Contract No. 1MC13

Hydrogeological Risk Assessment and Material Acceptability Criteria Risk Assessment Report : Pool Wood Embankment Landscape Bund

Document Number: 1MC09-BBV_MSD-EV-REP-NS04_NL10-100217

Current Revision	Author	Reviewed By	Approved By	Date Approved	Reason for Review
C01	J. Olsen	T. Hodges	A Sunners A Mobbs	20/02/2025	For HS2 Acceptance

Stakeholder Review Required (SRR)	Purpose of SRR
☐ Yes – Please Specify Below	☐ Comment
☒ No	☐ Information
Click or tap here to enter text.	☐ Approval

HS2 Signature Required
☐ Yes – Please Specify Below
☒ No
Click or tap here to enter text.

Handling Instructions: Produced by BBV for project use only

Review Required

Team	Yes/No	Name	Position	Date
Quality				
Health & Safety				
Environment & Sustainability				
Other teams if required				

Revision History

Previous Revision	Author	Reviewed By	Approved By	Date Approved	Reason for Review
P01	J. Olsen	T. Hodges	A. Sunners	20/09/2024	S3 - for Review and Comment
P02	J. Olsen	T. Hodges	A Sunners	17/02/2025	S4 - Fit for Stage Acceptance
C01	J. Olsen	T. Hodges	A Sunners A Mobbs	20/02/2025	For HS2 Acceptance

Revision Summary

Paragraph Modified	Details of Modification

Contents

1 SCOPE AND PURPOSE

This report is applicable to all activities undertaken by the Balfour Beatty VINCI Joint Venture (BBV) and its supply chain on the Main Works Civils Contracts (MWCC) for Sectors N1N2, project references [1MC08] and [1MC09] (referred to in this document as the Project) for the provision of Design and Construction services in accordance with the requirements of the contract.

This report has been prepared by the Design Joint Venture (Systra and Mott MacDonald) on behalf of Balfour Beatty Vinci (BBV) for HS2 (High Speed Two Limited) for three main purposes:

- Through a risk-based assessment approach, assess the contamination risks associated with the placement of remediated material sourced from Middle Bickenhill Landfill (MBL) in the landscape bund at Pool Wood Embankment on controlled waters and human health.
- Derive acceptability criteria for material reuse to be protective of controlled waters and human health post development to support a deposit for recovery environmental permit application (EPfWRA) to manage the materials sourced from MBL for reuse in the construction of the landscape bund. (The relevant permit application references are PR/SP3421SU/P001 and EPR/YP3626SB/P001)
- Provide commentary on groundwater and surface water monitoring requirements to be adopted by BBV before, during and following construction works to support ongoing assessment and the future surrender of the environmental permit.

It should be noted that this report is one of three environmental assessment reports prepared to support the environmental permit application process, the other two reports assess the risks to human health and property from ground gas and the risks associated with discharge from the bund on surface water quality. These assessments are listed in Section 2.1 under separate cover.

This report, together with the processes included in the BBV Way and any associated documents listed in section 2.3 meet the requirements of the Contract (as specified in the documents listed in section 2.1) and the standards listed in section 2.2. The report should be read in conjunction with the documents listed in section 2.3.

This report is written on the basis that BBV are able to undertake their business in the normal manner. Where significant disruption occurs that fundamentally affects the implementation of this report (e.g., health pandemic), an addendum will be prepared to describe how the requirements of this document shall be modified for the duration of the disruption. Once any period of disruption has ended, the addendum shall be withdrawn and BBV shall revert to the current version of this document.

2 REFERENCE DOCUMENTS

2.1 Contract

Document Title	Document Number
Specification for Civil Engineering Works – Contract Specific appendices – Series 0600 Earthworks: N1 and N2, 2021	1MC08-BBV_MSD-GT-SPE-N000-100001
HS2 MMP Route A Earthworks Contamination Risk Assessment, 2021 (C01)	MMP A 1MC08-BBV_MSD-EV-RIA-N001-100001
HS2 Materials Management Plan Route A Earthworks Remediation Strategy Report, January 2023	1MC08-BBV_MSD-EV-REP-N001-100058
HS2 N1 and N2 Earthworks Risk Assessment and Design Statement for MMP Route B Materials, 2020	1MC08-BBV_MSD-EV-RIA-N001-100002
HS2 Technical Standards (Water Resources and Flood Risk Consents) HS2 *"Technical Standard – Water resources and flood risk consents and approvals"*, March 2019	HS2-HS2-EV-STD-000-000015
HS2, Technical Standard - Land Quality, April 2019	HS2-HS2-EV-STD-000-000027 P05
HS2 Technical Standard – Groundwater, November 2017	HS2-HS2-EV-STD-000-000010 P07
HS2 Geo-environmental Report for Sub Lots 5 and 6, February 2021	1MC09-BBV_MSD-EV-REP-N002-100002
HS2 Pool Wood Embankment Land Quality Management Report, March 2022	1MC09-BBV_MSD-EV-REP-NS04_NL10-100167
Field Change Request – Pool Wood Embankment: PVD Reduction (CPT Tests), July 2023	1MC09-BBV-DS-CRR-NS04_NL10-000173
Field Change Request – Pool Wood Embankment: PVD Reduction (CPT Tests), September 2023	1MC09-BBV-DS-CRR-NS04_NL10-000175
HS2 Ground Investigation Specification, Pool Wood Embankment, March 2024	1MC09-BBV_MSD-EV-REP-NS04-100056
BBV Middle Bickenhill Landfill, Framework Remediation Implementation Plan (R1827/23/5296 – Rev. 7), February 2024	1MC09-BBV_ERG-GT-PLN-NS04_NL10-000001
BBV Landscape Bund at Pool Wood Embankment, Waste Recovery Plan (3020097), March 2024	TBC

Document Title	Document Number
HS2 Phase 1 Pool Wood Embankment, Gas Risk Assessment, March 2024	1MC09-BBV_MSD-EV-RIA-NS04_NL10-100006
H1 RA - TBC	TBC

2.2 Standards and Information Sources

This report has been produced in accordance with the following regulatory guidance documents and data sources:

- ISO 9001: 2015 Quality Management System
- ISO 14001: 2015 Environmental Management System
- ISO 45001: 2018 Occupational Health and Safety
- Environment Agency "Land Contamination: Risk Management (LCRM)", April 2021, (www.gov.uk)
- UK Government: Groundwater protection. (https://www.gov.uk/government/collections/groundwater-protection)
- Environment Agency (2009): "Updated Technical background to the CLEA Model", Science Report. SC050021/SR3
- Environment Agency (2009): "Human Health Toxicological assessment of contaminants in soil", Science Report. SC050021/SR2
- DEFRA (2010): "SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document"
- Contaminated Land: Applications in Real Environments (CL:AIRE), Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration, 2020
- Balfour Beatty Vinci joint venture *"iSpatial"* Ordnance Survey online mapping platform combining information gathered from multiple sources as part of the HS2 project, 2021.
- LIDAR digitized mapping 2019 (1MC08-BBV_SIX-GL-DM3-N001-100094 & 1MC08-BBV_SIX-GL-DM3-N001-100093)
- EA Waste recovery plans and deposits for recovery permits guidance, June 2023 (**Error! Hyperlink reference not valid.**)
- EA Groundwater risk assessment for your environment permit, April 2018 (**Error! Hyperlink reference not valid.**)
- EA landfill and deposit for recovery: aftercare and permit surrender, March 2022 (**Error! Hyperlink reference not valid.**)

2.3 Associated BBV Procedures

Document Title	Document Number
N/A	

2.4 The BBV Way

The BBV Way is the Balfour Beatty VINCI Integrated Management System for the project. It contains the processes that we will use to manage the project – it is held in the following location:

The BBV Way

3 RESPONSIBILITIES

Role	Main Responsibilities
John Olsen (MM/Systra DJV)	Report Author
Tim Hodges (MM/Systra DJV)	DJV Land Quality Lead, AC Assessment Report Checker
Anwen Sunners (MM/Systra DJV)	DJV Engineering Manager, AC Assessment Report Approver
Stephen Phipps (BBV)	BBV Materials Manager, BBV Reviewer
Paul Sandall (BBV)	BBV Contaminated Land Specialist, BBV Reviewer

4 DESIGN INFORMATION

A review of Pool Wood Embankment design information was completed to understand main construction elements, dimensions, and the materials to be used in its construction. This information was used to inform the development of a conceptual site model to understand the potential post construction risks to human health and controlled waters associated with construction specific to the landscape bund.

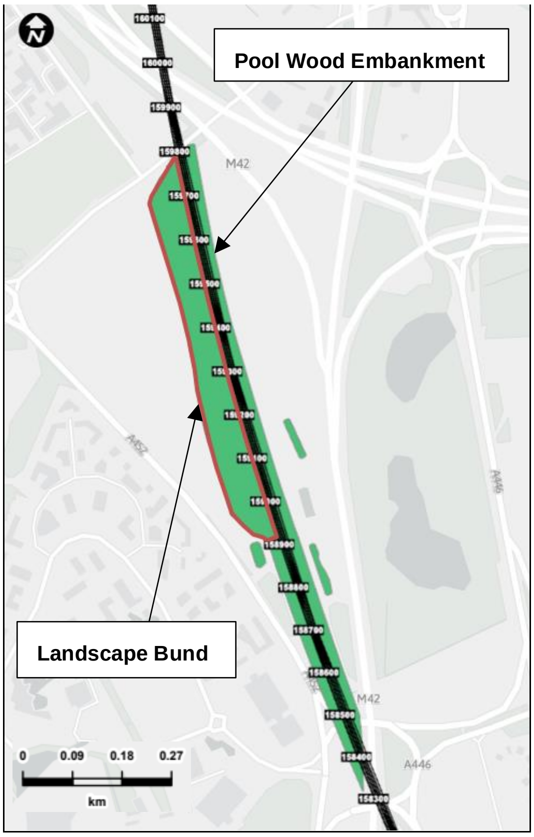
4.1 Landscape Bund Location

The wider Pool Wood Embankment asset is located to the west of the M42 Motorway between approximate Chainage (Ch.) 158+400 and 159+800 in Sub Lot 5 South. The landscape bund is located to the immediate west of the trace between approximate Ch. 158+900 to 159+750. Once constructed the landscape bund will be approximately 800m long, between 50 and 70m wide and up to 14.5m in height above the neighbouring ground elevations.

The location within the landscape bund to receive MBL sourced materials and subject to the conditions of the EPfWRA (hereafter referred to as the 'site') will be located between approximate Ch. 159+225 and 159+700.

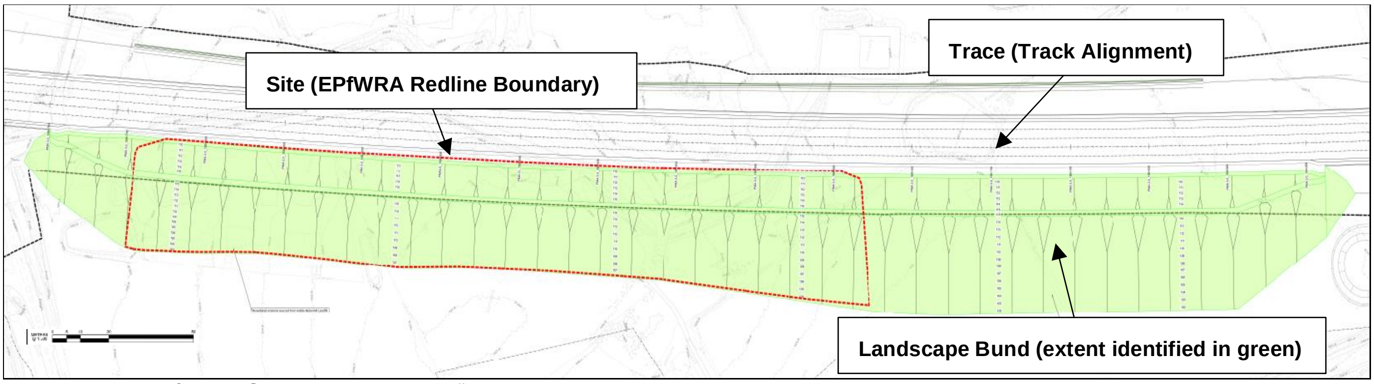
Figure 1 shows the location of the Pool Wood Embankment asset and the landscape bund. Figure 2 shows the location of the site (EPfWRA).

Figure 1: Location of Pool Wood Embankment



Source: iSpatial 2023

Figure 2: Location of Site Boundary

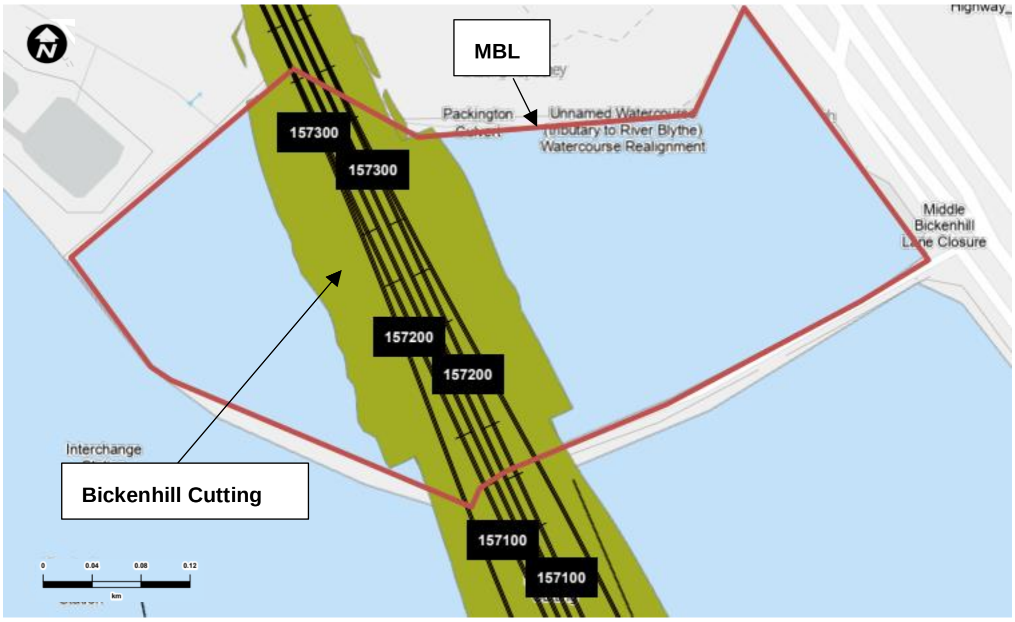


Source: extract from HS2 drawing entitled "Pool Wood Embankment, Approximate Extent of Permitted Boundary", January 2024 (1MC09-BBV_MSD-CV-DPP-NS04_NL10-219402)

4.2 Middle Bickenhill Landfill

The majority of material to be used in the construction of the site will be sourced from MBL located approximately 1.8km south of the site at Ch. 157+125 to 157+375. The location of MBL is shown in Figure 3. Specific commentary that relates to the material properties and the management of the material prior to reuse at the site is provided below.

Figure 3: Location of MBL



Source: iSpatial 2023

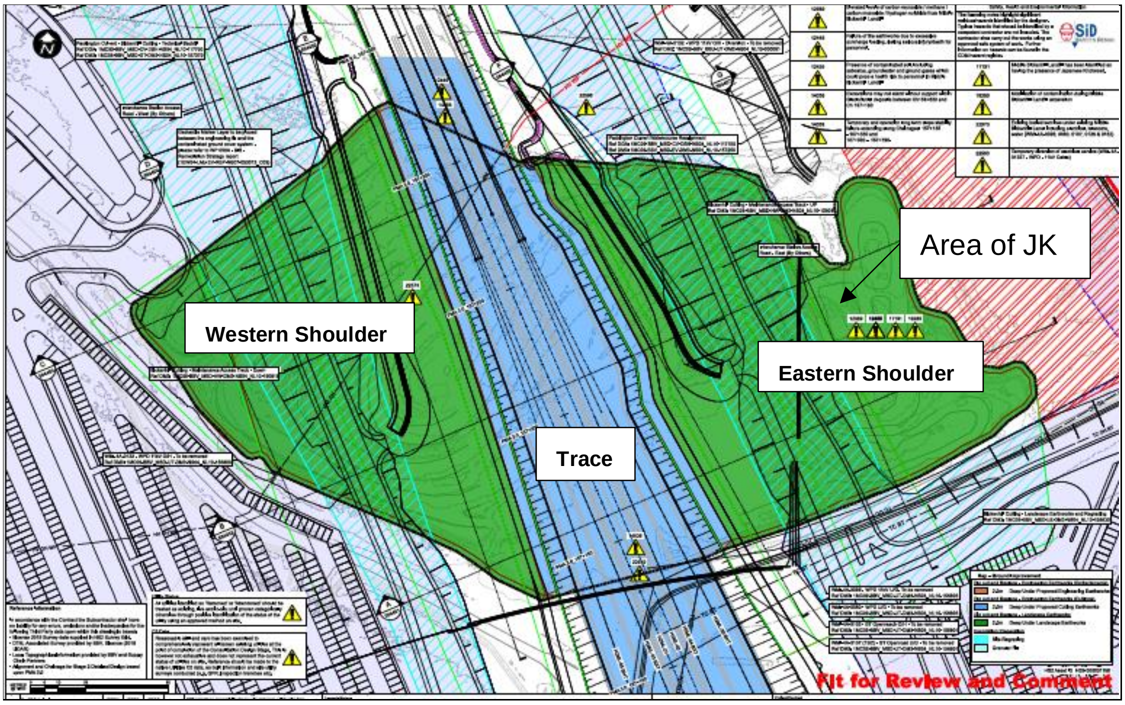
Prior to 1962, the MBL area was used for agricultural land use purposes. Between 1962 and 1985 MBL accepted inert, industrial, commercial, household, and special wastes. Ground investigations and assessments have reported the presence of asbestos, asbestos containing materials (ACM), hydrocarbons, and metal contaminants. Further that the landfill contained deleterious materials including wood, plastics, and "black bag" waste products. Following 1985, invasive species (Japanese

Knotweed) established themselves in the 'Eastern Shoulder' (eastern third) of the MBL footprint. The landfill was licensed in 1978 and became void in 1982 when the licence holder went into receivership.

To accommodate the construction of Middle Bickenhill Cutting, as part of the design, MBL will be removed under a stakeholder approved Remediation Implementation Plan (RIP) to a defined formation elevation to allow the placement of competent material upon which to construct the 'Trace' (track alignment) and adjacent features. The primary focus of the RIP is to manage the removal of all landfill materials from MBL. Where Japanese Knotweed growth extends beyond the boundaries of MBL, excavations will then be continued to achieve eradication. If it is not possible to excavate Japanese Knotweed outside of the site boundary, for example due to ecological constraints within Denbigh Spinney, then a root barrier will be installed at the boundary to prevent reinfestation.

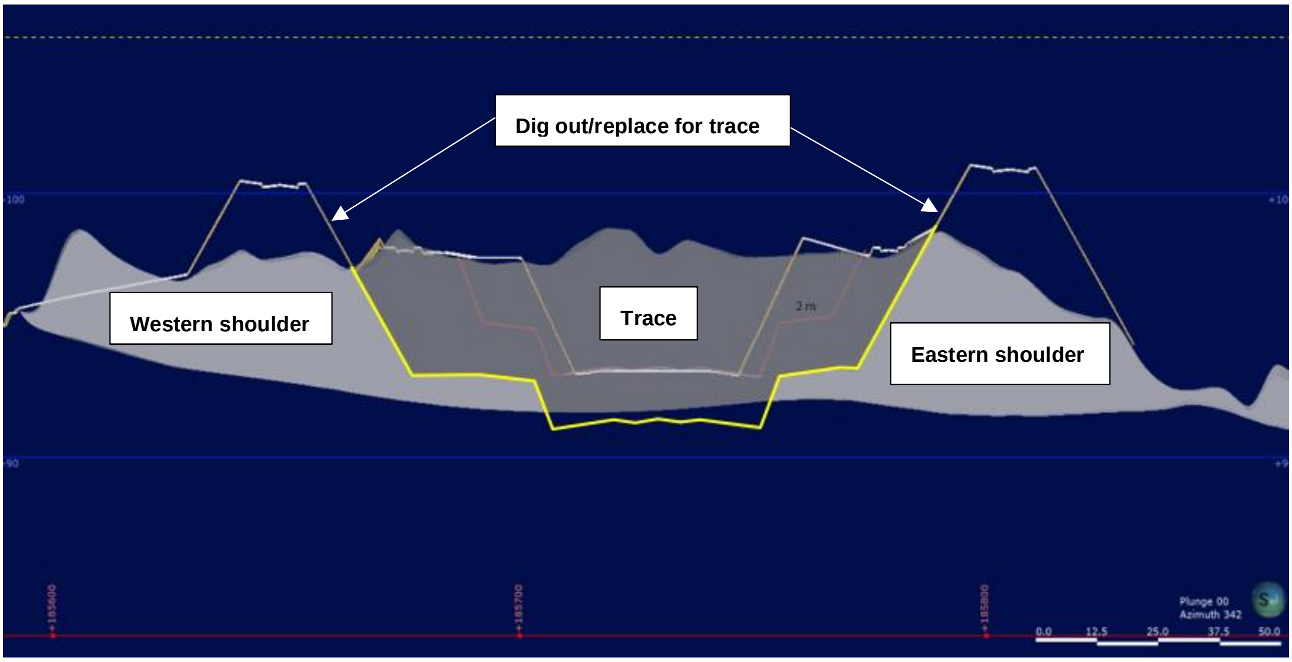
With respect to the EPfWRA, for assessment and acceptability criteria derivation purposes, it has been assumed that the entire volume of landfill (to include the 'Trace', 'Western and Eastern Shoulder') contained in the MBL footprint will be removed and placed at the site. As part of the sustainable approach, based on ground investigations and field observations, it is estimated that up to 90% (160,920m^3) of the total recoverable volume (178,800m^3) could be reused in the construction of the site. The 90% of reusable material comprises construction and rubble type materials. The remaining 10% of usable material mainly comprises deleterious arisings including putrescible and 'black bag' waste. Figure 4 shows the location of the main MBL areas in relation to the asset. Figure 5 shows a cross section of MBL.

Figure 4: Location of MBL areas



Source: extract from HS2 drawing entitled "Bickenhill Cutting (N3 BIS Triangle) Contaminated Land Remediation Plan View", August 2022 (1MC09-BBV_MSD-GT-DPL-NS04_NL10-564400)

Figure 5: Cross section showing design profile from east to west through MBL



Source: DJV, Volume Estimate drawing based on Leapfrog modelling, October 2023

A summary of the process outlined in the RIP to ensure the environmental suitability of material before transportation and use at the site is as follows:

- Excavation, screening, segregation, and stockpiling material. As part of these activities a visual assessment of the material composition and presence of contamination will be undertaken to aid decision making in the management and allocation of materials for reuse.
- Process and crush hardcore/soils materials into class 6F1 and 6F2 material for reuse at the site. Materials considered visual suitable will be subjected to validation sampling and laboratory analysis to allow comparison against Site Specific Acceptability Criteria (SSAC) for the site. Material adhering to the SSAC will be deemed suitable for reuse at the site. Materials failing the SSAC will either be subjected to remedial treatment (e.g. bioremediation and chemical oxidation or similar) to reduce determinant concentrations to comply with the SSAC or be subjected to further risk assessment and/or removed for offsite disposal to a licensed waste facility.
- Removal of asbestos and ACM for offsite disposal to a licenced waste facility.
- Removal of Japanese Knotweed, asbestos, ACM, and cohesive materials for offsite disposal to a licenced waste facility.
- Removal of deleterious arising, e.g. ‘black bag’, putrescible, wood, plastic wastes for offsite disposal to a licensed waste facility.

It should be noted that a Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) investigation was undertaken in June-July 2024 by the BBV remedial contractor, with the results presented to the Environment Agency on 9th August 2024. Soil samples were collected from MBL and surface and groundwater samples from MBL. Low levels of PFAS (above LOD) were identified in all but one water sample location and some soil sample locations. The assessment concluded that no soil or water remediation is required for PFAS, with remediation at MBL to remove PFAS high risk items. No additional sampling for PFAS was proposed during remediation works at MBL. The EA have raised no objections to the assessment findings, conclusions and the approach.

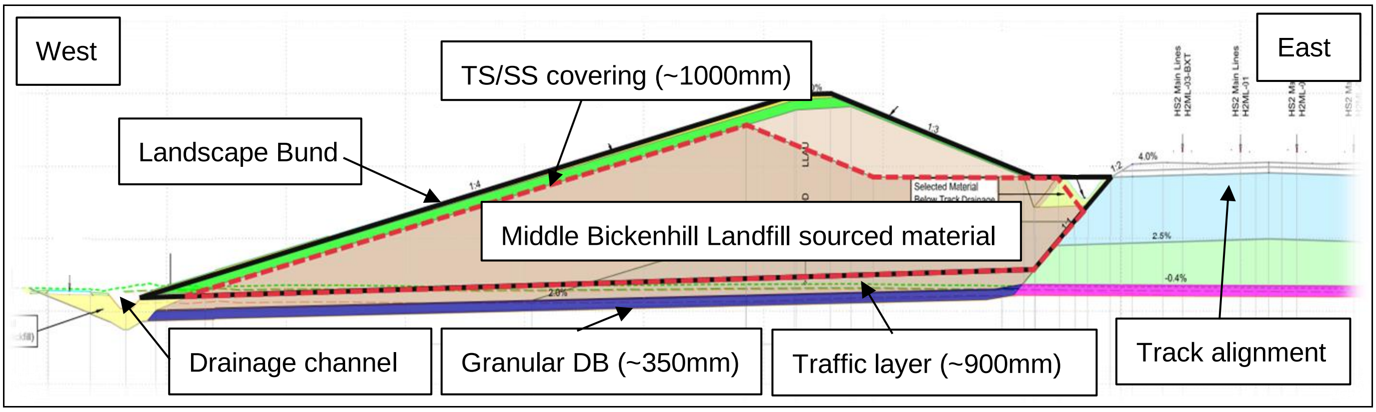
4.3 Landscape Bund Design

Once constructed the site will be approximately 475m long, between 50 and 70m wide and up to 14.5m (115mAOD) in height above the neighbouring ground elevations and cover an area of approximately 30,000m^2. The main design features for the site (as is the case for the wider landscape bund) are as follows:

- The site will be subject to dig out of between approximately 1 to 2m of below existing ground elevations to remove topsoil/subsoil materials and to accommodate design features.
- The base of the site will contain an approximate 350mm (6F5) thick granular blanket wrapped in a synthetic geotextile material to reduce the ingress of fines into the blanket. The primary purpose of the blanket is to allow the collection of pore water displaced from the underlying Glaciolacustrine Deposits due to the surcharging effects of the newly placed overburden.
- The drainage blanket will be graded with an approximate 2% fall to the west to promote the flow of water to a drainage channel located along the western toe of the site. The same drainage channel will also receive runoff water from the surface of the site.
- An approximate 900mm thick traffic layer comprising site won Glaciofluvial Deposits (main content) and Mercia Mudstone (minor content) placed above the drainage blanket layer. The purpose the permanent traffic layer is to protect the drainage blanket from the movement of plant and machinery during field operation and construction works.
- As described in Section 4.2 material used in the construction of the site will be sourced from MBL and managed in accordance with the EPfWRA. However, if there is a shortfall in materials from MBL, suitable materials from other locations in Sublot 5 and 6 will be sourced for reuse in the EPfWRA and managed using the SSAC presented in this report. Materials to be used in the construction of the bund outside the EPfWRA will be sourced from Sublot 5 and 6. In this case these materials will be managed under the HS2 Materials Management Plan Route A Earthworks Remediation Strategy Report, January 2023 report.
- The surface of the site will be completed with approximately 1m of clean topsoil and subsoil to provide a suitable growing medium for plant growth. The surface will be sloped (between 1:3 and 1:4 on the external side and 1:3 on the internal side) to promote surface runoff to the land drain at the western toe of the site and to limit infiltration through the material used to construct the site.

