004
	Max	0.00002	<0.001	<0.001	0.005	0.056	<0.001	<0.00003	0.005
BH22-04D	Median	<0.00002	<0.001	<0.001	0.002	0.012	<0.001	<0.00003	0.005
	85th %ile	<0.00002	<0.001	<0.001	0.003	0.022	<0.001	<0.00003	0.007
	Max	<0.00002	0.001	0.001	0.004	0.024	<0.001	<0.00003	0.007
East Boundary									
BHP-05	Median	0.0001	0.047	0.003	<0.001	0.018	<0.001	<0.00003	0.005
	85th %ile	0.0002	0.088	0.003	<0.001	0.039	<0.001	<0.00003	0.006
	Max	0.0002	0.148	0.003	<0.001	0.044	<0.001	<0.00003	0.007
North Boundary									
BH22-02S	Median	0.0011	<0.01	0.055	0.232	0.030	<0.010	<0.00030	0.118
	85th %ile	0.0016	<0.01	0.114	0.294	0.043	<0.010	<0.00030	0.154
	Max	0.0016	0.001	0.162	0.313	0.045	<0.010	<0.00030	0.163
BH22-02D	Median	0.0001	<0.001	0.028	0.098	0.016	<0.001	<0.00003	0.008
	85th %ile	0.00013	<0.001	0.061	0.149	0.023	<0.001	<0.00003	0.009
	Max	0.00013	0.003	0.110	0.158	0.043	<0.001	<0.00003	0.016
Northwest Boundary									
BHP-03S	Median	0.0005	<0.001	<0.001	0.018	0.041	<0.001	<0.00003	<0.001
	85th %ile	-	<0.001	<0.001	-	-	<0.001	<0.00003	<0.001
	Max	0.0010	0.001	<0.001	0.023	0.061	<0.001	<0.00003	<0.001
BHP-03D	Median	<0.00002	<0.001	<0.001	0.011	0.019	<0.001	<0.00003	<0.001
	85th %ile	<0.00002	<0.001	<0.001	0.012	0.025	<0.001	<0.00003	<0.001
	Max	0.00005	0.001	<0.001	0.022	0.090	<0.001	<0.00003	<0.001

Note: where substances are not detected during reporting period the average is represented as the <LOD. Where substances are both below and above the limit of detection, the values for <LOD are reported as half the LOD for statistical purposes only. Green shaded cells indicate where concentrations are in exceedance of MAC or typical water quality standards.
No data for BHP-06 or BHP-07, only 2 samples for BHP-03S, 85%ile concentration not determined.

No waste deposition has taken place at Sandown Quarry and hence all monitored groundwater / porewater quality is either a natural background level, or the baseline concentrations are modified by previous or ongoing activities.

The results obtained to date reported in Table 9 and Table 10 indicate a significant modification from a potential baseline condition evidenced at BH22-01 (a combined water from the made ground and underlying Etruria Formation strata).

Notwithstanding the above, and in direct comparison with BH22-01, chloride concentrations greater than DWS (250mg/l) are reported in tandem with increased sulphate at BH22-04S and 04D (up to a maximum SO_4 concentration of 1,350mg/l) which is a location that is conceptually cross-gradient / up-dip form the proposed landfill. These concentrations however are insignificant compared to those at BH22-02S and 02D. (adjacent to the Butterly Hole Landfill) and are significantly impacted particularly at BH22-02S within the made ground. Median concentrations of ammoniacal-N are 141mg/l, with a maximum of 190mg/l; chloride, sodium, potassium and sulphate maximum concentrations reported are 14,500mg/l, 6,100, 774mg/l and 742mg/l respectively.

Variability is also noted to the northeast at BHP-05 (ammoniacal-N up to 3.2mg/l) and also to the northwest at BHP-03S and 03D (ammoniacal-N up to 3.4mg/l) with additional increases above DWS for chloride, sodium and sulphate.

