

Appendix 2

Arup Environmental Strategy Report

The following is the Arup Report 'Proposed Redevelopment at Madejski Stadium, Environmental Strategy, Rev C' dated 7 December 2017.

Reading Football Club

**Proposed Redevelopment at
Madejski Stadium**

Environmental Strategy

E002

Rev C | 7 December 2017

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 240524

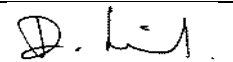
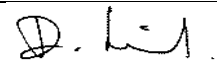
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1 Introduction

Reading Football Club (RFC) Limited has commissioned Ove Arup & Partners Ltd (Arup) to provide various services in respect of its proposals for redevelopment of the Madejski stadium site. The scheme is intended be a positive addition to South Reading and one which will deliver a raft of socio-economic benefits for the town and the wider Thames Valley sub region. The proposals seek to deliver a high quality, sustainable mixed use development on the land surrounding the existing Madejski Stadium.

The current Madejski Complex and development site lies over an area of made ground (formerly the Smallmead Landfill site), and consequently, the only viable foundation option is piling into the natural strata beneath the site.

1.1 Objective

The objective of this report is to assess risks and potential environmental impacts, predominantly to groundwater, associated with earthworks and piling for the proposed redevelopment. Only information directly relevant to this assessment of risks and potential impacts is presented in this report.

A considerable volume of additional information relating to the site is available. In particular, similar assessments have been completed by Arup, as follows:

- 1998 to assess the piling risks during construction of the Madejski Hotel;
- 2001 to assess the piling risks during the Hotel's extension; and
- 2006 for the proposed Stadium expansion.

A summary of previous investigations and a list of reports and assessments of the site are given in Section 4.

1.2 Limitations

This report has been prepared for and on behalf of Reading Football Club in response to their particular instructions. Except as provided for in our agreement with Reading Football Club, any other party using this information for any purpose whatsoever does so at their own risk and any duty of care to that party is excluded.

2 Proposed Works

The proposed development will contain a number of new buildings containing residential, leisure and commercial spaces.

A convention centre building housing conference facilities, office space and an ice rink is interlinked with an hotel and serviced apartment block with associated leisure facilities and food outlets.

A central public plaza separates this building from the rest of the development which consists of seven separate residential blocks and a multi storey car park.

A landscaped public amenity space is provided between the residential blocks which doubles up as a surface water drainage feature to handle run off during flood events.

The proposed buildings are typically six to nine storeys high of varying steel, concrete and timber construction. Due to the ground conditions they will be supported on piled foundations and will typically have suspended reinforced concrete slabs at their lowest level.

External levels will typically be raised above existing to cover fully, or in part, the basement level parking.

Phased development of the site is proposed. The detailed planning application (“Phase I”), will include the Convention Centre, Block 7 of the private residential units and the multi-storey car park. Early completion of these elements will unlock further areas of the existing surface car park for development. The ‘Phase II’ residential units will follow a further submission of a full detailed planning application for these elements.

An overall CGI view of the development and an outline plan are shown in Figures 1 and 2.



Figure 1: CGI of proposed development

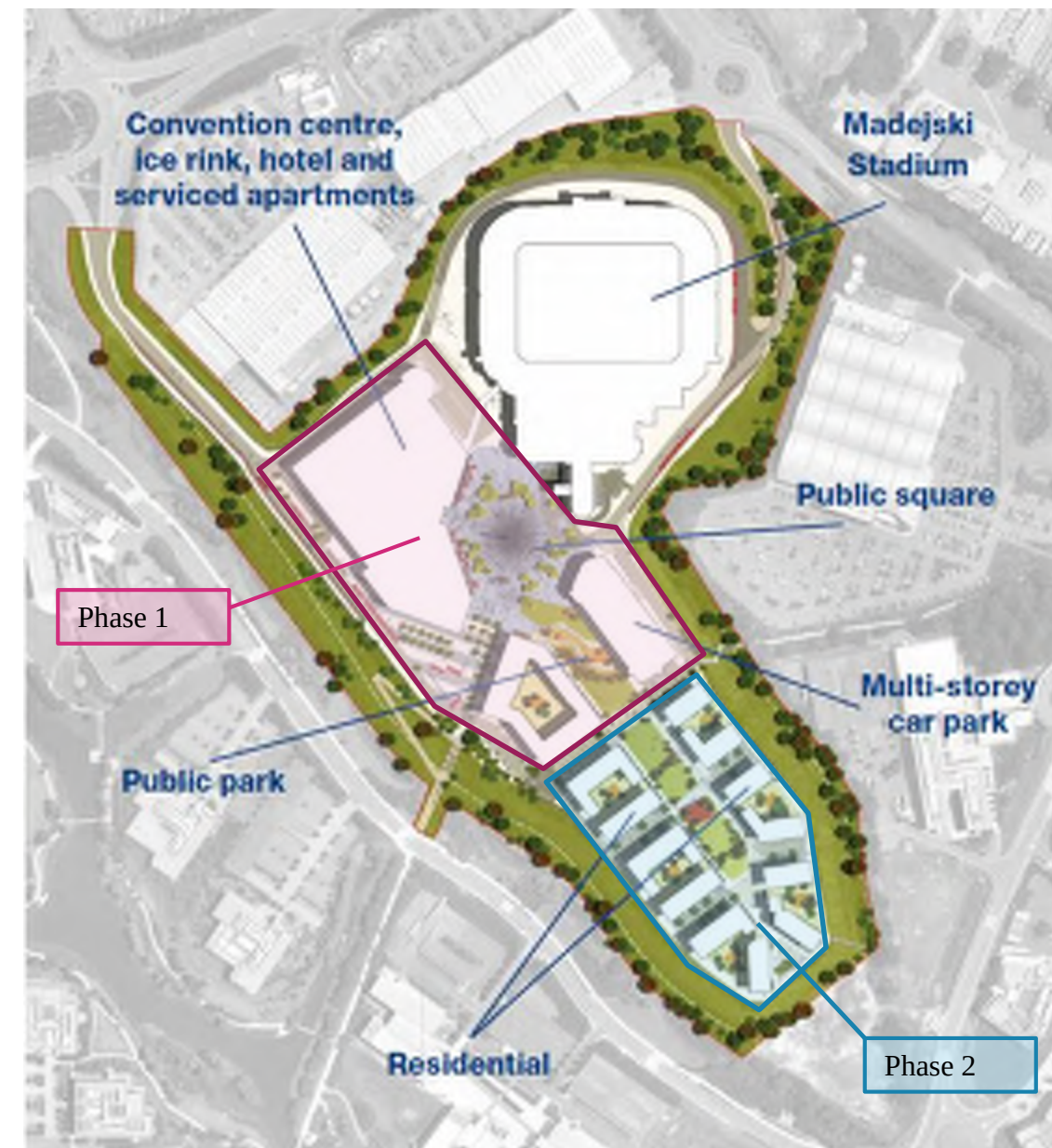


Figure 2: Plan showing proposed development

3 The Site

3.1 Location

The site is located to the South of Reading off Junction 11 of the M4. The site address is Reading Football Club, Madejski Stadium, Junction 11, M4, Reading, Berkshire, England, UK, RG2 0FL.

The site location and site layout are shown in Figures 3 and 4.

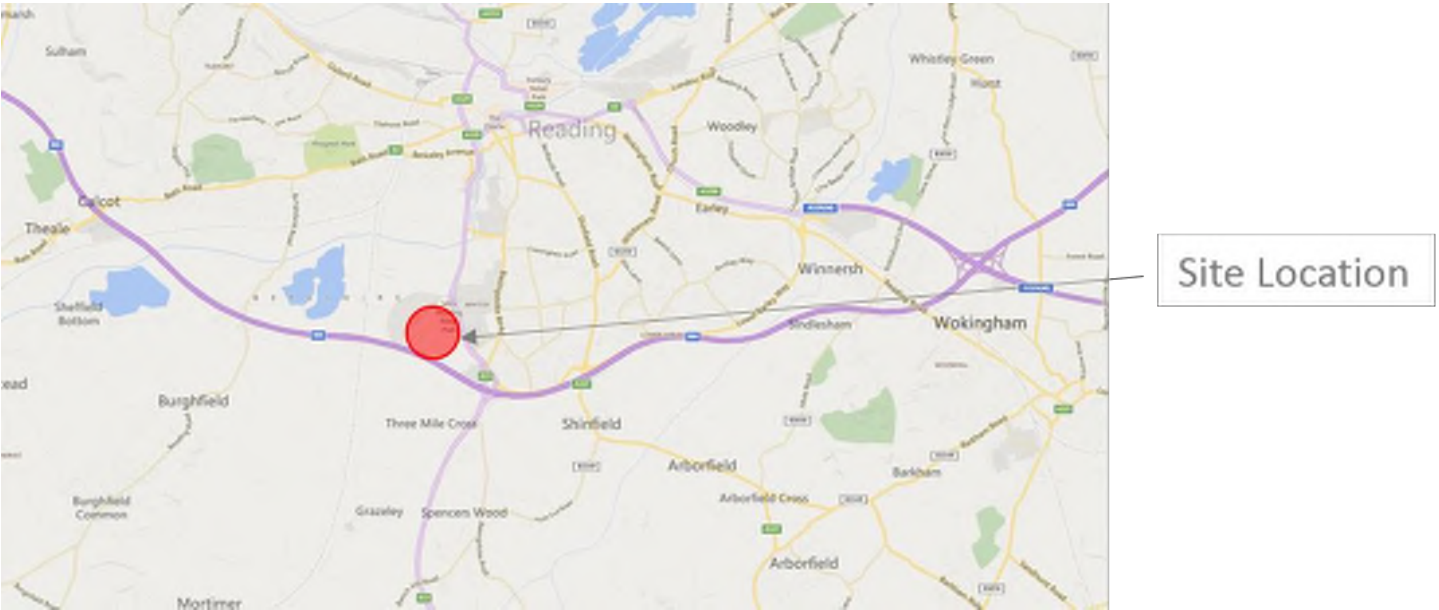


Figure 3: Site Location



Figure 4: Site Layout

3.2 Site History

Historical Ordnance Survey maps were provided in the Envirocheck Report obtained from Landmark Information Group as part of the Ground Conditions Chapter of the Environmental Statement (January 2016). Previous reports (listed in Section 4) were also reviewed to provide further details. A summary of the findings is given below:

- The historical maps, dated 1883 to 2015, show that prior to 1972 the Site remained relatively undeveloped. The maps show evidence of artificial surface water drainage channels across the site, which suggests possible evidence of attempts to reclaim the land for agriculture;
- By 1972, the north eastern most part of the Site was used for waste disposal known as the Smallmead Tip landfill. The historical maps shows the main body of the landfill was located immediately adjacent to the Site's north eastern boundary with landfill activity extending onto the Site.
- Records indicate that the components of waste within the Smallmead Tip were predominantly municipal solid waste and building waste. Waste was deposited in the form of landraise, under the 'dilute and disperse' philosophy, whereby the landraise was unlined to allow percolation of rainwater through the waste material, which was common practice at the time. The landraise originally covered approximately 24ha (in the northeast of the Site), with between 6m and 8m of fill;

- By 1985, historical maps indicate that the waste disposal site was grassed with no further change evident;
- During 1997, Smallmead Tip was re-located to make way for the construction of the retail parks to the East of the Site. The Tip material was re-deposited across the Site under a Waste Management Licence. From June 1997 the development and construction of the Madejski Stadium, the Royal Berkshire Conference Centre and associated infrastructure commenced. A summary of the works carried out at the wider Madejski complex is given in Section 6;
- By 1999, the historical map shows the southern section of the Site is occupied by the Madejski Stadium, with embankment earthworks marked along the north, east and southern boundaries;
- In January 1999, the construction of the Madejski Hotel commenced which was later extended in 2006; and
- By 2006, the maps shows the Madejski Hotel adjoining the stadium and a football centre in the western section of the Site. An internal road network is also shown.

The maps show very little change on the Site since then.

The development of the site is depicted using a 3D GIS model showing the topography over time as shown in Figure 5.

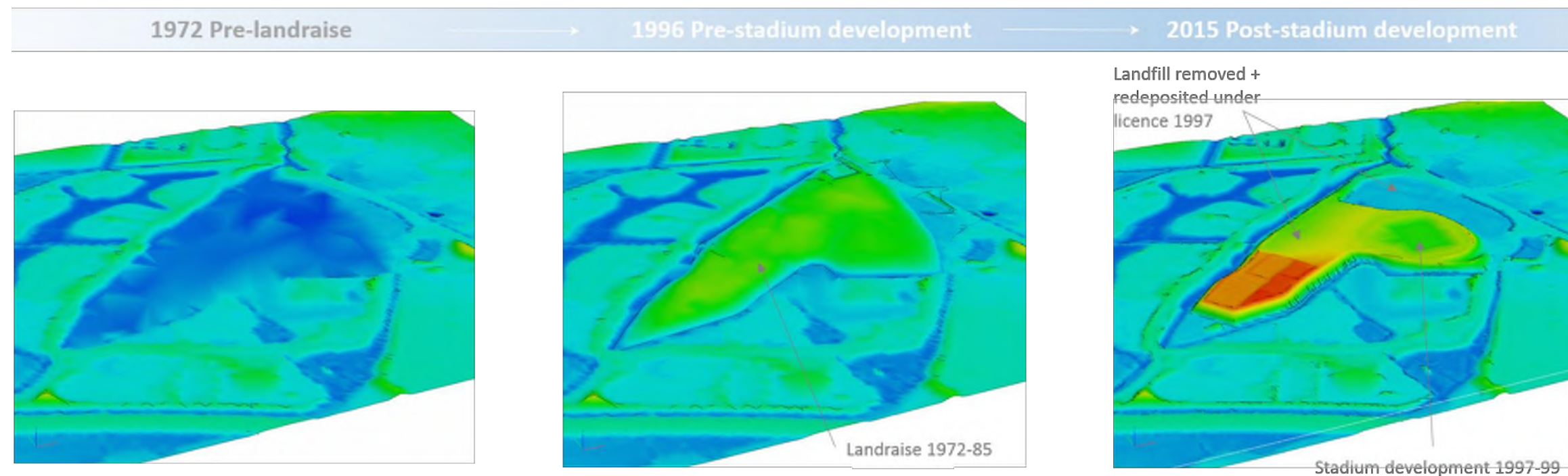


Figure 5: Site development shown through 3D GIS model

3.3 Site setting

The Environment Agency website shows an authorised landfill beneath the Site extending from the north eastern to the western boundary. The Waste Management Licence (WML)/ Environmental Permit is held by Reading Football Club. The licence status is given as “Closure”, which means the landfill no longer receives waste. The landfill was licenced to accept waste type A4, which includes household, commercial and industrial waste. The Environmental Permit is only for the surcharged waste (approximately 3 m deep) deposited in 1997 over the top of an existing historic land-raise[LS2] site. Figure 6 shows the extent of the permitted area in blue. The full map is shown on Figure 10.1 in Appendix A.

There is evidence of further landfill material located with the wider Madejski complex. Previous Arup reports for the proposed Stadium extension indicate that waste material was deposited beneath the stadium seating area.

3.3.1 Topography and Hydrology

The landfill material forms a plateau, with levels varying from around 51mAOD in the south western area of the site down to around 41mAOD at the approach road to the North East. Ground levels slope away from the waste towards the Site boundaries to between 38 and 40m AOD.

The Foudry Brook flows from south west to north east along the western and northern boundary. An additional brook flows north, alongside the A33, and joins with the Foudry Brook beneath the roundabout to the north east of the site.

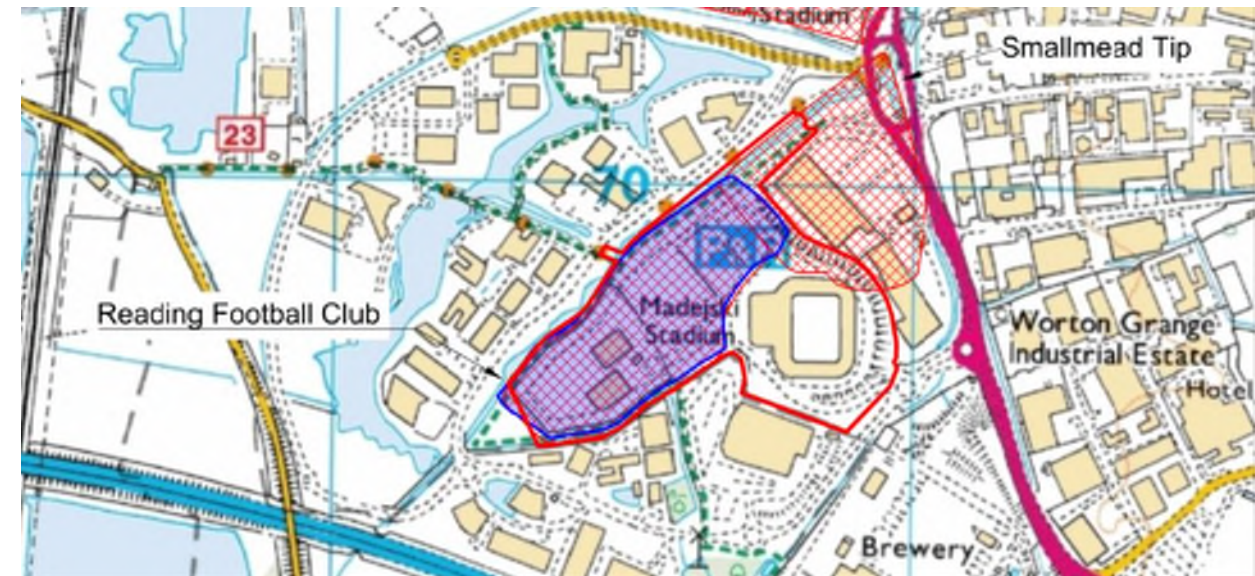


Figure 6: Extent of Waste Management Licence/ Environmental Permit

4 Previous Ground Investigations and Reports

There have been a number of ground investigations and reports produced for the Site and wider Madejski Stadium Complex. These relate to the various development phases which have taken place since the late 1980s.

4.1 Ground Investigations

Four intrusive site investigations have been carried out at the Site, as part of the wider Madejski Stadium Complex re-development. These date back to 1986 and are shown in Table 1.

Table 1: Previous Ground investigations carried out at the Site

Ground Investigation Date	Ground investigation Contractor
Late 1986	Geotesting Services
August/September 1995	Foundation & Exploration Services Ltd
February 1996	Thyssen Geotechnical
April 1997	Exploration Associates Ltd

4.2 Reports

In addition, Arup hold a number of documents relating to previous studies and development at the Site which have been reviewed as part of this assessment. These are as follows:

Table 2: Previous technical reports relevant to the Site

Report Date, Company	Report Title
Oct 1995, Arup	Reading Football Club Relocation - Geotechnical Report
Oct 1995, Arup	Reading Football Club Relocation - Geochemical Report
May 1996, Arup	Reading Football Club Relocation - Design Statement on Landfill Gas Management For Smallmead Site
Jun 1996, Arup	Reading Football Club Relocation - Design Statement on Leachate Management For Smallmead Site
Oct 1996, Arup	Reading Football Club Relocation - Hydrogeological Study
Nov 1996, Arup	Reading Football Club Relocation - Site Preparation Monitoring
July 1997, Arup	Reading Football Club, Executive Progress Report, Period Ending 31 July 1997
July 1998, Arup	Madejski Hotel - Assessment of Risk to Groundwater from Piling for the Proposed Madejski Hotel
Nov 1998, Arup	Madejski Hotel - Environmental Control Measures to be Employed During the Construction of the Madejski Hotel
2001, Arup	Reading Football Club Ltd, Millennium Madejski Hotel Extension, Environmental Report
Dec 2006, Arup	Reading Football Club Ltd, Madejski Stadium Expansion Environmental Assessment of Proposed Foundations
Various	Factual Reports relating to the various site investigations published by the Site Investigation Contractors.

5

Geology and Hydrogeology

5.1

Geology

The published geology of the area is shown on the 1:50,000 BGS Sheet 268 for Reading Solid and Drift, and can also be viewed on the BGS website. Figure 7 show an extract from the BGS map with site boundary shown in red.

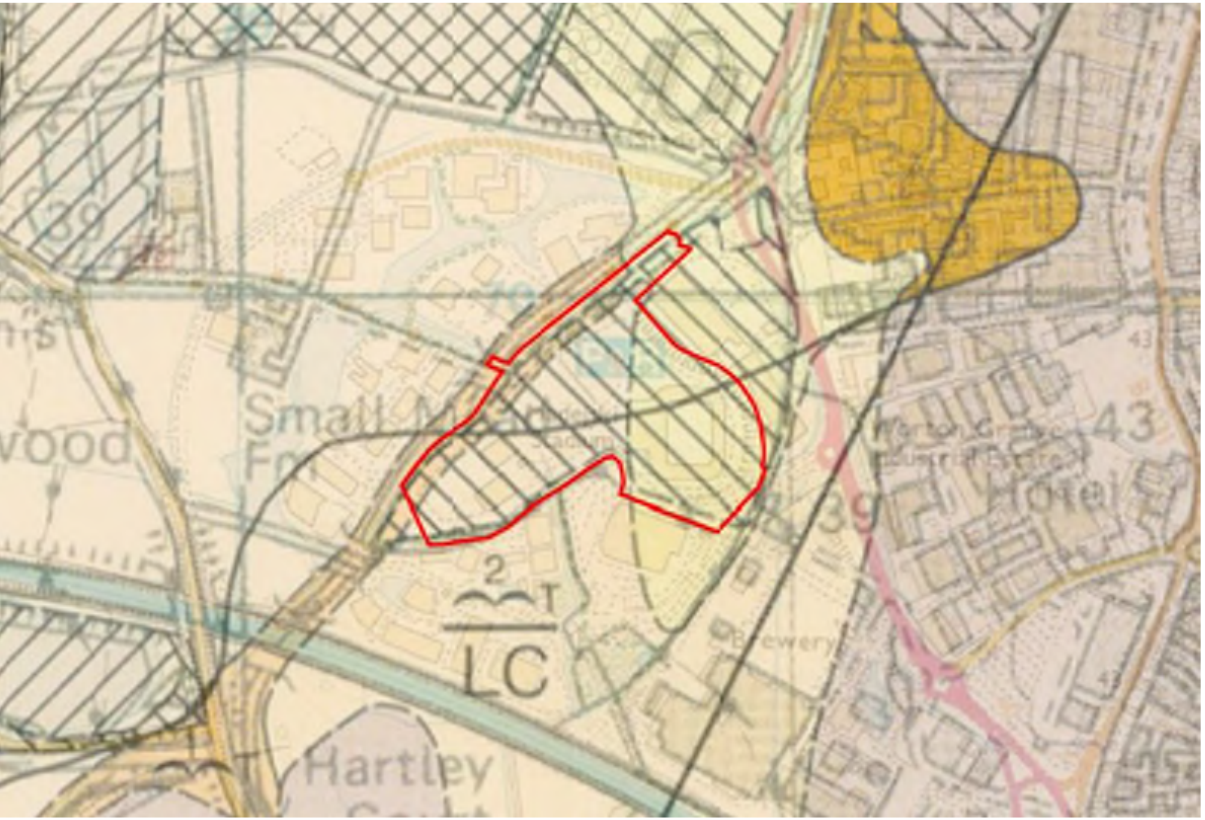


Figure 7: Extract from BGS 1:50,000 map

The superficial geology shown on the BGS map is:

- Made ground;
- Alluvium, described by the BGS as clay, sand and gravel. The alluvium is mapped within the eastern half of the Site;
- River Terrace Deposits 1 (RTD 1) are shown along the north western boundary of the Site. River Terrace Deposits 2 (RTD 2), are mapped across the remaining western section of the Site. The BGS describe the RTD as sand and gravel, with local lenses of silt, clay or peat.

The bedrock geology is as follows:

- The BGS maps show that the Site is underlain by London Clay and the Lambeth Group.

- London Clay is mapped across the southern half of the Site and is described by the BGS as mainly comprising bioturbated or poorly laminated, blue-grey or grey-brown, slightly calcareous, silty to very silty clay, clayey silt and sometimes silt, with some layers of sandy clay. It commonly contains thin courses of carbonate concretions ('cementstone nodules') and disseminated pyrite. It also includes a few thin beds of shells and fine sand partings or pockets of sand, which commonly increase towards the base and towards the top of the formation. At the base, and at some other levels, thin beds of black rounded flint gravel occur in places. Glauconite is present in some of the sands and in some clay beds, and white mica occurs at some levels. The BGS map indicates that the London Clay is absent in the north of the Site although this is not supported by the borehole data (refer to section 5.2).
- The Lambeth Group is mapped across the northern half of the Site beneath the superficial geology and is described by the BGS⁵ as variable sequences mainly of clay, some silty or sandy, with some sands and gravels, minor limestones and lignites and occasional sandstone and conglomerate. The Lambeth Group underlies the London Clay within the southern part of the Site.
- The Upper Chalk is present at depth beneath the Lambeth Group and is described as white nodular and soft Chalk with flint seams.

5.2

Ground Investigation Data

Data from the previous site investigations undertaken across the development site has been collated and a summary is given in Table 3 below showing the proven strata and thicknesses across the site. Figure 8 shows a conceptual section through the ground.

It should be noted that contrary to the BGS maps the London Clay and the London Clay Basement beds are present over the majority of the development site albeit with differing thicknesses as proven by existing borehole data.

Table 3: Summary of Proven Ground Conditions

Strata	Thickness (m)	Typical level of base (mAOD)
Made Ground (engineered clay cap)	1-1.3	42.4
Made Ground (waste soils)	6-8	37.7
Alluvial Clays	0 - 2.0	37.2
Alluvial/Terrace Gravels	0.3 – 2.0	36.2
London Clay Soft to Firm becoming Stiff sandy Clay	1.0 – 7.5	30.3
London Clay Basement Bed Dense grey silty fine sand locally cemented to form a strong grey green conglomerate	2.0 - 4.0	27.2
Lambeth Group (formerly Reading Beds) Stiff to very Stiff mottled blue grey and red slightly sandy Clay	~ 20	~7.2
Upper Chalk		

5.3 Hydrogeology

5.3.1 Overview

The RTD is designated by the Environment Agency (EA) as a Secondary A aquifer. A Secondary A aquifer is defined by the EA as having permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.

The London Clay is described by the EA as unproductive strata, defined as rock layers with low permeability that have negligible significance for water supply or river base flow.

The Lambeth Group is designated as a Secondary A Aquifer.

The Chalk is designated as a Principal Aquifer, which are defined by the EA as layers of rock that have high intergranular and/or fracture permeability meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, Principal Aquifers are aquifers previously designated as Major Aquifers.

The EA groundwater maps show the Site area is not within a groundwater source protection zone. The Site does fall within a Nitrate Vulnerable Zone (NVZ), which is defined by the EA as areas of land that drain into nitrate polluted waters, or waters which could become polluted by nitrates.

5.3.2 Proven Hydrogeology

During site investigations a perched water table has been identified in the upper licensed landfill between 37m and 40.25m AOD with no discernable overall flow direction. This perched water exists at a level approximately 1m above base of the original landraise waste.

Leachate elevations within the surcharged waste are monitored in passive collection sumps across the Madejski Complex site. Recent level data indicate leachate heads of between 1.0 to 1.5 metres above the base of the waste. Following an exercise in September 2015 to pump out the leachate in the sumps the level was found to rebound to these levels within 24-48 hours.

Groundwater levels in the Terrace Gravels (RTD) in the area of the Site are typically between 36.50m and 37m AOD. Previous studies have found flow to be generally from south to north-west towards the Foudry Brook, although more recent analysis indicates that the groundwater flow patterns at the Site are complex and there may be groundwater divides present.

Variable groundwater levels have been monitored in the Lambeth Group.

Groundwater levels in the Chalk around the Site were typically recorded between 33m and 34m AOD and historically flowed generally from north-west to south towards the nearby brewery abstraction well. The brewery abstraction closed in 2009 and groundwater is no longer extracted from the Chalk. Evidence from monitoring during the period 2011-2017 suggests that groundwater levels within the chalk have rebounded.

Groundwater flow directions in the chalk are difficult to determine and it is likely that there are groundwater divides across the site, meaning that locally groundwater flow directions may vary. Since Nov 2013 only 1 monitoring point (BH327) has been available in the Chalk, however, to rectify this, Boreholes BHX and BH328 which have frequently been reported as blocked and/or inactive were replaced with Boreholes 2016-01 and 2016-03 in 2016 (See Appendix A, Figure 10.6).

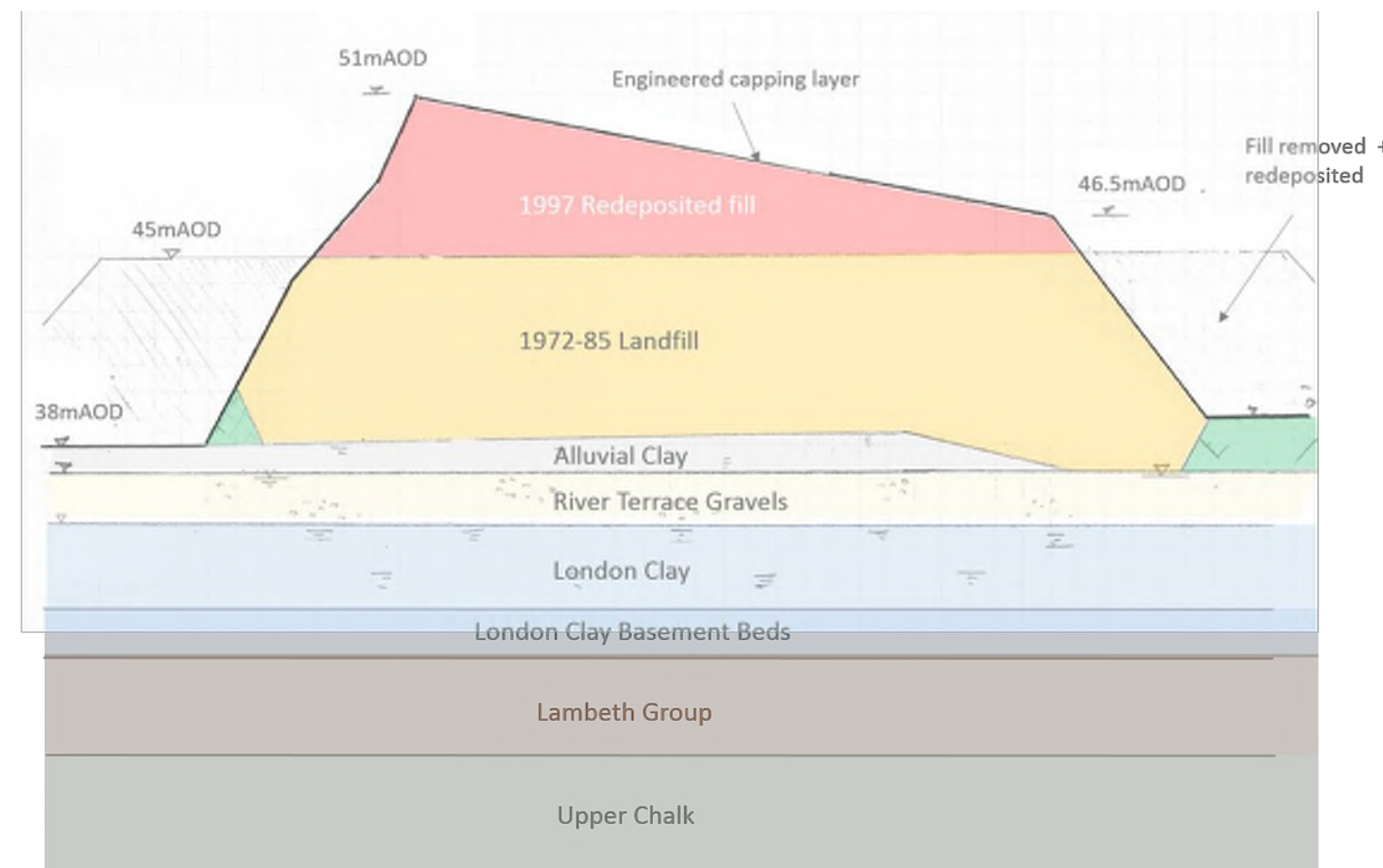


Figure 8: Simplified schematic section through ground stratum

6 Previous Site Remedial Works

The existing Madejski Stadium Complex is built on made ground. As part of the original development in the late 1990s, a series of environmental control measures and monitoring infrastructure were installed on the site to mitigate potential risks to the environment and human health. These works included the following:

- Excavation of approx. 490,000m³ of landfill in the north eastern part of the Site, and its re-deposition on the remaining landfill under a Waste Management Licence thereby reducing the area covered with made ground from 24ha to approximately 15ha.

Figure 10.1 in Appendix A shows the extent of the landfill area. Figure 10.2 shows the thickness of the re-deposited fill/waste material across the site with thickness ranging between 0.10m and 6.50m, giving an overall maximum waste thickness of 13m from existing 1972 ground level.

- Installation of a number of leachate fin drains and passive leachate collection sumps across the site in the surcharged landfill layer, 1m above the base of the original landraise waste to control leachate levels within this layer.

It was predicted that the leachate levels, which were measured at an average of 1m above the base prior to redeposition, would rise due to surcharge from the re-deposited waste. These fin drains and sumps were intended to collect leachate over 1m depth to be pumped away periodically. It is understood that this system has rarely been pumped out until recently in September 2015 when they were pumped dry and the rebound measured.

