Monitoring Plan & CQA Plan

Radlett SRFI Area 2

September 2023

Waterman Infrastructure & Environment Limited
Pickfords Wharf, Clink Street, London, SE1 9DG, United Kingdom
www.watermangroup.com

Client Name:	SEGRO Radlett Ltd
Document Reference:	WIE18710-100-R-31-2-2-MON&CQA
Project Number:	WIE18710
Asite Reference:	RAD-WAT-A2EX-XX-RP-I-0035
Status	P02
Revision	S3

Quality Assurance – Approval Status

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
31.2.2	September 2023	James Tew Graduate Consultant	Ben Greenfield Associate Director	Sarah Owen Associate Director

Comments

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1. Introduction

1.1 The Brief

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.

A Monitoring Plan and CQA (Construction Quality Assurance) Plan are required to support the EP application, due to the risk of ground gas emissions arising from the activity and the risk and impact on controlled waters through the recovery of waste.

With respect to ground gas and ground water this monitoring plan builds on the [1]Capita 2018 Geoenvironmental Monitoring Proposals as approved by St Albans pursuant to Condition 24.1 of planning permission 5/2009/0708.

1.2 Context

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] Capita Radlett Strategic Rails Freight Interchange Area 1 and 2, Geoenvironmental Monitoring Proposals dated January 2018 (Ref: CS-070751-PE-17-050-R, Rev V2

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 Report Structure and Scope

The EP application requires a Monitoring Plan and a Construction Quality Assurance Plan (CQA). This has been developed using the relevant EA guidance[2].

[2] 2022, Environment Agency, Engineering construction proposals for deposit for recovery, https://www.gov.uk/government/publications/deposit-for-recovery-operators-environmental-permits/engineering-construction-proposals-for-deposit-for-recovery, Accessed 15/06/2023.

This document follows on from the Gas Risk Assessment (GRA) and Hydrogeological Risk Assessment (HRA) presented elsewhere in the waste recovery EP application which should be read in conjunction with this document. It also reproduces the settlement monitoring required by the Earthworks Specification (RAD-WAT-A2EX-XX-SP-0023).

The monitoring plan and requirements for dust emissions are detailed separately in the Dust and Emissions Management Plan (DEMP) included in the EP application.

VFL's general and environmental management policies and procedures are in place for the wider construction site and will be applied as appropriate to the permitted activities. VFL documents referred to are included elsewhere in the application bundle.

The Monitoring Plan and CQA Plan will form part of the Environmental Management System (EMS) to be operated by the applicant for the lifetime of the EP. A copy of this document and EMS will be kept in VFL's site office, on the wider construction site.

Plans and drawings have been prepared and are presented separately elsewhere in the application bundle ("ESSD drawings and information bundle").

1.4 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.

2. Monitoring Plan

2.1 Ground Gas Monitoring

2.1.1 Purpose of the Monitoring Plan

A detailed assessment of the ground gas risk incorporating a detailed review of ground gas sources, pathway and receptors has been completed and included in the Gas Risk Assessment submitted with the EP application. The established ground gas conceptual model concluded the following:

Loading of undisturbed historic landfill underlying landscape bunds

The historic landfill material underlying the bunds will be loaded resulting in the displacement of ground gas within the pore space. The displacement will be spread over the period of time bunds are constructed such that a limited volume of ground gas will be produced. The gas displaced will be subject to limited lateral migration due to the several attenuation factors including the absence of a continuous impermeable overlying the area between the historic landfills and the sensitive receptors (Area 1 proposed Development). The bund construction would also not alter the historic landfill ground gas generational potential which from previous ground investigations and desk based assessment has been identified as Low. Generation of sustained ground gas will therefore be absent. The conceptual model for the bund construction on existing historic landfill therefore identifies the risk as low with the pollutant linkage broken through source and pathway removal. Notwithstanding the assessment, ground gas monitoring will be undertaken between the landscaping bunds and Area 1 to monitor ground gas concentrations and flow rates to determine whether a significant impact is being created.

Waste to be used within landscape bunds

Wastes to be used within landscape bunds and their associated ground gas generational potential include the following:

- Treated landfill waste – low ground gas generational potential as evidenced by ground gas monitoring results, and age of material.
- Restoration material including Made Ground – low ground gas generation potential with low labile organic matter content and as evidenced by ground gas monitoring results.
- Natural material – low ground gas generational potential.