The matrix ions observations noted above are mirrored for the metals data most notably at BH22-02S and BH22-02D where there are elevated concentrations of nickel above DWS (at BH22-02S) in addition to elevated concentrations of copper, zinc, cadmium and arsenic (above 0.01mg/l DWS). Neither lead nor mercury are reported above detection limit at any monitoring location.

A hazardous / non-hazardous organic, pesticide/ herbicide, hydrocarbon screen was undertaken in July 2022 and February 2023 to assist in baselining the local groundwater / porewater. Out of an analytical suite of 153 potential substances, low level PCB concentrations were reported at BHP-03D (<1.3µg/l) in addition to mecoprop and bentazone (both at 0.04µg/l).

All additional results reported above detection limit are attributed to either BH22-02S or BH22-02D. The data collected so far indicates the presence of total cyanide (0.17 – 1.24mg/l) in addition to Dichloroethane (3 – 55µg/l), Benzene (7µg/l), chlorobenzene (1µg/l), chloroethane (18 – 20µg/l), ethylbenzene (3 – 13µg/l), MBTE (1 - 11µg/l), m and p-xylene (7 – 25µg/l), o-xylene (2 – 7 µg/l), toluene (12 – 37µg/l) in addition to mecoprop (5 – 23µg/l), fenoprop (3 – 27µg/l) and dichloroprop (<2µg/l). Groundwater monitoring schedules and frequencies proposed are detailed in report 5430-BLP-R-009-02.

3.8.7 Ground Gas Monitoring and Analysis

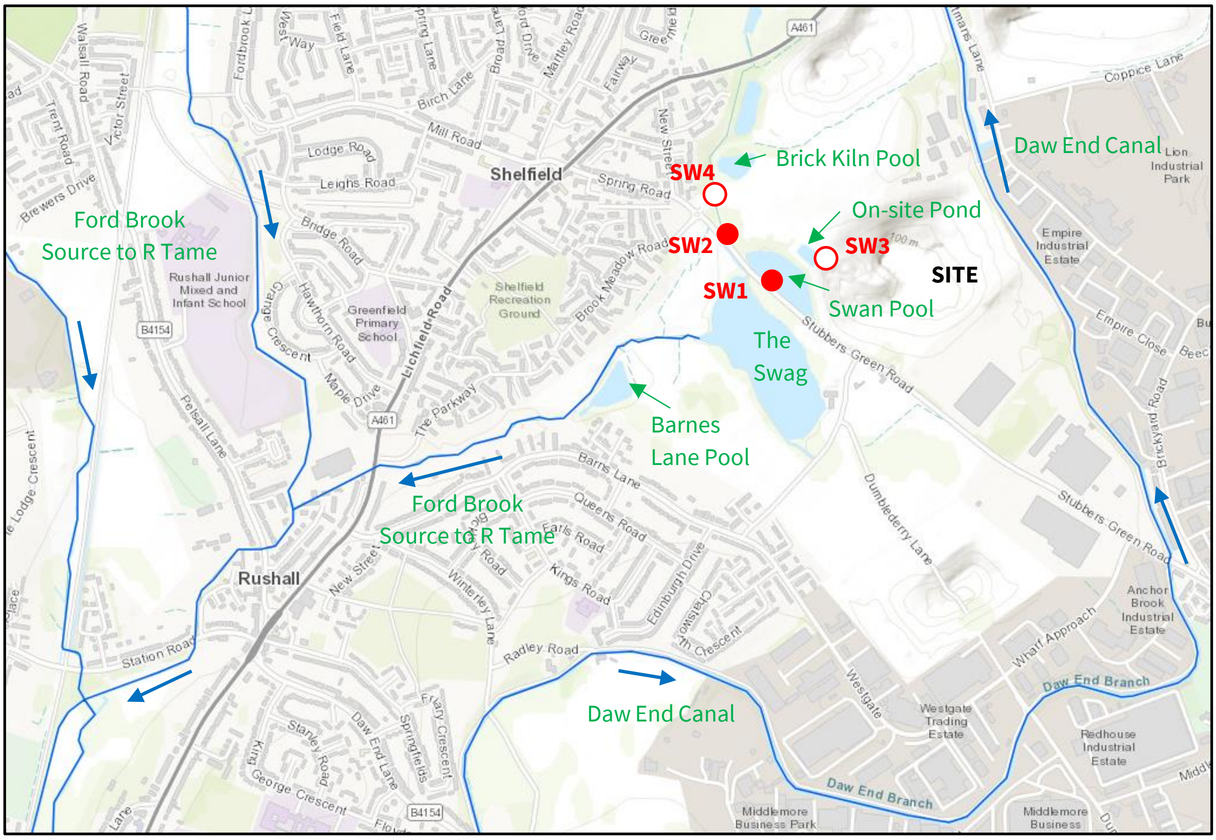
Monitoring post March 2022 from the monitoring locations depicted on Figure 21 has not reported the presence of methane at any location, all reported at <0.1%. Monitoring schedules and frequencies proposed are detailed in report 5430-BLP-R-009-02.