- A system of dewatering wells was installed around the perimeter of the site within the terrace gravels. This system was intended to be used to draw down ground water levels at the site perimeter and draw off contaminated water should the offsite migration of pollutants at agreed monitoring points exceed set trigger levels. Figure 10.3 in Appendix A shows the location of the dewatering wells.
- Construction of a low permeability composite engineered cap over all the landfill to prevent surface water infiltrating and landfill gas escaping. Part of the cap consisted of a gravel blanket beneath the membrane to collect landfill gases and transfer them to a system of gas vents inserted into the waste and sealed to the membrane. These stacks vent the landfill gases to atmosphere approximately 2m above ground level. Details of the capping layer and gas vent stacks are shown in Figures 9 and 10.
- Construction of Madejski Stadium and Royal Berkshire Conference Centre and associated infrastructure which included the installation of piles using CFA piling to a maximum depth of about 3m into the Lambeth Group. A passive gas venting system was employed beneath the stadium with an active system beneath the Conference Centre.
- A series of perimeter retaining walls were constructed around the perimeter of the stadium site to contain the waste. The void between the two interfaces was backfilled with well graded granular material.

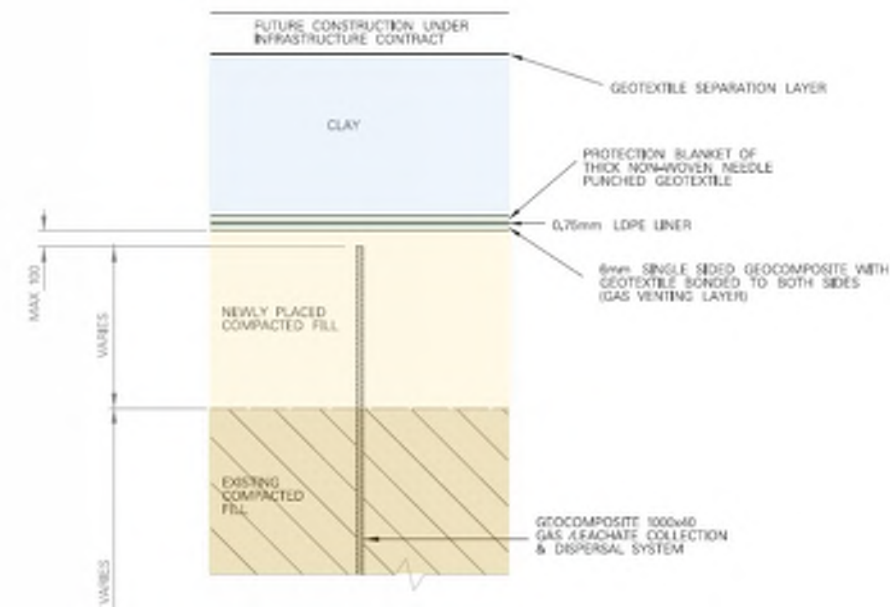


Figure 9:Engineered capping layer construction

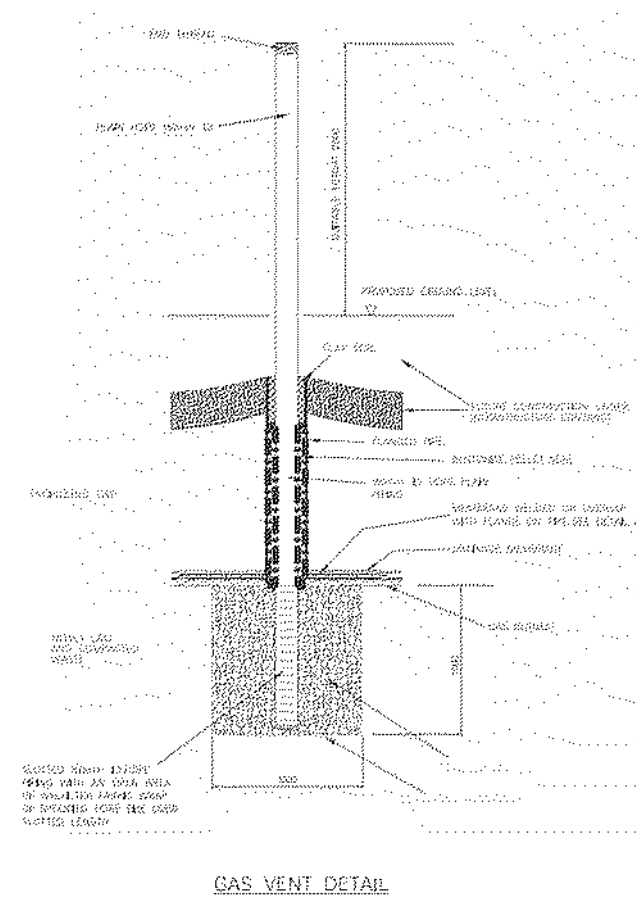


Figure 10: Typical gas vent detail

6.1 Environmental Monitoring

Following the redeposition of the waste Reading Football Club is required to carry out environmental monitoring of the landfill site under the Waste Management Licence, (Environmental Permit).

Gas, surface water and groundwater monitoring of the Site has been regularly taking place since July 1996 when the works were initially carried out. The current monitoring requirements are shown in Appendix B1. Environmental monitoring is carried out each month with varying analytical suites carried out on a monthly, quarterly, six monthly and annual basis. The environmental monitoring takes place at monitoring locations across the Site, see Figure 10.4 in Appendix A.

The original monitoring points included:

- 7 surface water monitoring locations (S1 to S7);
- 20 Leachate Sumps (LD1 to LD10, LD11A to LD20A) which were installed into the surcharged waste; and
- 45 standpipes

The 45 standpipes were located both within and outside the Site. The response zones to the standpipes are shown in Table 4 below.

Response Zone	Standpipes
Re-deposited landfill	LD1, LD2, LD3, LD4, LD5, ~~LD6~~ , ~~LD7~~ , ~~LD8~~ , ~~LD9~~ , LD10, to LD10, LD11A, ~~LD12~~ , LD13, LD14, LD15, LD16, LD17, LD18, LD19, LD20A , R, S, and T
Made Ground	L, M.
River Terrace Deposits	BH107, ~~BH301(s)~~ , ~~BH301(d)~~ , BH304A(s), ~~BH310~~ , ~~BH311~~ , BH314, BH315, BH316, BH317, BH318, BH319, ~~BH320~~ , A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, ~~P~~ , Q, and ~~V~~
Lambeth Group, London Clay and Chalk	BH301(d),BH320, BH322,BH324,BH323,BH321,BH304A(d),BH325,BH326 and ~~W~~
Chalk	~~BH328~~ , BH327 and ~~X~~

Note: Locations highlighted in red and crossed out are those lost/ destroyed

Table 4: Standpipe Response Zones

Over time, a number of the standpipes and leachate sumps have been lost or destroyed due to further construction and development of the Site. The leachate sumps lost include LD6, LD7, LD8, LD9 and LD12. The standpipes lost include P, BH301(s), BH301(d), BH310, BH311, E, BH320. In addition, BHC and BH328 have been infrequently monitored and BHs V, W and X have frequently been blocked or inaccessible.

A new borehole, GW05, was installed to sample gas concentrations and compare to that from R, S and T. The results showed good correlation with results measured in BHs R, S and T, suggesting that they are located in the waste body.

The borehole logs for L and M indicate that the response zones are sited both within the RTG and the “older” made ground material of the original Smallmead landfill

. New BHs have been installed on site during the period 2015 to 2017 to verify the existing data and replace key boreholes that have been lost or are inaccessible. They are as follows:

Table 5: 2016/17 Investigations and Interpretive Reports

Site Investigation	Additional BHs	Arup Report
July & August 2016	Gas: GW01, GW02, GW03 Leachate: LW01, LW02, LW03 EP BHs: BH01, BH02, BH03	Geo-Environmental Interpretive Report Dated 20 October 2016
Dec 2016 to Feb 2017	Gas: GW04, GW05, GW06, GW07, GW08 & GW09	Arup Technical Note Dated 17 February 2017
Dec 2016 to March 2017	Gas Monitoring of : GW04, GW05, GW06, GW07, GW08 & GW09	Arup Technical Note Dated 31 March 2017

The interpretive technical notes and location of boreholes can be found in Appendices A (Figure 10.6) and C.

The leachate collection wells installed into the waste within the historical landraise (at the base of the historical l waste will be pumped dry to dewater leachate from the waste prior to piling during each phase of the development (see also Section 10.2.2)).

6.1.1 Landfill Gas

Gas monitoring has been carried out at the Site in accordance with the Environmental Permit. In 1998, a gas risk assessment was carried out by Campbell Reith as part of the Madejski Hotel development. Further assessments were also carried out for the hotel extension in 2006.

In-situ field gas data has been collected for methane, carbon dioxide and oxygen. The latest available set of results between 2014 and 2015 within the RTG have been reviewed. The field results show that the concentration of methane within the RTG is typically <0.2%v/v. These boreholes are located around the periphery of the Site.

Boreholes R, S and T, which are located immediately north of the Stadium within the Site were observed to have recorded much higher concentrations of methane. Methane in borehole R peaked at 13.5%v/v in September 2014. Boreholes S and T both recorded consistently elevated concentrations of methane which are typically around 70%v/v. As noted above, further investigations of gas from BH GW05 installed into the waste and immediately adjacent R, S and T, identified gas concentrations similar to that from R, S and T. This reasonably confirms that the R, S and T results are recording gas from the waste.

Similarly, the carbon dioxide levels in BHs S and T are also significantly higher than other monitoring locations, typically ranging between 24%/v/v and 35%/v/v. In comparison, carbon dioxide in the other monitoring locations are generally less than 10%/v/v.

Additional gas monitoring boreholes were installed and monitored in 2016 and 2017 to further investigate the gas characterisation of the site. These investigations are noted above and the technical notes are included in Appendix C. The findings are summarised below:

The characterisation of the site has been assessed using the empirical method set out in CIRIA C665³ and in BS8485:2015 and involves the assignment of a design gas screening value (GSV) using site gas monitoring measurements, from which the site's characteristic gas situation (CS) is determined.

In accordance with the approach set out in Annex F of BS8485:2015, we have calculated the hazardous gas flow rate (GSV value) for methane for each in-situ monitoring occasion in 2017 at each borehole location using the flow rate recorded by the gas analyser and also using the gas concentration recorded at that time by the GasClam®. Only CH₄ concentrations were considered as these are always higher than CO₂, and therefore define the design case. The measurements used and the calculated GSVs and inferred CSs. The majority of measurements fall into either CS3 or CS4; and on few occasions in the lower CS5 range when a high gas flow rate is recorded.

7 Piling Proposals

7.1 Introduction

A total of approximately 5100no. piles are proposed for the construction of the new buildings on the development site. It is proposed that the piles will be constructed using the continuous flight auger (CFA) piling technique. This is the same piling method previously used successfully for the Stadium and Hotel construction and subsequent Hotel extension. It is also that proposed for the planned Stadium Expansion which has been granted planning permission. CFA piling has been chosen as this method minimises disturbance of the stratum surrounding the piles and will reduce the time during which potential vertical pathways are open. The piles will be terminated no greater than 3 m into the Lambeth Group (as stated on Page 10).

The extent of the proposed piling is indicated on drawings SK022 in Appendix A

7.2 Pile design

The calculated load capacity of a bored pile is the sum of the following components:-

- i. End Bearing Resistance - generated by the toe of the pile bearing against the underlying soil, and
- ii. Shaft Friction Resistance - generated by friction between the soil and the sides of the pile shaft.

These components are added together and divided by an appropriate factor of safety, in this case 2.5, to give a safe working load capacity for the pile.

The capacities of piles in this case are reduced by the effects of the long term settlement in the considerable depths of refuse on the site. Friction between the pile shaft and the made ground, as it settles, creates a drag down effect referred to as Negative Skin Friction. The component of negative skin friction must be calculated for the depth and type of refuse and the resulting value subtracted from the overall pile capacity.

It is anticipated that to generate sufficient capacity to support the building loads with an optimum arrangement and number, piles will typically be a minimum of 500mm diameter. Following the detailed design phase it will be possible to further refine and optimise the pile diameter and review if a lesser number of larger piles – up to 900mm diameter – would be beneficial to further minimise the environmental impact.

7.3 Continuous Flight Auger piling method

The CFA pile construction sequence is shown schematically in Figure 11. The pile shaft is formed by using a rotary auger which is effectively screwed down into the underlying strata much like a cork screw. Earth remains within the shaft as it is bored. Concreting commences at the base of the pile shaft with the concrete introduced via the hollow stem of the auger. Spoil is expelled by the rotating auger at the top of the shaft as the auger is lifted as simultaneously concrete is pumped through the stem of the auger to form the pile shaft in the ground.

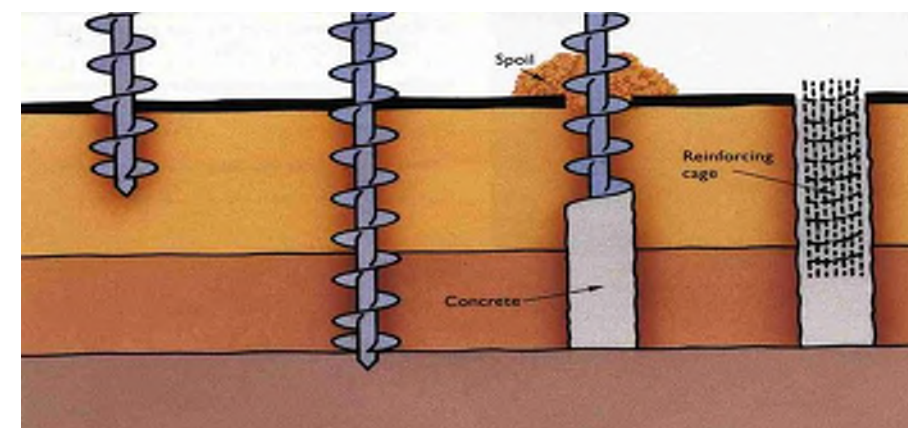


Figure 11: CFA Piling Sequence

The pile shaft remains filled at all times during construction, effectively mitigating the potential for vertical migration of perched groundwater. Considerable overburden pressure within the strata beneath the refuse ensures that the ground remains in intimate contact with the pile shaft, again minimising the potential for migration of leachate.

In addition, leachate and groundwater will be controlled in the vicinity of each phase of the development. New deep leachate collection wells will be installed into the historical land raise waste locally to each phase of the development. These will extract leachate from the waste prior to and during piling works. The perimeter groundwater abstraction system which surrounds the site will be readied for operation prior to each phase of the works. The extraction system is intended to intercept contaminated leachate before the RTG aquifer. The system will be operated as and when groundwater monitoring identifies concentrations of contamination at or above agreed trigger levels. .

For the new development, the proposed CFA piles will be taken down to found in the dense sand layer within the London Clay Basement Beds where the pile capacity would be generated predominantly through end bearing resistance. Piles will be in the region of 20m in length with varying toe levels to achieve this, in accordance with the local geology.

Existing borehole data suggests that this layer may be relatively thin or absent in places. Further intrusive site investigation will be carried out prior to detailed design to confirm this and further design optimisation carried out to ensure any protrusion into the Lambeth group will be no greater depth than 3 m.

A plan showing the Piling Layout and the locations of monitoring wells and leachate drains will be forwarded to the Environment Agency when detailed design has been completed prior to award of the piling contracts.

7.4 Records

The following records will be kept on a daily basis and made available to the Environment Agency:-

- 1) Piles constructed that day.
- 2) Pile depth and reference level
- 3) Reinforcement used
- 4) Concrete delivery records
- 5) Admixture details
- 6) Cube test frequency and location
- 7) Description of pile arisings and proposed destination (e.g.: testing completed, re-use of site, treatment, or disposal).
- 8) Record any cessation in individual pile construction due to e.g. lack of concrete; technical problems with auger.
- 9) Record which leachate collection wells and also which sections of the perimeter groundwater abstraction system have been employed.

8 Earthworks Proposals

8.1 Introduction

The new development will require significant earthworks in order to construct the foundations and ground floor slabs of each building. The presence of the capping layer needs to be taken into account and dealt with accordingly. An application will be made to vary the conditions of the Environmental Permit prior to any disturbance of the engineered landfill cap.

The capping layer currently serves two purposes. It prevents surface water from getting through to the waste layer below which in turn would percolate through and wash contaminants into the Foudry Brook and the secondary aquifer of the River Terrace Gravels below. It also provides a protection layer to stop any contact between the waste and people using the land above by sealing it off and providing a route for landfill gases to be collected and vented off 2m above ground level via vent stacks.

8.2 Proposed Construction

All of the buildings will have a suspended ground floor slab at their lowest level supported on piled foundations. This is primarily to remove the risk of any settlement in the spaces below the buildings due to the depth of variable fill. The existing capping layer is approximately 1.3m below existing ground level and while it would be possible to keep the slab above this layer, deeper areas of construction such as pile caps and lift pits will be required to penetrate below the membrane level. In addition there is a risk that the membrane would be compromised by the piling.

Therefore it is proposed to remove the capping layer locally over the building footprints during piling and construction of the pile caps. The ground floor slabs will then be cast on the pile caps which will replace the capping layer locally. The existing capping layer will be lapped and sealed with the ground floor slabs.

The outline sequence is shown on sketch SSK018 in Appendix A and is summarised as follows. Figure 12 shows the final condition.

1. Plan of building to be marked out and trial pits to be dug locally to confirm depth of membrane prior to reduced level dig.
2. The area to be excavated is to be bunded around the perimeter using a site won clay material or similar. This is to prevent any excess surface water from entering the excavation. Reduced level dig can then commence down to membrane level. Once reached the membrane is to be neatly cut around the new building perimeter. The level can then be reduced down to formation level through the waste and excess spoil disposed of appropriately.
3. A piling mat can then be installed to provide a stable surface for the subsequent piling operations.
4. A temporary membrane is then installed over the building area with sumps in order to collect any rainwater which falls into the excavation.

5. During piling the temporary sheeting is to be removed local to the working area and placed back once an area of piling is complete.
6. Piles to be trimmed down to cut off level and pile caps and lift pits constructed. Finally the suspended reinforced concrete ground floor slabs can be cast and the existing membrane lapped with the edge of the slabs ensuring that the impermeable capping layer is replaced and continuous over the waste below. Retaining walls are then built where required, backfilled and ground landscaped. Placement of the suspended ground floor slab signifies completion of the “Construction Phase” (see Section 11.2)

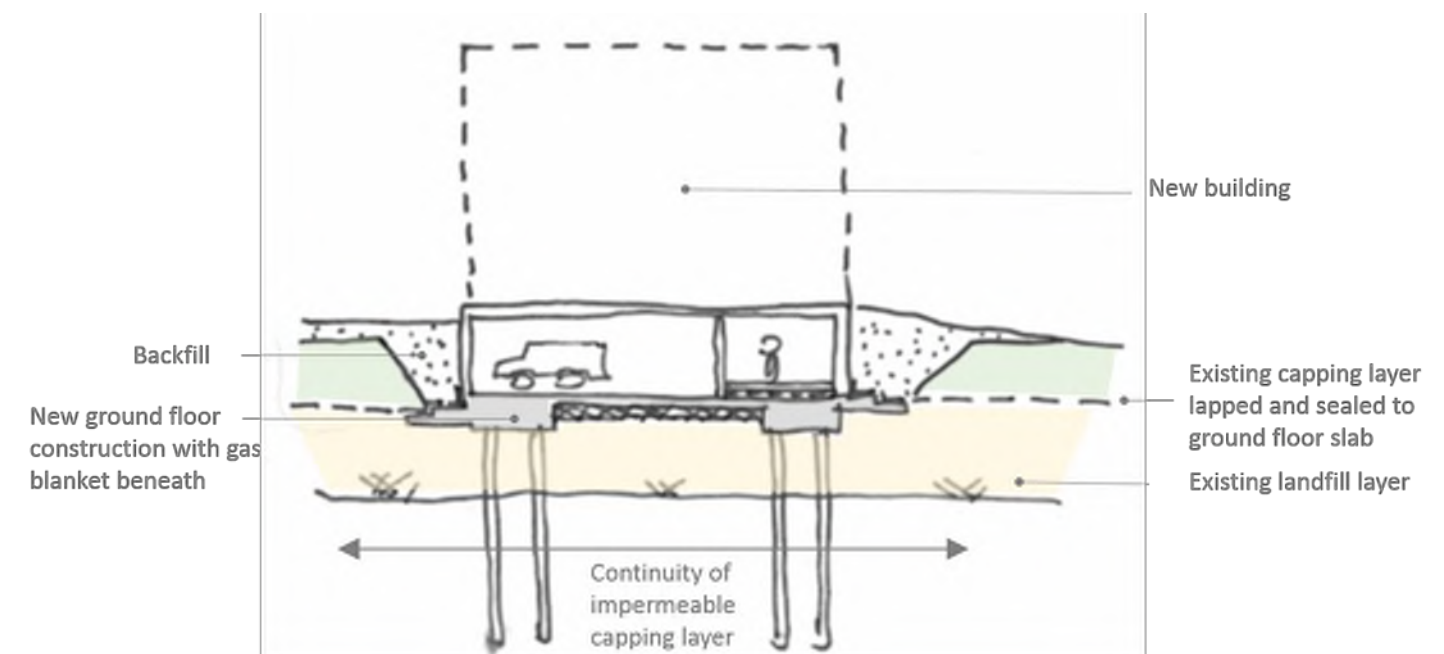


Figure 12: Section through building showing continuity of capping layer in final condition

8.3 Ground Floor Slab Details

The usage of the lowest building levels varies between buildings. Typically for the residential blocks the areas are ventilated car parks. Under the Convention Centre the use varies from a car park, loading bay, hotel lobby and bar and food and beverage areas.

The usage of each area and the Characteristic Gas Situation (CS) will govern the ground floor slab build-up. Final build-ups will be designed in accordance with the process described in BS8485:2015 'Code of Practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings'.

Based on existing gas monitoring data for the site it is anticipated that the CS classification will be CS2 or CS3 from Table 2. This is to be confirmed during detailed design. Building Type varies from B to D, as per Table 3 of the guidance. This gives a required gas score of between 2.5 and 4. The gas protection system should consist of a minimum of two out of three of either a structural barrier, ventilation system or membrane.

The anticipated build-ups are as follows.

- Ventilated car park area – Type D building/ CS3 (Min. gas protection score 2.5 points)

The suspended reinforced concrete ground floor slab will be cast on a membrane over a proprietary void former. The membrane beneath the slab will be lapped with the existing membrane around the perimeter of the building. Refer to figure 13.

Internal Occupied space - Type B building/ CS3 (Min. gas protection score 4 points)

- The suspended reinforced concrete ground slab will be cast on a DPM over a void former over stone fill acting as a passive ventilation layer. A further membrane will be installed on top of the slab to allow easy sealing and subsequent checking of all penetrations. Insulation and a further concrete slab over this will form the final surface. Refer to figure 14.

A perimeter 'transition' slab will be provided around the edge of each building. This will even out any settlement which may occur around the building edges between the unsupported fill and the stiff concrete slab supported on piles. This will prevent damage to the continuous membrane while also ensuring no steps develop between external and internal levels.

Gas vent pipes will channel any collected gas from beneath the sealed layer and vent it to atmosphere.

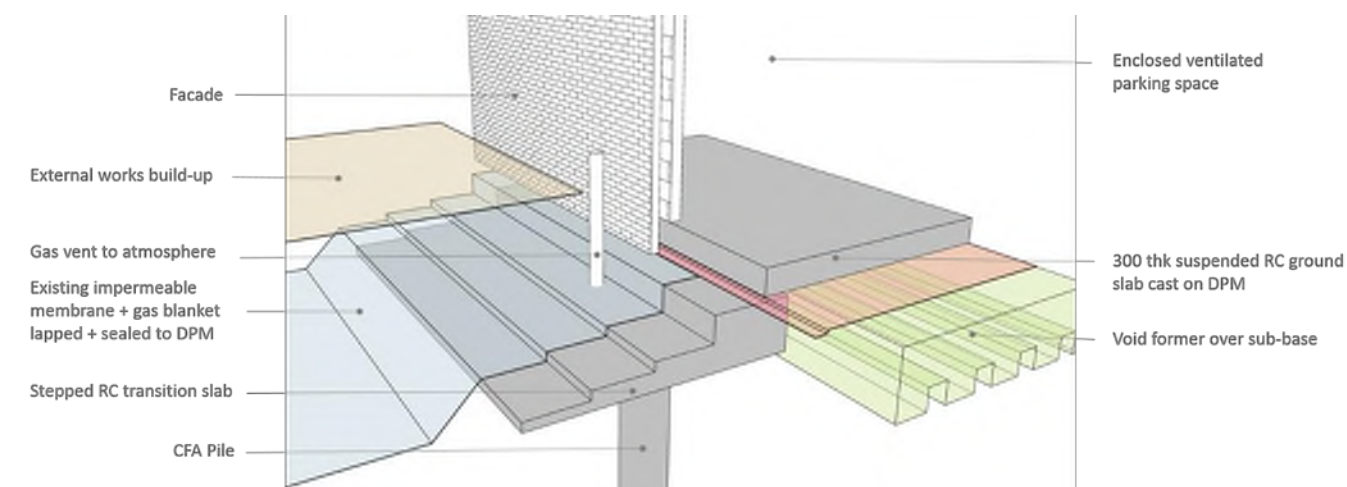


Figure 13: Proposed slab build-up – Ventilated car park area

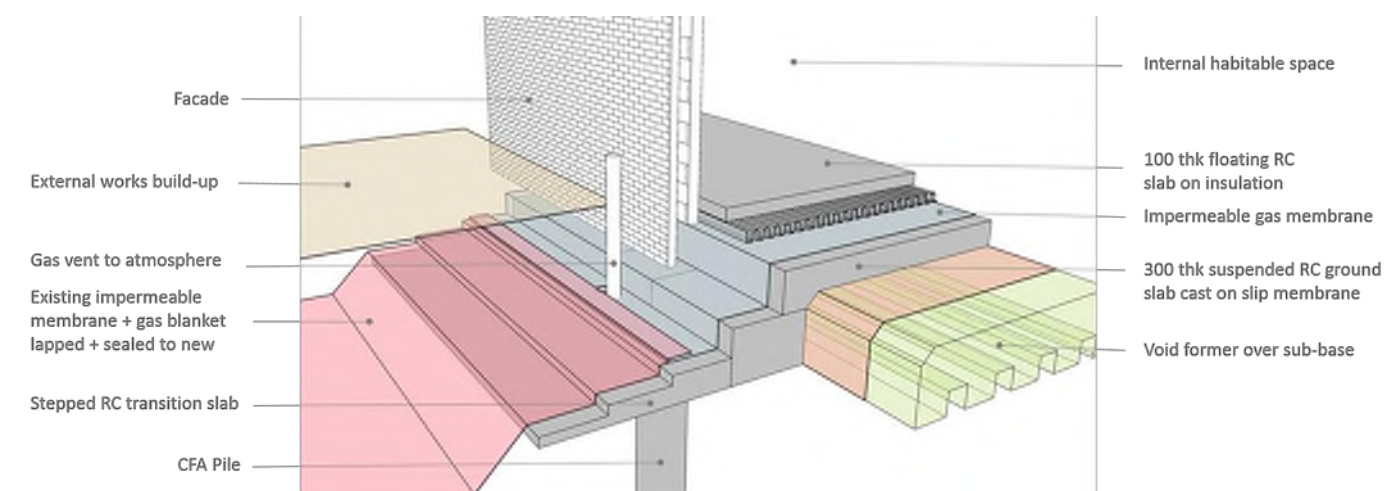


Figure 14: Proposed slab build-up – Internal occupied space

8.4 Site Drainage Scheme

8.4.1 Surface Water Drainage

The proposed surface water drainage scheme collects the rainwater incident on the developed site into a drainage network comprised of surface water collection systems, pipes, SuDS attenuation tanks and flow controls. Due to the site's elevation profile each major rainwater catchment is individually controlled to Greenfield runoff rates. A trunk sewer collects these individually controlled areas and the net effect is a free discharge into the Foudry brook through the existing outfall at a rate that is controlled at source. This proposed rate is a significant betterment on the existing condition. There is also a controlled outflow into the drainage ditch to the south of the site for two of the residential buildings^{[LS8][LS9]}. All of the drainage infrastructure will be above the sealed capping layer and so there will be no adverse effects of rainwater infiltration into the capped waste layer.

8.4.2 Foul Water Drainage

The foul drainage scheme is characterised by its reliance on pumps and storage for each new structure on the site. By pumping each building's foul effluent from a low level adjacent to the building into a gravity trunk sewer, the design controls the flow to a rate to be agreed with Thames Water and avoids penetration of the capping layer by pipes and manholes. The system ultimately discharges via a gravity connection to the Thames Water network to the North East of the site.

9 Earthworks and Piling Risk Assessment

9.1 Qualitative Risk Assessment Methodology

For a risk from contaminated land to exist, there must be a pollution source, a receptor and a viable pathway connecting the source to the receptor. In this section these three elements are investigated and their significance assessed.

Since the objective of this assessment is to determine the risks from the earthworks and piling operations associated with the construction of the new buildings only those pathways that could arise from these activities are considered.

Where such a pathway is identified its impact is compared with the situation that exists currently, i.e. without the proposed additional works necessary to construct the new buildings which comprise the development.

9.2 Pollutant Linkages

Six main potential source – pathway – receptor linkages have been identified for the earthworks and piling for the proposed new buildings as shown in Figure 15. These are:

1. Creation of preferential pathways through low permeability ground strata due to piling operations, allowing potential contamination of the underlying RTG and Chalk aquifers by landfill leachate.
2. Increased risk of contamination to the shallow RTG stratum due to removal of landfill capping layer under building footprints and exposure to rainfall increasing the flow of water through the leachate into the RTGs.
3. Creation of preferential pathways, through the landfill capping layer, to allow upward migration of landfill gas to the surface, which could be a hazard to site workers during construction and occupants of the proposed structures.
4. Direct contact of site workers and current and future site users with contaminated soil arisings which have been brought to the surface and following removal of the capping layer.
5. Contamination of surface water courses from uncontrolled run off from pile arisings in stockpiles or areas of excavation into the landfill material.
6. Direct contact of the piles with contaminated soil or leachate causing degradation of the pile materials.

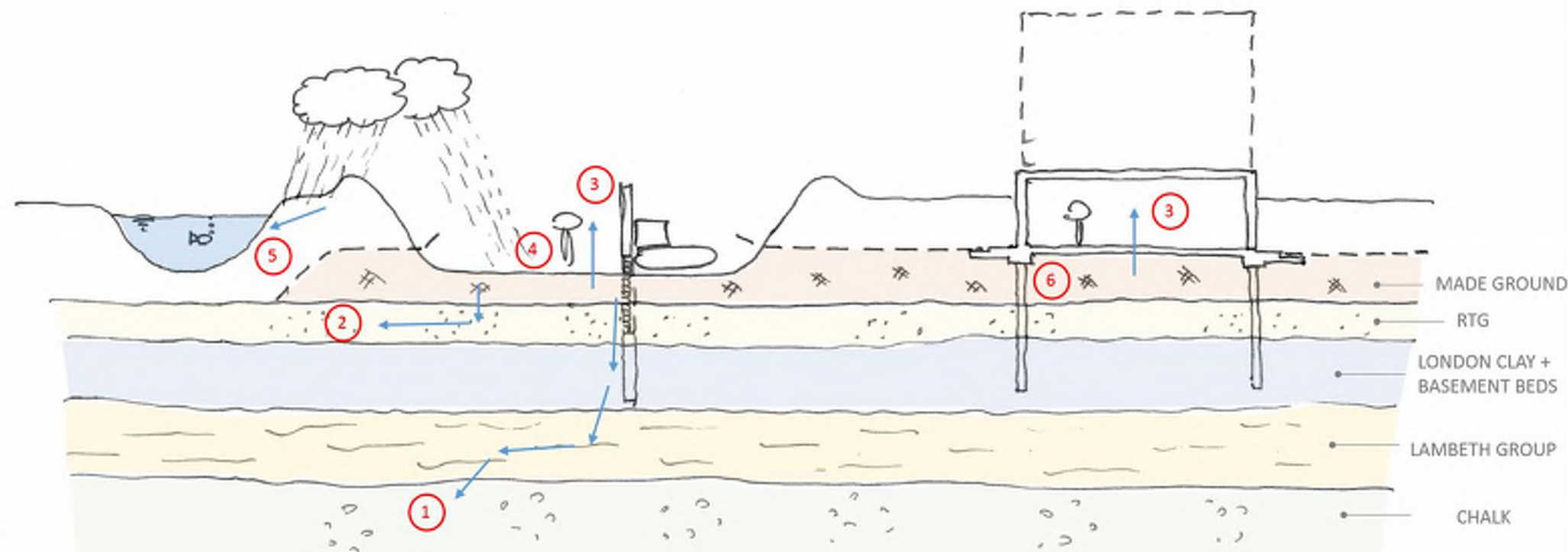


Figure 15: Conceptual site section

9.3 Source / Groundwater Contamination

Groundwater, leachate and gas data have been collected regularly from the Site since July 1996 prior to the development of the Madejski Stadium and latterly under the provision of the Environmental Permit (for the surcharged waste). Over the years, the monitoring programme has been reviewed, rationalised and amended.

