
The Cambridge South East Transport Order

Transport And Works Act 1992

Transport And Works (Applications And Objections Procedure) (England And Wales) Rules 2006

Appendix 9.1 – Ground Investigation Report

Document Reference	CSET-10-26
Revision Number	00
Applicant	Cambridgeshire County Council
Date	January 2025

Contents

Chapter	Page
1. Introduction	9
1.1. Scope and Objective	9
1.2. Overview of the Project	9
1.3. Geotechnical Category of the project	14
1.4. Other Relevant Information	14
1.5. Assumptions and limitations	15
2. Existing Information	16
2.1. General	16
2.2. Topography and Geomorphology	16
2.3. Published Geology	18
2.4. Hydrology	22
2.5. Hydrogeology	24
2.6. Flood Records	26
2.7. Geohazards	26
2.8. Historical development	28
2.9. Records of mines and mineral deposits	28
2.10. Unexploded Ordnance	29
2.11. Radon	29
3. Preliminary Ground Model	30
3.1. Route Section 1 (Ch. 0 to 500m)	30
3.2. Route Section 2 (Ch. 500 to 2800m)	30
3.3. Route Section 3 (Ch. 2800 to 4600m)	30
3.4. Route Section 4 (Ch. 4600-6070m)	31
3.5. Route Section 5 (Ch. 6070 to 8070m)	31
3.6. Route Section 6 and travel hub site (Ch. 6070 to 9270m)	32
4. Ground Investigation	33
4.1. Site walkover	33
4.2. Description of fieldwork	33
4.3. In-situ testing	36
4.4. Geotechnical Laboratory Testing	38
4.5. Groundwater Monitoring	39
5. Ground Conditions	40
5.1. Introduction	40
5.2. Geology overview	40
5.3. Distribution of geological strata	42
5.4. Ground models	43
5.5. Groundwater	82
5.6. Hydrogeological assessment	88
6. Geotechnical Material Properties	90
6.1. Introduction	90
6.2. Geotechnical Parameter Derivation	90
6.3. Geotechnical Parameters	95
6.4. Summary of Geotechnical Material Properties	110
6.5. Hydraulic Conductivity	112

7. Geotechnical Risk Register	114
7.1. Introduction and Rationale	114
8. Preliminary Engineering Assessment and Recommendations	121
8.1. Introduction	121
8.2. Bridge foundations	121
8.3. Culverting of existing drains	122
8.4. Retaining structures	123
8.5. Earthworks	124
8.6. California Bearing Ratio for pavements subgrade	124
8.7. Soils infiltration rates	125
8.8. Site won material for re-use (earthworks)	125
8.9. Ground Aggressivity	127
8.10. Summary and considerations	127
9. References	129
Appendices	131
Appendix A. Drawings	132
A.1. Scheme Location	132
A.2. BGS Geology and borehole records	133
A.3. Ground investigation exploratory locations	134
A.4. Dissolution features in Chalk	135
A.5. Mott MacDonald route alignment drawings	136
A.6. LiDAR (Geomorphology)	137
Appendix B. Ground Models	138
B.1. OpenGround Cross Sections	138
B.2. Geological Long Sections	139
Appendix C. Geotechnical Plots	140
C.1. Water content and index properties	140
C.2. Plasticity Charts	141
C.3. Particle Size Distribution	142
C.4. Particle Size Distribution for SHW Series 600	143
C.5. SPT N60 plots	144
C.6. Undrained Shear Strength by SPT and UU	145
C.7. Effective angle of internal friction	146
C.8. Effective Stress by Shear Box	147
C.9. CPT derived parameters	148
C.10. Density plots	149
C.11. Dry Density and Moisture Content relationship (compaction)	150
C.12. California Bearing Ratio	151
C.13. Coefficient of Compressibility vs. Applied Stress	152
C.14. Coefficient of Consolidation vs. Applied Stress	153
C.15. Applied Stress vs Voids Ratio	154
C.16. Organic matter	155
C.17. Point Load Test Plots	156
C.18. UCS Plots	157
C.19. Chalk Classification charts	158
C.20. Rock water content plots	159
C.21. Groundwater Level Charts	160
Appendix D. Tetra Tech Factual Report	161

Appendix E. Atkins Contaminated Land Risk Assessment Report

162

E.1. GCP_5210174_A1307 Cambridge South East Transport_CLRA

162

Tables

Table 1-1 - Route sectioning and chainages	11
Table 1-2 - Summary of the preferred travel route [3]	11
Table 1-3 - Summary of travel hub site [3]	11
Table 1-4 - Preferred route alignment description	13
Table 1-5 - Summary of the proposed scheme works along the preferred route	13
Table 2-1 - Site geomorphology	16
Table 2-2 - Geological sequence for the scheme	18
Table 2-3 - Summary of available BGS boreholes records with 500m of the route	20
Table 2-4 - Aquifer designations	24
Table 3-1 – Route Section 1 preliminary ground model	30
Table 3-2 – Route Section 2 preliminary ground model	30
Table 3-3 – Route Section 3 preliminary ground model	30
Table 3-4 – Route Section 4 preliminary ground model	31
Table 3-5 – Route Section 5 preliminary ground model	31
Table 3-6 – Route Section 6 preliminary ground model	32
Table 4-1 - Summary of scope of investigation [3]	33
Table 4-2 - Exploratory locations along preferred route alignment.	35
Table 4-3 - Exploratory locations at public transport stops, travel hub and borrow pit area	35
Table 4-4 - Summary of DCP testing locations along the preferred bus route	37
Table 4-5 - Summary of in-situ infiltration and permeability testing	38
Table 4-6 - Summary of Geotechnical Laboratory Assessment	38
Table 5-1 - Geological sequence for soils and rocks underlying the scheme	40
Table 5-2 - Summary of distribution of geology along the scheme	42
Table 5-3 - Section 1 preliminary ground model based on BGS records	43
Table 5-4 - Section 2 (GM2) strata summary	45
Table 5-5 - Topsoil - Section 2 typical thicknesses and engineering description	45
Table 5-6 - Made Ground - Section 2 typical thicknesses and engineering description	46
Table 5-7 - Alluvium/Head Deposits (undifferentiated) Route Section 2 typical thicknesses and engineering description	47
Table 5-8 – Route Section 3 (GM3) strata summary	50
Table 5-9 - Topsoil – Route Section 3 typical thicknesses and engineering description	51
Table 5-10 - Alluvium/Head Deposits (undifferentiated) - Route Section 3 typical thicknesses and engineering description	53
Table 5-11 - River Terrace Deposits - Section 3 typical thicknesses and engineering description	53
Table 5-12 – Route Section 4 (GM4) strata summary.	58
Table 5-13 - Topsoil – Route Section 4 typical thicknesses and engineering description.	59
Table 5-14 - Made Ground – Route Section 4 typical thicknesses and engineering description.	59
Table 5-15 - Alluvial deposits – Route Section 4 typical thicknesses and engineering description	60
Table 5-16 - River Terrace Deposits – Route Section 4 typical thicknesses and engineering description	61
Table 5-17 – Route Section 5 (GM5) strata summary	65
Table 5-18 - Topsoil - Section 5 typical thicknesses and engineering description	66

Table 5-19 - Made Ground – Route Section 5 typical thicknesses and engineering description	66
Table 5-20 - Alluvium/Head Deposits (undifferentiated) – Route Section 5 typical thicknesses and engineering description	67
Table 5-21 – Route Section 6 (GM6) strata summary	70
Table 5-22 - Topsoil – Route Section 6 typical thicknesses and engineering description	71
Table 5-23 - Alluvial deposits – Route Section 6 typical thicknesses and engineering description	72
Table 5-24 - River Terrace Deposits – Route Section 6 typical thicknesses and engineering description	73
Table 5-25 - Travel Hub Site (GM7) strata summary	77
Table 5-26 - Topsoil – Travel Hub Site typical thicknesses and engineering description	78
Table 5-27 - Alluvial deposits – Travel hub Site typical thicknesses and engineering description	79
Table 5-28 - River Terrace Deposits – Travel Hub Site typical thicknesses and engineering description	79
Table 5-29 - Lowestoft Formation – Travel Hub Site typical thicknesses and engineering description	79
Table 5-30 - Groundwater strikes during ground investigation in Section 2	82
Table 5-31 - Groundwater strikes during ground investigation in Section 3	83
Table 5-32 - Groundwater strikes during ground investigation in Section 4	83
Table 5-33 - Groundwater strikes during ground investigation in Section 5	84
Table 5-34 - Groundwater strikes during ground investigation in Section 6	85
Table 5-35 - Groundwater strikes during ground investigation at the Travel Hub Site	85
Table 5-36 - Summary of groundwater monitoring results	86
Table 6-1 - f2 values for fine grained soils [25]	92
Table 6-2 - Compressibility after Tomlinson (2001) Table 2.1	92
Table 6-3 - Values for Drained Modulus of Elasticity based on PI (on large strains)	93
Table 6-4 - Geotechnical parameters for the Made Ground	95
Table 6-5 - Geotechnical parameters for the Alluvium/Head Deposits (undifferentiated)	97
Table 6-6 - Geotechnical parameters for the River Terrace Deposits	99
Table 6-7 - Geotechnical parameters for the Lowestoft Formation (Diamicton Glacial Till)	101
Table 6-8 - Geotechnical parameters for the New Pit Chalk Formation/Holywell Chalk Formation (undifferentiated)	102
Table 6-9 - Geotechnical parameters for the Holywell Chalk Formation	104
Table 6-10 - Geotechnical parameters for Zig Zag Chalk Formation	106
Table 6-11 - Geotechnical parameters for the West Melbury Marly Chalk Formation	108
Table 6-12 - Summary of geotechnical parameters	110
Table 6-13 - Summary of soil infiltration testing data	112
Table 6-14 - Summary of downhole permeability testing	113
Table 7-1 - Likelihood Definitions	115
Table 7-2 - Severity Definitions	115
Table 7-3 - Perceived Degree of Risk	115
Table 7-4 - Risk Matrix	115
Table 7-5 - CSET Geotechnical Risk Register.	116
Table 8-1 - Summary of bridge locations and geotechnical considerations	121
Table 8-2 - Summary of proposed culvert locations and geotechnical considerations	123
Table 8-3 - Summary of soil infiltration rates	125
Table 8-4 - Summary of earthworks class to SHW (Series 600)	125
Table 8-5 - Summary of earthworks class for Chalk Group from CIRIA C574 [36]	126
Table 8-6 - Summary of ground aggressivity	127

Executive Summary

Figures

Figure 1-1 - Summary of general arrangement along preferred route alignment	12
Figure 2-1 - LiDAR DTM across the preferred route alignment (top) and route alignment elevation profile (bottom)	17
Figure 2-2 - Schematic cross section showing relationships of superficial deposits, adapted from BGS Map Sheet 205 [2].	20
Figure 2-3 - Nine Wells spring line in relation to the Chalk Formations, adapted from Cambridge Geological Society [13]	23
Figure 2-4 - Location of hydrological features near the site	23
Figure 2-5 - Summary of hydrogeology along the preferred route alignment	25
Figure 2-6 - Extract of the hydrogeological map	25
Figure 2-7 - Flood risk around the route alignment	26
Figure 2-8 - Location of BGS Mineral sites	29
Figure 5-1 - Distribution of logged Alluvium from Tetra Tech Report compared with BGS Superficial Deposits and located of anticipated Head Deposits	43
Figure 5-2 - Section 2 interpretation area	44
Figure 5-3 - Topsoil and Made Ground distribution along Section 2	46
Figure 5-4 - Distribution of logged Alluvium/Head Deposits (undifferentiated) along Route Section 2	47
Figure 5-5 - Distribution of the Zig Zag and West Marly Chalk Formation along Route Section 249	
Figure 5-6 - Route Section 3 interpretation area	50
Figure 5-7 - Topsoil and Made Ground distribution along Route Section 3	52
Figure 5-8 - Distribution of Alluvium and River Terrace Deposits along Route Section 3	54
Figure 5-9 - Distribution of the Holywell Nodular and Zig Zag Chalk Formation along Route Section 3	56
Figure 5-10 – Route Section 4 interpretation area	57
Figure 5-11 - Topsoil and Made Ground distribution along Route Section 4	60
Figure 5-12 - Distribution of Alluvium and River Terrace Deposits along Route Section 4	62
Figure 5-13 - Distribution of the Zig Zag and the West Melbury Marly Chalk Formation along Route Section 4	63
Figure 5-14 – Route Section 5 interpretation area	64
Figure 5-15 - Topsoil and Made Ground distribution along Route Section 5	66
Figure 5-16 - Distribution of Alluvium/Head Deposits (undifferentiated) along Route Section 5	67
Figure 5-17 - Distribution of the Holywell Nodular and Zig Zag Chalk Formation along Route Section 5	69
Figure 5-18 – Route Section 6 interpretation area	70
Figure 5-19 - Topsoil and Made Ground distribution along Route Section 6	72
Figure 5-20 - Distribution of Alluvium (top) and River Terrace Deposits (bottom) along Route Section 6	73
Figure 5-21 - Distribution of the Holywell Nodular Chalk (top) and Zig Zag Chalk (bottom) Formation along Route Section 6	75
Figure 5-22 - Travel Hub interpretation area	76
Figure 5-23 - Topsoil and Made Ground distribution at the Travel Hub Site	78
Figure 5-24 - Distribution of Alluvium, River Terrace Deposits and Lowestoft Formation in the Travel Hub Site	80
Figure 5-25 - Distribution of the New Pit and Holywell Nodular Chalk Formation in the travel hub site	82
Figure 6-1 - Trial pit soakaway locations at the proposed Haverhill PT stop and the travel hub site	113

The Cambridge South East Transport scheme aims to deliver a new High Quality Public Transport (HQPT) route and associated infrastructure between a travel hub facility near the A11 Junction and Cambridge Biomedical Campus (CBC), southeast of Cambridge. The route will also comprise a new Active Travel Path (ATP) for pedestrians, cyclists and equestrians. A new shared-use path for walkers, cyclists and horse riders, generally 3 metres wide, would be built alongside the new public transport route.

The route will connect the existing guided busway at the CBC along Francis Crick Avenue (FCA). The route will run via Sawston, Stapleford and Great Shelford and connections will be provided to Babraham, Babraham Research Campus and Granta Park via the travel hub site.

A ground investigation was designed and specified by Mott MacDonald and was undertaken by Tetra Tech and their subcontractors between 08 February and 04 June 2021. Mott MacDonald provided full time technical supervision during the ground investigation works in order to confirm that the works were in accordance with the issued GI Specification. Documents that have been used to inform this report include:

- Mott MacDonald Ltd, “Cambridge South East Transport - Phase 2, Ground Investigation Specification, 403394-MMD-HWA-00-RP-HW-0462,” Mott MacDonald Ltd, Norwich, October 2020 [1];
- Tetra Tech, “Cambridge South East Transport - Phase 2, Factual Ground Investigation Report, B024522,” Tetra Tech, London, April 2022 [2];
- Mott MacDonald Ltd, “A1307 Cambridge South East Transport - Phase 2, Geotechnical and Geo-Environmental Preliminary Risk Assessment, 403394-MMD-TGE-00-RP-GE-0248,” Mott MacDonald Ltd, Norwich, December 2019 [4]; and,
- Mott MacDonald Ltd, “Cambridge South East Transport Phase 2, High Quality Public Transport and Active Travel Path Corridor Design, 403394-MMD-HWA-00-RP-HW-0846 | P01,” Mott MacDonald Ltd, Norwich, May 2021 [6].

The development proposals for the Scheme include conventional geotechnical activities and no exceptional geotechnical risks have been identified allowing the Scheme to be assigned as Geotechnical Category 2.

There are six main ground model zones (Sections 1 to 6, listed in Table 1-1) within the Scheme boundary. Ground conditions encountered in each area have been interpreted and summarised in Section 5. Cross sections and long sections have been produced at all proposed development areas to inform the geotechnical design.

The British Geological Survey (BGS) provides geological mapping of the area through the online GeoIndex [1] and the published 1:50,000 mapping, (England and Wales, Map Sheet 205, Saffron Walden) [2]. BGS records indicate that the scheme is underlain by superficial deposits of Alluvium, River Terrace Deposits and Glaciogenic Deposits of the Lowestoft Formation. Superficial deposits overlie bedrock of the White Chalk Subgroup comprising the Newpit Chalk Formation and Holywell Nodular Chalk Formation. This is further underlain by the Grey Chalk Subgroup the Zig Zag Formation and the West Melbury Marly Chalk Formation.

The ground investigation generally confirmed BGS ground conditions along the preferred route. High (near surface) groundwater (<1.0m bgl) was encountered during follow-on monitoring in Sections 2 and Section 4.

A preliminary engineering assessment of the proposed geotechnical activities associated with the CSET preliminary design has been discussed in Section 8, highlighting any risks that may be associated with these activities given the ground conditions local to their proposed locations. Geotechnical activities proposed as part of the scheme include Bridge foundations (deep foundations), Retaining structures, retaining up to 1.5m of material in Section 1, earthworks (cuttings and embankments), up to 6m of fill material and Culverts. A standalone Contaminated Land Assessment Report (Ref. GCP_5210174_A1307 Cambridge South East Transport_CLRA) will append the GIR (Appendix E) which will provide a geo-environmental assessment of the scheme.

1. Introduction

1.1. Scope and Objective

Atkins Limited, a member of the SNC Lavalin Group, has been commissioned by Greater Cambridge Partnership to prepare a Ground Investigation Report (GIR) in support of the Cambridge South East Transport Public Transport and Active Travel Proposed Scheme (CSET). A ground investigation (GI) was designed and specified by Mott MacDonald Ltd [3] and was undertaken in March and April 2021 by Tetra Tech [4].

This report has been prepared to summarise the findings of the desk study and GI phases undertaken, to inform the scheme design development. The report follows the recommended format for a Ground Investigation Report (GIR) included within CD 622 – Managing Geotechnical Risk [5].

The objectives of this report are to:

- Summarise existing desk study information, including the previously undertaken Preliminary Risk Assessment written by Mott MacDonald [6] and factual report on the ground investigation written by Tetra Tech [4] as well as historical Ground Investigations (GI);
- Describe the recently undertaken GI works carried out;
- Provide an interpretation of the ground conditions recorded during the GI;
- Provide ground models in the form of geotechnical cross-sections along the route alignment which will help identify the anticipated ground conditions at the locations of critical structures;
- Provide an interpretation of the ground investigation including in-situ testing, geo-environmental and geotechnical testing, ground gas and groundwater monitoring;
- To develop characteristic geotechnical design parameters to inform design and provide justification for different sections of the route alignment;
- Assessment of geotechnical risk by production of a Geotechnical Risk Register to incorporate the findings of the site-specific GI and recommendations for mitigation;
- Provide a high level engineering assessment which will provide recommended options for each of the geotechnical elements of the proposed works; and,
- Contaminated Land and Piling Risk Assessment by producing a Generic Quantitative Risk Assessment (GQRA) include screening of the GI soil, leachate and water chemical data against appropriate generic criteria, and a preliminary waste assessment section utilising Atkins' CatWasteSoil™ web based tool.

A standalone Contaminated Land Assessment Report (Ref. GCP_5210174_A1307 Cambridge South East Transport_CLRA) will append the GIR (Appendix E) which will provide a geo-environmental assessment of the scheme. This is to identify any potential risks to human health and controlled waters, together with recommendations for mitigation; and a preliminary assessment to inform the potential for material reuse / waste disposal.

1.2. Overview of the Project

The Cambridge South East Transport scheme aims to deliver a new High Quality Public Transport (HQPT) route and associated infrastructure between a travel hub facility near the A11 Junction and Cambridge Biomedical Campus (CBC), southeast of Cambridge, presented in Appendix A.1.

The route will connect the existing guided busway at the CBC along Francis Crick Avenue (FCA). The route will run via Sawston, Stapleford and Great Shelford and connections will be provided to Babraham, Babraham Research Campus and Granta Park via the travel hub site. The route would be entirely off-road, only interacting with other traffic at junctions. Junctions between existing roads and the new public transport route would be controlled by traffic lights [7]. The scheme has been through a consultation process and public inquiry in late 2021. The executive board approved the scheme to proceed to the next stage at a meeting in July 2022. Currently preparations are underway for a Transport and Works Act Order application. This is planned to be submitted to the Secretary of State for Transport in 2023. It is anticipated the start of the works will be in early 2023 and completion in late 2024 [7].

The scheme aims to provide dedicated HQPT routes for transport into and out of the city from the southeast, as well as additional transport capability for develops proposed within Greater Cambridge to mitigate the impact of future growth along the A1307 corridor [8].

The scheme comprises three key elements, summarised below:

- 1) Construction of a new High Quality Public Transport Route (HQPT) between the A11 Travel hub Site and Cambridge with stops along the route. The Public Transport Stops include:
 - a) Babraham road in Sawston,
 - b) Haverhill road in Stapleford,
 - c) Hinton way for Shelford and
 - d) Near the busway bridge on the Cambridge biomedical campus.
- 2) New Travel Hub site off the A1307/A11 which will include:
 - a) The footbridge over the A11 would be improved to provide better access for cyclists, mobility impaired users and pushchairs.
 - b) It would have a maximum of 1,250 car parking spaces, including 62 for blue badge and 62 with facilities for charging electric vehicles.
 - c) Initially the site would have 188 cycle parking spaces with provision to expand to 314 spaces should demand for cycle parking be higher.
 - d) There would also be a drop-off area, motorcycle and coach parking spaces.
 - e) Shelters, waiting areas and drop-off/pick-up areas would be fitted with real-time public transport information.
- 3) New Active Travel Path (ATP) for pedestrians, cyclists and equestrians. A new shared-use path for walkers, cyclists and horse riders, generally 3 metres wide, would be built alongside the new public transport route.

Initial concepts for the scheme included five different HQPT routes which ran between three different travel hub sites (Options A, B and C) which are discussed in Mott MacDonald Geotechnical and Geo-Environmental Preliminary Risk Assessment report [6]. Following public consultation in 2019 and further developing the project, the most popular options from the public consultation were recommended to the Greater Cambridge Partnership Executive Board for consideration. The Board approved the recommendations as the preferred route to be taken forward to the next stage [7]. The preferred transport route is discussed within this report, which is referred to as the 'preferred route'.

Mott MacDonald produced various general arrangement drawings in November 2021 for the route and location of the travel hub site. These are provided on 19no. drawings, drawing references 403394-MMD-HWA-00-DR-HW-0925-P2 to -0943-P2. The overall scheme is provided on Mott MacDonald drawing reference 403394-MMD-HWA-00-DR-HW-0948-P2 titled 'Route Layout Plan'. These are shown in Appendix A.5 and outlined in Section 1.2.3.

A retirement village has recently been proposed for a land parcel to the northeast of Stapleford, to the northwest of Haverhill Road named 'Stapleford Retirement Village'. Currently, there are two options proposed for the realignment of the HQPT which both cross Haverhill Road approximately 120m northwest of the original alignment, named Option 1 and Option 2. This is presented in Appendix A.1 as Atkins drawing reference 5210174-ATK-HGN-00-DR-CH-0023. At this stage, Option 1 is the most likely route that the scheme will proceed with. Currently ground investigation has only been targeted at the initial alignment and limited data is presented for the realignment options.

A consultation has been relaunched in July 2022 for the proposed route change in Stapleford. The closing date for the extended deadline was the 30 August 2022. Results of the consultation will be presented to the GCP Joint Assembly and Executive Board in late 2022. The proposals for a retirement village in Stapleford have been approved on appeal by the Government's Planning Inspectorate [9].

1.2.1.1. Ground Model Zones

The preferred route has been divided into six route sections, which will be assessed within this report. These sections are based on the Atkins design development for the proposed works.

Current chainages slightly differ to that set out within the Mott MacDonald Corridor Design Report [8]. The sections have been summarised in Table 1-1 and presented in a schematic plan in Appendix A.1.

Table 1-1 - Route sectioning and chainages

Route Section	Location	Start Chainage (m)	End Chainage (m)
1	Cambridge Biomedical Campus to Dame Mary Archer Roundabout	0	500
2	Dame Mary Archer Roundabout to Hinton Way. Grahams Fields	500	2800
3	Hinton Way to public footpath leading from Bury Road	2800	4600
4	Public footpath to North Farm	4600	6070
5	West Way to High Street	6070	8070
6	High Street to A11 Travel Hub	8070	9270

Notes
Chainages rounded to the nearest 10m

1.2.2.

1.2.2. Description of the Scheme Area and Route Alignment

Within this report, the ‘scheme’ refers to land along the linear route in orange and red as presented in the schematic plan in Appendix A.1.

The scheme lies to the southeast of Cambridge and to the southwest of the junction between the A1134 and A1307 within the country town of Cambridgeshire. The south-eastern extent of the scheme is the Cambridge Biomedical Campus. Here the route will be at-grade with the current busway. The scheme alignment traverses agricultural land comprising arable fields segregated by hedgerows and treelines. The route passes adjacently through residential areas of Stapleford and Sawston to the west and southwest, and Babraham Research Campus to the north. The route will terminate at the travel hub site, located southwest of the junction between the A1307 and the A11. There is one main river system within the scheme extents, the River Granta transecting the scheme in two locations, the centre and south east located between the villages of Stapleford and Sawston and between Babraham and the Great Abingdon. Hobsons Brook, spring fed stream sourced from Nine Wells Nature Reserve, transects the route south of Addenbrooke’s Road. Other surface water features are also present along the scheme, including ponds, lakes, reservoirs and springs, which are presented in Mott MacDonald PRA in Figure 3-5.

The ground conditions encountered in each ground model section (Table 1-1) are discussed in Section 5.4 A series of cross sections and long sections have been produced to present the interpreted ground conditions along the proposed scheme alignment. The locations of the six areas, ground models including cross sections are presented on the site plan in Appendix B.

A summary of the preferred route and travel hub site are summarised in the tables below.

Table 1-2 - Summary of the preferred travel route [3]

Route Option	Start Grid Reference	End Grid Reference	Approximate Length (km)
Preferred Route	55180, 249784	545981, 255038	9.3

Table 1-3 - Summary of travel hub site [3]

Travel Hub Option Location	Grid Reference (Centre point)	Approximate area (m²)
Option B	551933, 249888	90,000

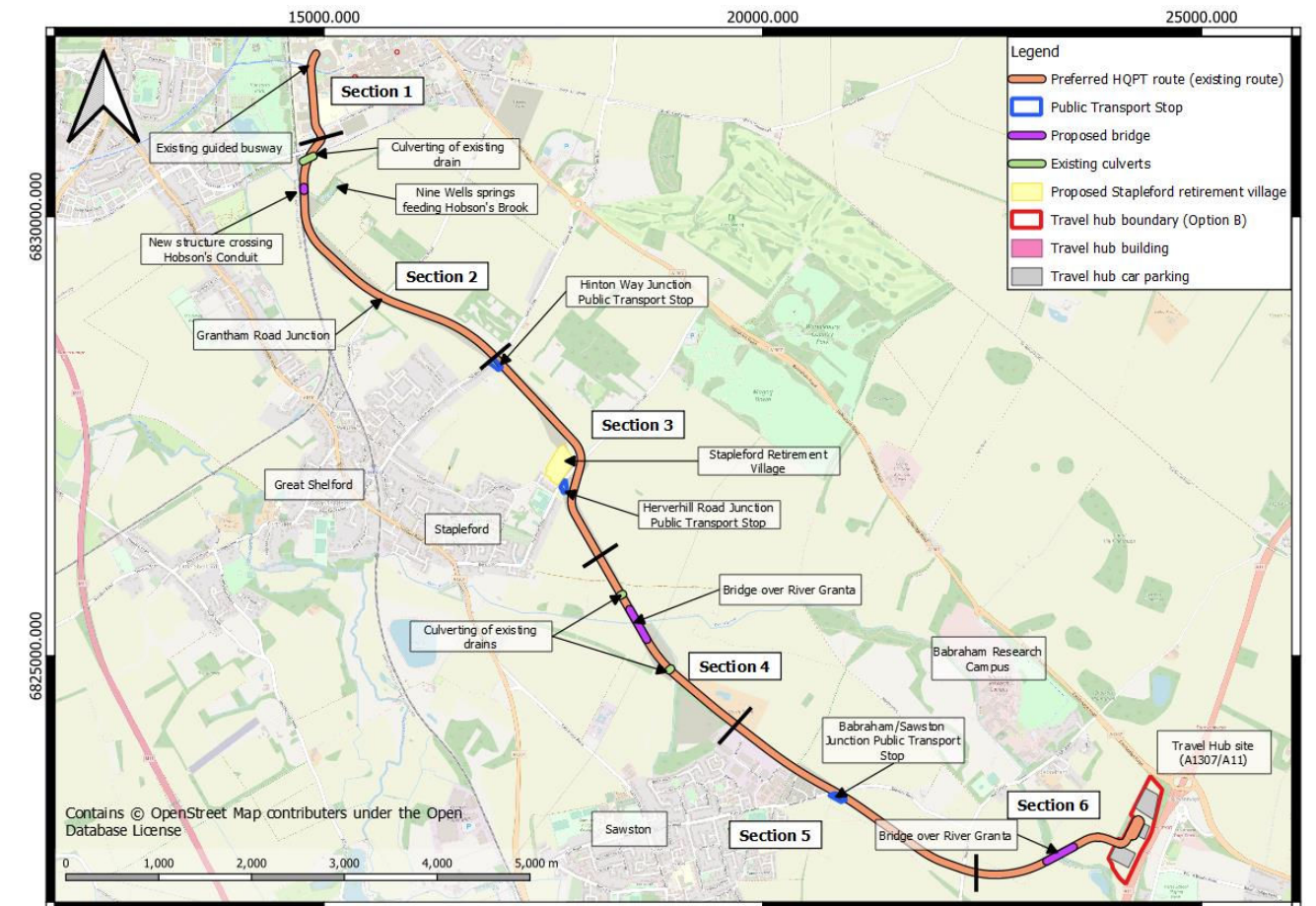


Figure 1-1 - Summary of general arrangement along preferred route alignment

1.2.3. Description of the Proposed Scheme

The description of the scheme has been summarised into Table 1-4 and Table 1-5, and shown on which describes the proposed works along each section of the preferred alignment. Additionally, reference to provided Mott MacDonald drawings has been made. The Mott MacDonald general arrangement drawings, showing the proposed infrastructure, are presented in Appendix A.5.