The main design elements of the site are shown in Figure 6 and 7

Figure 6: Cross section of Pool Wood Embankment showing main design elements of the site



Source: extract from drawings entitled "Pool Wood Embankment Ground Improvement – Advanced Works Drawing Index", March 2022 (1MC09-BBV_MSD-GT-DSH-NS04_NL10-218300)

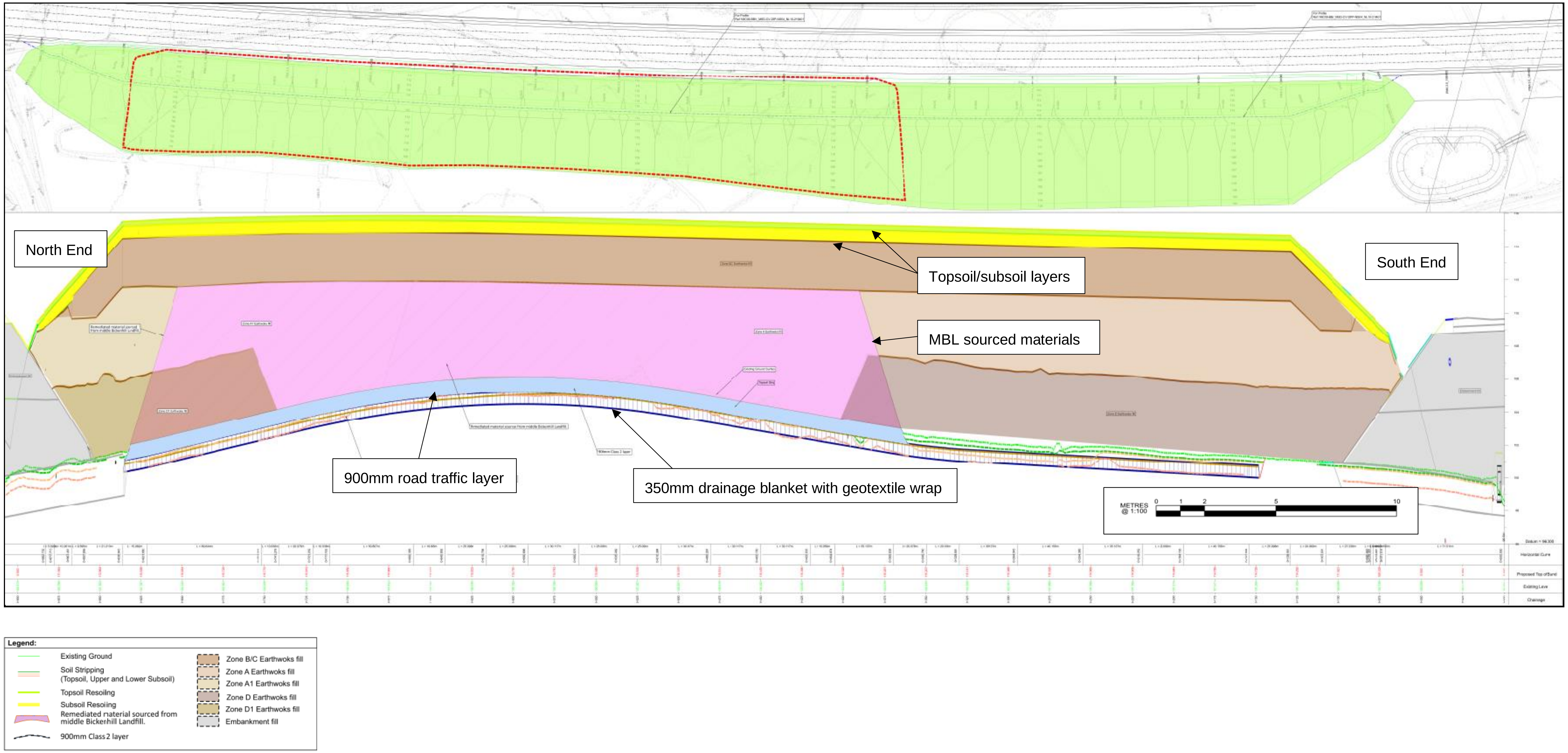
Notes: material below track alignment - blue = Upper Embankment Fill (Class 9h or 9J), green = Lower Embankment Fill (Class 9h or 9J) and pink = Load Transfer Platform (Class 6F5).

With respect the drainage blanket, it is worth noting that previous iterations of the design incorporated the use of prefabricated vertical drains (PVDs) installed on a grid basis to penetrate the full depth of the underlying Glaciolacustrine Deposits, terminating in the Glaciofluvial Deposits. The PVDs were to be connect to a 750mm drainage blanket situated at the base of the site (and wider landscape bund) and top of the Glaciolacustrine Deposits. In turn, water accumulating in the drainage blanket would discharge into a drainage channel at the western toe of the site.

The function of the PVD was to ensure the undrained shear strength of the foundation soils would achieve the design parameters though pore water pressure displacement caused by the surcharging effects of the newly placed overburden. However, as documented in two Field Change Requests (1MC09-BBV-DS-CRR-NS04_NL10-000175 and 1MC09-BBV-DS-CRR-NS04_NL10-000173), given the consolidation effects of the Glaciolacustrine Deposits associated with enabling works stockpiling the need for the PVDs was removed from the geotechnical design and the thickness of the drainage blanket reduced to 350mm.

From a land quality perspective, the elimination of the PVD removes a series of direct (preferential) pathways, thereby reducing the risks of contaminant migration into the underlying more sensitive and productive Glaciofluvial Deposits, and surrounding surface waters and groundwater dependent terrestrial ecosystems which largely fed by the Glaciofluvial Deposits.

Figure 7: Long section of Pool Wood Embankment showing main design elements of site



Source: extract from HS2 drawing entitled "Pool Wood Embankment Longitudinal Profile", (1MC09-BBV_MSD-CV-DPP-NS04_NL10-219401)

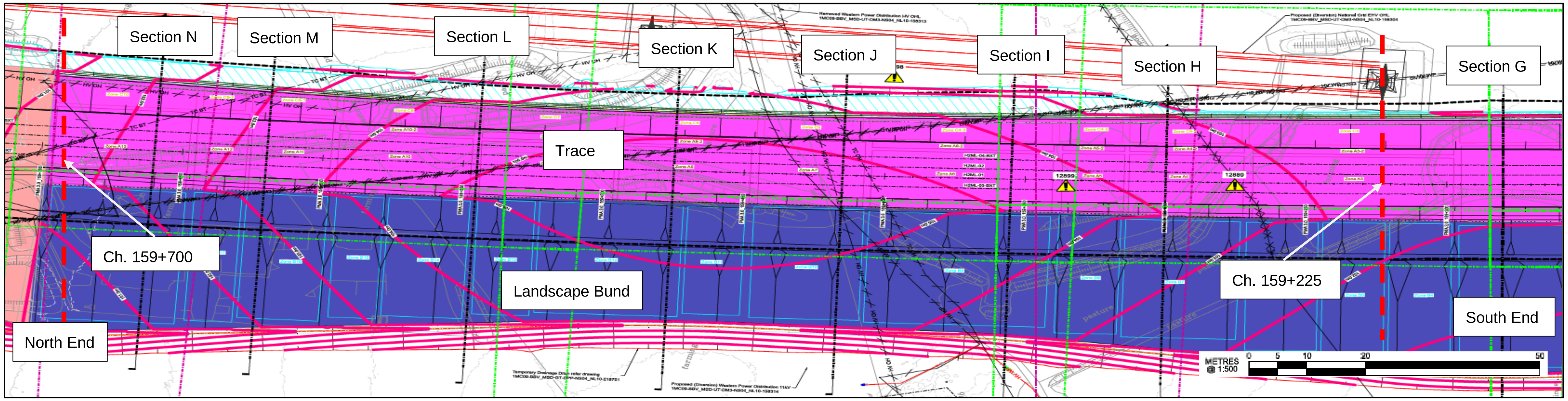
To inform the derivation of SSAC (discussed in Section 8 and 9), design elements relating to the proposed elevation of the MBL sourced materials were reviewed for the site. As summarised in Table 1 the elevation of the top of the drainage blanket was determined at nine chainages along the site from Ch. 159+035 to 159+620. From this the invert elevation of the drainage blanket and the MBL sourced material was calculated for the east (highest elevation) and west (lowest elevations) side of the site. Invert elevations for the MBL sourced materials is estimated to range from 101.44 to 105.34mAOD in the west of the site and from 102.88 to 106.47mAoD in the east of the site. Elevations tend to increase from south to north up to Ch. 159+475 and then decline as the northern boundary of the site is approached. Figures 8 and 9 show the location of section containing supporting data used to calculate the information presented in Table 1.

Table 1: Summary of design feature elevations

Section	West End - Lowest (mAoD)			East End – Highest (mAOD)		
	Top of DB	Invert of DB	Invert of Waste	Top of DB	Invert of DB	Invert of Waste
G (Ch159 +.180)	100.54	100.19	101.44	101.98	101.63	102.88
H (Ch.300)	102.42	102.07	103.32	103.86	103.51	104.76
I (Ch.355)	103.48	103.13	104.38	104.64	104.29	105.54
J (Ch.415)	104.3	103.95	105.2	105.43	105.08	106.33
K (Ch.475)	104.44	104.09	105.34	105.57	105.22	106.47
L (Ch.545)	103.69	103.34	104.59	104.88	104.53	105.78
M (Ch.620)	101.92	101.57	102.82	103.21	102.86	104.11
Min	100.54	100.19	101.44	101.98	101.63	102.88
Max	104.44	104.09	105.34	105.57	105.22	106.47
Mean	102.97	102.62	103.87	104.22	103.87	105.12
Geomean	102.96	102.61	103.86	104.22	103.87	105.12

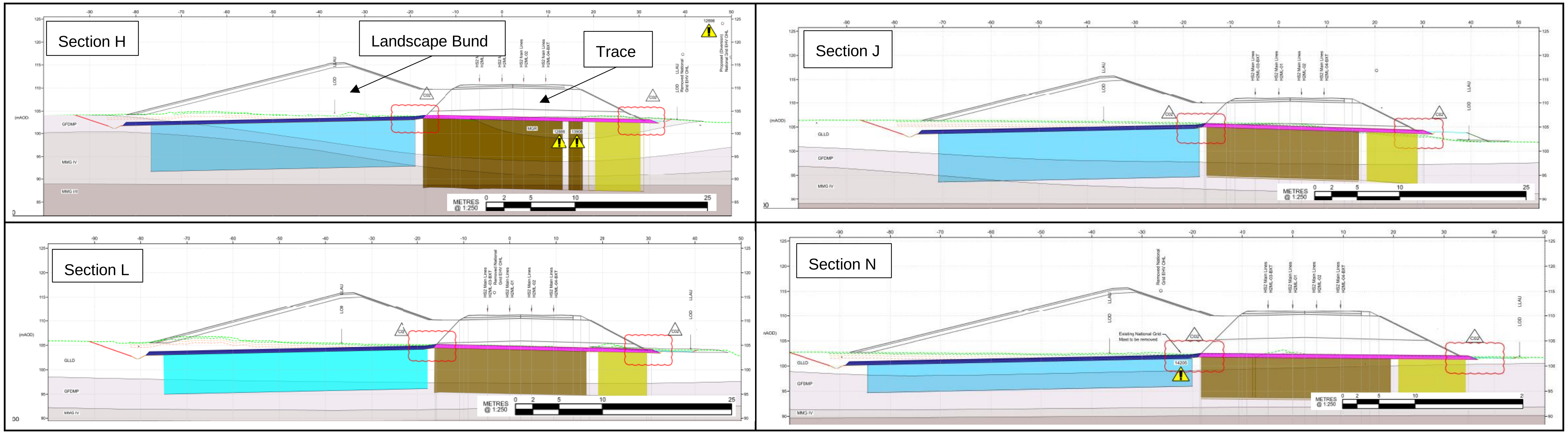
Notes: DB = Drainage Blanket, invert of DB calculation Top of DB minus 350mm, invert of waste calculation invert of DB plus 1.25m (350 and 900mm), Top of DB elevations verified by BIM modelling team

Figure 8: Location of cross sections used to calculate design base elevations for the placement of MBL sourced material at the site



Source: extract from drawings entitled "Pool Wood Embankment Ground Improvement – Advanced Works Drawing Index", March 2022 (1MC09-BBV_MSD-GT-DSH-NS04_NL10-218300)

Figure 9: Example cross sections used to calculate design base elevations for the placement of MBL sourced material at the site



Source: extract from drawings entitled "Pool Wood Embankment Ground Improvement – Advanced Works Drawing Index", March 2022 (1MC09-BBV_MSD-GT-DSH-NS04_NL10-218300)

5 BASELINE CONDITIONS

A review of ground conditions at site was undertaken to inform the Conceptual Site Model to understand the potential source, pathways, and receptors associated with the reuse and placement of materials sourced from MBL in the construction of the site. Although risks to human health are considered, given that the main risk driver is to controlled waters, the focus of the risk assessment was on reviewing potential post development interactions between surface water, groundwater and the MBL sourced materials and the associated hydrogeological risks.

The conceptual understanding of hydrogeological and hydrological interactions and the risks associated MBL material placement were used to inform the approach undertaken in the derivation of SSAC to be protective of controlled waters and human health post development.

5.1 Human health

Current land use at and near to the site is agricultural and grassed fields. Post development, the site and wider landscape bund will be covered in subsoil/topsoil and grassed landscape with no residential dwellings. The ownership of the site and wider landscape bund will be retained and maintained by HS2 post development. Consequently, the area will be fenced off with no public access. Only authorised personnel (operators and maintenance workers) will be permitted to access the area.

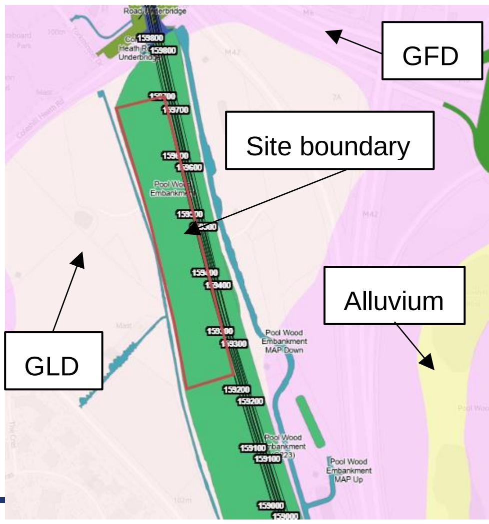
As indicated earlier in the report, a gas risk assessment was undertaken (1MC09-BBV_MSD-EV-RIA-NS04_NL10-100006) to assess the risks to human health and property from ground gases produced following the placement of MBL source materials at the site. The report concluded that based that the design of the site (and wider landscape bund), the age of the waste and the remediation practices that will be adopted during remediation, the risk to human health and property are negligible.

5.2 Controlled waters – Groundwater

5.2.1.1. Published geology

The geology at and near the site is underlain by superficial Glaciolacustrine Deposits (GLD) which are in turn underlain by Glaciofluvial Deposits (GFD). Alluvial deposits associated with Coleshill Pools are located to the east of the site. The superficial deposits are underlain by the bedrock geology of the Mercia Mudstone Group (MMG). Figure 10 shows the location of the published superficial geological units.

Figure 10: Location of published superficial geology



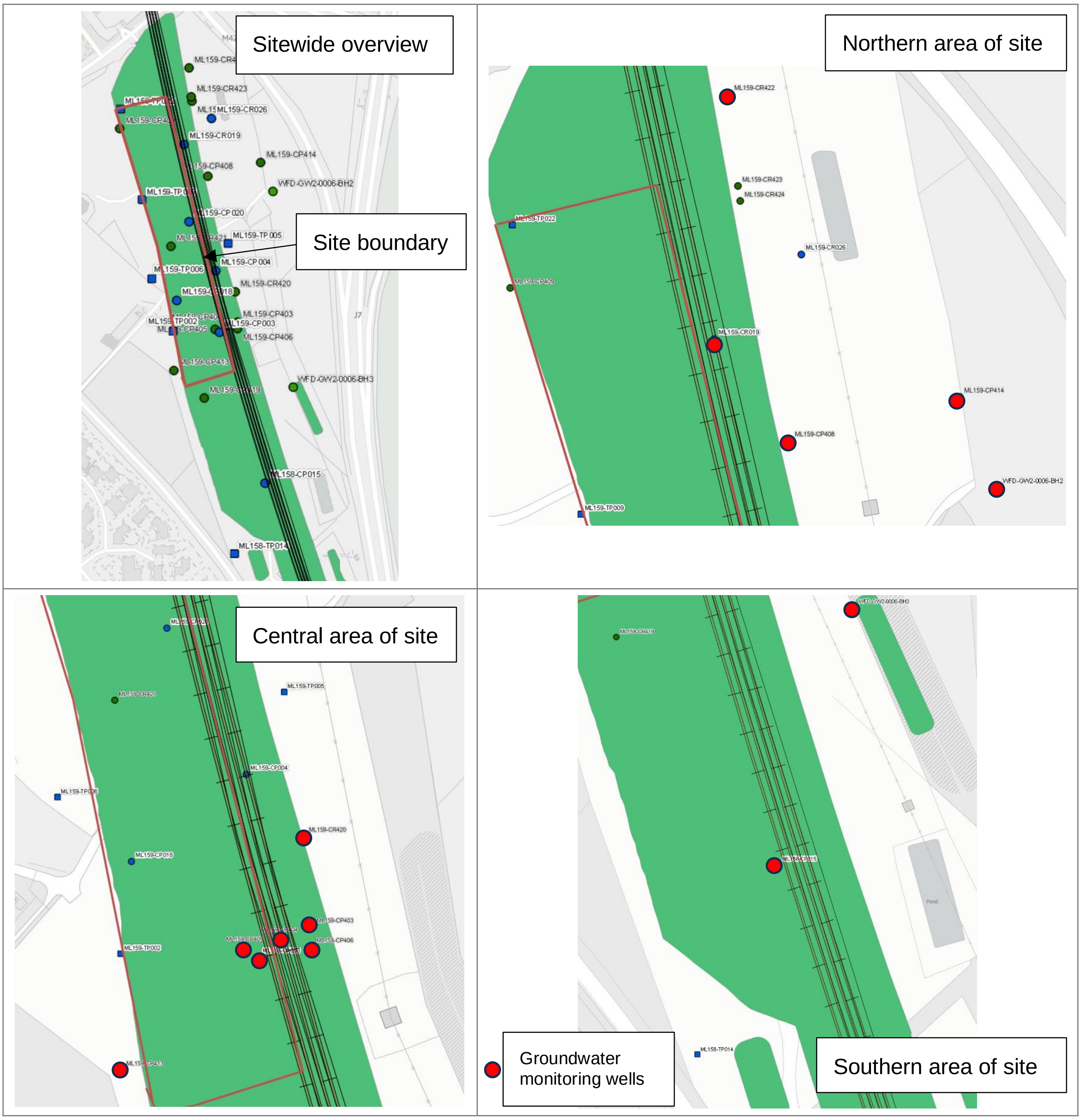
Source: iSpatial 2023

5.2.1.2. Ground Investigations

As documented in the Pool Wood Embankment Land Quality Management Report, March 2022 (1MC09-BBV_MSD-EV-REP-NS04_NL10-100167), the site and wider asset have been subject to a series of ground investigation between 2017 and 2023. Over this period 34 exploratory holes were formed using percussive, rotary, and trial pitting methods up to a maximum depth of 35.6mbgl. Twenty three of the 34 exploratory hole locations were located at and near the site boundary.

Figure 11 shows the location of the 23 exploratory holes used to support this assessment. Table 2 presents a summary of the geology encountered at and near the site during the ground investigations.

Figure 11: Exploratory hole location



Source: iSpatial 2023

Table 2: Summary of geology encountered at and near to the site

Strata	Distribution	Typical depth range (mbgl)	Description
Topsoil	Located across the site at all exploratory hole locations shown in Figure 12 except for those lists under Made Ground in the below line.	0 to 0.50	Mixture of granular and cohesive sandy and clayey soils with rootlets
Made Ground	ML159-CP003, ML159-CP004, ML159-TP005, ML159-CP403, ML159-CP404, ML159-CP405, ML159-CP406, ML159-CP408, ML159-CR423, and ML159-CR424 Encountered at the southern and northern boundary and the centre of the site and local area	0 to 5.65	Mixture of granular and cohesive materials. Mostly described as a sandy clayey gravel. Gravel includes ash, flint, brick, quartzite, concrete, glass, sandstone, wood and charcoal and localised bituminous material (ML159-CP405 and ML159-CP406 only)
Glaciolacustrine Deposits (cohesive and granular)	Encountered across the entire site at all 23 exploratory hole locations shown in Figure 12	0.50 to 11.1	Mostly cohesive material described as soft to firm sandy silt or sandy CLAY. The unit also contains some granular materials described as slightly gravelly silty clayey SAND.
Glaciofluvial Deposits	ML159-CP004, ML159-CP020, ML159-CR019, ML159-CR026, ML159-TP009, ML159-CP403, ML159-CP404, ML159-CP405, ML159-CP406, ML159-CP408, ML159-CP409, ML159-CR419, ML159-CR420, ML159-CR421, ML159-CR423, and ML159-CR424 Encountered across the site at 15 out of the 23 exploratory hole locations.	3.2 to 12.60	Mostly a granular material described as fine to coarse sandy gravel and gravelly SAND
Mercia Mudstone Group	ML159-CP003, ML159-CP018, ML159-CP404, ML159-CR419, ML159-CR420, ML159-CR421, ML159-CR423, and ML159-CR424 Encountered across the site at 8 of the 23 exploratory hole locations	0.80 to 16.1	Firm, stiff reddish brown slightly silty sandy clay silty CLAY (weathered mudstone)

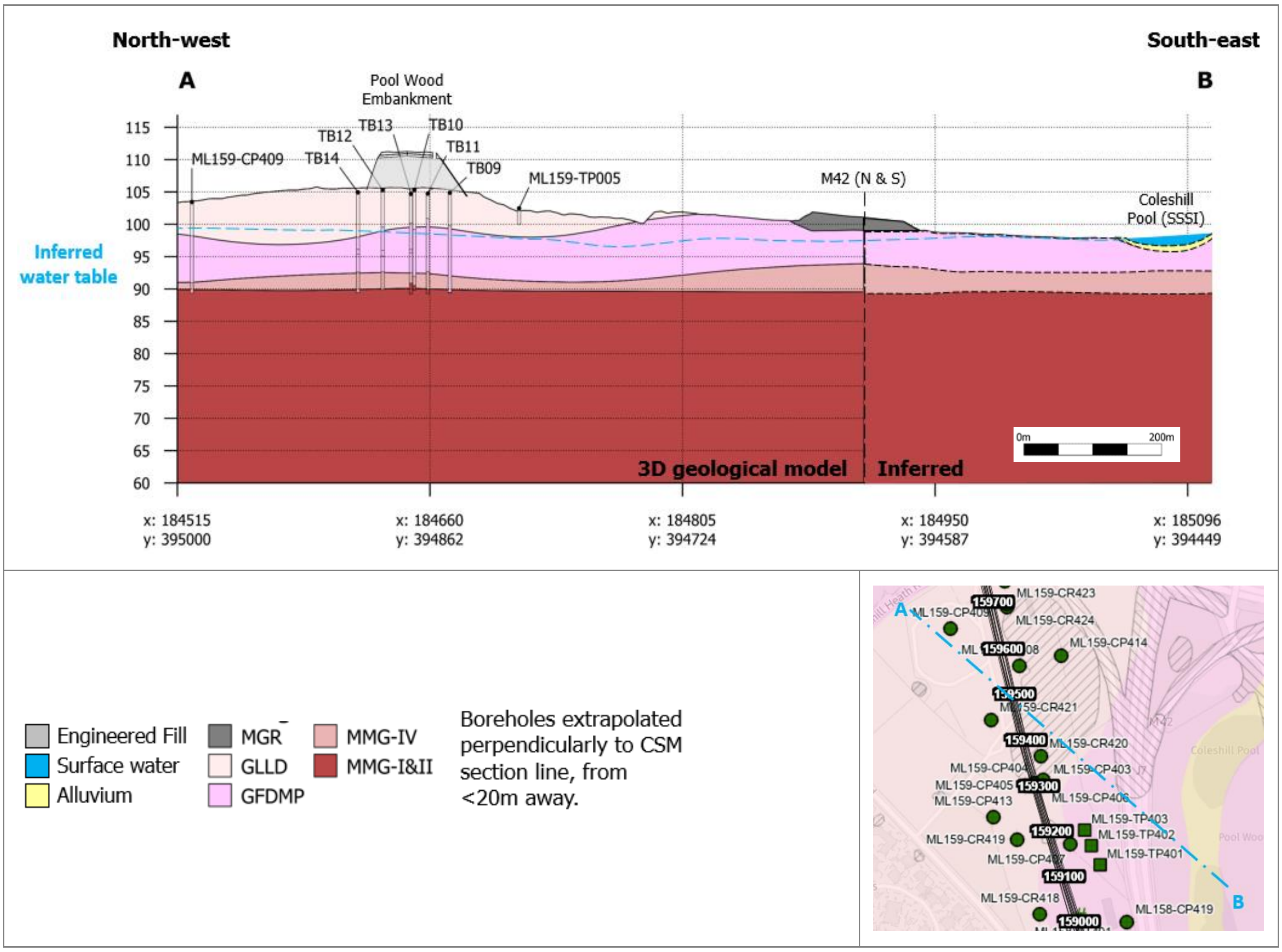
With reference to Table 2, most of the Made Ground (MGR) was encountered at ML159-CP003, ML159-CP403, ML159-CP404, ML159-CP405 and ML159-CP406 which is associated with a Land Quality Site - Potential Land Contamination Site (former brickworks with kiln and infilled pond). As part of the design the MGR associated with the Land Quality Site along with MGR identified during ground investigation and/or encountered during construction works will be removed from the footprint of the site and wider asset and backfilled with competent natural material. Suitable excavated MGR will be reused as landscape fill within the Pool Wood Embankment Landscape Bund and the residue disposed.

The combination of published and ground investigation data indicates that the presence of GLD (cohesive and granular) across the site and the main founding strata for the landscape bund. The recorded thickness of the GLD ranges from ~2.15 to 9.5m (geomean of ~4.5m). At all exploratory hole locations, the GLD contained cohesive materials with the thickness ranging from ~1.9 to 7.7m (geomean of ~3.8m). The GLD deposits are in turn underlain by granular GFD which range between ~0.3 to 6.8m in thickness (geomean of ~3.3m).

A spatial review of geology at and near the site was undertaken to assess the likely connectivity between the geological units underlying the site and surrounding features, especially the Coleshill

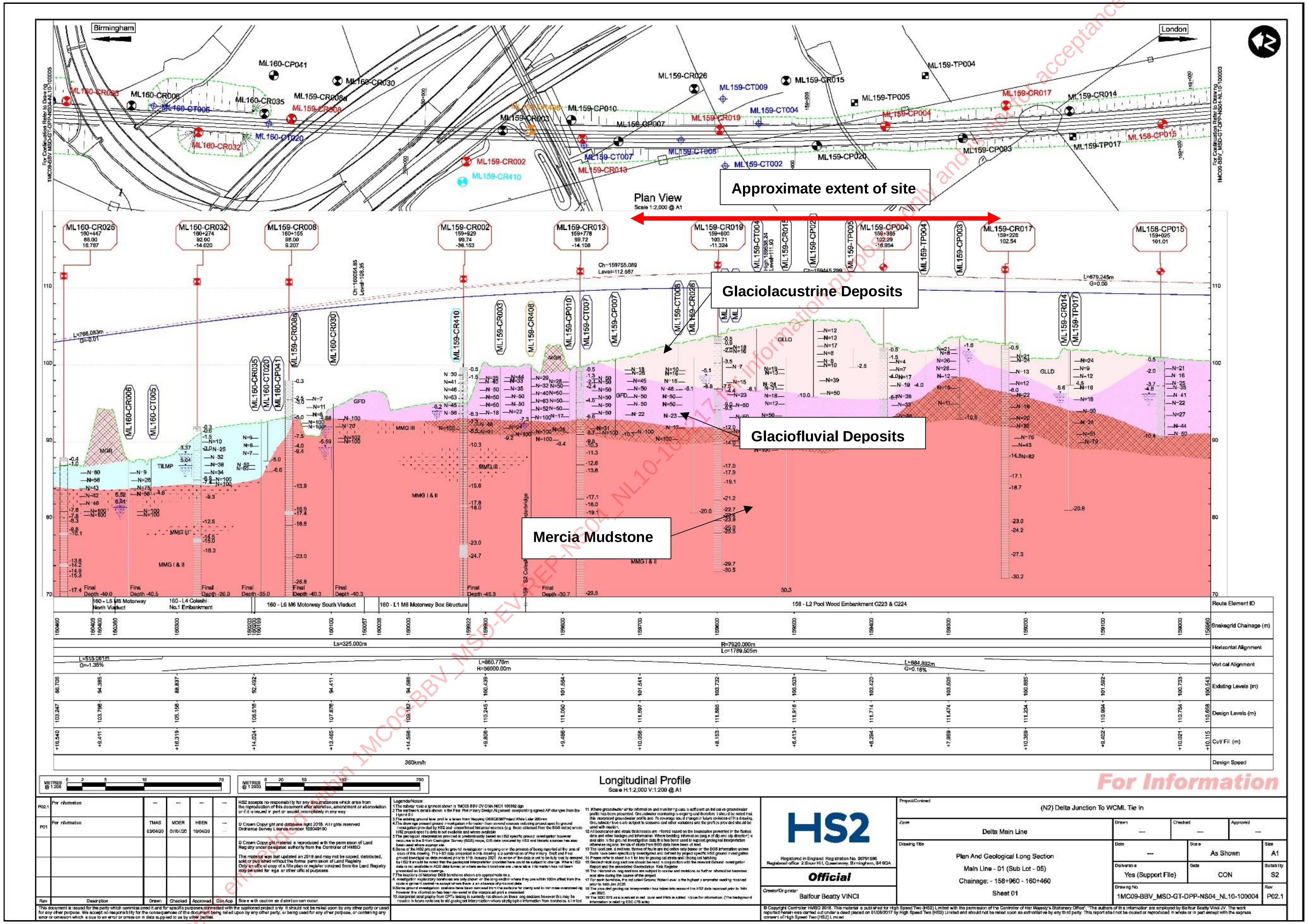
Pool area located to the east of the site. With reference to Figure 12 and 13, it appears as though the GLD forms a mounded feature with elevations and thickness declining in all directions from the approximate centre of the site. Modelling illustrated Figure 13 also indicates that the GFD beneath the site are likely continuous and extend east below the alluvial deposits associated with the Coleshill Pool area.