A review of the latest available field and laboratory data has been undertaken to understand the current groundwater and leachate quality. These data cover the period May 2011 to February 2015, with a detailed summary of results contained in Appendix B2.

The groundwater field and laboratory results from 2011 to 2015 have been reviewed and screened against the relevant groundwater criteria shown in Table 5 below. The table summarises the groundwater chemistry from all the strata response zones (Made Ground/ fill, RTD, Lambeth Group and Chalk).

Response Zone	Contaminant	Units	No. of samples	Min	Max	Mean	Groundwater criteria (UK DWS 2010)	Total no. of exceedances
Made Ground	ammoniacal nitrogen	mg/l	49	<0.27	197 (BHM)	71.0	0.39	43
Gravels	ammoniacal nitrogen	mg/l	374	0.19	181 (BHJ)	11.20	0.39	206
Lambeth Group	ammoniacal nitrogen	mg/l	73	0.19	35.8 (BH321)	35.8	0.39	46
Chalk	ammoniacal nitrogen	mg/l	10	2.62	37.4 (BH304d)	10.92	0.39	10

Table 5: Ammoniacal nitrogen results by response zone

Where exceedances have been identified a further analysis of the groundwater chemistry has been carried out for each of the response zones (Made Ground/landfill material, RTG, Lambeth Group and Chalk). The tables are presented in Appendix B2 (Tables B2.1-B2.6).

The chemical analysis of groundwater samples recorded over the last five years indicates that the main contaminants of concern are potassium and ammonium (measured in the laboratory as ammoniacal nitrogen). The latter is most concentrated in the Made Ground in which a maximum concentration of 197mg/l was recorded in June 2014 in BH M and in BH J in August 2015, where a maximum concentration of 181mg/l was recorded. Concentrations of ammoniacal nitrogen decrease through the lower geological succession with average readings in the Lambeth Group and Chalk at less than 10mg/l.

The groundwater field and laboratory ammoniacal nitrogen results from 2011 to 2015 are presented in Table 6 below. In summary, 260 exceedances of the groundwater criteria have been recorded and on average the concentration of ammoniacal nitrogen in the groundwater is

29.29 mg/l (Drinking Water Standard for ammoniacal nitrogen is 0.39mg/l - extrapolated from UK Drinking Water Standard, 2010, for ammonium of 0.5 mg/l).

Contaminant	No of samples	Units	Min	Max	Mean	Groundwater criteria (UK DWS 2000)	Total no. of exceedances
Arsenic	64	µg/l	<1	12.3	1.84	10	1
Cadmium	64	µg/l	<0.6	0.8	0.61	5	0
Copper	64	µg/l	1	9	6.4	2000	0
Iron	516	mg/l	<0.23	34.2	0.3	200	0
Lead	64	µg/l	5	11.3	5.97	10	1
Mercury	60	µg/l	<0.1	<0.1	<0.1	1	0
Nickel	64	µg/l	2	33	7.75	20	3
Zinc	64	µg/l	3	384	58.25	5000*	0
Nitrate as NO3	107	mg/l	0.12	79.6	11.69	50	3
Total ammoniacal nitrogen	506	mg/l	0.19	197	15.81	0.39	305
Potassium	414	mg/l	0.43	113	19.76	12*	210
Sodium	107	mg/l	4.31	186	71.99	200	0
Sulphate	107	mg/l	0.002	247	4.67	250	0
Magnesium	107	mg/l	1.9	61	23.04	50*	4

*UK DWS (1989)

Table 6: Groundwater Chemistry- Groundwater Monitoring Wells 2011 - 2015

There have also been over 200 exceedances of potassium recorded in the past five years, most of which have been identified in the RTD. Average concentrations in the gravels are approximately 18mg/l. BHs M, J, I and K have consistently recorded values above this average (2011-15), with BH N also showing an increasing trend since March 2014. The maximum Potassium value (2011-15) was 113mg/l, measured in BH M in September 2014. The DWS for potassium is 12mg/l. Potassium is widely used as a fertilizer and can be an abundant regional contaminant in groundwater.

Between 2011 and 2015 there has been only one exceedance each of the DWS for arsenic and lead; three each of nickel and nitrate, and four exceedances of magnesium.

Monitoring data gathered between 2015-7 indicated that the most elevated concentrations of Ammoniacal nitrogen (650mg/l) at the site were recorded in the lower leachate wells (LW series). Within the terrace gravels, the most elevated concentrations of ammoniacal nitrogen were measured in the boreholes BH J, BH2 and BH M with maximum concentrations recorded at 187mg/l (Oct-15), 149 mg/l (Nov-16) and 146 mg/l (May-16) respectively. The lettered series wells are designed to sample the RTGs. Although as discussed previously, the BH records in the past indicate that BH M intercepts the waste material, BH2 which was installed to replace BH M recorded higher concentration of ammoniacal nitrogen as compared to BH M.

Concentrations of ammonium are significantly lower in the underlying Chalk Formation with the highest concentration recorded at 53.1mg/l in BH 327 in Jun-16. Much lower (trace) concentrations were recorded in the surface water samples collected.

With respect to ammonia which is the main contaminant of concern, concentrations decrease from the waste, to the RTG and the Chalk, indicating significant dilution and dispersion, with increased vertical and lateral distance from the waste body.

10 Source – Pathway – Receptor Assessment

10.1 Scenario 1: Vertical migration of contaminated water / leachate to lower aquifers during piling.

10.1.1 Introduction

Attention is focused on the shallow RTG aquifer and the deeper Chalk aquifer as these groundwater resources are most at risk from contamination from the earthworks and piling operations. The RTG are classified as a secondary (A) aquifer although this resource is not currently used for potable supply.

The other two water bearing strata, the London Clay Sandy Basements Beds and the Lambeth Group are not considered as primary receptors but are assessed as potential pathways for migration. These strata are not exploited within the area and they generally considered as being of lower capacity in relation to the RTG and Chalk aquifers.

10.1.2 Assessment

The sequence of pile construction is described in Section 7.3. Initially the auger is "screwed" into the ground with little disturbance of the strata. At the base of the auger is a flap valve, which is held shut by the pressure arising from the downward motion of the auger

On reaching the required depth, the auger is raised. Once the auger has been raised by a distance equivalent to the size of the flap valve, approximately 200 - 300mm, the valve opens with the pressure of the concrete in the central core of the auger and the void is immediately filled with concrete. The concrete, under a 20 - 25m head, also fills any voids in the immediate surrounding material. Concrete continues to fill the pile as the auger is raised further until the pile is complete. For the depth of pile proposed, this process is estimated to take approximately 1 hour per pile.

During the construction of a pile there are two stages at which a temporary migration pathway between the perched water in the leachate and the RTG aquifer may be created. They are:

- As the auger is lifted, the section of gravel carried up on the auger breaches the Alluvial Clay between the landfill and RTG. This pathway is rapidly blocked when the London Clay section on the auger "plugs" the boundary between made ground and the RTG.
- A second migration path is created when the section of London Clay Basements Beds breaches the Alluvial Clay between the landfill and RTG. This again is rapidly blocked with concrete when the auger is lifted further.

It is possible to broadly estimate both the time during which these two pathways are open and the volume of downwards leachate flow into the RTG aquifer. This shows that during the construction of each pile the flow is negligibly small when compared with the natural flow of the perched water in the leachate through into the RTG. This calculation was detailed in Arup's 1998 report (The Assessment of Risk to Groundwater from Piling for the Proposed Madejski Hotel) and is summarised as follows.

For each pile the time during which the RTG pathway would be open was estimated as 2 to 3 minutes. For a conservative 2m head [LS10] of leachate above the base of the made ground, the volume of perched water flowing into the RTG through the identified pathways was estimated to be 7.0 litres per pile.

To further mitigate the potential for leachate to enter the pile bore, the following will be carried out prior to and during each phase of piling works:

1. The leachate sumps constructed into the surcharged waste will be pumped dry and maintained dry.
2. New leachate collection wells will be constructed to the base of the historic land raise to remove leachate from the full depth of the waste material..

The volume of perched water in the leachate flowing naturally through the Alluvium into the RTG over the footprint of a typical building, approximately 2000m², without piling was estimated to be 70 to 700 litres in the same time.

From this it is clear that the contribution of the piling to the flow of perched water within the leachate to the RTG is many time less than that which occurs through the alluvial clay without piling and is therefore considered to have a negligible effect.

Another mechanism for migration may also exist within the London Clay. This mechanism is also characterised by two stages;

- As the piling auger is lifted up, the material within the auger will shear from the surrounding strata. This may lead to a very small and temporary migration path along the sheared interface. This is only open until the concrete is pumped into the pile up to the base of the made ground.
- As the concrete is pumped into the pile under a considerable head, the concrete will be forced into any voids on the pile/soil interface, and this pathway will be effectively sealed again. Indeed part of the strength of the pile arises from the skin friction between the pile and the surrounding material and there must therefore be intimate contact between the two.

One of the advantages of CFA piling over other forms of pile construction is that the surface of the surrounding material is roughened by the rotation of the auger during piling. This provides a very good key for the concrete and better contact between concrete and ground.

Although this is considered a very unlikely pathway for significant migration, calculations in Arup's 1998 risk assessment report showed that the introduction of perched water into the London Clay Basements Beds has negligible impact due the very long times taken for perched water to migrate to the Chalk aquifer through the Lambeth group.

10.1.3 Review of baseline monitoring data

For 12 months prior to the original redevelopment of the Smallmead Landfill site, throughout the reclamation works and the construction of the Madejski Stadium and Hotel, and the subsequent Hotel extensions, the groundwaters beneath and surface waters around the site have been monitored. Regular monitoring continues in accordance with the requirements of the Environmental Permit.

The plan in SK-022-01 in Appendix A shows the position of those boreholes on and around the site in relation to the proposed area of piling for the new development.

From the 2011-15 data the overall picture at most monitoring locations in the RTG is one of general long term stability or improvement of water quality. There are some borehole locations with rising or fluctuating trends, specifically BHs J.K, M and N.

During previous phases of reclamation at the Site, water quality data indicated that some deterioration in water quality of the RTG had occurred following piling but that this deterioration had been reversed by abstraction from the groundwater abstraction system. When abstraction was again activated in 1999 during construction of the Hotel, it did not appear to have had a marked effect on concentrations within the RTG. It is considered that during the new phase of development, pumping from the RTG via the groundwater abstraction system and use of newly installed leachate collection wells will help to contain the migration of contaminated groundwater within the Site.

Monitoring data from boreholes in the London Clay Basement Beds and Lambeth group suggest that concentrations of ammoniacal nitrogen have been relatively stable and below 50mg/l in these strata.

10.1.4 Conclusions

Three plausible temporary pathways related to continuous flight auger piling have been identified. It has been demonstrated that these mechanisms are unlikely to have a significant impact on the quality of the water in the RTG compared with the rate at which perched water naturally passes through the discontinuous Alluvial Clay.

With some notable exceptions, water quality in the RTG has generally been improving since the reclamation of the site, despite the use of piled foundations on a number of previous occasions.

A further pathway for the enhanced downward migration of perched water as far as the London Clay Basement Beds has tentatively been identified. This involves the migration of water down the sheared interface between the pile under construction and the surrounding ground. Should such a pathway exist, it would only be open for a very short time for each pile. Such a short lived pathway would have a negligible effect on the overall rate at which contaminants may travel down to the Chalk aquifer through the Lambeth group.

Whilst it can never be said that there is no risk to groundwater from piling through the landfill, it has been shown that, in the particular circumstances of this site, the risk of adverse effects to the water bearing strata beneath the site by piling operations is very low. This risk decreases further with depth, with the relative risk to the RTG being greatest and that to the Chalk being the least.

Finally, it is clear from the calculations completed that the head of perched water has an effect on the likely risk from piling and that it would be beneficial to reduce the head of water prior to piling operations by dewatering the leachate sumps constructed into the surcharged waste and installing and operating new leachate abstraction wells constructed to the base of the historical land raise.

In addition pumping from the perimeter groundwater abstraction system during piling will help to contain the migration of contaminated groundwater within the site.

10.1.5 Mitigation and monitoring

In order to minimise the risk to groundwater a precautionary approach is to be adopted during the piling works. In addition to the measures specific to piling depth, piling method and records outlined in Section 7, the following will be undertaken:

- All leachate collection wells in the vicinity of the proposed piling works will be pumped dry and maintained in this condition prior to and during piling operations. A plan will be submitted to the Environment Agency detailing which sumps will be pumped.
- For the duration of the piling works, the lines of the groundwater abstraction system closest to the location of the proposed piling works will be made operational. Extracted contaminated groundwater and leachate will be discharged to the foul sewer under the existing consent to discharge.
- Groundwater monitoring will continue throughout the piling works and for a specified period afterwards (refer to Section 12).

10.2 Scenario 2: Vertical migration of contaminated water / leachate to the shallow RTG aquifer due to temporary removal of the capping layer and exposure to rainfall

10.2.1 Introduction

The engineered capping layer will be locally removed in a controlled manner over agreed areas in order to construct the substructure of the buildings. During this time a limited area of the made ground will be exposed and there is an increased risk of rainfall which falls over the area causing an increased head and thus increased flow of contaminated leachate down into the RTG aquifer below through the existing interface which consists in part of a layer of Alluvial clay.

10.2.2 Assessment

The water levels in the leachate are typically 1-2m above the base of the original landfill layer. Above this water level lies a further 4-6m of made ground. If rain falls on the exposed area during construction there will be a time lag between the rain event and the collected water permeating down to reach the existing leachate level and increase the head.

In addition, the leachate wells will be monitored during the works and pumped out to control this level in the vicinity of the construction area. Therefore during the time that the landfill is exposed the leachate level within the fill can be controlled.

The permeability of the layers beneath the area of excavation (ie. the remaining made ground and alluvial clay layer) will remain the same as the existing situation. Therefore the only change is the head of water in the leachate local to the exposed area which can be controlled.

A further measure to mitigate the risk of increased flow of contaminated leachate into the RTG and subsequently off site is the perimeter ground water abstraction system, which in

conjunction with frequent monitoring will be used to intercept and contaminated ground water.

10.2.3 Conclusions

A controlled sequence which limits the area of made ground exposed at any one time coupled with the monitoring and ground water control measures that will be in place means there is a low risk of adverse effect on the RTG aquifer on and off site from contaminated leachate.

10.3 Scenario 3: Upward migration of landfill gas to the surface

10.3.1 Introduction

Gas monitoring has been undertaken at the Site which has identified the presence of ground gas. Ground gases have the potential to migrate through the available pathways and accumulate within the trenches, excavations, basements and confined spaces.

There is potential for human health (construction workers and end users) to be affected by gas accumulation, the magnitude of which is assessed as major, having the potential to cause asphyxiation in the worse cause scenario.

The buildings themselves will require specially designed and detailed gas protection measures in the permanent condition to protect the internal spaces against ingress and build-up of ground gas.

10.3.2 Assessment

An existing four-component gas control system existing over the development site which was installed as part of the original Stadium development in the late 1990's comprising the following:

- A low permeability cap which in addition to providing a barrier to gas migration also reduces the rate of gas generation by reducing the rate of waste degradation
- Vertical fin drains in the waste, which provide a low resistance path for gases to flow through.
- A gas collection blanket (part of the engineered cap) that provides a low resistance flow path, below the cap, from the fin drains to the gas discharge vents.
- A series of gas vents across the site which discharge gases to atmosphere thereby minimising the pressure within the waste and the gas control system.

During Construction

The engineered capping layer will be locally removed in a controlled manner over agreed areas in order to construct the substructure of the buildings. During this time there will be increased risk of exposure of site workers to landfill gases which can migrate to the surface.

However the site will be fully open during these periods and so there is little risk of build-up of gases as any gas that does migrate will quickly disperse into the atmosphere.

As on all contaminated sites, extra precautions will be taken to comply with or improve upon the requirements of the CDM Regulations, Health and Safety at Work, Act 1974 COSHH Regulations and other relevant HSE guidance. All relevant details of the contamination on the site will be forwarded to the Principal Contractor who will be required to produce a comprehensive health and safety risk assessment and detailed method statement for the works. The Principal Contractor's risk assessment and method statement will need to address all issues in relation to potential exposure to ground gases during construction.

Post Construction

A series of landfill gas protection measures will be incorporated into the construction of the substructure of the new buildings. This will prevent the upwards migration of ground gases into and around the new buildings and reduce the risk of gas build-up in any confined spaces. The design of these will be based on further site investigation, monitoring of ground gases and subsequent quantitative risk assessment. Outline proposals are described in Section 8.3.

It is assumed that conditions will be similar to those considered during the original hotel, hotel extension and stadium extension risk assessments. Careful consideration will be given to the avoidance of areas with little or no ventilation.

The following landfill gas protection measures will be employed for the proposed redevelopment:

- Sealing of the existing capping layer to the perimeters of ground floor slabs of the new buildings providing continuity of the impermeable protection layer to reduce the risk of areas where gas might permeate upward between the buildings.
- Provision of sub-floor voids incorporating passive ventilation depending on floor plan depth. Care will need to be exercised to avoid producing pockets of entrapped air or "dead spots".
- A ground floor slab of suitable thickness and strength to limit surface crack widths and designed joints in the floor to control shrinkage stress and minimise full depth cracking.
- Services to be designed to enter above slab level where possible. Entry points to the building should be well sealed:
- Assessment of possible mechanical ventilation of large areas of ground floor slab, eg : the Convention Centre that are to be regularly occupied and therefore perceived to have a higher level of risk.
- Where possible, louvered doors should be used to ensure that all rooms including cupboards, service cupboards and toilets receive adequate ventilation;
- Where possible, construction activities to avoid damage to existing fin drains or gas venting shafts;
- Replacement of gas venting wells as vertical risers outside the proposed buildings; and.
- Replacement of any fin drains or gas vents outside the building footprint that are damaged or destroyed during construction works.

10.3.3 Conclusions and Recommendations

Based upon the findings of the landfill gas risk assessment the level of risk for the proposed redevelopment is considered acceptable provided that the similar protection measures are employed and that care is taken to fully integrate them with those already in place.

10.4 Scenario 4: Direct contact with contaminated soil arisings

As on all contaminated sites, extra precautions will be taken to comply with or improve upon the requirements of the CDM Regulations, Health and Safety at Work, Act 1974 and other relevant HSE guidance. All relevant details of the contamination on the site will be forwarded to the Principal Contractor who will be required to produce a comprehensive health and safety risk assessment and detailed method statement for the works. The Principal Contractor's risk assessment and method statement will need to address all issues in relation to potential exposure to contaminated soil arisings.

10.5 Scenario 5: Contamination of surface water courses from uncontrolled run off from pile arisings in stockpiles

It is recommended that a watching brief is carried out during the construction works; this will require that the excavated soils are inspected as they are removed from the excavations. In addition, should any spoil require disposal then this should be placed in a dedicated area within the site compound, in accordance with current best practice e.g. as defined in Construction Code of Practice for the Sustainable Use of Soils (DEFRA, 2009) and Working at Construction and Demolition Sites: PPG6 Pollution Prevention Guidelines (Environment Agency 2012). Soil samples should be collected from the stockpile for chemical and WAC analyses.

Excavation spoil will be re-used wherever possible, either on or off-site, in accordance with The Definition of Waste: Development Industry Code of Practice (CLAIRE). This will be facilitated through the use of a Materials Management Plan (MMP).

10.6 Scenario 6: Degradation of pile materials

A full risk assessment in accordance with BRE Special Digest 1:2005 will be conducted prior to construction of the piles. Concrete classes will be determined based on the results of this assessment. This will ensure that the risks of pile degradation and resultant vertical pathways for contaminant migration will be negligible. A copy of the risk assessment will be forwarded to the Environment Agency and Planning Authority if required.

11 Future Monitoring

Ground water monitoring is addressed in two parallel strategies:

1. Ongoing monitoring required for the existing Environmental Permit (Permit number T/W/54/12/4/436).
2. Additional monitoring during the proposed construction works.

It is highly likely that both strategies will overlap. This section outlines the proposed monitoring for both and how they would complement one another, should they overlap.

11.1 Existing Environmental Permit Monitoring

The existing monitoring of ground water, required under the Environmental Permit, is described in Section 6.1 and further detailed in Appendix B1.

This monitoring will continue and progress to permit closure (as outlined in Section 11.3 below). The permit may be surrendered before construction commences.

Ground water monitoring for the construction works would follow the strategy outlined in Section 11.2 below.

Should construction start before the permit is surrendered, the ground water monitoring for the construction works will be carried out in parallel to the permit monitoring and where appropriate take advantage of the permit monitoring (so that the same monitoring is not duplicated).

As commencement of the development approaches, monitoring in the areas local to the construction works will be revised to the proposed monitoring suites in Appendix B3 for the period of pre-, during and post construction. These will take precedence over the original requirements in these areas for the period in question. Once the post construction phase has ended the monitoring regime would then revert back to the original permit requirements, or a simplified permit requirement, to be agreed with the EA. The monitoring regime is shown conceptually in the timeline in Figure 16^[LS12].

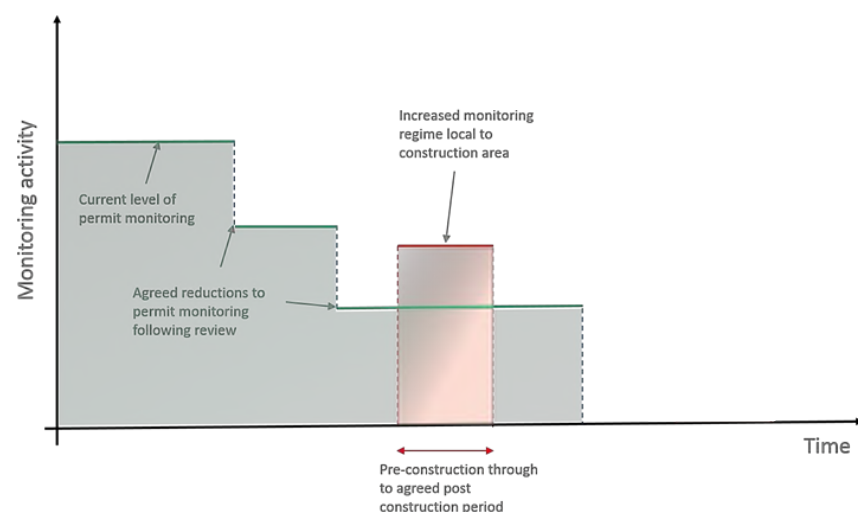


Figure 16: Monitoring Regime Timeline

11.2 Proposed Development

During Phase 1, shown in Figure 2, the existing monitoring suites shown in Appendix B1 are revised to those shown in Appendix B3 in the vicinity of Phase 1 construction area.

Monitoring of gas, ground and surface water will be carried out prior to, during and post construction of Phase I as outlined below. The same process would be repeated for Phase II.

The action plan described on section 11.2.5 is to be in place prior to any works commencing.

11.2.1 Pre-construction

The groundwater extraction system (Figure 10.4 in Appendix A) should be inspected and any necessary remedial works identified and proposals for these submitted to the EA. The dewatering system will be commissioned adjacent to each phase and groundwater lowered for a period of one month prior to any piling works. For phase I lines 1, 2, 4 and 6 will be operated for Phase II 2, 3 and 4 will be operated.

Carry-out 3 sets of groundwater monitoring at monthly intervals, the last set being at least 2 months prior to any excavation. This will allow the new and existing boreholes time to equilibrate and give time for review and discussion of the results with the EA.

Results from ongoing Permit monitoring may form part / all of the pre-construction development monitoring. If the Permit has been surrendered prior to construction and there is no ongoing monitoring, at least 4 No. boreholes into the River Terrace Gravels (RTG) and 2 No. boreholes into the chalk in the vicinity of each construction area should be monitored. The boreholes are to be chosen such that they are appropriate and account taken of the potentially varying groundwater flow directions.

11.2.2 Construction Phase

Carry-out monthly monitoring of the chosen 4 No. RTG boreholes near to each construction area and 2 No. Chalk boreholes.

Monitoring to commence at the start of excavation and continue until the site surface is re-sealed by reinstatement of gas resistant membrane and capping layer and placement of the ground floor slab (defined as the end of the construction phase).

Results are to be reviewed in consultation with the EA and outline Action Plan (as indicated below).

The groundwater abstraction system plus newly installed leachate collection wells are to be deployed if necessary, in accordance with the outline Action Plan.

11.2.3 Post Construction

This is defined as the period following completion of the ground floor slab. It is proposed to:

- Carry-out monthly monitoring of the 4 No. RTG boreholes for 6 months;
- Carry out monthly monitoring of the 2 No. Chalk boreholes for 12 months; and

- Continue Environment Permit monitoring, as defined in Appendix B1 or a simplified requirement to be agreed with the EA.
- The groundwater abstraction system plus newly installed leachate collection wells are to be deployed if necessary, in accordance with the outline Action Plan.

11.2.4 **Trigger Values**

Consultation with the Environment Agency¹ indicates that trigger values should be used as part of the monitoring programme for both the proposed development and the eventual surrender of the Environmental Permit. The purpose of these values in terms of the proposed redevelopment is that they will be set to allow action to be taken if necessary, so that the construction works will not lead to a significant worsening of the existing baseline groundwater quality within the RTG and Chalk aquifers. The quality of the leachate within the original waste should be measured in order to establish baseline quality.

The methodology for setting the trigger values is set out in Appendix D

The trigger values should be agreed once the current work to replace BHs M, X and 328 is complete and the monitoring data from these new wells has been collected, reviewed and assessed. The assessment should be carried out near to the proposed construction works, for example 3 months prior to construction, to take advantage of the most recent monitoring results.

11.2.5 **Action Plan**

Following each round of monitoring Reading Football Club will agree the status of results and any subsequent action using a ‘Red, Amber, Green’ status. The action to be carried out for each status is described in table 7. The following items should also be addressed:

- Communication: establishment of regular & emergency protocols for communication with relevant stakeholders, eg: EA, EHO, Retail Park, Green Park (site neighbours);
- Groundwater extraction system: inspection and any necessary remedial works identified and proposals for these submitted to the EA.

Table 7: Summary of outline Action plan[LS13]

Status	Action
Green	None specifically but continue monitoring in accordance with 11.1 and EP
Amber: rising trends recorded over at least 3 consecutive monitoring events	Review construction processes on site & agree improvements where appropriate
Red: trigger values met/exceeded over at least 3 consecutive monitoring events	Turn on dewatering lines and the new extraction wells to the base of the waste local to each construction phase and in agreement with the EA. Temporarily increase monitoring frequencies to fortnightly and review results.

11.3 Environmental Permit Variation

In order to manage the site procedures during the construction and post construction phases a permit variation will be required. The variation will include modification or additions to the current existing permit (T/W/54/12/4/436) including environmental monitoring, landfill gas and leachate management.

The proposed development must not compromise the ability of the current or future permit holder to comply with the conditions of the permit and ultimately demonstrate that the landfill can progress to permit surrender. This would *include* ensuring:

- That the site is operated to prevent or minimise pollution or harm to human health
- The inspection, maintenance and integrity of the landfill infrastructure, including the cap.
- Inspection/maintenance of the restoration profile.
- Landfill gas management
- Maintenance and monitoring of leachate infrastructure
- Maintenance and monitoring of groundwater infrastructure
- Surface water management and maintaining the quality of run off
- Access to the site for emergency works, installation of additional or replacement infrastructure etc.
- Assessing the settlement behaviour of the wastes (e.g. obtaining topographic surveys)
- Monitoring to provide evidence that the waste is ‘stable’ for a surrender application.
- Site security

Where the development impinges on the landfill infrastructure, including the landfill cap, work must be carried out in accordance with the permit and with the agreement of the Environment Agency.

A Construction Quality Assurance (CQA) report will also be prepared prior to construction. The CQA aims to provide confidence to the EA and will detail the mechanisms, standards and specifications which will be in place during construction. The CQA report will cover all engineering designs and monitoring, maintenance proposed and will be agreed with the EA prior to construction.

Throughout construction all records shall be documented to provide a clear audit trail. This will culminate in a validation report. The validation report will be submitted following construction, which shall include details of all testing, as built plans, daily site records and justification for any changes or deviation from the CQA plan etc.

11.4 Surrender of Environmental Permit [LS14]

In terms of the eventual surrender of the Environmental Permit compliance limits will need to be agreed with the EA in accordance with the relevant EA guidance documents. The

compliance limits will relate to the permitted waste only, re-deposited in 1996 and should be based upon the premise that the waste body is in “steady state” and if left undisturbed, will not cause pollution of the environment.

Going forward, key tasks for achieving surrender of the Environmental Permit are as follows:

- Complete a groundwater modelling study of key contaminants ,i.e.: ammoniacal nitrogen and potassium to establish site specific groundwater risk assessment criteria, assessment levels and compliance limits, in accordance with the EA guidance document “How to comply with your environmental permit, additional guidance for Landfill (EPR 5.02, 2009)” and other EA guidance referenced therein;
- Submit results for EA review and jointly agree risk based assessment and compliance limits (completion criteria) for the permit surrender;
- Propose and agree a reduced frequency monitoring regime based on the agreed risk based trigger/compliance limits, e.g.: monitor the following Controlled Waters for the revised suites, in accordance with the frequencies proposed in Appendix B3:
- Continue bi-monthly monitoring (to include gas, leachate and groundwater) for 12 months following the post construction phase,
- Establish a 6-month period (i.e. 3No, tests) of steady state conditions;
- Post steady state, carry out two further ‘closure’ suites at further 6 and 12 month intervals;
- Subject to closure results falling within the steady state levels surrender the permit and cease all further monitoring;
- Decommission and make safe all existing monitoring infrastructure at the site, in accordance with EA guidance.

Appendix A

Figures

A1.

Appendix A

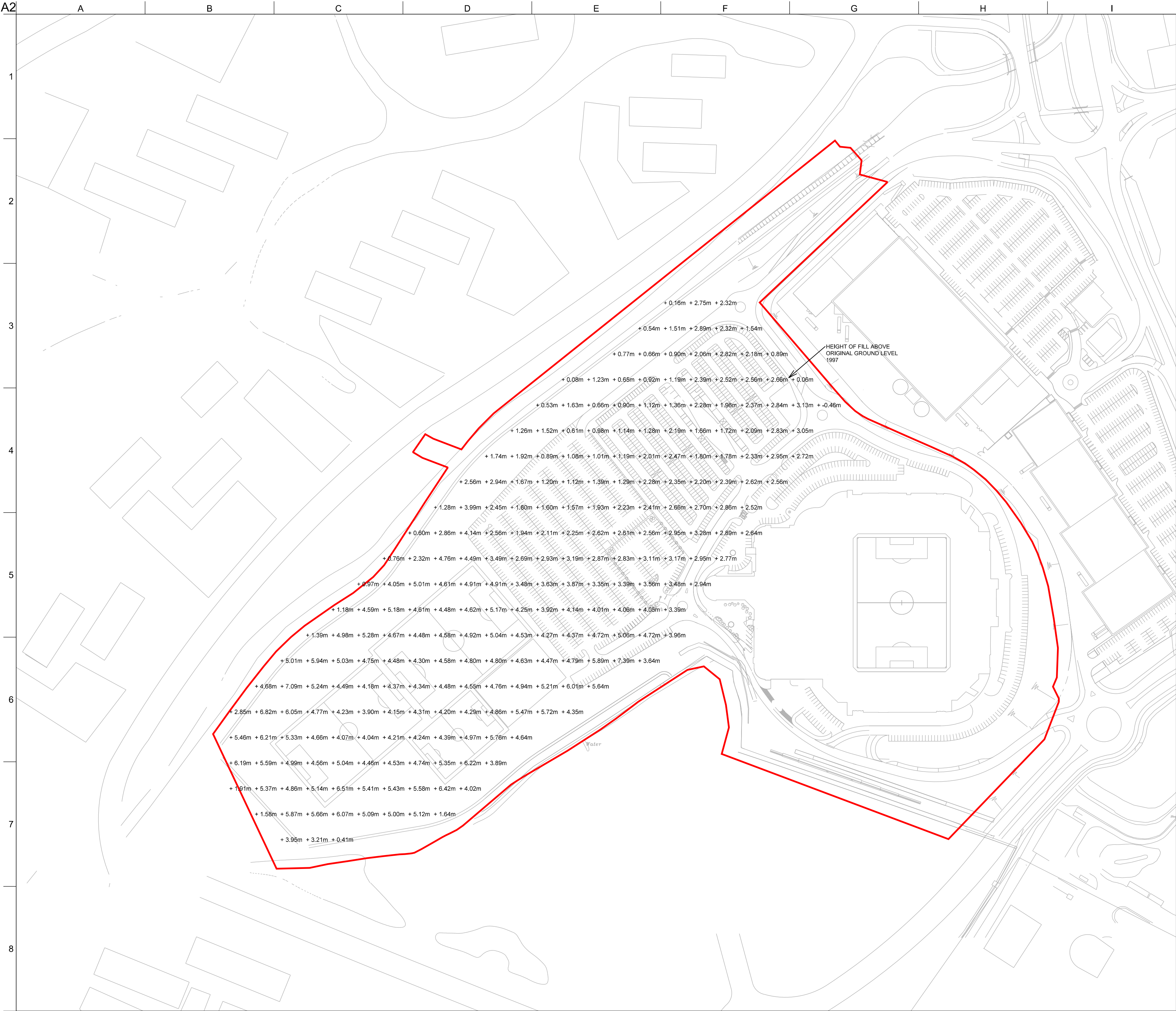
Figures

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A2	Figure 10.2 Historical Existing Thickness of Fill	2
A3	Figure 10.3 Perimeter Dewatering Well Points	3
A4	Figure 10.4 Monitoring Locations	4
A5	Figure 10.5 Overlay of Proposed Buildings on Monitoring Locations	5
A6	Figure 10.6 Additional and replacement monitoring well locations	6
A7	SSK018 Earthworks Construction Sequence	7

A1 **Figure 10.1 Areas of Recorded Landfill**

A2 **Figure 10.2 Historical Existing Thickness of Fill**



- Notes:
- Do not scale from this drawing.
 - All dimensions are in metres unless otherwise stated.

