Hydrogeological Risk Assessment

Radlett SRFI Area 2

September 2023

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This document has been prepared and checked in accordance with
Waterman Group's IMS (BS EN ISO 9001: 2015, BS EN ISO 14001: 2015 and BS EN ISO 45001: 2018)

Issue	Date	Prepared by	Checked by	Approved by
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Comments

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1. Introduction

1.1 Objectives

Waterman Infrastructure & Environment Limited ("Waterman") has been appointed to prepare an application for an Environmental Permit (EP). The EP application is to authorise the permanent deposit of waste on land as a recovery activity. The waste recovery activity is for site-derived waste to be used in the construction of landscape bunds associated with the construction of the Radlett Strategic Rail Freight Interchange (SFRI), located at North Orbital Road, Upper Colne Valley, Hertfordshire, AL2 2ET – specifically the two landscape bunds on Area 2.

SEGRO Radlett Ltd is the master developer – the party responsible for bringing the scheme to fruition. It has appointed VolkerFitzpatrick Limited (VFL) to undertake the earthworks including bund construction and other enabling activities. VFL is therefore the EP applicant and will be the EP operator.

The Hydrogeological Risk Assessment (HRA) has been prepared in-line with the June 2023 Guidance prepared by the Environment Agency (EA) titled "What to include in your Hydrogeological Risk Assessment".[1]

1.2 Report Structure and Scope

Through the Radlett SRFI scheme SEGRO Radlett Ltd proposes to develop an intermodal terminal, with rail and road distribution units. The SRFI is located to the south of St. Albans, adjacent to the M25 and Midland Main line (MML) railway. The terminal will be serviced by a new dual track rail chord connected to the MML.

The SRFI comprises a 419-hectare (ha) development area that is sub-divided into eight plots referred to as Areas 1 to 8. The areas have the following proposed uses:

- Areas 1 (146 ha) and 2 (26 ha) – the SRFI Development Area. Area 1 will comprise an intermodal terminal and a rail and road served distribution facility consisting of several large warehouses. The rail chord connecting Area 1 to the MML will run through Area 2. Area 2 will also feature two landscape bunds (LS1 and LS2) that will help to screen the SRFI from public view and provide acoustic screening; and
- Area 3 to 8 (247 ha) – will be developed with additional works and landscaping to provide publicly accessible open land and a community forest.

The Areas are shown on plan "Different Development Phases (Areas 1 – 8) of the SRFI" (D-ESSD1A - drawings are to be found in the separate "ESSD drawings and information bundle").

To enable construction of the SRFI, earthworks are required to prepare the SRFI Development Area as summarised below:

Area 1

Earthworks material will be excavated from the northern half of Area 1 where the levels need to be lowered to enable access from the public highway to the north, to install surface water flow attenuation features and to create suitable development platform levels. The cut will be used to raise levels across the southern half of Area 1, to construct landscape bunds around the perimeter of Area 1 and to construct the landscape bunds on Area 2.

[1] Landfill operators: environmental permits - What to include in your hydrogeological risk assessment - Guidance - GOV.UK (www.gov.uk)

Area 2

Excavation is required in Area 2 to construct the new rail chord linking the MML and the SRFI – the rail chord needs to pass under the MML. Some of the excavation will be into historic landfill, with the waste arising to be processed by mobile treatment EP to generate useable earthworks material (i.e. meeting the specification for the works) with the unusable waste despatched for recovery or disposal elsewhere. The waste recovered from processing the historic landfilled waste as well as restoration soils and capping material from Area 2 and excavation arisings cut from Area 1 will be used to construct the landscape bunds on Area 2.

The cut and fill locations across Areas 1 and 2 are shown on plan “Earthworks Analysis Cut and Fill Volumes” (D-ESSD4A).

Regulatory Control of Earthworks

Pre-application liaison has been undertaken with both local (Hertfordshire and North London) and national (Permitting Support Centre) EA teams, seeking to establish the waste / non-waste status of various excavation arisings and the appropriate mechanisms to regulate the use of the arisings as earthworks materials. Aspects of this liaison are not concluded at the time of writing.

The southern part of Area 1 has been subject to mineral extraction and restoration. The land is recorded in Landmark data as “EA historic landfill polygon” and “LA recorded landfill site”. If the restoration material can be demonstrated to comprise overburden and interburden from the mineral extraction activity, excavation arising generated from that area will be excluded from the scope of waste. In that case, the reuse of such material will be managed under the Definition of Waste Development Industry Code of Practice (DoWCoP) in order to maintain an auditable record of the materials use within the earthworks. If the non-waste status of such material cannot be demonstrated / agreed, the arisings would be managed as waste. The local EA team has been provided with evidence to support non-landfill history of the southern part of Area 1 and the information has been passed forward to the EA team responsible for maintaining the historic landfill dataset with a request that the record is removed.

Natural soils and Made Ground will arise from excavation into the northern part of Area 1 – i.e. from land outside the historic mineral workings. Whilst natural soils excavated and able to be used in construction on the same site are excluded from the scope of waste, their use in earthworks on this scheme would be managed under the DoWCoP, as would the use of Made Ground.

The arisings from excavation into the historic landfill in Area 2 will be waste. The arisings will be treated under mobile treatment EP and the useful products of treatment will retain their waste label until their permanent deposit into earthworks, regulated by waste recovery EP. For the avoidance of doubt, the treatment will not be regulated by the site-based waste recovery EP.

Due to the unsettled status of the material to be cut from the mineral restoration area in Area 1, the waste recovery EP will include both bunds on Area 2. The permitted area boundary is limited to the areas occupied by landscape bunds LS1 and LS2 and is shown on plan “Area 2 Bunds Waste Recovery Area Boundary”) (D-ESSD1C). The boundary for Area 2 is shown on plan “Site Location Plan” (D-ESSD1B).

1.3 Limitations and Constraints

Waterman has endeavoured to assess all information provided to them during the preparation of this document, but makes no guarantees or warranties as to the accuracy or completeness of this information.

The conclusions resulting from this report are not necessarily indicative of future conditions or operating practices at or adjacent to the site.

1.4 Previous Reports

The HRA has been informed by the following reports (Table 1) and associated ground investigations.

Table 1: Previous Environmental Reports Reviewed

Author	Title	Date	Reference
WSP	Phase I Environmental Audit	October 2004	12021964
WSP	Preliminary Contaminated Land and Ground Gas Assessment	October 2007	12220100/002
Capita	Ground Contamination Assessment and Remediation Strategy – Area 1	October 2016	CS-070751-PE-16-134-R, Rev. B
Capita	Ground Contamination Assessment and Remediation Strategy – Area 2	October 2016	CS-070751-PE-16-143-R, Rev. C
Capita	Controlled Waters Detailed Quantitative Risk Assessment – Area 2	January 2017	CS070751-CAP-00-XX-RP-Y-CWDQRA, Rev 2.0
Capita	Addendum to Controlled Water Detailed Quantitative Risk Assessment – Area 2	October 2017	CS070751-CAP-00-XX-RP-Y-CWDQRA, Rev. 1.2
Capita	Remediation Options Appraisal	August 2018	CS-070751-PE-18-075-R
Capita	Groundwater Monitoring Report – Area 1	February 2019	CS-070751-JD-R, Rev A
Bradbrook Consulting	Remediation Contingency Plan	April 2019	18-175, Rev 2
Waterman	Ground Investigation Report	January 2023	RAD-WAT-A2EX-XX-RP-I-0003
Waterman	Detailed Remediation Method Statement (draft)[2]	May 2023	RAD-WAT-A2EX-XX-MS-I-0024

[2] At the time of writing, the DRMS is currently in the process of being agreed with the EA Hertfordshire and North London team prior to formal submission to the planning authority. Once agreed with the local EA office this document will be submitted to the national permitting team.

2. The Works and Wider Context

Through the Radlett SRFI scheme the applicant proposes to develop an intermodal terminal, with rail and road distribution units. The SRFI is located south of St. Albans, adjacent to the M25 and Midland Main line (MML) railway. The terminal will be serviced by a new dual track rail chord connected to the MML.

The SRFI comprises a 419-hectare (ha) development area is sub-divided into eight plots referred to as Areas 1 to 8. The areas have the following proposed uses:

- Areas 1 (146 ha) and 2 (26 ha) – the SRFI Development Area. Area 1 will comprise an intermodal terminal and a rail and road served large distribution facility consisting of several large warehouses. The rail chord connecting Area 1 to the MML will run through Area 2. Area 2 will also feature two landscape bunds that will help to screen the SRFI from public view; and
- Area 3 to 8 (247 ha) – will be developed with additional works and landscaping to provide publicly accessible open land and a community forest.

