

APPENDIX 4
GROUND INVESTIGATION

Phase III Site Investigation Report

at Horsham Enterprise
Park, land off Parsonage
Road, Horsham,
West Sussex,
RH12 4AN

for West Sussex County
Council

Report Reference : LP2441

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EXECUTIVE SUMMARY

The site comprises a former pharmaceutical works currently undergoing demolition and clearance with a single 1930s Art Deco building retained in the centre, surrounded by areas of open ground. The site is approximately 7.5 Ha in size and has been the subject of a number of historic investigations, as well as remediation and validation activities carried out by the previous owners. It is proposed to be redeveloped for mixed residential and commercial use, including conversion of the retained building. This report summarises the historic on site activities and includes significant additional investigations.

Central areas are broadly flat and level, with a gentle downward slope from west to east (~57.5 m to 56.5 m AOD). North eastern and eastern boundaries slope downwards into the site from ~60 m AOD at the crest of the slope to ~58-57 m AOD at the toe of the slope. Slope angles are estimated to be between 20-22° on the north-eastern and eastern boundaries. The proposed development levels are not confirmed at the time of writing.

The site is bound by Parsonage Road to the north, Wimbleshurst Road to the west, and railway lines to the south (extending to the southwest) and to the east. The railway line on the eastern boundary is on an embankment raised by 2-3 m relative to the land to the west. The railway line to the south is broadly level with the site (although in a slight cutting in the far northeast of the site).

Historical features (now demolished) associated with the former pharmaceutical works included: fuel / solvent storage; boiler houses; above ground heating oil tanks; below ground fuel storage; below ground water storage; LPG storage; interceptors; tunnels; extensive below ground utility services including condensate and compressed air pipes; coal hopper; chillers; electrical sub-station; pharmaceutical research, development and manufacture; engineering works; water treatment; and offices.

The site is mapped as being underlain by the Upper Tunbridge Wells Sand Formation - Sandstone and Mudstone in the northwest, which is classed as a Secondary A Aquifer and Upper Tunbridge Wells Sand Formation - Mudstone for the remainder of the site, which is classed as an unproductive strata. The site is not located in a potable water supply source protection zone. No surface water features are present on site or within 250 m of the site boundaries, but a small pond located in a local park (~800 m to the southwest) is reported to be connected to the site via surface water drains. The site is not mapped as being within a radon affected area and no special protective measures are required in respect of radon gas.

A non-targeted ground investigation was undertaken across the site comprising 54 No. machine excavated trial pits to depths up to 3m, 6No. rotary cored boreholes to depths up to 20.5m and 17No. windowless sampler boreholes to depths of between 0.8m and 3m.

In areas of demolished buildings, ground conditions comprised made ground of around 1-2m up to a maximum depth of 4m, over firm to very stiff clays and silts to over extremely weak weathered interbedded mudstones, siltstones and sandstones, which were encountered from 0.8-4.05m bgl. Weak interbedded rock was encountered from 2.6m to 7.3m to the full excavation depth of 20.5m. Shallow groundwater was encountered during the intrusive investigation, (at surface in some areas of the site) as well as during subsequent monitoring of the installed monitoring wells. A deep groundwater aquifer was encountered within the rotary cored boreholes.

Future excavations below the shallow water within the made ground are likely to be highly unstable and require close lateral support and dewatering. It is considered that the soils on site are not suitable for soakaway drainage and allowance should be made for surface water to be drained off site.

In the western half of the site, it is advised that any shallow foundations are extended through any made ground and softer soils to the stiff clays at depth. An allowable bearing capacity of 100 kPa is recommended for the stiff clays below 1.2m. Foundations will require deepening in the clay soils near trees to NHBC Medium VCP precautions.

Based on the consistently large thicknesses of made ground >2.0m on the eastern half of the site, shallow foundations are considered unsuitable and piled foundations are recommended in this area. Shallow foundations may not be suitable in areas where tall residential structures are proposed over deep made ground. Some of the made ground in the east of the site may be suitable for use as engineered fill subject to screening and classification testing.

Given the thickness of the made ground on site, the medium VCP of the cohesive soils and the intention to pile across much of the site, suspended floor slabs are recommended.

Soil sulphates in the sandy silty clays fall within BRE design class DS-1 and the site conditions fall within the ACEC class AC-1.

A design CBR of 3% is recommended for natural soils in the western half of the site. CBR tests were not carried out in the east due to the variable depth and quality of the made ground soils. Allowance should be made for re-engineering selected soils beneath proposed roads in this part of the site.