Legend:

Site Boundary

01	28/09/15	SB	CM	LS
For Information				
Issue	Date	By	Chkd	Appd

ARUP

The Arup Campus, Blythe Gate, Blythe Valley Park
Solihull, West Midlands B90 8AE
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Client

Reading Football Club Ltd

Job Title

Land at Madejski Stadium, Reading
Environmental Impact Assessment

Historical Existing Fill
Thicknesses

Scale at A2 1:2000	
Discipline Environmental	
Job No 244202-00	Drawing Status For Information
Drawing No I	Issue 01

Figure 10.2

A3 **Figure 10.3 Perimeter Dewatering Well Points**



Job Title: READING FC RELOCATION WELL POINT SYSTEM LAYOUT		Sketch No. FIGURE 1	
Job No. J460	Date: 28/07/97	Drawn by: TR.	Checked by:

SCALE 1:2500 A3
0 50 100m

DISCHARGE
POINT



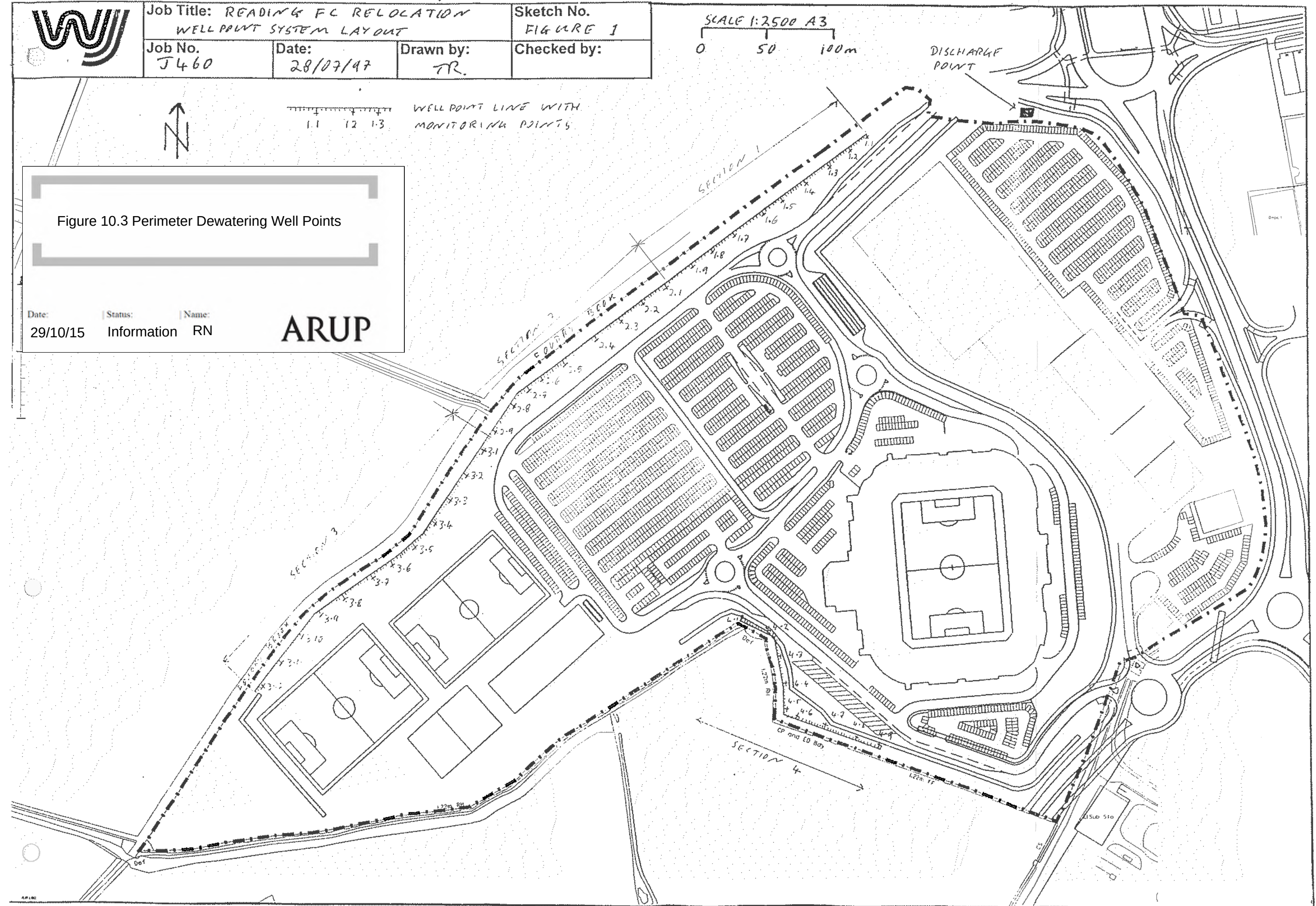
1.1 1.2 1.3

WELL POINT LINE WITH
MONITORING POINTS

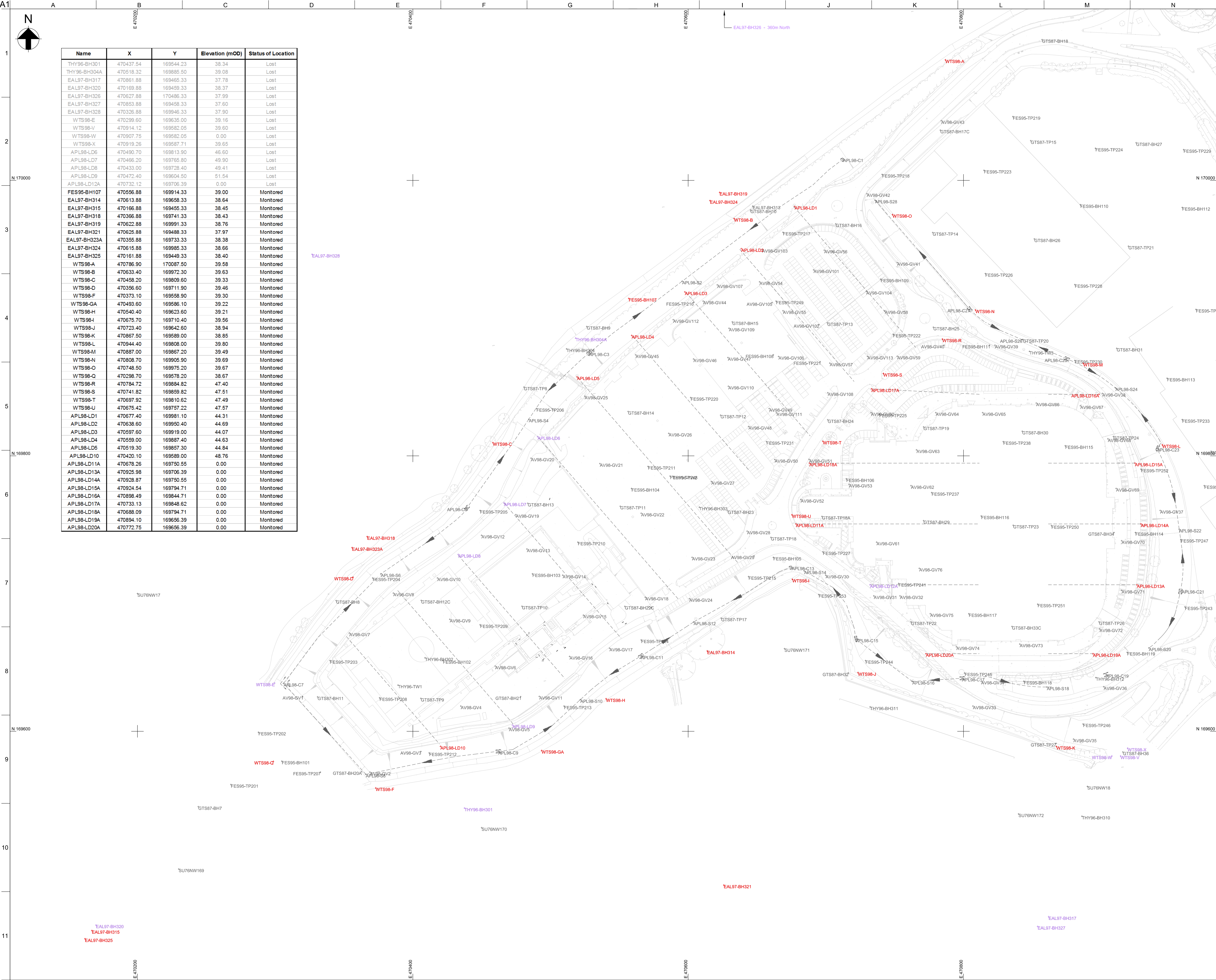
Figure 10.3 Perimeter Dewatering Well Points

Date: 29/10/15 | Status: Information | Name: RN

ARUP



A4 Figure 10.4 Monitoring Locations



Legend:

Monitoring Locations

GIXX-Name

Location Currently Monitored

GIXX-Name

Monitoring Location Lost

GIXX-Name

Historical Location / Not Monitored

Location of Drain

GI Name Description:

GI XX - Name

Contractor

Year

Hole Name

Notes:

1. Topo Survey dated 2015-02 by Midland Survey LTD

01	19/10/15	IJ	CM	LS
For Information				
Issue	Date	By	Chkd	Appd

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Reading Football Club Ltd

Job Title

Land at Madejski Stadium, Reading
Environmental Impact Assessment

Monitoring Locations

Scale at A1

1:1250

Discipline

Geotechnical

Job No

244202-00

Drawing Status

Draft

Drawing No

Figure 10.4

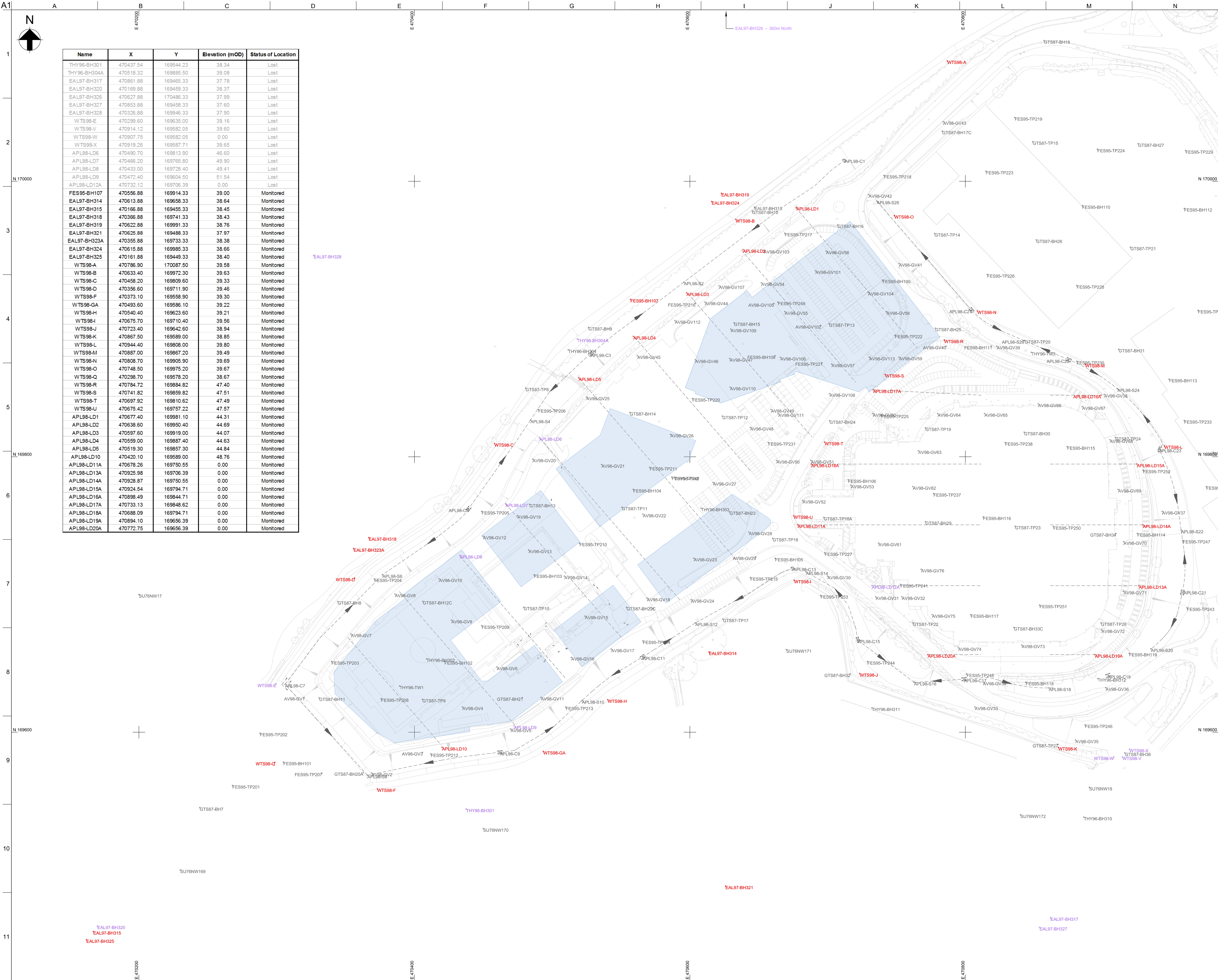
Issue

01

Do not scale

© Arup

A5 Figure 10.5 Overlay of Proposed Buildings on Monitoring Locations



Name	X	Y	Elevation (mOD)	Status of Location
THY96-BH301	470437.54	169544.23	38.34	Lost
THY96-BH304A	470518.32	169885.50	39.08	Lost
EAL97-BH317	470861.88	169465.33	37.78	Lost
EAL97-BH320	470169.88	169459.33	38.37	Lost
EAL97-BH326	470627.88	170486.33	37.99	Lost
EAL97-BH327	470853.88	169458.33	37.60	Lost
EAL97-BH328	470326.88	169946.33	37.90	Lost
WTS98-E	470299.60	169635.00	39.16	Lost
WTS98-V	470914.12	169582.05	39.60	Lost
WTS98-W	470907.75	169582.05	0.00	Lost
WTS98-X	470919.26	169587.71	39.65	Lost
APL98-LD6	470490.70	169813.90	46.60	Lost
APL98-LD7	470466.20	169765.80	49.90	Lost
APL98-LD8	470433.00	169728.40	49.41	Lost
APL98-LD9	470472.40	169604.50	51.54	Lost
APL98-LD12A	470732.12	169706.39	0.00	Lost
FES95-BH107	470596.88	169914.33	39.00	Monitored
EAL97-BH314	470613.88	169658.33	38.64	Monitored
EAL97-BH315	470166.88	169455.33	38.45	Monitored
EAL97-BH316	470366.88	169741.33	38.43	Monitored
EAL97-BH319	470622.88	169991.33	38.76	Monitored
EAL97-BH521	470625.88	169488.33	37.97	Monitored
EAL97-BH323A	470356.88	169733.33	38.38	Monitored
EAL97-BH324	470615.88	169985.33	38.66	Monitored
EAL97-BH325	470161.88	169449.33	38.40	Monitored
WTS98-A	470786.90	170087.50	39.58	Monitored
WTS98-B	470633.40	169972.30	39.63	Monitored
WTS98-C	470458.20	169809.60	39.33	Monitored
WTS98-D	470356.60	169711.90	39.46	Monitored
WTS98-F	470373.10	169558.90	39.30	Monitored
WTS98-GA	470493.60	169586.10	39.22	Monitored
WTS98-H	470540.40	169623.60	39.21	Monitored
WTS98-I	470675.70	169710.40	39.56	Monitored
WTS98-J	470723.40	169642.60	38.94	Monitored
WTS98-K	470867.50	169589.00	38.85	Monitored
WTS98-L	470944.40	169808.00	39.80	Monitored
WTS98-M	470887.00	169867.20	39.49	Monitored
WTS98-N	470808.70	169905.90	39.69	Monitored
WTS98-O	470748.50	169975.20	39.67	Monitored
WTS98-Q	470298.70	169578.20	38.67	Monitored
WTS98-R	470784.72	169884.82	47.40	Monitored
WTS98-S	470741.82	169859.82	47.51	Monitored
WTS98-T	470697.92	169810.62	47.49	Monitored
WTS98-U	470675.42	169757.22	47.57	Monitored
APL98-LD1	470677.40	169981.10	44.31	Monitored
APL98-LD2	470638.60	169950.40	44.69	Monitored
APL98-LD3	470597.60	169919.00	44.07	Monitored
APL98-LD4	470559.00	169887.40	44.63	Monitored
APL98-LD5	470519.30	169857.30	44.84	Monitored
APL98-LD10	470420.10	169589.00	48.76	Monitored
APL98-LD11A	470678.26	169750.55	0.00	Monitored
APL98-LD13A	470925.98	169706.39	0.00	Monitored
APL98-LD14A	470928.87	169750.55	0.00	Monitored
APL98-LD15A	470924.54	169794.71	0.00	Monitored
APL98-LD16A	470898.49	169844.71	0.00	Monitored
APL98-LD17A	470733.13	169848.62	0.00	Monitored
APL98-LD18A	470688.09	169794.71	0.00	Monitored
APL98-LD19A	470894.10	169656.39	0.00	Monitored
APL98-LD20A	470772.75	169656.39	0.00	Monitored

Legend:

Monitoring Locations

GIXX-Name

Location Currently Monitored

GIXX-Name

Monitoring Location Lost

GIXX-Name

Historical Location / Not Monitored

Location of Drain

Proposed Building Outlines

GI Name Description:

GI XX - Name

Contractor

Year

Hole Name

Notes:

1. Topo Survey dated 2015-02 by Midland Survey LTD

01	04/11/15	IJ	RN	LS
For Information				
Issue	Date	By	Chkd	Appd

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Client

Reading Football Club Ltd

Job Title

Land at Madejski Stadium, Reading
Environmental Impact Assessment

Overlay of proposed building footprints on existing monitoring locations

Scale at A1

1:1250

Discipline

Geotechnical

Job No

244202-00

Drawing Status

Draft

Drawing No

Figure 10.5

Issue

01

A6 **Figure 10.6 Additional and Replacement Monitoring Well Locations**



Legend:

Previous Monitoring Locations

GIXX-Name Previous Ground Investigation Location

+ Name Monitoring Location (Lost)

+ Name Monitoring Locations

⊗ Name Borehole Location

--- Location of Drain

GI Name Description:

GI XX - Name

Contractor Year - Hole Name

Notes:

1. Topo Survey dated 2015-02 by Midland Survey LTD

2. OS Mapping © Crown copyright (2016). All rights reserved. Licence Number 100039628.

3. The location of LW01, LW02, and LW03 have been artificially moved 5m to the East to aid drawing clarification.

01

15/02/17

IJ

RP

LS

For Information

Issue

Date

By

Chkd

Appd

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Client

Reading Football Club Ltd

Job Title

Royal Elm Park
(Land at Madejski Stadium)

Additional and replacement
monitoring well locations

Scale at A1

1:1250

Discipline

Geotechnical

Job No

240524-98

Drawing Status

For Information

Drawing No

Figure 10.6

Issue

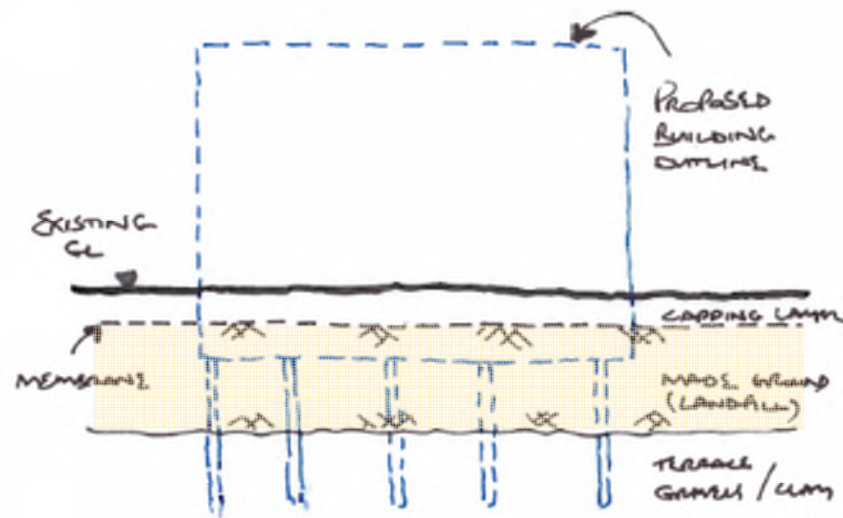
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Do not scale

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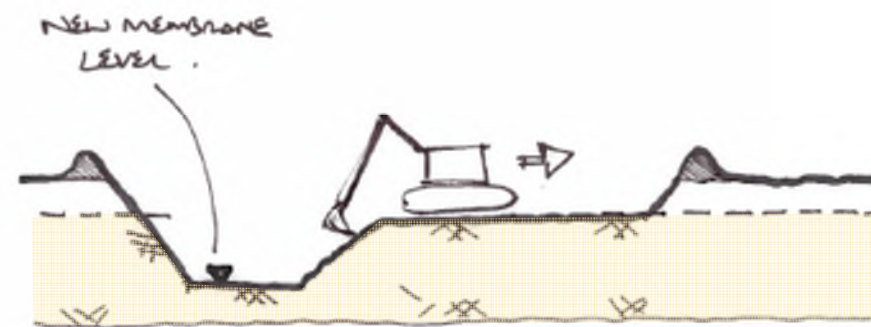
A7 SSK018 Earthworks Construction Sequence

1



- 1.1 Dig trial pits to confirm depth to membrane locally.
- 1.2 Mark out area of excavation.

2



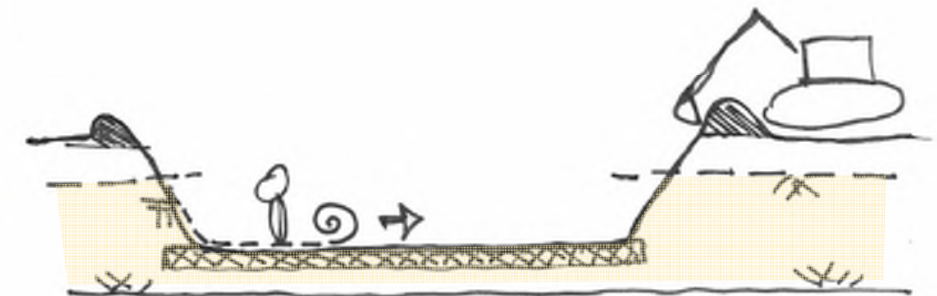
- 2.1 Bund area to be excavated to prevent any surface water ingress from outside area.
- 2.2 Excavate capping layer to expose membrane.
- 2.3 Cut membrane over local working area.
- 2.4 Excavate landfill down to formation level taking necessary precautions and disposing of spoil appropriately.

3

SSK018

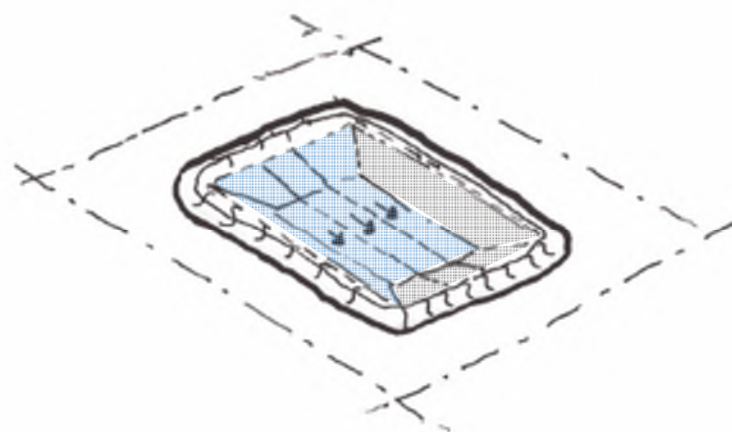
Date: 29/10/15 Status: Info Name: RN

ARUP



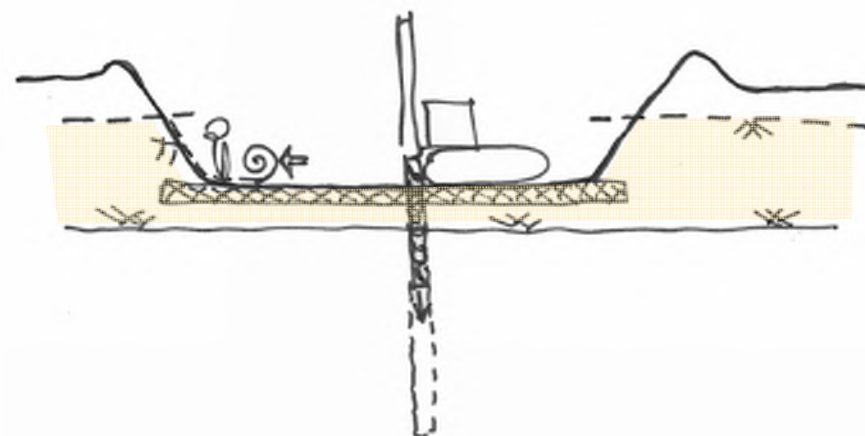
- 3.1 Install piling mat.
- 3.2 Roll out temporary sheeting to prevent water ingress over construction area – limited to one building plot.
- 3.3 No area of landfill to be left exposed for more than 12 hours.

4



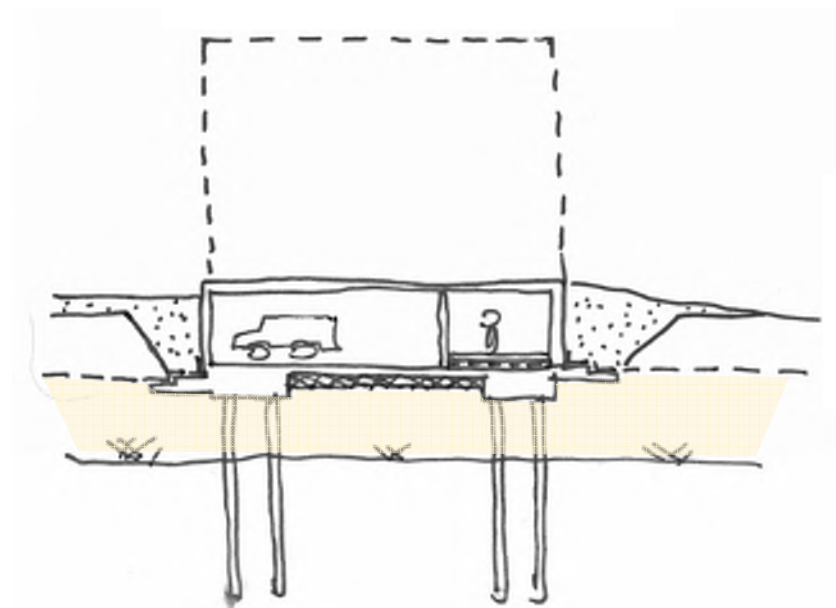
- 4.1 Repeat process in strips until temporary sheeting covers full area.
- 4.2 Install temporary sumps to pump away any rainwater collected.

5



- 5.1 Roll back temp sheeting over localised piling area.
- 5.2 Install CFA piles to area.
- 5.3 Cover area with temp sheeting.

6



- 6.1 Trim piles and excavate locally to construct pile caps.
- 6.2 Construct ground floor slab with external edge slabs.
- 6.3 Lap building membrane with existing capping layer around perimeter and continue internally where required.
- 6.4 Build retaining walls where required and backfill.

Appendix B

Environmental Monitoring

B1

.

Appendix B

Environmental Monitoring

Contents

B1	Existing Environmental Permit Monitoring Requirements	1
B2	Monitoring Results	4
B3	‘Phase 1’ Revised Monitoring Schedules	8

B1 Existing Environmental Permit Monitoring Requirements

B1.1 Analytical Suites

Analytical Suites (Waters)

Suite A (in-situ)	pH, DO, EC, temperature, water level
Suite B	NH ₄ -N, Cl, TOC, Fe, K & Mn
Suite B1	Suite B, plus COD
Suite B2	Suite B, plus COD and BOD
Suite C	Alkalinity, SO ₄ , NO ₃ /NO ₂ , sulphide, Na, Ca & Mg
Suite D	Cd, Cr, Cu, Ni, Zn, As, Hg & Pb
Suite E	SVOCs, VOCs & mineral oils by GC/FID

Analytical Suites (Gas)

Suite F (in-situ)	CH ₄ , CO ₂ , O ₂ , atmospheric/standpipe pressures, gas temperatures/flow rate, weather conditions
Suite G	CH ₄ , CO ₂ , O ₂ , N ₂ , H ₂ & H ₂ S (H ₂ S is in-situ)

B1.2 Monitoring Frequency

B1.2.1 Monthly Monitoring

Sample Type	Monitoring Location
Groundwater Gravels – Perimeter Suite A, Suite B1	107, 301(s), 304A(s), 310, 311, 314, 318, 319, A, B,C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, V
Groundwater Gravels – Other Suite A	315, 316, 317
Basement/Reading Beds and Chalk Suite A	301(d), 304A(d), 320, 321, 322, 323, 324, 325, 326, 327, 328, W & X
Surface Waters Suite A, plus Suite B2	S1, S2, S3, S4, S5, S6 & S7
Leachate Pumps Suite A	LD 1- 10 & LD11A – 20A, inclusive
Gas Monitoring Locations Suite F	310, A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U & V
Gas Monitoring Locations Suite G	3 of above, selected at random

B1.2.2 Quarterly Monitoring

Sample Type	Monitoring Location
Groundwater Gravels – Perimeter Suite A, B1, C	107, 301(s), 304A(s), 310, 311, 314, 318, 319, A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, V
Groundwater Gravels – Perimeter Suite A, B1, C & E	A, E and M
Groundwater Gravels – Other Suite A, B1, C,	315, 316, 317
Basement/Reading Beds and Chalk Suite A, B1, C,	301(d), 304A(d), 320, 321, 322, 323, 324, 325, 326, 327, 328, W & X
Surface Waters Suite A, B2	S1, S2, S3, S4, S5, S6 & S7
Leachate Pumps Suite A, B, C	LD 1- 10 & LD11A – 20A, inclusive
Gas Monitoring Locations Suite F	310, A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U & V
Gas Monitoring Locations Suite G	3 of above, selected at random

B1.2.3 6 monthly monitoring

Sample Type	Monitoring Location
Groundwater Gravels – Perimeter Suite A, B1, C, D	107, 301(s), 304A(s), 310, 311, 314, 318, 319, A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, V
Groundwater Gravels – Other Suite A, B1, C, D	315, 316, 317
Basement/Reading Beds and Chalk Suite A, B1, C, D	301(d), 304A(d), 320, 321, 322, 323, 324, 325, 326, 327, 328, W & X

B1.2.4 Annual Monitoring

Sample Type	Monitoring Location
Groundwater Gravels – Perimeter Suite A, B1, C, E	107, 301(s), 304A(s), 310, 311, 314, 318, 319, A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, V
Groundwater Gravels – Other Suite A, B1, C, E	315, 316, 317
Basement/Reading Beds and Chalk Suite A, B1, C, E	301(d), 304A(d), 320, 321, 322, 323, 324, 325, 326, 327, 328, W & X

B2 Monitoring Results

The groundwater field and laboratory results from 2011 to 2015 have been reviewed and screened against the relevant groundwater criteria and is shown in Table 10.5.1.

Table B2.1 Groundwater Monitoring Wells 2011- 2015

Contaminant	No of samples	Units	Min	Max	Mean	Groundwater criteria (UK DWS 2010)	Total no. of exceedances
Arsenic	64	µg/l	<1	12.3	1.84	10	1
Cadmium	64	µg/l	<0.6	0.8	0.61	5	0
Copper	64	µg/l	1	9	6.4	2000	0
Iron	516	mg/l	<0.23	34.2	0.3	200	0
Lead	64	µg/l	5	11.3	5.97	10	1
Mercury	60	µg/l	<0.1	<0.1	<0.1	1	0
Nickel	64	µg/l	2	33	7.75	20	3
Zinc	64	µg/l	3	384	58.25	5000*	0
Nitrate as NO3	107	mg/l	0.12	79.6	11.69	50	3
Total ammoniacal nitrogen	506	mg/l	0.19	197	15.81	0.39	305
Potassium	414	mg/l	0.43	113	19.76	12*	210
Sodium	107	mg/l	4.31	186	71.99	200	0
Sulphate	107	mg/l	0.002	247	4.67	250	0
Magnesium	107	mg/l	1.9	61	23.04	50*	4
*UK DWS (1989)							

Where exceedances were identified a further analysis of the groundwater chemistry has been carried out and broken down into each of the response zones (Made Ground, Gravels, Lambeth Group and Chalk). The findings are presented in the tables below.