Figure 12: Cross section showing the extent of geological units below the site and surrounding area



Source: DJV Leapfrog Model, 2024

Figure 13: Generalised geological cross section of the site



5.2.1.3. Published hydrogeology

The GLD is classified as a 'Unproductive' aquifer with inherent low permeability and productivity. The GFD and alluvial deposits are classified as a 'Secondary A' aquifer which are of higher relative permeability and productivity compared to the GLD. The MMG is classified as a 'Secondary B' aquifer which contain predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features mainly associated with the sandstone/siltstone bands within the formation. These formations are generally of lower permeability and productivity compared to the GFD. Overall, the GFD and alluvium deposits would be the main transport mechanism for groundwater and where present contaminant movement, whereas the GLD and MMG would restrict groundwater and contaminant movements.

A review of the iSpatial database has identified four groundwater abstraction wells within a 1km radius of the site as listed in Table 3. There are no source protection zones within a 2km radius of the site. Figure 14 shows the location of the aquifer designations and groundwater abstractions identified at the site.

Table 3: Summary of groundwater abstraction wells at and near to the site

ID	Location	Use	Geology	Status
Brickfields Farm Well (A)	Ch. 159+400 (within site boundary)	Presumed for agriculture – irrigation and potable water for livestock	Presumed to be installed in the GFD	Unknown
None (B)	Ch. 159+500 (~30m east of site boundary)	Presumed for agriculture – irrigation and potable water for livestock	Presumed to be installed in the GFD	Infilled – no further details available
Pool Farm (C)	~990m northeast of the site	Presumed for agriculture – irrigation and potable water for livestock	Presumed to be installed in the GFD	Unknown
Bogs Farm (D)	~890m southeast of the site	Presumed for agriculture – irrigation and potable water for livestock	Presumed to be installed in the GFD	Unknown

A Freedom of Information request was made to the Environmental Health and Licencing Manager of North Warwickshire Borough Council. They have no records of private water wells at and within a 1000m radius of the DFR boundary.

With respect to the Brickfields Farm Well (A), and discussions with BBV it is likely that Well A refers to Well B and does not exist. The error is likely associated with the coordinate positioning of Well A.

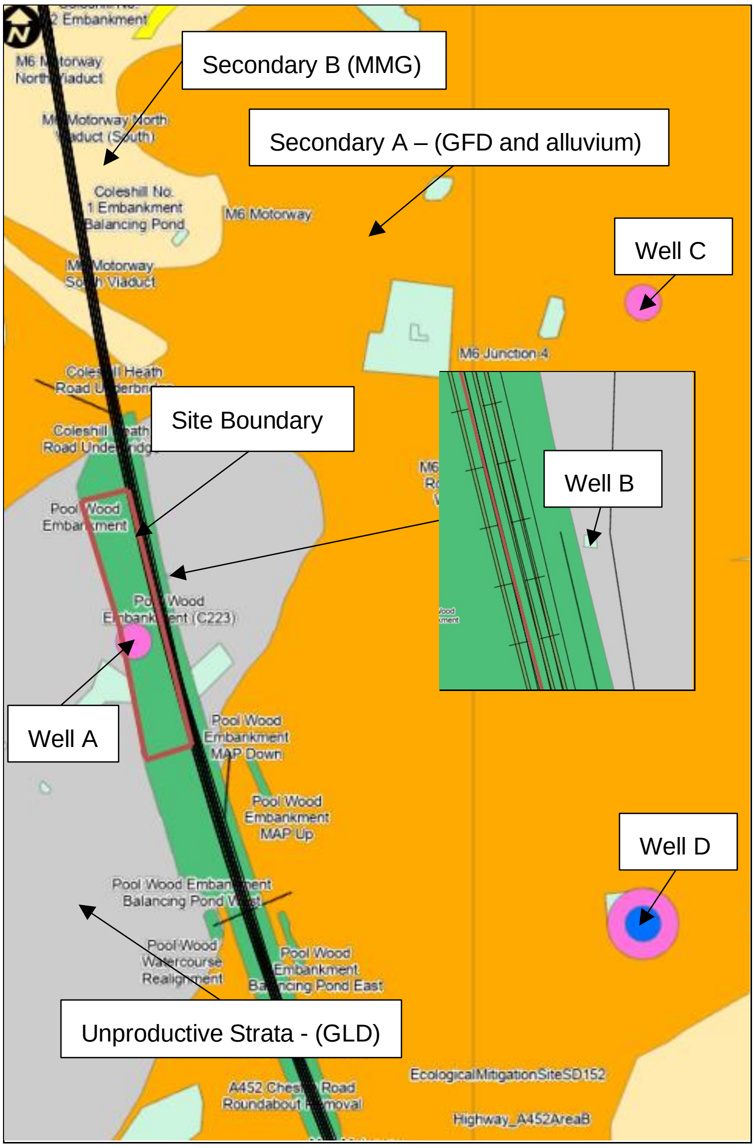
BBV have identified a localised area (<5m radius) subject to waterlogging withing a temporary access track at the mapped location of Well B. BBV are undertaking further investigation at the current time to confirm the presence of a well at this location.

As Well B is not located directly below the site, the risks of contaminant migration from the site into the underlying GFD should be low. Further, leachate and water contained in the MBL sourced material will be diverted into the drainage blanket that conveys water west into a drainage channel at the western toe of the site, downgradient of the former abstraction well further reducing the likelihood of vertical migration into the underlying GFD.

Notwithstanding the above, as part of its due diligence, if Well B is confirmed, BBV will develop a strategy to mitigate risks to controlled waters associated with the abstraction well, e.g. the Environment Agency document entitled ‘Good practice for decommissioning redundant boreholes and wells’, October 2012. Documentation on findings and mitigation measures (if required) will be presented in this report upon receipt.

For Pool Farm (C) and Bogs Farm (D), given the distance to these abstraction wells and the attenuation pathway, it is unlikely that mobile contaminants originating from site would adversely impact on water quality at the three abstraction points.

Figure 14: Aquifer classification and location of groundwater abstraction wells within a 1km radius of the site



Source: iSpatial 2024

5.2.1.4. Ground investigation monitoring data

As documented in the Pool Wood Embankment Land Quality Management Report, March 2022 (1MC09-BBV_MSD-EV-REP-NS04_NL10-100167), the site and wider asset have been subject to a series of ground investigation between 2017 and 2023. From this data 14 boreholes completed as groundwater monitoring wells were identified within and near the site boundaries. Figure 11 shows the location of the groundwater monitoring wells.

Except for ML159-CP404-1, the other 13 monitoring wells were screened within the GFD. It is likely that wells were not screened in the GLD as either no groundwater strikes were encountered, the material was dry, or it deemed unlikely that the wells would produce water given the geological setting.

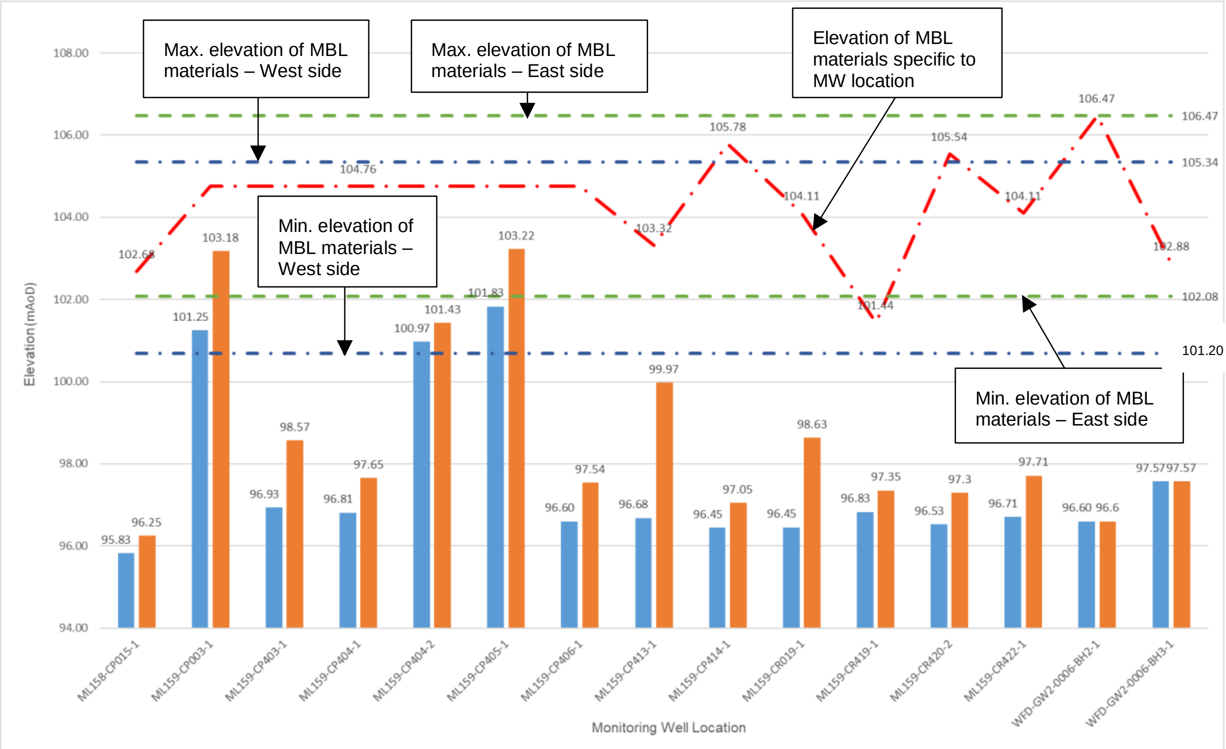
For wells installed in the GFD, maximum groundwater elevations between 2017 and 2022 ranged from 96.83 to 103.22mAoD. Average groundwater elevation for the same period ranged from 95.83 and 101.83mAoD. Maximum and average groundwater elevation at ML159-CP404-1 installed in MGR were 97.65 and 96.81mAoD respectively. Overall, maximum and average groundwater elevations remained consistent both spatially and temporarily with maximum and average elevations typically around 97mAoD and 96mAoD respectively. The noticeable exception was for ML159-CP003, ML159-CP404 and ML159-CP405 located around Ch. 159+300 where maximum and average elevations were ~ 102/103 and 101mAoD respectively. The higher elevations may be due to ground disturbance in this area associated with the former Land Quality Site (former brickworks with kiln and infilled pond). Figure 15 shows the maximum and average groundwater elevations recorded at and near to the site.

To understand the likelihood of groundwater interaction with the MBL sourced material and inform the CSM, a review of historical groundwater elevations against MBL material placement depths was undertaken. This exercise was also used to establish the thickness of the unsaturated zone to inform modelling inputs to derive SSAC described in Section 8 and 9. With reference to Table 1 and Figure 16 the invert of the MBL sourced materials will range from 101.20 to 106.47mAoD. Applying the minimum elevations over the extent of the site footprint would be overly conservative and unlikely to account for localised variations in placement and groundwater elevations. Accordingly, localised invert elevations for the MBL sourced material were plotted against the respective groundwater monitoring well elevations. Minimum unsaturated zone thicknesses ranged from 1.54 to 8.76m (average 5.36m). Average unsaturated zone thicknesses ranged from 2.93 to 9.33m (average 6.59m).

A review of groundwater strike and rest levels recorded during the ground investigations was conducted. Such data can provide an insight into where groundwater levels are under ‘non disturbed’ conditions. As shown in Figure 16 strikes and rises were recorded in 9 of the 14 monitoring wells. Strike elevations ranged from 92.12 to 100.48mAoD and rises ranged from 93.62 to 100.78mAoD. Except for ML159-CP404-1, the remaining stakes and rise were recorded in the GFD.

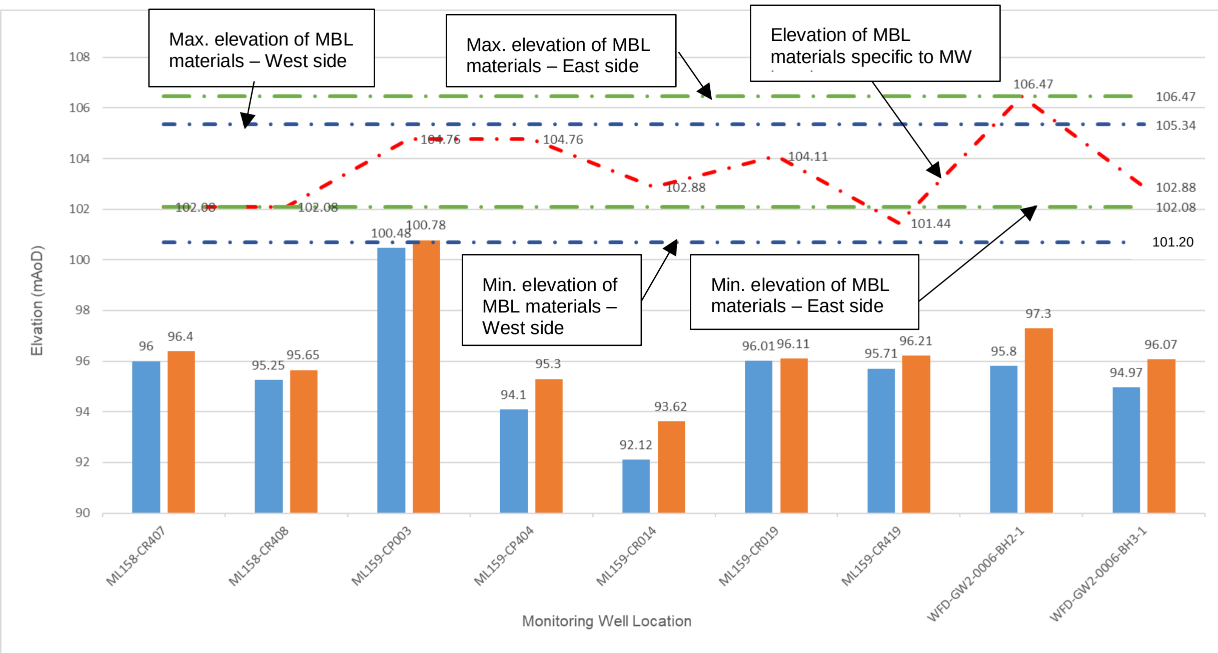
Using the groundwater elevation data, the horizontal groundwater flow direction was calculated at the site and surrounding area. The groundwater flow direction in the GFD recorded in July and December 2021 was easterly/northeasterly towards Coleshill Pools and the River Blyth. To assess groundwater flow direction, a review of geological continuity and connectivity was also undertaken with respect to the River Cole and Kingshurst Brook located to the northwest and west of the site respectively. No significant evidence of a groundwater connection was identified with the predominant drainage and collection occurring to the east of the site, which supports an easterly groundwater flow direction. Figure 17 shows the estimated groundwater flow directions in July and December 2021.

Figure 15: Maximum and average groundwater monitoring elevations for the period between 2017 and 2022



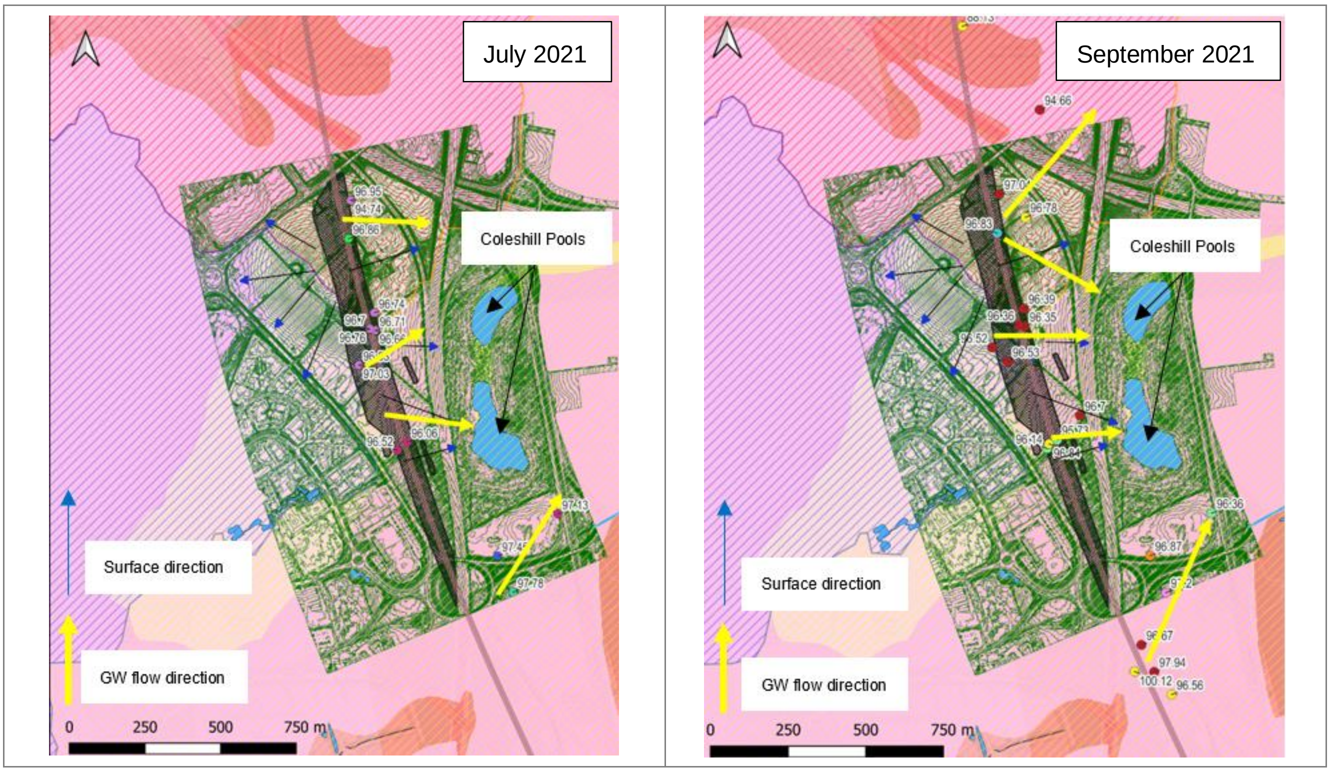
Source: DJV 2024

Figure 16: Strike and rest elevations recorded at and near to the site



Source: DJV 2024

Figure 17: Approximate groundwater flow directions recorded in July and September 2021



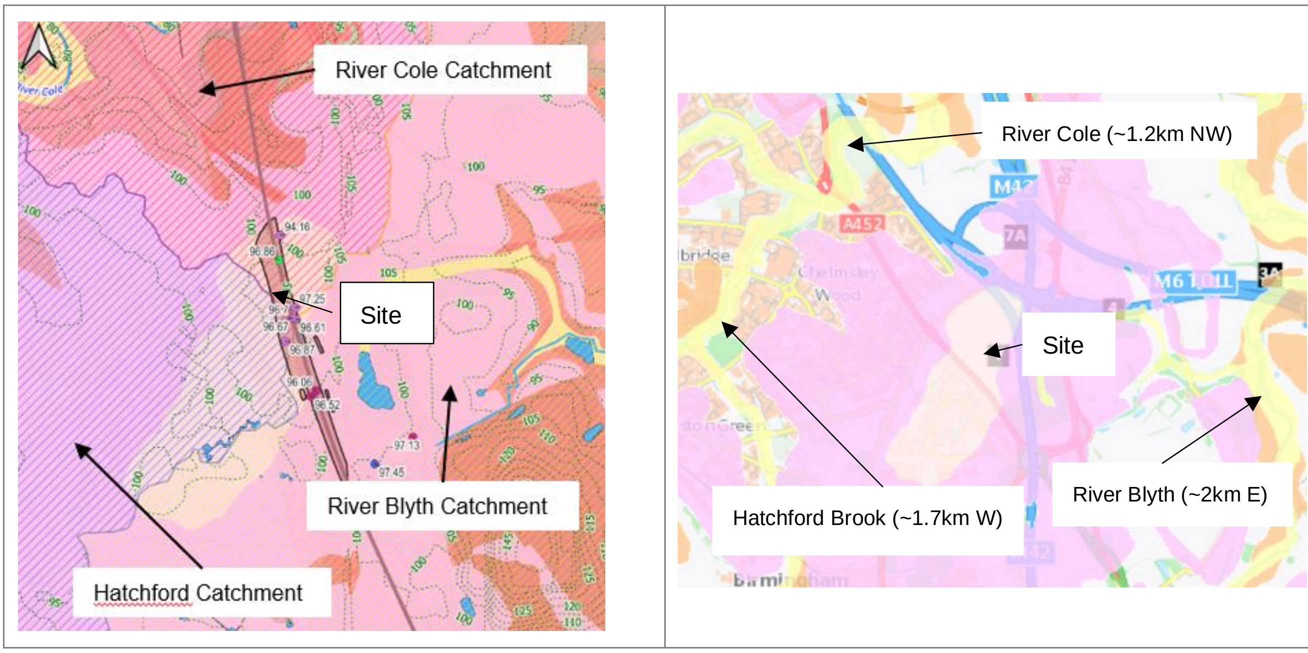
Source: QGIS 2024

A review of hydraulic conductivity values from route wide ground investigation data (rising/falling head tests and Particle Size Distribution) derived geomean values from $3.6x10^{-06}$ to $1.6x10^{-09}$m/s for the GLD and from $1.8x10^{-05}$ to $1.5x10^{-08}$m/s for the GFD. The lower values reported for the GLD reflects the lower permeability and productivity characteristics inherent in the GLD, as opposed to the relatively higher values that reflect the higher permeability and productivity conditions of the GFD.

5.3 Controlled waters – Surface water

The site is intersected by three surface water catchments associated with the River Cole, the River Blyth and Hatchford Brook located to the northwest (~1.2km), east (~2km) and west (~1.7km) of the site respectively. The catchments are in part associated with location of the site near to the watershed of these catchments. All three catchments will affect surface flow and runoff water but are unlikely to have a significant effect on GW flow direction, which is more likely to be dictated by localized surface waters including the Coleshill and Bannerley Pools. It should be noted that all surface water drainage originating from the bund will be collected and conveyed south to Holywell Brook via a network of drains, and none will enter Hatchford or the River Cole catchment. Figure 18 shows the location of catchments in relation to the site.

Figure 18: Location of catchments and main surface waters in relation to the site



Source: QGIS 2024

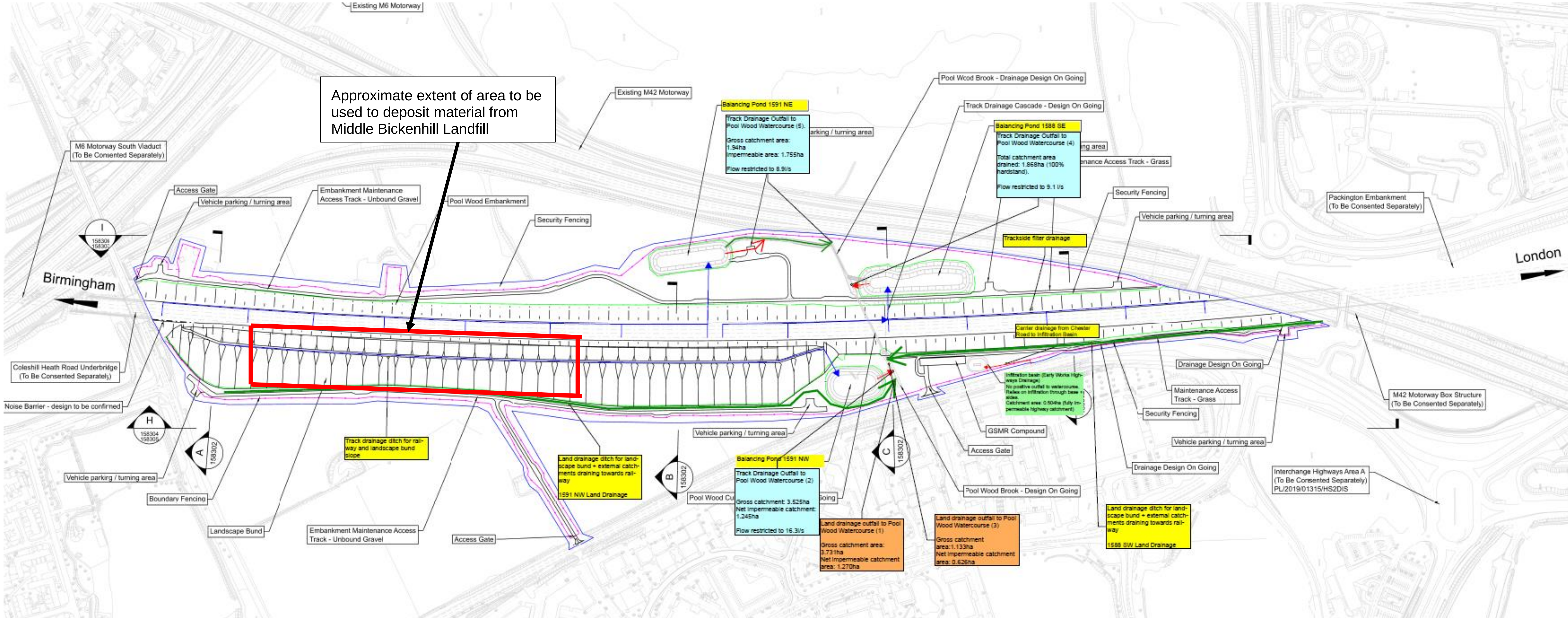
Coleshill and Bannerley Pools, two sensitive surface water features are located from approximately 350m east of the site. Both features are designated as Sites of Special Scientific Interest (SSSI) and groundwater dependent terrestrial ecosystems (GWDTE) likely to be fed by the GFD and alluvial deposits present in the vicinity of the site. Given the presence of GLD, the site is not considered a major recharge area for these features although some runoff (recharge)/infiltration into the GFD at the margins of the GLD is possible.

There is a network of land drains to the east of the site associated with the Colehill Pool area. The pools discharge into a drain located to the northeast of the pools, eventually discharging into the River Blyth via a network of west to east flowing land drains. A drain to the south of the pools was severed at Stonebridge Road and flows west into the M42 drainage system that flows south away from the site. Following the completion of a drainage survey, it was confirmed that the drainage channel to the south of pools was severed at Stonebridge Rd. Water in the channel flows west into the M42 highway drainage system. The survey also confirmed that the M42 Highway drainage conveying water from the asset to Hollywell Brook is piped and culverted just north of Hollywell Brook.

Post construction site drainage (surface runoff, groundwater from GLD pore water dissipation and porewater contained in the MBL sourced materials) will be conveyed to a land drain at western toe of site, flow south, pass east through Pool Wood culvert into attenuation ponds and then continue to flow south along the M42 drain systems eventually discharging into Hollywell Brook ~2.9km south of site. Similarly track drainage will be conveyed south via attenuation ponds into Hollywell Brook. As a precautionary approach and to provide added protection to groundwater, the western toe drain up to Pool Wood culvert and to the east of the culvert up to its point of discharge into the M42 highway drainage system will be lined (synthetic or using low permeability materials) . Post construction, it is unlikely that surface waters originating from the site would interact with the underling ground or discharge into the Coleshill Pool area. Figure 19 shows the current drainage design for Pool Wood Embankment.

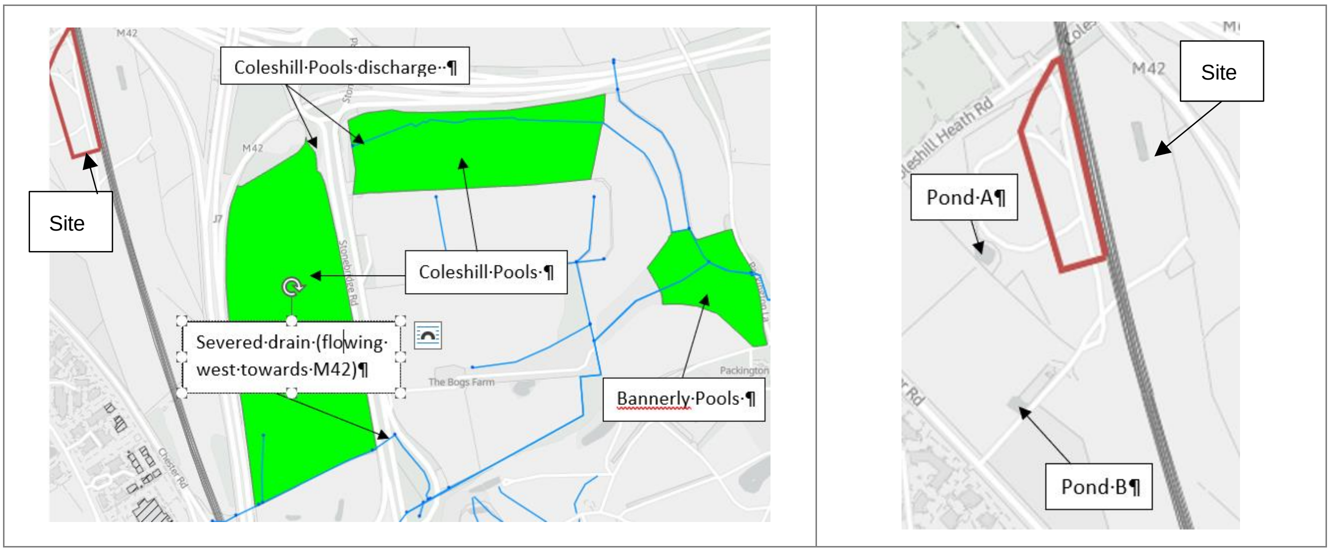
Two small surface water ponds (A and B) are located approximately 90 and 200m west of the site. Both ponds are likely to be runoff fed. Both ponds are to remain post development. Figure 20 shows the location of drainage and pond features.

