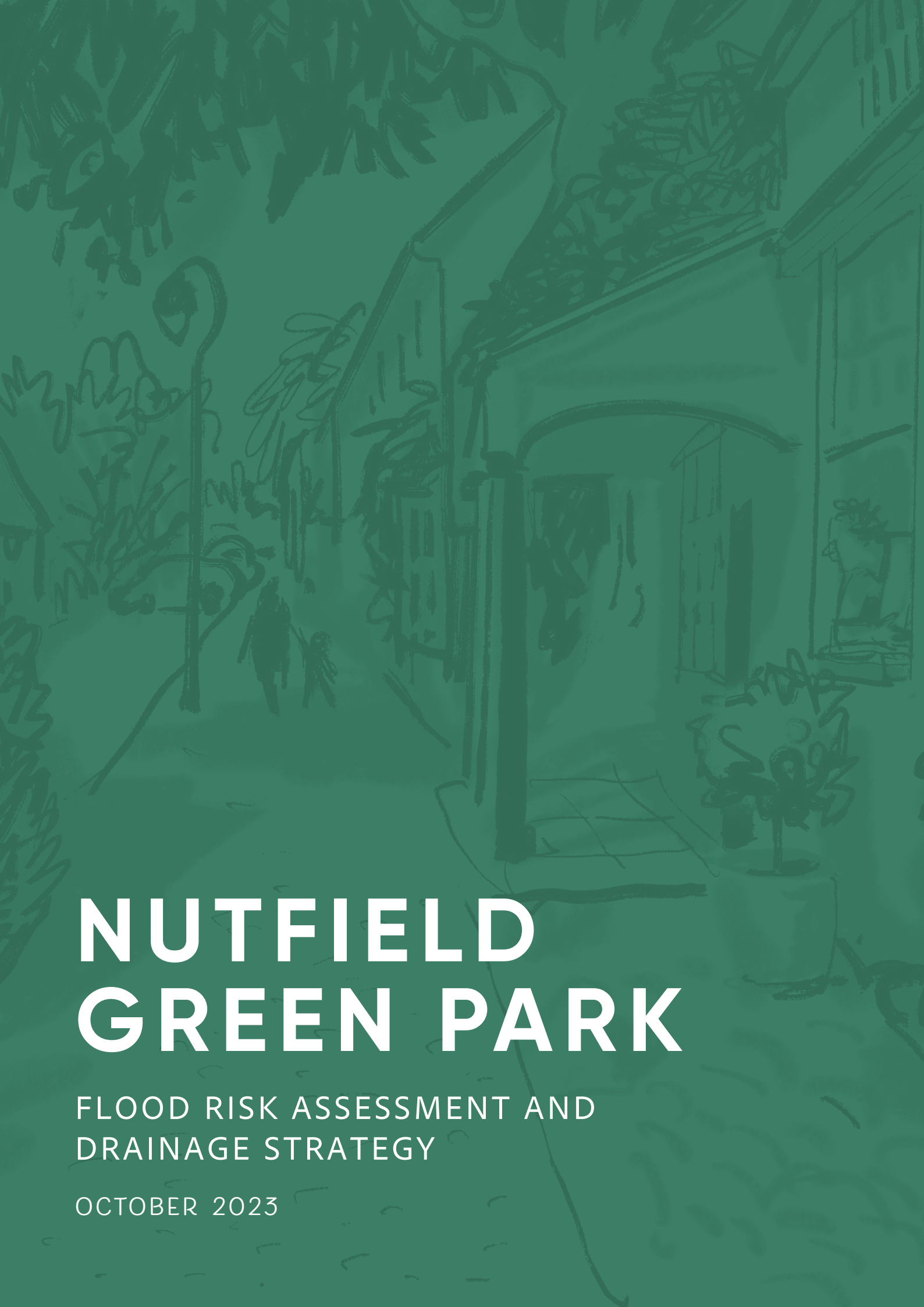

NUTFIELD GREEN PARK

FLOOD RISK ASSESSMENT AND DRAINAGE STRATEGY

OCTOBER 2023

Nutfield Green Park

Flood Risk Assessment and Drainage Strategy

October 2023

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Quality Assurance – Approval Status

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

Issue	Date	Prepared by	Checked by	Approved by
First	24/08/2023	Sean Whelan		
Comments		Draft issue for legal review		
Second	12/10/2023	Sean Whelan	Stephen Henry	Stephen Henry
Comments		Issued to support planning application, incorporating comments from LLFA and legal team		
Second	12/10/2023	Sean Whelan	Stephen Henry	Derek Armitage
Comments		Issued to support planning application, incorporating comments from LLFA and legal team		

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We disclaim any responsibility to the client and others in respect of any matters outside the scope of the above.

This report is confidential to the client and we accept no responsibility of whatsoever nature to third parties to whom this report, or any part thereof, is made known. Any such party relies on the report at its own risk.

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Executive Summary

Waterman has been commissioned by Nutfield Park Developments Limited (Ltd) to undertake a Flood Risk Assessment (FRA) and drainage strategy to support the Outline Planning Application for the Proposed Development of Nutfield Green Park.

The entire Site is designated as Flood Zone 1. This is land defined as having less than 0.1% (1 in 1,000) Annual Exceedance Probability (AEP) of flooding from rivers or sea in any year, classified as a low probability of fluvial flooding.

The EA's Risk of Flooding from Surface Water mapping indicates that the majority of the Site is at a 'very low' risk of surface water flooding (less than 0.1% AEP).

There are small pockets of ponding at 'high' risk (greater than 3.33% AEP) of flooding from surface water. However, these are due depressions in ground level, most of which are existing water features, and are all outside of the development areas. Therefore, the risk to the Proposed Development is low and surface water flood risk will not be affected by the Proposed Development.

Additionally, there is an offsite surface water flow route that runs through the south-eastern corner of the Site. This passes to the east of the Proposed Development, outside of any development areas and therefore will not be affected by the Proposed Development.

The Proposed Development area will be actively drained by the proposed drainage network, which will ensure the development is safe from surface water flooding over its lifetime. Any existing flow routes through the Site will be maintained. Therefore, the proposed drainage strategy will be sufficient to manage the risk of flooding from surface water.

The risk of flooding from groundwater, sewers and artificial sources have all been assessed and are not considered to require further mitigation.

The proposed drainage strategy has been developed to mitigate potential impacts on the local ecology. In line with the drainage hierarchy, surface water runoff will discharge to the Redhill Brook to the north of the Site, following the existing hydrological regime. Flow will discharge from the Site via an existing connection under Chilmead Lane to an offsite drainage ditch that runs north into the Redhill Brook.

Existing discharge rates from the Site are much lower (up to 96%) than greenfield runoff rates due to the existing onsite drainage features. Therefore, it is proposed to limit flow from the Site to existing rates rather than the much higher greenfield rates. The drainage strategy consists of three subcatchments: western, central (the Drive), and eastern.

Flows from each of the development parcels (western and eastern subcatchments) will be conveyed through to a network of detention lined basins and ponds to the recreation ponds at the north of the Site before connecting into the Redhill Brook via the existing outflow connection.

Surface water runoff from the road connecting the two development parcels (the Drive) will drain to a roadside filter drain before discharging overland to the historical settlement pond to the north, in line with the existing hydrological regime.

Source control, through the use of SuDS, is proposed throughout the Site to provide multiple benefits beyond flood risk management, such as water quality management, amenity, and biodiversity and ecology. Sitewide integration of these features will minimise any impact on the local environment.

A peak foul flow rate of 2.9 l/s has been calculated for the Proposed Development. Foul flows will

discharge to Thames Water's foul sewer, subject to confirmation of capacity within their network post-planning.

It is considered that the information provided within this report satisfies the flood risk requirements of the National Planning Policy Framework and local policy.

A previously planning application (TA/2021/1040) was refused citing flood risk as Reason for Refusal 16:

> *The applicant has failed to demonstrate that the proposed development would not increase flood risk elsewhere, that appropriate SuDS are being proposed nor that ground waters are sufficiently protected. As such the proposal is contrary to Policy DP21 of the of the Tandridge District Local Plan: Part 2 - Detailed Policies (2014) and the provisions of the National Planning Policy Framework 2021*

The proposed drainage strategy clearly lays out the existing and proposed flow rates from the Site, demonstrating that flow rates from the Site will not be increased and adequately ensuring that there will be no increase in flood risk elsewhere.

Infiltration is not proposed for the Site to ensure no potential for contamination of groundwater. Furthermore, lined SuDS features are proposed throughout the Site to ensure that surface water runoff is treated. Multiple SuDS features in series are proposed, in line with the SuDS Management Train approach as detailed within the CIRIA SuDS Manual.

It is considered that the proposed approach for flood risk management and drainage is a step forward for the Site and resolves the previous reason for refusal.

1. Introduction

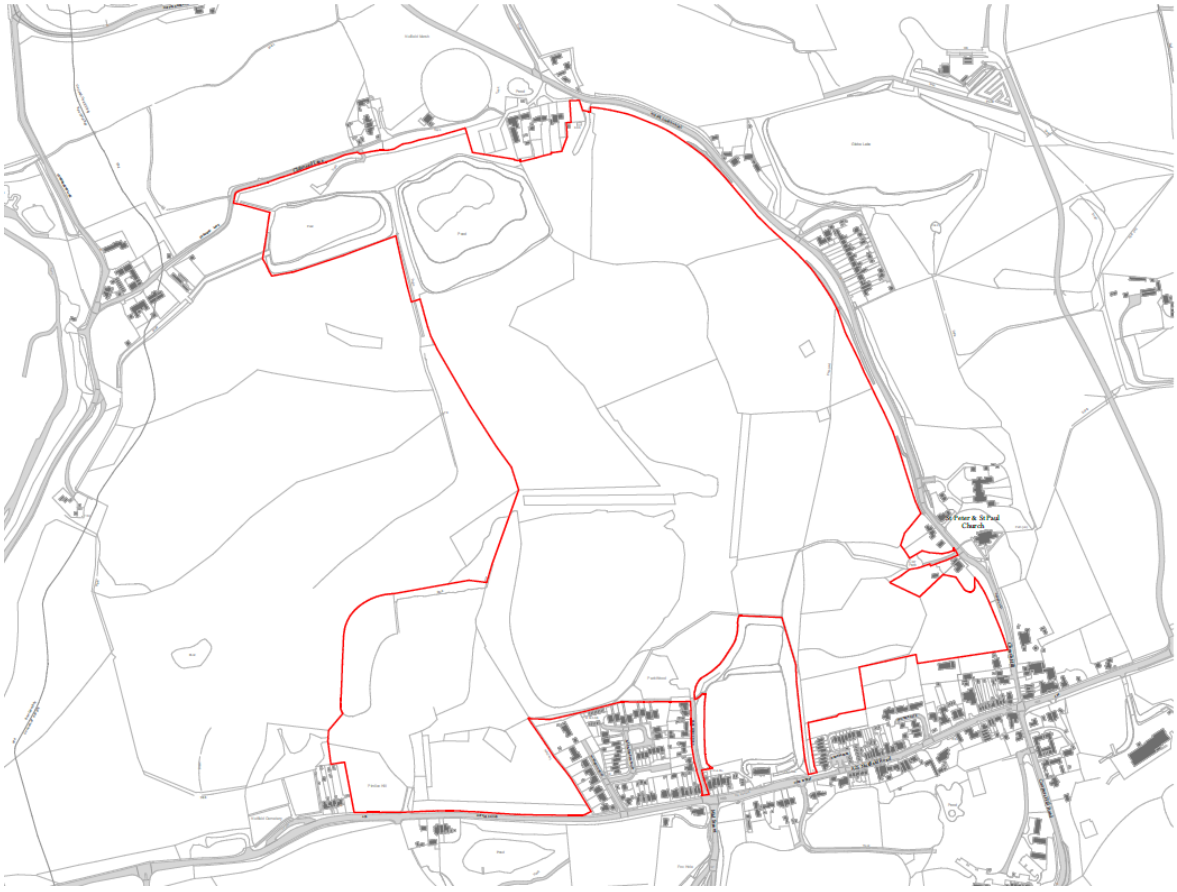
1.1. Waterman has been commissioned by Nutfield Park Developments Limited (Ltd) to undertake a Flood Risk Assessment (FRA) and drainage strategy to support the Outline Planning Application for the Proposed Development of Nutfield Green Park (hereafter referred to as the 'Site') at the Former Laporte Works Site, Nutfield Road, Nutfield, Surrey.

Site Description

1.2. The Site, as shown on Figure 1, covers an area of approximately 58.8 hectares (ha) in size. The existing Site is a mixture of grassland, blocks of self-seeding woodland and waterbodies with an area of the former infrastructure remains, such as access roads and pipework and former settlement lagoons. The site comprises the former Laporte Works Site which was an operational mineral extraction and processing facility until 1986 before it was decommissioned in 1997.

1.3. The Site is located to the north of Nutfield Road (A25) and is bounded by Nutfield Marsh Road to the east, Chilmead Lane to the north, and a former landfill site to the west.

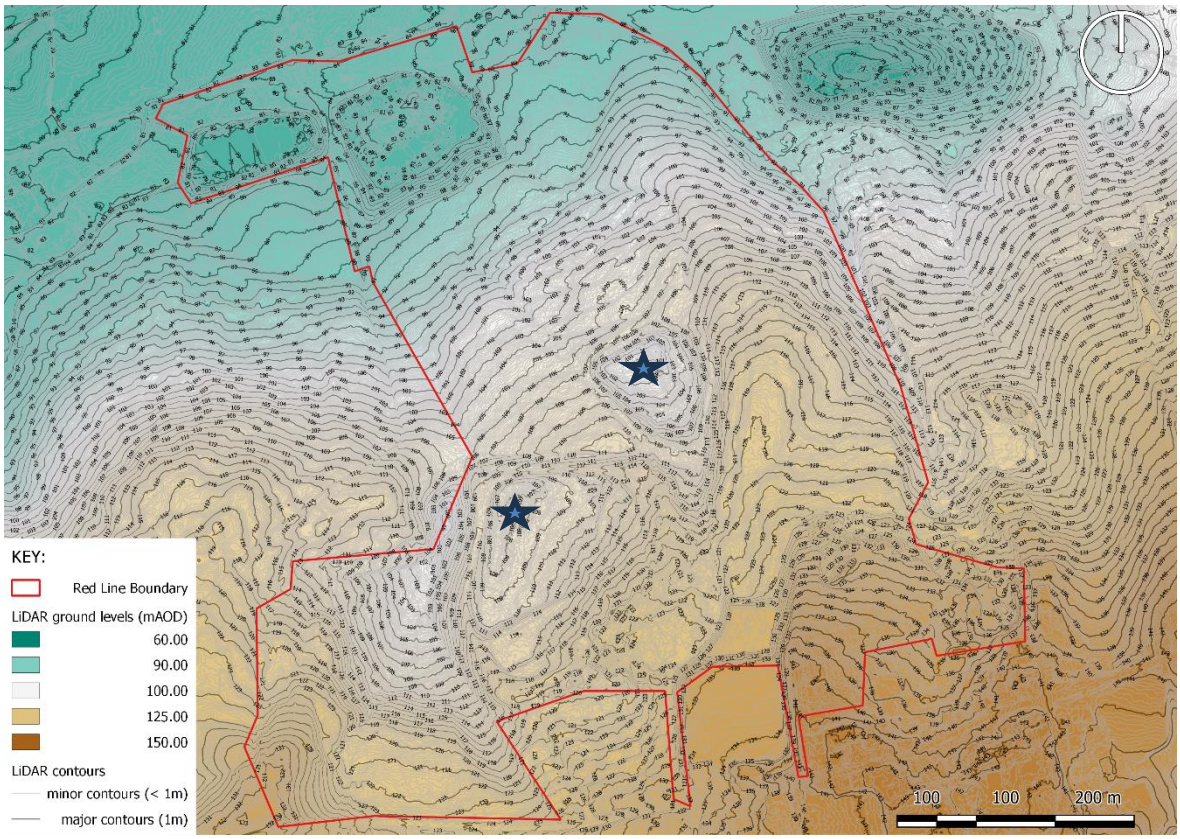
Figure 1: Site Location



1.4. LiDAR ground levels vary significantly across the Site, see Figure 2. Levels fall steeply from south (c.130 mAOD in the south-west corner and c.140 mAOD in the south-east corner) to north towards two recreation ponds (approximate crest levels of 81 mAOD and 84 mAOD for the east and west ponds, respectively) located by the northern boundary of the Site. There are two existing

depressions (c.3-5m deep) in the centre of the Site, which collect and retain surface water runoff, shown as stars on Figure 2.

Figure 2: LiDAR ground levels



1.5. Based on the British Geological Surveys (BGS) online Geology of Britain mapping, the geology of the Site consists of a combination of Folkestone Formation (Sandstone. Sedimentary bedrock formed between 126.3 and 100.5 million years ago during the Cretaceous period) and Sandgate Formation (Sandstone and mudstone. Sedimentary bedrock formed between 126.3 and 113 million years ago during the Cretaceous period). There is no information available in terms of the superficial deposits.

1.6. Intrusive Site Investigations (SI) were carried out in the wider Nutfield Park site during 2011 and 2012 with summary reports of these site investigations being prepared in 2013. Further SI were carried out between 27 February and 8 March 2023 and included the drilling of and collection of soil samples from 13 boreholes and the excavation of and collection of soil samples from 13 trial pits.

1.7. Based on these SI, ground conditions at the Proposed Development site comprise generally a thin layer of topsoil underlain by varying made ground and then natural strata of sand, silt and clay with sandstone and mudstone interpreted as the weathered Sandgate Formation. The made ground consists of sandy clay with varying amounts of silt, sand, gravel and cobbles of sandstone together with a bright yellowish orange silt and minor constituents of mudstone, brick, chalk, coal and flint. In the western area of the site the made ground includes occasional black clay with hydrocarbon odours. Made ground is generally absent in the east and central north of the western area of the site. In the central and eastern area of the site the orange silt is more prominent and the made

ground includes occasional clinker. The site investigation report (HGH/NU/JRC/20064/01D) can be found within Appendix A.

Site Visit

1.8. A site walkover was carried out on 21 March 2023 to familiarise the team with the Site, provide an initial understanding of the topography, ground conditions, and existing drainage, and to identify any potentially critical items for consideration. A catalogue of photos taken on site and an associated map with their locations is provided in Appendix B.

Proposed Development

1.9. The proposals (Appendix C) comprise the development of the site for new homes (Use Class C3) and Integrated Retirement Community (Use Classes C2, E(e), F2), creation of new access, landscaping and associated works to facilitate the development, in phases which are severable (Outline with Access, all other matters reserved).

Figure 3: Illustrative Masterplan

Scope of Report

1.10. This report assesses the potential effects of tidal, fluvial, pluvial (surface water), groundwater and artificial sources of flooding upon the Proposed Development, in line with national and local planning policy. The management of surface water runoff is also assessed, to ensure that flood risk is not increased to the Site or the surrounding area.

1.11. It is considered that the information provided within this report satisfies the flood risk requirements of the National Planning Policy Framework and local policy.

1.12. A previously planning application (TA/2021/1040) was refused citing flood risk as Reason for Refusal 16:

> *The applicant has failed to demonstrate that the proposed development would not increase flood risk elsewhere, that appropriate SuDS are being proposed nor that ground waters are sufficiently protected. As such the proposal is contrary to Policy DP21 of the of the Tandridge District Local Plan: Part 2 - Detailed Policies (2014) and the provisions of the National Planning Policy Framework 2021*

1.13. The proposed drainage strategy lays out the existing and proposed flow rates from the Site, adequately ensuring that there will be no increase in offsite flood risk.

1.14. Infiltration is not proposed for the Site to ensure no potential for contamination of groundwater. Furthermore, lined SuDS features are proposed throughout the Site to ensure that surface water runoff is treated. Multiple SuDS features in series are proposed, in line with the SuDS Management Train approach as detailed within the CIRIA SuDS Manual.

1.15. It is considered that the proposed approach for flood risk management and drainage is a step forward for the Site and resolves the previous reason for refusal.

2. Planning Policy and Guidance

National Planning Policy Framework

2.1. The National Planning Policy Framework[1] (NPPF, 2023) states that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk (whether existing or future). Where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere.

2.2. The NPPF states that when determining planning applications, Local Planning Authorities (LPA) should ensure that flood risk is not increased elsewhere. Where appropriate, applications should be supported by a site-specific Flood Risk Assessment. Development should only be allowed in areas at risk of flooding where it can be demonstrated that:

- Within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location.
- The development is appropriately flood resistant and resilient.
- It incorporates Sustainable Drainage Systems (SuDS), unless there is clear evidence that this would be inappropriate.
- Any residual risk can be safely managed; and
- Safe access and escape routes are included where appropriate, as part of an agreed emergency plan.

2.3. Major developments should incorporate SuDS unless there is clear evidence that this would be inappropriate. The systems used should:

- Take account of advice from the lead local flood authority.
- Have appropriate proposed minimum operational standards.
- Have maintenance arrangements in place to ensure an acceptable standard of operation for the lifetime of the development; and
- Where possible, provide multifunctional benefits.

Planning Practice Guidance

2.4. The Planning Practice Guidance[2] (PPG) provides additional guidance to LPAs to ensure effective implementation of the planning policies set out within the NPPF regarding development in areas at risk of flooding.

2.5. The PPG states that developers and LPAs should seek opportunities to reduce the overall level of flood risk in the area and beyond through the layout and form of the development, and the appropriate application of SuDS. Referencing information provided by the Environment Agency (EA), the PPG provides advice on taking account of climate change, setting out recommended contingency allowances for net sea level rise and peak rainfall intensities. It also advises on flood resilience and resistance measures when dealing with the residual risks remaining after applying the sequential approach and mitigating actions.

2.6. The PPG also includes advice on flood risk vulnerability and flood zone compatibility. The following flood zones refer to the probability of river and sea flooding, without the presence of defences:

[1] Ministry of Housing, Communities and Local Government, July 2021. *National Planning Policy Framework*
[2] Ministry of Housing, Communities and Local Government, March 2014. *Planning Practice Guidance*

- Zone 1 - low probability: less than 1 in 1000 annual probability of river or sea flooding (<0.1%) in any year;
- Zone 2 - medium probability: between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% to 0.1%) or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% to 0.1%) in any year;
- Zone 3a - high probability: 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability flooding from the sea (>0.5%) in any year; and
- Zone 3b - the functional floodplain: where water has to flow or be stored in times of flood; identification should take account of local circumstances but would typically flood with an annual probability of 1 in 30 (3.3%) or greater in any year or is designed to flood in an extreme 1 in 1,000 (0.1%) floods.

2.7. Flood risk vulnerability is split into five classifications in Table 2 of the PPG, as follows, and the compatibility of these within each Flood Zone is set out in Table 3 of the PPG:

- Essential Infrastructure, e.g. essential transport and utility infrastructure, wind turbines;
- Highly Vulnerable, e.g. emergency services (those required to be operational during flooding), basement dwellings;
- More Vulnerable, e.g. residential dwellings, hospitals, schools, hotels, drinking establishments;
- Less Vulnerable, e.g. retail, offices, storage and distribution, leisure, restaurants; and
- Water-Compatible Development, e.g. docks, marinas, wharves.

Sequential and Exception Test

2.8. The Site is located within Flood Zone 1 and therefore neither the Sequential Test nor Exception Test is required to be applied as set out in the NPPF.

Reigate and Banstead Borough Council, Mole Valley District Council and Tandridge District Council Level 1 Strategic Flood Risk Assessment

Summary of Level 1 Assessment

2.9. The SFRA has considered all sources of flooding including fluvial, surface water, groundwater, sewers and reservoirs within the study area. Fluvial flood risk is shown to generally be confined to the Main River floodplains such as the River Mole and its tributaries and the Eden Brook. Overall fluvial flood risk is in close proximity to watercourses, with a few areas of more extensive floodplain associated with the Burstow Stream.

2.10. Surface water flooding is shown to correlate with small watercourses and urban areas throughout the Councils' areas.

2.11. Groundwater flood risk is shown to vary across the area with areas of increased groundwater risk around Horley, Lower Kingswood, Walton on the Hill, Whyteleafe and parts of Leatherhead, with recent groundwater flooding occurring in Caterham and Whyteleafe in 2014.

2.12. The effect of climate change has been assessed. In most catchments, the extent of Flood Zone 3 is not likely to increase significantly with climate change. Climate change is predicted to result in more frequent and extreme rainfall events, increasing the frequency and severity (depth/hazard) of

flooding from fluvial and surface water sources.

2.13. Detail is given on how flood risk is assessed for planning using the Flood Zones and explains the Sequential Approach. It outlines the sources of national and local flood risk mapping data, information and evidence that has been available for use in this SFRA.

Guidance for planners and developers

2.14. The guidance should be read in conjunction with the NPPF and flood risk guidance from the Environment Agency. The guidance addresses: requirements for development in each of the Flood Zones, making development safe, river restoration and enhancement as part of development, dealing with existing watercourses and assets, developer contributions to flood risk improvements, dealing with surface water runoff and drainage, wastewater, water quality and biodiversity.

Local Flood Risk Management Strategy 2017-2032

2.15. SCC has produced a Local Flood Risk Management Strategy (LFRMS) to inform individuals, communities and businesses of the steps Surrey County Council (SCC) and its partners are taking to manage the impact of flooding in Surrey.

Tandridge District Core Strategy (2008)

2.16. The Tandridge District Core Strategy was adopted by the Council in October 2008. It sets out key planning policies for the District.

Local Plan Part 2: Detailed Policies 2014-2029 (July 2014)

2.17. On 24 July 2014, the Council adopted the Local Plan Part 2 - Detailed Policies. The Detailed Policies and support the implementation of the Council's adopted Core Strategy and should be used in the submission and determination of any planning application

Our Local Plan: 2033 (Draft)

2.18. At the time of writing, the Inspector examining the draft Tandridge Local Plan 'Our Local Plan: 2033' has issued a letter to the Council dated 10th August 2023, following a procedural meeting held on 27th July 2023. Following a three year protracted examination process, the Inspector has acknowledged a number of procedural challenges in progressing the Plan such that it is not possible to make the Plan sound by proposing main modifications to it and will therefore recommend that the Plan is unsound and that it is not adopted. Alternatively, the Inspector has suggested that the Council may wish to withdraw the Local Plan before his recommendation is confirmed within the Inspector's Examination Report. Until the position on the draft Plan is formalised this Report has included draft Local Plan policies, but in the circumstances, limited weight should now be attributed to them. Once the Local Plan has been found unsound / withdrawn, the draft policies referenced will no longer be relevant and carry no weight in the determination process.

3. Consultation

Environment Agency

3.1. The Environment Agency (EA) have been consulted to obtain the most up to date flood risk information relating to the Site, see Appendix D.

3.2. The Site is located within Flood Zone 1 (< 0.1% probability of flooding in any given year) and therefore no modelled flood levels are available.

3.3. There is no record of flooding (from river and/or sea) for this location.

Surrey County Council (Lead Local Flood Authority)

3.4. A pre-application meeting was held with SCC on the 25th of July 2023, see meeting notes in Appendix E.

3.5. SCC also provided a Flood Risk Report, advising on the risk of flooding and SuDS requirements for the Site.

3.6. SCC have reviewed the first draft of this FRA and provided the following comments:

Table 1: Comments from SCC on initial FRA

SCC Comments	Response
Report should include greenfield run-off calculations to evidence the values in table 6	Greenfield calcs are provided in Table 4 and Table 5.
Storage calcs only appear to have been included for west catchment? Please include (and clearly label) the calcs for each of the 3 catchments	Source Control calcs are provided for the Drive (central road that drains to an existing settlement lagoon). MicroDrainage calcs for site areas that drain to the recreation ponds. All calcs are provided in Appendix G.
The ha figures in Table 6 – are these the positively drained areas? It is unclear	Drainage areas have been clarified within Section 5.
Pro-forma in Appendix H is only partially completed	Completed, see Appendix I
Please include assurances that the existing pipe in the western parcel (outfall from the ponds to the south) will be retained in publicly accessible areas with an appropriate easement. As per our meeting notes please provide the justification for not being able to day light the watercourses that are currently pipes. The pipe should be clearly indicated on the drainage layout as requiring retention / diversion.	Existing 150mm pipe in the south-west corner of the Site is addressed in paragraph 5.6. Drainage strategy drawing (Appendix G) has been updated to reflect need to retain or replace existing 150mm pipe. Inability to daylight 1200mm culvert through third-party, former landfill land is address in paragraph 5.4.
Include reference to any remedial works required to	None required – referenced in paragraph

existing outfalls/watercourse and the requirement for Ordinary Watercourse consent for any alterations to existing.	5.24
What are the details for restricting flows from the western recreational ponds? How will these be managed and modelled? The drainage layout states 'use of flow control' on the plan but no details have been provided, how would this be followed through to detailed design? It is unclear how the rates for the western catchment would actually be managed what is the proposed restriction at the parcel?	Flows will be controlled using a 130mm diameter orifice plate. Calculations are provided in Appendix G to demonstrate that this is sufficient to restrict flows from the Site to existing discharge rates.
As per our pre-app discussions please include reference to maintenance responsibilities.	Maintenance responsibilities are addressed in paragraphs 5.41 and 5.42

Thames Water (Sewerage Undertaker)

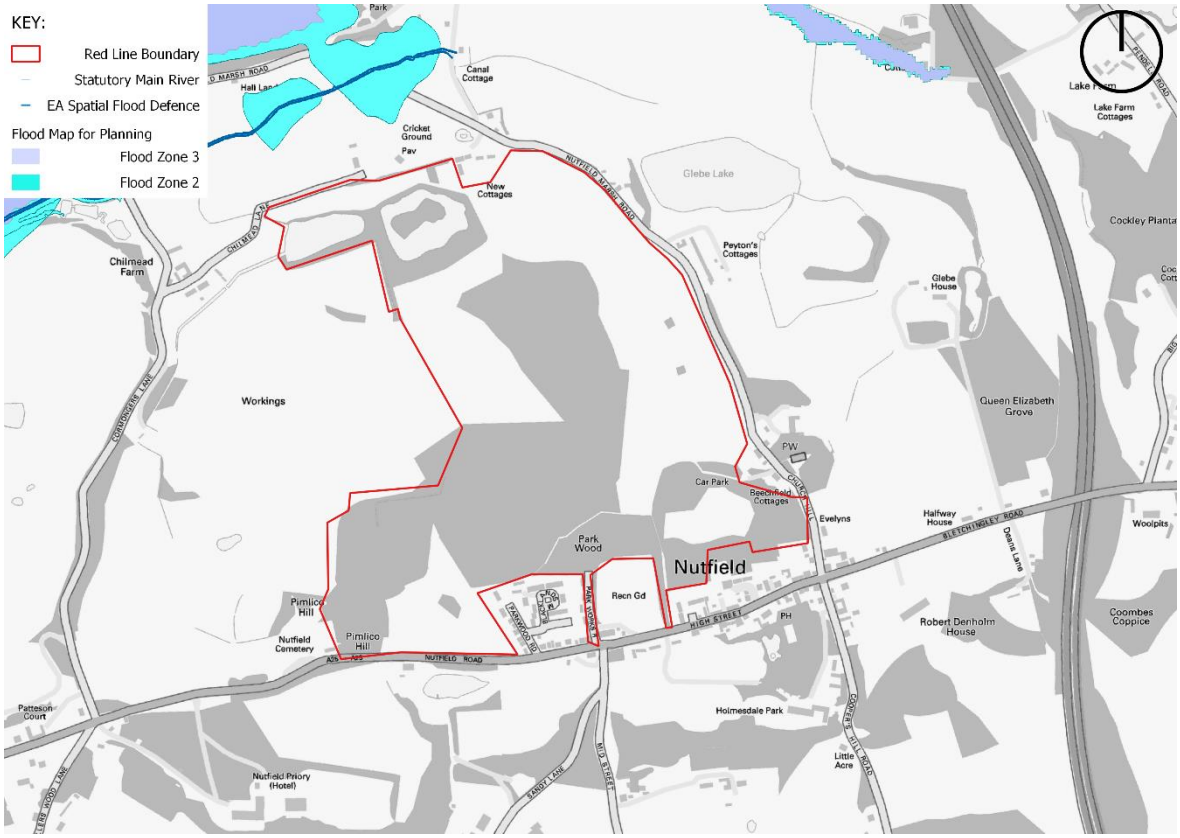
3.7. Thames Water is the local sewerage undertaker in the vicinity of the Site. Asset location information and a history of flooding was requested, see Appendix F. Any discharges from the Site to the Thames Water sewer network would be subject to post-planning consultation and agreement from Thames Water.

4. Sources of Potential Flooding

Tidal/Fluvial

4.1. According to the Environment Agency's (EA) Flood Map for Planning, the Site is located within Flood Zone 1 and is therefore classified as having a low probability of tidal and fluvial flooding of less than 1 in 1,000 (0.1% Annual Exceedance Probability (AEP)) in any given year. The closest potential source of flood risk is from the Redhill Brook Main River. The Redhill Brook flows in an easterly direction in this location approximately 150m to the north of the site.