Table B2.2 Made Ground/ landfill

Contaminant	No of samples	Units	Min	Max	Mean	Groundwater criteria (UK DWS 2010)	Total no. of exceedances
Arsenic	7	µg/l	<1.0	2.3 (bh m)	<1.4	10	0
Lead	7	µg/l	<5.0	7.3	6	10	0
Nickel	7	µg/l	<3.0	18.3	9.76	20	0
Nitrate as NO3	11	mg/l	<1.3	79.6 (BH L)	21.37	50	2

Contaminant	No of samples	Units	Min	Max	Mean	Groundwater criteria (UK DWS 2010)	Total no. of exceedances
Total ammoniacal nitrogen	49	mg/l	<0.27	197	71.0	0.39	43
Potassium	55	mg/l	7.46	113 (BHM)	51.30	12*	36
Magnesium	11	mg/l	22.7	61 (BHM)	40.75	50*	2
*UK DWS (1989)							

Table B2.3 River Terrace Gravels

Contaminant	No of samples	Units	Min	Max	Mean	Groundwater criteria (UK DWS 2010)	Total no. of exceedances
Arsenic	46	µg/l	<1.0	12.3 (BH315)	3.5	10	1
Lead	46	µg/l	<5.0	11.3 (BHN)	7.21	10	1
Nickel	46	µg/l	<2	33 (BHR)	27.9	20	3
Nitrate as NO3	77	mg/l	<1.3	62.3 BHI	9.39	50	1
Total ammoniacal nitrogen	374	mg/l	0.19	181 BH(J)	11.20	0.39	206
Potassium	278	mg/l	0.43	97.9 BHJ	17.56	12*	128
Magnesium	57	mg/l	1.9	59.7 BH N	20.78	50*	2
*UK DWS (1989)							

Table B2.4 Lambeth Group

Contaminant	No of samples	Units	Min	Max	Mean	Groundwater criteria (UK DWS 2010)	Total no. of exceedances
Arsenic	9	µg/l	<1.0	1.2 (Bh323)	1.35	10	0
Lead	9	µg/l	<5.0	6.2 (Bh321)	6.2	10	0
Nickel	9	µg/l	<2.0	4.9 (Bh324)		20	0
Nitrate as NO3	15	mg/l	<1.3	9.2 Bh324	4.4	50	0
Total ammoniacal nitrogen	73	mg/l	0.19	35.8 (Bh321)	5.85	0.39	46
Potassium	71	mg/l	1.33	17.6	8.9	12*	13
Magnesium	12	mg/l	6.95	26	16.4	50*	0
*UK DWS (1989)							

Table B2.5 Chalk

Contaminant	No of samples	Units	Min	Max	Mean	Groundwater criteria (UK DWS 2010)	Total no. of exceedances
Arsenic	2	µg/l	<1.4	<1.4	<1.4	10	0
Lead	2	µg/l	<5	<6	<5.5	10	0
Nickel	2	µg/l	2	<3	2	20	0
Nitrate as NO3	4	mg/l	<1.3	11.4	7.6	50	0
Total ammoniacal nitrogen	10	mg/l	2.62	37.4 (BH304d)	10.92	0.39	10
Potassium	10	mg/l	12.5	22.7	16.62	12*	0
Magnesium	3	mg/l	35.3	42.1 (BH X)	37.85	50*	0
*UK DWS (1989)							

Table B2.6: Leachate Chemistry - Leachate Sumps 2012- 2014

Contaminant	No of samples	units	Min	Max	Mean	UK DWS	Total no. of exceedances
Iron	58	mg/l	0.23	21.8	5.58	200	0
Nitrate	75	mg/l	<1.3	33.1	6.58	50	0
Total ammoniacal nitrogen	75	mg/l	<0.27	143	16.85	0.39	72
Potassium	58	mg/l	7.79	85.5	31.56	12	54
Sodium	58	mg/l	21.5	234	88.5	200	2
Sulphate	72	mg/l	0.002	104	3.91	250	0
Calcium	58	mg/l	49.7	303	187.3 2	250	10
Magnesium	58	mg/l	1.2	55.7	19.95	50	4
Chloride	75	mg/l	18.2	288	121.3 7	250	9
Manganese	58	ug/l	7	2390	784.0 7	47	29

B3 'Phase 1' Revised Monitoring Schedules

B3.1 Analytical Suites (Waters)

Suite A (in-situ)	pH, DO, EC, temperature, water level
Suite B	NH ₄ -N, Cl, TOC, Fe, K, COD, BOD
Suite C	Alkalinity, SO ₄ , NO ₃ , NO ₂ , sulphide
Suite D	Cd, Cr, Cu, Ni, Zn, As, Mn, Hg & Pb
Suite E	SVOCs, VOCs & TPH

B3.2 Analytical Suites (Gas)

Suite F (in-situ)	CH ₄ , CO ₂ , O ₂ , atmospheric/standpipe pressures, gas temperatures, flow rate, weather conditions
Suite G	CH ₄ , CO ₂ , O ₂ , N ₂ , H ₂ , trace VOCs & H ₂ S (H ₂ S is in-situ)

B3.3 Revised Monthly Monitoring

Sample Type	Monitoring Location
Made ground Suite A	L, M
River Terrace Gravels (RTG) Suite A	A, C, I, J, K, M, M(r)* and N ¹ A minimum of 4no, boreholes surrounding the construction phase if post surrender of the Environmental Permit ²
Basement/Reading Beds and Chalk Suite A	327, 328(r), X(r)
Surface Waters Suite A, plus Suite B	S1, S2, S3, S4, S5, S6 & S7
Leachate Pumps Suite A	LDs 1-5, 10A, 11, 13A- 20A
Gas Monitoring Locations Suite F	R, S and T plus 3 others
Gas Monitoring Locations Suite G	R, S and T plus 3 others

*(r) denotes replacement borehole

1. Where available as part of the ongoing monitoring permit
2. Post surrender of the Environmental Permit new boreholes will be installed if a suitable number of the existing boreholes are no longer available.

B3.4 Revised Quarterly Monitoring

Sample Type	Monitoring Location
Made ground Suite A, B, C	L, M
Groundwater Gravels – Perimeter Suite A, B, C	A, C, I, J, K, M and M(r)*
Basement/Reading Beds and Chalk Suite A, B, C	327, 328(r), X(r)
Surface Waters Suite A, B	S1, S2, S3, S4, S5, S6 & S7
Leachate Pumps Suite A, B, C	LDs 1-6 and 9-12
Gas Monitoring Locations Suite F	R, S and T plus 3 others
Gas Monitoring Locations Suite G	R, S and T plus 3 others

B3.5 Revised Annual Monitoring

Sample Type	Monitoring Location
Made ground Suite A, B, C, D, E	L, M
Groundwater Gravels – Perimeter Suite A, B, C, D, E	A, C, I, J, K, M and M(r)*
Basement/Reading Beds and Chalk Suite A, B, C, D E	327, 328(r), X(r)
Surface Waters Suite A, B, D, E	S1, S2, S3, S4, S5, S6 & S7
Leachate Pumps Suite A, B, C	LDs 1-6 and 9-12
Gas Monitoring Locations Suite F	R, S and T plus 3 others
Gas Monitoring Locations Suite G	R, S and T plus 3 others

Appendix C

Gas and Groundwater Technical Notes

C1.

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Project title	Madejski Stadium; Proposed Redevelopment	Job number
		240524-98
cc	Louise Stroud Damian Friel	File reference
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		26 June 2017
Subject	Groundwater Quality Review 2017	

Introduction

Monitoring data (gas, leachate and groundwater) have been collected regularly from the site since July 1996 prior to the development of the Madejski Stadium site and latterly under the provision of an Environmental Permit (EP). Over the years, the monitoring programme has been reviewed, rationalised and amended, in liaison with the Environment Agency.

Existing baseline

A review of the latest field and laboratory data since 2015-7 has been undertaken to understand the current groundwater and leachate quality.

Replacement Boreholes

Three replacement boreholes were installed during 2016 and 2017, to replace blocked or damaged boreholes which are required as part of the environmental permit.

BH1 was installed to the south east of the stadium in August 2016, to replace blocked BH X. The response zone lies between 32.00m & 35.35m bgl and is within the Chalk aquifer.

BH2 was installed in August 2016 to the north-east of the stadium to replace BH M. The response zone is within in the River Terrace Deposits between 2.90m and 3.60m bgl.

BH3 was installed in January 2017 and replaced the blocked BH328. BH3 has chalk response zone (26.50m and 40m bgl). BH328 had been blocked for many years with little or no groundwater data available for comparison.

Now that these replacement wells have been installed, the Contractor is able to provide complete monitoring data sets.

LW01 (Upper), LW02 (Upper and Lower) and LW03 (Lower)

The leachate wells (LW01, LW02 and LW03) were installed in August 2016 to monitor leachate generation from both the “old” waste at the bottom of the landfill, and the newer waste in the top 5m.

File Note

240524-98

26 June 2017

Ammoniacal nitrogen concentrations in LW01 (Upper) were relatively stable between 110mg/l and 130 mg/l. Ammoniacal nitrogen concentrations in LW03 (Lower) were recorded at <2mg/l except in March 2017 where the concentrations peaked at 70.3mg/l. Ammoniacal nitrogen concentrations recorded in LW02 (Upper) are generally stable at 19.5mg/l except in March 2017 where concentrations rose to 314mg/l. In the lower section of LW02, fluctuation concentrations of ammoniacal nitrogen were recorded from 0.5mg/l to 298 mg/l.

Potassium concentrations were generally stable at 75mg/l in the upper sections of LW01 and LW02 with an elevated concentration recorded in LW02 in March 2017 at 238mg/l. This result is an order of magnitude higher than previous readings in this well and it may represent an outlier. The lower section of LW03 shows gradual increase in potassium concentrations from 9.15mg/l in Nov-16 to 38.1mg/l in March 2017. Potassium concentrations in LW02 (lower) show fluctuations initially with a peak at 171 mg/l in December 2016 and then drops down to 32mg/l.

Standpipes A to O

These wells have response zones primarily in the River Terrace Gravels (RTG), although borehole records for BH M indicated that it also intersected the waste material and therefore, should be considered as representative of the leachate in the waste material. Therefore, the replacement borehole BH2 was installed with the response zone in the RTG only.

Fluctuating concentrations of elevated ammonium were measured in BH J (RTG) with peaks of 187mg/l (Oct-15) and 162mg/l (Oct-16). Since February 2014, concentrations of ammoniacal nitrogen in BHK and BHN have been rising from below 50mg/l to 83.8mg/l and 74.1mg/l in BHK and BHN recorded in Jan-17 and Dec-16 respectively.

Concentrations of ammoniacal nitrogen in BH2 was found to be consistently higher than BH M, ranging from 127mg/l to 149mg/l. Ammoniacal nitrogen was consistently high in BH M, averaging over 100mg/l and peaking at a maximum concentrations of 146mg/l in May 2016, since when concentrations have declined a little in this BH to 103mg/l. In the other RTG boreholes (A, B, C, D, E, F, G H, I, L, N, O, R), concentrations of ammoniacal nitrogen have remained below 50mg/l throughout 2015-2017.

300 series standpipes

The response zone for these standpipes are within the River Terrace Deposits, Reading Beds and the Chalk. Concentrations of ammonia were generally <50mg/l, except in BH 317, BH 321 and BH 327.

Ammoniacal nitrogen concentrations of 56.2mg/l and 53.1mg/l was measured in BH321 and BH327 which is within the Reading Beds and Chalk respectively. The maximum concentration of 144mg/l was recorded in BH317 in November 2015 within the RTG.

Ammoniacal nitrogen concentrations in BH 1 were fairly low with the maximum concentration recorded at 0.97mg/l in March 2017. This is below the proposed completion criteria for the landfill environmental permit (3.97mg/l)

File Note

240524-98

26 June 2017

Potassium concentrations of 17.5 mg/l were recorded in BH X in September 2012, after which no potassium was detected in this BH suggesting that the borehole was blocked. The replacement borehole BH1 recorded potassium concentrations at a maximum of 22.1 mg/l in August 2016.

Potassium concentrations recorded in these standpipes were <50mg/l throughout the remainder of the monitoring period.

Surface water monitoring points – S1 to S7

Surface water is monitored from the two water courses aligning the site, Smallmead Drain (S1, S2 and S3) and the Foundry Brook (S5, S6 and S7). Trace concentrations of ammoniacal nitrogen have occasionally been detected in S1, S2, S4 and S5. The maximum concentrations of ammoniacal nitrogen have been recorded in S1 at 0.95mg/l. Potassium concentrations generally range between 0.18mg/l to 20.1mg/l.

Main Findings

As expected, the most elevated concentrations of Ammoniacal nitrogen (315mg/l) at the site were recorded in the lower leachate wells. Within the terrace gravels, the most elevated concentrations of ammoniacal nitrogen were measured in the boreholes BH J, BH2 and BH M with maximum concentrations recorded at 187mg/l (Oct-15), 149 mg/l (Nov-16) and 146 mg/l (May-16) respectively. The lettered series wells are designed to sample the RTGs. Although the BH records in the past indicate that BH M intercepts the waste material, BH2 which was installed to replace BH M recorded higher concentration of ammoniacal nitrogen as compared to BH M.

Concentrations of ammonium are significantly lower in the underlying Chalk Formation with the highest concentration recorded at 53.1mg/l in BH 327 in Jun-16. Much lower (trace) concentrations were recorded in the surface water samples collected.

With respect to ammonia which is the main contaminant of concern, concentrations decrease from the waste, to the RTG and the Chalk, indicating significant dilution and dispersion, with increased vertical and lateral distance from the waste body.

DOCUMENT CHECKING (not mandatory for File Note)

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Subject	Site Characterisation Update Report		

1 Introduction

This technical note reports findings of a second phase of ground investigation (GI) and monitoring completed between 12th December 2016 and 14 February 2017 at the Madejski Stadium site. It is an addendum to work completed in summer 2016¹.

The Madejski Complex overlies an area of made ground (formerly the Smallmead Landfill site) which is licensed by the Environment Agency (EA) under the Environmental Permitting Regulations (EPR).

The second phase GI was designed to:

- collect additional ground gas data from the waste below the proposed residential buildings;
- to validate gas readings from Boreholes R, S and T; and
- to replace an existing deep groundwater monitoring well (BH2017-03).

2 Site work

The 2016 ground investigation was undertaken by Geotechnical Engineering Limited (GEL) while being monitored by Arup. Using a “clean drilling technique” six gas monitoring boreholes (GW04, GW05, GW06, GW07, GW08 and GW09) were drilled within the permitted area to a maximum depth of 14.7m. Borehole GW07 encountered groundwater at shallow depth and an obstruction, so was terminated at 2.8m and a monitoring well was not installed.

¹ Ove Arup and Partners (2016), Geo Environmental Interpretive report

The other boreholes were completed with two 50mm diameter standpipes, each slotted throughout the entire depth of waste material. Each borehole was terminated just about the interface between the waste and the natural ground. At each location (apart from GW07) one of the standpipes was fitted with a GasClam® battery operated continuous gas monitor. These take hourly readings of gas concentrations, borehole and atmospheric pressures. The second monitoring pipe at each location was completed with a screw on cap and gas monitoring taps, for weekly collection of in situ gas monitoring data.

During the drilling of Boreholes GW04, GW06, GW09 elevated concentrations of gas were observed, with landfill gas visibly venting from these boreholes once the base of the hole had been reached and the casing was being withdrawn. The boreholes were left to vent until the gases had dissipated, the casing could be safely withdrawn and the monitoring pipes installed.

A new deep groundwater monitoring borehole was also drilled to replace Borehole BH328 which had become blocked. The new well was drilled within close proximity to the existing one, with a response zone within the Chalk, at approximately 40m depth.

The above borehole locations are illustrated in the attached Appendix Figure 1, with borehole records and gas monitoring data included as Appendix B.

3 Ground Conditions

The ground conditions encountered confirmed the sequence of strata found during the historical and more recent ground investigations:

Ground level to 0.95-1.2m: MADE GROUND/CLAY CAP comprising firm brown and dark brown slightly sandy gravelly silty CLAY with gravel, angular to rounded fine to coarse flint, sandstone and rare chalk. In Boreholes GW04, GW06, GW07 and GW09 a geotextile membrane was encountered, below the cap.

0.95-14.7m: MADE GROUND/WASTE comprising firm greyish brown and dark brown slightly sandy gravelly silty CLAY with low subrounded brick cobble content and 20-30% fragments of glass (up to 50mm), plastic (bags), timber fragments (up to 100mm), paper (up to 40mm) and metal fragments (up to 50mm). Gravel is angular to rounded fine to coarse of brick, flint, sandstone and concrete.

4 Monitoring Results

Measurements of atmospheric pressure (from both the GasClams® and in situ) have been made over the monitoring period (22 December 2016 – 14th February 2017). These data show reasonably good correlation with each other and demonstrate that the monitoring has taken place during both high and low atmospheric pressure conditions (See Appendix A, 2). This is important as

changes in barometric pressure (particularly rapid ones) can be a major influence on gas emission rates³.

Water table elevations have also been measured at weekly intervals throughout the monitoring period (See Appendix A, 3). These data indicate that water levels are relatively stable over the monitoring period to date.

4.1 Boreholes R, S and T

Boreholes R, S and T are located within the Permitted area and methane (CH₄) and carbon dioxide (CO₂) concentrations and gas flow are routinely measured at these locations, as part of the EPR. The results are illustrated in Appendix A and show that gas flow rates are typically around 0.3-0.4 L/h, with a maximum flow rate of 0.9L/h recorded in BHS in August 2016 (see Appendix A, Figure 4).

CH₄ and CO₂ concentrations are consistently elevated with maximum concentrations of 79%v/v in BHS and 34.7%v/v in BHT recorded (see Appendix A, Figures 5 and 6).

Borehole GW05 recorded gas data from the waste, immediately adjacent to R, S and T. The results show good correlation and confirm that R, S and T are yielding gas results from the waste material.

4.2 2016 Investigation Boreholes (GW01-GW03)

Concentrations of methane and carbon dioxide in the waste material were elevated but consistent, as illustrated by BHs R, S, T, GW02 and GW03. These concentrations (together with the occasional occurrence of H₂S) are indicative of aerobic and anaerobic degradation occurring within the waste mass. (Standpipe GW01 is not useful for indicating ground gas conditions as the response zone is permanently flooded).

The highest flow rates recorded during summer 2016 in GW02 and GW03 were 6.6L/hr, 6.1L/hr respectively. These concentrations are an order of magnitude higher than those previously recorded in the lettered series boreholes.

The maximum CH₄ concentrations recorded in GW02, GW03 were 76.1%v/v and 82.8%v/v. These are consistent with the historical gas data obtained from the other boreholes in the vicinity and the previously collected data.

4.3 2016/7 Investigation (Boreholes GW04 – GW09)

The continuous GasClam® monitors were fitted to the tops of the monitoring standpipes sequentially as the boreholes were completed, with the weekly in situ monitoring programme commencing on 4th January 2017. This has enabled us to collect concurrent in situ and continuous data from all the latest borehole standpipes which has then been assessed.

³ Assessing Risks Posed by Hazardous Ground Gases to Buildings , CIRIA C665 (2007)

Gas flow rates were measured in Boreholes GW04, GW05, GW06, GW08 and GW09, with the most elevated values recorded in Boreholes GW08 and GW09, located in the central and northern areas of the site respectively.

The CH₄ and CO₂ concentrations and gas flow rates recorded in Boreholes GW04, GW05, GW06, GW08 and GW09 are illustrated in Appendix A (Figures 7 to 15). In terms of gas concentrations, the results recorded by the GasClams generally show reasonably good correlation with those measured in situ. For example, the GasClam® methane data was typically in the range of 27% to 78% (daily highs) with the in situ data typically being 20% to 78%.

There are some incidences of differing insitu and GasClam® readings. For example in Boreholes GW05 and GW09 on 24th January 2017 GasClam® methane concentrations of 78% (GW05) and 69% (GW09) were measured, as compared to in situ readings of 45% (GW05) and 39% (GW09). Reasons for these discrepancies are not immediately clear but could be influenced by a number of factors such as short term changes in gas concentration or pressure at the point of measurement.

4.3.1 Laboratory gas analysis

Gas samples were taken from standpipes GW02, GW03, GW04, GW05, GW06, GW08 and GW09 and the first set of laboratory analyses has been received (GW02, GW04, GW06 GW09). As with the laboratory gas analysis results for standpipes in Boreholes GW01-GW03 during summer 2016, the bulk gas results are contrary to expectations and do not reflect the field data. The reason for this is not known, but may be due to analytical error or leakage from the test sample. The laboratory results do however, indicate the presence of trace volatile gases and H₂S (maximum concentration of 20ppm recorded in Borehole GW02) which is in line with historical data for the site.

4.4 Refining the conceptual model for ground gases

The 2015 Environmental Statement⁴ and Geo-environmental Interpretative Report¹ included a risk line for ground gases in the conceptual site model (CSM). An excerpt of the CSM is presented below and the CSM has been updated to reflect the latest gas data:

⁴ Ove Arup & Partners (2016). Reading Football Club. Environmental Strategy

				Plausibility of linkage / risk			
	Source	Pathway	Receptor	Baseline	Construction	Operation* without mitigation	Mitigation
	Ground Gas	Migration and accumulation of explosive ground gases into excavations buildings and basements through preferential pathways e.g. abandoned pipes Inhalation of vapours	Human health: Construction workers future on-site residents, visitors and users; Adjacent site users Maintenance workers	Implausible – engineered cap and gas venting system in place (active venting in Hotel)	Plausible-disturbance to ground and existing systems. Potential to open new pathways through excavation & piling	Plausible-disturbance to ground and existing systems. Potential to open new pathways through excavation & piling, accumulation in new building stock, confined spaces, and service trenches	<i>Mitigation measures to include gas monitoring, gas risk assessment and installation of relevant gas protection (either passive or active to be designed/ upgraded); repair or upgrade to existing capping layer and gas system, as required.</i> Proposed Revisions to Mitigation Measures to include: Pre- development gas monitoring programme in accordance with the 2016 Reclamation Strategy Report⁵; Update of the gas risk assessment. Construction Phase Installation of relevant gas protection (both passive and active)

4.5 Calculation of Characteristic Situation

The characterisation of the site has been assessed using the empirical method set out in CIRIA C665³ and in BS8485:2015 and involves the assignment of a design gas screening value (GSV) using site gas monitoring measurements, from which the site's characteristic gas situation (CS) is determined.

In accordance with the approach set out in Annex F of BS8485:2015, we have calculated the hazardous gas flow rate (GSV value) for methane for each in-situ monitoring occasion in 2017 at each borehole location using the flow rate recorded by the gas analyser and also using the gas concentration recorded at that time by the GasClam®. Only CH₄ concentrations were considered as these are always higher than CO₂, and therefore define the design case. The measurements used and the calculated GSVs and inferred CSs are shown in Appendix A, Tables 1 and 2 and Figures 16 and 17. As can be seen, almost all of the measurement sets when a measureable emission flow rate is recorded (which is less than half the measurement sets) fall into either CS3 or CS4; on one occasion (GW08 on January 31, 2017) the GSV is just above the lower limit (15L/hr) of the CS5 range.

⁵ Reading Football Club Proposed Redevelopment at Madejski Stadium, Environmental Strategy (27 June 2016)

The ground gases currently present have built up over a period of 20 to 30 years and are locally confined in pockets or layers. The body of GasClam® data on differential gas pressures and the majority of in-situ measurement from standpipes throughout the whole depth of the waste do not indicate any significant confined gas pressures.

Adoption of a design GSV value for a site, or separate zones of a site, should represent potential worst case future gas emission rates across an area beneath the development; in view of this it is considered that adoption of a design GSV of 20L/hr (lower part of CS5) would be an appropriate value for the current dataset. This value is considered very conservative taking into account the whole body of information about the age and nature of the land-raised materials that are the source of the ground gases at the Madejski site.

CIRIA provides guidance for the type and number of protection measures to be considered for different types of accommodation constructed where there is a risk of gas. The protection proposed will accommodate a Characteristic Situation 5 for most sensitive form of development – residential. This consists of a 5-layer barrier construction including:

- A mechanically vented void formed using proprietary void formers placed below the ground floor slab.
- A proprietary gas membrane placed on top of the void former, lapped and tapped to all penetrations and to the existing membrane around the perimeter of the building
- A suspended reinforced concrete ground floor slab, reinforced to limit crack widths to 0.3mm
- A naturally ventilated layer above the basement slab (the car park)
- A further reinforced concrete suspended slab to all accommodation above the car park
- Shallow stone gas trenches below the ground floor slab. These trenches will be linked to the below slab void ventilation to provide a further measure for mitigating the build-up and ingress of gas to the buildings.

5 Summary

The 2016/7 ground investigation has confirmed the findings of the historical data available for the site and those measured during the previous phase (summer 2016) of investigation, as follows:

- The waste/land raise material extends to a maximum depth of 14.7m;
- Whilst predominately unsaturated, localised pockets of perched water are present within the fill;
- Significant elevated concentrations of methane and carbon dioxide are present at the site in the un-saturated land raise, as would be expected;
- During borehole drilling, notable flows of landfill gases were observed emanating from the base of several of the boreholes (GW06, GW04 & GW09). This occurred when the drilling casing was initially withdrawn, indicating that high gas concentrations may typically be concentrated at the base of the land raise; and
- The gas exclusion measures given in the Geo Environmental Interpretive report and Environmental Strategy Report are adequate to protect the development.

6 Conclusions

Ground gases, groundwater and leachate have been monitored on the site for nearly 20 years with all data regularly submitted to the EA for review. New site monitoring data have been gathered to confirm the gas characterisation for the site so that design proposals for mitigating gas ingress to the buildings can be confirmed.

The recent site investigation monitoring results identify gas concentrations and flow rates that are in line with the 20 years' of historical data. In accordance with the CIRIA guidance and based on the data that we have to date, the characteristic situation for the site is predominantly CS4. However, there are some results which would give gas design Characteristic Situation 5 (CS5).

The design proposals for planning provide robust protection measures suitable for preventing gas ingress to the proposed accommodations for a CS4/5 site.

The potential for the construction works to change the gas regime will be rigorously controlled. The proposed slab provides a level of protection consistent with CS5 classification and therefore is considered to robustly cater for any slight gas increases due to construction.

Mitigation of potential groundwater contamination has been reviewed in detail with the EA separately and is detailed in the report 'Environmental Strategy' dated 27 June 2016. This strategy includes a comprehensive schedule of ongoing monitoring prior to, during and post construction. It also includes an action plan

for sharing monitoring results with key stakeholders including the EA and EHO. It detailed the proposed construction methods for controlled earthworks and a specific foundation piling technique developed from those already successfully implemented for the construction of the on-site Madejski Stadium and adjoining Millennium Hotel.

DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by
Name	Louise Stroud	Richard Owen	Damian Friel
Signature			

Appendix A

Figures and Tables

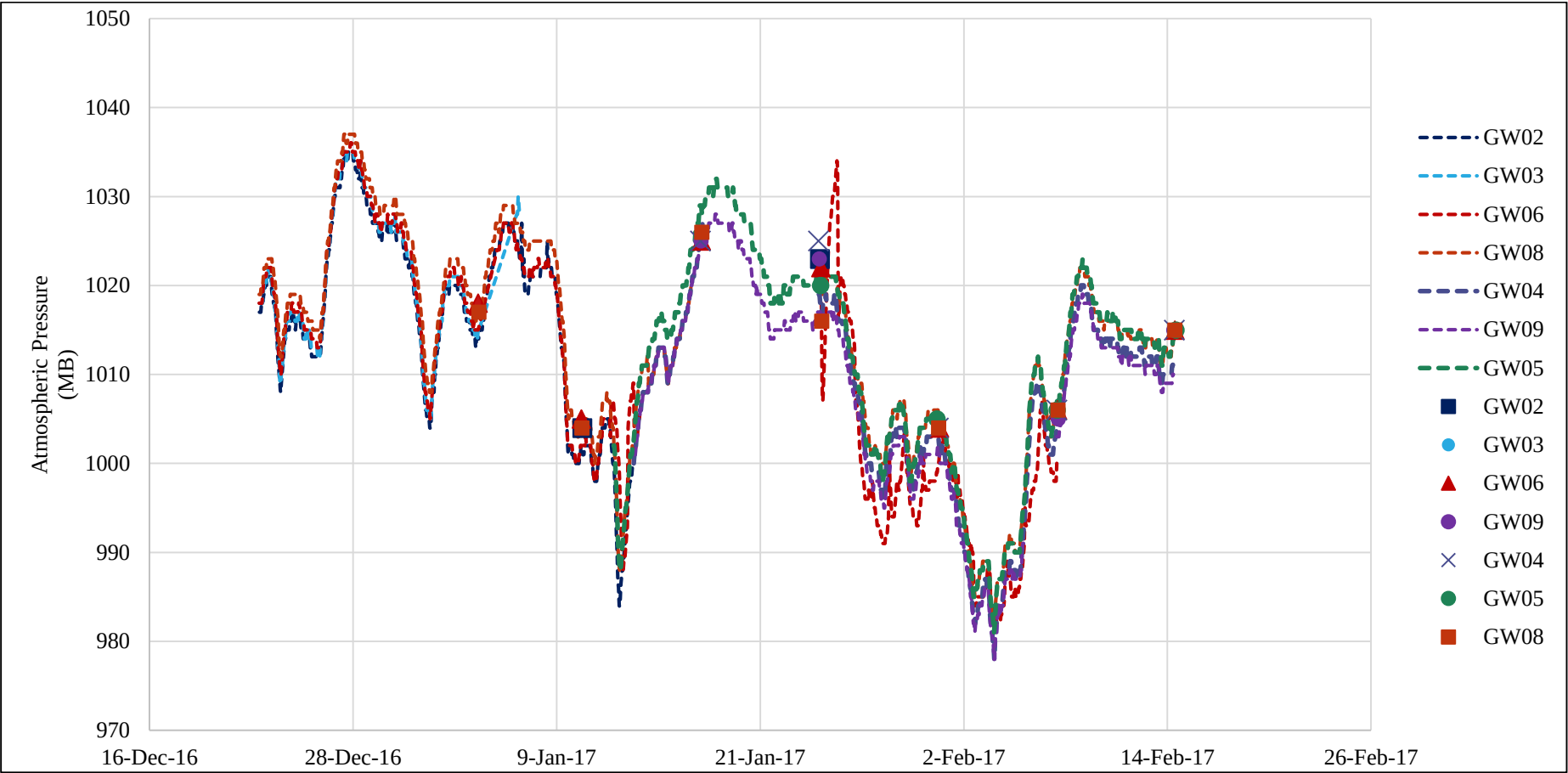


Figure 2: Atmospheric Pressure (GasClams and Insitu)

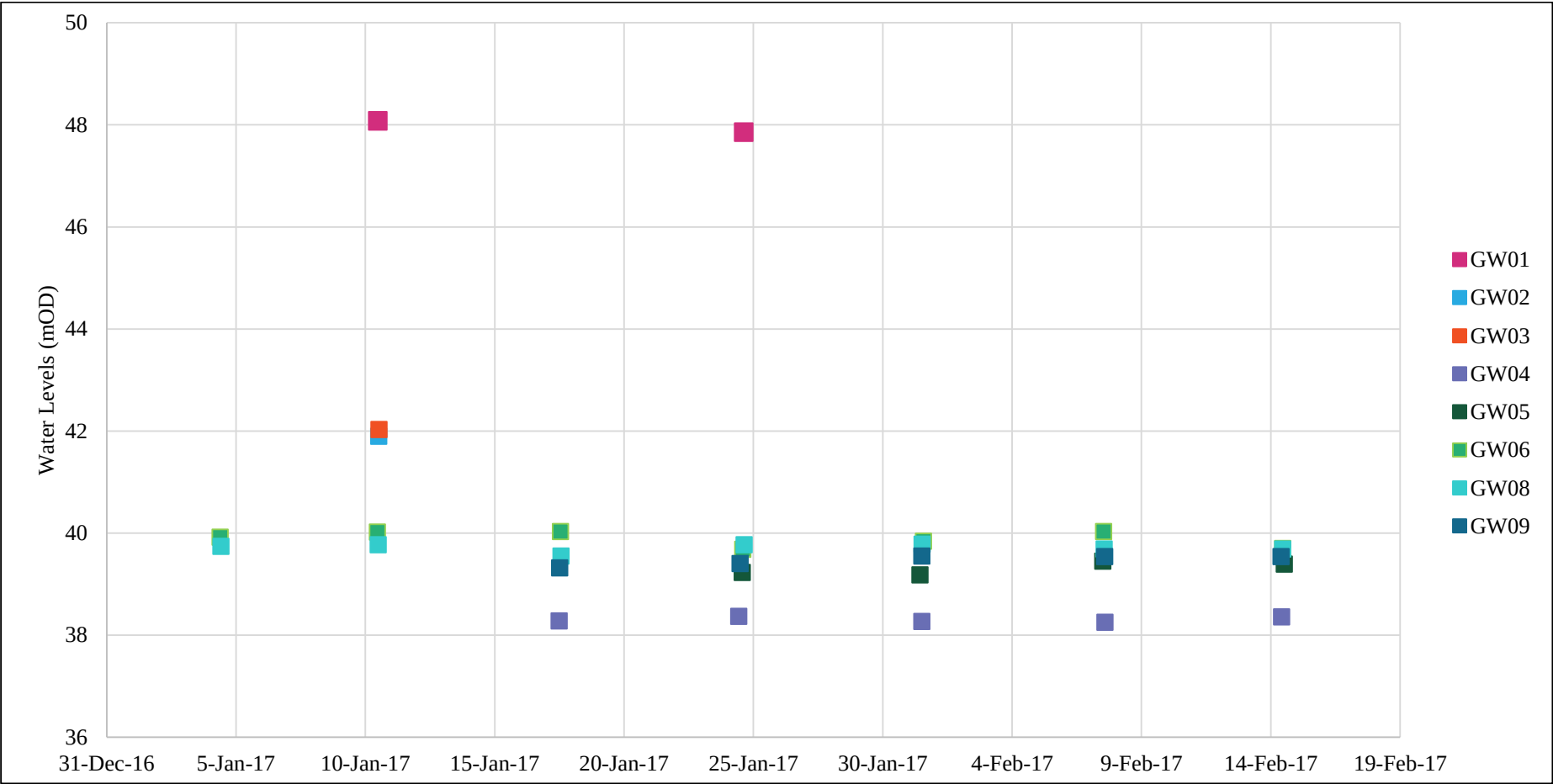


Figure 3: Water levels (mOD) measured at weekly intervals.

