Hampshire Water Transfer and Water Recycling Project

6.2 Environmental Statement Vol II Appendix 11.2 Geotechnical and geo-environmental reports - 9 of 18 documents - Geotechnical and Geo-environmental Interpretative Report for Ground Investigation in Section L (Phase 2 and Phase 3B/3C) Addendum to Summary Report

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WATER for LIFE

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Document Control	
6.2 Environmental Statement Vol II Appendix 11.2 Geotechnical and geo-environmental reports - 9 of 18 documents - Geotechnical and Geo-environmental Interpretative Report for Ground Investigation in Section L (Phase 2 and Phase 3B/3C) Addendum to Summary Report	
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Figure 1.1	Section L (NE) Ground Investigation Locations with PSCs	27/11/2024	• Ground investigation locations added to figure.
Figure 1.2	Section L (SE) Ground Investigation Locations with PSCs	27/11/2024	• Ground investigation locations added to figure.

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1 Introduction and Objectives

This document has been updated at Deadline 1 to include Phase 3 ground investigation soil sampling results in Appendix D (sample ID '3L60' ground investigation locations). References to other Application documents have not been updated from the original submission. Please refer to the latest version of the Guide to the Application (Document reference 1.3, Volume 1) for the list of current versions of documents.

1.1 Background and Scheme Overview

Water for Life Hampshire (WfLH) is a programme being undertaken by Southern Water Services Limited (hereafter referred to as 'the Applicant') to address the sustainability objectives of reduced abstractions on Hampshire's two main rivers, the River Test and River Itchen, and ensuring a resilient water supply for the Applicant's customers during times of drought. The Hampshire Water Transfer and Water Recycling Project (HWTWRP) (hereafter referred to as the 'Proposed Development') is the Strategic Resource Option project being delivered as part of the WfLH programme (Southern Water, 2024).. An overview of the Proposed Development, at the time of this report production, is provided in the Applicant's HWTWRP Technical Document Technology Guide (Southern Water, 2024).

1.2 Terms of Reference

Strategic Solutions Partner (SSP) has been instructed the Applicant, as part of the Proposed Development, to produce a Geotechnical and Geo-environmental Interpretative Report for ground investigations (GI) completed to provide information for the construction of the proposed underground pipeline. Investigations are being undertaken within the boundaries of the Draft Order Limits (DoL) for the Development Consent Order (DCO) for this nationally significant infrastructure scheme. The Proposed Development has been divided into 12 Sections by the Applicant; these are referred to as Sections A to M (excluding I).

1.3 Ground Investigation Programme

The GI for the Proposed Development is being completed using a phased approach as shown in **Table 1.1**~~**Table 1.1**~~. This document reports the findings of the GI works completed during Phase 2 and Phase 3B/3C within Section L only.

Table 1.1: Ground investigation programme

GI Phase	Description
Phase 0	This, with Phases 1 and 3A, was completed between July 2022 and October 2023 by SOCOTEC for Clancy (Principal Contractor), and as specified by SSP (AECOM), primarily for the purpose of tunnel and shaft design (Sections B, C, D and M only) and comprised 11 boreholes.
Phase 1	This, with Phases 0 and 3A, was completed between July 2022 and October 2023 by SOCOTEC for Clancy (Principal Contractor), and as specified by SSP (AECOM), primarily for the purpose of tunnel and shaft design (Sections B, C, D, L and M only) and comprised 35 exploratory hole locations.
Phase 2	This is part of a wider phased GI conducted along the route between February 2023 and July 2023 by SOCOTEC for Clancy (Principal Contractor), and as specified by SSP, primarily for the purpose of investigating areas for non-pipeline infrastructure, trenchless crossings and potential sources of contamination (PSC).

GI Phase	Description
Phase 3A	This, with Phases 0 and 1, was completed between July 2022 and October 2023 by SOCOTEC for Clancy (Principal Contractor), and as specified by SSP (AECOM), primarily for the purpose of tunnel and shaft design (Sections B, C, D, L and M only) and comprised 14 exploratory hole locations.
Phase 3B/3C	This, with several Phase 2 GI locations was completed between May 2023 and May 2024 by SOCOTEC for Clancy (Principal Contractor), and as specified by SSP, primarily for the purpose of investigating areas for non-pipeline infrastructure, trenchless crossings, PSCs and the linear route.

1.4 Section L Ground Investigation Objectives

The Phase 2 & Phase 3B/3C Section L GI investigated the following:

- Areas of potential sources of contaminant (PSCs) deemed Moderate/Low or higher risk as identified within HWTWRP Geotechnical and Geo-Environmental Desk Study Version 4 (SSP, 2024).
- Geological conditions along the linear route to comply with Eurocode 7: Part 2 (BSI, 2007).
- Trenchless crossings beneath the Winchester Road (B3354), Bow Lake and the tributary of the River Itchen.

The Phase 2 and Phase 3B/3C Section L GI comprised the following:

- Six exploratory holes associated with proposed launch/reception locations at the proposed trenchless crossings beneath Winchester Road (B3354) (2L6007DR and 2L6008DR), Bow Lake (2L6009DR and 2L6010DR) and a tributary of the River Itchen (2L6011SR and 2L6012SR).
- Seven exploratory holes along the route to assess potential contamination from historical Crowd Hill Landfill and BGS Made Ground (PSCs 441 and 440) (2L6000TP, 2L6001TP, 2L6004TP, 2L6006TP, 2L6002SA, 2L6003SA and 2L6005SA).
- Three exploratory locations targeting an additional two PSCs, Infilled Land – Pond (PSC 200) (3L6101DS), and the second historical Crowd Hill Landfill location (PSC 472) (3L6106DS and 3L6107DS).
- Seventeen locations to prove the geology along the linear route to comply with Eurocode 7: Part 2 comprising 3L6013HP (also coincides with an embankment [PSC 527]), 3L6015HP, 3L6017HP, 3L6023HP, 3L6024HP, 3L6026HP, 3L6027HP, 3L6028HP, 3L6029HP, 3L6044HP, 3L6045HP, 3L6046HP, 3L6100HP, 3L6102HP, 3L6103HP, 3L6104HP and 3L6105HP.

The GI targeted identified PSCs with a risk rating of moderate/low or higher as identified within HWTWRP Geotechnical and Geo-Environmental Desk Study Version 4 (SSP, 2024). Several PSCs identified within a 50 m radius of the proposed DoL in Section L were not investigated during Phase 2 and Phase 3B/3C. It is expected that the contractor will further assess identified PSCs (where additional information is needed), and other, additional PSCs, identified during subsequent phases of the Proposed Development as part of their construction phase works, to understand and comply with contaminated land, health & safety, waste classification and any other relevant guidance.

1.5 Report Format

This report comprises both geotechnical and geo-environmental interpretation of data collated during the GI as outlined below:

Section 1 Introduction and report objectives.

Section 2 Description including the location and site description.

Section 3 Summary of the GI (SOCOTEC, 2023), (SOCOTEC, 2024).

Section 4 Ground model.

Section 5 GI results, data interpretation and geo-environmental risk assessment, and geo-environmental considerations for the outline proposed works.

Section 6 Development of the land contamination risk assessment model from the GI.

Section 7 Geotechnical testing and assessment including geotechnical summary tables and figures and design parameters.

Section 8 Geotechnical considerations including hazard and mitigation table, discussions on ground conditions, foundation design, excavations, groundwater control, flotation, trenchless construction and concrete aggressivity.

Section 9 Conclusions.

Section 10 Recommendations based on the results of the GI.

This report provides a summary of encountered ground conditions, existing GI results, and geotechnical and geo-environmental interpretation of analysis undertaken to inform on potential future structures and pipeline design, health and safety of construction and future ground workers (construction) and excavated materials (waste) management.

A land contamination risk assessment for other potential future receptors such as farmers/ farm workers/ members of the public accessing and working within the Proposed Development is outside the scope of this report. Further ground investigation and human health risk assessment may be required to determine the risk to these, and any other identified potential future receptors, particularly in regard to appropriate excavated materials management (e.g. proposed reuse of soils).

Assessment of the GI data collected across the other pipeline Sections is included in the separate relevant pipeline sectional reports which are collated in the HWTWRP Geotechnical and Geo-environmental Interpretative Summary report (Ref.710166-SWS-XX-XX-RP-GE-00100).

2 Section L Description

2.1 Location and Description

The Section L Proposed Development route is approximately 5.9 km in length, illustrated in the **Figures** section. The pipeline will be constructed using open-cut and trenchless techniques. The majority of the approximate 5.9 km length of Section L will be a ductile iron (DI) pipeline at 1200 mm diameter in open-cut trenches between 3 – 6 m below ground level (bgl) across arable fields and minor roads with trenchless construction, to between approximately 7.6 – 9 m bgl, across main roads including the B3354 south of Fishers Pond and watercourses such as Bow Lake (within 20 to 40 m of boreholes 2L6007DR to 2L6010DR inclusive). Temporary launch and reception shafts at the trenchless crossing locations will be excavated. Launch shaft dimensions will range between 9.0 m and 9.5 m diameter and reception shafts range between 5.0 m and 5.4 m diameter.

Section L starts approximately 90 m northwest of Mortimers Lane (at National Grid Reference (NGR) 451992E, 119542N), at an elevation of approximately 46 m Ordnance Datum (OD). The proposed pipeline then travels northwest / west across agricultural / arable fields and small watercourses in an open-cut trench.

Approximately 3.3 km from the start of the route (90 m northwest of Mortimers Lane), there is an historic Environment Agency designated landfill site (NGR 449095E, 120275N) at approximately 50 m OD (the highest elevation across Section L).

The proposed pipeline then progresses northwards, parallel to Winchester Road (B3354), under the B3354 as a trenchless construction trending northwest in line with the Bow Lake watercourse. Following the trenchless crossing, the pipeline is to be constructed in an open-cut trench across the agricultural field, to the south of Bow Lake, before another trenchless crossing beneath Bow Lake (NGR 448545E, 120769N) at approximately 23 m OD. The proposed pipeline progresses across fields from this point, as open-cut construction towards Bishopstoke Lane, and subsequently across fields where trenchless construction will take place beneath an un-named watercourse. Lastly, Section L pipeline progresses northwest via open-cut construction to Highbridge Road (B3335) (NGR 446903E, 121619N) at approximately 20 m OD, where Section M begins.

3 Phase 2 and Phase 3B/3C Ground Investigation

3.1 Rationale for Ground Investigation Locations

The rationale for the Phase 2 and Phase 3B/3C GI is presented in **Table 3.1**.

Table 3.1: Rationale for Locations in Section L

Hole ID	Rationale for GI Location [1]
Phase 3B/ 3C GI	
3L6013HP	To confirm the geology along the linear route. 3L6013HP also coincides with an embankment (PSC 527)
3L6100HP	
3L6015HP	
3L6101DS	Previously identified Potential Source of Contamination, Infilled Land – Pond, PSC 200 (subsequently not assessed due to pond still being present.)
3L6102HP	To confirm the geology along the linear route
3L6017HP	
3L6103HP	
3L6104HP	To confirm the geology along the linear route
3L6105HP	
3L6023HP	
3L6024HP	
3L6106DS	Potential Source of Contamination, Crowd Hill Landfill, second location, PSC 472.
3L6107DS	
3L6026HP	To confirm the geology along the linear route
3L6027HP	
3L6028HP	
3L6029HP	
Phase 2 GI	
2L6000TP	To investigate the historical Crowd Hill Landfill (PSC No. 441) and BGS Made Ground (PSC No. 440) mapped on-Site
2L6001TP	
2L6002SA	
2L6003SA	
2L6004TP	
2L6005SA	
2L6006TP	To investigate the historical Crowd Hill Landfill (PSC No. 441) approximately 40 m north and on-Site BGS Made Ground (PSC No. 440).
2L6007DR	To investigate proposed excavation areas for the trenchless crossing beneath Winchester Road.

Hole ID	Rationale for GI Location [1]
2L6008DR	
2L6009DR	To investigate proposed excavation areas for the trenchless crossing beneath Bow Lake watercourse
2L6010DR	
3L6044HP	To confirm the geology along the linear route
3L6045HP	
3L6046HP	
2L6011SR 2L6012SR	To investigate proposed excavation areas for the trenchless crossing beneath a small watercourse in the northern part of Section L approximately 280 m northwest of Bishopstoke Lane.

[1] PSCs within a 50m buffer of the Section L route were identified by the desk study which warranted further investigation (SSP, 2023C).

Within Section L, some locations were cancelled due to land access permissions; this affected 3L6041HP, 3L6042HP and 3L6043HP, locations originally supplied to the GI Contractor to investigate prior to GI commencing.

BH501 was drilled along with TP501, TP502 and TP503, excavated within 20 m of Section L route for tunnelling purposes in Phase 1 GI for the Applicant, as specified by AECOM. The locations provide ground and groundwater conditions to the west of Brambridge. The geology and geotechnical results for the upper 20 m (out of 45.15 m) from BH501, and from the accompanying trial pits, is incorporated into this report as additional information.

3.2 Section L Ground Investigation

GI was carried out for Phase 2 at selected locations across Section L of the proposed route by SOCOTEC between 21st February 2023 to 22nd June 2023. The GI scope was specified by SSP (SSP, 2022).

A GI was carried out for Phase 3B/3C at selected locations across Section L of the proposed route by SOCOTEC between 2nd May 2023 to 14th May 2024. The GI scope was specified by SSP (SSP, 2023c) (SSP, 2023d).

The following exploratory holes and non-intrusive surveys were completed:

Phase 1 GI

- Three trial pits (TP501, TP502, TP503) were excavated to between 1.4 m bgl and 4 m bgl.
- One borehole, BH501, was completed using cable percussion and extended by rotary core drilling to 45.15 m bgl.

Phase 2 GI

- Four trial pits 2L6000TP, 2L6001TP, 2L6004TP and 2L6006TP were excavated to between 1.4 m bgl and 4 m bgl.
- Three boreholes (2L6002SA, 2L6003SA and 2L6005SA) were completed using cable percussion to between 10.00 m bgl and 15.95 m bgl.
- Two boreholes (2L6011SR and 2L6012SR within Phase 2) were completed using cable percussion methods and extended by rotary core drilling to 20 m bgl.

- Four boreholes (2L6007DR, 2L6008DR, 2L6009DR and 2L6010DR) were completed using dynamic sampling and extended by rotary core drilling to between 20.00 m bgl and 20.10 m bgl.

Phase 3B/3C GI:

- Seventeen hand excavated inspection pits (3L6013HP, 3L6015HP, 3L6017HP, 3L6023HP, 3L6024HP, 3L6026HP, 3L6027HP, 3L6028HP, 3L6029HP, 3L6044HP, 3L6045HP, 3L6046HP, 3L6100HP, 3L6102HP, 3L6103HP, 3L6104HP and 3L6105HP) were completed to between 0.20 m bgl and 1.20 m bgl.
- Three boreholes (3L6101DS, 3L6106Ds and 3L6107DS) were completed using dynamic sampling to 6.45 m bgl
- Electrical resistivity testing at nine locations (3L6017HP, 3L6023HP, 3L6024HP, 3L6026HP, 3L6028HP, 3L6029HP 3L6102HP, 3L6100HP and 3L6105HP).

A plan showing the exploratory hole locations is presented in the **Figures** section. The scope of the investigation included in-situ geotechnical tests, volatile headspace testing by a Photo Ionisation Detector (PID), geotechnical and geo-environmental sampling, and groundwater and gas monitoring.

The details of the GI, tests and laboratory analysis are presented in the SOCOTEC Ground Investigation Final Factual report (SOCOTEC, 2023) (SOCOTEC, 2024). A description of GI locations is shown in **Table 3.2**.

Table 3.2: Description of GI Locations

GI Locations	National Grid Reference [1]	Location
3L6013HP	451839, 119626	Located within an agricultural field, approximately 180 m northwest, of Mortimer Lane B3037.
3L6100HP	451758, 119684	Located in an agricultural field, approximately 215 m southwest of Winchester Road (B2177).
3L6015HP	451686, 119820	Located in an agricultural field, approximately 145 m southwest of Winchester Road.
3L6101DS	451626, 119889	Located in an agricultural field, approximately 160 m southwest of Winchester Road.
3L6102HP	451447, 119935	Located in an agricultural field, directly west of Stroudwood Lane.
3L6017HP	451380, 119966	Located in an agricultural field, approximately 65 m west of Stroudwood Lane.
3L6103HP	451146, 120062	Located in an agricultural field, adjacent to a wind break tree line, approximately 325 m west of Stroudwood Lane.
3L6104HP	450910, 120165	Located in an agricultural field, adjacent to a wind break tree line, approximately 480 m east of an unnamed farm road and Lowhill Farm buildings.
3L6105HP	450658, 120174	Located in an agricultural field, approximately 240 m east of an unnamed farm road and Lowhill Farm buildings, and approximately 540 m south of Portsmouth Road B2177.
3L6023HP	450441, 120206	Located in an agricultural field, approximately 15 m east of an unnamed farm road and northwest of Lowhill Farm buildings.
3L6024HP, A & B	450204, 120254	Located in an agricultural field, approximately 150 northwest of Lowhill Farm buildings.

GI Locations	National Grid Reference [1]	Location
3L6106DS	449956, 120300	Located in an agricultural field, approximately between 640 m – 680 m southwest of Portsmouth Road B2177.
3L6107DS	449884, 120321	
3L6026HP	449686, 120424	Located in an agricultural field, approximately 530 m south of Portsmouth Road B2177. Approximately 250 m southeast of Bow Lake.
3L6027HP	449517, 120487	Located in an agricultural field, approximately 430 m south of Portsmouth Road B2177. Approximately 112 m south of Bow Lake.
3L6028HP	449321, 120415	Located in an agricultural field, approximately 440 m east of Winchester Road B3354. Approximately 190 m southwest of Bow Lake.
3L6029HP	449075, 120344	Located in an agricultural field to the north of a residential property, 180 m east of Winchester Road B3354.
Phase 2 GI		
2L6000TP	449000, 120372	Located all in the same agricultural field and horse paddock within the footprint of a historical landfill (PSC No. 441 - Crowd Hill Landfill) and BGS Made Ground (PSC No. 440), approximately 100 m – 110 m east of Winchester Road B3354, approximately 170 m – 250 m south of linear watercourse Bow Lake and approximately 50 – 70 m west from a woodland
2L6001TP	448999, 120392	Located all in the same agricultural field and horse paddock within the footprint of a historical landfill (PSC No. 441 - Crowd Hill Landfill) and BGS Made Ground (PSC No. 440), approximately 100 m – 110 m east of Winchester Road B3354, approximately 170 m – 250 m south of linear watercourse Bow Lake and approximately 50 – 70 m west from a woodland.
2L6002SA	448996, 120402	Located all in the same agricultural field and horse paddock within the footprint of a historical landfill (PSC No. 441 - Crowd Hill Landfill) and BGS Made Ground (PSC No. 440), approximately 100 m – 110 m east of Winchester Road B3354, approximately 170 m – 250 m south of linear watercourse Bow Lake and approximately 50 – 70 m west from a woodland
2L6003SA	448993, 120423	Located all in the same agricultural field and horse paddock within the footprint of a historical landfill (PSC No. 441 - Crowd Hill Landfill) and BGS Made Ground (PSC No. 440), approximately 100 m – 110 m east of Winchester Road B3354, approximately 170 m – 250 m south of linear watercourse Bow Lake and approximately 50 – 70 m west from a woodland
2L6004TP	448981, 120451	Located all in the same agricultural field and horse paddock within the footprint of a historical landfill (PSC No. 441 - Crowd Hill Landfill) and BGS Made Ground (PSC No. 440), approximately 100 m – 110 m east of Winchester Road B3354, approximately 170 m – 250 m south of linear watercourse Bow Lake and approximately 50 – 70 m west from a woodland
2L6005SA	448973, 120473	Located all in the same agricultural field and horse paddock within the footprint of a historical landfill (PSC No. 441 - Crowd Hill Landfill)

GI Locations	National Grid Reference [1]	Location
		and BGS Made Ground (PSC No. 440), approximately 100 m – 110 m east of Winchester Road B3354, approximately 170 m – 250 m south of linear watercourse Bow Lake and approximately 50 – 70 m west from a woodland
2L6006TP	448959, 120507	Located approximately 35 m northwest of the six locations 2L6000TP – 2L60004TP, and 2L6002SA and 2L6005SA within an agricultural field, approximately 140 m south of linear watercourse Bow Lake and approximately 90 m east of Winchester Road B3354.
2L6007DR	448878, 120643	Trenchless crossing borehole paired with 2L6008DR located approximately 40m south of linear watercourse Bow Lake and approximately 30 m east of Winchester Road B3354 within an arable field.
2L6008DR	448809, 120646	Trenchless crossing borehole paired with 2L6007DR located approximately 40 m south of linear watercourse Bow Lake and approximately 30 m west of Winchester Road B3354 within an arable field.
2L6009DR	448545, 120745	Trenchless crossing borehole paired with 2L6010DR located approximately 20 m south of linear watercourse Bow Lake and approximately 270 m west of Winchester Road B3354 within the same arable field as 2L6008DR.
2L6010DR	448545, 120795	Trenchless crossing borehole paired with 2L6009DR located approximately 25 m north of linear watercourse Bow Lake and approximately 270 m west of Winchester Road B3354.
3L6044HP	447653, 121187	Located in an agricultural field 175 m east of Bishopstoke Lane.
3L6045HP	447383, 121332	Located in an agricultural field 35 m west of Bishopstoke Lane.
3L6046HP	447344, 121392	Located in an agricultural field 170 m west of Bishopstoke Lane.
2L6011SR	447176, 121476	Trenchless crossing borehole paired with 2L6012SR located approximately 30 m southeast of a small watercourse and approximately 30 m northeast of a woodland within a rectangular shaped arable field approximately 280 m northwest of Bishopstoke Lane.
2L6012SR	447131, 121517	Trenchless crossing borehole paired with 2L6011SR approximately 30 m northwest of a small watercourse and approximately 30 m north of a woodland. It is located within an agricultural field approximately 240 m southeast of Highbridge Road B3335.

[1] Coordinates provided from SOCOTEC (SOCOTEC, 2023) (SOCOTEC, 2024).

3.3 Exploratory Holes and Monitoring Well Installations

The exploratory hole locations and logs are presented in SOCOTEC's Ground Investigation Final Factual reports (SOCOTEC, 2023) (SOCOTEC, 2024).

Table 3.3 provides a summary of the locations and installation response zones. Groundwater and gas monitoring wells were installed in all boreholes along Section L. Data loggers were installed within two borehole locations and at depths as stated below:

- 2L6009DR 3.00 m bgl
- 2L6011SR 4.00 m bgl

Table 3.3: Summary of Groundwater and Ground Gas Monitoring

BH ID	Dual Installation	Response Zones (m bgl)	Groundwater monitoring visits	Gas Monitoring	Groundwater Sample (m bgl)
BH501	Yes	Shallow installation: 1.10 – 2.10 (River Terrace Deposits) Deep installation: Vibrating Wire Piezometer is below depth of interest	6 No. 14/06/23, 13/07/23, 24/08/23, 08/09/23, 07/02/24, 4/04/24	Not Applicable, only groundwater monitoring in shallow installation	None
2L6002SA	No	1.00 – 5.00 (London Clay Formation)	7 No. 20/04/23, 12/05/23, 25/05/23, 19/06/23, 18/07/23, 15/08/23, 13/09/23	7 No. 20/04/23, 12/05/23, 24/05/23, 19/06/23, 18/07/23, 15/08/23, 13/09/23	12/05/23: 3.29 20/07/23: 6.10 16/09/23: 5.90
2L6003SA	No	1.00 – 7.00 (London Clay Formation)	6 No. 20/04/23, 12/05/23, 24/05/23, 19/06/23, 15/08/23, 13/09/23	6 No. 20/04/23, 12/05/23, 24/05/23, 19/06/23, 15/08/23, 13/09/23	12/05/23: 4.02 20/07/23: 6.40 16/09/23: 5.80
2L6005SA	No	1.00 – 6.00 (London Clay Formation)	7 No. 20/04/23, 11/05/23, 25/05/23, 19/06/23, 18/07/23, 15/08/23, 13/09/23	7 No. 20/04/23, 12/05/23, 24/05/23, 19/06/23 18/07/23, 15/08/23, 13/09/23	11/05/23: 3.34 18/07/23: 6.70 16/09/23: 5.00
2L6007DR	No	7.70 – 8.00 (London Clay Formation)	10 No. 26/04/23, 24/05/23, 20/06/23, 20/07/23, 17/08/23, 13/09/23,	Gas Monitoring not undertaken – only groundwater monitoring required.	17/08/2023: 5.02

BH ID	Dual Installation	Response Zones (m bgl)	Groundwater monitoring visits	Gas Monitoring	Groundwater Sample (m bgl)
			11/10/23, 14/11/23, 9/02/24, 7/04/24		
2L6008DR	Yes	1.00 – 2.50 (Alluvium into Head Deposits) 8.50 – 9.00 (London Clay Formation)	12 No. Deep: 24/05/23, 20/06/23, 20/07/23, 16/08/23, 17/08/23, 13/09/23, 11/10/23, 14/11/23, 12/12/23, 9/02/24, 7/03/24, 4/04/24 13 No. Shallow: 18/04/2023, 10/05/23, 24/05/23, 20/06/23, 20/07/23, 16/08/23, 13/09/23, 11/10/23, 14/11/23, 9/01/24, 9/02/24, 7/03/24, 4/04/24	12 No. Shallow: 10/05/23, 24/05/23, 20/06/23, 20/07/23, 16/08/23, 13/09/23, 11/10/23, 14/11/23, 9/01/24, 9/02/24, 7/03/24, 4/04/24 2 No. Deep: 20/06/23, 12/12/23	Shallow: 10/05/23: 1.64 19/09/23: 2.20 Deep: 16/08/23 5.07 09/01/24: 6.31
2L6009DR	Yes	1.00 – 4.00 (Alluvium into London Clay Formation) 8.70 – 9.00 (London Clay Formation)	14 No. Shallow: 18/04/23, 10/05/23, 24/05/23, 19/06/23, 20/07/23, 16/08/23, 14/09/23, 11/10/23, 14/11/23, 12/12/23, 9/01/24, 9/02/24, 7/03/24, 4/04/24 15 No. Deep: 18/04/23, 20/06/23, 20/07/23, 16/08/23, 14/09/23, 11/10/23, 14/11/23, 12/12/23, 9/01/24, 9/02/24, 7/03/24, 4/04/24	14 No. Shallow: 18/04/23, 10/05/23, 24/05/23, 19/06/23, 20/07/23, 16/08/23, 14/09/23, 11/10/23, 14/11/23, 12/12/23, 9/01/24, 9/02/24, 7/03/24, 2/04/24	Shallow: 10/05/23: 2.52 19/09/23: 3.50 4/04/24: 3.30 Deep: 17/08/23: 5.41 14/09/23: 3.50 9/01/24: 4.17
2L6010DR	No	1.00 – 6.00 (River Terrace Deposits into London Clay)	14 No. 20/04/23, 10/05/23, 24/05/23, 20/06/23, 20/07/23, 16/08/23, 14/09/23, 11/10/23, 14/11/23, 12/12/23, 9/01/24, 9/02/24, 7/03/24, 4/04/24	14 No. 18/04/23, 10/05/23, 24/05/23, 20/06/23, 20/07/23, 16/08/23, 14/09/23, 10/10/23, 14/11/23, 12/12/23, 9/01/24, 9/02/24, 7/03/24, 4/04/24	10/05/23: 3.89 20/07/23: 3.44 14/09/23: 4.00 04/04/24: 3.33
2L6011SR	Yes	1.00 – 5.00	14 No.	2 No.	Shallow: 04/05/23: 4.86

BH ID	Dual Installation	Response Zones (m bgl)	Groundwater monitoring visits	Gas Monitoring	Groundwater Sample (m bgl)
		(River Terrace deposits into London Clay Formation) 9.50 – 11.00 (London Clay Formation)	Shallow: 26/04/23, 03/05/23, 04/05/23, 25/05/23, 20/06/23, 19/07/23, 16/08/23, 14/09/23, 12/10/23, 14/11/23, 12/12/23, 11/01/24, 9/02/24, 7/03/24 10 No. Deep: 26/04/23, 25/05/23, 20/06/23, 19/07/23, 16/08/23, 14/09/23, 12/10/23, 14/11/23, 12/12/23, 7/03/24	Shallow: 26/04/23, 4/05/23 8 No. Deep: 26/04/23, 25/05/23, 20/06/23, 19/07/23, 16/08/23, 14/09/23, 12/10/23, 14/11/23, 12/12/23, 11/01/24, 9/02/24, 7/03/24	11/01/24: 4.68 Deep: 14/09/23: 5.00
2L6012SR	No	1.00 – 8.00 River terrace Deposits into London Clay Formation)	8 No. 03/05/23, 25/05/23, 20/06/23, 18/07/23, 16/08/23, 14/09/23, 10/10/23, 7/03/24	7 No. 21/04/23, 25/05/23, 20/06/23, 18/07/23, 16/08/23, 14/09/23, 10/10/23, 7/03/24	03/05/23: 0.60 18/07/23: 5.00 19/01/24: 4.00
3L6106DS	No	1.00 – 6.00	5 No. 16/05/24, 29/05/24, 19/06/24, 03/07/24, 16/07/24	6 No. 16/05/24, 29/05/24, 19/06/24, 03/07/24, 16/07/24, 29/07/24	29/05/24 – 0.60 3/07/24 – 0.72 16/07/24 – 0.77

3.4 Geo-Environmental Testing

Geo-environmental laboratory testing was scheduled, by SSP, on selected soil and groundwater samples recovered during the ground investigation works. The testing was carried out by SOCOTEC at their UKAS accredited environmental chemistry laboratory at Bretby, near Burton-on-Trent, in accordance with MCERTS accreditation (where applicable) test methods as stated within the laboratory test reports. In addition, sampling from 2L6005SA (0.05 m bgl – 1.00 m bgl) was sub-contracted out to The Testing Lab (TTL) PLC, and sampling from 2L6011SR (0.1 m bgl and 0.5 m bgl) were sub-contracted out to IOM laboratory for asbestos testing only.