Figure 19: Drainage layout for Pool Wood Embankment



Source: HS2 (N2) Delta Junction to WCML Tie in, Pool Wood Embankment HS2 Consents ID: SMB.PS.10029 General Arrangement – Schedule 17, dated 19/01/23, Drawing No. 1MC09-BBV_MSD-PL-DGA-NS04_NL10-158301

Figure 20: Location of drains, ponds and GWDTE (Coleshill and Bannerley Ponds) at and near to the site



Source: iSpatial 2024

5.4 Summary - Conceptual Hydrogeological/Hydrology

The site and local area are underlain by a mixture of low to relatively moderately permeable geological units associated with Made Ground, glacial superficial deposits, and mudstone bedrock.

The MGR will likely have variable permeability due to a mixture of granular and cohesive materials. Due to its variable nature, it is anticipated that water within the MGR will be disconnected. As indicated above, MGR will be removed as part of the dig and replace with cohesive materials to prepare the ground for construction works. Following the removal of topsoil/subsoil, the footprint of the site will be underlain by GLD which are generally non-productive units, mainly containing low permeability materials that will inhibit the movement of groundwater. The GLD appear to shallow and disappear in all directions from the site and is generally localised to the site and wider footprint of the Pool Wood Embankment asset. Given its inherent properties, the GLD is not considered to be a major groundwater recharge area for the underlying GFD.

The GLD are underlain by GFD which are a Secondary A Aquifer mainly containing productive units of sand and gravel. Due to its higher permeability, these deposits can support the movement of groundwater. The inherently higher permeability of the GFD compared to the lower permeability of the GLD is reflected in the associated hydraulic conductivity rates recorded in both deposits. The GFD likely extends from below the site east below the alluvial deposits associated with the Coleshill Pool area.

A review of groundwater and MBL source material elevations indicates that the maximum thickness of the unsaturated zone averages 5.36m indicating a relatively low water table associated with the GFD, in part governed by the presence of the overlying GLD.

The GFD are underlain by laterally extensive MMG, which is a lower permeability lithological unit (Secondary B Aquifer) than the GFD. The exception to this is the siltstone/sandstone bands within the MMG, where permeability values may be slightly higher. While there may be some hydraulic connection between the superficial deposits and mudstone, the horizontal bedding of the mudstone is such that vertical permeabilities tend to be very low, hence they support a water table in the overlying superficial strata. Given the low permeability characteristics of the mudstones, they are likely to inhibit the movement of groundwater at the site.

Based on a review of groundwater elevations, catchment data and surface waters, the groundwater flow direction within the vicinity of the site is anticipated to be easterly/northeasterly towards Coleshill/ Bannerley Pools and the River Blythe, with dominant flow likely to be through the GFD. The Coleshill/ Bannerley Pools are SSSI and GWDTE and likely in part supplied by groundwater originating from the GFD underlying the site.

There is a network of existing and proposed land drains at and to the east of the site. Two ponds are located to the west of the site. Drainage originating from the site is to be conveyed to Hollywell Brook located approximately 2.9km south of the site via a network of land drains.

6 CONCEPTUAL SITE MODEL

Based on the information presented in Section 5 and 6 the risks associated with the placement of MBL sourced materials at the site on human health and controlled waters post development have been assessed.

6.1 Risks to human health

6.1.1.1. Sources

The source of contamination for this conceptual site model (CSM) is:

- S1: Potential contaminants contained in the MBL sourced materials (up to 90% of the total volume ~160,920m^3) to be used in the construction of the site including potential residual organic material contained in the source material which could lead to gas generation.

6.1.1.2. Pathways

The pathways for this CSM are:

- P1: Human uptake pathways including direct contact with soils and groundwater; dermal contact with exposed soil; inhalation of contaminated dust, and/or vapours and ingestion of contaminated soils.
- P2: Migration of ground gas

6.1.1.3. Receptors

The receptors for this CSM are:

- R1: Construction workers
- R2: Site end users – commercial users (maintenance and other workers)

6.2 Risks to controlled waters

6.2.1.1. Sources

The source of contamination for this CSM is:

- S1: Potential contaminants contained in the MBL sourced materials (up to 90% of the total volume ~160,920m^3) to be used in the construction of the site.

6.2.1.2. Pathways

The pathways for this CSM are:

- P3: Leaching of contaminants from imported material into the groundwater via infiltration
- P4: Vertical migration of contaminated groundwater in permeable strata through the unsaturated zone

6.2.1.3. Receptors

The receptors for this CSM are:

- R3: Groundwater principally within the GFD and the MMG. It should be noted that the Site-Specific Acceptability Criteria (SSAC) have a compliance target at the base of the unsaturated zone meaning that the SSAC are protective of groundwater contained within the superficial and bedrock geology.
- R4: Surface waters including the GWDTE Coleshill and Bannerley Pools, ponds, and drainage channels.

6.3 Risks to property and ecology

6.3.1.1. Sources

The source of contamination for this CSM is:

- S1: Potential contaminants contained in the MBL sourced materials (up to 90% of the total volume ~160,920m^3) to be used in the construction of the site including potential residual organic material contained in the source material which could lead to gas generation.

6.3.1.2. Pathways

The pathways for this CSM are:

- P2: Migration of ground gas
- P5: Direct Contact
- P6: Root uptake

6.3.1.3. Receptors

The receptors for this CSM are:

- R5: Property (in the vicinity of the site and the railway)
- R6: Ecology

6.4 Summary conceptual site model

A summary CSM is shown in Table 3 with follow on commentary. Definitions of probability, consequence, and risk are defined in the Technical Standard – Groundwater Protection[i] and presented in Appendix A.

Table 3: Summary conceptual site model

Source	Pathway	Receptor	Probability	Consequence	Pre-remediation risk	Covered in this methodology?	Post-remediation risk
S1: Potential contaminants contained in the MBL sourced materials to be used in the construction of the site.	P1: Human uptake pathways including direct contact with soils and groundwater; dermal contact with exposed soil; inhalation of contaminated dust, vapours, and ingestion of contaminated soils.	R1: Construction workers	Likely	Moderate	Moderate	No: To be addressed in COSHH risk assessment.	N/A
		R2: Site end users – commercial users (maintenance and other workers)	Likely	Moderate	Moderate	Yes: by HH screening criteria and site-specific acceptance criteria derivation (public open space – parks and commercial). It should be noted that the design allows for the use of ~1m thick, clean surfacing (subsoil/topsoil) across the entire site and wider landscape bund.	Low
	P2: Migration of ground gas	R1: Construction workers	Low likelihood	Moderate	Low	No: To be addressed in H&S risk assessment.	N/A
		R2: Site end users – commercial users (maintenance and other workers)	Low likelihood	Moderate	Low	No: to be controlled through preclusion of significant biodegradables in reused material addressed by H&S risk assessment. A ground gas risk assessment concluded the risk to human health are negligible 1MC09-BBV_MSD-EV-RIA-NS04_NL10-100006).	N/A
		R5: Property	Low likelihood	Minor	Low	No: Source to be controlled through preclusion of significant biodegradables in reused material. No measures included to control gas migration pathways. A ground gas risk assessment concluded the risk to property are negligible	N/A
	P3: Leaching of contaminants from imported	R3: Groundwater, principally within the GFD	Likely	Moderate	Moderate	Yes: by controlled waters site-specific acceptance criteria derivation	Low

Source	Pathway	Receptor	Probability	Consequence	Pre-remediation risk	Covered in this methodology?	Post-remediation risk
	material into the groundwater via infiltration P4: Vertical migration of contaminated groundwater in permeable strata through the unsaturated zone	R4: Surface waters including the GWDTE Coleshill and Bannerley Pools, ponds, and drainage channels.	Likely	Moderate	Moderate	Yes: by controlled waters site-specific acceptance criteria derivation	Low
	P5: Direct Contact	R5: Property	Low Likelihood	Medium	Moderate / Low	No- appropriate concrete class to be addressed in foundation design. No- appropriate potable water main material to be selected based on soil contamination status.	Low
	P6: Root uptake	R6: Ecology	Low Likelihood	Medium	Moderate / Low	No – to be addressed in Soil Resource Plan.	Low

In addition to the information presented in Table 3, the following should be noted with regards to human health and controlled waters risks.

6.4.1.1. Human health

Only post construction risks to site commercial maintenance workers has been considered in the risk assessment. Risks to the general public under a public open space land use designation have been discounted largely on the basis that ownership of the site (and the wide landscape bund) will be retained by HS2. The site (and wider landscape bund) will be fenced off, with access restricted to authorised personnel only. Public access will not be permitted, therefore direct exposure/ingestion is very low.

For offsite users (residents and commercial occupants) risks of exposure through inhalation of contaminated dusts from the site contaminants presents a very low risk. The inclusion of a clean cover system at the site will prevent the release and dispersion of contaminated dusts into the surrounding areas.

A ground gas risk assessment was completed under separate cover to assess the risks associated with the placement of MBL sourced materials at the site. The reported concluded that risks to offsite human health and property is negligible.

There are no existing operational potable groundwater abstraction wells within influencing distance of the site used for human consumption.

6.4.1.2. Groundwater

As a general point, with the presence of GLD, the site is not considered to be a major groundwater recharge area for the underlying GFD. Further, the post development covering, and sloped nature of the site will limit infiltration with runoff waters conveyed to drainage channels principally along the western toe of the site. It is also reasonable to assume that leachate/water volumes within the site (and wider landscape bund) will decline over time as system outputs should be greater than the system inputs. Both elements will limit the potential mobilisation of contaminants.

With the use of a drainage blanket to facilitate the consolidation of the GLD, the potential risks to groundwater from mobile contaminants can be divided into short and long-term risks, as follows:

- Short term risks - during GLD consolidation it is likely that there will be a dominant upward hydraulic gradient that will lead to a fall in hydraulic conductivity. The DJV geotechnical design team have estimated that ~94% of consolidation should be achieved within 12 months of completing the construction works. Porewater (and potentially localised groundwater) originating from the GLD will enter the drainage blanket and by conveyed west to the external drainage channel at the western toe of the site. Similarly, residual leachate and water contained in the MBL sourced material is likely to enter the drainage blanket and be conveyed to the same drainage channel. The combination of the upward hydraulic gradient, the path of least resistance generated by the sloped granular drainage blanket, and the inherent low permeability of the GLD are likely to inhibit the movement of contaminants into the groundwater contained in the GFD.
- Long term risks - once consolidation has been achieved, it is likely that there would be limited water movement from the GLD into the drainage blanket. The combination of a reduced hydraulic conductivity in the GLD and the granular drainage blanket (path of least resistance) is likely to promote the continued movement of potentially contaminated leachates/water originating from the MBL sourced materials into the western drain.

Under both the short and long term scenarios, the risk of contamination migration into underlying GFD under pre-remediated conditions is considered to be moderate.

A review of historical groundwater elevations against the base depth of the MBL sourced materials was undertaken, this indicates that groundwater elevations are unlikely to rise and interact with the material used to construct the site, with minimum unsaturated zone thickness ranging from 1.54 to 8.76m (average 5.36m) and maximum thickness ranging 2.93 to 9.33m (average 6.59m). Consequently, the unsaturated zone is likely to limit the entry of contaminants into groundwater contained in the GFD.

One infilled groundwater abstraction well was located ~30m east of the site associated with the former Brickfields Farm. Given that potentially mobile contaminants contained within the site will be conveyed west into surface water drains and the entire drainage system for the asset including attenuation pond are to be lined, it is unlikely that there would be discharge of surface water to the underlying ground. Further the well is not located directly under the permitted boundary so there is unlikely to be a direct preferential pathway to the underlying GFD from the site. Moreover, modelling will assess risks to the base of the unsaturated zone, if determinant concentrations meet the modelled output for the base of the unsaturated zone, they will be protective of the former well location. The risks to the infilled well from the site are likely to be low. It should also be noted that if needed the abstraction well will be decommissioned in accordance with EA guidance to mitigate risks further. Two other offsite wells are located ~900m northeast and southeast of the site, however, are not considered to be within influencing distance of the site, therefore the associated risks are likely to be low.

6.4.1.3. Surface waters

There will be several surface water features at and near to the site, these include the Coleshill and Bannerley Pools, ponds, and drainage channels.

Coleshill and Bannerley Pools located ~350m east (down hydraulic gradient) of the site are identified as both Site of Special Scientific Interests (SSSI's) and Groundwater Dependent Terrestrial Ecosystems (GWDTE's) and represent the most sensitive surface water features in the area. As indicated it is unlikely that contaminants originating from the site would impact groundwater quality, therefore are unlikely to affect water quality and aquatic life at the pools. All site discharge (including the wider asset) will be conveyed to Hollywell Brook located ~2.9km south of the site via network of land drains and attenuation ponds. The entire drainage system will be lined and will not interact with the underlying ground and pools. The risks to the drainage system, Hollywell Brook, and the need for control measures will be assessed in a Risk Assessment produced in accordance with the EA's H1 methodology. As mentioned, modelling will assess risks to the base of the unsaturated zone, if determinant concentrations meet the modelled output, they will be protective of both groundwater and the pools.

Two existing ponds located ~90 and 200m to the west of the site will remain post development. Given that they are underlain by GLD, likely surface runoff/water fed, and the land drain located at the western toe of the site will intercept site runoff it is unlikely that contaminated site water would enter the ponds. It is also worth noting that the western toe drain is designed to receive runoff to the west of the drain that would place the ponds upgradient of site.

Whilst there is a requirement to complete a H1 RA for the drainage channels and Holywell Brook, the risks to the pools and ponds described above associated with site contaminants are likely to be low.

7 METHOD OF ASSESSMENT

In accordance with the European Union Article 6(1) Waste Framework Directive (WFD), there are four conditions (A, B, C and D) that must be met to remove a waste from the waste hierarchy, i.e. demonstrate harmonised end of waste status: Conditions A, B and C will be addressed as part of the wider application for the permit for waste recovery. Condition D is designed to ensure that the reuse of material will not lead to an overall adverse impact on the environment and human health.

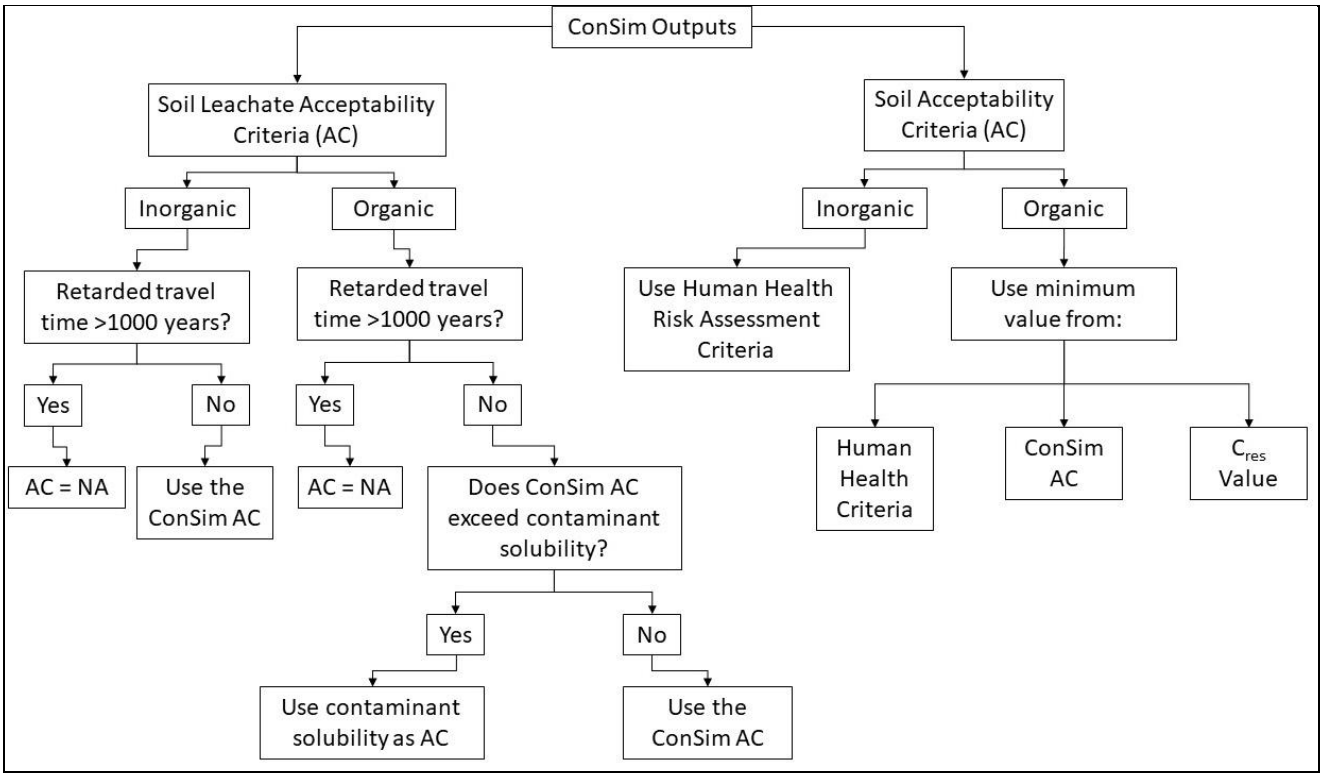
Based on the findings presented in Table 3, the main risk drivers (albeit assessed as low post development) are to human health and controlled waters. To manage the risk and demonstrate the suitability of the MBL waste material for reuse at the site, SSAC have been derived for a range of determinants to be protective of human health and controlled waters post development. The derivation of SSAC was informed by a review of the main design elements of the site (and wider landscape bund), baseline conditions and the conceptual understanding of groundwater, surface water and human health interactions with site.

This section of the report provides the methods of assessment adopted to derive the SSAC to be adopted (presented in Section 8 and 9) when undertaking the pending construction and remedial operations at MBL, before material transportation and placement at the site. The SSAC were also compared to the pre-remediated analytical data from MBL to determine if there are current exceedances that will likely need remediation to adhere to the SSAC before material reuse (presented in Section 10).

The majority of the HS2 assets are managed under Material Management Plans and a remediation framework. These documents have been developed in accordance with the CL:AIRE Definition of Waste: Code of Practice (DoWCoP) framework, which lay out the process of assessment to justify material reuse and demonstrate its suitability before it becomes a waste. As the material at MBL is already classified as waste, the DoWCoP framework does not apply and therefore assessment needs to follow the framework presented in the WDF, hence the reason why the site has been omitted from these documents. It should be noted that areas outside the permitted boundary and in the wider bund will receive non MBL sourced materials, that will be managed under the MMP Route A Framework. It is recognised that the conceptual models and contamination risks standards are similar for both DoWCoP and the WFD and where possible have sought where possible to develop SSAC which are consistent between both areas to make material management simpler.

For controlled waters, a combination of ConSim modelling, individual determinant solubility and C_{res} values was used to derive acceptability criteria to be protective of controlled waters post development. For human health, a combination of generic assessment criteria and CLEA modelling was used to derive acceptability criteria protective of human health post development consistent with minimal (EA 2009)[ii] and low level of toxicological concern toxicological benchmarks (DEFRA, 2014)[iii]. To ensure a conservative approach is adopted, the lowest values derived will be used to represent the SSAC, whether obtained from modelling, solubility, C_{res} or generic assessment criteria. Details of the criteria used in the assessment to derive a conservative SSAC for individual determinants along with the site-specific modelling input criteria are described in this section. The approach the SSAC derivation and selection is shown in Figure 21.

Figure 21: SSAC derivation process



Source: MMP Route A, 2023

7.1 Determinand parameters

Analytical data obtained from the previous ground investigations undertaken at MBL was used for modelling and comparison purposes. A total of 112 discrete samples collected between 2020 and 2021 from 30 exploratory holes located within the footprint of the landfill was available at the time of reporting. Analytical results are presented in Appendix B. Exploratory locations where soil samples were collected from is shown in Figure 22.

Soil samples were submitted for a range of analysis including total/leachable metals, inorganics, benzene, toluene, ethylbenzene, and xylene (BTEX), speciated total petroleum hydrocarbons (TPH), volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), phthalates, polychlorinated biphenyls (PCBs). A review of the analytical data reported a range of determinants at concentrations above method of detection (laboratory detection limits), all of which were subject to SSAC derivation and further assessment. Determinants containing one or more concentrations above the method of detection and subjected to SSAC derivation.

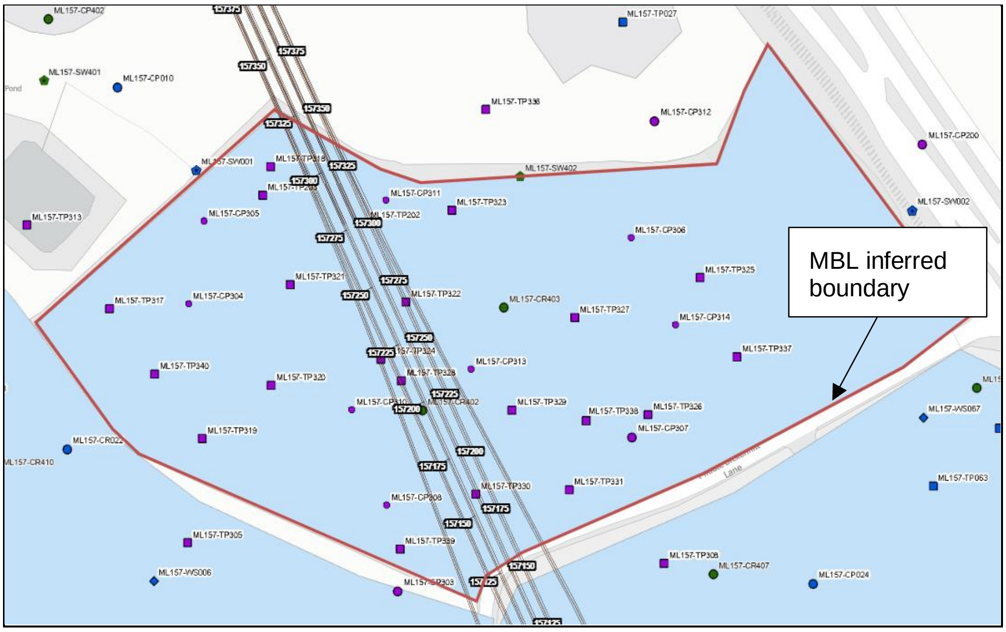
7.1.1.1. Statistical assessment

To allow for variations in the analytical concentrations geomeans were calculated for individual determinants and used for modelling input and assessment purposes. The geometric mean (geomean) was considered representative of the sample population for the individual determinants and to be a more representative indication of the source potential of the collective mass.

As part of the assessment presented in Section 10, determinant geomeans derived from the MBL analytical dataset were compared to the derived SSAC. This comparison was undertaken to gauge the current material quality and assess if determinant concentrations would pass or fail the derived SSAC in their pre-remediated state. It is assumed that if the geomean concentration for a specific determinant is below the SSAC, the determinant is unlikely to present a risk to controlled waters and human health.

For the remediation implementation plan, the contractor will ensure that material originating from MBL will be suitable for reuse and placement at the site by adherence to the SSAC. All individual validation samples will meet the SSAC to ensure that risks to controlled waters and human health post development are low.

Figure 22: Exploratory hole sample locations for MBL



Source: iSpatial 2024

7.2 Controlled Waters AC Determination

With reference to Table 3, the Source Pathway Receptors linkage S1>P3, P4>R3, R4 relate to risks from reused material sourced from MBL to controlled waters. A fate and contaminant transport model has been developed to generate Controlled Waters SSAC using ConSim software[iv] (Version 2.5).

ConSim is a fate and transport model which calculates retardation times and concentrations of compounds at a defined receptor compliance point using a tiered analysis, by incorporating the compound concentration at the source. The model incorporates algorithms to quantify the natural attenuation by dispersion, retardation and biodegradation which affect compounds along the flow path from the source. For derivation of the controlled waters SSAC, it is assumed that there is no background groundwater contamination.

The requirement for SSACs has been determined for all organic determinants reporting one or more concentrations above the soil detection limit and any inorganic leachates above relevant water quality standards (EQSs and DWSs). Table 4 lists the determinants subjected to SSAC derivation, with input (geomean) concentrations and compliance standards. Where applicable, for those contaminant concentrations reported below the laboratory detection limit, the laboratory detection limit has been used as the input concentration.

Compliance standards were selected by reviewing the range of water quality standards and selecting the most stringent standard, whether this be the Environmental Quality Standards, UK Drinking Water Standards or Minimum Report Values for hazardous substances. For some determinants, either in the absence of a standard or if the laboratory detection limit is above a standard, the compliance standard has been limited to the laboratory detection limit. Similarly, where available, background water quality (geometric) standards derived from ground investigations route wide have been adopted as the compliance standards. In all circumstances the lowest compliance standard or achievable compliance standard has been selected for modelling and assessment purposes.

Table 4: Determinants where SSACs will be derived for controlled waters

Determinand	*Hazardous substance	Compliance standard	Compliance standard value (mg/l)	Input concentration (geomean)	
				Soil (mg/kg)	Leachate (mg/l)
1,2,4-Trimethylbenzene	Yes	Detection limit	0.001	0.003	NA
1,3,5 Trichlorobenzene	No	Detection limit	0.001	0.002	NA
2-Methylnaphthalene	No	Detection limit	0.1	0.179	NA
4-Isopropyltoluene	No	Detection limit	0.001	0.002	NA
Antimony	No	UK DWS	0.005	0.09	0.09 (used soil as no leachate value)
Acenaphthene	Yes	UK DWS	0.01	0.218	0.00005
Acenaphthylene	No	n/a – Geometric mean of highest background groundwater quality along whole trace (route)	0.0000146	0.17	0.00002
Aliphatic >C10-C12	Yes	UK DWS	0.01	3.67	0.01 (derived from EPH>C10-12)
Aliphatic >C12-C16	Yes	UK DWS	0.01	4.8	0.02 (derived from EPH>C12-16)
Aliphatic >C16-C21	Yes	UK DWS	0.01	9.3	0.02 (derived from EPH>C16-21)
Aliphatic >C21-C35	Yes	UK DWS	0.01	32.91	0.03 (derived from EPH>C21-35)
Aliphatic >C35-C44	Yes	UK DWS	0.01	4.6	4.6 (used soil as no leachate value)
Aliphatic >C5-C6	Yes	UK DWS	0.01	0.43	0.001 (in absence of value used leachable benzene as representative of the carbon range)
Aliphatic >C6-C8	Yes	UK DWS	0.01	0.43	0.001
Aliphatic >C8-C10	Yes	UK DWS	0.01	3.0	0.01 (derived from GRO >C8-10)

Determinand	*Hazardous substance	Compliance standard	Compliance standard value (mg/l)	Input concentration (geomean)	
				Soil (mg/kg)	Leachate (mg/l)
Anthracene	Yes	EQS	0.0001	0.45	0.00001
Aromatic >C10-C12	Yes	UK DWS	0.01	2.87	0.01 (derived from EPH>C10-12)
Aromatic >C12-C16	Yes	UK DWS	0.01	4.53	0.02 (derived from EPH>C12-16)
Aromatic >C16-C21	Yes	UK DWS	0.01	16.35	0.02 (derived from EPH>C16-21)
Aromatic >C21-C35	Yes	UK DWS	0.01	58	0.03 (derived from EPH>C21-35)
Aromatic >C35-C44	Yes	UK DWS	0.01	6.78	6.7 (used soil as no leachate value)
Aromatic >C5-C7	Yes	UK DWS	0.01	0.076	0.001 (in absence of value used leachable benzene as representative of the carbon range)
Aromatic >C7-C8	Yes	UK DWS	0.04	0.076	0.001 (in absence of value used leachable toluene as representative of the carbon range)
Aromatic >C8-C10	Yes	UK DWS	0.01	3.02	0.01 (derived from GRO>C8-10)
Arsenic	Yes	UK DWS	0.01	-	0.0038
Barium	No	UK DWS	1	-	0.09
Benzo(a)anthracene	No	n/a – Geometric mean of highest background groundwater quality along whole trace (route)	0.00000017	0.78	0.00001
Benzo(a)pyrene	Yes	EQS	0.00000017	0.84	0.00001
Benzo(b)fluoranthene	Yes	EQS	0.00000017	0.90	0.00001
Benzo(g,h,i)perylene	Yes	EQS	0.00000017	0.62	0.00001
Benzo(k)fluoranthene	Yes	EQS	0.00000017	0.46	0.00001
Benzene	Yes	MRV	0.001	0.0017	0.001
Beryllium	No	n/a – Geometric mean of highest background groundwater quality along whole trace (route)	0.00022	-	0.003
Bis(2-ethylhexyl)phthalate	No	EQS	0.0013	0.39	NA

Determinand	*Hazardous substance	Compliance standard	Compliance standard value (mg/l)	Input concentration (geomean)	
				Soil (mg/kg)	Leachate (mg/l)
Boron	No	UK DWS	1	-	1.39
Cadmium	No	MRV	0.0001	-	0.00014
Chloroform	Yes	MRV	0.0001	0.0013	0.0013 (used soil as no leachate value)
Chromium VI	Yes	EQS	0.0034	-	0.00086
Chromium III	No	EQS	0.014	-	0.0017
Chrysene	No	n/a – Geometric mean of highest background groundwater quality along whole trace (route)	0.00009	0.86	0.00001
Copper	No	EQS – MBAT$	0.03	-	0.005
Coronene	No	Detection limits	0.3	0.53	NA
Dibenz(a,h)anthracene	No	n/a – Geometric mean of highest background groundwater quality along whole trace (route)	0.00007	0.33	0.0000
Dibenzofuran	No	Detection limit	0.1	0.19	NA
Diethylphthalate	No	Detection limit	0.1	0.17	NA
Dimethylphthalate	No	Detection limit	0.1	0.19	NA
Di-N-Butyl Phthalate	No	Detection limit	0.1	0.19	NA
Diphenyl ether	No	Detection limit	0.1	0.19	NA
Ethylbenzene	Yes	UK DWS	0.3	0.003	0.001
Fluoranthene	Yes	EQS	0.0000063	1.43	0.00002
Fluorene	No	n/a – Geometric mean of highest background groundwater quality along whole trace (route)	0.0001	0.27	0.0001
Indeno(1,2,3-cd)pyrene	Yes	EQS	0.00000017	0.66	0.00001
Isophorone	No	Detection limit	0.1	0.18	NA
Isopropylbenzene	No	Detection limit	0.001	0.002	NA
Lead	Yes	EQS	0.00671	-	0.002
Mercury	Yes	MRV	0.00001	-	0.00004
Naphthalene	No	EQS	0.002	0.17	0.00006
Naphthalene1-methyl-	No	Detection limit	0.1	0.17	NA
n-Butylbenzene	No	Detection limit	0.001	0.001	NA

Determinand	*Hazardous substance	Compliance standard	Compliance standard value (mg/l)	Input concentration (geomean)	
				Soil (mg/kg)	Leachate (mg/l)
Nickel	No	EQS – MBAT$	0.01	-	0.005
N-Nitrosodiphenylamine	No	Detection limit	0.1	0.19	NA
n-propylbenzene	No	Detection limit	0.001	0.002	NA
PCB 105	Yes	Detection limit	0.005	0.008	0.008 (used soil as no leachate value)
PCB 114	Yes	Detection limit	0.005	0.006	0.006 (used soil as no leachate value)
PCB 77	Yes	Detection limit	0.005	0.007	0.007 (used soil as no leachate value)
PCB-118 2,3',4,4',5 - Pentachlorobiphenyl	Yes	Detection limit	0.005	0.008	0.008 (used soil as no leachate value)
Phenanthrene	No	n/a – Geometric mean of highest background groundwater quality along whole trace (route)	0.00012	0.88	0.00002
Pyrene	No	n/a – Geometric mean of highest background groundwater quality along whole trace (route)	0.0001	1.6	0.00002
Phenol	No	UK DWS	0.0005	0.3	0.03
Sec-Butylbenzene	No	Detection limit	0.001	0.002	NA
Selenium	No	UK DWS	0.01	-	0.002
Styrene	Yes	UK DWS	0.02	0.0013	0.0013 (used soil as no leachate value)
Tert-Butylbenzene	No	Detection limit	0.001	0.0014	NA
Tetrachloroethene	No	EQS/UKDWS	0.01	0.0038	0.0038 (used soil as no leachate value)
Toluene	Yes	MRV	0.004	0.004	0.001
Trichloroethene	Yes	MRV	0.0001	0.0013	0.0013 (used soil as no leachate value)
Vanadium	No	Detection limit	0.001	-	0.002
Xylenes	Yes	Detection limit	0.002	0.01	0.002
Zinc	No	EQS – MBAT$	0.03	-	0.017

Notes: $The metals bioavailability assessment tool (M-BAT)[v] has been used to generate an $EQS_{bioavailable}$ value within the MMP Route A Report, (*)Joint Agencies Groundwater Directive Advisory Group (red cells indicate hazardous contaminants), MRV = Environment Agency Hazardous substances to groundwater: minimum reporting values, January 2017, UKDWS = UK Drinking Water Standards, EQS = Environmental Quality Standards, NA= leachate assessment not completed as risks associated with determinants assessed as negligible following soil assessment

7.2.1.1. Model input parameters and assumptions

The modelling is undertaken using physical and chemical parameters from site data and literature, as shown in Appendix C. Table 5 shows the general input parameters used for the model with Table 6 presenting the model assumptions.