The scheme comprised the following principal elements that were summarised in the Mott MacDonald report [8]:

- 1) A new HQPT route approximately 7.3m wide between the A11 Travel Hub and Cambridge Biomedical Campus, the majority of which is to be a dedicated HQPT route, however to the north there is a segregated HQPT route section along Francis Crick Avenue;
- 2) A new Travel Hub site off the A1307 / A11;
- 3) Construction of a new Active Travel Path (ATP) for cycling/walking facilities, running adjacent to the HQPT route between the A11 Travel Hub and a point south of Francis Crick Avenue;
- 4) Ancillary works including signal-controlled junctions, junction upgrades, tie-ins to existing infrastructure, lighting and landscaping;
- 5) Upgrades to Francis Crick Avenue to create segregated HQPT lanes along the road; and
- 6) Enhancements to the existing cycle provision (The DNA Cycle Path) between the ATP at the DNA Cycle Path tie in, and its junction with Francis Crick Avenue.

It is understood that the buses will run on the existing carriageway along Francis Crick Avenue, in Section 1. Footpath and cycleway widening, as well as changes to the Dame Mary Archer Way roundabout are proposed to be undertaken.

Table 1-4 - Preferred route alignment description

Route Section	Route Description
1	The section is c.500m trending north to south from the existing bus route (Ch. 0m) along Francis Crick Avenue to Cambridge Biomedical Campus, with an elevation of approximately 15mAOD along the route. The route lies to the east of Bellatrix development (Biological Support Building) and the west of Addenbrooke's Hospital.
2	The section of the scheme is c.2500m long beginning at Dame Mary Archer roundabout to the south of Cambridge Biomedical Campus. The section connects the existing guided busway approximately 450m north running along Francis Crick Avenue. The section aligns south to southeast crossing a drainage ditch and cycleway at Ch. 670m and Hobson's Brook (Ch. 900m), a spring fed stream. The stream is fed by Nine Wells Nature Reserve, located 80m east to where the route crosses the Hobson's Brook. The route runs parallel with Bethnal Green and King's Lynn Line until Ch. 1100m where it diverts to the southeast across agricultural fields to Hinton Way. Elevation gradually increases from 15mAOD at Dame Mary Archer roundabout to 30mAOD at Hinton Way.
3	The section is c. 1800m long commencing at Hinton Way, located on a corridor between residential properties at an elevation of 30mAOD. The route is orientated southeast for approximately 925m towards Haverhill Road, southwest of Fox Hill, where elevations are between 38 and 40mAOD, where it bears south to southeast towards the River Granta decreasing in elevation to 20mAOD. The borough of Stapleford lies approximately 150m east to the section.
4	The section is c.1500m long and crosses the River Granta at Ch. 5000m at an elevation of approximately 19mAOD, via a bridge. The section then bears to the southeast towards North Farm where elevation remains at 20mAOD. The town of Sawston lies immediately to the south of the section.
5	This section is c.2000m long beginning at North Farm and ending at High Street. The route runs parallel with South Cambridge Business Park (Sawston) for approximately 770m where it cross Sawston Road and Sawston-Babraham cycleway at Ch. 6870m where the elevation gradually increases from 23mAOD to 27mAOD. The route bears to the southwest towards High Street, at elevation approximately 28mAOD, located 80m northeast of a northwest to southeast trending disused railway and approximately 370m south of Church Farm.
6	This section is c.1200m long running northeast towards the A11 to the proposed travel hub site. The route crosses the River Granta Ch. 8560m. The route traverse across agricultural fields, from High Street at approximately 30mAOD elevation. The majority of the route lies at 27mAOD, where it then increases to 32mAOD at Two Acre Plantation (Ch. 9116m). The travel hub site is located immediately to the southeast of Two Acre Plantation, west of the A11. The section is located approximately 400m south of Babraham.

Table 1-5 - Summary of the proposed scheme works along the preferred route adapted from Mott MacDonald Corridor Design Report [8]

Route Section	Description of works	Drawing Document Reference
1	Approximately 0.5 km of on road HQPT route along Francis Crick Avenue. Public Transport Route crosses Dame Mary Archer Way/Addenbrooke's Road. Public footway and share use footway Tie in with existing earthworks Retaining wall to support access track	403394-MMD-HWA-00-DR-HW-0925
2	Proposed public Transport Route and Active Travel Route. Horse Crossing (Ch. 1900m) Retaining wall required at tie in point with existing earthworks near Addenbrooke's Road. Culverting of existing drain (Ch. 666 to 670m) to enter the drainage ponds immediately west of the Addenbrooke's Road/Dame Mary Archer Way roundabout. Bridge and embankment crossing 'Hobsons Conduit' (Ch. 874 to 917m) to cross the northwest to southeast trending Hobson's Brook. Signal controlled junction at Grahams Road Earthworks – embankments up to 2.5m high and cuttings between 0.5-1.0m.	403394-MMD-HWA-00-DR-HW-0926 403394-MMD-HWA-00-DR-HW-0927 403394-MMD-HWA-00-DR-HW-0928 403394-MMD-HWA-00-DR-HW-0929
3	Proposed public Transport Route and Active Travel Route.	403394-MMD-HWA-00-

Route Section	Description of works	Drawing Document Reference
	Public footpath. Horse Crossing (Ch. 3800m) Hinton Way Junction PT Stop (Ch. 2754 to 2869m) Haverhill Junction PT Stop (Ch. 3795 to 3903m) Earthworks – embankments up to 1.0m high and cuttings up to 2.8m.	DR-HW-0930 403394-MMD-HWA-00-DR-HW-0931 403394-MMD-HWA-00-DR-HW-0932
4	Proposed public Transport Route and Active Travel Route. Culverting of existing drain (Ch. 4784 to 4789m) Bridge over River Granta (4836 to 5057m) Culverting of existing drain (Ch. 5410 to 5414m) Crossing points of existing footpaths (Ch. 4027m) and Farm Crossing Point (Ch. 4958m) Crossing of West Way (Ch. 6100m) Earthworks – embankments up to 5m high and cuttings up to 0.5m.	403394-MMD-HWA-00-DR-HW-0933 403394-MMD-HWA-00-DR-HW-0934 403394-MMD-HWA-00-DR-HW-0935
5	Proposed public Transport Route and Active Travel Route. Crossing points of existing footpath (Ch. 6460m) Babraham / Sawston Road Junction PT Stop (6790 to 6880m) Junction with High Street – signal-controlled junction (Ch. 7857m) Earthworks – filling works up to 0.5m	403394-MMD-HWA-00-DR-HW-0936 403394-MMD-HWA-00-DR-HW-0937 403394-MMD-HWA-00-DR-HW-0938 403394-MMD-HWA-00-DR-HW-0939
6	Proposed public Transport Route and Active Travel Route. Bridleway Bridge over River Granta (8468 to 8683m) Existing gas main (8908 to 8911m) Earthworks – filling works up to 6m Travel Hub Site	403394-MMD-HWA-00-DR-HW-0939 403394-MMD-HWA-00-DR-HW-0940 403394-MMD-HWA-00-DR-HW-0941 403394-MMD-HWA-00-DR-HW-0942 403394-MMD-HWA-00-DR-HW-0943

1.3. Geotechnical Category of the project

The Scheme has been assessed in accordance with guidelines provided in BS EN 1997-1:2004 +A1:2013 (EC7) (BSI Standards Publication, 2013) and CD 622 (DMRB, 2019). The Scheme is considered to include conventional types of geotechnical structures, earthworks and construction activities, with no exceptional geotechnical risks, unusual or difficult ground or loading conditions. As such this scheme has been assigned a Geotechnical Category 2.

1.4. Other Relevant Information

A series of other reports and drawings have been produced that provide additional information on the scheme. These documents have been used to inform this report and include:

- Mott MacDonald Ltd, “Cambridge South East Transport - Phase 2, Ground Investigation Specification, 403394-MMD-HWA-00-RP-HW-0462,” Mott MacDonald Ltd, Norwich, October 2020 [3];
- Tetra Tech, “Cambridge South East Transport - Phase 2, Factual Ground Investigation Report, B024522,” Tetra Tech, London, April 2022 [4];
- Mott MacDonald Ltd, “A1307 Cambridge South East Transport - Phase 2, Geotechnical and Geo-Environmental Preliminary Risk Assessment, 403394-MMD-TGE-00-RP-GE-0248,” Mott MacDonald Ltd, Norwich, December 2019 [6]; and,

- Mott MacDonald Ltd, “Cambridge South East Transport Phase 2, High Quality Public Transport and Active Travel Path Corridor Design, 403394-MMD-HWA-00-RP-HW-0846 | P01,” Mott MacDonald Ltd, Norwich, May 2021 [8].

1.5. Assumptions and limitations

This report has been produced subject to the following assumptions and limitations:

- The findings contained in this report are based on information obtained from a variety of sources detailed in this report, which are considered to be reliable. No responsibility can be accepted by Atkins for the accuracy of the third-party information including reference data contained within site specific database reports.
- This report provides factual information pertaining to the ground investigation. This report presents an interpretation of ground conditions and geotechnical parameters to inform design. The interpretation of parameters has been based on Atkins understanding of the scheme, and assumptions about parameters for design. The designer is required to review and consider the relevant limit states and design requirements to select appropriate values for use in their design.
- This report is prepared and written in the context of an agreed scope of work and should not be used in a different context. Furthermore, new information, improved practices and changes in legislation may necessitate a re-interpretation of the report in whole or in part after its submission.
- Due to the inherent variability of the ground conditions between exploratory hole positions, interpretations are subject to the limitations of only assessing a relatively small proportion of sub-surface conditions at the Scheme.
- Monitoring data provide information pertaining to specific discrete locations on particular dates. Recorded ground conditions may differ from the recorded results if this monitoring was to be undertaken on other dates.
- This report should be read considering the legislation, statutory requirements and/or industry good practice applicable at the time the report was written. Any subsequent changes in legislation or guidance may necessitate the findings to be reassessed in light of these circumstances.

2. Existing Information

2.1. General

The purpose of this section of the report is to summarise the currently available information that is considered directly relevant to the geotechnical and geo-environmental elements of the proposed scheme. The information will be used in later sections of this report as background information to determine site conditions and aid the identification and determination of constraints and hazards that could impact on the proposed scheme.

A standalone Contaminated Land Assessment Report produced by Atkins (Ref. GCP_5210174_A1307 Cambridge South East Transport_CLRA) appends the GIR (Appendix E) which provides a summary of the existing environmental information and geo-environmental constraints of the scheme.

Information provided in the Geotechnical and Geo-Environmental Preliminary Risk Assessment by Mott MacDonald [6] for the scheme has been summarised and reviewed in this section.

2.2. Topography and Geomorphology

Topographic mapping and LiDAR shows that along the majority of the route elevation generally lies between 20m AOD and 30mAOD. Elevations between 30m AOD to 40mAOD are shown along Section 3 between chainages 2820m and 3455m.

Elevation generally increases from the end of Section 1, south of Dame Mary Archer roundabout, from 13m AOD to the beginning of Section 3, at 30mAOD at Hinton Way. The highest elevation point is 39mAOD recorded along Section 3 within agricultural fields. Ground level gently decreases towards Haverhill and further towards the River Granta at 17mAOD. Along the remainder of the route the elevation further increases towards Sawston Road in Section 5, noted at 26mAOD, and the travel hub site where ground levels are recorded up to 35mAOD.

An elevation profile and DTM hillshade model based on the publicly available LiDAR data is shown in Figure 2-1.

2.2.1. Geomorphology

The scheme sits within the Dissected Till Domain. This is described in BGS Onshore GeoIndex [1] as ‘a gently undulating spreads of weathered (Pre-Devensian) till, glaciofluvial and glaciolacustrine deposits, generally lacking constructional features and mainly restricted to interfluves. Widespread periglacial landforms and deposits at surface.’ This domain comprises lowlands of the Midlands and East Anglia lying between the Devensian and Anglian glacial limits. In East Anglia, the landscape is a low-lying, relatively flat, dissected till plateau with a coverage of superficial deposits that include various glacial lithofacies laid down by successive Middle Pleistocene advances of the British Ice Sheet [1].

An DTM hillshade model has been produced for the scheme presented within Appendix A.6.

Table 2-1 - Site geomorphology

Section	Surface geomorphology
1	Low lying ground approximately 16mAOD gently sloping to the south to 14mAOD.
2	Low lying ground at 14mAOD until Ch.1100m where elevation rises to 17mAOD on a lithological bench of the West Melbury Marly Chalk Formation. A marked chainage in elevation at Ch.1850m represents a change in geology to the more competent Zig Zag Chalk Formation. Elevation rising to 28mAOD at Ch.2800m.
3	Elevation rising to 39mAOD at Ch.3300m where it decreases to 23mAOD at Ch. 3700m onto a 200m lithological bench of the Zig Zag Formation. An incised dry valley is noted to the northeast of Section 3. Elevation gently decreases to 19mAOD at Ch.4500mAOD, where superficial deposits of the River Terrace Gravels are mapped. Evidence of historical field boundaries noted by the linear patterns across the agricultural fields. Hummocky ground is noted to the east of Section 3 in areas of dry valleys and a change in geology upslope to the Holywell Nodular Chalk Formation. Within these areas, Head Deposits are likely present, however they have not been mapped on BGS records.
4	Elevation gently increases from 19mAOD to 21mAOD across the section. Lower lying areas are associated with the River Granta. Hummocky ground indicates the presented of superficial deposits of River Terrace Gravels and Alluvium. Hummocky ground located on Chalk slopes may indicate solifluction and presence of Head Deposits.

Section	Surface geomorphology
	Possible dissolution features identified by circular depressions in areas of the Chalk Group.
5	Elevation generally increases along the section from 21mAOD to 29mAOD as bedrock of the Holywell Nodular Chalk is encountered. Evidence of historical field boundaries noted by the linear patterns across the agricultural fields. Two circular depressions are noted c.370m southwest from Ch.7500m which could be attributed to dissolution features.
6	Elevation decreases at Ch.8300mAOD from 30mAOD to 25mAOD which is attributed to the River Granta. River Terrace Deposits are mapped on BGS records on the flanks of the slope and Alluvial deposits are mapped in proximity to the lower lying areas around the River Granta. Superficial deposits were deposited at lower level as river systems eroded the chalk. Circular depressions are noted c.330m southwest from the Travel Hub Site which could be attributed to a dissolution feature.

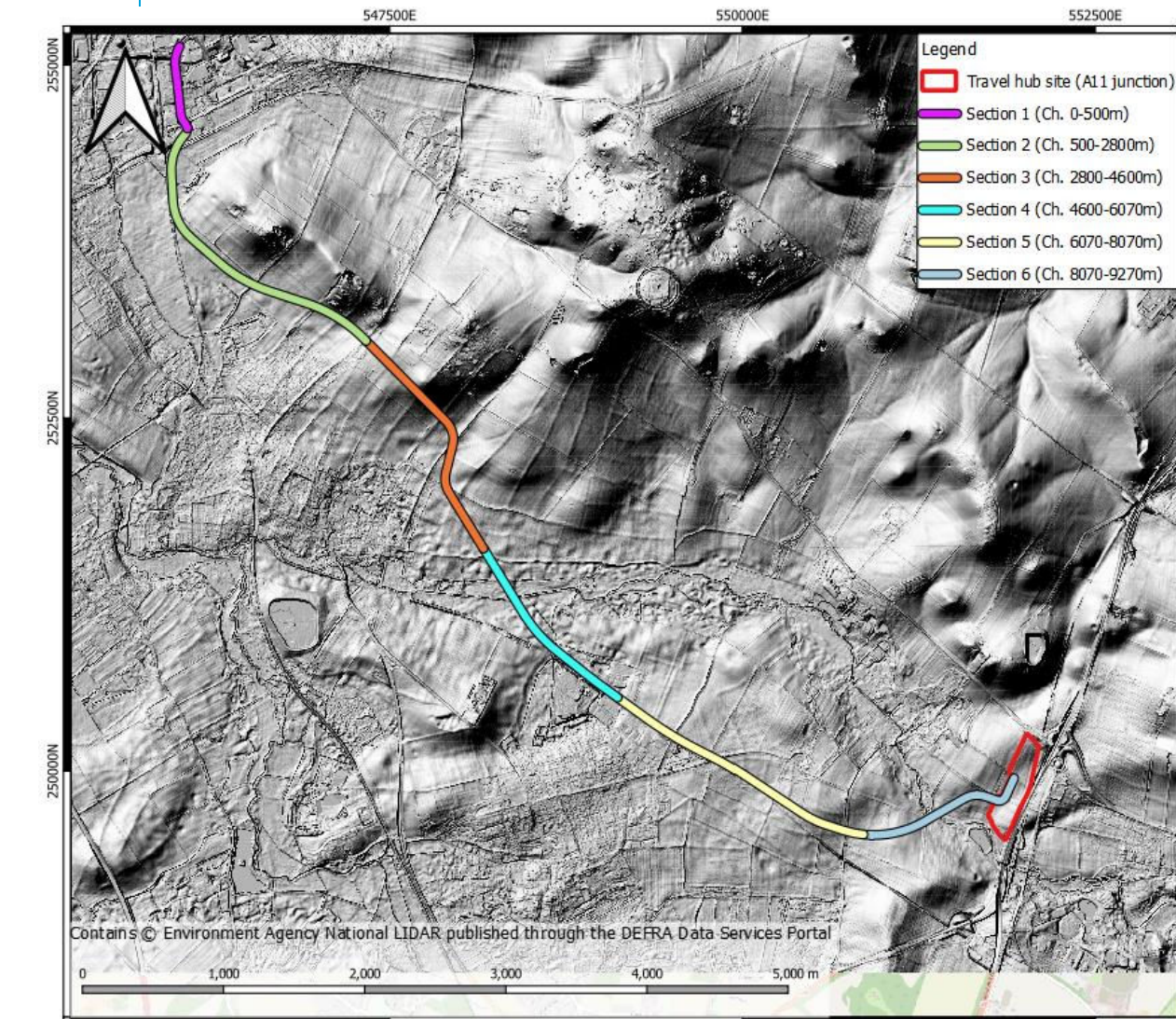
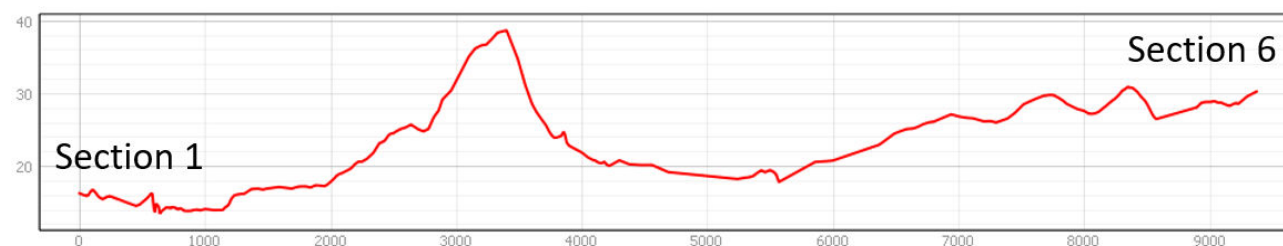


Figure 2-1 - LIDAR DTM across the preferred route alignment (top) and route alignment elevation profile (bottom)

2.3. Published Geology

The British Geological Survey (BGS) provides geological mapping of the area through the online GeoIndex [1] and the published 1:50,000 mapping, (England and Wales, Map Sheet 205, Saffron Walden) [2]. BGS records indicate that the scheme is underlain by superficial deposits of Alluvium, River Terrace Deposits and Glaciogenic Deposits of the Lowestoft Formation. Superficial deposits overlie bedrock of the White Chalk Subgroup, from youngest to oldest, (Middle Chalk) comprising the Newpit Chalk Formation and Holywell Nodular Chalk Formation. This is further underlain by the Grey Chalk Subgroup (Lower Chalk) comprising the Zig Zag Formation and the West Melbury Marly Chalk Formation.

Made Ground and engineered fill are not recorded along the route alignment on BGS mapping. Two entries of worked ground are located within 500m of the site boundaries.

The artificial, superficial and bedrock geology along the scheme is presented in Appendix A.2.

A summary of the geology of the scheme as reported within literature [10] and within the Mott MacDonald Report [6] is presented in stratigraphic order in Table 2-2. Formation descriptions have been based on BGS Lexicon [11] and the geological Memoirs of the Map Sheet 205 for Saffron Walden [10].

Table 2-2 - Geological sequence for the scheme

Formation/Member		Description	Thickness (m)	
Superficial Deposits	Alluvium	Alluvium is a general term for clay, silt, sand and gravel. It is the unconsolidated detrital material deposited by a river, stream or other body of running water as a sorted or semi-sorted sediment in the bed of the stream or on its floodplain or delta, or as a cone or fan at the base of a mountain slope. Synonym: alluvial deposits. Normally soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. A stronger, desiccated surface zone may be present [11].	Up to 3m	
	River Terrace Deposits (1-3)	Sand and gravel, locally with lenses of silt, clay or peat [11]. These sedimentary deposits are fluvial in origin. They are detrital, ranging from coarse- to fine-grained and form beds and lenses of deposits reflecting the channels, floodplains and levees of a river or estuary [11].	Up to 10m	
	Lowestoft Formation (Diamicton, Glacial Till)	These sedimentary deposits are glaciogenic in origin. They are detrital, created by the action of ice and meltwater, they can form a wide range of deposits and geomorphologies associated with glacial and inter-glacial periods during the Quaternary. The Lowestoft Formation forms an extensive sheet of chalky till, together with outwash sands and gravels, silts and clays. The till is characterised by its chalk and flint content. The carbonate content of the till matrix is about 30% [11].	Up to 55m in buried paleovalleys	
	Lowestoft Formation (Glaciofluvial Till)	Outwash deposits which are highly variable, ranging from gravels with well rounded chalk and flint pebbles and in a sparse sandy matrix; through coarse angular flint gravels; to coarse grained, ferruginous gravels which are generally very weathered; to pure golden brown sand [6].	Up to 6m	
Bedrock	White Chalk Subgroup (Middle Chalk)	New Pit Chalk Formation	Principally blocky, white firm to moderately hard chalk with numerous marls or paired marl seams. Flint occurs sporadically in the upper part in the deeper basin areas. In some localities flint, in seams, occurs to the base of the formation most notably over structural highs, towards the margins of the outcrop [12].	c.70m
		Holywell Chalk Formation	Generally hard nodular chalks with thin flaser marls and significant proportions of shell debris in part.	12 to 30m

Formation/Member		Description	Thickness (m)
Grey Chalk Subgroup (Lower Chalk)		Base marked by the interbedded coloured marl and chalk succession characteristic of the Plenus Marls member [12]. The Melbourn Rock Member is a hard to very hard off-white, blocky fractured chalk with numerous nodular chalk beds and thin anastomosing (net like pattern) marls, usually between 2 and 3m thick [11]. This member marks the base of the formation. The Plenus Marls Member is interbedded marl and chalk, which marks the lower boundary of the Formation and the upper contact of the Zig Zag Chalk Formation.	
	Zig Zag Chalk Formation	Firm, pale grey to off-white blocky chalk with a lower part characterised by rhythmic alternations of marls and marly chalks with firm white chalk. Thin gritty, silty chalk beds act as markers in the sequence [12]. The lower boundary is placed at the possible erosional surface marked by a concentration of phosphatic pebbles in the base of the Totternhoe Stone Member. The upper surface is conformable and is redefined as the bedding plane beneath the lowest of the marls in the Plenus Marls Member of the overlying Holywell Nodular Chalk Formation [11]. The Totternhoe Stone Member is typically brownish-grey fine grained calcarenite, phosphatic in part, containing fossils shell fragments. This member marks the base of the Zig Zag Chalk Formation.	24 to 32m
	West Melbury Marly Chalk Formation	Buff, grey off-white, soft marly chalk and hard grey limestone arrange in couplets [12]. The Cambridge Greensand Member marks the base of the Formation and comprises a richly phosphatic and glauconitic sandy horizon characteristic of the base of the Chalk Group [10].	25 to 30m

Although, not mapped on BGS records, Head Deposits are likely encountered on the flanks of the hill slopes. Comprising a variably clayey, silt sand and gravel with more gravelly Head comprising a poorly sorted Gravel. Head deposits comprise of fragmented material following a period of weathering, moving downslope via solifluction. Solifluction is the slow viscous downslope flow of waterlogged soil and other unsorted and unsaturated superficial deposits [1]. The location of Head deposits in relation to River Terrace Deposits and Alluvium is presented in the schematic diagram below.

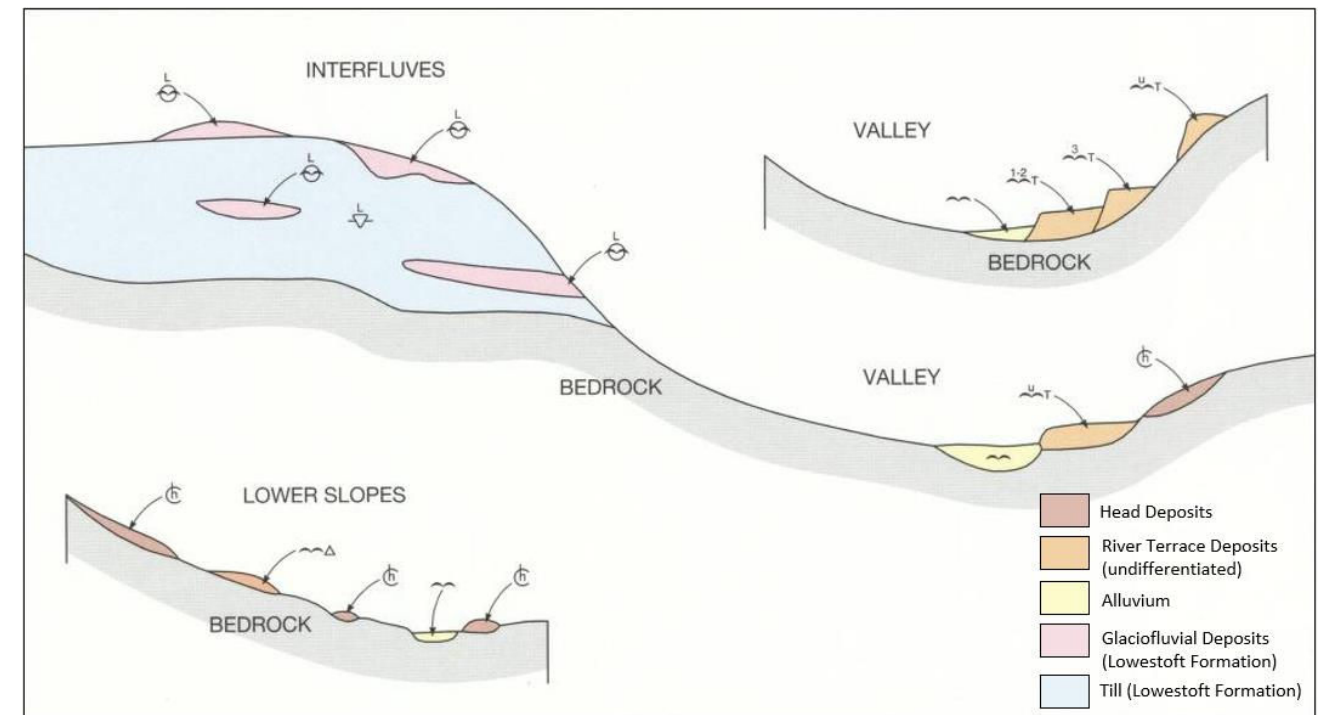


Figure 2-2 - Schematic cross section showing relationships of superficial deposits, adapted from BGS Map Sheet 205 [2].

2.3.1. BGS Historical Borehole Records

A search of the BGS GeoIndex shows a 65no. exploratory holes within a 500m radius of the proposed works, of which 26no. were available for review and 39no. records were confidential (attributed to Addenbrooke's Road and Addenbrooke's Treatment Centre along Section 1 of the route alignment). The available BGS borehole records are presented in Appendix A.2.

Table 2-3 shows available historical BGS boreholes found within 500m of the site. Appendix A shows the boreholes within a 500m radius of the site.

