March 2025
Ref: 1763-HRA-R2

Hydrogeological Risk Assessment for Middleton Quarry, Pollington

Contents

Disclaimer

APPENDICES

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1. Introduction

Middleton Quarry, Pollington is a disused sandstone quarry in the East Riding of Yorkshire. It is located on the west side of Pollington Village, approximately 12km west of Goole and 14km north of Doncaster. The closest postcode is DN14 0DS. The site has an unauthorised waste deposit in the northeastern area of the quarry.

This hydrogeological risk assessment is being prepared at the request of AA Environmental Limited (AAe) to support a proposal to restore the quarry. It is proposed that restoration will be by inert landfilling. The proposed end uses will comprise a combination of residential areas, commercial areas and public open space.

The site has a public supply borehole within 20m of the northern boundary. This report will assess the feasibility of restoration by use of inert wastes close to the public water supply.

Revisions have been made to the original version of this report (December 2022) as a result of the permit application review process and Schedule 5 notice. Changes are highlighted in green.

2. The Site

2.1. Location

Middleton Quarry is situated on the south side of Heck and Pollington Lane, from which access is gained, on the west of the village of Pollington. The site can be located by postcode DN14 0DS and is centred on National Grid reference SE 609 201. The main area of the quarry is rectangular in shape, being approximately 250m from north to south and 210m from east to west. There is an area northeast of the proposed landfill, which extends along Heck and Pollington Lane by approximately a further 170m and is approximately 70m in width. Unauthorised wastes were placed in this northeastern area of the quarry, refer to Figure 1A, however, this is outside of the area proposed for landfilling, as explained in sections below, due to the proximity of a public water supply borehole.

The ground level along Heck and Pollington Lane is around 14 to 15m AOD. This falls to approximately 7m AOD at the southeastern perimeter of the quarry. Sandstone has been extracted to a depth of -1mAOD in the northwest of the quarry and to less than -5mAOD in the south. There remains an area of undisturbed sandstone in the central southern area.

The site is set in largely agricultural land, approximately 1km south of the M62. There are works to the north and west of the site. To the south are fields leading on to a residential area and the New Fleet Drain North is approximately 550m south of the southern boundary. There are further residential properties to the southeast. Pinfold Lane is at the northeastern boundary of the site. To the east of this lane are commercial premises. A public water supply and sewage pumping station are located directly north of the site.

Figure 1A: Site Location Plan (taken from Envirocheck Report)

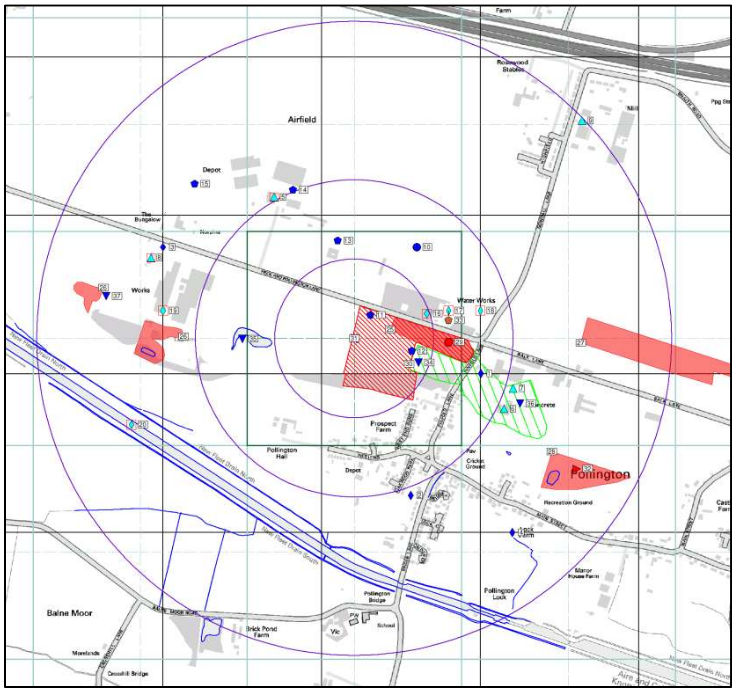
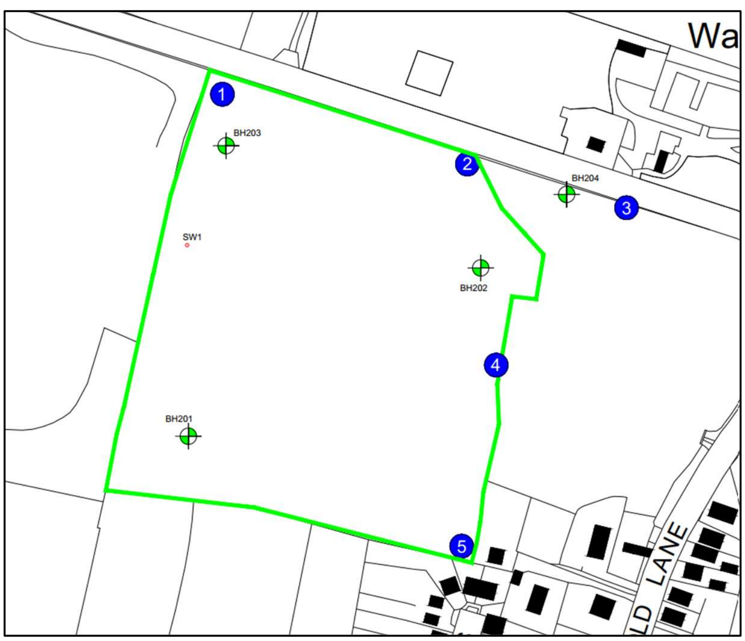


Figure 1B: Site Plan (taken from AAe drawing 163407/D/006)



2.2. Environmental Setting

The site is within a relatively low lying area, underlain by the Sherwood Sandstone principal aquifer. There is a public supply borehole directly north of the site and a further five public supplies within 6km of the site. Went Ings Meadows SSSI is 3.5km southeast of the site. Other local environmental features are presented in Table 1.

Table 1: Local Environmental Features

Feature	Nature of feature	Distance from site
Residential/Work-Place/Amenity -Within 50 m	Water works Residential properties Commercial units Commercial units	20m N 35m SE 20m E 100m N
Residential/Work-Place/Amenity - 50 - 250 m	Commercial buildings Residential buildings	150m NW 250m SW
Residential/Work-Place/Amenity > 250 m	Factory New Fleet Drain North M62 motorway	400m west 550m S 900m N
Habitats		
Habitats Directive sites	None within 2 km	
CROW Act 2000 sites	None within 2km Closest – West Ings Meadow SSSI	3.5 km E
Other habitat sites	None within 2 km	
Groundwater		
Aquifer	Sherwood Sandstone – principal aquifer	On site
Groundwater protection zone	SPZ2 – main site SPZ1 – NE extension	On site
Groundwater abstractions	Public water supply Celcon commercial borehole Pollington airfield Plasmor Limited	20m North 600m west 1.3km NW 1.8km NW
Surface Water		
Closest river	North Fleet Drain River Went River Aire	550m S 2.5km S 3.5km N
Direct runoff from site?	Surface water soakaway/pond	Within west of site
Surface water abstractions	Canal and Rivers Trust Canal and Rivers Trust	750m W 1.6km W
Nitrate vulnerable zone	Yes	
Wells and springs		
Wells	None identified on local maps, or by local council within 1km	
Springs	None identified on local maps within 1km	
Air quality management zone	No	
Flood zone	Flood zone 1 – low risk	

2.3. Site History

The site has been worked for sand and sandstone, with the central southern area remaining undisturbed. Historical maps indicate this began around the 1890s. The water works to the north was developed at the same time. Maps from the 1950s indicate the sand workings extended west of the site for approximately 1km.

The Envirocheck report, refer to Appendix 2, lists the site as a former inert landfill, named Middleton Quarry, licensed to C F Harris Limited from 1983 to 1993. The unauthorised wastes in the northeastern part of the quarry are understood to have been placed during the early 2000s.

2.4. Proposed Landfill Design

2.4.1. Environment Agency Guidance

The Environment Agency's (EA) approach to groundwater protection, 2018, gives the following guidance.

The EA will normally object to any proposed landfill site in a groundwater SPZ1.
For all other proposed landfill site locations, a risk assessment must be conducted based on the nature and quantity of the wastes and the natural setting and properties of the location. Where this risk assessment demonstrates that active long-term site management is essential to prevent long-term groundwater pollution, the Environment Agency will object to sites:

- *below the water table in any strata where the groundwater provides an important contribution to river flow, or other sensitive receptors*
- *within SPZ2 or 3*
- *on or in a principal aquifer.*

The quarry falls within SPZ1 and SPZ2, refer to section 3. There are unauthorised existing wastes placed within the area designated as SPZ1, closest to the public water supply. The management of these materials is outside the scope of this assessment.