Table 5: Model input parameters

Model input	Description
Level used	Level 2 analysis was used within this model to assess the risks to base of the unstaturated and mixing within underlying aquifer
Active processes	The ConSim model uses retardation in the unsaturated zone. Biodegradation was applied in the unsaturated zone. Dilution within the aquifer was not considered.
Simulation parameters	The model has been run for 1001 iterations to increase the confidence level (or percentile) in the results
Background concentrations	Background groundwater concentrations of determinants were not considered due to their variability route wide.
Declining source	No declining source as conservative assumption in line with EA's Remedial Targets Methodology.

Table 6: Model assumptions

Assumption	Description
Source Terms	
Source	Remediated landfill / Made Ground material originating from MBL - Ch. 157+250
Dry bulk density of source materials	Minimum, maximum and most likely values of dry density - Source 1: Data within GIR Annex E2 and ReWard publication. Only one MGR dry density values was available, therefore used Geotech verified source to supplement the data set. Triangular input used as most likely value derived, with data in the same order of magnitude.
Total Organic Carbon of source materials	Minimum, most likely and maximum values calculated using organic matter content (%) or obtained directly from Total Organic Carbon values for Made Ground/Landfill material derived from MBL Landfill pivot tables. Log triangular used for TOC as order of magnitude difference in data.
Pathway Terms	
Unsaturated pathway	In sequence, the geology underlying the landscape bund (area to receive the Made Ground/landfill material originating from MBL comprises a granular and fine coarse grained GLD, GFD and Mercia Mudstone. As the GFD is the more sensitive groundwater receptor and will likely act as the main transport mechanism for contaminant movement towards the Coleshill Pools, it has been conservatively assumed that contaminants will be in direct contact with the GFD and not the GLD. Accordingly, the pathway component has been modelled using input parameters characteristic of a GFD.
Infiltration	Minimum, mean, and maximum of infiltration values derived from rainfall - actual evaporation and slope runoff coefficient. Rainfall determined from UK hydrometric register and CEC and actual evaporation determined from Hess (2010), "Estimating green water footprints in a temperate environment".

Assumption	Description
Overall unsaturated zone thickness	A review of water strikes, rises and groundwater elevations at and in close proximity to the landscape bund was completed and compared to the design elevation of the landscape bund, specifically the base elevation of the Made Ground/landfill materials sourced from MBL to be placed in the bund. Based on maximum groundwater elevations and the elevation for material placement the min (1.54m), max (8.73m) and mean (5.36m) thickness of the unsaturated zone was calculated.
Total Organic Carbon of pathway	Minimum, most likely and maximum values calculated using organic matter content (%) for GFD from pivot tables for the landscape bund area. Log triangular used for TOC as order of magnitude difference in data.
Dry bulk density of pathway	Minimum. mean and maximum values calculated from data provided in GIR Annex E2. Most likely not calculated as only six data sets for granular GFD. Triangular input used as most likely value derived, with data in the same order of magnitude.
Unsaturated hydraulic conductivity	Minimum, mean, and maximum values from in-situ permeability tests undertaken in the area of the landscape bund and on GFD located at other locations along the alignment. Data reported in Option 2: Use all infiltration data from N1 & N2 and GIR Annex E2. Log triangular was used for hydraulic conductivity as there was an order of magnitude difference in the data.

7.2.1.2. Soil leachates

As per the process for SSAC derivation shown in Figure 22, soil and soil leachate AC values have been derived for organic determinants. For inorganic determinants, only soil leachate SSAC values have been determined using modelling and no soil SSAC for controlled waters have been determined.

7.2.1.3. For inorganics, Human Health Generic Assessment Criteria have been adopted as soil SSACs. Soil organic residual saturation

With reference to Figure 22, for soil Total Petroleum Hydrocarbon (TPH) determinants, where applicable a residual saturation value (C_{res}) was selected as the SSAC if lower than the human health and ConSim output. The C_{res} value represents the concentration in soil above which TPHs become mobile in the free (non-dissolved) phase.

For this assessment, C_{res} values have been derived from the research paper produced by Brost *et al*, entitled "Non-aqueous Phase Liquid (NAPL) Mobility Limits in Soil", Soil and Groundwater Research Bulletin, No.9 June 2000. Whilst the paper presents default values, a site-specific C_{res} value was calculated for the site. Using the methods, formula and data presented in the Brost *et al* paper, a soil bulk density of 1.48g/cm3 and a total porosity of 0.44 to represent the MBL sourced materials a C_{res} value of 4773mg/kg was calculated for a Middle distillate. A copy of the calculation sheet used to derive the C_{res} value is presented in Appendix D.

7.2.1.4. Organic solubility

With reference to Figure 22, should the retarded travel time be <1000 years for soil leachable organic determinants a comparison between the ConSim modelling output and the determinant solubility was undertaken. If the ConSim modelling output is greater than the determinant solubility, the SSAC is limited to the solubility value to prevent the determinant potentially partitioning and becoming mobile. Solubility values for all determinants are listed in Appendix C.

7.3 Human Health SSAC Determination

7.3.1.1. Acute Exposure

With reference to Table 3, Source Pathway Receptor linkages S1>P1>R1 relates to risks from imported material to construction workers. It is assumed that construction works will be undertaken according to COSHH risk assessments and with mitigation measures to control residual risks set out in method statements. Further, by adopting the physical acceptability criteria discussed within Table 2.4 of the MMP Route A report (1MC08-BBV_MSD-EV-REP-N001-100058), risks to construction personnel will be minimised.

The risks from free cyanide has been based on acute exposure GAC for a child presented within SoBRA (2019) Development of Acute Generic Assessment Criteria for Assessing Risks to Human Health from Contaminants in Soil. Free cyanide (rather than total cyanide) is more likely to be bioavailable and poses the greatest risk of toxicity. Free cyanide was reported below the laboratory detection limits in soil (<0.5 to <0.9mg/kg) and leachate (<0.05mg/l) samples. As no free cyanide has been detected, no SSACs have been derived for total or free cyanide.

7.3.1.2. Chronic Exposure

SPR linkage S1>P1>R2 relates to chronic risks from re-used and imported material sourced from MBL to future maintenance and end users.

As a default, human health SSAC are based on the SP1010 framework developed by Contaminated Land: Applications in Real Environments (CL:AIRE) on behalf of the Department for Environment, Food and Rural Affairs (DEFRA)[vi] and the Environment Agency Contaminated Land Exposure Assessment (CLEA) Framework[vii].

Human health criteria adopted in this risk assessment are based on public open space (park) and commercial land uses. Human health criteria used in the selection of the SSACs are summarised in Appendix E.

The human health criteria for free cyanide have been based on acute exposure GAC presented within SoBRA (2019) Development of Acute Generic Assessment Criteria for Assessing Risks to Human Health from Contaminants in Soil.

7.3.1.3. DQRA using CLEA Tool

As per Figure 22, based on the lowest derived value principal, SSAC were derived from the human health generic assessment criteria. A comparison of SSAC against analytical data indicated several individual sample exceedances for dibenz-a-h-anthracene and benzo(b)fluoranthene. To reduce the number of determinants to be tested for and assist the remedial programme whilst providing the same level of protection to human health, further assessment was undertaken to determine if alternative SSAC could be used. Accordingly, a review of site-specific exposure parameters was undertaken for dibenz-a-h-anthracene and benzo(b)fluoranthene as part of a DQRA.

As part of the CLEA assessment, site specific values were also generated for four PCBs (77, 105, 114, and 118). Reported analytical soil PCB concentrations ranged between <0.005 and 0.056mg/kg (geomean range 0.006 to 0.008mg/kg). Whilst most concentrations were reported below the laboratory detection limit, comparison of PCB concentrations against generic assessment criteria 0.008mg/kg (allotment land use Soil Guideline Value (SGV) in Table 5 of the Environment Agency report entitled “Soil Guideline Values for dioxins, furans and dioxin-like PCBs in soils, Science Report SC050021/Dioxins SGV”, September 2009), indicated that the geomean of the data matched the generic assessment criteria.

The CLEA model was developed by the Environment Agency to derive SGVs. The model uses a range of generic assumptions to estimate child and adult exposure to soil contaminants over long time periods for various land uses. The model allows for the modification of generic assumptions to derive site specific values reflective of site conditions.

The CLEA Tool developed by the DJV was based on the guidance and input information provided in the following reports. The model inputs and set up has been internally reviewed and approved for use by the DJV.

- Nathanail, C.P. *et al*. (2015): The LQM/CIEH Suitable 4 Use Levels for Human Health Risk Assessment. Land Quality Press, Nottingham (S4UL3389).
- Environment Agency (2009): Human health toxicological assessment of contaminants in soil (Science Report – Final SC050021/SR2).
- Defra, 2014: SP1010 Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination, Final Project Report Revision 2.
- Environment Agency (2009): Updated technical background to the CLEA model.

As mentioned in Section 6.4.1.1, only authorised personal will be permitted access to the site post development, no public access will be permitted. Consultation between the DJV and BBV have established that only maintenance workers will need periodic access to the site post development for grass mowing and inspections of the HS2 trace. The model has assumed that an individual of Age Class 17 (working age) will access the site 10 days during a year and not the default 170 days a year.

The CLEA model was set up using the following exposure parameters:

- Generic Settings: Land use: Public Open Space (Park, Lifetime C4SL). Female receptor. No building exposure. Sand Loam Soil. pH 7.
- Pathways:
    - Direct soil and dust ingestion
    - Dermal contact with soil
    - Inhalation of soil dust
    - Inhalation of outdoor vapour
- Site Specific Settings:
    - Age Class: 17
    - Exposure duration: 10 days per year
- Toxicity Benchmarks:
    - Human Criteria Values (oral and inhalation) published in the LQM/CIEH S4ULs for Human Health Risk Assessment, 2015 for dibenz-a-h-anthracene and benzo(b)fluoranthene.
    - Human Criteria Values (oral and inhalation) published in the Environment Agency Soil Guideline Values for dioxins, furans and dioxin like PCBs in soils, Science Report SC050021 / Dioxins SGV, 2009 for PCBs

The input and outputs associated with the human health DQRA are presented in Appendix F.

8 RISK ASSESSMENT OUTPUTS

8.1 Controlled waters

Outputs generated from the ConSim risk assessment models are presented within Table (leachate) and Table (soil).

The retarded travel time of each compound was simulated to predict the time of travel from source (imported material sourced from MBL) to receptor (base of the unsaturated zone at the site), including natural attenuation and dispersion. The Environment Agency Remedial Target Methodology (RTM) assumes the risk to a receptor acceptable if the retarded travel time is greater than 1,000 years and the contamination spreads no further than tens of metres from the source. This model is only used to generate SSAC for determinants with a retarded travel time of less than 1,000 years in accordance with the Environment Agency's RTM.

As previously discussed for organic leachate SSACs, if the model output is above the solubility value, the SSAC has been limited to the solubility threshold.

Table 7: Modelling outputs from ConSim (leachate source)

Contaminant	Compliance standard (mg/l)	Geomean leachate concentration (mg/l)	Retarded Travel time to the base of the unsaturated zone (50th %ile) (years)	Concentration at the base of the unsaturated zone at 1000 years (95th %ile) (mg/l)	Calculated controlled water leachate SSAC (mg/l)
Antimony	0.005	*0.09	>1000	-	NA
Acenaphthene	0.01	0.00005	>1000	-	NA
Acenaphthylene	0.0000146	0.00002	>1000	-	NA
Aliphatic >C10-C12	0.01	0.01	>1000	-	NA
Aliphatic >C12-C16	0.01	0.02	>1000	-	NA
Aliphatic >C16-C21	0.01	0.02	>1000	-	NA
Aliphatic >C21-C35	0.01	0.03	>1000	-	NA
Aliphatic >C35-C44	0.01	*4.6	>1000	-	NA
Aliphatic >C5-C6	0.01	0.001	844	$6.56x10^{-11}$	>100000
Aliphatic >C6-C8	0.01	0.001	>1000	-	NA
Aliphatic >C8-C10	0.01	0.01	>1000	-	NA
Anthracene	0.0001	0.00001	>1000	-	NA
Aromatic >C10-C12	0.01	0.01	>1000	-	NA
Aromatic >C12-C16	0.01	0.02	>1000	-	NA
Aromatic >C16-C21	0.01	0.02	>1000	-	NA
Aromatic >C21-C35	0.01	0.03	>1000	-	NA
Aromatic >C35-C44	0.01	*6.7	>1000	-	NA
Aromatic >C5-C7	0.01	0.001	80	$3.52x10^{-09}$	2840
Aromatic >C7-C8	0.01	0.004	223	$5.01x10^{-08}$	200
Aromatic >C8-C10	0.01	0.01	>1000	-	NA

Arsenic	0.01	0.0038	>1000	-	NA
Barium	1	0.09	574	9.51×10^{-02}	1.01
Beryllium	0.00022	0.003	>1000	-	NA
Benzo(a)anthracene	0.00000017	0.00001	>1000	-	NA
Benzo(a)pyrene	0.00000017	0.00001	>1000	-	NA
Benzo(b)fluoranthene	0.00000017	0.00001	>1000	-	NA
Benzo(g,h,i)perylene	0.00000017	0.00001	>1000	-	NA
Benzo(k)fluoranthene	0.00000017	0.00001	>1000	-	NA
Benzene	0.001	0.001	80	3.16×10^{-10}	284
Beryllium	0.00022	0.003	>1000	-	NA
Boron	1	1.39	>1000	-	NA
Cadmium	0.0001	0.00014	>1000	-	NA
Chloroform	0.0001	*0.0013	62	1.42×10^{-04}	0.001
Chromium VI	0.0034	0.00086	>1000	-	NA
Chromium III	0.014	0.0017	>1000	-	NA
Chrysene	0.00009	0.00001	>1000	-	NA
Copper	0.03	0.005	>1000	-	NA
Dibenz(a,h)anthracene	0.00007	0.0000	>1000	-	NA
Ethylbenzene	0.3	0.001	484	6.69×10^{-12}	>100000
Fluoranthene	0.0000063	0.00002	>1000	-	NA
Fluorene	0.0001	0.0001	>1000	-	NA
Indeno(1,2,3-cd)pyrene	0.00000017	0.00001	>1000	-	NA
Lead	0.00671	0.002	>1000	-	NA
Mercury	0.00001	0.00004	>1000	-	NA
Naphthalene	0.002	0.00006	697	1.03×10^{-07}	1.26
Nickel	0.01	0.005	>1000	-	NA
PCB 105	0.005	*0.008	>1000	-	NA
PCB 114	0.005	*0.006	>1000	-	NA
PCB 77	0.005	*0.007	>1000	-	NA
PCB-118 2,3',4,4',5 - Pentachlorobiphenyl	0.005	*0.008	>1000	-	NA
Phenanthrene	0.00012	0.00002	>1000	-	NA
Pyrene	0.0001	0.00002	>1000	-	NA
Phenol	0.0005	0.03	97	1.67×10^{-09}	8983
Selenium	0.01	0.002	699	1.76×10^{-03}	0.01
Styrene	0.02	*0.0013	477	2.53×10^{-07}	103
Tetrachloroethene	0.01	*0.0038	295	1.03×10^{-03}	0.04
Toluene	0.004	0.001	223	5.01×10^{-08}	80
Trichloroethene	0.0001	*0.0013	159	3.68×10^{-04}	0.0004

Vanadium	0.001	0.002	>1000	-	NA
Xylenes	0.003	0.002	486	3.67x10-^{07}	15.0
Zinc	0.03	0.017	>1000	-	NA

Note: Yellow cells relate to retarded travel times being greater than 1,000 years. Orange cells reflect when a compliance standard has been exceeded; (*) = leachate substitute, used soil so reported in mg/kg.

Table 8: Modelling outputs from ConSim (soil source)

Contaminant	Compliance standard (mg/l)	Geomean soil concentration (mg/kg)	Retarded Travel time to the base of the unsaturated zone (50th %ile) (years)	Concentration at the base of the unsaturated zone at 1000 years (95th %ile) (mg/l)	Calculated controlled water soil SSAC (mg/kg)
1,2,4-Trimethylbenzene	0.001	0.003	2.30x10^{-08}	644	120
1,3,5 Trichlorobenzene	0.001	0.002	-	>1000	-
2-Methylnaphthalene	0.1	0.179	-	>1000	-
4-Isopropyltoluene	0.001	0.002	-	>1000	-
Acenaphthene	0.01	0.218	-	>1000	-
Acenaphthylene	0.0000146	0.17	-	>1000	-
Aliphatic >C10-C12	0.01	3.67	-	>1000	-
Aliphatic >C12-C16	0.01	4.8	-	>1000	-
Aliphatic >C16-C21	0.01	9.3	-	>1000	-
Aliphatic >C21-C35	0.01	32.91	-	>1000	-
Aliphatic >C35-C44	0.01	4.6	-	>1000	-
Aliphatic >C5-C6	0.01	0.43	1.09x10^{-08}	802	>100000
Aliphatic >C6-C8	0.01	0.43	-	>1000	-
Aliphatic >C8-C10	0.01	3.0	-	>1000	-
Anthracene	0.0001	0.45	-	>1000	-
Aromatic >C10-C12	0.01	2.87	-	>1000	
Aromatic >C12-C16	0.01	4.53	-	>1000	-
Aromatic >C16-C21	0.01	16.35	-	>1000	-
Aromatic >C21-C35	0.01	58	-	>1000	-
Aromatic >C35-C44	0.01	6.78	-	>1000	-
Aromatic >C5-C7	0.01	0.076	9.6x10^{-08}	77	9510
Aromatic >C7-C8	0.01	0.076	6.7x10^{-07}	211	1523
Aromatic >C8-C10	0.01	3.02	-	>1000	-
Benzo(a)anthracene	0.00000017	0.78	-	>1000	-
Benzo(a)pyrene	0.00000017	0.84	-	>1000	-
Benzo(b)fluoranthene	0.00000017	0.90	-	>1000	-
Benzo(g,h,i)perylene	0.00000017	0.62	-	>1000	-

Contaminant	Compliance standard (mg/l)	Geomean soil concentration (mg/kg)	Retarded Travel time to the base of the unsaturated zone (50th %ile) (years)	Concentration at the base of the unsaturated zone at 1000 years (95th %ile) (mg/l)	Calculated controlled water soil SSAC (mg/kg)
Benzo(k)fluoranthene	0.00000017	0.46	-	>1000	-
Benzene	0.001	0.0017	-	>1000	-
Bis(2-ethylhexyl)phthalate	0.0013	0.39	-	>1000	-
Chloroform	0.0001	0.0013	1.33×10^{-04}	63	0.001
Chrysene	0.00009	0.86	-	>1000	-
Coronene	0.3	0.53	-	>1000	-
Dibenz(a,h)anthracene	0.00007	0.33	-	>1000	-
Dibenzofuran	0.1	0.19	-	>1000	-
Diethylphthalate	0.1	0.17	3.24×10^{-04}	124	53
Dimethylphthalate	0.1	0.19	3.14×10^{-10}	43	>100000
Di-N-Butyl Phthalate	0.1	0.19	No input data to run modelling		
Diphenyl ether	0.1	0.19	1.11×10^{-2}	>1000	1.71
Ethylbenzene	0.3	0.003	1.20×10^{-11}	471	>100000
Fluoranthene	0.0000063	1.43	-	>1000	-
Fluorene	0.0001	0.27	-	>1000	-
Indeno(1,2,3-cd)pyrene	0.00000017	0.66	-	>1000	-
Isophorone	0.1	0.18	1.71×10^{-05}	79	1054
Isopropylbenzene	0.001	0.002	No input data to run modelling		
Naphthalene	0.002	0.17	1.89×10^{-05}	724	18
Naphthalene1-methyl-	0.1	0.17	No input data to run modelling		
n-Butylbenzene	0.001	0.001	-	>1000	-
N-Nitrosodiphenylamine	0.1	0.19	-	>1000	-
n-propylbenzene	0.001	0.002	3.19×10^{-04}	910	0.0056
PCB 105	0.005	0.008	-	>1000	-
PCB 114	0.005	0.006	-	>1000	-
PCB 77	0.005	0.007	-	>1000	-
PCB-118 2,3',4,4',5 - Pentachlorobiphenyl	0.005	0.008	-	>1000	-
Phenanthrene	0.00012	0.88	-	>1000	-
Pyrene	0.0001	1.6	-	>1000	-
Phenols	0.0005	0.3	3.73×10^{-09}	94	39405
Sec-Butylbenzene	0.001	0.002	-	>1000	-
Styrene	0.02	0.001	2.14×10^{-08}	503	1243

Contaminant	Compliance standard (mg/l)	Geomean soil concentration (mg/kg)	Retarded Travel time to the base of the unsaturated zone (50th %ile) (years)	Concentration at the base of the unsaturated zone at 1000 years (95th %ile) (mg/l)	Calculated controlled water soil SSAC (mg/kg)
Tert-Butylbenzene	0.001	0.0014	-	>1000	-
Tetrachloroethene	0.01	0.0038	2.74×10^{-04}	285	0.14
Toluene	0.004	0.004	3.89×10^{-08}	219	607
Trichloroethene	0.0001	0.0013	1.68×10^{-04}	154	0.001
Xylenes	0.003	0.01	2.04×10^{-07}	512	184

Note: Yellow cells relate to retarded travel times being greater than 1,000 years. Pink cells reflect when a compliance standard has been exceeded

8.1.1.1. Screening assessment

As indicated in Section 7.1, any soil determinant reporting one or more samples at a concentration above the laboratory detection limit was subject to groundwater modelling. Using the model outputs and quantitative assessment, risks associated with several of the determinants have been deemed negligible and the need for a SSAC unwarranted. It should be noted where soil determinants have been assessed as presenting a negligible risk, the risks associated with the equivalent soil leachate have been ruled out and not assessed further. Table 9 presents a summary justifying the removal of specific determinants.

Table 9: Screening assessment for selective determinants

Determinant	Soil Minimum and Maximum concentration (mg/kg)	Soil Geomean concentration (mg/kg)	ComSim output		Human Health GAC [mg/kg]	Justification for exclusion
			Conc (mg/kg)	TT (yrs)		
1,2,4-Trimethylbenzene	0.001 to 0.15	0.003	120	644	39	Out of 31 samples tested (1 sample per ~5484m^3), all samples (maximum and geomean) were reported below the ConSim output value of 120mg/kg and human health criteria of 39mg/kg. There are no published water standards. As a VOC, 1,2,4-trimethylbenzene is likely to volatilise when worked and subjected to disturbance as part of the MBL RIP. There is also unlikely to be any meaningful improvement on the reported values from remediation.
1,3,5 Trichlorobenzene	0.001 to 0.3	0.002	0.44	>1000	23	Out of 31 samples tested (1 sample per ~5484m^3), all samples (maximum and geomean) were reported below the ConSim output value of 0.44mg/kg and human health criteria of 23mg/kg. There are no published water standards. Travel times were also more than 1000yrs. As a VOC, 1,3,5 trichlorobenzene is likely to volatilise when worked and subjected to disturbance as part of the MBL RIP. There is also unlikely to be any meaningful improvement on the reported values from remediation.
2-Methylnaphthalene	0.1 to 1.2	0.179	2.66	>1000	-	Out of 31 samples tested (1 sample per ~5484m^3), all samples (maximum and geomean) were reported below the ConSim output value of 2.66mg/kg. There are no published human health or water quality standards. Travel times were also more than 1000yrs. There is unlikely to be any meaningful improvement on the reported values from remediation activities.
4-Isopropyltoluene	0.001 to 0.2	0.002	0.01	>1000	-	Out of the 31 samples tested (1 sample per ~5484m^3), two samples (0.04 and 0.2mg/kg) were reported above the laboratory detection limit and the ConSim output value of 0.01mg/kg. There are no published human health or water quality standards. Travel times were also more than 1000yrs. There is unlikely to be any meaningful improvement on the reported values from remediation activities.
Chloroform	0.001 to 0.002	0.001	0.001	59	99	Out of the 31 samples tested (1 sample per ~5484m^3), two samples (0.0019 and 0.002mg/kg) were reported above the laboratory detection limit and the ConSim output value of 0.001mg/kg. Remainder of samples reported at laboratory detection limits <0.001mg/kg. The geomean of the sample population matched the ConSim output value. All sample data was reported at concentrations below human health criteria. As a VOC, chloroform is likely to volatilise when worked and subjected to disturbance as part of the MBL RIP. There is also unlikely to be any meaningful improvement on the reported values from remediation.
Coronene	0.3 to 3.6	0.53	-	>1000	-	Of the 31 samples tested, concentrations ranged from 0.3 to 3.6mg/kg (geomean of 0.53mg/kg). ConSim output did not derive a value as there was an excessive travel time associated with the determinant. There are no published human health or water quality standards associated with coronene. There is unlikely to be any meaningful improvement on the reported values from remediation.