Table 2-3 - Summary of available BGS boreholes records with 500m of the route

Section	BGS borehole reference	Date	Grid reference	Depth (m)	Engineering description and depth (m)	Ground water (m bgl)
1	TL45NE233	2002	545990, 255300	10	Topsoil (0.0 to 0.45m), Sandy Clay and Gravel (0.45 to 1.2m), Clay (1.2 to 10.0m).	5.8
	TL45SE63	2002	545600, 254250	10	Topsoil (0.0 to 0.55m), Clay (0.55 to 1.5m), Sand (1.5 to 3.5m) Sandy Clay (3.5 to 10.0m).	3.2
	TL45SE64	2002	545910, 254500	10	Topsoil (0.0 to 0.6m), Clay (0.6 to 10.0m).	7.3
	TL45SE65	2002	546500, 245700	10	Topsoil (0.0 to 0.45m), Sandy Clay and Gravel (0.45 to 0.9m), Clay (0.9 to 10.0m).	5.8
2	TL45SE11	May 1960	547230, 253360	35.96	Loose Lower Chalk (0.0 to 22.5m), Solid Lower Chalk (22.5 to 2.3m), Soft Lower Chalk (24.3 to 26.4m). Hard Lower Chalk (26.4m to 35.96m)	Not recorded
	TL45SE15	1929	546580, 253800	33.52	Lower Chalk	29.7
	TL45SE25	unknown	547250, 253450	37.49	Made Ground (0.0 to 0.9m), Loose chalk with layers of chert (0.9 to 24m), Solid hard chalk (24.0 to 36.9m) Lower Chalk	Not recorded
3	TL45SE8	April 1960	547500, 252100	17.37	Made Ground (0.0 to 2.1m), Lower Chalk (2.1 to 17.37m)	2.1

Section	BGS borehole reference	Date	Grid reference	Depth (m)	Engineering description and depth (m)	Ground water (m bgl)
	TL45SE10	unknown	548380, 252080	19.2	Lower Chalk (0.0 to 19.2m)	15.9
	TL45SE31	November 1993	548100, 252100	11.0	Grey clay and stone (0.0 to 0.6m), Firm light grey chalk (0.6 to 9.96m)	2.85
4	TL45SE36	1958	548910 251340	13.41	Topsoil (0.0 to 0.6m), Terrace Gravel (0.6 to 3.0m) Zone Chalk (3.0 to 4.2m), Barwell Rock (4.2 to 13.5m), Chalk Marl (13.5 to 45m)	14.4
	TL45SE56	2005	548310, 251000	15	Orange, brown slightly silty SAND with some fine rounded gravel (0.0 to 2.3m), Firm brownish grey clayey SILT with occasional gravel (2.3 to 3.2m), Orangey brown and grey weathered putty CHALK with gravel (3.2 to 3.6m), Orangey brown and grey weathered putty CHALK (3.6 to 7.0m), Grey rock and putty CHALK with bands of dark grey chalk (7.0 to 15.0m)	6.2 rising to 2.61
5	TL45SE40	unknown	549510, 250020	unknown	Not available for review	Not recorded
	TL45SE57	2005	549100, 250400	50	Made Ground (0 to 1.m), Black peaty soil, clay and sand (1 to 2m), Grey Chalk (2 to 5m), Soft white chalk and water (5 to 17m), Soft putty like chalk (17 to 33m), Medium Chalk (33 to 35m), Soft chalk (35 to 43m), Grey mudstone/clay (43 to 50m)	5.0
	TL55SW14	May 1960	550460, 250050	10.36	River Terrace Gravels onto Middle Chalk (boundary depths not recorded)	7.65 (well record)
	TL55SW30	1998	550500, 250100	50	Topsoil (0.0 to 0.4m) Sandy Clay (0.4 to 1.4m), Putty Chalk (1.4 to 12.0m), Tough Clay like Chalk with flints (12.0 to 18.4m), Broken weathered Chalk and flints (18.4 to 46.0m), Firm chalk and flints (46.0 to 50.0m)	10.88
	TL55SW34	unknown	550400, 250000	unknown	Chalk	Not recorded
	TL55SW44	2011	550465, 250100	34	Topsoil (0 to 2.m), Chalk (2 to 18m), Hard Chalk (18 to 24m), Chalk (24 to 34m)	6.0
	TL54NW12	1929	550670, 249240	3.2	Middle Chalk	Dry
	TL54NW17	May 1960	550740, 249830	13.14	River Terrace Gravels onto Middle Chalk (boundary depths not recorded)	10.08
6	TL54NW29	1953	55250, 249940	30.48	Topsoil (0.0 to 0.6m), Chalk (0.2 to 30.48m)	11.4
	TL54NW30	1957	552010, 249430	32.91	Topsoil (0.0 to 0.45m), Chalky Clay (0.45 to 1.95m), Sand and Gravel (1.95 to 5.7m), Soft Chalk (5.7 to 13.2m), Hard Chalk (13.2 to 14.25m), Medium Chalk (14.25 to 32.91m)	8.4
	TL54NW37	Unknown	551780, 249330	86	Topsoil and gravel (0.0 to 7.0m), Chalk – hard with soft banks (7.0 to 86.0m) Totternhoe Stone at 20.1m (interpreted from lost circulation)	Not recorded
	TL54NW42	1949	552030, 249440	23.77	Topsoil (0.0 to 0.6m), Chalk (0.6 to 23.77m)	7.8

Geological records for TL55SW31 and TL55SW32 (Section 5, Church Farm) were duplicate records of TL55SW14 and therefore are not presented above.

2.3.2. Structural Geology

The scheme is situated in the River Granta Valley, a tributary of the River Cam, at the base of the Gog Magog Hills, south of Cambridge. The regional dip of the strata is to the southeast, approximately 2-3° [2], locally disrupted by minor folding. The trend of the slope is from the top of White Hill Farm down through Nine Wells towards the River Granta. This forms the scarp slope of the major Chalk escarpment that runs from the Chilterns to the north Norfolk coast [13]. The previous Mott MacDonald report states that two main episodes of folding occurred affecting the Late Cretaceous rocks of the Chalk Group [6], followed by a period of erosion of which the Upper Greensands were deposits on top of truncated folding. Folding has trends of NNE-SSW with northward plunges trending on the line of the Upware inlier. The second episode of folding in the mid-Tertiary resulting in the Upware Anticline corresponding syncline can be found striking parallel to the anticline, with its axis approximately 1.6km to the west. Across the chalk there are minor folding with a general south-easterly dip [14].

2.4. Hydrology

The previous Mott MacDonald report [6] provides further details on the surface watercourses in Section 3.2.2 of their report, outlined below. Chainages, distances and sections have been updated to reflect the current route alignment.

Several water courses are located near the study area the most prominent being the River Granta, that trends northwest to southeast, and transects the transport route halfway along its length, between Stapleford and Sawston and again between Babraham and Great Abingdon. Other water features, including streams, ponds are reservoirs are listed below.

- Hobsons Brook transecting Section 2 at Ch.900m
- Pond, 75m northwest of Section 4 (Ch. 5800m)
- Reservoir, 90m southeast of Travel Hub Site
- Nine Wells Spring, 115m east of Section 2 (Ch. 1000m)
- Spring located proximal to North Farm, Sawston (Section 4)
- Hobson's Park Bird Reserve Lake, 370m northeast of Section 2
- Reservoir, 485m north of Travel Hub Site

Nine Wells Spring is located on the Cretaceous Grey Chalk where the thin stratum of Totternhoe Stone outcrops between the Zig Zag Chalk and the underlying West Melbury Marl. A spring line is located at the level of the Totternhoe Stone along its outcrop in the south of the county fed by White Hill Farm. At Nine Wells Spring the water emerges at four main springheads and many minor fissures, combining to form the Chalk stream, Hobson's Brook [13]. The Hobson's Brook orientates north to south and conjoins with the River Cam approximately 3km northwest of the site. A further spring is located on historical mapping (c.1900) proximal to North Farm, as shown on Figure 2-4. The Mott MacDonald report states that springs are noted at the base of the unit and it is likely where the unit is encountered at surface, groundwater could be close to the ground surface.

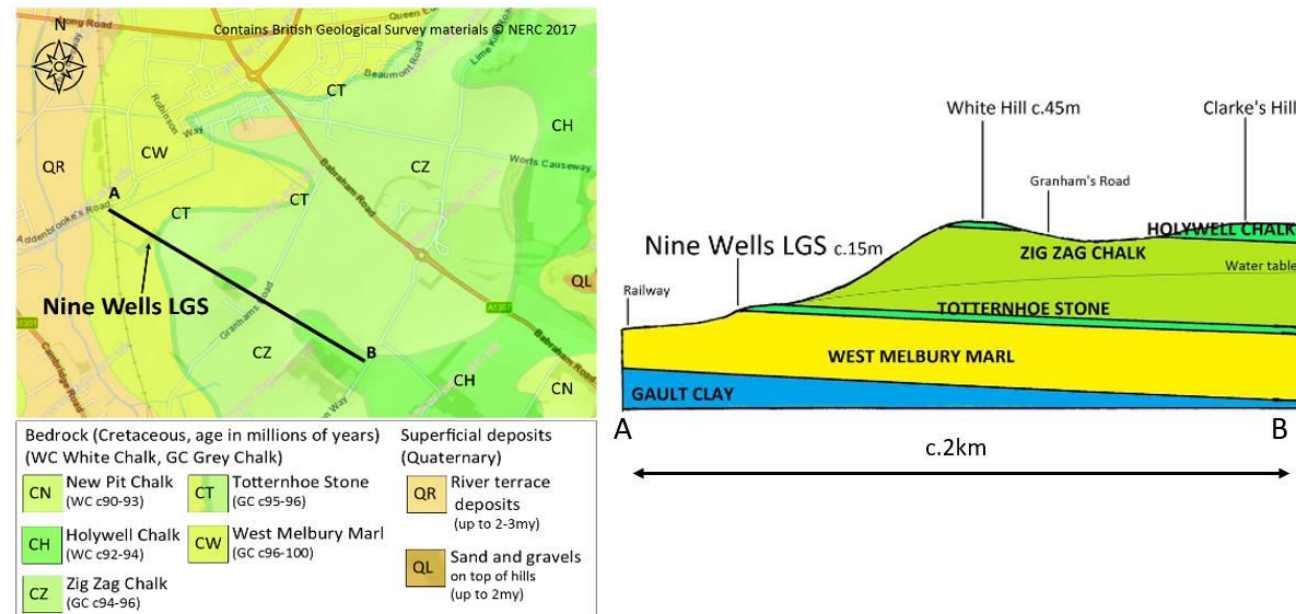


Figure 2-3 - Nine Wells spring line in relation to the Chalk Formations, adapted from Cambridge Geological Society [13]

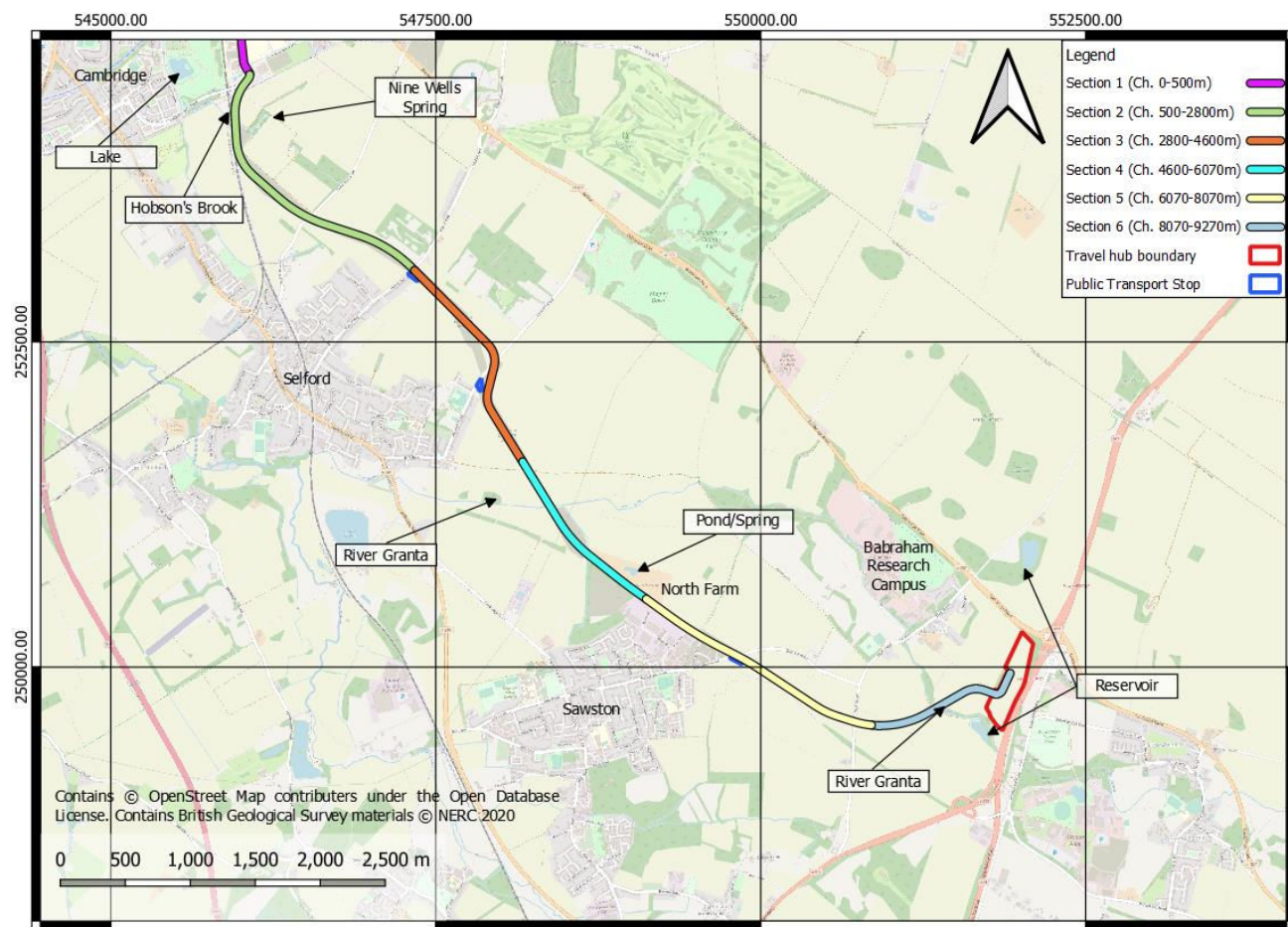


Figure 2-4 - Location of hydrological features near the site

2.5. Hydrogeology

Details of the known groundwater conditions can be found within the Mott MacDonald Report [6]. The hydrogeological characteristics of the scheme and the Environment Agency's (EA) aquifer designations are presented below.

Table 2-4 - Aquifer designations

Stratum/Formation		EA Aquifer Designation
Superficial Deposits	Alluvium	Secondary A
	River Terrace Deposits (1-3)	Secondary A
	Lowestoft Formation (Diamicton, Glacial Till)	Secondary Undifferentiated
	Lowestoft Formation (Glaciofluvial Till)	Secondary A
Bedrock	New Pit Chalk Formation	Principal
	Holywell Chalk Formation	Principal
	Zig Zag Chalk Formation	Principal
	West Melbury Marly Chalk Formation	Principal
	Gault Formation	Unproductive

According to the Envirocheck report, discussed in the Mott MacDonald Report [6], Groundwater Protection Zones are located to the southeast of the route alignment, summarised below and in Figure 2-5:

- Zone III 'Total Catchment', Section 4 (Ch. 4800m) to Section 5 (Ch. 6300m).
- Zone II 'Outer Zone', Section 5 (Ch. 6300m) to Travel Hub Site.
- Zone I 'Inner Zone':
 - 300m northwest of Section 6 near Babraham.
 - 340m southwest of Section 5 near Sawston.
 - 850m northeast of Section 5, north of Babraham Research Campus.

Review of BGS hydrogeological groundwater mapping indicates that groundwater levels range from 10mAOD in the northwest of the site to 20mAOD to the southeast within the Chalk Group, as shown in an extract of BGS mapping presented in Figure 2-6 [15, 6]. The BGS historical borehole records show groundwater levels at slightly shallower depths of approximately 14.4 to 29.7m bgl in the chalk in TL45SE10, TL45SE15, and TL45SE36.

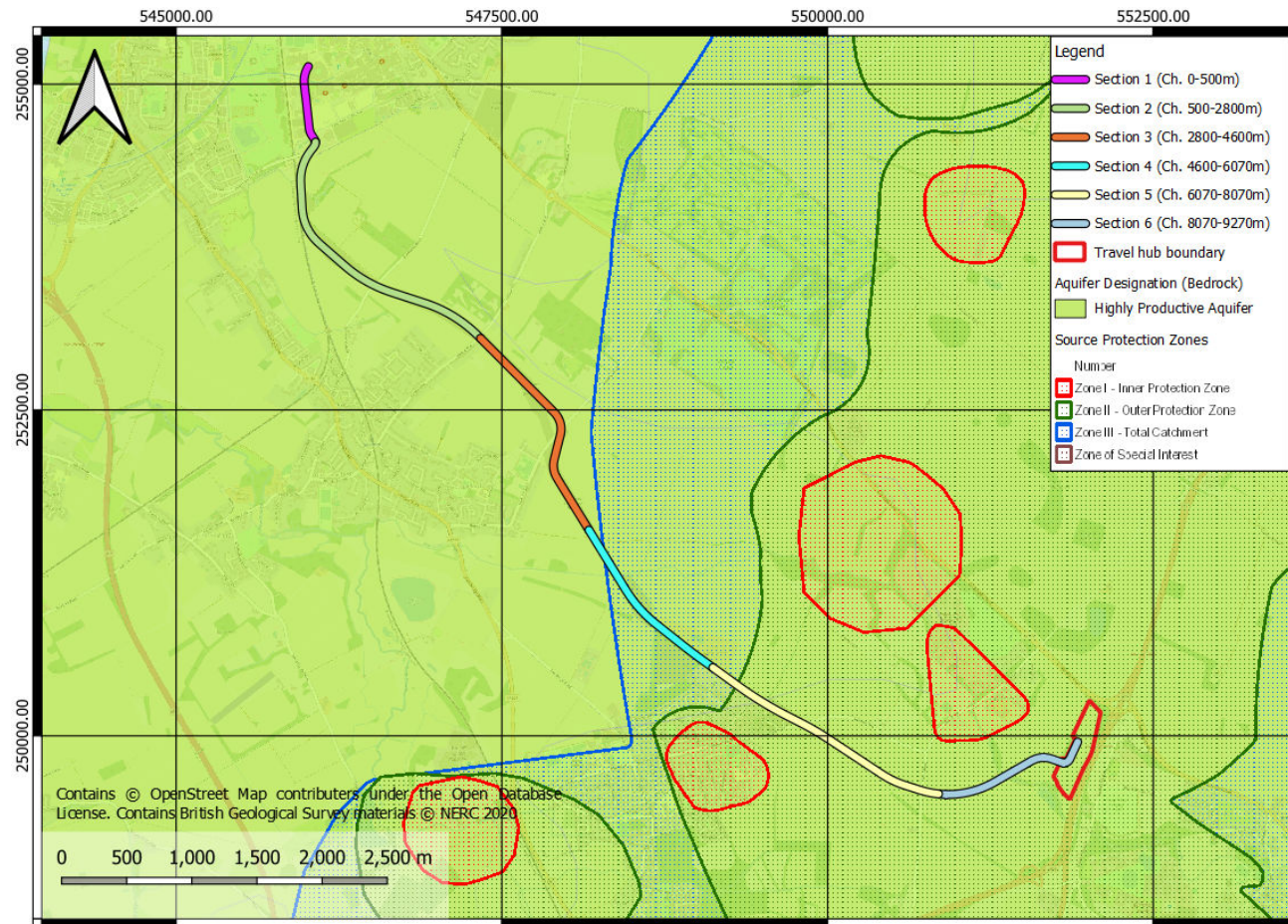


Figure 2-5 - Summary of hydrogeology along the preferred route alignment

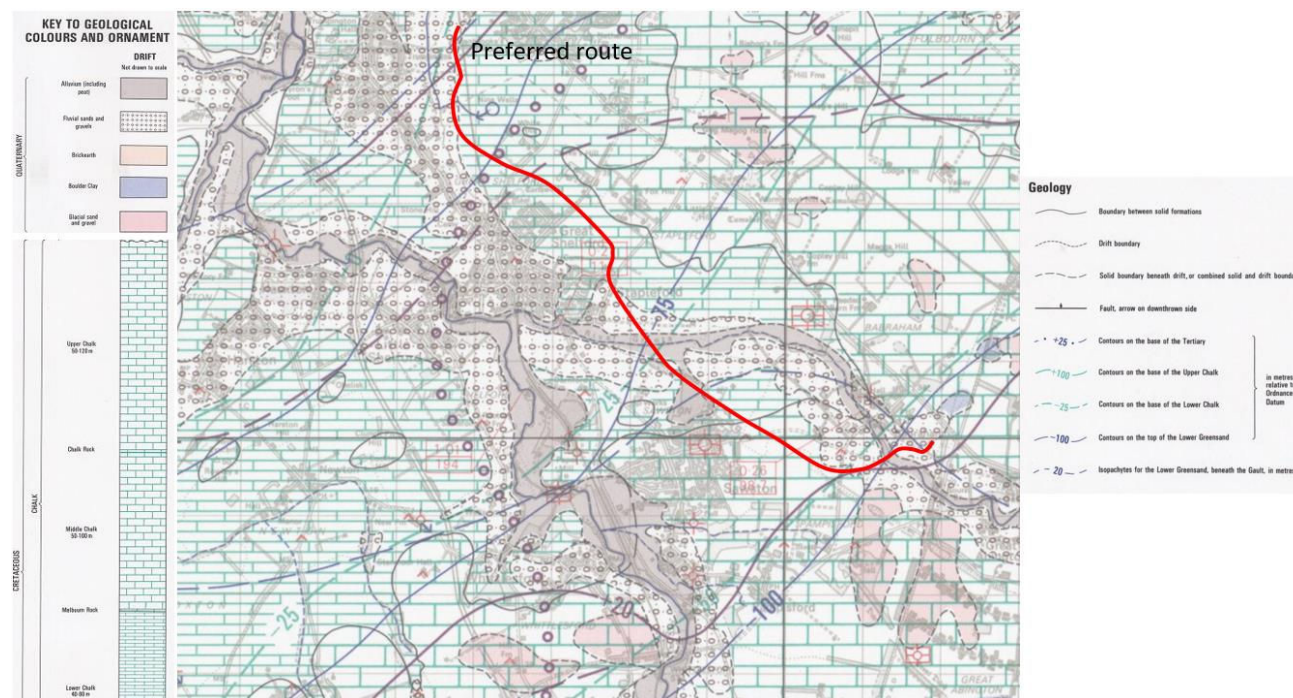


Figure 2-6 - Extract of the hydrogeological map for the site area showing groundwater potentiometric surface between 10 to 20m AOD [15]

2.6. Flood Records

A review of the information regarding flood risk and records at the scheme was undertaken in the Preliminary Risk Assessment (PRA) [6]. The PRA indicates that the overall risk of flooding for surface water from the site is low, with a 1 in 1000-year return period, with localised patches of medium and high risk with a return period of 100 to 30 years, indicated close to Addenbrooke Hospital and Sawston. Flood Zone 2 (medium risk) and Zone 3 (high risk) are found to be associated with the River Granta and area around Sawston, as indicated in Figure 2-7, indicating a medium to high risk of flooding. The PRA indicates there is the potential for groundwater flooding of property situated below ground level for the north-western extent of the scheme; for the land adjacent to the River Granta; and, for the land surrounding Sawston shown on the map below as Flood Risk Areas and Flood Warning Areas.

Areas deemed to be in flood zone 2 have been shown to have between 0.1% – 1% chance of flooding from rivers in any year. Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding. Areas within flood zone 3 have been shown to be at a 1% or greater probability of flooding from rivers. Land having a 1 in 100 or greater annual probability of river flooding. Both Flood zone 2 and 3 needs to submit a flood risk assessment as part of its planning application which shows the risk of flooding to the site.

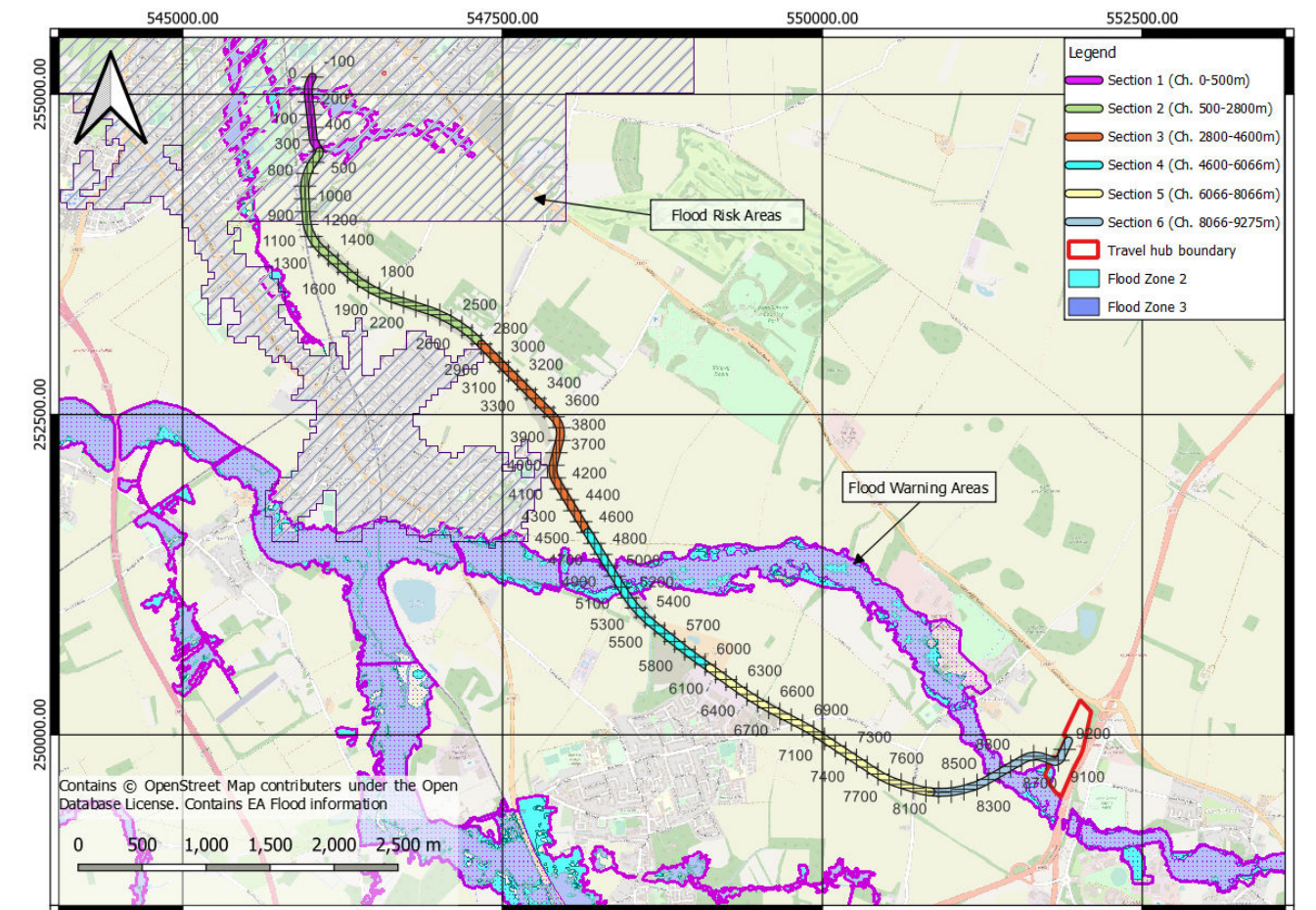


Figure 2-7 - Flood risk around the route alignment

2.7. Geohazards

The Mott MacDonald PRA report [6] summarised the hazard potential of the geotechnical hazards along the scheme from review of the Envirocheck Report.

Geohazards across the scheme have been discussed within the Mott MacDonald Geotechnical Preliminary Risk Assessment [6] and reviewed by Atkins below.

2.7.1. River Scour

The scheme area lies within the Cam and Ely Ouse Catchment Area. BGS Geosure GeoScour data states that 'the catchment has a very low to gently undulating morphology. Major alluvial tracts. Floodplains with silt and

clay commonly conceal water-saturated sand and gravel, river terraces mostly formed of sand and gravel. Can include lacustrine and peat deposits locally.'

The distribution of River Terrace Deposits and Alluvium are associated with the River Granta and low lying areas caused by incisions of rivers. Area noted to be affected by river incision are Section 4 and Section 6.

2.7.2. Landslides

In the PRA report [6] a 'Very Low' hazard were identified for landslides for each of the formations. Reference has also been made to the BGS 5km Hex dataset, where the scheme is classified as a Low susceptibility of potential ground movement caused by landslides.

2.7.3. Dissolution features

Dissolution occurs where slightly acidic surface water runoff discharges into and dissolves the underlying chalk which is comprised of calcium carbonate. This then becomes infilled with loose superficial soils. Areas of high risk are located when there is a cover of clay and sand. The Mott MacDonald PRA indicates that there is a 'Very Low' hazard rating for the presence of dissolution features for the Chalk Group. Reference has also been made to the BGS 5km Hex dataset, where the scheme is classified as a Low susceptibility of potential ground movement caused by soluble rocks. A moderate susceptibility is associated with the New Pit Chalk Formation and the Lewes Nodular Chalk Formation located approximately 3km south of the site.

The areas most at risk along the scheme are the low-lying areas which area covered by superficial deposits of Alluvium, River Terrace Deposits and glacial deposits of the Lowestoft Formation. Given the presence of shallow Chalk across the scheme and distribution of superficial deposits, Atkins consider the risk of dissolution features to be moderate to high in Sections 4 (Zig Zag Chalk Formation) and 6 (Holywell Nodular Chalk Formation), where there is mapped superficial cover.

2.7.4. Buried valleys

Evidence of buried valleys are present within the Cam Valley in the Safron Walden District. Deep channelling has been obtained at intervals from the head of the river near Quendon down to Whittesford. BGS boreholes suggest that the base of the channel rises northwards [10]. The channel is comprised of comminuted chalk in a silt matrix and locally of sand gravel and till. BGS records do not record evidence of buried channels north of Whittlesford. Buried channels are recorded again north of Petersfield, Cambridge, where up to 47.5m of drift is records in historical boreholes [10].

2.7.5. Shrink Swell

In the PRA report [6] a 'Very Low' hazard were identified for shrink-swell for each of the formations. Reference has also been made to the BGS 5km Hex dataset, where the Sections 1 to 5 of the scheme is classified as a Low susceptibility of potential ground movement caused by shrink-swell. Section 6 is classified as a Moderate susceptibility of potential ground movement caused by shrink-swell, this is attributed to superficial deposits of the Lowestoft Formation (Diamicton).

