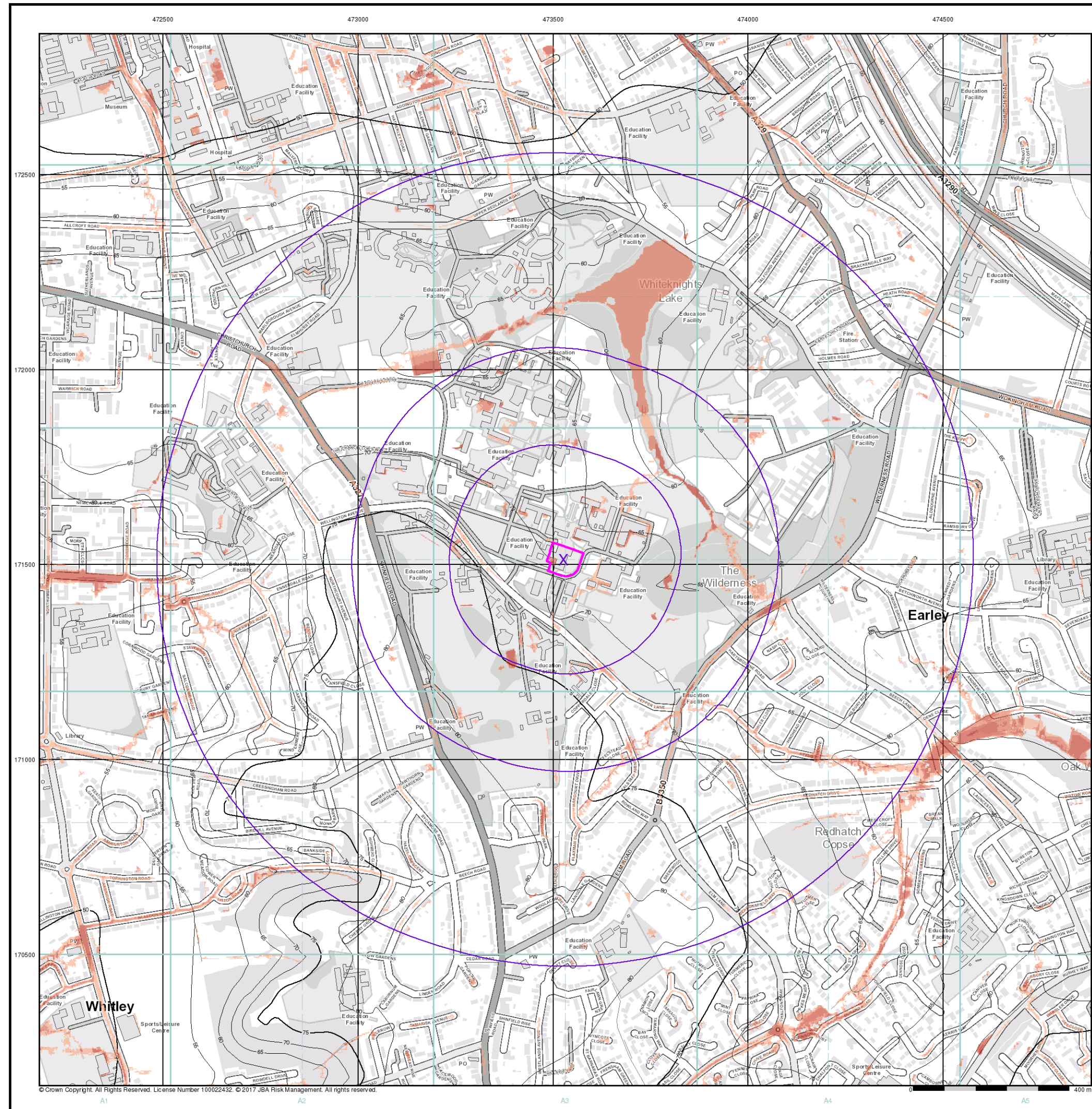




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Envirocheck[®]

LANDMARK INFORMATION GROUP[®]

EA/NRW Surface Water 100 Year Return Hazard Rating Map (1:10,000)

General
Specified Site Specified Buffer(s) Bearing Reference Point

Surface Water Hazard Rating

- Low (0.5 – 0.75)
- Moderate (0.75 – 1.25)
- Significant (1.25 – 2.0)
- Extreme (>2.0)

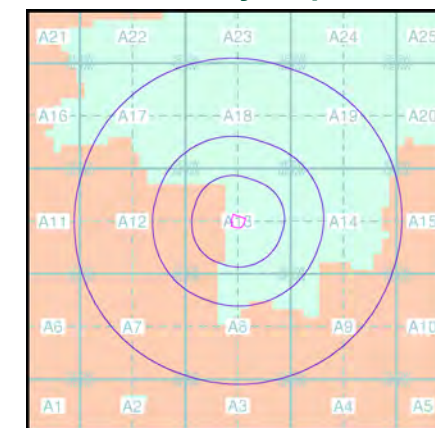
Contours (height in metres)

- Standard Contour
- Master Contour
- Spot Height
- MLW Mean Low Water
- MHW Mean High Water

Suitability

- See the suitability map below
- National to county
- County to town
- Town to street
- Street to parcels of land
- Property

EA/NRW Suitability Map - Slice A



Order Details

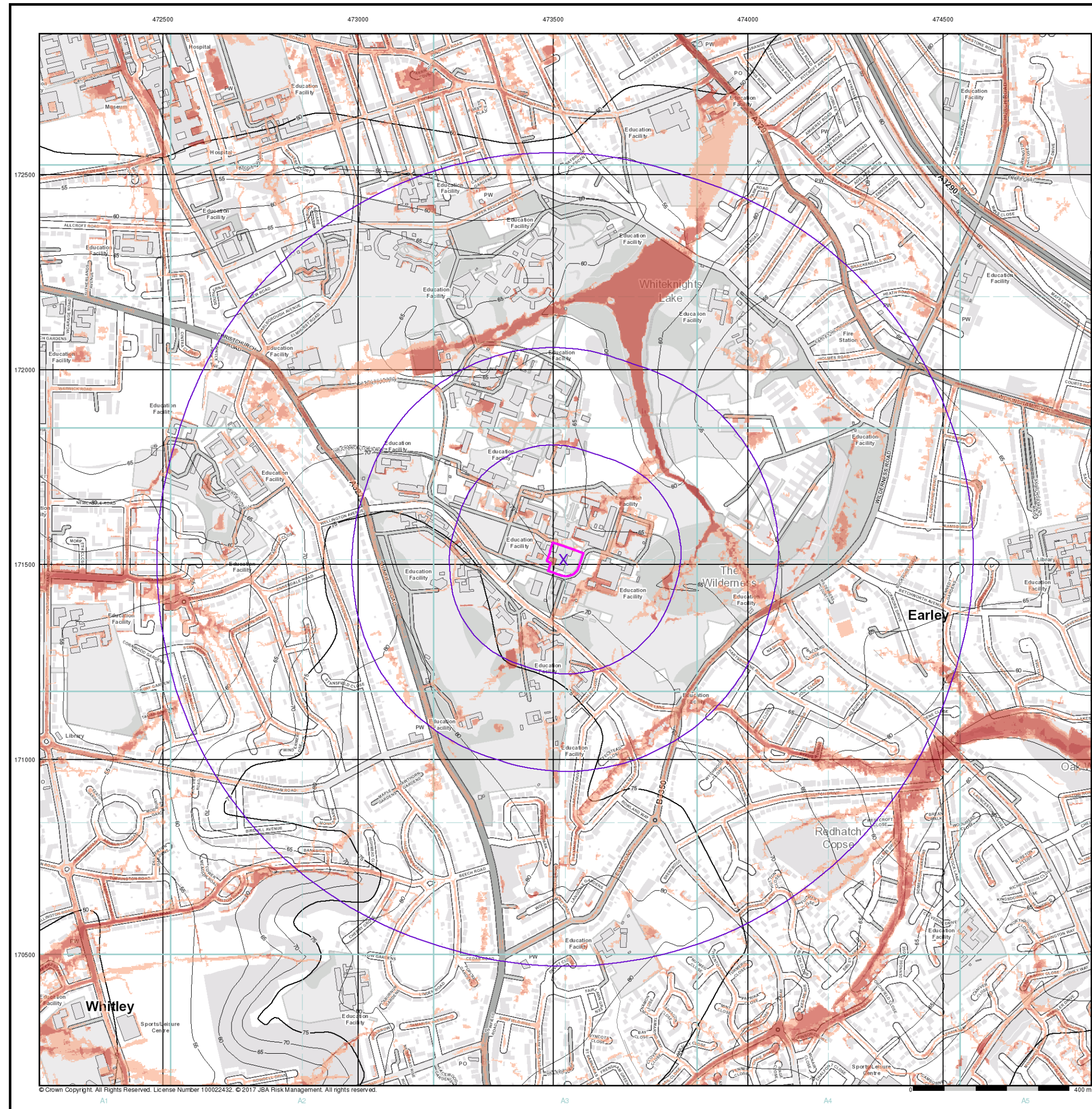
Order Number: 115805868_1_1
Customer Ref: 60441574/M001.003
National Grid Reference: 473530, 171510
Slice: A
Site Area (Ha): 0.56
Search Buffer (m): 1000

Site Details

Life Sciences Building, University of Reading, Shinfield Road, READING, RG6 6UR

Landmark
INFORMATION GROUP

Tel: 0844 844 9952
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EA/NRW Surface Water 1000 Year Return Hazard Rating Map (1:10,000)

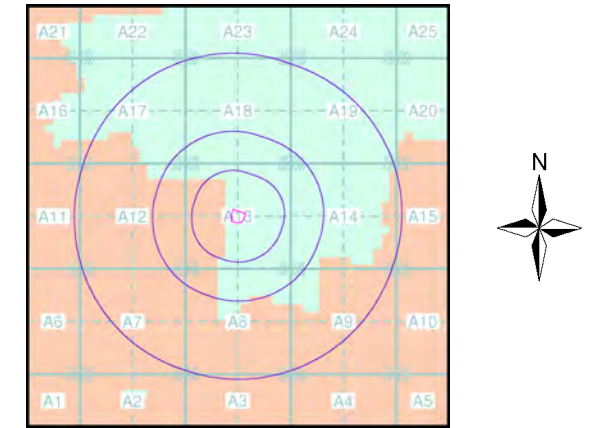
General
Specified Site Specified Buffer(s) Bearing Reference Point

Surface Water Hazard Rating
Low (0.5 – 0.75)
Moderate (0.75 – 1.25)
Significant (1.25 – 2.0)
Extreme (>2.0)

Contours (height in metres)
Standard Contour
Master Contour
Spot Height
MLW Mean Low Water
MHW Mean High Water
167.8

Suitability
See the suitability map below
National to county
County to town
Town to street
Street to parcels of land
Property