The earthworks across Areas 1 and 2 will be undertaken concurrently from spring 2024 to summer 2026. The majority of the cut will be taken from the northern part of Area 1 – both to reduce its level and to create surface water flow attenuation features. The cut will be used to raise levels across the south of Area 1 (so leading to an overall level development platform for the new warehouses), and to construct landscape bunds on Area 2 (LS1 and LS2) and on Area 1 (LS3 – 9). Area 2 will also be subject to excavation – to create the route for the new rail chord to cross Area 2 and pass under the MML. The excavations will include excavating historically landfilled waste.

Works on Area 2 will begin with construction of the Jack Box for the new underpass. This will be followed by earthworks to excavate the route of the new rail chord including historic landfill underlying part of the route. The larger of the two landscape bunds on Area 2 – LS1 – will be constructed over the two year period with earthworks occurring in campaigns as cut is available and the weather is likely to be most favourable. LS2 – the smaller, northern bund, is currently due to be constructed in 2026.

The remainder of the bunds fill need will be supplied by excavations to reduce ground levels and install surface water flow attenuation features across Area 1's northern half. The excavation arisings could include both natural ground and Made Ground and will be coded as waste arising from construction activities (Chapter 17 of the EWC).

The historically landfilled waste will be processed within Area 2 to recover usable earthworks material for use in bund construction on Area 2 (bunds LS1 and LS2). Ground investigation findings have established useable earthworks material can be extracted from the historic waste by mechanical screening and handpicking. The treatment will be regulated by mobile treatment permit; therefore, the products of treatment will be coded as wastes arising from the mechanical treatment of waste (Chapter 19 of the EWC). Waste unsuitable for use in the bunds will be separated during the treatment process and sent to an appropriate permitted facility for recovery or disposal.

Other bunds to be constructed around Area 1 will be constructed using soils from the northern part of Area 1. Such soils will either be excluded from the scope of waste (uncontaminated soil and other naturally occurring material excavated in the course of construction activities where it is certain that the material will be used for the purposes of construction in its natural state on the site from which it was excavated[3]) or will be suitable for use in accordance with the CL:AIRE Definition of Waste: Development Industry Code of Practice (DoWCoP). All non-waste material will be managed in accordance with the DoWCoP to enable lines of evidence to be clearly maintained.

Treatment of waste will consist of sorting at the point of excavation to separately remove any gross

[3] Article 2 paragraph 1(c) Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives

contamination or large lumps of hard materials, followed by treatment under a separate mobile treatment plant permit (mechanical screening and hand picking). There will be no treatment of waste associated with the waste recovery EP. Treated waste suitable for use will be stored in stockpiles, until required for use in construction of bunds LS1 and LS2 on the permitted site.

The waste recovery EP will not include for the use of hazardous waste material. Landfill waste due to be recovered under the EP will be tested for the relevant contaminants of concern and assessed in accordance with the requirements of WM3[4]. Waste which does not comply with non-hazardous waste classification will require either disposal or further treatment to achieve the non-hazardous waste classification.

Waste which complies with a non-hazardous waste classification will be recovered in accordance with the requirement of the EP.

Volker FitzPatrick has been appointed to carry out the detailed design and execution of the earthworks.

[4] 2021, Environment Agency, Technical Guidance WM3: Waste Classification – Guidance on the classification and assessment of waste

3. Conceptual Site Model

3.1 Site Description

Area 2 comprises an area of grassed land currently disused and closed-off to the public. It is 26ha and is irregular in shape – roughly rectangular becoming a point at the northwest corner. It is bordered to the south by the M25 and to the west by the MML and Area 1.

Access is via a concrete track that runs roughly southeast to northwest through the centre of Area 2. It extends from a bridge in the southeast corner, which passes over the M25. The concrete track continues off-site in the northwest through an underpass (below the MML) towards Area 1.

Ground levels generally fall from west (72 to 74mAOD) to east (68 to 70mAOD). This coincides with the railway embankment which is typically around 2.0m to 3.0m above current Site levels.

Two small ditches bisect Area 2 centrally from west to east, and then travel south adjacent to the eastern boundary. Vegetation is locally relatively dense, particularly adjacent to the ditches and around the boundary.

3.2 Site History – Area 2

Area 2 comprised undeveloped, assumed agricultural land, from at least 1883. From 1960's/early 1970's, Area 2 was subject to sand and gravel extraction followed by infilling in southern and eastern extents. Two waste licenses were previously active on-site.

- 78/48 (eastern boundary) – Napsbury tip operated from 1978 to 1981. Deposited waste: inert, commercial, and household waste. Understood to be capped with the following: "The uppermost layer of waste materials deposited on the site shall be covered with a layer of clay reject material from the site (or suitable imported material) not less than 30cm thick. This clay layer shall be covered to a depth of not less than 60cm with over-burden or subsoil." St Albans District Council was unable to confirm whether the capping layer was installed. Correspondence with the EA confirmed Napsbury Tip accepted putrescible waste.
- 77/20 (southern boundary) – 1954 to 1983. Deposited waste: inert, commercial, and household, domestic putrescible solid, non-putrescible and non-hazardous solid, rubble and excavated spoil. Details of landfill capping are not available.

3.3 Site History – Area 1

Historical records indicate Area 1 mainly comprised agricultural land up to around 1930 when Radlett Aerodrome was constructed. Radlett Aerodrome occupied the southern two-thirds of Area 1 until its closure in 1970.

Mineral extraction commenced in Area 1 in the early 1990s following planning approval for sand, gravel, and hoggin extraction and restoration to agriculture (planning permission ref. 5/0830-83). Mineral extraction is understood to have ceased in the late 1990s and restoration to agricultural using site-won overburden and interburden was completed in the early 2000s.

Landmark data records Area 1 as historical landfill (EAHLD12290 and PC8538). A detailed review of the Mineral Planning Authority Records available from Hertfordshire County Council and from ground investigations completed in 2016 have identified the option to complete landfilling post mineral extraction was not taken. Area 1 was instead restored with site won interburden and overburden. Landfill waste is therefore absent on Area 1.

3.4 Geology

Ground conditions on Area 2 encountered varied according to being located within or outside of the previously landfilled areas, as summarised in Table 2 and Table 3 respectively.

Table 2: Geology in Landfilled Areas Area 2

Strata	Thickness Range (Minimum – Max)	Description
Topsoil	0.1m – 0.4m	Grass over greyish brown/dark brown/brown slightly gravelly slightly sandy clayey silt with frequent rootlets, and occasional roots (up to 170mm diameter) and rare fragments (60x60mm) of textile. Gravel is subangular to rounded fine to coarse flint, brick, and rare concrete and chalk. Occasional pockets (up to 300mm) of stiff brown clay.
Made Ground – General Fill	0.1m – 1.85m	Soft brown/dark brown slightly gravelly slightly sandy clayey silt or slightly sandy gravelly silty clay with frequent roots (up to 250mm diameter) and rootlets. Gravel is angular to rounded fine to coarse flint, brick and concrete and rare chalk. Occasional fragments of plastic, textiles, glass, wood, and ceramic. Orangish brown/brown slightly gravelly clayey medium and coarse sand with occasional fragments of plastic. Gravel is angular to rounded fine to coarse flint and rare crystalline, chalk, brick and concrete.
Made Ground – Landfill Capping	0.1m – 2.5m	Stiff brown mottled greyish brown/orangish brown slightly sandy slightly gravelly silty clay. Gravel is subangular to rounded fine to coarse flint and rare brick, concrete, and chalk.
Made Ground – Landfill	0.2m – 5.7m	Domestic waste comprising glass, plastic, polystyrene, ceramic, metal, cables, textiles, paper, sponges, tin, newspaper (dated 1980), fragments of paper, cardboard, and book (1979) in a dark greyish brown and black sandy gravelly clay matrix. Construction-type waste including fragments of brick and masonry, concrete, and tarmacadam. Other fragments of wood, rubber, black and white plastic sheeting, electrical wires, ripped nylon sheet, wood chippings, rope, clumps of straw.
Made Ground – Basal Clay Layer	0.25m – 3.0m	Soft to stiff orangish brown/brown slightly gravelly silty clay with rare fragments of wood and plastic. Gravel is subangular to rounded fine to coarse flint, chalk and rare brick. Soft to firm greenish brown and dark brown grey slightly gravelly sandy clay with rare pockets of firm orangish brown mottled bluish grey clay. Rare fragments of metal, plastic, and wood. Gravel is angular to rounded fine to coarse flint and brick.
Kesgrave Catchment Subgroup	0.8m – 9.0m	Firm to stiff orangish brown and dark brown slightly gravelly sandy clay with rare pockets (up to 80x100m) of firm orangish brown mottled bluish grey clay. Gravel is angular to rounded fine to coarse flint.
	0.6m – 4.6m	Overlying very dense brown, light brown and greenish brown slightly clayey sandy angular to rounded fine to coarse flint gravel.
Chalk	0.85m – 12.1m	Structureless white mottled light grey/yellow white slightly sandy slightly gravelly silt or silty sandy gravel with a low subangular and

Strata	Thickness Range (Minimum – Max)	Description
		subrounded flint and cobble content. Gravel is angular to subrounded fine to coarse weak chalk and flint (CIRIA Grade Dc and Dm).
	>11.95m (total thickness not proven)	Becoming extremely to very weak medium locally high density white mottled grey with rare black specs chalk rarely stained orangish brown. Rare bivalve shell fragments. Frequent rounded dark grey/black cobble sized flints recovered between 0.05m and 0.5m thick (CIRIA Grade A3/B3).