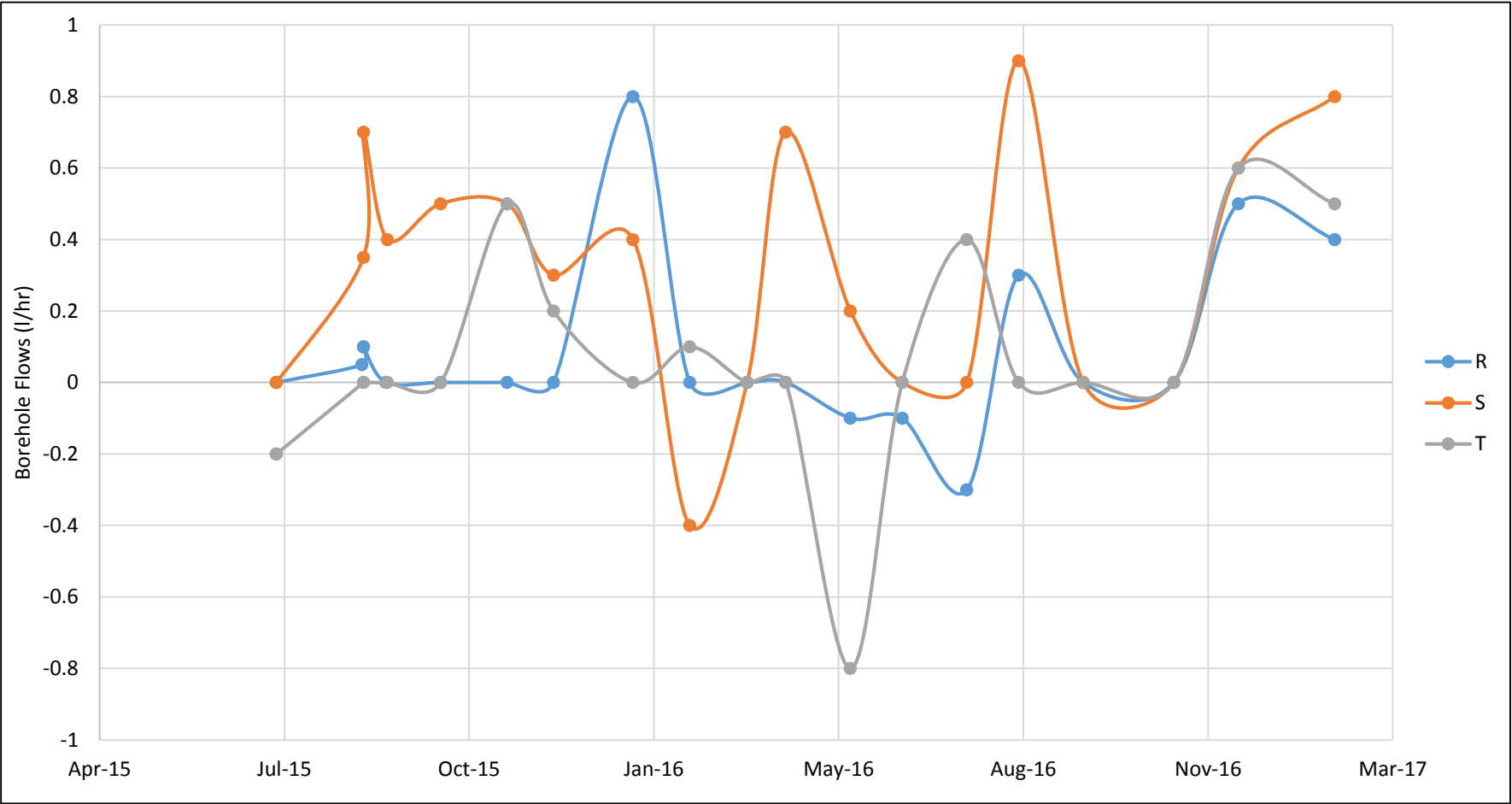


Figure 4: Boreholes R, S and T flows (l/hr).

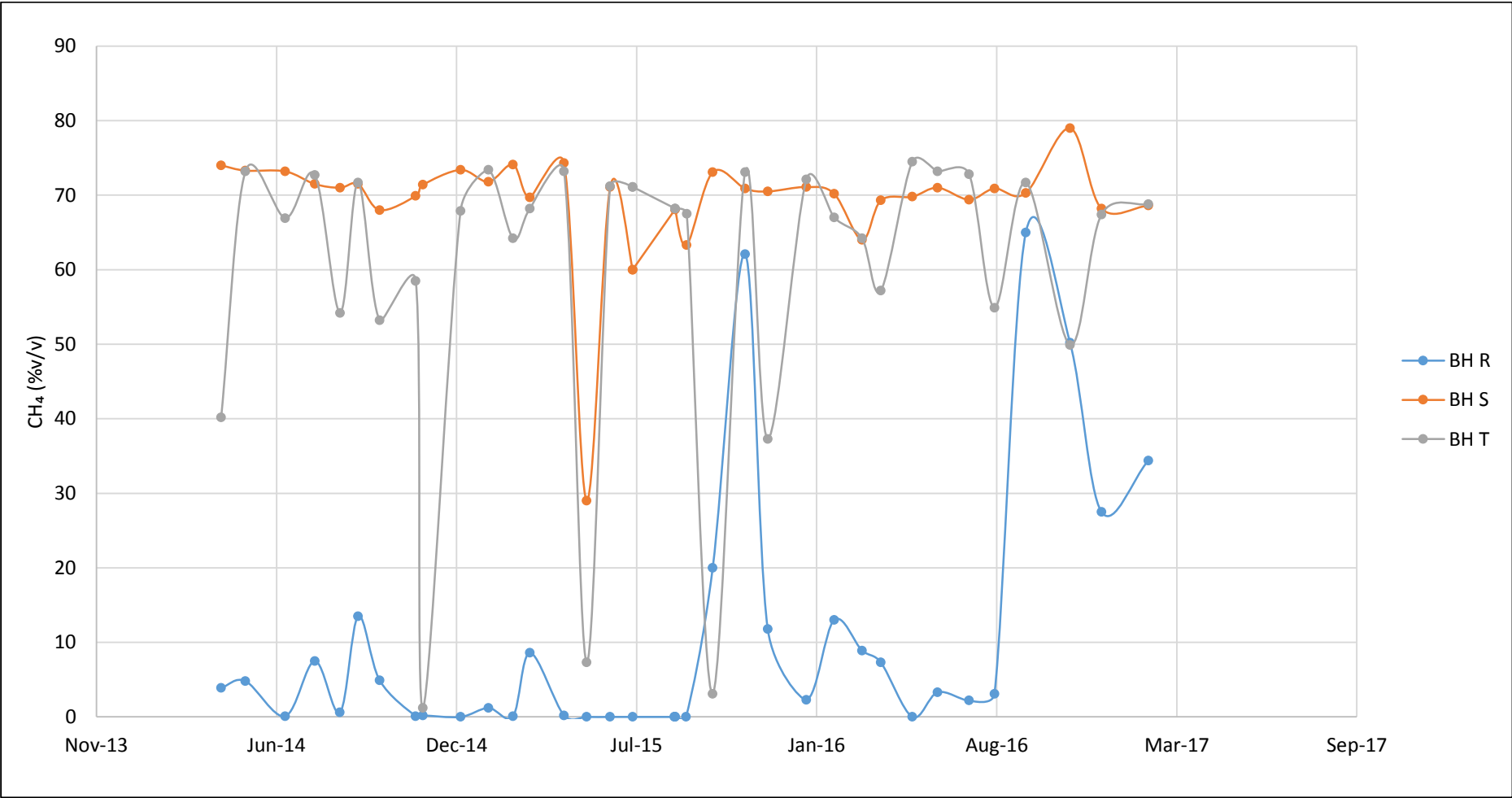


Figure 5: Methane concentrations recorded in boreholes R, S and T

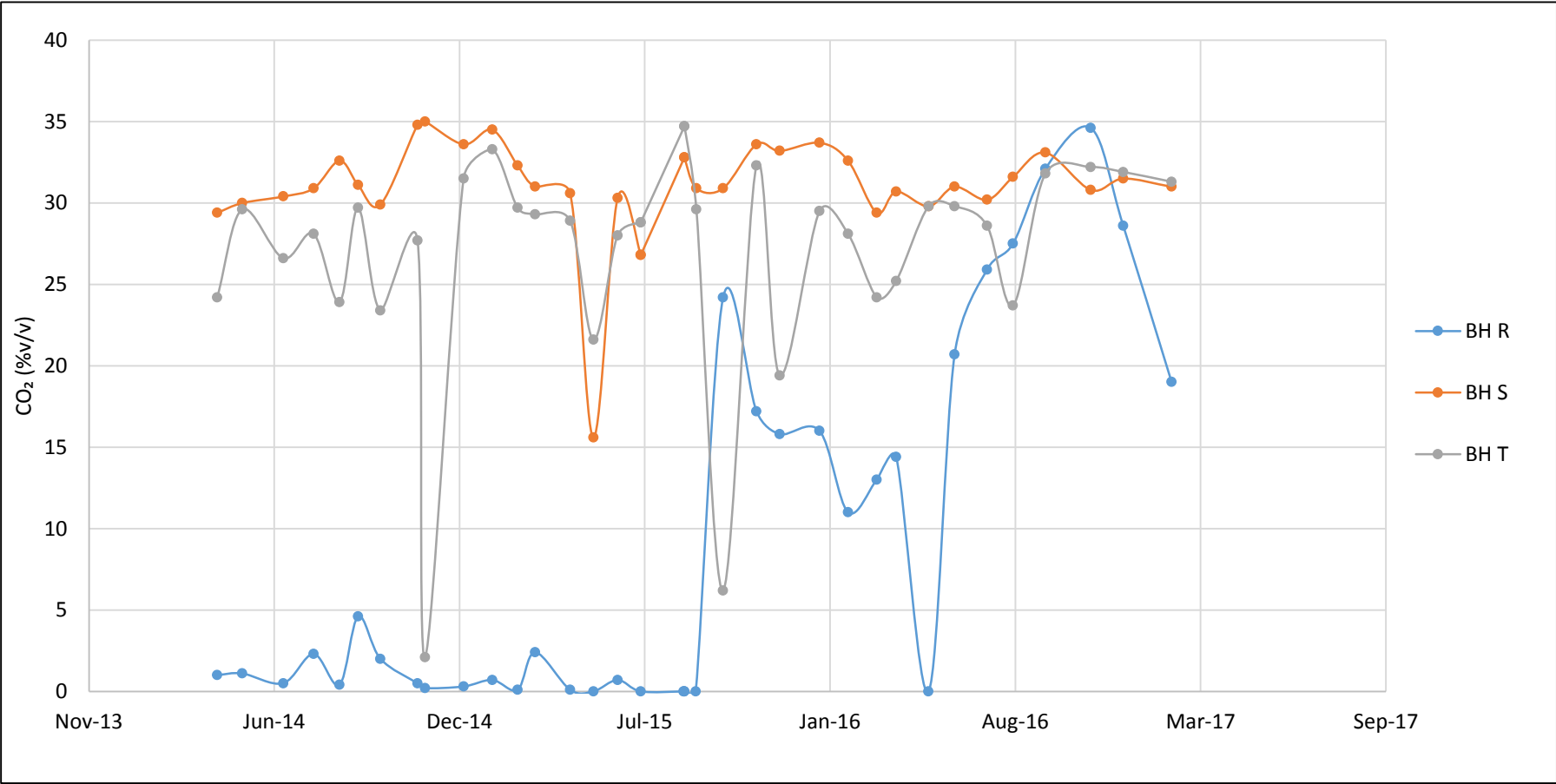


Figure 6: Carbon dioxide concentrations recorded in boreholes R, S and T

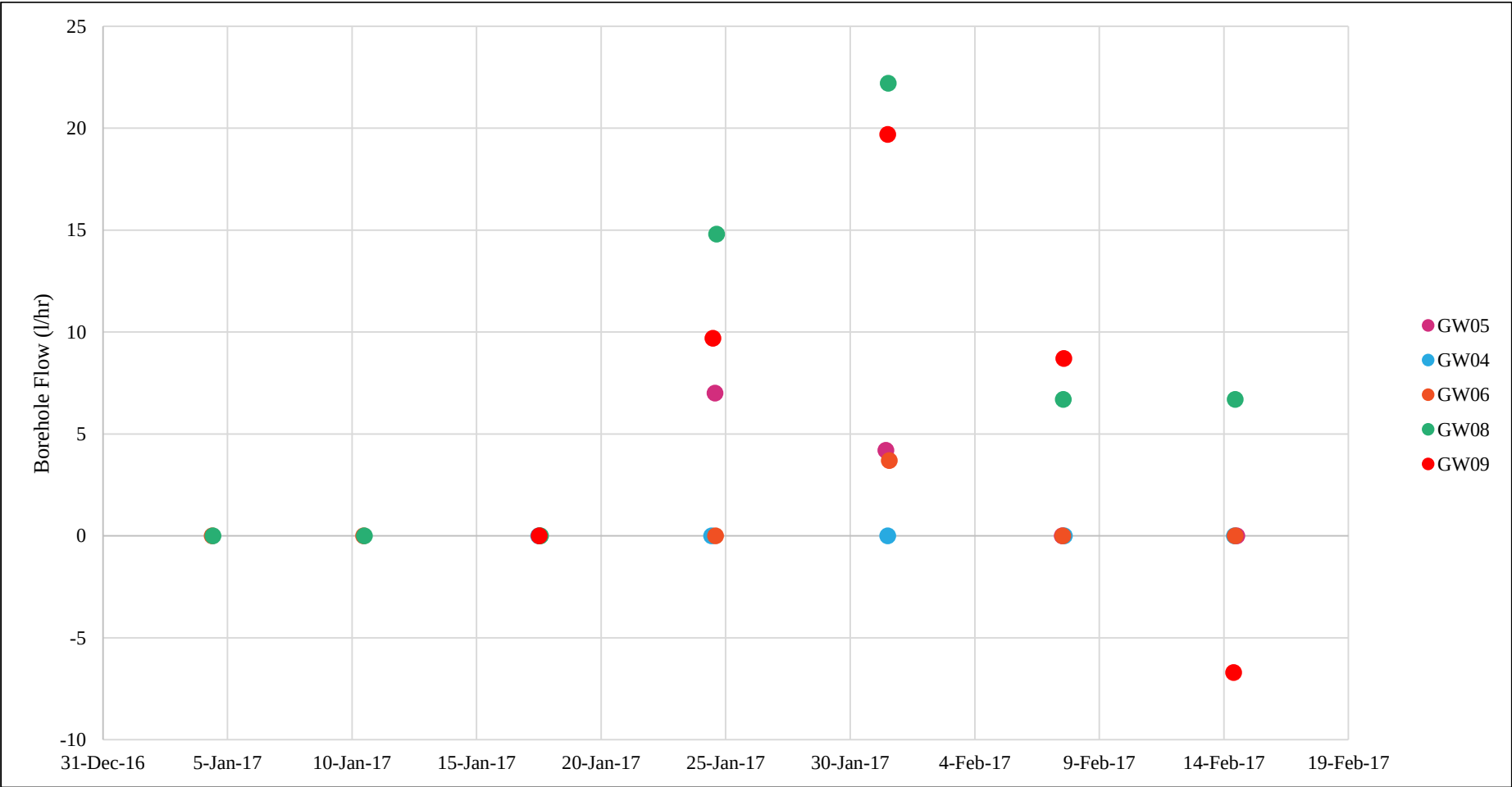


Figure 7: Borehole flows (l/hr) recorded in GW04, GW05, GW06, GW08 and GW09.

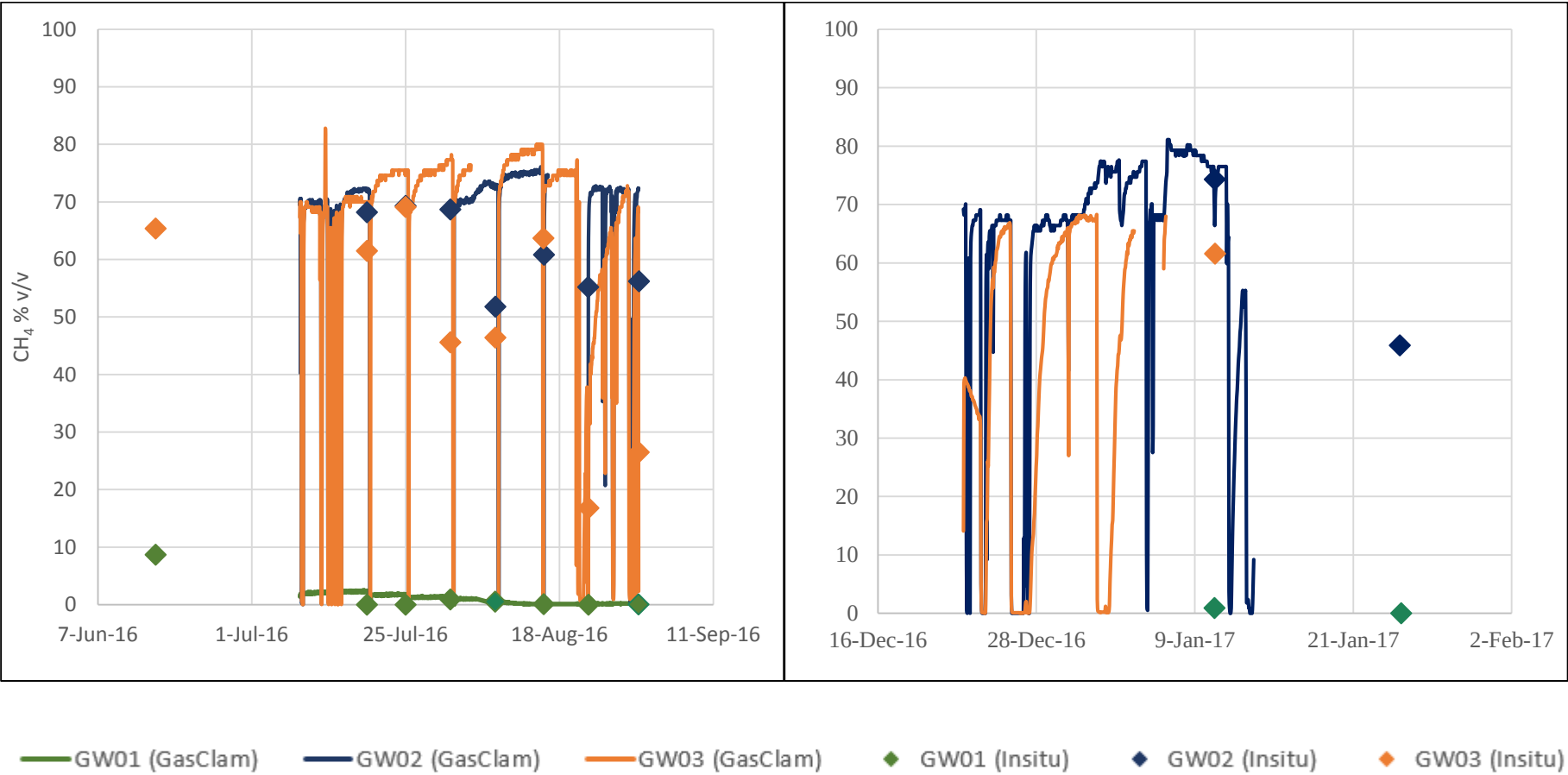


Figure 8: Methane concentrations (GasClam and Insitu) in GW01, GW02 and GW03.

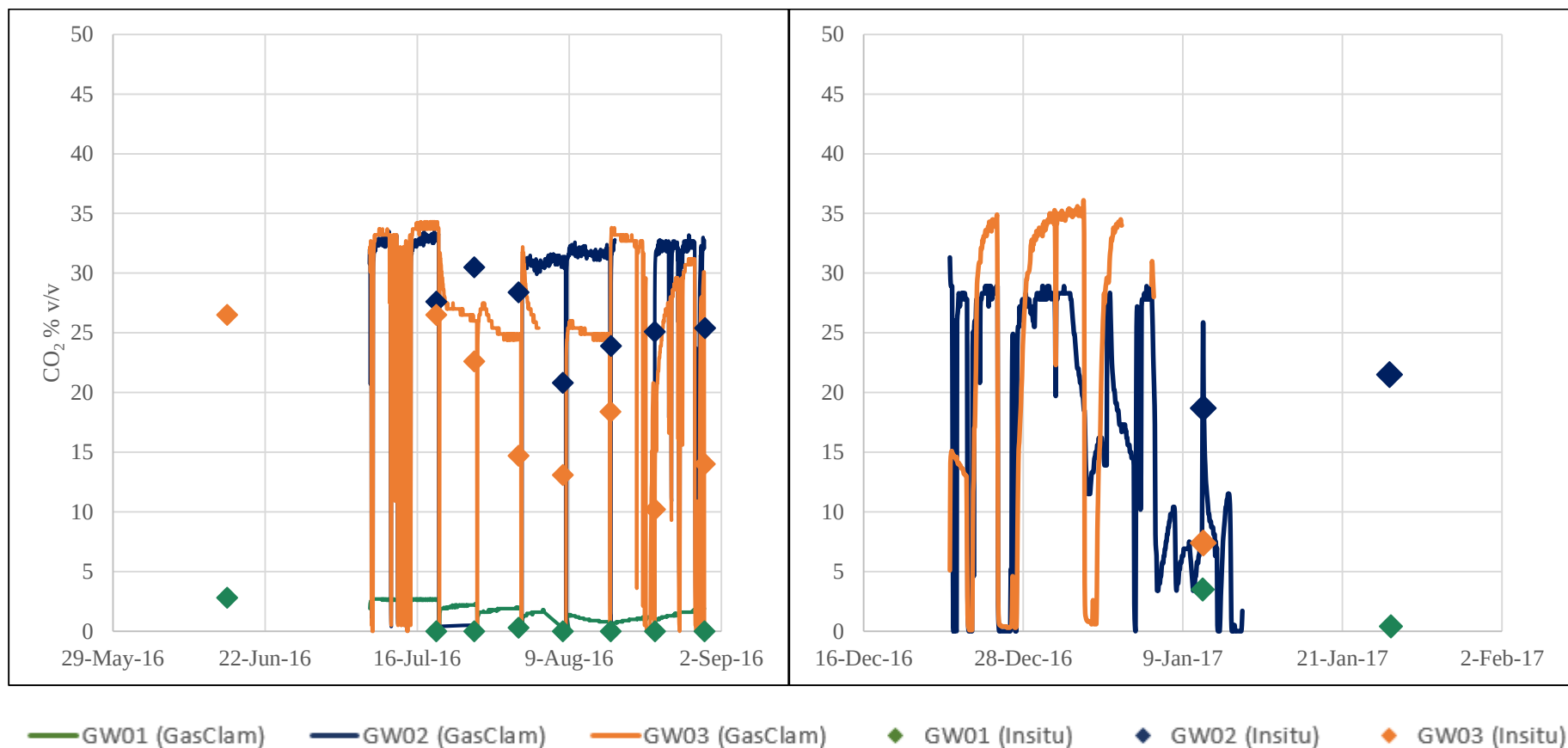


Figure 9: Carbon dioxide concentrations (GasClam and Insitu) in GW01, GW02 and GW03.