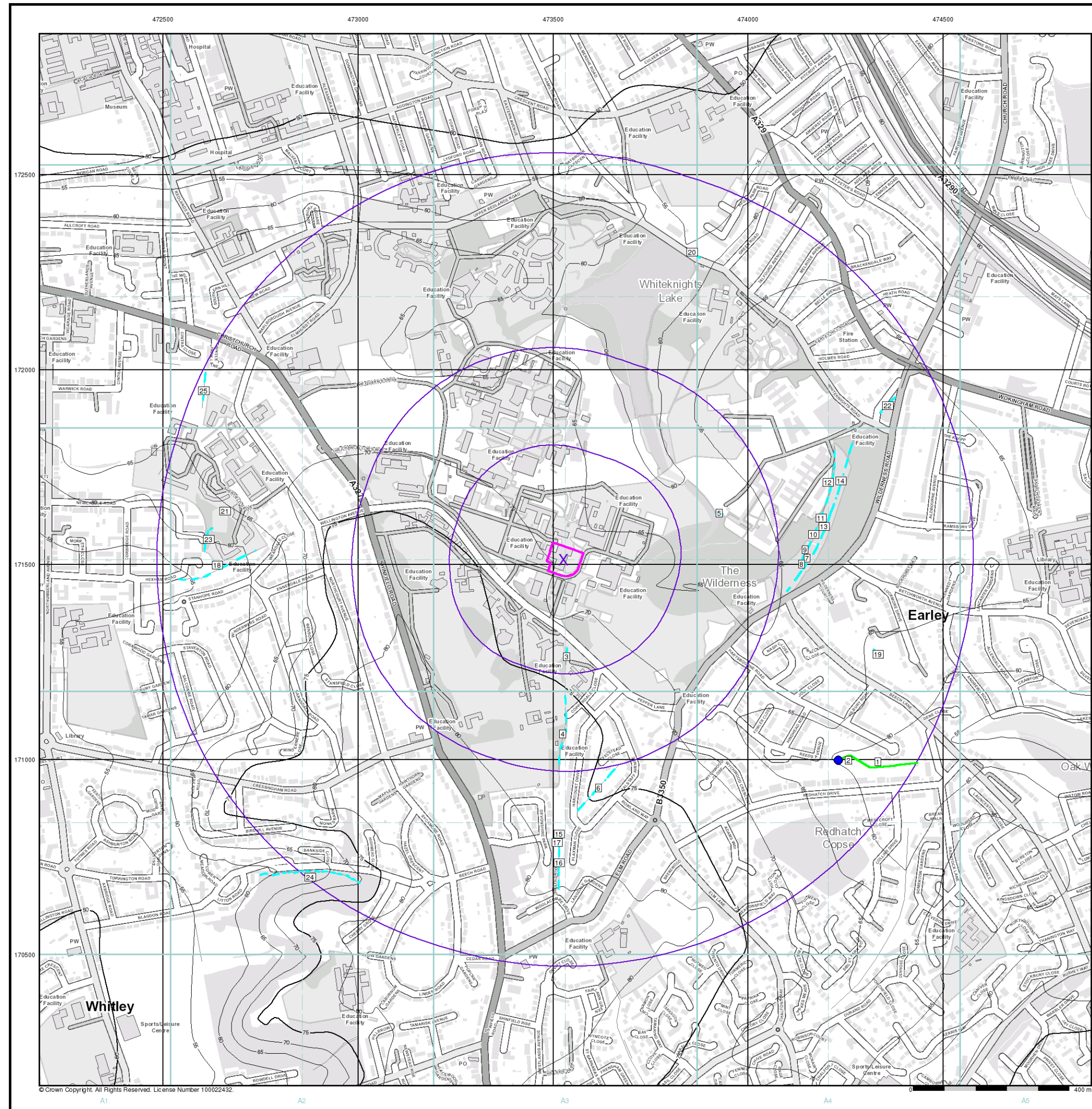
EA/NRW Suitability Map - Slice A



Order Details
Order Number: 115805868_1_1
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Detailed River Network Map (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point
- Map ID

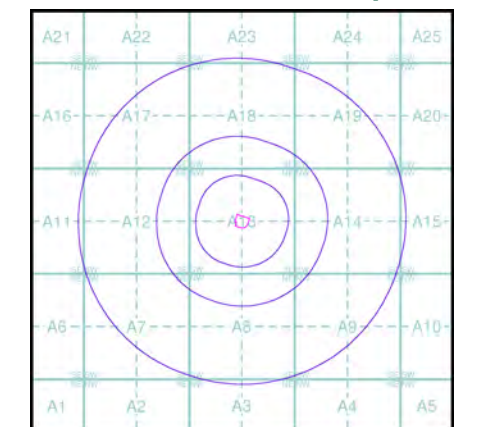
Detailed River Network Data

- | | |
|--------------------------|---|
| Primary River | Extended Culvert (greater than 50m) |
| Secondary River | Underground River (inferred) |
| Tertiary River | Underground River (local knowledge) |
| Canal | Downstream of High Water Mark |
| Canal Tunnel | Downstream of Seaward Extension |
| Undefined River | Not assigned River feature |
| Lake/Reservoir | |
| Source | Not assigned River feature |
| Junction | Pseudo Node (general) |
| Sink | Pseudo Node (High Water Mark) |
| Non-interactive Node | Pseudo Node (OS MasterMap polygon boundary) |
| Offline Drainage Feature | |

Contours (height in metres)

- Standard Contour 105 100 95
- Master Contour
- Spot Height 167.3
- MLW Mean Low Water
- MHW Mean High Water

Detailed River Network Map - Slice A



Order Details

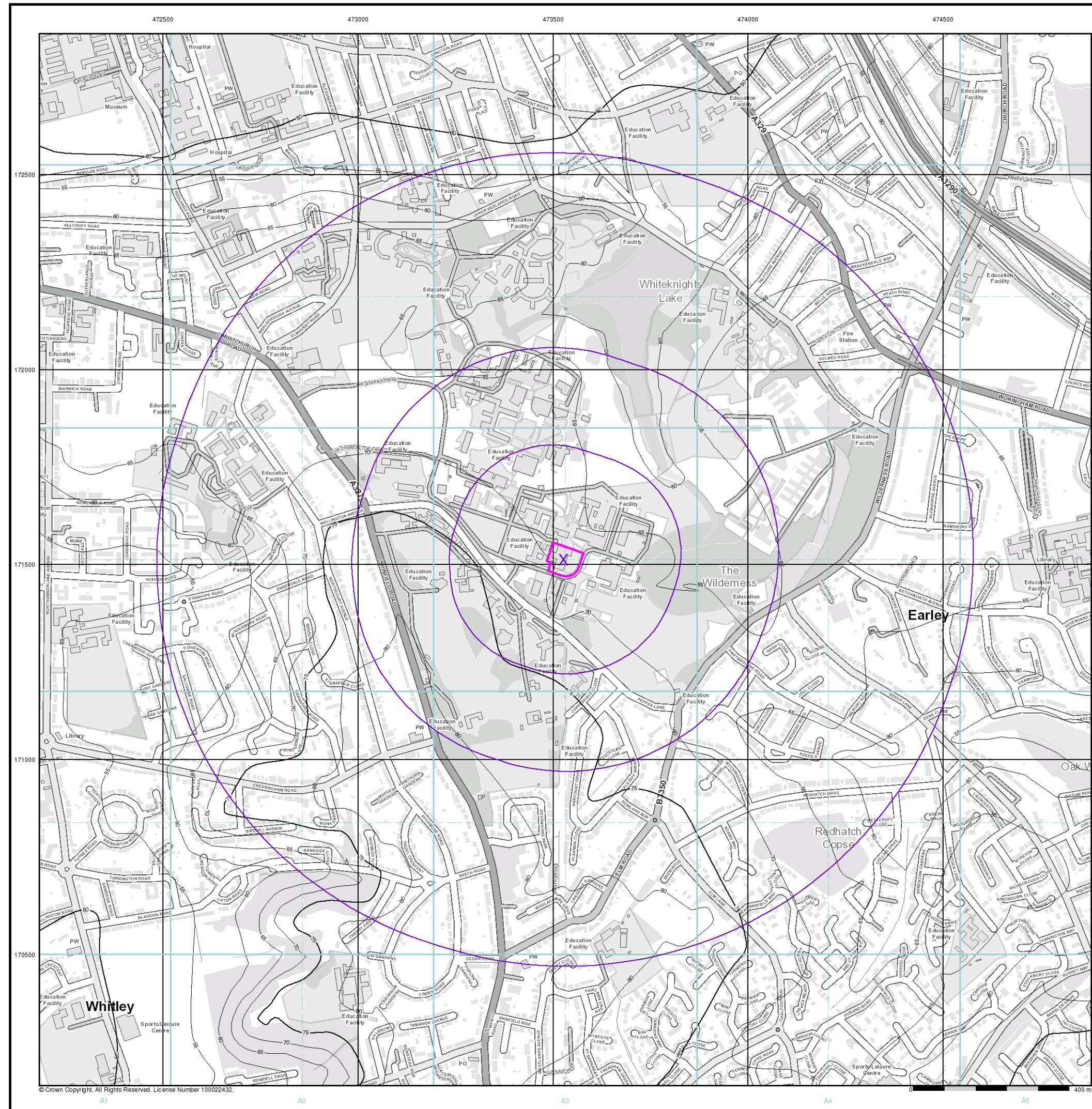
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Customer Ref: 60441574/M001.003
National Grid Reference: 473530, 171510
Slice: A
Site Area (Ha): 0.56
Search Buffer (m): 1000

Site Details

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EA/NRW Historic Flood Map (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point
- Map ID

Historic Flood Events Data

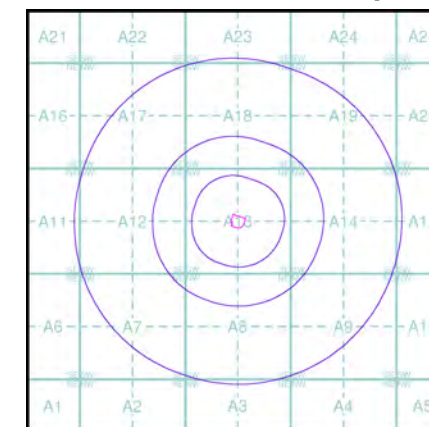
- | | |
|--|---------------------------------------|
| Channel Capacity Exceeded (no raised defences) | Obstruction/Blockage - Culvert |
| Groundwater/High Water Table | Obstruction/Blockage - Debris Screen |
| Local Drainage/Surface Water | Operational Failure/Breach of Defence |
| Mechanical Failure | Other |
| Obstruction/Blockage - Bridge | Overtopping of Defences |
| Obstruction/Blockage - Channel | Unknown |

- Historical Flood Liabilities

Contours (height in metres)

- Standard Contour 105
- Master Contour 100
- Spot Height 167.8
- MLW Mean Low Water
- MHW Mean High Water

EA/NRW Historic Flood Map - Slice A



Order Details

Order Number: 115805868_1_1
Customer Ref: 60441574/M001.003
National Grid Reference: 473530, 171510
Slice: A
Site Area (Ha): 0.56
Search Buffer (m): 1000

Site Details

Life Sciences Building, University of Reading, Shinfield Road, READING, RG6 6UR

Appendix B - GEL 2016 Site Investigation Report



UNIVERSITY OF READING - HEALTH AND LIFE
SCIENCES BUILDING

INTERPRETATIVE REPORT ON
GROUND INVESTIGATION

Prepared for KNOWLES & SON (OXFORD) LTD

Report Ref: 31710

Geotechnical Engineering Ltd
Centurion House, Olympus Park
Quedgeley, Gloucester. GL2 4NF

01452 527743
www.geoeng.co.uk





UNIVERSITY OF READING - HEALTH AND LIFE SCIENCES BUILDING

INTERPRETATIVE REPORT ON GROUND INVESTIGATION

Prepared for KNOWLES & SON (OXFORD) LTD

Report Ref: 31710

PROJECT: Proposed development

CONSULTANT: AECOM

VOLUME - VERSION	STATUS	ORIGINATOR	CHECKER	APPROVED	DATE
1 of 1 – A	DRAFT	JI	CT/NP	NP	05/05/16
1 of 1 – B	FINAL	JI	NP	NP	24/05/16
ORIGINATOR			APPROVER		
					
Jonathan Ind BSc (Hons) MSc FGS Geotechnical Consultant			N Parry BEng MSc CEng MICE MCIHT SiLC Director		

The report is not to be used for contractual or engineering purposes unless this sheet is signed and the report designated "Final".