Determinant	Soil Minimum and Maximum concentration (mg/kg)	Soil Geomean concentration (mg/kg)	ComSim output		Human Health GAC [mg/kg]	Justification for exclusion
			Conc (mg/kg)	TT (yrs)		
Diethylphthalate	0.1 to 1.2	0.17	57	117	89000	Out of 31 samples tested (1 sample per ~5484m^3), all samples (maximum and geomean) were reported below the ConSim output value of 57mg/kg and human health criteria of 89,000mg/kg. There are no published water standards. There is unlikely to be any meaningful improvement on the reported values from remediation activities.
Dimethylphthalate	0.1 to 1.2	0.19	>1000000	39	-	Out of 31 samples tested (1 sample per ~5484m^3), all samples (maximum and geomean) were reported below the ConSim output value of >1000000mg/kg. There are no published human health or water quality standards. There is unlikely to be any meaningful improvement on the reported values from remediation activities.
Di-N-Butyl Phthalate	0.1 to 1.2	0.19	-		2600	Of the 31 samples tested (1 sample per ~5484m^3), concentrations ranged from 0.1 to 1.2mg/kg (geomean of 0.19mg/kg). All samples (maximum and geomean) were reported below the human health criteria of 2600mg/kg. After research, input data required to complete modelling was not available at the time of reporting, therefore a ConSim output value could not be generated. There is unlikely to be any meaningful improvement on the reported values from remediation activities.
Diphenyl ether	0.1 to 1.2	0.19	1.71	>1000	-	Out of the 31 samples tested (1 sample per ~5484m^3), all samples (maximum and geomeans) were reported below the ConSim output value of 1.71mg/kg. There are no published human health or water quality standards. Travel times were also more than 1000yrs. There is unlikely to be any meaningful improvement on the reported values from remediation activities.
Isophorone	0.1 to 1.2	0.18	901	74	-	Out of 31 samples tested (1 sample per ~5484m3), all samples (maximum and geomean) were reported below the ConSim output value of 901mg/kg. There are no published human health or water quality standards. There is unlikely to be any meaningful improvement on the reported values from remediation activities.
Isopropylbenzene	0.001 to 0.036	0.002	-		1300	Of the 31 samples tested (1 sample per ~5484m^3), concentrations ranged from 0.001 to 0.036mg/kg (geomean of 0.002mg/kg). All samples (maximum and geomean) were reported below the human health criteria of 1300mg/kg. After research, input data required to complete modelling was not available at the time of reporting, therefore a ConSim output value could not be generated. There is unlikely to be any meaningful improvement on the reported values from remediation activities.
Naphthalene1-methyl-	0.1 to 1.2	0.17	-		-	Of the 31 samples tested (1 sample per ~5484m^3), concentrations ranged from 0.1 to 1.2mg/kg (geomean of 0.17). There are no published human health or water quality standards. After research, input data required to complete modelling was not available at the time of reporting, therefore a ConSim output value could not be generated. There is unlikely to be any meaningful improvement on the reported values from remediation activities.
n-Butylbenzene	0.001 to 0.01	0.001	0.012	>1000	-	Out of the 31 samples tested (1 sample per ~5484m^3), all samples (maximum and geomeans) were reported below the ConSim output value of 0.012mg/kg. There are no

Determinant	Soil Minimum and Maximum concentration (mg/kg)	Soil Geomean concentration (mg/kg)	ComSim output		Human Health GAC [mg/kg]	Justification for exclusion
			Conc (mg/kg)	TT (yrs)		
						published human health or water quality standards. Travel times were also more than 1000yrs. There is unlikely to be any meaningful improvement on the reported values from remediation activities.
N-Nitrosodiphenylamine	0.1 to 1.2	0.19	5426	>1000	-	Out of the 31 samples tested (1 sample per ~5484m^3), all samples (maximum and geomeans) were reported below the ConSim output value of 5426mg/kg. There are no published human health or water quality standards. Travel times were also more than 1000yrs. There is unlikely to be any meaningful improvement on the reported values from remediation activities.
n-propylbenzene	0.001 to 0.055	0.002	0.0054	910	3900	Out of the 31 samples tested (1 sample per ~5484m^3), one sample (0.05mg/kg) was reported above the laboratory detection limit and the ConSim output value of 0.005mg/kg, but below the human health value of 3900mg/kg. The sample geomean was below the ConSim output value. Travel times were also close to 1000yrs. There is unlikely to be any meaningful improvement on the reported values from remediation activities.
Sec-Butylbenzene	0.001 to 0.1	0.002	0.01	>1000	-	Out of the 31 samples tested (1 sample per ~5484m^3), one sample (0.1mg/kg) was reported above the laboratory detection limit and the ConSim output value of 0.01mg/kg. The sample geomean was below the ConSim output value. There are no published human health or water quality standards. Travel times were also more than 1000yrs. There is unlikely to be any meaningful improvement on the reported values from remediation activities.
Tert-Butylbenzene	0.001 to 0.007	0.0014	0.007	>1000	-	Out of the 31 samples tested (1 sample per ~5484m^3), all samples (maximum and geomeans) were reported at/below the ConSim output value of 0.007mg/kg. There are no published human health or water quality standards. Travel times were also more than 1000yrs. There is unlikely to be any meaningful improvement on the reported values from remediation activities.
Tetrachloroethene	0.003 to 0.007	0.004	0.14	285	24	Out of 31 samples tested (1 sample per ~5484m^3), all samples (maximum and geomean) were reported below the ConSim output value of 0.14mg/kg and human health criteria of 24mg/kg. Tetrachloroethene was reported above the laboratory detection limit in two samples. As a VOC, tetrachloroethene is likely to volatilise when worked and subjected to disturbance as part of the MBL RIP. There is also unlikely to be any meaningful improvement on the reported values from remediation.
Trichloroethene	0.001 to 0.002	0.001	0.001	154	0.73	Out of 31 samples tested (1 sample per ~5484m^3), two samples (0.002mg/kg) were reported above the ConSim output value of 0.001mg/kg. The sample geomean was the same as the ConSim value. All sample concentrations were below the human health criteria of 0.73mg/kg. As a VOC, trichloroethene is likely to volatilise when worked and subjected to disturbance as part of the MBL RIP. There is also unlikely to be any meaningful improvement on the reported values from remediation.

Notes: TT = travel time, GAC generic assessment criteria PoS Park 1% SOM (commercial 1% SOM value)

8.2 Human health

Soil outputs generated from the CLEA model are presented within Table . It should be noted that whilst SSAC could have been derived for all the soil determinants, where possible this assessment has remained consistent and not deviated with the values presented in Table F1: Soils SSAC and Table F2: Soil leachate in the EA approved MMP Route A document in its selection of soil SSAC.

Table 10: Human health CLEA model output for selective determinants

Contaminant	Soil Minimum and Maximum concentration (mg/kg)	Soil Geomean concentration (mg/kg)	Generic Assessment Criteria (mg/kg)	CLEA Model Output (mg/kg)
PCB 105	0.005 to 0.048	0.008	0.008	0.07 (oral)
PCB 114	0.005 to 0.009	0.006	0.008	0.07 (oral)
PCB 77	0.005 to 0.039	0.007	0.008	0.07 (oral)
PCB-118 2,3',4,4',5 -Pentachlorobiphenyl	0.005 to 0.059	0.008	0.008	0.07 (oral)
Dibenz(a,h)anthracene	0.08 to 5.9	0.33	1.1	171 (combined oral and inhalation)
Benzo(b)fluoranthene	0.09 to 20.4	0.9	13	2083 (combined oral and inhalation)

9 SUMMARY OF ACCEPTABILITY CRITERIA

Based on the outcome of the assessment described in Sections 7 and 8, a summary of the derived SSAC for each determinant is presented in Table 11. To aid interpretation the following should be noted:

- Grey cells represent concentrations above the soil saturation limits which could be mobile due to connectivity or gravity. To limit the potential for free phase oils, the maximum concentration of the sum of TPHs and PAHs has been limited to the residual NAPL concentration (Cres) (Brost, *et al.* 2000). As described in Section 7.2.1.3, this has been limited to 4773mg/kg.
- Orange cells represent organic leachate SSACs. As described in Section 7.2.1.4, where the model output is above the solubility value, this is limited to the solubility threshold.
- Where SSACs are marked as "N/A", the retarded travel time is >1000years and/or no SSAC has been quantified.
- Brown cells show where a soil SSAC has been derived from CLEA DQRA modelling.
- The phenol (turquoise cell) SSAC has been conservatively limited to 1mg/l on the basis that previous studies have shown that phenols at concentrations from 200mg/l inhibits or is toxic to bacteria. (Natural attenuation of organic contaminants in groundwater: biodegradation of high phenol concentrations under sulphate-reducing conditions and anaerobic oxidation of vinyl chloride. - White Rose eTheses Online).
- Blue cells show where a derived controlled water SSAC has been adopted.
- Green cells show where a human health SSAC has been adopted.

It should be noted that SSACs for asbestos in soils and invasive species are not derived as these will be managed in accordance with the asbestos acceptability criteria and the EWC biosecurity management plan[viii].

Table 11: SSAC

Contaminant	Leachate SSAC (mg/l)	Soils SSAC (mg/kg)
Acenaphthene	NA	4773
Acenaphthylene	NA	4773
Aliphatic >C10-C12	NA	4773
Aliphatic >C12-C16	NA	4773
Aliphatic >C16-C21	NA	4773
Aliphatic >C21-C35	NA	4773
Aliphatic >C35-C44	NA	4773
Aliphatic >C5-C6	36	4773
Aliphatic >C6-C8	NA	4773
Aliphatic >C8-C10	NA	4773
Anthracene	NA	4773

Antimony	NA	3300
Aromatic >C10-C12	NA	4773
Aromatic >C12-C16	NA	4773
Aromatic >C16-C21	NA	4773
Aromatic >C21-C35	NA	4773
Aromatic >C35-C44	NA	4773
Aromatic >C5-C7	1800	4773
Aromatic >C7-C8	200	1523
Aromatic >C8-C10	NA	4773
Arsenic	NA	170
Barium	1.01	5800
Benzo(a)anthracene	NA	49
Benzo(a)pyrene	NA	21
Benzo(b)fluoranthene	NA	2083
Benzo(g,h,i)perylene	NA	1400
Benzo(k)fluoranthene	NA	370
Benzene	284	27
Beryllium	NA	12
Boron	NA	46000
Cadmium	NA	410
Chromium Hexavalent	NA	49
Chromium III	NA	8600
Chrysene	NA	93
Copper	NA	44000
Dibenz(a,h)anthracene	NA	171
Ethylbenzene	180	4773
Fluoranthene	NA	4773
Fluorene	NA	4773
Indeno(1,2,3-cd)pyrene	NA	150
Lead	NA	1300
Mercury	NA	30
Naphthalene	1.26	18
Nickel	NA	800
PCB 105	NA	0.07
PCB 114	NA	0.07
PCB 77	NA	0.07
PCB-118 2,3',4,4',5 - Pentachlorobiphenyl	NA	0.07

Phenanthrene	NA	4773
Pyrene	NA	4773
Phenol	1	440
Selenium	0.01	1800
Styrene	103	1243
Toluene	80	607
TPH >C5-C44	-	4773
Total PAH	-	4773
Vanadium	NA	5000
Xylenes	15	184
Zinc	NA	170000

10 REMEDIATION FRAMEWORK

As indicated, the material to be used at the site will be sourced from MBL. To ensure that material originating from MBL is suitable for reuse it will be subjected to a remediation implementation plan (RIP). The primary purpose of the RIP will be to ensure that all materials destined for reuse at the site are protective of human health and controlled waters by complying with the SSAC presented in this report. The method and approach to remediation is detailed in the Englobe report entitled "Middle Bickenhill Landfill, Framework Remediation Implementation Plan" (R1827/23/5296 – Rev. 4), February 2024. A summary of the man design elements pertinent to the ensuring the suitability of material for reuse at the site are as follows:

- As per Table 2 and Section 3.3.1 of the RIP, the majority of remediation will focus on landfilled materials ('Bulk Excavation, Shallow Capping Soils and the Motorcross Track Soil Bunds') that will be subjected to mechanical segregation, screening, crushing, stockpiling, validation testing (1 sample per 250m^3), and the removal of putrescible/black bag removal. Once processed the material will be subject to validation testing to ensure that all individual samples comply with the SSAC before transportation and reuse at the site.
- Material failing to meet the SSAC will be subject to remediation. Dependent on the nature of the contaminant exceedances, remediation options will include bioremediation and stabilisation to be completed at MBL. Post treatment validation testing (1 sample per 250m^3) will be completed to ensure individual sample SSAC compliance. If treatment were required, this would be subject to separate investigation and an updated remediation implementation plan.
- As section 3.4 of the RIP, any materials failing to adhere to the SSAC either following mechanical segregation or treatment will be deemed unsuitable for reuse and will not be used in the construction of the site.
- Japanese Knotweed and associated soils have been identified in the east of MBL. Japanese Knotweed and soils will be excavated and removed from MBL for transportation to a licensed waste disposal facility. None of this material will be used at the site.

Soil asbestos and asbestos containing materials have been identified at MBL. These materials will be excavated, processed and removed from MBL for transportation to a licensed waste disposal facility. None of this material will be used at the site. Only soils reporting asbestos at <0.1(w/w) will be deemed acceptable for reuse at the site. As a further mitigation to be protective of human health as part of the design at the site, a clean topsoil/subsoil with no detectable asbestos approximately 1m thick will be placed across the site. From a controlled waters perspective, the incorporation of a drainage system described earlier in this report will prevent potential mobile contaminants from interacting with groundwater and surface waters at and near the site. Offsite discharge to Hollywell Brook will be assessed as part of a H1 RA. If needed treatment options will be incorporated into the drainage design

With respect to the application of the SSACs, it is important to note that in the first instance analytical data should be below or at all soil (organic and inorganic) and inorganic leachate SSAC to be protective of human health and controlled waters. If exceedances of these SSAC are reported, then the material would be subjected to remediation before reuse and have to meet all soil and leachate organic and inorganic SSAC.

It should be noted that whilst this report provides guidance on acceptability criteria for material reuse to be protective of human health and controlled waters, it does not provide commentary on geotechnical and earthworks specification requirements for material reuse.

11 SSAC DATA COMPARISON

As a gauge of material quality, a comparison of the derived SSACs presented in Table 11 against the maximum and geomean concentrations of the MBL analytical data set was completed to assess if the pre-remediated material sampled at the time of testing would be compliant.

11.1 Human health

Except for one individual soil sample collected from ML157-CR403 (2mbgl), all individual soil analytical concentrations (organic and inorganic) were reported below the SSAC. For ML157-CR403 aromatic >C16-21 was reported at a concentration of 15,000mg/kg compared to the human health generic assessment criteria of 7600mg/kg (PoS Parks).

11.2 Groundwater and surface water

Except for one individual soil sample collected from ML157-CR403 (2mbgl), all individual soil and soil leachate analytical concentrations (organic and inorganic) were reported below the SSAC. For ML157-CR403 aromatic >C16-21 was reported at a concentration of 15,000mg/kg compared to the derived SSAC of 4773mg/kg (C_{res}). The reported total petroleum hydrocarbon (>C5-44) concentration of 19,469mg/kg was also above the derived SSAC of 4773mg/kg. The aromatic >C16-21 fraction contained in the sample is the main driver for the total petroleum hydrocarbon exceedance.

11.3 Conclusion

Overall, except for one MBL sample location individual analytical data suggested that risks to human health and controlled waters from pretreated material is likely to be low. Where gross contamination is encountered (as identified at ML157-CR403), as part of the RIP the extent of the impacts associated with the source will be determined and the necessary remedial measures taken to reduce the concentrations to below the SSAC.

Post remediation, on the assumption that the individual validation samples comply with the SSAC, the reuse of material sourced from MBL is unlikely to present a risk to human health and controlled waters post development.

Whilst material quality will meet the SSAC, the inherent design of the site will limit/prevent interaction between the placed MBL sourced materials, human health, and controlled waters. Noticeable design features include the following:

- The site will be covered in subsoil/topsoil and sloped, both of which will promote surface runoff and limit infiltration through the MBL sourced materials.
- In terms of physical acceptability, materials containing the following will be rejected and not used at the site:
    - Material not meeting acceptable earthworks class defined in the Earthworks Specification
    - Sewage contaminated material

- Material exhibiting visual and olfactory evidence of gross contamination: e.g., visibly free flowing oil or chemicals, or odorous material likely to cause nuisance during placement or following incorporation into permanent works
- Refuse, deleterious materials including back bag waste rags, plastics, metals, glass, peat, coal, timber, gypsum, and other potentially gas generating material
- Asbestos containing material
- Material exhibiting pH outside of the limits 2 - 11.5 (Does not apply to materials stabilised in accordance with the Stabilised Materials Contamination Risk Assessment, 1MC09-BBV_MSD-EV-REP-NS04_NL10-100217[ix]
- Material which does not pass a COSHH risk assessment based on the specific work activities

- Mobile contaminants if present are likely to be intercepted by the underlying drainage blanket and conveyed west into the external drainage channel. Risks to water quality in drains and the receiving water course (Hollywell Brook) will be the subject of a H1 RA. If the assessment fails, the necessary treatment measures will be taken to ensure acceptable risks to receiving waters.
- The external drainage system, including attenuation ponds will be lined, so site discharge is unlikely to interact with the underlying ground and groundwater.
- No drainage channels are to be installed directly through the MBL sourced materials.
- The GLD underlying the site is of low inherent permeability, overtime, the GLD will become more consolidated and impermeable, inhibiting the potential mobilisation of contaminants, if present.
- Temporary works risks will be mitigated by adherence to the necessary technical standards, guidelines and measures as set out by CoCP, SCEW and contractor Site Environmental Management Plans.

12 OPERATIONAL CONTROLS

Although the analytical data from MBL indicates that material combined with the site design should present a low risk to controlled waters and human health, mitigation measures will be adopted to ensure that potential risks are controlled and minimised during and following construction works. Monitoring and testing (soil and water) will be undertaken for four main reasons:

- To ensure that risks associated with material placement at the site primarily to groundwater and surface waters remain low.
- Groundwater and surface water samples will be taken before major excavation and construction operations commence to establish baseline (background) conditions. Data collected during and following site operations will be compared to baseline conditions to assess the effects (if any) on water quality and potential risks to groundwater and surface water associated with the works.
- The water monitoring data will be used as an early warning to detect if there is a departure from baseline conditions that could be reasonably attributed to the placement of landfill material at the site and allow time for intervention to mitigate risks before determinants reach sensitive water receptors, primarily, the GWDTE and SSSI associated with Coleshill Pools to the east of the site.
- A robust dataset is required to support the future surrender of the Permit for Waste Recovery.

12.1 Material testing

Prior to the movement and placement of MBL sourced materials at the site, soil and soil leachate samples will be collected to ensure that the determinant concentrations remain below or at the SSAC (presented in Table 11) to be protective of human health and controlled waters.

With reference to the RIP, soil samples will be collected following the remediation and submitted for the range of determinants listed in Table 11 at a testing frequency of one sample per 250m^3. If needed, material will be subjected to treatment and further testing to ensure validation concentrations are compliant with the SSAC. Material failing to adhere to the SSAC will not be reused at the site.

12.2 Water Monitoring/testing

With reference to the HS2 report entitled “Ground Investigation Specification, Pool Wood Embankment”, March 2024 (1MC09-BBV_MSD-EV-REP-NS04-100056), routine surface water and groundwater analytical testing will be undertaken at designated surface water and groundwater monitoring points in the vicinity of the site before, during and following operations.

In addition to material testing described in Section 11.1, water sampling will be the principal mechanism used to assess the effects of operations on water quality and if needed identify intervention measures to address risks during and following operations. To adhere to the monitoring objectives described above, BBV will undertake the following:

- Groundwater is to be monitored to allow departures from background conditions (established from baseline monitoring) resulting from operations to be tracked. Should discernible changes in water quality that can be reasonably attributed to the placement of MBL materials at the site be observed over a sustained period BBV will contact an Environmental Scientist to advise on actions to be taken to mitigate against risks to groundwater either during or following construction works. On receipt of baseline data, the mean and the 95% confidence range for the mean will be calculated. The 95% confidence range will be used to compare subsequent water data against. A cumulative deviation of the confidence range (based on subsequent individual water sample results) will trigger the need for further assessment and/or to develop and implement mitigation controls.

- Surface water from existing surface waterbodies is to be monitored to allow departures from background (established from baseline monitoring) resulting from operations to be tracked. Should significant changes in surface water quality be observed, BBV will contact an Environmental Scientist to advise on risks and actions to be taken to mitigate against risks to surface waters either during or following construction works.
- Although water quality standards will be established and refined once baseline monitoring has been undertaken, as a guide and in the first instance, BBV will use the list of determinants and water quality standards listed in Table 12 when establishing baseline (background) conditions. Once baseline conditions have been established, BBV will consult with an Environmental Scientist to agree on the background water quality standards to be used for future comparison.
- Groundwater and surface water elevations are also to be monitored as part of the programme to confirm the current understanding of hydraulic gradients.

12.2.1.1. Monitoring locations

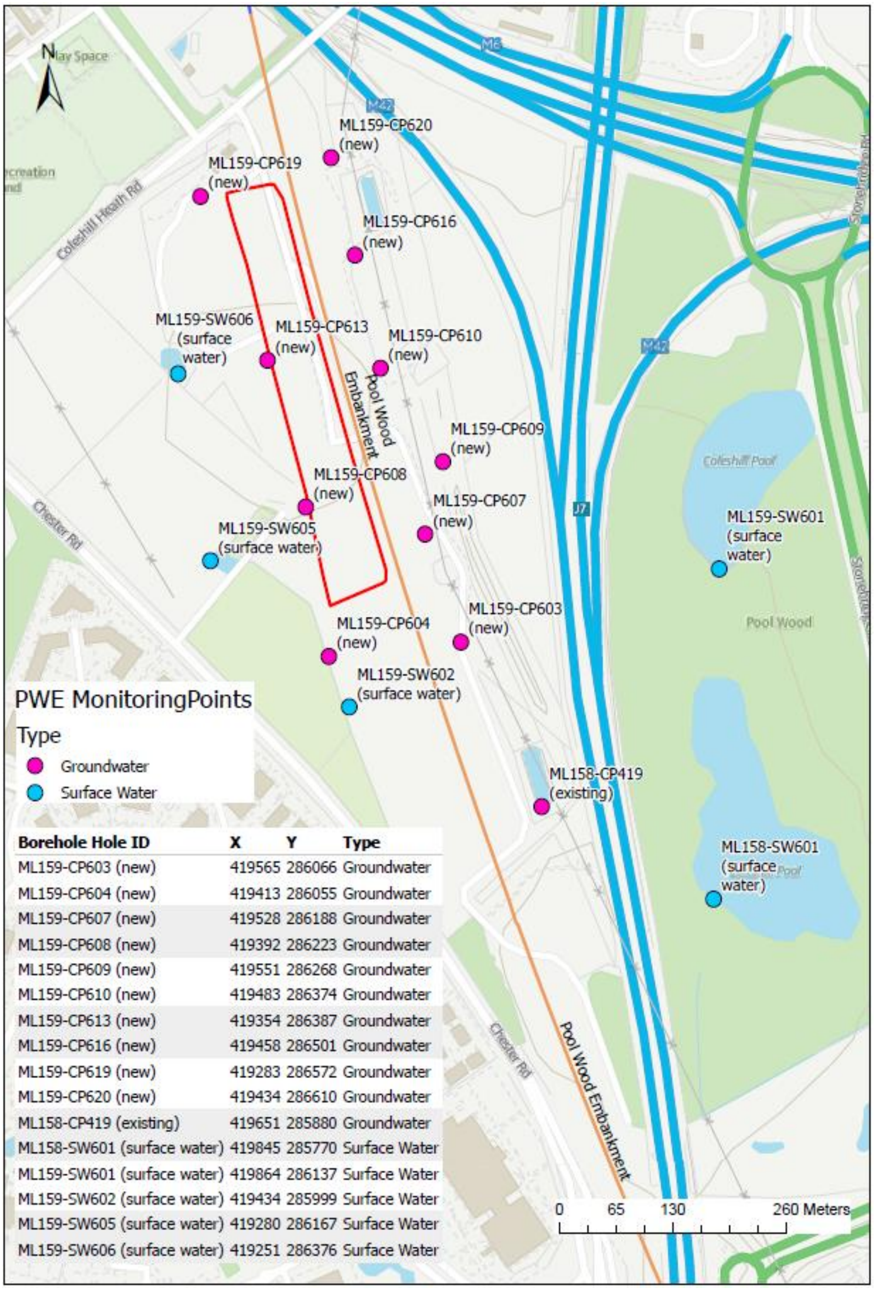
BBV and DJV have consulted on groundwater and surface water sampling locations. The main conditions around location selection were as follows:

- Where possible groundwater and surface water sampling locations should be situated both up and down gradient of the site to allow comparison with background locations/conditions.
- Monitoring/sampling locations will remain serviceable and present for the duration of the monitoring programme. If agreed monitoring points are to be removed to accommodate the development of the site or wider assets, or deemed inaccessible, monitoring points should be revised to accommodate the constraints. Monitoring wells that become unserviceable will be replaced to maintain the monitoring network.

Where possible existing monitoring/sampling locations have been selected. However, discussions with BBV have indicated that many of the existing monitoring locations at and in the vicinity of the site have or will be decommissioned to accommodate the future construction of the asset and/or are unlikely to remain serviceable or present for the duration of the monitoring programme, hence a further reason for revising the sampling locations.

As described in Appendix A and B of the March 2024 Ground Investigation Specification (1MC09-BBV_MSD-EV-REP-NS04_NL10-100218), it is the intention to use one (ML158-CP419) existing groundwater monitoring well (installed in the GFD) and install ten new (ML159-CP603, CP604, CP607 to CP610, CP613, CP616, CP619 and CP620) groundwater wells to provide sufficient network coverage. All new wells will be installed in the GFD. One existing (ML158-SW601) and four new (ML159-SW601, SW602, SW605 and SW606) surface water sample locations were also selected to form part of the monitoring network. Figure 22 shows the location of the existing and new groundwater and surface water monitoring/sampling locations.

Figure 22: Exploratory hole monitoring and sampling locations



Source QGIS, 2024

12.2.1.2. Monitoring programme

As described in Appendix B of the March 2024 Ground Investigation Specification, the proposed monitoring programme is as follows:

- Within a week following well installations, monitoring/sampling will be completed weekly to the point when MBL sourced materials start to be placed at asset (min 8 weeks).
- Monthly during the placement of MBL sourced material.
- Monthly on completion of MBL material placement for 12 months

- After 12 months, every two months for the duration of the monitoring programme.

It is currently assumed that 12 months of post-construction monitoring will be required to demonstrate that operations associated with the placement of MBL sourced materials at the site has not significantly impacted on water quality. However, if analytical data consistently demonstrates compliance with baseline conditions, with stakeholder approval, the post construction monitoring timeframe and range of determinants tested could be reduced. Conversely, should post construction monitoring demonstrate non-compliance and persistently elevated determinant concentrations, in consultation with stakeholders' intervention measures would be considered and/or the monitoring programme be extended.

12.2.1.3. Monitoring analysis

Water quality standards for groundwater and surface water will be established once baseline sampling has been completed. To initiate this process and as a guide BBV should undertake analysis to test for the determinants and the to meet the water quality standards listed in Table 12. As the dataset grows and becomes more robust, and consistency is identified it may be possible to refine the testing suite. As a guide, and a minimum requirement, the water quality standards in bold should be used for monitoring purposes. Where detection limits (DL) are cited, the lowest detection achievable whether this be for EQS or the UKDWS should be used.

It should be noted that although groundwater management is not anticipated for the temporary and permanent works, the suggested testing does not negate additional testing requirements that may be required to satisfy licences associated with water management and the H1 RA during temporary or permanent works. Where required, additional testing should be completed to meet these requirements.

Table 12: Suggested water testing requirements for monitoring programme

Determinand	Detection limit (mg/l)
Antimony	0.001
Acenaphthene	0.001
Acenaphthylene	0.001
Aliphatic >C10-C12	0.01
Aliphatic >C12-C16	0.01
Aliphatic >C16-C21	0.01
Aliphatic >C21-C35	0.01
Aliphatic >C35-C44	0.01
Aliphatic >C5-C6	0.01
Aliphatic >C6-C8	0.01
Aliphatic >C8-C10	0.01
Anthracene	0.0001
Aromatic >C10-C12	0.01
Aromatic >C12-C16	0.01
Aromatic >C16-C21	0.01

Determinand	Detection limit (mg/l)
Aromatic >C21-C35	0.01
Aromatic >C35-C44	0.01
Aromatic >C5-C7	0.01
Aromatic >C7-C8	0.01
Aromatic >C8-C10	0.01
Arsenic	0.001
Barium	0.001
Benzo(a)anthracene	0.001
Benzo(a)pyrene	0.001
Benzo(b)fluoranthene	0.001
Benzo(g,h,i)perylene	0.001
Benzo(k)fluoranthene	0.001
Benzene	0.001
Beryllium	0.001
Boron	0.02
Cadmium	0.0001
Chromium VI	0.001
Chromium III	0.001
Chrysene	0.001
Copper	0.0016
Dibenz(a,h)anthracene	0.001
Ethylbenzene	0.001
Fluoranthene	0.0000063
Fluorene	0.001
Indeno(1,2,3-cd)pyrene	0.0001
Lead	0.00005
Mercury	0.00001
Xylene	0.001
Naphthalene	0.001
Nickel	0.0015
Phenanthrene	0.001
pH	-
Phenol	0.0005
Pyrene	0.001

Determinand	Detection limit (mg/l)
PCB 105	0.000001
PCB 114	0.000001
PCB 77	0.000001
PCB 118	0.000001
Selenium	0.001
Styrene	0.02
Toluene	0.001
Vanadium	0.001
Zinc	0.005

12.3 Reporting

BBV will provide a baseline report detailing the findings of the groundwater and surface water assessment. The report will contain recommended baseline water standards to be compared against water data collected during and following the placement of MBL sourced materials. The report will be circulated to stakeholders including the EA for review. During and following construction BBV will continue to collect water monitoring/sampling and material test data that will be reviewed and compiled by BBV for the life of the project and presented to the stakeholders (including the EA). Reports will be produced by BBV on an annual basis and include an assessment of results.