The scope of testing is outlined in **Appendix D** and shows that several requested chemical analyses were not included in either AGS format or Final Factual GI report (SOCOTEC, 2023) (SOCOTEC, 2024). This data is still outstanding at the time of report production and, if received, it is recommended that this report is updated. Any data provided after issue of this report should be provided to the Contractor for them to complete further assessment.

3.5 Geotechnical Testing

Geotechnical testing was scheduled by SSP on selected soil samples recovered during the GI works. The testing was carried out by nominated UKAS-accredited geotechnical laboratories including: GEOLABS, near Watford, The Testing Lab (TTL) near Doncaster, and Derwentside Environmental Testing Services Ltd (DETS) near Durham. Depending on the samples available, the testing comprised a combination of moisture content,

Atterberg limits, density (linear), particle size distribution, saturation moisture content (chalk), unconfined compressive strength, point load index testing, unconsolidated undrained triaxial, compaction, chalk crushing value, chalk carbonate content, BRE testing, organic matter content and loss on ignition, as required. The tests completed are presented in the SOCOTEC final factual report (SOCOTEC, 2023) (SOCOTEC, 2024).

4 Ground Model

4.1 Geological Setting

Section L is underlain by Alluvium and Head Deposits surrounding the trenchless crossings, Bow Lake and small watercourses south of Fishers Pond, with River Terrace Deposits southwest of Brambridge near Lord's Wood. Mapped superficial deposits are summarised in **Table 4.1.**

Table 4.1: Summary of mapped superficial deposits at ground level

Chainages	Geology	Typical Description
29925 - 32400	No present	-
32400 - 32555	Alluvium	Clay, silt and sand, locally organic; with gravel
32555 - 32800	Not present	-
32800 – 32865	Alluvium	Clay, silt and sand, locally organic; with gravel
32865 - 33485	Not present	-
33485 - 34030	Alluvium	Clay, silt and sand, locally organic; with gravel
34030 - 35325	Not present	-
35325 - 35900	River Terrace Deposits	Undifferentiated sand and gravel

The chainages have been provided by the Applicant as of 12 March 2024 as part of the Summer 2024 Design Consultation Route.

Across Section L, London Clay Formation is the main underlying bedrock strata and is outcropping at surface. It thickens to the south. Geological mapping to the north of Section L suggests that Lambeth Group strata is encountered (described in the desk study as Reading Formation). Though not shown as a separate stratum on geological maps of this area, there may also be a thin layer of Harwich Formation (approximately 0.3 – 2.8 m thick) underlying London Clay Formation (above Reading Formation). Mapped bedrock is summarised in **Table 4.2.**

Table 4.2: Summary of mapped bedrock

Chainages	Geology	Typical Description
29925 - 35900	London Clay Formation	Grey and brown silty and sandy clays with sandy and pebbly beds

The chainages have been provided by the Applicant as of 12 March 2024 as part of the Summer 2024 Design Consultation Route.

These strata will be expanded upon within **Table 4.3, 4.4, 4.5** and **4.6** summarising the ground conditions encountered in Section L and also further shown within the factual report produced by SOCOTEC (SOCOTEC, 2023) (SOCOTEC, 2024).

4.2 Section L Ground Investigation Results

4.2.1 Encountered Ground

A brief summary of the ground conditions encountered during the ground investigation is provided in **Table 4.1 to 4.6**. Exploratory hole logs are presented in SOCOTEC's Ground Investigation Report (SOCOTEC, 2023) (SOCOTEC, 2024) to provide more details. The encountered ground corresponds with the Proposed Development desk study, in parts, as both London Clay Formation, possible Harwich Formation (described as red flint gravel in the desk study), and the Reading Formation (part of Lambeth Group described in the desk study) are present.

Table 4.3: Summary of Encountered Ground Conditions for Section L Exploratory Holes

Exploratory Hole ID		3L6013HP	3L6015HP	3L6017HP	3L6023HP	3L6024HP-B[1]	3L6026HP	3L6027HP	3L6028HP	3L6029HP	3L6044HP
Ground Level (m OD)		+45.90	+40.99	+44.13	+39.53	+36.96	+30.64	+30.29	+35.43	+48.78	+28.98
Chainage		30043	30315	30700	31690	31935	32500	32720	32935	33200	35005
Strata	Typical Description	Depth range (m bgl)									
Topsoil	Soft brown sandy gravelly CLAY / SILT with rootlets. Sand is medium.	0.0 - 0.15	0.0 – 0.35	0.0 – 0.30	0.0 – 0.30	0.0 – 0.10	0.0 – 0.35	-	0.0 – 0.25	0.0 – 0.10	0.0 – 0.14
Made Ground	Soft brown sandy gravelly CLAY with roots. Sand is fine. Gravel is subangular to subrounded fine brick and chert.	-	-	-	-	-	-	0.0 – 0.32	-	-	-
London Clay Formation	Soft locally very soft sandy gravelly silty CLAY. Sand is fine. Gravel is subangular to subrounded fine to coarse chert..	-	0.35 – 1.20	0.30 – 0.60	0.30 – 1.20	0.10 – 0.40	-	0.32 – 1.20	0.25 – 1.20	0.10 – 1.20	0.14 – 0.90
	Firm to stiff greyish brown mottled orange silty sandy CLAY. Sand is medium. Occasional fissures.	0.15 – 1.20	-	0.60 – 1.20	-	0.40 – 1.20	0.35 – 1.20	-	-	-	0.90 – 1.20
End of Hole (m bgl)		**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**

[1]3L6024HP and 3L6024HP-A terminated due to ingress of water at 0.20m.

Table 4.4: Summary of Encountered Ground Conditions for Section L Exploratory Holes

Exploratory Hole ID		3L6045HP	3L6046HP	3L6100HP	3L6101DS	3L6102HP	3L6103HP	3L6104HP	3L6105HP	3L6106DS	3L6107DS
Ground Level (m OD)		+32.58	+37.41	+56.94	+41.06	+43.62	+43.19	+43.32	+41.06	+36.87	+36.00
Chainage		35340	35420	30145	30415	30620	30950	31210	31465	32190	32265
Strata	Typical Description	Depth range (m bgl)									
Topsoil	Very soft to soft brownish grey sandy gravelly CLAY/SILT with rootlets.	-	-	0.0 – 0.40	0.0 – 0.29	0.0 - 0.30	0.0 – 0.30	0.0 – 0.25	0.0 – 0.30	-	-
Made Ground	Brown gravelly clayey SAND. Sand is fine to medium. Gravel is subangular to subrounded fine to coarse of chert and brick.	0.0 – 0.40	0.0 – 0.43	-	-	-	-	-	-	-	-
	Soft brown sandy gravelly CLAY wit rootlets. Sand is fine to medium. Gravel is subangular to rounded fine chert and brick.	-	-	-	-	-	-	-	-	0.0 – 0.35	0.0 – 0.30
River Terrace Deposits	Soft orangish brown sandy CLAY. Sand is fine.	-	0.43 – 0.95	-	-						-
	Yellowish brown sandy clayey GRAVEL. Sand is fine. Gravel is subangular to subrounded fine to coarse chert.	-	0.95 – 1.20	-	-	-	-	-	-	-	-
London Clay Formation	Soft brown mottled orange sandy gravelly SILT. Gravel is subangular to subrounded fine to medium chert.	-	-	-	-	-	0.30 – 0.80	0.25 – 0.90	-	-	-
	Soft to firm orangish brown sandy gravelly CLAY. Sand is fine. Gravel is subangular to subrounded fine to coarse chert.	0.40 – 1.20		0.40 – 1.20	0.29 – 2.00	0.30 - 1.20	0.80 – 1.20	0.90 – 1.20	0.30 – 1.20	-	-
	Firm to stiff greyish brown mottled orange sandy CLAY. Sand is coarse. Occasional gypsum.	-	-	-	-	-	-	-	-	0.35 – 6.45	-
Lambeth Group	Stiff to very stiff locally firm red or grey locally bluish grey sandy CLAY. Sand is fine to coarse. Occasional shell fragments.	-	-	-	2.00 – 6.45	-	-	-	-	-	0.35 – 6.45
End of Hole (m bgl)		**1.20**	**1.20**	**1.20**	**6.45**	**1.20**	**1.20**	**1.20**	**1.20**	**6.45**	**6.45**

Table 4.5: Summary of Encountered Ground Conditions for Section L Exploratory Holes

Exploratory Hole ID		2L6000TP	2L6001TP	2L6002SA	2L6003SA	2L6004TP	2L6005SA	2L6006TP	2L6007DR	2L6008DR	2L6009DR	2L6010DR	2L6011SR	2L6012SR
Ground Level (m OD)		+44.65	+43.35	+42.75	+41.27	+37.58	+35.54	+30.34	+25.02	+25.02	+23.12	+23.58	+21.35	+20.66
Chainage		33280	33300	33310	33330	33360	33380	333420	33570	33650	33935	33985	35595	35655
Strata	Typical Description	Depth range (m bgl)												
Topsoil	Grass over dark brown slightly gravelly sandy clay	-	0.00 - 0.15	-	0.00 – 0.15	-	-	-	0.00 - 0.20	0.00 – 0.30		0.00 – 0.40	0.00 – 0.50	0.00 - 0.15
Made Ground **	Soft very gravelly slightly sandy CLAY. Gravel is of glass, burnt wood, brick, concrete, plastic, charcoal, chalk, chert. At 2L6002SA and 2L6005SA, possible asbestos containing materials were noted.	0.00 – 0.15	-	0.00 - 0.25	-	0.00-0.30	0.00 – 1.00	0.00 – 0.30	-	-	0.00 – 0.40	-	-	-
Alluvium	Soft mottled brown, grey, locally black with organic material slightly fine sandy gravelly CLAY. Gravel of chert. Locally with partings of silt. Locally with beds of Gravel.	-	-	-	-	-	-	-	0.20 – 2.00	0.30 – 1.80	0.40 – 2.55	0.40 – 3.90	-	-
River Terrace Deposits	Dense brownish black slightly sandy clayey GRAVEL / Soft to firm very gravelly CLAY with medium cobble content	-	-	-	-	-	-	-	-	-	-	-	0.50 – 2.20	0.15 – 2.40
Head deposits	Soft locally firm orangish brown sandy very gravelly CLAY.	-	-	-	-	0.30 – 1.80	1.00 – 2.40	0.30 – 1.40	-	1.80 – 2.75		-	-	-
London Clay Formation	Firm to stiff laminated locally fissured brownish grey locally sandy CLAY locally with shell fragments and silt/sand lenses. At 2L6011SR only, very stiff from 4.00 – 12.40 m bgl	0.15 – 4.00	0.15 – 4.00	0.25 – 15.00	0.15 – 15.00	1.80 – 4.00	2.40 – 10.00	1.40 – 4.00	2.00 – 17.85	2.75 – 15.80	2.55 – 20.00	3.90 – 17.80	2.20 – 12.40	2.40 – 15.35
London Clay Formation	Medium strong to strong dark brown CLAYSTONE	-	-	-	9.45 – 9.50	-	-	-	6.80 – 6.85 8.45 – 8.55	4.20 – 4.70 9.05 – 9.20	10.05 – 10.35 (Occasional claystone fragments also noted from 8.30 – 11.50)	7.45 – 7.70 15.60 – 15.70	4.80 – 4.86 5.14 – 5.30	-
Possible Harwich Formation	Stiff grey sandy CLAY with frequent pockets of green and black glauconitic locally micaceous sand / At 2L6012SR Medium dense to dense bluish grey slightly micaceous SAND.	-	-	-	-	-	-	-	-	15.80 – 18.65	-	-	12.40 – 14.40	15.35 – 15.60
Lambeth Group	Stiff to very stiff bluish grey mottled yellowish brown and multicoloured locally sandy CLAY. At 2L6011SR from 16.10 – 17.10 m and 2L6012SR from 16.15 – 16.60 m: Bluish grey and speckled black fine and medium SAND with occasional pockets of decomposed organic material (30 mm x 15 mm) and lignitic with increasing depth At 2L6011SR from 17.10 – 18.60 m, locally cemented medium spaced strong to very strong nodules/concretions typical of Lower Mottled Clay subdivision (60 mmx100 mm)	-	-	-	-	-	-	-	17.85 – 20.00	18.65 – 20.10	-	17.80 – 20.00*	14.40 – 20.00	15.60 – 20.00
End of Hole (m bgl)		**4.00**	**4.00**	**15.00**	**15.00**	**4.00**	**10.00**	**4.00**	**20.00**	**20.10**	**20.00**	**20.00**	**20.00**	**20.00**

**Lab testing recorded positive results for asbestos fragments including insulating board and chrysotile / amosite free fibres in soil sample D2 within borehole 2L6005SA from 0.05 m to 1.00 m bgl (+35.49 m OD to +34.49 m OD). The asbestos results for 2L6005SA were taken from two samples - a bulk bag (B4) at 0.05-0.3m giving the 1.2083% results and also a disturbed sample (D2) at 0.05-1.00m which gave the 0.501% asbestos insulating board (AIB) (comprising chrysotile and amosite) result. At 2L6002SA the borehole log noted possible asbestos containing material (ACM) and possible asbestos fragments between ground level (42.75 m OD) and 0.20 m bgl (42.55 m OD); samples were collected and sent for testing and there was no detectable asbestos yielded. This information is also discussed within sections 4.2.3, 5.1.1, 5.1.2, 6.2, 9.2, 10.2 and Appendix I1.0

Table 4.6: Summary of Encountered Ground Conditions for Section L Exploratory Holes (Phase 1 Ground Investigation)

Exploratory Hole ID		*BH501	TP501	TP502	TP503
Ground Level (m OD)		+20.94	+21.06	+21.04	+20.97
Chainage		35715	35720	35710	35715
Strata	Typical Description	Depth Range (m bgl)			
Topsoil	Grass over dark brown slightly gravelly sandy clay/silt	0.00 – 0.40	-	0.00 – 0.25	0.00 – 0.25
Made Ground	Grass over soft to firm sandy gravelly SILT with occasional gravel sized angular fragments of concrete and brick with abundant rootlets.	-	0.00 – 0.25	-	-
River Terrace Deposits	Medium dense sandy GRAVEL with occasional to abundant cobbles of flint / At TP502 (0.25 – 0.60m) and TP503 (0.25 – 0.45m), soft to firm gravely sandy CLAY with rootlets and occasional cobbles of flint.	0.4 – 3.50	0.25 – 1.50	0.25 – 1.60	0.25 – 1.40
London Clay Formation	Stiff to very stiff dark bluish grey and brown slightly sandy CLAY.	3.5 – 17.25	-	-	-
*Lambeth Group and White Chalk Subgroup	From 17.25 – 20.75m, Very stiff dark brownish grey sandy silty CLAY with rare lignite fragments (possible Lambeth Group) From 20.75 – 41.50m, Very stiff fissured multicoloured CLAY – Lambeth Group. From 41.50 – 42.05m, stiff multi-coloured sandy gravelly CLAY with rinded flint – Lambeth Group Upnor Formation – Mottled From 42.05 – 45.15m, weak low to medium density white CHALK.	17.25 – 45.15	-	-	-
End of Hole (m bgl)		**45.15**	**1.50**	**1.60**	**1.40**

***** BH501 completed in Phase 1 in Section L, is relevant to this GIR, it was sunk to 45.15 m deep, but only the top 33 m is considered relevant to the proposed route as this is the approximate base of the trenchless construction .For the trenchless crossing boreholes 2L6007DR, 2L6008DR, 2L6009DR, 2L6010DR, 2L6011SR and 2L6012SR, the top 20 m is considered relevant as the proposed trenchless construction is between 7.6 – 8.99 m bgl.

4.2.2 Groundwater Levels

Groundwater and ground gas monitoring took place in selected boreholes specified by SSP. Monitoring was carried out by SOCOTEC during and after the main fieldwork period. A summary of groundwater and ground gas monitoring, ground water installations groundwater strikes and groundwater spot monitoring data at monitoring well locations is provided in **Table 4.7.**

Table 4.7: Summary of Groundwater Strikes and Spot Monitoring Records

Exploratory Hole	Response zone (m bgl)	Strike During Drilling – Depth, m bgl and (Elevation, m OD)	Stratum Within Which Strike Was Recorded	Spot Monitoring – Depth, m bgl and (Elevation, m OD)	Data Logger – Minimum/ Maximum Depth, m bgl (m OD)
BH501	1.10 – 2.00	Dry	-	1.86 (19.08) - 2.00 (18.94)	Not installed
2L6002SA	1.00 – 5.00	Dry	-	0.56 (42.19) – 2.18 (40.57)	Not Installed
2L6003SA	1.00 – 7.00	Dry	-	1.00 (40.27) – 2.00 (39.27)	Not Installed
2L6005SA	1.00 – 6.00	Dry	-	0.65 (34.89) – 1.56 (33.98)	Not Installed
2L6006TP	None	Slow seepage at 2.4 (27.94)	London Clay Formation	Not Applicable	Not Installed
2L6007DR	7.70 – 8.00	Dry	-	0.00 (25.02)	Not Installed
2L6008DR	1.00 – 2.50 8.50 – 9.00	1.00 (24.02)	Alluvium	Shallow installation 0.18 (24.84) - 1.24 (23.78) Deep installation 0.00 (25.02) – 0.06 (24.96)	Not Installed
2L6009DR	1.0 – 4.00 8.70 – 9.00	0.60 (22.52) dropping to 0.64 (22.56)	Alluvium	Shallow installation 0.20 (22.92) - 0.91 (22.33) Deep installation 0.00 (23.12) – 0.34 (22.78)	Installed in 50mm pipe (shallow installation) depths ranged from 0.06 (20.46) to 2.67 (23.05)
2L6010DR	1.00 – 6.00	0.58 (23.00)	Alluvium	0.10 (23.48) – 0.94 (22.80)	Not Installed
2L6011SR	1.0 – 5.00 9.50 – 11.00	Dry	-	Shallow installation 0.00 (21.35) – 2.14 (19.21) Deep installation 0.00 (21.35) – 1.01 (20.34)	Installed in 50mm pipe (shallow installation depths ranged from 0.55 (20.8) to 3.77 (17.58)

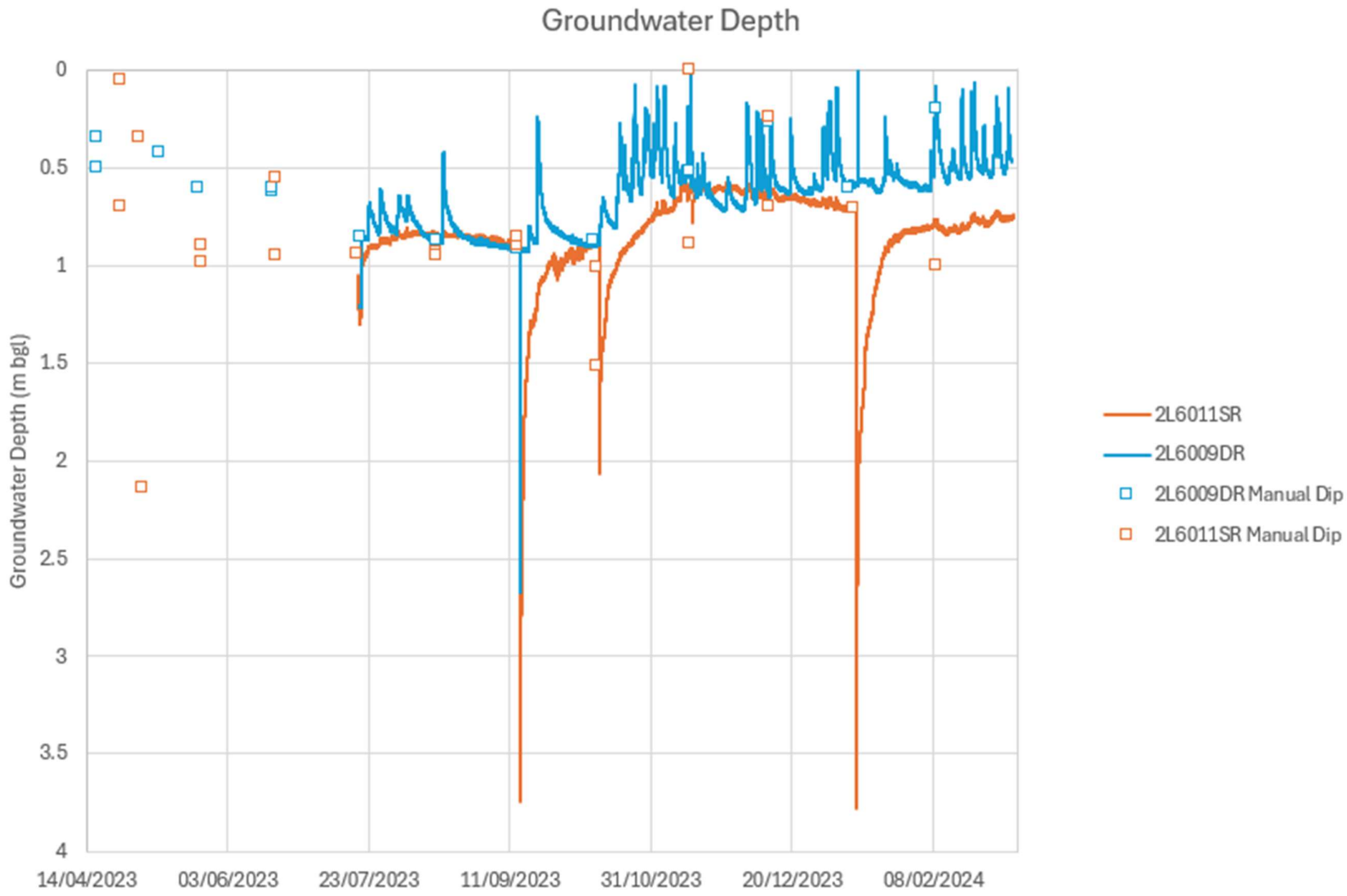
Exploratory Hole	Response zone (m bgl)	Strike During Drilling – Depth, m bgl and (Elevation, m OD)	Stratum Within Which Strike Was Recorded	Spot Monitoring – Depth, m bgl and (Elevation, m OD)	Data Logger – Minimum/ Maximum Depth, m bgl (m OD)
2L6012SR	1.00 – 8.00	1.20 (19.46) rising to 1.09 (19.57)	River Terrace Deposits	0.42 (20.24) – 1.03 (19.63)	Not Installed
BH501	1.10 – 2.00	Dry	-	1.86 (19.08) - 2.00 (18.94)	Not installed
3L6024HP 3L6024HP-A	None	0.20	Topsoil	Not Applicable	Not Installed
3L6100HP	None	0.60 1.20	London Clay Formation	Not Applicable	Not Installed
3L6103HP	None	1.10	London Clay Formation	Not Applicable	Not Installed
3L6106DS	1.00 – 6.00	Dry	-	0.24 – 0.86	Not Installed

Additionally, a Vibrating Wire Piezometer was installed at 32.0 m bgl (-11.06 m OD) in BH501 which was below the shallower installation listed in Table 4.7.

The ground conditions and groundwater results are mostly consistent with the anticipated ground conditions from the desk study and BGS boreholes.

Graph 4.1 shows the groundwater levels for 2L6009DR and 2L6011DR near Bow Lake monitored by downhole dataloggers originally placed 1m above the base of the slotted pipe. Please note that the large variation in borehole groundwater levels including 2L6009DR on 13th July and 11th September 2023 is a result of groundwater levels in the installation decreasing immediately after purging had taken place in order to get water samples for environmental testing. **Graph 4.1** is an extract received based on AGS data (SSP, 2023a) provided by SOCOTEC and includes information for other Section GI monitoring wells.

Graph 4.1 Datalogger Groundwater Levels for 2L6009DR and 2L6011SR.



4.2.3 Visual and/or Olfactory Contamination

No olfactory evidence of contamination was noted in the exploratory hole logs. **Table 4.8** details the potential ACM and quantified asbestos encountered within 2L6002SA and 2L6005SA respectively.

Table 4.8 Asbestos and Potential ACM Encountered

BH ID	Location	PSC No.	Visual / Olfactory Contamination
2L6002SA	448996, 120402	441 – Crowd Hill Landfill and 440 – BGS Artificial Ground	Possible ACM and possible asbestos fragments between ground level and 0.20 m bgl within Made Ground. Note: Soil samples collected did not yield any detectable asbestos (see Section 5.1.2 for further details).
2L6005SA	448973, 120473		Possible ACM within Made Ground between ground level and 0.70 m bgl with observations of plastic and cement sheeting (PACM). Note: A bulk bag (0.05 m bgl – 0.30 m bgl) and a disturbed sample (0.05 m bgl – 1.00 m bgl) yielded positive asbestos detections of 1.2083% and 0.501% respectively. The ACM material was identified as insulating board (chrysotile and amosite) (see Section 5.1.2 for further details).

Note - Exploratory Hole logs advanced to investigate PSC 441 (2L6000TP, 2L6001TP, 2L6004TP, 2L6006TP, 2L6002 & 003SA, 2L6005SA) yielded little to no evidence of landfill material. Made Ground was only present to a maximum depth of 0.70 m bgl. No obvious capping material was encountered.

4.2.4 Geo-Environmental Results

The results of the geo-environmental soil, soil leachate and groundwater chemical analysis are presented in the Factual GI report (SOCOTEC, 2023) (SOCOTEC, 2024).

5 Generic Quantitative Risk Assessment (GQRA)

This report section assesses the soil, soil leachate and groundwater concentrations collected at the selected Phase 2 and Phase 3B/3C GI locations within the Section L only.

Intrusive works were undertaken in Section L as part of the Phase 1 ground investigation for tunnel shaft design. Borehole BH501 was excavated to 45.15 m bgl and trial pits TP501, TP502, and TP503 were excavated up to 1.60 m bgl. Further information can be found in the Geo-environmental Interpretative Report for Phase 1 and 3A Ground Investigation (Shafts and Tunnels) (SSP, 2025) .

In accordance with the guidance given in 'Land Contamination Risk Management' (LCRM) (Environment Agency, 2023), the results of the geo-environmental laboratory testing undertaken on the samples of soil and groundwater recovered during the 2023 and 2024 SOCOTEC GI's have been compared to current published generic assessment criteria (GAC) to identify potential hazards to the plausible receptors.

5.1 Soil Chemical Results

5.1.1 Assessment of Potential Risk to Human Health Receptors

Across the Phase 2 and Phase 3B/3C GIs 81 No. samples were collected from exploratory hole locations across Section L. The soil samples included 16 No. samples of Made Ground, 11 No. samples of Topsoil, four samples of Head Deposits, three samples of River Terrace Deposits, three samples of Alluvium, 39 No. samples of London Clay and five samples of Lambeth Group. There were no exceedances of the human health GAC (commercial land use), within soil samples collected from the Phase 2 and Phase 3B/3C GIs.

Asbestos insulating board (comprising amosite and chrysotile) and free asbestos fibres (amosite and chrysotile) detected in a soil sample collected from 2L6005SA between 0.05 – 1.00 m as in Table 4.8 are included as notable soil concentrations in **Table 5.1**. No other asbestos was identified within samples collected from boreholes along Section L. Further details of the GAC used are provided in **Appendix G**.

5.1.2 Notable Soil Contaminant Concentrations

GAC are not available for all determinands analysed. A subjective list of chemical concentrations which appear to be elevated compared to other chemical results recorded during the GI are included in **Table 5.1**.

Table 5.1: Notable Soil Concentrations

Hole ID	Depth (m bgl)	Determinand	Concentration (mg/kg)	Notes
2L6002SA	0.10 – 0.20	Total PAH	249	Individual PAH concentrations are below corresponding GAC. Cumulative concentration is elevated compared to other locations.
2L6005SA	0.05 – 0.30	Asbestos	Amosite and Chrysotile insulating board and free fibres, 1.2083%	Statum described as: Made Ground to 0.7 m bgl. Grass over soft dark brown slightly sandy very gravelly clay, with occasional cobble and rootlets (<1mm). Sand is

Hole ID	Depth (m bgl)	Determinand	Concentration (mg/kg)	Notes
	0.05 – 1.00		Chrysotile and Amosite insulating board 0.501%	medium. Gravel is angular to subangular medium to coarse of glass, brick, concrete, burnt wood, plastic and cement sheeting (PACM) fragments. Cobble is angular concrete (100 x 90mm), metal (250 x 40mm) and brick (150 x 63mm). Second sample taken from a disturbed sample mixed with Glacial Head Deposits from 0.70 m bgl.
2L6000TP, 2L6001TP 2L6002SA, 2L6003SA, 2L6004TP, 2L6011SR, 3L6106DS and 3L107DS	0.10 – 6.00	Iron	23,400 - 47,600	Iron is noted at high concentrations within soil samples collected from a number of exploratory locations within the Phase 2 and 3B/3C GIs and within a relatively wide depth range. It is possible these concentrations are related to geology, though elevated concentrations are noted within samples collected from both Made Ground and natural deposits.

5.1.3 Soil Sample Deviations

A list of samples that did not wholly meet the laboratory Quality Management System (QMS) requirements is presented in **Appendix C**. These deviations were due to the acceptable (holding) time between the sampling date and laboratory analysis being exceeded.

Holding times are derived based on ‘stability’; the ability of a property to remain unchanged, within a stated uncertainty, under given storage conditions and a specific timeframe. If a reported result is within the holding time it is known that the degree of change (if it occurs) is not statistically meaningful. If the sample result is reported as ‘deviating’, the degree of change is unknown and, therefore, may have affected the result. The result must then be treated as potentially indicative.

5.2 Soil Leachate and Groundwater Results

5.2.1 Comparison of Soil Leachate Results Against GAC

From sampling obtained during the Phase 2 GI, 15 No. soil leachate (2:1 ratio) sample analyses were requested, however, only two results have been reported to date, both from 2L6008DR (0.30 m bgl - Alluvium) and (6.5 m bgl - London Clay Formation). This borehole targets a trenchless crossing rather than a PSC.

The Phase 3B/3C GI collected an additional 5 No. of samples for leachate testing. The concentrations exceeding selected GAC protective of controlled waters for soil leachate samples from Phase 2 and Phase 3B/3C GI are shown in **Table 5.2**.

