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THORPE MARSH LANDFILL (EPR/CP3091SC/V002) CONCEPTUAL SITE MODEL REPORT

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1. INTRODUCTION

1.1 Background

Ramboll UK Limited ("Ramboll") have produced this Conceptual Site Model (CSM) report for Thorpe Marsh Landfill (the "site") as part of our ongoing support to West Burton Energy, as Thorpe Marsh Green Energy Hub Limited ("TMGEHL" or herein "the "Client"). The landfill is to be redeveloped into a Battery Energy Storage System (BESS), and the design works are ongoing.

This report provides the pre-and post-intrusive investigation CSM for initial design purposes to support a permit variation application.

Pulverised fuel ash (PFA) was originally deposited at the site from the generation activities of Thorpe Marsh Power station, a 1GWatt coal-fired station, commissioned in 1963 and closed in 1994. It is understood that some of the PFA generated from commissioning in 1963 to 1977 was removed from site and used for construction foundation and fill material during the construction of the local motorway network in the region, prior to waste licensing in the UK. The residual PFA generated to 1977 that was not taken off site was stockpiled onsite up to a height of approximately 10m AOD. Then from 1977 (see below) licensed PFA disposal took place on top of the unlicensed PFA (discussed in detail within Section 4 of this report).

Thorpe Marsh Landfill is a regulated waste disposal site covered by an Environmental Permit (WML number WD20D53, originally granted in 1977, now EPR/CP3091SC/V002). The permit allowed the disposal of PFA as well as domestic, commercial, and industrial wastes from the adjacent Thorpe Marsh Power Station. The landfill was operated prior to the implementation of the 2001 Landfill Directive (LfD) and was designed as a 'dilute and disperse' land-raise landfill. The waste disposal cell was formed by the construction of a three sided, 'U' shaped ("horseshoe") bund using PFA. Within the cell, limited or no PFA deposition took place, due to the closure of the Power Station in 1994 when the landfill was put into closure. In a discrete area at the southern end of the site PFA waste was co-disposed with other permitted waste types. These discrete waste areas are identified in Section 6 and will not be disturbed by the proposed development work.

Despite closure of the Power Station in 1994 the landfill's environmental permit was not surrendered.

The current permit holder is HJ Banks and Company Ltd. A permit transfer application has been submitted (ref. EPR/CP3091SC/T002) to transfer the permit to Thorpe Marsh Green Energy Hub Limited. This transfer application is to be decided alongside the proposed permit variation application.

The proposed redevelopment of the landfill into a BESS will involve submission of a permit variation application for re-opening of the landfill to facilitate the creation of a development platform by re-profiling PFA from both the eastern and western arms of the 'U' shaped bund.

It is understood that PFA is not considered to be inert (as stated in an email from Helen Culshaw of the Environment Agency (EA) dated 9th October 2023) and therefore the LfD standards for hazardous or non-hazardous wastes[1] would apply. However, it was stated that some standards (including the specification of the lining and leachate collection system) could be reduced or removed based on a risk assessment and this aligns with the EAs landfill guidance[2] that allows sustainability to be considered in the design of landfill cells:

[1] Landfill operators: environmental permits - Design and build your landfill site - Guidance - GOV.UK (www.gov.uk)

[2] LFE4 - Earthworks in landfill engineering, Environment Agency, LFE4_earthworks_on_landfill_sites.pdf (publishing.service.gov.uk)

- *"Sustainability: demands that on-site or local materials are used where feasible. The Environment Agency actively encourages the use of low-grade materials, processed to make them acceptable, in appropriate situations within landfills"*

N.B. Directive EC67/584/ECC & Regulation (EC)1272/2008 – substance not classified as hazardous and all COSHH sheets refer to PFA as inert. Also still utilised within the construction industry as inert fill and in the manufacturing of cement as an additive and other cement-based materials.

A conceptual site model (CSM) is required to identify environmental receptors that may be affected by the new landfill cell and also inform the proposed design and operation of the landfill. This CSM considers sources of pollution (including waste, leachate, and landfill gas), pathways and receptors.

This CSM identifies the likely hazards at the site and will be updated over the operation of the landfill. It also informs the risk assessments, design details and management plans that are needed to support the permit variation application.

This CSM includes additional data gathered during ground investigation and monitoring works undertaken in 2024, as informed by a project specific desk study, and therefore supersedes an existing CSM Report completed by Egniol Consulting Ltd[3].

As set out in Section 10.1 (below) guidance within the LfD clearly states that following a robust, staged, risk assessment approach is acceptable in determining the engineering requirements of new landfill cells. Ramboll has therefore in producing this CSM report, followed such an approach taking account of the historical, and recent data to provide a sustainable and proportionate design.

As previously stated by the EA[4], any material not forming part of the new PFA landfill cell will continue to be regulated under the current WML conditions.

1.2 Objectives and Scope of Works

Key objectives of this CSM report are to:

- Assess potential risks associated with contaminant source-pathway-receptor linkages associated with the site in its current condition;
- Inform the design of the landfill cell; and
- Using available historical and current data, update the CSM to take account of the mitigation measures provided by re-opening the landfill and movement of PFA to create the proposed BESS development.

The scope of the CSM report has included the following:

- Examination of published records and plans on the shallow and deep geology and hydrogeology of the site to assess the vulnerability and sensitivity of groundwater and surface water resources to contamination, if present, and the possible direction of movement off site (if mobile contamination is present);
- Review of all available site-specific soil and groundwater data, including that collected during the 2024 ground investigation and monitoring works to assess potential linkages and risks to identified receptors; and

[3] Thorpe Marsh, Former Waste Disposal Site, Conceptual Site Model, Egniol Consulting Ltd, reference ECL.7991.R03.002 dated December 2020.

[4] Record of Meeting Minutes: Thorpe Marsh: Meeting with Environment Agency Application Ref: EPR/CP3091SC/V002 CM/NE/4181/PL-04 .Held on Thursday, 10 February 2022 via Microsoft Teams Commencing at 1.00pm.

- Review of historical records of the landfill during the operational activities of the power station.

1.3 Constraints and Limitations

This report has been prepared by Ramboll exclusively for the intended use by the Client in accordance with the agreement between Ramboll and the Client defining, among others, the purpose, the scope and the terms and conditions for the services. No other warranty, expressed or implied, is made as to the professional advice included in this report or in respect of any matters outside the agreed scope of the services or the purpose for which the report and the associated agreed scope were intended, or any other services provided by Ramboll.

In preparation of the report and performance of other services, Ramboll has relied upon publicly available information, information provided by the Client and information provided by third parties. Accordingly, the conclusions in this report are valid only to the extent that the information provided to Ramboll was accurate, complete, and available to Ramboll within the reporting schedule. Ramboll did not undertake full time supervision of the site investigation, and so has had to rely on the Client providing much of the general information on the works.

Ramboll's services are not intended as legal advice, nor an exhaustive review of site conditions and / or compliance. This report and accompanying documents are initial and intended solely for the use and benefit of the Client for this purpose only and may not be used by or disclosed to, in whole or in part, any other person without the express written consent of Ramboll. Ramboll neither owes nor accepts any duty to any third party, unless formally agreed by Ramboll through that party entering into, at Ramboll's sole discretion, a written reliance agreement.

Unless otherwise stated in this report, the scope of services, assessment and conclusions made assume that the site will continue to be used for its current purpose and end-use without significant changes either on-site or off-site.

The ground investigation works described were undertaken during a discrete period of time. The findings and conclusions presented in this report are accordingly factually limited by these circumstances. The previous field investigations were restricted to a level of detail necessary to meet the stated objectives of the services. The results of any measurements taken may vary spatially or with time and further confirmatory measurements should be made after any significant period of time has elapsed since the sampling took place. The interpretation of the geological and environmental quality conditions is therefore based on extrapolation from point-source data in a heterogeneous environment (i.e., the site conditions are not fixed; chemical quality will vary over time and also reflecting the variable nature of ground permeability).

Unless stated otherwise, the geological information provided is for general environmental interpretation and should not be used for other geotechnical and / or design purposes.

2. SITE DESCRIPTION

The site is located to the west of the former Thorpe Marsh Power Station (which was active between 1963 and 1994), approximately 6 km north of Doncaster town centre. The approximate centre of the site is at National Grid Reference 459480, 409490. A site location plan is presented as Figure 1, Appendix 1.

The original permit installation boundary drawing associated with WML number WD20D53 is shown on Figure 2, Appendix 1. The total permit site area extends to approximately 61 Ha (hectares). This includes c.17 Ha of land to the west which is currently occupied by the Thorpe Marsh Nature Reserve and the eastern 44 Ha comprises the former Thorpe Marsh Power Station pulverised fuel ash (PFA) landfill. The landfill plot is unsurfaced and is mostly covered by naturally regenerating grassland and some small areas of scrub / woodland. The outer flanks were spread with thin layer of topsoil historically and there are isolated areas of hard standing and surfaced roads.

The site topography is dominated by the deposited waste (PFA) that rises above the surrounding ground. The site levels vary between approximately 0m AOD in the south of the site (i.e., similar to surrounding ground level) to 24 m AOD at the top of the bund. A topographical survey was undertaken in February 2024 and is presented as Figure 3, Appendix 1.

The surrounding land use comprises predominantly agricultural land including the following:

- To the north, the existing Network Rail freight line with agricultural fields and minor roads beyond. Approximately 0.9 km from the northern boundary is the village of Thorpe-in-Balne.
- To the east, the former Thorpe Marsh (coal-fired) Power Station site (now demolished) and the existing National Grid 400 kV Thorpe Marsh Substation. Further to the east, Thorpe Bank (road), the River Don (approx. 1km), agricultural fields, and the River Dun Navigation. Approximately 1.5 km from the eastern boundary is the village of Barnaby Dun.
- To the south, the EA Beck (also referred to in documentation as the Thorpe Marsh Drain), agricultural fields and Fordstead Lane (road). Approximately 2 km from the southern boundary is the village of Arksey.
- To the west, the (Yorkshire Wildlife Trust managed) Thorpe Marsh Nature Reserve (with Thorpmere Pond present) followed by agricultural fields and another Network Rail line beyond. Approximately 4.75 km from the western boundary are the towns or Adwick-le-Street and Carcroft.

The raised Ea Beck is present approximately 90 m south and it is flanked by levees. Beyond the Ea Beck there is a further ground level drain located from approximately 20m with a network or drains in the wider agricultural land.

3. PREVIOUS REPORTS

Reports pertaining to the site, their objectives and scope of works are summarised below, with the reports included as Appendix 2.

3.1 September 1994, Hydrogeological Investigation and Waste Disposal Assessment[5]

Geraghty & Miller undertook investigations into the geological, hydrogeological and geotechnical conditions on-site to assess for the requirements and suitability of the facility for further waste disposal purposes (which did not take place).

The scope of works included a ground investigation (comprising of advancement of 16 boreholes, well installation, in-situ testing, geotechnical testing and groundwater and surface water testing), slope stability analysis and assessment of options for future site uses.

This report presents the findings on groundwater flow and quality, information on the engineering and chemical properties of the PFA and natural soils, and the quality of PFA leachate and its current impact on the groundwater resources, and assessment of the suitability of the site for development as a landfill for the disposal of further non-hazardous wastes.

3.2 March 2000, Completion Report on Construction of Intake Pipe Lagoon and Remedial Works to Slope[6]

ARCADIS Geraghty & Miller International Inc (ARCADIS GMI) produced a completion report on the construction of a gabion intake pipe lagoon at the site.

The objective of the works was to construct a lagoon and intake pipe protection at the location of the surface water drainage intake pipe internal to the south-western corner of the U-shaped bund, which had becomes silted up. Remediation works were also undertaken on the erosion gullies and a slip scar at the tow of the inner side of the U-shaped mound in the south.

The scope of works comprised of removal of silt and saturated PFA around the intake pipe; construction of the lagoon; construction of a sump adjacent to the intake pipe and slope stability works. Figure 3-A, below, shows the construction of the lagoon and associated pipework's.

Figure 3-A - Construction of the lagoon and intake pipe protection[4]

[5] Geraghty & Miller International Inc, 1994. Hydrogeological Investigation and Waste Disposal Assessment Main Technical Report. Dated: September 1994.

[6] ARCADIS Geraghty & Miller International Inc., 2000. Completion Report on Construction of Intake Pipe Lagoon and Remedial Works to Slope. Thorpe Ash Mound, Thorpe Marsh Power Station Doncaster. Ref: 90560.03, Dated: March 2001

3.3 January 2002, Ground Investigation at Thorpe Marsh, South Yorkshire[7]

H.B. Boring and Company Limited undertook a geotechnical ground investigation in October to November 2001 on behalf of Wardell Armstrong and presented the factual information within the report. No objectives or contextual information was given, and it is presumed that the ground investigation was undertaken to obtain geotechnical data at the site.

The scope of works comprised of advancement of cable percussive boreholes (total of eight boreholes, MW6 to MW13, to maximum depths of between 15.00 m and 36.50 m); in-situ geotechnical testing, sample recovery and laboratory testing. All boreholes were installed with slotted sections to allow for groundwater level monitoring and recording of soil gas concentrations.

3.4 March 2019, Environmental Management and Monitoring Plan[8]

TerraConsult prepared a report to identify groundwater, surface water and landfill gas monitoring requirements at the landfill site based on three scenarios; requirements which align with the permit and associated Working Plan; requirements recommended based on information held by TerraConsult; and requirements to support an eventual application to surrender the permit.

3.5 July 2021, Drilling and Ground Investigation Factual Report[9]

Egniol Consulting Limited (Egniol) were appointed by H.J Banks & Company Limited to carry out a ground investigation to obtain geological data across the site and to re-instate gas and groundwater monitoring boreholes within the waste (PFA), drift and sandstone geologies.

The scope of works comprised advancement of six replacement ground gas monitoring boreholes (BH1 to BH6), targeting the U-shaped bund; advancement of five boreholes around the perimeter with combined ground gas and groundwater installations of the underlying drift deposits (MW1D, MW4D to MW7D); and advancement of three additional perimeter boreholes with combined ground gas and groundwater installations of the underlying sandstone bedrock (MW4S, MW5S and MW7S). Two additional wells were installed in close proximity to the original location of MW2 and MW3 wells.

3.6 February 2022, Environmental Monitoring Plan[10]

Egniol prepared an Environmental Monitoring Plan (EMP) on behalf of H.J. Banks for the former waste disposal site, to facilitate compliance with the site's environmental permit and discharge consent. The EMP considers the landfill gas, surface water and groundwater monitoring requirements. Leachate monitoring was recommended, although noted to not be a requirement for the permit.

3.7 November 2022, Ground Investigation Report[11]

Egniol undertook a ground investigation on behalf of Banks Minerals for the proposed site redevelopment with a BESS.

The objective of the ground investigation was to confirm the suspected location of non-PFA (commercial) waste material which was deposited on-site during the power station activities; and to classify the PFA materials in the U-shaped bund to inform preliminary earthworks specification.

The scope of works comprised review of desk-based information such as the site geology, hydrogeology; advancement of six shallow trial pit exploratory holes (TP01 to TP06) in the area

[7] Wardell Armstrong, 2002. Ground Investigation at Thorpe Marsh, South Yorkshire. Ref: C2812, Dated: January 2002.
[8] TerraConsult, 2019. Thorpe Marsh Landfill Site. Environmental Management and Monitoring Plan. Ref: 4288/R/01/01. Dated: March 2019.
[9] Egniol Consulting Limited (Egniol), 2021. Thorpe Marsh Former Waste Disposal Site. Drilling and Ground Investigation Factual Report. Ref: ECL.7991.R06.001. Dated: July 2021.
[10] Egniol, 2022. Thorpe Marsh Tip. Environmental Monitoring Plan. Ref: ECL.7991.R03.001, Rev: D. Dated: February 2022.
[11] Egniol, 2022. Thorpe Marsh BESS. Doncaster. Ground Investigation Report. Ref: ECL.9463.R06.01. Dated: November 2022.

of the suspected commercial, or non-PFA, waste and geotechnical testing. One sample of the non-PFA (waste) material was sent for environmental testing purposes.

3.8 May 2023, Annual Environmental Monitoring Report - 2022 Review Period[12]

Egniol, on behalf of H.J Banks and Company Limited, prepared a report reviewing the monitoring data for 2022, in accordance with the site's environmental permit.

Egniol presented the obtained landfill gas, surface water and groundwater data and commented on the obtained concentrations against the compliance limits, where those have been previously set.

3.9 May 2023, Environmental Monitoring Technical Note[13]

Egniol prepared a Technical Note for Banks Group in relation to the detected concentrations within the groundwater samples against the surface water assessment criteria. It was recommended that monitoring wells MW5D and MW7D were decommissioned (due to well screens spanning two strata types) and re-drilled to provide good quality installations in these locations, with response zones within the drift only. These recommendations were completed and reported in the September 2023 report (see Section 3.11, below).

3.10 June 2023, Former Waste Disposal Site. Conceptual Site Model - Updated[14]

Egniol, on behalf of H.J. Banks and Company Limited, produced a CSM to support a future surrender or variation of the site Environmental Permit and inform the design of future ground investigation and monitoring works to be undertaken at the site.

The scope of works comprised a desk-based review of the site's environmental setting, history, identification of potential receptors and classification of the risks to the receptors from the identified sources and pathways.