Table 3: Geology in Non-Landfilled Areas Area 2

Strata	Typical Thickness (Minimum – Max)	Description
Topsoil	0.05m – 0.6m	Grass over greyish brown/dark brown/brown slightly gravelly sandy silt with frequent rootlets and occasional roots (up to 600mm diameter). Gravel is angular to rounded fine and medium flint, brick and rare glass, chalk, and concrete.
Made Ground – General Fill	0.2m – 2.95m	Silty very sandy gravel or slightly gravelly sandy silt with fragments of fine to coarse clinker, brick, flint, concrete and rare tarmacadam, coal, ash, ceramic, and glass gravel. Occasional medium subangular brick cobble content, roots (up to 90mm diameter) and rootlets. Firm to stiff sandy gravelly clay or clayey sandy gravel. Gravel is subangular to subrounded fine to coarse flint, brick, and chalk. Occasional fragments of clinker, plastic, and concrete.
Kesgrave Catchment Subgroup	3.0m – 8.2m	Firm becoming stiff orangish brown mottled light grey/dark grey, slightly sandy slightly gravelly clay. Gravel is angular to rounded fine to coarse flint and rare chalk. Occasional thin horizons (>0.5m thick) of reddish brown locally mottled grey slightly gravelly sandy clay with frequent black staining and rare remnant rootlets. Gravel is angular to rounded fine to coarse flint. Orangish brown very clayey very sandy angular to rounded fine to coarse flint gravel.
Kesgrave Catchment Subgroup	1.8m – 13.8m	Loose to very dense yellowish brown slightly gravelly fine and medium sand. Gravel is angular to rounded fine and medium flint and quartz. Becoming medium to very dense yellowish brown sandy subangular to rounded flint gravel with a low subrounded flint cobble content.
Chalk	0.9m – 10.3m	Interbedded very soft to soft off white/brown white/yellow white slightly sandy gravelly silt and silty sandy gravel with a low subangular and subrounded flint and chalk cobble content. Gravel is angular to subrounded fine to coarse weak chalk and flint (CIRIA Grade Dc and Dm).
	>16.05m (total thickness not proven)	Becoming extremely weak medium density white with rare black specs chalk rarely stained orangish brown. Rare bivalve shell fragments. Frequent rinded dark grey/black cobble sized flints

Strata	Typical Thickness (Minimum – Max)	Description
		recovered between 0.05m and 0.3m thick (predominantly CIRIA Grade B4/B3).

Ground conditions on Area 1 were established in a Capita ground investigation completed between 2015 and 2016 with results reported in a Ground Contamination Assessment and Remediation Strategy (CS-070751-PE-16-134-R). Ground conditions encountered comprised the following in sequential order.

- Topsoil – 0.05 – 0.7m thick (average 0.25m)
- Made Ground/Re-worked natural soils – 0.5 – 6.9m thick (average 2.58m)
  - Present as a discontinuous layer comprising a variable gravelly sandy clay
  - Thicker deposits were identified centrally associated with more extensive gravel extraction and infilling with site won material. Domestic waste or landfill waste not recorded.
- Lowestoft Formation – 0.5 – 10.6m thick (average 5.17m)
  - Present as a interbedded gravelly clay, clayey sand, and clayey/sandy gravel
- Kesgrave Catchment Subgroup – 0.4 – 7.3m thick (average 3.24m)
  - Present as a discontinuous layer comprising a sand and gravel
- Chalk Formation – Thickness not proven

3.5 Controlled Waters

Surface water bodies close to Area 2 include:

- Small ditches – Bisecting centre of Area 2 from west to east, and adjacent to eastern boundary;
- Lakes (assumed fishing ponds identifiable since 1972) – Between 200m and 325m south;
- River Colne (flows in a southerly direction) – 375m east;
  - River Colne is an annual river dry in the summer/autumn months
- River Ver (flows in a southerly direction) – 800m west.

Area 2 is situated within groundwater Source Protection Zone (SPZ) 1 (Inner Zone) and SPZ2 (Outer Zone), relating to an abstraction point 1.2km to the south/southwest identified as Netherwild Pumping Station.

The Kesgrave Catchment Subgroup is a Secondary A Aquifer, and the Chalk Formation is a Principal Aquifer. The SPZ1 and SPZ2 relate to the Principal Aquifer in the Chalk Formation. Landscape bund LS1 is within SPZ1 and SPZ2. Landscape bund LS2 is in SPZ2.

Groundwater monitoring completed by Capita (2016)[5]. recorded pockets of perched water in the landfill between 2.93mbgl and 5.98mbgl (67.51mAOD and 64.46mAOD, respectively). During groundwater monitoring undertaken by Waterman in 2022 typically, no groundwater was recorded in boreholes targeting the landfill waste (except for BH58(S)). In BH58(S) groundwater was recorded at 4.66 and 3.77mbgl (74.7mAOD and 70.93mAOD, respectively) in two of the three return monitoring visits. The groundwater level recorded in the landfill is higher than groundwater levels in the Kesgrave Gravels or Chalk Formation suggesting connectivity between water in the landfill and groundwater is restricted. This aligns with the fact a clay 'basal' layer (either purposely placed or natural clay occurring in the Kesgrave Deposits) is present directly underlying much of the landfill waste.

[5] Capita, Radlett SRFI – Area 2 Ground Contamination Assessment and Remediation Strategy, CS-070751-PE-16-143-R, Rev C, October 2016.

3.6 Sources

Waste to be recovered for use in construction of the landscape bunds will be sourced from the following:

- Treated landfill waste – Area 2 only
- Restoration material – Area 1 and Area 2
  - Including Made Ground within former landfill boundaries, landfill capping material, and site won interburden and overburden used to restore Area 1 post mineral extraction.
- Made Ground – Area 1 and Area 2
  - Outside former landfill and mineral restoration boundaries
- Natural material – Area 1 and Area 2
  - Including Kesgrave Catchment Subgroup and Chalk Formation
- Topsoil – Area 1 and Area 2

The landscape bunds will largely be constructed from restoration material, Made Ground, and natural material. The treated landfill waste will form a relatively small proportion of the total landscape bunds. Given an approximate total bund construction of 392,446m^3 and an anticipated 20,000m^3 of treated landfill waste arising from the excavations and screening process the screened landfill waste will form approximately 5.10% of the total content of the landscape bunds.

New sources of contamination are not being introduced. Imported waste / material used will not be used within the landscape bunds with the waste recovered under the EP won from the existing landfill on-site following treatment to remove undesirable and out of specification material, and site won restoration material, natural material, and Made Ground outside former landfill boundaries.

A review of the contamination status of the landscape bund source material separated into Area 2 and Area 1 is included below.

3.6.1 Area 2

Some of the waste, the subject of this waste recovery EP application is to be derived from the excavations into the following landfill. Excavations into the historic landfill along the southern boundary will not occur;

- 78/48 (eastern boundary) – Napsbury tip operated from 1978 to 1981. Deposited waste: inert, commercial, and household waste. Understood to be capped with the following: “The uppermost layer of waste materials deposited on the site shall be covered with a layer of clay reject material from the site (or suitable imported material) not less than 30cm thick. This clay layer shall be covered to a depth of not less than 60cm with over-burden or subsoil.” St Albans District Council was unable to confirm whether the capping layer was installed. Correspondence with the EA confirmed Napsbury Tip accepted putrescible waste.

The intrusive ground investigations completed by Capita in 2016 and more recently by Waterman in 2022 worked to establish the likely maximum extents of the two landfills. A plan detailing the understood extents of the two landfills located on-site are shown on drawing D-ESSD1C.