The report has been prepared for the sole use and reliance by Knowles & Son (Oxford) Ltd. GEL accepts no liability as a result of the use or reliance of this report by any other parties.



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1. INTRODUCTION

It is proposed to replace the existing Engineering Building at the University of Reading with a new purpose-built facility. A new electricity substation is also proposed adjacent to the existing JJ Thomson Building, to the northwest of the Engineering Building. Geotechnical Engineering Limited (GEL) was instructed by Knowles & Son (Oxford) Ltd, acting on behalf of the University of Reading, to carry out an investigation to determine the ground conditions and provide recommendations for foundation design. Contamination testing of soil and water was also undertaken, however this report does not include a full geoenvironmental assessment of the site.

The scope of work and terms and conditions of appointment were defined in correspondence by GEL, reference T23030 dated 2nd February 2016 and subsequent email communication. The investigation was carried out in accordance with the specification provided by the Consultant, being broadly in accordance with the guidance of BS10175:2011+A1:2013 and BS5930:2015.

This report describes the investigation, presents the findings and comments accordingly. The comments given in this report and the opinions expressed assume that ground conditions do not vary beyond the range revealed by this investigation. There may however, be conditions at or adjacent to the site, which have not been disclosed by the investigation and which, therefore, have not been considered in this report. Accordingly, a careful watch should be maintained during any future groundworks and the recommendations of this report reviewed as necessary.

The recommendations given in this report should not be used for any other schemes on or adjacent to this site without further reference to GEL.



2. SITE SETTING

2.1 Site Location and Description

The site is situated at the University of Reading Whiteknights Campus and may be located by its National Grid co-ordinates SU 7352, 7151 or the post code RG6 6UR.

The existing building was roughly T-shaped in plan, comprising a four-storey brick structure at the northern end with a single-storey element extending to the south. The ground level fell gradually from southwest to northeast, up to around 2.5m. The building was bound by a tarmacadam-surfaced car park to the east with the entrance at its southern end. The area to the north and south was mainly surfaced with grass with pedestrian pathways and a number of semi-mature/mature trees. A block-paved pathway was located west of the building. The building was bound by various buried services which are highlighted on Figure 2. Photographs are included in Appendix A.

The site of the proposed substation was located adjacent to a tarmacadam-surfaced access road, south of the existing JJ Thomson Building. The ground level was level and flat, occupying an area of grassed landscaping. A concrete pathway was situated at the northern end, linking to access road to a single-storey brick store with a flat roof. The area to the south was occupied by a skip and two steel storage containers, with a tree positioned beyond.

2.2 Regional Geology

British Geological Survey (BGS) England and Wales (Sheet No. 268 Reading, 1:50,000, published 2000) and the BGS online geology (1:50,000) indicate the site to be underlain by Head deposits, comprising “variably sandy and silty clay with sporadic pebbles”. The Boyn Hill Gravel Member (“sand and gravel”) is shown to the north, east and west of the site and is also likely to be present beneath the Head deposits. The superficial deposits overly the London Clay



Formation, which generally comprises “clay, variably silty, with beds of sand and silt and flint pebble seams; variably glauconitic and shelly”.

BGS boreholes located to the north of the existing library (National Grid co-ordinates SU 73539, 71567) recorded the following ground sequence:

- “Topsoil” to a depth of 0.38m below ground level (bgl);
- “Firm, brown and mottled brown and grey, sandy CLAY with some fine and medium gravel” to 1.68m bgl (Head deposits);
- “Dense to very dense, brown, clayey SAND and GRAVEL” to 4.27m bgl (Boyn Hill Gravel Member);
- “Stiff, brown , silty clay” to 4.57m bgl (London Clay Formation);
- “Stiff, fissured, grey, silty clay” to 6.10m bgl (London Clay Formation).

2.3 Regional Hydrogeology

The Environment Agency’s Groundwater Protection Policy (EA website, 2015) designates that superficial deposits as a Secondary (Undifferentiated) aquifer, meaning that they potentially contain “permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases form an important source of base flow to rivers”. The underlying bedrock (London Clay Formation) is classified as unproductive due to low permeability.

The EA website confirms the site to be located approximately 140m southwest of an Inner Zone (Zone 1) Source Protection Zone (SPZ), which is defined as “the 50 day travel time from any point below the water table to the source”.



2.4 Regional Hydrology

There are no surface water features on the site; the nearest relates to Whiteknights Lake, which is located approximately 300m east of the Engineering Building. The River Kennet is situated about 2.2km west of the site.

The EA website indicates the site does not lie within 250m of an Environment Agency fluvial floodplain. The nearest is approximately 1.5km to the west, associated with the River Kennet.

2.5 Radon

The Building Research Establishment (BRE) indicates that no radon protective measures are necessary (BR 211, 2007). It is advised that the local Building Control body is contacted to determine their minimum requirements in respect of radon protection.

3. PROPOSED WORKS

It is proposed to replace the existing Engineering Building at the University of Reading with a new purpose built facility. A new electricity substation is also proposed adjacent to the JJ Thomson Building, to the northwest of the Engineering Building. Exact details of the scheme and foundations loads were unknown at the time of preparing this report. A copy of the scheme drawing, included as part of the Consultants specification, is presented in Appendix B.



4. GROUND INVESTIGATION

4.1 Fieldwork

The fieldwork was carried out in general accordance with BS5930:2015 during the period 31st March to 12th April 2016 and comprised the following:

Existing Engineering Building

- Four cable percussion boreholes.
- In-situ SPT testing and undisturbed sampling (UT100/U100).
- Installation of ground gas and ground water observation wells in each borehole. Post fieldwork monitoring on two occasions.
- Two machine excavated trial pits.
- A single soakaway test in accordance with BRE 365 (2007).
- Three hand dug trial pits to establish existing foundation details.
- Two in-situ Dynamic Cone Penetrometer tests to establish CBR values.

Existing JJ Thomson building

- A single machine excavated trial pit.

The exploratory hole locations were selected by the Consultant and set out by this Company, within the limitations of access, and are shown on Figures 2 and 3. The ground level and co-ordinates at each exploratory hole were established by this Company using GPS techniques.



Boreholes

The boreholes, referenced BH01 to BH04 (Appendix C), were formed using a light cable tool (shell and auger) rig utilising 150mm tools and casing. Initially, an inspection pit was hand excavated at each borehole location to a depth of 1.20m to check for buried services. The boreholes were then advanced using a clay cutter and bailer with the occasional use of a heavy chisel to assist boring.

Representative disturbed samples were taken and retained in a combination of plastic tubs, bags and glass jars. Undisturbed samples of 100mm nominal diameter were taken in suitable cohesive soils using an open drive sampler (U100) or a thin walled, open drive sampler (UT100). Samples were wax sealed on site to prevent moisture loss.

Standard penetration tests (SPT) were carried out in general accordance with BS EN ISO 22476-3:2005+A1:2011. A split barrel or a solid cone was used depending upon the materials encountered and the split barrel samples retained in airtight jars. The SPT N value was taken as the number of blows to penetrate the 300mm test drive following a 150mm seating drive. Where low penetration was recorded the seating drive was terminated at 25 blows and the test drive completed after a further 50 blows. Detailed SPT results, together with the energy ratio (E_r), are presented in Appendix C and summarised as uncorrected N values on the borehole logs.

Boreholes were monitored for groundwater ingress as boring proceeded. Water levels were also recorded at the start and finish of each day's work and on completion of the borehole and are presented on the relevant log.

On completion gas/water monitoring standpipes were installed in each borehole. Each installation consisted of a 50mm ID HDPE slotted tube set in a filter response zone of non-calcareous pea gravel. The installation was sealed above and below with a bentonite plug and



accessed via a valve assembly. The installations were protected at the surface by a lockable stopcock cover set in concrete. Installation details are given on the relevant borehole log.

Following completion of the fieldwork, the installations in BH01 to BH04 were monitored on two occasions for gas flow and then tested for methane, carbon dioxide, oxygen, hydrogen sulphide and carbon monoxide using a Gas Data GFM 435 gas analyser. A MiniRAE 2000 PID was used to monitor for Volatile Organic Compounds (VOC's). Atmospheric readings for the three days prior to the monitoring visit were recorded from Weather Underground (www.wunderground.com). The readings are presented in Appendix D together with water level readings.

Trial Pits

The trial pits, referenced TP02 and TP03 (Appendix C), were formed by a wheeled excavator with a 0.60m wide backactor bucket. TP01 was not excavated due to existing trees.

The ground surface at TP02 consisted of hardstanding which required breaking out prior to excavation.

Representative disturbed samples were taken and retained in a combination of plastic tubs, bags and glass jars.

Hand vane tests were carried out in suitable cohesive material. The results are presented on the trial pit logs and tabulated in Appendix C.

A soakaway test was carried out in trial pit TP02 in general accordance with BRE 365 (2007). The excavation sides were squared using the excavator bucket and the dimensions recorded within the test section. The trial pit was partially filled with clean water using a dedicated



bowser with a 75mm diameter outlet and the fall in level recorded against time. The test was repeated three times. The results are presented in Appendix C.

Photographs of the trial pit profile and spoil heap were taken and are presented separately.

On completion all trial pits were backfilled with arisings compacted in suitable layers by the excavator bucket. The ground surface at TP02 was reinstated with tarmacadam, whilst the ground surface at TP03 was left slightly proud to accommodate the future inevitable settlement of the backfill.

Foundation Inspection Pits

Three inspection pits, referenced IP01 to IP03 (Appendix C), were hand excavated to uncover the existing foundation bases to the existing building.