3.11 September 2023, Installation of Replacement Perimeter Gas Monitoring Wells Construction Quality Assurance Report [15]

Egniol, on behalf of H.J. Banks and Company Limited, decommissioned two monitoring wells (MW5D and MW7D) and installed two new replacement monitoring wells (MW5DA and MW7DA). The report was to provide Construction Quality Assurance of the works undertaken, as well as compliance with the EMP which was approved by the Environment Agency (EA) in May 2021.

3.12 October 2023, Phase I Geotechnical & Contaminated Land Desk Study[16]

Ramboll, on behalf of West Burton Energy Limited, prepared a Phase I Geotechnical & Contaminated Land Desk Study of the proposed BESS. The report provided a summary of the site history, review of environmental databases and detailed summary of the third-party intrusive investigation reports summarised above.

Further ground investigation was recommended to confirm and fully characterise the ground conditions beneath the site and to allow a geotechnical ground model to be developed (based on the proposed end-use) and to further understand risks to sensitive receptors. The investigation would also provide additional information to address future environmental planning conditions and input into planned environmental permit variation(s). A revised CSM report would then be prepared (this report).

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[12] Egniol, 2023. Thorpe Marsh Landfill Site. Annual Environmental Monitoring Report. Ref: ECL.7991.R03.006. Rev: A. Dated: May 2023.

[13] Egniol, 2023. Thorpe Marsh. Environmental Monitoring Technical Note. Ref: 7991.ECL.TN03.001. Rev: A. Dated: May 2023.

[14] Egniol, 2023. Thorpe Marsh Former Waste Disposal Site. Conceptual Site Model - Updated. Ref: ECL.7991.R03.002. Rev: D. Dated: June 2023.

[15] Egniol, 2023. Thorpe Marsh Landfill Site. Installation of Replacement Perimeter Gas Monitoring Wells. Construction Quality Assurance Report. Ref; ECL.7991.R02.001. Dated: September 2023.

[16] Ramboll, 2023. Project Harrier; Thorpe Marsh Battery Energy Storage System (BESS) Phase I Geotechnical & Contaminated Land Desk Study. Ref. 1620016237-RAM-RP-SS-00001_2.0. Dated: October 2023.

3.13 February 2024, Annual Environmental Monitoring Report - 2023 Review Period[17]

Egniol, on behalf of H.J Banks and Company Limited, prepared a report reviewing the monitoring data for 2023, in accordance with the site's Environmental Permit.

Egniol presented the obtained landfill gas, surface water and groundwater data and commented on the obtained concentrations against the compliance limits, where those have been previously set.

3.14 May 2024, Factual Ground Investigation Report[18]

Ground Engineering Ltd (GEL) undertook a ground investigation between January and April 2024 which included drilling of 22 cable percussion boreholes (prefix RBH) and excavation of 27 trial pits (prefix RTP), with installation of sixteen monitoring wells. In-situ geotechnical testing was undertaken with the collection of samples for geotechnical and environmental laboratory analysis. This was specifically designed and completed to inform this CSM and the permit variation application.

[17] Egniol, 2024. Thorpe Marsh Landfill Site. Annual Environmental Monitoring Report. 2023 Review Period. Ref: ECL.7991..R03.006 Rev: 1. Dated: February 2024.

[18] Geotechnical Engineering Ltd, 2024. Thorpe Marsh Green Energy Hub: Battery Energy Storage Scheme (BESS), Factual Ground Investigation Report. Ref: 38004 Draft. Dated: May 2024.

4. SITE HISTORY

4.1 Historical Map Review

Ramboll has undertaken a review of publicly available information, and historical mapping and aerial imagery (where available) obtained from a proprietary environmental database and reported it within the Ramboll 2023 Phase I Geotechnical & Contaminated Land Desk Study[19] (presented in Appendix 2). The history of the site and surrounding area are summarised below:

- **1893:** The site is divided into agricultural fields, with drains along some of the east to west running field boundaries (later marked as Applehurst Drain in the north-east, with Stocking's Drain further south, which extends to the eastern site boundary). The Ea Beck is indicated to be present approximately 90 m south of the site on raised embankments. Norwood Sluice is noted on the Ea Beck approximately 100 m to the south. A footpath is shown at the southern end of the site, transecting roughly east to west. A railway line (West Riding & Grimsby) is adjacent to the northern site boundary.
- **1955-56:** There are no significant changes to the site until around 1955 to 1956, when Applehurst Lane is labelled in the north of the site area, and Ramsden Bridge is marked to the north-east on EA Beck. Small ponds are noted in the north-east, centre and south of the site area. Generally, ponds and drains line the eastern, southern and western site boundaries during this time. Thorpe Marsh Power Station and associated infrastructure are shown from approximately 450 m east.
- **1966-70:** The late 1960s mapping editions depict the northern portion of the site to be covered in water, with Applehurst Drain feeding into it in the north-west of the site. A Slag Heap is denoted in the north-east corner of the site. The southern portion of the site has remained undeveloped. Elongated ponds are now shown between the perimeter of the site and Ea Beck to the south-east. A drain is shown to connect one of the ponds with the drain located just inside the site boundary.
- **1978-84:** Construction of internal roads within the site; Field Station Road and Ash Fields Road in the north; Plantation Road in the east; and Thorpe Mere Road in the west. Lower Boundary Road is present immediately south and south-east of the site and extends to the west from the south-western boundary. Water and the slag heaps are no longer depicted on site, and Ash Tip is annotated towards the south of the site.
- Stockings and Applehurst Drains are no longer depicted on site. Thorpemere Pond, which is part of the Thorpe Marsh Nature Reserve, is present 70 m west of the site. Numerous drains are shown in the vicinity of the site.
- **Late 1980s:** There are discrete areas of vegetation (trees and similar) along the southern perimeter and in the east of the site. Tracks appear to be present in a roughly crescent shape around the western, southern and eastern boundaries. Thorpemere Pond has been extended northwards to also include a smaller pond.
- **1990s:** In 1996, the U-shaped bund is shown and the railway adjacent to the northern boundary of the site has been labelled as Dismantled. Ponds are noted on the southern bank of the Ea Beck to the south of the site, and a water pumping station is now present in close proximity of the south-western site boundary. By 1999, the main buildings associated with the power station have been demolished with only the electrical sub-station and cooling towers remaining. The Google Aerial historical imagery[20] indicate that the cooling towers were demolished between 2009 and 2014.

[19]Ramboll, 2023. Project Harrier; Thorpe Marsh Battery Energy Storage System (BESS) Phase I Geotechnical & Contaminated Land Desk Study. Ref. 1620016237-RAM-RP-SS-00001_2.0. Dated: October 2023.

[20] Google Earth Pro, 2024 Version 7.3. Accessed: March 2024.

The site has not undergone any further significant changes in the later mapping editions.

4.2 Anecdotal Evidence

Construction of Thorpe Marsh Power Station began in 1959, with operation from between 1963 and 1965, before it was officially opened in 1967. Excavation of land to the west of the power station (assumed to be within the landfill boundary) provided red shale to raise the foundation level. A total of 1 million tons of red shale and ash was used to raise and level the site[21].

A booklet on Thorpe Marsh Power Station from 1967[22] states that the finer fly ash was dampened and discharged into lorries, before it was taken to the station ash fields or sold direct for use on civil engineering projects. Approximately 100 tons of ash per hour was generated by the power station boilers, of which 30 tons was coarse ash, with the remainder fine fly ash.

The 1994 HRA[23] states that the site of the PFA landfill was a borrow pit to provide material for the railway embankments to the north. This then flooded with water naturally (as it was below ground level) and became a wildlife habitat (historical mapping from 1966 to 1980 show water or a lagoon in the north-west of the site).

Initial ash deposition is shown to be in the north-east of the site only on mapping between 1966 and 1980), with deposition in the south shown in mapping from 1982 onwards.

Anecdotal evidence suggests that a 10m high bund was created in the 1970s, although mapping from this time shows the area as fields. It should be noted that the original WML was granted in 1977 and the exact volume of PFA deposited pre and post licensing is not known. However, given the volume generated per hour by the power station it is likely that PFA was placed prior to the WML being in place in at least a proportion of the landfill area.

To facilitate ash disposal into the pond created on-site by earlier material excavation, a replacement pond was constructed to the west to retain the wildlife habitat (the current Thorpe Marsh Nature Reserve), which opened in 1980 and is shown on historical mapping from 1982. The material from the new ponds (assumed to be mainly clay and silt), was deposited in a low bund immediately adjacent to the eastern side of the new ponds and parallel with and possibly beneath Thorpe Mere Road. The first PFA was deposited in the old ponds located within the north-west of the earlier bund. In addition, Ramboll notes that as some clay was removed in this area, there will be a slightly reduced thickness of superficial deposit under the current landfill. Specific ground conditions are discussed later in this report.

The height of the bund was subsequently increased again to 20 meters in 1990 to allow additional storage and this represents the U-shaped bund that will be relocated to form the BESS development platform, i.e., the subject of this permit variation application.

The power station closed on 31st March 1994 and no subsequent material was deposited in the landfill.

[21] https://priorieshistoricalsociety.blogspot.com/2012/03/article-history-of-thorpe-marsh-power.html

[22] https://www.flickr.com/photos/robdaniels/albums/72157624390102313/

[23] Geraghty & Miller International Inc, 1994. Hydrogeological Investigation and Waste Disposal Assessment Main Technical Report.

5. GEOLOGY

5.1 Published Geology

According to BGS records, the site is directly underlain by the Hemingbrough Glaciolacustrine Formation (Clay, Silty) on site (Unproductive Strata), and off-site Alluvium (Clay, silt, sand and gravel, Secondary Aquifer) immediately east of the site, parallel to the Thorpe Marsh Drain.

The superficial deposits are underlain by bedrock geology of the Chester Formation (Sandstone, pebbly / gravelly), part of the Sherwood Sandstone Group.

Regional geology maps indicate the Chester Formation is faulted, with two parallel faults, orientated north-east to south-west transecting the site, with the downthrow side to the south-east of both faults. The faults are not present across the area of the PFA mound.

The mapped site geology is summarised in Table 5.1 below.

Table 5-1 - Published Geology On–Site

Geological unit	Description
Superficial deposits: Hemingbrough Glaciolacustrine Formation – Clay, Silty	Unfossiliferous laminated clays, silts and sands with rare dropstones (typically fine-grained pale coloured sandstone, grey limestone and dark mudstone).
Bedrock: Chester Formation (Pebbly)	Reddish brown sandy matrix with pebbles of brown or purple quartzite, with quartz conglomerate and vein quartz.

According to the BGS GeoIndex Viewer[24], much of the central and eastern area of the site is underlain by a buried valley. Buried valleys are ancient river or subglacial (beneath a glacier) drainage networks that are now abandoned and have become either partly or completely buried by more recent sediment.

5.2 2024 Ground Investigation

To support this CSM and the development of the new landfill cell and BESS project, a ground investigation (GI) was undertaken between 29th January and 4th March 2024 and comprised twenty-two boreholes and twenty-seven machine excavated trial pits. An investigation location plan is presented as Figure 4, Appendix 1. A plan showing the site geology as recorded in the 2024 GI is presented as Figure 5, Appendix 1 and cross-sections through the site are presented in Figure 6, Appendix 1.

This report and associated documents provide interpretation of the information generated by the GI.

5.3 Site-Specific Geology - Made Ground and PFA

Made Ground and PFA was recorded within the boreholes across the site area described as:

- Made Ground – soft, dark grey/grey, gravelly, clayey, fine to medium sand or gravelly, sandy, silty clay i.e., reworked natural deposits.
- PFA – very loose/loose, grey, gravelly, very silty, fine and medium sand.

The thickness of the combined Made Ground and PFA layers ranges between 0.8 m bgl / 6.96 m AOD (RBH146) and 24.5m bgl / 0.13 m AOD (RBH124), due to the raised nature of the PFA landfill. Thickness of Made Ground and PFA are shown in Figure 7, Appendix 1. The greatest thickness of PFA deposits are associated with the PFA U shaped bund in the east, south and west of the site.

[24] BGS, 2024. GeoIndex Onshore. Available at: https://www.bgs.ac.uk/map-viewers/geoindex-onshore/ Accessed: March 2024.

5.4 Site-Specific Geology – Drift

Hemingbrough Glaciolacustrine Formation was recorded within the boreholes across the site area.

The depths at which the superficial deposits were encountered from ranged between 0.80 m bgl / 6.96 m AOD (in RBH146, located along the dismantled railway line to the north of the site) and 24.50 m bgl / 0.13 m AOD (in RBH124, located on the southern part of the U-shaped bund).

The thickness of the glaciolacustrine deposits ranged between 4.50 m (in RBH119 in the east of the site, off the bund) and to >27.10 m (in RBH141A, in the south-east of the site). Although the base of the unit was not proven in this location, an historic borehole log (MW4S) indicates a drift thickness of 67.50 m in the area.

Generally, superficial deposits were found to be thicker in the south (MW4S) and in the north-west (MW7S) of the site area. A contour plan depicting the top of the drift deposits is presented as Figure 8, Appendix 1. The deposits were encountered beneath either the Made Ground or the PFA as firm to stiff, orangish brown mottled orange, or light grey, slightly sandy, silty clay with rare occurrences of fine to medium coal and silt partings. With depth, the clayey glaciolacustrine deposits are interbedded with layers of medium dense, greyish, dark brown or orangish brown, silty, fine to medium sand with thin laminae of dark grey silt or partings of brown clay and occasional fine to coarse siltstone, sandstone or quartzite gravel. Occasionally, layers of very dense, grey or brown, sandy, angular to well-rounded fine to coarse sandstone and quartzite gravel have also been recorded interbedding with the above. The thickness of the cohesive clay layer ranged between 0.5 m and to over 21.50 m (RBH141A), with sand layer thickness ranging between 0.7 m and 8.30 m (RBH121), and lastly with the gravel layers (where recorded), ranging in between 0.3 m and 4.9 m (RBH126).

5.5 Site-Specific Geology - Bedrock

The depth at which the Chester Formation bedrock was encountered in the 2024 ground investigation varied across the site. Probable weathered sandstone was encountered beneath the drift deposits, from the depths of between 10.50 m bgl / -2.06 m AOD (in RBH113 in the north-east of the site) and 33.0 m bgl / -10.16 m AOD (in RBH129 in the west of the site). The 2021 boreholes indicated that the bedrock unit was encountered at even greater depths of 40.70 m bgl (MW7S) in the north-west of the site and of 71.50 m bgl / -60.1 m AOD (MW4S) in the south-east. A contour plan depicting the top of the bedrock deposits is presented as Figure 9, Appendix 1. The depth to bedrock (and the deeper drift deposits) within the south-east of the site indicates the presence of an infilled glacial channel. This is identified as the Barnaby Dunn Station Channel by the BGS[25] (Figure 5-A). This could act as a preferential pathway for groundwater, however, based on the available evidence and as the channel and surrounding geology comprises low permeability glaciolacustrine deposits, this does not appear to be having a significant effect on groundwater on-site; see Section 7 fir a more detailed description of the hydrogeology.

[25] PRICE, S.J, BANKS, V, COOPER, A.H, WILDMAN, G,KESSLER, H, BURKE, H.F, TERRINGTON, R, BRIDGE, D & SHEPLEY, M. 2006.3-D hydrogeological characterisation of the superficial deposits between Doncaster and Retford. British Geological Survey Internal Report, CR/06/027. 30pp.

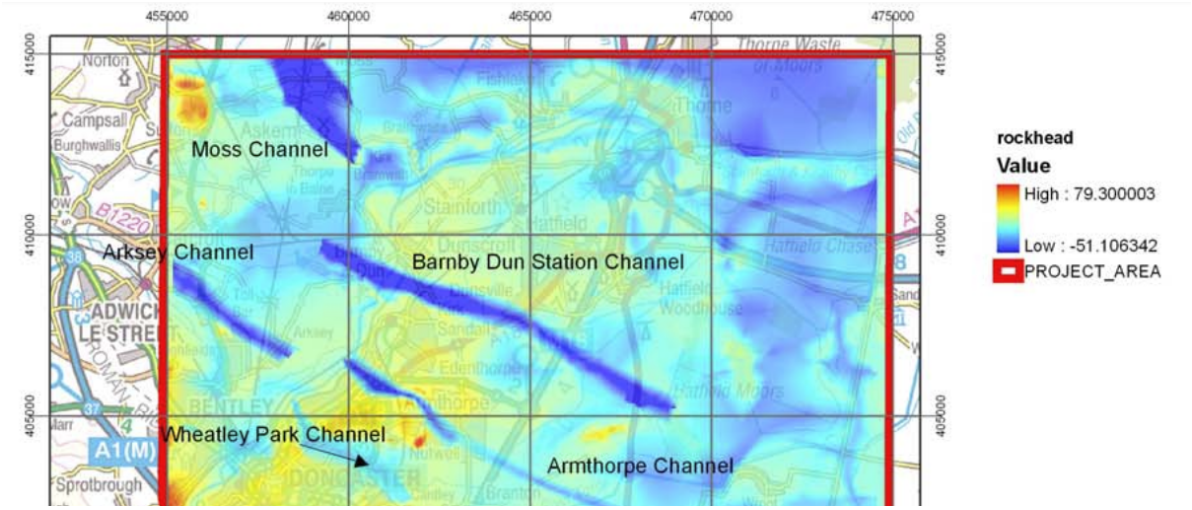

Figure 5-A - Rockhead Elevation map

The weathered sandstone has been described as very dense, reddish brown, slightly silty, fine and medium sand, and occasionally with clay and fine to coarse siltstone, sandstone or coal gravel. The base of the bedrock has not been proven in the historic or recent ground investigations.