The landfill as established from previous ground investigations generally comprised a capping layer, landfill waste, and basal clay liner. The landfill waste was described as having the following general composition: Range of wastes including domestic, construction and other fragments (wood, rubber, black and white plastic sheeting, electrical wires, ripped nylon sheet, wood chippings, rope and clumps of straw) in a black, dark grey and brown sandy gravelly clay matrix.

Visual and olfactory evidence of contamination was recorded in the landfill waste with hydrocarbon odours, malodours odours, rotten waste odours, and fragments of Asbestos Containing Materials (ACM) identified. Soil headspace analysis recorded concentrations generally between 15ppm and 50ppm, with a peak concentration of 194.5ppm.

Soil Laboratory Analysis

Laboratory analysis was completed on 41No. samples from both the 2016 Capita and 2022 Waterman ground investigations. To put the contamination concentrations into context they were assessed against the Generic Assessment Criteria (GAC) for a Public Open Space (Park) (POS_{PARK}). It is noted this assessment does not fit into the Conceptual Site Model (CSM) with the recovered waste solely being used below a cover layer that would restrict future human health receptors coming into direct contact with it. The assessment against the POS_{PARK} GAC recorded elevated beryllium, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene, di-benzo(a,h)anthracene in three landfill waste samples recovered during the 2022 Waterman ground investigation (WTP113, WTP115, WBH110). A review of other contaminant concentrations recorded in landfill waste samples identified the following;

- Ammoniacal nitrogen
  - 22No. samples tested with concentrations recorded between 1.7mg/kg and 200mg/kg. 5No. samples were recorded below the laboratory detection limit (0.5mg/kg).
- 1,4 Dioxane
  - 5No. samples tested, all samples below the laboratory detection limit (0.1mg/kg)
- Dioxins and Furans
  - 3No. samples tested, toxic equivalency values recorded between 3.31 and 10.0.
- Persistent Organic Pollutants (POPs)
  - 4No samples tested for a range of POPS include pesticides and insecticides;
    - Chlordane – trans (62µg/kg), chlordane – cis (35µg/kg), dieldrin (26µg/kg) were recorded in one sample all other samples below the laboratory detection limit (0.1mg/kg).
  - Per and Polyfluorolalkyl Substances (PFAS)
    - 7No. samples tested, 5No. below the laboratory detection limit (0.1µg/kg) and 2No. which recorded Polyfluorooctane Sulfonate (PFOS) at 0.6µg/kg and 0.8µg/kg.
  - Poly Chlorinated Biphenyls (PCB)
    - 14No. samples tested, 6No. recorded PCBs above the laboratory detection limit with concentrations between 0.002mg/kg and 0.014mg/kg. All 6No. samples were recovered from the Napsbury Tip landfill.
- Asbestos
  - 47No. samples tested, 11No. recorded asbestos fibres with quantification analysis recording concentrations between 0.007% and 0.349%.

Leachate analysis (2:1) was carried out on 11No. samples of landfill waste and assessed against both the Environmental Quality Standards (EQS) and Drinking Water Standards (DWS). Assessment against the EQS records cadmium (WBH114), nickel (WBH114), zinc (WBH114) and copper (WBH106) in exceedance. Assessment against the DWS records arsenic (WBH106), cadmium (WBH114) and nickel (WBH114) in exceedance.

Waste Classification Analysis

Assessment of the soil laboratory results for samples of the landfill waste from both the 2016 Capita ground investigation and 2022 Waterman ground investigation to understand their likely waste classification status recorded six samples as containing hazardous properties (ABH05 – HP14, WBH102 – HP8, WTP104 – HP7 HP11, WTP108 – HP7 HP11, WTT114A – HP7 HP11, TP63 – HP7 HP11). Completion of Waste Assessment Classification (WAC) analysis on selected non-hazardous samples recorded one sample with no failed criteria classifying the sample as inert waste, and two with failed criteria classifying the samples as non-hazardous waste.

Hazardous waste will be excluded from recovery. Waste will be limited to non-hazardous waste as set out in Table 4.

Table 4: Proposed list of site-derived wastes

EWC code	EWC description	Limitations
17 05 04	Soil and stones other than those mentioned in 17 05 03	Limited to site-derived material meeting the chemical and physical specifications for the works
17 09 04	Mixed construction and demolition waste other than those mentioned in 17 09 01, 17 09 02 and 17 09 03	Limited to site-derived material meeting the chemical and physical specifications for the works
19 12 09	19 12 09 minerals (for example sand, stones)	Limited to site-derived material meeting the chemical and physical specifications for the works
19 12 12	19 12 12 other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11	Limited to site-derived material meeting the chemical and physical specifications for the works

Groundwater Laboratory Analysis

Several groundwater monitoring rounds have been completed in boreholes installed in the Chalk Formation and landfill waste. A detailed assessment of the groundwater laboratory results is included in the 2023 Waterman Ground Investigation Report.

Groundwater laboratory analysis was completed in boreholes installed during both the 2016 Capita ground investigation and 2022 Waterman ground investigation. 40No. groundwater samples were tested including: 1No. from within the landfill, 3No. from the Kesgrave Catchment Subgroup, 9No. from the structureless Chalk underlying the landfill and 27No. from the structured Chalk (8No. underlying the landfill and 19No. outside of the landfilled area).

Assessment of the laboratory results against both the EQS and DWS identified elevated nickel (WBH124) and zinc (WBH110) and assessment against the DWS recorded elevated nickel (WBH124) and TPH Aromatic C12 – C16 (BH52(D)). Elevated contaminant concentrations were identified solely in monitoring wells with a response zone in the Chalk Formation. Elevated contaminants were not recorded in the perched water within the landfill waste or in the Secondary A Aquifer in the Kesgrave Catchment Subgroup.

A review of the elevated contaminant concentrations recorded in the Chalk Formation (Principal Aquifer) identifies the following;

- Elevated metal concentrations (nickel and zinc) were recorded in two locations; WBH110 installed in the structureless Chalk Formation and WBH124 installed in the structured Chalk Formation outside the landfill. The exceedances were identified in only some of the monitoring rounds indicating a consistent significant source as being absent. Based on a 2008 paper[6] it was also established based on the cobalt to nickel ratios of almost five that the nickel present was likely natural rather than from an anthropogenic source confirming the nickel present in the Chalk Formation was unlikely sourced from the landfill.

- An Aromatic TPH (C12 to C16 range) exceedance for DWS was reported in BH52(D) only. The remaining samples reported TPH below the laboratory limit of detection (<10µg/l). Borehole BH52 has a dual installation with the shallow installation having a response zone between 1.0 to 5.0mbgl, and deep response zone between 9.0mbgl and 15.0mbgl, leaving a 4.0m gap between the two installations. Given the absence of elevated petroleum hydrocarbons aside from those recorded in BH52, it suggests the seal between the shallow and deep installation is not functioning as it should, therefore groundwater samples from BH52(D) are unlikely to be representative of the Chalk Formation.

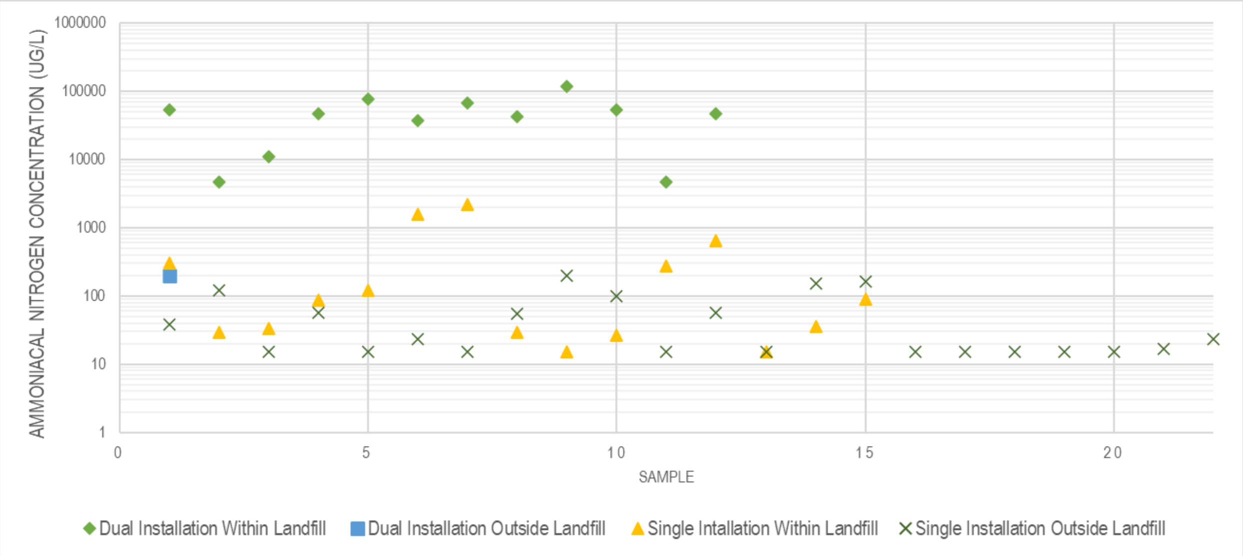
Concentrations of PAHs, VOCs an SVOCs were all below the laboratory limit of detection (excluding BH52 where a dual installation is assumed not to be functioning as intended).