The treated landfill waste will form only a small portion of the landscape bunds with bunds primarily constructed from natural material, and restoration material.

The landscape bunds will be located above ground, where ground gases are generated, they will disperse and dilute within the atmosphere. A plausible pathway to identified receptors is absent and a low risk is assigned to waste used to construct the landscape bunds.

A significant impact on the global climate has not been identified given the low ground gas generational potential of the material.

A potentially significant risk to construction workers and maintenance workers during excavations into the landscape bunds post completion as part of any future works or maintenance actions has been identified which will require management through the application of appropriate health and safety measures and wearing of PPE as required. All works will also require adherence to the 1997 Confined Space Regulations.

Preferential pathways

Potential preferential pathways identified include drainage swales, drainage filter trenches and culverts. A review identifies the pathways either open to air, open ended and/or vented, and they have therefore been discounted as preferential pathways.

The purpose of the ground gas monitoring plan will be to establish whether significant lateral ground gas migration is being caused through the construction of the landscape bunds (LS1 and LS2) on Area 2. This will be achieved through ground gas monitoring wells positioned west of the proposed landscaping bunds on Area 2.

2.1.2 In-waste Monitoring

In-waste monitoring of the landscape bunds (LS1 and LS2) is not proposed as they will be located above ground, and where ground gases if generated, will disperse and dilute within the atmosphere. A plausible pathway to identified receptors is absent and a low risk is assigned to the waste to be used to construct the landscape bunds.

A series of monitoring wells have been proposed in the footprint of the landscape bunds. A plan detailing the monitoring well locations for those on Area 2 (WIE WS04, WIE WS05, WIE WS06, WIE WS07, WIE WS08, WIE WS09, WIE WS10, WIE WS11, WIE WS12, WIE WS13, WIE WS14, WIE WS15, WIE WS16, WIE WS17, WIE WS18) can be found in the “ESSD drawings and information bundle” submitted with the EP application (D-ESSD7A).

The purpose of these monitoring wells is to provide further information in understanding the ground gas generational potential of the historic landfill to remain in place further to providing a more robust assessment of the lateral ground gas migration potential on loading.

During construction of the landscaping bunds the wells installed in the footprints of the bunds (WIE WS04, WIE WS05, WIE WS07, WIE WS11, WIE WS12, WIE WS16, WIE WS17) will be destroyed and no longer serviceable. Where destroyed they will not be replaced noting the principal purpose of this ground gas monitoring is not to monitor the ground gas generational potential of the historic landfill which will remain but the lateral migration of the ground gas on loading. Monitoring wells positioned outside the landscape bunds footprints which are destroyed or otherwise no longer serviceable will be replaced in the next closest position with a similar installation (and in line with the CQA Plan, see section 3.1).

2.1.3 Out-of-waste Monitoring

A series of monitoring wells have been positioned both within the footprint of the landscape bunds and external to the landscape bunds to establish the lateral migration of ground gas prior to and during the bunds construction, and during the aftercare period to quantify lateral ground gas migration. Those positioned within the footprint of the landscape bunds will be to establish baseline conditions and improve the robustness of the current assessment of the existing materials ground gas generational potential.

Monitoring wells will be positioned both on Area 1 and Area 2. Monitoring wells which will be installed and monitored on Area 1 are included on plan D-ESSD7B (BWBBH05, BWBBH06, BWBBH09, BWBBH10, BWBBH11, BWBBH12, BWBBH14, BWBBH15, BWBBH16, BWBBH17, BWBBH19, BWBBH21, BWBBH22, BWBBH24, BWBBH25, BWBBH27, BWBBH29, BWBBH31). Monitoring wells positioned on Area 2 include WIE WS06, WIE WS08, WIE WS09, WIE WS10, WIE WS13, WIE WS14, WIE WS15, WIE WS18 and are included on plan D-ESSD7A.

The monitoring of these wells will cease when the completion criteria for ground gas have been achieved. It should be noted, as identified in the GRA, given the identified negligible ground gas generation potential of the deposited waste and the underlying existing landfill waste beneath the landscaping bunds significant volumes and migration of ground gas are unlikely to occur.