6. WASTE OVERVIEW (SOURCE CHARACTERISATION)

6.1 Pre-Permit Waste Deposition

The original WML was granted in 1977, however, anecdotal evidence and historical mapping indicates that ash deposition occurred within the north-east of landfill from the 1960s when the power station began operation.

The foundation of the U-shaped bund was likely initiated in the late 1970s as a perimeter bund for the landfill using PFA, with further deposition of PFA and other domestic and commercial wastes within the bund occurring after the bund was formed. The U-shaped bund was then raised to 25m AOD in 1990, with this material proposed for relocation under the Permit variation.

The exact date on which waste deposition ceased and the date the landfill was put in to closure is unknown. However, it is likely that this occurred shortly after the power station closed in 1994.

6.2 Waste Types

Waste types permitted under the WML are listed in Table 6.1.

Table 6-1 - Permitted Waste Types

Waste Type		Permitted Quantity
1	Pulverised Fuel Ash (PFA)	1,250 tonnes / day
2	Untreated Domestic and Commercial Waste. Demolition Waste (plastic packing sections from cooling towers).	50 tonnes / day
Waste in categories 1 and 2 above will not exceed 9,678 tonnes per annum in total.		

Based on the available ground investigation information the majority of waste within the landfill is PFA, which has a non-hazardous waste classification. However, it is non-biodegradable, so it will not produce elevated concentrations of ammoniacal nitrogen, chloride and total organic carbon, which is typically associated with landfills which contain biodegradable waste.

The landfill was permitted to also accept commercial and domestic wastes from the power station only, although with a much lower daily weight allowance. These wastes comprised general office and canteen type wastes and would be classed as non-hazardous waste.

There is also anecdotal evidence for two areas of disposal of asbestos containing materials, however, excavation of PFA for the new landfill cell will not affect these areas. .

6.3 Waste Descriptions

6.3.1 Waste Type 1 - PFA

PFA was encountered across the entire site area, with the exception of the northern-most 2024 boreholes RBH1113 and RBH146, located adjacent to the dismantled railway tracks within the site boundary.

The PFA was generally described as very loose to loose (and medium dense with depth), light to dark grey, and in places grey brown, sandy silt with fine to medium sand; or, as light to dark grey, and grey brown, silty fine to medium sand. Gravel was frequently present within the PFA deposits and typically described as angular to sub-angular fine to coarse gravel of sandstone and fine coal, and rarely included clinker, brick, and siltstone, all of which are common deposits found within coal ash from coal-fired power stations.

Also noted within the PFA were instances of localised *'black staining'* (RBH124 at 14.50 to 15.40 m bgl) and *'hydrocarbon sheen'* (RBH136 at 13.50 to 13.60 m bgl) or *'hydrocarbon odours'* (RBH141 at 7.50 to 8.50 m bgl), although negligible (≤0.1 ppm) concentrations of volatile

organic compounds (VOC) were measured on-site (soil headspace analysis using a Photo-ionisation Detector, or PID).

The depths at which the PFA deposits were encountered ranged between ground level (as recorded within exploratory holes RBH121, RBH131, RTP135, RTP140, RTP146 and RTP155) to 0.90 m bgl (RTP153).

The thickness of the PFA ranged between 0.40 m (in RTP143, in the centre of the site) to the maximum of 24.5 m (in RBH124, present on the southern side of the bund). RBH124 represents the thickness of PFA deposits beneath the U-shaped bund, with the average thickness of approximately 17 m. Within the centre of the site (within the confines of the PFA bund) the PFA ranged in thickness between 8.4 m (RBH116, located in the north) and 15.8 m (RBH132m located in the south). Figure 7 in Appendix 1 illustrates the encountered PFA thicknesses across the site.

6.3.2 PFA with 'Waste' Inclusions

Non-PFA waste was identified within RBH120A (between 12.50 m bgl (9.44 m AOD) and 13.10 m bgl (8.84 m AOD)) and RBH141 (from 8.50 m bgl / 8.77 m AOD to a depth of 13.50 m bgl /3.77 m AOD), at which the borehole was terminated), both of which are not situated in the area of known commercial and domestic waste deposition.

An '*oily sheen and strong sweet hydrocarbon odour'* was noted at depth in RBH141 (between 13.0 and 13.50 m bgl), with a corresponding significantly elevated PID concentration of 986 ppm. This unit was described as dark greenish grey, silt, with angular to sub-angular fine to coarse and cobble-sized gravel of asphalt and concrete.

It should be noted that both these 'waste' inclusions are located within the deeper PFA deposits and will not be disturbed during the planned PFA relocation.

6.3.3 Waste Type 2 - Untreated Domestic / Commercial Waste

The untreated domestic / commercial waste deposited by Thorpe Marsh Power Station was encountered in one borehole (RBH132) and eight trial pits (RTP142 to RTP144, RTP150, RTP166, RTP177, RTP185 and RTP186) and were generally confined to the area where this waste was indicated to be present at the southern end of the site, as shown on Figure 10, Appendix 1.

Waste Type 2 was typically described as light to dark grey or greyish brown, slightly sandy and gravelly silt; or as very soft to soft, dark grey or brown grey (rarely greenish grey), gravelly and silty clay with frequent fragments of plastic bags, decomposed wood, newspaper, cardboard, textile, metal, rubber, polystyrene, ceramic, fibreglass insulation, foil packaging, glass, concrete, brick and clinker.

The depths at which these waste deposits were encountered was generally shallow and ranged between ground level / c.5-9m AOD (namely in RTP142, RTP144, RTP185) and 0.8 m bgl / – 3.0 m bgl / c.10-16 m AOD (RTP143, RTP150, RTP166, RTP177 and RTP186. The shallow waste type 2 deposits are at a similar depth to the waste inclusions within the PFA (see section 6.2.2) but as shown comprises different material, and extends to greater depths.

The thickness of the domestic and commercial waste ranged between 1.0 m (in RBH132) to at least 4.0 m (RBH132), although in majority of the exploratory holes the base could not be proven due to water ingress (as in the case of the advanced trial pits).

The waste deposits were not observed to be contaminated, with the exception of a *'hydrocarbon sheen'* recorded in RTP142 (at 0.30 m) and *'strong hydrocarbon odour'* in RTP185 (from 0.0 to 1.10 m bgl), with negligible (≤0.1 ppm) VOC concentrations measured on-site to correspond with these observations. No evidence of waste type 2 was identified within the PFA bund. This

material will not be disturbed during the proposed development and, for the avoidance of doubt, will not be relocated.

6.4 Location of Waste Types

The 1994 report[26] has indicated that the asbestos waste (covered with PFA) was deposited in two distinct areas in the north-east of the site: in a field to the east of Lower Boundary Road, and in a second field just south of Field Station Road. The general office and canteen type waste is indicated to be present in the south-western area on the inside of the U-shaped bund (as shown on Figure 10, Appendix 1). Intrusive works have not been required in the areas of asbestos disposal as these areas will not be disturbed by the proposed development. Figure 10, Appendix 1 depicts the extents of the proven Waste Type 2 deposits.

6.5 Waste Volumes

No records are available detailing the volume of waste deposited at the site. It should also be noted that waste disposal commenced in the 1960s, when the power station started operating, which is prior to the issue of the WML in 1977. Historical mapping suggests PFA was deposited in the northeast of the site, but as this area is now at a low elevation it is assumed the material was moved elsewhere on site, and potentially used to fill the pond located in the north-east. The U-shaped bund is assumed to have been deposited under the WML with likely the deeper layers of PFA deposited under unlicensed conditions. However, these deeper layers will not be disturbed by the proposed relevelling works. The volumes presented below are approximate total volumes and as such are likely to be an over representation as it will include pre-WML deposition:

- Estimated total volume of PFA within the current landfill = 4.44 million m^3.
- Volume of PFA to be excavated and redeposited = 600,000 m^3.

The volume of PFA to be excavated and redeposited represents c. 13% of the total PFA volume present on the site.

6.6 Historical Analytical Data

Prior to 2024, very little environmental analysis had been undertaken on the PFA or non-PFA waste.

During the 2022 trial pitting works undertaken by Egniol (see Section 4.7) to confirm the suspected location of non-PFA (commercial) waste material, one soil sample of the material was sent for laboratory analysis. The waste material was encountered between 0.60 m and 2.30 mbgl and was described as *"dark grey, gravelly, silty fine sand with gravel of slag and clinker and waste of plastic bags, metal components of machinery, fibrous material and other unknown anthropogenic material"*, which is generally in line with the waste encountered in this area in 2024.

The waste sample (recovered from 2.30 m bgl) was analysed for a range of determinands comprising: asbestos, pH, cyanide, sulphate as SO_4, PAH (Polyaromatic Hydrocarbons), heavy metals, BTEX (benzene, toluene, ethylbenzene and xylenes), MTBE (methyl tert-butyl ether) and TPH (total petroleum hydrocarbons). The analytical results have been screened by Ramboll against current Generic Assessment Criteria (GAC) protective of human health based on a continued commercial / industrial land use. Details on the derivation of GAC methodologies are presented in Appendix 3, with screening tables in Appendix 4.

[26] Geraghty & Miller International Inc, 1994. Hydrogeological Investigation and Waste Disposal Assessment Main Technical Report. Dated: September 1994

All concentrations were reported either below the laboratory method reporting limits (MRL), or at low concentrations well below the GAC. Loose fibres of chrysotile asbestos were detected within the sample at the concentration of <0.001 % w/w.

6.7 2024 Soil Analysis

A summary of the waste soil laboratory results obtained in 2024 are summarised in Table 6.2 below.

Table 6-2 - Soil Analytical Testing

Material Type	Number of Samples Analysed (soil)	Number of Samples with Conc > Human Health GAC (Location)
Topsoil	3	0
Non-PFA (waste/MG)	20	1 (RBH141)
PFA	51	0
Superficial Deposits	4	0

The majority of concentrations of all contaminants of concern recorded within the topsoil, PFA and non-PFA analysed were below the GAC protective of human health based on a commercial / industrial end use.

The exception is two volatile organic compounds (VOC) detections within a single sample of non-PFA recorded at RBH141 13.5-13.6m bgl as summarised in Table 6.3 below.

Table 6-3 - Soil GAC Exceedance Summary

Analyte	No. of Samples Results	GAC	Number of GAC Exceedances	Material Type	Max Conc (µg/l)
1,3,5-Trimethylbenzene	5	12,000 µg/kg	1	Non-PFA	25,000
1,2,4-Trimethylbenzene	5	22,000 µg/kg	1	Non-PFA	41,000

Elevated concentrations of some orgqnic solvents (xylenes, isopropylbenzene, n-propylbenzene, 1,3,5-trimethylbenzene and 1,2,4-trimethylbenzene) were also reported in the sample from RBH141 at 13.5 – 13.6 m bgl. However, as noted above, concentrations did not exceed the human health GAC.

6.7.1 New Landfill Cell Analysis

No soil GAC exceedances are recorded from any of the samples that represent the PFA to comprise the new landfill cell i.e., that from the upper parts of the U-shaped bund.

6.8 2024 Soil Leachate Analysis

A summary of the soil leachate laboratory results obtained in 2024 are summarised in the Table 6.4 below.

Table 6-4 – Soil Leachate Analytical Testing

Material Type	Number of Samples Analysed (soil)	Number of Samples with Conc > Controlled Waters GAC (Location)
Topsoil	0	0
Non-PFA (waste/MG)	5	4 (RTP182, RBH124, RTP166, RTP176)

Material Type	Number of Samples Analysed (soil)	Number of Samples with Conc > Controlled Waters GAC (Location)
PFA	39	29 (RBH141A, RBH136, RTP157, RBH138, RTP183, RTP184, RTP182, RBH145, RBH125, RBH116, RBH119, RBH137, RTP138, RBH145 RBH114, RBH126, RBH129, RBH132, RBH143, RTP134, RTP135, RTP139, RTP140, RTP144, RTP146, RTP150, RTP155, RTP177, RTP186)

The majority of concentrations of all contaminants of concern recorded within the topsoil, PFA and non-PFA analysed were below the GAC protective of control waters and potable drinking water.

The exception is for sulphate, as well as minor exceedances for arsenic and copper (all commonly associated with PFA) as summarised in Table 6.5 below.

Table 6-5 - Soil Leachate GAC Exceedance Summary

Analyte	No. of Samples Results	GAC	Number of GAC Exceedances	Material Type	Max Conc (µg/l)
Sulphate as SO_4	43	250*	26	PFA	1,590
		400**	10		
Antimony	23	5*	6	PFA	10
Arsenic	44	10*	37	PFA	120
		50**	5		
Boron	32	1,000*	5	PFA	1,900
		2,000**	0		
Chromium	44	50*	0	PFA	17
		4.7**	10		
Bioavailable Copper	21	1***	3	PFA	2.7
Lead	44	1.2*	2	PFA	35
Manganese	9	50*	5	PFA	78
Selenium	44	10*	10	PFA	43
Vanadium	28	20**	13	PFA	79
Naphthalene	9	0.075*	1	PFA	0.96

* Groundwater resource potential - risk based standards to protect potable water supply potential
** Freshwater AA EQS
*** Bioavailable GAC

Minimum reporting values (hazardous substances) exceedances are limited to heavy metals (arsenic and lead), as shown in Table 6.6 below.

Table 6-6 - Soil Leachate Hazardous Substances Minium Reporting Values Exceedance

Analyte	No. of Samples Results	Minimum reporting values (hazardous substances only)	Number of GAC Exceedances	Material Type	Max Conc (µg/l)
Arsenic	44	1*	43	PFA	120

Analyte	No. of Samples Results	Minimum reporting values (hazardous substances only)	Number of GAC Exceedances	Material Type	Max Conc (µg/l)
Lead	44	1*	16	PFA	35
* In the absence of published values, the laboratory method reporting limit has been used.					

6.8.1 New Landfill Cell Analysis

Of the materials that are to be excavated and redeposited in the new landfill "cell", GAC exceedances of these materials are limited to sulphate, naphthalene and heavy metals (arsenic, lead, selenium and vanadium), as shown in Table 6.7 below.

Table 6-7 - Soil Leachate GAC Exceedance; New Landfill Cell Summary

Analyte	No. of Samples Results	GAC	Number of GAC Exceedances	Material Type	Max Conc (µg/l)
Sulphate as SO_4	17	250*	11	PFA	1,590
		400**	4		
Antinomy	7	5.0*	1	PFA	8.1
Arsenic	17	10*	12	PFA	69
		50**	4		
Chromium	17	50*	0	PFA	13
		4.7**	4		
Bioavailable Copper	10	1***	1	PFA	1.04
Manganese	2	50*	1	PFA	78
Selenium	17	10*	4	PFA	33
Vanadium	10	20**		PFA	29
Naphthalene	4	0.075*	1	PFA	0.96
* Groundwater resource potential - risk based standards to protect potable water supply potential ** Freshwater AA EQS *** Bioavailable GAC					

All GAC exceedances are of the same order of magnitude, and with the exception of sulphate, only recorded in isolated locations. The sulphate exceedances are also quite marginal and not an order of magnitude difference. These are therefore not considered to be significant.

Of the materials that are to be excavated and redeposited in the new landfill "cell", Minimum reporting values (hazardous substances exceedances are limited to heavy metals (arsenic and), as shown in Table 6.8 below.

Table 6-8 - Soil Leachate Hazardous Substances Minium Reporting Values Exceedance; New Landfill Cell Summary

Analyte	No. of Samples Results	Minimum reporting values (hazardous substances only)	Number of GAC Exceedances	Material Type	Max Conc (µg/l)
Arsenic	17	1*	16	PFA	69
Lead	17	1*	6	PFA	2.5
* In the absence of published values, the laboratory method reporting limit has been used.					

6.9 Waste Characterisation

6.9.1 Preliminary Waste Assessment

The assessment has been undertaken using available soil chemical data and HazWasteOnline, a web-based tool for classifying waste. The software utilises EA guidance and European regulations to classify samples in line with current requirements.

Samples collected during the ground investigations were combined and entered into the HazWasteOnline assessment tool. The are shown in Table 6-9. The HazWasteOnline output sheets are provided in **Error! Reference source not found.**.