Soil leachate concentrations have been compared to the Drinking Water Inspectorate Drinking Water Standard (DWS) guidance (Drinking Water Inspectorate, 2024) and the withdrawn Water Supply (Water Quality)

Regulations 1989 (WQS) for petroleum hydrocarbons (Legislation.gov.uk, 2024). Concentrations of Total Ammonia as nitrogen have been compared to the Water Framework Directive (WFD) criteria (Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015). Screening against the Environmental Quality Standard (EQS) was also undertaken due to surface water receptors within 250 m of GI locations. Details on the selection of water GAC is provided in **Appendix G.**

Table 5.2: Soil Leachate Sample Exceedances of GAC

Hole ID	Depth (m bgl)	Ground Conditions	Determinand	Concentration (µg/l)	GC (µg/l)
2L6008DR	0.3	Topsoil	Copper	**2**	1 (EQS)
	6.5	London Clay	TPH (C_6 – C_{40})	**110**	10 (WQS)
			Total Ammonia (N)	**897.6**	200 - 600 (WFD)
			Total Ammonia (N)	**1,057**	
3L6101DS	2.85	Lambeth Group, Clay	Selenium	**18**	10 (DWS)
3L6106DS	0.20	Made Ground	Copper	**3**	1 (EQS)
			Iron	**580**	200 (DWS)
			TPH aromatic (C_6 – C_{40})	**20**	10 (WQS)
3L6107DS	0.15	Made Ground	Copper	**2**	1 (EQS)
			Iron	**910**	200 (DWS)
			TPH aromatic (C_6 – C_{40})	**30**	10 (WQS)

Potential contaminants for which the method detection limit (MDL) exceeds the corresponding GAC are present in **Appendix C**. It is noted that testing with an MDL lower than the environmental quality standards for the PAHs listed in the table below is, typically, not offered by standard commercial laboratories. For all determinands analysed, but not listed in the **Appendix C**, the MDLs were below the relevant GAC.

5.2.2 Comparisons of Groundwater Results Against GAC

Groundwater concentrations have been compared to the same GAC as soil leachate concentrations (Section 5.2.1). For the 23 groundwater samples, exceedances above the selected withdrawn water quality standards (WQS) for TPH are shown in **Table 5.3**, exceedances of GAC (DWS) are shown in **Table 5.4** and exceedances of selected GAC (EQS) are shown in **Table 5.5.**

Analytes with a laboratory MDL greater than the EQS used for the assessment are shown in **Appendix C**. While the laboratory did not detect these determinands in the sample, they may be present at a concentration above the GAC; however, in the absence of detected concentrations, these are not considered true exceedances.

Table 5.3: Groundwater TPH Exceedance of the Withdrawn Water Supply (Water Quality) Regulations 1989 GAC

BH ID, stratum targeted and response zone [1]	Sampling Date (Shallow/Deep for dual installs)	Determinand	Concentration (µg/l) exceeds the GAC (10 µg/l *)
2L6002SA (1.00 – 5.00 London Clay Formation)	12/05/2023	TPH aliphatic	**1,180**
		TPH aromatic	**70**
		TPH aliphatic and aromatic	**1,250**
	20/07/2023	TPH aliphatic	**1,360**
		TPH aromatic	**80**
		TPH aliphatic and aromatic	**1,440**
	16/09/2023	TPH aliphatic	**750**
		TPH aromatic	**490**
		TPH aliphatic and aromatic	**1,240**
2L6003SA (1.00 – 7.00 London Clay Formation)	12/05/2023	TPH aliphatic	**936**
		TPH aromatic	**100**
		TPH aliphatic and aromatic	**1,036**
	20/07/2023	TPH aliphatic	**770**
		TPH aromatic	**430**
		TPH aliphatic and aromatic	**1,200**
	16/09/2023	TPH aliphatic	**340**
		TPH aromatic	**80**
		TPH aliphatic and aromatic	**420**
2L6005SA (1.00 – 6.00 London Clay Formation)	11/05/2023	TPH aliphatic	**362**
		TPH aromatic	**70**
		TPH aliphatic and aromatic	**432**
	18/07/2023	TPH aliphatic	**750**
		TPH aromatic	**480**
		TPH aliphatic and aromatic	**1,230**
	16/09/2023	TPH aliphatic	**340**
		TPH aromatic	**70**
		TPH aliphatic and aromatic	**1,210**
2L6008DR	10/05/2023 (Shallow)	TPH (C_6 – C_{40})	**3,333**

BH ID, stratum targeted and response zone [1]	Sampling Date (Shallow/Deep for dual installs)	Determinand	Concentration (µg/l) exceeds the GAC (10 µg/l *)
(1.00 – 2.50 Alluvium into Head Deposits)	16/08/2023 (Deep)		**110**
	09/01/2024 (Deep)		**150**
2L6009DR (1.00 – 4.00 Alluvium into London Clay Formation)	10/05/2023 (Shallow)		**240**
	04/04/2024 (Shallow)		**130**
2L6010DR (1.00 – 6.00 Alluvium into London Clay Formation)	10/05/2023		**2,630**
	09/01/2024		**1,420**
	04/04/2024		**110**
2L6011SR (1.00 – 11.00 River Terrace Deposits into London Clay Formation)	11/01/2024		**240**
2L6012SR (1.00 – 8.00 River Terrace Deposits into London Clay Formation)	03/05/2023		**570**
3L6106DS (1.00 – 6.00 London Clay Formation)	29/05/2024	TPH aliphatic (C_8-C_{40})	**300**
		TPH aromatic (C_8-C_{40})	**350**
	03/07/2024	TPH aliphatic (C_8-C_{40})	**240**
		TPH aromatic (C_8-C_{40})	**140**
		TPH aliphatic (C_{21}-C_{35})	**200**

[1] m bgl

*Silica Gel clean up not reported on any of the Phase 2 samples. Testing for all samples above were for C_{10} – C_{40} range.

**High MDL recorded due to the following: "*The information in Labware suggests the sample was extracted on a x100 dilution for TPH and PAH which has resulted in the raised detection limit. There is also a comment in Labware that says 'emulsion', this means the sample was suitably 'murky' that on addition of solvent the technician would be unable to see the separation between sample and solvent and an extraction would not be successful. When emulsions occur, a dilution is made to minimise the matrix affect enabling extraction of the sample to take place.*"

Table 5.4: Groundwater Exceedances of the DWS

BH ID, stratum targeted and response zone [1]	Sampling Date	Determinand	Concentration (µg/l)	GAC - DWS (µg/l)
2L6002SA (1.00 – 5.00 London Clay Formation)	12/05/2023	Chloride	**525,000**	250,000
		Sulphate	**287,000**	
	20/07/2023	Chloride	**256,000**	
		Manganese	**80**	50
2L6003SA (1.00 – 7.00 London Clay Formation)	12/05/2023	Chloride	**393,000**	250,000
		Manganese	**70**	50
		Sulphate	**252,000**	250,000
	20/07/2023	Chloride	**268,000**	250,000
		Manganese	**100**	50
2L6005SA (1.00 – 6.00 London Clay Formation)	11/05/2023	Chloride	**676,000**	250,000
		Selenium	**11**	10
		Sulphate	**2,020,000**	250,000
	18/07/2023	Manganese	**90**	50
		Sulphate	**1,140,000**	250,000
	16/09/2023	Chloride	**1,890,000**	
		Lead	**24**	10
		Manganese	**260**	50
		Sulphate	**321,000**	250,000
2L6007DR (7.70 – 8.00 London Clay Formation)	17/08/2023	Ammonium (NH_4)	**1,899**	500
		Sulphate	**544,000**	250,000
2L6008DR (8.50 – 9.00 London Clay Formation)	16/08/2023 (Deep)	Ammonium (NH_4)	**1,270**	500
		Chloride	**531,000**	250,000
		Nitrite (NO_2)	**720**	500
		Sodium	**297,000**	200,000
	09/01/2024	Chloride	**250,000***	250,000
2L6009DR (8.70 – 9.00 London Clay Formation) (1.00 – 4.00 Alluvium)	16/08/2023 (Deep)	Ammonium (NH_4)	**2,025**	500
		Boron	**1,050**	1,000
		Sulphate	**525,000**	250,000
	14/09/2023 (Shallow)	Ammonium (NH_4)	**766**	500
		Sulphate	**508,000**	250,000
	09/01/2024 (Deep)	Boron	**1,020**	1,000
		Ammonium (NH_4)	**1,927.1**	500
		Sulphate	**479,000**	250,000
	04/04/2024 (Deep)	Boron	**1,050**	1,000
		Ammonium (NH_4)	**1,672.9**	500

BH ID, stratum targeted and response zone [1]	Sampling Date	Determinand	Concentration (µg/l)	GAC - DWS (µg/l)
		Sulphate	**492,000**	250,000
2L6010DR (1.00 – 6.00 Alluvium into London Clay Formation)	10/05/2023	Chloride	**351,000**	250,000
		Sodium	**219,000**	200,000
		Sulphate	**264,000**	250,000
	20/07/2023	Ammonium (NH_4)	**767**	500
		Sulphate	**286,000**	250,000
	14/09/2023	Ammonium (NH_4)	**641**	500
		Sulphate	**281,000**	250,000
2L6011SR 1.00 – 5.00 River Terrace Deposits into London Clay Formation) (9.50 – 11.00 London Clay Formation)	04/05/2023 (Shallow)	Chloride	**300,000**	
		Sodium	**360,000**	200,000
		Sulphate	**1,080,000**	250,000
	14/09/2023 (Deep)	Ammonium (NH_4)	**641**	500
		Sodium	**379,000**	200,000
		Sulphate	**1,370,000**	250,000
	09/01/2024	Ammonium (NH_4)	**515.8**	500
		Sodium	**379,000**	200,000
		Sulphate	**1,550,000**	250,000
		Indeno(1,2,3-cd)pyrene	**0.61**	0.1
2L6012SR (1.00 – 8.00 River Terrace Deposits into London Clay Formation)	03/05/2023	Sodium	**225,000**	200,000
		Sulphate	**735,000**	250,000
	19/01/2024	Ammonium (NH_4)	**515.8**	500
		Sulphate	**417,000**	250,000
3L6106DS (1.00 – 6.00 London Clay Formation)	29/05/2024	Manganese	**280**	50
		Sulphate	**1,040,000**	250,000
	03/07/2024	Sulphate	**273,000**	250,000
	16/07/2024	Manganese	**230**	50
		Sulphate	**1,220,000**	250,000

[1] m bgl
*Exceedance equal to the DWS GAC.

Table 5.5: Groundwater Exceedances of the EQS

BH ID, stratum targeted and response zone[1]	Sample Date	Determinand	Concentration (µg/l)	GAC (µg/l)
2L6002SA	18/07/2023	Zinc	**16**	10.9

BH ID, stratum targeted and response zone[1]	Sample Date	Determinand	Concentration (µg/l)	GAC (µg/l)
(1.00 – 5.00 London Clay Formation)		Fluoranthene	**0.08**	0.0063
2L6005SA (1.00 – 6.00 London Clay Formation)	11/05/2023	Copper	**3**	1
		Zinc	**12**	10.9
		Total Ammonia (N)	**247.1**	200-600*
	18/07/2023	Cadmium	**0.11**	0.08
		Copper	**2**	1
		Zinc	**12**	10.9
	13/09/2023	Cadmium	**0.27**	0.08
		Copper	**19**	1
		Lead	**24**	1.2
		Manganese	**260**	10
		Nickel	**7**	4
		Zinc	**82**	10.9
2L6007DR (7.70 – 8.00 London Clay Formation)	17/08/2023	Total Ammonia (N)	**1,498**	200 – 600*
2L6008DR (1.00 – 2.50 Alluvium into Head Deposits) (8.50 – 9.00 London Clay Formation)	10/05/2023 (Shallow)	Zinc	**26**	10.9
	17/08/2023 (Deep)	Total Ammonia (N)	**296.5**	200 – 600*
		Copper	**2**	1
		Lead	**8**	1.2
		Nickel	**9**	4
		Zinc	**17**	10.9
	14/09/2023 (Deep)	Nickel	**7**	4
		Total Ammonia (N)	**996.5**	200-600*
	09/01/2024 (Deep)	Lead	**7**	1.2
		Fluoranthene	**0.02**	0.0063
		Total Ammonia (N)	**296.5**	200-600*
		Zinc	**77**	10.9
2L6009DR (1.00 – 4.00 Alluvium deposits into London Clay Formation) (8.70 – 9.00 London Clay Formation)	10/05/2023 (Shallow)	Copper	**2**	1
	17/08/2023 (Deep)	Total Ammonia (N)	**2,025**	200 – 600*
		Lead	**10**	1.2
	14/09/2023 (Shallow)	Total Ammonia (N)	**1,597**	200-600*

BH ID, stratum targeted and response zone[1]	Sample Date	Determinand	Concentration (µg/l)	GAC (µg/l)
	09/01/2024	Chromium VI	**5**	3.4
		Lead	**6**	1.2
		Total Ammonia (N)	**1,498.8**	200-600*
		Zinc	**36**	10.9
	04/04/2024	Total Ammonia (N)	**1,301.2**	200-600*
		Zinc	**20**	10.9
2L6010DR (1.00 – 6.00 Alluvium into London Clay Formation)	10/05/2023	Total Ammonia (N)	**296.5**	200-600*
	20/07/2023		**601.2**	
	14/09/2023		**502.4**	
2L6011SR (1.00 – 5.00 River Terrace Deposits into London Clay Formation)	04/05/2023 (Shallow)	Total Ammonia (N)	**296.5**	200-600*
	14/09/2023 (Deep)		**502.4**	
(9.50 – 11.00 London Clay Formation)	11/01/2024	Nickel	**6**	4
		Total Ammonia (N)	**403.5**	200-600*
2L6012SR (1.00 – 8.00 River Terrace Deposits into London Clay Formation)	18/07/2023	Zinc	**11**	10.9
	19/01/2024	Total Ammonia (N)	**403.5**	200-600*
3L6106DS (1.00 – 6.00 London Clay Formation)	29/05/2024	Manganese	**280**	123
	16/07/2024	Zinc	**19**	10.9
		Cadmium	**0.13**	0.08
		Manganese	**230**	123
		Zinc	**12**	10.9

[1] m bgl
*Based on the Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 for good to high river quality.

It should be noted that selected soil leachate and groundwater samples were subjected to PFAS analysis. No samples were found to have individual per and poly-fluoralkyl (PFAS) concentrations above the Tier 3 threshold of 0.1 µg/l (the Drinking Water inspectorate [DWI] expects water companies to put emergency contingency measures in place to reduce concentrations to below 0.1µg/l (DWI, 2024). The groundwater sample from 3L6106DS at 5.70m (16/07/2024) was found to have concentrations of perfluorooctane sulfonic acid (PFOS) above the MDL at 0.085 µg/l, but below the action threshold.

Groundwater sample deviations and potential contaminants for which the laboratory Method Detection Limit (MDL) exceeded the corresponding GAC are presented in **Appendix C**. It is noted that testing with an MDL lower than the GAC for the PAHs listed is typically not offered by standard commercial laboratories. For all determinands analysed, but not listed in **Appendix C**, the MDLs were below the relevant GAC.
Further details on the selection of water GAC protective of aquatic ecosystems (controlled waters) are provided in **Appendix G**.

Where soil leachate and groundwater laboratory analysis include analytes where there is no corresponding GAC (e.g. selected VOCs, SVOCs, herbicides and pesticides) the data is only reported factually by SOCOTEC.

5.3 Tentatively Identified Compounds (TICs)

The following exploratory locations had soil, leachate and groundwater sampling tested for TICs: Section L - 3L6106DS and 3L6107DS. Low concentrations were detected, with the maximum recorded in soils at 30.3 mg/kg (diphenyl sulfone), leachates at 0.077 mg/l (pentane, 2,2,4-trimethyl-) and 0.022 mg/l (pentane, 2,2,3-trimethyl-) in groundwater samples.

A full tabulated list of TICs found is presented in Appendix D.

5.4 Excavated Materials (Waste) Management

5.4.1 Hazardous Properties

Soil analytical results for the 81 No. soil samples described above have been screened for hazardous properties as identified in Technical Guidance WM3 - Waste Classification - Guidance on the Classification and Assessment of Waste First Edition Version 1.2 (Environment Agency, 2021). Screening was carried out using HazWasteOnline™ (HazWasteOnline, 2023) (HazWasteOnline, 2024). The results are provided in **Appendix E** and are summarised in **Table 5.6.**

Table 5.6: Waste Classification – Hazardous Soils

BH ID	Sample Depth (m bgl)	Determinand	Concentration (mg//kg)	Hazardous Properties	Comments
2L6005SA	0.05 – 0.30	Amosite and Chrysotile insulating board and free fibres	**1.2083%**	HP7 Carcinogenic	The remainder of the soil matrix was not subject to a chemical analysis for other determinands. There are also no other soil samples from the Made Ground at this location that were subject to chemical testing.
	0.05 – 1.00 (mixed with natural soils from 0.7 m bgl)	Chrysotile and Amosite insulating board	**0.501%**		

Both samples identified as containing hazardous concentrations of asbestos were located within Crowd Hill Landfill and BGS Made Ground (PSCs 441 and 440).

All other soils samples analysed are classified as non-hazardous material.

5.3.2 Waste Acceptance Criteria (WAC)

WAC testing was completed in accordance with BSEN 12457/2 on 42 samples (7 of topsoil, 9 of Made Ground and 25 of natural soils) retrieved from Phase 2 and Phase 3B/3C Section L GI locations. Results have been screened against landfill WAC limit values for an Inert Landfill.

Of these, 16 samples did not meet the criteria for disposal to Inert Landfill due to concentrations exceeding WAC including those of fluoride, sulphate, PAHs, total dissolved solids (TDS) and total organic carbon (TOC). This material would be classed as non-hazardous for disposal. Further details are provided in **Table 5.7**.

Table 5.7: Inert Landfill Threshold Exceedances.

BH ID	Sample Depth (m bgl)	Stratum	Determinand	Sample Concentration (mg//kg) (w/w% for TOC)	Inert Landfill threshold concentration (mg/kg) (w/w% for TOC)
2L6000TP	0.1	Made Ground	TOC*	**3.09**	3
	3.10	London Clay	Fluoride	**13**	10
2L6001TP	1.00	London Clay		**18**	
	3.50	London Clay		**11**	
2L6002SA	0.1	Made Ground	TOC*	**3.35**	3
			PAHs	**253**	100
	0.50	London Clay	Fluoride	**16**	10
2L6003SA	1.00	London Clay		**17**	
2L6005SA	1.00**	Head Deposits		**11**	
	6.00**	London Clay	Sulphate (SO_4)	**7,320**	1,000
			TDS	**7,920**	4,000
2L6006TP	0.10	Made Ground	TOC*	**3.09**	3
	2.30	London Clay	Sulphate (SO_4)	**11,300**	1,000
			TDS	**11,200**	4,000
2L6009DR	0.10	Made Ground	TOC*	**3.06**	3
3L6014HP	0.50	London Clay	Fluoride	**21**	10
			Sulphate (SO_4)	**1,010**	1,000
	1.00		Fluoride	**17**	10
3L6106DS	3.50		Sulphate	**11,500**	1,000
			TDS	**10,800**	4,000
3L6107DS	1.6		Fluoride	**15**	10
	5.6		Selenium	**0.16**	0.1
			Sulphate	**1,320**	1,000

*May be accepted as inert waste as Dissolved Organic Carbon Concentration is below 500 mg/kg and the lowest pH is 6.9.
**It should be noted that these samples only relate to the WAC results at these depths in natural Head Deposits and London Clay – the sample at 0.05 m bgl should be treated as hazardous due to asbestos as outlined in the HazWasteOnline™ waste classification report in Appendix E.

It is important to note that specific inert landfills may have stricter and/or additional limits imposed for waste soil disposal, therefore the above assessment shall be treated as indicative only. Suitability of material for disposal must be discussed with the landfill operator in advance. It is likely that additional soil sampling with

chemical and WAC testing will be required beyond this preliminary GI to inform on suitable disposal routes. Topsoil is not normally accepted at landfill due to its high organic content.

5.5 Ground Gas Monitoring

Ground gas monitoring results are tabulated in the SOCOTEC GI Factual reports (SOCOTEC, 2023) (SOCOTEC, 2024). Nine boreholes drilled during the Phase 2 GI had monitoring carried out along Section L. 2L6002SA, 2L6003SA and 2L6005SA had six rounds of monitoring carried out between April 2023 and September 2023. Additional monitoring was carried out in 2L6008DR, 2L6009DR, 2L6010DR between September 2023 and April 2024, whilst 2L6011SR and 2L6012SR had additional monitoring between September 2023 and March 2024 totalling, within the aforementioned locations,12 or 13 rounds.

From exploratory hole locations advanced during the Phase 3B/3C GI only 3L6106DS had a well installed for monitoring. Six rounds of monitoring were carried out between May 2024 and July 2024.

The response zones in 2L6005SA and 2L6011SR were fully flooded on the 11th May 2023 and 26th April 2023 respectively. In addition, there was a pump flow failure in 2L6011SR on the 25th May 2023, 20th June 2023 and 19th July 2023, and in 2L60112SR on the 20th June 2023 and 18th July 2023, likely due to high groundwater levels. The aforementioned boreholes (which included monitoring to November 2023) recorded groundwater levels between ground level and 1.52 m bgl, furthermore 2L6012SR was noted to be flooded on the 14th November 2023.

In view of the flooded wells, the data from these monitoring rounds have been used as indicative as they may not be fully representative of the ground gas regime beneath the site due to "*The response zone of the gas monitoring standpipe should be wholly or partly above groundwater level to provide valid data... [and] gas standpipes with flooded response zones might exhibit measurements of elevated methane or carbon dioxide… due to dissolved gases or the presence of biodegradable material in the groundwater*" (BSI, 2015a).

Peak concentrations (minimum for oxygen) are presented in the summary **Table 5.8**. Although there are no permanent building structures proposed for these areas of the scheme, the ground gas data recorded in 2L6007DR, 2L6008DR, 2L6009DR, 2L6010DR, 2L6011SR and 2L6012SR should be considered at the preconstruction phase in terms of risks to groundworkers. In particular, temporary deep excavations are planned as reception pits for the trenchless crossings of Winchester Road, Bow Lake watercourse and unnamed tributary of the Itchen respectively.

5.5.1 Gas Thresholds

Peak concentrations recorded in monitoring wells have been compared to the following gas threshold concentrations:

- EH40/2005 (fourth edition 2020) Workplace Exposure Limits (WELs) (HSE, 2020)
- BSI (The British Standards Institution) Health and Safety in tunnelling in the construction industry-Code of Practice [BS 6164:2019] (BSI, 2019)

Exceedances of these thresholds are shown in **Table 5.9.**

Table 5.8: Ground Gas Monitoring Results Summary

Peak Gas Concentrations (minimum for Oxygen)								
Borehole	**Response Zone (m bgl) and Stratum**	**CH_4 %vol**	**CO_2 %vol**	**O_2 %vol**	**CO ppm**	**H_2S ppm**	**VOC ppmv**	**Max Gas Flow Rate (pk) l/hr**
2L6002SA	1.00 – 5.00 London Clay	<0.1	4.3	13.1	1.0	1.0	0.6	<0.11 and -1.3
2L6003SA	1.00 – 7.00 London Clay	<0.1	1.3	18.1	2.0	1.0	0.8	<0.1 and -0.1
2L6005SA	1.00 – 6.00 Head Deposits into London Clay	0.1	5.9	14.1	2.0	<1.0	1.3	<0.1 and -20.4
2L6008DR	1.00 – 2.50 Shallow – Alluvium into River Terrace	0.1	3.7	14.6	2.0	1.0	1.2	12.4 and -8.4
2L6009DR	1.00 – 4.00 Shallow – Head Deposits into London Clay	0.2	0.8	20.3	7.0	1.0	1.3	0.1 and -1.8
2L6010DR	1.00 – 6.00 River Terrace into London Clay	0.2	1.2	19.7	6.0	1.0	0.6	0.1 and -5.9
2L6011SR	1.00 – 5.00 Shallow – River Terrace into London Clay	0.5	5.1	0.1	42.0	1.0	2.1	8 and -12.3

Peak Gas Concentrations (minimum for Oxygen)								
Borehole	**Response Zone (m bgl) and Stratum**	**CH_4 %vol**	**CO_2 %vol**	**O_2 %vol**	**CO ppm**	**H_2S ppm**	**VOC ppmv**	**Max Gas Flow Rate (pk) l/hr**
2L6012SR	1.00 – 8.00 River Terrace into London Clay	<0.1	1.5	17.6	6.0	1.0	0.8	3.6 and -7.2
3L6106DS	1.00 – 6.00 London Clay Formation	1.3	0.8	19.8	0	<10	1	0

Notes: CH_4 - Methane, CO_2 – Carbon Dioxide, O_2 – Oxygen, CO – Carbon Monoxide, H_2S – Hydrogen Sulphide, VOC – Volatile Organic Compounds, ppmv - Part per Million Volume

Table 5.9: Gas Exceedances of Maximum Peak Recorded Concentrations

Area	Borehole	CH_4	CO_2	O_2	CO	H_2S	VOC
Location / substance threshold		4.4 % vol (LEL) to 17 % vol (UEL)	0.5 % vol (LTL) 1.5 % vol (STL)	<19% by volume	20 ppm (LTL) 100 ppm (STL)	5 ppm (LTL) 10 ppm (STL)	Approx. 10,000 ppmv[1] (LEL)[1]
Targeting Crowd Hill Historic Landfill and BGS Made Ground (PSCs 440 and 441)	2L6002SA	No	Yes	Yes	No	No	No
	2L6003SA	No	Yes	Yes	No	No	No
	2L6005SA	No	Yes	Yes	No	No	No
Trenchless Crossing – Winchester Road	2L6008DR	No	Yes	Yes	No	No	No
Trenchless Crossing – Bow Lake Watercourse	2L6009DR	No	Yes	N/A	No	No	No
	2L6010DR	No	Yes	N/A	No	No	No
Trenchless Crossing – Unnamed	2L6011SR	No	Yes	Yes	Yes – LTL	No	No

Area	Borehole	CH_4	CO_2	O_2	CO	H_2S	VOC
Tributary of the Itchen	**2L6012SR**	No	Yes	Yes	No	No	No
Targeting second location Crowd Hill Landfill (PSC 472)	**3L6106DS**	No	Yes - LTL	No	No	No	No

LEL – Lower explosive limit; UEL – Upper explosive limit; STL – Short Term Limit; LTL – Long Term Limit; [1] – dependant on constituents

6 Land Contamination Risk Assessment Model

6.1 Approach and Revised Conceptual Site Model

The land contamination risk assessment presented in this section is a revised risk assessment, that has been undertaken in accordance with the procedure outlined in LCRM (Environment Agency, 2023). This revised risk assessment uses information collated as part of the Phase 2 and Phase 3B/3C GI, and builds on the existing preliminary risk assessment completed as part of the desk study. The revised risk assessment will allow for recommendations to be made based on the identification and assessment of potential contaminant linkages. A summary of the guidance for the assessment of land contamination and the approach developed and adopted by SSP is presented in the Summary Report HWTWRP Geotechnical and Geo-environmental Interpretative Summary Report (Phase 2) (Ref. 710166-SWS-XX-XX-RP-GE-00100).

6.2 Potential Sources of Contamination

A summary of the on Site and off Site potential sources of contamination (PSCs) identified and associated potential contaminants of concern (PCOC) is presented in **Table A1 and A2 (Appendix A).**

6.2.1 Locations where PSCs were Identified

Crowd Hill Landfill Holder Reference EAHLD20508; Site Reference FEA22, EAST 5 (PSC 441) and BGS Made Ground (PSC 440).

The proposed Section L DoL crosses the assumed lateral extent of this Environment Agency recorded landfill and BGS Artificial Ground. As such, cable percussive boreholes (2L6002SA, 2L6003SA and 2L6005SA) and trial pits (2L6000TP, 2L6001TP, 2L6004TP and 2L6006TP) were advanced to determine the presence and nature of the landfill material. Observations from these sites are below.

- A limited thickness of Made Ground was encountered within locations (2L6002SA, 2L6005SA, 2L6001TP, 2L6004TP and 2L6006TP) possibly suggesting that the bulk of the material deposited within the landfill is not beneath the proposed pipeline route (since the expected thickness of Made Ground throughout much of the landfill would be greater, and because the Made Ground did not appear to contain any landfilled or capping materials (though without further investigation within this area this is difficult to establish).
- No concentrations exceeding the commercial GAC protective of human health were encountered within soil samples subject to chemical analysis; however, asbestos was detected in the Made Ground of 2L6005SA (which targeted the footprint of the BGS artificial ground) (from ground level to 0.70 m bgl). The asbestos material was identified in one sample as insulating board (amosite and chrysotile) and free fibres (amosite and chrysotile) at 1.2083% and detected in a second sample as insulating board (amosite and chrysotile) at 0.501%. Both asbestos concentrations exceed the hazardous properties' threshold of 0.1% for waste disposal. Any concentration of asbestos in soils poses a risk to human health. The borehole log descriptions for 2L6005SA also noted cement sheeting fragments (suspected ACM) within the Made Ground present between ground level and 0.70 m bgl.
- Notable soil concentrations of iron were encountered in samples tested from these locations at concentrations between 23,100 mg/kg and 41,200 mg/kg.
- Groundwater sampling and testing recorded concentrations in excess of GAC (EQS) protective of freshwaters for metals (copper, cadmium, lead, manganese, nickel and zinc), and one exceedance of fluoranthene within 2L6002SA. Total Ammonium as N concentrations has been compared to the standard for rivers in the Water Framework Directive (WFD) and shows several samples have exceeded the 200 – 600 µg/l threshold. Several determinand concentrations exceeded the GAC

(DWS) of chloride, manganese and sulphate. One sample collected from 2L6005SA also had one concentration exceeding the lead GAC and one exceeding the selenium GAC.