Figure 4: Flood Map for Planning



4.2. The risk of tidal and fluvial flooding is considered to be low and specific mitigation is therefore not required.

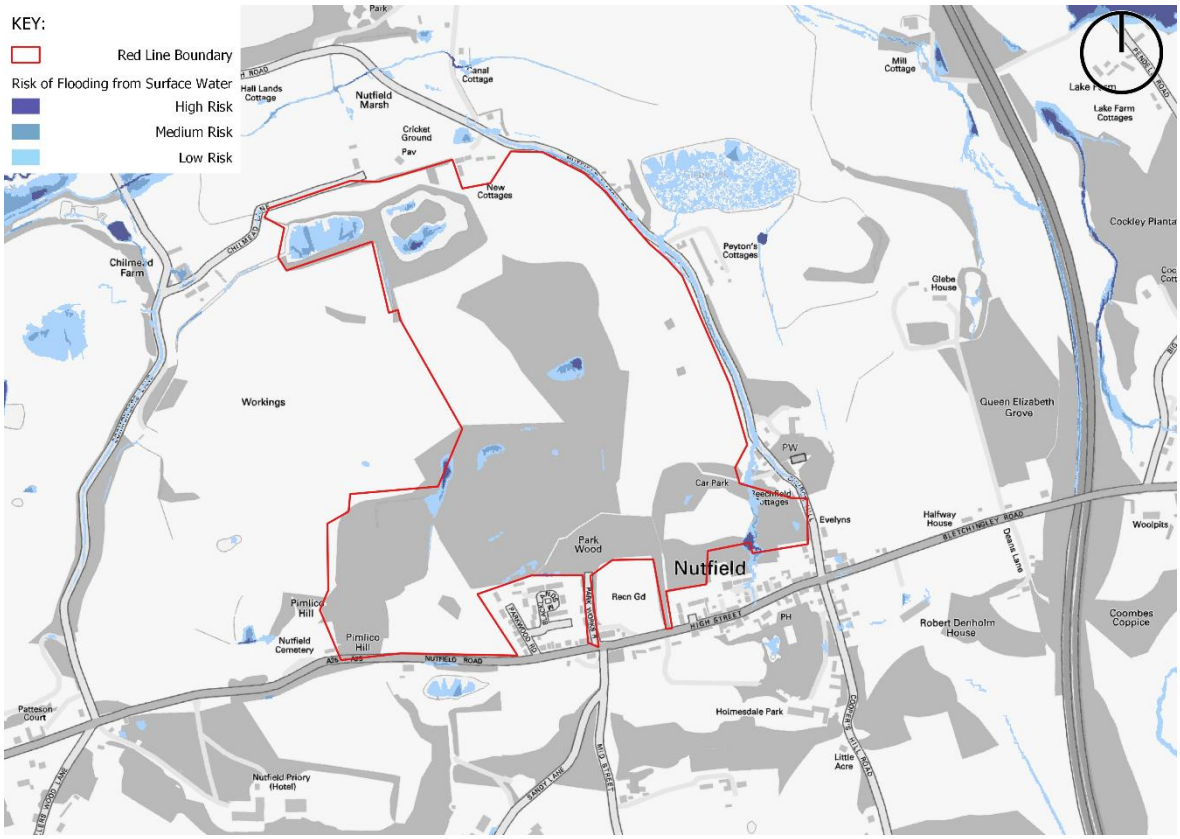
Pluvial

4.3. Pluvial flooding (also known as surface water and sewer flooding) occurs when natural and engineered systems have insufficient capacity to manage the volume of rainfall. Pluvial flooding can occur in urban areas during an extreme, high intensity, low duration summer rainfall event which overwhelms the local surface water drainage systems, or in rural areas during medium intensity, long duration events where saturated ground conditions prevent infiltration into the subsoil. This flood water would then be conveyed via overland flow routes based on the local topography.

4.4. The EA's Risk of Flooding from Surface Water mapping (Figure 5) indicates that the majority of the

Site is at a ‘very low’ risk of surface water flooding (less than 0.1% AEP). However, there are small pockets of ponding at ‘high’ risk (great than 3.33% AEP) of flooding from surface water.

Figure 5: Risk of Flooding from Surface Water Mapping



4.5. There is an offsite surface water flow route that runs through the south-eastern corner of the Site which is outside of the development parcels and will not be affected by the Proposed Development.

4.6. There is a 150 mm diameter pipe running through the south-west of the Site. The pipe connects a pond upstream of Nutfield Road (A25) to an existing ditch onsite. This flow route will be maintained (either retained or replaced - to be confirmed post-planning) as part of the development of the Site to protect the Site from flooding and to ensure flood risk is not increased upstream.

4.7. There are small pockets of ponding at ‘high’ risk (greater than 3.33% AEP) of flooding from surface water. However, these are due depressions in ground level, most of which are existing water features, and are all outside of the development areas. Therefore, the risk to the Proposed Development is low and surface water flood risk will not be affected by the Proposed Development.

4.8. The Proposed Development area will be actively drained by the proposed drainage strategy, which will prevent surface water flooding due to surface water runoff within the development areas up to and including the 1% (1 in 100) Annual Probability (AP) plus 40% climate change event. Any existing flow routes through the Site will be maintained. Therefore, once implemented the proposed drainage strategy will be sufficient to manage the risk of flooding from surface water.

Sewer Flooding

4.9. The SFRA sets out causes and effects of sewer flooding. It also sets out the record of Thames

Water and Southern Water sewer flooding register. The Site is shown to be in a postcode area with between 11 and 20 incidents of sewer flooding within the whole postcode area.

4.10. Any flood water from Thames Water foul sewerage within the A24 (see Appendix F) would be picked up by the road drainage in the first instance. If flooding from the sewer exceeds the capacity of the road drainage, then it would follow wider catchment topography, as shown by surface water mapping. The risk has therefore been assessed within the pluvial (surface water) section of the report.

4.11. There is a 150 mm diameter pipe running through the south-west of the Site, which is discussed in the surface water and drainage strategy sections of the report. This flow route will be maintained (either retained or replaced - to be confirmed post-planning) as part of the development of the Site to protect the Site from flooding and to ensure flood risk is not increased upstream.

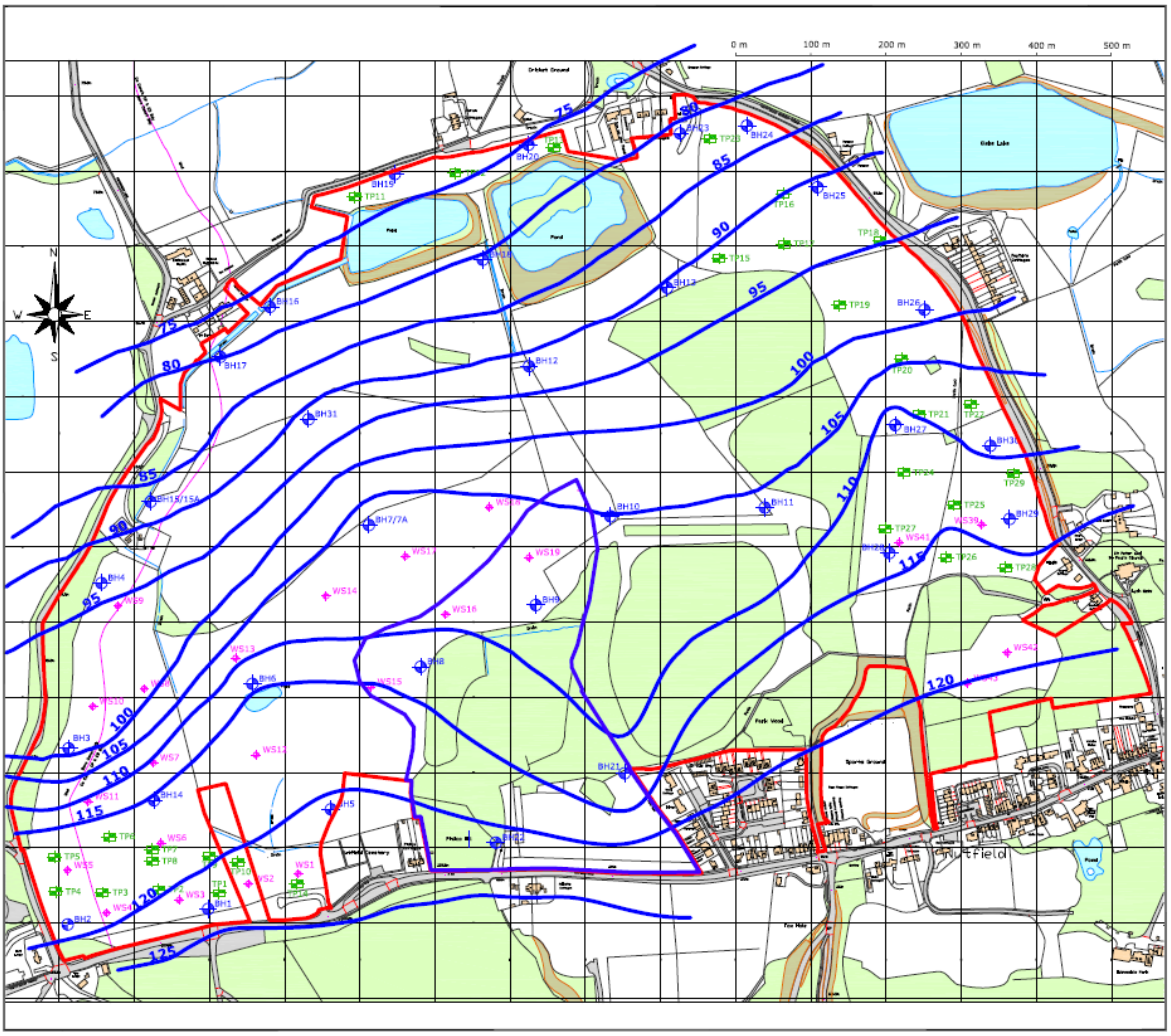
4.12. The risk of flooding from sewers is therefore not considered to require additional mitigation.

Groundwater

4.13. Based on groundwater monitoring between October 2011 and September 2013 (Appendix A), groundwater levels in the Folkestone Formation in the north and to the west of the wider Nutfield Park site ranged from approximately 71.5mAOD in borehole BH16D located approximately 510m north north-west of the site in July 2012 to approximately 84.3mAOD in borehole BH24 located approximately 600m north of the site in June 2013, see Figure 6 for borehole locations and approximate groundwater contours.

4.14. Groundwater levels in the Sandgate Formation in the south-west of the site, the south of the wider Nutfield Park site and to the west of the site ranged from approximately 105.4mAOD in borehole BH11 located approximately 200m north of the site in November 2011 to 123.5mAOD in borehole BH1 located approximately 360m south west of the site in May 2012, see Figure 6 for borehole locations and approximate groundwater contours.

Figure 6: Borehole locations



4.15. Based on recorded groundwater levels and LiDAR ground levels at the borehole locations, groundwater sits approximately 2.5 m – 4.7 m below ground level (BGL) across the Site.

4.16. Furthermore, SCC have advised that the majority of the Site is within an area classed as having a limited potential for groundwater flooding to occur. The north-west boundary of the Site is located within an area which is classified as having potential for groundwater flooding to occur; however, no development is proposed within this area of the Site.

4.17. Therefore, the risk of flooding from groundwater is not considered to require additional mitigation.

Artificial Sources

4.18. The EA's Flood Risk from Reservoir mapping indicates that the Site is not located within an area at risk from reservoir flooding. Therefore, no additional mitigation is proposed for flooding from artificial sources.

Mitigation

4.19. The Site has been sequentially designed to keep development away from areas at the highest risk

of flooding.

4.20. Surface water flow routes through the Site must be maintained to ensure the Site is safe from flooding and flood risk is not increased upstream.

4.21. EA standing advice suggests that Finished floor levels (FFLs) should be a minimum of whichever is higher of 300mm above the:

- average ground level of the site
- adjacent road level to the building
- estimated river or sea flood level

4.22. It will not be possible to achieve the EA's standing advice due to the significant variation in ground levels across the Site. However, site levels should be refined at the detailed design stage to prevent the ponding of surface water against buildings. Surface water runoff should be preferentially guided towards SuDS source control features or roads where they can be passed through the drainage network. The design of site levels should also facilitate the safe and controlled overland flow of surface water through the Site during blockage or exceedance events.

Summary of post-development flood risk from all sources

Table 2: Summary of flood risk from all sources

Type of Flooding	Source of Flooding	Existing Flood Risk to Site
Tidal/Fluvial	Redhill Brook	Low
Surface Water	Runoff generated by the Site; Overland flow route in south-east corner of the Site; and Existing 150 mm pipe connection through western development parcel.	Low
Sewers	Highways drainage or any nearby Thames Water sewers	Low
Groundwater	Underlying geology and groundwater levels	Low
Artificial sources	Nearby reservoirs or canals	Low

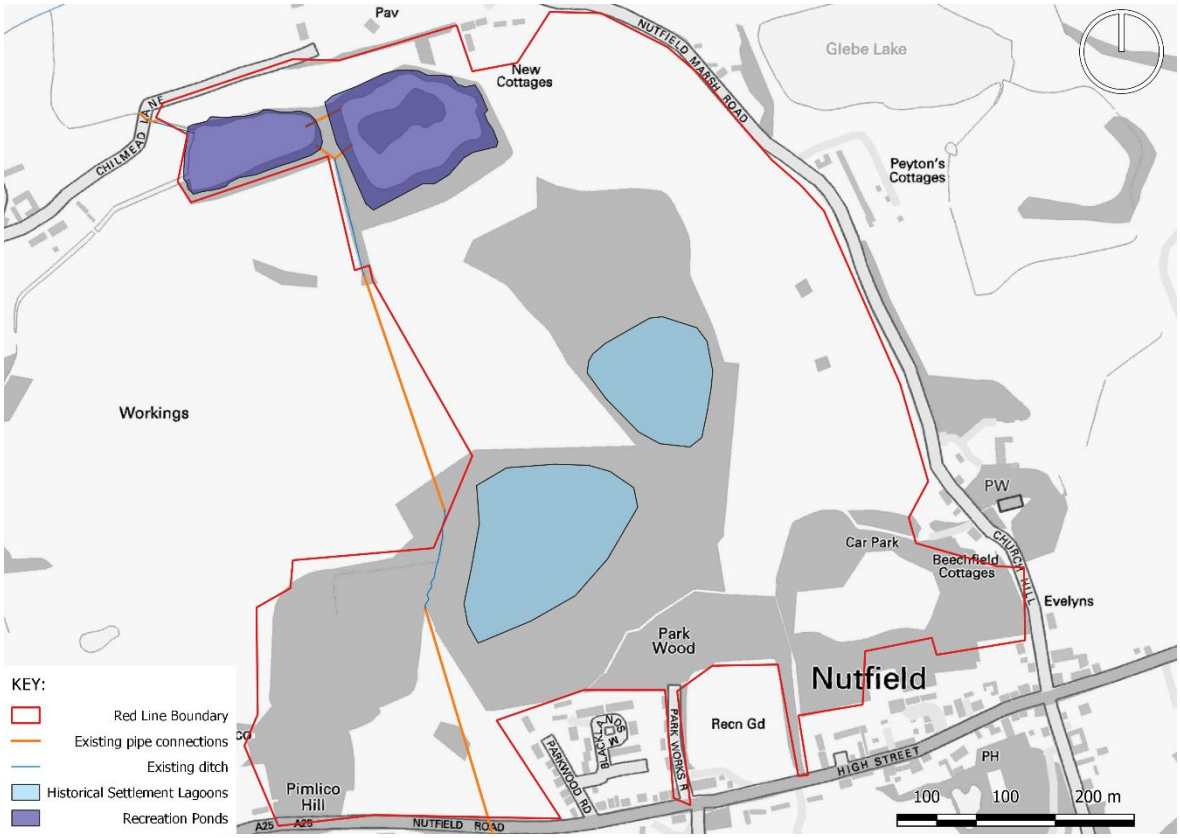
5. Surface Water Drainage Strategy

Existing Drainage

5.1. The Site consists of a mixture of grassland, blocks of self-seeding woodland and waterbodies with an area of the former infrastructure remains, such as access roads and pipework and former settlement lagoons.

5.2. The Site drains from south to north, in line with site levels. An overview of the existing site drainage is provided on Figure 7.

Figure 7: Existing Drainage Features



5.3. There are two historical settlement lagoons on the Site (leftover from the former usage) which collect and retain surface water runoff from the central and eastern parts of the Site.

5.4. The south-west corner of the Site drains via an existing ditch and culvert to the two recreation ponds at the northern end of the Site. The existing culvert has a diameter of 1.2m and a capacity of 7,300 l/s, see Appendix G. The existing culvert passes through third party land, which is former landfill. Therefore, it is not feasible to daylight this culvert.

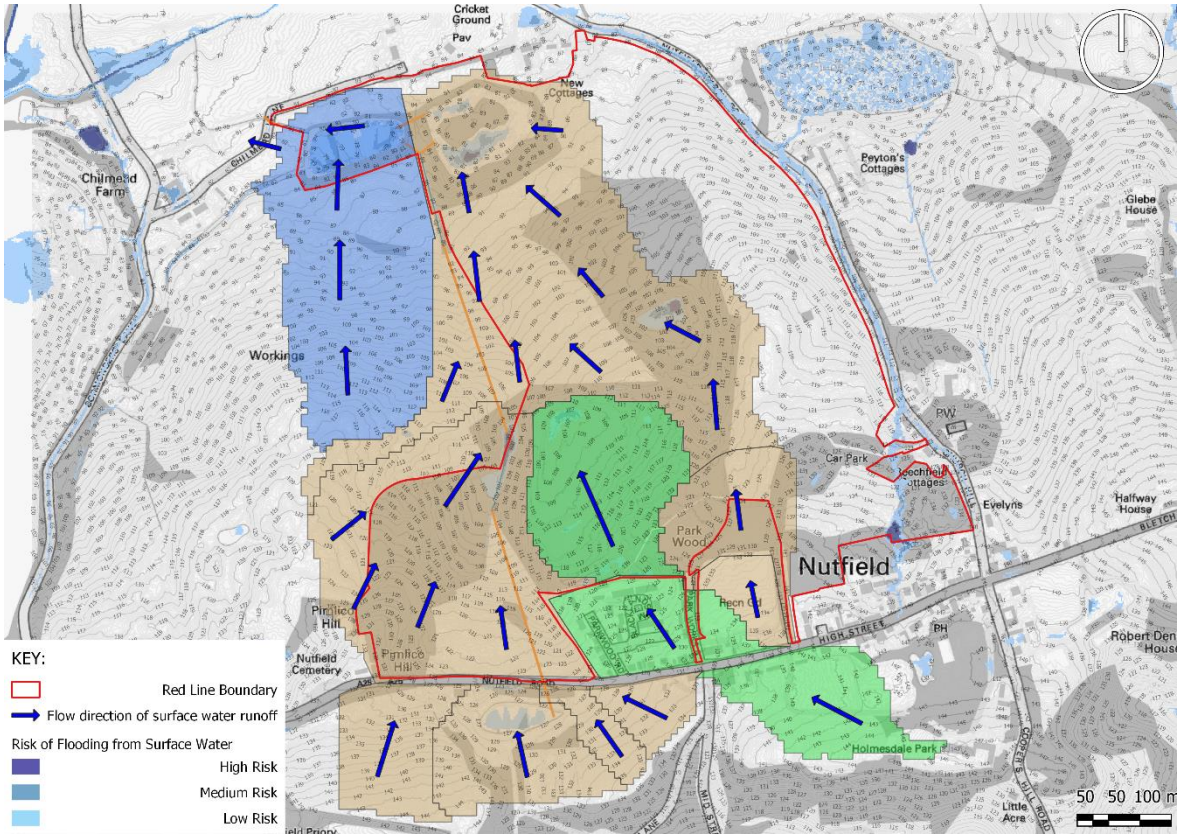
5.5. These ponds provide storage and attenuation to surface water runoff before discharging via an existing connection and offsite ditch, the Redhill Brook, to the north.

5.6. There is a 150 mm diameter pipe running through the south-west of the Site, as shown on Figure 7. The pipe connects a pond upstream of Nutfield Road (A25) to the existing ditch within the south-west corner of the Site. This pipe will need to be either retained with an easement to prevent

buildover and facilitate access or replaced and routed to follow the proposed road alignment with manholes within publicly accessible areas to ensure maintenance access. Details of the retained/replaced asset will be confirmed post-planning.

5.7. Existing drainage catchments have been identified based on LiDAR ground information, Figure 8. The Site is broadly divided into three catchments, with a further fourth catchment outside of the Proposed Development areas (and therefore unaffected by the proposals) that runs off overland to the north and east.

Figure 8: Baseline Drainage Catchments



5.8. Runoff from permeable surfaces has been calculated by assuming the percentage of impermeable area (PIMP) for permeable surfaces is equal to the Standard Percentage Runoff (SPR) for the Site (see Appendix G). Therefore, the contributing area = total permeable area x SPR. A summary of the existing drainage catchment areas is provided in Table 3.

Table 3: Existing drainage catchment areas

Drainage Catchment	Total Area (ha)	SPR	Contributing Area (ha)
Recreation Pond - East	51.09	0.47	24.01
Central Lagoon	13.95	0.47	6.56
Recreation Pond - West	12.18	0.47	5.73

5.9. Existing discharge rates from the eastern to the western recreation pond and from the western recreation pond out of the Site have been calculated using MicroDrainage based on the drainage

catchments shown on There are two historical settlement lagoons on the Site (leftover from the former usage) which collect and retain surface water runoff from the central and eastern parts of the Site.

5.10. The south-west corner of the Site drains via an existing ditch and culvert to the two recreation ponds at the northern end of the Site. The existing culvert has a diameter of 1.2m and a capacity of 7,300 l/s, see Appendix G. The existing culvert passes through third party land, which is former landfill. Therefore, it is not feasible to daylight this culvert.

5.11. These ponds provide storage and attenuation to surface water runoff before discharging via an existing connection and offsite ditch, the Redhill Brook, to the north.

5.12. There is a 150 mm diameter pipe running through the south-west of the Site, as shown on Figure 7. The pipe connects a pond upstream of Nutfield Road (A25) to the existing ditch within the south-west corner of the Site. This pipe will need to be either retained with an easement to prevent buildover and facilitate access or replaced and routed to follow the proposed road alignment with manholes within publicly accessible areas to ensure maintenance access. Details of the retained/replaced asset will be confirmed post-planning.

5.13. Existing drainage catchments have been identified based on LiDAR ground information, Figure 8. The Site is broadly divided into three catchments, with a further fourth catchment outside of the Proposed Development areas (and therefore unaffected by the proposals) that runs off overland to the north and east.

5.14. A summary of the existing flows is presented in Table 4 and their supporting calculations are provided in Appendix G.

Table 4: Existing discharge rates from east to west recreation pond

Event	Greenfield	Existing Scenario	Difference
QBAR/Q2	271.8	50.3	-81%
Q30	624.8	52.9	-92%
Q100	866.5	54.5	-94%
Q100 + 40% CC	1213.0	58.5	-95%

Table 5: Existing discharge rates from the Site

Event	Greenfield	Existing Scenario	Difference
Q2	336.6	48.0	-86%
Q30	773.8	51.3	-93%
Q100	1073.1	53.2	-95%
Q100 + 40% CC	1502.3	57.1	-96%

5.15. The results presented above demonstrate that the existing Site greatly restricts flows compared to Greenfield runoff rates for all events.

Proposed Surface Water Discharge Location

5.16. The proposed surface water drainage system would be designed to convey surface water only, with foul water being discharged separately. The design would be in accordance with BS EN 752 – Drain and Sewer Systems Outside Buildings, BS EN 12056 – Gravity Drainage Systems Inside Buildings, and Approved Document H of Building Regulations.

5.17. The Building Regulations and the Planning Policy Guidance set out a hierarchy of surface water discharge, which should be adhered to in decreasing order of preference:

Table 6: Drainage Hierarchy and Proposed Discharge Location

Discharge location	Feasibility
Reuse	Rainwater harvesting for reuse is not considered feasible for residential properties but should be considered for non-residential units (e.g. the care home) post-planning.
Into the ground (infiltration)	It is not proposed to discharge via infiltration due to the following constraints: • Superficial deposits generally consist of made ground or clay • The historical site usage was mineral extraction and landfill • The gradient of the Site (approx. 1:20) is not suited to infiltration A previously planning application (TA/2021/1040) was refused citing flood risk as Reason for Refusal 16: *The applicant has failed to demonstrate that the proposed development would not increase flood risk elsewhere, that appropriate SuDS are being proposed nor that ground waters are sufficiently protected. As such the proposal is contrary to Policy DP21 of the of the Tandridge District Local Plan: Part 2 - Detailed Policies (2014) and the provisions of the National Planning Policy Framework 2021* Infiltration is not proposed for the Site to ensure no potential for contamination of groundwater.
To a surface water body	The closest surface water bodies are the two recreation ponds at the north of the Site. These ponds discharge via an existing connection and offsite ditch to the Redhill Brook (EA Main River). The proposed drainage strategy for the development will drain to the ponds before eventually discharging to the Redhill Brook, in line with the existing hydrological regime.
To a surface water sewer, highway drain, or another drainage system	Has not been explored as drainage is proposed to drain to a more preferable discharge location.
To a combined sewer	Has not been explored as drainage is proposed to drain to a more preferable discharge location.

Sustainable Drainage Systems

5.18. The most sustainable way to drain surface water runoff is through the use of SuDS, which need to be considered in relation to Site-specific constraints.

5.19. SuDS mimic the natural drainage system and provide a method of surface water drainage which can decrease the quantity of water discharged, and hence reduce the risk of flooding. In addition to reducing flood risk, SuDS features can improve water quality, and provide biodiversity and amenity benefits.

5.20. A variety of SuDS are available to reduce or temporarily hold back the discharge of surface water runoff. The potential for SuDS was considered throughout the design development. Table 7 outlines the potential SuDS devices and their constraints and opportunities at the Site.

Table 7: Sustainable Drainage Techniques

Device	Description	Constraints/Comments	✓/×
Green/brown roofs (source control)	Provide soft landscaping at roof level which reduces surface water runoff	Not considered feasible for homes but should be considered for the Integrated Retirement Community facility post-planning.	✓
Infiltration devices & Soakaways (source control)	Store runoff and allow water to percolate into the ground via natural infiltration	Infiltration is unfeasible for the Site due to the low permeability of the soil.	×
Pervious surfaces (source control)	Storm water is allowed to infiltrate through the surface into a storage layer, from which it can either infiltrate and/or slowly release to sewers	Pervious surfaces could be accommodated within some of the residential carriageways.	✓
Rainwater harvesting (source control)	Reduces the annual average rate of runoff from the site by reusing water for non-potable uses e.g. toilet flushing or water butts	Not considered feasible for homes but should be considered for the Integrated Retirement Community facility post-planning.	✓
Swales (permeable conveyance)	Broad shallow channels that convey / store runoff, and allow infiltration (ground conditions permitting)	Could be accommodated within the development proposals.	✓

Device	Description	Constraints/Comments	✓/×
Filter drains & perforated pipes (permeable conveyance)	Trenches filled with granular materials (which are designed to take flows from adjacent impermeable areas) that convey runoff while allowing infiltration and/or slow release to the drainage network	Could be accommodated within the development proposals.	✓
Filter Strips (permeable conveyance)	Wide gently sloping areas of grass or dense vegetation that remove pollutants from runoff from adjacent areas	Not considered feasible as they require a large amount of space and the space available for SuDS is spatially constrained due to limiting impact on BNG and the steepness of the Site. Other SuDS features are preferred.	×
Infiltration basins (end of pipe treatment)	Depressions in the surface designed to store runoff and allow infiltration through the base	Infiltration is unfeasible for the Site due to the low permeability of the soil.	×
Bioretention Systems / Rain Garden (end of pipe treatment)	A shallow landscaped depression which allows runoff to pond temporarily on the surface before filtering through vegetation and underlying soils	Not considered feasible for residential properties but should be considered for non-residential units (e.g. the care home) or public open space post-planning.	✓
Detention Basins	Depressions in the surface designed to store runoff without infiltration through the base	Currently accommodated within the development proposals.	✓
Attenuation Underground (end of pipe treatment)	Oversized pipes or geo-cellular tanks designed to store water below ground level	Could be accommodated within the development proposals.	✓

Proposed Surface Water Drainage Strategy

5.22. The proposed drainage strategy has been developed to mitigate potential impacts on the local ecology. In line with the drainage hierarchy, surface water runoff will discharge to the Redhill Brook to the north of the Site, following the existing hydrological regime. Flow will discharge from the Site via an existing connection under Chilmead Lane to an offsite drainage ditch that runs north into the Redhill Brook.

5.23. Existing discharge rates from the Site are much lower (up to 96%) than greenfield runoff rates due to the existing onsite drainage features. Therefore, it is proposed to limit flow from the Site to

existing rates rather than the much higher greenfield rates. The drainage strategy consists of three subcatchments: western, central (the Drive), and eastern.

5.24. Flows from each of the development parcels (western and eastern subcatchments) will be conveyed through to a network of lined detention basins and ponds to the recreation ponds at the north of the Site before connecting into the Redhill Brook via the existing outflow connection. As the proposed strategy will reuse the existing connection under Chilmead Lane it is not expected that any remediation works will be required. It should be noted than any future works involving the downstream discharge location may be subject to an Ordinary Watercourse Consent (OWC).

5.25. Surface water runoff from the road connecting the two development parcels (the Drive) will drain to a roadside filter drain before discharging overland to the historical settlement pond to the north, in line with the existing hydrological regime.

5.26. Source control, through the use of lined SuDS, is proposed throughout the Site to provide multiple benefits beyond flood risk management, such as water quality management, amenity, and biodiversity and ecology. Sitewide integration of these features will minimise any impact on the local environment.

5.27. The surface water drainage strategy (19222-WIE-ZZ-XX-DR-D-92001) is provided in Appendix H.

Design Rainfall Event

5.28. The surface water drainage network has been designed to hold the Flood Estimation Handbook (FEH) 1% (1 in 100) annual exceedance rainfall event, including an allowance for climate change.

Climate Change

5.29. A 40% allowance for climate change has been used, in line with the 2070's upper end allowance for the 1% annual exceedance rainfall event within the Mole Management Catchment, see Table 8.

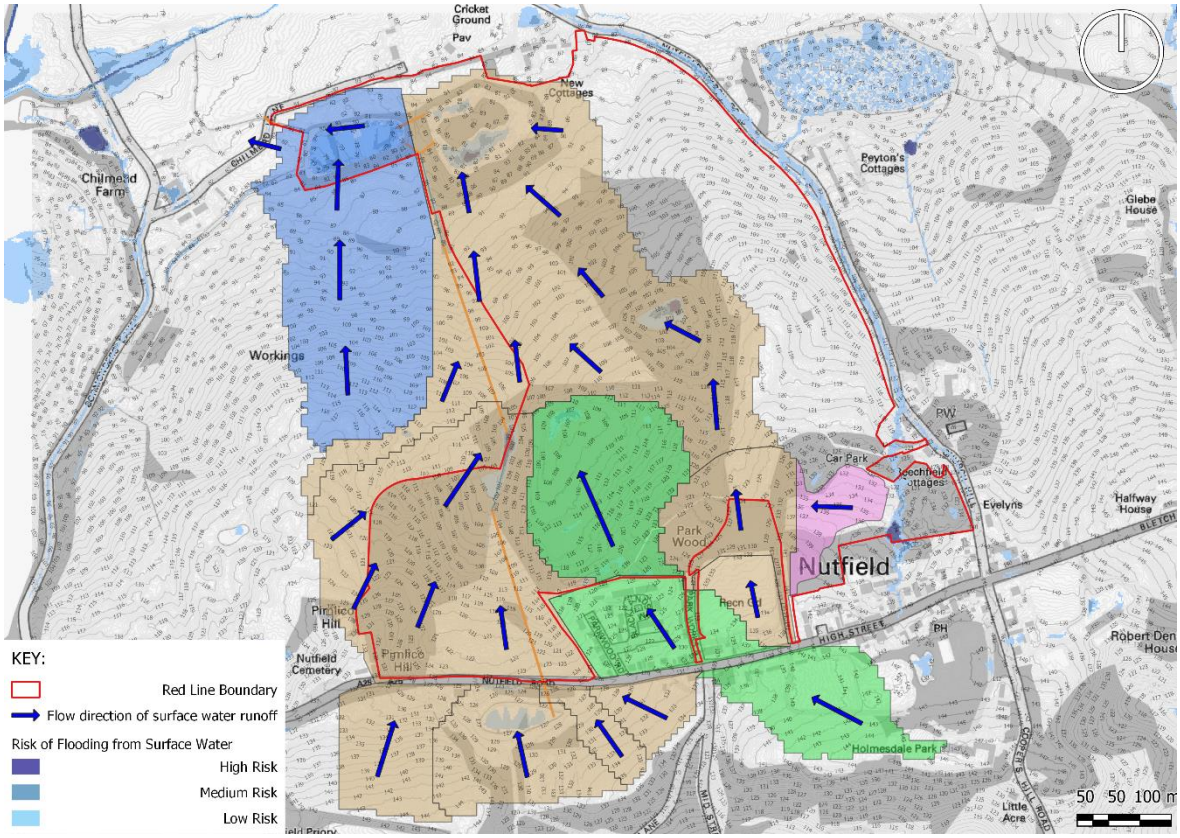
Table 8: Peak Rainfall Climate Change Allowances

Epoch	**3.3% exceedance rainfall event**		**1% exceedance rainfall event**	
	Central Allowance	Upper End Allowance	Central Allowance	Upper End Allowance
2050s	20%	35%	20%	40%
2070s	20%	35%	25%	40%

Drainage catchment areas

5.30. An additional area of 1.58 hectares will now drain to the eastern recreation pond, as shown in purple on Figure 9.

Figure 9: Proposed drainage catchments



5.31. The Proposed Development areas are shown on drawing 19222-WIE-ZZ-XX-DR-D-92002 within Appendix H and a summary is provided in Table 9. A percentage impermeable area of 60% has been assumed for the development parcels, uplifted by 10% to allow for uban creep. A percentage impermeable area of 100% is proposed for the Drive as consists of road and footway.

Table 9: Proposed impermeable areas

Drainage Subcatchment	Development Area (ha)	PIMP	Contributing Area (ha)
West	4.19	66%	2.76
The Drive	0.20	100%	0.20
East	2.54	66%	1.68

5.32. The proposed scenario has been conceptually modelled to conservatively route all flow from permeable surfaces directly to the recreation ponds at the bottom of the Site, in line with the baseline assessment. Flows from the proposed impermeable areas are routed through the proposed storage before discharging to the eastern recreation pond where runoff is further attenuated. The proposed impermeable areas have been subtracted from the total catchment area, which is assumed to be permeable, as in the baseline. A summary of the total catchment and contributing catchment areas for the proposed scenario is provide in Table 10.

Table 10: Proposed drainage catchment areas

Drainage Catchment	Total Area (ha)	Impermeable Area (ha)	Permeable Area (ha)	SPR	Contributing Permeable Area (ha)
Recreation Pond - East	52.67 (51.09 +1.58)	4.44 (2.76 + 1.68)	48.23 (52.67 – 4.44)	0.47	22.67
Central Lagoon	13.946	NA	13.946	0.47	6.555
Recreation Pond - West	12.184	NA	12.184	0.47	5.726

Proposed Discharge Rates

5.33. The baseline discharge rates from the Site are much lower (up to 96%) than greenfield runoff rates due to the existing onsite drainage features. Therefore, it is proposed to limit flow from the Site to existing rates rather than the much higher greenfield rates. Flows from the Site will be restricted by routing all runoff from the Site through the eastern recreation pond at the northern end of the Site, before it is passed to the western recreation pond via an orifice flow control, which will ensure flows do not exceed the existing (baseline) flow rates.

5.34. In addition to this, flow from each drainage catchment will be restricted as close to greenfield runoff rates as possible before they are passed downstream to the eastern recreation pond. Attenuation storage will be provided as close to each of the drainage subcatchments as possible i.e. source control.