Ammoniacal nitrogen was identified as a key contaminant of concern given the relatively high proportion of organic matter likely to have been deposited in the landfill (domestic waste). As part of the 2022 Waterman ground investigation a robust assessment of the migration to and impact on the Principal Aquifer in the structured Chalk Formation was undertaken. A key part in this assessment was to establish whether the dual response zone monitoring wells installed as part of the 2016 Capita ground investigation were reliably recording concentrations in the structured Chalk Formation or were creating preferential pathways with groundwater results instead representative of concentrations in water located within the landfill. The subsequent groundwater laboratory analysis completed by Waterman has identified the monitoring completed by Capita as being flawed. The 2016 dual installation monitoring wells have resulted in a preferential pathway being formed between the shallow and deep installations causing elevated contaminant concentrations being recorded in the Chalk Formation which are not representative of the Chalk groundwater contamination status.

Figure 1 details the ammoniacal nitrogen concentrations recorded in wells with a response zone in the Chalk Formation during both the 2016 Capita and 2022 Waterman GIs, split into concentrations recorded within and outside the landfill waste, and with a single or dual installation.

[6] 2008 Shahour, Origin of nickel in water solution of the chalk aquifer in the north of France and influence of geochemical factors.

Figure 1: Ammoniacal Nitrogen Concentrations Within/Outside Landfill, and with a Single/Dual Installation



Note: Values on the x axis relate to presenting the data in graph format and do not carry any significance.

Figure 1 identifies ammoniacal nitrogen concentrations in boreholes in the landfill and with a dual installation as having far higher concentrations than those in boreholes in the landfill with a single installation. The data indicates therefore for dual installation boreholes the seal between installations is not functioning as intended. The ammoniacal nitrogen concentrations therefore recorded in boreholes with a dual installation are not representative of the contamination status of groundwater in the Chalk Formation.

Removing the unrepresentative wells (dual installations) records ammoniacal nitrogen concentrations between <15 and 2,200µg/l in boreholes located in the landfill with a response zone in the Chalk Formation, and concentrations between <15 and 200µg/l in boreholes located outside the landfill with a response zone in the Chalk Formation.

Groundwater laboratory analysis for PFAS and 1,4 Dioxane recorded concentrations below the laboratory limit of detection.

Surface water Laboratory Analysis

The Waterman 2022 ground investigation included 7No. samples from the River Colne. Analysis of the 7No. samples against the EQS threshold criteria recorded no elevated contaminants.

3.6.2 Area 1

The ground investigation completed in 2015/2016 by Capita[7] recorded visual or olfactory evidence of contamination or obstructions were not encountered on Area 1 during the ground investigation, consistent with the Area 1 history in which extensive historical structures were absent and the records which show the Area 1 was restored with site won overburden and interburden.

Soil laboratory analysis for contaminants of concern based on the Area 1's historical and current use, and subsequent assessment against Generic Assessment Criteria (GAC) for a commercial end use recorded no elevated contaminant concentrations. Asbestos analysis on 61No. samples reported no asbestos fibres detected. Assessment of the materials likely waste classification based on the ground investigation results identified the material as generally complying with an inert waste classification.

[7] 2016, Capita, Ground Contamination Assessment and Remediation Strategy, CS-07051-PE-16-134-R

Given the previous Site history, notably the absence of landfilling on Area 1, Persistent Organic Pollutants (POPs) have not been identified as a contaminant of concern and were not therefore tested for.

27No. groundwater samples were collected as part of the 2016 ground investigation from monitoring wells installed within the superficial deposits (Kesgrave Catchment Subgroup) and bedrock deposits (Chalk Formation) and tested for the contaminants of concern. Assessing the groundwater laboratory results against the EQS and DWS recorded petroleum hydrocarbons below the laboratory limit of detection, and elevated nickel in two locations BH19 31µg/l and 54µg/l. The elevated contaminant concentrations are considered statistical outliers and not indicative of any significant adverse impacts to groundwater quality from material on Area 1.

The laboratory analysis of soils and groundwater identify the material on Area 1 as generally having low contaminant concentrations when assessed against relevant assessment criteria. It is noted the soil assessment against the commercial GAC is not suitable for assessing the potential impact on groundwater but helps to give context to the contaminant concentrations. The absence of elevated contaminant concentrations within groundwater samples with the exception of nickel in 2No. samples identifies the material from Area 1 as unlikely to generate leachate with elevated contaminant concentrations.

3.7 Pathway

Two potential pathways have been identified from which an impact on controlled waters could occur due to construction of the landscape bunds on Area 2, these include;

- Leachate generation from recovered waste material
  - Leachate generated from the waste migrating through the bund and underlying material including landfill waste to the underlying Principal Aquifer in the Chalk Formation.
- Squeezing of un-excavated landfill waste
  - The construction of the landscape bunds will increase the loading on the un-excavated landfill waste underlying the landscape bunds. The increased loading will squeeze the unexcavated landfill deposits resulting in entrained leachate vertically migrating to the underlying Principal Aquifer in the Chalk Formation.

An assessment of the identified pathway validity and relevant attenuation factors within the hydrogeological conceptual model is included below.

Leachate Generated from Recovered Waste

The landscape bunds will predominately be comprised of restoration material, natural material, and Made Ground arising outside the former landfill boundaries with treated landfill waste comprising approximately 5.10%. On works completion the recovered waste will be overlain by a planted topsoil/subsoil layer 0.95m thick. The planted cover layer will prevent direct runoff from the recovered waste, and reduce rainfall infiltration to ground. Subsequently, significant leachate generation from rainfall infiltration through the waste will be limited.

A review of contaminant pathways to the sensitive Principal Aquifer in the Chalk Formation was undertaken as part of the 2022 Waterman GI. This GI provided supplementary data to that recovered during the 2016 Capita ground investigation to understand the hydraulic connectivity between the landfill deposits and the Chalk Formation. A review of groundwater levels, and contaminant concentrations notably ammoniacal nitrogen identifies the landfill as hydraulically separated from the Chalk Formation. Several factors are contributing to the two deposits not being hydraulically connected including the clay basal landfill liner and the structureless Chalk Formation. In addition to the cohesive landfill cap restricting surface water infiltration through the waste deposits.

The Chalk can be conceptualised as a fractured porous medium comprised of matrix blocks bounded by interconnected fractures. Observations from the Chalk in the southeast England identify a relatively rapid response to rainfall at the water table combined with slow contaminant migration and very little dispersion of dissolved phase contaminants. The restricted migration is caused by the weathered structureless Chalk layers in which groundwater and contaminant migration will be via the matrix, which whilst having a high porosity has a low permeability. Rapid bypass of the structureless Chalk layers only occurs during heavy rainfall events. The short duration of the bypass events means matrix transport is the dominant mechanism for dissolved phase contaminants, with fractures playing a significant role for point contamination sources such as a leaking tank where contaminants are concentrated. Below the structureless Chalk layers within the structured Chalk fracture flow dominates groundwater flow and contaminant transport.

The GI has confirmed the presence of a clay landfill basal liner. The basal liner beyond providing a physical layer separating the landfill waste from the underlying natural deposits will also provide an important site for the cation exchange of ammoniacal nitrogen resulting in ammoniacal nitrogen adsorbing onto the clay and becoming unavailable for leaching.

The structured Chalk Formation and clay basal liner will provide an aquitard restricting the contaminant migration to the sensitive Principal Aquifer in the underlying structured Chalk deposits. This includes the limited leachate generated within the waste used to construct the landscape bunds of which approximately 5.10% will comprise screened landfill waste.

Squeezing of Un-excavated Landfill Waste

A key consideration during the previous ground investigations and assessments was the loading of landfill deposits through the construction of bunds on top. The increased loading was theorised as squeezing the landfill deposits causing entrained leachate within the pore space to vertically migrate to the Chalk Formation impacting sensitive aquifers and receptors. The loading effect is identified as a short term impact with the identification in the long term the bund loading would increase bulk density and decrease pore space decreasing effective porosity and decrease infiltration of surface water through the waste. In the long term the bunds are determined as having significant environmental betterment.