- Chloride and sulphate yielded particularly high concentrations from sampling taken from 2L6005SA; the most notable being concentrations of 2,020,000 µg/l for sulphate and 1,890,000 µg/l for chloride.
- Additionally, TPH concentrations detected in groundwater (total aromatic, total aliphatic and their combined total) from this area exceeded the withdrawn Water Supply (Water Quality) Regulations 1989 GAC of 10 µg/l. Concentrations of total TPH (C_{10} – C_{40}) were detected between 420 µg/l and 1,440 µg/l for samples collected from boreholes within this area in various stratum. These elevated concentrations could be attributed to the landfill as a potential source, though there are several other PSCs beyond the 50 m buffer, such as the industry along Portsmouth Road which could be a contributing to the quality of the groundwater locally. It should be noted that boreholes descriptions do not detail any visual or olfactory signs of the presence of TPH, and the laboratory results did not report on clean-up of the TPH samples, though this is to be confirmed with the labs.
- Ground gas monitoring carried out on installations within 2L6002SA, 2L6003SA and 2L6005SA yielded low concentrations of methane (max. 0.1 % v/v), hydrogen sulphide (max. 1 ppm), carbon monoxide (max. 2 ppm) and PID readings (max. 1.3 ppm), low oxygen levels of <19%, and generally low concentrations of carbon dioxide (max. 5.9% v/v) suggesting the landfill, if present beneath the Site, is not generating significant ground gas.

Landfill – Crowd Hill Landfill, Second Location, (PSC 472) 3L6106DS and 3L6107DS

The current Section L DoL crosses the assumed lateral extent of the second Crowd Hill Landfill location. As such 3L6106DS and 3L6107DS were advanced to determine the presence and nature of the landfill material.

- A limited thickness of Made Ground, 0.35 m, was encountered within both exploratory hole locations suggesting that the majority of the material deposited within the landfill is not necessarily beneath the DoL (expected thickness of Made Ground would be much greater)and because the Made Ground did not appear to contain any landfilled or capping materials (though without further investigation within this area this is difficult to establish)).
- Soil samples collected from these borehole locations did not yield any exceedances of the commercial GAC protective of human health.
- Leachate testing of Made Ground samples from the locations yielded two exceedances of copper (EQS), two exceedances of iron (DWS) and TPH Aromatics (C_6 – C_{40}) (withdrawn WQS) with concentrations between 20 µg/l and 30 µg/l.
- Groundwater sampling was only obtained from 3L6106DS due to 3L6207DS not having a well installed. Water from this location yielded TPH Aliphatic and Aromatic (C_8 – C_{40}) with concentrations between 140 µg/l and 350 µg/l respectively. At present the source of the TPH is unknown for this location. Groundwater sampling at this location also yielded exceedances of GAC (EQS) protective of freshwaters for metals (cadmium, manganese and zinc). Several determinands also exceeded GAC (DWS) within samples, these were manganese and sulphate. Sulphate concentrations, in particular, were most notable within sampling (1,040,000 µg/l and 1,220,000 µg/l).
- Although not a DWI exceedance, it should be noted that PFOS was detected above the MDL in the groundwater sample collected from 3L6106DS (16/07/24) at a concentration of 0.085 µg/l.
- Ground gas monitoring yielded concentrations of carbon dioxide that exceeded long term WELs.

6.2.2 Locations where Unexpected Contamination Detected

Trenchless Crossing Locations; 2L6007DR and 2L6008DR (Winchester Road), 2L6009DR and 2L6010DR (Bow Lake Watercourse), 2L6011SR and 2L6012SR (Unnamed Tributary of the Itchen).

Exploratory hole locations were not advanced to investigate PSCs and, therefore, data is limited to two boreholes per trenchless crossing making it difficult to delineate sources for contaminants encountered within groundwater.

- Soil samples collected from these borehole locations did not yield any exceedances of the commercial criteria protective of human health.
- Leachate testing carried out within 2L6008DR yielded one EQS exceedance of copper, two total ammonia as N WFD exceedances and one TPH (C_6 – C_{40}) WQS exceedance with a concentration of 110 µg/l.
- Groundwater sampling and testing from these locations yielded TPH (C_6 – C_{40}) with concentrations between 240 µg/l to 3,333 µg/l, though it should be noted that only samples from the first sampling round for each of these boreholes were tested for TPH. At present the source of the TPH is unknown for these locations, though it is suspected that clean-up of TPH from the laboratory was not carried out, though this is to be confirmed with the labs. Groundwater sampling at these locations also yielded exceedances of GAC (EQS) protective of freshwaters for metals (copper, lead, nickel and zinc), one exceedance of fluoranthene, as well as the WFD standard for total ammonia as N. Several determinands also exceeded GAC (DWS) within samples, these were Ammonium as NH_4, boron, chloride, indeno(1,2,3-cd)pyrene, nitrite as NO_2, sodium and sulphate. Sulphate concentrations in particular were most notable within sampling from 2L6011SR (1,080,000 ug/l, 1,370,000 µg/l and 1,550,000 µg/l) and 2L6012SR (417,000 µg/l and 735,000 µg/l).
- A high reading of carbon monoxide (42 ppm) was encountered within 2L6011SR, and lows of oxygen measured at 0.1% during the 25th May 2023 monitoring round.

6.3 Identification of Potential Pathways

During and post construction of the Proposed Development, the following potential pathways are considered:

- Dermal contact (soils and water), ingestion and inhalation of dusts, fibres, gases and vapours.
- Gas and vapour migration through permeable materials/strata and accumulation in voids and below ground chambers/receptor pits.
- Surface water runoff from stockpiles to surface watercourses and migration through groundwater.
- Leaching through unsaturated soil to underlying groundwater.
- Migration of contamination through proposed pipe bedding.

6.4 Identification of Potential Receptors

Based on the proposed construction works, end use and surrounding land uses, the following potential receptors previously identified in the desk study risk assessment have been further assessed following Phase 2 GI data:

- Construction workers
- Future site users (i.e., maintenance workers)
- Adjacent land users
- On-Site existing and future property (buildings and buried services)
- Surface water (Bow Lake watercourse, unnamed tributary of the Itchen)

- Groundwater (Secondary A (River Terrace and Alluvial Deposits) or Secondary Undifferentiated (Head Deposits) aquifers. Bedrock (London Clay and Lambeth) has not been considered as a receptor as it is an unproductive stratum. No major aquifers were encountered in Phase 2 and Phase 3B/3C exploratory hole locations.
- Ecological receptors (flora and fauna) to address statutory designated areas such as Ancient Woodlands (250 m).

The proposed pipeline has not been included as a potential receptor to contaminants that could be present in soils or groundwaters. The pipe material selection is to be made during design to prevent impact from existing PSCs.

There are no proposed permanent building structures at the areas investigated in Phase 2 of Section L. On-Site existing and future property is included as a receptor for completeness in the risk assessment.

6.5 Risk Assessment

The above CSM has been used to undertake a generic quantitative risk assessment. The method of risk evaluation adopted is consistent with LCRM (Environment Agency, 2023) and is being carried out in accordance with CIRIA C552 (CIRIA C552, 2001). Further details regarding the generic risk assessment methodology used are included in **Appendix I**.

The quantitative risk estimation is based on the evaluation of both desk study information collated for the route together with the Phase 2 and Phase 3B/3C GI data and is presented in Table H1 to Table H4 (**Appendix H**). Definitions for probability and consequence are in **Appendix I**. The findings of the revised risk assessment are summarised in **Tables 6.1**.

Table 6.1 summarises the risk classification (without mitigation measures) for the investigated PSCs, trenchless crossings and exploratory hole locations where unexpected contamination was encountered. The risk classification ratings are taken from the risk assessment tables (**Appendix H**). Where more than one pathway has been evaluated, the pathway with the highest risk rating is presented in **Table 6.1**. For example, the risk rating for construction, maintenance workers and future site users is High for an inhalation pathway and is shown in **Table 6.1**. The dermal contact and ingestion pathway risk rating is low as presented in Appendix H and is, therefore, not presented in **Table 6.1** but is expanded upon further in **Appendix H**.

Table 6.1: Summary of Risk Classification for Construction and Maintenance Activities for Areas Investigated in Section L

PSC No.	Section	PSCs	Risk Classification (without mitigation measures) for Receptors [1]					
			Construction and maintenance workers	Adjacent Land Users	On-Site existing and future property (buildings, reception pits and buried services)	Surface Water	Groundwater	Ecology
Historical Crowd Hill Landfill (PSC 441) / BGS Artificial Ground (PSC 440)	L exploratory holes advanced to target PSCs: 2L600TP, 2L6001TP, 2L6004TP, 2L6006TP, 2L6002SA, 2L6003SA and 2L6005SA Land adjacent to Winchester Road (2L6005SA), footprint of PSC. 440	**Crowd Hill Landfill (Potentially On-Site and Adjacent to) and BGS Made Ground:** Potential of encountering further Made Ground, asbestos, ground gas and contaminated groundwater. Groundwater sampling from boreholes yielded WQS exceedances of TPH. DWS exceedances of chloride, manganese, selenium, sulphate and ammonium (NH_4). EQS exceedances of cadmium, copper, lead, manganese, nickel and zinc as well as WFD standard exceedance for total ammonia (N). Ground Gas monitoring within 2L6003SA and 2L6005SA yielded carbon dioxide concentrations (which exceeded both short and long term WELs) as well as low oxygen concentrations.	Moderate	Moderate / Low	Low	Low	Moderate	Moderate / Low
		Asbestos encountered within 2L6005SA: A bulk sample (0.05 – 0.30 m bgl) and disturbed sample (0.05 – 1.00 m bgl) collected yielded positive detections, 1.2083% and 0.501% respectively of chrysotile and amosite insulation board.	High	Moderate	N/A			
N/A	Trenchless Crossing – 2L6007DR and 2L6008DR	**Leachate Exceedances within 2L6008DR (0.3 and 6.5 m bgl):** One EQS exceedance of copper, WQS exceedance of TPH and two total ammonia as N compared to the WFD standard. **Groundwater Exceedances:** WQS Total TPH (C_6 – C_{40}). DWS exceedances of ammonium (NH_4), chloride, boron, indeno(1,2,3-cd)pyrene, sodium and sulphate. EQS exceedances of copper, fluoranthene, lead, nickel, zinc and total ammonium as N. Leachate testing obtained from 2L6008DR yielded DWS and EQS exceedances of copper, cadmium and total ammonia as N. Ground gas, elevated concentrations of carbon monoxide (42 ppm) and carbon dioxide (exceeded both short and long term WELs) recorded as well as very low oxygen concentrations.	Moderate *(Inhalation pathway)*	Low	Moderate	Low	Moderate	Low
N/A	Trenchless Crossing – 2L6009DR and 2L6010DR		Moderate	Moderate / Low	Moderate	Moderate	Moderate	Low
N/A	Trenchless Crossing – 2L6011SR and 2L6012SR		Moderate	Moderate / Low	Moderate	Moderate	Moderate	Low
PSC 472	3L6106DS and 3L6107DS	**Leachate Exceedances:** One EQS exceedance of copper, two DWS exceedances of iron and two WFD exceedances of total ammonium as N. **Groundwater Exceedances:** WQS TPH Aliphatic and Aromatic (C_8 – C_{40}) with concentrations between 140 and 350 ug/l respectively. EQS exceedances of cadmium, manganese and zinc. DWS exceedances of manganese and sulphate. One detect of PFOS was also encountered within a sample obtained from 3L6106DS at a concentration of 0.085 ug/l, which is below the action threshold. Carbon dioxide exceeded long term WELs.	Moderate	Moderate / Low	Low	Low	Moderate	Low

[1] based on available analytical data (some requested chemical data not received to date), the risk classifications may change following additional data.
N/A not application as there is no identified receptor

6.6 Summary

The Phase 2 and Phase 3B/3C GI along Section L of the Proposed Development focussed on the identified PSCs on-Site (PSCs 440, 441 and 472 – BGS Made Ground, Crowd Hill Landfill both locations) principally located where open cut excavation is to take place.

Three trenchless crossing locations were also investigated: one proposed road crossing and two proposed watercourse crossings.

Based on the generic quantitative risk assessment, the following risks were determined:

- A High risk to construction, maintenance workers and future site users through the inhalation pathway can be considered applicable for soils within the vicinity of 2L6005SA due to the presence of asbestos within the footprint of the former Crowd Hill Landfill.
- For the remaining DoL within the footprint of Crowd Hill Landfill, where there is no asbestos present, a Moderate risk has been identified for impact to construction and maintenance workers and a Moderate / Low risk has been identified to adjacent land users due to recorded groundwater exceedances identified across the former Crowd Hill Landfill through dermal contact and ingestion pathways. A Moderate / Low risk has been identified for impact to ecological receptors based on the proximity of Crowd Hill Landfill to ancient woodland and the potential nature of the landfill material.
- A Moderate risk was identified for groundwater and surface waters due to the exceedances of the GAC at several GI locations for proposed trenchless crossings and by applying a conservative approach due to absence of soil leachate results.
- A Moderate risk has been identified at the remaining investigated locations for impact to construction, maintenance workers and future site users based on exceedances in groundwater and the findings of ground gas monitoring which showed carbon dioxide exceedances for short and long-term WELs and depleted oxygen levels.
- All other potential contaminant linkages were either identified as Low or Very Low.

7 Geotechnical Testing and Assessment

7.1 Geotechnical Testing and Assessment Summary Tables for Section L boreholes

The below **Table 7.1** shows the varying geotechnical tests per strata specific to Section L locations. Section L geotechnical testing is similar to adjacent Section K and Section M, that also encounter similar superficial deposits and bedrock. Results for boreholes in Section L and Section K are comparable regarding classification, SPT results, and geochemical testing results for superficial deposits (Alluvium, Head Deposits, River Terrace Deposits) and London Clay Formation. Possible Harwich Formation encountered in both Section L and Section K contains variable mixtures of clay, sand and gravel. As a consequence, the particle size distribution results differ.

Table 7.1: Geotechnical Testing and Assessment summary for Section L exploratory hole locations

Strata	Moisture (%)			Plasticity Index (%)			Particle Size Distribution (Average of values)		Triaxial Shear Strength, C_u (kPa)	SPT Results (uncorrected N value)			Uniaxial Compressive Strength, UCS (MPa)	Point Load Index Testing , PLT (MPa)	Compaction – Max Dry Density (Mg/m3) (Optimum Moisture content, %)		
Made Ground (MGR)	Min	Av	Max	Min	Av	Max	Particle Size	(%)	None	Min	Av	Max	Not Applicable	Not Applicable	Min	Av	Max
	17	24	36	12	17	21	Cobbles	0		None					None		
							Gravel:	46									
							Sand:	23									
							Silt:	27									
							Clay	4									
Total No. of tests	4			3			2		0	0			0	0	0		
Alluvium (ALV)	Min	Av	Max	Min	Av	Max	Particle Size	(%)	Min Av Max	Min	Av	Max	Not Applicable	Not Applicable	Min	Av	Max
	31	35	46	59	59	59	Cobbles	0							None		
							Gravel :	47									
							Sand :	13	51 61 71	0*	7	12					
							Silt :	23									
							Clay :	17									
Total No. of tests	3			1			1		2	4			0	0	0		
Head Deposits (HEAD)	Min	Av	Max	Min	Av	Max	Particle Size	(%)	Min Av Max	Min	Av	Max	Not Applicable	Not Applicable	Min	Av	Max
	33	33	33	40	40	40	Cobbles	0							None		
							Gravel :	38									
							Sand :	6	53 53 53	9	11	12					
							Silt :	29									
							Clay	27									
Total No. of tests	1			1			2		1	2			0	0	0		
River Terrace Deposits (RTD)	Min	Av	Max	Min	Av	Max	Particle Size	(%)	None	Min	Av	Max	Not Applicable	Not Applicable	Min	Av	Max
							Cobbles	3									
							Gravel :	75									

Strata	Moisture (%)			Plasticity Index (%)			Particle Size Distribution (Average of values)		Triaxial Shear Strength, C_u (kPa)			SPT Results (uncorrected N value)			Uniaxial Compressive Strength, UCS (MPa)			Point Load Index Testing , PLT (MPa)			Compaction – Max Dry Density (Mg/m3) (Optimum Moisture content, %)		
	1	22	10	10	17	32	**Sand :**	12				9	18	49**							None		
							Silt :	8															
							Clay :	2															
Total No. of tests	11			4 (plus 4 indicating non plastic)			13		0			7			0			0			0		
London Clay Formation (LC)	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Particle Size**	(%)	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**
	19	27	45	5	34	42	**Cobbles**	0	67	108	300	8	17	50	0.07	0.16	0.34	0.05	0.05	0.05	1.49 (26)	1.50 (27)	1.50 (28)
							Gravel :	13															
							Sand :	9															
							Silt :	44															
							Clay :	34															
Total No. of tests	68			40			9		27			37			25			1 set of 10 determinations			2		
Possible Harwich Formation (HWH)	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**						**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**
	20	21.6	23	22	23	23	None		None			50 (50 blows for 220 mm penetration – refusal not full 450 mm penetration)			0.26	0.26	0.26	0.03	0.03	0.03	None		
Total No. of tests	3			3			0		0			1			1			1			0		
Lambeth Group (LMBE)	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Particle Size**	(%)	**Min**	**Av**	**Max**	**Min*** **	**Av*** **	**Max*** **	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**
	10	19	26	17	32	40	**Cobbles**	0															
							Gravel :	0															
							Sand :	77	130	293	510	11	22	50+	0.11	0.17	0.32	0.03	0.03	0.03	None		
							Fines (Silt+Clay)	23															
Total No. of tests	17			11			2		6			13			5			1 set of 10 determinations			0		

*In Alluvium, one recorded SPT N value of 0 was encountered at 2L6008DR at 1.20 m bgl as a result of the SPT rod dropping under self-weight.
**In River Terrace Deposits, A recorded SPT N value of 49 (dense) was encountered at BH501 at 2.2 m bgl as a result of the SPT rod attempting to push through coarse gravel. Within BH501, at 1.2 m there was a SPT N value of 12 (medium dense) and following on from 2.2 m, the subsequent SPT at 3.2m, recorded a SPT N value of 17 (medium dense).
*** Lambeth Group encountered 2 No. SPT test results, 1 No. test result with 50 blows with a full penetration (450 mm) with the other 1 No. test result due to a refusal of 50 blows (50 from 185 mm penetration).

Table 7.2: Additional Geochemical Testing

Geology	BRE SD1 values[1]			
Made Ground (MGR)	Test type	Min	Max	Characteristic Value
	Water soluble SO4 (mg/l)	Below limit of detection	43	< 500
	Acid soluble SO4 (%)	0.08	0.1	0.1
	Total Sulphur (%)	0.03	0.05	0.05
	Total Potential Sulphate (%)	0.09	0.15	< 0.24
	pH	5.8	9.09	5.8
No. Tests	3			
Alluvium (ALV)	Test type	None		
	Water soluble SO4 (mg/l)			
	Acid soluble SO4 (%)			
	Total Sulphur (%)			
	Total Potential Sulphate (%)			
	pH			
No. Tests	0			
Head Deposits	Test type	None		
	Water soluble SO4 (mg/l)			
	Acid soluble SO4 (%)			
	Total Sulphur (%)			
	Total Potential Sulphate (%)			
	pH			
No. Tests	0			
River Terrace Deposits (RTD)	Test type	Min	Max	Characteristic Value
	Water soluble SO4 (mg/l)	Below limit of detection	30	< 500
	Acid soluble SO4 (%)	0.01	0.07	0.07

Geology	BRE SD1 values[1]			
	Total Sulphur (%)	Below limit of detection	0.06	0.06
	Total Potential Sulphate (%)	Below limit of detection	0.18	< 0.24
	pH	6.4	8.7	6.4
No. Tests	4			
London Clay Formation (LC)	Test type	Min	Max	Characteristic Value
	Water soluble SO4 (mg/l)	10	980	820
	Acid soluble SO4 (%)	Below limit of detection	2.01	2.01
	Total Sulphur (%)	0.01	0.71	0.66
	Total Potential Sulphate (%)	Below limit of detection	2.13	1.96
	pH	7.56	8.7	7.7
No. Tests	17			
Harwich Formation	Test type	Min	Max	Characteristic Value
	Water soluble SO4 (mg/l)	480	480	<500
	Acid soluble SO4 (%)	0.12	0.12	0.12
	Total Sulphur (%)	0.76	0.76	0.76
	Total Potential Sulphate (%)	2.28	2.28	2.28
	pH	8.2	8.2	8.2
No. Tests	1			
Lambeth Group	Test type	Min	Max	Characteristic Value
	Water soluble SO4 (mg/l)	Below limit of detection	1200	640
	Acid soluble SO4 (%)	0.02	0.26	0.26
	Total Sulphur (%)	Below limit of detection	0.65	0.36
	Total Potential Sulphate (%)	Below limit of detection	1.95	1.2
	pH	7.7	9.1	8.1
No. Tests	7			

[1] Total Potential Sulphate is calculated from section *C5.1.2* (BRE, 2005)

Table 7.3: Additional Geochemical / Geotechnical Testing

	Geochemical / Geotechnical property			
Geology	**Hand Vane Undrained Shear Strength, C_u (kPa)**	**Mass Loss on Ignition (%)**	**Organic Matter Content (%)**	**Linear (Bulk) Density (kg/m3)**
Made Ground (MGR)	None	None	None	1.78 (1 test)
Alluvium (ALV)	34 – 60 (6 tests)Average: 47	0.19 - 4 (2 tests) Average: 2.1	0 – 0.83 (3 tests) Average: 0.28	None
Head Deposits (HEAD)	43 – 72 (10 tests) Average: 55	None	0 (1 test)	1.78 – 1.89 (2 tests)
River Terrace Deposits (RTD)	None	3.3 – 3.4 (2 tests) Average: 3.35	0.43 (1 test)	None
London Clay Formation (LC)	34 – 101 (34 tests) Average: 64	4.1 – 5.0 (3 tests) Average: 4.5	0.7 – 0.83 (2 tests) Average: 0.77	1.78 – 2.16 (33 tests) Average = 1.99
Harwich Formation (HWH)	None			
Lambeth Group (LMBE)	None	None	0 – 0.72 (2 tests) Average: 0.36	None

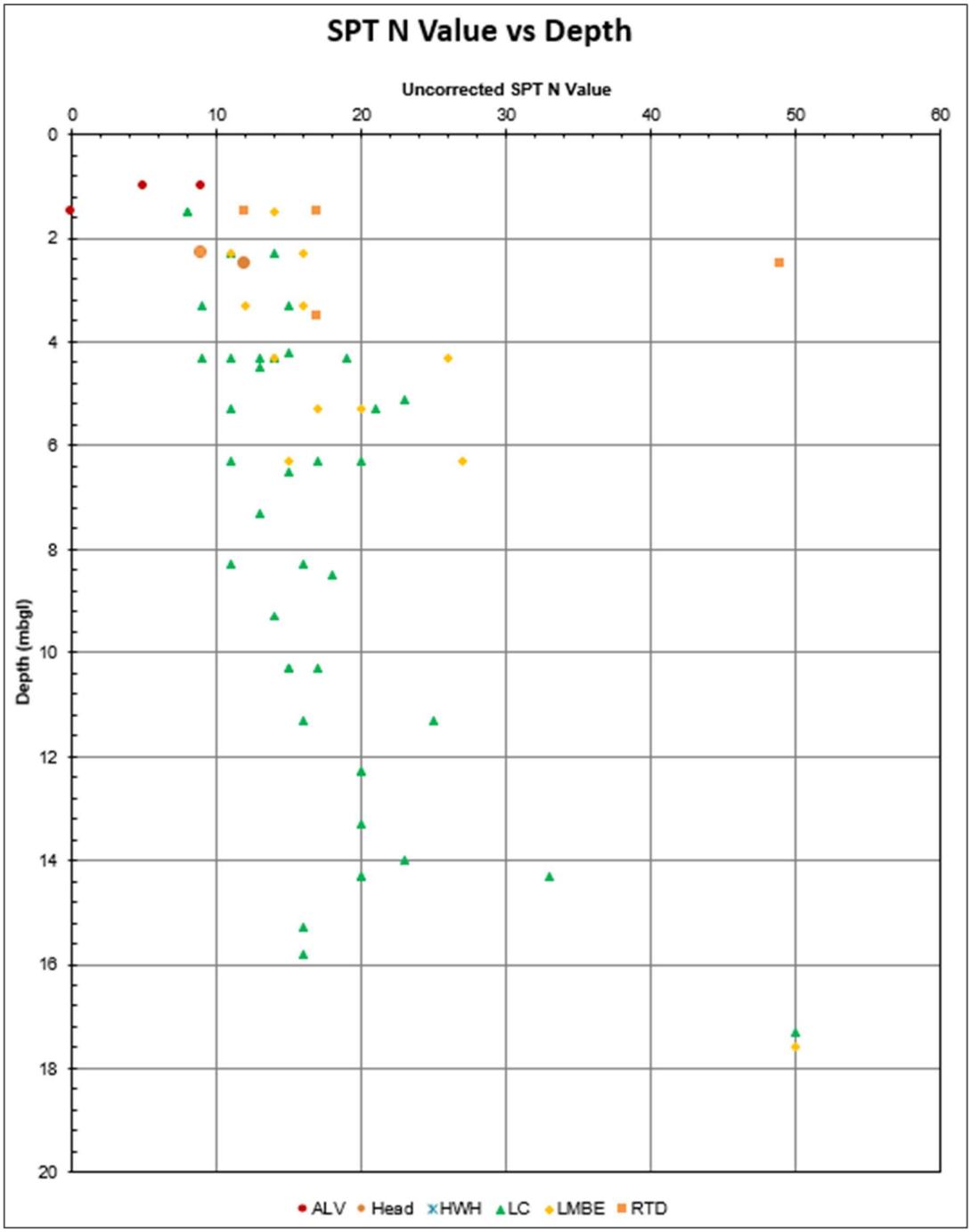
Table 7.4: Oedometer Effective Stress Testing BH501

Geology	Depth (m bgl)	Initial Voids ratio	Applied Pressure at Stage End (kPa)	Coefficient of Consolidation Log Time ($t_{50,log}$) m^2/yr	Volume Compressibility coefficient, M_v (m^2/MN)	Start Voids Ratio	End Voids Ratio
London Clay Formation (LC)	9.2	0.6	105 – 840 (8 stages)	Varied per stage range: between 0.26 – 5.7 (8 stages)	Varied per stage range: between 0.04 – 0.1 (8 stages)	Varied per stage range: between 0.54 – 0.6	Varied per stage range: between 0.51 – 0.59
Lambeth Group (Reading Formation)	20.92	0.37	225 – 1800 (8 stages)	Varied per stage range: between 0.52 – 2.5 (8 stages)	Varied per stage range: between 0.01 – 1.2 (8 stages)	Varied per stage range: between 0.26 – 0.37 (8 stages)	Varied per stage range: between 0.23 – 0.33 (8 stages)
Lambeth Group (Reading Formation)	32.87	0.24	345 – 2760 (8 stages)	Coefficient of consolidation root time Varied between stage range: between 3.1 - 35	Varied per stage range: between 0 – 0.06 (8 stages)	Varied per stage range: between 0.20 – 0.24 (8 stages)	Varied per stage range: between 0.18 – 0.22 (8 stages)

7.2 Standard Penetration Test (SPT) vs Depth Relationship

Graph 7.1 does not show enough values to define a clear relationship between SPT N value vs depth for Alluvium, River Terrace Deposits and Harwich Formation. London Clay Formation and Lambeth Group show an increase in SPT N value with depth.