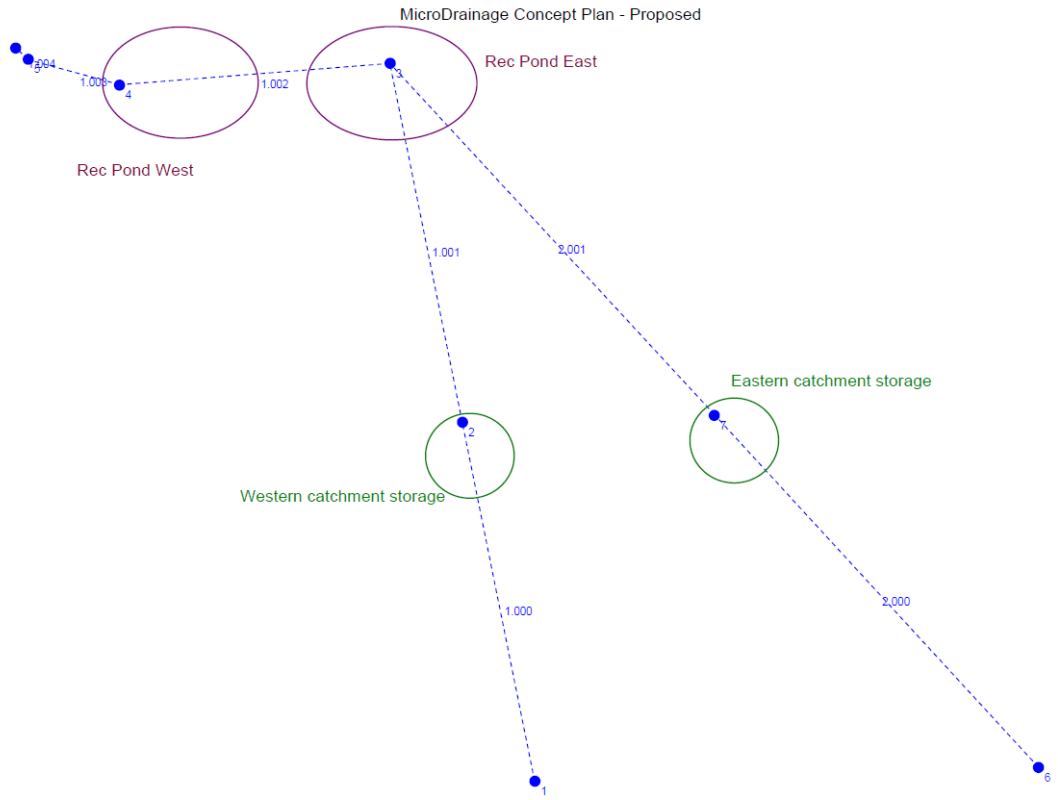
5.35. Surface water storage volume is provided for the eastern subcatchment within a lined detention basin. Further to this, discharge from the eastern basin will pass through a series of cascading lined ponds, which will provide multiple benefits and long-term storage.

5.36. Surface water runoff from the Drive will be collected and controlled at source by a roadside filter drain. The filter drain will provide water quality treatment of any potential contaminants in combination with a proprietary treatment system (e.g. downstream defender) to ensure runoff from the road is treated to an appropriate standard before discharging overland to the historical settling lagoon downstream. Storage will be provided within the filter drain and its oversized underdrain pipe.

5.37. Source control and surface water storage volume is provided for the Western Plot within a series of cascading lined basins. Due to spatial constraints within this catchment, it is not possible to provide sufficient storage within the catchment to match greenfield runoff rates for all events up to and including the 1% (1 in 100) AP plus 40% climate change event. Instead, the additional storage requirement is provided within the Eastern Recreation Pond by restricting flow to the Western Recreation Pond using an orifice plate (130mm diameter) flow control. Further calculations of the baseline and proposed discharge from the Site is provided within Appendix G.

5.38. The proposed scenario has been conceptually modelled to conservatively route all flow from permeable surfaces directly to the recreation ponds at the bottom of the Site. Flows from the proposed impermeable areas are routed through the proposed storage before discharging to the eastern recreation pond where runoff is further attenuated. A 130mm diameter orifice flow control is proposed to restrict flow from the eastern recreation pond to the western recreation pond, ensuring flows do not exceed the

Figure 10: Conceptual MicroDrainage model



5.39. A summary of the existing and proposed discharge rates for the Site are summarised in Table 11 and Table 12 with calculations provided in Appendix G.

Table 11: Existing and proposed discharge rates from east to west recreation pond

Event	Existing	Proposed	Difference
QBAR/Q2	50.5	48.5	-4%
Q30	53.2	51.1	-4%
Q100	54.9	52.7	-4%
Q100 + 40% CC	59.2	56.8	-4%

Table 12: Existing and proposed discharge rates from the Site

Event	Existing	Proposed	Difference
Q2	48.1	46.3	-4%
Q30	51.6	49.9	-3%
Q100	53.4	51.8	-3%
Q100 + 40% CC	59.2	56.8	-4%

Pro-forma

5.40. The SCC pro-forma has been completed to support this drainage strategy and is provided within Appendix I.

Sustainable Drainage Management Plan

5.41. The PPG sets out the requirement for developers to consider the operation, management and maintenance of all SuDS.

5.42. Post construction, the on-site management company (who would be appointed post-planning) would be responsible for the SuDS included in the scheme. The proposed drainage features would be accessed for maintenance via adjacent roads, footpaths, and verges.

6. Foul Water Drainage

6.1. The proposed foul drainage would be designed in accordance with BS EN 752 – Drain and Sewer Systems Outside Buildings, BS EN 12056 – Gravity Drainage Systems Inside Buildings, and Approved Document H of Building Regulations.

6.2. A peak foul flow rate of 2.9 l/s has been calculated, see Appendix J. Foul flows from the Proposed Development will discharge to a Thames Water foul sewer within the A25, subject to post-planning confirmation of capacity within their network.

6.3. New connections made to the public sewer system would be made through an S106 Agreement with Thames Water, under the Water Industry Act 1991.

7. Conclusion

7.1. The entire Site is designated as Flood Zone 1. This is land defined as having less than 0.1% (1 in 1,000) Annual Exceedance Probability (AEP) of flooding from rivers or sea in any year, classified as a low probability of fluvial flooding.

7.2. The EA's Risk of Flooding from Surface Water mapping indicates that the majority of the Site is at a 'very low' risk of surface water flooding (less than 0.1% AEP). However, there are small pockets of ponding at 'high' risk (great than 3.33% AEP) of flooding from surface water. Additionally, there is an offsite surface water flow route that runs through the south-eastern corner of the Site which is outside of the development parcels and will not be affected by the Proposed Development.

7.3. The areas at 'high' risk of surface water flooding are found where there are depressions in ground level, most of which are existing water features. The disconnected patches at 'high' risk of surface water flooding indicates that the flood risk is due to ponding of surface water runoff rather as opposed to flooding due to offsite flow routes. The Proposed Development area will be actively drained which will resolve any existing flood risk relating to ponding. Any existing flow routes through the Site will be maintained. Therefore, the proposed drainage strategy will be sufficient to manage the risk of flooding from surface water.

7.4. The risk of flooding from groundwater, sewers and artificial sources have all been assessed and are not considered to require further mitigation.

7.5. The drainage strategy has been developed to mitigate potential impacts on the local ecology. In line with the drainage hierarchy, surface water runoff will discharge to the Redhill Brook to the north of the Site, in line with the existing hydrological regime. Flow will discharge from the Site via an existing connection under Chilmead Lane to an offsite drainage ditch that runs north into the Redhill Brook.

7.6. The proposed drainage strategy will collect and attenuate rainwater onsite within Sustainable Drainage features (SuDS). The collected rainwater will be released at a controlled (greenfield) rate, in line with Surrey County Council guidance. Peak runoff from the Site will be greatly reduced for extreme rainfall events such as the 1% (1 in 100) AP plus 40% climate change event, which has been used to design the drainage network.

7.7. Flows from each of the residential parcels will be conveyed through to a network of lined detention basins and ponds to the recreation ponds at the north of the Site before connecting into the Redhill Brook via the existing outflow connection.

7.8. Source control, through the use of SuDS, is proposed throughout the Site to provide multiple benefits beyond flood risk management, such as water quality management, amenity, and biodiversity and ecology. Sitewide integration of these features will minimise any impact on the local environment.

7.9. A peak foul flow rate of 2.9 l/s has been calculated for the Proposed Development. Foul flows from will discharge to a Thames Water sewer, subject to post-planning confirmation of capacity within their network.

7.10. It is considered that the information provided within this report satisfies the flood risk requirements of the National Planning Policy Framework and local policy.

7.11. A previously planning application (TA/2021/1040) was refused citing flood risk as Reason for Refusal 16:

The applicant has failed to demonstrate that the proposed development would not increase flood risk elsewhere, that appropriate SuDS are being proposed nor that ground waters are sufficiently protected. As such the proposal is contrary to Policy DP21 of the of the Tandridge District Local Plan: Part 2 - Detailed Policies (2014) and the provisions of the National Planning Policy Framework 2021

7.12. The proposed drainage strategy lays out the existing and proposed flow rates from the Site, adequately ensuring that there will be no increase in offsite flood risk.

7.13. Infiltration is not proposed for the Site to ensure no potential for contamination of groundwater. Furthermore, lined SuDS features are proposed throughout the Site to ensure that surface water runoff is treated. Multiple SuDS features in series are proposed, in line with the SuDS Management Train approach as detailed within the CIRIA SuDS Manual.

7.14. It is considered that the proposed approach for flood risk management and drainage is a step forward for the Site and resolves the previous reason for refusal.

APPENDICES

A. Site Investigation

Technical advisers on environmental issues

DRAFT

A SITE INVESTIGATION OF LAND AT THE FORMER LAPORTE WORKS SITE AT NUTFIELD PARK, NUTFIELD ROAD

Report reference: HGH/NU/JRC/20064/01D
July 2023

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1. Introduction

1.1 MJCA is commissioned on behalf of Nutfield Park Developments Limited to undertake an intrusive site investigation on a site located in the south of the wider Nutfield Park site to the north and north west of the village of Nutfield in Surrey. The land comprises former Fuller's Earth works and former mineral extraction with various closed and active landfill sites in the vicinity of the site and the surrounding areas. For the purpose of this report the 'site' refers to the development area as shown on Figure 1. It is understood that the site will be developed into residential and commercial land use. A preliminary development layout of the site is presented at Appendix A.

1.2 The proposed development site the subject of the 2023 site investigation comprises a western and an eastern area joined by a proposed link road. For the purpose of this report the site is separated into three areas with a western area of proposed residential development and a central area including the proposed link road and residential development at the eastern end of the link road. The third area comprises an eastern area including the proposed care centre, doctors (GP) surgery and pharmacy.

1.3 The site investigation works was carried out between 27 February and 8 March 2023 and included the drilling of and collection of soil samples from 13 boreholes and the excavation of and collection of soil samples from 13 trial pits. The soil samples were submitted to laboratories for chemical and geotechnical analyses. Subsequent ground gas and groundwater level monitoring was carried out together with the collection of groundwater samples which were submitted to a laboratory for chemical analyses.

1.4 It is understood that intrusive site investigations were carried out in the wider Nutfield Park site during 2011 and 2012 with summary reports of these site investigations being prepared in 2013. The objective of the site investigation is to obtain further preliminary information on the ground conditions and to provide a technical report which will form part of the submission of information to support an application for outline planning for the proposed development of the site for residential and commercial land use.

1.5 The pollution control officer at Tandridge District Council were consulted on the scope of the site work prior to the 2023 site investigation. The Environmental Protection Group Limited (EPG) were commissioned on behalf of Tandridge District Council to review and comment on the investigation proposals. Following EPG comments a number of investigation locations were relocated to take account of potential areas of concern raised by EPG as far as possible in the areas accessible during the works. A copy of the EPG letter report commenting on the proposals are provided at Appendix B. A representative of EPG carried out a site visit during the 2023 site investigation to observe materials on site and the works being carried out.

Non-technical summary

1.6 Based on the findings of this report and the 2023 site investigation results, ground conditions at the proposed development site comprise generally a thin layer of topsoil underlain by varying made ground and then natural strata of sand, silt and clay with sandstone and mudstone interpreted as the weathered Sandgate Formation. The made ground consists of sandy clay with varying amounts of silt, sand, gravel and cobbles of sandstone together with a bright yellowish orange silt and minor constituents of mudstone, brick, chalk, coal and flint. In the western area of the site the made ground includes occasional black clay with hydrocarbon odours. Made ground is generally absent in the east and central north of the western area of the site. In the central and eastern area of the site the orange silt is more prominent and the made ground includes occasional clinker.

1.7 The chemical analysis has not revealed any significant contamination across the site. There is a location on the south western boundary of the site which has elevated concentrations of a number of hydrocarbons above recommended limits for residential land use. Arsenic and beryllium have been found to be slightly over the recommended limits for residential land use across the site. Beryllium in particular is likely to be derived from a natural source comprising the Fuller's Earth. Soluble sulphate concentrations recorded in the yellowish orange silt materials indicate that more sulphate resistant concrete mixes should be used for buried concrete in this material. No asbestos containing materials were recorded in the soil samples analysed. Shallow groundwater in the made ground/ top of the Sandgate Formation

is discontinuous across the site attributable to the variation in ground level, made ground and geology. Additional site investigation will be needed at the detailed design stage to investigate areas of the site which were not accessible during the 2023 site investigation.

1.8 The potential of ground gas migration at the site has been considered. The Gore Meadow/North Cockley Landfill is nearby and is evidenced to produce high concentrations of methane and carbon dioxide albeit with low gas flow rates recorded. The elevation of the landfill makes it unlikely for a significant pathway for gas to migrate onto areas of the site. Gas monitoring undertaken at the proposed development site show that where methane and carbon dioxide were recorded they were at low concentrations generally across the site including at the boundary next to the landfill. Precautionary gas protection measures should be incorporated into building design in proximity to the Gore Meadow/North Cockley Landfill. The detailed design should be informed by further monitoring.

1.9 The site investigations have not identified any significant contamination in the area of proposed residential and commercial development which it is considered cannot be remediated as part of the development. As is the accepted normal practice for developing sites with historical industrial uses further site investigation work will be carried out pursuant to planning conditions and a remediation strategy, to the extent that it is necessary, would be put in place to achieve ground conditions and a development which is protective of human health and the environment in accordance with appropriate standards.

2. Site Setting

Site Location

2.1 The proposed development site the subject of the 2023 site investigation is within the southern area of the wider Nutfield Park site and is shown on Figure 1. For the purpose of this report the proposed development site the subject of the 2023 site investigation is referred to as the site with the wider Nutfield Park site referenced as appropriate. The site is centred approximately on National Grid Reference TQ 3050 5065. The site is located to the north of A25 Nutfield Road and to the north and north west of the village of Nutfield, approximately 500m to the east of Cormongers Lane, approximately 700m to the south of Nutfield Marsh Road and west of Church Hill. The site currently comprises areas of woodland with the eastern and western areas containing areas of open grassland. Details of the wider Nutfield Park site are given in the historic land use section below.

2.2 An operational quarry and landfill operated by J&J Franks is located north east of the wider Nutfield Park site beyond Nutfield Marsh Road. Patteson Court Landfill site operated by Biffa is located approximately 550m to the west of the wider Nutfield Park site beyond an area of grassland and Cormongers Lane. The area of open grassland adjacent to and west of the wider Nutfield Park site is the restored former North Cockley Landfill which it is understood includes a landfill gas extraction system. Details of the operation of the gas control system are not known.

2.3 There are no statutorily designated ecological sites within 2km of the site boundary. The majority of the eastern area and the northern and western margins of the central and western areas of the site are within an area designated as the Holmethorpe Sandpits Complex Site of Nature Conservation Interest (SNCI) which is designated for feeding and breeding birds. The site also forms part of the Holmesdale Biodiversity Opportunity Area (BOA).

Topography

2.4 The topography of the site is varied. The western area of the site falls from an elevation of approximately 123m above Ordnance datum (mAOD) along Nutfield

Road in the south to a low point at approximately 102mAOD in the north eastern corner. The land falls more steeply across the central third of the western area from approximately 120mAOD to approximately 110mAOD with the elevation rising steeply along the western boundary back up to approximately 120mAOD. The land to the north and west of the western area rises to elevations of approximately 115mAOD to the north west and 132mAOD to the south west of the western area on the former North Cockley Landfill. The land to the east of the northern two thirds of the western area rises steeply on to an embankment on the wider Nutfield Park site at elevations of approximately 110mAOD in the north to approximately 118mAOD in the south. The southern third of the western area is adjacent to a residential area of Nutfield village.

2.5 The line of the proposed link road rises from approximately 118mAOD in the south west to approximately 123mAOD in the north east adjacent to the proposed residential development in the central area of the site. The topography of the wider Nutfield Park site falls to the north of the proposed link road with a residential area of Nutfield village to the south of the site boundary. The proposed residential area is at an elevation of between approximately 120mAOD and 124mAOD with elevations highest in the east and south west falling gently towards the central area of the proposed residential development. The topography of the wider Nutfield Park site falls to the north west of the proposed residential development and is at a similar elevation to the development to the north. A sports field is located to the south of the site boundary adjacent to the proposed residential development in the central area of the site.

2.6 The land rises steeply from the proposed residential development in the central area of the site up to the eastern area of the site to an elevation of approximately 141mAOD in the south west of the eastern area. The topography of the proposed development in the eastern area of the site falls from approximately 141mAOD in the south west to approximately 130mAOD in the north east. The land falls to the north of the proposed development in an area of retained woodland from between 135mAOD and 130mAOD at the care centre development towards the wider Nutfield Park site at approximately 123mAOD. Residential areas of Nutfield village are located to the south and east of the site boundary with an area of woodland remaining

between the proposed care centre development and the properties on Church Hill to the east.

Geological, hydrogeological, and hydrological setting

Geology

2.7 Information has been taken from the British Geological Survey (BGS) 1:50 000 scale sheet 286 Reigate, the BGS Digital Geological Map, information on the BGS website, and the 2013 site investigation reports. There are no superficial drift deposits recorded at the site and the site is underlain by bedrock comprising the Cretaceous Lower Greensand Group consisting of in turn the Folkstone Formation, the Sandgate Formation, the Hythe Formation and the Atherfield Clay Formation. Based on the BGS maps, the eastern area of the site is underlain by the Folkstone Formation and the Sandgate Formation. The Folkstone Formation comprises poorly consolidated cross-bedded medium grained quartz sand with the underlying Sandgate Formation comprising mainly clays, together with glauconitic, limonitic and ferruginous sands. The Sandgate Formation underlies the central and western areas of the site with the overlying Folkstone Formation absent in these areas of the site. It is understood that the Fuller's Earth reserves historically worked at the site are present in the Sandgate Formation comprising clay deposits derived from volcanic ash. The Hythe Formation underlying the Sandgate Formation comprises fine to medium grained sands, calcareous sands, sandstones and limestones with some clay. The Hythe Formation is underlain by the Atherfield Clay Formation which comprises yellowish brown to pale grey sandy mudstone. The bedrock dips approximately 5° to the north west bringing the underlying strata up to ground levels at and to the south of the site. The Cretaceous Lower Greensand Group geology at and in the vicinity of the site is shown on Figure 2 and summarised in the table below.

Geological Formation	Lithology
Folkestone Formation	Poorly consolidated cross- bedded medium-grained quartz sand (absent in the central and western part of the site)
Sandgate Formation	Clays and glauconitic, limonitic and ferruginous sands with seams of Fuller's Earth

Geological Formation	Lithology
Hythe Formation	Fine to medium grained sands, calcareous sands, sandstones and limestones with some clay
Atherfield Clay Formation	Yellowish brown to pale grey sandy mudstone, impersistent phosphatic pebble bed with gritty sandstone or very shelly sandy mudstone

Hydrogeology

2.8 Based on information presented on the magic.defra.gov.uk website the Folkstone Formation and the Hythe Formation are designated as Principal Aquifers by the Environmental Agency (EA). A Principal Aquifer is defined as layers of rock that have high intergranular and/or fracture permeability, meaning they usually provide a high level of water storage and may support water supply and/or river base flow on a strategic scale. The Sandgate Formation is classified as a Secondary A Aquifer which is defined as permeable rock 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.

2.9 The site is not located within a Source Protection Zone (SPZ) of a public water supply facility. The nearest SPZ is located approximately 1.25km east of the site. Based on the 2019 Envirocheck Report (Appendix C), there are two groundwater abstractions within a 2km radius of the site boundary. The closest licensed groundwater abstraction is located approximately 360m south of the site, is located within the Hythe Formation at Priory Farm and is for general farming and domestic use. There is also a licensed abstraction located approximately 1.5km north of the site. This abstraction is for groundwater used for mineral washing. The source of supply is not provided however based on the borehole location and the BGS maps it is considered that the source will be either river terrace drift deposits or the Folkestone Formation. ***[AWAITING UPDATED INFORMAITON FROM THE ENVIRONMENT AGENCY AND THE LOCAL AUTHORITY]***

2.10 Groundwater levels on the wider Nutfield Park site were recorded as part of the site investigation works between October 2011 and September 2013. A number of boreholes in the north and to the west of the wider Nutfield Park site monitor

groundwater in the Folkestone Formation and a number of boreholes in the south west of the site, the south of the wider Nutfield Park site and to the west of the site monitor groundwater in the Sandgate Formation with the remaining boreholes at and in the vicinity of the wider Nutfield Park site monitoring water within made ground. Groundwater levels in the Folkestone Formation in the north and to the west of the wider Nutfield Park site ranged from approximately 71.5mAOD in borehole BH16D located approximately 510m north north west of the site in July 2012 to approximately 84.3mAOD in borehole BH24 located approximately 600m north of the site in June 2013. Groundwater levels in the Sandgate Formation in the south west of the site, the south of the wider Nutfield Park site and to the west of the site ranged from approximately 105.4mAOD in borehole BH11 located approximately 200m north of the site in November 2011 to 123.5mAOD in borehole BH1 located approximately 360m south west of the site in May 2012. Based on the groundwater monitoring between October 2011 and September 2013, groundwater in the Folkestone Formation falls from east to west across the north and to the west of the wider Nutfield Park site and groundwater in the Sandgate Formation falls from south west to north east across the south west of the site, the south of the wider Nutfield Park site and to the west of the site.

2.11 Water levels monitored in made ground in the east of the wider Nutfield Park site and to the north of the site generally are within the base of the made ground with water levels falling from south to north. Water levels in the south (107.9mAOD to 113.3mAOD) were similar to those recorded in the Sandgate Formation and those in the north (87.4mAOD to 99.8mAOD) were perched above groundwater levels recorded in the Folkestone Formation.

Hydrology

2.12 The Nutfield Green Park site is located in the Redhill Brook sub-catchment of the Mole Upper Tributary operational catchment, part of the catchment of the River Mole within the Thames River Basin. The Redhill Brook loops around the site from north to west to south west before joining the Salfords Stream thence the River Mole approximately 5.5km south west of the site. The Redhill Brook is located approximately 980m north west of the site at its closest point where it flows in a south

west direction. There are a number of ponds located to the north and to the south of the site. Approximately 400m to the north west of the site are two ponds which are used for fishing in the wider Nutfield Park site. Approximately 870m north west of the site is Mercers Lake and Glebe Lake is located approximately 460m north east of the site. It is likely that Glebe Lake is a former mineral extraction area. Approximately 40m to the south of the site beyond Nutfield Road is a small lake. The surface water features in the proximity to the site are shown on Figure 1.

2.13 Based on the Flood Map for Planning taken from the gov.uk website, the site is located within Flood Zone 1 which is defined as a land assessed as having less than a 1 in 1000 annual probability of river flooding.

2.14 Based on the 2019 Envriocheck Report (Appendix C) the closest surface water abstraction to the site is located approximately 1.65km south of the site which is operated in Redhill Aerodrome Ltd. The abstraction is from The Redhill Brook and is used for spray irrigation purposes. ***[AWAITING UPDATED INFORMAITON FROM THE ENVIRONMENT AGENCY AND THE LOCAL AUTHORITY]***

Historic land uses

2.15 Historical maps dated between 1870 and 2019 have been reviewed and show the area of the site and the wider Nutfield site to have comprised grassland, deciduous woodland and sand and clay pits. In the 1:10560 1872 to 1897 and 1:2500 1870 to 1896 maps, the central area is shown as Park Wood. South east of Park Wood is Park Works (Fuller's Earth) and a clay pit, part of which is within the boundary of the site. On the 1896 map there are tanks shown on the Park Works which are considered to be settlement tanks associated with the manufacturing process for Fuller's Earth. Buildings adjacent to the eastern boundary are also labelled Fuller's Earth. The 1897 map shows a tramway passing through Park Wood from Park Works in a north west direction to a clay pit at the northern boundary of the western area of the site. Approximately 50m to the west of the western part of the site is another pit and buildings which are labelled as Cockley Works (Fuller's Earth) on the 1896 map. The remainder of the site and the wider Nutfield Park site are shown as fields with the exception of a small area in the south west of the site shown as a woods and

labelled Pimlico Hill. Marsh Barn is shown in the north west of the wider Nutfield Park site.

2.16 The 1:10560 1914 map shows a recreation ground to the south of Park Works which is partially in the area of the development site. There are residential properties shown along Park Road to the west of the recreation ground and south of the Park Works. A cemetery is shown to the south west of the site. The 1:2500 1912 map shows the area of the clay pit to the west of Park Wood has expanded and is partially on the site and had extended further west and is labelled as Marl Pit on the 1933 map. There are no significant changes shown on the site until the 1:10560 1934 map and 1:2500 1935 map. Park Works had expanded slightly and an area of refuse heap is shown between Park Works and Fuller's Earth Works in the east of the site. It is considered likely that this heap is the overburden soil which has been removed to extract the Fuller's Earth.

2.17 On the 1:10000 1961 map the tramways are no longer shown from Park Works. The 1:10000 1961 map shows the Cockley Works has expanded into the western area of the site with a potential unlabelled tramway running through the south of the western area of the site and the central area of the site linking Cockley Works with Park Works. On the 1:2500 1966 map the tramways are no longer shown from Park Works and the area to the north of Park Works is labelled as a sand pit although the extent is not shown on the map. Park Road has become Park Works Road. The Fuller's Earth Works in the east of the site is no longer shown. The 1:2500 1966 map shows the Cockley Works which has expanded into the western area of the site and multiple tanks are shown on the site which are assumed to be settlement tanks. The potential tramway linking Cockley Works with Park Works is not shown on the 1:2500 maps.

2.18 The 1:10000 1970 map shows Park Wood and most of the wider Nutfield Park site north of the Park Works as a sand pit. The 1:10000 1977 map shows the sand pit only occupying the area of the former Park Wood to the north of the Park Works. The 1:2500 1977 to 1978 map shows the area to the north west of the Park Works as a spoil tip and further residential development is shown to the south west of Park Works. The eastern pond in the north of the wider Nutfield Park site is shown on the 1:2500 1976 map in its current layout and part of the western pond is shown on the

1:2500 1978 map. A drain which runs along the western boundary of the wider Nutfield Park site is shown flowing to the eastern and western ponds on the 1:2500 1978 map.

2.19 One version of the 1:2500 1992 map shows Park Works although it is not shown on a second version of the 1:2500 1992 map. The Cockley Works to the west of the site is shown on the 1:2500 1992 map although it is not shown on the 1:2500 1993 map. The 1:2500 1992 map shows an outlet channel in the north west of the western pond in the north of the wider Nutfield Park site and the 1:2500 1993 map shows another channel to the west of the western pond although this may be an inlet channel. Glebe Lake is shown to the north east of the site together with a drain located to the east of the site which discharges to Glebe Lake on the 1:2500 1992 map. Mercers Lake to the north west of the site is shown as a sand pit on the 1:10000 maps from 1974 and is shown as a lake on the 1999 map. The works to the north of Mercers Lake and approximately 500m north of the wider site boundary is shown on the 1:10000 maps from 1974 and is labelled as a sewage works from 1999. The current site layout is shown on maps from 1999 onwards with the extent of the woodland in the west of the site shown from 2006 onwards.

Landfill

2.20 According to information from the 2019 Envirocheck report, areas of the site and most of the wider Nutfield site have been used as landfill historically. North of the site in the central area of the wider Nutfield Park site is a historical landfill known as Beechfield Quarry which was operated by Laporte Industries and accepted waste including inert, industrial, commercial and household waste and liquids and sludges. The landfill period of operation is recorded as 1969 to 1984. The landfill is also shown occupying a larger area to the north of the site and along the northern margins of the central area of the site on records held by Surrey County Council. Beechfield Quarry is recorded as a registered landfill site in the Envirocheck report operated by Laporte Industries Ltd with a recorded maximum input rate equal to or greater than 250,000 tonnes per year and the authorised waste includes excavated natural materials, hardcore and rubble, industrial effluent treatment sludge, metal scrap, paper/cardboard waste and wood waste/timber. The licence was issued in

September 1977 and is recorded as '*lapsed or cancelled or defunct or not applicable/surrendered*'. From EA information, the licence was surrendered in July 1994. A trade effluent consent in the south of Beechfield Quarry is recorded close to the northern limit of the central area of the site and is recorded as being operational from 1981 to 1990 . It is assumed that the trade effluent consent is associated with the disposal of industrial effluent treatment sludge.

2.21 Another registered landfill recorded as Gore Meadow, also operated by Laporte Industries Ltd is listed in the Envirocheck report on the site. The location of Gore Meadow is shown to span the northern boundary of the western area of the site and extending to the north west. The maximum input rate is recorded as equal to or greater than 25,000 and less than 75,000 tonnes per year and the site was licensed to accept industrial effluent treatment sludge. The licence was issued in June 1979 and is recorded as '*lapsed or cancelled or defunct or not applicable/surrendered'*.

2.22 Two parcels of potentially infilled land are shown in the Envirocheck report in the south of the central area and the north and west of the eastern area of the site. No further details are provided for these areas although they are recorded as former Fuller's Earth mineral sites. A further former Fuller's Earth mineral site is recorded in the east of the eastern area of the site.

2.23 The North Cockley Landfill is recorded in the Envirocheck report directly west and north west of the site. The landfill site was operated by Waste Management Ltd. The maximum input rate is recorded as equal to or greater than 75,000 and less than 250,000 tonnes per year. This landfill was licenced to accept asbestos, brick/concrete, commercial and industrial waste, dewatered industrial effluent treatment sludge, excavated natural materials, household waste and industrial effluent treatment sludge. From the Envirocheck report, the licence was issued in July 1983 and is recorded as '*lapsed or cancelled or defunct or not applicable/surrendered*'. From EA information, the licence was issued in March 1981 and surrendered in July 1990. The North Cockley Quarry is also recorded in the Envirocheck report as on records held by Surrey County Council.

2.24 Park Quarry is a recorded landfill approximately 285m west of the site and accepted inert, industrial, commercial, household and special waste. This landfill was in operation between April 1975 and March 1979. The operator is recorded as Greater London Council. This landfill is also recorded as Redhill Landfill which was licensed between March 2004 and October 2017 to Biffa Waste Services Ltd for household, commercial and industrial waste. Redhill Landfill is also recorded at 720m west of the site licensed to Biffa Waste Services Ltd in December 1989 and last modified in February 1998 as a co-disposal landfill site. In a separate entry it is stated that a licence was issued to Biffa Waste Services Ltd in September 2012 and last modified in October 2017 and that the landfill is located 940m west of the site. The licence is modified for the treatment of waste to produce soil.

2.25 Nutfield Priory Landfill Site is recorded approximately 10m from the south western boundary of the site as a historical landfill which accepted inert, industrial, commercial, household waste and was operated by Surrey County Council. From EA information, this landfill was in operation between April 1967 and October 1981 with the licence issued in July 1978 and surrendered in March 1993.

2.26 Mercers South Quarry landfill is the subject of an Environmental Permit issued to J & J Franks Ltd for the use of waste in a deposit for recovery operation and is recorded at approximately 285m and 360m north east of the wider Nutfield site. The permits were issued in August 2015 and November 2017.

[AWAITING UPDATED INFORMAITON FROM THE ENVIRONMENT AGENCY]

2.27 The areas of historical activity including worked ground and potentially undisturbed ground together with areas of known landfilling and potential infilled land are shown on Figure 3. The 2013 reports of the intrusive site investigations carried out in 2011 and 2012 were separated into six different areas associated with the former land use as shown on Figure 3 with four areas (Areas C to F) wholly or partially located on the wider Nutfield Park site and two areas (Areas A and B) located to the west of the wider Nutfield Park site. The western area of the proposed development site is located partially in Areas C, the central area of the site is located along the southern

margins of Area E and the eastern area of the site is located in the south of Area F as shown on Figure 3.

Pollution Incidents

2.28 Based on the 2019 Envirocheck report there have been eight pollution incidents to controlled waters within 1km of the wider Nutfield Park site. The closest pollution incident was located approximately 210m north east of the wider Nutfield Park site for which the pollutant is classified as miscellaneous - unknown. Five pollution incidents including the pollution incident closest to the site are classified as Category 2 severity indicating a significant incident. Three of the pollution incidents are considered a Category 3 incident indicating a minor incident. Two of these pollution incidents involved pollutants described as oils – unknown, three are described as unknown sewage, two are described as miscellaneous – unknown and one is described as chemicals – unknown. ***[AWAITING UPDATED INFORMAITON FROM THE ENVIRONMENT AGENCY]***

3. Previous site investigation works

3.1 Nutfield Park Developments Limited has provided site investigation reports which were prepared for Envonik Degussa UK Holdings Limited in 2013. As detailed above, the site investigations were carried out between 2011 and 2012 over a wider former Laporte land ownership and separate reports were prepared for six different areas across the wider Nutfield Park site. Four areas (Areas C to F) are wholly or partially located on the wider Nutfield Park site and two areas (Areas A and B) are located to the west of the wider Nutfield Park site. Partial sections of Area C (Appendix D), Area E (Appendix E) and Area F (Appendix F) are included in the proposed development area as shown in Figure 3. The site investigations included the collection and analysis of soil samples and groundwater samples from made ground and underlying in situ strata. The areas of the previous site investigations are listed below for clarity.

On site/ the wider Nutfield Park site

- Area C – Former Gore Meadow Quarry/Landfill (central/southern area partly within the western area of the proposed development site) (Appendix D)
- Area D – Former Sand Pit (largely in northern area of the wider Nutfield Park site) (reference 1)
- Area E – Former Beechfield Quarry/Landfill (southern limit within the central area of the proposed development site) (Appendix E)
- Area F – Former Church Hill Quarry/Landfill (southern area within the eastern area of the proposed development site) (Appendix F)

Off site

- Area A - Former Park Quarry/Landfill (western area to the west of the proposed development site) (reference 2)
- Area B - Former North Cockley Quarry/Landfill (central western area to the west of the proposed development site) (reference 3)

- Southern part of North Cockley – Area B (southern part of the central western area to the west of the proposed development site) (reference 4)

3.2 Site observations presented in the 2013 reports from the 2011/2012 site investigations over the area of the proposed development the subject of the 2023 site investigation are summarised in this section of the report together with relevant results from soil and groundwater testing. A summary of the former and proposed land uses at the 2011/2012 site investigation locations over the area of the proposed development is presented in Table 1.