The main area of the quarry is within SPZ2. Here it is proposed to infill with inert wastes above the prevailing groundwater level. As such the deposit will not require active long-term management to prevent ingress of groundwaters, or management of leachate.

2.4.2. Imported Waste Types

The permit application is for landfilling of inert wastes. The wastes will meet inert waste acceptance criteria and therefore, there will be no requirement for leachate management. Details of waste acceptance procedures are presented in the Operational Working Plan, AAe reference 163407/OP. The acceptable waste codes for landfilling are given in AAe report reference 163407/OP and are presented in Table 6 of this report.

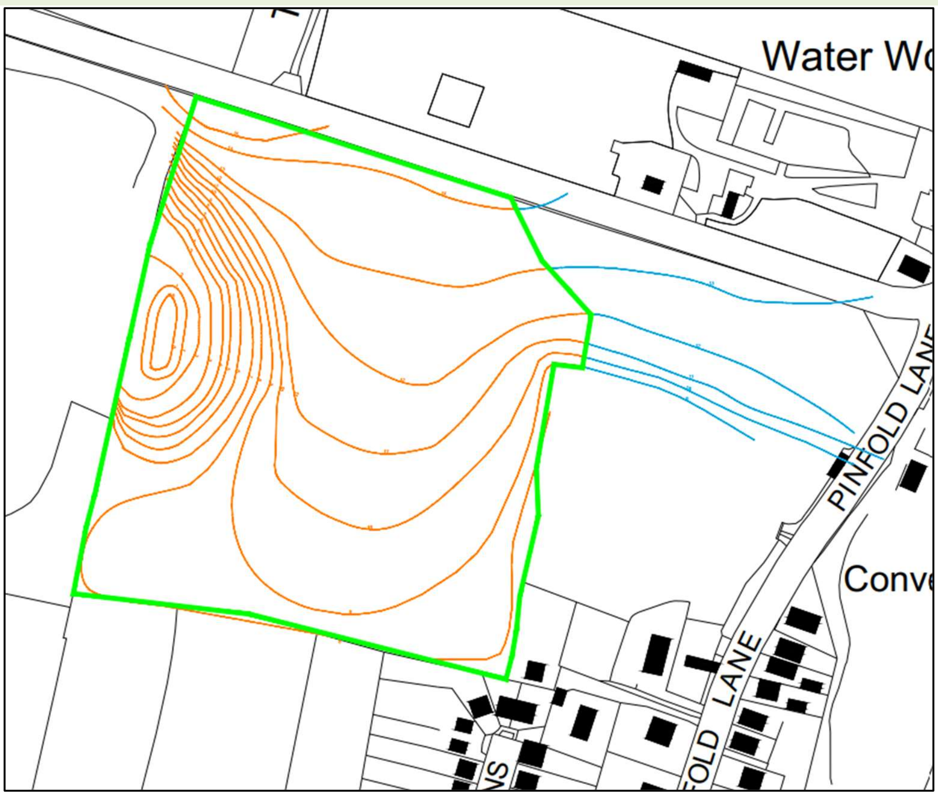
2.4.3. Basal Construction

This assessment and permit application is for a new inert landfill. The existing site has sand extraction to a depth of more than 5m below Ordnance Datum (OD) in places. The quarry base is uneven and has areas of undisturbed sandstone. The quarry will be developed to a level base. Those areas below 0m AOD will be backfilled with clean inert material. An engineered geological barrier of minimum 1m thickness and permeability of maximum 1×10^{-7} m/s will then be placed prior to the inert waste deposit.

2.4.4. Restoration

Landfilling will be completed to the profile presented in AAe drawing 163407/D/006, in accordance with a site-specific restoration plan as part of the environmental permit application, refer to Figure 2. An application is being made to modify the site's planning permission and this will include the landfill restoration contours.

Figure 2: Restoration Contours – AAe 163407/D/005



3. Geology and Hydrogeology

3.1. Geology

3.1.1. Site Geology

The British Geological Survey (BGS) Geology of Britain Viewer records superficial deposits at the site perimeter, where ground remains undisturbed by quarrying activities. The deposits are described as sand and gravel lacustrine beach deposits of the Quaternary period. The underlying bedrock geology is sandstone of the Sherwood Sandstone Group, formed during the Permian and Triassic Periods. The sandstone is fine to medium grained with thin mudstone lenses. It is thought to reach more than 450m in thickness in the area north of Goole.

The BGS holds details of borehole records for the public water supply boreholes, currently operated by Yorkshire Water, directly north of the site. Publicly available records are for the older wells from the early 1900s and from 1952. Sandstone is recorded to depths of 600 feet (183m).

3.1.2. Site Investigations

Site investigations were carried out by AAe during December 2020, refer to AAe Factual Report reference 163407/FR/001. This comprised a series of trial pits in the northeastern area of the site to investigate the waste deposit; four deep groundwater boreholes and further trial pitting for soakaway testing. The ground conditions encountered are summarised in Table 2.

Table 2: Ground Conditions

Stratum	Depth to base (m)	Thickness	Description
Made Ground	4 - 5	4 - 5	Mixed made ground/waste deposit composed of brick, concrete, soils with occasional tile, macadam, plastic, timber and fabric. Occasional black staining and weathered hydrocarbon odour. Odour of ammonia noted in TP204. Occasional asbestos fragments. Ash and burnt wood note in TP206.
Sandstone	35.5 (max)	31.5 penetrated	Dark orange to red medium grained sandstone. Sandstone with gravels recorded in upper 3m of BH202.

Samples from the wastes encountered within the trial pits were tested for both total and leachable concentrations of contaminants. Tables 3 and 4 summarise the soils and leachate data.

Table 3: Exceedances of Inert WAC in solid data

Location	Determinand	Concentration (mg/kg)	Inert WAC
TP201 1-2m	Total petroleum hydrocarbons	1100	500 mg/kg mineral oil
TP203 1.5-2m		890	
TP204 1-1.5m		500	
TP205 2.5-3m		570	
TP201 3-4m	Total PAHs (16)	180	100 mg/kg PAH Sum of 17
TP203 0-1m		150	
TP203 1.5 – 2m		100	
TP204 0-1m		300	
BH204	pH	4.8	>6 pH units

Table 4 presents the determinands that were found to exceed the inert WAC, or the UK Drinking Water Standards in the leachate analysis.

Table 4: Exceedances of the UKDWS in leachate data

Location	Determinand	Concentration (mg/l)	Environmental Assessment Level (mg/l)
TP201 1 – 2m	Ammoniacal nitrogen	1	0.39 [1]
TP201 2-3m		1.4	
TP201 3-4m		1	
TP202 1-2m		0.75	
TP202 3-4m		1.4	
TP204 0-1m		0.42	
TP204 1-1.5m		4.7	
TP204 2.8-4m		1.3	
TP204 1-1.5m	Arsenic	0.014	0.01 [1] (inert WAC = 0.05)
TP204 2.8-4m		0.029	
TP204 1-1.5	Mercury	0.0058	0.001 [1+2]
TP204 2.8-4		0.0014	
TP201 1-2m	Sulphate	300	100 [2] (UKDWS=250)
TP201 2-3m		300	
TP201 3-4m		150	
TP202 1-2m		1500	
TP202 3-4m		1600	
TP203 3-3.5m		190	
TP204 0-1m		480	
TP205 3-3.5m		420	
TP206 1-1		1400	
TP206 2-2.5		160	
TP206 3.5-4		130	
TP204 2.8-4	Vanadium	0.094	0.06 [3] (hardness > 200mg/l)

'1 UK Drinking Water Standard
2 Inert WAC equivalent leachability
3 Freshwater environmental quality standard in the absence of a drinking water standard, or inert WAC