During construction of the landscaping bunds the wells installed in the footprints of the bunds will be destroyed and no longer serviceable. Where destroyed they will not be replaced noting the principal purpose of this ground gas monitoring is not to monitor the ground gas generational potential of the historic landfill which will remain but the lateral migration of the ground gas on loading. Monitoring wells positioned outside the landscape bunds footprints which are destroyed or otherwise no longer serviceable will be replaced in the next closest position with a similar installation (and in line with the CQA Plan, see section 3.1).

2.1.4 Data Collection and Assessment

Monitoring during and following waste deposition completion will be at the following intervals in accordance with the 2014 EA guidance[3].

- At monthly intervals for 6 months prior to commencement of Area 2 bund construction;
- At commencement of bund construction;
- At monthly intervals during Area 2 bund construction (estimated to take 18 to 24 months in total);
- On completion of Area 2 bund construction; and
- At 2 month intervals post Area 2 bund construction.

The above monitoring intervals will be the initial intervals based on the body of information available and should be regarded as the minimum requirements. As ground gas information is obtained during the monitoring, further establishing the lateral ground gas migration risk, the monitoring interval and total time the monitoring is completed will be reviewed. As required and only in agreement with the EA will the monitoring interval and total time length may be decreased or increased.

The ground gas results will be collated and regularly reviewed by an experienced environmental consultant and reported to the EA as required by permit conditions and in due course in the surrender report. In addition, regular auditing of the ground gas monitoring will be completed to verify that it is being completed in accordance with this document, industry best practices, and as per a written procedure detailed and issued to the contractor prior to monitoring commencement.

The parameters monitored during each monitoring round will include; methane, carbon dioxide, oxygen, ground gas flow rate, atmospheric pressure (prior to and during), and differential pressure. The ground gas concentrations and ground gas flow rate will be recorded for a minimum duration of 5 minutes at the following intervals: 10s, 30s, 45s, 60s, then at 1-minute intervals until concentrations/flow rate have achieved a steady state. It will be the peak steady ground gas concentration and flow rate which will be used to assess the risk.

The baseline ground gas conditions will be established from the 6 rounds of monitoring completed at monthly intervals prior to commencing of the bunds construction. Previous ground gas monitoring results where representative and applicable will be incorporated into the baseline ground gas conditions with the 6 rounds of monthly monitoring taking precedence over the previous ground gas results.

During each monitoring round and in the report distributed to the EA the ground gas results will be compared against the baseline ground gas results (concentrations and flow rate), ground gas results recorded during previous ground investigations (Capita 2016 and MJ Carter Associates 1993-1997), and

[3] 2014, Environment Agency, Management of landfill gas: LFTGN 03, https://www.gov.uk/government/publications/management-of-landfill-gas-lftgn-03, Accessed 29/06/2023.

the ground gas results recorded during the preceding monitoring rounds. Where elevated ground concentrations/flow rates are recorded further assessment will be undertaken to determine whether an actual risk to receptors is present. The assessment will be heavily weighted on the ground gas flow rate given it is the rate at which a ground gas can migrate to a receptor rather than the ground gas concentration which dictates the level of risk.

2.1.5 Trigger Level and Action Plan

The most sensitive receptor identified at risk is the future completed Development on Area 1 in which a CS1 ground gas regime will be present in which ground gas protection measures would not be required. The development on Area 1 currently does not exist and will be phased from north to south between 2024 and 2026. A preliminary action/trigger level will therefore be set at the Gas Screening Value (GSV) for a which a CS2 classification should be considered (0.07l/hr (methane / carbon dioxide).

Where the 0.07l/hr GSV is exceeded following assessment of the ground gas concentrations and flow rates on each monitoring round the following actions may be undertaken in a stepwise sequence:

- an additional monitoring round will be undertaken to confirm the ground gas monitoring results, with monitoring increased to weekly intervals until clarification of the ground gas regime can be established;
- further risk assessment undertaken to determine if an increase beyond the GSV trigger level poses an actual risk to receptors, given the pathway inhibitors present, and whether the development on Area 1 is constructed; and
- installation and completion of continuous ground gas monitoring or completion of a flux box survey where appropriate to further establish the ground gas regime and lateral ground gas migration risk.