Site observations

Western area

3.3 During the 2011/2012 site investigations in Area C 12 window sample boreholes (WS201 to WS212) were drilled and two monitoring boreholes (BH21 and BH22) were installed across the western area of the site. There was no access to the field in the south eastern corner of the western area of the site during the Area C site investigations in 2011/2012. The site investigation locations in the western area are shown on Figures 4 and 5.

3.4 Based on the 2013 SI report, made ground was recorded in the western area of the site in Area C at locations WS201 to WS203 and WS210 in proximity to former Cockley Works buildings (Figure 3) at thicknesses between 1.1m to 2.4m albeit that the full thickness was not proved at WS202 and WS203. The made ground comprises brown and grey brown sandy clay interpreted as reworked Sandgate Formation with variable proportions of gravel of sandstone, flint and occasional brick and concrete. A thin band of soft yellow silty clay was recorded at WS201 in the south of the former Cockley Works interpreted in the 2013 report as sludges derived from the Fuller's Earth processing operations and deposited within lagoon areas. More extensive deposits of these yellow clays were recorded to the east of Area C in the south of the Former Beechfield Quarry/Landfill (Area E). Made Ground strata were observed to be generally absent in the south and east of Area C and natural strata were exposed near surface levels.

3.5 The natural topsoil of brown clayey sand and sandy clay with rootlets was recorded in the western area of the site in Area C at locations WS205 to WS207 in the north east, BH21 in the east and BH22 in the south west. The topsoil and reworked sandy clay made ground is underlain by natural ground of very stiff sand/very sandy clay with sandstone gravel and dense clayey/silty fine to medium sand interpreted in the 2013 reports as weathered and partially weathered Sandgate Formation.

3.6 No groundwater was recorded in window sample boreholes WS201 to WS212 were or monitoring boreholes BH21 and BH22 during drilling of the boreholes in the 2011/2012 site investigation. Of the 17 groundwater level monitoring occasions reported in the 2013 reports borehole BH21 was dry on 9 occasions and borehole BH22 was dry on 12 occasions. When groundwater levels were recorded in the boreholes they ranged from 2.9mbgl (110.5mAOD) to 0.7mbgl (112.7mAOD) at borehole BH21 in the east and from 6.8mbgl (115.5mAOD) to 6.5mbgl (115.8mAOD) in borehole BH22 in the south west. Boreholes BH21 and BH22 are recorded to be installed in the Sandgate Formation.

Central area

3.7 During the 2011/2012 site investigation in Areas E and F 7 window sample boreholes (WS213 to WS215 and WS226 to WS230) were drilled in the vicinity of the central area of the site. The site investigation locations in the central area are shown on Figures 4 and 6.

3.8 Based on the 2013 SI report, the made ground in the central area of the site in the south of Area E and south west of Area F comprises light grey and dark grey brown, orange brown and brown sandy clay with gravel and cobbles comprising predominantly sandstone, some brick, clinker and flint and occasional fragments of hessian and metal. The made ground was between 1.2m and 4.5m thick. Ash and clinker deposits of 1.2m and 1m thick were recorded beneath 0.8m and 0.7m of the sandy clay made ground at WS229 and WS230 respectively. 1.3m of soft yellow silty clay was recorded beneath the ash and clinker at WS230. The full thickness of made ground was not proved at WS229 and WS230. WS229 is adjacent to the mid-section of the proposed haul road between the former Park Works in the south and a former

silt lagoon to the north. WS230 is located in the area of proposed residential development in the east of the central area of the site in the vicinity of the former Park Works. As in Area C, the soft yellow silty clay recorded at WS230 is interpreted in the 2013 report as sludges derived from the Fuller's Earth processing operations and deposited within lagoon areas. 4.6m of soft yellowish orange occasionally laminate clay was recorded at WS227 to the north of the central area of the site and 1.8m of soft yellow brown silty clay was recorded at WS215 also to the north of the central area of the site interpreted as the more extensive deposits of these yellow clays in the south of the former Beechfield Quarry/Landfill in Area E. The full thickness of made ground was not proved at WS215.

3.9 The made ground is underlain by pale grey and brown silty clay, sandy clay and clayey sand with some sandstone and chert and occasional nodules of hard grey clay interpreted in the 2013 reports as weathered and partially weathered Sandgate Formation.

3.10 No groundwater was recorded in window sample boreholes WS213 to WS215 and WS226 to WS230 during drilling of the boreholes in the 2011/2012 site investigation.

3.11 Borehole BH21 is installed in the Sandgate Formation to the south west of the central area of the site. No groundwater was recorded in borehole BH21 during drilling. Of the 17 groundwater level monitoring occasions reported in the 2013 reports borehole BH21 was dry on 9 occasions. When groundwater levels were recorded in the borehole they ranged from 2.9mbgl (110.5mAOD) to 0.7mbgl (112.7mAOD) at borehole BH21. Borehole BH28 is installed in made ground comprising layers of orange clayey silt and sandy clay to the north east of the central area of the site with natural ground recorded beneath the installation depth comprising sand with clay bands at approximately 111.1mAOD. No groundwater was recorded in borehole BH28 during drilling. Of the 14 groundwater level monitoring occasions reported in the 2013 reports borehole BH28 was dry on 6 occasions. When groundwater levels were recorded in the borehole they ranged from 9.7mbgl (111.6mAOD) to 9.2mbgl (112.1mAOD) at borehole BH28 in sandy clay including occasional pockets of ash and brick and sandstone gravel.

Eastern area

3.12 During the 2011-2012 site investigation in Area F 7 window sample boreholes (WS42, WS43 and WS231 to WS235) were drilled in the vicinity of the eastern area of the site. The site investigation locations in the central area are shown on Figures 4 and 7.

3.13 Based on the 2013 SI report, no made ground was recorded round the perimeter of the eastern area in the south of Area F at WS231 to WS234. 0.6m of ash and clinker were recorded over cobbles of brick and sandstone at WS235 in the north east of the eastern area in an area of proposed retained woodland and potentially infilled land. Made ground was recorded in the central part of the eastern area of the site in the south of Area F at WS42 and WS43 comprising sandy and clayey topsoil underlain by a layer of very stiff to stiff brown and grey sandy clay with occasional sandstone gravel. The sandy clay is underlain by a clayey silty sand and gravel layer including a layer of brick, ash and clinker at WS43. The sand gravel layer is underlain by firm bright yellow silt which is 0.3m thick at WS42 and a minimum of 1.7m thick at WS43. The yellow silt is underlain by slightly sandy clay with occasional rubber fragments at WS42. The full thickness of made ground was not proved at WS42 and WS43. WS42 and WS43 are located adjacent to the proposed care centre and GP surgery in an area of former excavation or possible former excavation. The yellow silt is interpreted in the 2013 report as sludges derived from the Fuller's Earth processing operations and deposited within lagoon areas. More extensive deposits of these yellow clays were recorded in the south of the Former Beechfield Quarry/Landfill (Area E) as well as an area of the former Church Hill Quarry/Landfill to the north of the eastern area of the site.

3.14 The natural ground recorded at locations WS231 to WS234 in the eastern area of the site from ground level comprises brown sandy clay with occasional sandstone nodules of hard grey clay and hard grey sandstone bands. The natural ground in the eastern area of the site is interpreted in the 2013 reports as weathered and partially weathered Sandgate Formation. WS231 to WS234 are located round the periphery of the proposed built development in the eastern area of the site in areas of proposed

retained woodland. WS231, WS233 and WS234 are in area of potentially infilled land or former industrial works. WS235 is in an area of probable undisturbed ground.

3.15 No groundwater was recorded in window sample boreholes WS42, WS43 and WS231 to WS235 during drilling of the boreholes in the 2011/2012 site investigation.

3.16 Borehole BH28 is installed in made ground comprising layers of orange clayey silt and sandy clay to the north west of the eastern area of the site with natural ground recorded beneath the installation depth comprising sand with clay bands at approximately 111.1mAOD. No groundwater was recorded in borehole BH28 during drilling. Of the 14 groundwater level monitoring occasions reported in the 2013 reports borehole BH28 was dry on 6 occasions. When groundwater levels were recorded in the borehole they ranged from 9.7mbgl (111.6mAOD) to 9.2mbgl (112.1mAOD) at borehole BH28 in sandy clay including occasional pockets of ash and brick and sandstone gravel. Borehole BH29 is installed in made ground comprising predominantly orange clayey silt to the north east of the eastern area of the site with natural ground recorded beneath the installation depth comprising silty sand with clay bands at approximately 109.25mAOD. No groundwater was recorded in borehole BH29 during drilling. Of the 16 groundwater level monitoring occasions reported in the 2013 reports borehole BH28 was dry on 10 occasions. When groundwater levels were recorded in the borehole they ranged from 7.15mbgl (111.7mAOD) to 5.5mbgl (113.3mAOD) at borehole BH29 in the orange clayey silt.

Soil sample analyses

3.17 The results of the laboratory analysis of the soil from the 2011/2012 site investigation are summarised in the 2013 reports at Appendices D, E and F. A summary of the results of the 2011/2012 soil chemical analysis for the area of the proposed development is presented in Table 2. In general the results from the 2011/2012 soil analyses were below relevant Generic Assessment Criteria (GAC) value for residential land use with homegrown produce with the exception of the metal arsenic in the western, central and eastern areas of the proposed development and benzo(a)pyrene in the western and central areas of the site. Further information on GAC are presented in section 6 of this report.

3.18 Arsenic exceeded the GAC at discrete locations across the western area of the site including in clayey sand made ground, topsoil and natural strata. Arsenic exceeded the GAC at numerous locations across the central area of the site including in sandy clay made ground, ash and clinker made ground and natural strata. Arsenic exceeded the GAC at discrete locations across the eastern area of the site in natural strata only.

3.19 Benzo(a)pyrene exceeded the GAC in the western area of the site in sandy clay made ground at locations WS203 and WS210 in the central western area of the former Cockley Works and in the topsoil at location WS208 to the east of WS203 and WS210 in an area recorded as natural ground. Benzo(a)pyrene was recorded at concentrations below the GAC in topsoil, made ground and natural ground across the majority of the western area of the site. Benzo(a)pyrene exceeded the GAC in the central area of the site in sandy clay made ground at locations WS213 and WS214 in the central western area of the former Park Works in the south east of the central area. Benzo(a)pyrene was recorded at concentrations below the GAC in made ground and natural ground at numerous locations across and in the vicinity of the central area of the site.

Groundwater sample analyses

3.20 The results of the laboratory analysis of the groundwater from the 2011/2012 site investigation are summarised in the 2013 reports at Appendices D, E and F. Groundwater quality data is available for borehole BH21 located in the east of the western area of the site only with all other data for boreholes outside of the site on the wider Nutfield Park site. Data is available for February and December 2012 only. The concentrations of metals tested in the groundwater at borehole BH21 have been recorded below the respective guideline values where available with the exception of selenium in February 2012 and zinc in December 2012. The exceedance of the UK drinking water standards (UKDWS) for selenium and the freshwater Environmental Quality Standard (EQS) for zinc were marginal. All other parameters were either below respective guideline values or not recorded above the limit of detection of the analytical methods used including but not limited to volatile and semi-volatile organic compounds, polychlorinated biphenyls, total petroleum hydrocarbons, polycyclic

aromatic hydrocarbons, phenols, pH, cyanide, ammoniacal nitrogen, sulphate and chloride.

3.21 Groundwater quality data is available for borehole BH29 installed in made ground comprising predominantly orange clayey silt to the north east of the eastern area of the site for December 2012. As areas of orange clayey silt are present at the site groundwater quality at this borehole has been reviewed. The concentrations of metals tested in the groundwater at borehole BH29 have been recorded below the respective guideline values where available with the exception of lead and zinc. The exceedance of the freshwater EQS for zinc was marginal. The concentration of lead of 0.021mg/l was approximately double the UKDWS of 0.010mg/l. The electrical conductivity value of 2,630µS/cm and the sulphate concentration of 2,140mg/l both exceeded the UKDWS of 1500µS/cm and 250mg/l respectively. All other parameters were either below respective guideline values or not recorded above the limit of detection of the analytical methods used.

Gas monitoring

3.22 The results of gas monitoring in the 2011/2012 boreholes are presented in the 2013 reports at Appendices D, E and F. Site gas flows (Qhgs) have been calculated for methane and carbon dioxide for monitoring data from 2011, 2012 and 2013 based on the methodology specified in British Standard guidance BS8485:2015 + A1:2019. The Qhgs is calculated using the equation (British Standard BS8485 section 6.3.4), Qhgs = q (C_{hg}/100) where:

- q is the measured flow rate (in litres per hour) of the gases from the monitoring borehole.

- C_{hg} is the measured hazardous gas concentration (in percentage volume/volume).

The results for boreholes at and in proximity to the site in Areas C (former Gore Meadow Quarry/Landfill), E (former Beechfield Quarry/Landfill) and F (former Church Hill Quarry/Landfill) together with borehole BH5 in the south of Area B (southern part of North Cockley) are summarised in the table below. The locations of the boreholes

are shown on Figure 4. Between 13 and 17 monitoring visits were carried out from 2011 to 2013 at each location over a range of atmospheric pressure conditions from 980mbars to 1022mbars.

Monitoring location	Methane (%v/v) - CH4 (min/max)	Carbon dioxide (%v/v) - CO2 (min/max)	Flow rate (l/hr) (min/max)	Hazardous gas flow (Qhgs) (l/hr) - CH4 (min/max)	Hazardous gas flow (Qhgs) (l/hr) - CO2 (min/max)
Area B - Former North Cockley Quarry/Landfill to the west of the site					
BH5	0.0/44.4	0.0/13.3	-1.7/1.2	0.00/0.01	-0.07/0.03
Area C – Former Gore Meadow Quarry/Landfill to the north and west of the western area of the site					
BH8	0.0/38.5	0.0/24.0	-4.8/6.5	0.00/1.15	0.00/0.77
BH9	0.0/60.2	0.0/40.0	-2.6/5.5	0.00/3.26	0.00/1.46
Area C - In south west and east of the western area of the site					
BH21	0.0	0.0/4.1	-15.5/0.4	0.00	-0.28/0.02
BH22	0.0	0.0/6.0	-12.4/22.2	0.00	-0.04/0.36
Area E - Former Beechfield Quarry/Landfill to the north of the central area of the site					
BH10	0.0	0.0/2.1	-2.3/0.4	0.00	-0.03/0.00
BH11	0.0/0.2	0.0/8.8	-0.5/0.7	0.00	-0.03/0.01
Area F – Former Church Hill Quarry/Landfill to the north of the eastern area of the site					
BH27	0.0/0.5	0.0/1.4	0.00	0.00	0.00
BH28	0.0	0.1/3.2	-0.2/0.0	0.00	0.00
BH29	0.0	0.0/0.3	-0.2/1.0	0.00	0.00
BH30	0.0	0.0/1.2	-0.3/0.0	0.00	0.00

4. 2023 Site investigation works

4.1 An intrusive site investigation including soil sampling was undertaken by MJCA between 27 February and 3 March 2023. The site was revisited in March, April and May 2023 to collect groundwater samples and monitor groundwater levels and ground gas concentrations. The results of the soil testing are presented in section 6 of this report. The monitoring is reported in section 5 of this report. The scope of the site investigation works comprises the following:

- The excavation and backfilling of 13 trial pits (TP100 to TP112) across the site using a backhoe excavator to depths of between 1.91m below ground level (bgl) and 4.36mbgl with the depth excavated depending on ground conditions and stability of the trial pits. Trial pits TP104 to TP106 and TP112 in the east and central north of the western area of the site were located in the areas of underlying natural strata. Made ground was recorded in all other areas of the site comprising former industrial works, former or possible former excavation works and potentially infilled ground.

- The drilling and installation of 13 boreholes (BH1001, BH1002, BH1004 and BH1006 to BH1015) located across the site to depths of between 1.8mbgl and 5mbgl with the depth drilled depending on ground conditions. The boreholes were drilled using a dynamic sampling rig to facilitate the sampling of soil, in-situ ground testing and the installation of monitoring boreholes

- Installation of monitoring well facilities at all of the borehole locations to facilitate the monitoring of landfill gas and the monitoring and sampling of groundwater where encountered. The monitoring well facilities comprise the installation of 50mm diameter standpipes.

- Performance of in-situ standard penetration tests (SPTs) during the dynamic sampling drilling.

4.2 The locations of the trial pits and boreholes are presented on Figures 4 to 7. The trial pit and borehole locations were positioned across the site to provide spatial coverage to include the variation in the ground conditions based on historical land use

conditions and the areas of proposed development. There were environmental constraints limiting the coverage of site investigation locations as indicated on Figures 5 to 7 with the constraints principally being ecological. A copy of the environmental constraints plan is provided at Appendix G. In addition, the site investigation locations were constrained by an overhead electricity cable crosses the western area of the site that becomes buried in the central area of the site before remerging as overhead cables in the east of the central area of the site and continuing to the north of the eastern area of the site. The site investigation locations in proximity to the cable were selected at a safe distance from the cable route. The trial pit logs are presented at Appendix H and photographs of the trial pits are presented in Appendix I. The borehole logs are presented in Appendix J.

Borehole drilling

4.3 CC Ground Investigations Limited were commissioned by MJCA to carry out the borehole drilling using a track mounted dynamic sampling rig (Dando Terrier). The drilling works were supervised by MJCA. Prior to drilling the boreholes, inspection pits were excavated by hand to a depth of approximately 1.2mbgl at all borehole locations. Boreholes BH1001, BH1002, BH1004 and BH1006 to BH1015 were drilled into made ground terminating at 5mbgl or where ground conditions prevented drilling to 5mbgl. Proposed borehole BH1003 was replaced with trial pit TP100. Borehole BH1005 in the west of the western area of the site was attempted twice with drilling abandoned at this location as the ground could not be penetrated deeper than 0.5mbgl at BH1005A and BH1005B where clay was recorded above sand with frequent angular cobbles of grey sandstone. Borehole BH1016 in the central area of the site was attempted once with drilling abandoned at this location as the ground could not be penetrated deeper than 0.65mbgl where made ground was recorded above brick.

4.4 Borehole BH1002 in the south of the western area of the site was attempted twice before being drilled at its current location as the ground could not be penetrated deeper than 0.4mbgl at BH1002A and BH1002B in close proximity to BH1002. The upper 0.4m in BH1002A and BH1002B comprised brown soft slightly sandy clay with frequent cobbles and boulders of grey sandstone which impeded the progress of the

inspection pit. Borehole BH1013 in the east of the central area of the site was attempted once before being drilled at its current location as the ground could not be penetrated deeper than 1.7mbgl at BH1013A where made ground was recorded above concrete. BH1016 was drilled after BH1013 and was an attempt to drill a borehole closer to the original proposed location for BH1013. BH1016 was abandoned as the ground could not be penetrated deeper than 0.65mbgl where made ground was recorded above brick.

Monitoring borehole installation

4.5 Monitoring standpipes were installed in all of the boreholes to facilitate groundwater and ground gas monitoring. Slotted high density polyethylene (HDPE) pipe with a 50mm inside diameter (ID) was installed in each monitoring borehole. The slotted section of pipe installed in the boreholes were between 1.0m and 4.0m. The length of slotted section was subject to the type of ground conditions and the depth of borehole. Plain 50mm ID HDPE pipe was installed from the top of the slotted pipe to above ground level. The monitoring standpipes were fitted at the base with end caps and at the top with gas tight caps with gas taps. The depths to the base of the slotted and plain pipe for each borehole are recorded on the borehole logs presented at Appendix J.

4.6 At each borehole the annulus between the standpipe and the borehole was backfilled with a gravel filter pack from the base of the slotted section of pipe in the base of the borehole to approximately 0.1m above the top of the slotted pipe. Above the gravel adjacent to the plain pipe a bentonite seal was placed in the borehole annulus comprising bentonite pellets hydrated with clean water to 0.3m below ground level. Raised lockage steel headworks were installed around the standpipe and concreted in place to approximately 0.5m above ground level. The standpipe was fitted with a gas tight cap with integral gas tap. Details of the backfilling for each individual borehole is presented in the logs at Appendix J. The abandoned borehole locations were backfilled with borehole arisings.

Trial pit excavation

4.7 Thirteen trial pits were excavated at the site to depths of between 1.91mbgl and 4.36mbgl using a Caterpillar 311C U track mounted excavator. On completion of sampling and logging of the trial pits, the arisings from the trial pits were placed back in the trial pits and any excess spoil was placed in a mound above the trial pit. The locations of the trial pits are shown on Figures 4 to 7. The trial pit logs are presented at Appendix H and photographs of the trial pits are presented in Appendix I.

Sample acquisition

Soils

4.8 Selected samples of soil were taken at each borehole and trial pits and boreholes during the site investigation based on visual appearance and observations of potential contaminants and made ground. Where materials with potential contamination were not observed samples were taken of different made ground materials and some probable natural ground across the site to get an overview of the site. A total of 28 soil samples, 22 of made ground and 6 probable natural ground, were analysed for extractable petroleum hydrocarbons (EPH), polycyclic aromatic hydrocarbons (PAH), speciated phenols, a suite of metals (arsenic, barium, beryllium, boron (water soluble) cadmium, chromium including hexavalent chromium, copper, lead, mercury, nickel, selenium, vanadium and zinc), pH, total organic carbon (TOC), total cyanide, sulphate and sulphide. Screening for asbestos containing materials (ACM) was carried out on all samples. Volatile and semi-volatile organic compounds (VOC and SVOC) including tentatively identified compounds (TICs) and polychlorinated biphenyls (PCB) analyses were carried out on 7 samples of made ground selected based on visual inspection of suspected contaminants.

4.9 A soil sample from each of boreholes BH1001, BH1002, BH1004 and BH1006 to BH1015 was collected and submitted to a geotechnical laboratory for soil classification tests including moisture content, liquid limits, plastic limits and plasticity index together with Atterberg classifications. The samples were selected from cohesive materials between depths of 0mbgl and 4mbgl.

4.10 All samples were placed in clean containers provided by the laboratory suitable for the analyses specified. The sample containers were transferred directly into temperature controlled containers for onward transportation and submission to an independent accredited laboratory. Chain of custody documentation was maintained to record the details of the samples and the analytical suites to fulfil quality assurance/quality control (QA/QC) requirements.

Groundwater

4.11 Groundwater monitoring standpipes were installed at all 13 borehole locations. The monitoring borehole installation details are shown on the borehole logs presented at Appendix J.

4.12 Groundwater level monitoring was undertaken on 7 and 8 March 2023 in both the accessible boreholes installed in 2011/2012 and the 2023 boreholes. Groundwater level monitoring was undertaken on 27 April and 1 June 2023 in a selection of the 2011/2012 boreholes and the all of the 2023 boreholes. A total of 4 samples of groundwater were collected in March and April where there was sufficient volume of liquid in the boreholes and the samples were submitted for chemical testing. The groundwater samples were analysed for volatile and semi-volatile organic compounds (VOC and SVOC) including tentatively identified compounds (TICs), polychlorinated biphenyls (PCB), total petroleum hydrocarbons by criteria working group method (TPH-CWG), speciated phenols, a suite of metals (arsenic, barium, beryllium, boron, cadmium, chromium including hexavalent chromium, copper, lead, mercury, nickel, selenium, vanadium and zinc), pH, total cyanide, ammoniacal nitrogen, sulphate and sulphide.

4.13 All samples were placed in clean containers provided by the laboratory suitable for the analyses specified. The sample containers were transferred directly into temperature controlled containers for onward transportation and submission to an independent accredited laboratory. Chain of custody documentation was maintained to record the details of the samples and the analytical suites to fulfil quality assurance/quality control (QA/QC) requirements.

Ground observations

4.14 The site investigation was supervised by suitably qualified and experienced MJCA consultants. The arisings from the trial pits and boreholes were examined visually and logged in general accordance with BS 5930:2015 + A1:2020 Code of Practise for Ground Investigations. The trial pit logs are presented in Appendix H and photographs of the trial pits are presented in Appendix I. The borehole logs are presented in Appendix J. The ground conditions encountered are summarised below. A summary of the former and proposed land uses at the 2023 site investigation locations is presented in Table 1. A summary of the made ground thicknesses recorded at the 2023 site investigation locations is presented in Table 3.

Western area

4.15 The site investigation in the western area of the site consisted of the drilling of boreholes BH1001, BH1002, BH1004, BH1006, BH1007, BH1008, BH1009 and the excavation of trial pits TP100, TP101, TP102, TP103, TP104, TP105, TP106 and TP112. The site investigation locations in the western area of the site are shown on Figure 5 compared with historical land use and the proposes development. Based on the borehole and trial pit logs, the western area of the site is generally underlain by made ground comprising sandy clay with varying amounts of sand, gravel and cobbles of sandstone interpreted as reworked Sandgate Formation. At various locations across the western area the made ground includes occasional mudstone, brick, chalk, coal, grey silt/ clay, organic clay, black clay with hydrocarbon odours, orange clay/ silt and rare wood. Made ground was generally absent in the east and central north of the western area of the site.

4.16 Site investigation locations BH1001, BH1002, BH1004, TP100, TP101, TP102 and TP103 are located in areas of proposed residential development and in the area of the former Cockley Works in the southern half of the western area of the site. The made ground is approximately 1m thick in trial pits TP101 and TP102 in the north and east respectively of this area of the site with inclusions of soft bright orange silt and firm dark grey clay at trial pit TP101 and brick fragments and occasional grey clay at TP102. The made ground is between approximately 2.5m and 4m thick in the

remaining locations in this area of the site with the base of the made ground unproven at 4m in borehole BH1002 and at 4.36m in trial pit TP103 adjacent to BH1002.

4.17 A 2.21m thick layer of firm blackish grey clay with a hydrocarbon odour was recorded at 1.54mbgl to 3.75mbgl in trial pit TP103 with occasional black cohesive materials recorded above and below this level. The made ground above this layer included brick fragments. Borehole BH1002 was positioned adjacent to trial pit TP103 to pick up the black clay layer in a monitoring borehole. A 0.1m thick layer of firm black clay with a hydrocarbon odour was recorded at 2.35mbgl to 2.45mbgl in borehole BH1002 only. A 0.6m layer of firm dark black to grey clay with frequent coal and back organic streaking is recorded between 0.9mbgl and 1.5mbgl in borehole BH1002 with frequent black organic deposits as well as red iron staining on some of the sandstone cobbles and orange/grey granular materials recorded above this level. No hydrocarbon odour was recorded at this level. A 0.31m layer of black to blueish grey clay with occasional coal and a hydrocarbon odour was recorded at 1.55mbgl to 1.86mbgl in trial pit TP100 with black cohesive materials recorded above this level. Trial pit TP100 is located in the west approximately 125m north west of TP103 and BH1002. The black clay layer was not recorded elsewhere across the western area of the site.

4.18 A 0.47m thick layer of bright orange silt with frequent inclusions of coal with sections of waxy orange silt with red staining was recorded at 2.48mbgl to 2.95mbgl in trial pit TP100 with bright orange silt and coal inclusions recorded above this level. The base of the of bright orange silt was not proved at TP100. Other than at trial pit TP101 the orange silt was not recorded elsewhere across the southern half of the western area of the site. Consistent with the 2013 reports, it is considered that the orange silt is sludges derived from the Fuller's Earth processing operations and deposited within lagoon areas.

4.19 The made ground in borehole BH1001 in the south west of the site generally comprised the sandy clay with varying amounts of sand, gravel and cobbles of sandstone. Fragments of brick were recorded in the top 1m of the borehole with red iron staining recorded on some of the sandstone cobbles between 1.8mbgl and

2.3mbgl and orange/grey granular materials in the clay at various depths within the made ground.

4.20 In the northern half of the western area of the site made ground is recorded in boreholes BH1006 to BH1009 close to the presumed boundary between potentially undisturbed ground and the former Cockley Works at thicknesses between approximately 1.7m (BH1009) and 4.9m (BH1008). In general the made ground comprises the sandy clay with varying amounts of sand, gravel and cobbles of sandstone. Black organic deposits were recorded in the top of borehole BH1007 in the north east with orange granular materials and/or red staining on the sandstone gravel throughout the made ground up to approximately 2.8mbgl. The remainder of the made ground to approximately 3.5mbgl in borehole BH1007 comprises reworked Sandgate Formation. At borehole BH1008 in the central part of the northern half of the western area pale grey clayey silt is recorded between 2.2mbgl and 4.9mbgl with inclusions of a bright orange silt from 3.6mbgl to 4.9mbgl. A 0.1m layer of soft organic clay is recorded in the silt at 3.4mbgl. It is considered that the silt is derived from the Fuller's Earth processing operations. A soft to firm organic clay layer was recorded in borehole BH1009 in the north west from 0.6mbgl to the base of the made ground at 1.7mbgl with orange granular materials recorded in the top 0.7m.

4.21 The natural brown clayey and sandy topsoil with frequent to occasional rootlets and occasional gravel of sandstone and mudstone is recorded in the western area of the site at locations TP104 to TP106 and TP112 in the east and central north of the western area of the site. Trial pits TP104 to TP106 and TP112 are located in areas of proposed residential development in the western area of the site in areas of probable undisturbed ground. The natural topsoil is underlain by varying proportions of sand, silt and clay with sandstone and mudstone sand interpreted as weathered Sandgate Formation. The made ground across the rest of the western area of the site is underlain by natural ground comprising greenish grey sandy clay, grey medium grained sand and sandstone and brown and grey interbedded sandstone and mudstone interpreted as weathered and partially weathered Sandgate Formation.

4.22 A seepage of groundwater was recorded in the base of trial pit TP104 in the south east of the western area of the site. Slightly clayey silty sand was recorded in the

base of the trial pit at 1.91mbgl (approximately 121mAOD). No significant groundwater inflow was recorded at this location. A groundwater level at 2mbgl (approximately 109mAOD) was recorded in borehole BH1004 following completion of the borehole installation with the strata recorded as made ground of slightly clayey coarse sand with gravels of sandstone and clayey silt over sandstone of the Sandgate Formation at and below the groundwater level. The borehole was recorded as damp at 2mbgl during drilling. Groundwater was recorded flowing into trial pit TP105 from 1.85mbgl (approximately 104mAOD) as the trial pit was excavated in to a silty sand layer. Trial pit TP105 is located near the eastern boundary in the northern half of the western area of the site. Water entered the trial pit from the bottom up to approximately 1.85mbgl taking approximately 10 minutes to settle at this elevation in the trail pit.

4.23 A representative from EPG attended site during the site works and provided some observations noted in the western area of the site including old pipework with potential asbestos lagging inside and areas of Japanese knotweed.

Central area

4.24 The site investigation in the central area of the site consisted of the drilling of boreholes BH1010, BH1011, BH1012, BH1013 and the excavation of trial pits TP107 and TP108. The site investigation locations in the central area of the site are shown on Figure 6 compared with historical land use and the proposes development. Based on the borehole and trial pit logs, the central area of the site is generally underlain by made ground comprising sandy clay, silt and sand and gravel with varying amounts of each constituent and gravel of sandstone. At various locations across the central area of the site the made ground includes occasional gravel and/or cobbles of mudstone, coal, chalk, clinker and/or flint.

4.25 Site investigation locations BH1010, TP107 and TP108 are located in or close to the area of proposed residential development and in the area of former excavation or possible former excavation to the north east of the former Park Works in the east of the central area of the site. The made ground is recorded as between approximately 2.6m at TP107 and 5m thick at BH1010 albeit that the base of the made ground has

not been proven in any of the three site investigation locations in this area of the site. The sandy gravelly clay is underlain by approximately 0.5m of black sand and gravel of coal material with occasional cobbles of coal from 0.95mbgl to 1.43mbgl at TP107 and 1.22mbgl to 1.78mbgl at TP108. At borehole BH1010 frequent gravels of red sandstone, flint and clinker were recorded in a matrix of black sandy, slightly clayey, ash from 1mbgl to 1.45mbgl. The black coal sand and gravel at TP107 is underlain by 0.39m of a dark purplish brown sand and gravel with occasional cobbles of clinker and few cobbles of black shiny coal material.

4.26 Underlaying the black and purplish brown sand and gravel in trial pits TP107 and TP108 and borehole BH1010 is made ground comprising bright orange silt and clayey silt which displays both brittle and cohesive properties and is recorded as waxy or greasy. The orange silt was proved in the bottom 0.78m of trial pit TP107 to 2.6mbgl, the bottom 0.9m of trial pit TP108 to 2.68mbgl and the bottom 3.55m of borehole BH1010 to 5mbgl. The base of the orange silt was not proved in the east of the central area of the site. It is considered that the orange silt is sludges derived from the Fuller's Earth processing operations and deposited within lagoon areas. The silt deposits recorded in the east of the central area of the site may comprise part of the more extensive deposits recorded in the south of the Former Beechfield Quarry/Landfill (Area E) as well as an area of the former Church Hill Quarry/Landfill to the north east of the central area of the site.

4.27 Site investigation location BH1013 is located in an area of proposed residential development and in the area of the former Park Works in the east of the central area of the site. Borehole BH1013 is located in proximity to tanks shown in the former Park Works on the 1:2,500 scale historical maps from1896 until the works in no longer shown on the maps in 1992. The made ground at borehole BH1013 is 4.9m thick and comprises sandy clay with sandstone gravel with iron staining between 0.9mbgl and 3mbgl. The made ground comprises sand with occasional sandstone gravel from 3mbgl to 4.9mbgl.

4.28 Site investigation locations BH1011 and BH1012 are located in the central and western part of the central area of the site respectively along the route of the proposed link road between the western and eastern areas of the site and in the south of the

area of the former Fuller's Earth sludge lagoons in the south of the former Beechfield Quarry/Landfill (Area E). The made ground is recorded as a minimum 5m thick at boreholes BH1011 and BH1012 with the base of the made ground not proven at these locations.

4.29 The made ground at borehole BH1011 comprises bright orange silt with occasional organic material to 2m. Underlaying the bright orange silt the made ground comprises 1.2m of soft to firm brown sandy clays with frequent gravel of clinker, black coal and grey sandstone with occasional inclusions of the bright orange silt recorded above. The sandy clay is underlain by 0.2m of orange fine to medium sand which is in turn is underlain by 1.6m of stiff pale grey slightly clayey silt which is cohesive yet brittle. The base of the silt was not proved at BH1011. It is considered that the orange and grey silts are derived from the Fuller's Earth processing operations and comprise part of the former Fuller's Earth sludge lagoons in the south of the former Beechfield Quarry/Landfill (Area E).