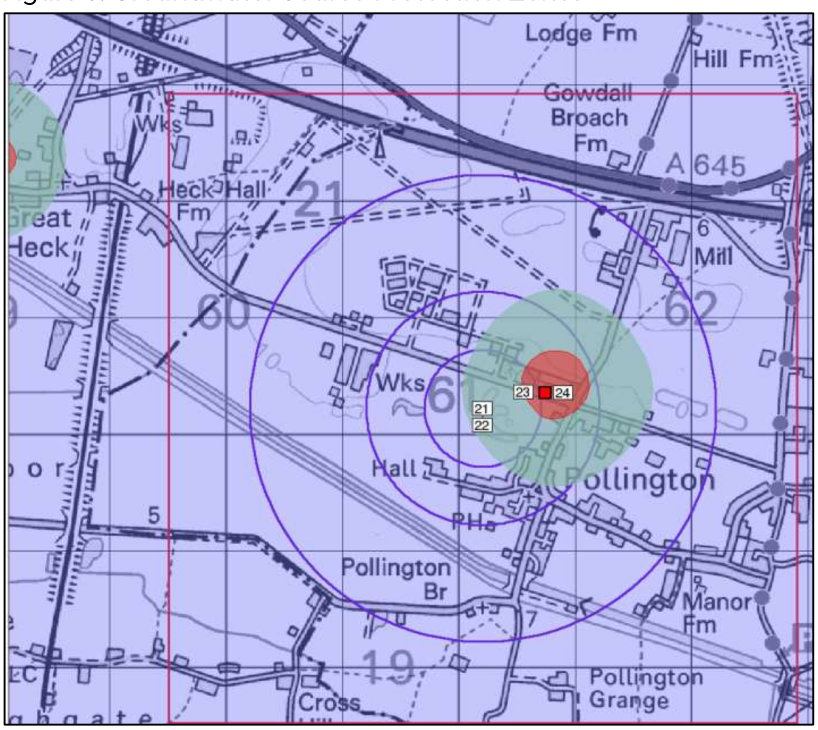
3.2. Hydrogeology

3.2.1. General Properties

The Sherwood Sandstone is designated as a principal aquifer. Surface soils are sandy and of high leaching potential. The region surrounding the site has several public supply boreholes abstracting from the Sherwood Sandstone. The closest is approximately 20m north of the site. There is a public supply at Great Heck, about 3km west and with a further four public supplies within 6km. Local businesses also use borehole water supplies, such as the factory (Celcon) approximately 600m to the west.

Figure 3 shows the location of the groundwater source protection zones 1 and 2 relative to the site, taken from the Envirocheck report. SPZ1, indicated in red, covers the area of the public water supply and extends below the northeastern area of the site. SPZ2, indicated in green extends to the boundary of the quarry in the southwest. The Great Heck public supply protection zones can be seen in part to the west.

Figure 3: Groundwater Source Protection Zones



The BGS hydrogeological sheet of South Yorkshire, 1982, records the potentiometric surface in the Sherwood Sandstone in the vicinity of the site as below 0mAOD. The zero metres contour is plotted approximately 1-1.5 km distant from the cluster of public supply boreholes.

3.2.2. Aquifer characteristics derived from BGS borehole records

Records from the public supply boreholes north of the site dated 1952 give a rest water level of 50 feet (15.24m) below ground level (bgl) and a total depth of 183m. The ground level in the location of this well is approximately 10m AOD, giving a rest water level of around 5m below Ordnance Datum. The pumped water level is recorded as 142 feet bgl, which would be approximately 33m below OD. The well record gives a transmissivity of 320m2/day. Using a saturated aquifer thickness of between 150 and 165m this would give average hydraulic conductivities of 2.3 to 2.5 x 10^{-5} m/s.

The BGS, 1997, gives an interquartile range of 5.4 x 10^{-6} to 2.4 x 10^{-5} m/s for hydraulic conductivity of the Sherwood Sandstone aquifer, north region of the UK, with a geometric mean of 1.16 x 10^{-5} m/s. The local pump test data corresponds with the upper interquartile for the saturated aquifer. The unsaturated sandstone will naturally have a lower hydraulic conductivity, due to less well-developed flow paths. A value equivalent to the lower interquartile hydraulic conductivity is considered suitable for the unsaturated zone.

To the west of the site there are well records for Celcon, giving a rest water level of 45 feet bgl for the 1983 well. The ground level is not recorded, but based on local maps, this would suggest a rest water level of between -3 and 0m AOD.

3.2.3. Abstractions and Springs

In addition to the public supply boreholes and the Celcon factory, there are abstractions recorded for Pollington airfield approximately 1.3km to the northwest and Plasmor Limited, 1.8 km to the northwest.

There are no springs recorded on maps of the area close to the site. The local environmental health department has been contacted for records of private water supplies and have confirmed that they hold no records of private water supplies within 1km of the site.

3.2.4. Local Hydrogeology

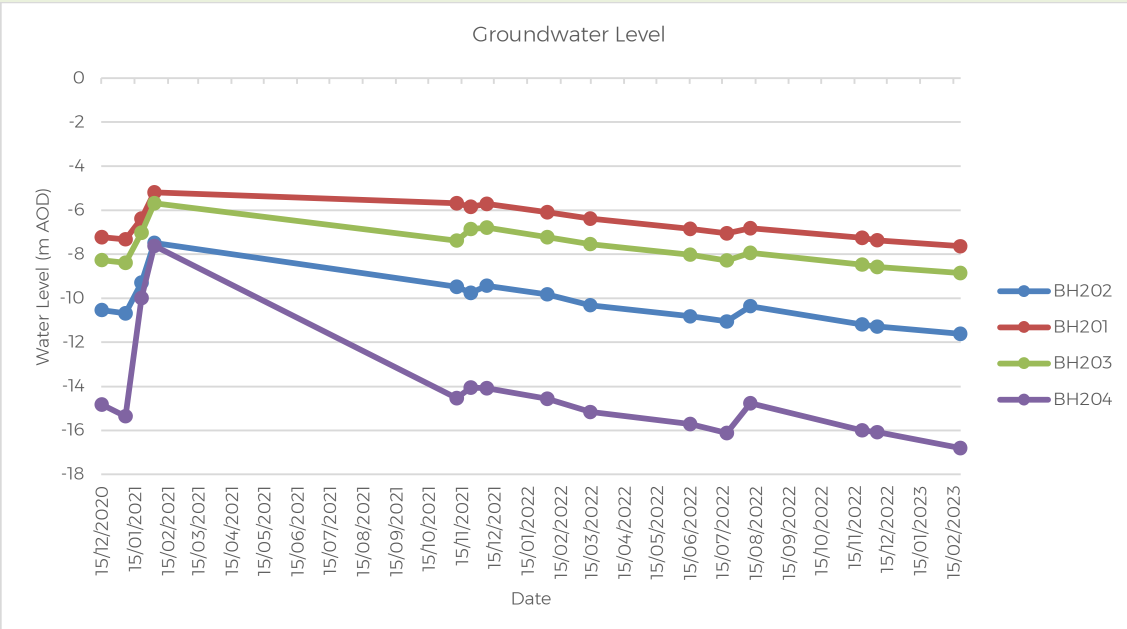
A site investigation was undertaken by AAe in 2020. The trial pits used to investigate the wastes in the northeast of the quarry went to a maximum depth of 4.6m and all were recorded to be dry.

Soakaway testing was carried out in the west of the quarry in TP207 and revealed infiltration rates of between 1.09 x 10^{-5} and 2.13 x 10^{-5} m/s. Infiltration rates are not directly comparable to the hydraulic conductivity of a soil/stratum and tend to be higher than the unsaturated hydraulic conductivity.

Four deep boreholes were constructed to depths below the prevailing groundwater level and have been monitored on four occasions since construction. Groundwater levels are presented in Figure 4. Groundwater is clearly deeper closer to the public water supply, however, the degree of drawdown is variable.

There have been two further groundwater level measurements since the first revision of the HRA: December 2022 and February 2023. Data is included in the graph below.

Figure 4: Groundwater Levels (to July 2024)



A conceptual model of the site is presented in AAe Drawings reference 163407-CSM-001 and 002, refer to Appendix 1.

Groundwater contours are presented in Figures 5A and 5B. Figure 5A is plotted from data from 15 December 2020 and Figure 5B using data from 2 February 2021. This is to demonstrate how the hydraulic gradient changes across the site, presumably connected to the timings of the pumps in the public water supply. The data presented in Figure 5A gives hydraulic gradients of 0.02 for the main quarry area and 0.068 closer to the public supply borehole. Figure 5B gives a hydraulic gradient of approximately 0.0125.