Should a deterioration in water quality or a breach of the SSAC occur, BBV will engage with the DJV and EA to seek a resolution.

13 CONCLUSIONS / RECOMENDATIONS

13.1 Conclusions

In support of the waste recovery plan, the review of design and baseline information indicated that the placement of material at the site sourced from MBL is likely to present a low risk to human health and controlled waters post development. Further, soil and soil leachate SSACs have been derived to ensure that the reuse of MBL sourced material does not present an unacceptable risk to human health and controlled waters. The SSAC will be adopted and adhered to as part of the MBL RIP.

A comparison of the SSAC against MBL pre-remediated analytical data was completed. Except for a sample collected from ML157-CR403 (2mbgl), all individual soil and soil leachate analytical concentrations (organic and inorganic) were reported below the SSACs. For ML157-CR403 aromatic >C16-21 was reported at a concentration of 15,000mg/kg compared to the SSAC of 4773mg/kg for controlled waters and the human health generic assessment criteria of 7600mg/kg. The reported total petroleum hydrocarbon (>C5 to44) concentration of 19,469mg/kg was also above the derived SSAC. Except for the sample at ML157-CR403, individual analytical data suggested that risks to human health and controlled waters from pretreated material is likely to be low. .

Where gross contamination is encountered (as identified at ML157-CR403), the extent of the impacts associated with the source will be determined and the necessary remedial measures taken to reduce the individual concentrations below the SSAC.

Post remediation, on the assumption that the SSAC are adhered too, the reuse of material sourced from MBL should present a Low risk to human health and controlled waters post development. Whilst individual determinants will meet the SSAC, the inherent design of the site and ground conditions will also limit/prevent interaction between the placed MBL sourced materials, human health, and controlled waters.

13.2 Recommendations

In terms of recommendations, the following should be completed:

- A validation report should be produced to document the works undertaken as part of the MBL RIP and demonstrate that analytical results have adhered to the SSAC.
- BBV will work with its remediation contractor to produce a validation report to document the remediation work undertaken at MBL. The report will include the scope of work, sampling/testing to demonstrate the suitability of material for reuse at the site.
- Groundwater and surface water monitoring/sampling should be commenced in advance of material placement operations to establish groundwater and surface water baseline (background) conditions. The programme should continue for a minimum of 12 months following the completion of construction works. BBV should prepare monitoring/sampling reports to document the works completed and the results of the analysis. This work will be required to ensure the material is chemically stable during and following construction. Topographical surveys to ensure that settlement has ceased, and the bund is physically stable.
- The above reports should be presented to the stakeholders (including the EA) for review and feedback, and to provide supporting evidence for Permit Surrender.

Appendix A Qualitative Risk Assessment Definitions

The qualitative risk summaries for controlled waters are derived from HS2 Technical Standard – Groundwater Protection (Document number HS2-HS2-EV-STD-000-000010).

Table A 1: Classification of Probability

Classification	Definition
High likelihood	There is a linkage and an event that either appears very likely in the short term and almost inevitable over the long term or there is evidence at the receptor of harm or pollution.
Likely	There is a linkage and all the elements are present and in the right place, which means that it is probably that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short term and likely over the long term.
Low likelihood	There is a linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such event would take place, and is less likely in the shorter term.
Unlikely	There is a linkage, but circumstances are such that it is improbable that an event would occur even in the very long term.

Table A 2: Classification of Consequence

Classification	Criteria	Example
Major	Adverse: Loss of an attribute and /or quality and integrity of an attribute	Adverse: Increased flood risk to essential infrastructure, highly or more vulnerable developments; loss of a fishery; decrease in surface water ecological or chemical WFD status or groundwater qualitative or quantitative WFD status
	Beneficial: Creation of new attribute or major improvement in quality of an attribute	Beneficial: Creation of flood plain and decrease in flood risk; increase in productivity or size of fishery; increase in surface water ecological or chemical WFD status; increase in groundwater qualitative or quantitative WFD status.
Moderate	Adverse: Loss of part of an attribute or decrease in integrity of an attribute	Adverse: Increased flood risk to less vulnerable developments; Partial loss of fishery; measurable decrease in surface water ecological or chemical quality or reversible change in the yield or quality of an aquifer, affecting existing users, but not changing any WFD status
	Beneficial: Moderate improvement in quality of an attribute	Beneficial: Measurable increase in surface water quality or in the yield or quality of aquifer benefiting existing users but not changing any WFD status
Minor	Adverse: Some measurable change to the integrity of an attribute	Adverse: Increased flood risk to water compatible development or impact which does not affect existing or any possible future developments; measurable decrease in surface water ecological or chemical quality; decrease in yield or quality of aquifer not affecting existing users or changing any WFD status
	Beneficial: Measurable increase, or reduced risk of negative effect to an attribute	Beneficial: Measurable increase in surface water ecological or chemical quality; increase in yield or quality of aquifer not affecting existing users or changing any WFD status

Classification	Criteria	Example
Negligible	No change to integrity of attribute	Negligible change to flood risk; discharges to watercourse or changes to an aquifer which lead to no change in the attribute's integrity

Table A 3: Comparison of Magnitude of Effect (Consequence) Against Probability

	Consequence			
Probability	**Major**	**Moderate**	**Minor**	**Negligible**
High likelihood	Very high risk	High risk	Moderate risk	Moderate/low risk
Likely	High risk	Moderate risk	Moderate/low risk	Low risk
Low likelihood	Moderate risk	Moderate/low risk	Low risk	Very low risk
Unlikely	Moderate/low risk	Low risk	Very low risk	Very low risk

Table A4: Definition of Classified Risks

Risk	Definition
6 (Very High risk)	There is a high probability that a contaminant linkage could exist between a source and a designated receptor resulting in detriment to the receptor. Investigation and remediation will be required prior to (or as part of) construction. During construction further mitigation and monitoring measures (in accordance with the draft Code of Construction Practice (CoCP)) are likely be required. Such sites are considered significant.
5 (High risk)	It is likely that a contaminant linkage exists with potentially a severe affect on designated receptors. Investigation and remediation is very likely to be required. Such sites are considered significant.
4 (Moderate risk)	It is possible that an effect could arise to a designated receptor through a contaminant linkage. However, the effect is most likely to be moderate to minor. Further investigative work is likely to be required to clarify the risk. Some remediation works may be required. Such sites may be considered significant.
3 (Moderate / Low risk)	It is possible that a contaminant linkage could exist, but if it does, any effects would normally be minor. Further investigative work (which is likely to be limited) to clarify the risk may be required. Any subsequent remediation works are likely to be relatively limited.
2 (Low risk)	It is a low possibility that a contaminant linkage could exist. However, should there be a linkage the effect to the receptor (with regards to controlled waters) would normally be minor or negligible and the effect on human health would be negligible. No investigation or remedial works are likely to be required.
1 (Very low risk)	It is unlikely that a contaminant linkage could exist between a source and a designated receptor.

Appendix B Analytical Data

Project Wise link to data: 1MC09-BBV_MSD-EV-CAL-NS04-100056

Appendix C ConSim Model Input Parameters

Parameter	Unit	Distribution	Value	Source of parameter value/ justification
Source:				
Lithology	N/A	Remediated landfill/Made Ground material originating from Middle Bickenhill Landfill (MBL) - Ch. 157+250		
Dry bulk density of source zone	g/cm^3	Triangular	1 ,1.47 ,1.95	Minimum, maximum and most likely values of dry density - Source 1: Data within GIR Annex E2 and ReWard publication. Only one MGR dry density values was available, therefore used Geotech verified source to supplement the data set. Triangular input used as most likely value derived, with data in the same order of magnitude.
Calculate porosities?	-	No		Minimum, mean, and maximum values calculated from dry bulk density and moisture content test results for MGR/Landfill material derived from MBL. Dry density and moisture content derived from minimum, most likely and maximum values from pivot tables. Log triangular used for air and water filled soil porosity as order of magnitude difference in data
Air filled soil porosity	fraction	Log uniform	0.081, 0.2, 0.529	
Water filled soil porosity	fraction	Log Triangular	0.094, 0.25, 0.47	
Thickness of source	m	Uniform	14.5	Although there will be variations in the height of the landscape bund along its length, based on the maximum height of the landscape bund it was conservatively assumed that the source thickness will be 14.5m
Length source	m	Single	451	95% of the approximate length of the landscape bund
Width source	m	Single	67	95% of the approximate width of the landscape bund
Area source	m^2	Single	30,008	Length x width
Total Organic Carbon/Fraction of organic carbon (in source soil)	%	Log triangular	0.261, 1.89, 5.81	Minimum, most likely and maximum values calculated using organic matter content (%) or obtained directly from Total Organic Carbon values for Made Ground/Landfill material derived from MBL Landfill pivot tables. Log triangular used for TOC as order of magnitude difference in data.
Declining source?	-	No	No	Conservative assumption

Parameter	Unit	Distribution	Value	Source of parameter value/ justification
Pathway (unsaturated pathway) (level 2):				
Lithology	N/A	In sequence, the geology underlying the landscape bund (area to receive the Made Ground/landfill material originating from MBL) comprises a granular and fine coarse grained Glaciolacusterine (GLD), Glaciofluvial Deposits (GFD) and Mercia Mudstone. As the GFD is the more sensitive groundwater receptor and will likely act as the main transport mechanism for contaminant movement towards the Coleshill Pools, it has been conservatively assumed that contaminants will be in direct contact with the GFD and not the GLD. Accordingly, the pathway component has been modelled using input parameters characteristic of a GFD. If required there will be an opportunity to modify the geology as a part of a sensitively analysis.		
Infiltration	mm/yr	Triangular	34, 69, 101	Minimum, mean, and maximum of infiltration values derived from rainfall - actual evaporation and slope runoff coefficient. Rainfall determined from UK hydrometric register and CEC and actual evaporation determined from Hess (2010), "Estimating green water footprints in a temperate environment"
Unsaturated zone thickness	m	Triangular	1.54, 5.36, 8.73	A review of water strikes, rises and groundwater elevations at and near to the landscape bund was completed and compared to the design elevation of the landscape bund, specifically the base elevation of the Made Ground/landfill materials sourced from MBL to be placed in the bund. Based on maximum groundwater elevations and the elevation for material placement the min (1.54m), max (8.73m) and mean (5.36m) thickness of the unsaturated zone was calculated.
Total Organic Carbon/Fraction of organic carbon (in source soil)	%	Triangular	0.058, 1.06, 8.12	Minimum, most likely and maximum values calculated using organic matter content (%) for GFD from pivot tables for the landscape bund area. Log triangular used for TOC as order of magnitude difference in data.
Water filled porosity	fraction	Triangular	0.023, 0.15, 0.34	Minimum, mean, and maximum values calculated from dry bulk density and moisture content test results for granular GFD from GIR Annex E2 and pivot tables for the landscape bund area. Dry bulk density derived from minimum, mean and maximum values and moisture content was derived from minimum, most likely and maximum values. Log triangular was used for water filled porosity as there was an order of magnitude difference in the data.
Dry bulk density	g/cm^3	Triangular	1.75 ,1.98 ,2.23	Minimum, mean, and maximum values calculated from dry bulk density and moisture content test results for granular GFD from GIR Annex E2 and pivot tables for the landscape bund area. Dry bulk density derived from minimum, mean and maximum values and moisture content was derived from minimum, most likely and maximum values. Log triangular was used for water filled porosity as there was an order of magnitude difference in the data.

Parameter	Unit	Distribution	Value	Source of parameter value/ justification
Unsaturated hydraulic conductivity	m/s	Triangular log	4.95×10^{-09}, 3.67×10^{-06}, 2.5×10^{-05}	Minimum, mean, and maximum values from in-situ permeability tests undertaken in the area of the landscape bund and on GFD located at other locations along the alignment. Data reported in Option 2: Use all infiltration data from N1 & N2 and GIR Annex E2. Log triangular was used for hydraulic conductivity as there was an order of magnitude difference in the data.
Vertical dispersivity	m	Uniform	0.154, 0.566, 0.873	10% of the unsaturated thickness
Retarded travel in the UZ?	-	-	Yes	Modelled due to retardation will happen within the GFD aquifer.
Biodegradation in the UZ?	-	-	Yes	The GFD are likely to have some aeration and provide attenuation during the mass transport of contaminants.
Flow model	-	-	Porous medium	Potentially coarse grained unsaturated zone - flow model will be porous medium associated with granular medium within the GFD
Aquifer Pathway (Level 3) – not considered				
Receptors				
Base of the unsaturated zone	N/A	N/A	Base of the UZ	Automatic ConSim compliance point (Level 2 analysis)

Chemical input parameters for ConSim

Contaminant	Group	Henry's Law Constant (unitless)	Max solubility (mg/l)	Koc/Kd (ml/g)	Half Life: (Source and USZ) (years)	Half Life: (Water) (years)
Ammoniancal Nitrogen	Other	6.58E-04	1.00E+07	0.4 - 0.9	1.00E+01	1.00E+01
Nitrate	Other	ND	9.12E-01	1.00E+00		
Sulphate	Other	ND	1.00E+07	1.00E+00	1.00E+07	1.00E+07
Antimony	Metals	0.00E+00	1.00E+07	4.50E+01	1.00E+07	1.00E+07
Arsenic	Metals	0.00E+00	1.00E+07	5.00E+02	1.00E+07	1.00E+07
Barium	Metals	0.00E+00	1.00E+08	4.10E+00	1.00E+07	1.00E+07
Beryllium	Metals	0.00E+00	1.00E+08	7.90E+02	1.00E+08	1.00E+08
Boron	Metals	0.00E+00	1.00E+07	1.00E+01	1.00E+07	1.00E+07
Cadmium	Metals	0.00E+00	1.00E+07	1.00E+02	1.00E+07	1.00E+07
Chromium (III)	Metals	0.00E+00	1.00E+07	4.80E+03	1.00E+07	1.00E+07
Chromium (VI)	Metals	0.00E+00	1.00E+07	1.80E+01	1.00E+07	1.00E+07
Cyanide	Other	4.15E-03	9.54E+04	9.90E+00	1.00E+07	1.00E+07
Copper	Metals	0.00E+00	1.00E+07	3.50E+01	1.00E+07	1.00E+07
Iron	Metals	0.00E+00	1.00E+07	2.50E+01	1.00E+07	1.00E+07
Lead	Metals	0.00E+00	1.00E+07	9.00E+02	1.00E+07	1.00E+07
Manganese	Metals	0.00E+00	1.00E+07	6.50E+01	1.00E+07	1.00E+07
Mercury	Metals	0.00E+00	1.00E+07	5.00E+02	1.00E+07	1.00E+07
Molybdenum	Metals	0.00E+00	1.00E+07	2.00E+01	1.00E+07	1.00E+07
Nickel	Metals	0.00E+00	1.00E+07	5.00E+02	1.00E+07	1.00E+07
Selenium	Metals	0.00E+00	1.00E+07	5.00E+00	1.00E+07	1.00E+07
Vanadium	Metals	0.00E+00	1.00E+07	1.26E+01	1.00E+07	1.00E+07
Zinc	Metals	0.00E+00	1.00E+07	3.80E+01	1.00E+07	1.00E+07
TPH Ali5-6	TPH	3.30E+01	3.60E+01	7.94E+02	4.00E-02	9.60E-01
TPH Ali6-8	TPH	5.00E+01	5.40E+00	3.98E+03	6.00E-02	5.50E-01
TPH Ali8-10	TPH	8.00E+00	4.30E-01	3.16E+04	3.00E-02	5.50E-01
TPH Ali10-12	TPH	1.20E+02	3.40E-02	2.51E+05	1.30E-01	8.20E-01
TPH Ali12-16	TPH	5.20E+02	7.60E-04	5.01E+06	2.05E+00	4.11E+00
TPH Ali16-21	TPH	4.90E+03	2.50E-06	6.31E+08	2.71E+00	5.43E+00
TPH Ali21-35	TPH	4.90E+03	2.50E-06	6.31E+08	2.71E+00	5.43E+00
TPH Ali35-44	TPH	4.90E+03	2.50E-06	6.31E+08	2.71E+00	5.43E+00
TPH Aro5-7	TPH	2.30E-01	1.80E+03	6.80E+01	4.00E-02	2.00E+00
TPH Aro7-8	TPH	1.15E-01	5.90E+02	2.04E+02	6.00E-02	5.50E-01
TPH Aro8-10	TPH	4.80E-01	6.50E+01	1.59E+03	3.00E-02	4.14E-01
TPH Aro10-12	TPH	1.40E-01	2.50E+01	2.51E+03	1.32E-01	8.22E-01
TPH Aro12-16	TPH	5.30E-02	5.80E+00	5.01E+03	2.05E+00	3.64E-01
TPH Aro16-21	TPH	1.30E-02	6.50E-01	1.58E+04	2.71E+00	3.59E+00
TPH Aro21-35	TPH	1.00E-03	6.60E-03	1.26E+05	2.71E+00	3.46E+00

TPH Aro35-44	TPH	1.00E-03	6.60E-03	1.26E+05	2.71E+00	3.46E+00
Acenaphthene	PAH	7.52E-03	3.90E+00	5.03E+03	2.79E-01	5.59E-01
Acenaphthylene	PAH	4.66E-03	1.61E+01	5.03E+03	1.64E-01	3.29E-01
Anthracene	PAH	1.60E-03	4.50E-02	2.95E+04	1.26E+00	2.52E+00
Benzo(a)anthracene	PAH	4.91E-04	9.40E-03	1.77E+05	1.86E+00	3.73E+00
Benzo(a)pyrene	PAH	1.76E-06	3.80E-03	1.29E+05	1.45E+00	2.90E+00
Benzo(b)fluoranthene	PAH	2.05E-06	2.00E-03	1.05E+05	1.67E+00	3.34E+00
Benzo(g,h,i)perylene	PAH	2.36E-06	2.60E-04	4.17E+05	1.78E+00	3.60E+00
Benzo(k)fluoranthene	PAH	1.74E-06	8.00E-04	1.48E+05	5.86E+00	1.17E+01
Chrysene	PAH	2.14E-04	2.00E-03	1.81E+05	2.72E+00	5.48E+00
Di-benzo(a,h)anthracene	PAH	5.76E-06	2.49E-03	1.91E+06	2.58E+00	5.15E+00
Fluoranthene	PAH	6.29E-05	2.30E-01	1.82E+04	1.21E+00	2.41E+00
Fluorene	PAH	3.93E-03	1.69E+00	9.16E+03	1.64E-01	3.29E-01
Indeno(1,2,3-cd)pyrene	PAH	2.05E-06	2.00E-04	8.71E+04	2.00E+00	4.00E+00
Indeno(1,2,3-cd)pyrene	PAH	1.42E-05	1.90E-04	1.95E+06	2.00E+00	4.00E+00
Naphthalene	PAH	6.62E-03	1.90E+01	6.46E+02	1.30E-01	7.10E-01
Phenanthrene	PAH	1.73E-03	1.15E+00	1.67E+04	5.48E-01	1.10E+00
Pyrene	PAH	4.87E-04	1.35E-01	1.62E+04	5.20E+00	1.04E+01
Ethylbenzene	BTEX	1.39E-01	1.80E+02	4.47E+02	2.70E-02	6.20E-01
Toluene	BTEX	1.15E-01	5.90E+02	2.04E+02	6.00E-02	5.50E-01
Benzene	BTEX	2.30E-01	1.80E+03	6.80E+01	4.00E-02	2.00E+00
Xylene	BTEX	1.04E-01	2.00E+02	4.54E+02	8.00E-02	1.00E+00
m&p xylene	BTEX				8.00E-02	1.00E+00
1,2-Dichlorobenzene	VOC	3.38E-02	1.33E+02	6.92E+02	5.00E-01	1.00E+00
1,2-Dichloroethene	VOC	1.67E-01	3.50E+03	3.96E+01	5.00E-01	7.91E+00
1,4-Dichlorobenzene	VOC	4.70E-02	5.12E+01	7.08E+02	5.00E-01	1.00E+00
Chloroform	VOC	7.65E-02	8.95E+03	5.00E+01	5.00E-01	5.00E+00
Cresol	VOC	2.53E-05	9.07E+03	3.07E+02	7.90E-02	1.30E-01
Hexachlorobutadiene	VOC	1.55E-01	4.80E+00	1.10E+04	5.00E-01	1.00E+00
Phenol	VOC	8.35E-06	8.41E+04	8.30E+01	2.70E-02	2.70E-01
Styrene	VOC	1.12E-01	3.10E+02	4.46E+02	8.00E-02	5.80E-01
Tetrachloroethene	VOC	3.16E-01	2.25E+02	2.69E+02	1.00E+00	2.00E+00
Trichlorobenzenes (Koc, and H are avg for 123, 124 and 135 TCB)	VOC	3.07E-02	4.14E+01	2.50E+03	5.00E-01	1.00E+00
Trichloroethene	VOC	1.87E-01	1.37E+03	1.41E+02	1.00E+00	4.50E+00
1,2,4-Trimethylbenzene	VOC	2.52E-01	5.70E+01	6.14E+02	7.67E-02	1.53E-01
1,3,5 Trichlorobenzene	VOC	7.66E-02	6.01E+00	1.33E+03	0.5	1
2-Methylnaphthalene	VOC	2.10E-02	2.50E+01	2.50E+03	1.00E+07	1.00E+07
4-Isopropyltoluene	VOC	4.50E-01	2.34E+01	1.12E+03	1.00E+07	1.00E+07
Bis(2-ethylhexyl)phthalate	PLASTICISER	1.10E-05	2.70E-01	1.20E+05	0.0026	0.04
Coronene	PAH	8.67E-07	1.40E-04	6.35E+06	1.00E+07	1.00E+07
Dibenzofuran	VOC	8.71E-03	3.10E+00	9.16E+03	7.70E-02	9.60E-02
Diethylphthalate	PLASTICISER	2.49E-05	1.08E+03	1.05E+02	1.54E-01	3.08E-01

Dimethylphthalate	PLASTICISER	8.05E-06	4.00E+03	3.16E+01	1.90E-02	3.80E-02
Di-N-Butyl Phthalate	PLASTICISER	XXX	XXX	XXX	6.30E-02	6.30E-02
Diphenyl ether	XX	1.14E-02	1.80E+01	1.95E+03	1.00E+07	1.00E+07
Isophorone	VOC	2.70E-04	1.20E+04	6.50E+01	7.70E-02	1.54E-01
Isopropylbenzene (cumene)	VOC	XXX	XXX	XXX	2.20E-02	4.40E-02
Naphthalene1-methyl-	PAH	XXX	XXX	XXX	XX	XX
n-Butylbenzene	VOC	6.50E-01	1.18E+01	1.48E+03	1.00E+07	1.00E+07
Nitrobenzene	VOC	9.81E-04	2.09E+03	2.35E+00	5.50E-01	1.08E+00
N-Nitrosodiphenylamine	XX	4.95E-05	3.50E+01	2.63E+03	1.86E-01	9.32E-02
n-propylbenzene		4.29E-01	5.22E+01	8.13E+02	1.00E+07	1.00E+07
PCB 105	PCB	1.70E-02	7.00E-01	7.81E+04	1.00E+07	1.00E+07
PCB 114	PCB	1.70E-02	7.00E-01	7.81E+04	1.00E+07	1.00E+07
PCB 77	PCB	1.70E-02	7.00E-01	7.81E+04	1.00E+07	1.00E+07
PCB 81	PCB	1.70E-02	7.00E-01	7.81E+04	1.00E+07	1.00E+07
PCB-118 2,3',4,4',5 - Pentachlorobiphenyl	PCB	1.70E-02	1.60E-02	7.81E+04	1.00E+07	1.00E+07
Sec-Butylbenzene	VOC	7.20E-01	1.76E+01	1.33E+03	1.00E+07	1.00E+07
Tert-Butylbenzene	VOC	5.40E-01	2.95E+01	1.00E+03	1.00E+07	1.00E+07

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Total Petroleum Hydrocarbon Criteria Working Group Series (TPHCWG), 1999. Human Health Risk-Based Evaluation of Petroleum Release Sites: Implementing the Working Group Approach, Volume 5, Table 1.

RAIS database (Risk Assessment Information System, http://rais.ornl.gov/tools/)

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Environment Agency 2008. Compilation of data for priority organic pollutants for derivation of Soil Guideline Values

See table to the right

Nathanail et al 2015: "The LQM / CIEH S4ULs for Human Health Risk Assessment ", Copyright Land Quality management Limited reproduced with permission: Publication No. S4UL3389

Agency for Toxic Substances and Disease Registry website

EA (2002): R&D technical Report P2-228/TR

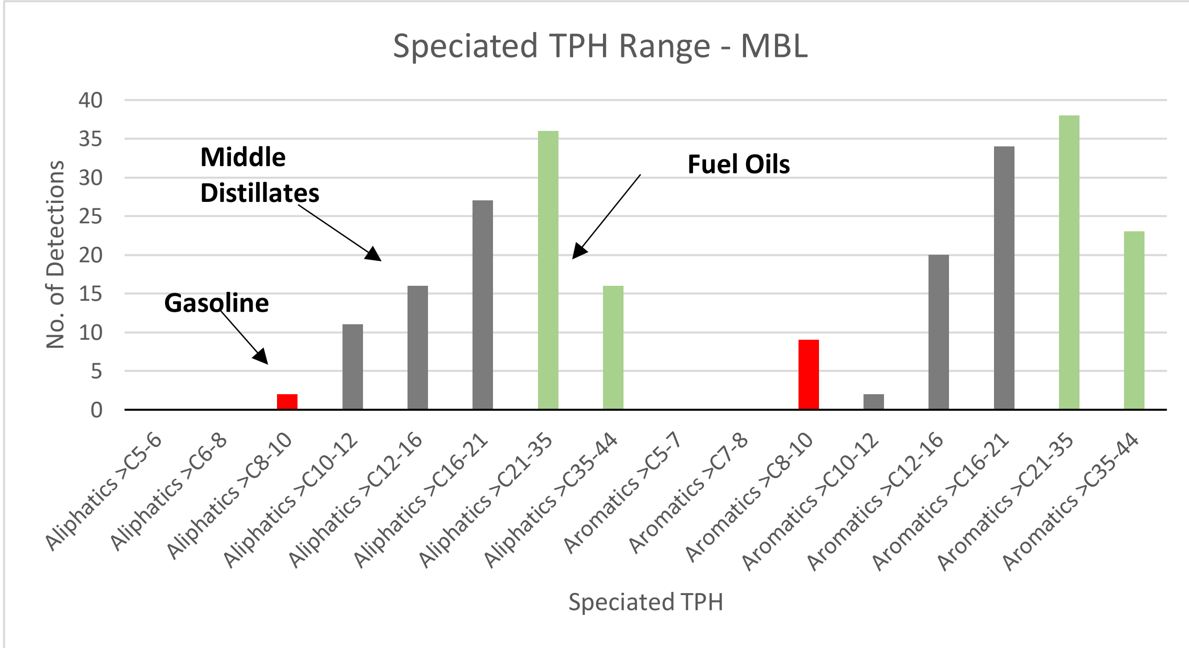
TPH fraction	***Soil half lives in unsaturated zone. Taken from Howard et al. 1991*** Error! Bookmark not defined.
Aliphatic C5-6	Maximum soil half-life for Benzene (C6): 16 days
Aliphatic C6-8	Maximum soil half-life for Toluene (C7): 22 days
Aliphatic C8-10	Maximum soil half live for Ethylbenzene (C8) and Xylene (C8): 10 days
Aliphatic C10-12	Maximum aerobic half live for Naphthalene (C10): 48 days
Aliphatic C12-16	Average of maximum soil half-lives for Pyrene (C16), Anthracene (C14), Phenanthrene (C14) and Fluoranthene (C16): 749 days
Aliphatic C16-21	Average of maximum aerobic half-lives for Benzo(a)anthracene (C18), Chrysene (C18), Benzo(a)pyrene (C20), Benzo(k)Fluoranthene (C20) and Benzo(b)Fluoranthene (C20): 989 days
Aromatic C8-10	Maximum soil half live for Ethylbenzene (C8) and Xylene (C8): 10 days
Aromatic C10-12	Maximum aerobic half live for Naphthalene (C10): 48 days

TPH fraction	Soil half lives in unsaturated zone. Taken from Howard et al. 1991 Error! Bookmark not defined.
Aromatic C12-16	Average of maximum aerobic half-lives for Pyrene (C16), Anthracene (C14), Phenanthrene (C14) and Fluoranthene (C16): 749 days
Aromatic C16-21	Average of maximum aerobic half-lives for Benzo(a)anthracene (C18), Chrysene (C18), Benzo(a)pyrene (C20), Benzo(k)Fluoranthene (C20) and Benzo(b)Fluoranthene (C20): 989 days
Aromatic C21-35	Average of maximum aerobic half-lives for Benzo(a)anthracene (C18), Chrysene (C18), Benzo(a)pyrene (C20), Benzo(k)Fluoranthene (C20) and Benzo(b)Fluoranthene (C20): 989 days

Appendix D CRES Assessment

Parameters	Symbol	Fixed values	Variable values			Source/Description
			Gasoline	Middle	Fuel	
Made Ground	MGR	-	-	-	-	Remediated landfill/Made Ground material originating from Middle Bickenhill Landfill (MBL) - Ch. 157+250
Soil bulk density (g/cm3	ρ_s	1.48	-	-	-	Used most likely value of dry density - Source 1: Data within GIR Annex E2 and ReWard publication. Only one MGR dry density values was available, therefore used Geotech verified source (Reward) to supplement the data set. (See Poro + Bulk Den - Source tab)
Fraction of organic carbon	foc	1.9	-	-	-	Not used - used for soil saturation limits
Total porosity	Θ_t	0.44	-	-	-	Mean of MGR total porosity calculations - calculated for Soil ConSim (Min = 0.264, Mean = 0.44, Max = 0.626)
Residual NAPL fraction in the voids	S_r	-	0.01	0.02	0.045	From Brost et al Table 2 for a coarse gravel and coarse sand and gravel
Density of NAPL (g/cm3)	ρ_o	-	0.7	0.8	0.9	From Brost et al Table 2 for a coarse gravel and coarse sand and gravel
Residual NAPL concentration (mg/kg)	Cres	-	**2088**	**4773**	**12081**	

Key
Input field
Calculated field



$$C_{res,soil} = \left(\frac{\theta_o \cdot \rho_o}{\rho_s}\right) \cdot 10^6 \ \frac{mg}{kg} \qquad [3]$$

with

$$\theta_o = S_r \cdot \theta_T \qquad \boxed{Therefore\ C_{res} = \left(\frac{S_r \times \theta_T \times \rho_o}{\rho_s}\right) \times 10^6}$$

$C_{res,soil}$	residual NAPL concentration in soil (mg-res/kg-soil)
θ_o	residual non-aqueous phase volume fraction (cm^3-res/cm^3-soil)
ρ_o	density of chemical residual non-aqueous phase liquid (g-res/cm^3-res)
ρ_s	dry soil bulk density (g-soil/cm^3-soil)
θ_T	soil porosity (cm^3-void/cm^3-soil)
S_r	fraction of residual non-aqueous phase filled void (cm^3-res/cm^3-void)

Brost et al. (2000) 'Non- Aqueous Phase Liquid (NAPL) Mobility Limits in Soil' (API Soil & Groundwater Research Bulletin No. 9, June 2000)

Table 2. (continued) Values for soil properties used in the calculations.