Where exceedances of the trigger values occur the specific measures enacted will be conveyed and agreed with the regulatory authorities including the EA in accordance with EP requirements.

2.2 Groundwater Monitoring

2.2.1 Purpose of the Monitoring Plan

To understand the groundwater quality throughout the works identifying any deterioration or alteration to the currently understood hydrogeological conceptual site model (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.

Where MNA is not identified as a suitable methodology in determining a risk to sensitive controlled water receptors after extensive detailed risk assessments a further contingency remedial action plan will be determined and undertaken. Including consideration of that detailed in the Bradbrook 2019 Report.[4]

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 and only enacted following agreement.

[4] Bradbrook Remediation Contingency Plan, Radlett Strategic Rail Freight Interchange Area 2, dated April 2019 (Ref 18-175)

2.2.2 Receptors

Receptors identified on Area 2 and in the surrounding area include:

- Principal Aquifer in the Chalk Formation
  - 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 ground investigation 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 a highly fractured zone of high permeability (structured Chalk) exists through which rapid groundwater and contaminant flow will occur. The structured Chalk is the principal layer from which potable groundwater is extracted and as such is where groundwater monitoring is targeted.
- 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 2022 Waterman GI. The groundwater flow direction on Area 2 is south west, whilst the River Colne at its closest point is 375m south east, its closest point accounting for the groundwater flow direction (south west) would place it around 800m from Area 2.
  - Given the distance from Area 2 substantial attenuation of contaminants will occur. In addition, between the River Colne and Area 2 is another former landfill making it difficult to attribute variations in water conditions to Area 2. For these reasons, monitoring of surface water receptors will not take place.

Monitoring will not take place within the deposits overlying the structured Chalk Formation as these have been assessed as being hydraulically separate from the Principal Aquifer in the structured Chalk Formation. Furthermore, any deterioration in groundwater quality that has the potential to pose a risk to the Principal Aquifer off-site and the groundwater abstraction well (Netherwild Pumping Station 1.2km south west) would be recorded by wells within the structured Chalk Formation.

2.2.3 Monitoring Well Locations

Installed wells which will be monitored include; WBH101, WBH107, WBH109, WBH110, WBH114, WBH116, WBH117, WBH118 and WBH119. The locations of these monitoring wells are included in the ESSD bundle of plans and information (D-ESSD10B).

Given the south and south westerly groundwater flow direction on site boreholes WBH101, WBH110, WBH114 represent upgradient monitoring location while boreholes WBH119, WBH117, WBH118 and WBH116 represent down gradient locations.

These locations were installed with response zones within the structured Chalk as this zone is highly fractured and has high permeability within which rapid groundwater flow and any contaminant flow would occur. It is also the most sensitive receptor as this is the principal layer from which potable groundwater is extracted. These locations will also provide a representative spread of the groundwater conditions across Area 2 and along the groundwater flow gradient.

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

they are replacing and be in accordance with the CQA Plan (see section 3.2 below). 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 monitored 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.

2.2.4 Data Collection and Assessment

As agreed with the Environment Agency monitoring prior to, during and following waste deposition completion will be at the following intervals. Monitoring during construction is at an increased frequency than that specified in the Capita 2018 Geo-Environmental Monitoring Proposals.[5]

- 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 above monitoring intervals will be the initial intervals based on the body of information available and should be regarded as the minimum requirements. As required and only in agreement with the EA the monitoring frequency may alter dependent on the recorded laboratory results.

The groundwater results will be collated and regularly reviewed by an experienced environmental consultant and reported to the EA as required by permit conditions and in due course in the surrender report. In addition, regular auditing of the groundwater monitoring will be completed to verify that it is being completed in accordance with this document, industry best practice, and issued written document provided to the contractor in advance of monitoring.

Dedicated low flow 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 1 have been met.

Table 1. 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

[5] Capita Radlett Strategic Rails Freight Interchange Area 1 and 2, Geoenvironmental Monitoring Proposals dated January 2018 (Ref: CS-070751-PE-17-050-R, Rev V2).

Once the stabilisation parameters have been met the groundwater samples will be collected in sampling containers supplied by and deemed appropriate by the laboratory for the required testing.