2.7.6. Aggressive Ground

Sulfates commonly occur both in the solid part of the ground (soil, rock or fill) and in groundwater. Sulfates can also be derived by oxidation of sulfides, such as pyrite, by natural processes such as weathering. This can cause aggressive ground conditions that can degrade concrete structures. The geological strata in proximity to the scheme most likely to have a significant amount of sulphides is the Gault Clay Formation, however there is a low risk due to the depth of the formation underlying the site. However, Alluvial deposits and peat, with is mapped on BGS records with its distribution following the path of the River Granta, may also have significant amount of sulphates. Additionally, Marcasite (FeS₂), a sulphur bearing mineral, may be found in nodules in chalk and limestones underlying the site.

2.7.7. Compressible ground

In the PRA report a 'Very Low' hazard were identified for compressible ground for each of the formations, except for Alluvium where a 'Moderate' rating was assigned. Alluvium is anticipated to be along Sections 4 and Section 6.

2.8. Historical development

The history of the site and surrounding area (within 500m of the site) has been reviewed and is discussed within the Mott MacDonald Desk Study [6].

Earliest available mapping (1886) indicated that the site area comprises mainly agricultural farmland. The Great Eastern Railway is located to the southwest of the proposed route and orientates southeast to northwest from Great Abington to White Hill. The Great Eastern Railway is shown to be dismantled sometime between 1973 and 1977. Old gravel pits are noted to the southeast of the alignment and a number of chalk pits are noted along the route. A spring is located at North Farm, Granham's Farm and Nine Springs.

The towns of Babraham, Sawston and Stapleford are shown on mapping in early 1900. Cherry Hinton and Trumpington are shown on mapping in early 1900 with development increasing in 1960 with Addernbrookes Hospital noted in mapping in early 1970 to the north of the site. In 1996 the A11 is noted to be widened with a new alignment which crosses the River Granta. The Four Went Ways roundabout is shown in the south of the site, which joins the A1307 to the A11.

2.9. Records of mines and mineral deposits

The site is underlain by Chalk Group and River Terrace Gravels, which has historically been quarried for building materials. The Mott MacDonald PRA report [6] and the Specification [3] indicates recoded mineral sites along the route alignment are summarised below:

- Grange Farm Chalk Pit (Chalk)
- Lagdens Grove Gravel Pit (Sand and Gravel)
- White Hill Clunch Pit (Chalk)
- North Farm Gravel Pit (Sand and Gravel)
- Grange Farm Chalk Pit (Chalk)

From review of the records within the desk study report, mineral sites are located in proximity to the travel hub site and Section 2, 4 and 6.

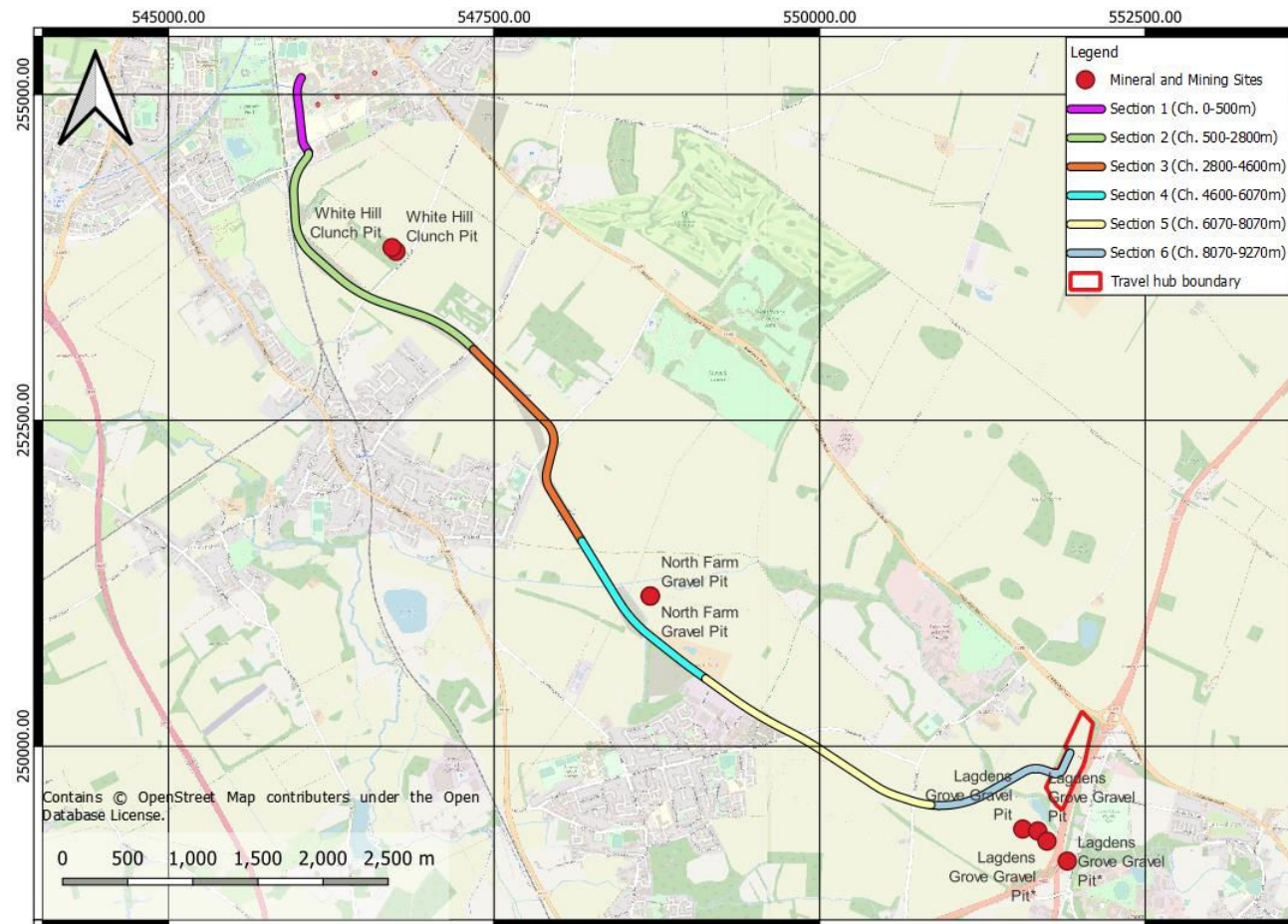


Figure 2-8 - Location of BGS Mineral sites

2.10. Unexploded Ordnance

A Preliminary UXO Risk Assessment report has been undertaken by 6 Alpha Associates, attached to the Mott MacDonald Report in Appendix E. The report indicates that there is a high risk of UXO and the potential for unexploded WWI and WWII ordnance is assessed as being likely. In accordance with CIRIA C681 Chapter 5 a detailed UXO threat and risk assessment was undertaken. The Tetra Tech Report stated, 'At the beginning of the site works programme, on instruction of CE notice 002, Tt commissioned Brimstone to undertake a focused UXO Risk Assessment ref 5 with the primary aim of establishing risk zoning across the site. This focused assessment, included as Appendix N, concludes that the area between approximate NGR 547250, 253136 and 548106, 251667 (between TP-PTR15 and TP-PTR-28) should be considered to carry a potentially elevated risk of UXO and that an EOD Engineer should be in attendance during ground investigations within this zone.'

2.11. Radon

The Mott MacDonald Report indicate that the site is within an area with less than 1% of homes are above the action level. Therefore, no protective measures are necessary in the construction of new dwellings. The action level is presented with respect to residential dwellings, which represents the most conservative values [6].

3. Preliminary Ground Model

BGS historical borehole records in the vicinity of the scheme have been reviewed and summarised below. Six preliminary Ground Models (GM) summaries have been developed based on the historical data. These will be built upon and finalised in the later sections of this report.

3.1. Route Section 1 (Ch. 0 to 500m)

Table 3-1 – Route Section 1 preliminary ground model

Strata/Formation	Historical Boreholes	Typical borehole log descriptions	Typical thickness (m)	Groundwater (m bgl)
Topsoil	TL45NE233	Topsoil	0.6	3.2 to 7.3
Superficial: River Terrace Deposits	TL45SE63 TL45SE64	Sandy clay and gravel	0.75 to 0.95	
Head (?)* or Cohesive River Terrace Deposits	TL45SE65	Sandy Clay	>8.8 to 9.4**	

Notes

*Presumed Head Deposits - not mapped on BGS.

**thickness not proven

The Gault Clay is described on borehole records >500m radius from Section 1. It is assumed that the Gault Clay Formation would be at approximately 30 to 50m bgl, underlain by the Lower Greensand.

3.2. Route Section 2 (Ch. 500 to 2800m)

Table 3-2 – Route Section 2 preliminary ground model

Strata/Formation	Historical Boreholes	Typical borehole log descriptions	Typical thickness (m)	Groundwater (m bgl)
Artificial: Made Ground	TL45SE11	Made Ground	0.9	29.7 (Chalk)
Bedrock: Lower Chalk (West Melbury Marly Chalk Formation)	TL45SE15	Loose chalk with layers of flint	22.5 to 23	
	TL45SE25	Hard chalk	>9.6 to 12.9*	

Notes

*thickness not proven

There is a lateral boundary between the West Melbury Marly Chalk Formation and the Zig Zag Chalk Formation at approximately Ch.1600m. This is marked by the Totternhoe Stone Member which marks the upper boundary of the West Melbury Marl Chalk. Totternhoe Stone is typically a hard, fissured, fine grey sandy Chalk limestone consisting mainly of small, even-sized shell fragments. A spring line is located at Nine Wells spring located to the northeast of the route, where the groundwater that flows through the permeable Zig Zag Chalk and fissures of the Totternhoe Stone is confined by the underlying relatively impermeable Marl [13].

3.3. Route Section 3 (Ch. 2800 to 4600m)

Table 3-3 – Route Section 3 preliminary ground model

Strata/Formation	Historical Boreholes	Typical borehole log descriptions	Typical thickness (m)	Groundwater (m bgl)
Artificial: Made Ground	TL45SE8	Grey clay and stone	0.6-2.1	2.1
Bedrock: Lower Chalk (Zig Zag Chalk Formation)	TL45SE10	Firm light grey chalk	>9.36-19.2*	12.9 to 15.9
	TL45SE31			

Notes

*thickness not proven

3.4. Route Section 4 (Ch. 4600-6070m)

Table 3-4 – Route Section 4 preliminary ground model

Strata/Formation	Historical Boreholes	Typical borehole log descriptions	Typical thickness (m)	Groundwater (m bgl)
Topsoil	TL45SE36 TL45SE56	Topsoil	0.6	6.2-14.4 (Chalk)
Superficial Deposits: River Terrace Gravels		Orange, brown slightly silty SAND with some fine rounded gravel and Firm brownish grey clayey SILT with occasional gravel	2.4-3.2	
Bedrock: Lower Chalk (Zig Zag Chalk Formation)		Soft white/orangey brown putty Chalk with gravel (weathered)	1.2-3.8	
		Grey Chalk Marl	>8.0-40.8*	

Notes

**thickness not proven*

Superficial deposits of the River Terrace Deposits (TL45SE36 and TL45SE56), found within BGS historical boreholes and Alluvial deposits recorded on BGS mapping records is expected to be present around the River Granta and low lying areas at approximately (<20mAOD).

3.5. Route Section 5 (Ch. 6070 to 8070m)

Table 3-5 – Route Section 5 preliminary ground model

Strata/Formation	Historical Boreholes	Typical borehole log descriptions	Typical thickness (m)	Groundwater (m bgl)
Artificial Ground: Made Ground	TL45SE40 TL45SE57 TL55SW14 TL55SW30 TL55SW34 TL55SW44 TL54NW12 TL54NW17	Made Ground	1.0	5.0-10.0
Topsoil		Topsoil	0.4-2.0	
Superficial Deposits: River Terrace Gravels		Sandy Clay with localised black peaty soil, clay and sand.	1.0	
Bedrock: Lower/Middle Chalk		Structureless putty/weathered Chalk with flints	16-31	
(Zig Zag Chalk Formation and Holywell Nodular Chalk Formation)		Medium to Hard Chalk	6-16	
Bedrock: Gault Formation(?)		Grey mudstone/clay	>7*	

Notes

**thickness not proven*

A lateral geological boundary between the Zig Zag Formation (Lower Chalk) and the Holywell Nodular Chalk (Middle Chalk) is located at approximately Ch. 6500m. The Zig Zag Chalk Formation was recorded within BGS borehole TL45SE57, which is noted as a soft grey chalk with soft putty chalk (presumed structureless chalk) within the sequence, consistent with BGS Lexicon descriptions. The remaining BGS borehole locations, noted above, recorded Holywell Nodular Chalk Formation, comprising hard Chalk with flints. Within borehole TL45SE57 a grey mudstone/clay was recorded from a depth of 43m below the Zig Zag Chalk Formation, attributed to the Gault Formation that underlies the Lower Chalk sequence, outcropping to the northwest of the scheme area.

3.6. Route Section 6 and travel hub site (Ch. 6070 to 9270m)

Table 3-6 – Route Section 6 preliminary ground model

Strata/Formation	Historical Boreholes	Typical borehole log descriptions	Typical thickness (m)	Groundwater (m bgl)
Topsoil	TL54NW29 TL54NW30 TL54NW37 TL54NW42	Topsoil	0.6	7.8-11.4
Superficial Deposits: River Terrace Deposits		Sand and Gravel	3.75-7.0	
Bedrock: Middle Chalk (Holywell Nodular Chalk Formation)		Soft chalk	4.5	
		Medium and hard chalk	>19-79*	

Notes

**thickness not proven*

Superficial deposits of the River Terrace Deposits (TL54NW30 and TL54NW37), found within BGS historical boreholes and Alluvial deposits recorded on BGS mapping records is expected to be present around the River Granta, from Ch. 8150m to 9150m, and low lying areas at approximately (<30mAOD). BGS mapping also indicates that the Lowestoft Formation (Diamcton) underlies the north of the travel hub site.

4. Ground Investigation

4.1. Site walkover

A site walkover was undertaken by Tetra Tech during the Ground Investigation works. Detailed site summary details are detailed within Section 2.1 and Table 1 of the Tetra Tech Factual Report [4] which is attached in Appendix D. Notable site summary details are detailed below:

- Cadent infrastructure (buried services)
 - Shown to run north of ‘Pemberton’s’
 - Medium pressure main crossing the proposed preferred route and the River Granta at ‘Deal’
 - High pressure gas main crossing ‘OBC North’ field from north to south
- Overhead Electric Cables crossing arable fields at ‘Deal’
- Land under stewardship (requiring a 4m buffer) near the Travel Hub Site, ‘OBC North’ and ‘Deal’
- Land north of the track at ‘Bury Farm’ and ‘OBC South’ is deeply furrowed arable land with undulations up to 1m high.

A constraints plan showing the access route, compound areas, landownership plans, ecology constraints, UXO Risk areas and buried services was provided by Tetra Tech on via Google Earth Pro [16].

4.2. Description of fieldwork

A ground investigation was designed and specified by Mott MacDonald and was undertaken by Tetra Tech and their subcontractors between 08 February and 04 June 2021. Mott MacDonald provided full time technical supervision during the ground investigation works in order to confirm that the works were in accordance with the issued GI Specification [3].

The investigation was undertaken in accordance with the general requirements of BS 5930:2015+A1:2020 [17], BS EN 1997-2 (2007) [18], BS EN ISO 22475-1 (2006) [19] and other relevant related standards identified in the Factual Report [4]. The Factual Report is presented in Appendix D.

Engineering geologists from Tetra Tech logged all exploratory holes, obtained soil samples and organised their delivery to a UKAS accredited geotechnical laboratory (Professional Soils Limited, PSL) and a third party geo-environmental laboratory as appropriate.

Logging was carried out in accordance with BS EN ISO 14688-1:2018 for soils, as specified by BS 5930:2015. The exploratory hole locations, logs and photos are provided within the Tetra Tech Factual Report [4].

The Tetra Tech Factual Report, presented in Appendix D, presents the locations of all the exploratory holes, borehole logs, groundwater monitoring and sampling, ground gas monitoring and in situ and laboratory test results.

The planned GI site works initially included the following, which is also set out in Section 1.5 of the Mott MacDonald Specification [3]. A plan of the proposed exploratory holes is presented in Appendix B of the Mott MacDonald Specification.

Table 4-1 - Summary of scope of investigation [3]

Location	Intrusive investigation technique
Preferred Route	<ul style="list-style-type: none">• 64no. dynamic sampling boreholes with rotary core follow-on to a maximum depth of 6 to 30m below ground level (mbgl) with associated SPT testing;• 8no. static cone penetration tests with measurements of pore water pressure to a maximum depth of 30mbgl or refusal;• 35no. machine excavated trial pits to a maximum depth of 3mbgl with dynamic cone penetrometer (DCP) testing to 1.5mbgl (continuous testing);• 21no. machine excavated trial pits to a maximum depth of 4mbgl with DCP testing to 1.5mbgl (continuous testing);• 30no. plate load tests;• 9no downhole variable permeability tests
Hinton Way PT Stop	<ul style="list-style-type: none">• 2no machine excavated trial pits to a maximum depth of 3mbgl, with associated DCP testing to 1.5mbgl;

Location	Intrusive investigation technique
	<ul style="list-style-type: none">• 8no.DCP tests to a maximum depth of 1.5mbgl, with associated 1.2mbgl inspection pit
Haverhill PT Stop	<ul style="list-style-type: none">• 4no machine excavated trial pits to a maximum depth of 3mbgl, with associated DCP testing to 1.5mbgl;• 2no BRE 365 soakaway testing;• 9no. DCP tests to a maximum depth of 1.5mbgl, with associated 1.2mbgl inspection pit
Sawston Road PT Stop	<ul style="list-style-type: none">• 2no machine excavated trial pits to a maximum depth of 3mbgl, with associated DCP testing to 1.5mbgl;• 7no. DCP tests to a maximum depth of 1.5mbgl, with associated 1.2mbgl inspection pit
OBC Travel route (Sawston Road to travel hub site)	<ul style="list-style-type: none">• 2 no. dynamic sampling borehole with rotary core follow on to a maximum depth of 8m to 30m below ground level (mbgl) with associated SPT testing;• 4 no. cone penetration tests with piezocone to a maximum depth of 30mbgl or refusal;• 13 no. machine excavated trial pits to a maximum depth of 4mbgl with associated DCP testing to 1.5mbgl;• 6 no. plate load tests
Travel hub site	<ul style="list-style-type: none">• 5no. dynamic sampling boreholes with rotary core follow on to depth 8m to 12m below ground level (mbgl) with associated SPT testing;• 15no. machine excavated trial pits to a maximum depth of 3mbgl, with associated DCP testing to 1.5mbgl;• 11no. DCP tests to a maximum depth of 1.5mbglwith associated 1.2mbgl inspection pit;• 10 no. BRE soakaway tests

Intrusive investigations were predominantly undertaken in arable farmland along the linear route, except for the northeast section extending across a cycle track and southern verge of Addensbrooke Road. Tetra Tech undertook the location under access licenses arranged between Greater Cambridge Partnership and private land owners [4].

All positions were surveyed on site by the Principal Contractor, with co-ordinates and ground levels taken in accordance with National Grid and Ordinance Datum.

Prior to breaking ground at each exploratory hole location an underground utility survey by Ground Penetrating Radar (GPR) and a cable avoidance tool (CAT) plus generator was carried out in accordance with PAS 128 Cat. B. Additionally, in all exploratory hole locations a hand dug inspection pit was excavated to 1.2 m bgl.

An Unexploded Ordnance (UXO) survey was conducted by a specialist contractor (Brimstone). While the UXO survey report documents a very low WWII bomb strike density over the full extent of the site, possible air raid targets and incendiary bomb strike at Pamsiford Camp, Babraham Park Camp, Hill Road and Trumpington Road present a higher UXO risk. Therefore, a risk zoning exercise was undertaken by Brimstone concluding that the area between approximate National Grid Reference (NGR) 547250, 253136 and 548106, 251667 (between TP-PTR15 and TP-PTR-28) should be considered to carry a potentially elevated risk of UXO and that an EOD Engineer should be in attendance during ground investigations within this zone. The assessment is presented in Tetra Tech factual Report Appendix N.

The ground investigation was originally scoped to comprise 241no. exploratory holes [3], as set out in Schedule 2 of the GI Specification and summarised in the following section. In-situ testing comprising 39no. plate load tests and 23no. permeability testing locations (11no. downhole variable head tests and 12no. BRE 365 soakaway test) within the exploratory positions. Since the issue of the ground investigation scoping report an updated Schedule 2 was issued detailing relocated positions and borehole positions that have been descoped from the works. A total of 44no positions were descoped as shown in Schedule 2 (BH-PTR-46 to BH-PTR-64, TP-PTR-45 to TP-PTR-55, CPT-PTR-05 to CPT-PTR-08, DCP-PTR-01 to DCP-PTR-07, DCP-HWS-01 to DCP-HWS-03). Additional boreholes were scheduled (TP-BP-01 to TP-BP-05 and BH-BP-01), post instruction to investigate the proposed borrow pit area to inform a Soil Survey and investigations for material management. 7no. boreholes were redrilled at a later date utilising a windowless sample rig to obtain UT100 samples of shallow soils due to damaged UT100 equipment in the initial visit. 10no. downhole permeability tests were descoped from the works due to high levels of groundwater encountered during stilling.

Further constraints relating to programme, land access issues, location of underground services and obstructions were encountered during the ground investigation. Where exploratory holes terminated shallow due to dense ground conditions or obstruction, the location was moved and re-drilled in an attempt to reach the scheduled depth where appropriate. A summary of specification limitations and deviations is set out in Section

3 (Table 3) of the Tetra Tech Factual Report and the updated Schedule 2 is included within Appendix D of this report.

The final number of exploratory holes completed during the ground investigation was 220no. comprising:

- 16no. windowless samples (WLC) with bored to depths ranging from 1.3m bgl and 5.45m bgl;
- 75no. windowless samples with rotary core-follow (WLS+RC) on bored to depths ranging from 1.1m bgl and 30.65m bgl;
- 11no. Static Cone Penetration tests with piezocone (CPT) to depths ranging from 1.14m bgl to 20.6m bgl;
- 33no. Dynamic Cone Penetrometer (DCP) locations with hand dig pits with depths ranging from 0.6m bgl and 1.2m bgl; and,
- 85no. Mechanically excavated trial pit (TP) locations with depths ranging from 0.8m bgl and 4.0m bgl.

33no. plate load tests and 13no. variable head permeability tests (12no. BRE soakaways and 1no. downhole permeability test) were undertaken in the above locations.

The stratigraphic logs for all exploratory location can be found within the factual report [4]. An as-built plan of the undertaken GI positions is provided in Appendix A of this report. Below shows the borehole positions along the preferred travel route.

Positions of exploratory holes are also presented in Appendix A.3.

Table 4-2 - Exploratory locations along preferred route alignment.

Section	Borehole/Windowless sample	Trial Pit	Static Cone Penetration Test
1	n/a	n/a	n/a
2	BH-PTR-01 to BH-PTR-14	TP-PTR-02 to TP-PTR-16	n/a
3	BH-PTR-15 to BH-PTR-18	TP-PTR-17 to TP-PTR-29	n/a
4	BH-PTR-19 to BH-PTR-44A	TP-PTR-30 to TP-PTR-36	CPT-PTR-01 to CPT-PTR-06
5	BH-PTR-45 and BH-PTR-45A	TP-PTR-37 to TP-PTR-44; TP-OBC-01 to TP-OBC-09	n/a
6	BH-OBC-01 to BH-OBC-16	TP-OBC-10 TP-OBC-12 TP-OBC-13 TP-PTR-56	CPT-OBC-01 to CPT-OBC-05

Table 4-3 - Exploratory locations at public transport stops, travel hub and borrow pit area

Section	Borehole/Windowless sample	Trial Pit	Dynamic Cone Penetrometer (inspection pit)
Hinton Way PT stop (HWS)	n/a	n/a	DCP-HWS-01; DCP-HWS-02; DCP-HWS-04; DCP-HWS-06 to DCP-HWS-08
Haverhill Road PT stop (HRS)	n/a	TP-HRS-01 to TP-HRS-04	DCP-HRS-01 to DCP-HRS-09
Sawston Road PT stop (SRS)	n/a	TP-SRS-01; TP-SRS-02	DCP-SRS-01 to DCP-SRS-07

Section	Borehole/Windowless sample	Trial Pit	Dynamic Cone Penetrometer (inspection pit)
Travel hub site (TH)	BH-TH-01 to BH-TH-10	TP-TH-01 to TP-TH-15	DCP-TH-01 to DCP-TH-11
Borrow Pit Area	BH-BP-01	TP-BP-01 to TP-BP-06	n/a

4.3. In-situ testing

4.3.1. Standard Penetration Testing (SPT)

Standard Penetration Tests (SPT) were carried out in all windowless samples and rotary core boreholes. The SPTs were carried out in accordance with techniques outlined in BS EN ISO 22476-3+A1 (2011). The ‘N’ value (number of blows per 300mm penetration) was recorded for each test.

485no. SPTs were taken with Standard Penetration Resistance (N) values ranging from 1 to 50, of which 136no. SPTs refused (SPT N >50).

BS EN ISO 22476 provides the following equation for adjusting Standard Penetration Resistance (N) values to account for the energy delivered to the drive rods (N60 = N value adjusted to a reference energy ratio of 60 %):

$$N_{60} = \frac{E_r}{60} N$$

The results of these in-situ tests, including full blow counts, are presented on the borehole logs within the Tetra Tech factual report discussed in Section 6.3.

4.3.2. Static Cone Penetration Testing (SCPT)

11no. SCPT tests were scheduled targeting either side of the proposed bridge locations in Section 4 (between Haverhill Road and North Farm) and Section 6 (located between High Street and the travel hub site). These were undertaken on the 05/03/2021 and the 22/4/2021.

The 11no. SCPTs (CPT-PTR-01 to CPT-PTR-06 and CPT-OBC-01 to CPT-OBC-05) were performed with a 20.5-tonne track truck mounted CPT unit (UK3 & UK15) equipped with a 17-tonne capacity hydraulic ram set.

All holes terminated shallow of the specified 30m depth either due to total reaction force and lateral support.

SCPTs were carried out in accordance with Part 9 of BS 1377 (1990) and BS EN ISO 22476-1 (2012) with cone tip resistance, sleeve friction, dynamic pore water pressure and inclination measured throughout the test and reported at 1 cm intervals of penetration.

The cone ID of the cone used is indicated on the test plots in the Factual Report. The calibration certificate is included in Appendix D of the Factual Report [4] and provides details of the manufacturer, cone dimensions, capacity and geometry.

The test output can be interpreted to provide a profile of soil type and strength. Correlation with other geotechnical properties can also be carried out.

Interpretation of the SCPT data has been provided by Tetra Tech on the logs using the recommendations of (Lunne, 1997) [20] to derive, where appropriate: friction ratio, pore pressure ratio, undrained shear strength (minimum and maximum range presented using typical cone factors of 20 and 15 respectively), relative density angle of friction and soil type. The SCPT tests do not detail soil type based on physical characteristics, such as grain size distribution, but provide a guide to the mechanical characteristics (strength, stiffness, compressibility) of the soil, or the soil behaviour type (SBT).

The soil classification uses the normalised soil behaviour type chart of Robertson (1990) [21] as the SCPT data requires normalisation for overburden stress. The chart identifies general trends in ground response and provides a guide to soil behaviour type (SBT). Overlap in some zones should be expected. A nominal groundwater level of 3.0m bgl has been assumed for the data interpretation of effective stress, based on the general groundwater level indicated by monitoring of borehole installations as part of the main ground investigation works.

Geotechnical parameters derived from SCPT's, including undrained shear strength, friction angle and relative densities, are provided in Section 6.3.

Testing location positions are presented in Appendix A.

4.3.3. Plate Load testing (PLT)

Plate load testing was carried out using 455mm diameter plates in accordance with BS 1377-9 using a 20-Tonne excavator to provide a kentledge of approximately 200 to 250kPa at 31no trial pit locations. Settlement and load were measured using a digital gauge and initially incrementally loaded until stabilisation of the dial gauge was achieved. The specification was adjusted due to slow rates of settlement as loads increase, and the increments reduced as set out Table 4 of the Terta Tech Report (10 to 30 minutes). The plate load test logs are included as Appendix E of the Tetra Tech Report.

Testing location positions are presented in Appendix A.

4.3.4. Dynamic Cone Penetration testing (DCP)

Dynamic cone penetrometer (DCP) testing was undertaken from ground level at 73no. machine excavation locations ('TP' ref.) and 32no. hand excavated inspection pits ('DCP' ref.). The tests were undertaken using a standard Transport and Roads Research Laboratory (TRRL) specification DCP probe to drive a 20mm diameter 60° cone using an 8kg weight dropped from a height of 575mm. A California Bearing Ratio (CBR) was derived from the testing positions, using the TRRL standard relationship of uniform penetration (blows/10mm). Testing certificates are set out in Appendix G of the Tetra Tech Report and set out in Section 6.3.

DCP and inspection pit locations were targeted at the public transport stops (Hinton Way, Haverhill Road, Sawston Road) and the travel hub. DCPs undertaken adjacent to trial pits were undertaken along the route alignment. A summary of the number of testing locations along the preferred route alignment are summarised in the table below.