	Hydrocarbon NAPL	Soil Type	θ_T Soil Porosity (cm^3/cm^3)	θ_w Pore Water (cm^3/cm^3)	f_{oc} Fraction of Organic Carbon (f_{oc})	ρ_s Soil Bulk Density (g/cm^3)	ρ_o Liquid Density (g/cm^3)	d_p Soil Particle Size (mm)
1.	Gasoline	coarse gravel	0.28	0.02	0.001	1.75	0.7	2 to 4
2.	Gasoline	coarse sand and gravel	0.35	0.03	0.002	1.65	0.7	0.5 to 4
3.	Gasoline	medium to coarse sand	0.39	0.04	0.003	1.55	0.7	1 to 0.25
4.	Gasoline	fine to medium sand	0.41	0.043	0.005	1.5	0.7	0.5 to 0.1
5.	Gasoline	silt to fine sand	0.44	0.045	0.01	1.4	0.7	0.25 to 0.002
6.	Middle distillates	coarse gravel	0.28	0.02	0.001	1.75	0.8	2 to 4
7.	Middle distillates	coarse sand and gravel	0.35	0.03	0.002	1.65	0.8	0.5 to 4
8.	Middle distillates	medium to coarse sand	0.39	0.04	0.003	1.55	0.8	1 to 0.25
9.	Middle distillates	fine to medium sand	0.41	0.043	0.005	1.5	0.8	0.5 to 0.1
10.	Middle distillates	silt to fine sand	0.44	0.045	0.01	1.4	0.8	0.25 to 0.002
11.	Fuel oils	coarse gravel	0.28	0.02	0.001	1.75	0.9	2 to 4
12.	Fuel oils	coarse sand and gravel	0.35	0.03	0.002	1.65	0.9	0.5 to 4
13.	Fuel oils	medium to coarse sand	0.39	0.04	0.003	1.55	0.9	1 to 0.25
14.	Fuel oils	fine to medium sand	0.41	0.043	0.005	1.5	0.9	0.5 to 0.1
15.	Fuel oils	silt to fine sand	0.44	0.045	0.01	1.4	0.9	0.25 to 0.002
16.	Light oil and gasoline	soil	0.4	0.04	0.005	1.5	0.75	
17.	Diesel and light fuel oil	Soil	0.4			1.5	0.9	
18.	Lube and heavy fuel oil	Soil	0.4			1.5	0.9	
19.	Gasoline	Coarse sand	0.4	0.04	0.002	1.6	0.7	1 to 0.5
20.	Gasoline	Medium sand	0.4	0.04	0.002	1.6	0.7	0.5 to 0.25
21.	Gasoline	fine sand	0.4	0.04	0.002	1.6	0.7	0.25 to 0.1
22.	Gasoline	well graded fine-coarse sand	0.4	0.04	0.002	1.6	0.7	1 to 0.1
23.	Mineral oil	Ottawa sand [NA]	0.35	No water	0.002	1.7	0.9	0.5
24.	Mineral oil	Ottawa sand [NA]	0.35	No water	0.002	1.7	0.9	0.35
25.	Mineral oil	Ottawa sand [NA]	0.35	No water	0.002	1.7	0.9	0.25
26.	Mineral oil	Ottawa sand [NA]	0.35	No water	0.002	1.7	0.9	0.18
27.	Mineral oil	glacial till [NA]	0.2	No water	0.002	2	0.9	
28.	Mineral oil	glacial till	0.2	0.02	0.002	2	0.9	
29.	Mineral oil	alluvium [NA]	0.5	No water	0.002	1.4	0.9	
30.	Mineral oil	Alluvium	0.5	0.03	0.001	1.4	0.9	
31.	Mineral oil	loess [NA]	0.49	No water	0.002	1.4	0.9	
32.	Paraffin oil	coarse sand	0.4			1.6	0.9	1 to 0.5
33.	Paraffin oil	fine sediments	0.44			1.4	0.9	0.05 to 0.002
34.	Paraffin oil	Ottawa sand	0.35			1.7	0.9	0.5 to 0.18
35.	Trichloroethene	medium sand	0.39	0.04	0.003	1.6	1.46	0.5 to 0.25
36.	Trichloroethene	fine sand	0.43	0.04	0.005	1.5	1.46	0.25 to 0.1
37.	Trichloroethene	loamy sand	0.41	0.06	0.005	1.4	1.46	
38.	Tertrachloroethene	fine to medium beach sand	0.41	0.04	0.005	1.6	1.62	0.5 to 0.1
39.	O-Xylene	Coarse sand	0.33	0.04	0.003	1.6	0.88	1 to 0.5
40.	Gasoline	Sandy loam	0.45			1.5	0.75	
41.	Tertrachloroethene	Sandy loam	0.45			1.5	1.62	
42.	Trichloroethene	Sandy loam	0.45			1.5	1.46	

Notes: Porosity data and particle size information (ranges) estimated from USEPA (1991); pore water data adapted from Carsel and Parrish, (1988); f_{oc} data adapted from Wiedemeier et al., (1999).

Table 2. Summary values of residual NAPL concentration in soil, $C_{res,soil}$, residual NAPL volume fraction, θ_o, and residual NAPL fraction in the voids, S_r. Calculated values for soil saturation limit, $C_{sat,soil}$, are also shown. Parameters for the calculations are shown in the second part of the table.

	NAPL	Soil Type	Ref	Measured S_r (cm^3/cm^3)	Measured $1000 \cdot \theta_o$ (cm^3/cm^3)	Measured $C_{res,soil}$ (mg/kg)	$C_{sat,soil}$ (mg/kg)
1.	Gasoline	coarse gravel	1	*0.01*	2.5	1,000	57
2.	Gasoline	coarse sand and gravel	1	*0.01*	4	1,697	102
3.	Gasoline	medium to coarse	1	*0.02*	7.5	3,387	143
4.	Gasoline	fine to medium sand	1	*0.03*	12.5	5,833	215
5.	Gasoline	silt to fine sand	1	*0.05*	20	10,000	387
6.	Middle distillates	coarse gravel	1	*0.02*	5	2,286	2
7.	Middle distillates	coarse sand and gravel	1	*0.02*	8	3,879	4
8.	Middle distillates	medium to coarse	1	*0.04*	15	7,742	5
9.	Middle distillates	fine to medium sand	1	*0.06*	25	13,333	9
10.	Middle distillates	silt to fine sand	1	*0.1*	40	22,857	18
11.	Fuel oils	coarse gravel	1	*0.04*	10	5,143	2
12.	Fuel oils	coarse sand and gravel	1	*0.05*	16	8,727	4
13.	Fuel oils	medium to coarse	1	*0.08*	30	17,419	6
14.	Fuel oils	fine to medium sand	1	*0.1*	50	30,000	9
15.	Fuel oils	silt to fine sand	1	*0.2*	80	51,429	18
16.	Light oil & gasoline	soil	2	0.18	*72*	40,800	9 (a)
17.	Diesel & light fuel oil	Soil	2	0.15	*60*	34,000	NE (b)
18.	Lube & heavy fuel oil	Soil	2	0.2	*80*	53,067	NE
19.	Gasoline	coarse sand	3	0.15 to 0.19	*61 to 77*	24,954 to 31,609	106
20.	Gasoline	medium sand	3	0.12 to 0.27	*48 to 109*	19,767 to 44,476	106
21.	Gasoline	fine sand	3	0.19 to 0.6	*76 to 240*	31,065 to 98,100	106
22.	Gasoline	Graded fine-coarse	3	0.46 to 0.59	*184 to 236*	80,500 to 103,250	106
23.	Mineral oil	Ottawa sand	4	0.11	*39*	20,116	3
24.	Mineral oil	Ottawa sand	4	0.14	*49*	25,602	3
25.	Mineral oil	Ottawa sand	4	0.172	*60*	31,454	3
26.	Mineral oil	Ottawa sand	4	0.235	*82*	42,975	3
27.	Mineral oil	glacial till [NA]	4	0.15 to 0.28	*30 to 56*	13,500 to 25,200	3
28.	Mineral oil	glacial till	4	0.12 to 0.21	*24 to 42*	10,800 to 18,900	3
29.	Mineral oil	alluvium [NA]	4	0.19	*95*	61,071	3
30.	Mineral oil	Alluvium	4	0.19	*95*	61,071	3
31.	Mineral oil	loess [NA]	4	0.49 to 0.52	*240*	154,000 to 163,800	3
32.	Paraffin oil	coarse sand	5	0.12	48	27,000	
33.	Paraffin oil	fine sediments	5	0.52	229	147,086	
34.	Paraffin oil	Ottawa sand	5	0.11 to 0.23	39	20,382 to 42,618	
35.	Trichloroethene	medium sand	6	0.2	*78*	70,448	1045
36.	Trichloroethene	fine sand	6	0.15 to 0.2	*65 to 86*	62,344 to 83,125	1067
37.	Trichloroethene	loamy sand	7	0.08	*33*	30,713	1057
38.	Tetrachloroethene	Fine/med. beach sand	8	0.002 to 0.20	1 to 82	830 to 83,025	195
39.	O-Xylene	Coarse sand	9	0.01	3	1,936	143
40.	Gasoline	Sandy loam	10	0.42 to 0.59	189 to 266	94,500 to 132,750	
41.	Tertrachloroethene	Sandy loam	10	0.85	383	413,000	
42.	Trichloroethene	Sandy loam	10	0.75 to 0.92	338 to 412	328,000 to 401,208	

Notes: 1 = Fussell et al. (1981); 2 = API (1980); 3 = Hoag and Marley (1986); 4 = Pfannkuch (1984); 5 = Converly (1979); 6 = Lin et al. (1982); 7 = Cary et al. (1989); 8 = Poulsen and Kueper (1992); 9 = Boley and Overcamp, (1998); 10 = Zytner et al. (1993).
(a) - Assumed 50:50 mixture diesel and gasoline to estimate $C_{sat,soil}$. (b) - NE = Not estimated, composition data not available.
Between reported S_r or θ_o, the italicized values represent the calculated term. These values were converted to concentrations in soil using available values for NAPL density, soil bulk density and porosity, as shown in the table.

Appendix E Human Health Generic Asssment Criteria

Determinand	Commercial 1% SOM (mg/kg)	PoS Park 1% SOM (mg/kg)	$AC_{Human\ Health}$
Antimony	7400	3300	3300
Arsenic	640	170	170
Barium	22000	5800	5800
Beryllium	12	63	12
Boron	240000	46000	46000
Cadmium	410	880	410
Chromium (III)	8600	33000	8600
Chromium - Hexavalent	49	250	49
Copper	68000	44000	44000
Cyanide (Free)	1400	24	24
Nickel	980	800	800
Mercury	58	30	30
Selenium	12000	1800	1800
Vanadium	9000	5000	5000
Zinc	730000	170000	170000
Lead	2300	1300	1300
Aliphatics >C5-6	3200	95000	3200
Aliphatics >C6-8	7800	150000	7800
Aliphatics >C8-10	2000	14000	2000
Aliphatics >C10-12	9700	21000	9700
Aliphatics >C12-16	59000	25000	25000
Aliphatics >C16-35	1600000	450000	450000
Aliphatics >C35-44	1600000	450000	450000
Aromatics >C5-7	26000	76000	26000
Aromatics >C7-8	56000	87000	56000
Aromatics >C8-10	3500	7200	3500
Aromatics >C10-12	16000	9200	9200
Aromatics >C12-16	36000	10000	10000
Aromatics >C16-21	28000	7600	7600
Aromatics >C21-35	28000	7800	7800
Aromatics >C35-44	28000	7800	7800

Determinand	Commercial 1% SOM (mg/kg)	PoS Park 1% SOM (mg/kg)	$AC_{Human\ Health}$
Acenaphthene	84000	29000	29000
Acenaphthylene	83000	29000	29000
Anthracene	520000	150000	150000
Benzo(a)anthracene	170	49	49
Benzo(a)pyrene	77	21	21
Benzo(b)fluoranthene	44	13	13
Benzo (g,h,i) perylene	3900	1400	1400
Benzo(k)fluoranthene	1200	370	370
1,1-Biphenyl	18000	17000	17000
Chrysene	350	93	93
Dibenz-a-h-anthracene	3.5	1.1	1.1
Dichloromethane	260	1500	260
1,2-Dichloropropane	3.1	160	3.1
1,2-Dibromo-3-Chloropropane	-	-	-
Fluoranthene	23000	6300	6300
Fluorene	63000	20000	20000
Indeno(1,2,3-cd)pyrene	500	150	150
Naphthalene	190	1200	190
Phenanthrene	22000	6200	6200
Pyrene	54000	15000	15000
Ethylbenzene	5700	17000	5700
o-Xylene	6600	17000	6600
m-Xylene	6200	17000	6200
P-Xylene	5900	17000	5900
Styrene	3200	5900	3200
Tetrachloroethene	24	1400	24
Trichloroethene	0.73	41	0.73

Published S4UL (Nathanail et al, 2015)

C4SL (DEFRA, 2014), modelled using CLEA 1.071 based on SOM = 1%

Mott MacDonald criteria modelled using CLEA 1.071 based on HCV from CLAIRE, EIC, AGS, 2010 and pathway and receptor parameters from DEFRA, 2014

Appendix F CLEA Model Outputs

STEP 2: BASIC SETTINGS

Apply Settings to Model | Back to Guide

SELECT LAND USE Public Open Space (park lifetime C4SL)

RATIO M ALSE

LAND USE OPTIONS

RECEPTOR Female (allot)

BUILDING No building

START AC 17 **END AC** 17

SOIL TYPE Sandy loam

pH 7 **SOM (%)** 1

EXPOSURE PATHWAYS

ORAL ROUTES

consumption of homegrown produce	SE
soil attached to homegrown produce	SE

DERMAL ROUTES

indoor	SE
outdoor ☑	TRUE

INHALATION ROUTES

indoor dust	SE
outdoor dust ☑	UE
indoor vapour	SE
outdoor vapour ☑	TRUE

STEP 3: SELECT CHEMICALS

Clear All Chemicals | Apply Chemicals to Model | Back to Guide

Select chemicals of interest from pulldown list. Up to thirty chemicals can be assessed at one time. If site concentrations are known these can be entered to over ride model estimates.

Number	Chemical	Soil	Air, Soil Gas	Vapour, Outdoor	Vapour, Indoor	Green veg	Root veg	Tuber veg	Herb. fruit	Shrub fruit	Tree fruit
		Site Measured Media Concentrations (If Known)									
		mg kg^{-1} DW	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg g^{-1} FW	mg g^{-1} FW	mg g^{-1} FW	mg g^{-1} FW	mg g^{-1} FW	mg g^{-1} FW
	Dibenz[ah]anthracene	171.370291									
	Benzo[b]fluoranthene	23413.3606									
		2083.33741									
	PCB-77	0.07810983									
	PCB-105	0.07814873									
	PCB-114	729123.483									
	PCB-118	36153346.5									
		3018792.64									
		1286312.77									

ADVANCED SETTINGS

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Chemical Name	Chemical type	Oral HCV Type	Oral HCV (µg kg^{-1} BW day^{-1})	Compare with: Oral exposure	Compare with: Dermal exposure	Compare with: Inhalation exposure	Inhalation HCV Type	Inhalation HCV (µg kg^{-1} BW day^{-1})	Compare with: Oral exposure	Compare with: Dermal exposure	Compare with: Inhalation exposure	Combine oral and inhalation AC
Dibenz[ah]anthracene	organic	ID	3.10E-03	Yes	Yes	No	ID	3.00E-05	No	No	Yes	Yes
Benzo[b]fluoranthene	organic	ID	3.90E-02	Yes	Yes	No	ID	3.80E-04	No	No	Yes	Yes
	organic	ID	3.90E-02	Yes	Yes	No	ID	3.80E-04	No	No	Yes	Yes
PCB-77	organic	TDI	2.00E-06	Yes	Yes	Yes	NR	0.00E+00	NR	NR	NR	NR
PCB-105	organic	TDI	2.00E-06	Yes	Yes	Yes	NR	.00E+00	NR	NR	NR	NR
PCB-114	organic	TDI	2.00E-06	Yes	Yes	Yes	NR	0.00E+00	NR	NR	NR	NR
PCB-118	organic	TDI	2.00E-06	Yes	Yes	Yes	NR	0.00E+00	NR	NR	NR	NR

Chemical Name	Oral MDI for adults (µg day^{-1})	Inhalation MDI for adults (µg day^{-1})	Air-water partition coefficient (K_{aw}) (cm^3 cm^{-3})	Diffusion coefficient in air (m^2 s^{-1})	Diffusion coefficient in water (m^2 s^{-1})	Relative molecular mass (g mol^{-1})	Vapour pressure (Pa)	Water solubility (mg L^{-1})	K_{oc} (Log (cm^3 g^{-1}))	K_{ow} (Log (dimensionless))	K_d (cm^3 g^{-1})	Dermal absorption fraction (dimensionless)	Soil - plant availability correction (dimensionless)	Root - shoot correction factor (dimensionless)	Root - root store correction factor (dimensionless)
Dibenz[ah]anthracene	4.00E-02	3.30E-02	5.40E-06	4.08E-06	3.40E-10	2.78E+02	1.66E-10	6.00E-04	5.27E+00	6.38E+00	NR	1.30E-01	NR	NR	NR
Benzo[b]fluoranthene	1.10E-01	1.30E-02	2.05E-06	4.36E-06	3.62E-10	2.52E+02	6.34E-08	2.00E-03	5.02E+00	6.08E+00	NR	1.30E-01	NR	NR	NR
	1.10E-01	1.30E-02	2.05E-06	4.36E-06	3.62E-10	2.52E+02	6.34E-08	2.00E-03	5.02E+00	6.08E+00	NR	1.30E-01	NR	NR	NR
PCB-77	4.90E-05	0.00E+00	7.11E-04	4.52E-06	3.63E-10	2.92E+02	3.86E-04	6.63E-02	6.22E+00	6.68E+00	NR	1.40E-01	NR	NR	NR
PCB-105	4.90E-05	0.00E+00	1.04E-03	4.32E-06	3.47E-10	3.26E+02	1.68E-04	2.27E-02	6.73E+00	7.19E+00	NR	1.40E-01	NR	NR	NR
PCB-114	4.90E-05	0.00E+00	1.04E-03	4.32E-06	3.47E-10	3.26E+02	1.68E-04	2.27E-02	6.73E+00	7.19E+00	NR	1.40E-01	NR	NR	NR
PCB-118	4.90E-05	0.00E+00	1.04E-03	4.32E-06	3.47E-10	3.26E+02	1.68E-04	2.27E-02	6.73E+00	7.19E+00	NR	1.40E-01	NR	NR	NR

ADVANCED

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		AGE CLASS						AGE CLASS						AGE CLASS					
LAND USE		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
EF (soil and dust ingestion)	day yr^{-1}	85	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	10	170
EF (consumption of homegrown produce)	day yr^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
EF (skin contact, indoor)	day yr^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
EF (skin contact, outdoor)	day yr^{-1}	85	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	10	170
EF (inhalation of dust and vapour, indoor)	day yr^{-1}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
EF (inhalation of dust and vapour, outdoor)	day yr^{-1}	85	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	10	170
Occupancy Period (indoor)	hr day^{-1}	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Occupancy Period (outdoor)	hr day^{-1}	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Soil to skin adherence factor (indoor)	mg cm^{-2} day^{-1}	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Soil to skin adherence factor (outdoor)	mg cm^{-2} day^{-1}	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
Soil and dust ingestion rate	g day^{-1}	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	2.00E-02	2.00E-02	2.00E-02	2.00E-02	2.00E-02	2.00E-02

		AGE CLASS						AGE CLASS						AGE CLASS					
RECEPTOR		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Body weight	kg	5.60	9.80	12.70	15.10	16.90	19.70	22.10	25.30	27.50	31.40	35.70	41.30	47.20	51.20	56.70	59.00	70.00	70.90
Body height	m	0.70	0.80	0.90	0.90	1.00	1.10	1.20	1.20	1.30	1.30	1.40	1.40	1.50	1.60	1.60	1.60	1.60	1.60
Inhalation rate	m^3 day^{-1}	10.30	18.80	20.70	19.10	21.30	24.90	17.60	20.20	21.80	25.00	28.40	19.80	22.70	24.50	27.20	28.30	27.40	25.40
Max exposed skin fraction (indoor)	m^2 m^{-2}	0.32	0.33	0.32	0.35	0.35	0.33	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.21	0.21	0.33	0.33
Max exposed skin fraction (outdoor)	m^2 m^{-2}	0.26	0.26	0.25	0.28	0.28	0.26	0.15	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.14	0.14	0.27	0.27

ADVANCED

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SOIL PROPERTIES for	Sandy loam	
Porosity, total	$cm^3\ cm^{-3}$	0.53
Porosity, air-filled	$cm^3\ cm^{-3}$	0.20
Porosity, water-filled	$cm^3\ cm^{-3}$	0.33
Residual soil water Content	$cm^3\ cm^{-3}$	0.12
Saturated hydraulic conductivity	$cm\ s^{-1}$	3.56E-03
van Genuchten shape parameter (*m*)	dimensionless	3.20E-01
Bulk density	$g\ cm^{-3}$	1.21
Threshold value of wind speed at 10m	$m\ s^{-1}$	7.20
Empirical function (F_x) for dust model	dimensionless	1.22
Ambient soil temperature	K	283

BUILDING PROPERTIES for	No building	
Building footprint	m^2	0.00E+00
Living space air exchange rate	hr^{-1}	0.00
Living space height (above ground)	m	0.0
Living space height (below ground)	m	0.0
Pressure difference (soil to enclosed space)	Pa	0.0
Foundation thickness	m	0.00E+00
Floor crack area	cm^2	0.00E+00
Dust loading factor	$\mu g\ m^{-3}$	0.00E+00

AIR DISPERSION MODEL		
Mean annual windspeed (10 m)	$m\ s^{-1}$	5.00
Air dispersion factor at height of 0.8 m	$g\ m^{-2}\ s^{-1}$ per $kg\ m^{-3}$	120.0
Air dispersion factor at height of 1.6 m	$g\ m^{-2}\ s^{-1}$ per $kg\ m^{-3}$	280.0
Fraction of site with hard or vegetative cover	$m^2\ m^{-2}$	0.75

VAPOUR MODEL		
Use default soil gas ingress rate	TRUE	
Default soil gas ingress rate	$cm^3\ s^{-1}$	0.00
Depth to top of source (beneath building)	cm	50
Depth to top of source (no building)	cm	0

Use limited source thickness	FALSE	
Thickness of contaminant layer	cm	200

Time average period for surface emissions	years	49
User defined effective air permeability	cm^2	3.05E-08

3.05037E-08

STEP 5:

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		Ratio of ADE to relevant Health Criteria Value			Soil Assessment Criteria			SAC Flag
		oral HCV	inhal HCV	Combined	oral HCV	inhal HCV	Combined	Current SAC used for determining pathway contributions
Number	Chemical	(dimensionless)	(dimensionless)	(dimensionless)	$mg\ kg^{-1}$	$mg\ kg^{-1}$	$mg\ kg^{-1}$	(unitless)
1	Dibenz[ah]anthracene	0.88	0.12	1.00	1.94E+02	1.48E+03	1.71E+02	Combined
2	Benzo[b]fluoranthene	0.85	0.15	1.00	2.44E+03	1.43E+04	2.08E+03	Combined
3								
4	PCB-77	1.00	NR	NR	7.81E-02	NR	NR	Oral
5	PCB-105	1.00	NR	NR	7.81E-02	NR	NR	Oral
6	PCB-114	1.00	NR	NR	7.81E-02	NR	NR	Oral
7	PCB-118	1.00	NR	NR	7.81E-02	NR	NR	Oral
8								
9								

	Soil Saturation Limit	Pathway Contributions (%)						
		direct soil ingestion	sum of consumption of homegrown produce and attached soil	dermal contact (indoor)	dermal contact (outdoor)	inhalation of dust (indoor)	inhalation of dust (outdoor)	inhalation of vapour (indoor)
Number	$mg\ kg^{-1}$	%	%	%	%	%	%	%
1	3.93E-03	48.86	0.00	0.00	51.02	0.00	0.02	0.00
2	1.22E+00	48.84	0.00	0.00	51.00	0.00	0.02	0.00
3								
4	6.38E+02	30.57	0.00	0.00	34.38	0.00	0.01	0.00
5	6.98E+02	30.58	0.00	0.00	34.39	0.00	0.01	0.00
6	6.98E+02	30.58	0.00	0.00	34.39	0.00	0.01	0.00
7	6.98E+02	30.58	0.00	0.00	34.39	0.00	0.01	0.00
8								
9								

Appendix G Disclaimer

This report has been prepared solely for use by the party which commissioned it (the "client") in connection with the captioned project. It should not be used for any other purpose. No person other than the client may rely on the content, information or any views expressed in this report. We accept no duty of care, responsibility or liability to any other recipient of this report. This report is confidential and contains proprietary intellectual property.

No representation, warranty or undertaking, express or implied, is made and no responsibility or liability is accepted by us to any party other than the client, as to the accuracy or completeness of the information contained in this report.

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This report represents the technical findings and opinions of experienced geo-environmental specialists and does not constitute legal, insurance or financial advice, for which separate, independent advice should be consulted from qualified professionals if so required.

The findings and opinions of this report are based on information obtained from a variety of sources as detailed in this report. We cannot and do not guarantee the authenticity or reliability of the information from other sources upon which we have relied. To the extent that this document is based on information supplied by other parties, we accept no liability for any loss or damage suffered by the client due to an error or omission in this report which is (i) due to an error or omission data, information or statements supplied to us by other parties including the client ("Data") or (ii) which arises from any conclusions based on such Data. We have not independently verified such Data and have assumed it to be accurate, complete, reliable and current as of the date of such information.

To the extent that this report is based on information obtained from a ground investigation, any such investigation can examine only a small part of the subsurface conditions. Where we have been responsible for the design of a ground investigation, we shall have used reasonable skill and care. However, in any ground investigation there remains a risk that pockets or "hot-spots" of contamination may not be identified, because investigations are necessarily based on sampling at localised points. Not finding any indicators of contamination does not mean that hazardous substances do not exist at the Site.

Certain indicators or evidence of hazardous substances or conditions may have been outside the limited portion of the subsurface investigated or monitored and thus may not have been identified or their full significance appreciated. Such risks may be mitigated to a degree by carrying out further ground investigation, or during construction works, by on-Site visual observation and validation testing.

It is also possible that environmental monitoring has not identified certain conditions because of the relatively short monitoring period. Accordingly, it is possible that the ground investigation and monitoring failed to indicate the presence or significance of hazardous substances or conditions. If so, their presence could not have been considered in the formulation of our findings and opinions.

For the avoidance of doubt, where the words "remediation" or "remedial" actions / operations are used in this report, these words and phrases shall refer to actions to eliminate, control or reduce risks from relevant pollutant linkages associated with the Site. Unless explicitly stated, remediation shall NOT be assumed to refer to actions to eliminate contamination risks.

This report has been produced using due skill and care, in accordance with statute and best practice at the reporting date stated in the report. We accept no liability for any change in geo-environmental risk interpretation resulting from changes in guidance and/or statute after the reporting date.

We believe that providing information about limitations is essential to help the client identify and thereby manage its risks. These risks can be mitigated – but they cannot be eliminated - through additional research. We will, on request, advise the client of the additional research opportunities available, their impact on risk, and their cost.

Appendix H References

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[ix] Mott MacDonald Systra DJV (2021): "Stabilised Materials Contamination Risk Assessment", Ref. 1MC08-BBV_MSD-EV-RIA-N001-100003