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. Where NAPL is recorded photographs will be taken of the NAPL as contained in a bailer or sampling vial.

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 EA prior to implementation.

2.2.5 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[6], 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

[6] 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).

- 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.

- 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.
  - Consideration will be given to implementing the Bradbrook 2019[7] 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 on-site, 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 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.

[7] Bradbrook Remediation Contingency Plan, Radlett Strategic Rail Freight Interchange Area 2, dated April 2019 (Ref 18-175)

3. Monitoring Well Design and CQA Plan

3.1 Ground Gas Monitoring

The monitoring wells will be for the sole purpose of monitoring ground gas concentrations and fluxes within the undisturbed historical landfill and/or possible lateral migration off-site, respectively.

Given the shallow depth and short response zone of the monitoring wells and singular strata within the response zone stratification of ground gas within the headspace are unlikely to occur. Gas taps capable of recirculation monitoring will therefore not be installed or monitoring undertaken.

The monitoring well design will have the following design details:

- an HDPE plain pipe (30mm) section a minimum of 1.0m in length surrounded by a cement / bentonite mix to create a seal;
- an HDPE slotted pipe (30mm) remaining within the vadose zone (out-of-waste), surrounded by a non-calcareous 10mm pea gravel. The slotted pipe will have a plastic end-cap;
- Where the borehole annulus extends below the base of the slotted pipe it will be backfilled with a cement/ bentonite mix;
- the monitoring well headworks will comprise a rubber bung with single valve gas tap, within a road cover/top hat cover. The cover will be concreted into place and protected accordingly.

The groundwater levels indicating the vadose zone have been determined from the 2022 Waterman Ground Investigation which recorded;

- no groundwater in the landfill material, except for BH58, which recorded at 4.66 and 3.77mbgl (74.7mAOD and 70.93mAOD, respectively).
- between 8.26 and 8.53mbgl (64.89mAOD and 64.62mAOD) in the Kesgrave Gravel Subgroup.

The monitoring wells, including replacement wells, will be installed by a competent ground investigation contractor, with the specific well design completed by the environmental consultant responsible for works on-site.

The integrity of the monitoring wells will be inspected during each monitoring interval. Where the integrity of the well is compromised in such a way in which ground gas concentrations and flow rate are unrepresentative a replacement monitoring well 2.0m from the damaged well be completed and installed. A period of one week between monitoring well installation and completion of a monitoring round will be allowed for.

A specification for the ground gas monitoring wells is included in Appendix A. These details comprise the “construction proposals” required by an anticipated EP “site engineering” condition.

The CQA Validation Report(s) required by an anticipated EP “site engineering” condition will comprise the ground investigation contractor’s factual report incorporating the following details for both the original and replacement monitoring wells:

- the location of each monitoring well;
- the geology present at each monitoring well;
- the well installed including; length of response zone and total well depth; and
- pictures of the well in-situ.

The reports will incorporate any variances to the monitoring well design, monitoring plan, or action plan including justifications for these variances.

The reports will be signed off by a chartered civil engineer or geologist and submitted within 4 weeks of the installation works having been completed.

3.2 Groundwater Monitoring

Groundwater monitoring will be completed within the existing monitoring wells which were installed with response zones within the structured Chalk Formation at depths detailed in Table 2. WBH101, WBH107, WBH109, WBH110, WBH114, WBH116, WBH117, WBH118, WBH119.

Table 2: Groundwater monitoring well installations

Borehole	Base Depth (m)	Response Zone (m)	Targeted Strata
WBH101	21.0	16.9 – 21.0	Structured Chalk
WBH107	20.45	17.0 – 20.45	Structured Chalk
WBH109	21.0	14.9 – 21.0	Structured Chalk
WBH110	20.36	17.0 – 20.36	Structured Chalk
WBH114	20.0	15.9 – 20.0	Structured Chalk
WBH116	25.54	20.0 – 25.54	Structured Chalk
WBH117	20.2	15.0 – 20.2	Structured Chalk
WBH118	20.1	16.0 – 20.1	Structured Chalk
WBH119	25.0	18.0 – 25.0	Structured Chalk

The design of replacement monitoring wells will be in accordance with the 2006 EA guidance[8]. The monitoring wells will be for the purposes of monitoring groundwater quality and groundwater level.