4.30 The made ground at borehole BH1012 comprises 2m of firm brown sandy clays with frequent inclusions of bright orange silt, sandstone and chalk. The sandy clay becomes greenish grey below 2m to 2.7mbgl with gravels of sandstone and orange granular materials with iron staining. From 2.7mbgl the sandy clay becomes light brown to grey in colour with frequent sandstone gravel. Chalk gravel is recorded in the clay from 2.7mbgl to 3.8mbgl. From 4.5mbgl to approximately 4.8mbgl the sandy clay becomes grey mottled orange and more sandy grading into a grey/orange clayey sand with grey sandstone gravel to approximately 4.8mbgl. It is considered that borehole BH1012 is on the southern limits of the former Fuller's Earth sludge lagoons with limited Fuller's Earth processing materials proved in the borehole.

4.31 No groundwater strikes or seepages were recorded in boreholes BH1010, BH1011, BH1012 or trial pits BH1013, TP107 and TP108 in the central area of the site during the 2023 site investigation.

Eastern area

4.32 The site investigation in the eastern area of the site consisted of the drilling of boreholes BH1014 and BH1015 and the excavation of trial pits TP109, TP110 and

TP111. The site investigation locations in the eastern area of the site are shown on Figure 7 compared with historical land use and the proposes development. Based on the borehole and trial pit logs, the eastern area of the site is generally underlain by made ground comprising sandy clay, silt, sand and gravel with varying amounts of each constituent and gravel of sandstone. At various locations across the eastern area of the site the made ground includes occasional gravel of mudstone, coal, chalk, clinker and/or flint and inclusions of bright orange silt.

4.33 Site investigation locations BH1014 and TP109 are located in or adjacent to the proposed GP surgery and pharmacy and site investigation locations TP110 and TP111 are located adjacent to the proposed care centre. Site investigation locations BH1014, TP109, TP110 and TP111 are in an area of former excavation or possible former excavation in the central part of the eastern area of the site to the south and west of the former Fuller's Earth Works near the eastern boundary. The made ground is recorded as between approximately 4.1m and 5m thick at TP109 and BH1014 respectively in the west and between approximately 2.75m and 3.4m thick at TP110 and TP111 respectively in the centre and east albeit that the base of the made ground has not been proven in any of these four site investigation locations.

4.34 The made ground at TP109 and BH1014 in the west comprises yellowish brown silty clay and sandy silt/clay with gravel of grey sandstone to 2.25mbgl and 2.9mbgl respectively. Occasional coal gravel is recorded in the top 2m of BH1014 with occasion chalk beneath this level. In trial pit TP109 the sandy silt is underlain by 0.25m of black sand and gravel material with occasional cobbles including coal and ash followed by 0.5m of soft brown slightly clayey silty sand. The clay and sand in borehole BH1014 and trial pit TP109 is underlain at approximately 3mbgl by bright yellowish orange silt which displays both brittle and cohesive properties and is recorded as waxy or greasy. The orange silt includes gravels comprising coal and clinker clays in borehole BH1014. The orange silt made ground is recorded to the base of the trial pit and borehole at 4.1m and 5m at TP109 and BH1014 respectively.

4.35 The made ground at TP110 and TP111 in the centre and east comprises brown and black clayey silt, sand and gravel with gravel of coal, sandstone and mudstone to 1.72mbgl and 1.47mbgl respectively. A 0.13m black coal rich sand and gravel

horizon is recorded at 0.75mbgl in trial pit TP110 with similar thicknesses recorded at 0.57mbgl and 0.77mbgl in trial pit TP111. The silty sand in trial pit TP111 has inclusions of bright orange silt between 0.9mbgl and 1.47mbgl. The clayey silt, sand and gravel in trial pits TP110 and TP111 is underlain by bright yellowish orange silt which displays both brittle and cohesive properties and is recorded as waxy or greasy consistent with that recorded to the west at borehole BH1014 and trial pit TP109. The orange silt made ground is recorded to the base of the trial pits at 2.75m and 3.4m TP110 and TP111 respectively. The orange silt ranges in elevation from approximately 134mAOD to 131.5mAOD in site investigation locations BH1014, TP109, TP110 and TP111.

4.36 Site investigation location BH1015 located to the east of the proposed care centre in an area of proposed retained woodland and in an area of former Fuller's Earth Works near the eastern boundary. The made ground is recorded as 5m thick at BH1015 with the base of the made ground not proven at this location. The made ground at BH1015 in the comprises yellowish brown and grey sandy clay and clayey sand with varying amounts of gravel of sandstone, coal, clinker and/or flint to 1.5mbgl. The sandy clay is underlain by yellowish orange silt from 1.5mbgl to 2.9mbgl at the borehole. The orange silt is underlain by soft light brown to grey sandy clay to clayey sand with iron staining, frequent inclusions of a bright yellowish orange silt and occasional coal and sandstone gravels. The sandstone gravels are surrounded with red staining. The made ground is recorded to the base of the borehole 5m. The bright yellowish orange silt is recorded at the lower end of and lower than the elevations recorded to the west of borehole BH1015 with elevations from approximately 132mAOD and 130mAOD.

4.37 No groundwater strikes or seepages were recorded boreholes BH1014 and BH1015 and the excavation of trial pits TP109, TP110 and TP111 in the eastern area of the site during the 2023 site investigation.

5. Field testing and Monitoring

Groundwater monitoring

5.1 Groundwater monitoring was undertaken on 7 and 8 March, 27 April and 1 June 2023. The monitoring comprised measuring the depth to the groundwater if present at the installed monitoring boreholes from the 2023 site investigation and at select boreholes from the 2011/2012 site investigation. The results of the groundwater level monitoring are presented in Tables 4 and 5 and the locations of the boreholes are shown on Figures 4 to 7. Where samples were able to be recovered from the 2023 boreholes the samples were submitted to an independent laboratory for chemical analysis. Samples of the groundwater were collected from borehole BH1008 in March and from boreholes BH1002 and BH1009 in April. A sample was obtained in March 2023 from borehole BH28 which was installed during the 2011/2012 site investigation works as it was the closest accessible borehole from the 2011/2012 works to the site from which water could be sampled.

5.2 Groundwater was recorded in one out of the thirteen monitoring boreholes on 8 March 2023, in five boreholes on 27 April 2023 and nine boreholes on 1 June 2023. The groundwater elevation at borehole BH1008 in the central part of the northern half of the western area of the site was recorded between 106.90m above Ordnance Datum (AOD) in March 2023 and 108.9mAOD in April 2023 at elevations within the made ground at the borehole. Groundwater elevations of approximately 120.3mAOD, 100.23mAOD and 107.35mAOD were recorded at boreholes BH1002, BH1007 and BH1009 respectively in April 2023 within the made ground at the boreholes. Boreholes BH1002, BH1007 and BH1009 are located in the south, north east and north of the western area of the site respectively. Groundwater is recorded in the bottom 0.1m to 0.2m of borehole BH1001 in April 2023 and in boreholes BH1001, BH1002, BH1007, BH1009, BH1010, BH1012, BH1014 and BH1015 in June 2023. It is considered that these do not constitute records of significant groundwater present at these locations.

5.3 The results of the groundwater level monitoring in select boreholes from the 2011/2012 site investigation are included in Table 5. The water levels recorded in

borehole BH5, BH8 and BH9 are within waste in areas of landfill to the west and north of the western area of the site. No or little water were recorded in borehole BH5 and BH9 to the west and north respectively. The water level at 113.74mAOD and the base of the waste at 113.45mAOD recorded in BH8 are at elevations above ground level in the northern half of the western area of the site closest to the borehole. Ground levels and water levels, where recorded in the boreholes (BH10 to BH13, BH18, BH19 and BH23 to BH30) to the north of the central and eastern areas of the site and in the north of the wider Nutfield Park site are at elevations below the base of the boreholes in the central and eastern areas of the site.

5.4 It is considered that based on the limited amount of groundwater recorded across the site and the spatial variation in water levels where recorded during the monitoring visits, groundwater is unlikely to exist as a continuous groundwater body across the site at the elevations monitored. This is likely to be attributable to the variation in ground conditions observed at and in the vicinity of the site.

Ground gas monitoring

5.5 Ground gas monitoring was undertaken on 7 and 8 March, 27 April and 1 June 2023. The concentrations of methane, carbon dioxide and oxygen together with the atmospheric pressure and pressure differential and flow rate were monitored and recorded at the monitoring boreholes from the 2023 site investigation and at select boreholes from the 2011/2012 site investigation. The results of the ground gas monitoring are presented in Tables 6 and 7.

Gas monitoring at the 2023 site investigation borehole locations

5.6 In March 2023 an elevated concentration of methane of 9.2% by volume was recorded at borehole BH1002 in the south east of the western area of the site. Methane was not recorded above the detection limit of the gas analyser of <0.1% by volume in boreholes BH1006 and BH1012 in the north of the western area and the west of the central area of the site respectively. Methane was recorded in all other boreholes at 0.1% with the exception of borehole BH1007 in the north east of the western area of the site where a methane concentration of 0.2% was recorded.

Methane was not recorded above the detection limit of the gas analyser of <0.1% in any of the 2023 boreholes during the April or June monitoring visits.

5.7 The concentrations of carbon dioxide are more varied across the site with concentrations ranging from 8.7% by volume recorded at borehole BH1002 in the south east of the western area of the site in March 2023 to 0.1% recorded at BH1011 in the central area of the site April 2023. In general carbon dioxide concentrations are less than 5% by volume with the following exceptions:

- 8.7% at borehole BH1002 in the western area of the site and 5.5% at borehole BH1014 in the eastern area of the site in March 2023
- 6.8% at borehole BH1006 in the western area of the site and 6.7% at borehole BH1014 in the eastern area of the site in April 2023
- 6.7% at borehole BH1002 and 7.2% at borehole BH1006 in the western area of the site and 7.7% at borehole BH1014 in the eastern area of the site in June 2023

5.8 Hydrogen sulphide was not recorded in the 2023 boreholes above the detection limit of the gas monitoring equipment of 1ppm with the exception of at boreholes BH1008 and BH1009 in April 2023 and boreholes BH1002 and BH1009 in June 2023 in the western area of the site together with borehole BH1010 and BH1014 in the central and eastern area of the site respectively in June 2023. Where hydrogen sulphide concentrations were recorded the concentrations were at the detection limit of the gas monitoring equipment of 1ppm. Carbon monoxide was not recorded in the 2023 boreholes above the detection limit of the gas monitoring equipment of 1ppm with the exception of at boreholes BH1008 and BH1009 in the western area of the site in April 2023 when concentrations of 2ppm and 6ppm were recorded respectively.

5.9 The concentrations of oxygen ranged between 3.4% by volume at borehole BH1002 in June 2023 and 21.0% at borehole BH1011 in March 2022. In general oxygen concentrations are greater than 15% by volume with reduced oxygen concentrations generally associated with the higher carbon dioxide concentrations reported above in boreholes BH1002, BH1006 and BH1014.

5.10 Gas flow rates were recorded between no flow (0.0litre/hour (l/h)) at boreholes BH1006, BH1008 and BH1013 in June 2023 and 0.7l/h at BH1001 in March 2023. Average gas flow rates at the boreholes across the site over the three monitoring visits range from 0.53l/hr at borehole BH1001 to 0.27l/hr at borehole BH1006 in the western area of the site. All flow rates suggest that gas is unlikely to be actively produced at the site.

Gas monitoring at the 2011/2012 site investigation borehole locations

5.11 Elevated concentrations of methane were recorded in boreholes BH5 and BH9 in the waste in areas of landfill to the west and north of the western area of the site respectively at between 69.4% by volume in borehole BH5 in June 2023 and 83.7% by volume in borehole BH9 in April 2023. Elevated concentrations of carbon dioxide were recorded in boreholes BH5 and BH9 at between 18.0% and 27.5% by volume in borehole BH9 in April and March 2023 respectively. The concentrations of oxygen ranged from 0.2% by volume in borehole BH9 in March 2023 to 1.8% by volume in borehole BH5 in June 2023. Hydrogen sulphide concentrations were recorded at the detection limit of the gas monitoring equipment of 1ppm in borehole BH5 in June 2023 and in borehole BH9 in April 2023. Hydrogen sulphide was not recorded above the detection limit of the gas monitoring equipment of 1ppm in borehole BH9 in June 2023. Carbon monoxide was recorded at the detection limit of the gas monitoring equipment of 1ppm at borehole BH9 in April and June 2023 and at 2ppm at borehole BH5 in June 2023. Hydrogen sulphide and carbon monoxide were not monitored in March 2023. Gas flow rates between 0.3l/h and 0.6l/h were recorded in boreholes BH5 and BH9 between March and June 2023.

5.12 Of the boreholes monitored to the north of and in proximity to the central and eastern areas of the site (BH10, BH11, BH28 and BH29) methane concentrations either were not recorded above the detection limit of the gas analyser of <0.1% or were recorded at the detection limit of 0.1%. Carbon dioxide concentrations between 0.4% and 4.3% were recorded together with oxygen concentrations between 7.5% and 19.7%. Hydrogen sulphide and carbon monoxide were monitored at boreholes BH10 and BH28 to the north of the central and eastern areas of the site respectively in June 2023 when hydrogen sulphide was not recorded above the detection limit of the gas

monitoring equipment of 1ppm. Carbon monoxide was not recorded above the detection limit of the gas monitoring equipment of 1ppm at borehole BH28 and was recorded at the detection limit of the gas monitoring equipment of 1ppm at borehole BH10. Gas flow rates between 0.3l/h and 0.6l/h were recorded in boreholes BH10, BH11, BH28 and BH29 between March and June 2023.

Gas screening values

5.13 To assess whether the concentrations of methane or carbon dioxide have the potential to pose a hazard to the proposed development, a gas screening value (GSV) is calculated (reference 5). The GSV is calculated by multiplying the maximum gas concentration (as a mathematical form) by the maximum measured borehole flow rate (reference 6). GSV is comparable with the site gas flows (Qhgs) based on the methodology specified in British Standard guidance BS8485:2015 + A1:2019 calculated for monitoring data from 2011, 2012 and 2013 in the 2011/2012 boreholes presented in section 3 above.

On site - 2023 boreholes

5.14 The highest concentration of methane recorded in the 2023 boreholes at the site was a concentration of 9.2% (therefore a value of 0.092) at borehole BH1002 in March 2023 with a flow rate of 0.6l/hr results in a calculated GSV of 0.0552. All other calculated GSV for methane at the site are between 0 and 0.0012. The highest concentration of carbon dioxide was a concentration of 8.7% (therefore a value of 0.087) also recorded at borehole BH1002 in March 2023 with the flow rate of 0.6l/hr and therefore a calculated GSV of 0.0522. All other calculated GSV for carbon dioxide at the site are between 0 and 0.0335.

5.15 The calculated GSVs can be used to assess the ground gas regime at the development site within a specified 'characteristic situation'. Based on the results of the ground gas monitoring undertaken in March, April and June 2023 a GSV Characteristic Situation 1 (very low risk) for methane and carbon dioxide was calculated for the results at the monitoring boreholes at the site. The GSV Characteristic Situation values for the site were calculated as representing very low

risk as there is little gas flow and the recorded concentrations of methane and carbon dioxide are low.

5.16 As a concentration of methane of 9.2% by volume was recorded at borehole BH1002 in the south east of the western area of the site and carbon dioxide concentrations in excess of 5% have been recorded at boreholes BH1002 and BH1006 in the western area of the site and at borehole BH1014 in the eastern area of the site it is recommended that further monitoring is carried out to assess whether the areas of the site local to these boreholes should be upgraded to Characteristic Situation 2 (low risk).

Off site - 2011/2012 boreholes

5.17 The highest concentration of methane recorded in the 2011/2012 boreholes was a concentration of 83.7% (therefore a value of 0.837) at borehole BH9 in April 2023 with a flow rate of 0.3l/hr results in a calculated GSV of 0.2511. The calculated GSV for methane at borehole BH9 is higher in March 2023 when the methane concentration is lower at 71.9% but the flow rate is higher at 0.6l/hr giving a GSV of 0.4314. The highest concentration of carbon dioxide was a concentration of 27.5% (therefore a value of 0.275) recorded at borehole BH9 in March 2023 with the flow rate of 0.6l/hr and therefore a calculated GSV of 0.1650. With the exception of the highest values reported above, boreholes BH5 and BH9 in the landfill to the north and west of the western area of the site had calculated GSV for methane of between 0.2082 and 0.2145 and for carbon dioxide of between 0.0540 and 0.0675. At the remaining select boreholes from the 2011/2012 site investigation monitored in March, April and June 2023, calculated GSVs for methane are between 0 and 0.008 and for carbon dioxide are between 0.0016 and 0.038.

5.18 Based on the results of the ground gas monitoring undertaken in March, April and June 2023 a GSV Characteristic Situation 2 (low risk) for methane was calculated for the results at the monitoring boreholes in the former Gore Meadow Quarry/Landfill and North Cockley Quarry/Landfill to the north and west of the western area of the site at boreholes BH5 and BH9. A GSV Characteristic Situation 2 (low risk) for carbon dioxide was calculated for the result at monitoring borehole BH9 in March 2023 and

a GSV Characteristic Situation 1 (very low risk) for carbon dioxide for the remaining results from borehole BH9 and the results from borehole BH5 in the former Gore Meadow Quarry/Landfill and North Cockley Quarry/Landfill to the north and west of the western area of the site. The Characteristic Situation values are calculated as representing a low risk because there is little or no gas flow although the concentrations of methane and carbon dioxide are highly elevated in the area of the former Gore Meadow Quarry/Landfill and North Cockley Quarry/Landfill and consequently gas protection measures associated with Characteristic Situation 2 are unlikely to provide suitable mitigation measures.

5.19 Based on the results of the ground gas monitoring undertaken in March, April and June 2023 a GSV Characteristic Situation 1 (very low risk) for methane and carbon dioxide was calculated for the results at the monitoring boreholes in the former Beechfield Quarry/Landfill to the north of the central area of the site and in the former Church Hill Quarry/Landfill to the north of the eastern area of the site as well as in the former Sand Pit in north of the wider Nutfield Park site. The GSV Characteristic Situation values are calculated as representing a very low risk as there is little gas flow and the recorded concentrations of methane and carbon dioxide are low.

6. Chemical Analysis

Introduction

6.1 Chemical analyses of selected samples of soil and groundwater were submitted for chemical testing. The results of the soil chemical analysis from the 2023 site investigation are presented at Appendix K and summarised in Tables 8 to 10 and the results from the groundwater chemical analysis from the 2023 site investigation are presented at Appendix K and in Table 11.

Criteria for assessment of the chemical testing data

6.2 In accordance with UK statutory guidance including Part IIA of the Environmental Protection Act 1990 and based on the principles of risk assessment, MJCA undertakes assessments of chemical data from an intrusive investigation through a tiered approach. The first stage is a Generic Quantitative Risk Assessment (GQRA) comparing the analytical results against published guideline criteria on the potential risks from soil contamination to human health for residential and commercial land use. These include:-

- The Category 4 Screening Levels (C4SL) published in December 2013 by Contaminated Land: Applications in Real Environments (CL:AIRE) and released by Defra in March 2014 and SP1010 Erratum (December 2014) (reference 7).
- A set of generic assessment criteria referred to as ‘Suitable for use levels’ (S4ULs) produced by Land Quality Management Limited in partnership with The Chartered Institute of Environmental Health (CIEH) [LQM/CIEH S4ULs for Human Health Risk Assessment] (reference 8).
- Soil Generic Assessment Criteria (GAC) for Human Health Risk Assessment published by CL:AIRE in association with Environmental Industries Commission (EIC) and the Association of Geotechnical and Geoenvironmental Specialists (AGS) (reference 9)

6.3 The chemical results for soil testing have been compared with the generic assessment criteria (GAC) for residential land use with plant uptake (reference 7) or

with home grown produce (references 8 and 9). The soil guidelines focus on the potential risk from soil contamination to human health assessed against residential land use criteria.

6.4 The results of the chemical analysis of the groundwater samples have been assessed using published UK drinking water standards (UKDWS) where available or published Environmental Quality Standards (EQS) where drinking water guideline criteria are not available. This approach is for an initial screening of the results compared against UKDWS and EQS for the potential risks from groundwater contamination to human and ecological receptors.

Discussion of the analytical results for the soil samples

Western Area

6.5 Seventeen samples of soil were obtained from boreholes BH1001, BH1002, BH1004 and BH1006 to BH1009 and trial pits the excavation of trial pits TP100 to TP106 and TP112 in the western area of the site and submitted for chemical testing for EPH, PAH, speciated phenols, a suite of metals, pH, TOC, total cyanide, sulphate and sulphide together with screening for ACM. Three of these samples from each of borehole BH1002 (1.2m to 1.4m), trial pit TP100 (1.55m to 1.86m) and trial pit TP103 (1.54m to 3.75m) were submitted for additional testing for VOC and SVOC including TICs and PCB. Samples collected from borehole BH1002 (1.2m to 1.4m), trial pit TP100 (1.55m to 1.86m) and trial pit TP103 (1.54m to 3.75m) comprise made ground in areas where hydrocarbon odours were recorded in the southern half of the western area of the site in areas of proposed residential development and in the area of the former Cockley Works. The results of the soil chemical analysis for the western area of the site are summarised in Tables 8.

6.6 EPH was recorded below the detection level of <30mg/kg in fourteen out of the seventeen soil samples taken from the western area of the site. Samples taken from borehole BH1002 (2.30m to 2.45m) and trial pits TP100 (1.55m to 1.86m) and TP103 (1.54m to 3.75m) recorded EPH concentrations with values of 4003mg/kg, 149mg/kg and 166mg/kg respectively. Hydrocarbon odours were recorded in the horizons sampled at all three locations. The EPH at borehole BH1002 is interpreted as PAHs

and at trial pits TP100 and TP103 are interpreted as naturally occurring compounds by the analytical laboratory. All three samples were within the range of GACs for residential land use with home grown produce for EPH. The GAC for EPH are separated into different carbon bands which were not analysed in the samples from the site. The EPH at trial pits TP100 and TP103 should be investigated further to determine whether the relevant GACs have been exceeded. The EPH at BH1002 has been identified as PAH which was analysed in the soil samples and is reported below.

6.7 Total PAH was recorded below the detection limit of <0.6mg/kg in thirteen of the seventeen soil samples taken from the western area of the site. Soil samples taken from trial pits TP100 (1.55m to 1.86m), TP101 (0.89m to 2.65m) and TP103 (1.54m to 3.75m) recorded values of total PAH of 2.5mg/kg, 1.4mg/kg and 1.2mg/kg respectively. The soil sample taken from borehole BH1002 (2.30m to 2.45m) recorded a value of total PAH of 298.9mg/kg from the very black slightly sandy clay with a strong hydrocarbon odour. Six of the 16 PAHs analysed have been recorded above the GAC for residential land use with home grown produce at borehole BH1002 (2.30m to 2.45m). The benzo(a)pyrene (BaP) concentration at borehole BH1002 is the highest concentration of the PAHs at 30.99mg/kg compared with the GAC for residential land use with home grown produce for BaP of 2.2mg/kg. For all other locations in the western area the concentrations of PAHs were below the respective GACs for residential land use with home grown produce.

6.8 Total speciated phenols were recorded below the detection limit of <0.15mg/kg in sixteen of the seventeen soil samples taken from the western area of the site. A total speciated phenols concentration of 0.44mg/kg was recorded in the soil sample taken from trial pit TP106 (0.34m to 0.71m). This value is significantly lower that the GAC for phenols of 280mg/kg.

6.9 None of the metals have values above the GAC for residential land use with home grown produce with the exception of arsenic and beryllium. Arsenic is recorded above the GAC for residential land use with home grown produce of 37mg/kg in samples from four boreholes. The samples with arsenic concentrations above the residential GAC were collected from boreholes BH1001 (50.3mg/kg at 1.8m to 2.5m)

and BH1002 (44.4mg/kg at 2.30m to 2.45m) in the far south and boreholes BH1007 (50.8mg/kg at 2.80m to 3.00m) and BH1009 (38.1mg/kg at 1.60m to 1.70m) in the far north of the western area. The samples were taken from the layers of sandy clay to clayey sand. The material at BH1001 comprises brownish sandy clay including sandstone gravels and cobbles which are stained red whereas BH1007 and BH1009 are from a brownish sandy clay only. The sample from borehole BH1002 was taken from a very black slightly sandy clay with a strong hydrocarbon odour. Beryllium is recorded above the GAC residential land use with home grown produce of 1.7mg/kg in samples collected from the majority of locations across the western area of the site with the exception of at borehole BH1004 and trial pits TP104, TP105 and TP112 along the eastern limits and in the deeper sample at trial pit TP100 (1.55m to 1.86m). The samples with beryllium concentrations above the residential GAC were taken from a range of made ground materials comprising sandy clay to clayey sand, sand and gravel as well as potential natural strata of sandy silty clay, sandstone and mudstone. Concentrations above the residential GAC range from 1.8mg/kg at BH1002 (1.2m to 1.4m) and BH1006 to 3mg/kg at borehole BH1008 comprising grey clayey silt.

6.10 The results of the pH analysis in soil samples from the western area have a range of between 5.99 and 8.57. In general the pH values are highest in samples from the west and lowest in samples from the north east of the western area of the site. TOC results in soil samples from the western area range between 0.11% and 6.7% with the maximum value recorded in the sample from borehole BH1002 (2.30m to 2.45m) comprising the very black slightly sandy clay with a strong tar odour.

6.11 Total cyanide was not recorded above the detection limit of <0.5mg/kg at all locations in the western area of the site except at trial pit TP103 (1.54m to 3.75m) where a concentration of 0.9mg/kg was recorded. Sulphide was not recorded above the detection limit of 10mg/kg at all locations in the western area of the site except at trial pit TP100 (1.55m to 1.86m) where a concentration of 17mg/kg was recorded. Asbestos was not detected in any of the soil samples from the western area of the site

6.12 VOCs, SVOCs and PCB were all recorded below the detection limits of the analytical methods in the three soil samples taken from borehole BH1002 (1.2m to 1.4m) and trial pits TP100 (1.55m to 1.86m) and TP103 (1.54m to 3.75m) submitted for additional testing with the exception of two SVOC TICs recorded in the sample from TP103 (Table 8).

Central Area

6.13 Five samples of soil were obtained from 4 boreholes BH1010, BH1011, BH1012 and BH1013 and 1 trial pit TP107 in the central area of the site and submitted for chemical testing for EPH, PAH, speciated phenols, a suite of metals, pH, TOC, total cyanide, sulphate and sulphide together with screening for ACM. The sample from borehole BH1011 (2.50m to 3.00m) was submitted for additional testing for VOC and SVOC including TICs and PCB. The soil sample collected from borehole BH1011 (2.50m to 3.00m) comprises made ground from the central area of the site along the route of the proposed link road between the western and eastern areas of the site and in the south of the area of the former Fuller's Earth sludge lagoons in the south of the former Beechfield Quarry/Landfill (Area E). The results of the soil chemical analysis for the central area of the site are summarised in Tables 9.

6.14 EPH was recorded below the detection level of <30mg/kg in four of the five soil samples from the central area of the site. An EPH concentration of 303mg/kg was recorded in the soil sample from borehole BH1011 (2.50m to 3.00m) comprising light brown slightly sandy slightly organic clay with clinker, sandstone gravel, coals and occasional inclusions of vibrant orange silt and black ash. The EPH at borehole BH1011 is interpreted as possible lubricating oil by the analytical laboratory. The EPH at borehole BH1011 is within the range of GACs for residential land use with home grown produce for EPH. The GAC for EPH are separated into different carbon bands which were not analysed in the samples from the site. The EPH at borehole BH1011 should be investigated further to determine whether the relevant GACs have been exceeded.

6.15 Total PAH 16 was recorded below the detection limit of <0.6mg/kg in two of the five soil samples with values of 0.9mg/kg, 1.6mg/kg and 1.1mg/kg recorded in the soil

samples from borehole BH1011 (2.50m to 3.00m), BH1012 (2.30m to 2.50m) and BH1013 (4.50m to 4.70m) respectively. None of the 16 PAHs analysed have been recorded above the respective GACs for residential land use with home grown produce in the central area of the site. Total speciated phenols were recorded below the detection limit of <0.15mg/kg in all five soil samples taken from the central area of the site.

6.16 None of the metals have values above the GAC for residential land use with home grown produce with the exception of arsenic and beryllium. Arsenic is recorded above the GAC for residential land with home grown produce of 37mg/kg in soil samples from three of the boreholes in the central area of the site. The samples with arsenic concentrations above the residential GAC were collected from boreholes BH1011 (2.50m to 3.00m) and BH1012 (2.30m to 2.50m) along the route of the proposed haul road and borehole BH1013 (4.50m to 4.70m) in an area of proposed residential development. The soil samples from boreholes BH1011 (2.50m to 3.00m) and BH1012 (2.30m to 2.50m) were collected from firm slightly sandy clays with clinker, coal and sandstone gravel and inclusions of bright orange silt. The soil sample from borehole BH1013 (4.50m to 4.70m) was collected from a sand made ground with occasional sandstone gravel. Beryllium is recorded above the GAC for residential land use with home grown produce of 1.7mg/kg in all samples collected from the central area of the site. Concentrations of beryllium range from 2.1mg/kg at borehole BH1013 (4.50m to 4.70m) to 4.4mg/kg at borehole BH1011 (2.50m to 3.00m).

6.17 The pH of the soil samples collected within the central area of the site ranges from 6.22 to 8.17. In general the pH values are highest in the area of proposed residential development in the east and lower along the route of the proposed haul road in the central and western parts of the central area of the site. TOC in soil samples from the central area range between 0.46% and 24.84% with the highest value recorded at trial pit TP107 (1.43m to 1.82m) in the black coal sand and gravel materials. The TOC in samples from boreholes BH1010 (1.50m to 1.70m) and BH1011 were recorded at 6.52% and 5.62% respectively with those recorded boreholes BH1012 and BH1013 below 1%. The sample from BH1010 was taken from the bright orange silt with black

ash. As detailed above, the sample at BH1011 was taken from firm slightly sandy clay with clinker, coal and sandstone gravel and inclusions of bright orange silt.

6.18 Total cyanide was not recorded above the detection limit of <0.5mg/kg and sulphide was not recorded above the detection limit of <10mg/kg in the soil samples from all locations in the central area of the site. Asbestos was not detected in any of the soil samples from the central area of the site.

6.19 VOCs and SVOCs including TICs and PCB were all recorded below the detection limits of the analytical methods in the sample taken from BH1011 (2.50m to 3.00m) submitted for additional testing.

Eastern Area

6.20 Six samples of soil were obtained from 2 boreholes BH1014 and BH1015 and 3 trial pits TP109, TP110 and TP111 in the eastern area of the site and submitted for chemical testing for EPH, PAH, speciated phenols, a suite of metals, pH, TOC, total cyanide, sulphate and sulphide together with screening for ACM. Three of these samples from each of borehole BH1015 (2.90m to 3.40m), trial pit TP109 (2.25m to 2.50m) and trial pit TP111 (1.47m to 3.40m) were submitted for additional testing for VOC and SVOC including TICs and PCB. Samples collected from trial pit TP109 (2.25m to 2.50m) and trial pit TP111 (1.47m to 3.40m) comprise made ground including coal materials and orange silt materials respectively in an area of former excavation or possible former excavation in the central part of the eastern area of the site. The sample collected from borehole BH1015 (2.90m to 3.40m) comprises made ground including bright yellowish orange silt and coal in an area of former Fuller's Earth Works near the eastern boundary. The eastern area of the site includes the proposed GP surgery and pharmacy and the proposed care centre as well as extra care units. The results of the soil chemical analysis for the eastern area of the site are summarised in Tables 10.

6.21 EPH was recorded below the detection limit of <30mg/kg in five of the six samples from the eastern area of the site. The sample taken from trial pit TP110 (0.88m to 1.36m) of clayey silty sand with coal and sandstone gravel recorded an EPH concentration of 39mg/kg. The EPH at trial pit TP110 could not be interpreted by the

analytical laboratory. The EPH at trial pit TP110 is at the lower end of the range of GACs for residential land use with home grown produce for EPH. The GAC for EPH are separated into different carbon bands which were not analysed in the samples from the site. The EPH at trial pit BH1011 should be investigated further to determine whether the relevant GACs have been exceeded.

6.22 Total PAH was recorded below the detection limit of <0.6mg/kg in five of the six samples from the eastern area of the site, with a concentration of 2.4mg/kg recorded in the soil sample from borehole BH1014 (3.10m to 3.30m). None of the 16 PAHs analysed has been recorded above the respective GACs for residential land use with home grown produce in the soil sample from borehole BH1014 (3.10m to 3.30m). Total speciated phenols were recorded below the detection limit of <0.15mg/kg in all six soil samples taken from the eastern area of the site.

6.23 None of the metals have concentrations above the GAC for residential land use with home grown produce with the exception of arsenic and beryllium. Arsenic is recorded above the GAC for residential land use with home grown produce of 37mg/kg in soil samples taken from borehole BH1015 (2.90m to 3.40m) in the east and trial pit TP110 (0.88m to 1.36m) in the central part of the eastern area. At borehole BH1015 (2.90m to 3.40m) the sample compromised soft brown sandy clay with orange silt inclusions, coal sand/gravel and iron staining. At trial pit TP110 (0.88m to 1.36m) the sample comprised clayey silty sand with coal and sandstone gravel. Beryllium is recorded above the GAC for residential land use with home grown produce of 1.7mg/kg in all samples collected from the eastern area of the site. Concentrations of beryllium range from 2.4mg/kg at trial pit TP110 (0.88m to 1.36m) to 7.1mg/kg at trial pit TP111 (1.47m to 3.40m) in the central part of the eastern area of the site. The sample from trial pit TP111 (1.47m to 3.40m) were taken from bright orange silt.

6.24 The results of the pH analysis in soil samples from the eastern area ranges between 7.26 and 7.74. A range of total organic carbon (TOC) values were recorded from between 0.22% at borehole BH1015 (2.90m to 3.40m) to 12.81% at trial pit TP109 (2.25m to 2.50m). The sample taken from TP109 (2.25m to 2.50m) was from the black coal sand and gravel material. The second highest value in the eastern area was 3.43% taken from borehole BH1014. The sample from borehole BH1014 (3.10m

to 3.30m) comprised the bright orange clayey silt with some of the black coal gravel. The remaining soil samples from the eastern area of the site had TOC values at or less than 1%.

6.25 Total cyanide was not recorded above the detection limit of <0.5mg/kg and sulphide was not recorded above the detection of <10mg/kg in the soil samples from the eastern area of the site. Asbestos was not detected in any of the soil samples from the eastern area of the site.

6.26 VOCs, SVOCs and PCB were all recorded below the detection limits of the analytical methods in the three soil samples taken from each of borehole BH1015 (2.90m to 3.40m), trial pit TP109 (2.25m to 2.50m) and trial pit TP111 (1.47m to 3.40m) submitted for additional testing. The SVOC analyses for the sample from trial pit TP109 (2.25m to 2.50m) was outside of the surrogate recovery performance criteria which may be an indication of a matrix effect.