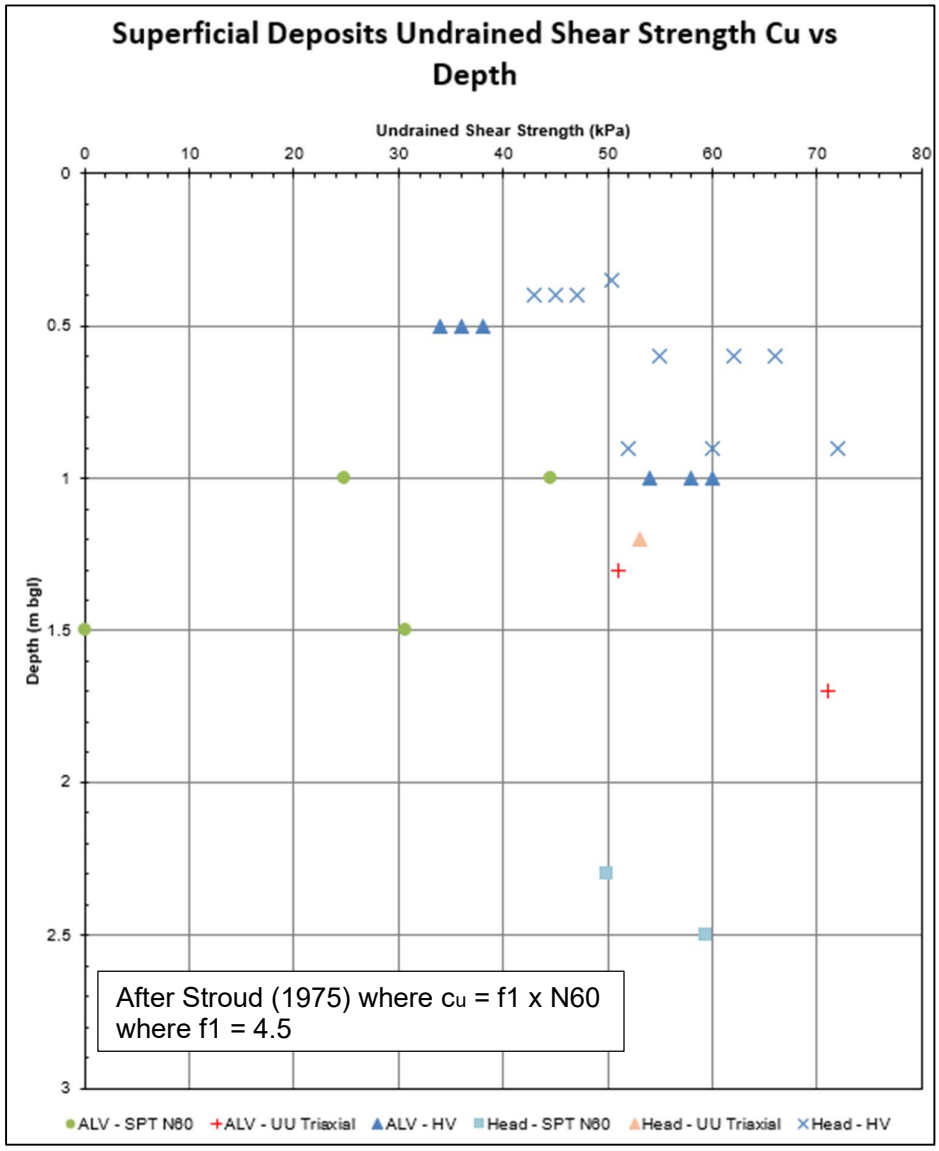
Figure 7.1 Uncorrected SPT vs Depth per strata across Section L boreholes



7.3 Undrained Shear Strength Cu vs Depth Relationship

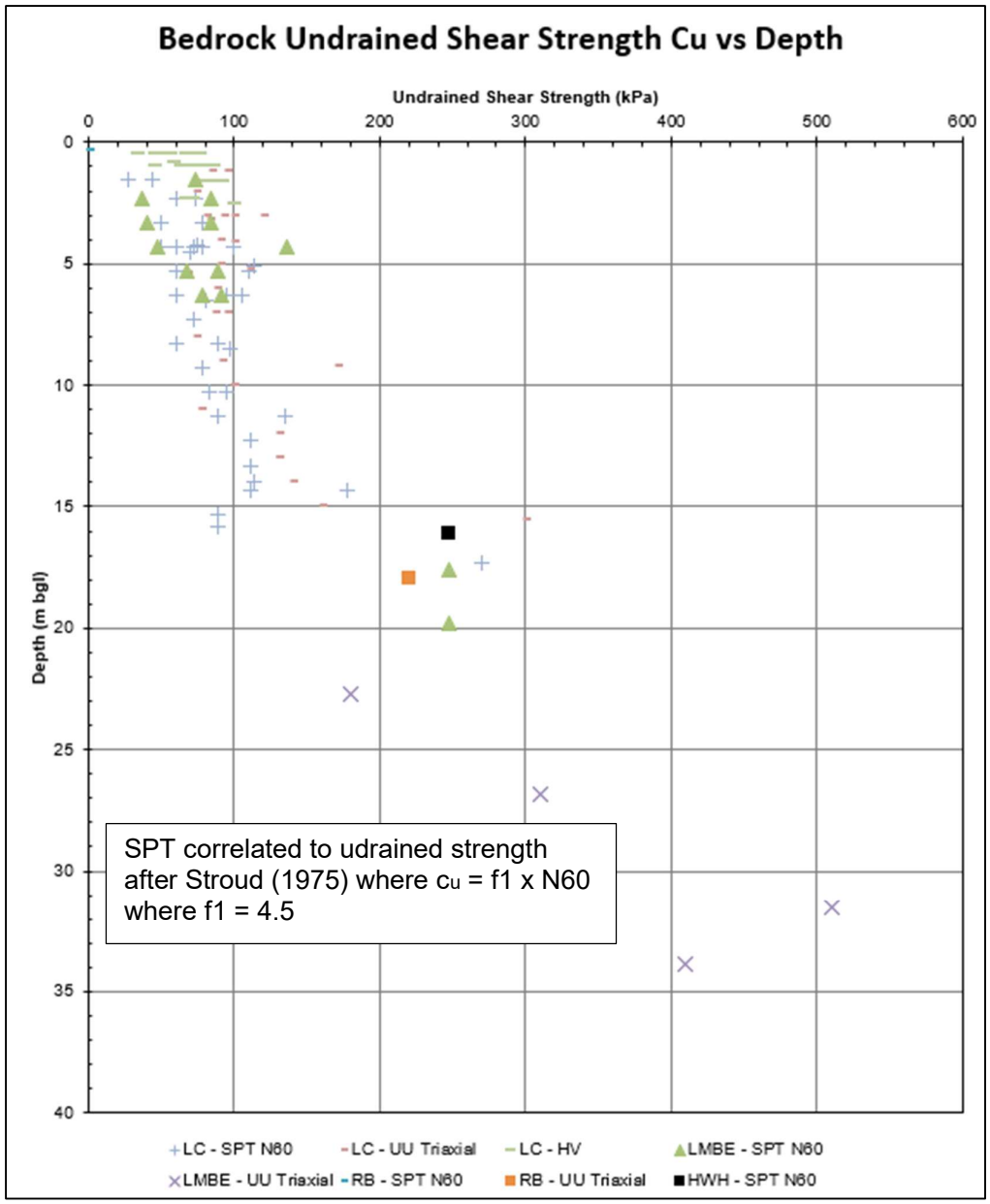
Graph 7.2 shows undrained shear strength vs depth for Superficial Deposits cohesive strata (based on corrected SPT N60 correlated to undrained shear strength using a factor of 4.5, and unconsolidated undrained (UU) triaxial tests). Alluvium and Head Deposits show an increase in strength with depth.

Graph 7.2 Undrained Shear Strength C_u vs Depth Relationship for Superficial Deposits



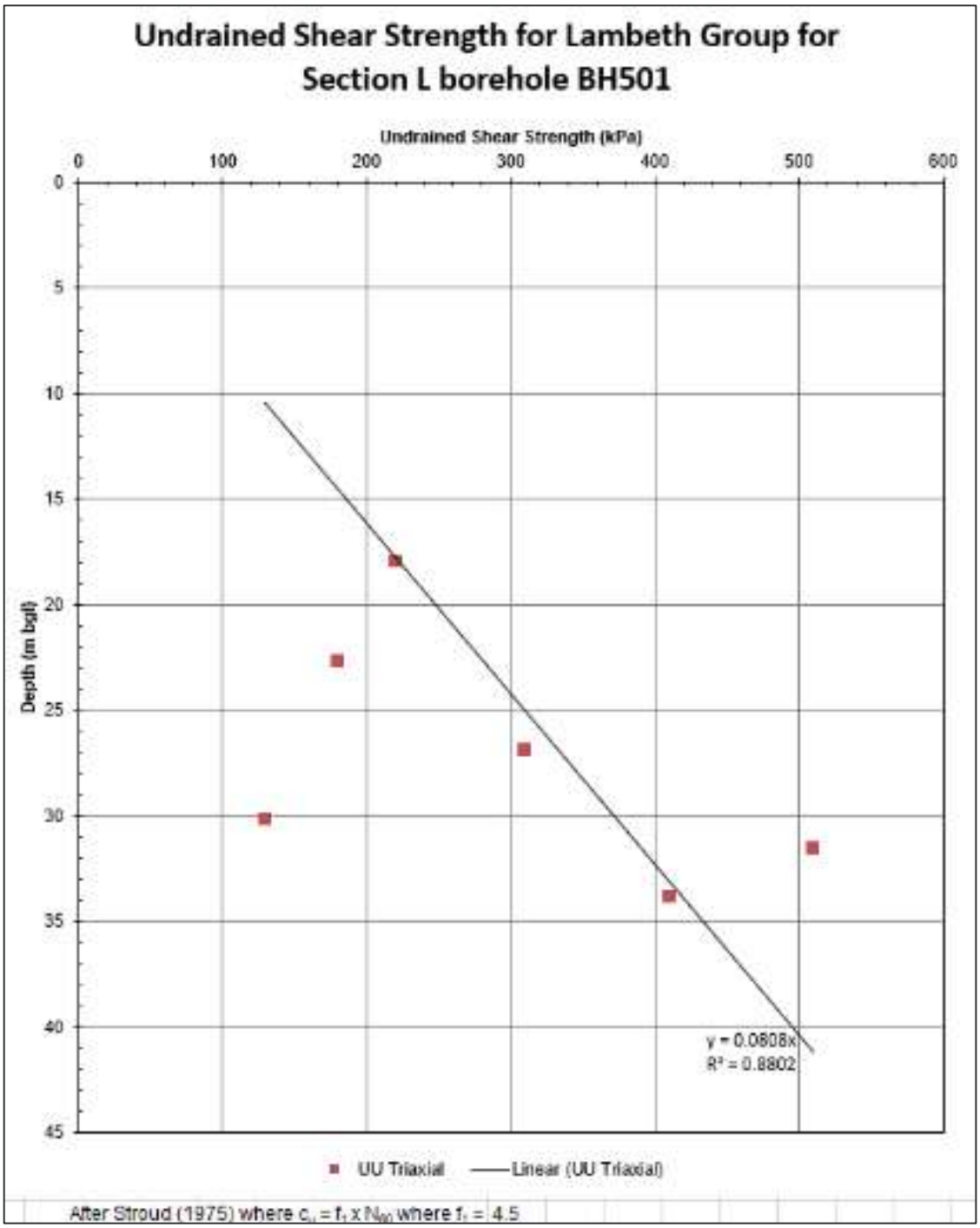
Graph 7.3 shows undrained shear strength for bedrock. London Clay Formation, Harwich Formation and Lambeth Group (based on corrected SPT N60 correlated to undrained shear strength using a factor of 4.5, and unconsolidated undrained (UU) triaxial tests) and shows a clear relationship between undrained shear strength and depth, increasing approximately linearly with depth. Both Harwich Formation (HWH) and Lambeth Group (LMBE) mirror Figure 7.1 between 16.0 – 20.0 m.

Graph 7.3 Undrained Shear Strength C_u vs Depth Relationship for Bedrock



Graph 7.4 shows the Cu vs depth relationship for BH501 where trenchless construction is estimated to be approximately 33 m bgl. There were only triaxial tests undertaken within Lambeth Group strata (no SPTs) between 17.95 m – 33.86 m for BH501, which is shown below in addition to **Graph 7.2** above.

Graph 7.4 Undrained Shear Strength C_u (trial axial compression tests) vs Depth Relationship for Section L borehole BH501

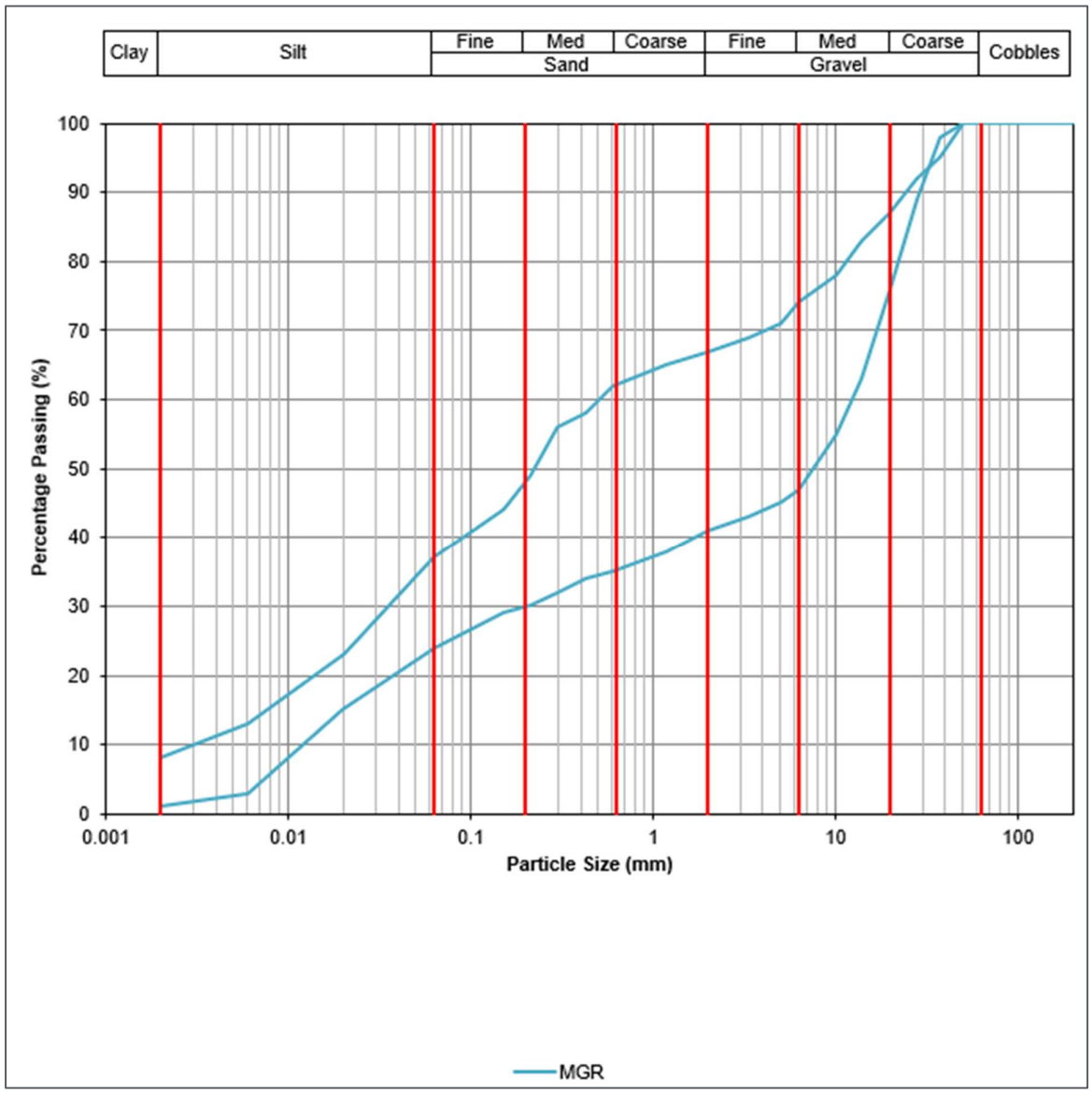


7.4 Particle Size Distribution for Section L boreholes

7.4.1 Made Ground

Although the PSD suggests a potentially granular material in **Graph 7.5**, this does not align with engineering log descriptions which suggest the soil will behave more as a fine-grained material.

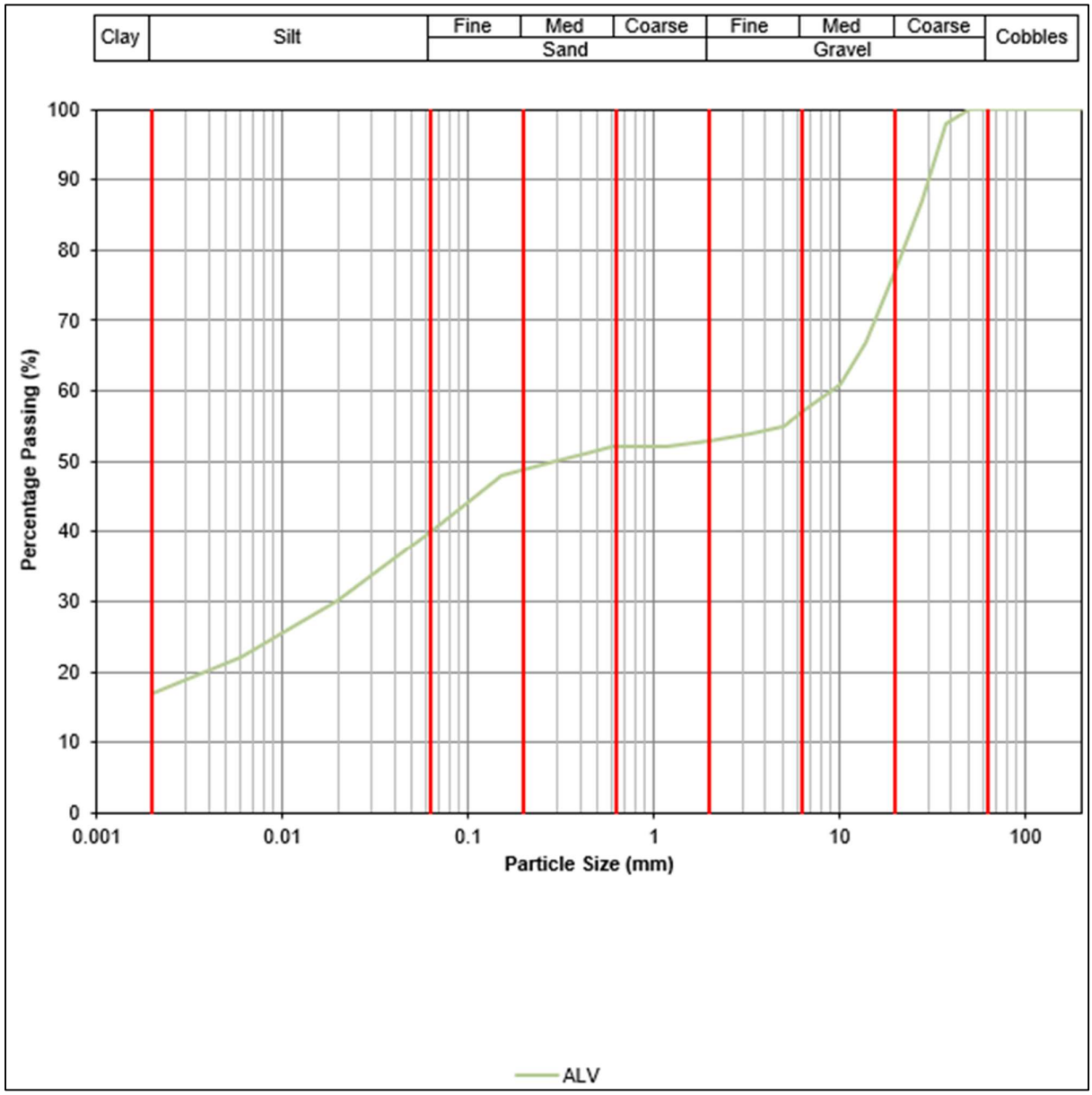
Graph 7.5 Particle Size Distribution for Made Ground across Section L exploratory hole locations



7.4.2 Alluvium

Graph 7.6 shows the Alluvium PSD plot to be predominantly composed of sand and gravel, not fully consistent with soil descriptions listed in **Table 4.1, 4.2, 4.3 and 4.4** as a cohesive clay soil across 4No. boreholes within Section L. When logging to BS5930:2020, the standard defines a soil as fine or coarse based on whether it sticks together when wet (which with 40% fines is possible), a description of slightly sandy very gravelly silt/clay would be expected as per the PSD plot shown below in **Graph 7.6**. However, this plot is based only 1 bulk sample from 2L6007DR at 0.6 m bgl. More samples within Alluvium should have classification testing to confirm the cohesive designation as outlined in the soil descriptions.

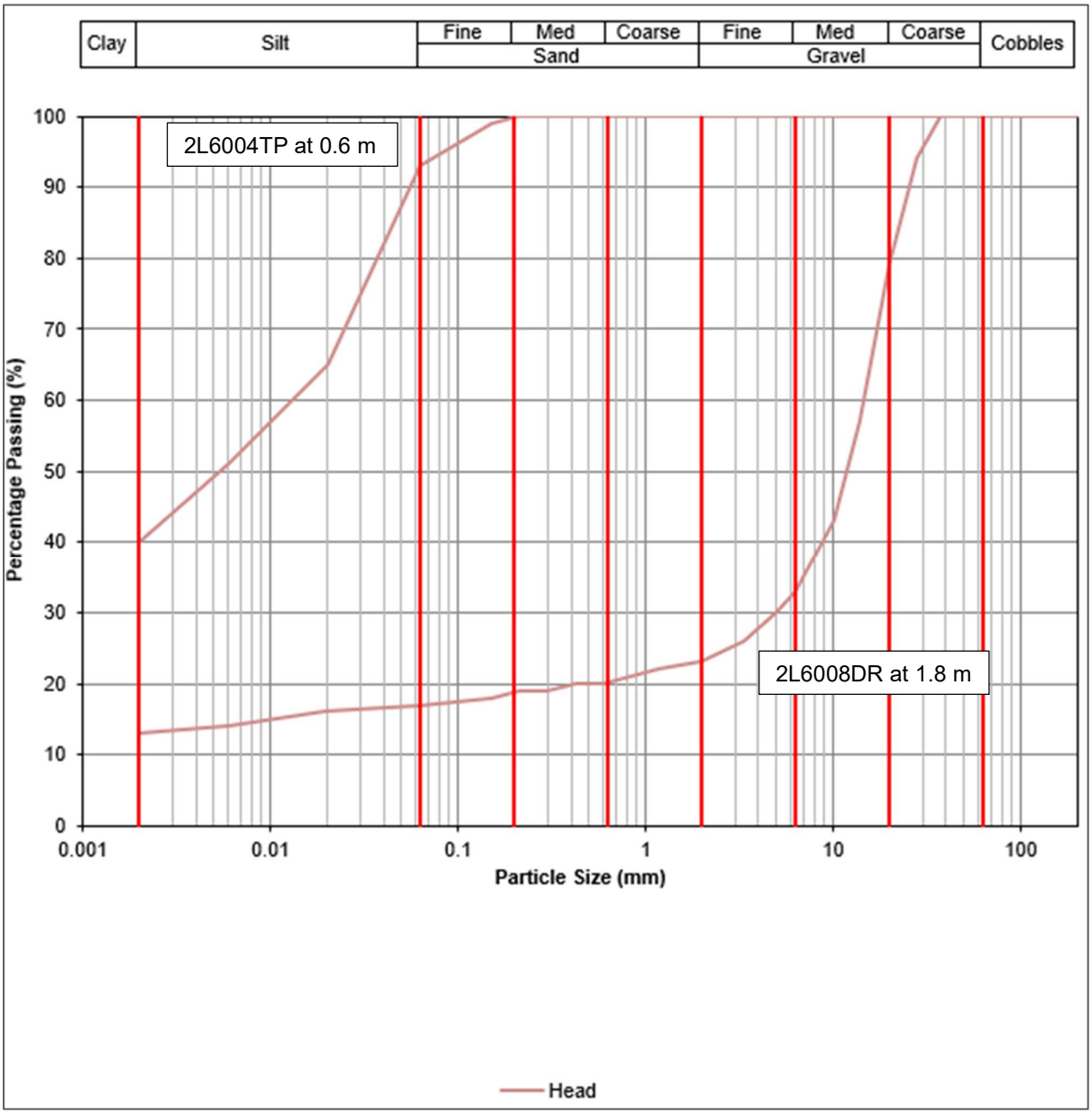
Graph 7.6 Particle Size Distribution for Alluvium across Section L exploratory hole locations



7.4.3 Head Deposits

The PSD plots below for Head Deposits in **Graph 7.7** show some consistency with the soil description in **Table 4.1, 4.2, 4.3 and 4.4 -** a slightly sandy clay - similar to 4No. locations is shown by 2L6004TP at 0.6 m and 2L6008DR at 1.8 m which shows a granular soil (silty sandy gravel). Head Deposits is inherently a variable material, and that perhaps some of this is River Terrace Deposits given the similar grading in the graph below. It is recommended that further classification testing takes place to confirm the validity of the soil descriptions.

Graph 7.7 Particle Size Distribution for Head Deposits across Section L exploratory hole locations

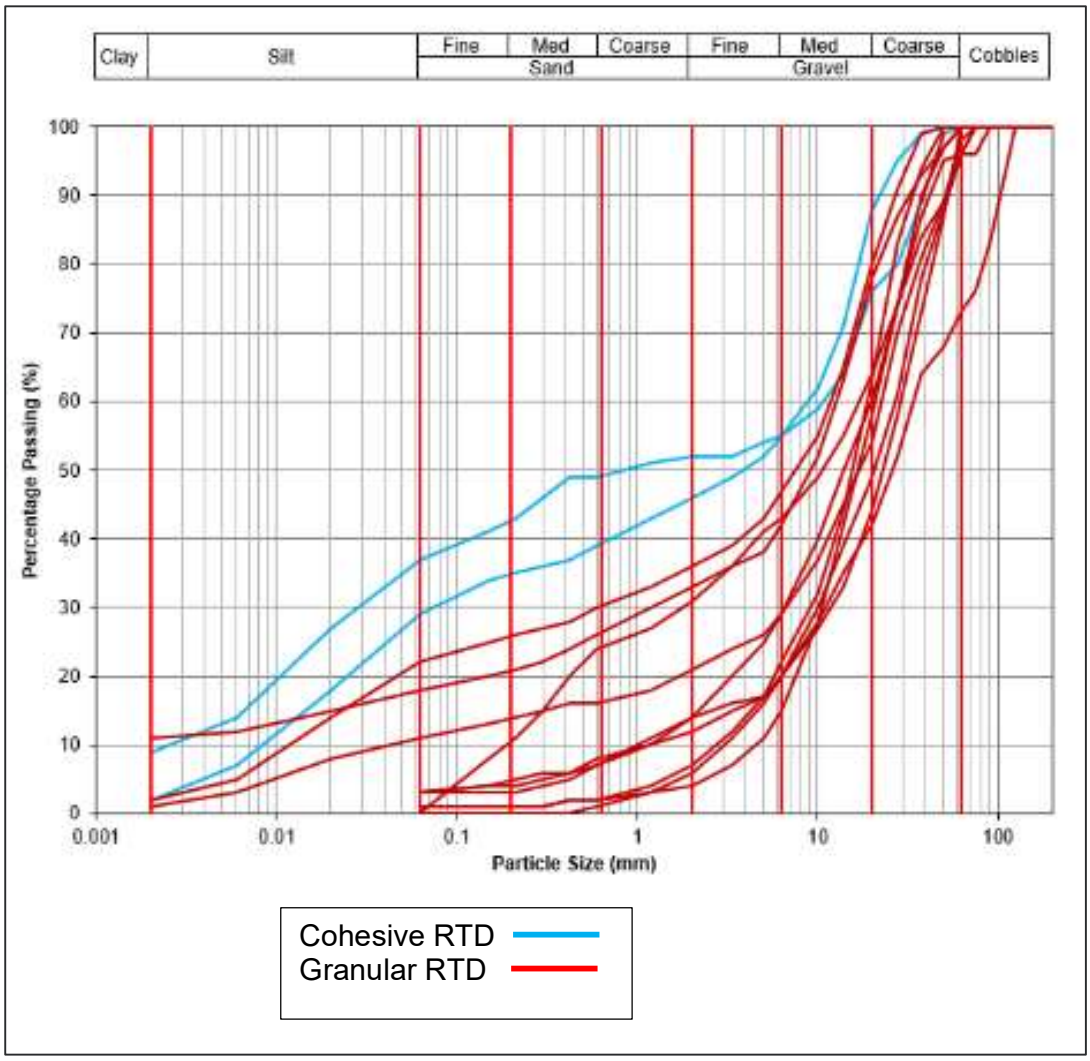


7.4.4 River Terrace Deposits

Graph 7.8 shows PSD plots for granular and cohesive River Terrace Deposits for Section L boreholes that are consistent with the soil descriptions in **Table 4.1, 4.2, 4.3 and 4.4**. The cohesive PSD plots in blue are for TP503 at 0.3 m, which is described as soft clay with cobbles and 2L6012SR, which is described as gravelly clayey fine to coarse Sand at 0.15 m (noted on the log as Head Deposits though due to geological mapping it is thought that the material is better designated River Terrace Deposits).

River Terrace Deposits are generally described as sandy clayey gravel, these materials are depicted by the red lines across in **Graph 7.8** (Granular River Terrace Deposits). The PSD results note a variable fines content within the granular River Terrace Deposits ranging between 0 and 22%. Some River Terrace Deposit horizons do contain lenses of clay and silt in addition to granular material (1st and 3rd Terraces) and it is considered that these are the probable source of this fine material. Granular River Terrace Deposits showed cohesive material greater than 20% passing through clay and silt grain size fractions.

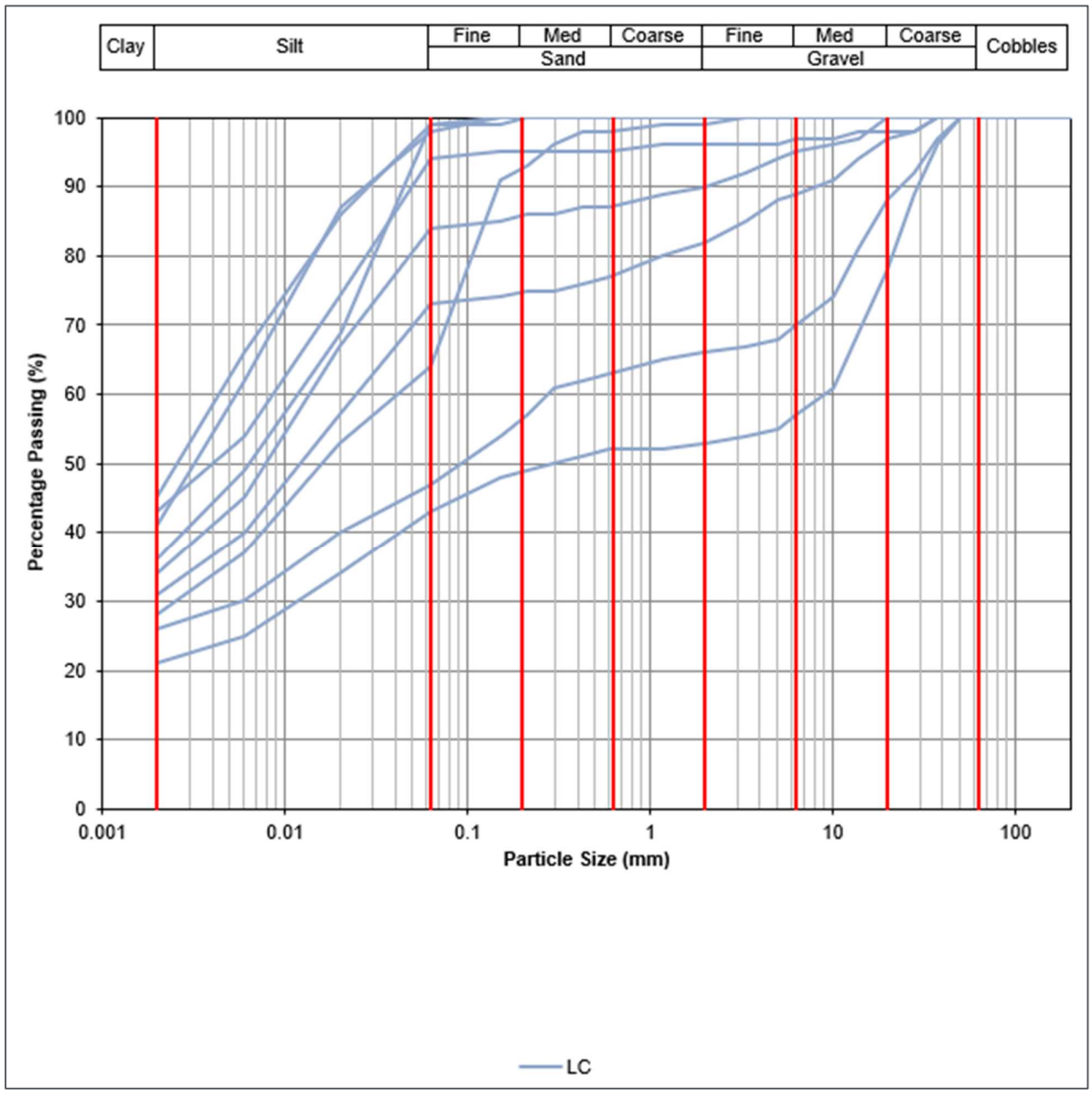
Graph 7.8 Particle Size Distribution for River Terrace Deposits (RTD) across Section L exploratory hole locations



7.4.5 London Clay Formation

Graph 7.9 shows PSD plots for London Clay Formation, that are consistent with the exploratory hole logs for Section L, showing a predominantly clay/silt, locally slightly sandy and/or slightly gravelly.