The replacement monitoring well design will have the following design details:

- an HDPE plain pipe (50mm) section a minimum of 1.0m in length surrounded by a cement / bentonite mix;
- an HDPE slotted pipe (50mm) screen with response zone within the structured Chalk Formation, surrounded by a non-calcareous 10mm pea gravel. The slotted pipe will have a geotextile sock and plastic end-cap;
- Where the borehole annulus extends below the base of the slotted pipe it will be backfilled with a cement/ bentonite mix;
- the monitoring well headworks will comprise a rubber bung within a road cover raised from ground level. The road cover will be concreted into place.

Replacement wells, will be installed by a competent ground investigation contractor, with the specific well design completed by the environmental consultant responsible for works on-site.

The integrity of the monitoring wells will be inspected during each monitoring interval. Where the integrity of the well is compromised in such a way in which groundwater quality and levels are unrepresentative a replacement monitoring well 2.0m from the damaged well be completed and installed.

[8] 2006, Environmental Agency, Guidance on the design and installation of groundwater quality monitoring points, https://www.gov.uk/government/publications/guidance-on-the-design-and-installation-of-groundwater-quality-monitoring-points, Accessed 05/07/2023.

A specification for replacement groundwater monitoring wells is included in Appendix C. These details comprise the “construction proposals” required by an anticipated EP “site engineering” condition.

The CQA Validation Report(s) required by an anticipated EP “site engineering” condition will comprise the ground investigation contractor’s factual report incorporating the following details for both the original and replacement monitoring wells:

- the location of each monitoring well;
- the geology present at each monitoring well;
- the well installed including; length of response zone and total well depth; and
- pictures of the well in-situ.

The reports will incorporate any variances to the monitoring well design, monitoring plan, or action plan including justifications for these variances.

The reports will be signed off by a chartered civil engineer or geologist and submitted within 4 weeks of the installation works having been completed.

3.3 Earthworks Monitoring

The programme of earthworks monitoring will be carried out for both landscaping bunds during their construction and following their completion. Monitoring will comprise three types including:

- vibrating wire piezometers;
- slope movement monitors; and
- settlement monitors.

The locations of these monitoring wells are included in the ESSD bundle of plans and information (D-ESSD4D).

The following shall also be recorded:

- any evidence of instability in the slopes surrounding the works area;
- any evidence of potential instability within completed sections of slope;
- the consistency of ground conditions exposed through the course of the works against those assumed in design / shown on design drawings;
- general groundwater observations and the presence of any localised seepages; and
- prevailing weather conditions including short and long-range forecasts, with works to stop during period of high rainfall or forecast high winds.

Settlement and slope monitoring. If movements are greater than pre-determined limits, the Contractor shall await instruction from The Engineer.

Vibrating Wire Piezometers

Piezometers will be required below areas of fill to monitor pore water pressures in response to placement of fill. The Contractor will be required to control and stage placement of fill such that there are no excess pore water pressures created. The locations of piezometers are to be agreed taking cognisance of site operations, but generally as shown on plan D-ESSD4D.

Piezometers to be installed as defined in BS5930.

Piezometers shall be a proprietary multi-level vibrating wire (VW) piezometer system, such as that manufactured by Geosense or similar approved. Vibrating wire piezometers shall have a porous ceramic element of the low air entry type and be supplied to site pre-saturated. The Contractor shall confirm saturation by boiling the ceramic elements in water for at least two hours and storing the ceramic elements in de-aired water. The Contractor shall ensure that the tips are maintained in a saturated state throughout installation.

The multi-level VW piezometers shall be installed using the “fully grouted in” method described by Contreras et al. (2008). Any borehole housing VW piezometers shall be grouted using cement-bentonite grout throughout the full length of the hole, up to the base of the headworks.

The VW installation at a given borehole shall be fully grouted in-place within 1 work shift. It is recommended that careful planning and checking of the grouting equipment prior to backfilling commencement is undertaken, so that the chance of breakdown during the backfilling process is minimized, and it is recommended that starts such works adequately early in the work shift.

Any un-grouted piezometers left in a borehole overnight shall be deemed non-acceptable and shall be replaced with piezometers with ceramic elements saturated by boiling in water as described above. In case such replacement is not feasible (for example, in the case of a partly grouted hole), a new borehole drilled adjacent to the original borehole may be needed in order to complete the as-specified piezometer installation.