Disturbed samples were taken and retained in a combination of plastic tubs, bags and glass jars.

All inspection pits were backfilled with arisings and the surface reinstated.

Foundation sketches and photographs are presented with the inspection pit logs in Appendix C.

Dynamic Cone Penetrometer Tests

Dynamic Cone Penetrometer tests (DCP), referenced DCP01 and DCP02 (Appendix C), were carried out using a CNS Farnell A2465 dynamic cone penetrometer. Probe depths were measured with respect to ground level and the number of blows for the penetration of the



probe was recorded. Equivalent CBR values have been calculated and presented with the results in Appendix C.

Samples for chemical analyses were dispatched daily to ALcontrol, Hawarden, under a Chain of Custody. The remaining samples were brought to this Company's laboratory for testing and storage.

4.2 Logging

The logging of soils was carried out by an Engineering Geologist in general accordance with BS5930:2015. A key to the exploratory hole logs is presented in Appendix B.

Detailed descriptions of the samples are given in the borehole logs, Appendix C, along with details of sampling, in situ testing, groundwater ingress and relevant comments on drilling techniques.

The trial pits and foundation inspection pits were logged in situ to a depth of approximately 1.20m and thereafter from the surface. Detailed descriptions are given in the trial pit logs, Appendix C, along with details of sampling and in situ testing, groundwater ingress and relevant comments on stability.

4.3 Laboratory Testing

A schedule of laboratory tests was prepared by this Company, the following tests being carried out in accordance with BS1377:1990, unless stated otherwise. The number in brackets refers to the test number given in that standard. The results are presented in Appendix E.

The natural water content was determined on sixteen selected samples in accordance with BS EN ISO 17892-1:2014.



Liquid limit, plastic limit and plasticity index tests [Part 2:4.3, 5.3 and 5.4] were carried out on sixteen selected samples. Atterberg line plots have also been presented.

Particle size distributions were determined for five samples by wet sieving [Part 2:9.2]. The fine fractions of two of these samples were further analysed by sedimentation using the pipette method [Part 2:9.4]. The results are presented as grading curves.

The California Bearing Ratio (CBR) test [Part 4:7] was carried out on a single recompacted sample. The results are presented as graphs of force against penetration.

The one-dimensional consolidation properties [Part 5:3] were determined in the oedometer on four 63.5mm diameter by 19mm thick specimens prepared from U100/UT100 samples. The results are presented in tabular form and also as graphs of void ratio versus log (effective pressure).

Unconsolidated undrained triaxial compression tests were carried out under a single cell pressure on fifteen specimens prepared from full diameter U100/UT100 samples [Part 7:8]. A cell pressure equal to the approximate overburden pressure at sample depth was used. Fully saturated, $\phi_u = 0$, conditions were assumed and the undrained cohesion, c_u was taken as half the deviator stress at failure.

Consolidated undrained multistage triaxial compression tests with pore-water pressure measurements [Part 8:4, 5, 6, 7 and Head (1986)] were carried out on two full diameter specimens prepared from U100/UT100 samples.

Hand vane tests were carried out on fifteen undisturbed U100/UT100 samples.



The BRE SD1 (2005) reduced suite; water soluble sulphate, total sulphate and total sulphur, together with pH were determined for ten samples by ALcontrol Laboratories, Hawarden, using in-house methods.

4.4 Chemical Testing

Selected soil samples were despatched to ALcontrol Laboratories under full chain of custody documentation and tested for a suite of contamination as detailed below. The laboratory holds UKAS ISO17025 and MCERTS accreditation for most of the analyses undertaken.

- Arsenic, cadmium, total chromium, lead, mercury, selenium, boron (water soluble), copper, nickel, zinc, speciated polyaromatic hydrocarbons, speciated petroleum hydrocarbons, BTEX, MTBE, speciated phenols, total cyanide, sulphide (acid soluble), sulphate (water soluble) and pH.

Nine soil samples were also screened for asbestos fibres.

The potential risk to groundwater resources was determined by analysis of four groundwater samples taken from standpipes in BH01 to BH04, which were tested for the above suite of contamination together with hardness.

Chemical test results are presented in Appendix F.



5. DISCUSSION AND CONCLUSIONS

5.1 Ground Conditions

The ground conditions revealed by the investigation confirm the strata indicated by the geological records, proving Head deposits over the Boyn Hill Gravel Member. The superficial deposits were underlain by the London Clay Formation. A variable thickness of Made Ground was present above these materials.

Made Ground

Made Ground was recorded to depths of between 0.30m and 1.90m below ground level (bgl) [69.00m and 66.20m OD], with a greater thickness in BH02 and TP03. Below 0.10m of tarmacadam (BH03 and IP02) or block paving (BH04), sub-base comprised very gravelly sand or sandy gravel to a depth of 0.50m bgl, which was further underlain in BH03 by 0.10m of concrete. Within soft landscaping, topsoil comprised dark brown, slightly gravelly, clayey sand or soft/firm, slightly sandy, gravelly clay (including flint and brick). These materials were underlain by very soft, light brown, slightly gravelly, sandy clay (BH02) or dark greenish brown, slightly clayey, gravelly sand, locally with cobbles of brick (TP02, IP01 and IP02). Similar granular material was observed in BH03 to a depth of 1.10m bgl, which may also represent Made Ground. In TP03, the topsoil was underlain by soft, light brown, sandy clay overlying light grey, silty sand. The gravel in these materials comprised flint, brick and concrete.

Head Deposits

With the exception of BH02, the Made Ground was underlain by material which is considered to represent Head deposits. The material comprised soft to firm/firm, locally firm to stiff/stiff, light brown/orangish brown, sandy, locally slightly gravelly clay, where the



gravel was flint. The foundations inspection pits, IP01 to IP03, and TP03 were completed within this material.

Boyn Hill Gravel Member

The Boyn Hill Gravel Member was encountered below depths of between 2.10m and 3.25m bgl [66.40m and 65.85m OD] in BH01 to BH04 and TP02. The material was generally granular in nature, generally comprising light brown slightly clayey, typically very gravelly sand or sandy/very sandy gravel. Towards the base of these deposits, BH01 to BH03 proved beds of stiff/very stiff, slightly sandy/sandy, locally slightly gravelly (flint) clay, between 0.30m and 0.80m thick. The thickness of these deposits ranged between 2.70m and 3.55m, extending to depths of 4.70m and 6.30m bgl [63.40m to 62.30m OD]. TP02 was completed within the granular material at a depth of 2.70m bgl.

London Clay Formation

Underlying the superficial deposits, the London Clay Formation comprised stiff, dark brownish grey, silty clay with rare shell fragments. With increasing depth, the material became locally dark grey in colour with sand sized selenite crystals, gravel sized pockets of fine sand and mica crystals. A very stiff consistency was recorded below depths of around 10.40m to 12.95m bgl. All boreholes were completed at a depth of 18.00m bgl [51.50m to 50.10m OD].

Groundwater

Groundwater was encountered in BH03, within the Boyn Hill Gravel Member, at a depth of 3.50m bgl [65.10m OD], rising to 3.10m bgl [65.50m OD] after a 20 minute monitoring period. Perched water was also encountered in TP02 at the interface of the Made Ground



and underlying Head deposits at a depth of 1.10m bgl [67.40m OD]. The remaining holes remained dry during the short time they remained open.

Post fieldwork monitoring of the observation wells in BH01 to BH04 recorded at depths of between 3.22m and 3.91m bgl (65.62m and 64.28m OD).

5.2 Existing Foundations

Inspection pits, referenced IP01 to IP03 were excavated by hand to establish foundation details of the existing engineering building.

IP01 revealed a concrete foundation, extending 0.30m from the face of the wall, bearing at a depth of 0.90m bgl upon firm to stiff, slightly sandy slightly gravelly clay, which is considered to represent Head deposits.

In IP02, a concrete foundation was uncovered, extending 0.95m from the face of the wall, bearing at a depth of 1.15m bgl upon soft to firm, slightly sandy clay (Head deposits).

A concrete ground beam (?) was revealed in IP03, underlain at a depth of 0.40m bgl by firm to stiff, slightly gravelly, sandy clay (Head deposits).

Sketches are presented with the trial pit logs in Appendix C. Photographs are included in Appendix A.



5.3 Geotechnical Appraisal

Made Ground

No laboratory testing was carried out on the Made Ground.

A single SPT test was carried out within the cohesive Made Ground in BH01, inferring a very soft consistency after the application of a 5kPa correlation factor (Stroud, 1974).

Head Deposits

Index tests indicate the material is typically of intermediate plasticity and possesses a medium volume change potential in response to changes in moisture content (NHBC, 2014).

A high plasticity was indicated for the material from BH04 at 3.15m bgl.

SPT N values of between 11 and 16 were obtained for the Head deposits, indicating a firm/stiff consistency after the application of a 5kPa correlation factor (Stroud, 1974). Hand vane readings of 61kPa and 126kPa infer the clay to firm/stiff.

Consolidation tests carried on samples of the Head deposits from BH01 at 2.80m bgl, BH03 at 2.30m bgl and BH04 at 2.80m bgl provided coefficient of compressibility (m_v) values of between 0.098 and 0.290m²/MN for the pressure range 100kPa to 200kPa (i.e. low to medium compressibility).

CBR values of 4.8% and 7.4% were obtained for the cohesive Head deposits from a recompacted laboratory test on material from BH01 at 0.50m bgl.



A consolidated undrained triaxial test carried out on a sample of the Head Deposits in BH04 at 2.90m bgl provided an angle of shearing resistance (ϕ') of 26.6° and an effective cohesion (c') of 10.1kPa.

Boyn Hill Gravel Member

Index tests indicate the cohesive soils are of high plasticity and possesses a medium volume change potential in response to changes in moisture content (NHBC, 2014).

Particle size distribution tests indicate the granular soils to comprise:

- 1-11% fines (clay/silt), 46-56% sand and 36-52% gravel or
- 9% fines, 72% sand and 19% gravel.

Typically, SPT N values (13 to 46) indicate the granular deposits to be of medium dense/dense relative density. A further N value of 8 infers the basal deposits in BH04 to be loose. Further tests were partially carried out within the underlying London Clay Formation, suggesting a medium dense/dense relative density (N values of 20 to 36).

London Clay Formation

Index tests indicate the London Clay is of high plasticity. Based upon the plasticity indices, this material is considered to be of medium and high volume change potential in response to changes in moisture content (NHBC, 2014).

SPT N values of between 13 and 48 infer the London Clay to be typically stiff, becoming very stiff with increasing depth, after the application of a 5kPa correlation factor (Stroud, 1974).



Triaxial tests yielded undrained cohesion of between 94kPa and 242kPa, indicating the upper weathered part of the London Clay to be stiff, becoming very stiff with increasing depth. Hand vane readings suggest the material to be at least stiff.