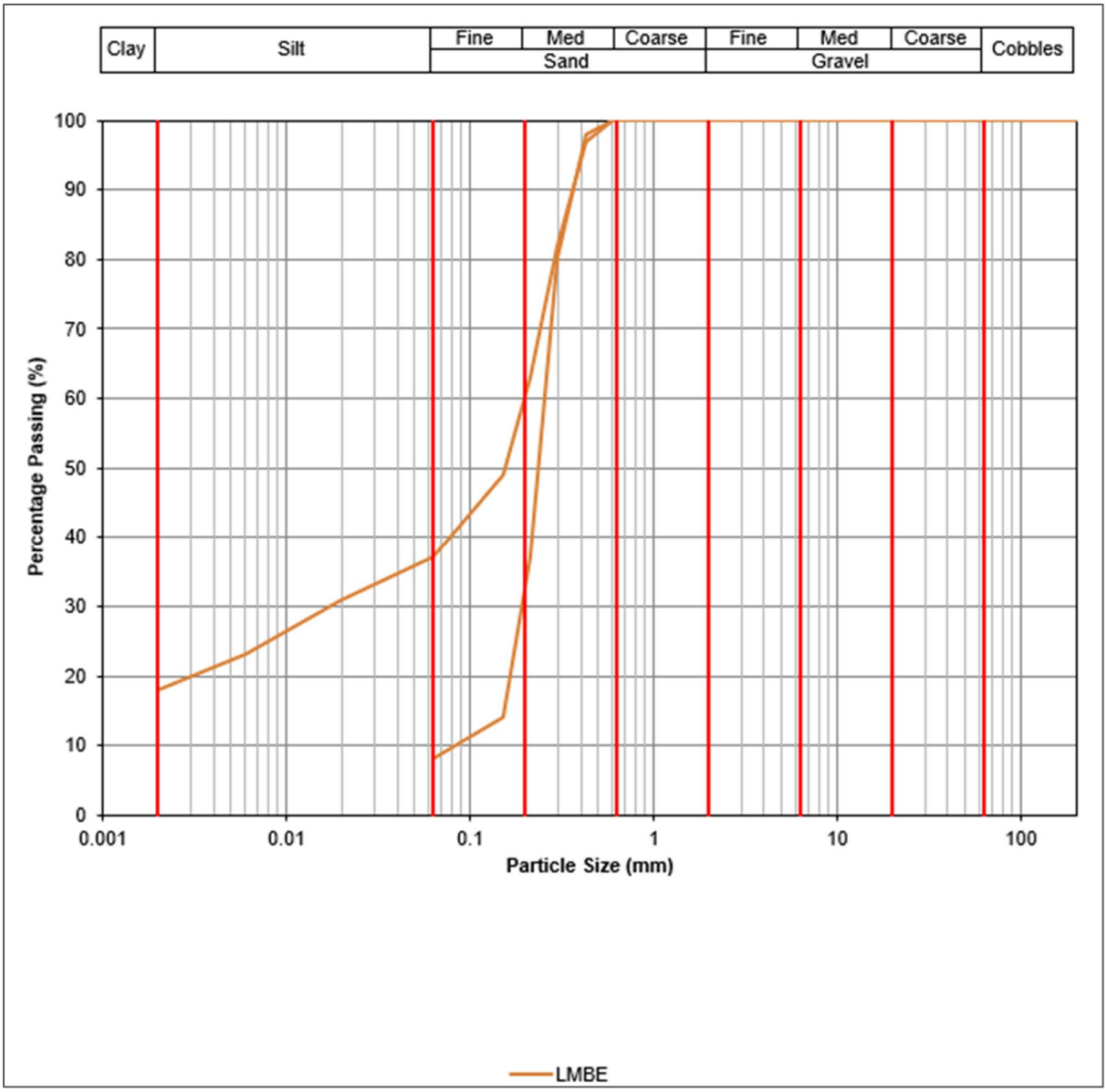
Graph 7.9 Particle Size Distribution for London Clay Formation across Section L exploratory hole locations



7.4.6 Lambeth Group

Graph 7.10 shows a PSD plot for Lambeth Group that is consistent with the exploratory hole logs for Section L showing a fine to medium sand description, although some logs do show a more cohesive material. Lambeth Group is also variable so can also be cohesive though only 1 sample was tested at 2L6011SR at 16.3 m, which is below the depth of trenchless construction. More classification testing is recommended for Section L.

Graph 7.10 Particle Size Distribution for Lambeth Group across Section L exploratory hole locations

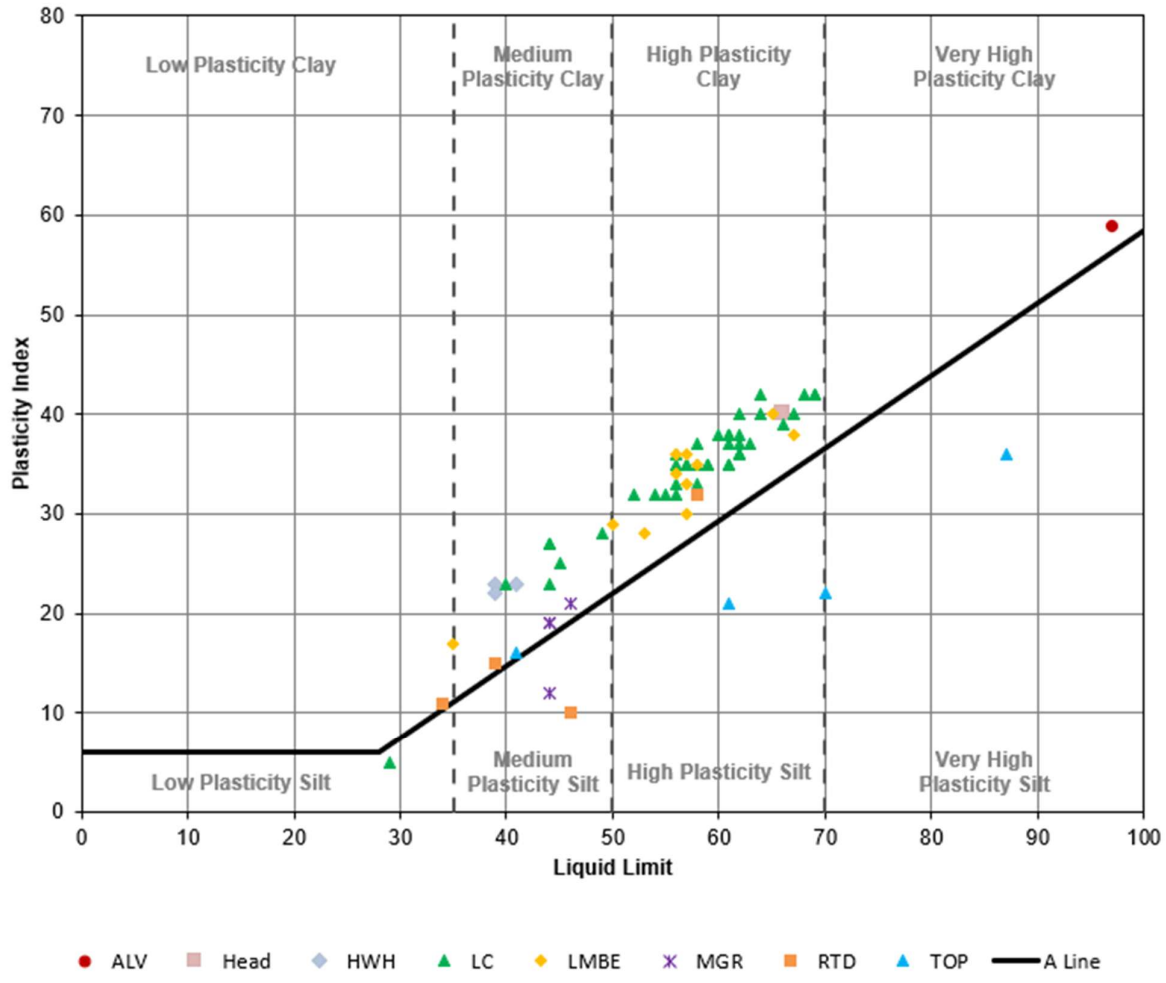


7.5 Plasticity for Section L boreholes

Graph 7.11. shows Made Ground (MGR) has three plasticity index results from 12 – 19% varying between a medium plasticity silt and medium plasticity clay. Alluvium (ALV) shows a high plasticity clay (59%) and high liquid limit (LL) of 97 % exceeding other PI and LL values across the pipeline. This may be a result of potential highly organic material in the top 0.4 m bgl at 2L6008DR within 30 m of the Bow Lake linear watercourse. River Terrace Deposits (RTD) show 4 No. results varying between low to high plasticity clay and one result of medium plasticity silt. Head Deposits (HEAD) show 1 No. plasticity index result as a high plasticity clay (40%).

London Clay Formation is the most variable from low plasticity silt (an outlier) to high plasticity clay though is most commonly a high plasticity clay with plasticity index (PI) ranging between 32 – 42%. One outlier data point showing London Clay with a low plasticity silt (Plasticity Index of 5 % and Liquid Limit of 29 %) was at 2L6003SA at 8.5 m bgl possibly due to the interbedded mudstone / claystone at that approximate depth. Harwich Formation (HWH) is within the intermediate plasticity range. Lambeth Group (LMBE) varies between intermediate and high plasticity clay (17 – 40%).

Graph 7.11 Plasticity across Section L exploratory hole locations



7.6 Geotechnical Design Parameters for Section L boreholes

Based on the soil descriptions and results obtained from the in-situ and laboratory tests, the characteristic values for each stratum have been derived and are shown in **Table 7.5.**

Table 7.5: Geotechnical Design Parameters for Section L

Geotechnical Design Parameters										
Strata	**Native Soil Modulus, E'_3 (MN/m^2) [a]**	**Elastic Modulus E_u [b2]**	**Bulk density, γ (kN/m^3) [c]**	**Constant volume angle of shearing resistance, φ (°) [c]**	**Undrained Shear Strength, C_u (kPa) [b1]**	**Coefficient of Volume Compressibility, m_v (m^2/MN) [b1]**	**Uniaxial Compressive Strength (MPa)**	**Concrete Aggressivity [d]**	**Earthworks [b2]**	**From PSD results Embedment class with 'as-dug' soils [e]**
Made Ground	Soft clay: 1.5	Short Term: 2 MPa Long Term: 1 MPa	15 – 19	Based on 2 plasticity results of 17%, φ = 27°	20	0.3	Not Applicable	DS-1 AC-2z	1 V : 2 H	Variable – unsuitable for re-use
Alluvium (ALV)	Soft clay: 1.5	Short Term: 2 MPa Long Term: 1 MPa	15 – 19	Based on 1 plasticity result of 59%, φ = 20°	20	0.3	Not Applicable	Not available for Section L from other sections G and M : DS-1 AC-1	1 V : 3 H	Fine grained, liquid limit > 50%. Unsuitable for re-use
Head Deposits (HEAD)	Firm clay: 3	Short Term: 5 MPa Long Term: 4 MPa	16 – 20	Based on 1 plasticity result of 40%, φ = 22°	40	0.1	Not Applicable	DS-1 AC-1	1 V : 2.5 – 3 H	Fine grained, liquid limit > 50% and more than 50% fines. Unsuitable for re-use
River Terrace Deposits (RTD)	Medium dense gravel : 9 And Soft gravelly clay : 1.5	Medium dense gravel: 50 MPa Soft Clay Short Term: 2 MPa Long Term: 1 MPa	15 – 21	Based on 1 plasticity result of 32%, φ = 23° Medium dense gravel : φ = 34°	For soft clay: 20	Soft clay: 0.3	Not Applicable	DS-1 AC-1	1 V : 2.5 H	Potentially selected material suitable as S3 bedding – subject to further classification testing including liquid limit and PSD.
London Clay Formation (LC)	Soft clay:1.5 And Firm to very stiff clay: 6	Soft clay: Short Term: 2 MPa Long Term: 1 MPa Firm to very stiff clay: Short Term: 5 MPa Long Term: 4 MPa	Soft clay: 15 – 19 Firm to very stiff clay: 18 – 23	Based on average plasticity result of 34%, φ = 23°	Soft clay: 20 Firm to very stiff clay: 75	Soft clay: 0.3 Firm to very stiff clay: 0.1	0.07 – 0.34	DS-4 AC-4	1 V: 2.5 H	Fine grained, liquid Limit > 50% with < 25% fines. Unsuitable for re-use
Harwich Formation (HWH)	Stiff clay: 4 And Dense sand : 9	<u>Stiff clay</u> Short Term: 10 MPa Long Term: 7 MPa <u>Dense sand</u> 25 MPa	18 – 22	Based on average plasticity result of 23%, φ = 25°	<u>Stiff clay</u> 75	<u>Stiff clay:</u> 0.05	0.26	DS-4 AC-4	1 V : 2 H	Potentially selected material suitable as S4 bedding – subject to further classification testing including liquid limit and PSD. No PSD results in Section K. In Section H at 18.65m bgl, S4 was advised. Coarse grained soil with more than 12% fines

Geotechnical Design Parameters										
Strata	**Native Soil Modulus, E'_3 (MN/m^2) [a]**	**Elastic Modulus E_u [b2]**	**Bulk density, γ (kN/m^3) [c]**	**Constant volume angle of shearing resistance, φ (°) [c]**	**Undrained Shear Strength, C_u (kPa) [b1]**	**Coefficient of Volume Compressibility, m_v (m^2/MN) [b1]**	**Uniaxial Compressive Strength (MPa)**	**Concrete Aggressivity [d]**	**Earthworks [b2]**	**From PSD results Embedment class with 'as-dug' soils [e]**
Lambeth Group (LMBE)	Very stiff clay : 6 Very dense sand : 15	Very stiff clay Short Term: 25 MPa Long Term: 15 MPa Very dense sand 40 MPa	19 – 23	Based on average plasticity result of 26%, φ = 24°	Very stiff clay 150	Very stiff clay: <0.05	0.11 – 0.32	DS-3 AC-3	1 V : 2 – 2.5 H	Liquid limit >50, high plasticity. Unsuitable for reuse.

[a] (BSI, 2020) Table 13
[b1] (Tomlinson, 2001) Table 2.5,Table 2.11, Figure 2.33, Section 2.6.6
[b2] (Look, 2007) Table 11.7, Table 11.8, Figure 14.1, Table 14.10
[c] (BSI, 2015) Figure 2 and Section 4.3.1.4.8
[d] (BRE, 2005) Table C1
[e] (BSI, 2020) Table 24
Table 24 of BS9295:2020 corresponds to Table A.3 from the Water Industry Specification for Bedding and Side fill Materials for buried pipelines WIS 4-08-02 February 1994: Issue 1 document.

7.7 Resistivity Testing

In situ apparent resistivity testing was undertaken at four locations, the results are presented in **Table 7.6**

Table 7.6: Electrical Resistivity Results for Section LF

Hole ID	Electrode Spacing (m)			
	4.0m	3.0	2.0	1.0
	Apparent Resistivity (mean) (Ω.m)			
3L6017HP	9	12	10	7
3L6023HP	7	8	10	12
3L6024HP	7	7	8	12
3L6026HP	9	10	11	15
3L6028HP	7	7	9	10
3L6029HP	14	15	16	18
3L6100HP	10	12	16	26
3L6102HP	13	19	16	10
3L6105HP	7	8	9	11

7.8 Permeability Testing

Falling head permeability testing was undertaken at borehole 2L6011SR. The results are presented in **Table 7.7**.

Table 7.7: Falling head permeability testing results.

BH ID	Depth of Test (m bgl)	Test Type	Borehole / Standpipe	Permeability (k)	Strata
2L6011SR	1.00 – 5.00	Falling Head Permeability	Standpipe	3.1×10^{-8}	River Terrace Deposits & London Clay Formation

8 Geotechnical Considerations

8.1 Ground Conditions

The ground conditions recorded are generally in line with geological mapping for the area.

London Clay was mapped extensively at ground level across Section L, this was confirmed at 2L6001TP, 2L6003SA, 3L6013HP, 3L6015HP, 3L6017HP, 3L6023HP, 3L6024HP-B, 3L6028HP, 3L6029HP, 3L6044HP, 3L6100HP, 3L6101DS, 3L6102HP, 3L6103HP, 3L6104HP, 3L6105HP. At 3L6026HP Alluvium was mapped at ground level but London Clay was encountered on site in the borehole.

Made Ground was encountered at many unmapped locations but at the sites of PSCs as highlighted by the desk study, these were 2L6000TP, 2L6002SA, 2L6004TP, 3L6027HP, 3L6106DS, 3L6107DS. Made Ground was also encountered where no PSCs had been identified at 2L6009DR with Alluvium underlying it. 2L6005SA and 2L6006TP had Made Ground and Head Deposits overlying London Clay where London Clay had been mapped at ground level. At 3L6045HP Made Ground encountered where River Terrace Deposits was mapped, with London Clay underlying the Made Ground. At TP501 and 3L6046HP Made Ground was at the surface overlying River Terrace Deposits, which were mapped at the surface.

2L6007DR, 2L6008DR, 2L6010DR aligned with mapping, with Alluvium at ground level, while 2L6011SR encountered alluvium where River Terrace Deposits were mapped.

BH501, TP502, TP503, 2L6012SR aligns with mapped River Terrace Deposits.

Made Ground is more extensive across Section L than was suggested by the geological mapping, comprising soft brown sandy slightly gravelly.

Superficial deposits noted within the boreholes comprise a mixture of:

- Soft mottled brown grey slightly fine sandy gravelly clay (Alluvium) to 3.90 m bgl.
- Soft brown very gravelly clay with medium cobble content or medium dense brownish black slightly sandy clayey gravel (River Terrace Deposits) to 3.60 m bgl.
- Soft locally firm orangish brown sandy gravelly clay (Head Deposits) to 2.75 m bgl.

Bedrock deposits noted in boreholes comprise a mixture of:

- London Clay Formation noted as firm to locally very stiff laminated locally fissured brownish grey locally sandy clay locally with shell fragments and silt/sand lenses. A band of approximately 0.05 – 0.30 m, locally fragmented up to 0.50 m, thickness of medium strong to strong dark brown claystone is commonly encountered between 4.20 m – 15.70 m bgl. Where not shown on the borehole log 2L6002SA, 2L6005SA and 2L6012SR, it is also expected to be encountered in that area.
- Harwich Formation composed of a mixture of stiff grey sandy clay and medium dense to dense green and black glauconitic locally micaceous sand across boreholes 2L6008DR, 2L6011SR and 2L6012SR.
- Lambeth Group is encountered between 14.40 m bgl to >20 m bgl in 2L6007DR, 2L6008DR, 2L6010DR, 2L6011SR, 2L6012SR and BH501 from Phase 1 ground investigation (to 42.05 m bgl in BH501) though only the top 33 m is being considered relevant at BH501. Phase 3B/3C investigations 3L6101DS and 3L6107DS encountered Lambeth Group as shallow as 0.35 m bgl. Lambeth Group comprises stiff to very stiff locally fissured bluish grey mottled yellowish brown and multicoloured locally sandy clay in addition to grey and speckled black fine and medium sand with occasional pockets of decomposed organic material (30 mm x 15 mm) and progressively more lignitic material with increasing depth.
- Additionally, within the Lambeth Group, at 2L6011SR from 17.10 – 18.60 m locally cemented medium spaced strong to very strong nodules/concretions typical of Lower Mottled Beds subdivision (60 mm x

100 mm) were noted. Published literature also refers to these bands as duricrusts, which are cements within the Lambeth Group within the Lower Mottled Beds subdivision, a deposit that can cause difficulties in excavation (Hight et al. , 2004).

Alluvium, River Terrace Deposits, London Clay Formation and Lambeth Group are generally likely to be founding strata for the 1200 mm diameter ductile iron (DI) open-cut pipeline sections within 3 – 6 m bgl.

Trenchless crossings such as at the Bow Lake area within very close proximity to 2L6007DR – 2L6010DR inclusive. The trenchless crossing near 2L6011SR and 2L6012SR is expected to be founded within the London Clay Formation bedrock as it was encountered from 2.0 – 20.0 m bgl.

Harwich Formation was also encountered locally between 12.40 – 18.65 m bgl at 2L6008DR, 2L6011SR and 2L6012SR. It is expected though not shown on the borehole log for 2L6007DR that was originally paired with 2L6008DR that Harwich Formation may be encountered at a similar level to 2L6008DR in the area.

Lambeth Group was encountered locally between 14.40 – 20.10 m bgl at 2L6007DR, 2L6008DR, 2L6010DR, 2L6011SR and 2L6012SR. It is expected, though not shown on the borehole log for 2L6009DR that was originally paired with 2L6010DR, that Lambeth Group may be encountered at a similar level to 2L6009DR in the area. Lambeth Group is also encountered from 17.25 – 42.05 m bgl within BH501.

8.2 Foundation Design

Open-cut pipeline sections are expected to be founded with all strata within Section L described above.

For the approximate 5.9 km length of pipeline proposed across Section L, bearing resistance or settlement issues are not expected due to a net reduction in ground bearing pressure at formation level, and hence bearing resistance and settlement issues are not anticipated.

8.3 Shallow Excavation

8.3.1 Excavation

Shallow excavations for the proposed open-cut pipeline route are expected to be constructed between 3 m – 6 m bgl, all within superficial deposits, London Clay Formation and Lambeth Group . Excavations are expected to be within the capability of conventional plant.

Full excavation support would likely be required in all strata, particularly where these deposits are encountered near watercourses. Where space permits (e.g. in open land), it may be possible to construct the shallow pipework within unsupported battered trenches though sides of the excavation may be prone to drying out and weathering which could cause sides to slip. This is generally applicable to clays and with excavations open for a long time. Stepping temporary slopes and/or supporting trenches would be beneficial to prevent this from occurring (CIRIA, 1992).

8.3.2 Groundwater Control

Based on the ground investigation records, groundwater is likely to be encountered in shallow excavations across all monitored boreholes in Section L as the groundwater was encountered during drilling and within monthly and hourly downhole dataloggers (2L6009DR, 2L6011SR) monitoring between ground level and 3.74 m bgl (+17.61 m OD).

- At 2L6009DR: groundwater was recorded between 0.06 m bgl (+23.05 m OD) and 2.67m bgl, (20.46m OD) and at 2L6011SR: groundwater recorded a minimum of 0 m bgl (+21.35 m OD) and 3.77 m bgl (17.58 m OD) within Superficial deposits and London Clay Formation.

- At BH501, groundwater was recorded at a minimum of 1.86 m bgl (+19.08 m OD) to 2.00 m bgl (+18.94 m OD) within Superficial Deposits.

These are expected to be controllable by conventional sump pumping; it would need careful monitoring of fines removed. Well pointing alongside potential trenches created is another option to be considered.

There are no instances of artesian groundwater conditions above ground level during the investigation.

8.4 Flotation

The structures should be designed to resist flotation in all stage of temporary and permanent works.

8.5 Trenchless Construction

The Applicant has confirmed the current trenchless crossing pipeline, shaft dimensions and depths. Launch shaft dimensions will range between 9.0 m – 9.5 m diameter and reception shafts range between 5.0 m – 5.4 m diameter with a 700 mm – 800 mm diameter DI pipe within a 1200 mm internal diameter pipejack. Trenchless crossings are presumed to be driven west to east, so the launch shafts are always the most westerly shafts.

The majority of boreholes in Section L encountered a medium strong to strong, 0.05 – 0.50 m thick locally fragmented mudstone between 4.20 m and 15.70 m bgl within the London Clay Formation between 4.20 m and 15.70 m bgl. The pipe jack tooling would need to be able to drill through isolated bands of mudstone encountered near to Bow Lake, Winchester Road (2L6007DR – 2L6010DR inclusive) and near to the watercourse southeast of Highbridge Road B3335 (2L6011SR). These may also be encountered in shaft construction.

2L6007DR – 2L6008DR, 2L6009DR – 2L6010DR, 2L6011SR – 2L6012SR three trenchless crossings
Trenchless crossings are expected to be between 7.6 m bgl (east reception shaft) – 8.99 m bgl (west launch shaft) under the Bow Lake; London Clay Formation is encountered in these six boreholes (stiff/very stiff silty clay) which is considered optimum for pipe jacking for the 1200 mm DI pipeline.
In addition, originally the pipeline route in early 2023 was going through boreholes 2L6011SR and 2L6012SR, which also encountered London Clay Formation between 7.6 – 8.99 m bgl.

As of the current route is based on March 2024 information, the trenchless crossing changed to no longer connect from boreholes 2L6011SR and 2L6012SR. Instead, the trenchless crossing zone changed to connect between 2L6011SR and BH501.

Table 8.1: Shaft construction geology.

Trenchless Hole Location (Launch Pit)	Base of Shaft Construction Depth m bgl (m OD)	Shaft Strata	Trenchless Hole Location (Reception Pit)	Base of Shaft Construction Depth m bgl (m OD)	Reception Pit Shaft Strata
2L6008DR	8.99 (+16.03)	Alluvium and London Clay Formation	2L6007DR	7.63 (+17.39)	Alluvium and London Clay Formation
2L6010DR	8.99 (+14.59)	Alluvium and London Clay Formation	2L6009DR	7.63 (+15.49)	Alluvium and London Clay Formation

BH501 – 2L6011SR trenchless crossing

The other proposed crossings near to Phase 1 borehole (BH501), between Section L and Section M is expected to be approximately 33 m bgl, the trenchless construction tunnel depth. This trenchless construction zone is connected to 2L6011SR (east reception shaft), estimated depth here is to be provided by the Applicant. At the time of writing exploratory holes have not been undertaken at the location of the launch shaft.

Within Phase 1 borehole BH501, a groundwater strike was noted between 21.75 – 21.80 m bgl (-0.81 until -0.86 m OD) above the proposed trenchless construction depth of 33 m bgl (-12.06 m bgl) within the Lambeth Group strata. This may have been as a result of fissures and shear surfaces described on the borehole log between 20.75 m bgl (+0.19 m OD) – 30.90 m bgl (-9.96 m OD). Groundwater is above the depth of trenchless construction. The trenchless construction depth is greater than 11 m below this and is mid tunnel drive.

UCS Strength

Uniaxial Compressive Strength (UCS) test results near the proposed construction zone from 7.6 – 8.99 m bgl for 2L6007DR and 2L6008DR are of the same order of magnitude (0.084 MPa and 0.094 MPa maximum), comparable to firm clay (40 – 75 kPa); both 2L6011SR and 2L6012SR have similar UCS results between 0.18 – 0.19 MPa, comparable to stiff clay (75 – 150 kPa). For 2L6010DR, samples nearest available to the trenchless construction zone between 7.0 m bgl and 10.0 m bgl, UCS ranged between 0.07 and 0.10 MPa, comparable to firm clay (40 – 75 kPa). Also, at 2L6009DR and 2L6010DR (below the trenchless zone at 13.8 and 13.9 m bgl respectively) have similar UCS results between 0.17 – 0.19 MPa, comparable to stiff clay (75 – 150kPa). There are average strength differentials across each of these crossings, but they are of the same order of magnitude.

8.6 Ground Aggressivity

8.6.1 Concrete

The results of the pH and sulphate tests (SO_4) undertaken on Head Deposits, Alluvium and River Terrace Deposits natural ground material samples recovered indicate that worst case design sulphate class is DS-1 and the worst case aggressive chemical environment for concrete (ACEC) class AC-1. Made Ground worst case design sulphate class is DS-1 and the worst case aggressive chemical environment for concrete (ACEC) class AC-2z. For London Clay Formation, Harwich Formation and the Lambeth Group have worst case design sulphate class is DS-4 and the worst case aggressive chemical environment for concrete (ACEC) class AC4.

8.6.2 Ferrous Metals

Strata across the proposed pipeline route has the potential to be aggressive towards ferrous metals.

Following guidance published by TRL (Eyre, D., & Lewis, D.A., 1987) if clay (within Superficial deposits and clays within bedrock including London Clay Formation, Harwich Formation and Lambeth Group) are encountered with the below characteristics, it is considered aggressive towards ferrous metals with:

- Characteristic apparent resistivity value of 10 Ωm
- Organic content greater than 0.2 %
- Plasticity index greater than 15
- Poorly drained area or groundwater above pipework level
- Moisture content greater than 20 %
- pH greater than 6
- Soluble sulphate 500 to 1000 mg/l
- Aggressive compounds in Made Ground (e.g. cinder or coke)

Eyre and Lewis' (1987) Contractor Report has two soil corrosivity assessment methods; Table A1 and B1. Using worst case scenario, these two assessments class Section L as highly aggressive (Table A1) and very aggressive (Table B1) respectively (Eyre, D., & Lewis, D.A., 1987).

8.7 Geotechnical Hazard Assessment

Table 8.1 summarises potential geotechnical hazards associated with the Site during and post construction.