Use of bentonite pellets shall not be permitted for backfilling VW piezometer boreholes.

Reference shall be made to Mikkelsen (2002) and Contreras et al (2008) regarding the cement-bentonite grout mix, mixing sequence and backfilling method. A trial mix shall be undertaken on site. Under no circumstances shall the permeability of the bentonite-cement grout mix be higher than 1 x 10-9 m/s.

Each piezometer shall be connected to a single, continuous length of armoured cabling which shall be long enough to reach from the piezometer tip to the ground surface. Joints in the cable will not be permitted. The cables shall be securely and permanently labelled with the depth of the piezometer tip so that where multiple instruments are installed in the same borehole, these can be clearly identified.

Monitoring shall be by continuous data logger, with The Contractor bearing all responsibility for monitoring pore water pressures in response to placement of fill.

Slope Movement Monitors

Slope movement monitoring targets shall be installed where indicated on plan D-ESSD4D.

Targets shall comprise of Triaxial Tiltmeter Sensors or Laser Survey Targets.

Settlement Monitoring

Settlement monitoring is required in order to monitor levels of movement during construction of the bunds. Settlement monitoring shall be by means of rod and plates plus surface pins at locations shown on plan D-ESSD4D.

All monitoring points will be adequately protected from damage during the course of the works and shall be clearly visible.

Data shall be recorded to +/- 2mm. All monitoring results are to be referred back to the Engineers for review and checking within 24 hours. Data to be provided in Microsoft Excel format.

3.4 Monitoring Requirements

Monitoring requirements and trigger and action levels are detailed in the following tables.

Table 3: Monitoring during construction

Monitoring type	Monitoring Equipment	Frequency	Target
Pore water pressure	Vibrating wire piezometers (VWP)	Continuous data logger	Targets levels and pore water pressures to be established using background readings taken from VWP to be installed at enabling works phase prior to construction of the bunds.
Settlement	Rod and plate	Weekly	Refer to “Settlement Trigger Values and Actions”

Table 4: Monitoring post construction

Monitoring type	Monitoring Equipment	Frequency	Target
Settlement	Rod and plate	Weekly, to be reviewed as monitoring progresses	Refer to “Settlement Trigger Values and Actions”
	Surface pins	Weekly, to be reviewed as monitoring progresses	
Slope movement	Triaxial tiltmeter sensors / laser survey targets	Weekly, to be reviewed as monitoring progresses, up to 2 years	Zero movement within limits of survey / equipment accuracy.
Settlement close-out monitoring	Surface pins	Weekly, to be reviewed as monitoring progresses, up to 2 years	Provisional target 30mm at 2 years, to be confirmed based on data collected / confirmation of settlement trend v design prediction during construction stage monitoring

Table 5: Settlement Triger Values and Actions

Trigger	Settlement (mm)	Action
North bund (LS2)		
Green	Less than or equal to 168mm	The Contractor will carry out and issue monitoring reports to the Supervising Engineer, as per the stated frequencies of the Monitoring Proposal.
Amber	Greater than 168mm, but less than or equal to 210mm	In the event of an amber trigger level being breached, the Contractor will firstly investigate and verify that the recorded readings are correct and report back by the end of the same shift. Where confirmed as true readings, the Contractor will provide the Supervising Engineer with details of the recorded movement, work progressing on site and immediate actions taken. Within 24hrs, the Supervising Engineer and the Contractor shall carry out condition survey of the bunds to assess any changes evident. Thereafter, the Supervising Engineer and the Contractor shall determine remedial measures to prevent further movement.
Red	Greater than 210mm	In the event of a red trigger level being breached, the Contractor will firstly investigate and verify that the recorded readings are correct and report back by the end of the same shift. Where confirmed as true readings, the Contractor will shall immediately stop works, make the area safe and inform the Supervising Engineer. A meeting is to take place between the contractor supervising Engineer and geotechnical designers and client (client representative) within 2hrs. Depending on the outcome of the meeting the following will take place; Carry out remedial measures as agreed will client/client representative. Continue monitoring and arrange additional manual monitoring surveys until asset movements or deformations have stabilised.