Figure 5A: Groundwater Contours 15/12/20

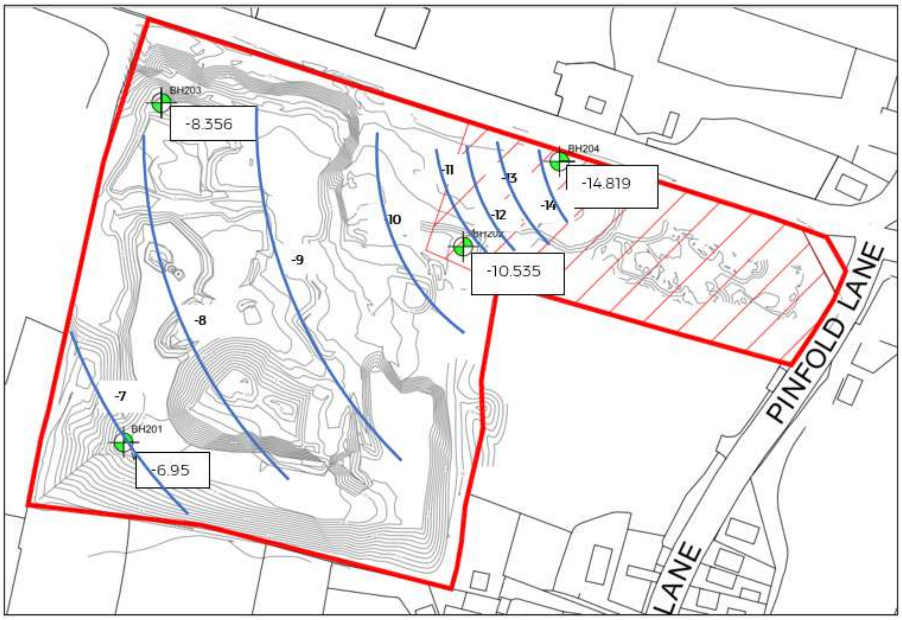
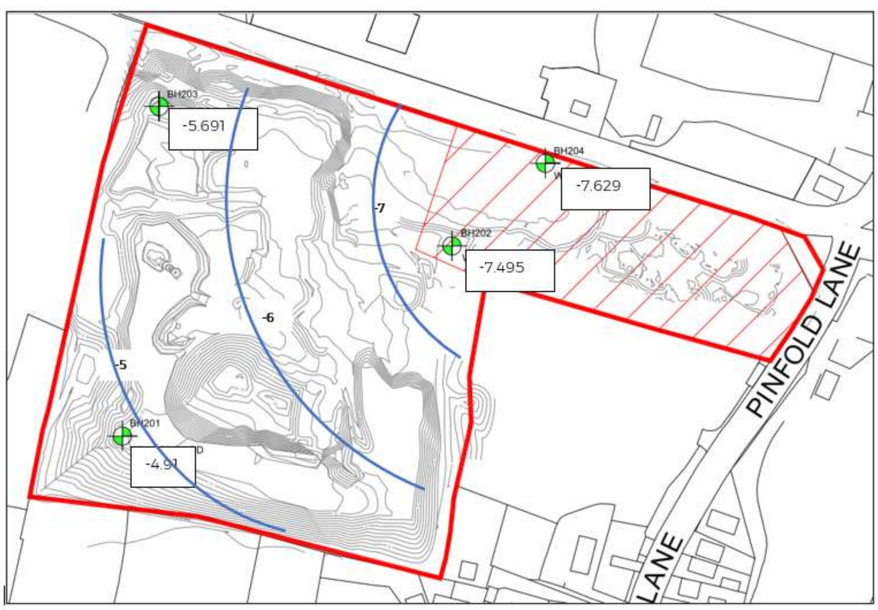


Figure 5B: Groundwater Contours 2/2/21



Groundwater quality is summarised in Table 5.

Table 5: Groundwater Quality Monitoring Data

Determinand (metals = dissoved concentration)	Units	Average BH201	Average BH202	Average BH203	Average BH204	UKDWS as EAL unless indicated
pH		8.01	7.94	8.14	7.99	6.5 – 9.5
Electrical Conductivity	µS/cm	973.33	867.50	527.50	802.50	-
Biochemical Oxygen Demand	mg O2/l	4.27	4.55	4.00	4.18	-
Chemical Oxygen Demand	mg O2/l	12.82	12.18	11.91	11.18	-
Chloride	mg/l	57.75	21.83	13.03	29.92	250
Fluoride	mg/l	0.11	0.10	0.12	0.14	1.5
Ammoniacal Nitrogen	mg/l	0.27	0.17	0.18	0.19	0.39
Sulphate	mg/l	121.08	70.83	37.33	93.75	250
Cyanide (Total)	mg/l	0.05	0.05	0.05	0.07	0.05
Total Hardness as CaCO3	mg/l	411.67	415.83	184.58	356.25	-
Arsenic	µg/l	2.33	1.07	1.73	1.07	10
Boron	µg/l	48.58	48.00	44.00	44.17	1000
Cadmium	µg/l	0.19	0.11	0.10	0.24	5
Chromium	µg/l	5.98	5.54	4.97	6.30	50
Copper	µg/l	1.54	1.55	3.18	1.58	2000
Mercury	µg/l	0.16	0.16	0.16	0.16	1
Nickel	µg/l	0.97	0.89	0.67	1.32	20
Lead	µg/l	1.10	1.08	0.63	1.35	10
Selenium	µg/l	1.39	1.26	0.63	1.70	10
Vanadium	µg/l	0.64	0.63	0.63	0.89	-
Zinc	µg/l	18.88	32.23	4.68	26.15	-
Chromium (Hexavalent)	µg/l	18.19	18.19	18.19	18.19	-

Table 5 shows only cyanide has exceeded the UKDWS and this relates to one sample only from BH204. Concentrations differ slightly between boreholes, with slightly higher concentrations of BOD, COD and sulphate in BH201. This borehole is where the highest electrical conductivity has also been recorded and is in the most upgradient position. The lowest concentrations are generally recorded in BH203.

Groundwater has also been tested for total petroleum hydrocarbons (TPH), polyaromatic hydrocarbons (PAHs), BTEX compounds and phenol in all locations. Generally results are all lower than detection limit. There has been an exception in March 2022, when heavy chain aliphatic TPH was identified in BH201 and BH204. Phenol has also been identified above the laboratory limit of detection (LOD) in BH201 and BH204 on one occasion each, but on different dates. The full dataset is presented in Appendix 3.

The data used to generate Table 5 is provided in Excel format as part of the permit application process, file reference 1763 HRA Appendix 3 GWQ.

3.3. Hydrology

Ground levels surrounding the site fall from approximately 15m AOD to 5m AOD in a southerly direction. The North Fleet Drain North is located approximately 550m south of the site. Further south the ground is relatively flat and cut by drains. The River Went flows from west to east approximately 2.5km south of the site. The meandering course of the River Aire is approximately 3.5km north of the site.

There are no surface water features on the site itself. A small pond is located approximately 275m west of the site.

During construction, surface water will be directed to a soakaway on the west of the site. The final restoration will include a pond and soakaway feature in this location.

4. Conceptual Hydrogeological Site Model

4.1. Source

The source considered in this assessment is the landfilling of inert wastes within the main area of the quarry, which falls within SPZ2. The configuration of the source is illustrated in the conceptual cross sections AAe drawings 163407/CSM/001 and 002 in Appendix 1.

The area of the quarry is approximately 5 ha. The wastes will be placed above an engineered geological barrier, of thickness 1m and permeability no greater than 1 x 10^{-7} m/s. The base of geological barrier will be placed at 0m AOD. This will mean that should there be a rise in groundwater levels due to cessation of the public supply, the wastes will remain above the prevailing groundwater level. The proposed restoration contours for the main quarry fall from approximately 13m AOD in the north to 8m AOD in the south, giving a range of waste thickness from 7 to 12m.

Council Directive 2003/33/EC lists those wastes which may be accepted at inert landfills without testing. The proposed codes for the inert landfill are presented in Tables 6, which includes wastes that are considered inert without testing and wastes which will be subjected to testing in accordance with the site's waste acceptance procedures, refer to the Operational Working Plan, AAe report reference 163407/OP.

Table 6: Proposed Inert Waste Codes

Description	EWC code
Concrete	17 01 01
Bricks	17 01 02
Tiles and ceramics	17 01 03
Mixtures of concrete, bricks, tiles and ceramics	17 01 07
Natural soils and stones (must be proven prior to receipt)	17 05 04 20 02 02
Wastes from mineral non-metalliferous excavation	01 01 02
Waste gravel and crushed rocks	01 04 08
Waste sand and clays	01 04 09
Solids from physical treatment (limited to soil washing silts only)	19 02 06
Minerals from waste facilities	19 12 09
Solids from soil remediation (limited to soil washing silts only)	19 13 02

WAC are expressed as mg/kg within the incoming wastes, but the majority of determinands are tested for their potential to leach from the waste. An equivalent leachate concentration in mg/l is 10% of the WAC concentration expressed in mg/kg. Council Directive 2003/33/EC also presents "first flush" leachate concentrations (C_o) and these are incorporated into the leachate source term. For organic determinands an equivalent leachability and C_o

concentration is available for phenol. Other organics are limited by a total soil concentration.