A geo-environmental risk assessment has been carried out and laboratory test results have been screened against generic assessment criteria (GAC) for both residential with home grown produce land use and commercial land use. The assessment identified elevated concentrations of arsenic, lead, nickel and benzo(a)pyrene above residential GAC within the made ground fill material to the northwest of the retained building and in the eastern half of the site. Asbestos was identified to be present in one location in the entirety of the soil testing carried out by LEAP. Locations of contaminant exceedances of residential GAC are shown in

Figure 13. With the exception of the single asbestos result no potential contaminant of concern exceeded commercial use GAC. We note that the western half of the site is proposed for residential land use and the eastern half as commercial land use.

Six rounds of ground gas monitoring have been undertaken. The site is characterised as CS1 very low risk or green following NHBC, with the exception of one deep monitoring well in the northwest of the site (BH106), that recorded initial very high flow rates over several days (maximum reported flow of 104 l/hr) and carbon monoxide at 13.6%. The follow-on monitoring reported lower steady state flow rates (2.8 l/hr to 7.2 l/hr) and periodic concentrations of carbon dioxide above 5% (7.9% and 8.1%).). The response zone was screened across the bedrock of the Tunbridge Wells Sand Formation and no certain sources of the land gas were identified. Further monitoring and gas characterisation is recommended around this location.

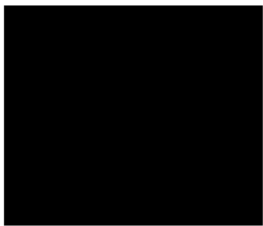
Groundwater sampling targeted the deep groundwater aquifer in six location. In one location (BH101D) xylene at concentrations above minimum reporting values (MRV) for groundwater. A single shallow groundwater sample was tested at this location to confirm if shallow groundwater was impacted with xylene. Xylene was present but at lower concentrations than in the deep groundwater body. Xylene was not considered to pose a significant risk to offsite groundwater receptors on the basis that the CSM did not identify plausible contaminant migration pathways from onsite groundwater to offsite groundwater receptors. Groundwater remediation is not proposed at this stage.

However, we note that surface water drains that extend through the site and discharge into the Horsham Pond 800 m to the southwest. Further investigation is recommended in terms of checking the integrity of the drains and the water quality within them, as this is a potential preferential pathway and remains a residual risk.

The asbestos, arsenic, lead, nickel and benzo(a)pyrene contamination identified poses a risk to human health, where present in critical areas such as gardens or areas of soft landscaping.

Recommendations are made for remedial works with respect to the contamination identified on site and where made ground extends into soft landscaped areas.

As with any redevelopment site, there is always the risk of hitherto undetected contamination, and further investigations should be carried out prior to complete redevelopment.

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Date:	7 May 2021
Revision:	FINAL

A INTRODUCTION

1 Authority

Leap Environmental Ltd (hereafter referred to as **LEAP**) has been appointed by West Sussex County Council (WSCC) to undertake a Phase III intrusive Site Investigation of a site referred to as Horsham Enterprise Park, land off Parsonage Road, Horsham, West Sussex, RH12 4AN. A site location plan is included as Figure 1 in Appendix B. The site was formerly occupied by Novartis Pharmaceuticals. The instruction was given in an email dated 22nd December 2020 by Katie Manning of WSCC under order reference PO4100185400.

2 Proposed Development

Outline planning permission has been granted for the site under planning application reference DC/18/2687 dated 6th August 2019. The outline application includes for the erection of up to 300 residential dwellings (C3) including the conversion of an existing office to 123 residential units and the provision of 618sqm of flexible commercial/community space (A1 A2 A3 D1 Creche) within the ground floor of the building. Land to the west of the retained building is proposed to include approximately 177 dwellings, which include flats 3 to 4 storeys in height and low rise residential houses. East of the retained structure up to 25,000sqm of new employment (B1) floorspace is proposed. We understand that this will be made up of 10 to 15 separate buildings up to 5 storeys tall. Class B1 land use includes research and development of products or processes, light industrial processes, and offices. The application also allows for improvements to existing pedestrian and vehicular accesses from Parsonage Road and Wimblehurst Road, a new cycle and pedestrian access, together with associated parking and landscaping. An illustrative masterplan (drawing ref: MP001 rev C dated 14/12/18) and an outline plan showing the split between commercial / residential areas are provided in Appendix B.

3 Objective

The proposed development is currently at the outline masterplan design phase and has been assessed in accordance with BS EN 1997¹, as being a Geotechnical Category 2 structure.

The objectives of this report are to:

¹ BS EN 1997-1(2004)+A1:2013 Eurocode 7:Geotechnical Design: General Rules

- Provide information on the geotechnical and environmental quality of the ground present on the site;
- Assess the potential health and other environmental risks posed by the site to the proposed development and to other specifically identified receptors; and
- Assess the potential for offsite contamination to adversely affect the proposed development.