A detailed assessment of the likely impact on the sensitive controlled water receptors was completed as part of the work completed by Capita in response to planning conditions. A review of the assessment identified it as being conservative due to several factors as detailed in the 2023 Waterman DRMS[8]. Accounting for these factors identifies the squeezing effect on un-excavated material as unlikely impacting sensitive controlled water receptors, principally the Principal Aquifer in the structured Chalk Formation.

Attenuation factors and assessment considerations in determining the risk posed to the Principal Aquifer are summarised below.

- The landfill deposits are not in hydraulic continuity with the Principal Aquifer in the Chalk Formation as confirmed through the supplementary 2022 Waterman ground investigation[9] in which the two deposits were identified in limited hydraulic continuity. The restricted hydraulic continuity will mean where additional leachate is generated through decreasing pore space a direct migration of these contaminants to the aquifer will be absent.
- The bunds will be constructed over a 1 year (northern bund) and 3 year (southern bund) period so the instantaneous loading assessed previously will not occur. The increased leachate generation will be

[8] Waterman, May 2023, Detailed Remediation Method Statement, RAD-WAT-A2EX-XX-MS-I-0024
[9] Waterman, January 2023, Ground Conditions Report, RAD-WAT-A2EX-XX-Rp-I-0003

spread over a relatively long time frame, so a short term spike in leachate entering groundwater will therefore not occur.

- The GI identifies a vadose zone 3.7 – 4.6m thick within the landfill deposits. Loading of the landfill deposits through bund construction will result in the decrease in pore space and increase in soil bulk density in this vadose zone. The absence of large quantities of entrained leachate within this phreatic zone will mean the quantum of leachate generated through the loading of bunds will be substantially reduced relative to the previous assumption increased leachate will be generated through the whole landfill deposit.
- The proposed bunds will increase the phreatic zone over the landfill waste significantly decreasing surface water infiltration through the waste body, and leachate generated.

During the construction phase the exposed and stockpiled waste may also generate leachate through surface run-off. These risks would be managed through implementation of a Construction Environment Management Plan (CEMP) and a Dust Emissions Management Plan (DEMP) prepared for the works.

3.8 Receptor

Receptors identified on-site and in the surrounding area include;

- Principal Aquifer in the Chalk Formation
  - The Chalk Formation has varying permeabilities leading to the groundwater sitting within zones of higher permeability. The Chalk Formation has a dual porosity with groundwater flow travelling slowly through the highly porous but low permeability chalk matrix and travelling rapidly through fissures/cracks in the Chalk which have low porosity but a high permeability. The GI has identified structureless Chalk on-site within which groundwater flow through the matrix will dominate. The presence of fractures will be limited within this highly weathered zone, with interconnectivity between fractures also very limited. Below the structureless deposit it is expected a highly fractured zone of high permeability (structured Chalk) will exist through which rapid groundwater and contaminant flow will occur. The structured Chalk is the principal layer from which potable groundwater is extracted. This structured Chalk layer is overlain by a significant deposit of structureless Chalk and is at significant depth from the landfill which forms only a thin deposit close to the Site surface. The relatively high depth to structured Chalk and overlying low permeability deposits means impacts from Area 2 are highly unlikely to impact the groundwater abstraction boreholes. Its noted substantial attenuation will also occur along the lateral contaminant pathway further decreasing risks to sensitive controlled water receptors.
  - Groundwater flow in the Chalk Formation has been determined as being south west towards the groundwater abstraction borehole system at Netherwild Pumping Station located 1.2km from Area 2. The Netherwild Pumping Station comprises a shaft 54.9m deep with a diameter of 0.9m cased to 34.1mbgl, a series of adits radiating out from the shaft the longest of which is 275.8m long and is northwest. The floor of the adits is at 40.7m (22.3mAOD) and are 1.2m x 1.8m. Two additional boreholes are present close to the main shaft installed after the shaft was constructed and are also 54.9m deep have a diameter of 0.9m and are cased to a depth of 33.5mbgl. Groundwater is abstracted from the shaft and two boreholes using electrical submersible pumps. The pumping station layout identifies the Principal Aquifer as being abstracted from below a depth of 27.5mAOD. Given ground levels on Area 2 were recorded between 70.25mAOD and 73.3mAOD it identifies the aquifer abstracted from (located 1.2km south west) being between 42.75m and 45.8m below Area 2 existing level. A substantial vertical distance between the recovered waste deposits and sensitive part of the Principal Aquifer is therefore present, this distance would allow a significant amount of attenuation of contaminants where present to occur.

   - Area 2 is within the Mid-Chiltern Chalk groundwater body which is classified as poor by the EA. The groundwater body is 30km^2, Area 2 covers <1% of the total groundwater body. Overall the groundwater body has been classified as poor due to poor water balance and quantitative status of dependent surface water bodies. The classification chemical element is poor due to failures to meet the Drinking Water Protected Area standards and in 2019 due to failure to meet a General Chemical Test. Reasons given for poor status are contaminated land, sewage discharges, poor nutrient management, private sewage treatment, incidents (industry), and groundwater abstraction.
- Surface Water Receptors
   - The River Colne is located 375m east of Area 2, is founded in the Chalk, and is seasonal being largely dry during the GI. The River Colne is potentially fed by surface water run-off from the M25 through a series of drains off the main bridge structure. The groundwater flow direction beneath Area 2 is south west, whilst the River Colne at its closest point is 375m south east, its closes point accounting for groundwater flow direction would place it around 800m from Area 2. Between the River Colne and Area 2 is another former landfill. Given the distance from Area 2 substantial attenuation of contaminants will occur. Laboratory analysis of surface water samples from the River Colne recorded contaminant concentrations below the EQS threshold concentrations, and ammoniacal nitrogen between 0.027mg/l and 0.1mg/l. The ammoniacal nitrogen concentrations are consistent with those recorded in the Chalk and orders of magnitude lower than those recorded in the landfill.
   - The River Ver is 800m at its closest point to boundary of Area 2 and is considered not be a significant receptor.
   - Several surface water drains are present on Area 2 running west to east at a shallow depth terminating in the River Colne. The drains run between and above the landfills and are fed by surface water run off rather than groundwater.

3.8.1 Receptors at Completed Permitted Area

On completion of the works the recovered waste will be located in bunds raised above ground level underlain by an existing landfill as clarified by completed ground investigations. The recovered waste will be overlain by a planted topsoil subsoil layer in its final state. This will prevent runoff and dust emissions, and reduce rainfall infiltration to ground. Subsequently, contaminant migration through groundwater driven by rainfall infiltration will be reduced.

The squeezing of the un-excavated landfill waste underlying the landscape bunds will occur over a short time period with limited squeezing occurring following initial loading. Post works completion the proposed bunds will increase the phreatic zone over the un-excavated landfill waste significantly decreasing surface water infiltration through the waste body, and leachate generated.

The waste recovery works undertaken to construct the landscape bunds will result in Area 2 having a decreased impact in the surrounding controlled water receptors.

As part of the bunds construction, a combination of filter trenches and swales will be installed around the base of each bund to intercept overland water flows from the bunds and Area 2 more generally. Collectively these features will slow the flow and reduce the particulate load of surface waters before discharge to the existing stream on the eastern boundary of Area 2. All drainage features are to be lined to prevent infiltration. For further information refer to the proposed landscaping bund surface water drainage plans (D-ESSD6A to D-ESSD6D).

The drainage system will have the secondary benefit in substantially reducing rainwater filtration through the bund to the underlying waste, decreasing the production of leachate from landfill waste and resulting in an improvement in groundwater and surface water quality compared to existing.

3.9 Conceptual Hydrogeological Conclusion

The 2016 Capita ground investigation and 2022 Waterman ground investigation has identified historic landfill on Area 2 as containing a variety of wastes consistent with that authorised. Soil laboratory analysis has identified contaminant concentrations generally at low concentrations. Leachate laboratory analysis has recorded elevated metal contaminants in 2No. locations. The soil and leachate laboratory results indicate the waste present is unlikely to impact the identified receptors.

The 2016 Capita ground investigation completed on Area 1 in which Made Ground, restoration material, and natural material will be gained and used under the waste recovery activity, has been identified as having low contaminant concentrations. The use of material from Area 1 within the landscape bunds is unlikely to have a significant impact on identified receptors.

A robust assessment of the groundwater contamination status has completed given Area 2 is located in a groundwater SPZ1 and SPZ 2, and the River Colne is present 375m east. A review of the groundwater laboratory results has identified Area 2 as not currently having a significant impact on the Principal Aquifer within the structured Chalk Formation. The intervening structureless Chalk Formation, and basal clay liner together with other attenuation factors means the water entrained in the landfill deposits is hydraulically separated from the structured Chalk Formation.