A consolidation test carried on a sample of the London Clay from BH04 at 6.5m bgl provided a coefficient of compressibility (m_v) value of $0.096\text{m}^2/\text{MN}$ for the pressure range 200kPa to 400kPa (i.e. low compressibility).

A consolidated undrained triaxial test carried out on a sample of the London Clay in BH03 at 7.15m bgl provided an angle of shearing resistance (ϕ') of 25° and an effective cohesion (c') of 2.6kPa.

5.4 Foundation Considerations

Details of the scheme including foundation loads were unknown at the time of preparing this report. As such, the following comments are of a general nature and should be reviewed when appropriate information becomes available.

The exploratory holes proved a variable thickness of Made Ground, up to 1.90m thick, which is considered an unsuitable bearing stratum. Due to the changeable bearing characteristics and localised absence of the Head deposits, it is generally recommended that foundations bear within underlying natural materials, although it may be locally utilised to support lightly loaded structures.

The Boyn Hill Gravel Member, as encountered between depths of between 2.10m and 3.25m bgl [66.40m and 65.85m OD] would offered an allowable bearing capacity of at least 200kPa, however the depth of excavation through Made Ground and localised groundwater ingress may pose problems for construction and health and safety.



Given the above, it is considered that the most suitable solution is likely to be piles, extending into the London Clay Formation.

Given the potential problems with noise/vibrations during pile driving within proximity to existing buildings and services, continuous flight auger (cfa) or bored piles are likely to be considered the preferred option.

Temporary casing will be required to maintain hole stability within the Made Ground and superficial deposits.

Piles will need to be designed to resist tensional forces that may be caused by rehydration of the clay soils within proximity to existing trees/vegetation and should therefore be designed as tension piles and/or sleeved to accommodate heave.

It will be important that the concrete is poured as soon as the excavation is completed to avoid softening and the potential for groundwater ingress into the base of the shaft.

Based on the undrained shear strength plot in Appendix G, preliminary allowable working loads have been calculated for a single bored cast in-situ pile of given diameter, as presented in Table 5.1 below. The toe depth given is based on piles being installed from an assumed formation level of 69m OD to a level of 53m OD, providing a minimum of 9.3m penetration into the London Clay. An adhesion factor (α) of 0.45, bearing capacity factor (N_c) of 9 and a combined factor of safety of 2.5 have been applied. Skin friction associated with the Made Ground, Head deposits and Boyn Hill Gravel Member has been ignored. An average undrained cohesion of 130kPa has been assumed over the shaft and an undrained shear strength of 180kPa at the pile toe.



Pile length (m)	Allowable Working Load (kN)					
	Pile Diameter					
	300mm	450mm	600mm	750mm	900mm	1200mm
16	250	410	595	800	1030	1555

Table 5.1: Preliminary Pile Working Loads

Once more detail is available with respect to the proposed scheme and loadings, it is recommended that specialist piling contractors should be consulted to advise further on the most suitable pile type, installation method and to provide final design working loads on their chosen system.

Given the presence of shrinkable soils at shallow depth and the potential for shrinkage/heave within the influence zone of existing trees, it is recommended that the ground floor slab is constructed as fully suspended.

5.5 Excavations

Excavations should be within the scope of conventional backhoe excavators. Recourse to hydraulic breakers may be required to break out existing obstructions.

Excavations through the Made Ground are likely to be unstable, even in the short term. If potentially unstable excavations or any excavations deeper than 1.00m are to be entered then the sides should be battered back and/or shoring methods and equipment should be utilised in accordance with relevant Health and Safety legislation.

All excavations should be closely inspected and any loose or soft spots should be removed and replaced with suitably compacted granular material. In order to prevent formation



softening and deterioration it is recommended that all foundations be cast as soon as possible after the excavation or a concrete blinding is placed to protect the formation.

5.6 Buried Concrete

In accordance with the BRE Special Digest 1 (2005) the site is not regarded as brownfield, however the ground is considered to contain sulfides.

The chemical analyses recorded in the investigation fall within the Design Sulfate Class DS-1 for the superficial deposits, based upon the water soluble and groundwater sulphate values. Taking into account mobile groundwater conditions and with alkaline pH values, an ACEC site classification of AC-1 is proposed.

For piled foundations extending into the London Clay Formation, a Design Sulfate Class DS-1 and ACEC site classification of AC-1 is also recommended since the material should not be significantly disturbed.

The total sulphur results indicate that the London Clay Formation possesses a high sulphide content. Any excavated clay should not be reused on site where it could come into contact with, or influence, any buried concrete as it is likely to become sulphate rich upon oxidation.

5.7 Pavement Design

Dynamic Cone Penetrometer (DCP) tests, referenced DCP01 and DCP02, were carried out along the route of a proposed access road. The results suggest a California Bearing Ratio (CBR) value of at least 5% for the Head deposits in DCP01 (with comparison to the ground profile in BH01). Below a depth of around 1.1m bgl, an increase in CBR value was recorded with increasing depth (>16%). Index testing on samples of the near surface Head deposits



(BH01 at 0.50m bgl) suggest the near surface clays should yield a CBR value of approximately 3-4% as per Table 5.1 of the Highways Agency publication IAN 73/06 (2009), based on a plasticity index of 30%. CBR values of 4.8% and 7.4% were obtained for the cohesive Head deposits from a recompacted laboratory test on material from BH01 at 0.50m bgl. A conservative CBR value of 3% is therefore suggested for the Head deposits.

Within the existing car park, DCP02 initially recorded CBR values of at least 32% (probable Made Ground), decreasing below around 0.75m bgl, where CBR values of at least 11% are indicated.

For Made Ground, unless it is removed or suitably proof-rolled/compacted prior to road construction, a CBR value of 2% is recommended, unless in-situ CBR test are carried out closer to the time of construction.

On the basis of classification testing and using TRRL and published data (Croney et al, 1967), the near Head deposits are not considered to be susceptible to frost heave.

5.8 Soakaway Design

Soakaway testing in TP02 recorded negligible infiltration during the test period. Soakaway drainage would therefore not be expected to form a viable solution and alternative forms of drainage should be sought (i.e. drainage to storm water sewers).

5.9 Contamination Considerations

5.9.1 Basis of Assessment - Soils

The concentration of contamination present at a site must be assessed in relation to a recognised system of defining whether a site presents a significant possibility of significant



harm to human health. In the UK, the Department of the Environment Food and Rural Affairs (DEFRA) and the Environment Agency (EA) prepared a method for deriving generic and site-specific assessment criteria to establish actual or potential risk to human health. This comprised the Contaminated Land Exposure Assessment (CLEA) methodology, and the associated DEFRA/EA Soil Guideline Value (SGV) reports.

Further guidance was produced by DEFRA in “Environmental Protection Act 1990: Part 2A, Contaminated Land Statutory Guidance (2012)” supporting the use of Generic Assessment Criteria (GACs) as screening tools in generic quantitative human health risk assessment to help assessors decide when land can be excluded from the need for further inspection and assessment, or when further work may be warranted. They may be used to indicate when land is very unlikely to pose a significant possibility of significant harm to human health but they should not be used as direct indicators of whether a significant possibility of significant harm to human health may exist. Furthermore the Category 4 Screening Levels (C4SLs) derived by DEFRA in 2014 will generally be used in place of SGVs and other guidance. In the absence of a suitable C4SL or SGV, risk assessors are advised to identify and select appropriate generic assessment criteria in accordance with established good practice.

The CLEA computer model has been used for this assessment to derive S4ULs and similarly EIC/AGS/CL:AIRE (2010) and Soil Screening Values (SSVs), in lieu of any other available guidance. The basis for assessment of soils is discussed in full in Appendix H.

5.9.2 Basis of Assessment - Water

In the absence of any National Standards relating to groundwater it is recommended by the Environment Agency to compare the results with the general water quality guidelines from the UK, European Union and World Health Organisation. These are published in Appendix A of the publication “Environment Agency technical advice to third parties on Pollution of Controlled Waters for Part IIA of the Environmental Protection Act 1990” (2002). New



values published in accordance with the Water Framework Directive (2015) may also be relevant in assessment of groundwater.

5.9.3 Basis of Assessment - Ground Gases

Approved Document Part C2 of the Building Regulations (DoE) recommends a tiered risk assessment approach in respect of “methane and other gases” (used to define hazardous soil gases which originate either from waste deposited in landfill sites or are generated naturally). Approved Document C does not include radon (which is dealt with separately) but does include volatile organic compounds (VOC’s). The methodology for the semi-quantitative risk assessment is defined in BS 8485:2015, which provides a framework in line with CLR 11 (2004). For gases not covered by BS8485:2015, a risk assessment basis is considered appropriate with standards taken from occupational exposure limits or other accepted data. Reference should also be made to CIRIA Report C665 (Wilson et al, 2007).

For the determination of the acceptability of volatile vapours (VOCs) in soils, values derived from Soil Gas Acceptance Criteria for the Protection of Indoor Air Quality for a commercial end-use, documented in the New Zealand Guidelines (1999) shall be used. A “trigger” value of 100ppm was used for the determination of acceptability of soils based on the New Zealand Guidelines.

5.9.4 Comparison of Results - Soil

Potential contamination at the site has been compared with the Generic Assessment Criteria (GAC) screening values for a commercial end use. The screening values are defined by C4SLs or SGVs, LQM/CIEH S4ULs (2014), EIC/AGS/CL:AIRE values (2010) and ATRISK SSVs (2011), calculated using the CLEA (2009) computer model. An assumed Soil Organic Matter of 6% SOM (defined by Environment Agency) was used for the SGVs and C4SLs, whilst a worst case, conservative Soil Organic Matter of 1% SOM was used for the S4ULs (where



applicable), EIC/AGS/CL:AIRE and SSVs (defined by Atkins), as closest to conditions on site [measured SOM of between 0.44% and 1.71%].

General Contaminants

When compared to the published GACs for a commercial end use, no exceedances of general contaminants were recorded. As such, these soils are considered unlikely to present a significant possibility of significant harm to human health with respect to the general contaminants in Table 5.2 below.

Contaminant	Concentration ranges with exceedances	GACs (mg/kg)
Arsenic	Range: 7.0 – 18.3mg/kg	640 [•] [°] [#]
Boron	Range: <1.00 – 1.05mg/kg	240,000 [•]
Cadmium	Range: <0.02 – 1.92mg/kg	190 [•] , 410 [°] , 230 [#]
Chromium	Range: 12 – 21.5mg/kg	8,600 [•]
Copper	Range: 4.01 – 12.7mg/kg	68,000 [•]
Cyanide	All less than 1mg/kg	34 [*]
Lead	Range: 11.2 – 36mg/kg	2,300 [°]
Mercury (Methyl)	All less than 0.14mg/kg	410 [#] , 320 [•]
Nickel	Range: 7.39 – 18.1mg/kg	980 [•] , 1,800 [#]
Phenol	All less than 0.18mg/kg	3,200 [#]
Selenium	All less than 1mg/kg	12,000 [•] , 13,000 [#]
Zinc	Range: 17.8 – 139mg/kg	730,000 [•]

[•]GACs derived from Land Quality Management (LQM)/CIEH S4ULs (2014) for commercial end use (6% SOM)

[#]SGVs (2009) for commercial end use (6% SOM)

[°]C4SLs for commercial end use (6% SOM)

^{*}ATRISK (2011) Soil Screening Values (SSVs) for commercial end use (1% SOM)

Exceedances marked in **bold**

Table 5.2: GAC for General Contaminants



Polyaromatic Hydrocarbons (PAHs)

No exceedances of PAHs were recorded above the published GACs for a commercial end use, as shown in Table 5.3 below. On this basis, these soils are considered unlikely to present a significant possibility of significant harm to human health with respect to PAHs.