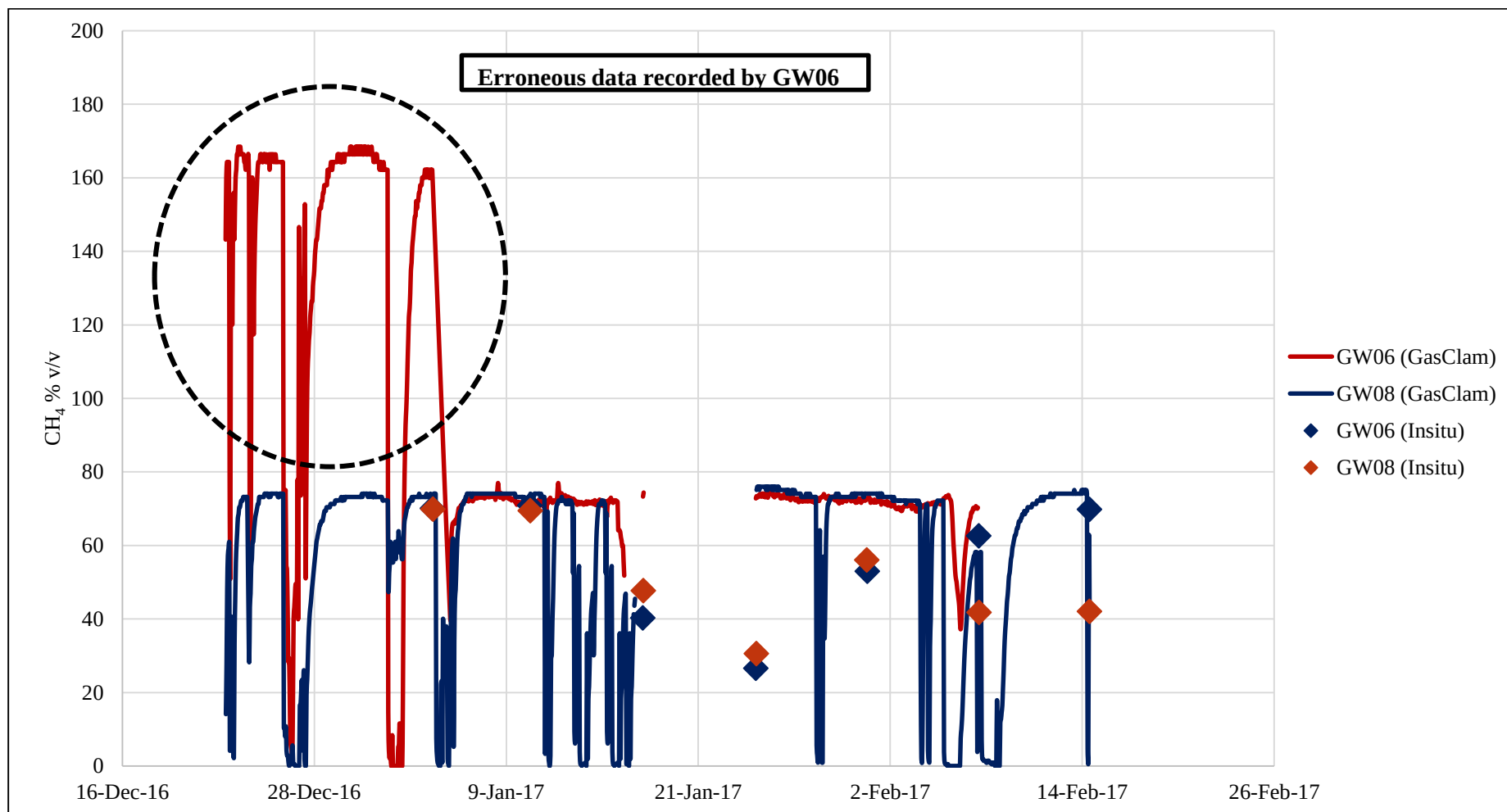


Figure 10: Methane concentrations (GasClam and Insitu) in GW06 and GW08

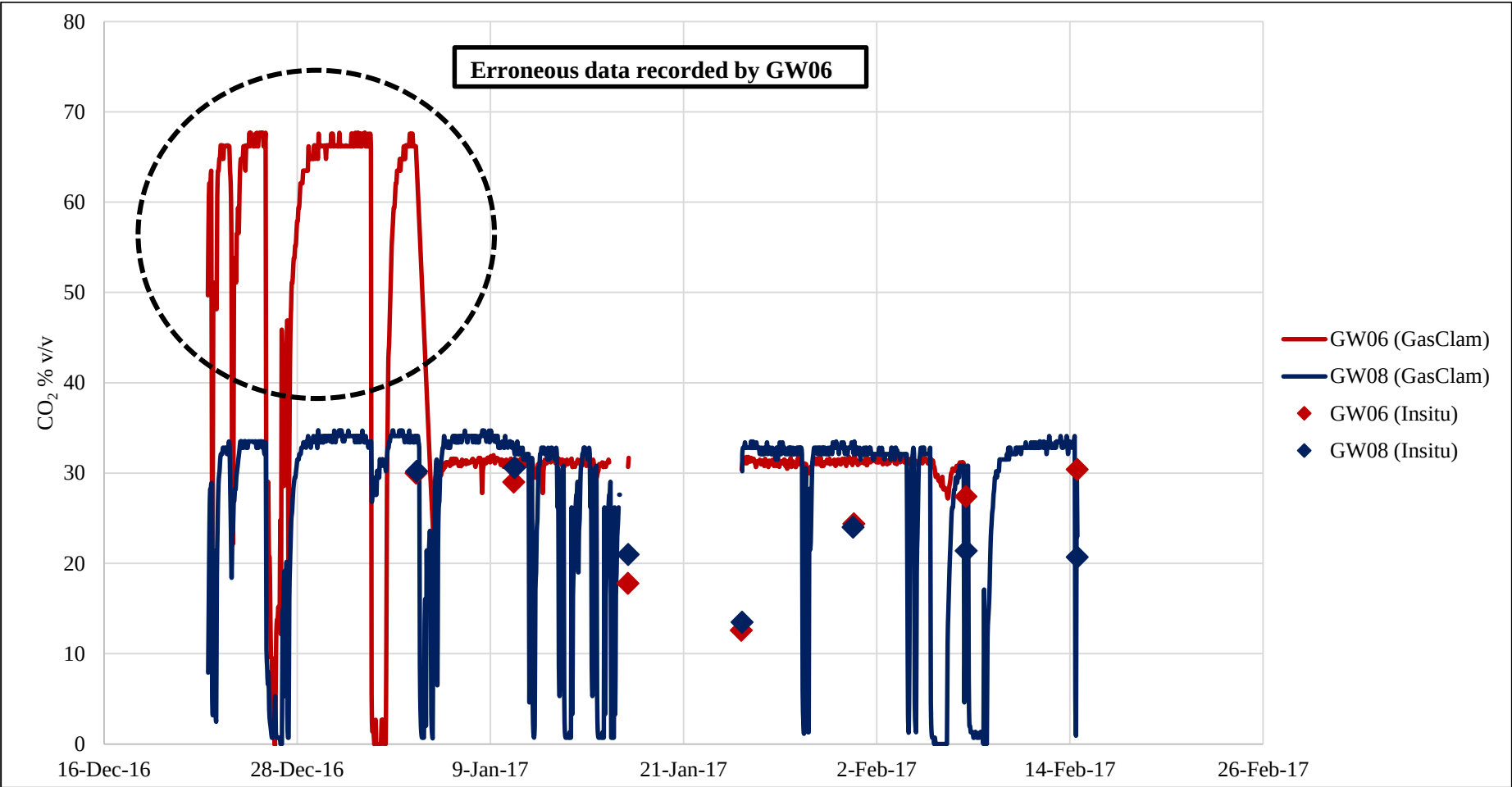


Figure 11: Carbon dioxide concentrations (GasClam and Insitu) in GW06 and GW08

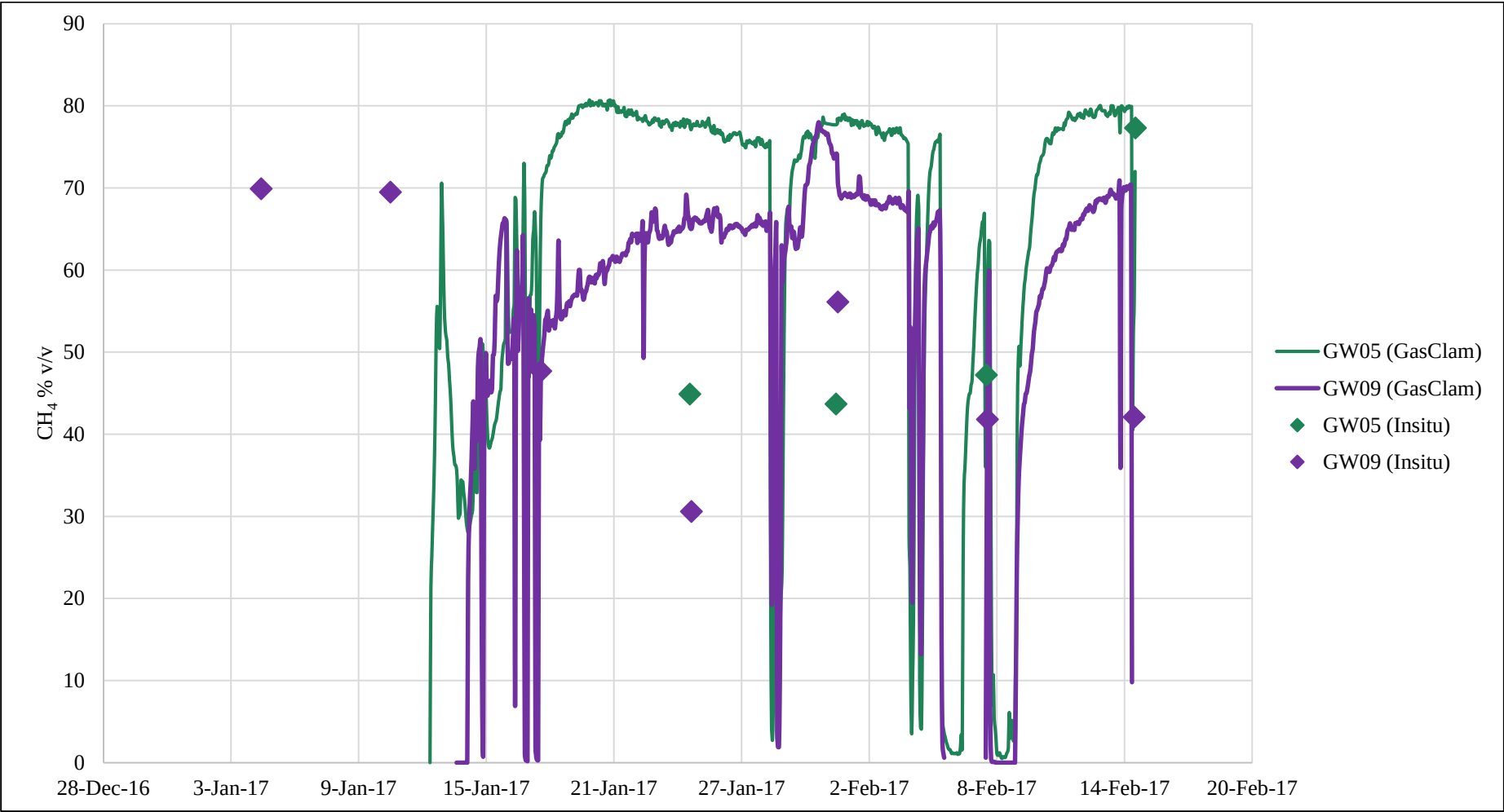


Figure 12: Methane concentrations (GasClam and Insitu) in GW05 and GW09

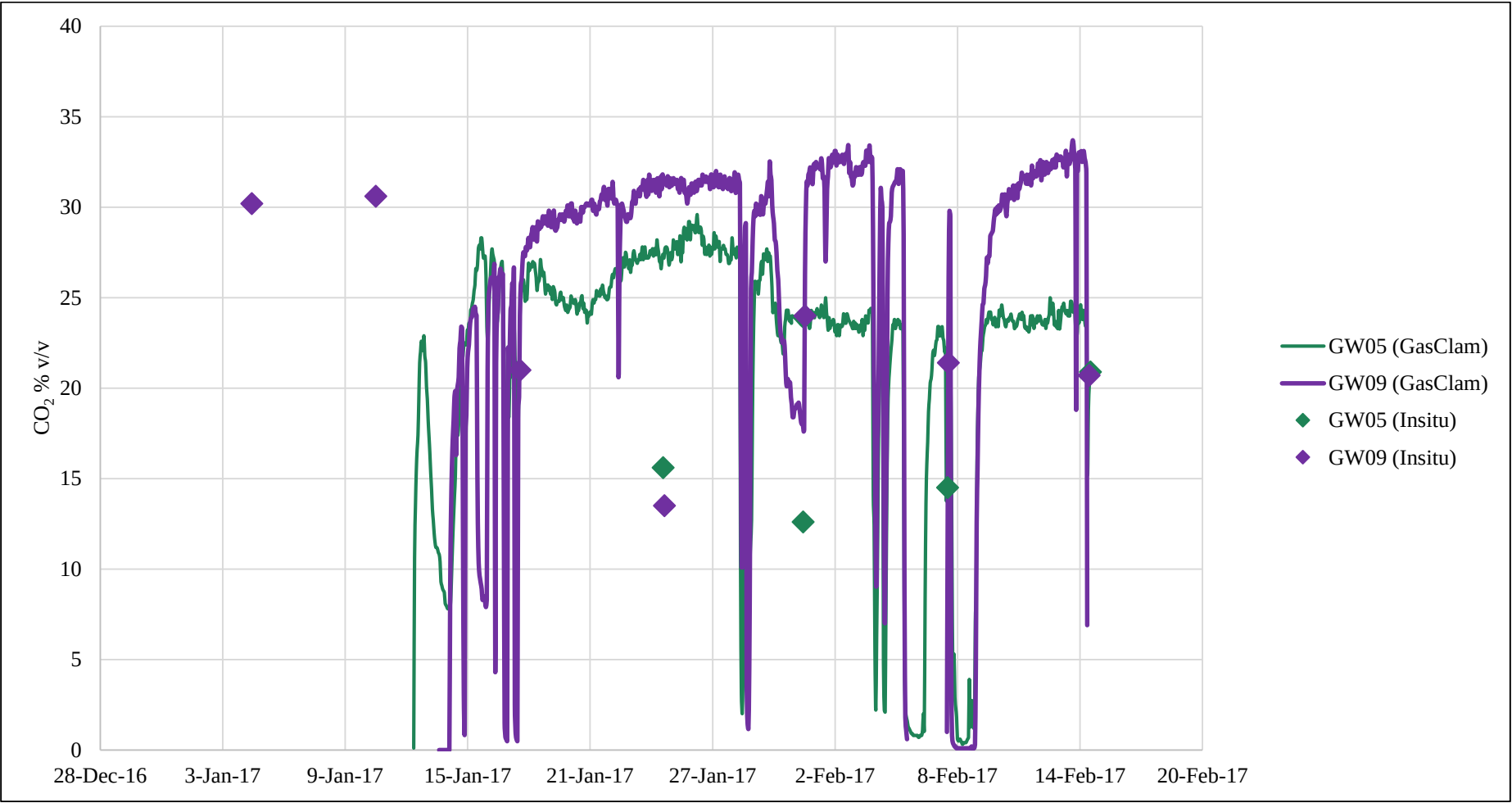


Figure 13: Carbon dioxide concentrations (GasClam and Insitu) in GW05 and GW09

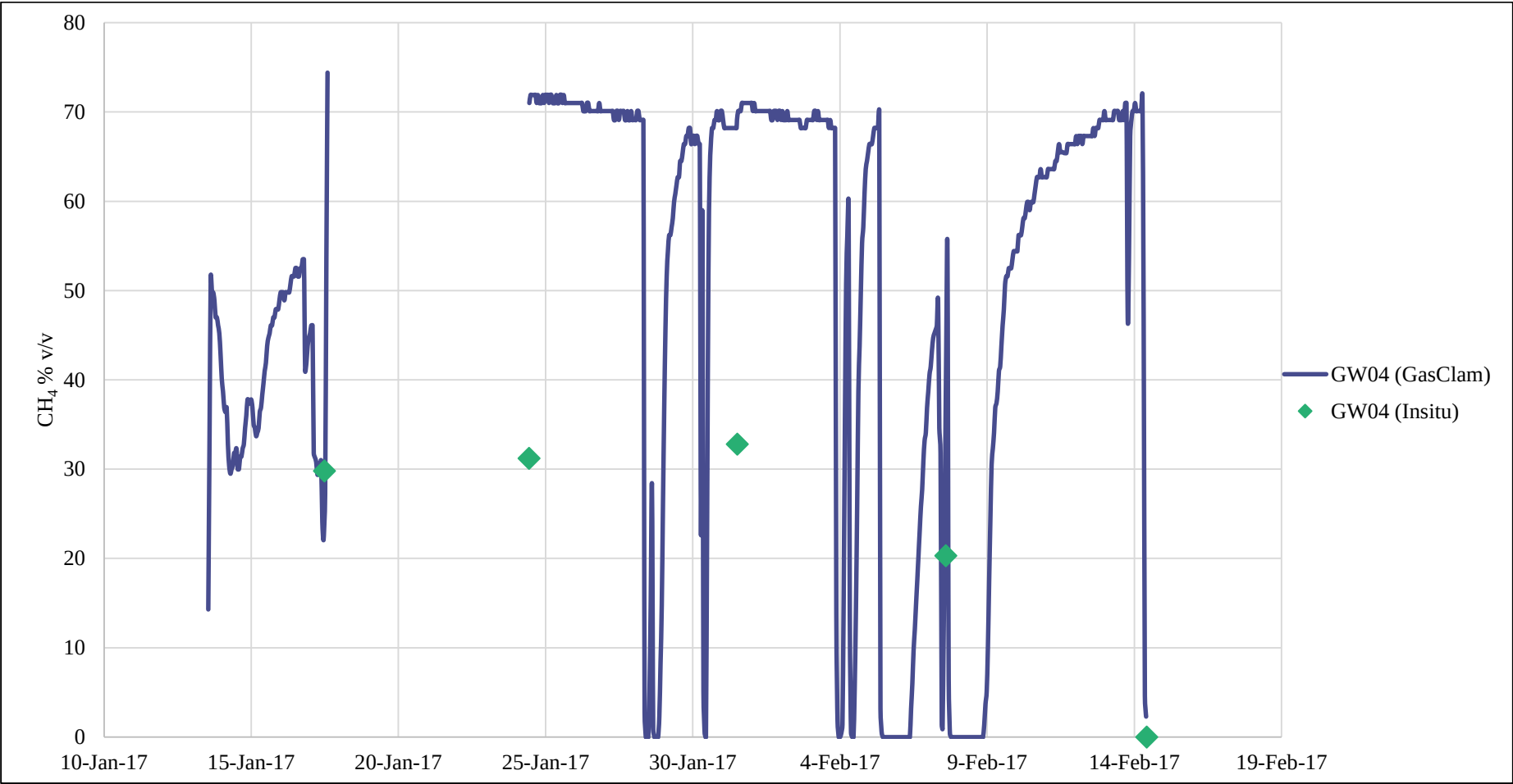


Figure 14: Methane concentrations (GasClam and Insitu) in GW04

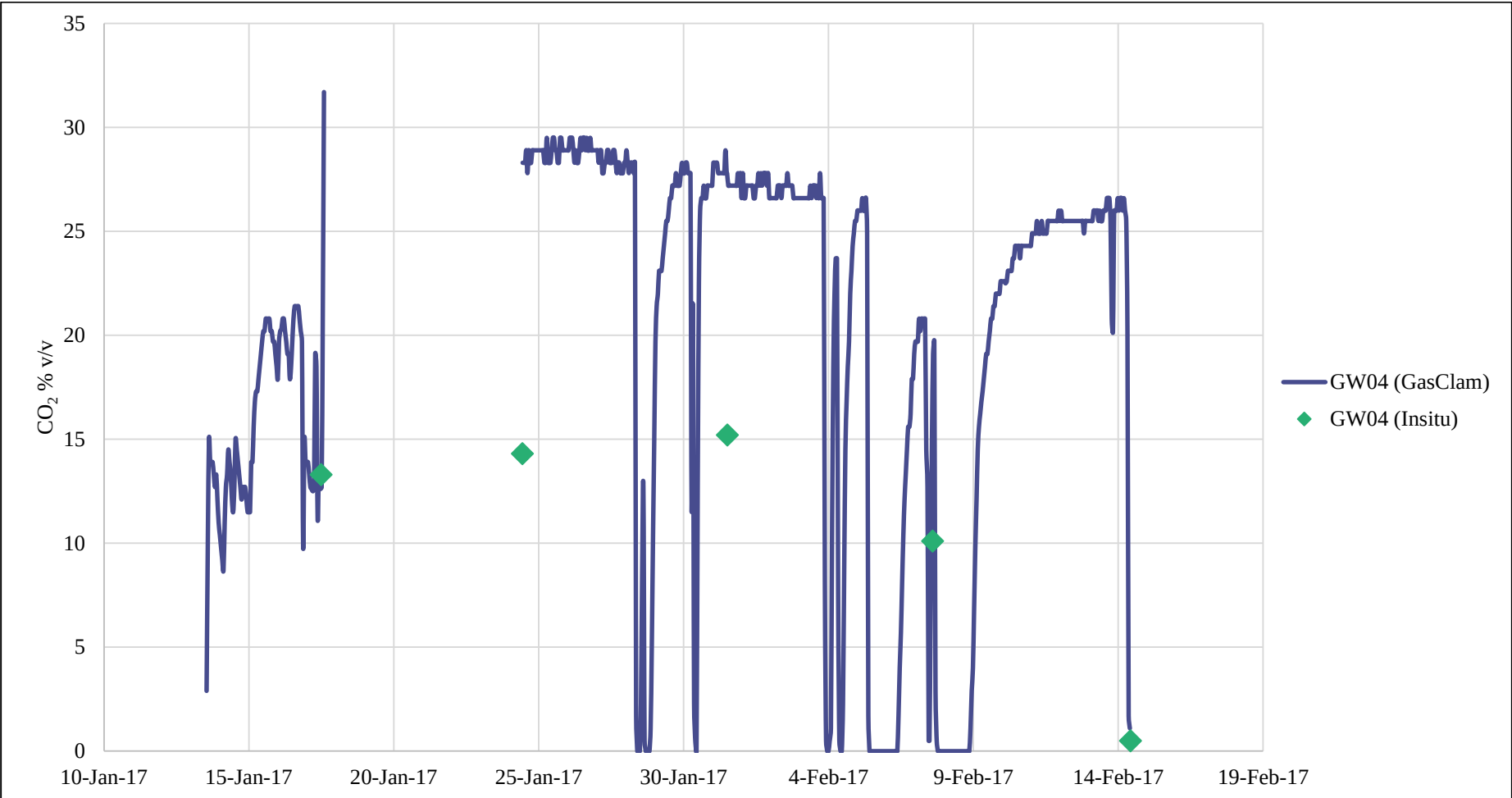


Figure 15: Carbon dioxide concentrations (GasClam and Insitu) in GW04

Table 1: Insitu gas data used for GSV Calculations.

Measurement Date	Standpipe	Atm Pressure (mbar)	Diff BH Pressure (mbar)	Max CH ₄ (%)	Max CO ₂ (%)	Flow (L/h)	Methane GSV (L/h)	Methane CS (analyser)	Round
04-Jan-17	GW02								0
10-Jan-17	GW02	1004	0	78	19	0	0.00	1	1
24-Jan-17	GW02	1023	0	46	22	0	0.00	1	3
10-Jan-17	GW03	1004	0	62	7	0	0.00	1	1
17-Jan-17	GW04	1025	0	30	13	0	0.00	1	2
24-Jan-17	GW04	1025	0	31	14	0	0.00	1	3
31-Jan-17	GW04	1004	0	33	15	0	0.00	1	4
07-Feb-17	GW04	1006	0	20	10	0	0.00	1	5
14-Feb-17	GW04	1015	0	0	0.5	0	0.00	1	6
24-Jan-17	GW05	1020	0	45	16	7	3.15	3	3
31-Jan-17	GW05	1005	2.1	44	13	4.2	1.85	3	4
07-Feb-17	GW05	1006	0	56	17	0	0.00	1	5
14-Feb-17	GW05	1015	0	77.5	0.4	0	0.00	1	6
04-Jan-17	GW06	1018	0	70	30	0	0.00	1	0
10-Jan-17	GW06	1005	0	71	29	0	0.00	1	1
17-Jan-17	GW06	1025	0	47	20	0	0.00	1	2
24-Jan-17	GW06	1022	0	27	13	0	0.00	1	3
31-Jan-17	GW06	1004	1.7	55	24	3.7	2.04	3	4
07-Feb-17	GW06	1006	0	64	28	0	0.00	1	5
14-Feb-17	GW06	1015	0	69.9	30.6	0	0.00	1	6

04-Jan-17	GW08	1017	0	70	30	0	0.00	1	0
10-Jan-17	GW08	1004	0	70	31	0	0.00	1	1
17-Jan-17	GW08	1026	0	48	21	0	0.00	1	2
24-Jan-17	GW08	1016	0	31	14	14.8	4.59	4	3
31-Jan-17	GW08	1004	17.9	56	24	22.2	12.43	4	4
07-Feb-17	GW08	1006	4.3	51	24	6.7	3.42	3	5
14-Feb-17	GW08	1015	2.7	66.9	28.3	6.7	4.48	4	6
17-Jan-17	GW09	1025	0	26	11	0	0.00	1	2
24-Jan-17	GW09	1025	0	39	18	9.7	3.78	4	3
31-Jan-17	GW09	1005	15.7	25	6	19.7	4.93	4	4
07-Feb-17	GW09	1005	6	38	17	8.7	3.31	3	5
14-Feb-17	GW09	1015	-42	2.1	1.8	-6.7	0.00	1	6

Table 2: GasClam data used for GSV Calculations.

Measurement Date	Standpipe	Gas Clam Atm Pressure	Gas Clam Diff P	Gas Clam CH4	Gas Clam CO2	Methane GSV (L/h)	Methane CS (gas clam)	Groundwater (m bgl)
04-Jan-17	GW02	1015	3	75	17			
10-Jan-17	GW02	1001	-1	77	8	0	1	5.6
24-Jan-17	GW02							Dry
10-Jan-17	GW03							4.67
17-Jan-17	GW04	1025	6	27	13	0	1	8.52
24-Jan-17	GW04	1019	3	72	28	0	1	8.43
31-Jan-17	GW04	1003	-1	69	28	0	1	8.53
07-Feb-17	GW04	1002	-1	49	21	0	1	8.55

14-Feb-17	GW04	1011	1	80	27	0	1	8.44
24-Jan-17	GW05	1021	0	78	27	5.46	4	8.27
31-Jan-17	GW05	1005	1	78	23	3.28	3	8.32
07-Feb-17	GW05	1006	0	67	22	0	1	8.08
14-Feb-17	GW05	1013	0	80	24.6	0	1	8.11
04-Jan-17	GW06	1015	-6					10.98
10-Jan-17	GW06	1002	-3	72	31	0	1	10.88
17-Jan-17	GW06	1027	-7	74	32	0	1	10.87
24-Jan-17	GW06	1009	4	73	31	0	1	11.22
31-Jan-17	GW06	1001	-1	73	31	2.70	3	11.06
07-Feb-17	GW06	1000	2	70	31	0	1	10.87
14-Feb-17	GW06							11.2
04-Jan-17	GW08	1017	1	74	34	0	1	10.36
10-Jan-17	GW08	1005	0 / -1	72	33	0	1	10.33
17-Jan-17	GW08	1021	5	44	28	0	1	10.55
24-Jan-17	GW08	1019	1	75	30	11.10	4	10.33
31-Jan-17	GW08	1006	0	74	33	16.43	5	10.32
07-Feb-17	GW08	1007	0	40	24	2.68	3	10.41
14-Feb-17	GW08	1013	0	75	34.1	5.03	4	10.41
17-Jan-17	GW09	1025	6	46	19	0	1	8.93
24-Jan-17	GW09	1017	3		32	6.69	4	8.85
31-Jan-17	GW09	1001	2		18	14.58	4	8.7
07-Feb-17	GW09	1005	2	60	30	0	1	8.71
14-Feb-17	GW09	1009	3	70.4	33.1	0	1	8.71

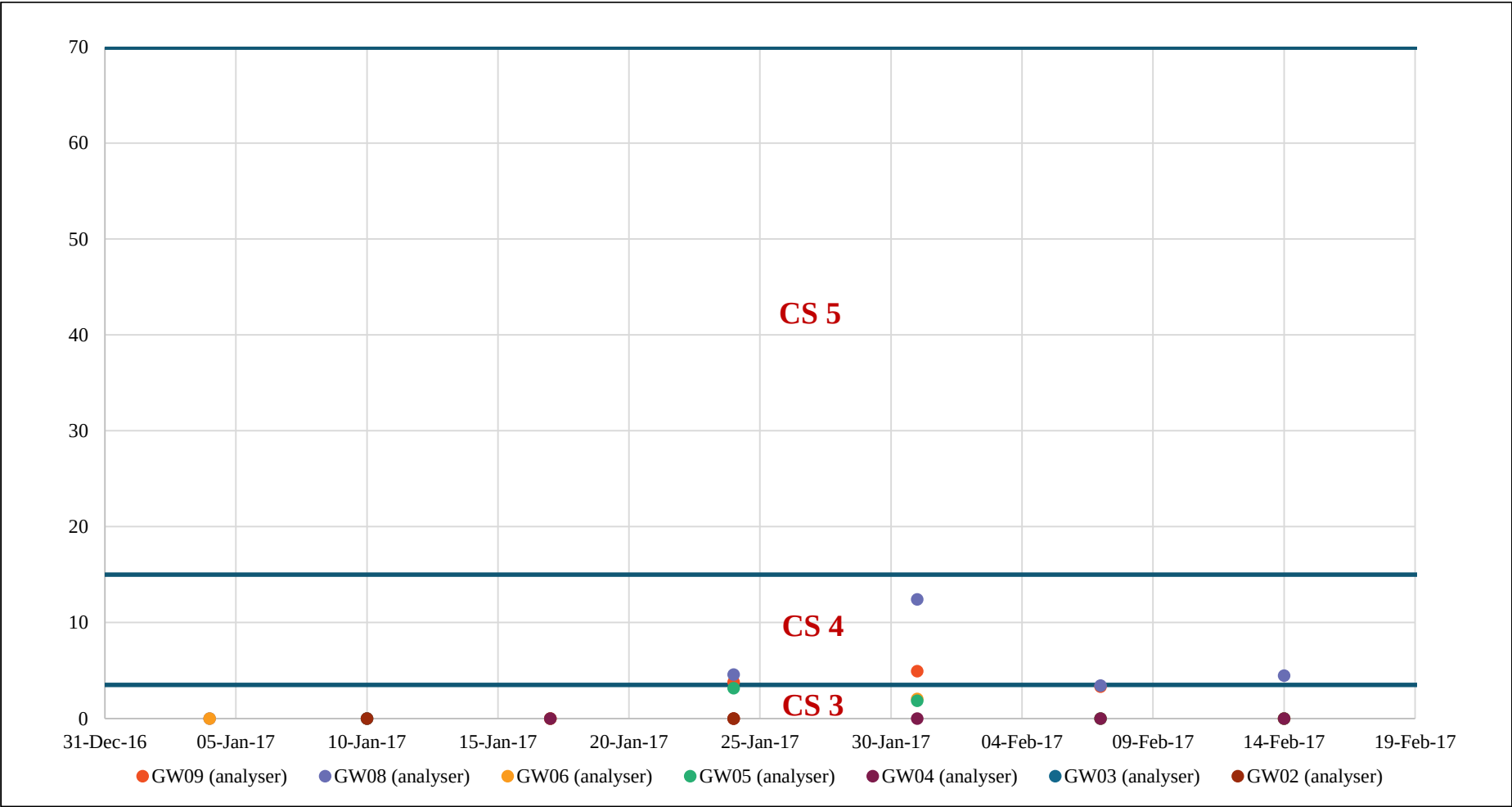


Figure 16: Methane Gas Screening Values (GSVs) - Gas Analyser Measurements

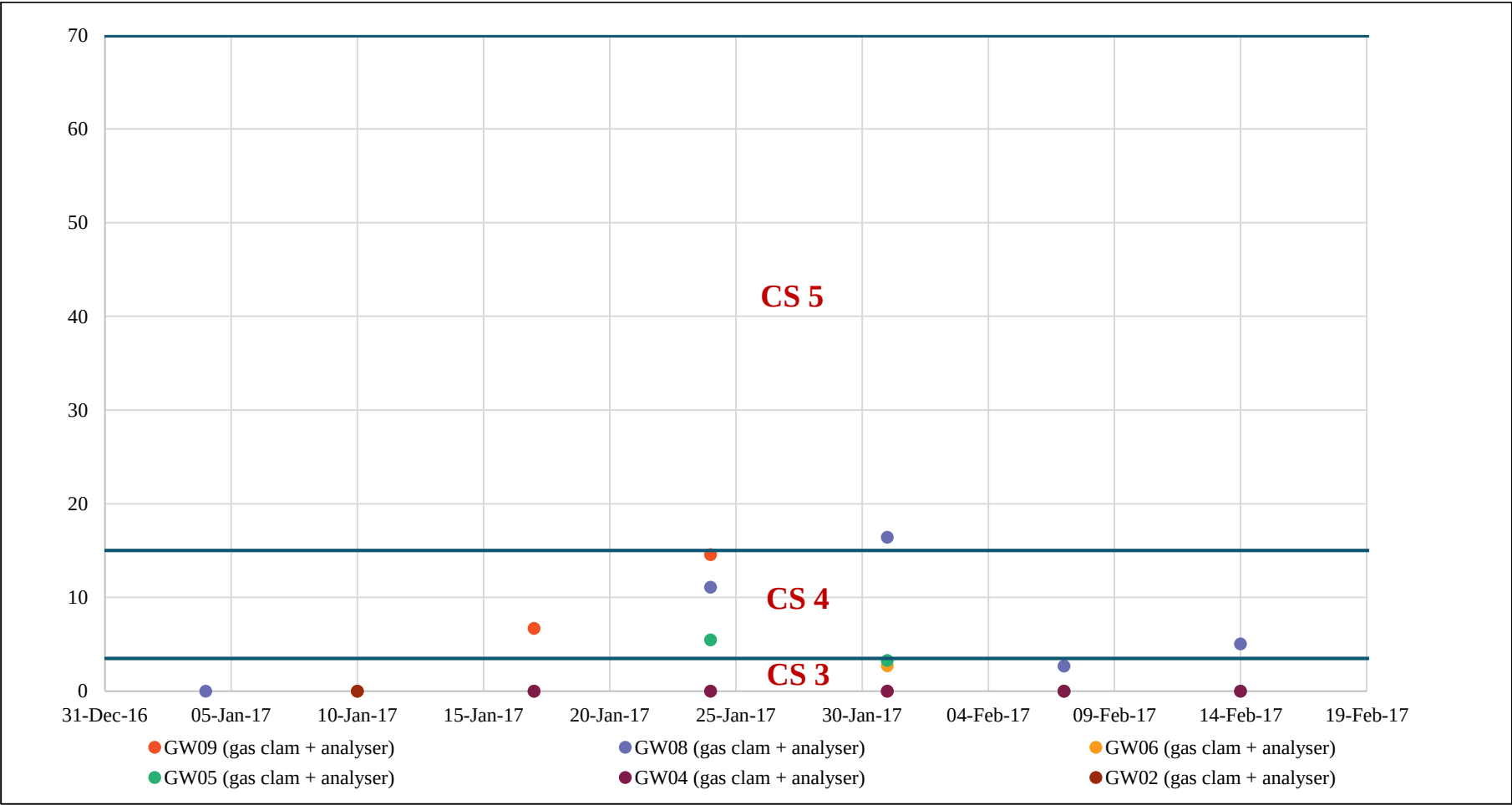


Figure 17: Methane Gas Screening Values (GSVs) - Gas Clam with Analyser Flow Measurements

Appendix B

Borehole Logs



Sample type

D	Small disturbed	U	Undisturbed	X/L	Dynamic	D*/ES	Environmental - soil	Cs	Core subsample (prepared)
B	Bulk disturbed	UT	Undisturbed thin wall	C	Core	EW	Environmental - water	Xs/Ls	Dynamic subsample (prepared)
LB	Large bulk disturbed	P	Piston	W	Water				

Test type

S SPT - Split spoon sampler followed by uncorrected SPT 'N' Value

C SPT - Solid cone followed by uncorrected SPT 'N' Value

(*250 - Where full test drive not completed, linearly extrapolated 'N' value reported, ** - Denotes no effective penetration)

H Hand vane - direct reading in kPa - not corrected for BS1377 (1990). Re* denotes refusal

M Mackintosh probe - number of blows to achieve 100mm penetration

PP Pocket penetrometer - direct reading in kg/sq.cm

Vo Headspace vapour reading, uncorrected peak values in ppm, using a PID (calibrated with Isobutylene, using a 10.6eV bulb)

Sample/core range/L.

- Dynamic sample

■ Undisturbed sample - open drive including thin wall. Symbol length reflects recovery

x x = Total Core Recovery (TCR) as percentage of core run

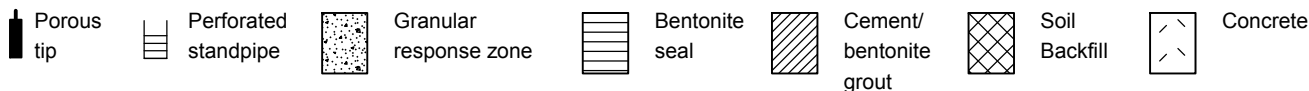
y = Solid Core Recovery (SCR) as percentage of core run. Assessment of core is based on full diameter.

z z = Rock Quality Designation (RQD). The amount of solid core greater than 100mm expressed as percentage of core run.

Where SPT has been carried out at beginning of core run, disturbed section of core excluded from SCR and RQD assessment.

l_f - fracture spacing - the modal fracture spacing (mm) over the indicated length of core. Where spacing varies significantly, the minimum, mode and maximum values are given. NI = non-intact core NA = not applicable

Instrumentation



Stratum boundaries

----- Estimated boundary -.-.-.-.- Grading boundary

Logging

The logging of soils and rocks has been carried out in general accordance with BS 5930:2015.

Chalk is logged in general accordance with Lord et al (2002) CIRIA C574. Where possible, dynamic samples in chalk have been logged in accordance with CIRIA C574: descriptions and gradings (if presented) should be treated with caution given the potential for sample disturbance.

For rocks the term fracture has been used to identify a mechanical break within the core. Where possible incipient and drilling induced fractures have been excluded from the assessment of fracture state. Where doubt exists, a note has been made in the descriptions. All fractures are considered to be continuous unless otherwise reported.

Made Ground is readily identifiable when, within the material make up, man made constituents are evident. Where Made Ground appears to be reworked natural material the differentiation between in situ natural deposits and Made Ground is much more difficult to ascertain. The interpretation of Made Ground within the logs should therefore be treated with caution.

The descriptors "topsoil" and "tarmacadam" are used as generic terms and do not imply conformation to any particular standard or composition.

Rootlets are defined as being less than 2mm in diameter, roots are defined as in excess of 2mm diameter.

General Comments

The process of drilling and sampling will inevitably lead to disturbance, mixing or loss of material in some soil and rocks.

Indicated water levels are those recorded during the process of drilling or excavating exploratory holes and may not represent standing water levels.

All depths are measured along the axis of the borehole and are related to ground level at the point of entry. All inclinations are measured normal to the axis of the core.

BOREHOLE LOG**GW04**

CLIENT READING FOOTBALL CLUB

SITE MADEJSKI STADIUM, READING

Sheet 1 of 3

Start Date 20 December 2016 Easting 470545

Scale 1 : 25

End Date 12 January 2017 Northing 169797 Ground level 46.80mOD Depth 11.00 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	instru- ment	description	depth (m)	reduced level (m)	legend
20/12/16 1100hrs	L	0.00 - 1.20	Nil				Dark brownish grey sandy subangular fine to coarse brick, concrete and flint GRAVEL. (MADE GROUND)	0.15	46.65	
							Dark brownish grey slightly clayey sandy subangular fine to coarse concrete, flint and brick GRAVEL. Rare fibrous textile material. (MADE GROUND)	0.85	45.95	
20/12/16 1300hrs Dry							Firm brownish grey slightly sandy slightly gravelly CLAY. Gravel is subangular to rounded fine to coarse chalk, flint and brick. (MADE GROUND)			
11/01/17 1100hrs Dry	L	1.20 - 1.60	1.20				1.20m: Geotextile membrane.	1.30	45.50	
							MADE GROUND comprising firm dark grey mottled black slightly sandy gravelly (ashy) CLAY with 10% fragments (up to 110mm) of textile and plastic. Gravel is angular and subangular fine to coarse brick, mudstone and flint.	1.60	45.20	
	L	1.60 - 2.20	1.60				1.50 - 1.55m: Subangular brick cobble.			
							MADE GROUND comprising light grey and brown angular and subangular fine to coarse concrete and flint GRAVEL with a high subangular concrete cobble content and 10% fragments (up to 120mm) of wood, plastic and polythene.	2.20	44.60	
	L	2.20 - 2.30	1.60							
	C	2.30 - 2.70	2.20		75		MADE GROUND comprising concrete COBBLES with 5% fragments of (up to 50mm) of plastic, steel and wood.	2.60	44.20	
	C	2.70 - 2.90	2.70		75		Greyish brown mottled yellowish brown gravelly fine to coarse SAND. Gravel is angular and subangular fine to coarse flint. (MADE GROUND)	2.85	43.95	
	C	2.90 - 4.00	2.70		100		MADE GROUND comprising light brown and grey CONCRETE.	3.30	43.50	
							Stiff locally very stiff slightly sandy gravelly CLAY. Gravel is angular to subrounded flint, concrete and brick. (MADE GROUND)	3.65	43.15	
							MADE GROUND comprising fragments (up to 120mm) of metal, rubber, batteries, aluminium cans (John Smith's Ale, Newcastle Brown Ale), polythene, paper, plastic (low fat gooseberry flavour yoghurt pot) and rare glass.			
							Continued Next Page	{4.00}		

EQUIPMENT: Geotechnical Pioneer rig.