Table 8.1: Potential Hazards

Hazard	Source of information/comment	Mitigation method
Unforeseen Ground Conditions	Project specific ground investigation undertaken in 2023 and 2024 to inform outline design. Trenchless bore collapse and uncontrolled ground settlement, very soft / loose material present that is inadequate for founding of pipework / chambers.	No further GI required sufficient GI undertaken.
Groundwater	Lack of knowledge of groundwater conditions. Potentially result in inappropriate/inadequate choice of dewatering techniques, excessive sump pumping causing settlement, unstable ground, inappropriate bore support.	Groundwater results should be reviewed over a minimum period of 6 months. Downhole data loggers installed such as at 2L6009DR and 2L6011SR at a trenchless crossing location should inform the groundwater levels over a 12 month period to estimate any potential dewatering requirements prior to construction. Continued monitoring or groundwater at boreholes with installations.
Bore Collapse	Fracture indices during rotary coring highlighting areas of assumed zones of core loss. Inadequately defining mudstone bands commonly encountered in Section L boreholes or encountering sand/gravel horizons within the Harwich Formation / Lambeth Group that could lead to collapse if not supported.	When excavating, assess the degree of fracturing and structure as the excavation progresses in depth and lateral extent. Check to see if the excavation remains intact or blocky. If the ground becomes increasingly laminated and irregular, excavate in reduced thicknesses rather than larger blocks at a time to prevent the likelihood of collapse. Use vertical sided trench support: trench sheets or boxes, where required.
Excessive settlement, pipe failure / bursts.	Geological logs displaying strata to a maximum of 20 m BGL for the majority of locations with 1 location (BH501) drilled to 45.15 m. Subsidence and hidden soft areas of ground previously not identified during the GI.	Ensure that proposed pipework avoids these areas of unsuitable ground and buried structures where possible. If structures are within the route alignment, arrange with the Applicant and appropriate landowners for these to be investigated/removed as early as practicable. Other mitigation might include overdrive and replace, or increase pipe bedding due to poor native soil

Hazard	Source of information/comment	Mitigation method
Existing buried services - strike, injury	Utility drawings provided to the Principal Contractor / Ground Investigation Contractor may not reveal all services underground and may differ.	Ensure that utility providers are contacted in advance of excavation works with any uncertainty proven on site by those providers having engineers on site. They should be in attendance where necessary such as near high risk locations. For further confirmation, Ground Penetrating Radar (GPR) and/or PAS128 surveys may also be performed.
Unexploded ordnance (UXO) risk	The Site was impacted by bombing in WWII.	Preliminary Risk Assessments were conducted specific to each exploratory hole location to reduce the section-wide greater UXO risk. Preliminary Risk Assessments were conducted specific to each exploratory hole location to reduce the section-wide greater UXO risk. Detailed UXO assessment undertaken with the following findings (Zetica, 2024): ■ No significant sources of UXO hazard have been identified. ■ Proceed with works. An UXO awareness briefing is prudent for staff involved in excavations. LOW UXO hazard level is applied to Section L
Risk of concrete degradation, failure of concrete structures and proposed DI pipe.	BRE test results on Alluvium, Head Deposits and River Terrace Deposits from the GI show the maximum available design sulphate class is DS1. Corresponding Aggressive Chemical Environment for Concrete (ACEC) is AC1.Made Ground is DS-1 AC-2z. For London Clay Formation, Harwich Formation and Lambeth Group BRE test results show maximum available design sulphate class is DS4. Corresponding Aggressive Chemical Environment for Concrete (ACEC) is AC4.	No further testing required. London Clay Formation, Harwich Formation and Lambeth Group contain high amounts of pyrite and consequently aggressive towards concrete. Resistivity testing undertaken at several locations.

9 Conclusions and Further Considerations

9.1 Geotechnical

The ground investigation data for Section L comprising 37 exploratory locations is appropriate for the selected areas of trenchless crossings beneath Winchester Road, Bow Lake and smaller courses east of Highbridge Road and at the Potential Sources of Contamination.

Shallow superficial deposits, London Clay Formation and Lambeth Group are likely to be encountered during open-cut construction with London Clay Formation bedrock only likely to be expected at trenchless crossings.

High water levels across the borehole locations may require conventional sump pumping to take place. With deeper shafts, groundwater control may be difficult using ejectors, so other dewatering methods may have to be used.

Pipejacking techniques have been decided by the Applicant as the trenchless crossing technique due to passing under multiple sensitive land-uses.

Proposed open-cut construction between 3 – 6 m bgl will be within Alluvium, River Terrace Deposits, London Clay Formation and Lambeth Group, and trenchless construction will be between 7.6 – 8.99 m bgl are expected to be within London Clay Formation. Between BH501 and 2L6011SR, trenchless construction will be approximately 33 m bgl within Lambeth Group deposits. All natural superficial deposits are not aggressive to concrete suggesting a worst-case design sulphate class of DS-1 and the worst case aggressive chemical environment for concrete (ACEC) class AC-1, while Made Ground is DS-1 AC-2z. The bedrocks (London Clay Formation, Harwich Formation and Lambeth Group) are all aggressive to concrete, with a worst case design sulphate class of DS-4 and the worst case ACEC class of AC-4.

As a result of particle size distribution (PSD) tests, Made Ground (MGR), Alluvium (ALV), Head Deposits (HEAD) and London Clay Formation (LC) and Lambeth Group (LMBE) are unlikely to be suitable for re-use. River Terrace Deposits and Harwich Formation indicate the material embedment class without processing is S4 (coarse grained material with more than 12% fines). As a result, on-Site screening would be required prior to pipeline placement within the open-cut trench or trenchless crossing where cohesive River Terrace Deposits and Harwich Formation are likely to be encountered. Where granular natural deposits are not encountered throughout pipeline construction such as with MGR, ALV, HEAD and LC and LMBE granular side-fill materials would require importing.

9.2 Geo-Environmental

The Phase 2 GI along Section L focused on two high-risk PSCs identified by the desk study: BGS Made Ground (PSC 440) and the historic Crowd Hill Landfill (PSC 441) (SSP, 2023). The Phase 3 GI focused on an additional high-risk PSC second location, historic Crowd Hill Landfill (PSC 472). Testing within the GI was performed to assess their potential impact on the pipeline installation within this section (which is largely via open cut installation and in some places beneath watercourses in trenchless crossings). Soil samples were collected from exploratory holes advanced within the DoL route and post-GI groundwater and ground gas monitoring was carried out from the six trenchless crossing boreholes. Soil and groundwater samples were analysed in the laboratory.

Visual signs of contamination encountered during ground investigations (Phase 2 and Phase 3B/3C) were isolated to potential asbestos fragments and concrete sheeting (PACM) in Made Ground within 2L6002SA and

2L6005SA. Made Ground was encountered within this area to a maximum depth of 0.70 m bgl and there was little evidence within the boreholes to suggest this material corresponds to the suspected landfilling (PSC 441) in the area. The Phase 3B/3C GI also advanced two locations (3L6016DS and 3L6107DS) to target a second BGS identified Crowd Hill Landfill Location (PSC 472), Made Ground was encountered within this area to a maximum depth of 0.35 m bgl, with little evidence of landfilling.

The preliminary risk assessment prepared during the desk study was revised to incorporate findings from the results from the Phase 2 and Phase 3B/3C GI data; this identified the following summarised risks:

- A High risk to construction and maintenance workers can be considered applicable for soils within the vicinity of 2L6005SA due to asbestos identified. The potential of encountering further asbestos within the vicinity of this location cannot be discounted.
- A Moderate risk also applies to construction and maintenance workers due to exceedances in groundwater or elevated pockets of ground gas.
- A Moderate risk to groundwater and surface waters at the trenchless crossings, specifically those that go beneath or close to watercourses which may be within hydraulic continuity with groundwater and areas where open cut excavation is due to take place.
- All other potential contaminant linkages were either identified as Low or Very Low.

Due to a high-water table across borehole locations, dewatering will be required during construction works. Because of exceedances encountered within groundwater samples, laboratory analysis results are to be forwarded as part of a discharge consent application. If groundwater is to be contained in a storage vessel for off-Site disposal, laboratory analysis results must be forwarded to the waste disposal Site for confirmation of acceptance prior to works.

10 Recommendations

10.1 Geotechnical

Further Ground Investigation is recommended.
Section L locations are representative of the majority of the of the approximate 5.9 km length of the Proposed Development.

- Additional GI along the route is performed to fully understand and characterise the soil required to be excavated / removed / reused at additional potential trenchless crossings beneath roads, water courses and vegetation.

10.2 Geo-Environmental

Further GI is recommended.
The Phase 2 and 3 GIs have provided limited data with regards to the extent and nature of the Crowd Hill Landfill, both locations (PSCs 441 and 472), and BGS Artificial Ground (PSCs 440) which the desk study suggested extended across the Proposed Development route. ACM material has been identified within the vicinity of 2L6005SA which was advanced to investigate PSCs 440/441. Soil leachate data is also lacking across the Site and groundwater exceedances encountered in samples will require further investigation.

Specific details of the additional recommended GI are outlined below:

- With regards to the extent of PSCs 440, 441 and 472 it may be that current exploratory holes are positioned on the periphery of the BGS Made Ground/Landfills. Further GI should investigate ground conditions within this part of the DoL.
- The extent of ACMs identified within 2L6005SA is currently unknown and further asbestos could therefore be present and disturbed by open cut excavations. Further GI in this area should therefore be undertaken to inform on health and safety for construction workers, and also to determine excavated materials management including the potential for reuse.
- Following further GI to delineate extent of asbestos impact, construction / future maintenance workers should be asbestos awareness trained. Should identifiable asbestos fragments or suspected asbestos containing material be observed, during construction works should stop whilst a sample(s) is/are collected and sent for analysis. The area should then be backfilled, and further investigation may be necessary to determine the extent of asbestos on Site. Any works involving the sampling and removal of asbestos on Site should be managed by an appropriately licenced and/or accredited Third Party where necessary.
- Install or continue monitoring groundwater / gas monitoring wells at / near PSCs with the potential to generate ground gases (e.g., historical landfills or areas of potentially infilled land). In addition to provide further information regarding PCOCs within groundwater at these locations.
- Further soil, leachate and groundwater sampling at trenchless crossing locations in order to further investigate exceedances identified at these locations, such as TPH, PAH and inorganics.
- Include an exploratory location within the expected areas to obtain further information regarding PCOCs in groundwater and risks to workers from inhalation of ground gases, particularly for trenchless crossing locations.
- Include groundwater sampling and water quality testing as part of future phases of GI at selected locations across the Section L route.

- Ground Gas is considered unlikely to pose an adverse risk to human health on-Site, however monitoring has yielded sporadically high concentrations of carbon monoxide (42 ppm) and very low concentrations of oxygen (0.1%) around the trenchless crossing point in the north of the site. Encountering further pockets during construction cannot be discounted, as an extra precaution constructions workers could wear personal gas monitors.
- There are currently no known proposals to reuse soils on Site. However, based on the limited soil leachate data and limited groundwater data specifically in the northern part of the Section, if reuse is proposed, to assess suitability for reuse further soil sampling and testing would be recommended prior to construction to determine the potential risks posed to human health and controlled waters.

Conduct additional geo-environmental monitoring during construction.
Recommendations for ground gas and groundwater monitoring / testing during the construction phase to be provided within the Construction Phase Environmental Management Plan.

Watching Briefs
Watching briefs should be in place during construction. Groundworkers should remain vigilant throughout construction, particularly within the vicinity of PSCs, and should visual and/or olfactory indicators of contamination (including asbestos) be encountered, works should cease in that area and advice be sought from a suitably qualified geo-environmental professional. Further testing and specialist advice may be required. This is particularly applicable to parts of Section L being constructed using open-cut excavation.

Stockpile Management
Stockpile material must be well managed and kept on an area of hardstanding located down gradient of surface water drainage that may potentially discharge to a watercourse. It is recommended that any stockpiled material is covered to prevent rainfall infiltration, run off, and leachate and dust generation. Stockpiles should be secured when not in use to prevent third party access.

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Figures

Appendices

Appendix A: Section L Desk Study Information Specific to the Ground Investigation

Table A1 summarises desk study information specific for the Phase 2 GI areas in Section L. The information was used to develop the preliminary conceptual site model (CSM) presented in the HWTWRP Geotechnical and Geo-environmental desk study Version 4 (SSP, 2024).

Table A1: Geo-environmental Desk Study Summary Information for Phase 2 GI Locations Section L

		2L6000TP, 2L6001TP, 2L6004TP, 2L6006TP, 2L6002SA, 2L6003SA and 2L6005SA	2L6007DR and 2L6008DR	2L6009DR and 2L6010DR	2L6011SR and 2L6012SR
Geology	**Superficial Deposits**	Head Deposits	Alluvium	Alluvium and River Terrace Deposits	River Terrace Deposits
	Bedrock Geology	London Clay Formation (Sand), London Clay Formation (Clay, Silt, Sand)	London Clay Formation (Clay, Silt, Sand)	London Clay Formation (Clay, Silt, Sand)	London Clay Formation (Clay, Silt, Sand) and Lambeth Group
	Artificial/Made Ground [1]	Made Ground (PSCs No. 440 and 441)	None	None	None
Hydrogeology	**Bedrock Aquifer Classification**	Unproductive stratum (London Clay)		Unproductive stratum (London Clay and Lambeth)	
	Superficial Aquifer Classification	Secondary Undifferentiated	Secondary A Aquifer	Secondary A Aquifer	Secondary A Aquifer
	Source Protection Zones (SPZs)	None			
	Groundwater Abstractions [1]	Fish Farm / Cress Pond: c. 470 m north	Fish Farm / Cress Pond: c. 85 m north	Fish Farm / Cress Pond: c. 400 m east.	None within 500 m
Hydrology	**Surface Watercourses**	Bow Lake Watercourse from approximately 140 m north.	Bow Lake watercourse approximately 50 m north.	Bow Lake Watercourse Trenchless Crossing to go beneath watercourse.	Unnamed tributary of the Itchen Trenchless Crossing beneath watercourse.
	Surface Water Abstractions [1]	Fish / Cress Farm throughflow c. 470 m north	Fish / Cress Farm throughflow c. 370 m north/northeast	None within 500 m	
	Nitrate Vulnerable Zone	S811 Bow Lake NVZ			
Flooding	**Risk for Surface Water**	Low Risk within the vicinity of Winchester Road	High Risk due to the Bow Lake Watercourse	High Risk due to unnamed tributary of the Itchen	
	Risk for Rivers and the sea	Flood Zone 1	Flood Zone 3		
Site History	**On-Site**	Earliest and current mapping shows the location of the exploratory holes as agricultural land. There is no evidence of earthworks / landfilling activity on historical mapping over time at the location of the Crowd Hill historical landfill (PSC No. 441) / BGS Made Ground (PSC No. 440), however, EA records show this to be active between 1962 and 1972.			
	Surrounding Land	Colden Common village developed to the north of the route and a pond was noted within Colden Common Wood. Other notable features from early mapping include Bow Lake situated approximately 1 km west with an associated watercourse flowing in an east/west direction. A Brick works and associated brick field is noted to have been present in the west (closest borehole is 2L6005SA, to the east) of Section L between the late 1880s to the 1930s and along Portsmouth Road a row of industrial premises including garages, workshops and a scrap yard which have been present since the 1980s, between approximately 170 m to 450 m north/northeast of the current pipeline route.			
Pollution Incidents		There are no pollution incidents (category 1 or 2) within 50 m of the GI locations.			
Landfill Sites		PSC No. 441 Crowd Hill Landfill assumed on-Site and approximately 50 m from 2L6006TP.	PSC No. 441 c.230m southeast of borehole location.	None within 250 m.	None within 250 m.
Ecological Sensitivity (250m radius)	**Sites of Special Scientific Interest (SSSI)**	None Present			
	Special Areas of Conservation (SAC)				

		2L6000TP, 2L6001TP, 2L6004TP, 2L6006TP, 2L6002SA, 2L6003SA and 2L6005SA	2L6007DR and 2L6008DR	2L6009DR and 2L6010DR	2L6011SR and 2L6012SR
	Special Protection Areas (SPAs)				
	RAMSAR site				
	National Parks	South Downs National Park >1 km northeast			
	Ancient Woodlands	Hill Copse Woodland	Fishers Pond Wood <50 m north	Park Hills Wood 50 m to 250 m	Lords Wood <50m south
Preliminary Risk Assessment	**Overall Risk Assessment**	High risk though posed to construction workers from PSC No's. 440 and 441 due to potentially coming into contact with landfill material.	N/A – not targeting PSCs		

1. active groundwater and surface water abstractions within 1 km; surface waters up to 250 m; artificial ground up to 250 m. All distances are approximate.

Table A2 summarises desk study information specific for the Phase 3B/3C GI areas in Section L. The information was used to develop the preliminary conceptual site model (CSM) presented in the HWTWRP Geotechnical and Geo-environmental desk study Version 3 (SSP, 2023)

Table A2: Geo-environmental Desk Study Summary Information for Phase 3 GI Locations Section L

		3L6013HP, 3L100HP, 3L6015HP, 3L6101DS, 3L6102HP, 3L6017HP	3L6103HP, 3L6104HP, 3L6105HP, 3L6023HP, 3L6024HP	3L6106DS, 3L6107DS	3L6026HP, 3L6027HP, 3L6028HP, 3L6029HP	3L6041HP, 3L6042HP, 3L6043HP, 3L6044HP, 3L6045HP, 3L6046HP
Geology	**Superficial Deposits**	None	None	None	Alluvium (only recorded beneath 3L6026HP)	River Terrace Deposit (only recorded beneath 3L6046HP)
	Bedrock Geology	London Clay Formation (Clay, Silt, Sand)	London Clay Formation (Clay, Silt, Sand)	London Clay Formation (Clay, Silt, Sand)	London Clay Formation (Clay, Silt, Sand)	London Clay Formation (Clay, Silt, Sand)
	Artificial/Made Ground [1]	None	None	None	None	None
Hydrogeology	**Bedrock Aquifer Classification**	None				
	Superficial Aquifer Classification	None			Secondary A Aquifer	Secondary A Aquifer (only 3L6046HP)
	Source Protection Zones (SPZs)	None				
	Groundwater Abstractions	None within 500 m	113 m southwest of 3L6023HP and 150 m southeast 3L6024HP. 320 m west of 3L6105HP	397 m and 471 m southeast from 3L6106DS and 3L6107DS respectively.	445 m northwest of 3L6029HP	None within 500 m
Hydrology	**Surface Watercourses**	None within 500 m	Bow Lake 460 m north of 3L6024HP.	Fish Farm / Cress Point approximately 490 m northeast.	None within 500 m	Bow Lake watercourse 70 m, 180 m and 295 m south of 3L6041HP, 3L6042HP and 3L6043HP respectively. Unnamed tributary of the Itchen Trenchless Crossing beneath watercourse 78 m and 310 m northwest of 3L6046 HP and 3L6045HP.
	Surface Water Abstractions [1]	None within 500 m		Fish Farm / Cress Point approximately 490 m northeast.	None within 500 m	Fish Farm / Cress Point approximately 480 m west (only for 3L6041HP)
	Nitrate Vulnerable Zone	S811 Bow Lake NVZ				
Flooding	**Risk for Surface Water**	High Risk within the vicinity of Winchester Road	High Risk within the vicinity of Portsmouth Road approximately 450 m to 500 m north of locations.	High Risk mapped 150 m west due to drain from Bow Lake Watercourse.	High Risk mapped 150 m east of 3L6027HP due to drain from Bow Lake Watercourse.	High Risk mapped between 80 m to 285 m south of 3L6041HP, 3L6042HP and 3L6043HP.
	Risk for Rivers and the sea	Flood Zone 1				Flood Zone 3
Site History	**On-Site**	The earliest mapping from the late 1800s from indicates the Section is largely woodland and farms. Fisher's Pond is shown within Colden Common Wood. Bow Lake and the associated watercourse flowing east to west is also present. Brick works and a brick field are recorded in the West section L are no longer shown by the 1930s. A row of industrial premises including garages, workshops and a scrap yard is shown along Portsmouth Road during the 1980s until the present day. The remaining areas of the Section have little development from the c.1888-1913 mapping to present.				
	Surrounding Land	Colden Common village developed to the north of the route and a pond was noted within Colden Common Wood. Other notable features from early mapping include Bow Lake situated approximately 1 km west with an associated watercourse flowing in an east/west direction. A Brick works and associated brick field is noted to have been present in the west (closest borehole is 2L6005SA, to the east) of Section L between the late 1880s to the 1930s and along Portsmouth Road a row of industrial premises including garages, workshops and a scrap yard which have been present since the 1980s, between approximately 170 m to 450 m north/northeast of the proposed pipeline route.				
Pollution Incidents		There are no pollution incidents (category 1 or 2) within 50 m of the GI locations.				
Landfill Sites		None within 250 m.			PSC No. 441 Crowd Hill Landfill assumed on-Site and approximately 70 m west from 3L6029HP	None within 250 m.

		3L6013HP, 3L100HP, 3L6015HP, 3L6101DS, 3L6102HP, 3L6017HP	3L6103HP, 3L6104HP, 3L6105HP, 3L6023HP, 3L6024HP	3L6106DS, 3L6107DS	3L6026HP, 3L6027HP, 3L6028HP, 3L6029HP	3L6041HP, 3L6042HP, 3L6043HP, 3L6044HP, 3L6045HP, 3L6046HP
Ecological Sensitivity (250m radius)	Sites of Special Scientific Interest (SSSI)	None Present				
	Special Areas of Conservation (SAC)					
	Special Protection Areas (SPAs)					
	RAMSAR site					
	Ancient Woodlands	Park Hills Wood approximately southwest 380 m.	Park Hills Wood approximately 300 - 400 m south/southwest of 3L6103HP, 3L6104HP and 3L6105HP.	Park Hills Wood approximately 130 m south.	Park Hills Wood approximately 300 - 400 m south of locations	Lords Wood <50m south of 3L6045HP and 3L6046HP.
Preliminary Risk Assessment	Overall Risk Assessment	N/A – not targeting PSCs		High risk though posed to construction workers from PSC 472 due to potentially coming into contact with landfill material.	N/A – not targeting PSCs	

Taken from Groundsure reports - Groundsure report GSIP-2024-14509-18298_2A, Groundsure report GSIP-2024-14509-18298_2B

Appendix B: Chemical Analysis List of Suites and Geo-Environmental Testing

Table B1: Summary of Geo-environmental Laboratory Tests

Analysis Suites [1]																
Borehole ID	Sample Depth (m)	Soils							Leachates including Suite 3.0 Leachate Preparation				Groundwaters			
		Suite 1.1 Made Ground including WAC	Asbestos Identification and Quantification if detected	Suite 1.3 Natural	Suite 1.7 Pesticides	Suite 1.8 Herbicides	Suite 1.10 WAC	Suite 2.16 BGS Landfill including WAC	Suite 4.15 BGS Made Ground / Landfill Leachate	Suite 3.1 Standard leachate	Suite 3.6 Pesticide leachate	Suite 3.7 Herbicide leachate	Suite 3.0 Standard	Suites 3.6 & 3.7 Pesticides and Herbicides	Suite 3.9 Hydrogeology	Suite 4.15 BGS Made Ground / Landfill
2L6000TP	0.1							✓	R				N/A	N/A	N/A	N/A
	0.5							✓								
	3.1							✓								
2L6001TP	0.1							✓	R							
	0.3							✓								
	1							✓								
	3.5							✓								
2L6004TP	0.1							✓	R							
	0.5							✓								
	3							✓								
	4							✓								
2L6006TP	0.1							✓	R							
	0.5							✓	R							
	2.3			✓			✓									
2L6002SA	0.1		✓					✓					N/A			✓ 12/05/23 20/07/23 16/09/23
	0.5		✓					✓								
	3							✓								
	5.2							✓								
2L6003SA	0.1							✓	R							✓ 12/05/23 20/07/23 16/09/23
	1							✓								
	6							✓								
2L6005SA	B4 0.05 – 0.3		✓										N/A			
	D2 0.05 – 1.00		✓										N/A			
	0.1		✓						R	R						
	0.3		✓													
	0.5		✓													
	0.65		✓										N/A			✓ 11/05/23 18/07/23 16/09/23
	1							✓								
	3							✓								
	6							✓								

Analysis Suites [1]																
Borehole ID	Sample Depth (m)	Soils							Leachates including Suite 3.0 Leachate Preparation				Groundwaters			
		Suite 1.1 Made Ground including WAC	Asbestos Identification and Quantification if detected	Suite 1.3 Natural	Suite 1.7 Pesticides	Suite 1.8 Herbicides	Suite 1.10 WAC	Suite 2.16 BGS Landfill including WAC	Suite 4.15 BGS Made Ground / Landfill Leachate	Suite 3.1 Standard leachate	Suite 3.6 Pesticide leachate	Suite 3.7 Herbicide leachate	Suite 3.0 Standard	Suites 3.6 & 3.7 Pesticides and Herbicides	Suite 3.9 Hydrogeology	Suite 4.15 BGS Made Ground / Landfill
2L6007DR	0.55			✓									✓ 17/08/2023			
2L6008DR	0.3									✓	✓	✓	✓ Shallow : 10/05/23 19/09/23 R Deep : 16/08/23			
	3			✓						✓						
	6.5			✓						✓						
	16.3			✓												
2L6009DR	0.1	✓	✓		✓	✓	n✓			R	R	R	✓ Shallow: 10/05/23 19/09/23 Deep: 16/08/23			
	0.55			✓												
	2.9			✓						R						
2L6010DR	0.1			✓						R			✓ 10/05/23 ✓ 20/07/23 R 14/09/23			
	1			✓												
	11.25			✓						R						
2L6011SR	0.1		✓	✓	✓	✓	n✓						✓ Shallow: 04/05/23 Deep: 14/09/23			
	0.5		✓	✓			n✓									
	3			✓												
	6			✓												
2L6012SR	0.3			R*									✓ 03/05/23 18/07/23			
	1			R*						R						
	3			R*						R						
3L6013HP	0.1			✓									N/A		N/A	
	0.5			✓												
3L6017HP	0.2			✓												
	1			✓												
3L6024HP-B	0.5			✓												
3L6026HP	0.5			✓												
3L6100HP	0.2			✓												
	1			✓												
3L6102HP	0.2			✓												
	0.5			✓												
3L6104HP	0.5							✓								
	1							✓								
3L6106DS	3.5							✓							✓ 01/06/24 03/07/24	

Analysis Suites [1]																
Borehole ID	Sample Depth (m)	Soils							Leachates including Suite 3.0 Leachate Preparation				Groundwaters			
		Suite 1.1 Made Ground including WAC	Asbestos Identification and Quantification if detected	Suite 1.3 Natural	Suite 1.7 Pesticides	Suite 1.8 Herbicides	Suite 1.10 WAC	Suite 2.16 BGS Landfill including WAC	Suite 4.15 BGS Made Ground / Landfill Leachate	Suite 3.1 Standard leachate	Suite 3.6 Pesticide leachate	Suite 3.7 Herbicide leachate	Suite 3.0 Standard	Suites 3.6 & 3.7 Pesticides and Herbicides	Suite 3.9 Hydrogeology	Suite 4.15 BGS Made Ground / Landfill
																19/07/24
3L6107DS-A	1.6							✓	✓				N/A			N/A
	5.6							✓								
Total Completed/Requested		**1/1**	**11/11**	**25/28**	**3/3**	**3/3**	**4/1**	**28/29**	**1/8**	**3/9**	**1/2**	**1/2**	**11/13**			**12/12**

Notes:
[1] List of analytes included in each suite is presented in **Appendix B**.
✓ Requested and completed.
n✓ Not requested but received.
R requested but not received to date in either AGS format or Final Factual GI report (SOCOTOC, 2023)
*Sample disposed of prior to testing
B4 Bulk Sample
D2 Disturbed Sample
N/A not applicable

Appendix C: Deviations Reported by Analytical Laboratory

The Quality Control (QC) associated with the results of the following soil analysis did not wholly meet the QMS requirements, therefore the accreditation has been removed by the analytical laboratory. However, the laboratory has confidence in the performance of the method as a whole and the integrity of the data has not been significantly compromised:

- 2L600TP 1.5 m, 2L6001TP 0.05 m, 2L6003SA 1.65 m and 2L6005SA 0.30 m: Sample date not supplied, Anions 2:1 (30 days), Total Sulphur ICP (7 days), Total Sulphate ICP (30 days), Metals ICP Prep (182 days), pH + Conductivity (7 days).
- 2L6010DR 0.10 m, 1.00 m and 11.25 m: GRO (>C6-C10) Total and pH (2:5:1) exceeded holding times.
- 2L6003SA 6.40 m water sample: BTEX & MTBE by GCMS exceeded holding time.
- 2L6005SA 3.34 m water sample: Electrical conductivity and pH exceeded holding time.
- 2L6011SR 4.86 m water sample: Electrical conductivity and pH exceeded holding time.
- 2L6012SR 0.60 m water sample: Electrical conductivity and pH exceeded holding time.
- 3L6013HP 0.10 m soil sample: GRO (>C6-C10) Total exceeded holding time.
- 3L6027HP 0.15 m soil sample: GRO (>C6-C10) Total, BTEX by GCFID and BTEX for WAC by GCFID exceeded their holding times.
- 3L6100HP 0.20 m and 1.00 m soil samples: GRO (>C6-C10) Total and TPH (>C10-C40) Total with Silica Cleanup exceeded their holding times.
- 3L6101DS 2.85 m soil sample: Cyanide (Complex) by SFA, Cyanide (Free) by SFA, Cyanide (Total) by SFA, Phenol Index (Total) by SFA, Phenol Index in Solids (BSEN 12457-2) Filtered, Sulphide by SFA, Thiocyanate by SFA, TPH (>C6-C40) Total (Calc), BTEX & MTBE by GCMS, VOCs (Target List and TICs) by GCMS exceeded their holding times.
- 3L6106DS 0.20 m soil sample: Cyanide (Complex) by SFA, Cyanide (Free) by SFA, Cyanide (Total) by SFA, Phenol Index (Total) by SFA, Phenol Index in Solids (BSEN 12457-2) Filtered, Sulphide by SFA, Thiocyanate by SFA, VOCs (Target List and TICs) by GCMS, TPH (>C10-C40) Total with Silica Cleanup, SVOCs (Target List and TICs) by GCMS, PFOS & PFOA by LC-MSMS, BTEX by GCFID, Electrical conductivity, pH, BTEX for WAC by GCFID, MTBE by GCFID and PAHs (inc. Coronene) for WAC by GCMS exceeded their holding times.
- 3L6107DS 0.15 and 1.00 m soil samples: Cyanide (Complex) by SFA, Cyanide (Free) by SFA, Cyanide (Total) by SFA, Phenol Index (Total) by SFA, Phenol Index in Solids (BSEN 12457-2) Filtered, Sulphide by SFA, Thiocyanate by SFA, VOCs (Target List and TICs) by GCMS, TPH (>C10-C40) Total with Silica Cleanup, SVOCs (Target List and TICs) by GCMS, PFOS & PFOA by LC-MSMS, BTEX by GCFID, Electrical conductivity, pH, BTEX for WAC by GCFID, MTBE by GCFID and PAHs (inc. Coronene) for WAC by GCMS exceeded their holding times.
- 3L6106DS 3.50 m soil sample: BTEX for WAC by GCFID, MTBE by GCFID Electrical conductivity, pH, GRO (>C6-C10) Total, SVOCs (Target List and TICs), VOCs (Target List and TICs) by GCMS
- 3L6106DS 1.00 m soil sample: Ammoniacal Nitrogen as N, Chloride by Colorimetry, Chromium VI (Hexavalent) by Colorimetry, Nitrate as NO3 by Colorimetry, Nitrite as NO2 by Colorimetry, Orthophosphate as P by Colorimetry, Thiocyanate by Colorimetry, LOC: Leached Organic Carbon Filtered exceeded their holding times.
- 3L6107DS 1.60 m and 5.60 m soil samples: TPH (>C10-C40) Total with Silica Cleanup, SVOCs (Target List and TICs) by GCMS, PFOS & PFOA by LC-MSMS and PAHs (inc. Coronene) for WAC by GCMS exceeded their holding times.
- 3L6107DS 1.60 m soil sample: PFOS & PFOA by LC-MSMS exceeded their holding times.