Contaminant	Concentration ranges with exceedances	GACs (mg/kg)
Acenaphthene	Range: <0.008 – 0.0191mg/kg	84,000 [57] ^{sol}
Acenaphthylene	All less than 0.0433mg/kg	83,000 [86.1] ^{sol}
Anthracene	Range: <0.016 – 0.114mg/kg	520,000
Benzo(a)anthracene	Range: <0.014 – 0.597mg/kg	170
Benzo(a)pyrene	Range: 0.015 – 0.660mg/kg	35, 77 [°]
Benzo(b)fluoranthene	Range: 0.015 – 0.964mg/kg	44
Benzo(ghi)perylene	Range: 0.024 – 0.472mg/kg	3,900
Benzo(k)fluoranthene	Range: <0.014 – 0.297mg/kg	1,200
Chrysene	Range: <0.010 – 0.565mg/kg	350
Dibenzo(ah)anthracene	Range: <0.023 – 0.110mg/kg	3.5
Fluoranthene	Range: 0.017 – 0.979mg/kg	23,000
Fluorene	Range: <0.010 – 0.020mg/kg	63,000 [30.9] ^{sol}
Indeno(123-cd)pyrene	Range: <0.018 – 0.416mg/kg	500
Naphthalene	Range: <0.009 – 0.0116mg/kg	190 [76.4] ^{sol}
Phenanthrene	Range: <0.015 – 0.289mg/kg	22,000
Pyrene	Range: <0.015 – 0.828mg/kg	54,000

GACs derived from Land Quality Management (LQM)/CIEH S4ULs (2014) for commercial end use (1% SOM)

[°]C4SL for commercial land use (1% SOM)

Figure in square brackets [] refer to where GAC presented exceeds the solubility or vapour saturation limit

Exceedances marked in **bold**

Table 5.3: GAC for Polyaromatic Hydrocarbons

Total Petroleum Hydrocarbons (TPHs), BTEX and MTBE

When compared to the published GACs for a commercial end use, no exceedances of TPHs, BTEX or MTBE were recorded, therefore, these soils are considered unlikely to present a



significant possibility of significant harm to human health. The results are shown in Table 5.4 below.

Contaminant	Concentration ranges with exceedances	GACs (mg/kg)
TPH Aliphatic >C ₅ to C ₆	Range: 0.01 – 0.0104mg/kg	3,200 [340] ^{sol}
TPH Aliphatic >C ₆ to C ₈	Range: 0.01 – 0.0253mg/kg	7,800 [144] ^{sol}
TPH Aliphatic >C ₈ to C ₁₀	Range: 0.01 – 5.02mg/kg	2,000 [78] ^{sol}
TPH Aliphatic >C ₁₀ to C ₁₂	Range: 0.01 – 6.68mg/kg	9,700 [48] ^{sol}
TPH Aliphatic >C ₁₂ to C ₁₆	Range: <0.10 – 15.8mg/kg	59,000 [24] ^{sol}
TPH Aliphatic >C ₁₆ to C ₂₁	Range: <0.10 – 39.6mg/kg	1,600,000
TPH Aliphatic >C ₂₁ to C ₃₅	Range: 21.9 – 105mg/kg	1,600,000
TPH Aliphatic >C ₃₅ to C ₄₄	Range: <0.10 – 90mg/kg	1,600,000
TPH Aromatic >C ₅ to C ₇	All less than 0.01mg/kg	26,000 [1,220] ^{sol}
TPH Aromatic >C ₇ to C ₈	All less than 0.01mg/kg	56,000 [869] ^{sol}
TPH Aromatic >C ₈ to C ₁₀	Range: 0.01 – 3.35mg/kg	3,500 [613] ^{vap}
TPH Aromatic >C ₁₀ to C ₁₂	Range: 0.01 – 4.45mg/kg	16,000 [364] ^{sol}
TPH Aromatic >C ₁₂ to C ₁₆	Range: <0.10 – 3.55mg/kg	36,000 [169] ^{sol}
TPH Aromatic >C ₁₆ to C ₂₁	Range: <0.10 – 24.9mg/kg	28,000
TPH Aromatic >C ₂₁ to C ₃₅	Range: 2.57 – 76.7mg/kg	28,000
TPH Aromatic >C ₃₅ to C ₄₄	Range: 0.976 – 127mg/kg	28,000
Benzene	All less than 0.01mg/kg	27, 95 [#] , 98 [°]
Toluene	Range: 0.002 – 0.00234mg/kg	56,000, 4,400 [#]
Ethylbenzene	All less than 0.003mg/kg	5,700, 2,800 [#]
m,p-Xylene	All less than 0.006mg/kg	5,900, 3,200 (p-xylene) [#]
o-Xylene	All less than 0.003mg/kg	6,600, 2,600 [#]
Methyl-tertiary-butyl-ether (MTBE)	All less than 0.005mg/kg	7,900 [*]

GACs derived from Land Quality Management (LQM)/CIEH S4ULs (2014) for a commercial end use (1% SOM)

Figure in square brackets [] refer to where GAC presented exceeds the solubility or vapour saturation limit

[#]SGVs (2009) for commercial end-use (6% SOM)

[°]C4SL for commercial land use (1% SOM)

^{*}GAC derived from EIC/AGS/CL:AIRE GAC for commercial end use (1% SOM)

Table 5.4: GAC for Total Petroleum Hydrocarbons, BTEX and MTBE



Asbestos

Asbestos fibres were not detected in the nine samples of Made Ground tested.

5.9.5 Comparison of Results - Water

The potential risk to groundwater resources was determined by analysis of four water samples obtained from the monitoring standpipes in BH01 to BH04, taken following completion of the fieldwork on 18th April 2016.

The Water Quality Standards (WQS) employed as Tier 1 Water Environment screening criteria are given in Table 5.5 below. The more conservative values of the UK Drinking Water Standards (UK DWS) and Environmental Quality Standards (EA EQS) (Freshwater) have been selected as the primary Tier 1 Screening Values.

The results in Table 5.5 above fall below the published WQS with the exception of the following:

- Selenium in BH04 (26.5µg/l), above the UK DWS (10µg/l) and WFD (7.5µg/l).
- Sulphide in BH04 (1,300 µg/l), above the EA EQS (250µg/l).
- Polyaromatic hydrocarbons in all standpipes (7.89 – 687µg/l), above the UK DWS (0.1µg/l).
- Total petroleum hydrocarbons in all standpipes (977 - 2790µg/l), above the UK DWS (10µg/l).

The results are discussed further in Section 6.2.



Contaminant	Concentrations ranges with exceedances	EA EQS (µg/l)	UK DWS (µg/l)	WFD* (µg/l)
Arsenic	Range: 0.369 – 1.18µg/l	50	10	7.5
Boron	Range: 15.7 – 30.3µg/l	2,000	1,000	750
Cadmium	Range: <0.1 – 0.209µg/l	5	5	3.75
Chromium	Range: 2.76 – 4.66µg/l	250*	50	37.5
Copper	Range: 0.9 – 1.96µg/l	28**	2,000	1,500
Cyanide (total)	All less than 50µg/l	-	50	-
Lead	Range: 0.05 – 0.158µg/l	250*	10	7.5
Mercury	All less than 0.01µg/l	1	1	0.75
Nickel	Range: 4.35 – 30.6µg/l	200**	50	15
Selenium	Range: 1.53 – 26.5µg/l BH04 above the UK DWS	-	10	7.5
Sulphate	Range: 27,500– 99,400µg/l	400,000	250,000	188,000
Sulphide	Range: <100 – 1,300µg/l BH04 above the EA EQS	250		-
Zinc	Range: 2.7 – 14.6µg/l	500*	5,000	-
Phenols	All less than 1µg/l	300	0.5	
Polyaromatic hydrocarbons***	Range: 7.89 – 687µg/l All above the UK DWS	-	0.1	-
Benzo(a)pyrene	Range: 2.17 – 244µg/l All above the UK DWS	-	0.01	0.0075
TPH (total)▲	Range: 977 - 2790µg/l All above the UK DWS	-	10	-
Benzene	All less than 7µg/l	30	1	-
Toluene	All less than 4µg/l	50	-	-
Xylene	All less than 11µg/l	30	-	

* For freshwater, suitable for coarse fish; hardness band CaCO₃ >250mg/l;

** For freshwater, suitable for all fish life; hardness band CaCO₃ >250mg/l;

*** UK DWS for total PAHs relates to the sum of the individual concentrations of benzo(k)fluoranthene, benzo(ghi)perylene, indeno(1,2,3-cd)pyrene and benzo(b)fluoranthene.

▲ Drinking Water Guidance. 1989 Water quality Regulations (superseded).

•WFD – Water Framework Directive drinking water protected areas

Table 5.5: Inorganic and Organic Tier 1 Water Environment Screening Criteria



5.9.6 Comparison of Results - Ground Gases

The observation wells in BH01 to BH04 were monitored on two occasions following completion of the fieldwork to assist in ground gas risk assessment and provide recommendations for gas protective measures, if required. The results are presented in Appendix B and summarised in Table 5.6 below. A preliminary assessment of the results is provided in Section 6.2.

Borehole	Response Zone/Strata (m bgl)	Evidence of Contamination	No. of Monitoring Visits	Methane (%)	Carbon Dioxide (%)	Oxygen (%)	Flow (l/hr)	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)	Volatile Organic Compounds (ppm)	Water Level (m bgl)	Atmospheric Pressure (Mb)
BH01	1.00 – 6.20/ HD & BHG	No	2	0.0- 0.1	2.8- 4.1	9.9-13.0	0.0	0-1	0	1.7-1.8	3.50- 3.91	1003- 1017
BH02	1.00-4.30/ MG, HD & BHG	No	2	0.0	2.1- 5.1	11.2- 17.9	0.0	0-1	0	0.2-1.4	3.22- 3.85	1003- 1010
BH03	1.00 – 6.30/ HD & BHG	No	2	0.0- 0.1	0.2- 5.2	14.0- 19.8	0.0	0-1	0	0.5-0.9	3.25- 3.52	1004- 1019
BH04	1.00 – 6.20/ HD & BHG	No	2	0.0	1.1- 3.0	15.5- 18.8	0.0	0-1	0	0.6-1.7	3.83- 3.91	1003- 1016

Notes: MG – Made Ground; HD – Head deposits; BHG – Boyn Hill Gravel Member

Table 5.6: Summary of Gas Monitoring Data



6. CONTAMINATION RISK ASSESSMENT AND RECOMMENDATIONS

6.1 Qualitative Risk Assessment

6.1.1 General

The assessment of potential sources of contamination were limited to a site walkover and the findings of the ground investigation. Further assessment should be considered, in accordance with the DEFRA and Environment Agency publication CLR 11 (2004), including a Phase 1 desk study of the site to suitably establish the environmental setting.