4 Previous Studies

The site has been the subject of previous investigations by others. The following site investigation reports have been supplied by the Client or have been found under the existing planning application and the reader is referred to these earlier reports, which should be read in conjunction with this report.

- *Phase 1 Desk Study & Site Reconnaissance Report* by LEAP ref. LP2441 dated 5th March 2021
- *Asbestos Investigation Letter Report*, Parsonage Road, Horsham, RH12 4AN by LEAP ref. OA/20/LP2309 dated 18th September 2020
- *Phase I Geo-Environmental Site Assessment* by REC Ltd dated June 2018
- *Land Quality Interim Report* by KDC Contractors Ltd dated November 2016
- *Phase 2 Environmental Investigation* by KDC Contractors Ltd dated June 2016
- *Historical Land Quality Investigations Data Review and Preliminary Risk Assessment* by KDC Contractors Ltd March 2016
- *Asbestos Demolition Survey Reports* by Riverside Environmental Services Ltd dated January 2015
- *Further Land Quality Investigation* by Jacobs dated 17 October 2014
- *Phase 2 Land Quality Assessment* by SKM Enviros dated 12 July 2013

We understand that the Client does not have reliance on the site investigations undertaken by SKM Enviros / Jacobs and KDC Contractors Ltd.

5 Scope of Works

This report describes a two stage process whereby the site is investigated and risks are assessed. The terms geotechnical and geoenvironmental are referred to throughout the report.

Geoenvironmental refers principally to the chemical nature of the ground and the degree of soil, water and/or land gas contamination and the impact that contamination may have on current or future development and also on the wider environment.

Geotechnical refers to all other aspects of the ground conditions and the impact they may have on the physical construction of existing or future development, principally foundations, slope stability, drainage, pavement and road design and groundwater control.

5.1 Intrusive Investigation Scope

The Phase III work comprises intrusive investigation, onsite monitoring and laboratory analysis. The results of this and previous investigation and remediation reports are used to validate and/or update the initial site conceptual model. This phase of site investigation comprised the following tasks:

- 6 No. 20m deep rotary cored boreholes with gas and groundwater monitoring wells installed to depths between 2m to 20m in selected boreholes;
- 17 No. 3m deep windowless boreholes drilled with a tracked rig with shallow gas monitoring wells to depths between x m and x m in selected boreholes ;
- 54 No. machine excavated trial pits up to 3.0 m deep;
- 3 No. BRE365 soakage tests;
- 6 No. *in-situ* dynamic cone penetrometer CBR tests;
- *In-situ* geotechnical testing including Standard Penetrometer Tests and Hand Penetrometer tests in the boreholes and in the trial pits;
- Geotechnical Laboratory Testing including Atterberg Limit Tests, Particle Size Distribution, California Bearing Ratio, Rock Unconfined Strength, Point Load Tests, and Sulphate Tests; and
- Chemical Laboratory tests including 63 No. LEAP standard soil suite tests.

The intrusive works were completed by contractors who have been scrutinised and are on LEAP's approved contractor list. The windowless sampling was carried out by Oakland Site Investigation Limited and the rotary coring by Roots Geo Limited. The machine excavated trial pits were carried out by Spillane Plant Limited and supervised by LEAP.

Selected samples of soil and groundwater were scheduled for laboratory testing for a wide range of potential contaminants including metals, non-metals, asbestos, polycyclic aromatic and petroleum hydrocarbons and volatile organic compounds. The laboratory testing has been carried out by The Environmental Laboratory Ltd at its laboratories in East Sussex.

Selected soil samples have been classified by laboratory analysis for geotechnical design purposes. The laboratory testing has been carried out by Geolabs Ltd at its laboratories in Watford.

The final stage in the geoenvironmental assessment comprises a quantitative risk assessment and revision of the preliminary Conceptual Site Model. Preliminary recommendations for remediation have been provided, based on various development assumptions, which are detailed in the following section and in the text of this report. The risk assessment has been carried out in accordance with UK industry standards and in particular in accordance with CLR11² and BS10175:2011+A2:2017.

The final stage of the geotechnical assessment is the provision of preliminary soil parameters for use in geotechnical design, and broad recommendations for appropriate foundation options. It is intended that the Geotechnical Information section of this report will fulfil the general requirements of the Ground Investigation Report as set out in Section 6 of Eurocode7³.

6 Limitations

This report has been prepared by Leap Environmental Ltd on the basis of information received from a variety of sources which Leap Environmental Ltd believes to be accurate. Nevertheless, Leap Environmental Ltd cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.