Surface water samples recorded all contaminants below the EQS threshold criteria identifying Area 2 as not having a significant impact on the River Colne.

The construction of the landscape bunds will increase the loading on the un-excavated landfill waste underlying the landscape bunds. The increased loading will squeeze the unexcavated landfill deposits resulting in entrained leachate vertically migrating to the underlying Principal Aquifer in the Chalk Formation. A review of the conceptual model identifies the volume of entrained leachate generated at any one time as being limited with the loading occurring over an extended period of time. Several attenuation factors have also been identified for which the migration of leachate and associated contaminants to sensitive controlled water receptors will be limited. A significant risk to controlled water receptors through the squeezing of un-excavated landfill waste caused through construction of the landscape bunds is therefore absent.

4. Hydrogeological Risk Assessment

4.1 Qualitative Risk Screening

The qualitative risk screening purpose is to assess whether the potential discharge from depositing the recovered waste is acceptable and will not require further assessment. Waste will be used to construct landscape bunds LS1 and LS2 situated above historical landfill deposits. The bunds will only be partly constructed from excavated landfill waste with the remainder of the bunds constructed from other site won material comprising restoration soil, made ground and natural strata from Areas 1 and 2. The recovered landfill waste will occupy a fraction (5.10%) of the total material present within bunds LS1 and LS2.

The restoration material, Made Ground, and natural material have not been identified as a plausible source based on the previous ground investigation results and will be excluded from further consideration.

Intrusive ground investigations have established in situ landfill waste and associated entrained leachate and water as being hydraulically separate from the Principal Aquifer in the structured Chalk Formation. Placement of treated landfill waste in the bunds will increase the distance to the Principal Aquifer in the structured Chalk Formation in addition to decreasing the infiltration of surface water through the existing landfill waste that will remain beneath the completed bunds thereby reducing the leachate production potential of the landfill waste beneath the completed bunds.

Following bund completion a reduction in the risk to the Principal Aquifer in the structured Chalk Formation will therefore exist.

The bunds design will incorporate surface water management to substantially reduce infiltration of water through the recovered landfill waste used in the bunds, the surface water management will work in tandem with a cover layer which will be situated above the waste. The placement of the recovered landfill waste above ground level, and restriction of surface water infiltration through the bunds and underlying un-excavated landfill waste will mean an increased risk to the River Colne will be absent.

The waste recovery EP will exclude hazardous waste. The use of the recovered landfill waste will not introduce a new contamination source. Acceptance procedures for the waste set out in the Waste Acceptance Procedures (WAP – RAD-WAT-A2EX-XX-RP-I-0034) included in the EP application will ensure any unacceptable contamination in the waste is identified, and is not recovered.

Potential contaminant pathways have been identified during the works from runoff or dust emissions from exposed soils. These risks would be managed through implementation of a Construction Environment Management Plan (CEMP) and a Dust Emissions Management Plan (DEMP) prepared for the works. This will include the provision of working methods to restrict the release of leachate generated within stockpiled material. The required actions may include the use of impermeable membranes beneath landfill waste.

The qualitative assessment identifies a positive impact on the existing conceptual hydrogeological model for Area 2 with a reduction in the risk to identified sensitive controlled water receptors. It is noted the existing conceptual hydrogeological model for Area 2 identifies a significant impact on controlled water receptors as being absent.

4.2 Quantitative Risk Assessment

The recovered landfill waste proposed to be used under the waste recovery EP will comprise non-hazardous waste which will have the potential to generate leachate. Restoration material, Made Ground, and natural material has been removed as a viable pollutant source. As demonstrated in the completed ground investigations and assessments, notably through the completion of supplementary ground investigation a significant risk or impact to identified controlled water receptors has not been identified.

A detailed assessment of the risk to controlled water receptors has been completed in the 2017 Capita Detailed Quantitative Risk Assessment (DQRA) which was approved under planning controls by the regulatory authorities.

The 2017 Capita DQRA was completed prior to the 2022 Waterman supplementary ground investigation which increased the body of information and allowed a greater understanding of the conceptual site model. The updated CSM as summarised in this HRA identifies the landfill waste (in-situ) as being hydraulically separate from the Principal Aquifer in the structured Chalk Formation. The Capita 2017 DQRA assumes a greater degree of connectivity between the two deposits in its assessment.

Whilst the 2017 Capita DQRA does not account for the updated CSM as assessed in the 2023 Waterman DRMS excluding the determination the two deposits are hydraulically discontinuous and excluding the associated attenuation of contaminants between them ensures the 2017 Capita DQRA and associated model is overly conservative rather than conservative.

The 2017 Capita DQRA was submitted and approved under planning controls by both the EA and council Environmental Health Officer. The 2017 Capita DQRA utilised the ConSim modelling software and was completed assessing the following scenarios:

- Regular Model
  - Model run assuming no construction activities undertaken. Assumes no reduction in infiltration or reduction in pore space through construction of bunds[10].
- Squeezed Model
  - Alterations to the regular model to account for the constructed bunds and associated increased loading. Model was altered through a decrease in porosity and increase in density within the source zone.
- Capping Model
  - Model run to simulate Area 2 post development construction with associated reduction in infiltration created through the construction of the bunds.

The model was run for three receptors; the base of the unsaturated zobe, 50m down hydraulic groundwater compliance point, and the River Colne 380m down hydraulic gradient. For contaminants, ammoniacal nitrogen and nitrite, an absence of soil laboratory data required the model to be run with these contaminants originating in the aquifer.

Contaminants modelled by Capita in their 2017 DQRA were those recorded in exceedance of the EQS and DWS during their assessment of groundwater laboratory results. Those contaminants modelled included the following;

- Ammoniacal Nitrogen;
- Nitrite;
- Naphthalene;
- Anthracene;
- Fluoranthene;
- Boron;
- Copper
- Nickel;
- Zinc;
- TPH Aromatic C10 – C12
- TPH Aromatic C12 – C16.

Of these elevated contaminants anthracene is listed as a priority hazardous substance and nickel and

[10] The Capita work used the term “earth mounds”

naphthalene as priority substances under the Water Framework Directive (WFD). Given emissions of priority hazardous substances and priority substances should be reduced entirely within the environment, these contaminants were modelled assuming the receptor was the aquifer, therefore not accounting for dilution to an off-site receptor such as an abstraction borehole or surface watercourse.

The model results identified contaminants generally being modelled below the target criteria with the exception of ammoniacal nitrogen which exceeded the target criteria (0.3mg/l EQS, 0.5mg/l DWS) within all three model scenarios ran.

It was however noted a reduction in ammoniacal nitrogen modelled concentrations was present in the Capping Model. Naphthalene, whilst elevated in the Regular Model was recorded below the target criteria in the Capped Model. The Squeezed Model identified the effects of squeezing through loading did not significantly increase the concentrations of contaminants at the receptors. The Capita DQRA concluded the enhanced landfill capping created by the construction of bunds would show improvement, and mitigate the long term impacts on controlled waters.

The Capita 2017 model therefore identifies implementation of the proposed Development as improving groundwater quality in the Principal Aquifer (Chalk Formation) through a reduction in infiltration by enhancing the landfill capping layer. The placement of material (waste) within bunds LS1 and LS2 as modelled and as approved by the regulatory authorities (EA and St Albans Environmental Health Officer) would have a beneficial impact only on the controlled water receptors.

4.3 Review of Technical Precautions

Complete pathways from the recovered landfill waste to the identified groundwater receptors do not exist therefore due to the absence of pathways compliance with the Groundwater Regulations is not relevant. Capping, a liner or leakage detection, leachate drainage system, leachate head control or groundwater and surface water management for the protection of groundwater are not required. Details of waste acceptance procedures are provided in the WAP.

During earthworks, control measures will be in place to prevent surface water runoff leaving the permitted site.

4.4 Hydrogeological Completion Criteria

During earthworks, the waste placement activities will be managed to prevent contamination of controlled water receptors. The active management of leachate during the earthworks or in the completed Development would not be required.

As detailed in this report an in agreement with the EA (Hertfordshire and North London area) a programme of groundwater monitoring will be completed prior to, during, and post completion of the work to assess whether the works is having or has had an impact on the groundwater contamination status and associated risk to controlled water receptors. A sequence of appropriate contingency measures have been set out should the groundwater results identify an increased risk to controlled water receptors. Application of the contingency measures would ensure a long term negative impact on controlled water receptors is absent.