Table 7: Waste Acceptance Criteria for Leachates

Determinand	WAC Leachate Criteria (LS=10l/kg) (mg/kg)	Equivalent leachability (mg/l)	Co concentration 2.1.2.1 2003/33/EC (mg/l)	EAL (mg/l) UKDWS unless noted otherwise
Arsenic (total)	0.5	0.05	0.06	0.01
Barium (total)	20	2	4	0.7 [1]
Cadmium (total)	0.04	0.004	0.02	0.005
Chromium (total)	0.5	0.05	0.1	0.05
Copper (total)	2.0	0.2	0.6	2
Mercury (inorganic)	0.01	0.001	0.002	0.001
Molybdenum (total)	0.5	0.05	0.2	0.07 [1]
Nickel (total)	0.4	0.04	0.12	0.02
Lead (total)	0.5	0.05	0.15	0.01
Antimony (total)	0.06	0.006	0.1	0.005
Selenium (total)	0.1	0.01	0.04	0.01
Zinc (total)	4.0	0.4	1.2	0.0109 [2] bioavailable + background
Chloride (total)	800	80	460	250
Fluoride (total)	10	1	2.5	1.5
Sulphate (as SO4)*	1000	100	1500	250
TDS	4000	n/a	n/a	n/a
Phenol Index	1.0	0.1	0.3	0.0077 [2]

1- World Health Organisation (WHO) Molybdenum is a health-based value as no guideline available
2- EQS – freshwater environmental quality standard
The values of TDS can be used instead of Cl or SO4.

In most instances, as demonstrated by Table 7 the equivalent leachability, or Co concentration exceeds the EAL (see highlighted cells) and therefore, it must be demonstrated that sufficient attenuation is available below the wastes.

4.2. Pathway

The groundwater level depending on the rate of pumping from the nearby public supply has been observed to be between approximately -5 and -7m relative to OD in the southern area of the site furthest from the public supply and between -7 and -10m relative to OD in the north. This gives a minimum unsaturated thickness of 5m below the 1m thickness of engineered geological barrier. The hydraulic conductivity and hydraulic gradient are described in section 3.2.

The saturated Sherwood Sandstone is designated as a principal aquifer. The Environmental Permitting Regulations 2016 require that there is no discernible discharge of hazardous substances to groundwater and therefore, the pathway for hazardous substances is limited to the base of the unsaturated zone. For non-hazardous pollutants it is required that input is limited to ensure there is no pollution. Non-hazardous pollutants are, therefore, assessed once they have entered the aquifer, but the length of pathway will be limited to a position on the downgradient boundary of the site. Refer to section 5 for more details of the risk assessment modelling.

4.3. Receptor

The receptor is the public supply borehole approximately 20m from the edge of the quarry. The modelled receptor will be a theoretical receptor on the boundary of the site.

Given that the groundwater in the Sherwood Sandstone is used locally for public water supply the UK Drinking Water Standards (UKDWS), given in the Water Supply (Water Quality) Regulations 2018, are considered to be the appropriate Environmental Assessment level (EAL).

5. Hydrogeological Risk Assessment

5.1. The Nature of the Hydrogeological Risk Assessment

Environment Agency guidance on landfill developments (EA webpage accessed March 2021 https://www.gov.uk/guidance/landfill-operators-environmental-permits/landfills-for-inert-waste) indicates that, if an inert waste landfill is in a sensitive area, such as in an aquifer, source protection zone (SPZ), or below the water table, then a simple risk assessment is insufficient and a more detailed risk assessment is required. Middleton Quarry, Pollington is in a SPZ1 and SPZ2. Landfilling with inert wastes is proposed in SPZ2 and therefore the potential risks posed to groundwater are assessed quantitatively. This is done using Landsim, for the proposed landfilled inert wastes.

5.2. The proposed assessment scenarios

It is proposed that the main quarry area will be an inert landfill, with a geological barrier and therefore, no long-term management controls. The geological barrier and underlying unsaturated zone will be assessed to determine the degree to which attenuation can be provided before potential contaminants reach the saturated zone. Scenario 1 will assess the site as it is designed to operate, with incoming waste meeting inert WAC. Additional modelled scenarios (models RLA1 and RLA2) will examine the potential for wastes to be received unknowingly in exceedance of the inert WAC. This is often referred to as a rogue load assessment.

5.3. The Priority Contaminants

The priority contaminants are considered to be those listed within the inert waste acceptance criteria to which a leachate limit is applied and where this limit exceeds the EAL as presented in Table 7. These determinands are listed below:

> Non-hazardous pollutants: Barium, Cadmium, Chromium, Molybdenum, Nickel, Antimony, Selenium, Zinc, Chloride, Fluoride, Sulphate,
> Hazardous substances: Arsenic, Lead and Mercury
> Organic contaminant: Phenol
>
> Additionally, in order to asses the potential for rogue loads from the waste types proposed, including fuel spillages, benzene and hydrocarbons representative of the diesel range (TPH aromatic C10-C12) have been added to the list of contaminants. Ammoniacal nitrogen is added to account for the potential receipt of biodegradable wastes.

5.4. Review of Technical Precautions

The technical precautions appropriate to an inert landfill are:

- A geological barrier, of 1m thickness and a maximum permeability of 1×10^{-7} m/s;
- Suitable capping to support the designated end use.

A leachate containment system is not required. The permeability of the geological barrier will control the rate of release of any leachate, but prevent a build-up, which would require long term management.

Landsim requires a fixed head of leachate to be entered into the model in order for the contaminant model to be run. It can be difficult to obtain a realistic leachate head for an inert landfill within Landsim and this is acknowledged by the EA. A manual water balance is presented below, which indicates that a build up of leachate is unlikely at Pollington.

The surface area of the landfill is approximately 5.35 ha (53500 m^2).
The effective rainfall is 150 mm per annum (4.76×10^{-9} m/s).
Therefore, the rainfall infiltration is 2.5×10^{-4} m^3/s.. Q_{rain}

The base of the landfill, is approximately 34000m^2.
The maximum permeability is 1×10^{-7} m/s.
Therefore, the basal seepage is 3.4 x 10-3 m^3/s.. Q_{seep}

The basal seepage (Q_{seep}) is 13 times greater than the rainfall infiltration (Q_{rain}). Therefore, it is unlikely that there will be a build-up of leachate at the base of the landfill.

In order for the model to run, a low nominal range of heads is used, which have been selected as a triangular distribution of 0.05, 0.1 and 0.2m.

5.5. Justification for Modelling Approach and Software

Landsim has been selected as the assessment tool for the inert landfill. This is also an Environment Agency approved assessment tool. The Landsim model allows the selection of properties for the geological barrier separate to those of the rest of the unsaturated zone.

5.6. Model Parameterisation

Input parameters are sourced from site information where possible. Where there is insufficient site specific data, values are sourced from literature, much of which is described in the preceding sections of this report. The leachate source term is derived from inert waste acceptance criteria, including potential for rogue loads and includes the higher Co values, to include conservatism to the leachate concentration. The leachate source chemistry is presented in Table 10. For metals, which are generally more easily attenuated, the Co concentration is used as the source concentration. For other determinands a range is used between the inert WAC equivalent leachability and the higher EQS, or Co values. General input parameters are presented in Table 11.

Table 8: Landsim Input Criteria, Leachate

Determinand	Modelled concentration	Comment	Partition coefficient (ml/g)	Justification
Arsenic	0.06	Co	117 [1]	Consim - unspecified
Barium	4	Co	Uni (11,52) [2]	Range from USEPA as no value for sand, or unspecified in Consim
Cadmium	0.02	Co	LogTri (3.7, 74, 1500) [1]	Consim range for sand
Chromium	0.1	Co	67 [1]	Consim for sand
Mercury	0.002	Co	450 [1]	Consim range for sand
Molybdenum	0.2	Co	110 [1]	Consim unspecified as no value for sand
Nickel	0.12	Co	LogTri (20, 400, 8100) [1]	Consim value for sand
Lead	Log tri (0.007, 0.05, 0.15)	EA most likely, inert WAC, Co	LogTri (27, 270, 2.7e^{4}) [1]	Consim value for sand
Antimony	0.1	Co	Uni(45,550) [2]	US EPA used as no data in Consim
Selenium	0.04	Co	9.5 [1]	Consim unspecified as no data for sand
Zinc	1.2	Co	200 [1]	Consim values for sand
Chloride	Tri (80, 230, 460)	Inert WAC - Co	-	No retardation assumed
Fluoride	Tri (1, 1.25, 2.5)	Inert WAC - Co	0.8 [1]	Consim unspecified as no value for sand
Sulphate (as SO4)	Tri (100, 400, 800)	Inert WAC, EQS, 2xEQS	-	No retardation assumed
Phenol	Tri (0.1, 0.2, 0.3)	Inert WAC - Co	Koc=27, foc for sandstone = 0.007 [1]	Conservatively low from Consim
Phenol half life	Engineered barrier: Uni (0.03, 0.82) [1]			Aerobic to anaerobic
Phenol half life	Unsaturated: Uni (0.03, 0.27) [1]			Aerobic- as less compacted
Ammoniacal nitrogen	Tri (0.3, 4, 8)	10 X DWS on average	(0.5, 2, 3.2) [1]	
Benzene	0.1	10 x WHO guideline	0.57 [1]	
TPH aromatic (C10-C12)	500	Solids limit for mineral oil as leachate conc	Koc=2510, foc = 0.007	TPHCWG, Vol 3 for Koc
Notes i. Phenol half life: potential anaerobic conditions allowed for at base of waste in engineered barrier ii. Landsim check for "leachate species is a VOC and landfill gas extraction is taking place" unchecked, as no gas extraction. iii. Kappa constants for benzene and TPH left as zero default				