Leap Environmental Ltd has used all reasonable skill, care and diligence in the design and execution of this report, taking into account the manpower and resources devoted to it in agreement with the Client. Although every reasonable effort has been made to obtain all relevant information, all potential contamination, environmental constraints or liabilities associated with the site may not necessarily have been revealed.

The conclusions reached in this report are necessarily restricted to those which can be determined from the information consulted and may be subject to amendment in the light of additional information becoming available. These conclusions may not be appropriate for alternative schemes.

² Environment Agency, 2004. Model Procedures for the management of land contamination. Contaminated Land Report 11.

³ BS EN 1997 Eurocode 7- Geotechnical Design- Part 2: Ground Investigation and Testing (2007)

This report is confidential to the Client, and Leap Environmental Ltd accepts no responsibility whatsoever to third parties to whom this report, or any part thereof, is made known, unless formally agreed by Leap Environmental Ltd beforehand. Any such party relies upon the report at their own risk.

Full details of the limitations are provided in Appendix A.

B SITE SETTING

7 Site Location and Description

A site location plan is provided as Figure 1, Appendix B and the layout of the site at the time of the investigation is provided as Figure 2, Appendix B. Historical structures relating to former pharmaceutical land use at the site is provided as Figure 3, Appendix B. A summary of the site location, historical and environmental setting, based on LEAP's Phase 1 Desk Study Report dated March 2021 is provided in Table 1, below:

Table 1: Summary of Site Description and Environmental Setting

Information ⁴	Details
Name and site address	Horsham Enterprise Park, land off Parsonage Road, Horsham, West Sussex, RH12 4AN
National Grid Reference	TQ 1789 3170
Site area	Approximately 7.5 hectares
Topography and elevation	Central areas are broadly flat and level, with a gentle downward slope from west to east (~57.5 m to 56.5 m AOD). North eastern and eastern boundaries slope downwards into the site from ~60 m AOD at the crest of the slope to ~58-57 m AOD at the toe of the slope. Slope angles are estimated to be between 20-22° on the north-eastern and eastern boundaries. Regionally, the topography of the surrounding area slopes downwards to the southwest.
Site description and current use	The site is currently unoccupied and cleared of most of the former pharmaceutical buildings, with the exception of the retained central structure (historically numbered as Building 3/36). At the time of writing a soft strip including asbestos removal is being undertaken by others on the central building and the installation of secure fencing around the site perimeter. The site is bound by Parsonage Road to the north, Wimblehurst Road to the west, and railway lines to the south (extending to the southwest) and to the east. The railway line on the eastern boundary is on an embankment raised by 2-3 m relative to the land to the west. The railway line to the south is broadly level with the site (although in a slight cutting in the far northeast of the site). The raised ground present along the north-eastern and eastern boundaries appears in part to be related to earthworks during the construction of the

⁴ Source: LP2441 Phase I Desk Study and Site Reconnaissance by LEAP dated March 2021. The report includes publicly available data in the form of an Envirocheck Report.

Information ⁴	Details
	pharmaceutical works, where land was presumed to have been 'cut' into to create a level construction platform for buildings. A concrete crib wall is present along the eastern boundary embankment ~95 m south of Parsonage Road. It is ~15 m long and ~2 m high and formed of interlocking precast concrete.
Surrounding area	The site is located to the north of Horsham town centre in a predominantly residential setting, with residential housing to the north, southwest and west of the site. A commercial/light industrial development is located beyond the railway line to the east. To the south beyond the railway line are college playing fields and a mix of residential and light industrial land uses. Approximately 230 m to the northeast of the site is Parsonage Farm Industrial Estate.
Site history	In summary, from the earliest provided mapping (1875) the site is shown as open land with an 'old clay pit' in the far south-eastern corner. Three historical drainage ditches are mapped for the site, two in the eastern half of the site and one in the western half. Railway lines are shown to be present forming the southern and eastern boundaries. Mapping from the late 1930's show Building 3 present and labelled as 'laboratories'. Further expansion of the site with new structures, is shown on historical maps dating from the 1960's, 1980's and 1990's. Minor additions to the site layout are noted from the 2000's. Land immediately surrounding the site broadly follows a similar trajectory in that it was largely open fields, but with minor areas of residential development to the southwest and industrial usage (Horsham Iron Works) to the southeast from the late 19th century. From the 1930's and 1960's further residential expansion of Horsham town is noted to the west, south and east. By the 1980's extensive industrial / commercial land use is mapped on land to the east and southeast of the site, but with residential use shown beyond that. Playing fields are mapped to the north of the site in the 1980's and but are mapped as residential land use from the 2010's. Features associated with the pharmaceutical works included: fuel / solvent storage; boiler houses; above ground heating oil tanks; below ground fuel storage; below ground fire water storage; LPG storage; interceptors; tunnels; extensive below ground utility services including condensate and compressed air; coal hopper; chillers; electrical sub-station; pharmaceutical research, development and manufacture; engineering works; water treatment; and offices.
Regional geology	The site is mapped as being underlain by the sandstone and mudstone of the Upper Tunbridge Wells Sand on the north western part of the site and mudstone of the Upper Tunbridge Wells Sand across the remainder of the site. Superficial deposits are not mapped for the site.
Regional hydrogeology	The Upper Tunbridge Wells Sand - Sandstone and Mudstone which is mapped in the northwest of the site, is classified as a Secondary A Aquifer. These represent permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases form an important source of base flow to