Appendix D: Geo-Environmental Laboratory Analysis Summary Screening Tables

Appendix E: HazWasteOnline™ Reports

Appendix F: Gas Monitoring Results

Table F1: Ground Gas Monitoring Results Summary for 2L6002SA

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
20 April 2023	<0.1	0.1	21.3	<1	<1	0.1	<0.1
12 May 2023	<0.1	<0.1	20.8	<1	<1	<0.1	<0.1
24 May 2023	<0.1	<0.1	21.1	1	1	<0.1	-1.3
19 June 2023	<0.1	2.2	16.6	<1	1	0.3	<0.1
18 July 2023	<0.1	3.6	17.4	<1	1	0.3	<0.1
15 August 2023	<0.1	4.3	13.1	<1	<1	0.6	<0.1
13 September 2023	<0.1	4.2	16	<1	1	0.1	<0.1

Notes:
CH_4 - Methane, CO_2 – Carbon Dioxide, O_2 – Oxygen, CO – Carbon Monoxide, H_2S – Hydrogen Sulphide, VOC – Volatile Organic Compounds.
ppmv - Part per Million Volume

Table F2: Ground Gas Monitoring Results Summary for 2L6003SA

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
20 April 2023	<0.1	<0.1	21.1	<1	1	<0.1	<0.1
12 May 2023	<0.1	<0.1	21	<1	<1	<0.1	<0.1
24 May 2023	<0.1	<0.1	21	1	<1	<0.1	-0.1
19 June 2023	<0.1	<0.1	20.7	2	<1	<0.1	<0.1
15 August 2023	<0.1	1.3	15.7	<1	1	0.8	<0.1
13 September 2023	<0.1	1.2	18.4	<1	<1	0.1	<0.1

Notes:
CH_4 - Methane, CO_2 – Carbon Dioxide, O_2 – Oxygen, CO – Carbon Monoxide, H_2S – Hydrogen Sulphide, VOC – Volatile Organic Compounds.
ppmv - Part per Million Volume

Table F3: Ground Gas Monitoring Results Summary for 2L6005SA

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
20 April 2023	<0.1	<0.1	21.8	<1	<1	<0.1	<0.1
12 May 2023	<0.1	-	-	<1	<1	<0.1	<0.1
24 May 2023	<0.1	<0.1	21.7	1	<1	<0.1	<0.1
19 June 2023	<0.1	0.3	21.2	2	<1	0.1	<0.1
18 July 2023	<0.1	3.9	16.6	1	1	0.4	-20.4
15 August 2023	0.1	4.1	16	<1	<1	1.3	<0.1
13 September 2023	<0.1	5.9	13.4	<1	<1	0.4	<0.1

Notes:
CH4 - Methane, CO2 – Carbon Dioxide, O2 – Oxygen, CO – Carbon Monoxide, H2S – Hydrogen Sulphide, VOC – Volatile Organic Compounds.
ppmv - Part per Million Volume. – Result missing.

Table F4: Ground Gas Monitoring Results Summary for 2L6008DR (Shallow)

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
10 May 2023	<0.1	<0.1	20.7	<1	<1	<0.1	<0.1
24 May 2023	<0.1	0.1	20.6	2	<1	0.4	<0.1
20 June 2023	<0.1	0.3	20.8	2	<1	1.2	0.2
20 July 2023	<0.1	0.2	19.7	2	1	1.2	0.4
16 August 2023	<0.1	0.1	21.4	1	<1	0.2	1.1
13 September 2023	<0.1	0.3	20.7	1	<1	0.5	-0.4
11 October 2023	0.1	0.2	20.6	<1	<1	0.3	-1.1
14 November 2023	0.1	2.3	17.6	<1	<1	<0.1	-8.4
09 January 2024	0.1	3.7	14.6	Not recorded	<1	0.4	-2.5

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
09 February	0.2	0.1	21.3	<1	<1	<0.1	0.6
07 March 2024	0.2	2.6	16.7	<1	<1	<0.1	-3.5
04 April 2024	<0.1	<0.1	<0.1	<1	<1	<0.1	12.4

Notes:
CH4 - Methane, CO2 – Carbon Dioxide, O2 – Oxygen, CO – Carbon Monoxide, H2S – Hydrogen Sulphide, VOC – Volatile Organic Compounds.
ppmv - Part per Million Volume

Table F5: Ground Gas Monitoring Results Summary for 2L6009DR

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
18 April 2023	<0.1	0.1	20.4	<1	<1	<0.1	0.1
10 May 2023	<0.1	<0.1	20.6	1	1	<0.1	<0.1
24 May 2023	<0.1	0.4	21.1	5	<1	0.2	-1.1
20 June 2023	<0.1	0.6	21	7	<1	0.7	-1.8
20 July 2023	<0.1	0.4	20.6	2	<1	1.2	<0.1
16 August 2023	<0.1	0.1	20.4	2	1	1.3	<0.1
14 September 2023	<0.1	0.2	20.3	1	1	0.4	<0.1
11 October 2023	0.1	0.6	20.4	<1	1	<0.1	-0.6
14 November 2023	0.1	0.6	20.4	<1	<1	<0.1	-0.1

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
12 December 2023	0.1	0.4	21.6	<1	<1	<0.1	-0.9
09 January 2024	0.1	0.8	21.1	<1	<1	0.2	-1.7
09 February 2024	0.2	0.2	21.1	<1	<1	<0.1	-0.2
07 March 2024	0.2	0.7	20	<1	<1	<0.1	-0.1
04 April 2024	<0.1	<0.1	19.7	<0.1	<10	<0.1	0

Notes:
CH4 - Methane, CO2 – Carbon Dioxide, O2 – Oxygen, CO – Carbon Monoxide, H2S – Hydrogen Sulphide, VOC – Volatile Organic Compounds. ppmv - Part per Million Volume

Table F6: Ground Gas Monitoring Results Summary for 2L6010DR (Shallow)

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
18 April 2023	<0.1	0.1	21.1	1	<1	0.2	<0.1
10 May 2023	<0.1	0.1	20.9	<1	<1	<0.1	<0.1
24 May 2023	<0.1	0.5	20.6	6	<1	<0.1	<0.1
20 June 2023	<0.1	0.2	21.6	1	<1	0.4	-3.7
20 July 2023	<0.1	0.1	19.8	1	1	0.6	0.1
16 August 2023	<0.1	0.2	20.9	1	<1	0.6	Not recorded
14 September 2023	<0.1	0.2	20.2	<1	1	0.2	<0.1
10 October 2023	<0.1	0.2	20.7	<1	<1	<0.1	<0.1
14 November 2023	0.1	0.5	20.6	<1	<1	<0.1	-2.7
12 December 2023	0.1	0.7	21.3	<1	<1	<0.1	<0.1

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
09 January 2024	0.1	1.2	21.1	<1	<1	0.2	-2.9
09 February 2024	0.2	0.8	19.8	<1	<1	<0.1	--5.9
07 March 2024	0.2	0.9	19.8	<1	<1	<0.1	-4.8
04 April 2024	<0.1	<0.1	19.7	<1	<10	<0.1	0

Notes:
CH4 - Methane, CO2 – Carbon Dioxide, O2 – Oxygen, CO – Carbon Monoxide, H2S – Hydrogen Sulphide, VOC – Volatile Organic Compounds.
ppmv - Part per Million Volume

Table F7: Ground Gas Monitoring Results Summary for 2L6011SR (Shallow)

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
26 April 2023	0.1	0.1	21.1	<1	<1	-	-
25 May 2023	<0.1	1.6	5.7	2	<1	0.3	4.3
20 June 2023	<0.1	1.5	19	5	<1	0.6	-12.3
19 July 2023	<0.1	1.4	18.3	4	1	0.3	-6
16 August 2023	<0.1	1	18.5	26	1	0.7	-0.3
14 September 2023	0.1	0.8	18.7	3	<1	0.3	-4.2
12 October 2023	0.5	5.1	0.1	<1	<1	2.1	8
14 November 2023	0.2	5	0.4	1	<1	<0.1	0.1
12 December 2023	0.1	3.6	12.3	2	<1	2.9	-5.6

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
11 January 2024	0.1	2.1	19.8	3	<1	0.5	-0.2
09 February 2024	0.2	0.6	21	42	<1	<0.1	-7.3

Notes:CH4 - Methane, CO2 – Carbon Dioxide, O2 – Oxygen, CO – Carbon Monoxide, H2S – Hydrogen Sulphide, VOC – Volatile Organic Compounds.
ppmv - Part per Million Volume, – Result Missing

Table F8.0: Ground Gas Monitoring Results Summary for 2L6012SR

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
21 April 2023	<0.1	0.2	17.6	1	<1	<0.1	0.2
25 May 2023	<0.1	<0.1	21.3	1	1	<0.1	<0.1
20 June 2023	<0.1	0.3	20.6	6	<1	<0.1	-7.2
18 July 2023	<0.1	0.4	19.9	3	<1	0.4	-4.2
16 August 2023	<0.1	1.5	18.1	<1	1	0.8	1.1
14 September 2023	<0.1	1.4	18.2	2	1	0.7	3.6
10 October 2023	<0.1	0.2	20.7	<1	<1	<0.1	<0.1
14 November 2023	Position Flooded						
09 February 2024	Position Flooded						

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
07 March 2024	Not recorded						<0.1

Notes:
CH4 - Methane, CO2 – Carbon Dioxide, O2 – Oxygen, CO – Carbon Monoxide, H2S – Hydrogen Sulphide, VOC – Volatile Organic Compounds.
ppmv - Part per Million Volume

Table F9.0: Ground Gas Monitoring Results Summary for 3L6106DS

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
16 May 2024	<0.1	<0.1	20.5	0	<10	1	0
29 May 2024	<0.1	<0.1	21.1	0	<10	None recorded	0
19 June 2024	<0.1	0.1	20.6	0	<10	0	0
03 July 2024	<0.1	0.8	19.8	0	<10	None recorded	-0.1
16 July 2024	1.3	0.2	20.5	0	<10	0	0
29 July 2024	<0.1	1.4	18.9	0	<10	<0.1	0

Appendix G: Guidance for the assessment of Land Contamination

Selection of Soil Assessment Criteria Protective of Human Health

Generic Assessment Criteria (GAC)

To evaluate potential risks to human health receptors, including future Site users, the soil analytical results have been assessed against the following Generic Assessment Criteria (GAC):

- Suitable for Use Values (S4ULs) for commercial land use (Nathanail et al, 2015) adopting a 1% soil organic matter (SOM) value.
- Lead was compared against the Defra Category 4 Screening Level (C4SL) for commercial end use, (Defra, 2014) because a S4UL for lead has not been published, also adopting a 1% SOM value.
- Cyanide (free) was compared to the Society of Brownfield Risk Assessment (SoBRA) Acute Generic Risk Assessment criteria for assessing risks to human health from contaminants in soil (Society of Brownfield Risk Assessment (SoBRA), 2020) since there are currently no C4SLs or S4ULs for cyanide. The assessment criteria used evaluates potential for acute harm to a child by inhalation of free cyanide. This is a conservative assessment criterion used as generic assessment criteria as allows the criteria to be adjusted if the site-specific conditions are suitable.

The GAC for a Commercial/industrial end-use have been selected as these are considered to be the most appropriate for the protection of construction workers undertaking the development and the Applicant's workers who will be present at the Site during its operational phase. The GAC have been generated assuming short exposure periods over a long timescale.

The GAC have been generated using assumptions regarding soil characteristics. Where the published GAC are dependent upon Soil Organic Matter (SOM), a value of 1% has been used to provide a conservative assessment. Consideration of the default soil properties used to generate the soil GAC for protection of human health is important as these influence the fate, transport and behaviour of contaminants.

- Soil type – the model default is set as Sandy Loam and assumes a dry and relatively porous soil. The default is considered sufficiently similar to the cover/restoration soils which are variably clayey/ sandy. The waste mass is not a soil type and comparison to the GAC are provided for information.

- pH – pH influences the cation exchange capacity and the portioning behaviour of a chemical between soil and water. The default is pH 7. The cover soils at the Site have been found to have a pH of typically between 6.5 and 9, with only one sample of the cover soils recording a pH considerably outside of this range (9.4).

Selection of Water Assessment Criteria Protective of Aquatic Eco-Systems (Controlled Waters)

Generic Assessment Criteria

The Site is located over a superficial Secondary A Aquifer (Alluvium / River Terrace Deposits), Secondary Undifferentiated Aquifer (Head deposits) and a bedrock Unproductive Strata (London Clay and Lambeth Group). The Site is not located within groundwater SPZ or DWSZ. To evaluate potential risks to human health via ingestion of drinking water from the underlying aquifers, the leachate analysis results (2:1) and groundwater analysis results were assessed against the following GAC:

- Freshwater Environmental Quality Standards (EQS) annual average (AA) concentrations and maximum allowable concentrations (MAC) used where there is no AA.

- In the absence of a TPH threshold within the Water Supply [1](Water Quality) Regs 2021, the value of 10 µg/l as presented within the withdrawn Water Supply (Water Quality) Regs 1989 has been used for reference purposes. These thresholds are considered protective of human health.
- In the absence of a EQS for total ammonia the total ammonia as N (i.e., ammoniacal nitrogen as N) standard for rivers in the Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 has been used; assuming a Good status.
- The Drinking Water Inspectorate (DWI) Guidance on the Water Supply (Water Quality) Regulations 2016 (as amended) for England and Water Supply (Water Quality) Regulations 2018 for Wales specific to PFAS (per-and poly-fluoroalkyl substances) in drinking water (August 2024) Tier 3 action threshold has been used for reference purposes. The threshold is that beyond which water companies should not be supplying water to customers.

When assessing ground condition data and the potential to harm Controlled Waters, the approach presented in Groundwater Protection Policy and Practice (GP3) (EA, 2017) has been used.

Bioavailable Environmental Quality Standards (EQS)

Bioavailable Environmental Quality Standards (EQS) have been developed for UK Specific Pollutants copper, zinc and manganese and the EU priority substances lead and nickel. An EQS is the concentration of a chemical in the environment below which there is not expected to be an adverse effect on the specific endpoint being considered, e.g., the protection of aquatic life.

The bioavailability of a metal depends on a number of physico-chemical factors which govern both metal behaviour and the interactions of the toxic forms of the metals with a biological receptor.

The EQS bioavailable corresponds to the bioavailable fraction (BioF) of dissolved metal in a sample, as determined by the physico-chemical characteristics of the water and can be calculated using a biotic ligand model (BLM) or other calculation method. To assess compliance, the bioavailable fraction of dissolved metal can be compared to the EQS bioavailable. However, bioavailable metal is not the same metric as dissolved metal as only a fraction of the dissolved metal will usually be bioavailable.

It is very difficult to measure the bioavailable concentration of a metal directly. Biotic Ligand Models (BLMs) are a predictive tool that can take account of water quality parameters such as pH, and calcium to determine the amount of bioavailable metal present. However, the complexity of the models, the runtime per sample, input data requirements and level of operator skill needed to interpret the model outputs mean that few regulatory organisations have adopted the full BLMs. The UK has developed simplified Metal Bioavailability Assessment Tool (M-BAT) for copper, zinc, nickel, and manganese.

Geo-environmental laboratory analyses required to generate site-specific Predicted No Effect Concentrations (PNEC) suitable for the protection of the identified receptors has not been undertaken. On this basis, to provide a conservative assessment the results have been compared against the EQS for copper, zinc, manganese, lead and nickel without a correction for bioavailability.

[1] DWI (2024) Guidance on The Water Supply (Water Quality) Regulations 2016 (as amended) for England and Water Supply (Water Quality) Regulations 2018 for Wales specific to PFAS (per-and polyfluoroalkyl substances) in drinking water DWI, August 2024.

Limit of Detection vs. Generic Assessment Criteria

Where the concentration of a determinand is below the limits of detection and the limits of detection are below the relevant threshold criterion, the concentrations recorded are not considered to present a hazard to human health or controlled waters.

Where the concentration of a determinand is below the limit of detection and the limit of detection is greater than the relevant threshold criterion, ultra-low analysis or further Detailed Quantitative Risk Assessment would be required to robustly conclude that these can be eliminated as hazards.

Appendix H: Risk Assessment Tables

Table H1: Contaminated Land Risk Assessment for Section L

PSCs 441 & 440	**Crowd Hill Landfill Holder Reference EAHLD20508; Site Reference FEA22, EAST 5 – Section L (2L6000TP, 2L6001TP, 2L6004TP, 2L6006TP, 2L6002SA, 2L6003SA and 2L6005SA)** It is noted that a BGS historical landfill point positions Crowd Hill Landfill in a different location to that provided by the EA. The EA Crowd Hill landfill boundary includes an area of ancient woodland in the east of the landfill and may be inaccurate. To date there is no additional information to confirm the second location, and a risk assessment table has not been included. The second location (PSC No. 472).					
Potential Source of Contamination	**Potential Contaminants of Concern**	**Potential Receptors**	**Potential Pathways**	**Potential Consequence of Pollutant Linkage**	**Probability of Pollutant Linkage**	**Risk (without mitigation measures)**
Historical landfill (PSC No. 441) recorded on the DoL accepted inert and industrial waste types. BGS identified Made Ground (PSC No. 440) coincides with the landfill and on land to the north and northwest. Borehole logs show Made Ground is present up to 0.70 m in thickness but not indicative of landfill materials. DoL crosses the mapped landfill and artificial ground.	Asbestos detected and identified as amosite and chrysotile insulation board from a bulk sample (0.05 – 0.3 m bgl, 1.2083%) and disturbed sample (0.05 – 1.00 m bgl, 0.501%). No exceedances of GAC in soil samples. No soil leachate testing carried out due to contractor error, therefore the leachability of contaminants from soils cannot be assessed. Groundwater sampling yielded the following concentration exceedances: ▪ TPH exceeded the 1989 withdrawn Water Quality Standards. ▪ DWS exceedances of chloride, ammonium (NH4), lead, manganese, and sulphate. ▪ EQS exceedances of cadmium, copper, lead, manganese, nickel, zinc, total ammonia (N) (WFD Standard). One exceedance of fluoranthene also noted. Landfill ground gas (methane, carbon dioxide, carbon monoxide, hydrogen sulphide).	**Construction, maintenance workers and future site users:** Construction workers during open cut excavations/construction, maintenance workers during operation.	Ingestion and inhalation of asbestos fibres.	Severe	Likely Asbestos fragments identified within a sample taken from 2L6005SA (0.05 to 1.00 m bgl). In addition to suspected Asbestos fragments noted within 2L6002SA borehole log. Open cut excavations through this area may disturb further asbestos.	High
			Direct dermal contact (soils and groundwater), ingestion of contaminated groundwater.	Medium	Likely Shallow groundwater encountered in boreholes may lead to contact with potentially contaminated groundwater during construction activities.	Moderate
			Inhalation of gases and vapours.	Medium	Likely	Moderate
		Adjacent land users: Farmland, closest residential property located approximately 50 m south of the proposed pipeline. Residential properties approximately 100 m west of the proposed route.	Ingestion and inhalation of asbestos fibres.	Medium	Likely	Moderate
			Direct dermal contact.	Medium	Low Likelihood	Moderate / Low
		On-Site existing and future property (buildings and buried services): No building structures as part of scheme. Open cut excavations taking place.	Gas migration / accumulation.	Medium	Unlikely Open cut excavations within the vicinity of these PSCs, therefore any concentrations of ground gas that might pose a risk to human health are unable to accumulate and/or get dissipated once disturbed in the excavation process.	Low Based on recorded concentrations
		Surface water bodies/watercourses: Bow Lake approximately 145 m north.	Surface water runoff from stockpiles and migration through groundwater and underground utilities.	Medium	Unlikely	Low
		Groundwater Superficial Head deposits present classified as a Secondary Undifferentiated Aquifer.	Leaching through unsaturated and saturated soil.	Medium	Likely Groundwater during spot monitoring confirmed to be shallow. Shallow groundwater also encountered during the advancement of boreholes within the GI.	Moderate
		Ecological receptors (flora and fauna): Ancient woodland shown approx. 30 m west of Crowd Hill Landfill. Hill Copse Ancient Woodland approximately 140m northwest.	Plant uptake, direct contact, ingestion and inhalation of dusts, gases and vapours by animals.	Medium	Low	Moderate / Low

Table H2: Contaminated Land Risk Assessment for Section L

Location	Trenchless Crossing Locations: 2L6007DR, 2L6008DR (Winchester Road)					
Potential Source of Contamination	**Potential Contaminants of Concern**	**Potential Receptors**	**Potential Pathways**	**Potential Consequence of Pollutant Linkage**	**Probability of Pollutant Linkage**	**Risk (without mitigation measures)**
Trenchless Crossing at Winchester Road (B3354) PSC 154 (Embankment) adjacent to Winchester Road	Leachate testing obtained from 2L6008DR had one exceedance of the WQS for TPH. Groundwater sampling from 2L6007DR and 2L6008DR yielded the following exceedances: ▪ TPH exceeded 1989 withdrawn Water Quality Standards. ▪ DWS exceedances of chloride, ammonium (NH4), sodium and sulphate. ▪ Exceedances of total ammonia (N) (WFD Standard). ▪ EQS exceedances of copper, lead, nickel and zinc.	**Construction, maintenance workers and future site users:** Construction workers during installation of trenchless crossings.	Direct dermal contact (soils and groundwater), ingestion.	Medium	Unlikely Shallow groundwater encountered in boreholes may lead to contact with potentially contaminated groundwater during construction activities.	Low
		Groundwater Superficial River Terrace Deposits and Alluvium classified as Secondary A Aquifers.	Leaching through unsaturated and saturated soil.	Medium	Likely Groundwater during spot monitoring confirmed to be shallow. Shallow groundwater also encountered during the advancement of boreholes within the GI.	Moderate
		Surface water bodies/watercourses: Bow Lake approximately 140 m northwest.	Surface water runoff from stockpiles and migration through groundwater and underground utilities.	Medium	Unlikely	Low
		Adjacent land users: Farmland, Residential properties approximately 100 m west of the proposed route.	Direct dermal contact	Medium	Unlikely	Low
		Ecological receptors (flora and fauna): Ancient woodland approx. 75m southwest and 215m southeast	Plant uptake, direct contact, ingestion and inhalation of dusts, gases and vapours by animals.	Mild	Low	Low
	Ground Gas – carbon dioxide recorded above STL's and LTLs and low oxygen levels (14.6 %v/v) recorded within 2L6008DR.	**Construction, maintenance workers, adjacent land users and future site users:** Construction workers during open cut excavations / construction, maintenance workers during operation.	Inhalation of gases and vapours.	Medium	Likely	Moderate
		On-Site existing and future property (buildings and buried services): Temporary reception pits.	Gas migration / accumulation.	Medium	Likely	Moderate Based on recorded concentrations

* The potential for the presence of gas and the associated risks during trenchless crossing techniques will need to be evaluated and assessed in accordance with BS 6164:2019 H&S in Tunnelling in the Construction Industry - Code of Practice.

Table H3: Contaminated Land Risk Assessment for Section L

Trenchless Crossing Locations: 2L6009DR, 2L6010DR (Bow Lake Watercourse), 2L6011SR, 2L6012SR (Unnamed Tributary of the Itchen). None of the aforementioned boreholes were advanced to target PSCs.						
Potential Source of Contamination TBC	**Potential Contaminants of Concern**	**Potential Receptors**	**Potential Pathways**	**Potential Consequence of Pollutant Linkage**	**Probability of Pollutant Linkage**	**Risk (without mitigation measures)**
N/A	Groundwater at Watercourse trenchless crossings sampling yielded the following exceedances: ▪ TPH (C_6 – C_{40}) exceeded 1989 withdrawn WQS. ▪ DWS exceedances of chloride, ammonium as NH_4, indeno(1,2,3-cd)pyrene, selenium, boron, sodium, and sulphate. ▪ EQS exceedances of cadmium, copper, fluoranthene, lead, manganese, nickel and zinc. ▪ total ammonia as N exceeded WFD Standard.	**Construction, maintenance workers and future site users:** Construction workers during installation of trenchless crossings.	Direct dermal contact (soils and groundwater), ingestion.	Medium	Likely Shallow groundwater encountered in boreholes may lead to contact with potentially contaminated groundwater during construction activities.	Moderate
		Adjacent land users: Farmland, closest residential property located approximately 50 m south of the proposed route. Residential properties approximately 100 m west of the proposed route.	Direct dermal contact.	Medium	Low likelihood	Moderate / Low
		Surface water bodies/watercourses: Bow Lake Watercourse (2L6009DR and 2L6010DR), Unnamed Tributary of the Itchen (2L6011SR and 2L6012SR)	Surface water runoff from stockpiles and migration through groundwater and underground utilities.	Medium	Likely	Moderate
		Groundwater Superficial River terrace deposits and alluvium classified as Secondary A Aquifers.	Leaching through unsaturated and saturated soil.	Medium	Likely. Groundwater during spot monitoring confirmed to be shallow. Shallow groundwater also encountered during the advancement of boreholes within the GI.	Moderate
		Ecological receptors (flora and fauna): Ecology associated with watercourses / drains overlying the trenchless crossing.	Plant uptake, direct contact, ingestion and inhalation of dusts, gases and vapours by animals.	Mild	Low	Low
	Ground Gas: High concentrations of carbon monoxide (42 ppm) and concentrations of carbon dioxide above STL's and LTLs, plus very low levels of oxygen (0.1 %) encountered in some locations	**Construction, maintenance workers, adjacent land users and future site users:** Construction workers during open cut excavations / construction, maintenance workers during operation.	Inhalation of gases and vapours.	Medium	Likely	Moderate
		Scheme on-Site existing and future property (buildings and buried services): Temporary reception pits.	Gas migration / accumulation.	Medium	Likely. Temporary reception pits may bring constructions workers into contact with potentially high levels of carbon monoxide and carbon dioxide.	Moderate Based on recorded concentrations

* The potential for the presence of gas and the associated risks during trenchless crossing techniques will need to be evaluated and assessed in accordance with BS 6164:2019 H&S in Tunnelling in the Construction Industry - Code of Practice.

Table H4: Contaminated Land Risk Assessment for Section L

PSC 472	Crowd Hill Landfill, second location – BGS Historical Landfill Point – Section L (3L6106DS and 3L6107DS)					
Potential Source of Contamination	**Potential Contaminants of Concern**	**Potential Receptors**	**Potential Pathways**	**Potential Consequence of Pollutant Linkage**	**Probability of Pollutant Linkage**	**Risk (without mitigation measures)**
British Geological Survey (BGS) identified historical landfill (PSC 472) . This is in a different location to the Environment Agency. Following GI at PSC 472, waste was not encountered. Exploratory hole locations advanced to target this PSC yielded a maximum of 0.35 m thickness of Made Ground. The point provided by the BGS identifying the landfill is within the DoL.	No exceedances of GAC in soil samples. Leachate testing yielded the following exceedances: ▪ TPH exceeded the 1989 withdrawn WQS. ▪ EQS exceedances of copper. ▪ DWS exceedances of iron. Groundwater sampling yielded the following exceedances: ▪ TPH exceeded the 1989 withdrawn WQS. ▪ DWS exceedances manganese, and sulphate. ▪ EQS exceedances of cadmium, manganese and zinc. ▪ One detect of PFOS at 0.085 ug/l, which is below the action threshold. Landfill ground gas (methane, carbon dioxide, carbon monoxide, hydrogen sulphide), carbon dioxide exceeded long term WELs. Methane was not detected above the limit of detection.	**Construction, maintenance workers and future site users:** Construction workers during open cut excavations/construction, maintenance workers during operation.	Direct dermal contact (soils and groundwater), ingestion of contaminated groundwater.	Medium	Likely Shallow groundwater encountered in boreholes may lead to contact with potentially contaminated groundwater during construction activities.	Moderate
			Inhalation of gases and vapours.	Medium	Likely	Moderate
		Adjacent land users: Farmland, closest residential property located approximately 176 m northwest.	Direct dermal contact, ingestion and inhalation of dusts, gases and vapours during excavation works and stockpiling.	Medium	Low Likelihood	Moderate / Low
		On-Site existing and future property (buildings and buried services): No building structures as part of scheme. Open cut excavations taking place.	Gas migration / accumulation.	Medium	Unlikely Open cut excavations within the vicinity of these PSCs, therefore any concentrations of ground gas that might pose a risk to human health are unable to accumulate and/or get dissipated once disturbed in the excavation process.	Low Based on recorded concentrations
		Surface water bodies/watercourses: Bow Lake Watercourse approximately 140 m east/northeast.	Surface water runoff from stockpiles and migration through groundwater and underground utilities.	Medium	Unlikely	Low
		Groundwater London Clay – Unproductive stratum.	Leaching through unsaturated and saturated soil.	Medium	Likely Groundwater during spot monitoring confirmed to be shallow. Shallow groundwater also encountered during the advancement of boreholes within the GI.	Moderate
		Ecological receptors (flora and fauna): Park Hills Ancient Woodland approximately 130 m south.	Plant uptake, direct contact, ingestion and inhalation of dusts, gases and vapours by animals.	Mild	Low	Low

Appendix I: Risk Assessment Methodology