3.9 Hydrology

Off-site

The Daw End Canal (part of the Wyrley and Essington Canal) flows parallel to then eastern boundary of the site, the canal is a man-made lined water system and is topographically higher than the site (towpath at ~143mAOD), as such there are no hydrogeological or surface run-off linkages to this water feature. According to the Canal and River Trust, the Daw End Canal is 5.4 miles in length, local works recently have been undertaken to eradicate invasive aquatic species (Floating pennywort and water fern). The surrounding area contains numerous ponds, some of which have been designated as SSSI's (see Section 1.4). These ponds are named Brick Kiln Pool (not a SSSI), located to the north (topographically above the site), Swan Pool, The Swag and Barnes Lane Pond to the west (Figure 23).

Figure 23 Location of Nearby Surface Water Features



SW1 and SW2 are positions of monitoring for baselining purposes. SW3 (on-site pond) will be incorporated the monitoring scheme during and throughout the infilling period, then monitored post restoration as the sites discharge point. A further point (SW4) should be identified and included if possible (upstream of the site discharge to monitor effects from the "Brick Kiln Pool" area and potential effects derived from the north.

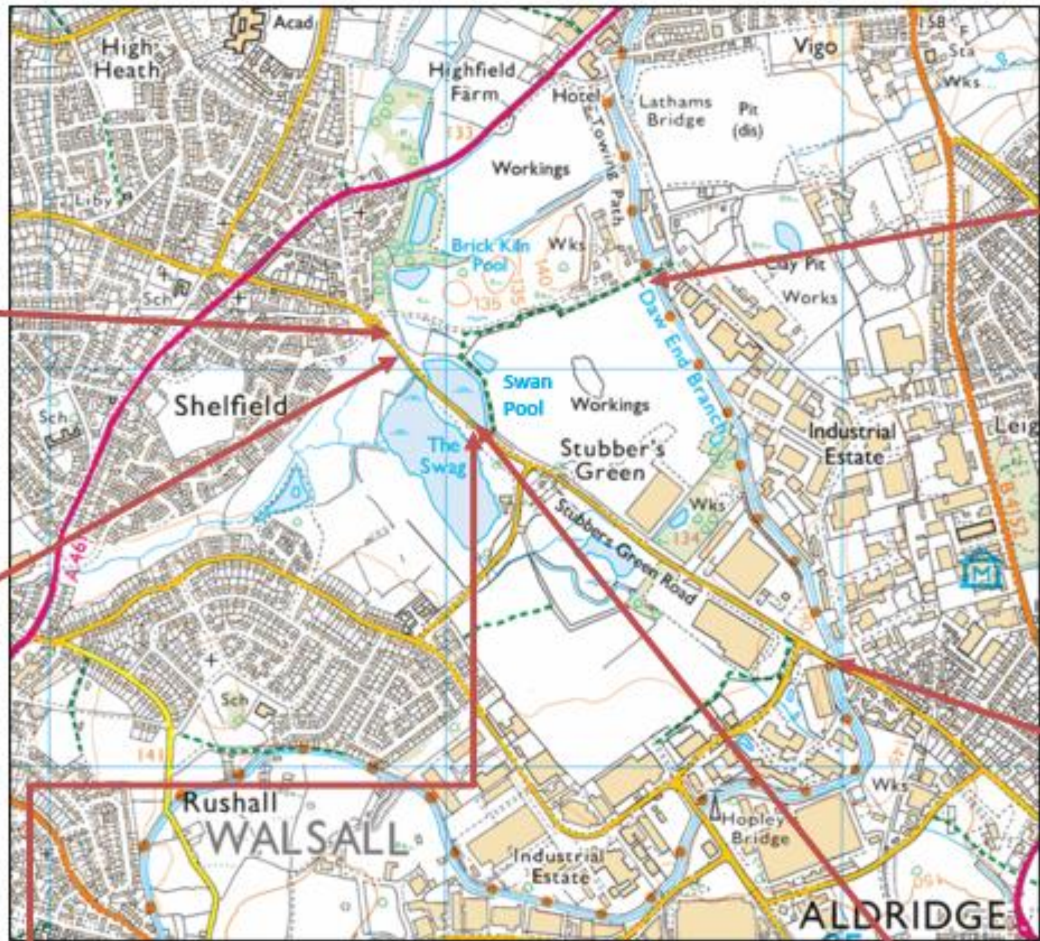
The site drainage (towards the northern discharge point of consent T/08/35782/T, outlet A) enters a "drain" system referred to as part of Vigo Brook. The watercourse takes a contribution of flow from ponds to the north (e.g. Brick Kiln Pool adjacent to Butterley Hole Landfill and further north, adjacent to Highfields South Landfill) and additional surface water drainage between the two sites (on the southern flanks of Highfields South Landfill).