Table 6-9 Preliminary Waste Classification Assessment

ID	Depth (mbgl)	Waste Classification (European Waste Management Regulations)	Hazardous Properties
Topsoil			
RTP151	0.1-0.3	Non-hazardous	n/a
RTP183	0.0-0.1	Non-hazardous	n/a
RTP184	0.2-0.4	Non-hazardous	n/a
Non PFA (waste/MG)			
RBH113	0.6-0.8	Non-hazardous	
RBH138	0.4-0.5	Non-hazardous	n/a
RBH141	9.1-9.2	Non-hazardous	n/a
RTP153	0.2-0.4	Non-hazardous	n/a
RTP185	0.2-0.4	Non-hazardous	n/a
RTP186	4.0-4.2	Non-hazardous	n/a
RTP134	0.1-0.3	Non-hazardous	n/a
RTP124	0.2-0.4	Non-hazardous	n/a
RTP138	0.1-0.3	Non-hazardous	n/a
RTP154	0.5-0.7	Non-hazardous	n/a

ID	Depth (mbgl)	Waste Classification (European Waste Management Regulations)	Hazardous Properties
RTP150	1.1-1.2	Non-hazardous	n/a
RTP142	0.3-0.4	Non-hazardous	n/a
RTP143	0.9-1.0	Non-hazardous	n/a
RTP143	1.5-1.6	Hazardous	HP3(I) Flammable, HP7 Carcinogenic, HP11 Mutagenic
RTP125	0.0-0.1	Non-hazardous	n/a
PFA			
RBH116	0.5-0.6	Non-hazardous	n/a
RBH116	5.5-5.7	Non-hazardous	n/a
RBH119	1.0-1.2	Non-hazardous	n/a
RBH119	6.9-7.0	Non-hazardous	n/a
RBH119	6.9-7.0	Non-hazardous	n/a
RBH136	13.5-13.6	Non-hazardous	n/a
RBH138	4.0-4.1	Non-hazardous	n/a
RBH141	7.5-7.6	Non-hazardous	n/a
RBH141A	3.0-3.1	Non-hazardous	n/a
RTP151	0.5-0.7	Non-hazardous	n/a
RTP153	2.9-3.1	Non-hazardous	n/a
RTP157	0.4-0.6	Non-hazardous	n/a
RTP181	0.4-0.6	Non-hazardous	n/a
RTP182	0.5-0.7	Non-hazardous	n/a
RTP84	1.7-1.9	Non-hazardous	n/a
RTP124	5.0-5.1	Non-hazardous	n/a
RTP186	1.5-1.7	Non-hazardous	n/a
RTP134	0.5-0.7	Non-hazardous	n/a
RTP137	1.6-1.8	Non-hazardous	n/a
RTP135	3.2-3.4	Non-hazardous	n/a
RTP124	1.2-1.4	Non-hazardous	n/a
RTP140	2.2-2.4	Non-hazardous	n/a

ID	Depth (mbgl)	Waste Classification (European Waste Management Regulations)	Hazardous Properties
RTP138	3.5-3.7	Non-hazardous	n/a
RTP139	3.5-3.7	Non-hazardous	n/a
RTP154	0.9-1.1	Non-hazardous	n/a
RTP155	2.6-2.8	Non-hazardous	n/a
RTP166	0.8-0.9	Non-hazardous	n/a
RTP177	1.2-1.3	Non-hazardous	n/a
RTP143	0.4-0.5	Non-hazardous	n/a
RBH129	6.5-6.6	Non-hazardous	n/a
RBH126	0.1-0.3	Non-hazardous	n/a
RBH114	0.2-0.4	Non-hazardous	n/a
RBH114	0.4-0.6	Non-hazardous	n/a
RBH131	5.0-5.5	Non-hazardous	n/a
RBH131	6.0-6.5	Non-hazardous	n/a
RBH143	2.5-2.6	Non-hazardous	n/a
RBH132	10.0-10.5	Non-hazardous	n/a
Waste			
RBH141	13.5-13.6	Non-hazardous	n/a

All samples have been assessed as non-hazardous apart from a single sample of non PFA (Made Ground). This single hazardous classification is located at TP143 (1.5-1.6 m bgl) and is due to elevated total petroleum hydrocarbons (TPH C6-C40).

6.9.2 Waste Acceptance Criteria

Twelve soil samples were scheduled for WAC analysis. The results are summarised in Table 6.10 below.

Table 6-10 - Summary of Soil WAC Results

Material Type	Number of Samples Analysed (soil)	Waste Classification		
		Inert	Non-Hazardous	Hazardous
Non PFA (waste/MG)	2	0	1	1
PFA	10	2	9	0

6.9.3 Waste Classification

On the basis of recent ground investigations, it is anticipated the excavated landfill material will not require treatment to enable its use in earthworks. Any gross contamination observed during

excavation will have been isolated at that point. The EWC codes for the landfill material are anticipated to be as set out in Table 6.11.

Table 6-11 - Proposed list of site-derived wastes

EWC Waste Code	EWC Description	Limitations
10 01 01	bottom ash, slag and boiler dust (excluding boiler dust mentioned in 10 01 04)	Limited to site-derived material meeting the chemical and physical specifications for the works
10 01 02	coal fly ash	Limited to site-derived material meeting the chemical and physical specifications for the works

6.9.4 Discussion

The WAC analysis has confirmed that the PFA would be classified as non-hazardous (and in two occasions inert), in line with the EAs comments that this was the expectation (section 1.1, above).

The waste classification and WAC testing both identified a single investigation location that includes materials that would be classified as hazardous. This is associated with non-PFA (waste/MG), from RTP143 (0.9-1.0 and 1.5-1.6 m bgl). The hazardous classification associated with slightly elevated hydrocarbons, total organic carbon (TOC) and loss of ignition (LoI). This material will not be disturbed during the proposed development and will not be relocated. The planned new PFA waste cell will be placed on top of this material, reducing infiltration and removing any future contact.

6.10 Ground Gas Monitoring Results

Prior to 2021, there has been ground gas monitoring undertaken at the site in 1994 and 2004-05. The data that is available is of poor quality (as no gas taps were installed on the monitoring wells) and therefore has not been included as part of this assessment.

A total of 12 ground gas monitoring rounds have been undertaken between May 2021 and April 2024 across the site area, to meet the requirements of the Environmental Permit. As stipulated by the Permit, there are gas compliance limits set out for methane and carbon dioxide concentrations for the ten perimeter wells MW1D, MW2, MW3, MW4S, MW4D, MW5S, MW5D, MW6D, MW7S and MW7D, as shown in Table 6.12 below. No compliance limits are provided for in-waste monitoring wells BH01 to BH06.

Table 6-12 - Ground Gases Compliance Limits

Gas	Compliance Limit*
Methane	1 %
Carbon Dioxide	1.5 %
Notes: *Compliance Limits apply to perimeter monitoring boreholes MW1 to MW7 only.	

It should be noted that although gas monitoring has been undertaken of monitoring wells MW4S, MW5S and MW7S which have response zones within the sandstone bedrock, the wells screened sections are fully saturated and as such concentrations recorded in these wells may not be indicative of ground gas conditions.

Atmospheric Pressure

Ground gas monitoring was undertaken at a range of atmospheric pressures throughout the three years, i.e., in between 983 mb (millibars) in November 2023 and 1035 mb in November 2021, capturing both low and high atmospheric pressure conditions.

Carbon Dioxide

Within the in-waste wells, carbon dioxide concentrations ranged between ≤0.1 % v/v to the maximum of 3.0 % v/v (BH03, October 2021).

Within the perimeter wells, carbon dioxide was recorded between 0.1 % v/v to the maximum concentration of 6.3 % v/v (MW4D, November 2023). Carbon dioxide has been found typically above the compliance limits throughout the monitoring period in MW4D (ten rounds) and MW7D (five rounds). It was also above the compliance limit twice in MW1D, MW2 and MW5S and once in MW7S (in July 2021 only). It should be noted that the compliance limited of 1.5%v/v is conservative, especially given the control limit for new residential properties requiring gas protection considerations is 5%v/v. The concentrations are within the range of what could be expected from natural drift deposits (i.e., alluvium) as recorded on site.

Methane

Methane concentrations were generally below the compliance limits in the perimeter wells, and at very low concentrations (i.e., ≤0.2 % v/v) within non-perimeter, in-waste wells BH01 to BH06.

In November 2022, methane was recorded at a high concentration of 34.5 % in MW1D well, which is well over the 1 % v/v compliance limit. The concentration is regarded to be anomalous, as methane in this location has ranged between ≤0.1 % v/v (in November 2021) to the maximum concentration of 0.4 % v/v (November 2023). As such, the high concentration is not considered to represent the methane condition within this well, and methane concentrations in MW1D are typically below the compliance limit.

Within MW2, methane was recorded at the compliance limit concentration of 1.0 % v/v in the latest monitoring round (November 2023), but typically it is below this concentration.

Oxygen

There are no compliance limits for oxygen, and it ranged between 0.1 % v/v (MW4D, November 2023) and 22.8 % v/v in the perimeter wells; and between 11.4 % v/v (BH03, November 2023) and 22.0 % v/v in the in-waste wells.

7. HYDROGEOLOGY

7.1 Published Hydrogeology

The underlying Hemingbrough Glaciolacustrine Formation is designated as an Unproductive Strata which is 'rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow'.

The Alluvium (located immediately east of the site) is designated as a Secondary A Aquifer which comprises permeable layers that can support local water supplies and may form an important source of base flow to rivers. However, this is likely to be of limited thickness and extent. The Secondary A Aquifer is unlikely to be used for potable or commercial water supply due to limited lateral extent and thickness.

The bedrock geology comprising the Chester Formation is designated as a Principal Aquifer which has a high intergranular and / or fracture permeability meaning it is highly likely to provide a high level of water storage and may also support water supply and / or river base flow on a strategic scale.

The site is located within Zone III (Total Catchment) of an EA designated groundwater Source Protection Zone (Figure 7-A, below). This is the total catchment area around the source (point of abstraction), where pollutant travel times are greater than 400 days. The SPZ is associated with nine abstraction wells to the south-east and south of the site all of which are greater than 2km from the site.

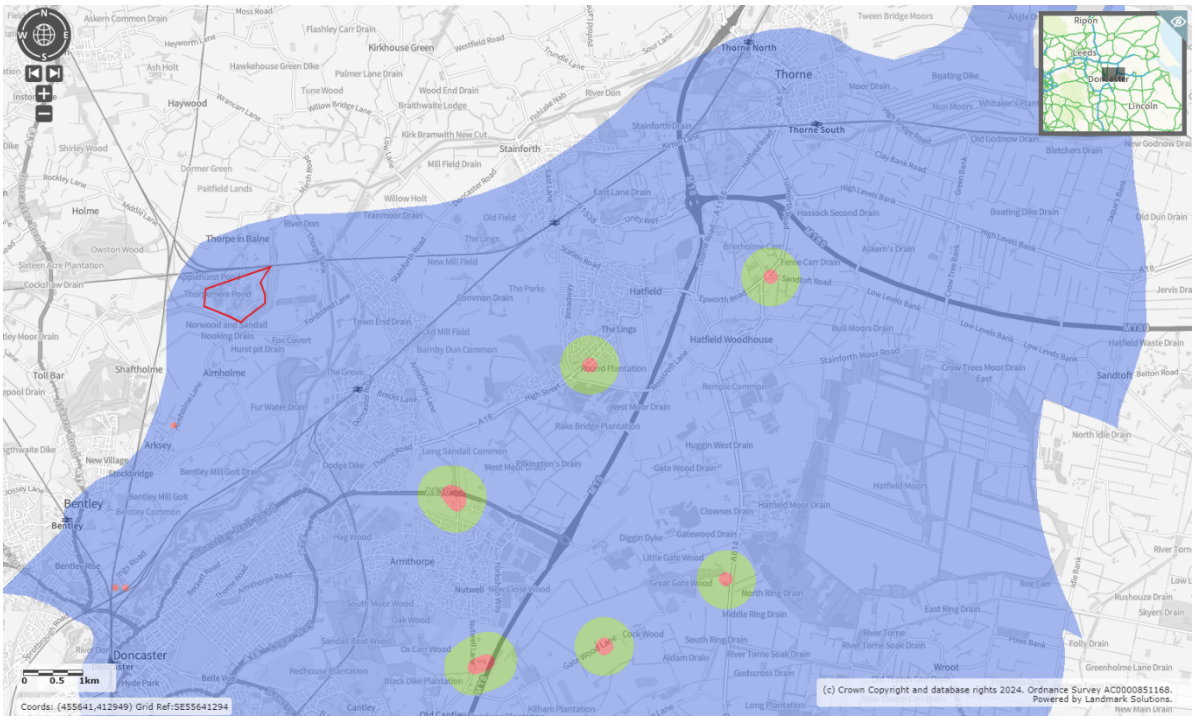

Figure 7-A - Groundwater Source Protection Zone[27]

There are five licensed groundwater abstractions within a 2 km radius of the site, with the nearest located approximately 370 m east of the site and utilised for general industrial use (by National Power Plc); and 890 m to the north-east of the site utilised for general farming and domestic purposes with abstractions taken from the underlying Sherwood Sandstone.

The shallow natural soils at the site have a low leaching class, meaning that they will provide significant protection to the underlying aquifer.

[27] https://magic.defra.gov.uk/MagicMap.aspx, accessed 10/05/2024.

The EA currently classifies groundwater (in relation to the groundwater in the Aire & Don Sherwood Sandstone Water Body) at the site/regionally as being of 'Poor' Chemical Quality and Quantitative Status under the Water Framework Directive (WFD) classification scheme (2019).

The reginal groundwater flow within the Principal Aquifer is generally to the east / south-east and is likely influenced by the groundwater abstraction wells shown in Figure 5-B (above).

7.2 Hydrogeological Properties

Historical permeability testing of the PFA undertaken by Geraghty & Miller[28] recorded values of 6.2x10-8, 1.9x10-7 and 7.0x10-9 m/s with a conservative value of 2.0x10-7 being a representative value.

The hydrogeological properties recorded by Geraghty & Miller[29] are presented in table 7.1 below. The 1994 report also states that information from the British Geological Survey Bulletin 56[30] provides a mean vertical permeability of 1 m/d and a mean horizontal permeability of 13.62 m/d / 1.57x10^{-4} m/s.

Table 7-1 - Aquifer Properties

Borehole	Soil Type	Permeability (K) (m/d)	Specific Yield (Sy) (%)	Porosity (%)
MW1	Gravels	+100[5]	15[4]	25-40[4]
MW3	Sands and Gravels	56.0[5]	15[4]	25-50[4]
MW2A	Silts	0.26[2]	8[4]	35-40[4]
MW2	Sherwood Sandstone	9.7[2]	20-22[1]	30[1]
MW4	Sherwood Sandstone	3.74[2]	20-22[1]	30[1]
Power Station Borehole	Sherwood Sandstone	2.5[3]	20-22[1]	30[1]

In-situ permeability testing was completed by Egniol between the 24-25th and 29-30th April 2024. A summary of the results is provided in table 7-2 below.

Table 7-2 - Egniol In-situ Permeability Testing

Well ID	Strata Screened	Volume of water recovered (l)	Time borehole pumped for (min)	Permeability (m/s)
RBH124	PFA	260	65	2.15x10-6
RBH131	PFA	42	30	1.13x10-5
RBH131(D)	Drift	112	30	1.08x10-4
MW5DA	Drift	30	4	7.86x10-6
MW4S	Sandstone	300	30	5.69x10-4
MW5S	Sandstone	520	120	5.84x10-5
MW7S	Sandstone	322	30	2.63x10-4

[28] Geraghty & Miller International Inc, 1994. Hydrogeological Investigation and Waste Disposal Assessment Main Technical Report. Dated: September 1994.

[29] Geraghty & Miller International Inc, 1994. Hydrogeological Investigation and Waste Disposal Assessment Main Technical Report. Dated: September 1994.

[30] Lovelock, P.E.R. (1977). Bulletin 56: Aquifer properties of Permo-Triassic sandstones in the United Kingdom. Institute of Geological Sciences.

As part of the 2024 ground investigation works, laboratory derived permeability testing (undisturbed and remoulded (compacted)) was undertaken and is summarised in Table 7.3, below.

Table 7-3 - Laboratory Permeability Testing

Location ID	Sample Depth (m bgl)	Strata Type	Undisturbed / Remoulded	Coefficient Of Permeability (m/s)
RBH120A	2.0-2.45	PFA	Remoulded	1.00x10-07
RBH120A	12.0-12.45	PFA	Undisturbed	1.80x10-07
RBH120A	21.0-21.45	PFA	Undisturbed	1.20x10-10
RBH121	2.5-2.45	PFA	Remoulded	2.90x10-08
RBH121	6.0-6.45	PFA	Remoulded	1.40x10-07
RBH121	9.0-9.45	PFA	Undisturbed	1.90x10-07
RBH121	12.0-12.45	PFA	Undisturbed	1.20x10-07
RBH121	15.0-45.45	PFA	Remoulded	8.00x10-08
RBH125	12.0-12.45	PFA	Remoulded	1.40x10-07
RBH125	15.0-15.45	Superficial	Undisturbed	1.60x10-10
RBH129	3.5-3.95	PFA	Remoulded	2.40x10-07
RBH129	4.0-4.3	PFA	Remoulded	2.00x10-07
RBH129	8.5-8.95	PFA	Undisturbed	2.40x10-07
RBH129	9.4-9.7	PFA	Remoulded	3.10x10-07
RBH129	11.5-11.95	PFA	Undisturbed	3.30x10-07
RBH129	20.5-20.95	PFA	Undisturbed	4.10x10-08
RBH143	4.0-4.3	PFA	Remoulded	9.80x10-08
RBH143	7.7-8.0	PFA	Remoulded	9.40x10-08
RBH144	10.5-10.95	Superficial	Undisturbed	6.80x10-07
RBH145	4.2-4.5	PFA	Remoulded	1.30x10-07
RTP135	2.2-2.4	PFA	Remoulded	1.20x10-07
RTP136	3.2-3.4	PFA	Remoulded	2.00x10-07
RTP137	0.6-0.8	PFA	Remoulded	2.60x10-07
RTP138	1.5-1.7	PFA	Remoulded	1.20x10-07
RTP155	3.6-3.8	PFA	Remoulded	9.60x10-08

7.3 Summary of Monitoring Undertaken

Groundwater elevation and analytical data has been collected during thirteen monitoring rounds since May 2021 by Egniol and is summarised in Appendix 5, and discussed below.