Notwithstanding the above, chemical analysis of soils fell below the published GACs for a commercial end use. Asbestos fibres were not detected in the samples of Made Ground tested, although this does not prove the absence of asbestos at the site.

Chemical analysis of groundwater in BH01 to BH04 identified exceedances of selenium, sulphide, polycyclic aromatic hydrocarbons and total petroleum hydrocarbons in groundwater beneath the site.

The concentrations of ground gases (based on methane and carbon dioxide) and vapours observed in BH01 to BH04 during post fieldwork monitoring at the site are discussed in Section 6.2 below.



6.1.1 Receptors and Pathways

Human Health

The results of the chemical analysis and asbestos screening indicate the site presents a **LOW** risk to the human health of end-users of the site based on a commercial end use.

Direct human contact could occur during demolition and construction activities proposed for the site, however the potential risk would be deemed to be **LOW** if precautionary measures discussed in Section 7.5 below are adhered to.

Buried Services

Potential receptors would also include buried services (particularly water pipes); further comment is made in Section 6.3.

Controlled Waters

The superficial deposits are designated as a Secondary (Undifferentiated) aquifer, whilst the underlying bedrock (London Clay Formation) is classified as unproductive due to low permeability. The site is located approximately 140m southwest of an Inner Zone (Zone 1) SPZ.

There are no surface water features on the site; the nearest relates to Whiteknights Lake, which is located approximately 300m east of the Engineering Building. The River Kennet is situated about 2.2km west of the site.



The proposed scheme indicates that the majority of the site will be covered by the new building or hardstanding, which will serve to limit potential contamination into the underlying Secondary (Undifferentiated) Aquifer.

Whilst chemical analysis of groundwater in BH01 to BH04 was generally recorded below the WQS, exceedances of selenium, sulphide, polyaromatic hydrocarbons and total petroleum hydrocarbons, above the WQS, indicate that further assessment will be required.

Given the above, the risk to controlled waters is therefore considered to be **LOW to MEDIUM**.

6.2 Gas Protection Measures

The risk posed by gassing sites can be determined from a semi-quantitative assessment of the risk, as proposed by Wilson and Card (1999), following development of the system as detailed in BS8485:2015. The method uses both gas concentrations and borehole flow rates to define a characteristic situation (CS) for a site based on the limiting borehole gas volume-flow or “Gas Screening Value” (GSV) for methane and carbon dioxide. The GSV (litres of gas per hour) can be calculated from the borehole flow rate (litres per hour) and gas concentration (%). The calculation is carried out for both methane and carbon dioxide and the worst case GSV value is generally adopted for comparison with the Classification Situation.

The ground gas observation wells installed in BH01 to BH04 were monitored on two occasions following completion of the fieldwork. The results indicate a maximum concentration of carbon dioxide (CO₂) at 5.2%, up to 0.1% methane and 1ppm carbon monoxide. Hydrogen sulphide was not measured above the limits of detection. Oxygen concentrations varied between 9.9% and 19.8%. No gas flow was detected during the two visits. Given the recorded concentrations of carbon dioxide, it is recommended that at least



two further gas monitoring visits (four in total) are carried out in to provide more robust data for the site. Once the final gas data has been received, the detailed design of protective measures (if any) should be carried out in accordance with BS8485:2015. This design will depend on the type and use of the proposed building.

Based on the maximum recorded concentration of volatile organic compounds to date (up to 1.8ppm), vapour protection measures would not be considered necessary for development at the site.

The BRE indicates radon protective measures are not required in new developments at this site, however it is recommended that the local Building Control body is contacted to establish their minimum requirements for the area.

6.3 Further Work/Remedial Work

Based on the outline scheme, pre-construction remedial action is not considered necessary to protect the human health of future end-users of the site. Further assessment is however recommended to assess the potential risk to controlled waters, which is likely to include a Phase 1 desk study of the site to establish the environmental setting.

Whilst the results to date indicate that ground gas protection measures are not likely to be required, it is recommended that a further two monitoring visits are carried out (four in total) are carried out to provide more robust data for the site.

The concentrations of organic and inorganic contaminants may have an effect on the choice of materials used for underground services. Particularly at risk are drinking water supplies as any deterioration may have a direct effect on water quality and human health. It is therefore recommended that the specification for underground water supply pipes is



agreed with the Water Supply Company where potentially exposed to elevated contaminants.

6.4 Waste Disposal

No assessment has been made within this report with regard to the classification of material for potential offsite disposal. In order to classify materials as non-hazardous and within the Waste Acceptance Criteria (WAC), further testing may be required prior to the dispatch of waste to landfill. We can assist if necessary, with testing usually taking two weeks at the laboratory. Landfill sites may require pre-treatment of waste prior to disposal. Registration of the site may also be required before materials are dispatched. It is recommended that a suitably competent and licensed waste broker be contacted for advice/guidance on how to proceed and to provide a suitable waste classification of the material.

6.5 General Groundworks

Where construction workers are likely to come into contact with potentially contaminated materials during any redevelopment of the site it will be necessary to ensure that a strict personal hygiene regime is observed. Accordingly, skin contact with and possible ingestion of contaminated materials must be avoided. Adequate washing, toilet and first aid facilities should be provided. Construction workers coming into contact with potentially contaminated materials should wear protective clothing including gloves, overalls, boots and eye protection.

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7. REFERENCES

British Standards Institution (1990): Methods of tests for soils for civil engineering purposes. BS 1377 Parts 1-9.

British Standards Institution (2012): Geotechnical investigation and testing. Field testing. Standard penetration test. BS EN ISO 22476-3:2005+A1:2011.

British Standards Institution (2013): Code of practice for investigation of potentially contaminated sites. BS10175:2011+A1:2013.

British Standard Institution (2014): Geotechnical investigation and testing — Laboratory testing of soil. Part 1: Determination of water content. BS EN ISO 17892-1:2014.

British Standards Institution (2015): Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings. BS 8485.

British Standards Institution (2015): Code of practice for ground investigations. BS 5930:2015.

Building Research Establishment (2005): Concrete in aggressive ground. BRE Special Digest 1, Part C. Third Edition.

Building Research Establishment (2007): Radon: guidance on protective measures for new buildings (including supplementary advice for extensions, conversions and refurbishment). BRE Report BR211.

CL:AIRE (2013): Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination. PS1010 – Final Project Report. Contaminated Land: Applications in Real Environments (CL:AIRE) dated 20th December 2013.



Department Of The Environment and Welsh Offices (2010): Site Preparation and resistance to contaminants and moisture. Approved Document C, Building Regulations 2010. HMSO London.

Department for Environment, Food and Rural Affairs (2012). Environmental Protection Act 1990: Part 2A, Contaminated Land Statutory Guidance.

EIC/AGS/CL:AIRE (2010): Soil Generic Assessment Criteria for Human Health Risk Assessment. January 2010.

Environment Agency (2002): Technical Advice to third parties on Pollution of Controlled Waters for Part IIA of the EPA1990.

Environment Agency (2004): Model Procedures for the Management of Land Contamination (CLR 11).

Environment Agency (2016) 'What's in your backyard?' Wiyby www.environment-agency.gov.uk/wiyby/

National House Building Council (2014): NHBC Standards. Chapter 4.2. Foundations: Building near trees.

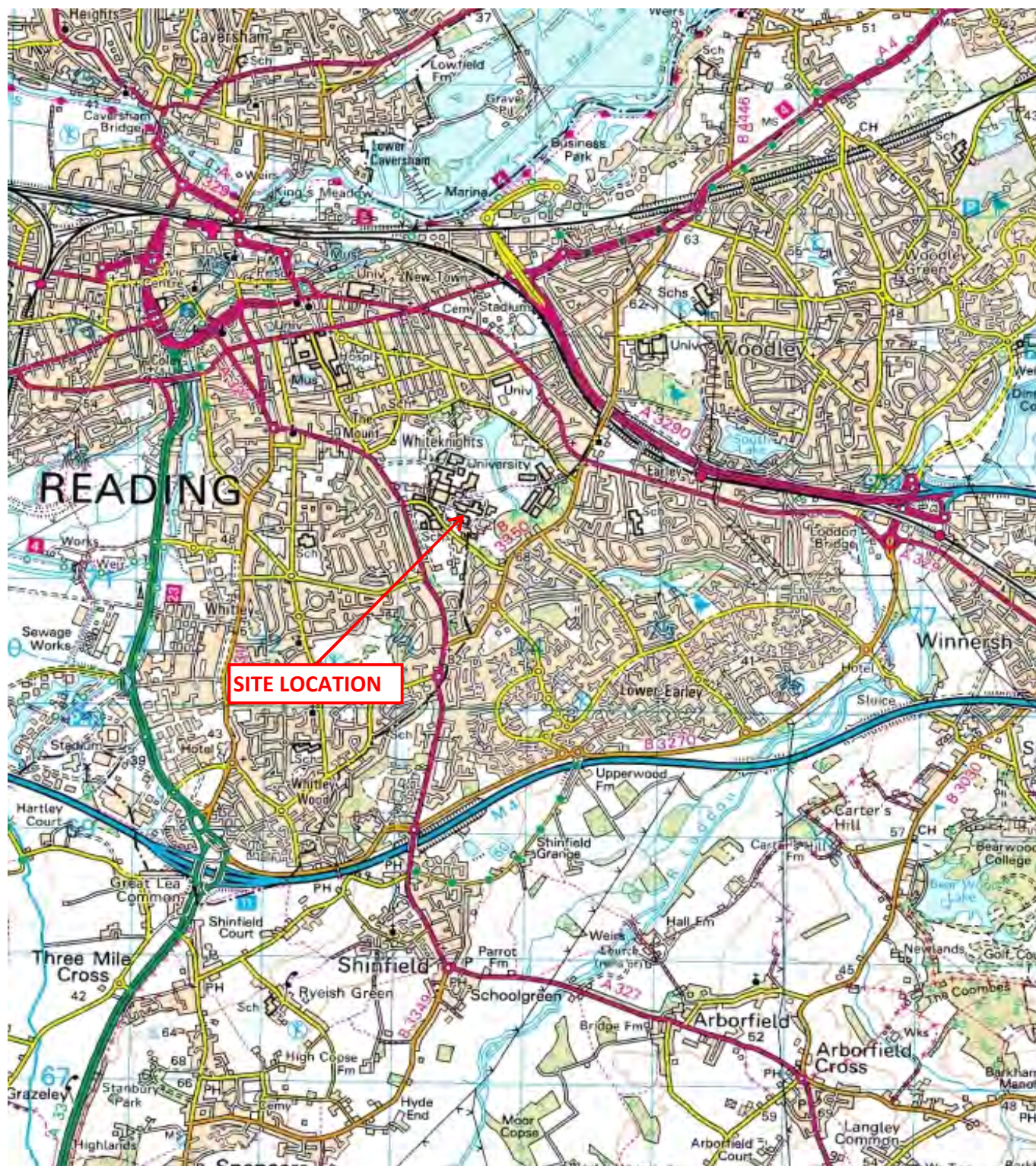
New Zealand Ministry for the Environment (1999): Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand. August 1999.