The Brook also takes a contribution upstream from the north of Walsall Road in areas associated with allotment usage (adjacent to Greenfields Road / Green Lane) and drainage from the Jockey Fields SSSI. The site drainage to Vigo Brook flows (via a short ~130m ditch) proceeds through outlet A then flows towards Stubbers Green Road and the road culvert (Figure 24).

Flow towards "The Swag" SSSI is within the heavily vegetated ditch adjacent to Stubbers Green Road (Figure 24). Surface water linkages from Swan Pool to the Swag (culvert connection under Stubbers Green Road) are illustrated pictorially and described on Figure 24.

Figure 24 Local Hydrology

Drain with flow from "Brick Kiln Pool" area at Culvert with Stubbers Green Road. Headwall and secondary inflow from ditch adjacent to the roadside verge which continues towards the roundabout. View Northwest.



View Southeast, Wyrely and Essington Canal (Daw End Branch).

View South, adjacent to Stubbers Green Road showing "The Swag" and roadside ditch connection.

View North, Wyrely and Essington Canal (Daw End Branch).

Twin Culvert at Stubbers Green Road, flow into "The Swag". View Northeast.

Swan Pool, culvert between this pool and the "The Swag" is within the reeds. View Northwest.

Swan Pool, culvert in foreground, view Northeast.

According to on-line data sources (https://www.wwf.org.uk/uk-rivers-map) the Swag drains towards the west to Barnes Lane Pool, which then flows as one of three local tributaries referred to as "*Ford Brook, from Source to River Tame*". The River Tame is ~ 6.7km to the southwest beyond the Walsall Ring Road (Broadway) and the M6.

There are no hydrogeological linkages to the surface water systems / ponds to the north (e.g Brick Kiln Pool). Monitoring requirements in association with site surface water run-off during the infilling phase is discussed in report 5430-BLP-R-009-02, assessment of potential surface water impact is detailed in report 5430-BLP-R-006-02.

Monitoring has been undertaken to date at two locations; results are presented in Table 11. Further analysis / baseline data collection is ongoing. Location SW1 is Swan Pool, SW2 is at the ditch / Vigo Brook prior to the culvert that passes beneath Stubbers Green Road (Figure 24). There are no direct linkages from the site to Swan Pool.