Table 7-4 - Summary of Monitoring Undertaken

Date Installed	Screened Strata	IDs	No. of Dipping Rounds	No. of Sampling Rounds
2021 Monitoring Wells	PFA	BH1-BH6	13 May-21, Jun-21, Aug-21, Oct-21 (2 rounds), Nov-21, Mar-22, May-22, Nov-22, Jul-23, Nov-23, Mar-24 and Apr-24	7 Jun-21, Nov-21, Nov-22, Nov-23, Jan-24, Mar-24, Apr-24
	Drift	MW1D, MW2, MW3, MW4D, MW5D/5DA, MW6D and MW7D/7DA		
	Sandstone	MW4S, MW5S and MW7S		
2024 Monitoring Wells	PFA / Waste	RBH124, RBH125, RBH131(PFA), RBH132, RBH141(MG) and RBH141A(MG)	2 Mar-24 and Apr-24	2 Mar-24 and Apr-24
	Drift	RBH113, RBH116, RBH19, RBH126, RBH129, RBH131(D), RBH138, RBH141(D), RBH143 and RBH145		

The location of the groundwater sampling points are presented as Figure 11, Appendix 1.

7.4 Groundwater Elevation Data

7.4.1 PFA

The Egniol groundwater data from May 2021 to March 2024 illustrates an inferred groundwater flow from approximately 10 m AOD (BH1) in the north-east to approximately 5 m AOD (BH3) in the south-west within the PFA waste (i.e., groundwater sitting above, and not in, the drift).

Groundwater elevations within BH4 located to the west of BH3 and near to the pipe intake lagoon have historically been lower than BH3, however this borehole has been recorded as dry during

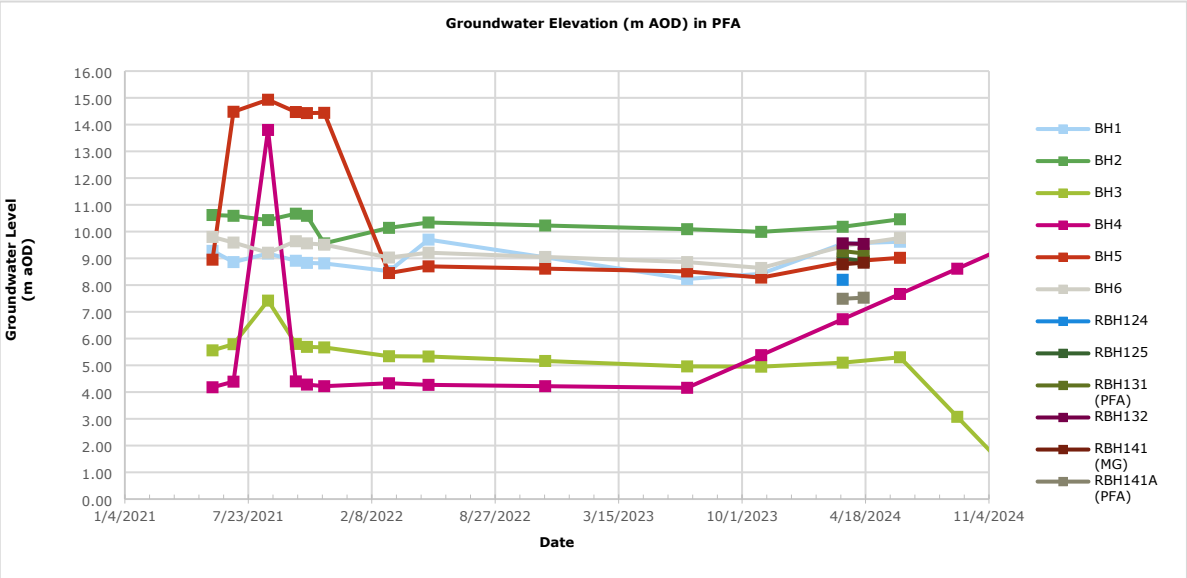

Figure 7-B - Groundwater elevation within the PFA

the last two monitoring rounds. The groundwater elevation trends recorded by Egniol are

presented in Figure 7-A. Groundwater flow contours are presented in Figure 12, Appendix 1 and generally show flow to the south with local variation.

In April 2024 (the latest groundwater monitoring event available), groundwater elevations within the PFA ranged between 5.3 m AOD (BH3) and 10.46 m AOD (BH2). From the elevation data, BH3 and BH4 are at a lower elevation (c.16 m AOD) compared with the remaining PFA wells (c. 19 m AOD). This would suggest that there are two perched water bodies within the PFA, at these two levels, or locally groundwater is lower/more depleted around the lagoon intake due to reduced surface inflow.

Since the March 2022 monitoring, groundwater levels within the PFA deposits have been relatively stable. Seasonally, there has been minimal variation, however there was a general rise of seasonal groundwater levels between November 2023 and March-April 2024. This is likely to be associated with the wet winter 2023/spring 2024 season in the UK.

7.4.2 Drift (Unproductive Strata)

The Egniol groundwater data illustrates an inferred groundwater flow to the south-east from approximately 5-7 m AOD (MW1D and MW7D) in the north to approximately 1-2 m AOD (MW3 and MW5D) in the south within the drift deposits. It should be noted that monitoring wells MW5D and MW7D were decommissioned due to poorly designed installations which covered both PFA and drift deposits and were replaced with wells screened entirely within the drift in 2023 (MW5DA and MW7DA). The groundwater elevation trends recorded by Egniol are presented in Figure 7-B. Groundwater flow contours are presented in Figure 13, Appendix 1. This indicates a local groundwater flow within the drift deposits is generally to the east/south-east which is in line with the anticipated regional groundwater flow to the east / south-east.

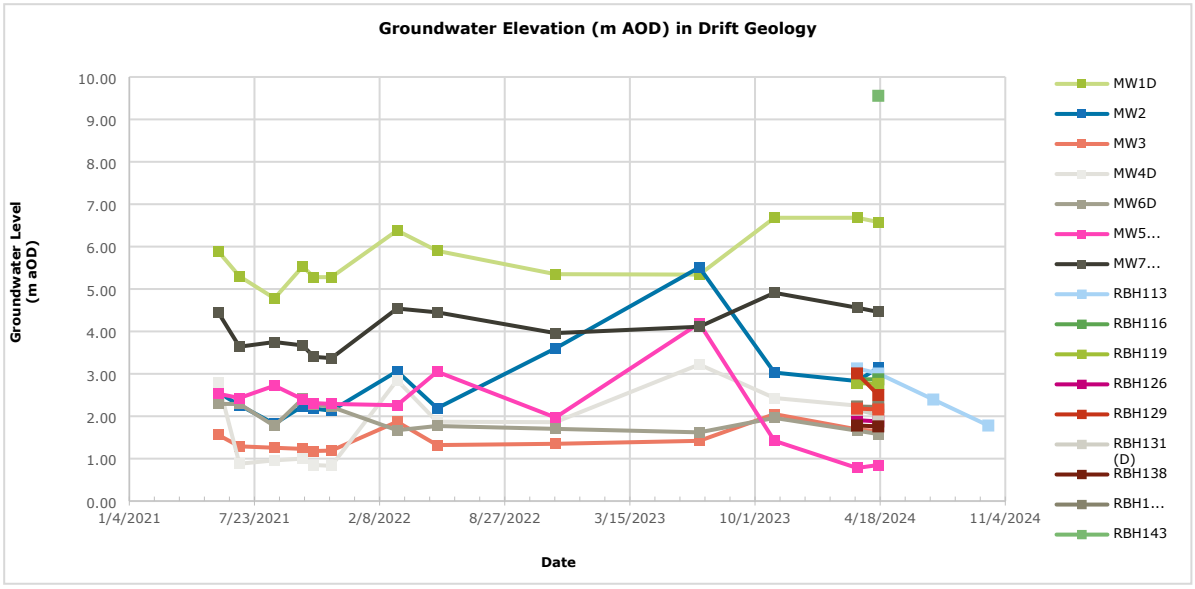

Figure 7-C - Groundwater elevation within the drift geology

In April 2024 (the latest groundwater monitoring event available), groundwater elevations within the drift deposits ranged from 0.85 m AOD (WM5DA) and 9.56 m AOD (RBH143).

Seasonally, there is little clear trends within the drift groundwater body. MW2, MW4D and MW5D/5DA all show a raise in groundwater levels between May/November 2022 through to July 2023. These three monitoring wells are located in the south on the lower flanks of the PFA bund. As groundwater levels fall in these wells, MW1D and MW7D/7DA levels raise, located in the north of the site. There is known to be variable permeability and bands of gravels that are likely to act

discontinuously. There may be some local degree of hydraulic connectivity between the PFA and drift where permeable bands are present close to the surface of the drift.

7.4.3 Sandstone Bedrock (Principal Aquifer)

There is limited groundwater data for the sandstone bedrock as it is based on three boreholes, although this is sufficient to triangulate a flow direction. The Egniol groundwater data illustrates an inferred groundwater flow to the south-east (in line with the anticipated regional groundwater flow to the east / south-east) from approximately 5-6 m AOD (MW7S) in the north to approximately 1-2 m AOD (MW5S) in the south within the drift deposits. The groundwater elevation trends recorded by Egniol are presented in Figure 7-C. Groundwater flow contours are presented in Figure 14, Appendix 1.

In April 2024 (the latest groundwater monitoring event available), groundwater elevations within the solid geology deposits ranged from 1.78 m AOD (WM5S) and 5.98 m AOD (WM7S). The groundwater within the sandstone bedrock is semi-artesian and confined by the low permeability drift deposits and not in direct continuity with shallow groundwater. The overall trend in groundwater levels within the bedrock are fairly minor with the exception of November 2023 which saw a marked increase in levels, particularly within WM4S, which had recovered by March 2024. Groundwater levels are generally higher in 2023/24 and are likely associated with the wet winter 2023/spring 2024 season in the UK.

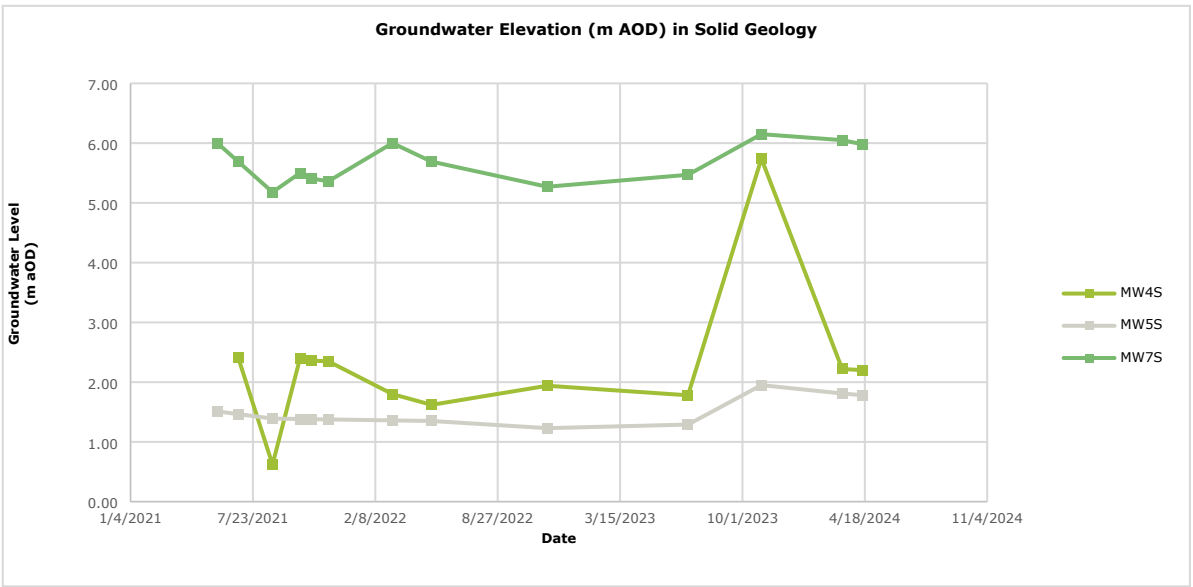

Figure 7-D - Groundwater elevation within the solid geology

7.5 Permeability

7.6 Groundwater Analytical Data

Groundwater samples have been collected from twelve PFA/MG wells, seventeen drift monitoring wells and three sandstone monitoring wells and analysed for a suite of contaminants associated with PFA.

The groundwater data has been screened within this report to provide a baseline of information which will then be taken forward in the Hydrogeological Risk Assessment.

Groundwater analytical data from 2023 and 2024 has been screened against the following criteria protective of groundwater and surface water:

- **Groundwater GAC:** Water Framework Directive (WFD) Threshold Values (TVs) for 'Good' Status - Schedule 5, The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.
- **Surface Water GAC:** Priority substances in surface water and selected (other determinands to which this policy relates): 2013/39/EU: Priority Substances in the Field of Water Policy Directive and 2008/105/EC: Environmental Quality Standards in the Field of Water Policy Directive.
- **Surface Water GAC:** Specific and other pollutants in surface water: The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 or where not available Environment Agency (EA) Environmental Quality Standards (EQS) to be utilised in surface water risk assessments as part of environmental permit (discharge consent) applications and WFD assessments of works in coastal and transitional waters in England.

Where groundwater concentrations exceed the water environment GAC, these are summarised in Table 7.5 below, with screening tables provided in full in Appendix 3. Exceedances of screening criteria do not infer that an unacceptable risk is present; the outcome of the screening is assessed further in the context of a qualitative source-pathway-receptor risk assessment in Section 10.

N.B. The current WML does not contain compliance limits for groundwater.

Table 7-5 Contaminant Concentration Exceedances

Contaminant	No. of Samples	GAC (µg/l)	Number of GAC Exceedances	Minimum Concentration (µg/l)	Maximum Concentration (µg/l)	Distribution Comment
Aluminium	33	200*	1	<MRL	200	A single concentration is recorded at the GAC in WM6D (March 2024) and has since reduced to below the GAC in April 2024.
Antimony	33	5*	9	<MRL	17	The concentrations of antimony have been recorded in the majority of monitoring wells, with only periodic exceedances in the GAC within MW6D and newly installed RBH116, RBH125, RBH132 and RBH145.
Arsenic	83	10*	29	0.35	399	The concentrations of arsenic have been recorded above both the drinking water GACs within MW1D, MW2, WM6D, RBH116, RBH125, RBH132, RBH141 as well as isolated exceedances within WM4D, WM5D, BH119, RBH131(S), RBH138, RBH145.
		50**	11			Exceedances of the surface water GAC only is limited to isolated results from MW1D, WM2, WM5D, RBH131(S), RBH132 and RBH141.
Cadmium	83	5*	2	<MRL	25	Two isolated exceedances of the drinking water GAC ae located within MW4D and MW5D, both screened within the drift deposits.
		0.25**	24			The cadmium GAC is consistently exceeded within MW2, MW4D, MW6D, RBH116, RBH132. Isolated exceedances are also recorded within MW5D, RBH129, RBH145.
Chromium (total)	63	4.7**	16	<MRL	340	The concentrations of total chromium have been recorded consistently above the GAC in MW2 and MW6D, both of which are screened within drift deposits.
		50*	2			Concentrations above the drinking water GAC have only been recorded on two occasions within WM6D and have since reduced below the GAC in the last two monitoring rounds.
Copper (bioavailable)	83	1.0***	5	0.01#	2.03#	Concentrations of bioavailable copper that exceed the GAC were recorded in five isolated occasions only

						associated with MW6D, RBH116 and RBH145, all screened within the drift deposits.
Manganese	83	50*	79	1.8	3,600	The concentrations of manganese consistently exceed the GAC in all locations across the site, including the wells screened within the sandstone. This may suggest that elevated manganese is associated with background concentrations.
Manganese (bioavailable)	83	123***	48	1.08[#]	1,232.5[#]	Concentrations of bioavailable manganese consistently exceed the bioavailable GAC in MW2 MW3, MW4D, MW7D RBH113, RBH116, RBH119, RBH125, RBH132 and RBH131.
Mercury	34	0.07**	16	<MRL	3.16	The concentrations of mercury exceeding the GAC were recorded consistently in MW1D, MW2, RBH116, RBH125, RBH132, and RBH141, with isolated exceedances in MW4D, RBH131(S), RBH132 and RBH145. With the exception of RBH145, all concentrations are within the same order of magnitude as the GAC.
		1.0*	1			A single sample from RBH145 exceeded the GAC.
Nickel (bioavailable)	81	4***	2	0.11[#]	5.8[#]	A single sample of bioavailable nickel exceed the GAC in MW6D and RBH125.
Selenium	27	10*	8	0.7	210	The concentrations of selenium exceeding the GAC were recorded consistently in MW2 and RBH116, with an isolated exceedance in MW6D.
Vanadium	33	20**	10	<MRL	220	The concentrations of selenium exceeding the GAC were recorded consistently in MW2 and RBH116, with isolated exceedances in MW4D, MW6D, RBH125 and RBH145.
Zinc (bioavailable)	83	10.9***	1	0.29	12.61	A single sample from MW4D exceeded the bioavailable GAC in 2021 but has consistently been recorded below the GAC in future monitoring rounds.
Boron	83	1000*	39	38	36,000	The concentrations of boron have been recorded consistently above the GAC in MW1D, MW2, MW4D,

		2000**	38			WM5D/5DA, MW6D all located around the perimeter of the PFA bund. The 2024 install wells of RBH113, RBH116, RBH125, RBH129, RBH131(S), RBH132, RBH141, and RBH145 on a least one of the two monitoring rounds.
Iron	83	0.2*	4	<MRL	0.7	The concentrations of iron have only been detected in three samples, MW7D, RBH119 and RBH132 and are not considered to be significant.
		1.0	0			No exceedances of the surface water GAC.
Selenium	19	10*	8	1.5	220	Isolated exceedances of the GAC are recorded within MW4D, WM5DA, MW6D, RBH116, RBH125 and RBH132.
Sodium	83	200*	24	23	2,000	The concentrations of sodium have been recorded consistently above the GAC in MW2, MW4D, MW5D/5DA and MW6D. RBH113, RBH116, RBH129, RBH141, RBH145 also recorded exceedances.
Naphthalene	62	0.075*	4	<MRL	3.9	The concentrations of naphthalene exceeding the GAC were recorded in MW1D only.
		2**	2			
Anthracene	62	0.1**	5	<MRL	0.24	The concentrations of anthracene exceeding the GAC were recorded in MW1D and RBH141.
Fluoranthene	62	0.0063**	5	<MRL	0.74	The concentrations of fluoranthene exceeding the GAC were recorded in MW1D and RBH141
Benzo(a)pyrene	62	0.00017**	1	<MRL	0.10	One sample was found above the limit of detection in MW1D, with a concentration of 0.1 µg/l.
Benzo(b)fluoranthene	62	0.00017**	1	<MRL	0.12	One sample was found above the limit of detection in MW1D, with a concentration of 0.12 µg/l.