Discussion of the groundwater analytical results

6.27 Groundwater samples were collected on 8 March 2023 from borehole BH1008 in the north of the western area of the site and borehole BH28 from the 2011/12 investigations to the north of the central/ eastern area of the site approximately 50m north east of borehole BH1010. Borehole BH28 is installed in inert waste comprising layers of orange clayey silt and sandy clay and is the closest borehole to the site with a recorded groundwater level in March 2023. Groundwater was not observed in any other of the 2023 boreholes at the time of monitoring in March 2023. Groundwater samples were collected on 27 April 2023 from boreholes BH1002 and BH1009 in the south east and north west of the western area of the site respectively. No groundwater samples were taken in June 2023 as there was insufficient water in the boreholes to collect samples from those which had not yet been sampled in 2023. The results of the groundwater quality monitoring are presented at Appendix K and summarised in Table 11.

6.28 The groundwater samples were analysed for VOC and SVOC including TICs, PCB, TPH-CWG, speciated phenols, a suite of metals, pH, total cyanide, ammoniacal nitrogen, sulphate and sulphide. VOC and SVOC including TICs, PCBs, TPH-CWG,

speciated phenols, total cyanide and sulphide were all recorded below the detection limit of the analytical methods. The concentrations of metals tested in the groundwater have been recorded below the respective guideline values where available with the exception of zinc in the groundwater at borehole BH1008. There is no UK DWS for zinc. The concentration of zinc recorded at 36µg/l in the groundwater sampled from borehole BH1008 in March 2023 is higher than the bioavailable EQS for zinc in the Thames region of 12.9 µg/l. The EQS comprises an average annual limit rather than a maximum allowable limit and is specifically relevant to aquatic environments.

6.29 The pH value was consistent between the samples from boreholes BH1002 and BH1008 in the western area of the site at 7.33 and 7.34 respectively and BH28 to the north of the eastern area of the site at 7.33. The pH recorded in the groundwater from borehole BH1009 in the north west of the western area of the site was slightly lower at 6.64. The pH values are all within the range specified in the UK DWS. Ammoniacal nitrogen was under the detection limit of <0.03mg/l in the groundwater from borehole BH1008 and below the UK DWS in the groundwater from borehole BH1009 in the western area of the site and at borehole BH28 to the north of the eastern area of the site. An ammoniacal nitrogen concentration of 2.85mg/l was recorded in the groundwater collected from borehole BH1002 in the south east of the western area of the site which is above the UK DWS of 0.39mg/l.

6.30 The sulphate concentrations recorded in the groundwater in the western area of the site are all below the UK DWS of 250mg/l with concentrations of 25.02mg/l and 28mg/l recorded at borehole BH1002 and BH1009 and a concentration of 197.1mg/l recorded at borehole BH1008. Borehole BH1008 intercepted a significant thickness of grey clayey silt between 2.2mbgl and 4.9mbgl with inclusions of a bright orange silt. It is considered that the silt is derived from the Fuller's Earth processing operations. While the sample of grey silt analyses from borehole BH1008 (4.50m to 5.00m) had a relatively low concentration of water soluble sulphate, the concentrations recorded in the orange silts in the central and eastern areas of the site had much higher concentrations of water soluble sulphate (see section 7). The sulphate concentrations recorded in the groundwater at borehole BH28 to the north of the eastern area of the site is elevated higher than the UK DWS at a concentration

of 1,644mg/l. As stated above, borehole BH28 is installed in made ground comprising layers of orange clayey silt and sandy clay. The elevated sulphate concentration at borehole BH28 is consistent with the high water soluble sulphate concentrations in the soil samples from similar materials in the central and eastern areas of the site (see section 7).

6.31 Borehole BH1009 is located approximately 50m north of borehole BH1008 in the centre of the northern part of the western area of the site with ground levels being approximately 1.77m lower at borehole BH1009 compared with borehole BH1008. In April 2023, when measurable groundwater levels were recorded in each of the boreholes, the groundwater level was approximately 1.5m lower at borehole BH1009 compared with borehole BH1008 (Table 4). The fact that the groundwater chemistry is considerably different at borehole BH1008 compared with at borehole BH1009 downhill and at a lower groundwater elevation confirms the assumption that groundwater is unlikely to exist as a continuous groundwater body across this area of the site.

7. Geotechnical testing

7.1 The material at and in the vicinity of the site has been observed to be variable comprising cohesive and incohesive soils from sandy clay and silt through to sand and gravel. Where deposits comprised cohesive soils the consistency of the clay generally ranged between very soft and stiff.

Standard Penetration Tests

7.2 In-situ standard penetration tests (SPTs) were carried out during the drilling works. The results are recorded on the borehole logs as the standard penetration resistance N value. SPT testing was carried out at approximately 1.0m intervals in the boreholes drilled. Where the number of blows reaches 50 blows before a penetration of 300mm, no further blows are recorded and the depth of penetration is recorded on the borehole log. This dynamic penetration test is used to assess the in situ relative density of a granular deposit although the test has been carried out at each borehole and in different strata. The N values are presented with the borehole logs at Appendix J.

Laboratory testing

7.3 Thirteen soil samples were collected from the boreholes selected based on ground conditions in which the material was observed to be cohesive. The samples were tested for soil classification tests comprising moisture content, liquid limits, plastic limits and plasticity index with an associated Atterberg classification. The geotechnical laboratory test results are presented at Appendix L.

7.4 The soil samples from the western area of the site were taken from sandy clay and have a range of Atterberg classifications from clays of intermediate plasticity to high plasticity. The sample collected at borehole BH1004 (1.20m to 1.40m) in the east of the western area of the site, described as a clayey sand, lacked cohesion with a result of non-plastic determination recorded. Soil samples from boreholes BH1001 (3.50m to 3.70m) and BH1002 (1.80m to 2.00m) in the south of the western area of the site are recorded as clay of intermediate plasticity and clay of high plasticity respectively. Soil samples from boreholes BH1006 (1.30m to 1.40m) and BH1008 (1.50m to

1.60m) in the north and west respectively of the northern half of the western area are recorded as clay with intermediate plasticity. Soil samples from BH1007 (2.20m to 2.35m) and BH1009 (1.20m to 1.35m) in the north east and north west respectively of the northern half of the western area are recorded as clay with high plasticity.

7.5 In the central area of the site the soil samples were collected from sandy clays with results ranging from clays of low plasticity to very high plasticity. As seen on Figure 6 boreholes BH1011 (2.10m to 2.30m) and BH1012 (1.75m to 1.90m) are positioned along the route of the proposed link road. The results for samples from these boreholes were both recorded as clays with intermediate plasticity. The result for the sample from borehole BH1010 (0.6m to 0.9m) in the north east central area of the site, located near but not on the proposed road, was recorded as a clay with a very high plasticity. The result for the sample from borehole BH1013 (2.30m to 2.45m) located in the area of proposed residential development in the east of the central area of the site is recorded as clay with a low plasticity.

7.6 In the eastern area of the site the two samples were collected from sandy clays with the plasticity results being intermediate at borehole BH1015 (3.5m to 3.6m) in the east and high at borehole BH1014 (1.60m to 1.70m) in the west.

7.7 A total of 28 samples were analysed for assessment of the Building Research Establishment (BRE) Special Digest 1 (SD1) Concrete in Aggressive Ground (reference 10) with 6 samples of probable natural ground and 22 samples of made ground. The sample were from a range of depths of between 0.34mbgl to 5.00mbgl. The samples were analysed for water soluble sulphate (2:1 water: soil extract). The results are presented at Appendix K and summarised in Tables 8 to 10.

7.8 A range of water soluble sulphate concentrations from 0.0057g/l at borehole BH1002 (2.30m to 2.45m) to 0.4214g/l at trial pit TP102 (1.00m to 3.80m) were recorded in the western area of the site with an elevated concentration of 1.7721g/l at trial pit TP103 (1.54m to 3.75m). The sulphate concentrations recorded in the groundwater in the western area of the site are at concentrations of 25.02mg/l and 28mg/l recorded at boreholes BH1002 and BH1009 respectively and a concentration of 197.1mg/l recorded at borehole BH1008. Borehole BH1008 intercepted a significant thickness

of grey clayey silt between 2.2mbgl and 4.9mbgl with inclusions of a bright orange silt. With the exception of at TP103, the results indicate that in terms of buried concrete within the natural ground and made ground in the western area of the site an Aggressive Chemical Environment for Concrete (ACEC) classification of AC-1s should be adopted for the site as detailed in Table C2 of BRE Special Digest 1 Part C (2005) (reference 10). The sample collected at trial pit TP103 (1.54m to 3.75m) comprises blackish grey clay with a hydrocarbon odour. Should made ground materials at trial pit TP103 be retained at this location the concentration recorded at TP103 indicate that in terms of buried concrete within the made ground at this location an ACEC classification of AC-2s should be adopted for this area of the site.

7.9 The concentration of water soluble sulphate in the soil samples collected in the central area of the site range from 0.0135g/l at borehole BH1012 (2.30m to 2.50m) to 0.2233g/l at trial tip TP107 with elevated concentrations of 1.5138g/l and 1.5812g/l at BH1011 (2.50m to 3.00m) and BH1010 (1.50m to 1.70m) respectively. The sample from borehole BH1010 (1.50m to 1.70m) was taken from the bright orange silt and the sample from borehole BH1011 (2.50m to 3.00m) was taken from firm slightly sandy clay with bright orange silt inclusions. The results indicate that in terms of buried concrete within the orange silt made ground in the central area of the site an ACEC classification of AC-2s should be adopted as detailed in Table C2 of BRE Special Digest 1 Part C (2005). The results indicate that in terms of buried concrete within the remaining made ground in the central area of the site an ACEC classification of AC-1s should be adopted consistent with the western area of the site.

7.10 The concentration of water soluble sulphate in 4 of the 6 soil samples collected from the eastern area of the site range from 1.5719g/l at borehole BH1014 (3.10m to 3.30m) to 2.5238g/l at trial pit TP109 (3.00m to 4.10m) with the samples at trial pit TP109 and borehole BH1014 (3.10m to 3.30m) taken from the bright orange silt together with at TP111 (1.47m to 3.40m). The sample from borehole BH1015 (2.90m to 3.40m) comprised sandy clay with orange silt inclusions as well as coal sand/gravel. The results indicate that in terms of buried concrete within the orange silt and sandy clay with orange silt inclusions in the eastern area of the site an ACEC classification of AC-2s should be adopted as detailed in Table C2 of BRE Special Digest 1 Part C (2005). The remaining two soil samples from the eastern area of the

site had soluble sulphate concentrations of 0.0776g/l and 0.1219g/l at TP110 (0.88m to 1.36m) and TP109 (2025m to 2.50m respectively. The results indicate that in terms of buried concrete within the remaining made ground in the central area of the site an ACEC (Aggressive Chemical Environment for Concrete) classification of AC-1s should be adopted.

7.11 The sulphate concentration recorded in the groundwater at borehole BH28 to the north of the eastern area of the site is elevated at a concentration of 1,644mg/l. Borehole BH28 is installed in made ground comprising layers of orange clayey silt and sandy clay. The elevated sulphate concentration at borehole BH28 is consistent with the high water soluble sulphate concentrations in the soil samples from similar materials in the central and eastern areas of the site. Consistent with the water soluble sulphate concentrations in the soil samples from similar materials in the central and eastern areas of the site, the sulphate concentration recorded in the groundwater at borehole BH28 indicate that in terms of buried concrete within the orange silt at the site an ACEC classification of AC-2s should be adopted as detailed in Table C2 of BRE Special Digest 1 Part C (2005).

7.12 A summary of the records of orange/yellow clay/silt across the site is presented in Table 12.

8. Conceptual site model

Introduction

8.1 A Conceptual Site Model (CSM) is one of the primary planning tools which is used to support the decision making process in terms of managing land contamination and understanding potential contamination pathways. The CSM organises the available information on ground conditions to facilitate an understanding of the potential sources of contamination, the potential significance and likely pollutant linkages at the site and to assess the sensitive environmental receptors. Based on the concept of significant pollutant linkages, the source – pathway – receptor principle is considered regarding potential risks to human health and the environment. The essential components of a pollutant linkage comprise

- A contaminant source which has the potential to cause harm to human health or to have an impact on the environment;
- A receptor which in general terms is something that could be affected adversely by the contaminant such as people or a water body which then will be used by people;
- A pathway or route by which a receptor can be exposed to and affected by the contaminant.

8.2 Each of the components can exist independently but an effect can occur only where the components are linked together so that a contaminant can affect a receptor by a pathway. The linked combination of contaminant-pathway-receptor is referred to as a pollutant linkage or exposure pathway. Without an exposure pathway there is no risk even if a contaminant is present. Where there is an exposure pathway an assessment must be carried out to determine whether the potential effect is acceptable.

8.3 Schematic cross sections through the site showing areas of made ground, probable natural ground and topography together with groundwater levels, where available, are presented on Figure 8 with the lines of section shown on Figure 4.

8.4 As is the accepted normal practice for developing sites with historical industrial uses, prior to the detailed design of the development further site investigation work will be carried out pursuant to planning conditions and a remediation strategy, to the extent that it is necessary, would be put in place to achieve ground conditions and a development which is protective of human health and the environment in accordance with appropriate standards.

Source

8.5 The majority of the site has been active historically, having been used for Fuller's Earth works, mineral extraction and landfilling (Figure 3). Based on a review of documentation it is understood that the North Cockley Fuller's Earth works was located to the west of the site from at least 1870 and encroached into the west of the site from at least 1961 up to 1992. Gore Meadow landfill spanned the northern boundary of the western area of the site extending to the north west and was licensed to accept industrial effluent treatment sludge from 1979. Between at least 1870 up to 1966 there was a Fuller's Earth works called Park Works in the south east of the central area of the site together with an associated clay pit and further Fuller's Earth works adjacent to the eastern boundary of the site. There are two parcels of land in the south of the central area and the north and west of the eastern area of the site which have potentially been infilled. It is unknown when the areas were infilled and what they were infilled with although they are recorded as former Fuller's Earth mineral sites. An approximate 50m corridor along the northern boundary of the central area of the site is within the southern limits of an area of historical landfill comprising former Fuller's Earth sludge lagoons in the south of the former Beechfield Quarry/Landfill. Beechfield Landfill accepted waste including inert, industrial, commercial, household waste, liquids and sludges with waste deposited between 1969 and 1984.

8.6 The North Cockley landfill boarders the north and west of the western area of the site and is another historic landfill which was licensed to accept asbestos, brick/concrete, commercial and industrial waste, dewatered industrial effluent treatment sludge, excavated natural materials, household waste and industrial effluent treatment sludge. The licence was issued in July 1981 with waste input between 1981 and

1990. Nutfield Priory Landfill Site is recorded approximately 10m from the south western boundary of the site as a historical landfill which accepted inert, industrial, commercial, household waste between April 1967 and October 1981.

8.7 Based on the 2023 site investigation, the western area of the site is generally underlain by made ground between approximately 1m and 5m thick comprising sandy clay with varying amounts of sand, gravel and cobbles of sandstone interpreted as reworked Sandgate Formation. At various locations across the western area the made ground includes occasional mudstone, brick, chalk, coal, grey silt/ clay, organic clay, black clay with hydrocarbon odours, orange clay/ silt and rare wood. Made ground was generally absent in the east and central north of the western area of the site. The central area of the site is generally underlain by made ground between a minimum 2.6m and greater than 5m thick comprising sandy clay, orange silt and sand and gravel with varying amounts of each constituent and gravel of sandstone. At various locations across the central area of the site the made ground includes occasional gravel and/or cobbles of mudstone, coal, chalk, clinker and/or flint. The eastern area of the site is generally underlain by made ground between a minimum 2.75m and greater than 5m thick comprising sandy clay, orange silt, sand and gravel with varying amounts of each constituent and gravel of sandstone. At various locations across the eastern area of the site the made ground includes occasional gravel of mudstone, coal, chalk, clinker and/or flint and inclusions of bright orange silt.

8.8 No significantly elevated concentrations of contaminants were recorded in the samples of soil or groundwater throughout the site the subject of the 2023 site investigation. No asbestos containing materials have been recorded although observations were made on site that old pipework has potential asbestos lagging. With the exception of arsenic and beryllium, none of the metals recorded in the soils from the site have been observed above their respective GACs for residential land use with home grown produce throughout the site. Arsenic concentrations above the residential GAC have been recorded in 4 soil samples from the western area, 3 soil samples from the central area and 2 soil samples from the eastern area of the site. The materials in which arsenic has been recorded above the residential GAC is mainly made ground of sandy clay. Beryllium concentrations above the GAC for

residential land use with home grown produce have been recorded in the majority of samples across the site with 4 soil samples only from the western area of site with concentrations below the GAC. The materials in which beryllium has been recorded above the residential GAC is a range of made ground materials comprising sandy clay to clayey sand, silt, sand and gravel as well as potential natural strata of sandy silty clay, sandstone and mudstone. Volcanic dust is noted as a source of beryllium (reference 8) hence the ubiquity of beryllium across the site could be sourced from the Fuller's Earth which comprises clay deposits derived from volcanic ash. In general, the samples with the highest values of beryllium comprised silt samples interpreted as being derived from the Fuller's Earth processing operations.

8.9 The soil sample from depths of 2.30m to 2.45m at borehole BH1002 near the southern boundary in the western area of the site recorded arsenic, beryllium and a number of PAHs including BaP concentrations above the relevant GACs for residential land use with homegrown produce. In addition, EPH and total PAH concentrations of 4003mg/kg and 298.9mg/kg respectively were recorded in the soil sample which was significantly higher than elsewhere across the site. The GAC for EPH are separated into different carbon bands which were not analysed in the samples from the site. The EPH at BH1002 has been identified as PAH and is assessed against the GAC for PAHs above. The soil sample from borehole BH1002 (2.30m to 2.45m) had a TOC of 6.7%. Methane was recorded at 9.2% at this location in March 2023 which is much higher than anywhere else across the site with a corresponding carbon dioxide concentration of 8.7% and low oxygen concentration of 8.9%. The soil sample from depths of 2.30m to 2.45m at borehole BH1002 was taken from a very black dense clay which had a strong hydrocarbon odour. Similar material was sampled at trial pits TP100 and TP103 in the south of the western area of the site with trial pit TP103 adjacent to borehole BH1002. Concentrations of EPH, BaP and PAH were recorded in these samples from trial pits TP100 and TP103 with TOC values of 2.41% and 2.38% respectively. However, none of the concentrations were above the GAC for residential use with the exception of Beryllium at trial pit TP103. This suggests that the soils recorded from depths of 2.3m to 2.45m at borehole BH1002 comprises a specific hotspot.

8.10 The concentrations of water soluble sulphate recorded in samples of orange silt and sandy clay with orange silt inclusions in the central and eastern areas of the site indicate that in terms of buried concrete an Aggressive Chemical Environment for Concrete (ACEC) classification of AC-2s should be adopted as detailed in Table C2 of BRE Special Digest 1 Part C (2005) (reference 10) rather than an ACEC classification of AC-1s across the rest of the site. A summary of the records of orange/yellow clay/silt across the site is presented in Table 12. Borehole BH28 is installed in made ground comprising layers of orange clayey silt and sandy clay to the north of the eastern area of the site. The sulphate concentration recorded in the groundwater at borehole BH28 confirms the ACEC classification of AC-2s in the orange silt at the site. In addition, the concentration of water soluble sulphate recorded at trial pit TP103 (1.54m to 3.75m) near the southern boundary in the western area indicates that an ACEC classification of AC-2s should be adopted at this location if the blackish grey clay with a hydrocarbon odour made ground is retained.

8.11 Across the site methane has been recorded at and below 0.2% and carbon dioxide has been recorded below 5.0% expect at boreholes BH1002 in the western area of the site. In addition, carbon dioxide has been recorded above 5.0% at borehole BH1006 in the western area of the site at a maximum of 7.2% and at borehole BH1014 in the eastern area of the site at a maximum of 7.7%. A GSV Characteristic Situation 1 (very low risk) was calculated for the results of gas monitoring in March, April and June at the 2023 borehole locations at the site. As a concentration of methane of 9.2% by volume was recorded at borehole BH1002 in the south east of the western area of the site and carbon dioxide concentrations in excess of 5% have been recorded at boreholes BH1002 and BH1006 in the western area of the site and at borehole BH1014 in the eastern area of the site it is recommended that further monitoring is carried out to assess whether the areas of the site local to these boreholes should be upgraded to Characteristic Situation 2 (low risk).

Pathways

8.12 As discussed above, there are no significant elevated concentrations of contaminants including no asbestos containing materials recorded in the samples of soil tested, in

the groundwater, where encountered and tested, or in the gas monitored at each borehole of the 2023 site investigation. Arsenic and beryllium are recorded above the GACs for residential land use with home grown produce throughout the site and a hotspot of PAHs above respective GAC for residential land use with home grown produce is recorded at borehole BH1002 in the south of the western area of the site. Water soluble sulphate concentrations recorded in samples of orange silt and sandy clay with orange silt inclusions in the central and eastern areas of the site indicate an Aggressive Chemical Environment for Concrete (ACEC) classification of AC-2s should be adopted for buried concrete in this material as detailed in Table C2 of BRE Special Digest 1 Part C (2005) (reference 10) rather than an ACEC classification of AC-1s across the rest of the site. The pathways for groundwater and gas are expected to be within the natural ground of the Sandgate Formation.

8.13 There have been elevated concentrations of gas recorded in some of the 2011/2012 boreholes to the north west and west of the site. Based on the results of the ground gas monitoring undertaken in 2023 a GSV Characteristic Situation 2 (low risk) for methane was calculated for the results at the monitoring boreholes in the former Gore Meadow Quarry/Landfill and North Cockley Quarry/Landfill to the north and west of the western area of the site at boreholes BH5 and BH9. A GSV Characteristic Situation 2 (low risk) for carbon dioxide was calculated for the result at monitoring borehole BH9 in March 2023 and a GSV Characteristic Situation 1 (very low risk) for carbon dioxide for the remining results from borehole BH9 and the results from borehole BH5 in the former Gore Meadow Quarry/Landfill and North Cockley Quarry/Landfill to the north and west of the western area of the site. The Characteristic Situation values are calculated as representing a low risk because there is little or no gas flow although the concentrations of methane and carbon dioxide are highly elevated in the area of the former Gore Meadow Quarry/Landfill and North Cockley Quarry/Landfill and consequently gas protection measures associated with Characteristic Situation 2 are unlikely to provide suitable mitigation measures in proximity to the landfill.

8.14 As can be seen on cross sections AA’ to CC’ on Figure 8 ground elevations at the site along the northern and north western boundaries are at similar or lower elevations to the base of the Gore Meadow/ North Cockley landfills with the pathways

for gas migration within the natural ground of the Sandgate Formation. The weathered Sandgate Formation is recorded at the site as sand, silt and clay with sandstone and mudstone. It is not known if there are preferential fracture pathways in the Sandgate Formation. Low methane and carbon dioxide concentrations have been recorded at boreholes BH1006 and BH1007 located approximately 30m and 20m from the northern site boundary respectively and approximately 60m from borehole BH9 in the landfill. Methane concentrations of less than (<) 0.1% and carbon dioxide between 3.6% and 7.2% were recorded at borehole BH1006 and methane concentrations from <0.1% to 0.2% and carbon dioxide between 0.1% and 4.1% were recorded at borehole BH1007 between March and June 2023. These compare with concentrations of methane between 71.5% and 83.7% by volume and carbon dioxide concentrations of between 18.0% to 27.5% by volume in borehole BH9 between March and June 2023.

8.15 Borehole BH1002 (2.3m to 2.45m) has been noted as a hotspot for PAHs above respective GAC for residential land use with home grown produce as well as the arsenic and beryllium concentrations recorded above residential GAC consistent with other locations across the site. Borehole BH1002 is approximately 120m east north east of the Nutfield Priory Landfill Site, however, it is unlikely that this landfill is the source of the elevated concentrations recorded at BH1002. BH1001 is located approximately 35m north east of the Nutfield Priory Landfill Site and does not have elevated gas readings or significant contamination. If the pathway for contamination was from this landfill it is likely that BH1001 would record elevated gas concentrations and contamination consistent with BH1002. As the contamination and gas concentrations are low at this location it is likely that Nutfield Priory Landfill is not the source of this contamination. The sample taken at BH1002 (2.3m to 2.45m) was taken from a very black slightly sandy clay with a strong hydrocarbon odour. This layer is likely to be the source of the contamination and higher gas concentrations.

8.16 Shallow groundwater was recorded during the 2023 site investigation at isolated locations in the east of the western area of the site (TP104, TP105 and BH1004). Shallow groundwater has been recorded consistently at only one location across the site at borehole BH1008 in the central part of the northern half of the western area during the three monitoring visits. Shallow groundwater was recorded in borehole

BH1002 in the south and borehole BH1007 and BH1009 in the north of the western area of the site and in borehole BH1015 in the east of the eastern area of the site in April 2023 with a limited depth of groundwater recorded at borehole BH1001 in the south of the western area of the site. Very limited depths of groundwater only were recorded in the same boreholes in June 2023 as well as at boreholes BH1010 and BH1012 in the central area of the site and at borehole BH1014 in the west of the eastern area of the site. The monitoring boreholes are predominantly installed in made ground across the site at varying elevations reflecting the variation in ground levels across the site. The monitoring data shows that shallow groundwater in the made ground/ top of the Sandgate Formation is likely to be discontinuous across the site and not a significant pathway for the migration of contaminants to surface water bodies or deeper groundwater. The discontinuous nature of the shallow groundwater is likely to be attributable to the variation in ground level, made ground and geology. The 2023 boreholes, where deep enough, intercept the top of the Sandgate Formation only across the site. Deeper groundwater could be present in the Sandgate Formation beneath the site and is likely to be present at depth in the underlying Hythe Formation.

8.17 A pathway for exposure to the made ground materials above the relevant GAC for residential land use with home grown produce could be created during the development works proposed for the site subject to the nature of the activities carried out and any standard mitigation measures that are implemented. The construction of the proposed development may lead to the creation of potential migration pathways for shallow groundwater and ground gas from the adjacent landfill sites, for example, via services and foundations. The construction of buildings, structures and paved area may cause a lateral migration of the ground gas from the adjacent landfill if there are existing passive venting pathways from the landfill on the site which become restricted.

Receptors

8.18 The potential receptors are those associated with the proposed development of the land for residential and commercial land use together with groundwater resources and surface water bodies.

8.19 Persistent shallow groundwater was recorded at one location only across the site in 2023 and therefore likely to be discontinuous across the site with no superficial deposits recorded at the site. It is unlikely that the Redhill Brook watercourse is in continuality with shallow groundwater at the site. Based on the assessment of the ground conditions it is considered that there is no significant risk to the quality of the nearby surface watercourses associated with the contaminants present at the site.

8.20 Where shallow groundwater is recorded and has been tested no significantly elevated concentrations of contaminants are recorded in the samples of groundwater. It is considered that there is no significant impact on the quality of the shallow groundwater at the site associated with contaminants present at the site. It should be noted that deeper groundwater could be present in the Sandgate Formation beneath the site and is likely to be present at depth in the underlying Hythe Formation. Any deeper groundwater has not been the subject of the 2023 site investigation.

8.21 The site is not located in the Source Protection Zone (SPZ) of a public water supply facility. The nearest SPZ is located approximately 1.25km to the east of the site. There are two groundwater abstractions within a 2km radius of the site boundary. The closest licensed groundwater abstraction is located approximately 360m south of the site with the other being located approximately 1.5km north of the site. The closest licensed groundwater abstraction is from the Hythe Formation at Priory Farm. ***[AWAITING UPDATED INFORMAITON FROM THE ENVIRONMENT AGENCY AND THE LOCAL AUTHORITY]***

8.22 It is likely that there is deeper groundwater in the underlying bedrock deposits. The Sandgate Formation is a Secondary A aquifer defined by the EA as permeable rock layers capable of supporting water supplies at a local rather than strategic scale. The Hythe Formation is a Principal aquifer defined by the EA as having a high intergranular and/or fracture permeability. Groundwater in the Sandgate Formation and the Hythe Formation are considered to be sensitive receptors.

8.23 Based on the site observations and the results of chemical testing of soil and groundwater samples at the site there are no significantly elevated concentrations of contaminants which are considered to represent a potential risk to proposed future

site users. Arsenic and beryllium are recorded above the GACs for residential land use with home grown produce throughout the site and a hotspot of PAHs above respective GAC for residential land use with home grown produce is recorded at borehole BH1002 in the south of the western area of the site. Soluble sulphate concentrations recorded in samples of orange silt and sandy clay with orange silt inclusions in the central and eastern areas of the site indicate an ACEC classification of AC-2s should be adopted for buried concrete in this material as detailed in Table C2 of BRE Special Digest 1 Part C (2005) (reference 10) rather than an ACEC classification of AC-1s across the rest of the site. The development of the site will introduce receptors and therefore new pollutant linkages which represent a potential risk to site structures and users. Development will need to be designed and constructed with suitable mitigation measures. Should materials be excavated from the site the materials will need to be suitably managed including implementing a suitable watching brief to identify significantly contaminated materials that may be excavated. Further details are presented in Section 9.

8.24 High concentrations of methane and carbon dioxide recorded in the former Gore Meadow/ North Cockley landfills to the north and west of the western area of the site although significant methane was not recorded at the monitoring boreholes located outside of the landfills. The development of the site will introduce receptors and therefore new pollutant linkages which represent a potential risk to site structures and users. Development adjacent to landfill will need to be designed and constructed with suitable gas mitigation measures. Further details are presented in Section 9.

9. Conclusions and recommendations

Introduction

9.1 Based on the site investigation it is considered that the proposed development itself may introduce a need to manage made ground materials which are excavated, particularly in the area of PAH hotspot in the south of the western area of the site, and a need to install suitable gas mitigation measures as part of the engineering design and construction of buildings which may be close to the historical landfill site to the north and west of the western area of the site. Where buildings and structures are to be constructed, particularly in the areas of yellow/orange silt/clay deposit derived from the Fuller's Earth processing operations, further detailed assessment may be necessary in order to design the foundations including the use of sulphate resistant materials. Where gardens are proposed and arsenic and beryllium concentrations are above GAC for residential use with homegrown produce suitable cover materials and protection measures may be needed.

9.2 The conclusions and recommendations presented in this report are based on the investigation works carried out on the site and assumptions are made with regard to the ground conditions between the borehole and trial pit locations. Prior to the detailed design of the development further site investigation will be carried out at the development site focussed particularly on the areas of known former land use and proposed residential development which were inaccessible during the 2023 site investigation and in the area of PAH hotspot in the south of the western area of the site. Further gas monitoring will be needed at the site to confirm ground gas conditions and in the vicinity of the historical landfill to the north and west of the western area of the site to help inform the suitable design of gas mitigation measures as part of the engineering design and construction of buildings which may be close to the historical landfill site. Subject to the findings of the further site investigation and risk assessments a remediation strategy, to the extent that it is necessary, will be prepared based on an options appraisal pursuant to planning conditions to achieve ground conditions and a development which is protective of human health and the environment in accordance with appropriate standards.

Ground conditions

9.3 The site is underlain by the Sandgate Formation comprising mainly clays together and glauconitic, limonitic and ferruginous sands with seams of Fuller's Earth. Based on the 2023 site investigation the weathered Sandgate Formation is recorded at the site as sand, silt and clay with sandstone and mudstone. The majority of the site has been used historically for Fuller's Earth works with mineral extraction and landfilling close to the boundary with slight cross over in the west and the north of the site. Based on the 2023 site investigation the site is generally underlain by made ground between approximately 1m and a minimum 5m thick comprising sandy clay with varying amounts of silt, sand, gravel and cobbles of sandstone together with orange silt and occasional mudstone, brick, chalk, coal and flint. In the western area of the site the made ground includes occasional grey silt/ clay, organic clay, black clay with hydrocarbon odours, orange clay/ silt and rare wood. Made ground is generally absent in the east and central north of the western area of the site. In the central and eastern area of the site the orange silt is more prominent and the made ground includes occasional clinker.

9.4 A range of metals and PAHs were recorded in the samples of made ground however the concentrations recorded are below the GAC for residential land use with home grown produce with the exception of arsenic and beryllium concentrations across the site and the area of PAH hotspot in the south of the western area of the site. It will be necessary to implement a watching brief for development works in order that excavated materials are suitably managed. It may also be necessary to make sure that should there be residential gardens in this area that there is a sufficient cover of clean materials.

9.5 Geotechnical information

9.6 The made ground and geological conditions vary across the site and consequently the geotechnical properties of the made ground and underlying strata vary. Accordingly, this variability will influence the engineering design for the components of the proposed development. Information on geotechnical properties of the ground are presented in section 7 of this report and should be reviewed by a suitably qualified

engineer to inform the detailed engineering design of the site. Additional geotechnical parameters could be gathered at the time of the proposed further site investigation to inform further the detailed engineering design of the site.

9.7 Based on the results of the 2013 site investigation, water soluble sulphate concentrations in soil samples indicate an Aggressive Chemical Environment for Concrete (ACEC) classification of AC-2s (reference 10) should be adopted for buried concrete in the orange silt material whereas an ACEC classification of AC-1s can be adopted for buried concrete across the rest of the site. A summary of the records of orange/yellow clay/silt across the site is presented in Table 12.

Cut and fill

9.8 Given the topographic falls across the site and the nature of the proposed development a 'cut and fill' groundworks scheme will be necessary. With regard to the possible reuse of made ground materials, chemical testing of the materials comprise primarily sandy clay associated with reworked natural strata and has not recorded significantly elevated concentrations of contaminants and, other than a need to carry out treatment by sorting, separation and segregation for the removal of unsuitable materials, once the materials are segregated it may be possible to reuse components on site where it is safe and suitable to do so and where the separated materials meet the relevant engineering criteria and contamination guideline criteria. It is considered that it will be possible to reuse suitable excavated materials to facilitate the development on other areas of the development site if these activities are managed under the Definition of Waste: Development Industry Code of Practice (DoWCoP) (reference 11) site of origin scenario whereby materials are reused on the site from which they are excavated, without treatment (a non-waste) or after on-site treatment (a waste) and whereby treatment is carried out under relevant authorisation. It will be necessary to prepare supporting technical guidance, for example a risk assessment and remediation strategy together with a site specific materials management plan if the reuse of materials is undertaken. Should it not be possible to reuse these materials it will be necessary to remove these wastes off site to a suitably permitted waste management facility.