Table 4-4 - Summary of DCP testing locations along the preferred bus route

Section	Location	Number of tests
2	TP-PTR-02, TP-PTR-03, TP-PTR-04, TP-PTR-05, TP-PTR-06, TP-PTR-07, TP-PTR-08, TP-PTR-09, TP-PTR-10, TP-PTR-11, TP-PTR-11, TP-PTR-12, TP-PTR-13, TP-PTR-14, TP-PTR-15, TP-PTR-16	16
3	TP-PTR-17, TP-PTR-18, TP-PTR-19, TP-PTR-20, TP-PTR-21, TP-PTR-23 TP-PTR-24A, TP-PTR-25, TP-PTR-26, TP-PTR-27, TP-PTR-28, TP-PTR-29	11
4	TP-PTR-30, TP-PTR-31, TP-PTR-34, TP-PTR-35, TP-PTR-36	5
5	TP-PTR-37, TP-PTR-38, TP-PTR-39, TP-PTR-40, TP-PTR-41, TP-PTR-42, TP-PTR-43, TP-PTR-44, TP-OBC-01, TP-OBC-02, TP-OBC-03A, TP-OBC-04, TP-OBC-05, TP-OBC-06, TP-OBC-07, TP-OBC-08, TP-OBC-09	17
6	TP-OBC-10, TP-OBC-12, TP-OBC-13, TP-PTR-56	4
Hinton Way PT Stop	DCP-HWS-01, DCP-HWS-02, DCP-HWS-04, DCP-HWS-06, DCP-HWS-07, DCP-HWS-08	6
Haverhill PT Stop	DCP-HRS-01, DCP-HRS-02, DCP-HRS-03, DCP-HRS-04, DCP-HRS-05, DCP-HRS-06, DCP-HRS-07, DCP-HRS-09, TP-HRS-03, TP-HRS-01, TP-HRS-04	11
Sawston Road PT Stop	DCP-SRS-01, DCP-SRS-02, DCP-SRS-03, DCP-SRS-04, DCP-SRS-05, DCP-SRS-06, DCP-SRS-07, TP-SRS-01, TP-SRS-02	9
Travel Hub Site	DCP-TH-01, DCP-TH-02, DCP-TH-03, DCP-TH-04, DCP-TH-05, DCP-TH-06, DCP-TH-07, DCP-TH-08, DCP-TH-09, DCP-TH-10, DCP-TH-11, TP-TH-01, TP-TH-02, TP-TH-03, TP-TH-04, TP-TH-05, TP-TH-06, TP-TH-07, TP-TH-08, TP-TH-09, TP-TH-10, TP-TH-11, TP-TH-12, TP-TH-13, TP-TH-14, TP-TH-15	26

4.3.5. Permeability and soil infiltration testing

10no. exploratory holes were scheduled for downhole permeability testing and 12no. exploratory holes where schedule for BRE 365 soakaway testing within the updated Schedule 2 for the works. One downhole permeability test and 12no. infiltration tests were completed during the ground investigation.

Permeability tests (variable head tests) were undertaken in a single borehole (BH-PTR-15) in accordance with BS EN ISO 22282-2:2012. Boreholes were drilled to a specified depth and the casing pulled back to create a specified response zone. For falling head tests clean water was added to the borehole at the top of the casing and time was recorded against the fall in water level.

A total of 12no. infiltration tests were attempted, comprising mechanically excavated trail pits. Infiltration tests were completed in general accordance with BRE DG 365 (2016) [22] whereby the soakage pit was filled and allowed to drain to near empty three times. Tests were generally limited to a single day. Non-compliant infiltration tests were noted where three repeat fills were not achieved over the course of the testing period. During these periods the required 25% and 75% effective storage depths intercepts are required to be reached in order for it to be a successful test. Tests that failed to drain 50% of their capacity within a 24-hour period are deemed unsuccessful. All tests were undertaken in the bedrock chalk (Grade Dc and Dm) along the route. The testing locations were tested in an open pit, as the chalk remained stable throughout the test. The exploratory holes were partially filled with clean water and the fall in water level recorded against time. Typically, the inflow of water achieved an inflow rate of approximately 500ltrs in 2minutes.

Carter (1991) [23] has been used to provide information of the typical permeability values for the infiltration tests referring to permeability and drainage conditions.

Table 4-5 - Summary of in-situ infiltration and permeability testing

Test type	Test Compliance	Total Quantity of tests	Location
Downhole rising head test	BS EN 1997-2:2007,2.1.4 and BS EN ISO 22282-1	1	BH-PTR-15
Soakaway (trial pit)	Compliant in accordance with BRE DG 365 (2016)	7	TP-HRS-03A, TP-HRS-04, TP-TH-02, TP-TH-04, TP-TH-08, TP-TH-11, TP-TH-13
	Non-compliant in accordance with BRE DG 365 (2016)	5	TP-HRS-03, TP-TH-06, TP-TH07, TP-TH-09, TP-TH-14

Testing location positions are presented in Appendix A.

4.4. Geotechnical Laboratory Testing

Selected representative soil samples were scheduled by Mott MacDonald and submitted to PSL for a range of geotechnical testing, in accordance with UKAS (ISO 17025: 2005) methodology where applicable. All analysis was carried out in accordance with BS1377:1990 Methods of Test for Soils for Civil Engineering Purposes, comprising:

Table 4-6 - Summary of Geotechnical Laboratory Assessment

Geotechnical Test	Standard	Number of tests
Moisture Content	BS 1377: Part 2: Clause 3.2: 1990	154
Moisture Content of Rock	BS 1377: Part 2: Clause 3.2: 1990	318
Atterberg Limits	BS EN ISO 17892-12:2018	133
Dry density and saturation moisture content for chalk	BS 1377: Part 2: Clause 3.3&7.3: 1990	256
Particle distribution by wet sieving including SHW: Clause 600	BS EN ISO 17892-4:2016, clause 5.2	104
Sedimentation by hydrometer	BS EN ISO 17892-4:2016, clause 5.3	58
Organic matter content	BS 1377: Part 3.2: 1990	22
Geotechnical Chemistry - BRE SD1 Suite A (Table D1 inclusive of triggered determinants)	BRE SD1 2005, BS1377: Part 3: 1990	147
One-dimensional consolidation properties	BS EN ISO 17892-5: 2017	2
Undrained strength (100mm diameter) in triaxial compression	BS EN ISO 17892-8:2018	3
Uniaxial compressive strength	ISRM: Parts 1 & 2: 2007	54
Single measurements of point load strength on core sample	ASTM / ISRM: 2007	435
Chalk crushing value	BS1377: Part 4 Clause 6.4: 1990	6
Extrude, split, photograph, describe structure	BS5930	19

Geotechnical Test	Standard	Number of tests
LA Coefficient	SHW: 600	4
Direct Shear Strength (300mm shear box)	SHW: 636: Part 2	5
Compaction (vibrating hammer)	BS1377: Part 4: Clause 3.7: 1990	6
Geotechnical Chemistry	SHW: 600: Clauses 601-17	5

4.5. Groundwater Monitoring

45no. dual purpose ground gas and groundwater monitoring standpipes were installed in 36no. boreholes for the purpose of groundwater monitoring and sampling and ground gas monitoring. Four water level monitoring and groundwater sampling visits have been undertaken in the installed boreholes undertaken on 10 May 2021, 17 to 24 May 2021, 4 June 2021 and 17 October 2021.

Groundwater sampling and ground gas monitoring is discussed in the appended Contaminated Land Assessment Report (Ref. GCP_5210174_A1307 Cambridge South East Transport CLRA).

Details of the monitoring installation type, response zone depths and target stratum are presented in the Terta Tech Report in Appendix D and summarised as follows:

- 9no. dual installations for shallow and deep groundwater monitoring across the scheme; and,
- 36no. single slotted standpipes for gas and groundwater monitoring.

97no. groundwater strikes were recorded within 89no. holes during the 2021 ground investigation; details of the groundwater strikes are presented in Section 0 and monitoring information is presented in Table 5-36.

When groundwater strikes were encountered during drilling, drilling was stopped for 20-minutes, and the groundwater levels measured at 5-minute intervals during this time. The ‘strike’ and ‘rise to’ levels are recorded on the exploratory hole records within the factual report [4].

It should be noted that water was often added to assist with drilling, either as flush for rotary drilling, or to help advance through granular material during cable percussion drilling or dynamic sampling. It is difficult to observe groundwater strikes when water is added during drilling. Therefore, the absence of an observable groundwater strike does not necessarily mean that water was not present during the investigation. Details of depths at which water was added is recorded on the exploratory hole record.

5. Ground Conditions

5.1. Introduction

An interpretation of the geology has been compiled using the typical ground profiles developed across the scheme during the recent ground investigation by Tetra Tech (2021), supplemented with the results of from the BGS historical logs. This is presented in 20no. cross sections. The cross sections are included in Appendix A.

The scheme has been split into six ground models zones (GM1 to GM6) based on the referred route sections: Route section 1 to route section 6 as discussed in Section 1.2.1.1. The ground conditions in each of these areas are presented in Section 5.4 An overview of the site’s geology is provided below.

Typical soil descriptions are generic, based on frequently occurring material types. Specific soil descriptions can be found on logs included in Tetra Tech Factual Report [4] (provided in Appendix D).

5.2. Geology overview

The ground conditions encountered during the recent 2021 ground investigation confirm the geological succession expected at the Scheme, as described in , based on available historical investigations and literature on the area.

The geological sequence, in stratigraphic order is shown in Table 5-1.

Table 5-1 - Geological sequence for soils and rocks underlying the scheme

Type	Formation
Artificial	Made Ground
Superficial	Topsoil
	Alluvium
	River Terrace Deposits
	Lowestoft Formation
Bedrock	Newpit Chalk Formation
	Hollywell Nodular Chalk Formation
	Zig Zag Chalk Formation
	West Melbury Marly Chalk Formation

Where encountered, each stratum has been further sub-divided from the formation/member name into coarse soils (sand and gravels; greater than or equal to 0.063mm grain size) and fine soils (clay and silts; less than 0.063mm grain size) as recommended in BS 8004:2015. Formations/Members are referred to in their subdivisions here-in.

Extracts from the Tetra Tech Factual Report [4] of the summary characteristics and distribution of the geology over the scheme has been extracted and summarised in the following sections below.

5.2.1. Topsoil

Most exploratory hole locations were commenced in arable fields and surface soils typically comprised predominantly fine soils with a lessor sand and gravel content below recently planted or established crops or grass. Occasional anthropogenic inclusions were noted in local areas, including plastic, ceramic and concrete fragments.

5.2.2. Artificial deposits

Made Ground (MGR)

Obvious signs of anthropogenic influence were noted to deeper levels in local areas, notably in North Farm (TP-PTR-32 to TP-PTR-37 inclusive, and BH-PTR-43A, BH-PTR-43B, BH-PTR-44, BH-PTR-44A and BH-PTR-45) where inclusions of brick, concrete, asphalt and fused ash, possibly associated with the former rail line, were noted to depths of up to 2.7m bgl.

5.2.3. Superficial deposits

Alluvium (ALV)

Alluvial soils were prevalent across the site and generally thicker towards the river crossings and drainage ditches. The deposit was highly variable in composition, and typically comprised low-consistency (typically soft to firm) fine soils, with organic rich and peat horizons, often with predominantly coarse pockets and layers, which have typically been defined as alluvium where they grade back into predominantly fine soils at deeper levels. Shell fragments and organic odours were also noted.

The highly variable composition of the Alluvium, particularly in central areas of the site, could possibly be attributable to the heterogeneity of likely local parent materials, such as the Lowestoft Formation (glacial till). Further evidence of possible glacial influence is presented by locally zones, where, in addition to flint, limestone and sandstone gravels were also recorded.

River Terrace Deposits (RTD)

The River Terrace Deposits were also noted in all areas of the site, and typically comprised sandy flint gravel and to a lesser extent, layers of sand. Layers / pockets of fine soil were also recorded, particularly towards the base of the unit, within the transition zone with the underlying chalk units, where pockets of light orangish brown clay or silt of chalk occur as remnants of the weathered chalk horizons. At deeper levels within the River Terrace Deposits, flints were often less fragmented, nodular and rinded (indicative of close association with the underlying chalk formations).

Lowestoft Formation (LOFT)

The characteristically high-strength (stiff), predominantly fine, shallow soils encountered below the River Terrace Deposits in the north of the travel hub site area, are distinguished from the more typical coarse soils of the River Terrace Deposits, are identified on the engineering logs as the Lowestoft Formation.

5.2.4. Bedrock

Hollywell Nodular Chalk / Newpit Chalk Formation Undifferentiated (HNCK)

Chronological biomarker fossils and established marker beds (Glynbourne Tubular Flints and the Guns Gardens Main Marl) indicative of the transition zone between the Hollywell Nodular Chalk Formation and the Newpit Chalk Formation have been tentatively identified within chalk recovered from the travel hub site boreholes. Therefore, although the anticipated youngest chalk unit in this area comprises the Hollywell Nodular Chalk Formation, these markers suggest that the Newpit Chalk Formation could also be present as the youngest / shallowest units and potentially outcrops further north and west as part of a structural low. The engineering logs have therefore not attempted to differentiate these units within travel hub boreholes.

Hollywell Nodular Chalk Formation (HCK)

The presence of characteristically weak to strong, low to medium density, off-white to white chalk, with discrete marl seams and flaser marls that displayed high contrast with the chalk, generally coincided with the anticipated lateral extent and depth of the Hollywell Nodular Chalk Formation. Established marker beds such as the Plenus Marls Member (interbedded chalk and marl), and the Melbourne Rock Member (hard off-white chalk with nodular chalk beds and flaser marls), along with biomarkers, were often found to occur at the anticipated base depth of this formation, the shallowing of which ties in with the southerly dipping succession. These characteristics were absent from BHs north of BH-PTR-16, where it has been assumed the underlying units outcrop in the north of the scheme area. The Melbourne Rock Member was noted in BH-OBC-05, -06, -07, -08, -10, -14 and -15 at tops depths between 14.2m and 17.3m bgl.

Zig Zag Chalk Formation (ZZCH)

The Zig Zag Chalk Formation was encountered from ground level in the north central area of the site, and below the Hollywell Nodular Chalk Formation, and was characteristically off-white, becoming light or pale grey chalk, with rhythmic gradational marl seams, and frequent intraclastic zones, typically occurring as off-white chalk clasts in a grey, occasionally marly matrix.

West Melbury Marly Chalk Formation (WMCH)

The West Melbury Marly Chalk Formation was encountered from ground level in the north area of the site, and below the Zig Zag Chalk Formation, and was characteristically grey, silty marl.

5.3. Distribution of geological strata

The geological strata in each area is summarised in .

Table 5-2 - Summary of distribution of geology along the scheme

Formation	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6
Topsoil	✓	✓	✓	✓	✓	✓
Made Ground	✓	✓	-	✓	✓	-
Alluvium/Head Deposits (undifferentiated)**	-	✓	✓	✓	✓	✓
Head Deposits***	-	✓	✓	-	✓	-
River Terrace Deposits (undifferentiated)	✓	-	✓	✓	-	✓
Lowestoft Formation	-	-	-	-	-	✓
Hollywell Nodular Chalk / Newpit Chalk Formation Undifferentiated	-	-	-	-	-	✓
Hollywell Nodular Chalk Formation	-	-	-	-	✓	✓
Zig Zag Chalk Formation	-	✓	✓	✓	✓	✓
West Melbury Marly Chalk Formation	✓	✓	-	✓*	-	-

Notes

Section 1 – no exploratory boreholes advanced in the section. Therefore, model has been based on historical BGS borehole records.

*Transitional strata change at depth

** At locations this formation may have been incorrectly assigned as Alluvium rather than Head Deposits (see below).

***Anticipated Head Deposits location (mapped as Alluvium in Tetra Tech Report)

After review of the Tetra Tech engineering logs and geological maps, it is considered that geology mapped as Alluvium that differs from the BGS Map sheet 205 [10] is attributed to Head Deposits (notably in Route Sections 2, 3 and 5). The logged deposits are noted on the flanks of the chalk escarpment to the northeast of the scheme. It is likely that the deposits are a result of erosional and solifluction processes. Hummocky ground is noted on the scheme DTM model on the chalk slopes and dry valleys which coincide with the location of the assumed Head Deposits. For the purpose of this report, as the geological descriptions and geotechnical parameters are generally consistent, the report refers to the contractors' logged descriptions. This has also been discussed within the Geotechnical Risk Register in Section 7.

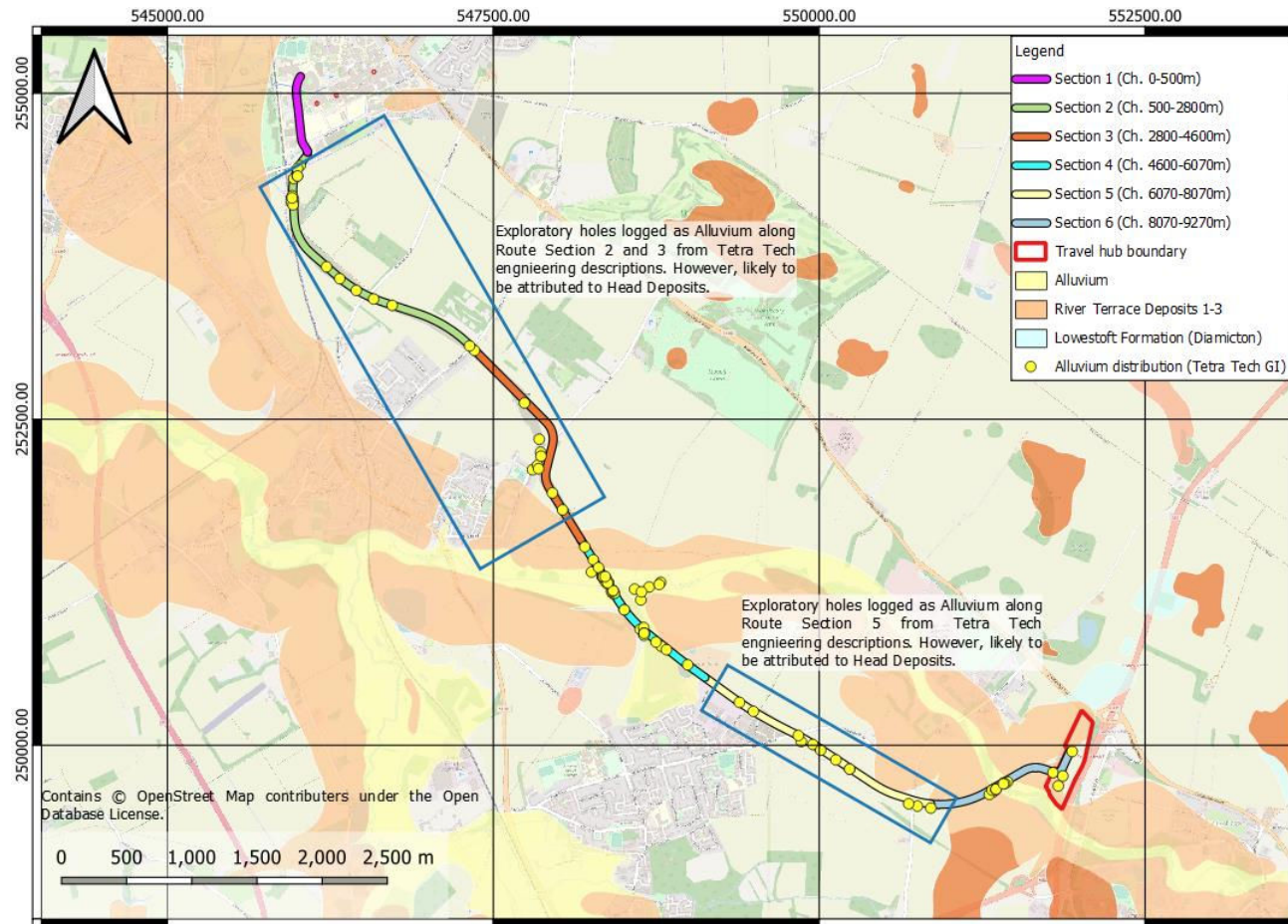


Figure 5-1 - Distribution of logged Alluvium from Tetra Tech Report compared with BGS Superficial Deposits and located of anticipated Head Deposits

Localised geology is described in the section below with the approximate thicknesses and levels of strata as well as the boreholes they are present in.

5.4. Ground models

Ground models have been produced for Route Section 1 to 6 (GM1 to GM6) and the Travel Hub Site (GM7) along the preferred route. A series of cross sections have been produced along the route and presented in Appendix B.

5.4.1. Route Section 1

No exploratory holes were advanced in Route Section 1 (Ch. 0 to 500m) of the preferred route alignment. Therefore, a ground model utilising BGS borehole records (Section 2.3.1) have been produced below:

Table 5-3 - Section 1 preliminary ground model based on BGS records

Strata/Formation	Historical Boreholes	Typical borehole log descriptions	Top Depth (m bgl)	Bottom Depth (m bgl)	Groundwater (m bgl)
Topsoil	TL45NE233	Topsoil	0.0	0.45 to 0.6	3.2 to 7.3
Superficial: River Terrace Deposits/Head	TL45SE63 TL45SE64	Sandy clay and gravel	0.45	1.2 to 3.5	
Bedrock: West Melbury Marly Chalk Formation (weathered)	TL45SE65	Sandy Clay	0.45 to 3.5	>10	

Notes

*Base not proven

The ground model above is consistent with the preliminary ground model set out in the Mott MacDonald Specification Report [3]. The report states, 'It is assumed that the 'clay' encountered in borehole TL45SE64 is a marl horizon within the West Marly Chalk Formation. This is based on the unit being indicated on BGS 1:50,000 scale mapping in the location of the borehole and other historical boreholes outside of the study area which encountered this unit, describing it as being a calcareous clay. It is possible that the unit may be a cohesive unit within the River Terrace Deposits (indicated c. 200m west), however the thickness of the encountered unit would indicate that this is unlikely.'

Piezometers records indicate a groundwater level between 1.45 to 2.69m bgl which was recorded on the 08 May 2002 in TL54SE63 and TL54SE64.

Given the relatively consistent geology to the encountered geology set out in the following sections, the geotechnical parameters for each formation can be assigned within Section 1. However, ground conditions are recommended to be confirmed at early stages of the construction phase via a watching brief to reduce risk to the project.

5.4.2. Route Section 2

Route Section 2 includes the preferred route from Dame Mary Archer Way roundabout to Hinton Way. The section is described in Table 1-4 and in Section 1.2. The relevant drawings, including exploratory hole locations, and cross sections are provided in Appendix A.

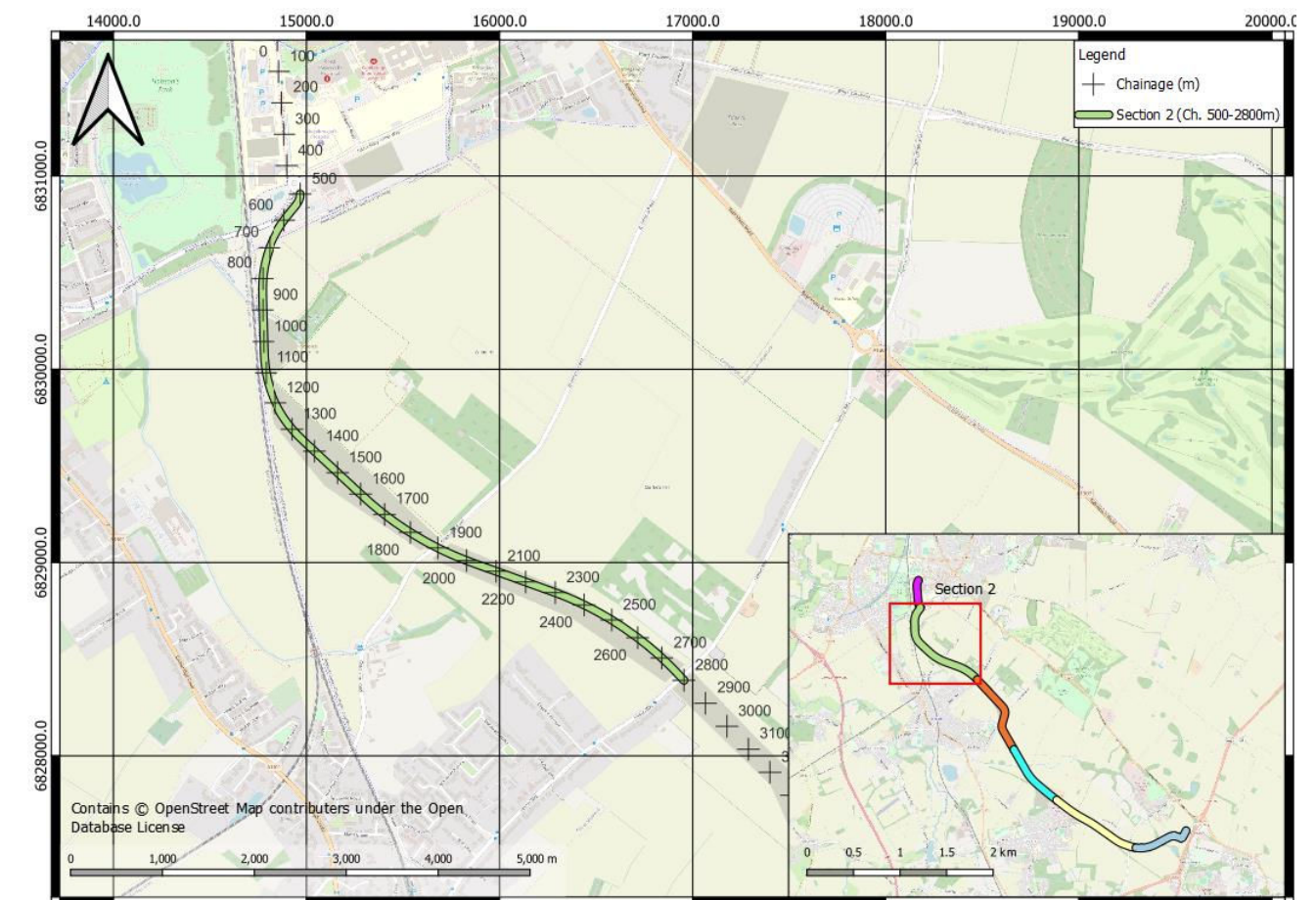


Figure 5-2 - Section 2 interpretation area

The exploratory hole at the lowest elevation is BH-PTR-06, located north of Hobson's Brook, at 13.8m AOD. The exploratory hole at the highest elevation is TP-PTR-16, near the Hinton Way, at 27.9 m AOD.

The strata encountered in Section 2 is presented in Table 5-4 including the thickness range (m), Upper-level Range (mAOD) and Basal Level Range (mAOD). Where the base of the stratum was not encountered, this is recorded as not proven.

Table 5-4 - Section 2 (GM2) strata summary

Strata/Formation		Holes Encountered	Top of Stratum Depth (m bgl) range [average]	Top of Stratum Elevation (m OD) range [average]	Base of Stratum Depth (m bgl) range [average]	Base of Stratum Elevation (m OD) range [average]	Thickness (m) range [average]
Topsoil		BH-PTR-01; BH-PTR-03 to BH-PTR-14; TP-PTR-02 to TP-PRT-06; TP-PTR-08; TP-PRT-10 to TP-PTR-16	0.0	13.8 to 27.9 [17.3]	0.16 to 1.0 [0.5]	13.2 to 27.5 [16.8]	0.2 to 1.0 [0.5]
Artificial Deposits	Made Ground (undifferentiated)	BH-PTR-02, 03, 07, 09	0.0 to 0.2 [0.0]	13.9 to 18.6 [16.2]	0.4 to 1.4 [0.6]	13.5 to 18.1 [15.7]	0.3 to 1.4 [0.6]
Superficial Deposits	Alluvium/Head Deposits (undifferentiated)	BH-PTR-01 to BH-PTR-10; BH-PTR-13; TP-PTR-04, 07, 10, 11, 16	0.3 to 1.5 [0.5]	13.2 to 27.5 [15.3]	0.6 to 4.1 [1.9]	9.8 to 27.2 [13.9]	0.3 to 3.8 [1.5]
Bedrock	Zig Zag Chalk Formation (ZZCH)	BH-PTR-13; BH-PTR-14; TP-PTR-06 to TP-PTR-16	0.7 to 1.0 [0.7]	16.1 to 27.2 [20.1]	2.7 to 10.7 [4.2]	7.9 to 23.9 [16.6]	2.0 to 10.5 [3.5]
	West Melbury Marly Chalk Formation (WMCH)	BH-PTR-01 to BH-PTR-12; TP-PTR-02 to TP-PTR-05	0.3 to 4.1 [1.8]	9.8 to 16.3 [12.9]	2.5 to 16.5 [9.4]	-2.6 to 14.3 [5.4]	2.0 to 14.4 [7.5]

Notes
*thickness not proven. Strata thicknesses were not proven in all exploratory holes. Some thicknesses and depths given represent termination of exploratory holes within a stratum. Interpreted strata thicknesses are presented in the geological sections.

Topsoil

Topsoil is recorded in all exploratory location in Section 2, except for BH-PTR-02, TP-PTR-07 and TP-PTR-09. The topsoil is predominantly fine-grained, although BH-PTR-03 recorded a Dark brown slightly gravelly clayey silty fine to coarse SAND with occasional rootlets. The maximum thickness of the topsoil is 1.0m recorded in BH-PTR-01 and BH-PTR-06.

Table 5-5 - Topsoil - Section 2 typical thicknesses and engineering description

Stratum	Typical Thicknesses range (m)	Typical Engineering Description
Topsoil	0.16 to 1.0	Soft brown slightly gravelly sandy clayey SILT. Sand is fine to coarse. Gravel is subangular fine to coarse flint and chalk; and, Soft dark brown slightly gravelly sandy silty CLAY. Sand is fine to coarse. Gravel is subangular fine to coarse flint.