Table 11 Surface Water Matrix Constituents (mg/l) 2022

Location		EC µS/cm	NH_4-N	Chl	Ca	Mg	Na	K	SO_4	Alk
SW1	30/06/22	1,810	0.3	114	60	12	68	8	17	157
Swan Pool	09/09/22	640	0.3	114	65	12	67	9	30	138
SW2	30/06/22	7,540	4.6	115	87	16	68	15	89	199
Vigo Brook	09/09/22	716	1.8	81	97	16	48	12	130	149

Swan Pool, SW2 – Vigo Brook at the culvert with Stubbers Green Road.

The data collected to date indicates some variability, particularly in the ammoniacal-N concentration at Vigo Brook.

On-site

During the operational / infilling phase, monitoring will be undertaken additionally at SW3 for discharged water quality until the pond enlargement is undertaken (ESID 12, ESID 13 – drawing 07200-100 – Rev 4). At that point SW3 will move locations to the new discharge location. Monitoring schedules and frequencies proposed are detailed in report 5430-BLP-R-009-02.

Report 07200/SWMP/R02 (Appendix D) outlies that discharge to a watercourse is the most favoured feasible option in the SUDS hierarchy for all areas of the restoration where flows can reach the Vigo Brook watercourse by gravity.

The first pond is the existing pond that will be used for both sediment control and attenuation volume. A second pond is to be constructed to provide further attenuation volume.

Discharge rates and associated modelling is discussed further in report 07200/SWMP/R02 and addendum (Appendix D). "*The two attenuation ponds providing a total available attenuation storage volume of 5,900m3. The maximum final discharge to the brook is limited to 4.01l/s/ha (74.75l/s total) in all storms up to the 1:100 year plus 40% climate change event with no surface flooding*". Final pond details will be agreed through the determination of the twin tracked Planning Application.

4 Receptors and Compliance Points

4.1 Groundwater /Porewater

It has been determined, hydraulically and chemically that the groundwater in the Etruria Formation has no resource value (information contained herein and assessed in report 5430-BLP-R-006-02). However, for completeness and based on current guidance[39,40,41] the following compliance points (and positions) are proposed:

- For Hazardous substances the compliance point is the edge of site monitoring point. In reality, it is anticipated that hazardous substances (of concentrations that could cause environmental harm) are not expected to be present within the source term based on the proposed waste types;
- For non-hazardous pollutants the principal receptor is porewater which practically is taken to be the Site's monitoring locations (at a pragmatic monitoring location). The compliance criteria will normally be Environmental Assessment Limits (EALs) typically developed by reference to UK Drinking Water Standards (or relevant equivalent) or Environmental Quality Standards (or relevant equivalent).

There are no known groundwater abstractions at risk from the proposed scheme, hydrogeologically the site is in a "low sensitivity" setting. The water quality is not potable and is significantly impacted on the "down-dip" direction to the north.

Around the site periphery, interburden / overburden material are present at variable depths / thicknesses which are not considered a receptor.

As such, water contained within this material is also not a receptor. However, based on good environmental practice, the water quality will be monitored (if present) albeit there are no requirements for compliance points to be assigned or limits set. The lateral thickness of this material is significant (from the infill scheme to the monitoring points). Based on the site investigation it is apparent that lateral thickness (as a minimum to the monitoring locations) is between 15m and 135m at BH22-01, 12m and 55m at BH22-02S / 2D and 20m and 110m at BH22-04S / 4D.

4.2 Surface Water

There are no surface water receptors on the site, the adjacent Swan Pool is topographically equivalent to the current surface water settlement pond. As such, this pond is above the infill and hence is not at risk from the scheme.