1 = Consim Help File, 2 = US EPA : 1996 : Soil Screening Guidelines: Technical Background Document

Table 9: Landsim Input Parameters

Parameter	Unit	Value	Source
Waste			
Infiltration to open waste	mm/yr	Norm (150,15)	Effective rainfall: ADAS 1982. Site is borderline Area 16 + Area 12. Take worst case to be conservative.
Cap design infiltration	mm/yr	Norm (112.5,11.25)	Low permeability capping not required. Value equal to effective rainfall – less 25% runoff for sloping profile. Rational Method for estimation of storm runoff (Hammer, 1986)
End of filling	yr	10	Operational life of the site assumed to be 10 years
Cell dimensions	ha	5.35	Top area from site plan=5.35 ha (L=250m, W=210m approx.). Base area from site plan= 3.4 ha (L=200m, W=170m approx..)
Thickness	m	Tri (7,10,12)	Based on restoration contours and a base at 0m AOD
Waste porosity	fraction	Uni (0.2, 0.4)	Inert waste
Waste Dry Density	g/cm³	Uni (1.15, 1.25)	Inert waste
Waste field capacity	fraction	Uni (0.2, 0.4)	Inert waste
Head of leachate when breakout occurs	m	7	Minimum thickness of waste, which is on southwest boundary
Drainage System			
Head on EBS	m	Tri (0.05, 0.1, 0.2)	Initial starting point as leachate build up unlikely – refer to water balance calculations, section 5.4 and model results for head on EBS after management control ceases
Waste hydraulic conductivity	m/s	Uni (1e-^{7}, 1e-^{3})	Hydraulics not used in model
Primary drainage system		None	No leachate drainage required for inert landfills
Sump diameter	m	n/a	Hydraulics model not used
Geological barrier			
Thickness	m	1	Landfill design requirement
Moisture content	fraction	0.22	Assumed for silty sand
Hydraulic conductivity	m/s	1e-^{7}	Landfill design requirement
Longitudinal dispersivity	m	0.1	10% pathway length
Density	kg/l	2	Assumed for silty sand
Unsaturated zone – Sherwood Sandstone			
Thickness	m	5 m	Minimum thickness of unsaturated zone based on water levels in SW corner furthest from pumping well, with landfill base at 0m AOD
Moisture content	fraction	0.12	Assumed for unsaturated sandstone

Parameter	Unit	Value	Source
Hydraulic conductivity	m/s	5.4e-6	Lower interquartile value for Sherwood Sandstone North Region. Note that where groundwater is highest in SW the unsaturated zone will be partially backfilled with clean, naturally arising fill, likely to be of a lower hydraulic conductivity, so value is conservative
Longitudinal dispersivity	m	0.5	10% of path length
Aquifer Pathway			
Pathway width	m	320	Perpendicular to direction of flow
Thickness	m	180	Local borehole record shows depth of 182.88m – all sandstone
Density	kg/l	2	Assumed for sandstone
Mixing zone thickness	m	15	Based on difference in water levels observed across the site, as affected by the proximity to the public supply borehole and allowing for further drawdown close to well
Relative vertical dispersivity	-		1% of pathway length
Hydraulic conductivity	m/s	Tri (5.4e-6, 2.3e-5, 2.5e-5)	Pumping station well record and interquartile range, Sherwood Sandstone, North Region, BGS Major Aquifers
Hydraulic gradient	-	Uni (0.0125, 0.02)	Site monitoring data, winter 2020/21. It is unclear how often the hydraulic gradient changes with pumping. Conservative values from range observed.
Pathway porosity	fraction	Uni(0.1,0.3)	Assumed range for sandstone
Distance to receptor	m	5	Distance to default receptor
Longitudinal dispersivity	m	18	10% of pathway length
Lateral dispersivity	m	1.8	10% of longitudinal

5.7. Landsim Sensitivity Analysis and Results

5.7.1. Hydraulics

Model Scenario 1 was presented in earlier versions of the HRA. A jump in the leakage from the engineered barrier system (EBS) was identified, which appears to be a timestepping issue in Landsim associated with fixing a leachate head higher than can be supported by the infiltration. Section 5.4 demonstrates that the landfill is unlikely to support a build-up of leachate with the base engineered to a permeability of 1 x 10^{-7} m/s as required. However, Landsim requires a fixed head of leachate in order to run.

As a conservative compromise to remove instability in the model hydraulics, the head of leachate has been fixed for the full 20,000 years modelled. This step is recommended by Golders in their letter to the EA of December 2019. In recent communications with WSP (formerly Golders) regarding the problem identified in the leakage, it was recommended to set the fixed leachate head to zero. This has also been done, with the head set to zero for the full 20,000 years. The results are the same as setting the original fixed head for the full 20,000 years. A manual check on the result of these changes in the model is given below.

Maximum basal leakage

The basal leakage should not exceed the infiltration to the landfill. Given a cap area of 5.35ha (53500m2) and effective rainfall of 150mm per annum during landfilling, rainfall infiltration is 2.5×10^{-4} m^3/s, or approximately 8000m3/yr. Following capping, where at least 25% of effective rainfall can be expected to runoff the domed profile, this would reduce to approximately 4400m3/yr. The Landsim models give basal leakage of approximately 6000 m3/yr at the 50^{th} percentile.

Aquifer flow

Using Darcy's Law

Q=kia

Where

k = most likely aquifer hydraulic conductivity = 2.3e-5 m/s

i = mid value for hydraulic gradient = 0.0165

a = aquifer pathway width (320m) x mixing zone thickness (15m) = 4800m2

Q = 1.82e-3 m3/s = 57446 m3/yr

The Landsim model gives leakage + aquifer flow of approximately 50,000 m3/yr at the 50^{th} percentile.

Dilution

Using rainfall infiltration to open waste and average / most likely aquifer conditions, this would give a dilution of approximately 7 times in the modelled aquifer mixing zone. It is noted that rainfall infiltration will decrease once the landfill is complete and the domed profile is created, resulting in a slightly increased dilution. The mixing zone thickness is less than 10% of total aquifer thickness, which is 180m.

The Landsim model gives a dilution of approximately 8 at the 50^{th} percentile.

5.7.2. Results

Modelled outputs are presented in Table 10. Results are displayed for hazardous substances at the base of the unsaturated zone. Results for all other determinands are assessed at the monitor well. The position of the monitor well is fixed by Landsim to be 5 m downgradient of each landfill phase. In the instance of Middleton Quarry, Pollington the whole site is represented as one cell and therefore, the monitor well is the appropriate point of assessment. It is noted that the model gives an error message that leakage exceeds 10% of the aquifer flow. This is true when compared to the thickness of the mixing zone modelled, but not for the full thickness of the aquifer, which is more than 10 times the mixing zone thickness. However, as this error is highlighted, it is not appropriate to consider results from the off site compliance point. Only the results at the monitor well should be considered. The results presented are the 95th percentile peak concentrations, unless otherwise noted.

In addition to the main modelled scenario (Scenario 2) the sensitivity of the following parameters is assessed.
S2 Sens 1 – Reduced pathway width to 210m
S2 Sens 2 – Reduced aquifer dispersion, to 2 and 0.2
S2 Sens 3 – Reduced aquifer hydraulic conductivity to Uni (5.4e-6, 2.4e-5)
S2 Sens 4 – Reduced leachate head: Tri (0.005, 0.01, 0.02)
S2 Sens 5 – Increase infiltration by 40% to account for climate change
S2 Sens 5 – Reduce unsaturated zone thickness from 5 to 1m
Scenario 2 zero head – Leachate head set to zero for 20,000 yrs

Discussion

Table 10 highlights where the modelled sensitivity runs produced exceedances of the EAL. For all modelled scenarios exceedances were only recorded for ammoniacal nitrogen (in several scenarios) and benzene in the situation where the unsaturated zone was reduced to 1m.