Artificial Deposits: Made Ground (MGR)

Made Ground was encountered in five exploratory holes in Section 2. The Made Ground is predominantly fine-grained, although there are areas of sand encountered in BH-PTR-02 (0.15-0.25m bgl) and BH-PTR-03A (0.0 to 0.35m bgl) which are located to the north of the section, adjacent to Addenbrookes Great Shelford Cycleway. The maximum thickness of the Made Ground is 1.4m recorded in BH-PTR-02. This stratum typically comprised reworked soils containing fragments of anthropogenic material including brick and concrete located in the agricultural fields.

Table 5-6 - Made Ground - Section 2 typical thicknesses and engineering description

Stratum	Typical Thicknesses range (m)	Typical Engineering Description
Made Ground	0.1 to 1.35	Grass over soft brown, slightly gravelly, sandy CLAY with occasional rootlets. Sand is fine to medium. Gravel is subangular, fine to coarse flint and chalk with brick and concrete fragments. Orangish brown slightly clayey silty gravelly fine to coarse SAND with low cobble content. Gravel is subangular to subrounded fine to coarse flint with brick and rare glass fragments. Cobbles are subangular flint.

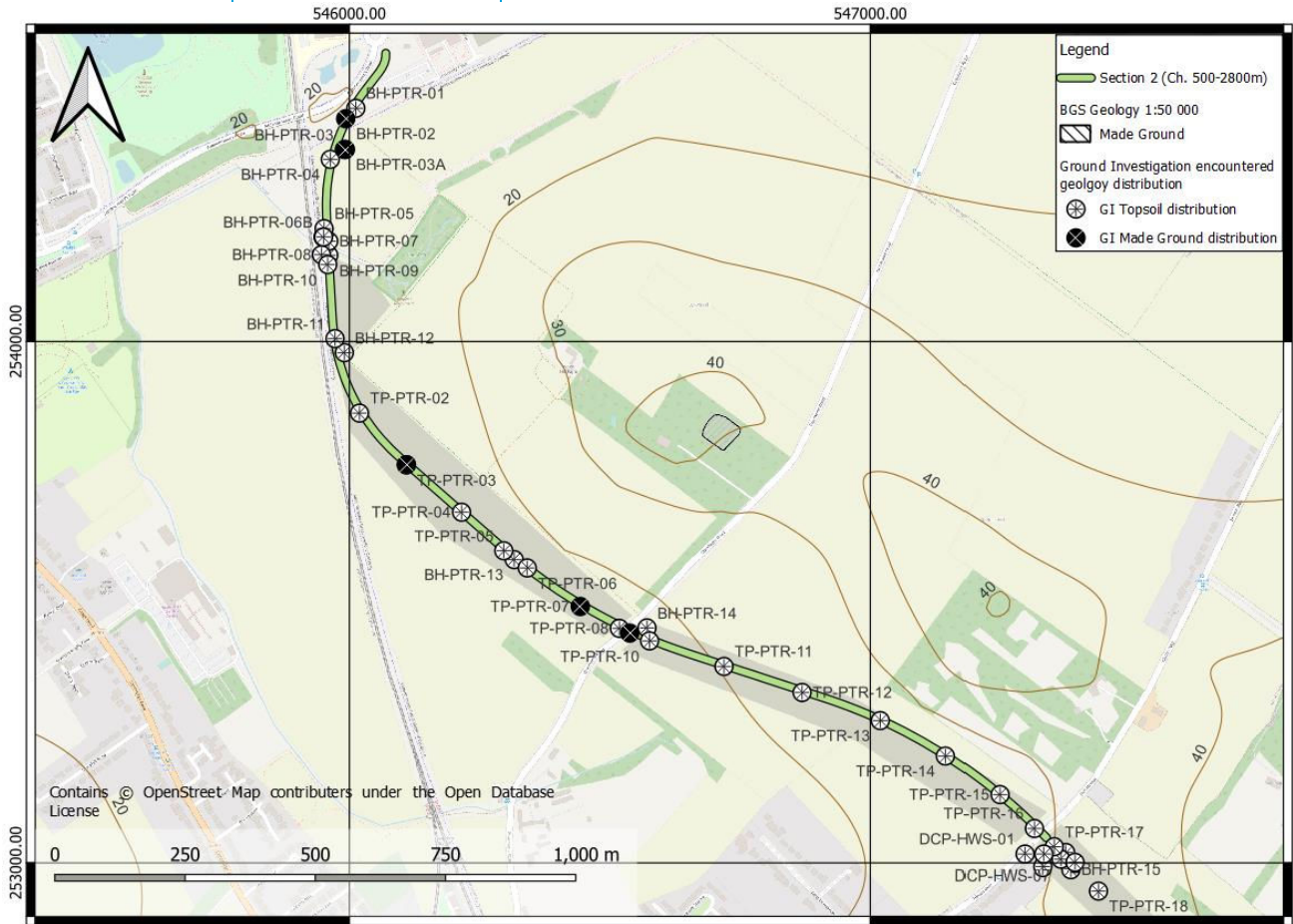


Figure 5-3 - Topsoil and Made Ground distribution along Section 2, from the Tetra Tech ground investigation

Superficial Deposits: Alluvium/Head Deposits (undifferentiated)

Tetra Tech logged Alluvium within the route section. However, it is likely attributed to Head Deposits as set out in Section 5.3 of this report. The Tetra Tech reported Alluvium/Head Deposits (undifferentiated) in 19no. exploratory holes in Section 2 to a maximum depth of 4.1m bgl (BH-PTR-01). The distribution of Alluvium differs from that of BGS records, no Alluvium has been mapped on BGS records (likely Head Deposits). The distribution of Alluvium/Head Deposits (undifferentiated) appears to be associated with lower lying areas and flanks of slopes, in areas having an elevation of less than 20mAOD, as shown in Figure 5-4. The stratum is predominantly fine-grained with sand only encountered in BH-PTR-03A and BH-PTR-06B. The maximum

proven thickness was 2.9m in BH-PTR-04 to the north of the section. Alluvium overlies Chalk bedrock and the base was proven in all locations. Table 5-7 summarises the alluvial deposits encountered.

Table 5-7 - Alluvium/Head Deposits (undifferentiated) Route Section 2 typical thicknesses and engineering description

Formation/Stratum	Typical Thicknesses range (m)	Typical Engineering Description
Alluvium/Head Deposits (undifferentiated)	0.25 to 2.85	<p>Soft to firm orangish brown and light grey, slightly gravelly, sandy CLAY. Sand is fine to medium. Gravel is subangular to subrounded, fine to coarse flint and chalk.</p> <p>Medium dense, light grey mottled orange, slightly clayey, slightly gravelly, fine to coarse SAND with variable silty content. Gravel is subangular to subrounded, fine to medium flint and chalk.</p>

Variations of the typical fine-grained Alluvium description include:

- 2 to 5mm diameter live and decaying roots extending vertically.
- Occasionally stiff and laminated with thin beds of sand
- Granular units encountered in BH-PTR-03A and BH-PTR-06B

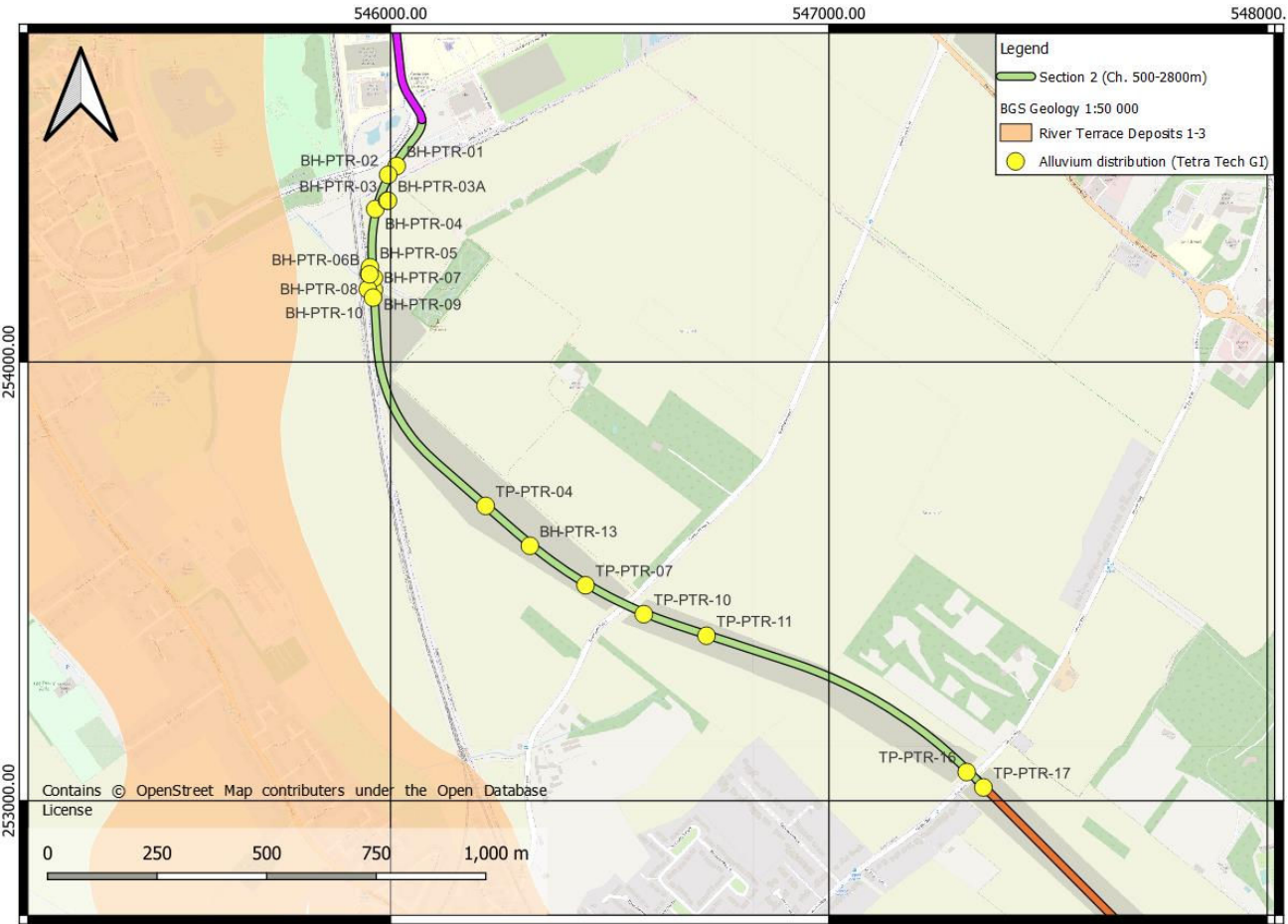


Figure 5-4 - Distribution of logged Alluvium/Head Deposits (undifferentiated) along Route Section 2, from the Tetra Tech ground investigation compared to BGS records along the preferred route alignment

Bedrock: Zig Zag Chalk Formation (ZZCH)

The Zig Zag Chalk Formation (ZZCH) was encountered in 11no. boreholes in Section 2 to the full depth of the ground investigation.

Typically, the formation comprised chalk increasing in CIRIA grade with depth. Structureless chalk and structured chalk were both encountered in all exploratory holes. The distribution of the chalk generally matches the published geological information as shown in Figure 5-5. BGS mapping shows the outcrop of the Totternhoe Stone Member at the transition between the WMCH and the ZZCH, noted as a harder unit comprising a brownish grey, fine grained calcarenite. However, the basal unit of the ZZCH was not encountered in the Tetra Tech ground investigation. It is shown and proven in the adjacent Nine Wells spring.

Structureless chalk (Grade Dm and Grade Dc) was encountered from approximately 0.2m bgl to 6.0m bgl, however generally between 0.2m bgl to 4.0m bgl. Grade Dm chalk was encountered between 0.2m bgl to 1.0m bgl and comprised structureless CHALK composed of light greyish sandy gravelly SILT. Sand is fine to medium. Gravel is angular to sub-angular chalk and rare flint. Chalk is very weak with occasional yellow staining.

Grade Dc chalk, typically encountered below 1.0m bgl, comprised structureless CHALK composed of off-white subangular, medium to coarse GRAVEL with a medium cobble content. Clasts are very weak to weak, low to medium density with occasional orangish brown staining and black specks. Rare fragments are angular medium flint.

Structured Chalk (Grade C3 to C5) was encountered in BH-PTR-14 (from 9.0m bgl) and BH-PTR-13 (from 2.5m bgl), respectively. This comprised an extremely weak to weak, low-density, grey with some orange staining around darkish grey, marly CHALK with rare inoceramid fragments. Two notable discontinuity sets were recognised: Discontinuity 1) Joints are 70 to 90° undulating rough, closed, clean with occasional black specks. Discontinuity 2) Bedding is 0 to 10°, close, partly open to open, infilled with comminuted chalk and grey chalk clasts with occasional orange/black staining. Light grey relict fossil burrows were observed in BH-PTR-14 at 9.0-10.5m bgl.

Grade B3 chalk was encountered from BH-PTR-14 from 5.35m bgl and comprised a very weak to weak, low to medium-density light grey marly CHALK with rare inoceramid fragments. With two fracture sets described as: Discontinuity 1) Joints are 70°, closed to partly open, smooth polished with greenish grey clay smear and black and orange staining. Discontinuity 2) Bedding is 0 to 10°, close, closed to partly open smooth polished with greenish grey clay smear and black and orange staining

Bedrock: West Melbury Marly Chalk Formation (WMCH)

The West Melbury Marly Chalk Formation (WMCH) was encountered in 19no. exploratory holes in Section 2 to the full depth of the ground investigation.

Typically, the formation comprised chalk increasing in CIRIA engineering grade with depth. Structureless chalk and structured chalk were both encountered.

Structureless chalk (Grade Dm and Grade Dc) was encountered from approximately 0.3m bgl to a basal depth of 4m bgl. Grade Dm chalk comprised structureless light grey CHALK composed of gravelly SILT with variable sand content. Gravel is subrounded to rounded, fine to coarse, very weak to weak, low and medium-density with occasional orange staining. Grade Dc chalk, typically encountered below 2m bgl, comprised structureless grey CHALK composed of silty GRAVEL. Gravel is extremely weak to weak, low-density, subangular to subrounded, fine to coarse with occasional orange staining and rare shell fragments.

Grade B (B4 to B2) chalk was encountered from approximately 4m bgl to 11m bgl and comprised an extremely weak to very weak, low to high-density light grey CHALK with occasional orange staining in relict trace fossil burrows. Typically, the chalk had between one or two discontinuity sets, often described as: Discontinuity 1) Joints are between 60 to 90° planar rough, closed to open, clean with occasional black staining. Discontinuity 2) Bedding is 0 to 10°, close, planar/undulating and rough/smooth, closed to partly open. With typical fracture spacing between 50-90°. Infilled pyrite burrows were noted in BH-PTR-08 at 4.0 to 4.5m bgl.

Grade A (A5 to A3) chalk was generally found below 6.0m bgl. The grade generally increased with depth and Grade A3 chalk was most commonly found between 6.0m bgl to >14.5m bgl. Grade A chalk typically comprised weak to extremely weak, low-density grey marly CHALK with occasional orange staining from trace fossil burrows. Discernible structure: Discontinuity 1) Joints are 70 to 90° inclined, sub-vertical, closed to partly open, clean planar undulating with some black and orange speckling. Discontinuity 2) Bedding is 0 to 10°, closed, subhorizontal, planar smooth closed clean.

Minimum typical and maximum fracture spacing can be found on the engineering logs in the Tetra Tech Factual report [4].

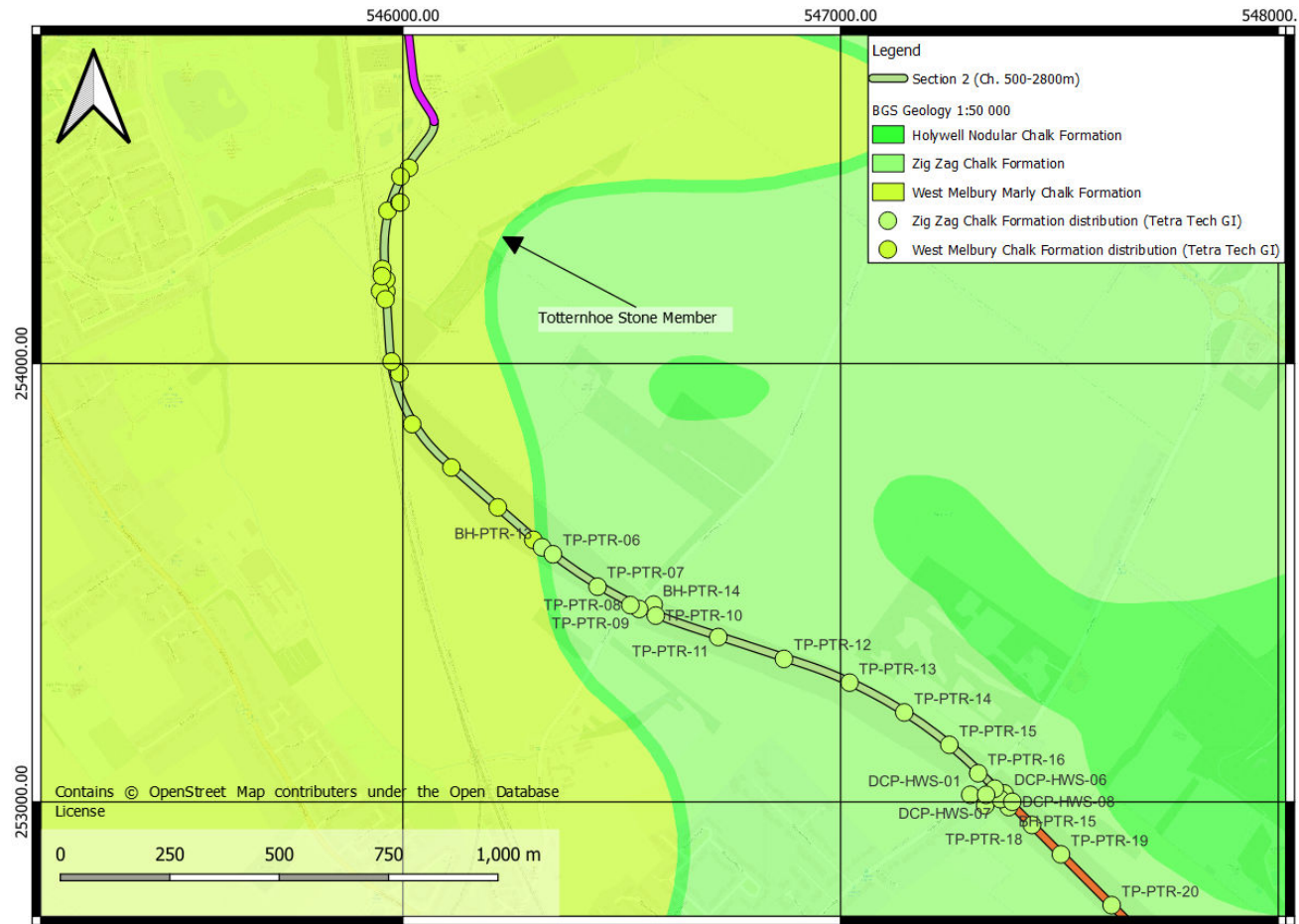


Figure 5-5 - Distribution of the Zig Zag and West Marly Chalk Formation along Route Section 2, from the Tetra Tech ground investigation compared to BGS records along the preferred route alignment

5.4.3. Route Section 3

Route Section 3 includes the preferred alignment route from Hinton Way to public footpath leading from Bury Road, including the Haverhill Public Transport (PT) Stop. The section is described in Table 1-4 and in Section 1.2. The relevant drawings, including exploratory hole locations, and cross sections are provided in Appendix B.

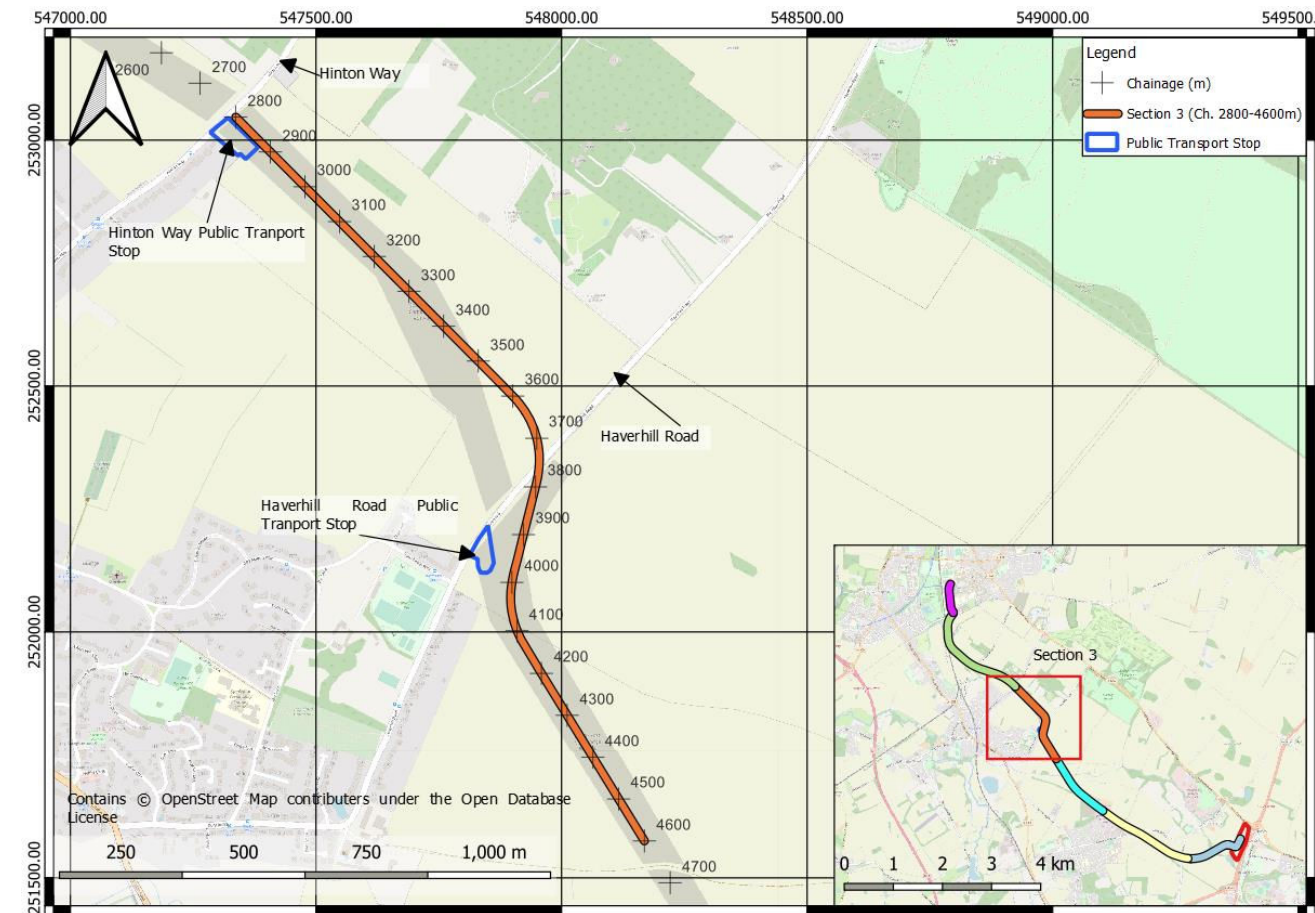


Figure 5-6 - Route Section 3 interpretation area

The exploratory hole at the lowest elevation is TP-PTR-29, located south of the section near the public footpath, at 19.5 m AOD. The exploratory hole at the highest elevation is BH-PTR-16, between Hinton Way and Haverhill, at 38.8m AOD.

The strata encountered in Section 3 is presented in Table 5-8 including the thickness range (m), Upper-level Range (mAOD and m bgl) and Basal Level Range (mAOD). Where the base of the stratum was not encountered, this is recorded as not proven.

Table 5-8 – Route Section 3 (GM3) strata summary

Strata/Formation		Holes Encountered	Top of Stratum Depth (m bgl) range [average]	Top of Stratum Elevation (m OD) range [average]	Base of Stratum Depth (m bgl) range [average]	Base of Stratum Elevation (m OD) range [average]	Thickness (m) range [average]
Topsoil		BH-PTR-15 to BH-PTR-18; TP-PTR-17 to TP-PTR-29; TP-HRS-01 to TP-HRS-04	0.0 to 0.3 [0.01]	19.5 to 38.8 [25.1]	0.2 to 1.1 [0.37]	19.1 to 38.5 [24.8]	0.2 to 1.1 [0.4]
Artificial Deposits	Made Ground	TP-HRS-01	0.4	20.3	1.4	19.3	1.0

Strata/Formation		Holes Encountered	Top of Stratum Depth (m bgl) <i>range</i> <i>[average]</i>	Top of Stratum Elevation (m OD) <i>range</i> <i>[average]</i>	Base of Stratum Depth (m bgl) <i>range</i> <i>[average]</i>	Base of Stratum Elevation (m OD) <i>range</i> <i>[average]</i>	Thickness (m) <i>range</i> <i>[average]</i>
Superficial Deposits	Alluvium/Head Deposits (undifferentiated)	TP-HRS-01, -02; TP-PTR-17, -21, -22, -23, -24, 26, 27	0.2 to 1.1 [0.4]	20.0 to 33.9 [23.7]	0.4 to 2.2 [0.9]	19.2 to 33.7 [22.6]	0.1 to 1.9 [0.6]
	River Terrace Deposits	BH-PTR-18; TP-HRS-03A	0.4 to 1.2 [0.8]	19.7 to 20.4 [19.8]	1.4 to 1.7 [1.5]	18.7 to 19.4 [19.05]	0.5 to 1.0 [0.7]
Bedrock	Holywell Nodular Chalk Formation	BH-PTR-16	0.3	38.5	5.8	32.9	5.5
	Zig Zag Chalk Formation	BH-PTR-15 to BH-PTR-18; TP-PTR-17 to TP-PTR-29; TP-HRS-01 to TP-HRS-04	0.3 to 9.4 [2.8]	11.3 to 37.4 [23.0]	0.9 to 10.5 [3.9]	9.9 to 36.8 [21.9]	0.8 to >10.0* [3.3]

Notes

*thickness not proven. Strata thicknesses were not proven in all exploratory holes. Some thicknesses and depths given represent termination of exploratory holes within a stratum. Interpreted strata thicknesses are presented in the geological sections.

Topsoil

Topsoil is recorded in all exploratory location in Section 3 (23no.), except for TP-HRS-01. The topsoil is predominantly fine-grained, comprising silt and clay, however coarse-grained material was encountered in TP-PTR-26 and BH-PTR-15 to 0.3m bgl, described as a loose brown, slightly gravelly, clayey, very silty, fine to coarse SAND. Frequent rootlets. Gravel is sub-angular, fine to coarse flint and occasional chalk. The maximum thickness of the topsoil is 1.1m recorded in TP-PTR-24A, however generally was 0.3 to 0.4m thick. Rare to occasionally brick fragments were noted which would be consistent with reworked agricultural land.

Table 5-9 - Topsoil – Route Section 3 typical thicknesses and engineering description

Stratum	Thicknesses range (m)	Typical Engineering Description
Topsoil	0.2 to 1.1	Grass over dark brown, sandy, gravelly CLAY with abundant rootlets. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse flint and chalk.

Artificial Deposits: Made Ground (MGR)

Made ground was encountered in a single borehole location (TP-HRS-01) located near Haverhill Road located in agricultural land. The Made Ground comprised grass cover over a brown, sandy, gravelly CLAY with abundant rootlets. Sand is fine to coarse. Gravel is angular to sub-rounded, fine to coarse flint, chalk and rare brick. Made ground is thought to be attributed to reworked soils of the farming fields due to the limited anthropogenic material. The maximum thickness of the Made Ground is 1.0m and overlays bedrock of the Zig Zag Chalk Formation.