Gas protection measures

9.9 Elevated concentrations of methane and carbon dioxide and depleted concentrations of oxygen have been recorded at the boreholes located in the Gore Meadow/North Hockley Landfill. Gas screening values (GSV) have been calculated based on the results of the gas monitoring. Based on the GSVs the values calculated for the boreholes within the landfill are "Characteristic Situation 2 (low risk)" for methane and carbon dioxide and the GSVs for the site are "Characteristic Situation 1 (very low risk)" for methane and carbon dioxide. Although the GSV Characteristic Situation are calculated at a low risk, the Characteristic Situation are calculated at a low risk because there is little or no gas flow but the concentration of methane and carbon dioxide are high in the area of the landfill. The design of buildings constructed adjacent to the landfill may need to incorporate gas protection measures as a precautionary action.

Further investigations

9.10 Due to environmental, principally ecological, constraints it was not possible to gain access to carry out suitable site investigation in areas of known former land use and proposed residential development, in particular in the west of the western area of the site. Further site investigation may be necessary to inform the detailed design such as more information on geotechnical properties of the ground to inform suitable foundation design.

9.11 In accordance with guidance for ground gas assessment additional ground gas monitoring may be necessary to assess suitable mitigation measures.

Conclusion

9.12 The site investigations have not identified any significant contamination in the area of proposed residential and commercial development which it is considered cannot be remediated as part of the development. As is the accepted normal practice for developing sites with historical industrial uses further site investigation work will be carried out pursuant to planning conditions and a remediation strategy, to the extent

that it is necessary, would be put in place to achieve ground conditions and a development which is protective of human health and the environment in accordance with appropriate standards.

10. References

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2. Encia, 2013. Summary Environmental Risk Report of the former Park Quarry Landfill (Area A), Nutfield Road, Redhill, Surrey. Prepared for Evonik Degussa UK Holdings Limited report number 20096/6A, May 2013.

3. Encia, 2013. Summary Environmental Risk Report of the North Cockley Landfill (Area B), Nutfield Road, Redhill, Surrey. Prepared for Evonik Degussa UK Holdings Limited report number 20096/6B, May 2013.

4. Encia, 2013. Summary Environmental Risk Report, Plot 3 (Southern part of North Cockley – 'Area B'), Nutfield Road, Redhill, Surrey. Prepared for Evonik Degussa UK Holdings Limited report number 20096/83, November 2013

5. Wilson, S, Card, G and Haines. S., 2009. Ground gas handbook.

6. Wilson, S; Oliver, S; Mallett, H; Hutchings, H and Card, G, 2007. Assessing risks posed by hazardous ground gases to buildings. CIRIA publication 665 updated 2007.

7. CL:AIRE, 2014. SP1010 – Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination. December 2014.

8. 2015. The LQM/CIEH S4ULs for Human Health Risk Assessment. Land Quality Press, Nottingham.

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10. BRE Special Digest 1:2005: Concrete in aggressive ground. Table C2 Aggressive Chemical Environment for Concrete (ACEC) classification for brownfield locations

11. CL:AIRE, 2011. Definition of Waste: Development Industry Code of Practice (DoWCoP). Version 2 March 2011

TABLES

Table 1
Former and proposed land uses at the 2023 site investigation locations and the 2011/1012 site investigation locations

2023 Site investigation locations	Former land use	Proposed land use	2011/2012 Site investigation locations	Former land use	Proposed land use
Western area					
BH1001, BH1002, BH1004, TP100, TP101, TP102 and TP103	Area of the former Cockley Works in the southern half of the western area of the site	Areas of proposed residential development in the southern half of the western area of the site	WS201 to WS204, WS209 to WS212 and BH22	Area of the former Cockley Works in the west of the western area of the site	WS201, WS204, WS209 to WS212 and BH22 in areas of proposed retained woodland/public open space in the west of the western area of the site WS202 and WS203 areas of proposed residential development in the west of the western area of the site.
BH1006 to BH1009	Close to the presumed boundary between potentially undisturbed ground and the former Cockley Works in the northern half of the western area of the site	BH1006, BH1008 and BH1009- Areas of proposed residential development in north and west of the western area of the site. BH1007 in an area of proposed retained woodland/public open space in the north east of the western area of the site			
TP104 to TP106 and TP112	Areas of probable undisturbed ground in the east and central north of the western area of the site.	Areas of proposed residential development in the east and central north of the western area of the site.	WS205 to WS208 and BH21	Areas of probable undisturbed ground in the east and central parts of the northern half of the western area of the site.	WS205, WS206, WS208 and BH21 in areas of proposed residential development in the east and central north of the western area of the site. WS207 in an area of proposed woodland/public open space in the east of the western area of the site.
Central area					
BH1010, TP107 and TP108	Area of former excavation or possible former excavation to the north east of the former Park Works in the east of the central area of the site.	In or close to the area of proposed residential development in the east of the central area of the site.	WS230	Area of former excavation or possible former excavation to the north east of the former Park Works in the east of the central area of the site.	In the area of proposed residential development in the east of the central area of the site.
BH1013	Area of the former Park Works in the east of the central area of the site.	Area of proposed residential development in the east of the central area of the site.	WS213, WS14, WS228 and WS229	Area of the former Park Works in the south east and east of the central area of the site.	WS214 in the area of proposed residential development in the east of the central area of the site. WS213 in an area of proposed retained woodland in the south east of the central area of the site WS228 and WS229 close to the route of the proposed link road between the western and eastern areas of the site in the central part of the central area of the site.
BH1011 and BH1012	In the south of the area of the former Fuller's Earth sludge lagoons in the south of the former Beechfield Quarry/Landfill (Area E) in the central and western part of the central area of the site.	Along the route of the proposed link road between the western and eastern areas of the site in the central and western part of the central area of the site.	WS215, WS226 and WS227	In the south of the area of the former Fuller's Earth sludge lagoons in the south of the former Beechfield Quarry/Landfill (Area E) to the north of the central area of the site.	In an area of proposed retained woodland to the north of the central area of the site.

2023 Site investigation locations	Former land use	Proposed land use	2011/2012 Site investigation locations	Former land use	Proposed land use
Eastern area					
BH1014, TP109, TP110 and TP111	Area of former excavation or possible former excavation in the central part of the eastern area of the site to the south and west of the former Fuller's Earth Works near the eastern boundary.	BH1014 and TP109 are located in or adjacent to the proposed GP surgery and pharmacy in the central part of the eastern area of the site. TP110 and TP111 are located adjacent to the proposed care centre in the central part of the eastern area of the site.	WS42 and WS43	Area of former excavation or possible former excavation in the central part of the eastern area of the site to the south and west of the former Fuller's Earth Works near the eastern boundary.	WS43 is located in or adjacent to the proposed GP surgery and pharmacy in the central part of the eastern area of the site. WS42 is located adjacent to the proposed care centre in the central part of the eastern area of the site.
BH1015	Area of former Fuller's Earth Works near the eastern boundary.	East of the proposed care centre in an area of proposed retained woodland.	WS233 and WS234	Area of former Fuller's Earth Works near the eastern boundary.	East of the proposed care centre in an area of proposed retained woodland.
			WS231 and WS235	Area of potential infilled land in the north of the eastern area of the site.	Area of proposed retained woodland in the north of the eastern area of the site.
			WS232	Areas of probable undisturbed ground in the south west of the eastern area of the site.	Adjacent to the proposed extra care facility in the south west of the eastern area of the site.

Table 2
Summary of the results of the 2011/2012 soil chemical analysis for the site

Determinands	Units	Count	Count >DL	Minimum	Maximum	Location of maximum	Generic Assessment Criteria (GAC) value for residential land use with homegrown produce (mg/kg)	No of samples exceeding GAC
Western area								
Metals								
Arsenic	(mg/kg)	19	19	8.9	50	WS208 (0.1m)	37 [1&2]	4 (WS201 (0.8m), WS208 (0.1m), WS209 (0.1m) and WS212 (0.4m)
Boron	(mg/kg)	19	14	4.2	9.8	WS201 (0.1m)	290 [1]	0
Cadmium	(mg/kg)	19	4	<0.20	0.41	WS208 (0.1m)	11 [1]	0
Chromium	(mg/kg)	19	19	4.5	62	WS202 (0.2m)	910 [1]	0
Copper	(mg/kg)	19	10	<5	31	WS201 (0.1m)	2400 [1]	0
Lead	(mg/kg)	19	13	<2	100	WS201 (0.1m)	200 [2]	0
Mercury	(mg/kg)	19	1	<0.35	0.89	WS201 (0.1m)	40 [1]	0
Nickel	(mg/kg)	19	19	8.9	60	WS208 (0.1m)	180 [1]	0
Selenium	(mg/kg)	19	4	<0.35	0.51	WS212 (0.4m)	250 [1]	0
Zinc	(mg/kg)	19	19	34	320	WS208 (0.1m)	3700 [1]	0
Target Polycyclic aromatic hydrocarbon (PAH) compounds								
Benzo(a)pyrene	(mg/kg)	19	16	<0.01	32	WS203 (0.1m)	2.2 [1]	3 (WS203 (0.1m), WS208 (0.1m) and WS210 (0.4m))
Total PAH	(mg/kg)	19	16	<0.1	560	WS203 (0.1m)		0
Hydrocarbons								
GRO (C6-C10)	(mg/kg)	2	0	<50	<50		27 to 130 [1]	0
DRO (C10 - C20)	(mg/kg)	2	0	<50	<50		74 to 65000 [1]	0
LRO (C20 - C40)	(mg/kg)	2	0	<50	<50		1100 to 65000 [1]	0
Others								
Total sulphate	(mg/kg)	3	3	320	26000	WS201 (0.35m)	NG	0
Soluble sulphate	(g/l)	4	1	<0.06	1.2	WS201 (0.35m)	NG	0
Cyanide	(mg/kg)	4	0	<2.5	<2.5		NG	0
TOC	(%)	2	2	1.1	1.1	BH21 (0.5m) and BH22 (0.6m)	NG	0
pH	(pH	19	19	4.2	8.9		NG	0
Asbestos	Type	1	0	NAD	NAD			
Central area								
Metals								
Arsenic	(mg/kg)	19	19	8.8	110	WS229 (1.1m)	37 [1&2]	8 (WS214 (0.1m), WS215 (0.1m), WS226 (0.5m), WS227 (4.8m), WS228 (0.1m), WS228 (1.3m), WS229 (0.05m) and WS229 (1.1m)
Boron	(mg/kg)	19	10	<4	18	WS229 (1.1m)	290 [1]	0
Cadmium	(mg/kg)	19	14	<0.2	3.3	WS229 (1.1m)	11 [1]	0
Chromium	(mg/kg)	19	19	1.1	68	WS214 (0.1m)	910 [1]	0
Copper	(mg/kg)	19	16	<5	130	WS229 (0.05m)	2400 [1]	0
Lead	(mg/kg)	19	13	<2	97	WS213 (1.8m)	200 [2]	0
Mercury	(mg/kg)	19	1	<0.35	0.55	WS229 (0.05m)	40 [1]	0
Nickel	(mg/kg)	19	19	6.7	71	WS214 (0.5m)	180 [1]	0
Selenium	(mg/kg)	19	5	<0.35	0.56	WS230 (0.1m)	250 [1]	0
Zinc	(mg/kg)	19	19	19	610	WS213 (1.8m)	3700 [1]	0
Target polycyclic aromatic hydrocarbon (PAH) compounds								
Benzo(a)pyrene	(mg/kg)	19	11	<0.01	18	WS213 (0.25m)	2.2 [1]	2 (WS213 (0.25m) and WS214 (0.5m))
Total PAH	(mg/kg)	19	11	<0.1	390	WS213 (0.25m)		0
Hydrocarbons								
GRO (C6-C10)	(mg/kg)	2	0	<0.1	<0.1		27 to 130 [1]	0
DRO (C10 - C20)	(mg/kg)	2	2	65	385	WS214 (0.5m)	74 to 65000 [1]	
LRO (C20 - C40)	(mg/kg)	2	2	496	1162	WS214 (0.5m)	1100 to 65000 [1]	
Phenols								
Phenols	(mg/kg)	1	0	<0.75	<0.75		NG	0
Others								

Determinands	Units	Count	Count >DL	Minimum	Maximum	Location of maximum	Generic Assessment Criteria (GAC) value for residential land use with homegrown produce (mg/kg)	No of samples exceeding GAC
Total sulphate	(mg/kg)	4	3	<240	40000	WS227 (0.2m)	NG	
Soluble sulphate	(g/l)	2	1	<0.6	1.2	WS215 (0.4m)	NG	0
Cyanide	(mg/kg)	4	0	<2.5	<2.5		NG	0
pH	(pH	19	19	4.8	10.5		NG	0
Eastern area								
Metals								
Arsenic	(mg/kg)	7	7	5.5	255	WS232 (0.1m)	37 [1&2]	4 (WS231 (0.1m), WS232 (0.1m), WS233 (0.1m) and WS233 (1.5m)
Boron	(mg/kg)	7	3	<4	9.1	WS42 (0.5m)	290 [1]	0
Cadmium	(mg/kg)	7	4	<0.2	1.7	WS233 (0.1m)	11 [1]	0
Chromium	(mg/kg)	7	7	9.4	64	WS231 (0.1m)	910 [1]	0
Copper	(mg/kg)	7	4	<5	15	WS235 (0.2m)	2400 [1]	0
Lead	(mg/kg)	7	4	<2	29	WS232 (0.1m)	200 [2]	0
Mercury	(mg/kg)	7	0	<0.35	<0.35		40 [1]	0
Nickel	(mg/kg)	7	7	26	59	WS231 (0.1m)	180 [1]	0
Selenium	(mg/kg)	7	0	<0.35	<0.35		250 [1]	0
Zinc	(mg/kg)	7	7	14	68	WS231 (0.1m)	3700 [1]	0
Target polycyclic aromatic hydrocarbon (PAH) compounds								
Benzo(a)pyrene	(mg/kg)	7	4	<0.01	0.039	WS232 (0.1m)	2.2 [1]	0
Total PAH	(mg/kg)	7	4	<.1	0.6	WS235 (0.2m)		0
Phenols								
Phenols	(mg/kg)	7	0	<0.75	<0.75		NG	0
Others								
Total sulphate	(mg/kg)	2	1	<240	260	WS42 (0.5m)	NG	0
Soluble sulphate	(g/l)	2	0	<0.06	<0.06		NG	0
Cyanide	(mg/kg)	2	0	<2.5	<2.5		NG	0
TOC	(%)	1	1	2.3	2.3	WS42 (0.5m)	NG	0
pH	pH units	7	7	4.2	6.2		NG	0
Asbestos	Type	2	0	NAD	NAD			0

Notes:

>DL	Greater than detection limit of analytical method used
NAD	No asbestos detected
GRO	Gasoline range organics
DRO	Diesel range organics
LRO	Lubricating range organics
1	Concentrations taken from Suitable for use levels (S4ULs) produced by Land Quality Management Limited in partnership with The Chartered Institute of Environmental Health (CIEH) (The LQM/CIEH S4ULs for Human Health Risk Assessment 2015) for residential land use with homegrown produce based on 1% soil organic matter (SOM) (Reference 5).
2	Concentrations taken from Category 4 screening levels published by Contaminated Land: Applications in Real Environments (CL:AIRE) dated September 2014, release by Defra in December 2014 for residential land use with homegrown produce based on 1% soil organic matter (Reference 4)

Table 3
Summary of made round thicknesses proved at the 2023 site investigation locations

Location	Made ground thickness (m)	Thickness of Sandgate Formation proved (m)	Borehole or trial pit depth (m)
Western area			
BH1001	3.7	>0.1	3.8
BH1002	>4		4
BH1004	2.45	>0.05	2.5
BH1006	2.65	>0.1	2.75
BH1007	3.5	>0.1	3.6
BH1008	4.9	>0.1	5
BH1009	1.7	>0.1	1.8
TP100	>2.95		2.95
TP101	0.89	>1.76	2.65
TP102	1	>2.8	3.8
TP103	>4.36		4.36
TP104	0	>1.53	1.91
TP105	0	>1.77	2.3
TP106	0	>2.13	2.47
TP112	0	>2.3	2.83
Central area			
BH1010	>5		5
BH1011	>5		5
BH1012	>5		5
BH1013	4.9		5
TP107	>2.6		2.6
TP108	>2.68		2.68
Eastern area			
BH1014	>5		5
BH1015	>5		5
TP109	>4.1		4.1
TP110	>2.75		2.75
TP111	>3.4		3.4

Notes:
> Greater than

Table 4
Results of groundwater level monitoring carried out in the 2023 boreholes in March, April and June 2023

Borehole	Ground level (mAOD)	Base of borehole (mbgl)	Base of borehole (mAOD)	8 March 2023		27 April 2023		1 June 2023	
				Water level (mbgl)	Water level (mAOD)	Water level (mbgl)	Water level (mAOD)	Water level (mbgl)	Water level (mAOD)
Western area									
BH1001	122.99	3.80	119.19	Dry		3.78	119.21	3.86	119.13
BH1002	122.23	3.70	118.53	Dry		1.92	120.31	3.87	118.36
BH1004	110.88	2.50	108.38	Dry		Dry		Dry	
BH1006	106.16	2.75	103.41	Dry		Dry		Dry	
BH1007	101.18	3.60	97.58	Dry		0.95	100.23	3.82	97.36
BH1008	110.09	5.00	105.09	3.19	106.90	1.20	108.89	2.88	107.21
BH1009	108.32	1.80	106.52	Dry		0.97	107.35	1.93	106.39
Central area									
BH1010	120.89	5.00	115.89	Dry		Dry		5.22	115.67
BH1011	119.74	5.00	114.74	Dry		Dry		Dry	
BH1012	118.17	5.00	113.17	Dry		Dry		5.22	112.95
BH1013	122.06	5.00	117.06	Dry		Dry		Dry	
Eastern area									
BH1014	136.68	5.00	131.68	Dry		Dry		5.12	131.56
BH1015	133.31	5.00	128.31	Dry		3.78	119.21	5.22	128.09

Notes:
mAOD metres above Ordnance Datum – All mAOD in table approximated based on survey reference NGP-NU-15593.LSS
mbgl metres below ground level
Recorded groundwater level in the bottom 0.1m to 0.2m of the borehole
All recorded groundwater levels are within made ground within the boreholes

Table 5
Results of groundwater level monitoring carried out in the 2011/2012 boreholes at the site and in the wider Nutfield Park site in March, April and June 2023

Borehole	Ground level (mAOD)	Base of borehole (mAOD)	Monitoring horizon	8 March 2023		27 April 2023		1 June 2023	
				Water level (mbgl)	Water level (mAOD)	Water level (mbgl)	Water level (mAOD)	Water level (mbgl)	Water level (mAOD)
Area B - Former North Cockley Quarry/Landfill to the west of the site & Area C – Former Gore Meadow Quarry/Landfill to the north and west of the western area of the site									
BH5	123.75	117.75	CDI Waste	Damaged		Damaged		5.95	117.80
BH8	117.45	113.45	CDI Waste	Unable to locate		Unable to locate		3.71	113.74
BH9	110.30	104.80	CDI Waste	Dry		4.99	105.31	5.54	104.76
Area E - Former Beechfield Quarry/Landfill to the north of the central area of the site									
BH10	105.30	102.30	Inert Waste	Dry		2.41	102.89	2.63	102.67
BH11	110.70	99.70	Sandgate Formation	2.90	107.80	1.72	108.98	Unable to access	
BH12	91.55	87.65	Inert Waste	0.90	90.65	Not monitored in April or June 2023			
BH13	94.20	90.60	Folkestone Formation	Dry					
Area F – Former Church Hill Quarry/Landfill to the north of the eastern area of the site									
BH25	92.95	87.65	Inert Waste	3.05	89.90	Not monitored in April or June 2023			
BH26	102.20	93.20	Inert Waste	Dry					
BH28	121.30	111.30	Inert Waste	9.65	111.65	9.34	111.96	9.52	111.78
BH29	118.85	110.25	Inert Waste	6.43	112.42	6.02	112.83	Unable to access	
BH30	112.90	106.90	Inert Waste	3.38	109.53	Not monitored in April or June 2023			
Area D – Former Sand Pit in north of the wider Nutfield Park site									
BH18	85.55	80.05	CDI/Inert Waste	4.42	81.13	Not monitored in April or June 2023			
BH19	82.60	76.25	Inert Waste	1.78	80.82				
BH23	88.20	81.20	Folkestone Formation	Dry					
BH24	88.15	75.15	Folkestone Formation	6.18	81.97				

Notes:
mAOD metres above Ordnance Datum – All mAOD in table taken or calculated from the borehole logs

mbgl metres below ground level

Recorded water level in the bottom 0.1m to 0.2m of borehole

CDI - Commercial Domestic and Industrial Waste

Boreholes BH21 and BH22 which monitor the Sandgate Formation in the western area of the site, borehole BH27 which monitors inert waste in the Former Church Hill Quarry/Landfill to the north of the eastern area of the site and borehole BH20 which monitors inert waste in the Former Sand Pit in north of the wider Nutfield Park site could not be located.

Table 6
Results of ground gas monitoring carried out in the 2023 boreholes in March, April and June 2023

Date	Borehole	Methane (%v/v)	Carbon dioxide (%v/v)	Oxygen (%v/v)	Hydrogen sulphide (ppm)	Carbon monoxide (ppm)	Atmospheric pressure (mbar)	Relative pressure (mbar)	Flow rate (l/h)
Western area									
07/03/2023	BH1004	0.1	1.5	19.9			989	-1.34	0.6
	BH1006	0.0	3.6	18.0			990	-1.25	0.5
	BH1007	0.2	4.1	15.5			991	-1.23	0.6
	BH1008	0.1	2.3	20.0			989	-1.30	0.6
	BH1009	0.1	1.1	20.6			990	-1.29	0.5
08/03/2023	BH1001	0.1	2.7	18.6			978	-1.30	0.7
	BH1002	9.2	8.7	8.9			978	-1.37	0.6
27/04/2023	BH1001	0.0	2.3	17.4			1002	0.05	0.4
	BH1002	0.0	1.8	13.2			1003	-3.97	0.4
	BH1004	0.0	2.2	18.5			1005	0.09	0.4
	BH1006	0.0	6.8	9.7			1005	-0.76	0.3
	BH1007	0.0	0.1	21.0			1006	0.11	0.3
	BH1008	0.0	1.7	19.3	1	2	1005	-5.94	0.3
	BH1009	0.0	1.1	19.9	1	6	1005	3.32	0.3
01/06/2023	BH1001	0.0	2.5	16.0	0.00	0.00	1014	0.36	0.5
	BH1002	0.0	6.7	3.4	1.00	0.00	1015	0.41	0.3
	BH1004	0.0	1.8	19.8	0.00	0.00	1015	-0.09	0.1
	BH1006	0.0	7.2	16.0	0.00	0.00	1017	-0.02	0.0
	BH1007	0.0	1.1	19.3	0.00	0.00	1015	0.03	0.1
	BH1008	0.0	4.7	17.8	0.00	0.00	1015	0.09	0.0
	BH1009	0.0	3.5	17.0	1.00	0.00	1015	0.29	0.3
Central area									
07/03/2023	BH1010	0.1	2.9	12.1			988	-1.10	0.5
08/03/2023	BH1011	0.1	0.2	21.0			979	-1.17	0.5
	BH1012	0.0	4.6	15.6			979	-1.17	0.6
	BH1013	0.1	1.4	21.0			978	-1.29	0.5
27/04/2023	BH1010	0.0	1.3	15.9			1002	0.05	0.4
	BH1011	0.0	0.1	20.7			1004	0.07	0.4
	BH1012	0.0	1.3	19.1			1004	0.11	0.4
	BH1013	0.0	2.3	17.4			1003	0.14	0.4
01/06/2023	BH1010	0.0	0.2	19.9	1.00	0.00	1014	-0.07	0.1
	BH1011	0.0	0.1	20.9	0.00	0.00	1014	-0.10	0.1
	BH1012	0.0	1.5	20.0	0.00	0.00	1014	-0.09	0.2
	BH1013	0.0	3.3	16.2	0.00	0.00	1014	-0.02	0.0
Eastern area									
08/03/2023	BH1014	0.1	5.5	14.7			978	-1.05	0.4
	BH1015	0.1	2.2	19.9			977	-0.96	0.4
27/04/2023	BH1014	0.0	6.7	7.9			1002	-0.11	0.5
	BH1015	0.0	2.5	16.9			1002	0.56	0.6
01/06/2023	BH1014	0.0	7.7	11.4	1.00	0.00	1012	-0.12	0.1
	BH1015	0.0	3.6	16.9	0.00	0.00	1012	-1.01	0.2

Notes:
21.0 – Instrument recorded >21.0%

Table 7
Results of ground gas monitoring carried out in the 2011/2012 boreholes at the site and in the wider Nutfield Park site in March, April and June 2023

Date	Borehole	Methane (%v/v)	Carbon dioxide (%v/v)	Oxygen (%v/v)	Hydrogen sulphide (ppm)	Carbon monoxide (ppm)	Atmospheric pressure (mbar)	Relative pressure (mbar)	Flow rate (l/h)
Area B - Former North Cockley Quarry/Landfill to the west of the site & Area C – Former Gore Meadow Quarry/Landfill to the north and west of the western area of the site									
07/03/2023	BH9	71.9	27.5	0.2			989	-1.22	0.6
27/04/2023	BH9	83.7	18.0	0.5	1	1	1004	0.40	0.3
01/06/2023	BH5	69.4	20.8	1.8	1.00	2.00	1014	0.31	0.3
01/06/2023	BH9	71.5	22.5	1.5	0.00	1.00	1015	0.38	0.3
Area E - Former Beechfield Quarry/Landfill to the north of the central area of the site									
07/03/2023	BH10	0.1	2.6	7.5			990	-1.99	0.5
07/03/2023	BH11	0.1	4.1	19.5			989	-0.75	0.5
07/03/2023	BH13	2.0	5.3	0.3			992	-0.72	0.4
27/04/2023	BH10	0.0	2.1	11.7			-	-	0.3
27/04/2023	BH11	0.0	3.3	18.2			1003	1.76	0.4
01/06/2023	BH10	0.0	4.3	13.3	0.00	1.00	1016	0.34	0.3
Area F – Former Church Hill Quarry/Landfill to the north of the eastern area of the site									
07/03/2023	BH25	0.1	3.5	7.6			991	-1.00	0.4
07/03/2023	BH26	0.2	7.6	0.8			990	-3.40	0.5
07/03/2023	BH28	0.1	3.2	9.4			988	-1.13	0.5
07/03/2023	BH29	0.1	0.6	19.7			978	-1.41	0.6
27/04/2023	BH28	0.0	2.3	12.6			1004	0.02	0.4
27/04/2023	BH29	0.00	0.40	17.30			1002	0.16	0.40
01/06/2023	BH28	0.0	2.1	17.4	0.00	0.00	1014.00	0.27	0.3
Area D – Former Sand Pit in north of the wider Nutfield Park site									
07/03/2023	BH18	0.0	3.8	17.0			993	-2.18	0.3
08/03/2023	BH19	0.0	4.0	16.8			993	-0.84	0.4
08/03/2023	BH23	0.0	1.4	20.5			992	-1.75	0.5

Table 8
Summary of the results of the 2023 soil chemical analysis for the western area of the site

Determinands	Units	Count	Count >DL	Minimum	Maximum	Location of maximum	Generic Assessment Criteria (GAC) value for residential land use with homegrown produce (mg/kg)	No of samples exceeding GAC
Metals								
Arsenic	(mg/kg)	17	17	6.3	50.8	BH1007 (2.8m - 3.0m)	37 [1&2]	4 (BH1001, BH1002 (2.30m - 2.45m), BH1007 and BH1009)
Barium	(mg/kg)	17	17	70	503	TP101 (0.89m - 2.65m)	1300 [3]	0
Beryllium	(mg/kg)	17	17	1	3	BH1008 (4.5m - 5.0m)	1.7 [1]	13 (BH1001, BH1002, BH1006 to BH1009, TP100 (0.60m – 1.55m), TP101, TP102, TP103 and TP106)
Boron (Water Soluble)	(mg/kg)	17	17	0.2	6.3	BH1002 (2.30m - 2.45m)	290 [1]	0
Cadmium	(mg/kg)	17	0	<0.1	<0.1		11 [1]	0
Chromium III	(mg/kg)	17	17	4.3	60.5	TP103 (1.54m - 3.75m)	910 [1]	0
Hexavalent Chromium	(mg/kg)	17	0	<0.3	<0.3		6 [1]	0
Copper	(mg/kg)	17	17	2	45	BH1002 (2.30m - 2.45m)	2400 [1]	0
Lead	(mg/kg)	17	17	5	117	BH1002 (2.30m - 2.45m)	200 [2]	0
Mercury	(mg/kg)	17	4	0.1	0.3	BH1002 (2.30m - 2.45m)	40 [1]	0
Nickel	(mg/kg)	17	17	6.8	50	BH1007 (2.8m - 3.0m)	180 [1]	0
Selenium	(mg/kg)	17	6	1	3	BH1002 (2.30m - 2.45m)	250 [1]	0
Vanadium	(mg/kg)	17	17	6	75	BH1002 (2.30m - 2.45m)	410 [1]	0
Zinc	(mg/kg)	17	17	20	313	BH1002 (2.30m - 2.45m)	3700 [1]	0
Target polycyclic aromatic hydrocarbon (PAH) compounds								
Naphthalene	(mg/kg)	17	1	<0.04	1.8	BH1002 (2.30m - 2.45m)	2.3 [1]	0
Acenaphthylene	(mg/kg)	17	1	<0.03	6.45	BH1002 (2.30m - 2.45m)	170 [1]	0
Acenaphthene	(mg/kg)	17	1	<0.05	0.84	BH1002 (2.30m - 2.45m)	210 [1]	0
Fluorene	(mg/kg)	17	1	<0.04	1.16	BH1002 (2.30m - 2.45m)	170 [1]	0
Phenanthrene	(mg/kg)	17	5	<0.03	12.79	BH1002 (2.30m - 2.45m)	95 [1]	0
Anthracene	(mg/kg)	17	2	<0.04	7.61	BH1002 (2.30m - 2.45m)	2400 [1]	0
Fluoranthene	(mg/kg)	17	6	<0.03	38.7	BH1002 (2.30m - 2.45m)	280 [1]	0
Pyrene	(mg/kg)	17	6	<0.03	33.26	BH1002 (2.30m - 2.45m)	620 [1]	0
Benzo(a)anthracene	(mg/kg)	17	5	<0.06	20.02	BH1002 (2.30m - 2.45m)	7.2 [1]	1 (BH1002 (2.30m - 2.45m))
Chrysene	(mg/kg)	17	6	<0.02	23.45	BH1002 (2.30m - 2.45m)	15 [1]	1 (BH1002 (2.30m - 2.45m))
Benzo(bk)fluoranthene	(mg/kg)	17	5	<0.07	54.4	BH1002 (2.30m - 2.45m)	77 [1]	0
Benzo(a)pyrene	(mg/kg)	17	4	<0.04	30.99	BH1002 (2.30m - 2.45m)	2.2 [1]	1 (BH1002 (2.30m - 2.45m))
Indeno(123cd)pyrene	(mg/kg)	17	5	<0.04	33.11	BH1002 (2.30m - 2.45m)	27 [1]	1 (BH1002 (2.30m - 2.45m))

Determinands	Units	Count	Count >DL	Minimum	Maximum	Location of maximum	Generic Assessment Criteria (GAC) value for residential land use with homegrown produce (mg/kg)	No of samples exceeding GAC
Dibenzo(ah)anthracene	(mg/kg)	17	1	<0.04	5.81	BH1002 (2.30m - 2.45m)	0.24 [1]	1 (BH1002 (2.30m - 2.45m))
Benzo(ghi)perylene	(mg/kg)	17	4	<0.04	28.47	BH1002 (2.30m - 2.45m)	320 [1]	0
PAH 16 Total	(mg/kg)	17	4	1.2	298.9	BH1002 (2.30m - 2.45m)		0
Benzo(b)fluoranthene	(mg/kg)	17	5	0.08	39.17	BH1002 (2.30m - 2.45m)	2.6 [1]	1 (BH1002 (2.30m - 2.45m))
Benzo(k)fluoranthene	(mg/kg)	17	5	0.03	15.23	BH1002 (2.30m - 2.45m)	77 [1]	0
VOC TICs		3	0	ND	ND			
SVOC TICs		3	1	ND	TICs	TP103 (1.54m - 3.75m)		
Hexathiane					17.218	TP103 (1.54m - 3.75m)	NG	
Cyclic octaatomic sulfur					385.534	TP103 (1.54m - 3.75m)	NG	
Hydrocarbons								
EPH (C8-C40	(mg/kg)	17	3	<30	4003	BH1002 (2.30m - 2.45m)	27 to 65000 [1]	3 (BH1002 (2.30m to 2.45m), TP100 (1.55m to 1.86m) and TP103 (1.54m to 3.75m))
Polychlorinated biphenyls (PCBs)								
Total 7 PCBs	(ug/kg)	3	0	<35	<35		NG	0
Speciated Phenols								
Total Speciated Phenols HPLC	(mg/kg)	17	1	<0.15	0.44	TP106 (0.34m - 0.71m)	NG	0
Resorcinol	(mg/kg)	17	3	<0.01	0.41	TP106 (0.34m - 0.71m)	NG	0
Catechol	(mg/kg)	17	0	<0.01	<0.01		NG	0
Phenol	(mg/kg)	17	0	<0.01	<0.01		280 [1]	0
m/p-cresol	(mg/kg)	17	0	<0.02	<0.02		NG	0
o-cresol	(mg/kg)	17	0	<0.01	<0.01		NG	0
Total cresols	(mg/kg)	17	0	<0.03	<0.03		80 [3]	0
Xylenols	(mg/kg)	17	0	<0.06	<0.06		NG	0
1-naphthol	(mg/kg)	17	0	<0.01	<0.01		NG	0
2,3,5-trimethyl phenol	(mg/kg)	17	0	<0.01	<0.01		NG	0
2-isopropylphenol	(mg/kg)	17	1	<0.01	0.03	TP106 (0.34m - 0.71m)	NG	0
Others								
Natural Moisture Content	(%)	17	17	13.7	52.8	BH1002 (2.30m - 2.45m)		0
Sulphate as SO4 (2:1 Ext)	(g/l)	17	17	0.0057	1.7721	TP103 (1.54m - 3.75m)	NG	0
Total Cyanide	(mg/kg)	17	1	<0.5	0.9	TP103 (1.54m - 3.75m)	NG	0
Total Organic Carbon	(%)	17	17	0.11	6.7	BH1002 (2.30m - 2.45m)	NG	0
Sulphide	(mg/kg)	17	1	<10	17	TP100 (1.55m-1.86m)	NG	0
pH	pH units	17	17	5.99	8.57		NG	0
Asbestos Type	Type	17	0	NAD	NAD			

Notes:

>DL	Greater than detection limit of analytical method used
NAD	No asbestos detected
1	Concentrations taken from Suitable for use levels (S4ULs) produced by Land Quality Management Limited in partnership with The Chartered Institute of Environmental Health (CIEH) (The LQM/CIEH S4ULs for Human Health Risk Assessment 2015) for residential land use with homegrown produce based on 1% soil organic matter (SOM) (Reference 5).
2	Concentrations taken from Category 4 screening levels published by Contaminated Land: Applications in Real Environments (CL:AIRE) dated September 2014, release by Defra in December 2014 for residential land use with homegrown produce based on 1% soil organic matter (Reference 4)

Determinands	Units	Count	Count >DL	Minimum	Maximum	Location of maximum	Generic Assessment Criteria (GAC) value for residential land use with homegrown produce (mg/kg)	No of samples exceeding GAC
Notes (continued):								
[3]	Concentrations taken from Soil Generic Assessment Criteria (GAC)for Human Health Risk Assessment published by CL:AIRE in association with Environmental Industries Commission (EIC) and the Association of Geotechnical and Geoenvironmental Specialists (AGS) dated January 2010 for residential land use without homegrown produce (with homegrown produce were not derived as part of the study) (reference 6)							

Table 9
Summary of the results of the 2023 soil chemical analysis for the central area of the site

Determinands	Units	Count	Count >DL	Minimum	Maximum	Location of maximum	Generic Assessment Criteria (GAC) value for residential land use with homegrown produce (mg/kg)	No of samples exceeding GAC
Metals								
Arsenic	(mg/kg)	5	5	17.2	62.1	BH1011 (2.5m - 3.0m)	37 [1&2]	3 (BH1011 to BH1013)
Barium	(mg/kg)	5	5	122	832	BH1011 (2.5m - 3.0m)	1300 [3]	0
Beryllium	(mg/kg)	5	5	2.1	4.4	BH1011 (2.5m - 3.0m)	1.7 [1]	5 (BH1010 to BH1014 and TP107)
Boron (Water Soluble)	(mg/kg)	5	5	0.7	3.1	BH1011 (2.5m - 3.0m)	290 [1]	0
Cadmium	(mg/kg)	5	0	<0.1	<0.1		11 [1]	0
Chromium III	(mg/kg)	5	5	34.6	64.3	BH1013 (4.5m to 4.7m)	910 [1]	0
Hexavalent Chromium	(mg/kg)	5	0	<0.3	<0.3		6 [1]	0
Copper	(mg/kg)	5	5	3	58	TP107 (1.43m - 1.82m)	2400 [1]	0
Lead	(mg/kg)	5	5	12	36	BH1011 (2.5m - 3.0m)	200 [2]	0
Mercury	(mg/kg)	5	2	<0.1	0.1	BH1012 (2.3m - 2.5m) and BH1013 (4.5m to 4.7m)	40 [1]	0
Nickel	(mg/kg)	5	5	39.3	95	BH1012 (2.3m - 2.5m)	180 [1]	0
Selenium	(mg/kg)	5	2	<1	2	BH1012 (2.3m - 2.5m)	250 [1]	0
Vanadium	(mg/kg)	5	5	57	78	BH1011 (2.5m - 3.0m)	410 [1]	0
Zinc	(mg/kg)	5	5	37	135	BH1012 (2.3m - 2.5m)	3700 [1]	0
Target polycyclic aromatic hydrocarbon (PAH) compounds								
Naphthalene	(mg/kg)	5	0	<0.04	<0.04		2.3 [1]	0
Acenaphthylene	(mg/kg)	5	1	<0.03	0.05	BH1012 (2.3m - 2.5m)	170 [1]	0
Acenaphthene	(mg/kg)	5	0	<0.05	<0.05		210 [1]	0
Fluorene	(mg/kg)	5	0	<0.04	<0.04		170 [1]	0
Phenanthrene	(mg/kg)	5	4	<0.03	0.19	BH1011 (2.5m - 3.0m)	95 [1]	0
Anthracene	(mg/kg)	5	0	<0.04	<0.04		2400 [1]	0
Fluoranthene	(mg/kg)	5	5	0.05	0.22	BH1012 (2.3m - 2.5m)	280 [1]	0
Pyrene	(mg/kg)	5	5	0.04	0.45	BH1012 (2.3m - 2.5m)	620 [1]	0
Benzo(a)anthracene	(mg/kg)	5	3	<0.06	0.16	BH1013 (4.5m to 4.7m)	7.2 [1]	0
Chrysene	(mg/kg)	5	5	0.04	0.13	BH1012 (2.3m - 2.5m)	15 [1]	0
Benzo(bk)fluoranthene	(mg/kg)	5	4	<0.07	0.25	BH1013 (4.5m to 4.7m)	77 [1]	0
Benzo(a)pyrene	(mg/kg)	5	1	<0.04	0.11	BH1012 (2.3m - 2.5m)	2.2 [1]	0
Indeno(123cd)pyrene	(mg/kg)	5	2	<0.04	0.11	BH1012 (2.3m - 2.5m)	27 [1]	0
Dibenzo(ah)anthracene	(mg/kg)	5	0	<0.04	<0.04		0.24 [1]	0
Benzo(ghi)perylene	(mg/kg)	5	3	<0.04	0.13	BH1012 (2.3m - 2.5m)	320 [1]	0
PAH 16 Total	(mg/kg)	5	3	<0.6	1.6	BH1012 (2.3m - 2.5m)		0
Benzo(b)fluoranthene	(mg/kg)	5	4	<0.05	0.18	BH1013 (4.5m to 4.7m)	2.6 [1]	0
Benzo(k)fluoranthene	(mg/kg)	5	4	<0.02	0.07	BH1013 (4.5m to 4.7m)	77 [1]	0
VOC TICs		1	0	0	0			0
SVOC TICs		1	0	0	0			0
Hydrocarbons								
EPH (C8-C40	(mg/kg)	5	1	<30	303	BH1011 (2.5m - 3.0m)	27 to 65000 [1]	1 (BH1011 (2.5m - 3.0m))
Polychlorinated biphenyls (PCBs)								

Determinands	Units	Count	Count >DL	Minimum	Maximum	Location of maximum	Generic Assessment Criteria (GAC) value for residential land use with homegrown produce (mg/kg)	No of samples exceeding GAC
Total 7 PCBs	(ug/kg)	1	0	<35	<35		NG	0
Speciated Phenols								
Total Speciated Phenols HPLC	(mg/kg)	5	0	<0.15	<0.15		NG	0
Resorcinol	(mg/kg)	5	0	<0.01	<0.01		NG	0
Catechol	(mg/kg)	5	0	<0.01	<0.01		NG	0
Phenol	(mg/kg)	5	0	<0.01	<0.01		280 [1]	0
m/p-cresol	(mg/kg)	5	0	<0.02	<0.02		NG	0
o-cresol	(mg/kg)	5	0	<0.01	<0.01		NG	0
Total cresols	(mg/kg)	5	0	<0.03	<0.03		80 [3]	0
Xylenols	(mg/kg)	5	0	<0.06	<0.06		NG	0
1-naphthol	(mg/kg)	5	0	<0.01	<0.01		NG	0
2,3,5-trimethyl phenol	(mg/kg)	5	0	<0.01	<0.01		NG	0
2-isopropylphenol	(mg/kg)	5	0	<0.01	<0.01		NG	0
Others								
Natural Moisture Content	(%)	5	5	18.7	50.8	BH1010 (1.5m - 1.7m)		0
Sulphate as SO4 (2:1 Ext)	(g/l)	5	5	0.0135	1.5812	BH1010 (1.5m - 1.7m)	NG	0
Total Cyanide	(mg/kg)	5	0	<0.5	<0.5		NG	0
Total Organic Carbon	(%)	5	5	0.46	24.84	TP107 (1.43m - 1.82m)	NG	0
Sulphide	(mg/kg)	5	0	<10	<10		NG	0
pH	pH units	5	5	6.22	8.17		NG	0
Asbestos Type	Type	5	0	NAD	NAD			0

Notes:

>DL Greater than detection limit of analytical method used

NAD No asbestos detected

[1] Concentrations taken from Suitable for use levels (S4ULs) produced by Land Quality Management Limited in partnership with The Chartered Institute of Environmental Health (CIEH) (The LQM/CIEH S4ULs for Human Health Risk Assessment 2015) for residential land use with homegrown produce based on 1% soil organic matter (SOM) (Reference 5).

[2] Concentrations taken from Category 4 screening levels published by Contaminated Land: Applications in Real Environments (CL:AIRE) dated September 2014, release by Defra in December 2014 for residential land use with homegrown produce based on 1% soil organic matter (Reference 4)

[3] Concentrations taken from Soil Generic Assessment Criteria (GAC)for Human Health Risk Assessment published by CL:AIRE in association with Environmental Industries Commission (EIC) and the Association of Geotechnical and Geoenvironmental Specialists (AGS) dated January 2010 for residential land use without homegrown produce (with homegrown produce were not derived as part of the study) (reference 6)

Table 10
Summary of the results of the 2023 soil chemical analysis for the eastern area of the site

Determinands	Units	Count	Count >DL	Minimum	Maximum	Location of maximum	Generic Assessment Criteria (GAC) value for residential land use with homegrown produce (mg/kg)	No of samples exceeding GAC
Metals								
Arsenic	(mg/kg)	6	6	16.6	48	TP110 (0.88m - 1.36m)	37 [1&2]	2 (BH1015 (2.9m - 3.4m) and TP110 (0.88m - 1.36m))
Barium	(mg/kg)	6	6	54	260	TP110 (0.88m - 1.36m)	1300 [3]	0
Beryllium	(mg/kg)	6	6	2.4	7.1	TP111 (1.47m - 3.40m)	1.7 [1]	6 (BH1014, BH1015 and TP109 (both depths) to TP111)
Boron (Water Soluble)	(mg/kg)	6	6	0.6	2	TP109 (3.0m - 4.1m)	290 [1]	0
Cadmium	(mg/kg)	6	0	<0.1	<0.1		11 [1]	0
Chromium III	(mg/kg)	6	6	11.5	84.4	TP110 (0.88m - 1.36m)	910 [1]	0
Hexavalent Chromium	(mg/kg)	6	0	<0.3	<0.3		6 [1]	0
Copper	(mg/kg)	6	6	5	71	BH1014 (3.1m - 3.3m)	2400 [1]	0
Lead	(mg/kg)	6	6	13	78	BH1014 (3.1m - 3.3m)	200 [2]	0
Mercury	(mg/kg)	6	1	<0.1	0.1	BH1015 (2.9m - 3.4m)	40 [1]	0
Nickel	(mg/kg)	6	6	24.8	55.8	TP110 (0.88m - 1.36m)	180 [1]	0
Selenium	(mg/kg)	6	2	<1	2	TP110 (0.88m - 1.36m)	250 [1]	0
Vanadium	(mg/kg)	6	6	16	101	TP110 (0.88m - 1.36m)	410 [1]	0
Zinc	(mg/kg)	6	6	40	371	BH1014 (3.1m - 3.3m)	3700 [1]	0
Target polycyclic aromatic hydrocarbon (PAH) compounds								
Naphthalene	(mg/kg)	6	0	<0.04	<0.04		2.3 [1]	0
Acenaphthylene	(mg/kg)	6	0	<0.03	<0.03		170 [1]	0
Acenaphthene	(mg/kg)	6	0	<0.05	<0.05		210 [1]	0
Fluorene	(mg/kg)	6	0	<0.04	<0.04		170 [1]	0
Phenanthrene	(mg/kg)	6	2	<0.03	0.18	BH1014 (3.1m - 3.3m)	95 [1]	0
Anthracene	(mg/kg)	6	0	<0.04	<0.04		2400 [1]	0
Fluoranthene	(mg/kg)	6	3	<0.03	0.38	BH1014 (3.1m - 3.3m)	280 [1]	0
Pyrene	(mg/kg)	6	3	<0.03	0.29	BH1014 (3.1m - 3.3m)	620 [1]	0
Benzo(a)anthracene	(mg/kg)	6	1	<0.06	0.32	BH1014 (3.1m - 3.3m)	7.2 [1]	0
Chrysene	(mg/kg)	6	3	<0.02	0.23	BH1014 (3.1m - 3.3m)	15 [1]	0
Benzo(bk)fluoranthene	(mg/kg)	6	2	<0.07	0.43	BH1014 (3.1m - 3.3m)	77 [1]	0
Benzo(a)pyrene	(mg/kg)	6	1	<0.04	0.2	BH1014 (3.1m - 3.3m)	2.2 [1]	0
Indeno(123cd)pyrene	(mg/kg)	6	1	<0.04	0.18	BH1014 (3.1m - 3.3m)	27 [1]	0
Dibenzo(ah)anthracene	(mg/kg)	6	0	<0.04	<0.04		0.24 [1]	0
Benzo(ghi)perylene	(mg/kg)	6	1	<0.04	0.16	BH1014 (3.1m - 3.3m)	320 [1]	0
PAH 16 Total	(mg/kg)	6	1	<0.6	2.4	BH1014 (3.1m - 3.3m)		0
Benzo(b)fluoranthene	(mg/kg)	6	2	<0.05	0.31	BH1014 (3.1m - 3.3m)	2.6 [1]	0
Benzo(k)fluoranthene	(mg/kg)	6	2	<0.02	0.12	BH1014 (3.1m - 3.3m)	77 [1]	0
VOC TICs		3	0					
SVOC TICs		3	0					
Hydrocarbons								
EPH (C8-C40	(mg/kg)	6	1	<30	39	TP110 (0.88m - 1.36m)	27 to 65000 [1]	1 (TP110 (0.88m - 1.36m))
Polychlorinated biphenyls (PCBs)								
Total 7 PCBs	(ug/kg)	3	0	<35	<35		NG	0
Speciated Phenols								

Determinands	Units	Count	Count >DL	Minimum	Maximum	Location of maximum	Generic Assessment Criteria (GAC) value for residential land use with homegrown produce (mg/kg)	No of samples exceeding GAC
Total Speciated Phenols HPLC	(mg/kg)	6	0	<0.15	<0.15		NG	0
Resorcinol	(mg/kg)	6	0	<0.01	<0.01		NG	0
Catechol	(mg/kg)	6	0	<0.01	<0.01		NG	0
Phenol	(mg/kg)	6	0	<0.01	<0.01		280 [1]	0
m/p-cresol	(mg/kg)	6	0	<0.02	<0.02		NG	0
o-cresol	(mg/kg)	6	0	<0.01	<0.01		NG	0
Total cresols	(mg/kg)	6	0	<0.03	<0.03		80 [3]	0
Xylenols	(mg/kg)	6	0	<0.06	<0.06		NG	0
1-naphthol	(mg/kg)	6	0	<0.01	<0.01		NG	0
2,3,5-trimethyl phenol	(mg/kg)	6	0	<0.01	<0.01		NG	0
2-isopropylphenol	(mg/kg)	6	0	<0.01	<0.01		NG	0
Others								
Natural Moisture Content	(%)	6	6	20.5	270.6	TP109 (3.0m - 4.1m)		0
Sulphate as SO4 (2:1 Ext)	(g/l)	6	6	0.0766	2.5238	TP109 (3.0m - 4.1m)	NG	0
Total Cyanide	(mg/kg)	6	0	<0.5	<0.5		NG	0
Total Organic Carbon	(%)	6	6	0.22	12.81	TP109 (2.25m - 2.50m)	NG	0
Sulphide	(mg/kg)	6	0	<10	<10		NG	0
pH	pH units	6	6	7.26	7.74		NG	0
Asbestos Type	Type	6	0	NAD	NAD			0

Notes:

>DL	Greater than detection limit of analytical method used
NAD	No asbestos detected
1	Concentrations taken from Suitable for use levels (S4ULs) produced by Land Quality Management Limited in partnership with The Chartered Institute of Environmental Health (CIEH) (The LQM/CIEH S4ULs for Human Health Risk Assessment 2015) for residential land use with homegrown produce based on 1% soil organic matter (SOM) (Reference 5).
2	Concentrations taken from Category 4 screening levels published by Contaminated Land: Applications in Real Environments (CL:AIRE) dated September 2014, release by Defra in December 2014 for residential land use with homegrown produce based on 1% soil organic matter (Reference 4)
3	Concentrations taken from Soil Generic Assessment Criteria (GAC) for Human Health Risk Assessment published by CL:AIRE in association with Environmental Industries Commission (EIC) and the Association of Geotechnical and Geoenvironmental Specialists (AGS) dated January 2010 for residential land use without homegrown produce (with homegrown produce were not derived as part of the study) (reference 6)

Table 11
Summary of the results of groundwater quality monitoring carried out in March and April 2023

Sample location		BH28	BH1008	BH1009	BH1002
Sample date		08/03/23	08/03/23	27/04/23	27/04/23
Determinands (units)	UK DWS [1,2]				
Dissolved Arsenic (ug/l)	10	0.9	1.6	<2.5	<2.5
Dissolved Barium (ug/l)		22.2	86.9	71	207
Dissolved Beryllium (ug/l)		<0.5	<0.5	<0.5	<0.5
Dissolved Boron (ug/l)	1000	261	84	38	36
Dissolved Cadmium (ug/l)	5	<0.03	0.16	<0.5	<0.5
Total Dissolved Chromium (ug/l)	50	0.9	0.2	2.5	<1.5
Hexavalent Chromium (ug/l)		<2	<2	<6	<6
Total Dissolved Chromium III (ug/l)		<2	<2	<6	<6
Dissolved Copper (ug/l)	2000	1	1	<7	<7
Dissolved Lead (ug/l)	10	0.5	<0.4	<5	<5
Dissolved Mercury (ug/l)	1	<0.5	<0.5	<1	<1
Dissolved Nickel (ug/l)	20	2.1	6.6	5	4
Dissolved Selenium (ug/l)	10	<1.2	<1.2	<3	<3
Dissolved Vanadium (ug/l)[1]	20 - 60	1.2	<0.6	2.9	<1.5
Dissolved Zinc (ug/l)[2]	12.9	10.4	36	8	<3
Sulphate as SO4 (mg/l)	250	1644	197.1	28	25.2
Total Cyanide (mg/l)	0.05	<0.01	<0.01	<0.01	<0.01
Ammoniacal Nitrogen as N (mg/l)	0.39	0.33	<0.03	0.12	2.85
pH (pH units)	6.5 to 9.5	7.33	7.34	6.64	7.33

Notes:
UK DWS - UK Drinking Water Standards taken from The Water Supply (Water Quality) Regulations 2016 Statutory Instrument 2016 No. 614.
1 There is no UK DWS for vanadium. The standard presented comprises the freshwater operational average annual EQS specified by the Environment Agency at https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit with an EQS of 20ug/l for waters with 0-200mg/l of calcium carbonate and 60ug/l for waters with more than 200mg/l of calcium carbonate.
2 There is no UK DWS for zinc. The standard presented comprises the average annual freshwater EQS and comprises a bioavailable concentration (10.9ug/l) plus the ambient background concentration of 2ug/l for the Thames region. The EQS for zinc is taken from The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.
Concentration is above the guideline value

VOC and SVOC including TICs, PCBs, TPH-CWG, speciated phenols, total cyanide and sulphide were all recorded below the detection limit of the analytical methods.

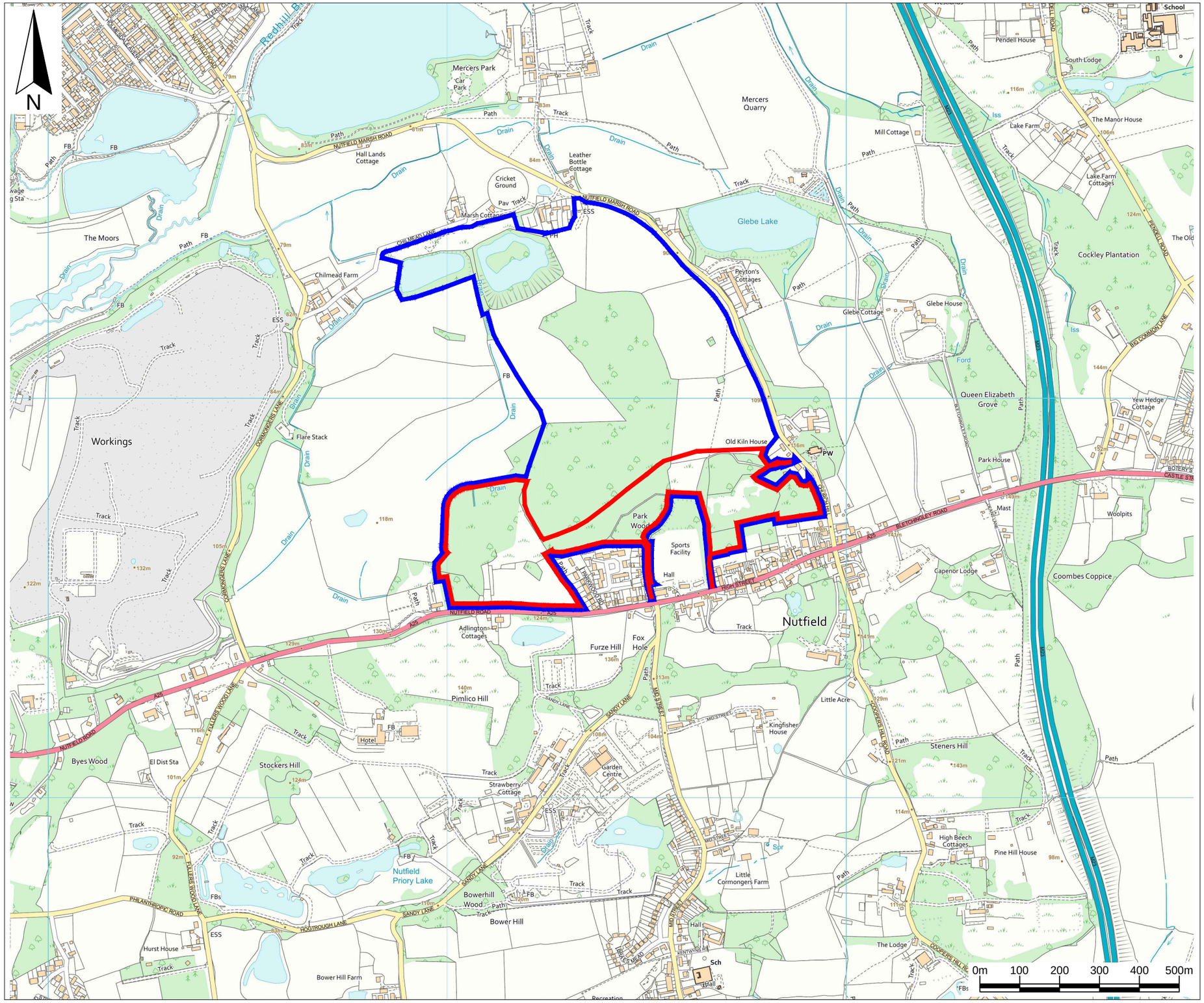
Table 12
Summary of the records of orange/yellow clay/silt across the site

Location	Description of silt/ clay & depths (m)	Thickness (m)	Elevation of top (mAOD)	Engineering properties		Sample depth (m)	Soluble sulphate (g/l)	Total sulphate (mg/kg)	Sample material type
					SPT N				
Western area									
BH1008	Frequent orange silt inclusions 3.6m-4.9m within grey silt (2.2m-4.9m)			Firm	15	4.50-5.00	0.0579		Grey Clayey Silt
BH1008	Pale grey clayey silt 2.2m-4.9m	2.7	107.9	Firm	12-15	Not tested			
TP100	Orange silt 2.48m-2.95m Base not proved (orange silt inclusions 1.86m-2.48m)	0.47	118.3	Soft		Not tested			
TP101	Orange silt inclusions 0.4m-0.89m					Not tested			
WS201	Yellow silty clay 0.3m-0.4m	0.1	120.7	Soft		0.35	1.2	26,000	Yellow Clay
Central area									
BH1010	Orange silt 1.45m-5m Base not proved	>3.55	119.4	V Stiff	0-1	1.50-1.70	1.5812		Orange Clayey Silt
BH1011	Orange silt 0.1m-1.8m (occasional orange silt inclusions 2.4m-3.2m)	1.7	119.6	V Stiff	0	2.50-3.00	1.5138		Sandy clay with clinker and coal and occasional orange silt inclusions
BH1012	Orange silt inclusions 0.1m-2.0m			Firm	13	Not tested			
TP107	Orange silt 1.82m-2.6m	0.78	120.6	Soft		Not tested			
TP108	Orange silt 1.79m-2.68m Base not proved	>0.89	122.0	Soft		Not tested			
WS215	Yellow brown silty clay 0.2m-2.0m Base not proved	>1.8	118.1	Soft		0.4	1.2	29,000	Sandy clay
WS227	Yellowish orange clay 0m-4.6m	4.6	114.5	Soft		0.2		40,000	Yellow clay
WS230	Yellow silty clay 1.7m-3.0m Base not proved	>1.3	121.2	Soft		Not tested			
Eastern area									
BH1014	Orange silt 2.9m-5m Base not proved	>2.1	133.8	V Stiff	0-6	3.10-3.30	1.5719		Orange clayey silt with coal
BH1015	Orange silt 1.5m-2.9m (occasional orange silt inclusions 0.8m-1.5m/ orange silt inclusions 2.9m to 4.2m)	1.4	131.8	V Stiff	0	2.90-3.40	1.5961		Sandy clay with inclusions of orange silt and coal
TP109	Orange silt 3.0m-4.1m Base not proved	>1.1	134.3	Soft		3.00-4.10	2.5238		Orange Silt
TP110	Orange silt 1.72m-2.75m Base not proved	>1.03	132.7	Soft		Not tested			
TP111	Orange silt 1.47m-3.4m Base not proved (orange silt inclusions 0.9m-1.47m)	>1.93	133.5	Soft		1.47-3.40	1.6812		Orange Silt
WS42	Bright yellow silt 1.1m-1.4m	0.3	133.4	Firm	1 blow[1]	Not tested			
WS43	Bright yellow silt 1.3m-3.0m Base not proved	>1.7	135.7	Firm	1 blow[2]	Not tested			

Notes:

	Yellow/ orange silt/ clay
	Inclusions of yellow/orange silt/clay
	Pale grey clayey silt
	2011/2012 site investigation location includes yellow/orange silt/clay
1	1 blow for each 0.3m penetration
2	1 blow for each 1m penetration

FIGURES



Key / Notes

Approximate boundary of the 2023 site investigation works

Approximate boundary of the wider Nutfield Park site

Rev	Status	Drn	App	Chk	Date
	Draft	KR	JCO	JRC	25/07/23

Site
NUTFIELD GREEN PARK

Client
Nutfield Park (Developments) Limited

Title
The indicative boundary of the 2023 site investigation works

DRAFT

Figure 1

Scale
1:10,000@A3

Drawing Ref
HGH/NU/04-23/23669

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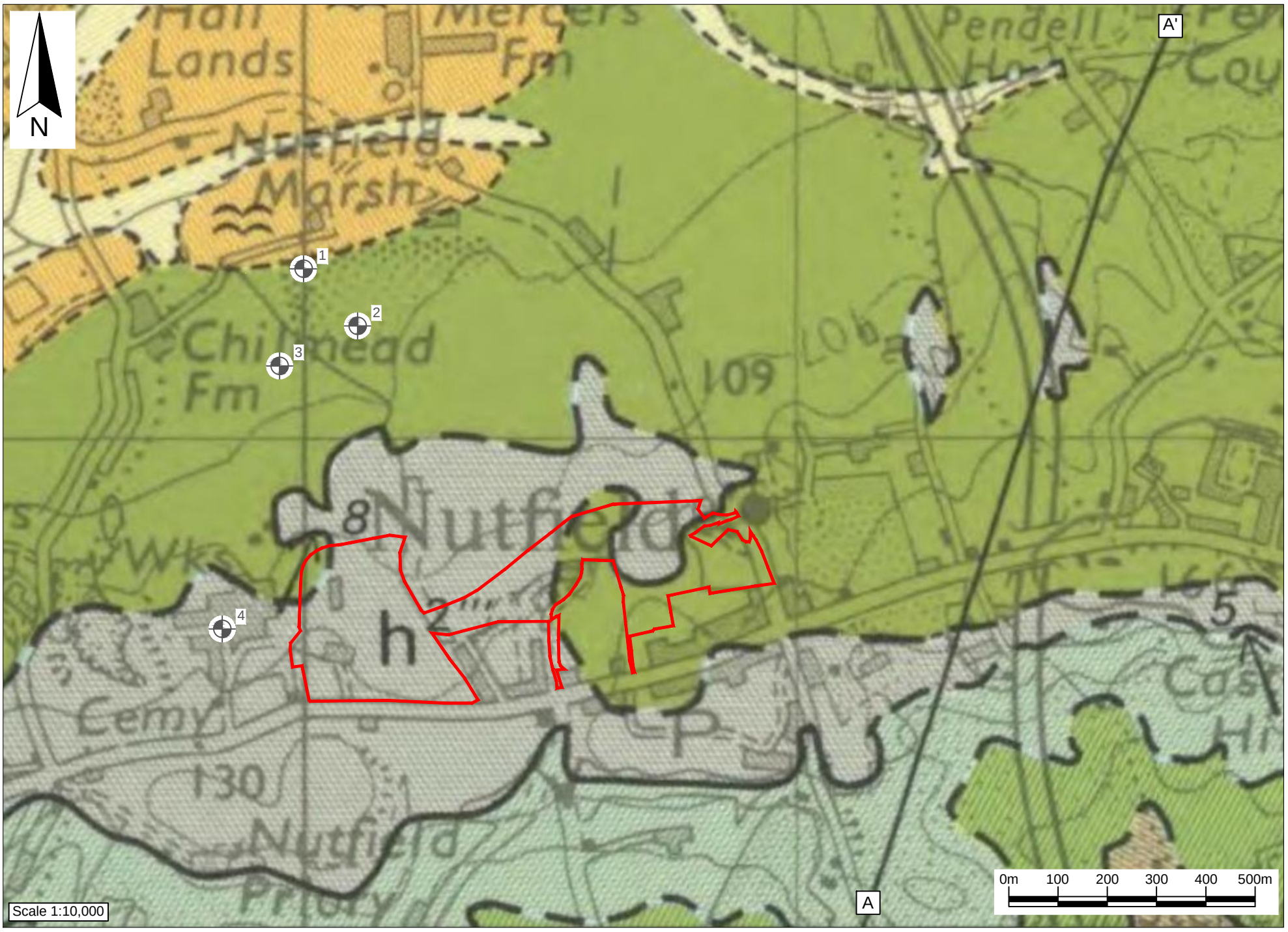

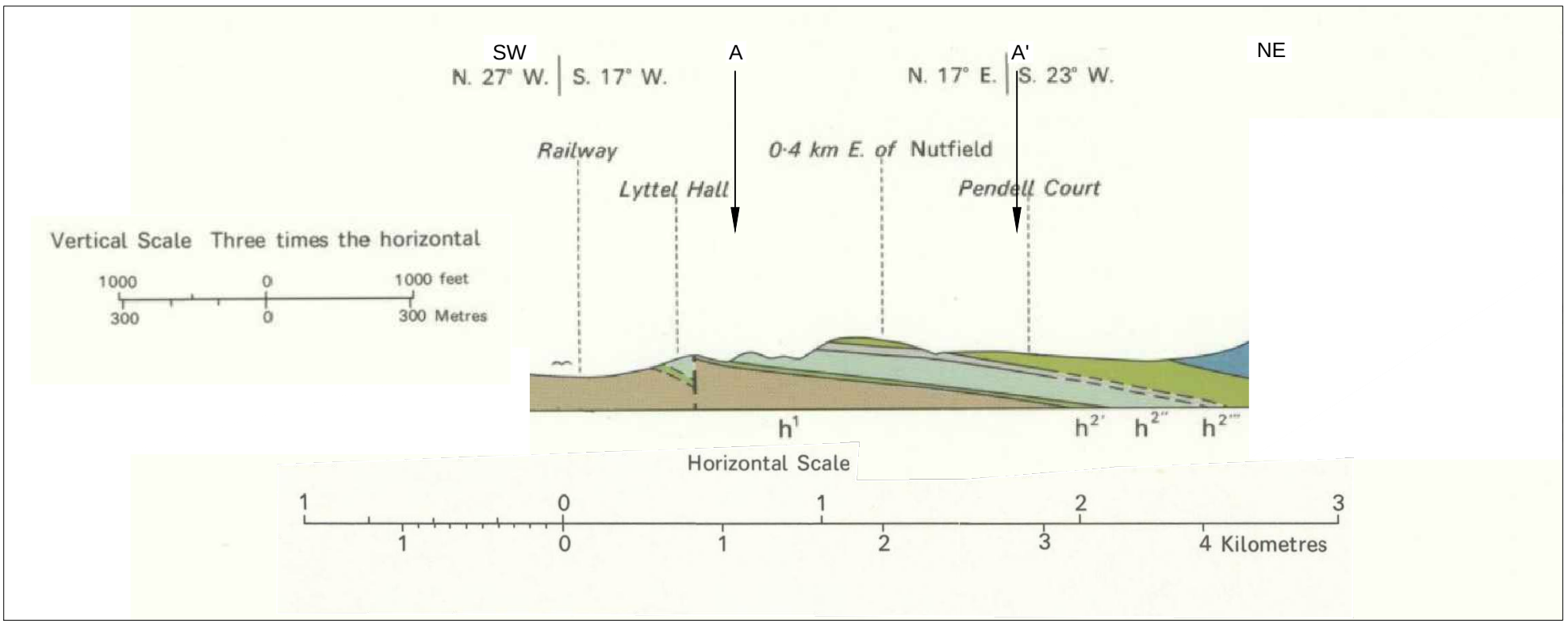

Key / Notes

Approximate boundary of the 2023 site investigation works

1 TQ35SW2

2 TQ35SW37

3 TQ35SE187

4 TQ25SE215

Geology Drift

- Alluvium
- Brickearth
- Inclined strata, Dip in degrees
- Geological boundary, Drift
- Geological boundary, Solid

Geology Bedrock

- h^3 Gault 45-102m
- Lower Greensand Group:
  - $h^{2''''}$ Folkestone Formation - Sandstone (36-75m)
  - $h^{2'''}$ Sandgate Formation - Sandstone and mudstone (0-21m)
  - $h^{2''}$ Hythe Formation - Sandstone (45-75m)
  - $h^{2'}$ Atherfield Clay Formation - Mudstone (up to 12m) within Lower Greensand
- h^1 Weald Clay Formation - Mudstone (180-210m)

Rev	Status	Drn	App	Chk	Date
	Draft	KR	JCO	JRC	25/07/23

Site: NUTFIELD GREEN PARK

Client: Nutfield Park (Developments) Limited

Title: The geology at and in the vicinity of the site

DRAFT

Figure 2 | Scale: As shown

Drawing Ref: HGH/NU/04-23/23670

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