Stroud M A (1974): The standard penetration test in insensitive clays and soft rocks. Proc. Eurp. Symp. on Penetration Testing, Stockholm.



Wilson S and Card G (1999): Reliability and Risk in Gas Protection Design. Ground Engineering.

Wilson S, Oliver S, Mallett H, Hutchings H & Card G. CIRIA (2007). Assessing risks posed by hazardous ground gases to buildings. CIRIA Report C665 (London).



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LOCATION PLAN



CLIENT KNOWLES & SON (OXFORD) LTD
SITE UNIVERSITY OF READING - HEALTH & LIFE SCIENCES BUILDING
SCALE Approximately 1:50,000

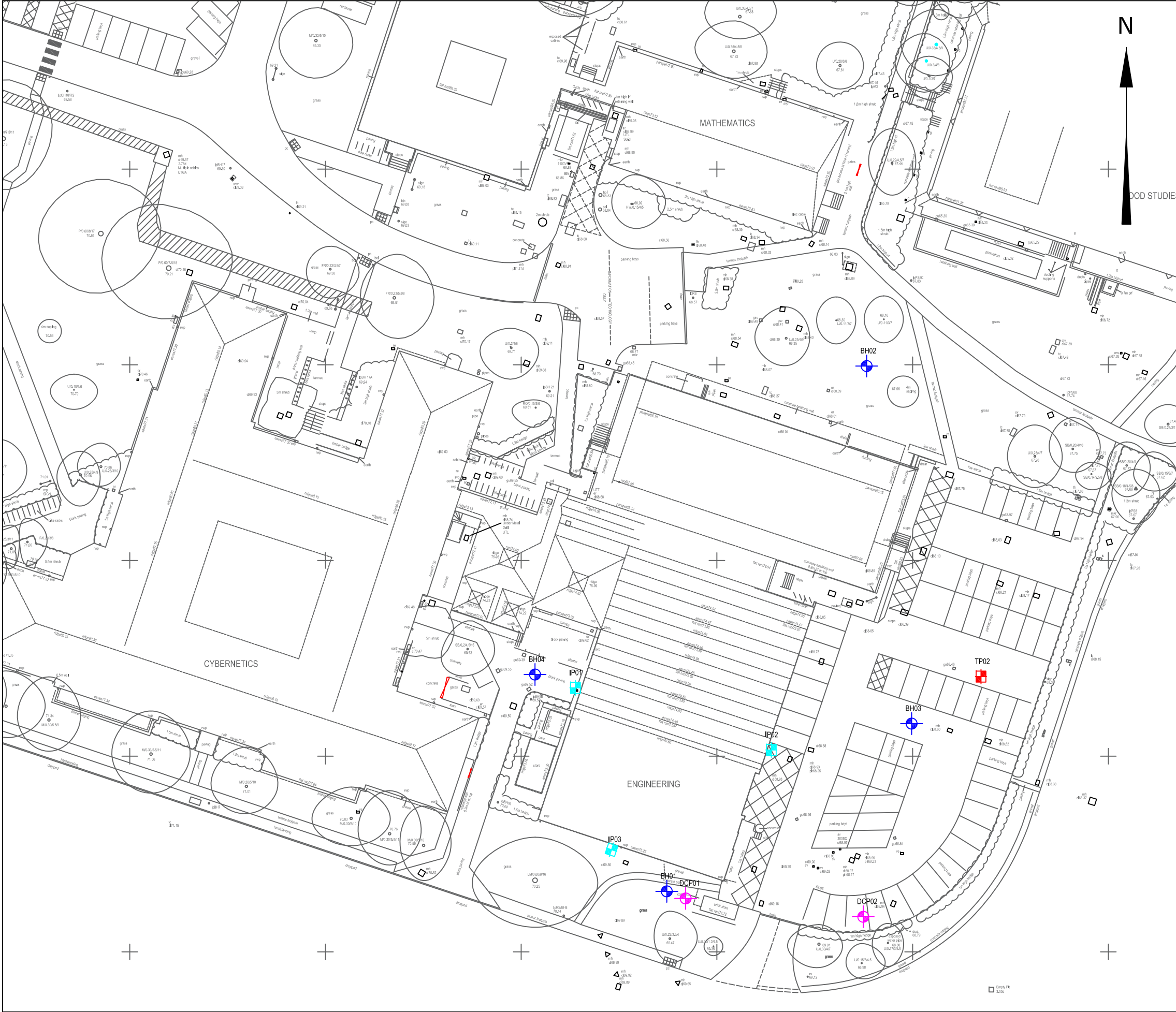
Reproduced from the 2012, 1:50,000 Ordnance Survey Map (Sheet 175 Reading & Windsor) with the permission of Ordnance Survey on behalf of The Controller of Her Majesty's Stationary Office, Crown Copyright. Geotechnical Engineering Limited, Gloucester. AL100002447.

CONTRACT

FIGURE

31710

1



Key.

Borehole Location

DCP Location

Trial Pit Location

Inspection Pit Location

Notes:

Drawing supplied by client.

geotechnical

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Client:

KNOWLES & SON (OXFORD) LTD

Engineer:

AECOM

Site:

UNIVERSITY OF READING - HEALTH AND LIFE SCIENCES BUILDING

Title:

Exploratory Hole Location Plan

Drawn By:

GJS

Checked By:

JJ

Paper Size:

A3

Scale:

1:500

Date:

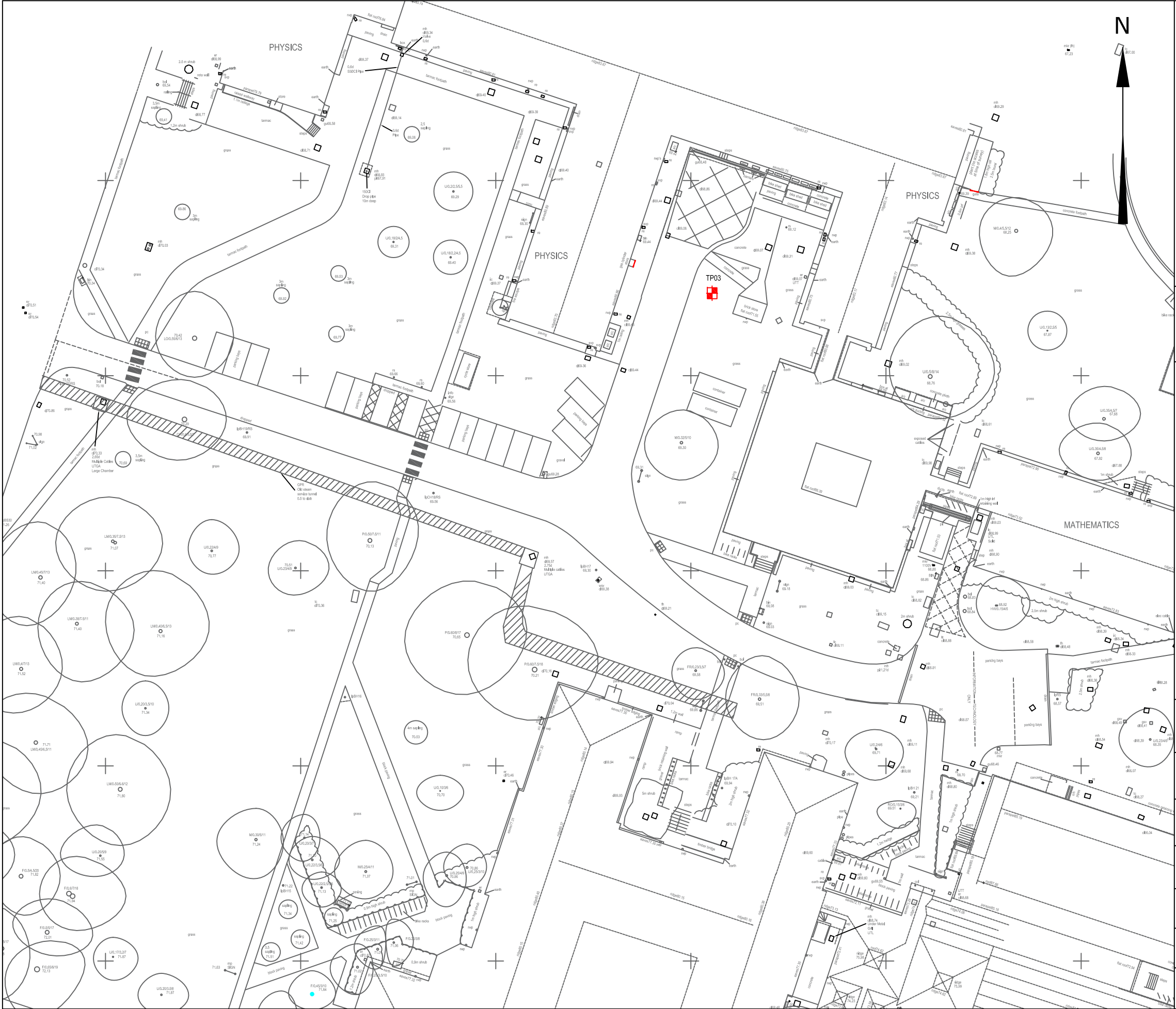
April 2016

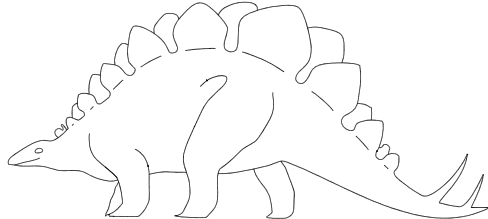
Contract:

31710

Figure:

02



Key.  Borehole Location  DCP Location  Trial Pit Location  Inspection Pit Location		
Notes: Drawing supplied by client.		
 geotechnical Geotechnical Engineering Ltd Centurion House, Olympus Park, Quedgeley, Gloucester GL2 4NF Telephone: (01452) 527743 Facsimile: (01452) 729314 E-mail: geotech@geoeng.co.uk Web: www.geoeng.co.uk		
Client: KNOWLES & SON (OXFORD) LTD		
Engineer: AECOM		
Site: UNIVERSITY OF READING - HEALTH AND LIFE SCIENCES BUILDING		
Title: Exploratory Hole Location Plan		
Drawn By: GJS	Checked By: JI	Paper Size: A3
Scale: 1:500		Date: April 2016
Contract: 31710		Figure: 03



APPENDIX A

PHOTOGRAPHS