Benzo(k)fluoranthene	62	0.00017**	1	<MRL	0.05	One sample was found above the limit of detection in MW1D, with a concentration of 0.05 µg/l.
TPH - Aromatic >EC10 - EC12>EC12 - EC16,	33	90*	1	<MRL	110	Minor exceedances of the GAC were found in MW1D. The majority of other samples tested were found to be below the limit of detection.
TPH - Aromatic >EC16 - EC21, >EC21 - EC35	33	90*	1	<MRL	120	
Sulphate as SO_4	83	250*	52	38.2	6,930	The concentrations of sulphate as SO_4 exceeding the GAC were recorded consistently at MW1D, MW2, MW4D, MW5D, MW6D, MW7D, MW7S, RBH113, RBH116, RBH119 and RBH141, with isolated exceedances at RBH125, RBH131(S), RBH131(D), RBH132 and RBH145.
		400**	43			
Chloride	83	250*/**	9	14	560	The concentrations of chloride exceeding the GAC were recorded consistently at MW4D, with isolated exceedances in MW5D, RBH129 and RBH145.
Ammoniacal Nitrogen as N	83	500*	27	0.07	6,700	The concentrations of ammoniacal nitrogen as N exceeding the GAC were recorded consistently in MW1D, MW2, MW4D and RBH141, with isolated exceedances in RBH129, RBH 131(D), RBH132 and RBH145.
		600**	26			
Nitrite as N	62	500*	4	<MRL	1,300	Two exceedances of nitrite as N were recorded in RBH116, screened in drift deposits.

Notes

* Drinking water standard

** Freshwater AA EQS

*** Bioavailable GAC

Bioavailable Concentration (bioavailable concentrations have been derived for each sample. The concentrations given for these determinands have been derived by Ramboll and differ from the data received from the laboratory)

MRL – Method reporting limit

MW5D and MW7D were redrilled in May 2023 and replaced with MW5DA and MW7DA respectively.

Within the groundwater monitoring data, Minimum reporting values (hazardous substances) exceedances are limited to heavy metals (arsenic, cadmium, lead and mercury) PHAs and three VOC compounds, as shown in Table 7.6 below.

Table 7-6 - Groundwater Hazardous Substances Minium Reporting Values (MRV) Exceedance

Analyte	No. of Samples Results	Minimum reporting values (MRV) (hazardous substances only)	Number of GAC Exceedances	Max Conc (µg/l)	Location of exceedances
Acenaphthene	62	0.01	6	6.5	The concentrations of anthracene exceeding the MRV were recorded in MW1D and RBH141.
Anthracene	62	0.01*	5	0.24	The concentrations of anthracene exceeding the MRV were recorded in MW1D and RBH141.
Fluoranthene	62	0.01*	5	0.74	The concentrations of fluoranthene exceeding the MRV were recorded in MW1D and RBH141
Benzo(a)pyrene	62	0.01*	1	0.1	One sample was found above the MRV in MW1D, with a concentration of 0.1 µg/l.
Benzo(b)fluoranthene	62	0.01*	1	0.12	One sample was found above the MRV in MW1D, with a concentration of 0.12 µg/l.
Benzo(k)fluoranthene	62	0.01*	1	0.05	One sample was found above the MRV in MW1D, with a concentration of 0.05 µg/l.
Arsenic	83	1*	55	399	The concentrations of arsenic have been recorded above the MRV within MW1D, MW2, WM6D, RBH116, RBH125, RBH132, RBH141 as well as isolated exceedances within WM4D, WM5D, BH119, RBH131(S), RBH138, RBH145.
Lead	83	1*	1	1.7	The concentrations of mercury exceeding the MRV were recorded consistently in MW1D, MW2, RBH116, RBH125, RBH132, and RBH141, with isolated exceedances in MW4D, RBH131(S), RBH132 and RBH145. With the exception of RBH145, all

Analyte	No. of Samples Results	Minimum reporting values (MRV) (hazardous substances only)	Number of GAC Exceedances	Max Conc (µg/l)	Location of exceedances
					concentrations are within the same order of magnitude as the MRV.
Mercury	33	0.01	16	3.16	
1,3Dichlorobenzene	33	0.05*	1	0.15	Single detection recorded in the April 2024 monitoring event within MW5DA
1,2Dichlorobenzene	33	0.05*	1	1.4	Single detection recorded in the April 2024 monitoring event within MW5DA
1,4Dichlorobenzene	33	0.05*	1	0.12	Single detection recorded in the April 2024 monitoring event within MW5DA
* In the absence of published values, the laboratory method reporting limit has been used.					

7.7 Groundwater Summary

The current landfill is underlain by low permeability unproductive strata of the Hemingbrough Glaciolacustrine Formation, with proven thicknesses of 4.50 m (in RBH119 in the east of the site, off the mound) and to >27.10 m (in RBH141A, in the south-east of the site). Although the base of the unit was not proven in this location, an historic borehole log (MW4S) indicates a drift thickness of 67.50 m in the area. This is likely to afford some protection to downward migration of impacted groundwater from the landfill, where present. Furthermore, the semi-artesian nature of the underlying sandstone is likely to further limit the potential for significant mixing of groundwater bodies on-site. Groundwater flow in the PFA/drift appears to be broadly to the south-south-east with local variation.

Regional groundwater flow in the deeper sandstone is likely to be to the east / south-east towards the potable water abstractions, with the inferred localised groundwater flow direction in the vicinity of the landfill is to the south-east in the drift deposits and south / south-east in the sandstone. They may be local influence of infilled Glacial Channel to groundwater flow direction in the drift deposits.

The majority of heavy metal GAC exceedances recorded to date have been periodically detected and do not appear to present a continual elevated source of contaminants. These are likely to be associated with the fluctuations in groundwater levels between the three water bodies (PFA, drift and bedrock) as well as some background concentrations.

There are, however, a number of locations that consistently record concentrations above the associated GAC, as discussed further below:

- Boron: Recorded in all monitoring wells across the site. Boron consistently exceeds both the drinking water and controlled waters GAC within drift wells MW1D*, MW2, MW4D, WM5D/5DA and MW6D. These are located around the perimeter of the PFA Bund and represent the downgradient wells of the main PFA waste mass. Notably, the boron GAC is not exceeded within the three sandstone wells (MW4S, MW5S, MW7S) as well as three drift wells

(MW3, MW5DA and MW7D). Within the newly installed 2024 monitoring wells (i.e., in PFA waste) the GAC are exceeded in the majority of locations although concentrations fluctuate.

- Barium: Exceeds the low drinking water GAC (1 µg/l) in all samples recovered across the site.
- Manganese: Exceeds the drinking water GAC in the majority of samples recovered across the site in all groundwater bodies.
- Arsenic: Exceedances of the lower drinking water GAC is limited to in waste locations (RBH116, RBH125, RBH132, RBH141) and drift monitoring wells in the north-east / east (MW1D* and MW2) and MW6D in the south-west.
- Cadmium: There are no exceedances of the drinking water GAC. The cadmium-controlled waters GAC is consistently exceeded within MW2 and MW4D in the east of the site as well as MW6D located in the south-west. In waste monitoring wells (RBH116, RBH132) also recorded concentrations above the GAC.
- Mercury: controlled waters GAC are consistently exceeded within the drift wells MW1D* and MW2 located in the north-east / east of the site and in-PFA Waste locations RBH116 and RBH141.

* MW1D is located in the north-east of the site and likely up gradient of the main PFA waste mass which suggests some of the elevated metals recorded may be representative of natural/background concentrations or from offsite sources.

Except for manganese, there are limited GAC exceedances recorded within the monitoring wells screened within the sandstone bedrock. Elevated concentrations of PFA derived contaminants such as boron and molybdenum in groundwater sampled from the sandstone do not exceed the GAC. This would add further support to the fact that the low-permeability superficial drift deposits are forming a barrier (aquitard) to the underlying Principal Aquifer.

8. HYDROLOGY

8.1 On-Site Surface Water Courses

Internal to the centre of the landifill area there is a shallow pool of water present at surface level (approximately 10 m AOD) within the U-shaped bund which is considered to be ecologically sensitive (due to the likely presence of newts and other organisms). The pooled water fluctuates in extent, likely drains into the ground and is recharged with rainfall and surface water run-off that falls within the U-shaped bund. Groundwater in this area is approximately 9.2 m AOD within the PFA and 2.0 m AOD within the drift deposits. The shallow pool is not directly connected to the surrounding surface water network.

There is also a drainage feature internal to the south-west of the U-shaped bund that is referred to as the 'lagoon in take' that was designed to capture surface water run off locally inside the landfill and discharge it into the adjacent lake of the nature reserve. Otherwise, water across the landfill infiltrates to ground and is then potentially in continuity/discharges into the toe drains as described below.

Other than the above surface water features there are no significant water courses present on-site. However, a series of drains (finger drains) are referred to as being present around the perimeter of the site which discharge into a pair of toe drains that run parallel around the southern and eastern edges of the landfill. In places the toe drains are connected. The toe drains appear relatively static and no obvious flow direction has been identified during previous monitoring events.

During a topographical survey, the water levels within the toe drains were not recorded, however, based on the elevation of the ground level along the drains, the surface of the water within the closest toe drain is expected to be below -0.70 to -0.28 m AOD, and the second drain to be around - 0.62 m AOD.

The 1994 report30 indicated that the southern part of the site is underlain by a drainage blanket which drains on-site groundwater into the toe drains via short finger drains in the south-east of the mound and a drainage pipe in the south-west. Most or all recharge (infiltrating rainfall) falling within the bunded area of the landfill moves south through the PFA and exits into the toe drains via either the drainage pipe, the finger drains or a spring line at the base of the PFA. This report has found that the PFA groundwater levels dip to the south, indicating that most of the generated PFA groundwater is directed towards the toe drains. The toe drain may have historically been connected to the adjacent pumping station, to discharge into the Thorpe Marsh Drain, albeit the end of the toe drains is silted and no obvious connection pipe was identified during walkovers.

8.2 Off-Site Surface Water Courses

Additionally, a representative from West Burton Energy Ltd conducted a dye test of the toe drains to the south of the site in 2024 to better understand the connectivity of these to the pumping station. It was found that there was no connectivity between the toe drains and pumping station, however it is believed that the pumping station may not have been in operation during this testing period. Off-Site Surface Water Courses

Beyond the toe drains, and located off-site, there are linear ponds present in the south-east and east of the site, with the water level recorded at approximately 1.97 m AOD in the south-east. Google Earth™ satellite imagery indicates that the water within these ponds fluctuates, and the area appears to be flooded at times, suggesting vertical draining into the sub-surface and evaporation occur over time.

Beyond these the nearest significant watercourse to the site is the EA Beck / Thorpe Marsh Drain. The water elevation of Thorpe Marsh Drain is identified to be between 6.22 to 6.25 m AOD from the south to the north-east. Thorpe Marsh Drain is located close to the southern and eastern

boundaries of the site. It flows from the south-west to north-east and it discharges into River Don approximately 1.0 km to the north-east (which is distant). At this point a set of sluice gates are located controlling the waters from the drain and River Don. The EA currently classifies the Don (from Mill Dyke to River Ouse Water Body) as being of 'Moderate' Ecological Status and 'Fail' on Chemical Quality under the Water Framework Directive classification scheme. The EA Beck is raised above surrounding ground level through this area as a raised levee, thus is not considered to be in continuity with groundwater through this area.

A further drain is then present from approximately 50 to 75m beyond the EA Beck / Thorpe Marsh drain at an elevation of approximately 1-2m AOD. To the south-west this drain appears to be formed more of shallow strips of open water. Further land drainage and watercourses are located in the wider surrounds.To the west, in the natural reserve, Thorpemere Pond is present from approximately 70 m west, and the surface water elevation was measured at 1.53 m AOD. According to anecdotal evidence, a surfacw water runn-off local to the south-west of the landfill drains to the lake from the lagoon intake which drains into Thorpemere Lake. No such drain was noted whilst on-site and coupled with the predominant groundwater flow within the underlying groundwater to the south and the south-east, Thorpemere Pond is unlikely to be impacted by the on-site water and soil leachates.

There is an outlet from the south of the pond which flows southward and connects to the pumping station. During a walkover at the site conducted in March 2024, visual evidence of the pumping station discharging water from Thorpemere Pond into Thorpe Marsh Drain via flap valves was observed approximately 60 m to the south-east of the site.

In summary, on-site groundwater in the PFA may be in connectivity with the nearby toe drains but there is no clear evidence of a direct pathway to the nearby surface water courses other than potentially through groundwater flow mechanisms. However, the potential for groundwater to flow and be connected to the wider surface water network appears limited by the presence of the toe drains themselves and the generally static nature of shallow on-site groundwater. The surface water courses are shown on Figure 16, Appendix 1.

8.3 Summary of Monitoring Undertaken

Surface water analytical data has been collected during up to twelve monitoring rounds since May 2021 by Egniol and is summarised in Appendix 5, and discussed below.

Table 8-1 Surface Water Sampling Summary

Date Installed	Screened Strata	IDs	No. of Dipping Rounds	No. of Sampling Rounds
2021 Surface Water Sample Locations	Not applicable	SS1-SS6	Not applicable	12 May-21, Jun-21, Jul-21, Aug-21, Oct-21 (2 rounds), Nov-21, Nov-22, Oct-23, Jan-21, Mar-21 and Apr-21
2024 Surface Water Sample Locations	Not applicable	SS7-SS16	Not applicable	2 Mar-24 and Apr-24

Surface water samples have been collected at up to sixteen locations (SS1-SS16) and at both discharge consent points (DP1-DP2). The location of the groundwater sampling points are presented as Figure 11, Appendix 1.

Table 8-2 - Summary of Surface Water Sampling Locations

Sampling Location	Description
DP1	Landfill surface water run off discharge point to toe drain
DP2	Coal stockyard surface water run off discharge point on Thorpe Marsh Drain Ea Beck
SSW1	West of DP1 - move location west of any inputting drains (if needed)
SSW2	Midstream and down hydraulic gradient based on groundwater flow direction to south-east
SSW3	Upstream on Thorpe Marsh Drain / Ea Beck
SSW4	East of DP1
SSW5	Thorpemere Pond discharge point
SSW6	North-east of landfill (downstream)
SSW7	Upstream of landfill
SSW8	Upstream of landfill
SSW9	Midstream and down hydraulic gradient based on groundwater flow direction to south-east
SSW10	Midstream and down hydraulic gradient based on groundwater flow direction to south-east
SSW11	Midstream and down hydraulic gradient based on groundwater flow direction to south-east
SSW12	North-east of landfill (possibly upstream?)
SSW13	North-east of landfill (possibly upstream?)
SSW14	Upstream of DP2
SSW15	Downstream of DP2
SSW16	Upstream on discharge from toe drain to Thorpemere pond

8.4 Surface Water Analytical Data

Surface water analytical data from 2023 and 2024 has been screened against the following criteria protective of surface water:

- **Surface Water GAC:** Priority substances in surface water and selected (other determinands to which this policy relates): 2013/39/EU: Priority Substances in the Field of Water Policy Directive and 2008/105/EC: Environmental Quality Standards in the Field of Water Policy Directive
- **Surface Water GAC:** Specific and other pollutants in surface water: The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 or where not available Environment Agency (EA) Environmental Quality Standards (EQS) to be utilised in surface water risk assessments as part of environmental permit (discharge consent) applications and WFD assessments of works in coastal and transitional waters in England.