During operation, the current on-site pond will be monitored in line with the current discharge consent at a designated point SW3. The pond is to be enlarged accordingly to accommodate flow from the final landform / restored surface, as such the surface water run-off from the restored site

[39]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/602593/Groundwater-discernibility.pdf

[40]https://www.gov.uk/government/publications/groundwater-protection-technical-guidance/groundwater-protection-technical-guidance#discernibility

[41]https://www.gov.uk/guidance/groundwater-risk-assessment-for-your-environmental-permit#identify-compliance-points

will continue to be monitored at SW3 (in the longer term) however at a slightly revised location dependant on the position of the final outfall (to be constructed).

Monitoring will be undertaken at SW2 as a reference check against discharged water from site at SW3. At SW2, flow continues under Stubbers Green Road towards the Swag which is referenced as the primary surface water receptor. It is noted that SW2 can be influenced by upstream sources, such as those from Brick Kiln Pool / Butterley Hole Landfill run-off (and associated access road) or discharges from Highfields South Landfill, as such there are no requirements to monitor the water quality of the Swag.

As the site surface water is to be collected, managed and diverted to the enlarged “on site” pond there can be no influence on the adjacent Swan Pool. Monitoring however at SW1 will continue in the short term (until restoration is complete) in line with good practice and to record baseline conditions for refence against data collected at SW2 and SW3.

4.3 Amenity

The nearby receptors are identified within Table 1 and are described briefly within this document. An Amenity Risk Assessment (H1) has been undertaken and is provided as part of the permit application (report 5430-BLP-R-004-02). The assessment includes qualitative assessments of dust, odour, mud, noise, bird, insect and vermin and includes consideration of the on-site processing / screening is provided therein, including mitigation and appropriate controls and monitoring. Receptor locations are provided on drawing ESID 2 and ESID 3.

4.4 Habitats

A Habitats Assessment has been provided in report 5430-BLP-R-004-02, this wider assessment details the potential hazards presented by landfilling activities on the European Site and will include mitigating measures which prevent an adverse impact on the integrity of the European Sites.

As outlined in Section 1.4, a ‘Nature and Heritage Conservation Screening Report’ (ref: EPR/LB3107UP/A001) has also been obtained. The Screening Report highlighted that there are no Special Areas of Conservation (SAC), Special Protection Areas (SPA), RAMSAR sites within screening distances however there are Sites of Special Scientific Interest (SSSI) and Local Naturel Reserves (LNR) located nearby.

The Screening Report is attached as Appendix A and is also included within the associated H1 Environmental Risk Assessment (Report 5430-BLP-R-004-02).

4.5 Source – Pathway – Receptor Framework

A simple conceptual model can be constructed for the Site, based on the relationship

Source → Pathway → Receptor

Where the:

- Source is the Qualifying Materials used to fill the void;
- The Pathway is the basal and sidewall engineering and the geological pathway towards a water resource; and
- The Receptor is an underlying or adjacent water resource.

Source:

- Leachate / soil porewater generated by the Qualifying Material fill within the engineered contained site.

Pathway:

- Diffusive transport through the basal and sidewall liner (advective flow if infill leachate / porewater levels are above groundwater porewater levels), mixing with porewater and (and dispersion) in the direction of groundwater / porewater flow.

Receptor:

- For Hazardous Substances – porewater at the down-gradient boundary of the landfill, (including dilution)
- For Non-Hazardous Substances – porewater at the down-gradient boundary of the landfill (pragmatically positioned peripheral monitoring boreholes).

Although the Etruria Formation are classified as a Secondary A Aquifer and are the first aquifer beneath / adjacent to the site that any migrating leachate / soil porewater could encounter, due to the poor water quality (particularly to the north) and hydraulic properties, the unit is not considered a receptor but could "in theory" provide a pathway to any downgradient receptors that are fed by porewater from the formation.

Considering the encapsulated nature of these layers within bulk low-permeability mudstones however, this is also considered highly unlikely. Notwithstanding the above, the progressively deepening sequence (in a northerly direction) also indicates that if any layers that are present they will not contribute are link to surface water courses.

5 Monitoring

A rationalised schedule is proposed in the supporting monitoring plan, this is derived based on risk assessment and targeted specifically towards potential sensitive receptors. Relevant guidance has been reviewed including LFTGN02 (Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water) and aftercare monitoring detailed within How to surrender your environmental permit Additional guidance for: Landfill (EPR 5.02) version 2, September 2014.