Information ⁴	Details
	rivers. The Upper Tunbridge Wells Sand - Mudstone across the remainder of the site is mapped as an unproductive strata. The site is not located within a groundwater source protection zone (SPZ). It is noted that there are two historical groundwater abstraction licences for the site which are mapped to a single point southwest of Building 3.
Surface water	There are no recorded surface water features on site or immediately bounding the site (within 250 m). An unnamed surface water feature is mapped 326 m to the northeast of the site. It is understood that two surface water drains are present in the eastern half of the site and connect to the Horsham Brook ~800 m to the southwest of the site. One of the drains extends from the northeast corner along the northern boundary towards Building 3/36, where it turns to the south and extends southwards towards the southern boundary. It then turns to the southeast following the southern boundary past Building 11, before exiting the site beneath the railway line. A second surface water drain is present in the southern half of the site aligned east to west from the Foundry Lane industrial estate apparently connecting to the same outfall along the southern boundary. It has been reported to LEAP anecdotally that the site drainage did not connect into these features. A historical decommissioned drain is mapped from the north east crossing the centre of the eastern half of the site and connecting to the outfall along the southern boundary. We understand that this was decommissioned with the construction of Building 42. The approximate routes of the drains are shown on Figure 3, Appendix B. It is not known if historical drains / ditches (that were mapped pre-development of the site) are still active.
Flood risk	According to the Envirocheck data, the site is not located within a flood zone at risk from Rivers or Sea. The north-western part of the site, where the Upper Tunbridge Wells Sand - Sandstone and Mudstone is present is mapped in the Envirocheck Report as an area with 'limited potential for groundwater flooding to occur'. The remainder of the site is not mapped as being at risk of groundwater flooding. Parts of the site are mapped⁵ as being at risk from surface water flooding. The main areas at risk of surface water flooding are mapped in the eastern half of the site and land to the west of Building 3.

8 Previous Investigations

The site has been the subject to numerous reports undertaken by others and a Phase I Desk Study by LEAP, as listed above. A summary of the reports by other consultants is provided in

⁵ <https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>

the Phase I Desk Study report and pertinent information has been included within the preliminary conceptual site model. Known historical site investigation locations and remediation areas reported by KDC are shown on Figure 4⁶.

We also note the following:

- KDC Contractors Ltd undertook post demolition site investigations and localised remediation works on areas of gross contamination or where a volatile vapour risk was identified. Following the issue of the LEAP, Phase 1 Desk Study, WSCC have provided further information relating to the extent of the investigation and remediation works undertaken by KDC, which have been included on Figure 4 and listed below.
- Areas reported to be remediated included:
 - Former Building 11 and oil sump;
 - Below ground diesel tank in southeast of the site (in proximity to former Building 27);
 - An area on southeast corner of former Building 42;
 - Remediation excavation around KDC trial holes: TP3, TP16, TP28/TP46, TP33/TPCP4, TP37;
 - Remediation dewatering around KDC trial holes: TP30, TP40, TP46;
 - Petrol tank removal (in former petrol station area southwest of Building 3); and
 - Further remediation in area around US07, US46, US33, TP52.
- The LEAP Desk-Study highlighted:
 - a potential below ground interceptor south of Building 3/36; below ground decommissioned fuel tanks associated with a former onsite fuel filling station (located to southwest of Building 3/36), which may have been decommissioned as part of KDC's work; and below ground service ducts / access tunnels.
 - Potential residual risks from site soils to residential land users from heavy metals (arsenic, lead, beryllium, copper), benzo(a)pyrene and to all land users from asbestos in soils.
- The LEAP Desk Study highlighted that although the KDC risk assessments discounted a controlled waters risk (to offsite surface water receptors and onsite groundwater

⁶ The locations are indicative

resources) the assessment of risk to the bedrock aquifer was incomplete, as the groundwater monitoring wells predominantly targeted the perched aquifer in the made ground.

- The Desk Study highlighted a residual risk from point (direct) source contamination to the Horsham Pond, if site drains extending through the site were damaged or received water shallow groundwater from the site.