Where surface water concentrations exceed the water environment GAC, these are summarised in Table 8.3 below, with screening tables provided in full in Appendix 5. Exceedances of screening criteria do not infer that an unacceptable risk is present; the outcome of the screening is assessed further in the context of a qualitative source-pathway-receptor risk assessment in Section 12.

Table 8-3 Contaminant Concentration Exceedances in Groundwater of GAC Protective of Surface Water

Contaminant	No. of Samples	GAC (µg/l)	Number of GAC Exceedances	Minimum Concentration (µg/l)	Maximum Concentration (µg/l)	Distribution Comment
Sulphate as SO_4	56	400 mg/l	20	43.3	1,890	Sulphate concentrations above the GAC are consistently recorded at DP1, SS2/SSW2, SS4/SSW4, SSW1, and isolated exceedances are recorded in SS1, SSW9 and SSW12.
Ammoniacal Nitrogen as N	56	600	3	17	850	Ammoniacal Nitrogen (as N) are recorded in isolated samples from SS6 SSW10 and SSW15 only.
Total Suspended Solids (TSS)	46	50 mg/l	17	2.0	490	TSS is consistently above the GAC within DP1 and SS5/SSW5 with isolated exceedances recorded within DP2, SS2/SSW2, SSW6, SSW8, SSW9, SSW12, SSW14, SSW15, SSW16.
Cadmium	32	0.25	4	<MRL	0.6	Cadmium is only recorded above the GAC at SSW2 (two occasions) and SSW4 and SSW12 (single occasion each)
Copper (bioavailable)	32	1*	1	0.03	1.16	A single marginal exceedance of the bioavailable cooper GAC is recorded at SSW5.
Manganese (bioavailable)	56	123*	15	1.8	673	Exceedances of the bioavailable manganese GAC are recorded in DP1, SSW1, SSW4, SSW6, SSW8, SSW10, SSW13 and SSW15.
Mercury	35	0.07	3	<MRL	0.21	Mercury is recorded above the GAC on one occasion from DP2, SSW12 and SSW15 only.
Vanadium	32	20	1	<MRL	3.7	A single exceedance of the vanadium GAC was recorded in SSW12 only.
Nickel (bioavailable)	32	4*	1	0.22	5.88	A single marginal exceedance of the bioavailable nickel GAC is recorded at SSW8.
Vanadium	32	20	1	0.2	21	A single marginal exceedance of the vanadium GAC is recorded at SSW12.
Boron	55	2000	17	28	14,000	Boron consistently exceeds the GAC at DP1, SS2, SS4/SSW4, SSW1, SSW4 as well as isolated exceedances at SSW9 and SSW12.
Total Phenols	24	7.7	1	<MRL	14	A single marginal exceedance of the phenol GAC is recorded at SSW6.

Notes

*Several GAC are based on bioavailable concentrations which are derived for each sample. The concentrations given for these determinands have been derived by Ramboll and differ from the data received from the laboratory.

NC – No criteria available

N/A – Not applicable

MRL – Method reporting limit

N.B. SS1-SS6 and SSW1-SSW6 are collected from the same sampling point.

Boron concentrations consistently exceeds the associated GAC within at DP1, SS2/SSW2, SS4/SSW4, SSW1, all located in the south of the PFA bund within the inner most finger drain and the landfill discharge sampling point. This trend is largely repeated for sulphate, and bioavailable manganese. However, boron is not recorded above the GAC (and an order of magnitude lower) within the samples recorded from Thorpe Marsh Drain.

Within the samples recovered from SSW15 (upgradient of the site) within Thorpe Marsh Drain, sulphate, bioavailable manganese and mercury exceed the surface water GAC. This would suggest that these concentrations are from off-site sources and may presented more background concentrations. The other sampling points along Thorpe Marsh Drain (SSW10 and SSW14) only recorded marginal exceedances for ammoniacal nitrogen bioavailable manganese and mercury, all within the same order of magnitude as the GAC.

Samples taken from SSW16 and SSW5, associated with the intake and outfall of Thorpemere Pond respectively, do not exceed any of the GAC with the exception of a single marginal exceedance of bioavailable copper (SSW16) (1.6 µg/l against a GAC of 1.0 µg/l). This would suggest that the surface water pond is not in direct connectivity with the underlying groundwater bodies (PFA, drift or sandstone) and is more likely surface water fed.

The limited exceedances of the GAC, particularly compared to the groundwater monitoring data, supports the current understanding of the site drainage, with only surface water runoff, and drainage from the PFA Bund via the pumping station having connections to the surface water bodies.

8.5 Rainfall and Flood Risk

The nearest climate station at Robin Hood Doncaster Sheffield Airport indicates that between 1991 and 2020 annual rainfall was 582 mm. According to the EA's fluvial and tidal flood map for planning:

- The west of the site (the area of the PFA mound) is Flood Zone 2 (Medium Probability). This zone comprises land assessed as having between a 1 in 100 (1%) and a 1 in 1000 (0.1%) annual probability of river flooding and / or a 1 in 200 (0.5%) and a 1 in 1000 (0.1%) annual probability of sea flooding.
- The remainder of the site is located in Flood Zone 3 (High Probability). This zone comprises land assessed as having a 1 in 100 (1%) or greater annual probability of river flooding and / or a 1 in 200 (0.5%) or greater annual probability of sea flooding.

According to the EA Flood Map for Surface Water which presents the theoretical potential for flooding from pluvial sources (i.e., flooding caused by rainwater exceeding capacity of drainage systems), the site is generally located in an area of Very Low flooding probability. This zone comprises land assessed as having a less than 1 in 1,000 annual probability of pluvial flooding (<0.1% in any year).

There are sporadic areas on the map where surface water flooding is between a Low (0.1% and 1% of annual probability) and High risk (greater than 3.3% of annual probability). This is at generally low points in the topography in the vicinity of surface water features such as Thorpe Marsh Drain.

A separate Flood Risk Assessment Report is provided in Appendix 2.

9. ECOLOGY

The site is not a statutory designated sites with the nearest designated site being Quarry Park Local Nature Reserve (LNR), located approximately 3.6km southwest of the Site.

The site is located within a Nitrile Vulnerable Zone (Nvz) relating to surface water (Ea Beck from Abbess Dyke to River Don Nvz and Lower Don Nvz). An Nvz relating to groundwater is situated approximately 470 m from the site.

Thorpe Marsh Nature Reserve Local Wildlife Site is located within the permit boundary and adjacent to the west of the landfill and extends to approximately 70ha and includes waterbodies, diverse grasslands, hedgerows and small woodlands. This site will not be disturbed by the potential development.

10. CONCEPTUAL SITE MODEL

10.1 Landfill Directive (LfD)

The existing landfill was operated under a WML granted in 1977 and is of dilute and disperse construction. The proposed movement of PFA will create a new landfill cell which will be subject to conditions of the LfD[31]. The overall aim of the LfD is to prevent or reduce as far as possible negative effects on the environment, in particular the pollution of surface water, groundwater, soil and air, and on the global environment including the greenhouse effect, as well as resulting risks to human health, from landfilling of waste, during the whole life-cycle of the landfill.

Guidance for the implementation of the LfD[32] indicates that an environmental risk assessment should be undertaken in accordance with the requirements of the Regulations that relate to groundwater (Schedule 22). The Regulations require that the regulator must, in exercising its relevant functions, take all necessary measures to:

(a) prevent the input of any hazardous substance to groundwater; and

(b) limit the input of non-hazardous pollutants to groundwater to ensure that such inputs do not cause pollution of groundwater.

10.1.1 Water Control and Leachate Management

The collection of contaminated water and leachate is not required if the landfill poses no potential hazard to the environment, as shown by the site's environmental risk assessment. 'No potential hazard' in this context means there is no likelihood of an unacceptable discharge over the entire lifecycle of the site. If the quantity or quality of any leachate produced by the waste is insignificant or if there is no identified pathway or receptor for contamination, then the collection of leachate is unnecessary and a sealing liner is not required (as is the case for this potential development).

10.1.2 Protection of Soil and Water

Landfills must be situated and designed to prevent pollution of the soil, groundwater or surface water and ensure efficient collection of leachate as and when required. The protection of soil, groundwater and surface water is to be achieved by the combination of a geological barrier and a basal liner during the operational phase, and by the combination of a geological barrier and a top liner after closure.

Paragraph 3.4 of Annex I to the Directive provides for the reduction of the requirements in the geological barrier, basal liner and top liner in two situations based on the environmental risk assessment:

(a) if collection and treatment of leachate is not necessary; or

(b) if it has been established that the landfill poses no potential hazard to soil, groundwater or surface water.

'No potential hazard' in this context means that the environmental risk assessment demonstrates that the reduction of the requirements will result in an acceptable risk to soil and water.

There are circumstances where the requirements of Paragraph 3.1 (i.e., a geological barrier, basal or top liner) are not needed to meet the overall objective of the Directive, and in particular the purpose of paragraph 3.1 - the protection of soil and water.

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[31] European Community (EC) Directive 1999/31/EC on the landfill of waste (the Directive).
[32] Environmental Permitting Guidance, The Landfill Directive, For the Environmental Permitting (England and Wales) Regulations 2010, Department for the Environment, Food and Rural Affairs, dated March 2010.

In order to remove the requirement for one or more of a geological barrier, basal or top liner, the environmental risk assessment must show that a particular requirement would provide a negligible contribution to the protection of soil and water. 'Negligible contribution' means that the necessary conditions were in place to protect soil and water and the addition of the barrier or liner in question would add little or nothing to environmental protection.

10.1.3 Landfill Gas

One of the main purposes of the Landfill Directive is to minimise the contribution of landfill sites to the production of greenhouse gases. This is achieved by reducing the production of methane and also through landfill gas controls.

10.2 Water Framework Directive[33] and Groundwater Daughter Directive[34]

The Water Framework Directive (2000/60/EC) and Groundwater Daughter Directive (2006/118/EC) (GDD) require the prevention of inputs of hazardous substances into groundwater subject to various exemptions. This includes substances confirmed to be hazardous or non-hazardous pollutants and the Environment Agency has indicative minimum reporting values (MRVs) for selected hazardous substances in clean water[35].

The requirements of the Groundwater Directive apply independently and in addition to the requirements in Annex I to the Landfill Directive.

10.3 Environmental Risk Assessment Framework

The landfill CSM will be used to gather sufficient information to facilitate risk assessments and landfill design[36]. The CSM must:

- Consider the location of the site in relation to groundwater and surface water;
- Establish that the site can be developed to protect the environment;
- Establish background conditions at the site;
- Identify the possible impact of the site on local people and the environment;
- Develop a monitoring programme to confirm that there are no environmental impacts from emissions from the site and that the proposed control measures are effective; and
- Develop the engineering design for the site, including how risks will be effectively managed.

The CSM must consider all sources of pollution (including waste, leachate and landfill gas), pathways the pollution may travel away from the site and all the receptors which may be affected.

The information presented in the previous sections of this report has been collated and evaluated to refine the preliminary conceptual site model for the site. The CSM assesses risks from the proposed movement of PFA to form a new landfill cell and the BESS development platform.

10.4 Contaminant Sources

The potential contaminant sources at the site comprise of:

- Historical use of the site as a landfill:
  - Deposition of PFA between the mid-1960s and 1977 (pre WML) .

[33] Water Framework Directive (2006/60/EC)
[34] Groundwater Daughter Directive (2006/118/EC)
[35] Hazardous substances to groundwater: minimum reporting values - GOV.UK (www.gov.uk)
[36] Landfill operators: environmental permits - Plan the environmental setting of your site - Guidance - GOV.UK (www.gov.uk)

- Deposition of PFA, domestic and commercial waste in accordance with the WML, including construction of the horseshoe bund and placement of waste within the southern part of the bund

Historical landfilling activities are discussed within the CSM in terms of background concentrations where this material is not being excavated and/or disturbed as part of this proposed variation. The untreated domestic and commercial waste in the south of the U-shaped horseshoe bund will remain in-situ as part of this variation and will not be disturbed.

The excavation of the upper parts of the current horseshoe bund, exposing the underlying PFA is not anticipated to create additional sources of contamination as this waste was deposited within a dilute and disperse landfill and has been in place for over 50 years.

- **Existing PFA waste to be moved from within the waste site to form the new landfill cell:** Approximately 600,000 m^3 of PFA will be excavated from the horseshoe bund and be redeposited across the existing PFA landfill. The location, size, depth and shape of the areas of PFA excavation and the new landfill cell are presented in Appendix 6. The proposed final landform and use are presented in [, Appendix 6. The new landfill cell will be filled from the south, moving northwards, in layers approximately 250 mm thick before compaction.

  There are no soil exceedances of the human health GAC based on a commercial / industrial end use associated with the PFA to be moved and redeposited, therefore no source is present. In general, PFA consists primarily of silicon dioxide (SiO_2), aluminium oxide (Al_2O_3), and iron oxide (Fe_2O_3). However, the exact composition may vary depending on the source of coal and can include trace heavy metals including calcium, nickel, vanadium, zinc, lead, magnesium and sulphur[37].

  Ground investigations in 2021 and 2024 only identified PFA in the proposed area of cut. However, if non-PFA waste is encountered during landfill operations then this material will be recorded and quarantined for off-site licenced disposal.

- **PFA Leachate:** Existing PFA was deposited up to nearly 50 years ago and no new waste is to be accepted as part of the proposed variation to move the existing PFA. The new landfill cell is not considered probable to produce additional quantities of leachate, particularly given the long term exposure to rainfall and infiltration since deposition, some 50-years ago. However, there may be a short-term increase in leachate generation as the PFA is excavated and existing slopes are exposed. The leachate anticipated is likely to have the same chemical characteristics as the leachate data generated by the recent site investigation, although as noted the majority if leaching has likely already occurred and peak leachate concentration is already likely to have been reached in the landfill as baseline conditions.

- Concentrations of sulphate, arsenic, lead, manganese, selenium, vanadium and naphthalene within soil leachate analytical results for PFA to be moved and redeposited exceeded the GAC protective of surface waters and / or groundwater. All GAC exceedances are of the same order of magnitude, except for sulphate, only recorded in isolated locations.

- **Landfill gases:** PFA is not biodegradable and cannot produce landfill gas. During previous monitoring of the perimeter wells, carbon dioxide (CO2) was recorded between 0.1 % v/v to the maximum concentration of 6.3 % v/v consistently exceeding the compliance limited of 1.5%v/v at WM4D and MW7D. Further occasional exceedances of the CO2 compliance limit have been recorded in MW1D, MW2, MW5S and MW7S.

[37] Kar, K.K. (2022) Handbook of fly ash. Oxford: Elsevier.

Methane concentrations were generally below the compliance limits in the perimeter wells, and at very low concentrations (i.e., ≤0.2 % v/v) within non-perimeter, in-waste wells BH01 to BH06.

- **Nuisance and fugitive emissions:** including dust, odour, birds, vermin, noise and vibration.
- **Potential off-site sources**:
  - The site is located approximately 100m west of the former coal stock yard associated with Thorpe Marsh Power Station.
  - 400m east is the National Grid Substation.
  - The site is situated in a general agricultural area.

Given the distance to these off-site sources and the location of the coal stock yard, power station and substation cross inferred hydraulic gradient, these are not considered to be off-site sources of contamination beneath the site.

10.5 Receptors

Sensitive receptors at this site are presented on Figure 15 (Appendix 1) and include:

- Human health:
  - Future site users, such as the maintenance and security workers;
  - The nearest residential properties are small farmhouses located 175m north and 830m south respectively. These locations also include commercial buildings associated with the respective farm operations. A National Grid compound is located 540m to the east but is not understood to be permanently occupied (i.e., other than working hours). These potential off-site receptors are therefore not considered to be a potential receptor of significance.
  - Members of the public, walking on footpaths or at Thorpe Marsh Nature Reserve.
- Surface waters (presented on Figure 16, Appendix 1):
  - The two inner surface water toe drains for the existing landfill are not considered to be sensitive surface water receptors.
  - Thorpe Marsh Drain (Ea Beck) (surface water to south and east of the site). Although the drain is not in hydraulic connectivity with groundwater beneath the site as it is topographically higher, this is considered as a receptor as it's the location of the recorded discharge consent for surface water run-off from the landfill. This is located approximately 30m to the south-west of the WML permit boundary and c.250m south-west from the new landfill cell, albeit there is no clear pathway to the EA beck as the toe drains appear silted up.
  - The land drain beyond the EA Beck.
  - The adjacent Thorpe Marsh Nature Reserve is located within the wider WML permit boundary.
- Groundwater:
  - Off-site Secondary A Aquifer associated with the alluvium. This is unlikely to be used for potable pr commercial water supply due to its limited lateral and vertical extent, so is considered a limited receptor and as a pathway to surface waters only.
  - Principal Aquifer associated with the sandstone of the Chester Formation. The site is located within a SPZ Zone III (Total Catchment) relating to groundwater at significant

depth in the bedrock. There are five (5) licensed groundwater abstractions listed within 2km of the site (closest 370m east) for a variety of uses including general industrial and general farming and domestic. The SPZ is associated with nine abstraction wells to the south-east and south of the site all of which are greater than 2km from the site. The nearest is located 4.6km to the south-east.

- Ecology:
  - Thorpe Marsh Nature Reserve is located within the wider WML permit boundary. Vegetation is present on-site over the PFA, but is generally of limited ecological value. The vegetation will need to be cleared prior to the works commencing and will be managed through the planning system, including achieving Biological Net Gain (BNG) targets.
- Buildings / Infrastructure
  - A National Grid compound is located 540m to the east but is not understood to be permanently occupied (other than standard working patterns).