Ammoniacal nitrogen is not required to be tested for as part of WAC analysis. It has been included to assess the consequences of receipt of rogue loads containing biodegradable wastes. The Landsim model indicates that if the entire site comprised waste with ammoniacal nitrogen leaching at more than 10 times the UKDWS on average, the concentration in the modelled mixing zone of the aquifer would not exceed the UKDWS. It is noted that it is unlikely that biodegradable waste would be found in a significant proportion of the landfill due to the comprehensive waste acceptance procedures that would be put in place.

Benzene was found to equal the EAL in the model run to assess unsaturated zone reduction in thickness to 1m. It is noted that modelled unsaturated zone thickness of 5m in Scenario 2 is already a conservative estimate based on current site conditions, where the maximum groundwater level is -5m AOD, as groundwater levels can be -10m AOD closer to the pumping station. The area surrounding Pollington has a large number of abstraction boreholes. The Hydrogeological Sheet of South Yorkshire shows a major abstraction approximately 5km to the eastnortheast of the site and one approximately 3km to the west. There are a further two abstractions on the south side of the River Aire northeast of the site and within 10km. The Hydrogeological sheet shows that all these abstractions fall within an area where the groundwater level is below zero m AOD. It is likely to take a large shift in groundwater usage for groundwater levels to rise significantly in this region. The BGS future flows data for Permo-Triassic Sandstone indicates that for the period 2041 – 2070, maximum predicted rebound is of the order of 1m, using Heathlanes as the closest sandstone borehole with future flows data. Therefore this scenario is considered to be extreme.

In general the model sensitivity analysis indicates that the majority of likely contaminants in the wastes will be of low concentration and will benefit from sufficient attenuation and dilution to prevent exceedances of the EAL in the groundwater directly downgradient of the site. Ammoniacal nitrogen and benzene have low attenuation properties and the potential to be present at concentrations of 10 times the EAL within the waste makes them sensitive to the modelling process. It is noted that the presence of these substances would only occur due to receipt of rogue loads and is unlikely to affect the whole waste mass as modelled. This is discussed further below.

5.7.3. Rogue Load Assessment

Further rogue load assessment has been undertaken by increasing the concentrations of contaminants within the leachate source term. An initial doubling of concentration is modelled in RLA1. Concentrations are then increased iteratively up to 10 times to determine whether this is acceptable. The results are presented in Table 11. The results demonstrate that all modelled determinands, with the exception of ammoniacal nitrogen can be doubled in concentration from that in the original source term and many can increase 10-fold, while still managing resultant concentrations below the EAL.

Table 10: Landsim Model Results and Sensitivity Analysis (mg/l)

Determinand	Scenario 2	Sens 1 Reduced pathway width	Sens 2 Reduced aquifer dispersion	Sens 3 Reduced aquifer hydraulic conductivity	Sens 4 Reduced leachate head	Sens 5 Increase infiltration by 40%	Sens 6 Reduced unsaturated thickness	Scenario 2 zero head of leachate	EAL (mg/l) UKDWS unless stated	LOQ/MRV (mg/l)
Leakage from EBS (50%ile) l/day	16500	16500	16500	16500	16500	23000	16500	16500		
Leakage from EBS (50%ile) m3/yr	6022	6022	6022	6022	6022	8395	6022	6022		
Leak + aquifer flow (50%ile) m3/yr	50000	35000	50000	40000	50000	52000	50000	50000		
Dilution (50%ile)	8.2	5.7	8.2	6.7	8.2	6.1	8.2	8.4		
Arsenic	0 for 2000 yrs	0 for 2000 yrs	0 for 2000 yrs	0 for 2000 yrs	0 for 2000 yrs	0 for 1500 yrs	1100 yrs to reach EAL	0 for 2000 yrs	0.01	0.005
Barium	0.21	0.28	0.2	0.27	0.2	0.27	0.36	0.19	0.7 [1]	
Cadmium	0.0008	0.0013	0.0009	0.0011	0.0009	0.0012	0.0013	0.0008	0.005	
Chromium	0.0037	0.005	0.0038	0.0048	0.0038	0.0048	0.009	0.0033	0.05	
Mercury	0 for 8000 yrs	0 for 8000 yrs	0 for 8000 yrs	0 for 8000 yrs	0 for 8000 yrs	0 for 6000 yrs	0 for 2000 yrs	0 for 8000 yrs	0.001	0.00002
Molybdenum	0.0057	0.008	0.0058	0.0076	0.0057	0.0073	0.014	0.0055	0.07 [1]	
Nickel	0.0037	0.006, 0 for 3000 yrs	0.0042	0.0052	0.0042	0.00540	0.0065	0.0032	0.02	
Lead	0 for 3000 yrs	0 for 3000yrs	0 for 3000yrs	0 for 3000 yrs	0 for 3000 yrs	0 for 2000 yrs	900 yrs to reach LOQ	0 for 3000 yrs	0.01	0.0002
Antimony	0.0032	0.0046	0.0033	0.0042	0.0033	0.0043	4000 yrs to reach EAL	0.0026	0.005	
Selenium	0.0037	0.0053	0.0039	0.005	0.0039	0.0048	0.006	0.0034	0.01	
Zinc	0 for 4000 yrs	0 for 4000 yrs	0 for 4000 yrs	0 for 4000 yrs	0 for 4000 yrs	0 for 3000 yrs	2000 yrs to exceed EQS	0 for 4000 yrs	0.0109 [2] bioavail' +	
Chloride	69	95	70	91	68	84	65	60	250	
Fluoride	0.29	0.39	0.28	0.38	0.28	0.37	0.34	0.26	1.5	
Sulphate (as SO4)	120	173	130	161	127	160	1.6e-4	106	250	
Phenol	<1e-8	<1e-8	<1e-8	<1e-8	<1e-8	2e-8	119	<1e-8	0.0077 [2]	
Ammoniacal nitrogen	0.37	0.53	0.38	0.51	0.38	0.49	0.5	0.36	0.39	
Benzene	1.8e-7	1.5e-7	1.5e-7	1.5e-7	1.5e-7	2.8e-6	0.001	1.8e-7	0.001	
TPH aromatic C10- C12	<1e-8	<1e-8	<1e-8	<1e-8	<1e-8	<1e-8	0.0001	<1e-8	0.01 WHO	
	Hazardous substance									

Sensitivity runs have been made with 201 model iterations

Arsenic and lead, hazardous substances, are modelled at concentrations higher than the EA default source term for inert landfill.

[1]– WHO; [2] - EQS

Results for hazardous substances are assessed at the base of the unsaturated zone. Results for non-hazardous pollutants are assessed at the monitor well

Table 11 Results of Rogue Load Assessment

Determinand	Results of Scenario 2 (mg/l)	RLA1 source con'c x 2 (mg/l)	RLA1 results (mg/l)	RLA2 conc'n x 10 unless stated (mg/l)	RLA2 multiplier	RLA2 results (mg/l)	EAL (mg/l) UKDWS unless stated	LOQ/MRV (mg/l)	Notes
Arsenic	0 for 2000 yrs	0.12	0 for 2000 yrs	0.6	10	0 for 2000 yrs	0.01	0.005	
Barium	0.21	8	0.38	16	4	0.71	0.7 [1]		
Cadmium	0.0008	0.04	0.0017	0.1	5	0.004	0.005		
Chromium	0.0037	0.2	0.007	1	10	0.034	0.05		EQS = 0.0047, not exceeded for >2000 yrs
Mercury	0 for 8000 yrs	0.004	0 for 8000 yrs	0.02	10	0 for 8000 yrs	0.001	0.00002	
Molybdenum	0.0057	0.4	0.011	2	10	0.055	0.07 [1]		
Nickel	0.0037	0.24	0.0082	1.2	10	0.032 0 for 2000 yrs	0.02		EQS=0.004, not exceeded for >4000 yrs
Lead	0 for 3000 yrs	Logtri(0.014, 0.1, 0.3)	0 for 3000yrs	Logtri (0.07, 0.5, 1.5)	10	0 for 3000 yrs	0.01	0.0002	
Antimony	0.0032	0.2	0.006, 0 for 2000 yrs	1	10	0.029, 0 for 2000 yrs	0.005		
Selenium	0.0037	0.08	0.007	0.16	4	0.0125	0.01		
Zinc	0 for 4000 yrs	2.4	0 for 4000 yrs	12	10	0 for 4000 yrs	0.0109 [2] bioavail' +		
Chloride	69	Tri (160, 460, 920)	136	Tri (250, 750, 1000)	3	175	250		
Fluoride	0.29	Tri (2, 2.5, 5)	0.57	Tri (4,5,10)	4	1.14	1.5		
Sulphate (as SO4)	120	Tri (200, 800, 1600)	253	750	2	205	250		
Phenol	<1e-8	Tri (0.2, 0.4, 0.6)	<1e-8	Tri (1, 2,3)	10	< 1e-8	0.0077 [2]		
Ammoniacal	0.37	Tri (0.6, 8, 16)	0.77	5	1.2	0.63	0.39		
Benzene	1.8e-7	0.2	3.1e-7	1	10	1.75e-6	0.001		
TPH aromatic C10- C12	<1e-8	1000	<1e-8	5000	10	<1e-8	0.01 WHO		

5.7.4. Climate Change

Current research into climate change (e.g. UKCP18 and BGS future flows data) indicates that with a changing climate we are likely to have drier summers, with more risk of drought and wetter winters, with the period of recharge being shorter and more intense. This could result in short term groundwater rebound in the winter months. With rainfall intensity likely to increase, the potential effects of 40% more rainfall should now be considered within hydrogeological risk assessments.