Monitoring and inspection details are provided in report 5430-BLP-R-009-02.

5.1 Leachate Monitoring

No leachate monitoring will be required as the infilling Qualifying Materials have very low content of putrescible matter, therefore the production of "free porewater" or leachate is anticipated to be minimal (see Section 2.8). Notional monitoring is proposed in accordance with similarly permitted sites with leachate spine drains (ESID 7A) and a vertical chamber in the base of the cell (ESID 7B).

5.2 Landfill Gas Monitoring

The use of Qualifying Materials as the infill means that there will not be degradable material component that can produce landfill gas (5430-BLP-R-007-02).

Data will be collected from "in-waste" infrastructure as part of a proposed monitoring programme in line with similar applications at other sites 5430-BLP-R-009-02.

5.3 Groundwater / Porewater Monitoring

This aspect is described further in the supporting HRA (5430-BLP-R-006-02) and monitoring plan 5430-BLP-R-009-02.

5.4 Surface Water Monitoring

This aspect is described further in the supporting HRA (5430-BLP-R-006-02) and monitoring plan 5430-BLP-R-009-02.

5.5 Ground Gas Monitoring

No ground gas monitoring will be required in accordance with the proposed infilling scheme, however as part of good practice and to validate the source term, a nominal number of boreholes are proposed adjacent to key amenity receptors. Further detail is provided in report 5430-BLP-R-007-02.

6 Site Condition Report

6.1 Site Report

Background information

The details of the Site including location, proposed permit boundary and surrounding receptors are presented in Section 1. An outline of the proposed development is detailed in Section 2, geology and hydrogeology are described in Section 3.

Assessment Objectives

The 2016 Permit Regulations require that a permit application must be accompanied by a (Baseline) Site Report, which describes the condition of the whole site, not just the landfill. It is a requirement that operators applying for a permit "identify any substances in, on or under land which may constitute a pollution risk". The Site Report needs to be a factual "baseline" account of the land that may later be compared against the findings of a Closure Site Report, or the results of other investigations. It allows pollutants that were present on site prior to the issue of the permit to be distinguished from those that occurred as a result of its operation under the permit.

This section (Section 6) of the Environmental Setting and Installation Design Report constitutes the Site Report for the Sandown Quarry landfill site and is written in line with the Environment Agency's guidance for meeting the requirements of a Site Report. However, the Site Report is not required to provide a "baseline" for areas of permanent deposit of wastes, although this remains a requirement for other areas of the Site, e.g. leachate treatment compound or gas utilisation plant compound, neither of which however form part of this application as they are not required.

The different types of contaminants to be considered at the site include the components of landfill leachate (pore-water) in addition to the activities associated with site's history including the quarrying of clay for brick manufacture.

These are discussed in Section 2 and 3, environmental risk has been covered in reports 5430-BLP-R-004-02 (amenity), 5430-BLP-R-006-02 (groundwater / surface water), 5430-BLP-R-007-02 (gas) and 5430-BLP-R-008-02 (stability).

Site Investigation

A comprehensive ground investigation (GI) program has been undertaken as part of the scheme, these details are included in Section 2, a Groundsure report / historic map search is included at Appendix A, borehole logs are provided at Appendix C. Investigation findings are summarised within this ESID and associated qualitative assessments (5430-BLP-R-006-02, 5430-BLP-R-008-02).

Data Collection

Details relating to the baseline conditions for the site obtained to date are detailed within this permit application, a proposed program of monitoring will be undertaken in accordance with report 5430-BLP-R-009-02. As a result of the final mineral resource removal activities for void preparation, infilling is unlikely to commence for ~2 years.

The further collection of information will include additional groundwater, surface water and perimeter gas data which will further "baseline" the activities prior to waste infilling.