In addition to the above, it has been anecdotally reported to LEAP that the water used for the fire suppression system on site did not contain chemical additives i.e. PFOS/ PFOA.

Following the production of the Desk Study Report WSCC have made available to LEAP the findings of a CCTV survey that was completed in 2018. The CCTV included parts of the surface water drainage network in the eastern half of the site. The survey noted a damaged section and infiltration seepages along parts of the surface water drains that extend to immediate east of Building 3/36.

WSCC has reported to LEAP that a number of security breaches occurred at the site between 2018 and 2019 including theft of materials (copper wire etc) from the retained building in May-October 2019 and entries in March and April 2020. Following these occurrences, the council commissioned target hardening works involving the installation of steel protective shutters to basement and ground floor windows. Further breaches occurred in September and November 2020, which resulted in damage to ceilings and ducting in the basement of building 3 and release of asbestos containing material within the structure. Whilst the accidental transport of disturbed ACMs outside the building by these criminal activities cannot be ruled out, it is noted that no visual signs of asbestos contamination/ACMs were noted at surface during the ground investigation by LEAP.

C PRELIMINARY CONCEPTUAL SITE MODEL

9 Environmental Risk Assessment

A summary of the preliminary CSM reported in the LEAP Phase 1 Desk Study is provided below.

9.1 Qualitative Risk Assessment of Contaminant Linkages

Phase I desk study listed the following potential onsite sources of contamination.

Table 2: Onsite sources of contamination

	Source	Contaminants of Concern
1	Residual contamination in near surface made ground soil	Heavy metals and PAHs, residual PHC's. KDC in 2016 identified benzo(a)pyrene and PHC at concentrations that posed a risk to residential land users in discrete locations. LEAP in 2020 identified arsenic and lead at concentrations above GACs for residential land users in discrete locations
2	Asbestos fibres within soils	KDC identified loose asbestos fibres in made ground soils
3	Backfilled areas (former clay pit) / deep made ground	Ground gases (carbon dioxide, methane)
4	On site sources impacting deep groundwater	Metals, PAHs, PHC
5	Unidentified contamination	Potential asbestos, metals, PAHs, petroleum hydrocarbons, BTEX, VOCs and SVOCs

Previous reports did not find evidence of offsite migration of potential contaminants migrating to site (railway line / fuel storage depot). However, there is the potential for ground gas from offsite sources to migrate to site, and as such it is considered as a potential risk to the site.

The identified receptors included:

- Future residential and commercial users;
- Construction workers;
- Groundwater – Secondary A Aquifer;

- Horsham Pond via surface water drainage; and
- Material construction of buildings and infrastructure.

The outline planning consent for the site development allows for residential properties, communal open space and commercial development. Whilst the details for the proposed development have not been finalised, it is likely that some of the residential development will include low rise housing with private gardens. Preliminary plans suggest the residential development will be on the western part of the site, although this is not finalised. As a conservative assessment, this risk assessment therefore considered all potential contaminant linkages involving residential land users and soil contaminants i.e. direct ingestion of soil, ingestion of soil attached to plants as well as via plant uptake, inhalation of indoor and outdoor vapour and of dust tracked back into the house and finally ingestion of water carried by plastic water pipes through contaminated ground. In public open spaces, communal gardens and soft landscaping associated with commercial activities the pathways will be different, which generally results in lower levels of exposure and therefore risk.

Ground workers are at risk as a result from all of the above, except for those involving edible plants.

The site is underlain by the Tunbridge Wells Sand Formation mapped as a Secondary A Aquifer in the northwestern part of the site, and as unproductive aquifer⁷ elsewhere including along the full length of the southern boundary. The site is not located within a potable water source protection zone. There are no surface water features that immediately bound the site or are located within 250 m of the site boundary.

There is a potential pathway for leachate from residual soil contaminants and for mobile liquid contaminants to enter the deep aquifer onsite, if perched and deep aquifers are connected. But there is unlikely to be an active pathway between onsite groundwater (shallow or deep) to offsite groundwater on the basis of the low permeability of the unproductive strata.

This applies to offsite surface water receptors i.e. there is unlikely to be an active pathway between the groundwater onsite to offsite surface water features, with the exception of a potential direct preferential pathway via the drains that are present on site. Surface water drains that run through the site connect to the Horsham Pond.

A CCTV undertaken in 2018 suggested that sections of the drains were damaged and may receive water from the site. This could allow a preferential pathway to the pond from shallow

⁷ areas comprised of rocks that have negligible significance for water supply or baseflow to rivers, lakes and wetlands. They consist of bedrock or superficial deposits with a low permeability that naturally offer protection to any aquifers that may be present beneath.

groundwater via the surface water drainage network. Three historical drains / ditches were also mapped for the site, it is not known if these are still active or whether there is connectivity from offsite contaminant sources to offsite receptors.