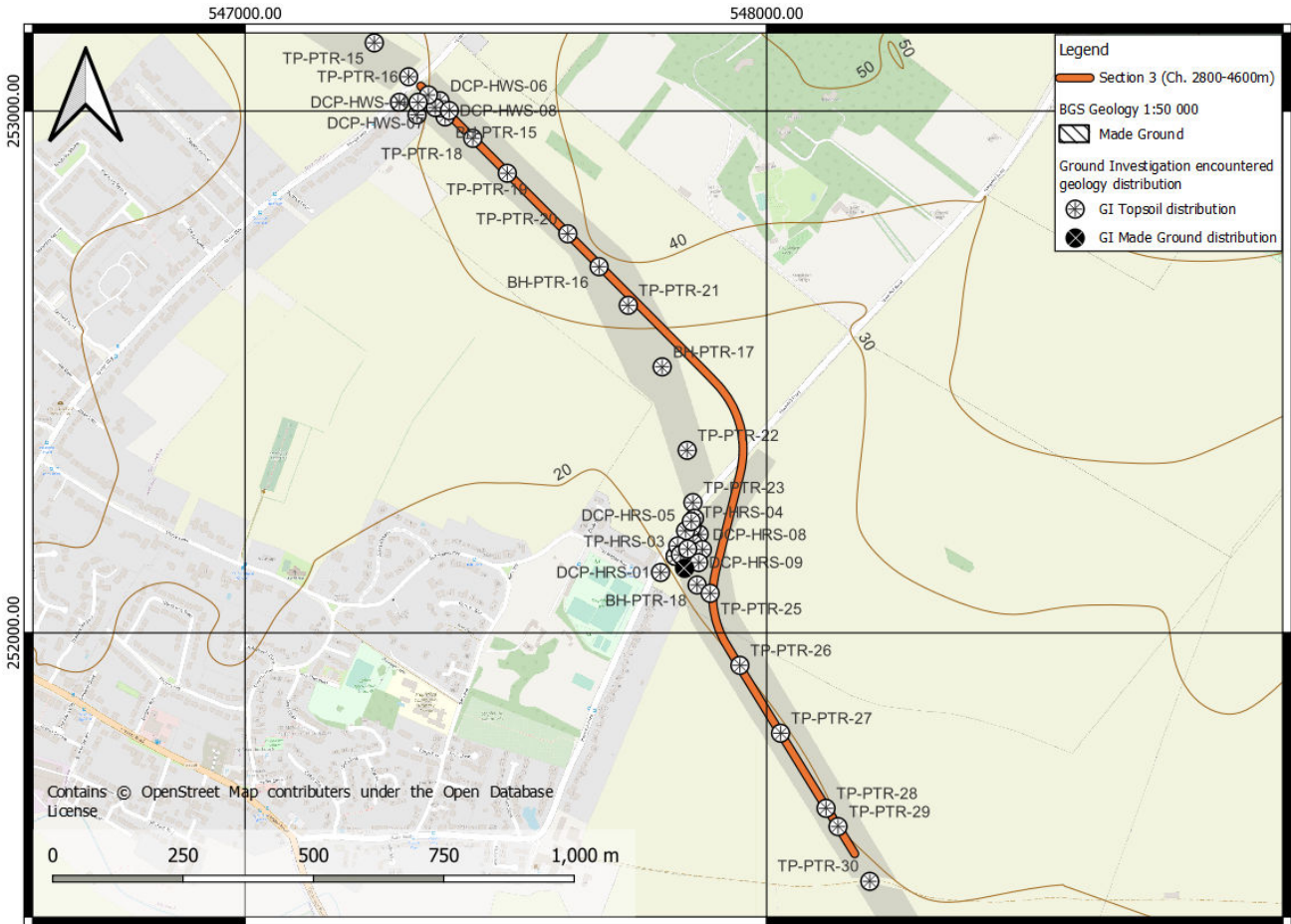


Figure 5-7 - Topsoil and Made Ground distribution along Route Section 3, from the Tetra Tech ground investigation

Superficial Deposits: Alluvium/Head Deposits (undifferentiated)

Tetra Tech logged Alluvium within the route section. However, it is likely attributed to Head Deposits as set out in Section 5.3 of this report. Alluvium/Head Deposits (undifferentiated) was encountered in nine exploratory holes in Section 3 to a maximum depth of 2.2m bgl (TP-PTR-23). The distribution of Alluvium differs from that of BGS records, no Alluvium has been mapped on BGS records (likely to be Head Deposits). The distribution of Alluvium/Head Deposits (undifferentiated) appears to be associated with lower lying areas and flanks of slopes, in areas with an elevation of less than 20mAOD, as shown in Figure 5-8. The stratum is predominantly fine-grained with coarse grained soils only encountered in TP-PTR-26. The maximum proven thickness was recorded at 1.9m (TP-PTR-23) located near Haverhill Road. The Alluvium/Head Deposits (undifferentiated) overlies Chalk bedrock and the base was proven in all locations. Figure 5-8 summarises the alluvial deposits encountered.

Table 5-10 - Alluvium/Head Deposits (undifferentiated) - Route Section 3 typical thicknesses and engineering description

Formation/Stratum	Typical Thicknesses range (m)	Typical Engineering Description
Alluvium/Head Deposits (undifferentiated)	0.1 to 1.9	<p>Soft to firm light orangish brown/brown, slightly gravelly, sandy CLAY. Sand is fine to medium. Gravel is angular to subangular, fine to medium flint and chalk.</p> <p>Loose brown, slightly gravelly, clayey, very silty, fine to coarse SAND. Occasional rootlets. Gravel is sub-angular, fine to coarse, flint and occasional chalk.</p>

Variations of the typical fine-grained Alluvium description include:

- Occasionally silty with low cobble content in TP-PTR-27 (0.3-0.55m bgl)

Superficial Deposits: River Terrace Deposits (RTD)

River Terrace Deposits was recorded in two exploratory holes in Section 3 (TP-HRS-03A and BH-PTR-18) to a maximum depth of 1.65m bgl (BH-PTR-18). However, on further review of the Tetra Tech engineering logs, the material logged as RTD in BH-PTR-18, between 1.2 and 1.7m bgl, is logged below the Zig Zag Chalk Formation and has a high chalk gravel content. Therefore, it is likely that this is a possible infilled dissolution features and is not representative of the superficial deposits.

The distribution of RTD slightly differs from BGS records, where RTD are noted 170m southwest of TP-HRS-03A, as shown in . Additionally, no RTD was encountered in positions TP-PTR-28 and TP-PTR-29. The stratum is coarse grained and overlies the Zig Zag Chalk Formation. The base was proven in all locations. summarises the alluvial deposits encountered.

Table 5-11 - River Terrace Deposits - Section 3 typical thicknesses and engineering description

Formation/Stratum	Typical Thicknesses range (m)	Typical Engineering Description
River Terrace Deposits	1.0	Loose to medium dense, light brown cream, very gravelly, very clayey, fine to medium SAND. Gravel is subangular to subrounded flint and chalk.

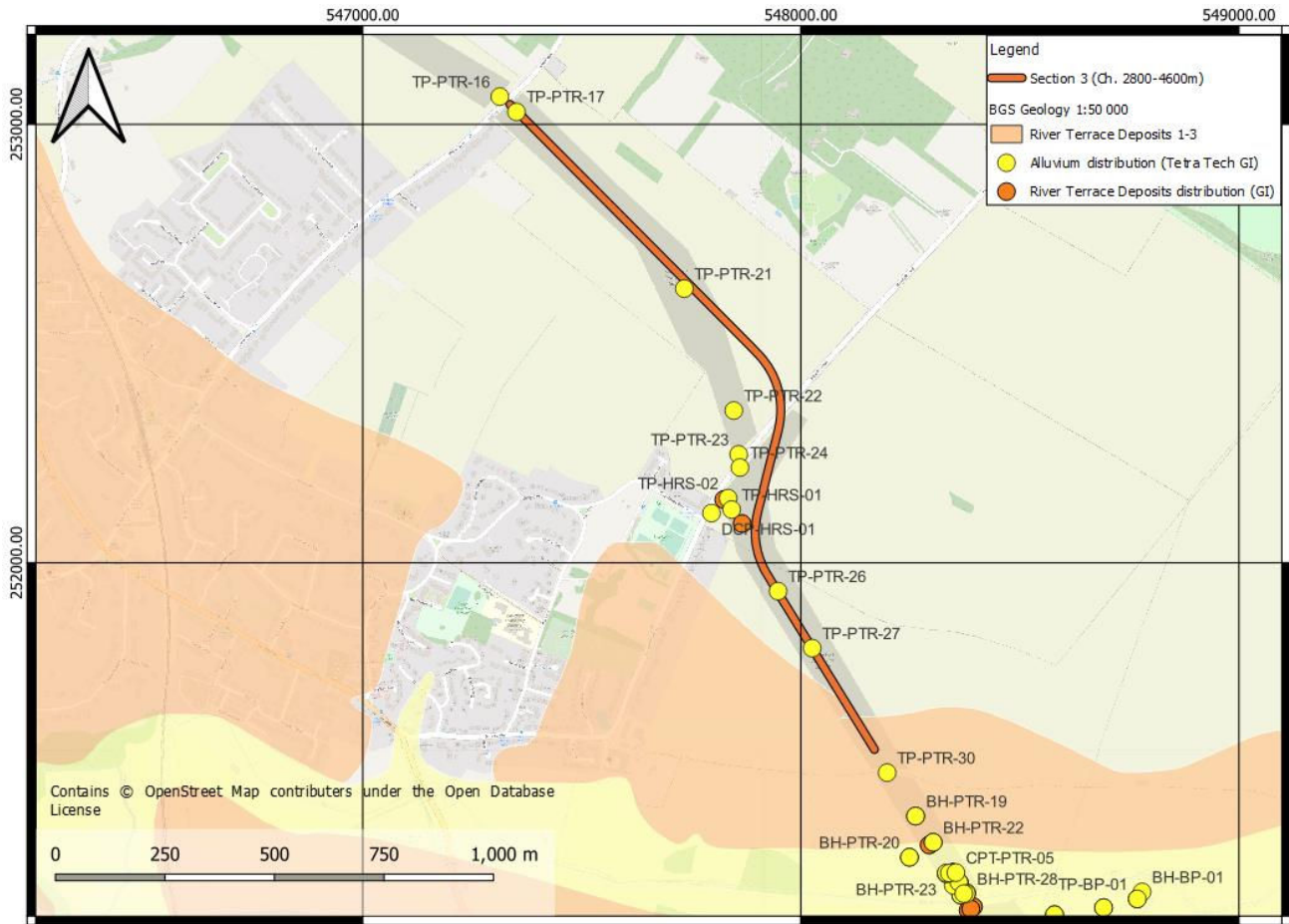


Figure 5-8 - Distribution of Alluvium and River Terrace Deposits along Route Section 3, from the Tetra Tech ground investigation compared to BGS records along the preferred route alignment

Bedrock: Holywell Nodular Chalk Formation (HNK)

The Holywell Nodular Chalk Formation (HNK) was encountered in a single borehole location along Route Section 3 (BH-PTR-16), noted to be the highest in elevation at 38.8mAOD. The boundary between the HNK and the ZZCH was observed at 5.82m bgl. The geology noted in the Tetra Tech boreholes slightly differed from that of BGS records. The HNK was noted on BGS records 165m northeast of BH-PTR-16, as shown in Figure 5-9.

Typically, the formation comprised Chalk increasing in CIRIA Engineering grade with depth, from Dc to B3.

Structureless chalk (Grade Dm and Grade Dc) was encountered from approximately 0.3m bgl to 1.2m bgl. Grade Dm chalk comprised structureless light grey CHALK composed of gravelly SILT with variable sand content. Grade Dc chalk, typically encountered below 2m bgl, comprised structureless grey CHALK composed of silty GRAVEL.

Grade C4 Chalk, noted to be the Melbourn Rock Member marking the basal units of the Holywell Nodular Chalk Formation, was encountered from 1.2m bgl to 4.0m bgl, distinguished by the lack of shell material. This comprised a very weak to weak, low to medium-density white CHALK gravel. Discernible structure: Discontinuity 1) Joints 60 to 90°, subvertical to irregular, partly open to open, infilled with comminuted chalk and white chalk clasts, with a smear of grey with black specks clay / marl, undulating and rough. Discontinuity 2) Bedding 0 to 10°, subvertical to irregular, partly open to open infilled with comminuted chalk, white chalk clasts and a smear of grey with black specks clay / marl, undulating and rough.

Grade B3 chalk, noted to be the Plenus Marl Member marking the lower boundary of the Holywell Nodular Chalk Formation, was encountered from 4.0m bgl to 5.8m bgl and comprised an extremely weak to weak, low to high-density yellowish white CHALK with frequent marl seams, shears and possible intraclastic horizons.

Bedrock: Zig Zag Chalk Formation (ZZCH)

The Zig Zag Chalk Formation (ZZCH) was encountered in 22no. exploratory holes in Section 3 to the full depth of the ground investigation, which is consistent with BGS records, as shown in .

Typically, the formation comprised chalk increasing in CIRIA Engineering Grade with depth. Structureless chalk and structured chalk were both encountered.

Structureless chalk (Grade Dm and Grade Dc) was encountered from approximately 0.3m bgl to 4.0m bgl. Grade Dm chalk was encountered between 0.3m bgl to 2.2m bgl and comprised structureless CHALK composed of slightly clayey gravelly SILT with low cobble content. Chalk gravel is weak, high-density, fine to coarse, sub-angular with occasional orange staining on surfaces. Occasional flint gravel and cobbles. Frequent pockets of orangish brown clayey silty sand with round pebbles. Grade Dc chalk, typically encountered below 1.0m bgl, comprised Structureless CHALK with zones of structured chalk composed of silty, sub-angular, medium to coarse GRAVEL with a low to medium cobble content. Clasts are very weak and weak, low and medium-density with occasional black specks and occasional orangish brown staining. Rare sub-angular fine to medium gravel of flint.

Grade C (C5) chalk was encountered in BH-PTR-17 (from 2.2 to 3.0m bgl). This comprised a very weak to weak, low to medium-density light grey CHALK. Two discontinuity sets were noted: Discontinuity 1) Joints are 70 to 85° planar to undulating, rough, open with occasional black specks. Discontinuity 2) Bedding is 10 to 15° extremely close, planar rough open with occasional orangish brown staining.

Grade B (B4 to B3) chalk was encountered from approximately 3.5m bgl to 9.5m bgl (BH-PTR-15, BH-PTR-16, BH-PTR-17) and comprised a weak low-density light grey CHALK with rare Inoceramids throughout. Two discontinuity sets were noted within Grade B4: Discontinuity 1) Joints are probably tight undulating, rough with black specks and orange brown staining following discontinuity planes. Discontinuity 2) Bedding is 0 to 10° probably subhorizontal, very closely to closely spaced, tight, planar and rough and infilled with comminuted chalk. Grade B3 chalk was generally described as weak low density light grey marly CHALK with a single discontinuity set which was closely spaced, planar rough, tight, open and clean.

Minimum typical and maximum fracture spacing can be found on the engineering logs in the Tetra Tech Factual report [4].

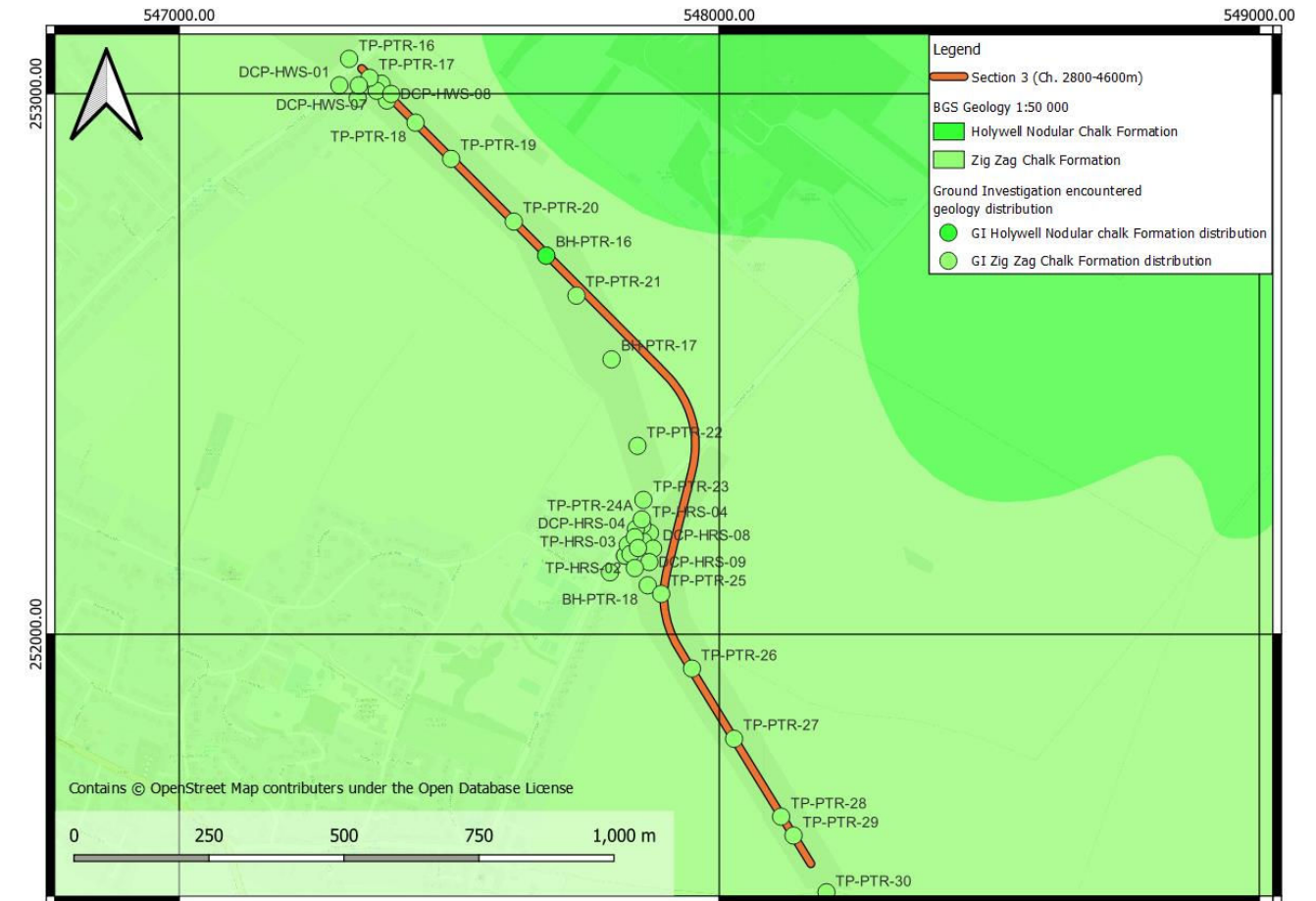


Figure 5-9 - Distribution of the Holywell Nodular and Zig Zag Chalk Formation along Route Section 3, from the Tetra Tech ground investigation compared to BGS records along the preferred route alignment

5.4.4. Route Section 4

The section of Route Section 4 includes the preferred alignment route from the public footpath leading to Bury Road to North Farm to public footpath leading from Bury Road. The section includes the borrow pit located, added onto the scope of works for the soil material management assessment. The section is described in Table 1-4 and in Section 1.2. The relevant drawings, including exploratory hole locations, and cross sections are provided in Appendix B.

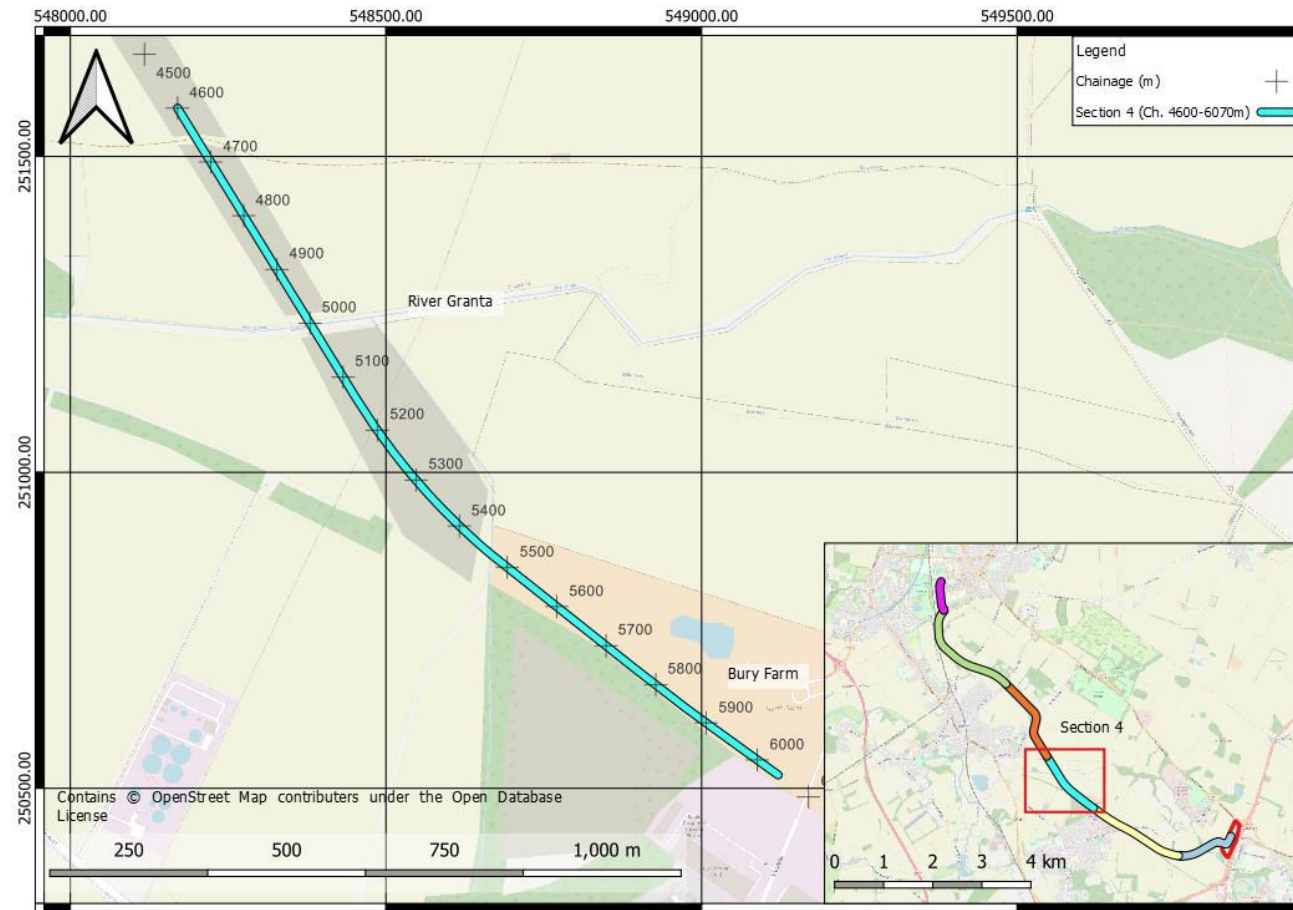


Figure 5-10 – Route Section 4 interpretation area

The exploratory hole at the lowest elevation is BH-PTR-31, located south of the River Granta, at 17.2 m AOD. The exploratory hole at the highest elevation is TP-PTR-36, located to the south of the section at North Farm, at 20.82m AOD.

The strata encountered in Section 4 is presented in Table 5-12 including the thickness range (m), Upper-level Range (mAOD and m bgl) and Basal Level Range (mAOD). Where the base of the stratum was not encountered, this is recorded as not proven.

Table 5-12 – Route Section 4 (GM4) strata summary.

Strata/Formation		Holes Encountered	Top of Stratum Depth (m bgl) <i>range [average]</i>	Top of Stratum Elevation (m OD) <i>range [average]</i>	Base of Stratum Depth (m bgl) <i>range [average]</i>	Base of Stratum Elevation (m OD) <i>range [average]</i>	Thickness (m) <i>range [average]</i>
Topsoil		BH-BP-01; BH-PTR-19 to BH-PTR-44A; CPT-PTR-01 to CPT-PTR-06; TP-BP-04; TP-BP-05; TP-PTR-30 to TP-PTR-36	0.0 to 0.4 [0.03]	0.1 to 1.4 [0.5]	16.8 to 20.8 [18.6]	16.2 to 20.5 [18.1]	0.6 to 1.4 [0.7]
Artificial Deposits	Made Ground	BH-PTR-23; BH-PTR-32B: BH-PTR-39 to BH-PTR-44A; TP-BP-01 to TP-BP-03; TP-PTR-32 to TP-PTR-36	0.0 to 2.6 [0.7]	17.2 to 20.5 [19.11]	0.05 to 2.9 [1.2]	17.1 to 20.1 [18.6]	0.05 to 2.7 [0.9]
Superficial Deposits	Alluvium (undifferentiated)	BH-PTR-19 to BH-PTR-28A; BH-PTR-31 to BH-PTR-36 to BH-PTR-44A; CPT-PTR-01, -02, -05; TP-PTR-31 to TP-PTR-33	0.0 to 2.9 [0.6]	13.2 to 33.9 [20.0]	0.4 to 5.5 [1.9]	9.8 to 33.7 [18.7]	0.1 to 5.0 [1.3]
	River Terrace Deposits (undifferentiated)	BH-PTR-19; BH-PTR-24A; BH-PTR-28 to BH-PTR-30; BH-PTR-34; BH-PTR-36; BH-PTR-38; TP-BP-01 to TP-BP-05	0.2 to 3.5 [0.9]	14.9 to 34.5 [23.7]	0.5 to 6.5 [2.6]	11.9 to 33.5 [22.1]	0.2 to 5.6 [1.7]
Bedrock	Zig Zag Chalk Formation (ZZCH)	BH-PTR-29, BH-PTR-33	26.4 to 28.5 [27.4]	-9.0 to -11.0 [-10.03]	30.0 to 30.5 [30.2]	-13.7 to -12.2 [-12.9]	1.5 to 4.1 [2.8]
	West Melbury Marly Chalk Formation (WMCH)	BH-PTR-19 to BH-PTR-44A; BH-BP-05 TP-PTR-30, TP-PTR-32; TP-PTR-34 to TP-PTR-36	0.5 to 6.5 [3.7]	-12.7 to -20.0 [-13.7]	2.5 to 3.6 [16.6]	4.9 to 18.5 [13.3]	0.6 to 27.6 [12.8]

Notes

*thickness not proven. Strata thicknesses were not proven in all exploratory holes. Some thicknesses and depths given represent

termination of exploratory holes within a stratum. Interpreted strata thicknesses are presented in the geological sections.

Topsoil

Topsoil is recorded in all exploratory locations along Route Section 4, except for TP-BP-01 to TP-BP-03. The topsoil is predominantly fine-grained, comprising silt and clay. The maximum thickness of the topsoil is 1.4m recorded in BH-PTR-36A, however generally was 0.3 to 0.4m thick. Rare to occasionally brick fragments were noted which would be consistent with reworked agricultural land.

Table 5-13 - Topsoil – Route Section 4 typical thicknesses and engineering description.

Stratum	Typical Thicknesses range (m)	Typical Engineering Description
Topsoil	0.2 to 1.5, generally between 0.0 to 0.4	Soft to firm brown sandy slightly gravelly CLAY/SILT with abundant rootlets. Sand is fine to coarse. Gravel is angular and fine to coarse flint.

Artificial Deposits: Made Ground (MGR)

Made ground was encountered in 21no. exploratory hole locations. borehole location (associated with soils near the River Granta and North Farm. The Made Ground comprised predominantly clay and silt strata with limited granular material found in BH-PTR-43, BH-PTR-44A, TP-PTR-32. Maximum thickness of Made Ground was found in BH-PTR-44A at 2.7m. Anthropogenic material was dominantly found to the south of the Section in proximity to North Farm (BH-PTR-42 to BH-PTR-44).

Table 5-14 - Made Ground – Route Section 4 typical thicknesses and engineering description.

Stratum	Typical Thicknesses range (m)	Typical Engineering Description
Made Ground	0.1 to 2.7	<p>Firm greyish brown silty sandy very gravelly CLAY/sandy SILT. Sand is fine to coarse. Gravel is subangular to subrounded, fine to coarse flint and chalk with variable atherogenic material containing: brick, breeze block, fused ash, limestone and asphalt fragments;</p> <p>Loose to medium dense, brown silty, very gravelly fine to coarse SAND with medium cobble content. Gravel is subangular to subrounded, fine to coarse flint and chalk with brick, breeze block, fused ash, limestone and asphalt fragments. Cobbles comprise angular flint with whole and part red brick, breeze block fragments.</p>

Made ground was also recorded in BH-PTR-22 between 4.0 and 4.7m bgl, below the Zig Zag Chalk Formation, however on review of the logs it comprised an orange brownish orange gravelly fine becoming coarse SAND with no anthropogenic material. This is likely attributed to an infilled solution feature rather than Made Ground.

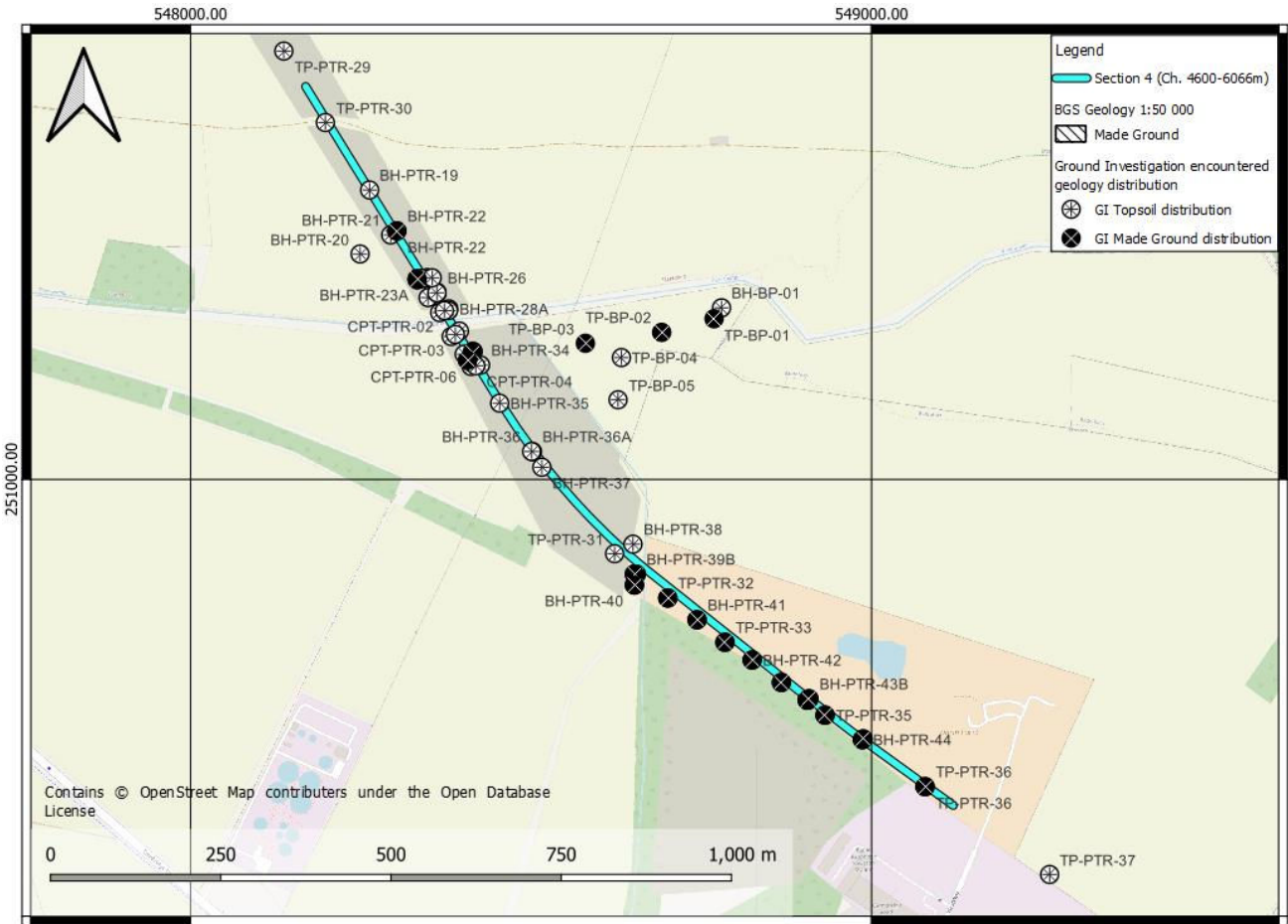


Figure 5-11 - Topsoil and Made Ground distribution along Route Section 4, from the Tetra Tech ground investigation

Superficial Deposits: Alluvium (ALV)

Alluvium was encountered in 37no. exploratory locations Alluvium broadly matched the published geological information. The distribution of the ALV in Section 4 appears to be associated with topographic low points and the River Granta. The stratum is predominantly fine-grained with coarse grained soils encountered in 13no. positions.