A review of the BGS future flows data for Permo-Triassic Sandstone indicates that for the period 2041 – 2070, maximum predicted rebound is of the order of 1m, using Heathlanes as the closest sandstone borehole with future flows data. Sensitivity analysis 6 considers a reduction in the thickness of the unsaturated zone to 1m, which is a much more extreme scenario. The potential for groundwater rebound has been assessed by the model and results are found to be generally acceptable.

Sensitivity analysis 5 above has been used to model an increase of 40% infiltration. Results are presented in Table 10 and are discussed above.

5.7.5. Additional Schedule 5 Assessment – Hydraulic Conductivity

The hydraulic conductivity of the aquifer has been modelled as a uniform distribution between the lower and upper inter quartiles for the Sherwood Sandstone aquifer based on transmissivity data from the British Geological Survey Major Aquifers publication – Sensitivity Analysis 3. It is noted that there is site specific pump test data from the public supply borehole, which would put the hydraulic conductivity of the aquifer on site at the upper end of the BGS interquartile data. Modelling the full interquartile range within the Landsim model is a conservative approach, as this will give lower rates of dilution than the site specific data would derive. The hydraulic conductivity of the aquifer in model Scenario 2 has been adjusted to reflect the data available from the adjacent abstraction borehole.

5.7.6. Model Validation

The risk assessment indicates that there will be very little potential for build up of leachate within the wastes. Ongoing visual inspections of the site once operational will be used to validate this assumption.

The model predicts a low likelihood of deterioration in groundwater quality relative to the existing background conditions. Future groundwater monitoring of the site will be used to validate these predictions.

5.7.7. Accidents and their consequences

An accident which requires assessment within an inert landfill is the potential for the site to receive non-inert waste, or rogue loads. In order to assess the consequence of such a scenario the Landsim model has been run iteratively to determine the increase in concentrations within the leachate which could be tolerated without adverse impact at the appropriate point of assessment. This is discussed in Section 5.7.3 above.

It should be noted that, for many determinands, these increases in leachate concentrations for the rogue load assessment are increases above the Co leachate concentration, which is already higher than inert WAC.

5.8. Emissions to Groundwater

5.8.1. Hazardous Substances

The Landsim modelling and sensitivity analysis shows that the acceptance of inert waste to landfill at Middleton Quarry, Pollington should not release discernible concentrations of hazardous substances into the groundwater. The assessment of accidents in the form of receipt of non-inert waste indicates that there is some tolerance in the inert waste acceptance criteria in relation to this site and the accidental receipt of non-inert waste may not cause discernible discharge of hazardous substances.

5.8.2. Non-hazardous pollutants

The Landsim modelling and sensitivity analysis shows that the acceptance of inert waste at Middleton Quarry, Pollington should not cause pollution of groundwater by non-hazardous pollutants. The assessment of accidents in the form of receipt of non-inert waste indicates that there is some tolerance in the inert waste acceptance criteria in relation to this site and the accidental receipt of non-inert waste will not automatically lead to pollution, depending on the volume and concentration of contaminants in the rogue load.

5.8.3. Surface water management

There are no surface water bodies on site. Perimeter ditches will be used to direct rainfall away from the open waste during filling.

5.9. Hydrogeological Completion Criteria

The site will receive inert waste and will have no active leachate controls. The Landsim modelling indicates that the site is unlikely to fail to comply with the requirement of the Environmental Permitting Regulations in the absence of leachate control. Therefore, no hydrogeological completion criteria are required.

6. Requisite Surveillance

6.1. The Risk Based Monitoring Scheme

6.1.1. Leachate Monitoring

Leachate infrastructure is not required for an inert landfill and therefore, no leachate monitoring will be undertaken. Visual inspections of the site will be made on a regular basis as good working practice. This will include checks for any unusual seepages, or discolouration in low lying areas of the site that might indicate the landfill is generating unexpected leachate. This will enable investigation and any corrective measures to be undertaken. While this is an unlikely scenario, routine inspections should include such checks rather than assume that the potential for leachate generation is so low as to be disregarded.

6.1.2. Groundwater Monitoring – control and compliance levels

Groundwater monitoring data available at the time of the 2022 HRA was used to set groundwater quality compliance limits for the following substances:

Hazardous substance – arsenic
Non-hazardous pollutants – chloride, chromium, sulphate
Organic – phenol

The groundwater quality has been assessed using the ESI Soil and Groundwater Statistics Calculator version 2, to determine whether there are outliers in the data. This uses the same techniques as the Environment Agency R+D technical report P1-471, A.3 Statistical Analysis. The outputs are summarised in Appendix 4. The mean and standard deviation are derived after excluding outliers. Control and compliance levels are derived as described below.

Non-hazardous substances
The derived control levels are set at the mean + 2 x standard deviation.
The derived compliance levels are set at the mean + 3 x standard deviation.

Hazardous substances
The selected hazardous substance for compliance is arsenic. The UK Technical Advisory Group on the Water Framework Directive (UKTAG) gives the limit of quantification (LOQ) for arsenic as 5ug/l. All measured concentrations of arsenic are below the LOQ. Therefore, the control level has been set as the maximum. The compliance level has been set as the LOQ.

Data presented includes BH201, however, this is in an upgradient position and therefore, compliance levels are not required. In the event of borehole decommissioning, or construction of any new boreholes, these would be subject to an improvement condition to agree on new borehole-specific compliance limits.

Table 16: Control and Compliance Levels

		BH201 [1]	BH202	BH203	BH204
Arsenic (ug/l)	Mean	0.54	0.44	1.11	0.80
	Std Dev.	0.35	0.36	0.12	0.37
	Control	1.24	1.16	1.36	1.54
	Compliance	5	5	5	5
Chloride (mg/l)	Mean	47.30	21.83	13.03	29.92
	Std Dev.	11.36	10.31	7.11	13.32
	Control	70.03	42.46	27.26	56.55
	Compliance	81.39	52.77	34.38	69.87
Chromium (ug/l)	Mean	5.98	5.54	4.97	6.03
	Std Dev.	3.39	3.19	3.15	4.79
	Control	12.77	11.92	11.26	15.61
	Compliance	16.16	15.11	14.41	20.41
Phenol (ug/l)	Mean	0.03	0.03	0.03	0.03
	Std Dev.	0.00	0.00	0.00	0.00
	Control	0.03	0.03	0.03	0.03
	Compliance	0.033	0.033	0.033	0.033
Sulphate (mg/l)	Mean	121.08	70.83	37.33	93.75
	Std Dev.	35.75	28.21	28.30	34.53
	Control	192.57	127.25	93.93	162.81
	Compliance	228.32	155.45	122.23	197.34

1 - upgradient borehole – data for information only
2 – Control and compliance levels calculated after removal of outliers using ESI spreadsheet

6.1.3. Surface Water Monitoring

There are no surface water bodies on site.

7. Conclusions

7.1. Conceptual Model of the Site

The conceptual model of the site comprises a proposed inert landfill cell, with an engineered geological barrier, in the main area of the quarry, which is SPZ2. The landfill has been quantitatively assessed using Landsim.

7.2. Compliance with Environment Agency Position Statements

Landfilling within SPZ2 is permitted if there is no requirement for long term management controls. The proposed landfill is inert and as such there is little likelihood of gas, or leachate generation and therefore, no need for long term management controls.

7.3. Compliance with the Environmental Permitting Regulations

A quantitative hydrogeological risk assessment of the proposed new landfill cell has been undertaken using the Environment Agency approved assessment tool. This indicates that the new landfill is unlikely to cause discernible discharge of hazardous substances, or pollution by non-hazardous pollutants. The new phase will be engineered with a 1m geological barrier to a maximum permeability of 1×10^{-7} m/s. This is, therefore, considered to be compliant with the Environmental Permitting Regulations, 2016.

Groundwater compliance levels have been derived for downgradient monitoring boreholes.

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