10 Geotechnical Risk Assessment

10.1 Geotechnical Risk Register

The following geotechnical hazards have been identified as substantial risks;

- Presence of deep made ground.
- High groundwater table.
- Deep obstructions.
- Possible voids in former service ducts / tunnels.
- Deep excavations.
- Local stability issues on northern and eastern site boundaries.

The report also noted that the two active and one decommissioned surface water drains that extend through the east of the site could be a constraint if the locations are not accurately mapped.

D PHASE II - INTRUSIVE INVESTIGATION

11 Investigation Rationale

A total of 77 trial holes were excavated across the site. These included 54 No. machine excavated trial pits to depths up to 3m, 6No. rotary cored boreholes to depths of between 20.0m and 20.5m and 17No. windowless sampler boreholes to depths of between 0.8m and 3m.

The trial hole spacing was consistent with the recommended density of 25 to 50m for an exploratory investigation as according to BS10175 Section 7.7. A broadly non-targeted approach was adopted to allow for the use of a statistical assessment if required. However, due to the density of sampling, many areas identified as potential contaminated land sources in earlier reports were covered by this phase.

Gas monitoring wells have been installed in selected window sampling locations and have been located generally in accordance with the spacing requirements given in CIRIA C665⁸.

The investigation rationale for the trial holes is summarised below:

Table 3 Rationale for Investigation Locations

Trial Hole/Test Location	Rationale	Proposed Depth (mbGL)	Notes
BH101-BH106	Provide Information on ground conditions and geotechnical parameters for pile design and location of groundwater and gas monitoring wells.	20	Deep groundwater monitoring wells installed within each borehole to depths between 14m to 20.2m. Gas wells to a depth of 2m were also installed within BH101 and BH103.
WS1-WS118	Provide information on the ground conditions, location of gas monitoring well and provide samples for contamination and geotechnical testing.	4	Positions terminated early at depths ranging from 0.8m to 3.0m due to refusals in bedrock or below ground obstructions. Gas monitoring wells were installed within WS102, WS103, WS105, WS106, WS108, WS109, WS111, WS113, WS115, WS116 and WS118. WS114 was aborted due to a surficial obstruction.

⁸ CIRIA C665 Assessing risks posed by hazardous ground gases to buildings

TP101-TP152	Provide information on the ground conditions, location of full scale soakage tests and provide samples for contamination and geotechnical testing.	3	Soakage tests were performed within TP147, TP126A and TP138. Locations that terminated early due to confirmed and potential below ground services were: TP101, TP104, TP129, TP137 Locations that terminated early due to refusal on bedrock were: TP103, TP105, TP107, TP108, TP111, TP112, TP120, TP121, TP123, TP127, TP133, TP135, TP136, TP139, TP143, TP145, TP146, TP148, TP150, TP151, Locations terminated early due to obstructions were: TP116, TP122, TP125, TP132,
B1-B4	Shallow pits to provide information on ground composition of the raised ground/bund on the north-eastern perimeter.	0.5-1m	B3 terminated at 1m due to encountered electrical cable caution tape.

A number of proposed trial holes were not excavated due to site restrictions as listed below:

- Access to TP109 prevented due to protective fencing assembled around large mature trees.
- TP114 southwest of Building 3 was not excavated due to the presence of below ground utility services at the location.
- TP119 north of Building was not excavated as access was restricted by heras fencing with a warning sign of live electricity services at the location.
- Only surface sampling was undertaken at TP141 due to proximity to site hoarding and presence of potential below ground services.

After completion of BH101 on 26th of January, the well installation became damaged on rebar and obstructions within deep made ground at this location as the casing was withdrawn. After repeated attempts to re-install the standpipe the borehole was aborted due to the obstructions and borehole collapse to 6 m bgl. BH101 was backfilled from 6 m bgl with bentonite to ground level. A second well BH101A was drilled adjacent to the aborted position to allow for the monitoring well installations.

Only a limited number of hand-held DCP tests were undertaken due to the extensive areas of disturbed ground and potential below ground utility services.

The site investigation locations are shown on Figure 5, Appendix B and a photographic record of the exploratory hole locations is provided as Appendix C.

12 Site Work

12.1 Date and Weather Conditions

The intrusive investigations were undertaken between 11th January and 1st February 2021. At the time of the investigation, the weather was overcast with periods of heavy rain and sub-zero temperatures.

Based on long term averages⁹ the weather preceding the investigation in November 2020 reported temperatures slightly above the average, but with below average rainfall for the month. In December 2020 temperatures were reported at slightly above the long term average and with above average rainfall. In January 2021 temperatures for the UK were ~1.5°C below the historical average, but with above average rainfall.