METHOD: Hand dug inspection pit 0.00-1.20m (backfilled prior to drilling). Dynamic sampled (128mm) 0.00-1.20m (sample not retained), 1.20-2.20m, 4.00-4.60m, 6.50-7.60m, 10.60-11.00m and (113mm) 2.20-2.30m and 7.60-7.65m. Waterflush rotary core drilled (146mm) 2.30-4.00m, 4.60-6.50m and 7.60-10.60m. CASING: 168mm diam to 9.50m.

BACKFILL: On completion, borehole sidewalls collapsed 11.00-10.50m, then backfilled with bentonite 10.50-9.50m. Two slotted standpipe (50mm) were installed to 9.50m, granular response zone 9.50m-0.90m, bentonite seal 0.90-0.35m, gravel drain 0.35-0.25m, concrete and stopcock cover 0.25- 0.00m. A gas clam was installed in one standpipe and a dual gas tap was installed on the second standpipe.

REMARKS: Driller notes no flush returns 8.00-10.60m and limited flush returns 2.90-4.00m (50%) and 7.60-8.00m (20%). Gas noted by driller during installation.

EXPLORATORY HOLE LOGS SHOULD BE READ IN CONJUNCTION WITH KEY SHEETS

water strike (m) casing (m) rose to (m) time to rise (min) remarks

Groundwater not encountered prior to use of water flush.



CONTRACT
32534

CHECKED
EC

BOREHOLE LOG

CLIENT READING FOOTBALL CLUB

GW04

SITE MADEJSKI STADIUM, READING

Sheet 2 of 3

Start Date 20 December 2016 Easting 470545

Scale 1 : 25

End Date 12 January 2017 Northing 169797 Ground level 46.80mOD

Depth 11.00 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	instru- ment	description	depth (m)	reduced level (m)	legend
11/01/17 1715hrs 0.20m 12/01/17 0800hrs 0.22m	L	4.00 - 4.60	4.00							
	C	4.60 - 5.00	4.00		100					
	C	5.00 - 6.50	5.00		87		MADE GROUND comprising dark brown rarely mottled black slightly sandy clayey angular and subangular fine to coarse brick, concrete, flint and sandstone GRAVEL with 5% fragments (up to 90mm) of plastic.	5.00	41.80	
							MADE GROUND comprising fragments (up to 120mm) of plastic, paper, electrical wire, rubber and polythene. 5.60m: Broken badminton racket head.	5.55	41.25	
	L	6.50 - 7.60	6.50				MADE GROUND comprising firm brownish grey rarely mottled black slightly sandy gravelly CLAY with 10-15% fragments (up to 60mm) of metal, wood, plastic (food wrapper) and a plastic cup. Gravel is angular and subangular fine to coarse brick and flint.	6.50	40.30	
	C	7.60 - 8.00	6.50		100		7.00 - 7.30m: Sandy.			
	C	8.00 - 9.10	7.60		64		7.55 - 7.60m: Subangular brick cobble.	7.80	39.00	
							MADE GROUND comprising fragments (up to 150mm) of tyre rubber, plastic, paper, wood, plastic bag (Tesco), aluminium cans and rare glass.			
							8.10 - 8.25m: Roll of carpet.			
Continued Next Page								{9.00}		
water strike (m) casing (m) rose to (m) time to rise (m) remarks								CONTRACT		CHECKED
Groundwater not encountered prior to use of water flush.								32534		EC

BOREHOLE LOG

CLIENT READING FOOTBALL CLUB

GW04

SITE MADEJSKI STADIUM, READING

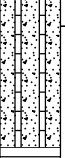
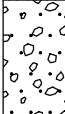
Sheet 3 of 3

Start Date 20 December 2016 Easting 470545

Scale 1 : 25

End Date 12 January 2017 Northing 169797 Ground level 46.80mOD

Depth 11.00 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	instru- ment	description	depth (m)	reduced level (m)	legend
12/01/17 1345hrs 9.70m	C	9.10 - 10.60	7.60		40		NO RECOVERY.	9.10	37.70	
										
							Firm greyish brown slightly gravelly sandy CLAY with rare fragments of plastic (up to 60mm). Gravel is subangular fine to coarse flint. (MADE GROUND)	9.90	36.90	
							Light brown and orangish brown sandy angular and subangular fine to coarse flint GRAVEL.	10.20	36.60	
	L	10.60 - 11.00	9.50							
							Borehole completed at 11.00m.	11.00	35.80	
								{14.00}		
water strike (m) casing (m) rose to (m) time to rise (m) remarks							Groundwater not encountered prior to use of water flush.	CONTRACT 32534		CHECKED EC

BOREHOLE LOG**GW05**

CLIENT READING FOOTBALL CLUB

SITE MADEJSKI STADIUM, READING

Sheet 1 of 3

Start Date 9 January 2017 Easting 470748

Scale 1 : 25

End Date 10 January 2017 Northing 169890 Ground level 47.50mOD Depth 12.10 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	instru- ment	description	depth (m)	reduced level (m)	legend
20/12/16 1140hrs	C	0.00 - 0.06	Nil				MADE GROUND comprising dark grey and black TARMACADAM.	0.06	47.44	
							Brown slightly silty slightly sandy angular and subangular fine to coarse concrete, brick, flint and tarmacadam GRAVEL with a low angular brick cobble content. (MADE GROUND)	0.40	47.10	
							0.35m: Black angular metal fragment (100mm). 0.40m: Root (15mm diam) on eastern edge of pit.	0.70	46.80	
							Light yellowish brown rarely mottled orange slightly clayey fine to coarse SAND with rare organic fragments (up to 15mm). Rare rootlets. (MADE GROUND)	0.90	46.60	
20/12/16 1230hrs Dry	L	1.13 - 1.20	Nil				Soft brown and greyish brown slightly sandy slightly gravelly CLAY with rare pockets of fibrous organic material (up to 50mm). Gravel is angular and subangular fine to coarse flint and rare chalk. (MADE GROUND)	1.13	46.37	
09/01/17 1340hrs Dry	L	1.20 - 2.10	1.20				Soft locally firm dark grey slightly sandy gravelly CLAY. Gravel is angular and subangular fine to coarse flint and brick. (MADE GROUND) 1.13m: Geotextile membrane.			
							MADE GROUND comprising firm dark grey mottled black slightly sandy gravelly CLAY with 5-10% fragments (up to 50mm) of metal and textile. Gravel is angular fine to coarse brick. 1.40m: Subangular tarmacadam cobble.			
	L	2.10 - 3.60	2.10				2.05m: Metal lid (70mm diam). Firm light brown slightly gravelly sandy CLAY. Gravel is angular fine to coarse brick and mudstone. (MADE GROUND)	2.10	45.40	
								2.90	44.60	
							MADE GROUND comprising firm dark greyish brown slightly sandy gravelly CLAY with 20-30% fragments (up to 60mm) of wood, plastic, polythene and rare glass. Gravel is angular and subangular brick and mudstone.			
	L	3.60 - 5.10	2.10					3.80	43.70	
							Stiff to very stiff greyish brown slightly sandy gravelly CLAY. Gravel is angular to subrounded brick, flint and			
							Continued Next Page	{4.00}		

EQUIPMENT: Geotechnical Pioneer rig.

METHOD: Rotary core drilled (300mm) 0.00-0.06m. Hand dug inspection pit 0.06-1.13m. Dynamic sampled (128mm) 1.13m-6.70m and (113mm) 6.70-7.70m and 8.20-12.10m. Waterflush rotary core drilled (146mm) 7.70-8.20m.

CASING: 168mm diam to 10.70m.

BACKFILL: On completion, borehole backfilled with bentonite 12.10-10.70m. Two slotted standpipe (50mm) were installed to 10.70m, granular response zone 10.70m-1.00, bentonite seal 1.00-0.30m, concrete and stopcock cover 0.30-0.00m. A gas clam was installed in one standpipe and a dual gas tap was installed on the second standpipe.

EXPLORATORY HOLE LOGS SHOULD BE READ IN CONJUNCTION WITH KEY SHEETS

water strike (m)	casing (m)	rose to (m)	time to rise (min)	remarks
0.67	Nil			Seepage.


CONTRACT
32534
CHECKED
EC

BOREHOLE LOG**GW05**

CLIENT READING FOOTBALL CLUB

SITE MADEJSKI STADIUM, READING

Sheet 2 of 3

Start Date 9 January 2017 Easting 470748

Scale 1 : 25

End Date 10 January 2017 Northing 169890 Ground level 47.50mOD

Depth 12.10 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	instru- ment	description	depth (m)	reduced level (m)	legend
09/01/17 1800hrs Dry							mudstone. (MADE GROUND)			
								4.90	42.60	
							Reddish orange sandy angular and subangular fine to coarse brick GRAVEL. (MADE GROUND)	5.05	42.45	
10/01/17 0815hrs Dry	L	5.10 - 6.60	5.00				MADE GROUND comprising orangish brown clayey subangular and subrounded fine to coarse brick and mudstone GRAVEL with 30-40% fragments (up to 150mm) of newspaper, plastic, polythene, wood and glass.			
								5.80	41.70	
							MADE GROUND comprising dark grey mottled reddish brown clayey angular and subangular fine to coarse mudstone and brick GRAVEL with 5% fragments (up to 90mm) of plastic and rare glass.			
	L	6.60 - 6.70	5.00							
	L	6.70 - 7.70	5.00							
							6.80 - 6.90m: Plastic wrapping paper.	6.90	40.60	
							Orangish grey subangular fine to coarse flint GRAVEL. (MADE GROUND)	7.00	40.50	
							MADE GROUND comprising stiff brownish grey slightly sandy gravelly CLAY with 10-20% fragments (up to 80mm) of plastic, wood, textile and newspaper. Gravel is angular and subangular fine to coarse brick and flint.	7.40	40.10	
	C	7.70 - 8.20	7.70		50		MADE GROUND comprising fragments (up to 100mm) of wood, plastic, glass, paper, textiles and metal with 5-10% slightly sandy subangular fine to coarse flint gravel. 7.50 - 7.90m: Metal rod (50mm diam).			
							7.95 - 8.05m: Clothing and furniture catalogue (potentially Littlewoods, year unknown).			
	L	8.20 - 9.70	7.70					8.60	38.90	
							MADE GROUND comprising stiff dark grey mottled reddish brown slightly sandy gravelly CLAY with 5-10% fragments (up to 70mm) of plastic. Gravel is angular and subangular fine to coarse brick, flint and mudstone.			
							Continued Next Page	{9.00}		
water strike (m) casing (m) rose to (m) time to rise (m) remarks							AGS	CONTRACT 32534		CHECKED EC

BOREHOLE LOG**GW05**

CLIENT READING FOOTBALL CLUB

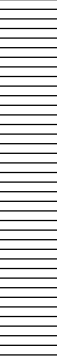
SITE MADEJSKI STADIUM, READING

Sheet 3 of 3

Start Date 9 January 2017 Easting 470748

Scale 1 : 25

End Date 10 January 2017 Northing 169890 Ground level 47.50mOD Depth 12.10 m

progress date/time water depth	sample no & type	depth (m) from to		casing depth (m)	test type & value	samp. /core range		instru- ment	description	depth (m)	reduced level (m)	legend
10/01/17 1815hrs 6.35m	L	9.70 - 11.10		7.70						10.20	37.30	
									Very stiff dark grey slightly sandy CLAY. (MADE GROUND)			
									10.60 - 10.70m: Polythene bags.	10.70	36.80	
	L	11.10 - 12.10		10.70					Light grey and yellowish grey slightly silty very sandy fine to coarse flint GRAVEL.			
									Borehole completed at 12.10m.	12.10	35.40	
										{14.00}		
water strike (m) casing (m) rose to (m) time to rise (m) remarks												
										CONTRACT 32534	CHECKED EC	

BOREHOLE LOG**GW06**

CLIENT READING FOOTBALL CLUB

SITE MADEJSKI STADIUM, READING

Sheet 1 of 4

Start Date 12 December 2016 Easting 470484

Scale 1 : 25

End Date 13 December 2016 Northing 169622 Ground level 50.90mOD Depth 14.20 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	instru- ment	description	depth (m)	reduced level (m)	legend
12/12/16 1345hrs	B	0.00 - 1.20					Light brown sandy subrounded medium flint GRAVEL over black and dark brown slightly sandy (ashy) subangular fine to coarse slag, concrete and brick GRAVEL. (MADE GROUND)	0.10 0.20	50.80 50.70	
							Brown slightly silty slightly sandy angular and subangular fine to coarse concrete, brick and slag GRAVEL with a low subangular brick and concrete cobble content. (MADE GROUND) 0.20m: Geotextile membrane.			
12/12/16 1500hrs Dry	L	1.20 - 2.50	Nil				Firm dark grey and dark brownish grey slightly sandy gravelly silty CLAY with a medium angular brick cobble content. Gravel is angular to rounded fine to coarse brick, concrete and flint. (MADE GROUND) 1.00m: Geotextile membrane.	1.00	49.90	
13/12/16 0800hrs Dry							MADE GROUND comprising firm dark grey locally black slightly sandy slightly gravelly CLAY with 20-30% fragments (up to 120mm) of plastic sheet, textiles, wood and rare sponge. Gravel is subangular and subrounded fine to coarse brick, sandstone, and chalk.			
	L	2.50 - 4.00	2.50							
Continued Next Page								{4.00}		

EQUIPMENT: Geotechnical Pioneer rig.

METHOD: Hand dug inspection pit 0.00-1.20m. Dynamic sampled (128mm) 1.20-5.00m and (113mm) 5.00-6.50m, 8.00-8.70m and 12.30-12.60m. Waterflush rotary core drilled (146mm) 6.50-8.00m, 8.70-12.30m and 12.60-14.20m with polymer added.

CASING: 168mm diam to 10.80m.

BACKFILL: On completion, borehole sidewall collapsed 14.20-13.60m, bentonite seal 13.60-12.50m. Two slotted standpipe (50mm) were installed to 12.50m, granular response zone 12.50-1.00m, bentonite seal 1.00-0.50m, concrete and stopcock cover 0.50-0.00m. A gas clam was installed in one standpipe and a dual gas tap was installed on the second standpipe.

REMARKS: Driller notes reduced flush returns 6.50-14.20 (30-65% returned).

EXPLORATORY HOLE LOGS SHOULD BE READ IN CONJUNCTION WITH KEY SHEETS

water strike (m) casing (m) rose to (m) time to rise (min) remarks

Groundwater not encountered prior to use of water flush.

CONTRACT
32534CHECKED
EC

BOREHOLE LOG**GW06**

CLIENT READING FOOTBALL CLUB

SITE MADEJSKI STADIUM, READING

Sheet 2 of 4

Start Date 12 December 2016 Easting 470484

Scale 1 : 25

End Date 13 December 2016 Northing 169622 Ground level 50.90mOD Depth 14.20 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	instru- ment	description	depth (m)	reduced level (m)	legend
	L	4.00 - 5.00	4.00					4.40	46.50	
							MADE GROUND comprising firm light brown slightly sandy gravelly CLAY with up to 10% fragments of plastic sheet and bags. Gravel is angular and subangular fine to coarse flint and brick.	4.55	46.35	
	L	5.00 - 6.50	4.00				MADE GROUND comprising firm black mottled greyish brown slightly gravelly CLAY with 10-20% fragments (up to 50mm) of plastic sheet and plywood (up to 120mm). Gravel is angular to rounded fine and medium flint, brick, pumice and glass.	4.90	46.00	
							MADE GROUND comprising firm black slightly sandy slightly gravelly CLAY with 40-50% fragments (up to 120mm) of plastic sheet, plastic lids, metal wire, plywood and carpet. Gravel is angular to rounded fine to coarse flint, brick and concrete.			
							6.00 - 6.20m: Abundant fibrous textile fragments (up to 0.5mm diam).			
	C	6.50 - 8.00	6.50		73		MADE GROUND comprising fragments (up to 120mm) of wood, plastic sheet and rare metal, wire and textile with 5% dark grey and brown angular to rounded fine to coarse flint gravel.	6.50	44.40	
							MADE GROUND comprising firm grey mottled black sandy gravelly CLAY with 10-20% fragments (up to 80mm) of plastic sheet, wood and metal wire (2mm diam). Gravel is angular to rounded fine and medium flint, concrete, brick and glass.	7.25	43.65	
	L	8.00 - 8.70	8.00				8.00 - 10.00m: Malodourous.	8.20	42.70	
							MADE GROUND comprising firm to stiff dark grey mottled brownish grey and yellowish brown slightly sandy slightly gravelly CLAY with up to 10% fragments (up to 60mm) of glass, wood and metal. Gravel is subangular fine to coarse brick, flint and concrete.	8.70	42.20	
	C	8.70 - 9.30	8.00		100		MADE GROUND comprising brown and grey slightly clayey subangular and subrounded fine to coarse flint, brick and concrete GRAVEL with up to 10% fragments (up to 120mm) of plastic sheet, plastic lids, metal wire, plywood and carpet. Gravel is angular to rounded fine to coarse flint, brick and concrete.	9.00	41.90	
							Continued Next Page	{9.00}		
water strike (m) casing (m) rose to (m) time to rise (m) remarks							Groundwater not encountered prior to use of water flush.	CONTRACT 32534		CHECKED EC

BOREHOLE LOG**GW06**

CLIENT READING FOOTBALL CLUB

SITE MADEJSKI STADIUM, READING

Sheet 3 of 4

Start Date 12 December 2016 Easting 470484

Scale 1 : 25

End Date 13 December 2016 Northing 169622 Ground level 50.90mOD

Depth 14.20 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	instru- ment	description	depth (m)	reduced level (m)	legend
13/12/16 1630hrs 0.00m	C	9.30 - 10.80	8.00		40		to 50mm) of wood, plastic and hair.			
							MADE GROUND comprising fragments of fabric (up to 200mm), wood and plywood (up to 30mm thick), plastic (up to 2mm), rubber gloves and hair with 5% brown and grey subangular and subrounded fine to coarse flint and concrete gravel. 9.00m: Subangular flint cobble. 9.10 - 9.30m: Layers of fabric, carpet, newspaper (April 1980) and fragments of low fat yoghurt pot (up to 80mm). 9.30 - 9.80m: Limited recovery.			
14/12/16 0800hrs Dry	C	10.80 - 12.30	10.80		67		MADE GROUND comprising grey and light brown subangular and subrounded medium and coarse flint, brick and concrete GRAVEL with a low subangular brick and concrete cobble content and 30-40% fragments (up to 120mm) of wood, plastic sheet, metal, tin and glass.	10.80	40.10	
	L	12.30 - 12.60	10.80				MADE GROUND comprising stiff greyish brown mottled grey slightly gravelly CLAY with up to 10% fragments (up to 50mm) of foil, paper and plastic. Gravel is angular to subrounded fine to coarse flint and brick.	12.30	38.60	
	C	12.60 - 13.00	10.80		100		MADE GROUND comprising fragments (up to 100mm) of plastic, paper, plywood and metal sheet and up to 5% of yellow fine to coarse sand. 12.70 - 12.95m: Daily Express newspaper dated 1978. 12.95m: Subangular concrete cobble with steel reinforcement bars (5mm diam).	12.50	38.40	
	C	13.00 - 14.20	10.80		50					
							Stiff grey mottled brown sandy CLAY. Rare rootlets.	13.70	37.20	
Continued Next Page								{14.00}		
water strike (m) casing (m) rose to (m) time to rise (m) remarks Groundwater not encountered prior to use of water flush. AGS CONTRACT 32534 CHECKED EC										



GW06

Sheet 4 of 4

Scale 1 : 25

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range		instru- ment	description	depth (m)	reduced level (m)	legend
14/12/16 1630hrs 2.85m									14.20	36.70	
								Borehole completed at 14.20m.			



CONTRACT
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BOREHOLE LOG

CLIENT READING FOOTBALL CLUB

GW07

SITE MADEJSKI STADIUM, READING

Sheet 1 of 1

Start Date 15 December 2016 Easting 470372

Scale 1 : 25

End Date 15 December 2016 Northing 169612 Ground level 50.55mOD Depth 2.80 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	instru- ment	description	depth (m)	reduced level (m)	legend
15/12/16 0800hrs	B	0.00 - 1.20					Grass over brown slightly clayey slightly gravelly fine to coarse SAND. Gravel is subangular and subrounded fine and medium flint. Frequent fragments of artificial grass (up to 80mm). (MADE GROUND)	0.70	49.85	
	L	1.20 - 2.50	Nil				Brown gravelly fine to coarse SAND with a low subangular brick and concrete cobble content. Gravel is angular and subangular fine to coarse brick, concrete and slag. (MADE GROUND) 0.95m: Geotextile membrane. 1.20 - 1.30m: Brownish yellow fine to coarse sand with frequent artificial grass (up to 80mm). Firm dark brown mottled black slightly sandy slightly gravelly CLAY. Gravel is subangular and subrounded fine to coarse flint and brick. Rare plastic fragments (up to 20mm). (MADE GROUND)	1.30	49.25	
							Firm light brown mottled black slightly sandy very gravelly CLAY. Gravel is subangular fine to coarse flint and brick. (MADE GROUND)	1.90	48.65	
15/12/16 1015hrs 2.10m	L	2.50 - 2.80	2.50				Soft dark grey mottled black slightly gravelly sandy clayey SILT. Gravel is subangular and subrounded fine and medium flint and chalk. (MADE GROUND) White and grey subangular fine and medium chalk GRAVEL. (MADE GROUND) Borehole completed at 2.80m.	2.50 2.65 2.80	48.05 47.90 47.75	
								{4.00}		

EQUIPMENT: Geotechnical Pioneer rig.

METHOD: Hand dug inspection pit 0.00-1.20m. Dynamic sampled (128mm) 1.20-2.80m, (113mm) attempted from 2.80m yielding no penetration.

CASING: 168mm diam to 2.50m.

BACKFILL: On completion, hole backfilled with bentonite pellets 2.80-0.90m and arisings 0.90-0.00m.

REMARKS: Borehole terminated on Consultant's request due to perched water table.

EXPLORATORY HOLE LOGS SHOULD BE READ IN CONJUNCTION WITH KEY SHEETS

water strike (m)	casing (m)	rose to (m)	time to rise (min)	remarks	AGS	CONTRACT	CHECKED
2.10	Nil	2.10	20	Struck following run 2.50-2.80m.		32534	EC

BOREHOLE LOG**GW08**

CLIENT READING FOOTBALL CLUB

SITE MADEJSKI STADIUM, READING

Sheet 1 of 4

Start Date 15 December 2016 Easting 470419

Scale 1 : 25

End Date 20 December 2016 Northing 169717 Ground level 50.10mOD

Depth 14.50 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	instru- ment	description	depth (m)	reduced level (m)	legend
15/12/16 1350hrs	B	0.00 - 1.20					Grass over brown slightly clayey slightly gravelly fine to coarse SAND with a low subangular concrete cobble content and frequent fragments of artificial plastic grass (up to 80mm). Gravel is angular to subrounded fine to coarse flint. (MADE GROUND)			
	L	1.20 - 2.50	Nil				Firm dark brown and brown slightly sandy gravelly CLAY. Gravel is angular to subrounded fine to coarse flint, brick and rare chalk. (MADE GROUND)	1.00	49.10	
	L	2.50 - 4.00	2.50				MADE GROUND comprising dark brown and black slightly sandy gravelly CLAY with 30-40% fragments (up to 100mm) of plastic sheet, plastic tubes, plastic lids, tin, glass bottles, newspaper, wood and textiles. Gravel is angular and subangular fine to coarse brick and chalk. Low subangular brick cobble content.	2.40	47.70	
15/12/16 1645hrs 0.80m							Continued Next Page	{4.00}		

EQUIPMENT: Geotechnical Pioneer rig.

METHOD: Hand dug inspection pit 0.00-1.20m. Dynamic sampled (128mm) 1.20-6.70m and (113mm) 6.70-7.70m and 13.40-14.50m. Waterflush rotary core drilled (146mm) 7.70-13.40m.

CASING: 168mm diam to 12.20m.

BACKFILL: On completion, borehole sidewall collapsed 14.50-13.40m, bentonite seal 13.40-12.40m. Two slotted standpipes (50mm) was installed to 12.40m, granular response zone 12.40-1.00m, bentonite seal 1.00-0.50m, concrete and stopcock cover 0.50-0.00m. A gas clam was installed in one standpipe and a dual gas tap was installed in the second standpipe.

REMARKS: Driller notes reduced flush returns 7.70-9.20m and 12.20-13.30m (40-70%) and loss of flush returns 9.20-12.20m and 13.30-13.40m. Driller notes presence of gas at 14.50m.

EXPLORATORY HOLE LOGS SHOULD BE READ IN CONJUNCTION WITH KEY SHEETS

water strike (m) casing (m) rose to (m) time to rise (min) remarks

Groundwater not encountered prior to use of water flush.

CONTRACT
32534CHECKED
EC

BOREHOLE LOG

CLIENT READING FOOTBALL CLUB

GW08

SITE MADEJSKI STADIUM, READING

Sheet 2 of 4

Start Date 15 December 2016 Easting 470419

Scale 1 : 25

End Date 20 December 2016 Northing 169717 Ground level 50.10mOD

Depth 14.50 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	instru- ment	description	depth (m)	reduced level (m)	legend
16/12/16 0745hrs 0.90m	L	4.00 - 5.50	4.00							
	L	5.50 - 6.70	5.50				5.10 - 7.70m: Limited recovery.			
	L	6.70 - 7.70	5.50							
	C	7.70 - 9.20	7.70		60		MADE GROUND comprising fragments (up to 150mm) of metal, plastic bags, plastic tubes, netting, textiles, carpet, glass, paper and wood with 10-20% brown and dark grey subangular fine to coarse brick and flint gravel.	7.70	42.40	
							Continued Next Page	{9.00}		
water strike (m) casing (m) rose to (m) time to rise (m) remarks							Groundwater not encountered prior to use of water flush.	CONTRACT 32534		CHECKED EC

BOREHOLE LOG**GW08**

CLIENT READING FOOTBALL CLUB

SITE MADEJSKI STADIUM, READING

Sheet 3 of 4

Start Date 15 December 2016 Easting 470419

Scale 1 : 25

End Date 20 December 2016 Northing 169717 Ground level 50.10mOD

Depth 14.50 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	instru- ment	description	depth (m)	reduced level (m)	legend
	C	9.20 - 10.70	7.70		63					
	C	10.70 - 12.20	7.70		53		MADE GROUND comprising white and grey slightly sandy slightly clayey subangular fine to coarse chalk, flint and brick GRAVEL with 40-50% fragments (up to 80mm) of plastic and textiles. Limited recovery.	10.70	39.40	
16/12/16 1500hrs 10.50m										
19/12/16 0915hrs 4.30m	C	12.20 - 13.30	12.20		80		MADE GROUND comprising fragments (up to 150mm) of metal, plastic bags, tubes, netting, textiles, carpet, glass, paper and wood with 10-20% brown and dark grey subangular fine to coarse brick and flint gravel.	12.20	37.90	
	C	13.30 - 13.40	12.20		100					
	L	13.40 - 14.50	12.20							
							Greyish brown sandy subangular and subrounded fine to coarse flint GRAVEL.	13.80	36.30	
							Continued Next Page	{14.00}		
water strike (m) casing (m) rose to (m) time to rise (m) remarks							Groundwater not encountered prior to use of water flush.	CONTRACT 32534		CHECKED EC



GW08

End Date	20 December 2016	Northing	169717	Ground level	50.10mOD	Depth	14.50 m
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progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range		instru- ment	description	depth (m)	reduced level (m)	legend
19/12/16 1120hrs 10.20m									14.50	35.60	
								Borehole completed at 14.50m.			
									{19.00}		
water strike (m)	casing (m)	rose to (m)	time to rise (m)	remarks							
Groundwater not encountered prior to use of water flush.							CONTRACT 32534		CHECKED EC		

BOREHOLE LOG**GW09**

CLIENT READING FOOTBALL CLUB

SITE MADEJSKI STADIUM, READING

Sheet 1 of 3

Start Date 20 December 2016 Easting 470547

Scale 1 : 25

End Date 21 December 2016 Northing 169743 Ground level 48.25mOD Depth 10.50 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	instru- ment	description	depth (m)	reduced level (m)	legend
20/12/16 1345hrs	L	0.00 - 1.50	Nil				Brown sandy angular to rounded flint, concrete and brick GRAVEL. (MADE GROUND)			
							0.30 - 0.60m: High subangular brick and concrete cobble content.			
							0.50 - 0.60m: Fragments (up to 100mm) of plastic sheet.	0.70	47.55	
20/12/16 1445hrs Dry							Firm brownish grey sandy gravelly CLAY. Gravel is angular and subangular fine to coarse concrete, brick and flint. (MADE GROUND)	1.00	47.25	
21/12/16 1230hrs Dry	L	1.50 - 3.00	Nil				Greenish brown slightly gravelly fine to coarse SAND. Gravel is subangular fine to coarse chalk, brick and concrete. (MADE GROUND)			
							MADE GROUND comprising firm black rarely mottled light yellowish grey slightly sandy slightly gravelly CLAY with 10-20% fragments (up to 100mm) of plastic bag, wood and fibres. Gravel is angular to subrounded fine to coarse flint, brick, glass and concrete. Oily sheen.	2.00	46.25	
	L	3.00 - 4.50	Nil							
Continued Next Page								{4.00}		

EQUIPMENT: Geotechnical Pioneer rig.

METHOD: Hand dug inspection pit 0.00-1.20m (backfilled prior to drilling). Dynamic sampled (128mm) 0.00-1.50m and (113mm) 1.50-6.00m and 9.00-10.50m. Waterflush rotary core drilled (146mm) 6.00-9.00m.

CASING: 168mm diam to 6.00m.

BACKFILL: On completion, borehole backfilled with bentonite 10.50-9.50m. Two slotted standpipe (50mm) were installed to 9.50m, granular response zone 9.50m-1.00, bentonite seal 1.00-0.30m, concrete and stopcock cover 0.30-0.00m. A gas clam was installed in one standpipe and a dual gas tap was installed on the second standpipe.

REMARKS: Driller notes presence of gas at 10.00m. Driller notes loss of flush returns 6.00-9.00m.

EXPLORATORY HOLE LOGS SHOULD BE READ IN CONJUNCTION WITH KEY SHEETS

water strike (m)	casing (m)	rose to (m)	time to rise (min)	remarks	AGS	CONTRACT	CHECKED
1.00	Nil	1.00	20	Encountered following run 0.00-1.50m.		32534	EC

BOREHOLE LOG**GW09**

CLIENT READING FOOTBALL CLUB

SITE MADEJSKI STADIUM, READING

Sheet 2 of 3

Start Date 20 December 2016 Easting 470547

Scale 1 : 25

End Date 21 December 2016 Northing 169743 Ground level 48.25mOD Depth 10.50 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	instru- ment	description	depth (m)	reduced level (m)	legend
	L	4.50 - 6.00	Nil				4.45m: Subangular brick cobble (80mm). MADE GROUND comprising grey slightly clayey slightly sandy subangular fine to coarse concrete, flint and brick GRAVEL with up to 10% fragments (up to 80mm) of plastic bags and glass.	4.50	43.75	
							Firm greyish brown gravelly CLAY. Gravel is subangular to rounded fine to coarse flint and brick. (MADE GROUND)	5.20	43.05	
							Firm grey mottled brown slightly sandy CLAY with rare subangular fine flint gravel. (MADE GROUND)	5.60	42.65	
	C	6.00 - 7.50	6.00		33		MADE GROUND comprising angular and subangular fine and medium flint, concrete and brick gravel with 10-20% fragments (up to 80mm) of wood. Limited recovery.	5.95	42.30	
	C	7.50 - 9.00	6.00		33		7.40m: Three wood fragments (up to 130x80x70mm). MADE GROUND comprising fragments (up to 100mm) of textile, plastic sheet, wood and paper with up to 10% subangular and subrounded fine to coarse brick and flint gravel and a low subrounded brick cobble content. Limited recovery.	7.50	40.75	
							Continued Next Page	9.00 {9.00}	39.25	
water strike (m) casing (m) rose to (m) time to rise (m) remarks							AGS	CONTRACT 32534		CHECKED EC

BOREHOLE LOG

CLIENT READING FOOTBALL CLUB

GW09

SITE MADEJSKI STADIUM, READING

Sheet 3 of 3

Start Date 20 December 2016 Easting 470547

Scale 1 : 25

End Date 21 December 2016 Northing 169743 Ground level 48.25mOD Depth 10.50 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range		instru- ment	description	depth (m)	reduced level (m)	legend
21/12/16 1630hrs 7.90m	L	9.00 - 10.50	6.00					MADE GROUND comprising fragments (up to 100mm) of textile, plastic sheet, wood and paper with up to 10% slightly silty subangular and subrounded fine to coarse brick and flint gravel with a low subrounded brick cobble content.	9.50	38.75	
								Stiff dark greenish grey mottled orangish brown slightly sandy CLAY. Rare rootlets.	9.70	38.55	
								No recovery.			
											
											
											
											
											
											
											
											
											
											
											
											
											
											
											
											
											
											
											
											
											
											
											
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