5. Requisite Surveillance

5.1 Risk Based Monitoring Scheme

A groundwater monitoring strategy has been devised covering the entire enabling works on Area 2 including the recovery of waste under the waste recovery EP. The groundwater monitoring strategy initially set out in the January 2018 Capita Geo-environmental Monitoring Proposals[11] and amended in the April 2019 Bradbrook Consulting Remediation Contingency Plan[12] has been amended from that agreed to account for boreholes located in areas which will be destroyed during construction of the landscape bunds and to ensure boreholes installed with a dual installations are not monitored.

All new boreholes will be single well installations, with existing boreholes not due to be retained as part of the groundwater monitoring regime decommissioned in accordance with the 2012 Environment Agency Good Practice for Decomissioning Redundant Boreholes and Wells.

5.1.1 Leachate Monitoring

Leachate monitoring is not required.

5.1.2 Groundwater Monitoring

The groundwater monitoring purpose is to understand the groundwater quality throughout the works identifying any deterioration or alteration to the currently understood hydrogeological CSM. Where deterioration in groundwater quality or alteration to the hydrogeological CSM occurs the groundwater monitoring undertaken will inform the risk assessment and determination of the suitability of monitored natural attenuation (MNA) in reducing contaminant concentrations within a suitable distance and timeframe. Additional monitoring beyond that specified may be undertaken as required to inform the risk assessment.

The monitoring programme and methodology will be continually reviewed to confirm it is suitable and is optimised. Where the programme/methodology is altered the regulatory authorities will be advised accordingly.

The overall groundwater monitoring objective is to identify deterioration in groundwater quality and where identified provide a substantial body of information to assess the risk. A deterioration in groundwater quality will be defined as an increase in contaminant concentrations by two orders of magnitude relative to baseline conditions, and relative to wells representative of background groundwater quality as recorded during each monitoring round.

Full details of the groundwater monitoring plan are included in the Monitoring Plan and CQA Plan (RAD-WAT-A2EX-XX-RP-I-0035) which should be referred for the complete groundwater monitoring details.

Monitoring Wells

Installed wells which will be monitored include; WBH101, WBH107, WBH109, WBH110, WBH114, WBH116, WBH117, WBH119, WBH118. The locations of these monitoring wells are included on plan D-ESSD10B.

Where a monitoring well is destroyed or becomes unserviceable, a replacement monitoring well will be progressed in the closest available positions. The replacement monitoring well design will mirror the well

[11] January 2018, Capita, Radlett Strategic Rail Freight Interchange Areas 1 and 2, Geo-environmental Monitoring Proposals, CS-070751-PE-17-050-R

[12] April 2019, Bradbrook Consulting, Radlett Strategic Rail Freight Interchange Area 2, Remediation Contingency Plan, 18-175

they are replacing. Where ground conditions alter substantially in the area of the proposed monitoring well the design will be reviewed cognisant of the monitoring wells objectives.

The results from specified wells will be continually reviewed throughout the groundwater monitoring programme and decisions made as to the suitability and requirement for the groundwater monitoring in all identified monitoring well localities. Where changes are required, these will be agreed with the regulatory authorities.

Monitoring Frequency

An enhanced monitoring frequency to that proposed and agreed by Bradbrook Consulting will be undertaken. The monitoring frequency employed is included below.

- Prior to commencement of Area 2 excavation activities/bund construction
  - 1 month intervals for six months
- During excavations and Area 2 bund construction
  - Fortnightly intervals
- Post Area 2 bund completion
  - 1 month intervals for 12 months
- 12 months post Area 2 bund completion
  - 3 month intervals for 12 months

The frequency of the sampling visits will be reviewed and may alter dependent on the recorded laboratory results. Any changes will be agreed with the regulatory authorities prior to implementation.

Monitoring Methodology

Dedicated sampling equipment will be used for each monitoring well, with the tubing tip positioned at the midpoint of the well response zone. The groundwater samples will be collected once the following parameters detailed in Table 5 have been met.

Table 5: Low flow monitoring stabilisation parameters

Parameter	Stabilisation Levels
Dissolved Oxygen	±10% of reading or ±0.2mg/l, whichever is greater
pH	±0.2 pH units
Eh or ORP	±20mV
Conductivity	±3% of reading
Temperature	Not in use as a stabilisation parameter

Once the stabilisation parameters have been met the groundwater samples will be obtained within sampling containers deemed appropriate to undertake the required testing. Discussions will be undertaken with the testing laboratory to ensure the sampling containers are appropriate to avoid contamination bias.

UKAS and MCERT accredited laboratories will be used for the chemical analysis of groundwater.

During each monitoring round the groundwater level and any potential NAPL thickness will be recorded. Photographs will be taken of the NAPL as contained in a bailer or sampling vial.

Testing Regime

As agreed with the EA groundwater samples will be tested for the following contaminant suite:

- TPH CWG (Total Petroleum Hydrocarbon Criteria Working Group)
- BTEX (Benzene, Toluene, Ethyl Benzene, Xylene (m/p and o)
- VOC (Volatile Organic Compounds)
- SVOC
- Speciated PCBs
- Speciated PAH (Poly-cyclic Aromatic Hydrocarbons)
- Ammoniacal nitrogen as N
- Nitrate as N
- Nitrite
- Ammonia (NH3)
- Metals (As, Bo, Cd, Cr (VI), Cu, Pb, Hg, Zn, Ni, Co).
- Fluoride, bromide, chloride,
- PFAS Standard suite.

As with the other groundwater monitoring factors the contaminants tested for may be altered following the continual review of the results. Any changes will be agreed with regulatory authorities prior to implementation.

Contingency Plan

The overall groundwater monitoring objective is to identify deterioration in groundwater quality and where identified provide a substantial body of information to assess the risk. A deterioration in groundwater quality will be defined as an increase in contaminant concentrations by two orders of magnitude relative to baseline conditions[13], and relative to wells representative of background groundwater quality as recorded during each monitoring round.

The contingency plan when implemented due to a deterioration in groundwater quality being identified would comprise the following actions;

- Stage 1
  - Confirmation with the laboratory no errors could have occurred during testing.
  - Review of actions undertaken on-site to confirm pollution incidents which could have caused the recorded change in groundwater contaminant status.
  - Re-testing of the original sample if sufficient quantity remains.
  - Completion of an additional sampling round to confirm the contaminant concentrations.
  - Communication with the regulatory authorities as to the results recorded.
- Stage 2
  - Additional risk assessment to determine whether the concentrations recorded pose a risk to identified controlled water receptors.
  - Should a risk be identified, the assessment will consider whether based on the parameters recorded and known hydrogeological risk assessment whether MNA is a suitable remedial action to ensure sensitive controlled water receptors are protected.

[13] Baseline conditions will be gained from the six monthly monitoring rounds completed for six months in advance of the Area 2 bunds construction, and from the groundwater results gained form the 2022 Waterman ground investigation as reported in the 2023 Waterman Ground Conditions Report (RAD-WAT-A2EX-XX-RP-I-0003).

- Stage 3
  - Where MNA is not identified as a suitable methodology in ensuring a significant risk to sensitive controlled water receptors is absent after extensive detailed risk assessments, a further contingency remedial action plan will be determined and undertaken. The contingency measure will be appropriate to the contaminants of concern identified, the contaminant magnitudes, receptor/receptors at risk, and strata the contaminant is identified within. The determined contingency measure under Stage 3 will be agreed with the regulatory authorities prior to implementation.
  - Whilst we have identified several possible flaws in the current agreed contingency system as detailed in the 2019 Bradbrook Consulting Report, consideration will be given to implementing the proposed contingency system. This measure will not be installed at the outset of the works and will only be implemented should other appropriate contingency measures not be identified, and where extensive risk assessments have been completed in advance.

As required an appropriately qualified environmental consultant will review and interpret the change in groundwater conditions or contamination status, and in agreement with the regulatory authorities determine whether an increased risk is present to controlled water receptors and if so, what remedial measures may be required.

Consistent with the current agreed approach groundwater monitoring will remain to ensure any deterioration in Chalk groundwater quality is identified and any inconsistencies with the CSM identified. Where deterioration is identified dependent on the contaminants of concern present, location, receptor at risk, and magnitude of contaminants determination of an appropriate remedial technique will be established and agreed with regulatory authorities.

The determined and agreed remedial technique will account for the presence of other landfills down hydraulic gradient and may be preceded by detailed modelling to clarify whether a significant risk to sensitive controlled water receptors exists. The remedial techniques will also be proportional to the identified risk and will not follow an unsustainable or impractical approach.

6. Conclusions

6.1 Compliance with the Landfill Directive

The Landfill Directive is not applicable as this is an application for a permanent deposit of waste for recovery.

6.2 Compliance with the Groundwater Regulations (2009)

The recovered waste will not pose a threat to groundwater and surface water due to the absence of any complete source-pathway-receptor linkages to identified receptors.

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