Trigger	Settlement (mm)	Action
		Carry out survey of assets to assess the condition following remedial measures or repair work as necessary. Agree with client/client representative a safe method of working or modifications to the proposed development to complete the work.
South Bund (LS1)		
Green	Less than or equal to 316mm	As above.
Amber	Greater than 316mm, but less than or equal to 395mm	As above.
Red	Greater than 395mm	As above.

4. Validation Report

The groundwater and ground gas monitoring results during and post waste placement will be compared against baseline conditions and reported periodically as required by anticipated EP conditions (likely at 3-month intervals).

These periodic reports will incorporate the following details for both the original and replacement monitoring wells:

- the location of each monitoring well;
- the geology present at each monitoring well;
- the well installed including; length of response zone and total well depth; and
- pictures of the well in-situ.

The periodic reports will incorporate any variances to the monitoring well design, monitoring plan, or action plan including justifications for these variances.

The results of earthwork monitoring will also be reported on a 3 month intervals the duration of the monitoring period, unless a slope failure has or is at risk of occurring, in this instance the EA will be informed immediately.

The Validation Report will be prepared by an Environmental Consultant and will include groundwater, ground gas and earthworks monitoring.

APPENDICES

A. Monitoring Well Specification Ground Gas – Installation and Monitoring

The below details the required specification for the installation of monitoring wells.

Prior to drilling of the exploratory hole the Contractor shall satisfy themselves the area is free of services and will complete a 1.2mbgl hand pit. The exploratory hole will be drilled to the base of the deposited waste using window sampling techniques. The strata encountered shall be confirmed by and with a environmental consultant. Termination depth will be set by the environmental consultant following review of the encountered strata.

The monitoring well design is as follows:

- an HDPE plain pipe (30mm) section a minimum of 1.0m in length surrounded by a cement / bentonite mix to create a seal;
- an HDPE slotted pipe (30mm) remaining within the vadose zone (out-of-waste), surrounded by a non-calcareous 10mm pea gravel. The slotted pipe will have a plastic end-cap;
- Where the borehole annulus extends below the base of the slotted pipe it will be backfilled with a cement/ bentonite mix;
- the monitoring well headworks will comprise a rubber bung with single valve gas tap, within a road cover/top hat cover. The cover will be concreted into place and protected accordingly.

The strata encountered will be logged to BS5930 2017+A1:2020 standards and included in a log with the monitoring well design installation.

Parameters monitored during each round will include:

- methane;
- carbon dioxide;
- hydrogen sulphide;
- ground gas flow rate;
- atmospheric pressure (prior to and during); and
- differential pressure.

The ground gas concentrations and ground gas flow rate will be recorded at the following intervals: 10s, 30s, 45s, 60s, then at 1minute intervals until concentrations/flow rate have achieved a steady state. Ground gas flow and ground gas concentration will be monitored for a minimum of five minutes.

B. Monitoring Well Specification Groundwater – Installation and Monitoring

The below details the required specification for the installation of monitoring wells.

Prior to drilling of the exploratory hole the Contractor shall satisfy themselves the area is free of services and will complete a 1.2mbgl hand pit. The exploratory hole will be drilled to the base of the deposited waste using window sampling techniques. The strata encountered shall be confirmed by and with a environmental consultant. Termination depth will be set by the environmental consultant following review of the encountered strata.

The replacement monitoring well design will have the following design details:

- an HDPE plain pipe (50mm) section a minimum of 1.0m in length surrounded by a cement / bentonite mix;
- an HDPE slotted pipe (50mm) screen with response zone within the structured Chalk Formation, surrounded by a non-calcareous 10mm pea gravel. The slotted pipe will have a geotextile sock and plastic end-cap;
- Where the borehole annulus extends below the base of the slotted pipe it will be backfilled with a cement/ bentonite mix;
- the monitoring well headworks will comprise a rubber bung within a road cover raised from ground level. The road cover will be concreted into place.

Dedicated low flow 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 1 have been met.

Table B1. 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 collected in sampling containers supplied by and deemed appropriate by the laboratory for the required testing.

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. Where NAPL is recorded photographs will be taken of the NAPL as contained in a bailer or sampling vial.

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 (Semi Volatile Organic Compounds)

- 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

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