12.2 Site Work Methods

12.2.1 Borehole Drilling

Boreholes were drilled using a rotary coring rig (Fraste MultidrillPL). The rotary boreholes were drilled using 146mm diameter casing. All locations were hand dug to 1.2 m below ground level (bgl) with following drilling using percussive methods to bedrock. The bedrock was drilled using a Geobore-S type system. Drilling flush was added as the boreholes progressed. Drill cores were recovered for logging and monitoring wells were installed in each location. Borehole logs are available in Appendix D.

12.2.2 Windowless Sampler

The Windowless sampling rig consists of a tracked barrow with a sampling unit mounted on the top. When in the required position, the mast was raised to a height allowing a mechanised drop weight to fall repeatedly onto an anvil, and drive attached sample tubes or probe rods into the ground to produce reasonably intact continuous samples, which were then extracted using the integrated hydraulic ram.

To reduce any tendency of the tubes to stick in the ground, a succession of smaller diameters may be used to obtain full depth. Excavated soils were placed aside for inspection and sampling. Hand dug starter pits to 1.2 m bgl were excavated in all locations.

⁹<https://www.metoffice.gov.uk/research/climate/maps-and-data/summaries/index>

On completion the trial hole was backfilled with excavated material, placed in reverse order, and the surface reinstated unless a monitoring well was installed. The windowless sampler logs are available in Appendix D.

12.2.3 Trial Pitting

Trial pits were dug by a backhoe excavator. The trial pits had a target depth of 3mbgl and were typically 2m wide by 0.5m long. Spoil was replaced in reverse order to prevent cross-contamination. Trial pits were left mounded to allow for future settlement. The trial pit logs are available in Appendix D.

12.2.4 Soil Logging and Sampling

Soil samples were recovered from the boreholes and trial pits for field screening, logging and sampling.

Boreholes were logged in general accordance with the requirements of BS 5930:¹⁰ and BS EN ISO 14688¹¹.

Visual and olfactory evidence of contamination was noted if encountered. These observations were used to aid scheduling of samples for chemical laboratory analyses, and are included on the exploratory hole logs in Appendix D and summarised in Section 13.4.

Samples were collected with a clean sampling trowel or by hand (using dedicated nitrile gloves for each sampling location). Samples were placed into laboratory supplied sampling containers, specific to the type of analyses required.

All sample containers were sealed and labelled with a unique location identity, depth and date of sampling.

12.2.5 Monitoring Well Installation

19 No. monitoring wells were installed during this investigation. 8 No. were installed within the rotary coring boreholes (two locations had nested shallow and deep monitoring wells) and 11 No. were installed within the windowless sample boreholes. The monitoring wells were constructed of 50mm diameter HDPE pipe. Installations within the rotary boreholes included a deep response zone to intercept groundwater within the bedrock and was surrounded by washed filter gravel. The window sampler locations and two rotary boreholes had shallow installations to target potential land gas sources and the response zones were also surrounded by washed filter gravel. The plain zone was surrounded with bentonite pellets (saturated with

¹⁰ BS5930:2015+A1:2020 Code of Practice for Ground Investigation

¹¹ BS EN ISO 14688 Parts 1-2 (2018) Geotechnical Investigation and Testing. Identification and classification of soil

water) to provide a seal. The monitoring wells were finished with bungs with gas taps and flush mounted or raised steel covers. Monitoring well installations are shown on the borehole logs and summarised in the following table.

Table 4: Borehole installation details

Borehole	Type G-gas W-water	Plain Well Screen (mbgl)	Slotted Well Screen (mbgl)	Bentonite Seal (mbgl)
BH101D	W	GL-8	8-14	0.3-1
BH101S	G	GL-1	1-2	2-4.5 7-9 14-20.1
BH102	W	GL-17.5	17.5-20.2	0.3-2 15-17 20.2-20.5
BH103D	W	GL-17	17-20	0.3-1
BH103S	G	GL-1	1-2	2-4 7-17 20-20.3
BH104	W	GL-10	10-15	0.3-2 8-10 15-20
BH105	W	GL-10	10-16	0.3-2 7.5-9.5 16-20.2
BH106	W	GL-11.3	11.3-20	0.3-2 8.8-10.8 20-20.3
WS102	G	GL-1	1-2	0.2-1
WS103	G	GL-1	1-2	0.2-1
WS105	G	GL-0.9	0.9-1.9	0.2-0.9
WS106	G	GL-1	1-2	0.2-1
WS108	G	GL-1	1-3	0.2-1
WS109	G	GL-1	1-3	0.2-1