Data Interpretation

The purpose of this section of the report is to define baseline conditions for non-disposal areas of the site prior to the granting of the Environmental Permit. Assessment protocols for the continued monitoring of potential receptors of emissions associated with the Site are presented in the Amenity Risk Assessment (5430-BLP-R-004-02) and the accompanying Emissions and Monitoring Management Plan (5430-BLP-R-009-02). Interpretations of analytical results are provided in the associated technical risk assessments that support the application, a baseline appraisal should be documented prior to waste infilling activities.

Off-waste Areas

A site condition report (SCR) is required for areas of the site where that are not subject to the permanent deposit of waste (i.e. outside the area of engineered landfill) where there may be a significant risk to land or groundwater (e.g. leachate treatment compound – although not relevant to this application). A summary is provided in the Environment Agency H5 template below.

All land is previously modified at the site perimeter and there is no remaining soils / superficial strata present. Initial results indicate porewater in the Etruria Formation is variable and poor, water within the made ground is also poor in quality. In locations to the north of the site boundary, significant impact is observed that is unrelated to the site.

H5 Site Condition Report

1.0 SITE DETAILS	
Name of the applicant	Booth Ventures Waste (Midlands) Ltd (company number 12508267)
Activity address	Sandown Quarry, Aldridge
National grid reference	(NGR) SK 04386 019

Document reference and dates for Site Condition Report at permit application and surrender	Application Documents 5430-BLP-R-001-02 to 5430-BLP-R-009-02 inclusive

Document references for site plans (including location and boundaries)	ESID drawings contained therein (ESID 1 to ESID 13 inclusive)

2.0 Condition of the land at permit issue	
Environmental setting including: • geology • hydrogeology • surface waters	Superficial Deposits and soils (removed through marl extraction activities) Made ground at surface (all boundaries) variable thickness Etruria Formation (variable thickness) 5430-BLP-R-006-02 Underlying and peripheral Etruria Formation strata - chemical and water level data 5430-BLP-R-006-02 Surface Water – no chemical data for surrounding lakes / ponds, no data for course that links to The Swag. Monitoring required as per 5430-BLP-R-009-02, to further document baseline
Pollution history including: • pollution incidents that may have affected land • historical land-uses and associated contaminants • any visual/olfactory evidence of existing contamination • evidence of damage to pollution prevention measures	Previous Mineral Extraction Previous Landfilling (Stubbers Green Road to the south, Butterley Hole / Empire Landfill to the north, Banpiece Swag west, Mitco and numerous sites to the east) – contamination potential and impacts unknown drainage, road constructions, industrial estate, sewerage releases, chemical industries data included in Groundsure Report (Appendix A of 5430-BLP-R-003-02)

Evidence of historic contamination, for example, historical site investigation, assessment, remediation and verification reports (where available)		Groundsure Report (Appendix A of 5430-BLP-R-003-02)
Baseline soil and groundwater reference data		Groundsure Report (Appendix A of 5430-BLP-R-003-02) 5430-BLP-R-006-02, 5430-BLP-R-009-02 Significant modification to the groundwater / porewater are noted from adjacent land uses – prior to site infilling.
Supporting information	• Source information identifying environmental setting and pollution incidents • Historical Ordnance Survey plans • Site reconnaissance • Historical investigation / assessment / remediation / verification reports • Baseline soil and groundwater reference data **See additional information included in:** Groundsure Report (Appendix A of 5430-BLP-R-003-02) 5192/R/003/01, 5192/R/007/01	

3.0 Permitted activities	
Permitted activities	Application for a non-hazardous landfill – the non-landfill areas only. No leachate, gas impact expected to off-waste areas. Fuel storage, vehicle storage to be undertaken with appropriate management / containment practices
Non-permitted activities undertaken	None
Document references for: • plan showing activity layout; and • environmental risk assessment.	Application Documents 5430-BLP-R-001-02 to 5430-BLP-R-009-02 inclusive ESID drawings contained therein (ESID 1 to ESID 12 inclusive)

Appendix A

Appendix B

Appendix C

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Appendix D

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