The nearest residential properties are small farmhouses located 200m north and 830m south respectively. These locations also include commercial buildings associated with the respective farm operations.

Construction workers have not been considered in the CSM as potential receptors because risks to this group will be evaluated under the Health and Safety legislation.

10.6 Pathways

The plausible pathways are summarised below:

- Human health:
  - Direct contact, soil and dust ingestion, dust inhalation);
  - Soil vapour inhalation
- Groundwater: leaching from waste into shallow groundwater in the landfill followed by further vertical migration through the superficial deposits (unproductive strata) into the bedrock Principal Aquifer
- Surface waters:
  - Leaching from waste into shallow groundwater followed by lateral migration to surface waters
  - Direct discharge of surface water run-off from the landfill via the landfill's discharge consent (reference WRA 7038) into Thorpe Marsh Drain.
- Buildings and Infrastructure: Ground gas migration
  - Ground gas and soil gas inhalation/ingress;
  - Vertical and lateral migration including leaching;

10.7 Background Conditions

It is estimated that approximately 600,000 m^3 of PFA will be excavated and used to form the new landfill cell. Ground models based on previous phases of intrusive investigation estimate that there is a total of approximately 4.44 million m^3 of PFA on-site (both unlicensed and licensed). As such, the new landfill cell will include up to 13% of the total PFA volume. The new PFA landfill cell will be between 0 m and 9.9 m thick, across an area of approximately 22.1 Ha (representing approximately 50% of the current PFA landfill area).

The remaining 3.8 million m^3 of PFA represents the bulk of the old unlicensed PFA landfill. Samples taken within this material have shown that the majority of concentrations of all contaminants of concern recorded within the PFA were below the GAC protective of human health based on a commercial / industrial end use. Soil leachate analysis identified minor (less than an order of magnitude) exceedances of the GAC for sulphate, arsenic, copper, lead, manganese, selenium, vanadium and naphthalene.

Within the underlying groundwater in the drift deposits (unproductive strata), the majority of heavy metal GAC exceedances recorded to date have been periodically detected and do not reasonably present a continual elevated source of contaminants. These are likely to be associated with the fluctuations in groundwater levels between the three water bodies (PFA, drift and bedrock) as well as background concentrations. There are, however, a few locations that consistently record concentrations above the associated GAC for boron, barium, manganese, arsenic, cadmium, and mercury. Except for manganese, there are limited GAC exceedances recorded within the monitoring wells screened within the sandstone bedrock. This would add further support to Ramboll's opinion that the low-permeability superficial drift deposits are forming a barrier (aquitard) to the underlying Principal Aquifer.

Within surface water, boron concentrations consistently exceed the associated GAC at DP1, SS2/SSW2, SS4/SSW4, SSW1, all located in the south of the main PFA bund within the inner most finger drain including the compliance point for the sites surface water discharge, albeit this drain appears to have limited connectivity to wider surface waters. This trend is largely repeated for sulphate, and bioavailable manganese. The limited exceedances of the GAC, particularly compared to the groundwater monitoring data, supports the current understanding of the site drainage, with only surface water runoff, and drainage from the U-shaped Bund to Thorpemere Lake via the intake lagoon having connections to the surface water bodies.

The concentrations and GAC exceedances summarised above are evidence of existing legacy impacts heavily related to unlicensed PFA deposition and therefore considered to be background concentrations in terms of the proposed PFA relocation. Ramboll conclude that in this context, the proposed new landfill cell will have negligible impact to the underlying ground and controlled waters. It is also noted that the existing WML does not contained compliance limits, due to the dilute and disperse nature of the landfill.

Table 10-1 – Pollutant Linkages Risk Assessment

Source	Pathway	Potential Receptor	Comments
Relocated PFA (i.e., new landfill cell) soil concentrations exceed the GAC. Soil Leachate (i.e., new landfill cell) exceedances were recorded for Sulphate, antinomy, arsenic, chromium, bioavailable copper, manganese, selenium, vanadium, naphthalene	Leaching from PFA through unsaturated PFA into shallow groundwater	Unproductive strata (Hemingbrough Glaciolacustrine Formation)	All soil leachate of the cut PFA GAC exceedances are of the same order of magnitude, and with the exception of sulphate, only recorded in isolated locations. The sulphate exceedances are also quite marginal and not an order of magnitude difference. These are therefore not considered to be significant. This is in contrast with the GAC exceedances recorded within groundwater beneath the site, which would suggest that the water body has been previously impacted from the existing landfill. Therefore, the cut and relocated PFA (i.e., new landfill cell) will have a **negligible impact** to the underlying groundwater bodies. However, for robustness further assessment of this S-P-R should be undertaken as part of a hydrogeological risk assessment (HRA).
	Leaching from PFA through unsaturated PFA into shallow groundwater, followed by lateral migration	Secondary A Aquifer (alluvium)	
	Leaching from PFA into shallow groundwater followed vertical migration to deeper groundwater	Principal Aquifer in the Chester Formation (sandstone bedrock) and SPZ III	The domestic water and the potable water abstractions associated with the SPZ are down inferred regional hydraulic gradient of the new landfill cell. However, local hydraulic gradient appears to be more to the south, and therefore the nearest abstractions wells are cross hydraulic gradient and ~4.6km distant with dilution, dispersion and attenuation in the qider aquifer. All soil leachate of the cut PFA GAC exceedances are of the same order of magnitude, and with the exception of sulphate, only recorded in isolated locations. The sulphate exceedances are also quite marginal and not an order of magnitude difference. These are therefore not considered to be significant. The GAC exceedances recorded within groundwater beneath the site would suggest that the drift aquifer has been previously impacted from the existing landfill. However, concentrations of PFA derived contaminants such as boron and molybdenum which are elevated within the drift aquifer are much lower in the sandstone aquifer and do not exceed the GAC. Ramboll considers that the low-permeability superficial drift deposits (4.50 m (in RBH119 in the east of the site, off the mound) and to >27.10 m (in RBH141A, in the south-east of the site). Although the base of the unit was

Source	Pathway	Potential Receptor	Comments
			not proven in this location, an historic borehole log (MW4S) indicates a drift thickness of 67.50 m in the area) are forming a barrier (aquitard) to migration of impacted groundwater to the underlying Principal Aquifer. Therefore, the cut PFA (i.e., new landfill cell) will have a **negligible impact** to the underlying groundwater bodies and no further evaluation is considered necessary. However, the HRA proposed above will further support this assessment.
	Leaching from PFA into shallow groundwater followed by lateral migration to surface water	Thorpe Marsh Nature Reserve & Thorpmere Pond	All soil leachate of the cut PFA GAC exceedances are of the same order of magnitude, and with the exception of sulphate, only recorded in isolated locations. The sulphate exceedances are also quite marginal and not an order of magnitude difference. These are therefore not considered to be significant. The pond is located up/cross hydraulic gradient and therefore the cut PFA (i.e., new landfill cell) will have a **negligible impact** on the pond.
	Entrainment of sediment into surface water run-off, followed by direct discharge via the pipe beneath the PFA horseshoe		Following the intake pipe repairs in 2000 additional measures were taken to prevent silt entering surface waters. In addition, the surface water monitoring results to date have not shown impacts associated with groundwaters below the PFA and therefore there is considered to be a **negligible impact.** This pathway will be removed as part of the future drainage scheme and a new drainage system installed. Temporary measures, including silt controls, will be needed on-site during the construction phase work.
	Leaching from PFA into shallow groundwater followed by lateral migration to surface water	Thorpe Marsh Drain (Ea Beck) and Toe Drains	EA Beck / Thorpe Marsh Drain is not hydraulically connected to on-site groundwater as a raised structure (Thorpe Marsh Drain) and wider watercourses are at a significant distance. There is no clear pathway between the toe drains that intercept groundwater on-site and the Ea Beck. Therefore, the cut PFA (i.e., new landfill cell) will have a **negligible impact** on the Thorpe Marsh Drain (Ea Beck) or wider watercourses. It cannot entirely be ruled out that there may previously have been connectivity between the western end of the Toe Drain and the adjacent pumping station (that handles the discharge from the nature reserve lake)

Source	Pathway	Potential Receptor	Comments
			to the EA Beck. However, the ends of the drains appear silted up and no obvious current pathway has been identified.
	Additional loading of relocated PFA onto existing PFA resulting in enhanced migration of existing contamination	Nearby groundwater resources	Shallow groundwater on-site is already impacted as a result of historic leaching practices and the general low permeability nature of the surrounding ground is expected to limit the potential for enhanced migration to occur as a result of the proposed relocation activities. Furthermore, the underlying drainage blanket and fingers drains would likely direct additional groundwater migration into the surrounding toe drains where it would be captured, as already occurs.
No PFA cut (i.e., new landfill cell) soil concentrations exceed the GAC. Cut Soil Leachate (i.e., new landfill cell) exceedances were recorded for sulphate, arsenic, lead, manganese, selenium, vanadium and naphthalene.	Fugitive emissions (dust/particulates)	Thorpe Marsh Drain (Ea Beck)	Dust will be controlled in line with good practice measures on construction sites including the use of damping down during mechanical excavation, where temporary stockpiles are created and during placement activities. Contractors working at the site will be responsible for developing and implementing detailed method statements and controls.
	Entrainment of sediment into surface water run-off, followed by direct discharge under consent	Thorpe Marsh Drain (Ea Beck)	Following the intake pipe repairs in 2000 additional measures were taken to prevent silt entering surface waters. In addition, the surface water monitoring results to date have not shown impacts associated with groundwaters below the PFA and therefore there is considered to be a **negligible impact**. The proposed landfill cell surface water drainage system assumes a discharge rate of 103.5 m/s based on a greenfield run off rate and landfill cell area.
No PFA/topsoil or made ground cut (i.e., new landfill cell) soil concentrations exceed the human health GAC.	Fugitive emissions (dust) during landfill operation	Public visitors to Nature Reserve and walking nearby footpaths during landfill operation	Reported concentrations in the cut PFA did not exceed the human health GAC. **No potential hazard.**
	Dermal contact / ingestion of soils / dust / inhalation of dusts – completed development	Future site users	Restoration plans for the landfill will be confirmed at a later date. However, these are likely to include a cover layer of gravel or topsoil combined and geotextile membrane which will break any potential pathway from dusts or direct contact with the PFA. **No potential hazard**.

Source	Pathway	Potential Receptor	Comments
Elevated carbon dioxide concentrations above the 1.5%v/v compliance limit	Vapour inhalation	Future site users	Analytical results did not identify a potentially volatile contaminants in samples of PFA to be excavated and re-deposited. **No potential hazard**
	Ground gas generation and migration into buildings and confined spaces	Future site users	PFA is not biodegradable so cannot produce landfill gases. There is untreated domestic waste within the historical landfill, but this waste will not be excavated as part of these works. Ground gas monitoring has not identified concentrations of methane above the 1% v/v compliance limit. Slightly elevated carbon dioxide levels above the conservative compliance limit however, any structures will be raised above ground level (i.e., portacabins) providing an air vent and therefore there will be **negligible impact**. However, the concentrations are within the range of what could be expected from natural drift deposits (i.e., glaciolacustrine deposits and alluvium) as recorded on site or may be associated with the untreated domestic waste present in the south of the site, which is not being excavated and re-deposited as part of these works. Therefore, these minor exceedances are not considered to be significant.
		Sickle Croft Farm, located 175m north	
Landfill Operation Phase	Noise (nuisance)	Future site users	Once the landfill operation has been completed, there will be no noise issues. **No potential hazard.**
		Public visitors to Nature Reserve and walking nearby footpaths	Landfilling activities will generate noise that will require appropriate controls though the implementation of an Environmental Management System and Construction Environmental Management Plans (CEMP).
		Sickle Croft Farm, located 175m north	Landfilling activities will generate noise that will require appropriate controls though the implementation of an Environmental Management System and Construction Environmental Management Plans (CEMP).
	Dust generation	Future site users	Once the landfill operation has been completed, there will be no noise issues. **No potential hazard.**
		Public visitors to Nature Reserve and walking nearby footpaths	Landfilling activities will generate dust that will require appropriate controls though the implementation of an Environmental Management System and Construction Environmental Management Plans (CEMP).

Source	Pathway	Potential Receptor	Comments
		Sickle Croft Farm, located 175m north	Landfilling activities will generate dust that will require appropriate controls though the implementation of an Environmental Management System and Construction Environmental Management Plans (CEMP).
	Odours, birds and vermin	Future site users	Once the landfill operation has been completed, this will be unlikely and controlled through the implementation of an Environmental Management System and Construction Environmental Management Plans (CEMP). **No potential hazard.**
		Public visitors to Nature Reserve and walking nearby footpaths	Odours, birds and vermin are unlikely as the PFA is non-biodegradable and strict management controls will be in place through the implementation of an Environmental Management System and Construction Environmental Management Plans (CEMP). **No potential hazard.**
		Sickle Croft Farm, located 175m north	Odours, birds and vermin are unlikely as the PFA is non-biodegradable and strict management controls will be in place through the implementation of an Environmental Management System and Construction Environmental Management Plans (CEMP). **No potential hazard.**
Disturbance of on-site ecological receptors during landfill operation	Movement of PFA	On-site ecological receptors	Risks to on-site receptors have been assessed separately as part of the ongoing planning application. Reference should be made to the Ecology Reports.
Stability and settlement of the new landfill cell and regraded cut slopes of the existing landfill	Exposure of waste at the surface if integrity of landfill cap is affected.	Future site users	Exposing the underlying PFA is not anticipated to create additional sources of contamination as this waste was deposited within a dilute and disperse landfill and has been in place for over 50 years. **Negligible impact**.
	Change in ground gas regime	Future site users	The planned works will not excavate into the commercial waste deposits, and the works will act as an additional cap to this material therefore the ground gas regime will not change. **Negligible impact**.
		Sickle Croft Farm, located 175m north	The planned works will not excavate into the commercial waste deposits, and the works will act as an additional cap to this material therefore the ground gas regime will not change. **Negligible impact**.

Source	Pathway	Potential Receptor	Comments
	Increased rainwater infiltration resulting in greater leaching of contaminants from the PFA	Groundwater (Principal Aquifer in the Chester Formation (sandstone bedrock) and SPZ III)) and subsequently surface waters (Thorpe Marsh Drain (Ea Beck) and Toe Drains)	Exposing the underlying PFA is not anticipated to create additional sources of contamination as this waste was deposited within a dilute and disperse landfill and has been in place for over 50 years. All surface water on the new landfill cell will be collected, minimising potential infiltration across the site. In additional, the new PFA cell will be engineered into place, forming a low permeability cell across the whole site area limiting any further infiltration into the historical PFA landfill deposits. **Negligible impact**

11. CONCLUSIONS AND RECOMMENDATIONS

This report was prepared by Ramboll, on behalf of Thorpe Marsh Green Energy Hub Ltd, and presents the objectives, scope, findings and conclusions of a conceptual site model undertaken for the proposed Thorpe Marsh Green Energy Hub, Battery Energy Storage System development.

This phase of assessment follows several phases of ground investigation work and is required to benefit the Environment Agency in understanding the environmental setting of the site and inform the design and operation of the site.

11.1 Conclusions – Risks to Human Health

In relation to the soil environment, no soil exceedances were observed. Ramboll therefore concluded that further detailed assessment was not required for the soil environment in the context of risks to human health and the proposed development. Future landfill operational activities will generate dust that will need to be managed through appropriate controls.

Potential risks to the water environment were identified from elevated concentrations of metals, ammoniacal nitrogen, sulphate and sodium in groundwater on-site.

A detailed review of the data to develop the conceptual site model and provide a review of potential risks to water resource receptors has been completed.

11.2 Conclusions - Risks to Water Resources

All soil leachate of the cut PFA (i.e., the new PFA landfill call) GAC exceedances are of the same order of magnitude, and with the exception of sulphate, only recorded in isolated locations. The sulphate exceedances are also quite marginal and not an order of magnitude difference. These are therefore not considered to be significant.

This is in contrast with the GAC exceedances recorded within groundwater beneath the site, which would suggest that the water body has been previously impacted from historical sources. This is in line with a dilute and disperse landfill. It is also noted that there are no compliance limits set within the current WML.

Therefore, the cut PFA (i.e., new landfill cell) will have a negligible impact to the underlying groundwater bodies. However, further assessment of this S-P-R should be undertaken to confirm.

Future landfill operational activities will generate dust that may be released to watercourses and that will need to be managed through appropriate controls.

11.3 Recommendations

On the basis of the findings of this risk assessment, no further remedial action in relation to the groundwater impacts is required.

However, as required by the environmental permitting regulations a Hydrogeological Risk Assessment (HRA) should be completed to further demonstrate the negligible nature of the proposed work.

APPENDIX 1
FIGURES

APPENDIX 2
PREVIOUS THORPE MARSH REPORTS

APPENDIX 3
SOIL, GROUNDWATER AND SURFACE WATER SUMMARY TABLES

APPENDIX 4
HAZWASTEONLINE OUTPUT SHEETS

APPENDIX 5
GROUNDWATER AND SURFACEWATER MONITORING SUMMARIES

APPENDIX 6
STIRLING MAYNARD DESIGN DRAWINGS