The maximum proven thickness was recorded at 4.8m (BH-PTR-25) located immediately to the north of the River Granta. The Alluvium overlies the River Terrace Deposits and bedrock chalk and the base was proven in all locations. Table 5-15 summarises the alluvial deposits encountered.

Table 5-15 - Alluvial deposits – Route Section 4 typical thicknesses and engineering description

Formation/Stratum	Typical Thicknesses range (m)	Typical Engineering Description
Alluvium (undifferentiated)	0.2 to 3.8	<p>Very soft light brown/dark brown mottled orange, gravelly, slightly sandy, silty CLAY with low cobble content. Sand is fine to coarse. Gravel is fine to coarse, angular to sub-angular flint.</p> <p>Locally coarse grained fraction was encountered comprising Loose to medium dense, brown silty, clayey, gravelly fine to coarse SAND. Gravel is subangular to subrounded fine to coarse flint;</p> <p>Medium dense, orange, brown, sandy, fine to coarse, subangular to angular flint GRAVEL.</p>

Variations of the typical fine-grained Alluvium description include:

- Puesdo fibrous dark brown slightly gravelly PEAT with occasional decaying roots was encountered at depths of between 0.9 and 2.9m bgl with thicknesses of between 0.2m (BH-PTR-23) and 0.7m (BH-PTR-27 and BH-PTR-32). Peat was encountered in the following borehole positions, associated with the River Granta:
 - BH-PTR-23
 - BH-PTR-23B
 - BH-PTR-26A
 - BH-PTR-26B
 - BH-PTR-27
 - BH-PTR-28A
 - BH-PTR-32
 - BH-PTR-32B
 - BH-PTR-39
- Granular deposits were encountered in the following exploratory holes:
 - BH-PTR-20 to BH-PTR-26B;
 - BH-PTR-36;
 - BH-PTR-39 to BH-PTR-41;
 - TP-PTR-31;
 - TP-PTR-33

Superficial Deposits: River Terrace Deposits (RTD)

River Terrace Deposits was recorded in 25no. exploratory holes in Route Section 4 to a maximum depth of 5.6m bgl (BH-PTR-37). The distribution of the undifferentiated River Terrace Deposits broadly matched the published geological information. The distribution of the RTD in Section 4 appears to be associated with topographic low points, ground levels between 20-30m AOD. This stratum is predominantly coarse-grained, with a higher clay content in areas where Alluvium was also recorded in proximity to the River Granta in location (BH-PTR-19 to BH-PTR-22, BH-PTR-24, BH-PTR-26 to BH-PTR-38, TP-BP-01 to TP-BP-05). The base was proven in all borehole locations (BH prefix). Table 5-16 summarises the alluvial deposits encountered in route Section 4.

Table 5-16 - River Terrace Deposits – Route Section 4 typical thicknesses and engineering description

Formation/Stratum	Typical Thicknesses range (m)	Typical Engineering Description
River Terrace Deposits (undifferentiated)	0.4 to 5.6	<p>Orangish brown, slightly clayey, very gravelly SAND with low cobble content. Sand is medium to coarse. Gravel is angular to subangular, fine to coarse flint. Cobbles are angular to subangular flint;</p> <p>Loose orangish brown, sandy, medium to coarse, subrounded to rounded flint GRAVEL. Sand is medium to coarse.</p> <p>Soft to firm mottled orangish grey, gravelly CLAY. Gravel is subangular to subrounded, fine to medium chalk and flint.</p>

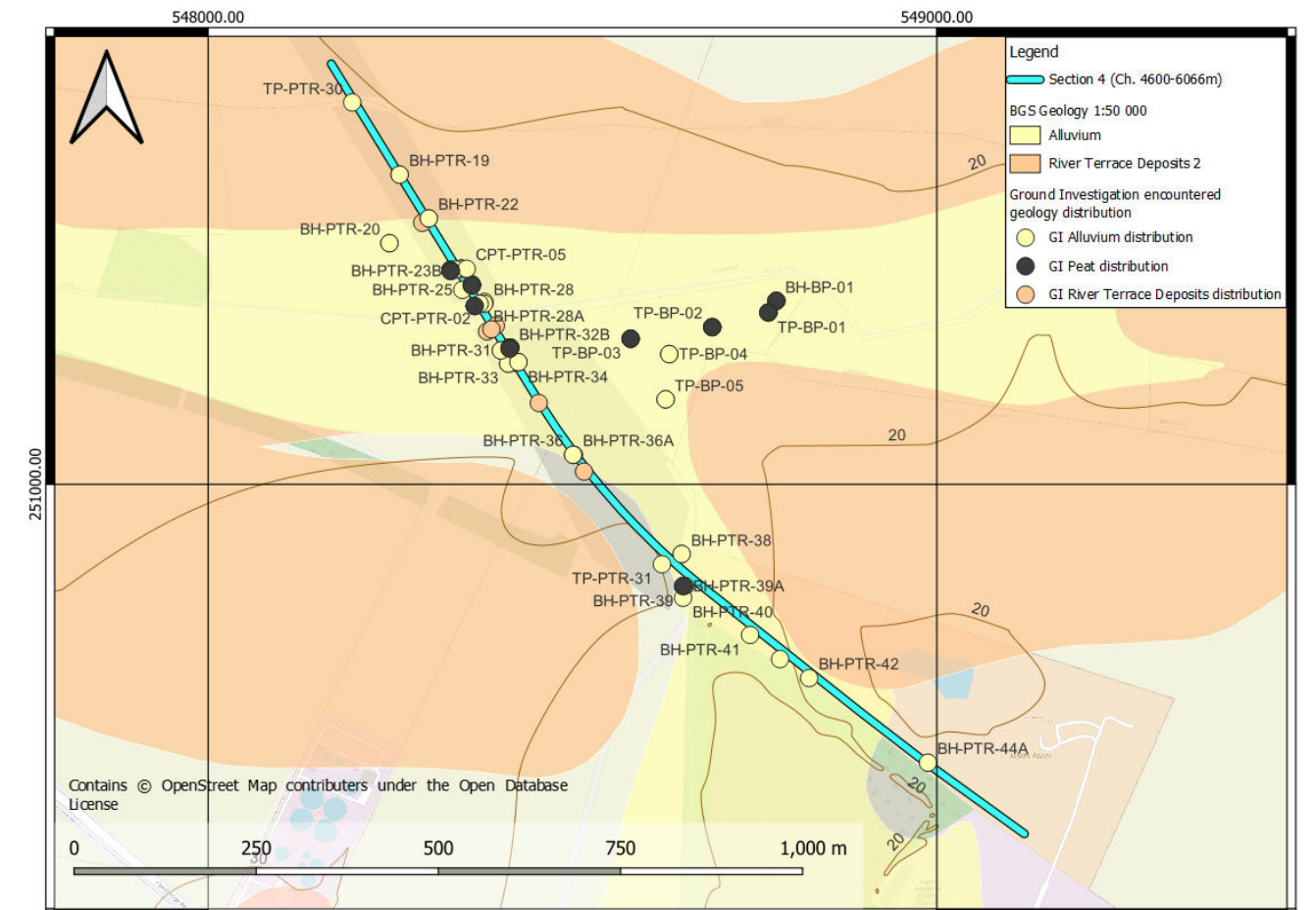


Figure 5-12 - Distribution of Alluvium and River Terrace Deposits along Route Section 4, from the Tetra Tech ground investigation compared to BGS records along the preferred route alignment

Bedrock: Zig Zag Chalk Formation (ZZCH)

The Zig Zag Chalk Formation (ZZCH) was in 34no. exploratory holes in Route Section 4, to the full depth of the ground investigation, which is consistent with BGS records, as shown in Figure 5-13. The base of the Zig Zag Formation was encountered in BH-PTR-9 and BH-PTR-33 at 26.4m and 28.5m, respectively, direction underlain by the West Melbury Marly Chalk Formation. .

Typically, the formation comprised Chalk increasing in CIRIA Engineering Grade with depth. Structureless chalk and structured chalk were both encountered.

Structureless chalk (Grade Dm and Grade Dc) was encountered from approximately 0.5m bgl to 16.5m bgl, however was generally encountered up to 9.0m bgl. Grade Dm chalk comprised structureless CHALK composed of light grey, slightly sandy, gravelly SILT. Sand is fine to medium. Gravel is angular to sub-rounded, fine to coarse chalk and occasional flint. Grade Dc chalk, generally between 4.0 to 16m bgl, comprised structureless grey CHALK composed of silty GRAVEL with occasional orange staining. Gravel is angular to subrounded, fine to coarse, extremely weak to weak low to medium-density chalk.

Grade C (C5 to C3) chalk was encountered in nine boreholes from 6.4 to 27.2m bgl. This comprised a very weak to weak, low to medium-density light grey CHALK with occasional orange staining. One to two discontinuity sets were noted: Discontinuity 1) Joints are close, undulating, smooth, partly open to open, infilled with chalk clasts, randomly orientated. Discontinuity 2) Bedding is close, undulating, smooth, open to occasionally wide with breccia infill

Grade B (B4 to B3) chalk was encountered from approximately 10.7m bgl to 25.5m bgl and comprised Very weak to weak, low to medium-density grey CHALK with orange staining and rare black zoophycos streak, occasionally pyritised. Discernible structure: Discontinuity 1) Joints are planar, smooth, closed and clean. Discontinuity 2) Bedding is close, planar, rough, closed and clean.

Grade A3 chalk was encountered from approximately 11.8 to 29.1m bgl and comprised a weak, medium-density, pale grey CHALK with black specks, inoceramid fragments and rare pyritized fossils. Discernible

structure: Discontinuity 1) Joints are planar, smooth, closed and clean. Discontinuity 1) Bedding is close, planar, rough, closed and clean.

Bedrock: West Melbury Marly Chalk Formation (WMCH)

The West Melbury Marly Chalk Formation (WMCH) was encountered in two locations (BH-PTR-29 and BH-PTR-33, located immediately to the south of the River Granta. The WMCH was encountered between 26.37m bgl and 28.5m bgl and presented the conformable boundary between the Zig Zag Chalk Formation stratigraphically above.

Typically, the formation comprised chalk increasing in grade with depth, from A3 and A2.

Grade A3 chalk comprised a very weak low-density grey marly CHALK with occasional orange stained and occasional mineralised trace fossil streaks (rare inoceramids throughout). Two denotable fracture sets were observed: Discontinuity 1) Joints are closed and clean, with occasional orange staining. Discontinuity 2) Bedding is closed and clean with occasional orange staining and black clay smeared surfaces.

Grade A2 comprised a weak, low to medium-density, cream/grey with grey banding CHALK with rare pyritised trace fossils throughout. Two denotable fracture sets were observed: Discontinuity 1) Joints are closed and clean. Discontinuity 1) Bedding is close, planar, smooth, closed and clean.

Minimum typical and maximum fracture spacing can be found on the engineering logs in the Tetra Tech Factual report [4].

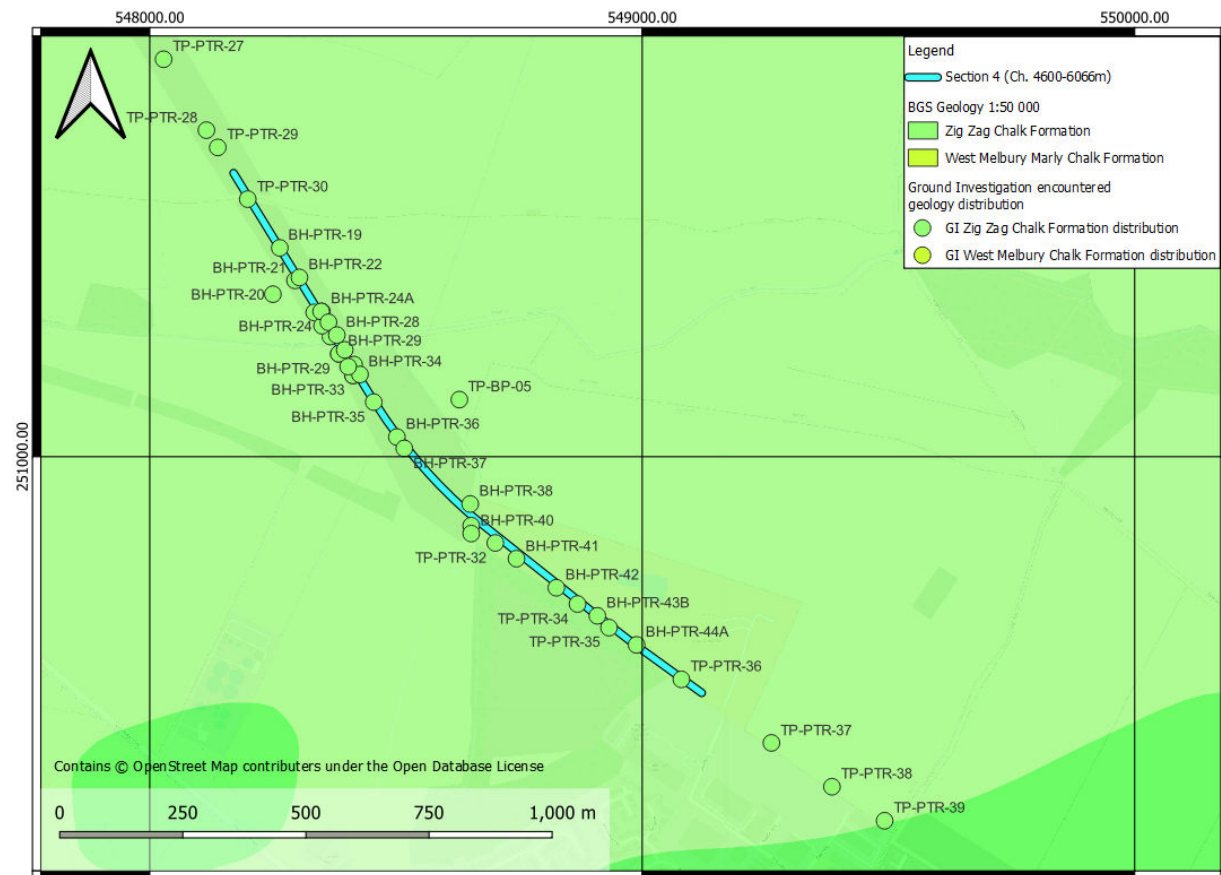


Figure 5-13 - Distribution of the Zig Zag and the West Melbury Marly Chalk Formation along Route Section 4, from the Tetra Tech ground investigation compared to BGS records along the preferred route alignment

5.4.5. Route Section 5

The section of Route Section 5 includes the preferred route from West Way to High Street including the Sawston Public Transport Stop. The section is described in Table 1-4 and in Section 1.2. The relevant drawings, including exploratory hole locations, and cross sections are provided in Appendix B.

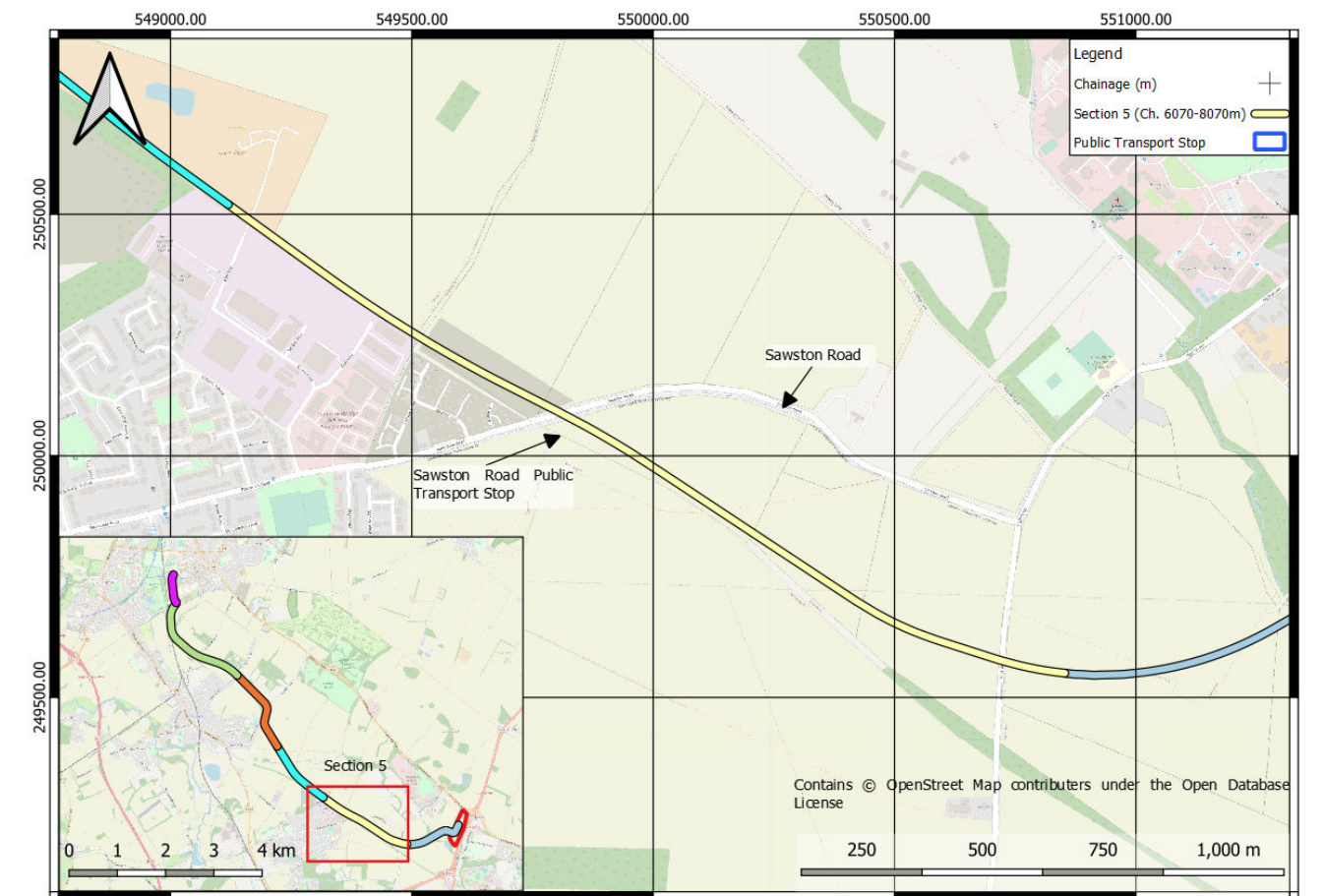


Figure 5-14 – Route Section 5 interpretation area

The exploratory hole at the lowest elevation is TP-PTR-37, located north of the section near North Farm, at 22.7 m AOD. The exploratory hole at the highest elevation is TP-OBC-05, located to the southeast of the section, at 29.6m AOD.

The strata encountered in Route Section 5 is presented in Table 5-17 including the thickness range (m), Upper-level Range (mAOD and m bgl) and Basal Level Range (mAOD). Where the base of the stratum was not encountered, this is recorded as not proven.

Table 5-17 – Route Section 5 (GM5) strata summary

Strata/Formation		Holes Encountered	Top of Stratum Depth (m bgl) range [average]	Top of Stratum Elevation (m OD) range [average]	Base of Stratum Depth (m bgl) range [average]	Base of Stratum Elevation (m OD) range [average]	Thickness (m) range [average]
Topsoil		BH-PTR-45 DCP-SRS-01 to DCP-SRS-07; TP-OBC-01 to TP-OBC-09; TP-PTR-37 to TP-PTR-44; TP-SRS-01, 02	0.0	22.7 to 29.6 [26.8]	0.3 to 1.2 [0.5]	22.3 to 19.2 [26.4]	0.3 to 1.2 [0.5]
Artificial Deposits	Made Ground	BH-PTR-45; BH-PTR-45A; DCP-SRS-02; TP-PTR-40; TP-PTR-41; TP-SRS-01; TP-SRS-02	0.0 to 0.5 [0.2]	25.4 to 26.9 [26.3]	0.3 to 2.7 [1.4]	24.2 to 25.8 [25.1]	0.3 to 2.1 [1.3]
Superficial Deposits	Alluvium/Head Deposits (undifferentiated)	BH-PTR-45A; TP-OBC-01 to TP-OBC-03A; TP-OBC-08; TP-OBC-09; TP-PTR-38; TP-PTR-39; TP-PTR-43 TP-PTR-44;	0.3 to 1.9 [0.5]	24.0 to 27.0 [25.9]	0.5 to 2.0 [1.0]	23.56 to 26.5 [25.3]	0.2 to 1.4 [0.6]
Bedrock	Holywell Nodular Chalk Formation (HNK)	BH-PTR-45A; DCP-SRS-01 to DCP-SRS-07; TP-OBC-01 to TP-OBC-09; TP-PTR-40 to TP-PTR-44; TP-SRS-01; TP-SRS-02	0.3 to 2.3 [0.9]	24.5 to 19.2 [26.2]	1.2 to 10.2 [3.5]	16.7 to 25.9 [23.6]	0.4 to 8.2 [2.6]
	Zig Zag Chalk Formation (ZZCH)	BH-PTR-45A; TP-PTR-37; TP-PTR-38; TP-PTR-39	0.4 to 10.2 [2.9]	16.7 to 24.6 [21.8]	3.0 to 10.5 [5.4]	16.4 to 21.1 [19.4]	0.3 to 3.5 [2.4]

Notes

*thickness not proven. Strata thicknesses were not proven in all exploratory holes. Some thicknesses and depths given represent termination of exploratory holes within a stratum. Interpreted strata thicknesses are presented in the geological sections.

Topsoil

Topsoil is recorded in all exploratory location 25no. exploratory holes along Section 5. The topsoil is predominantly fine-grained, comprising silt and clay, however coarse-grained material was encountered in TP-OBC-03 from 0.0 to 0.3m bgl, described as a light brown, slightly gravelly silty fine to medium SAND. Gravel is

subangular to rounded, fine to coarse flint. The maximum thickness of the topsoil is 1.2m recorded in DCP-SRS-04, however generally was 0.3 to 0.4m thick.

Table 5-18 - Topsoil - Section 5 typical thicknesses and engineering description

Stratum	Thicknesses range (m)	Typical Engineering Description
Topsoil	0.3 to 1.2 (generally, 0.3 to 0.4)	Grass over dark brown, sandy, gravelly CLAY/clayey SILT with abundant rootlets. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse flint and chalk.

Artificial Deposits: Made Ground (MGR)

Made ground was encountered in seven exploratory holes located immediately to the north and south of Sawston Road. The Made Ground comprised dominantly clay strata with limited granular material found in BH-PTR-45, DCP-SRS-02 and TP-SRS-02.

Table 5-19 - Made Ground – Route Section 5 typical thicknesses and engineering description

Stratum	Typical Thicknesses range (m)	Typical Engineering Description
Made Ground	0.3 to 2.13	Firm brown mottled orangish brown, sandy, gravelly CLAY. Sand is fine to medium. Gravel is angular fine to coarse flint and chalk with concrete, and asphalt fragments; Brown gravelly slightly clayey silty SAND. Sand is fine. Gravel is fine to coarse, subangular to subrounded flint and chalk with brick fragments.

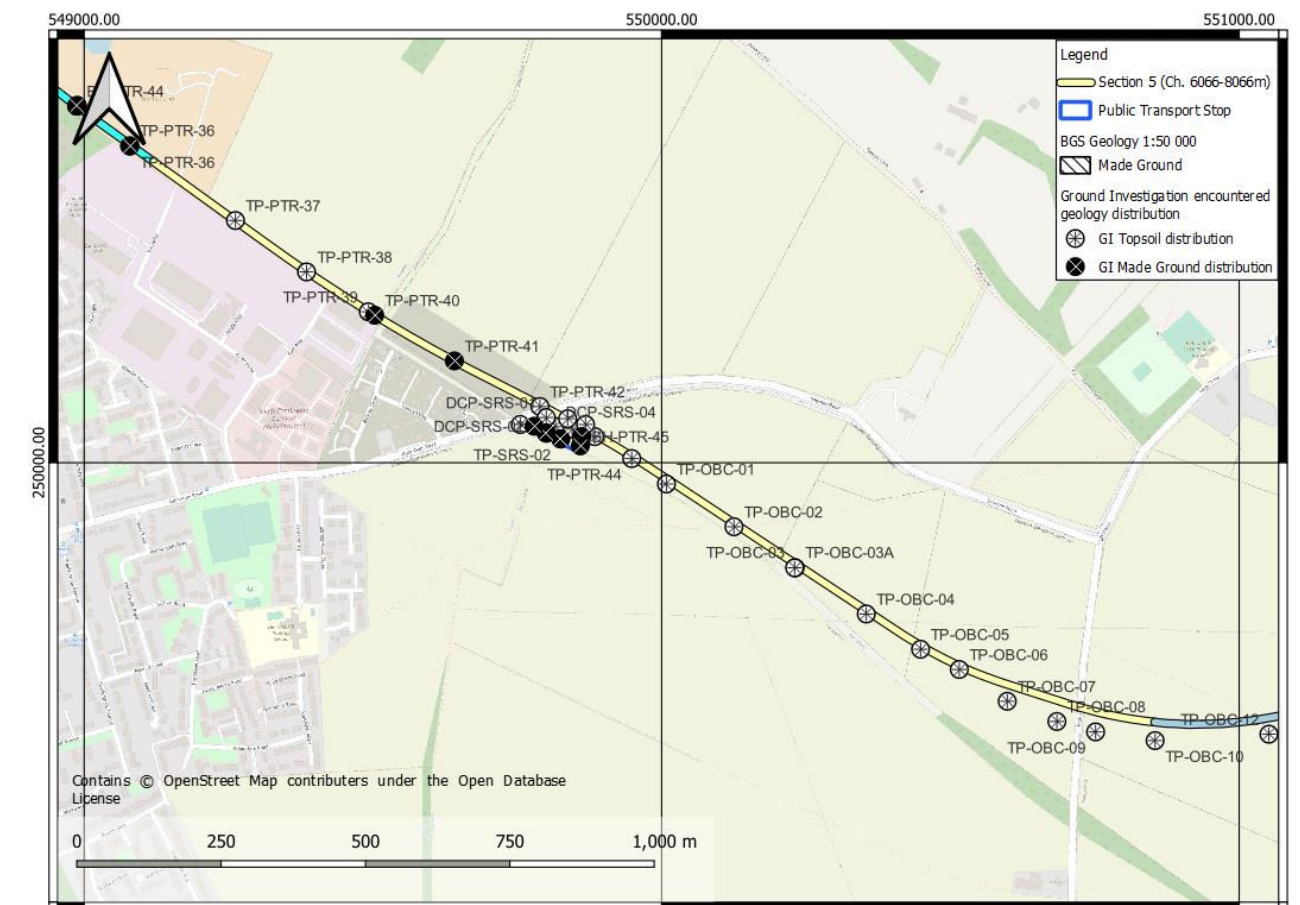


Figure 5-15 - Topsoil and Made Ground distribution along Route Section 5, from the Tetra Tech ground investigation

Superficial Deposits: Alluvium/Head Deposits (undifferentiated)

Tetra Tech logged Alluvium within the route section. However, it is likely attributed to Head Deposits as set out in Section 5.3 of this report. The Tetra Tech reported Alluvium/Head Deposits (undifferentiated) was encountered in 11no. exploratory holes along Section 5 to a maximum depth of 2.0m bgl (BH-PTR-45). No Alluvium has been mapped on BGS records (likely Head Deposits). The distribution of Alluvium/Head Deposits (undifferentiated) appears to be associated with lower lying areas and flanks of slopes, in areas of less than 30mAOD, as shown in Figure 5-16. The stratum is predominantly fine-grained with coarse grained soils only encountered in TP-PTR-39 and TP-PTR-43. The maximum proven thickness was recorded at 1.35m (TP-OBC-09) located near High Street. The Alluvium overlaid bedrock chalk and the base was proven in all locations. Table 5-20 summarises the alluvial deposits encountered.

Table 5-20 - Alluvium/Head Deposits (undifferentiated) – Route Section 5 typical thicknesses and engineering description

Formation/Stratum	Typical Thicknesses range (m)	Typical Engineering Description
Alluvium/Head Deposits (undifferentiated)	0.15 to 1.35	Soft orangish brown gravelly very clayey / silty, fine to medium SAND. Gravel is subangular to subrounded, fine to coarse flint. Medium dense, light brown, silty, gravelly, fine to medium SAND. Gravel is angular to subangular, fine to coarse flint and chalk; and, Medium dense brown mottled white, clayey sandy GRAVEL. Gravel is sub-angular to rounded, fine to coarse chalk and flint.

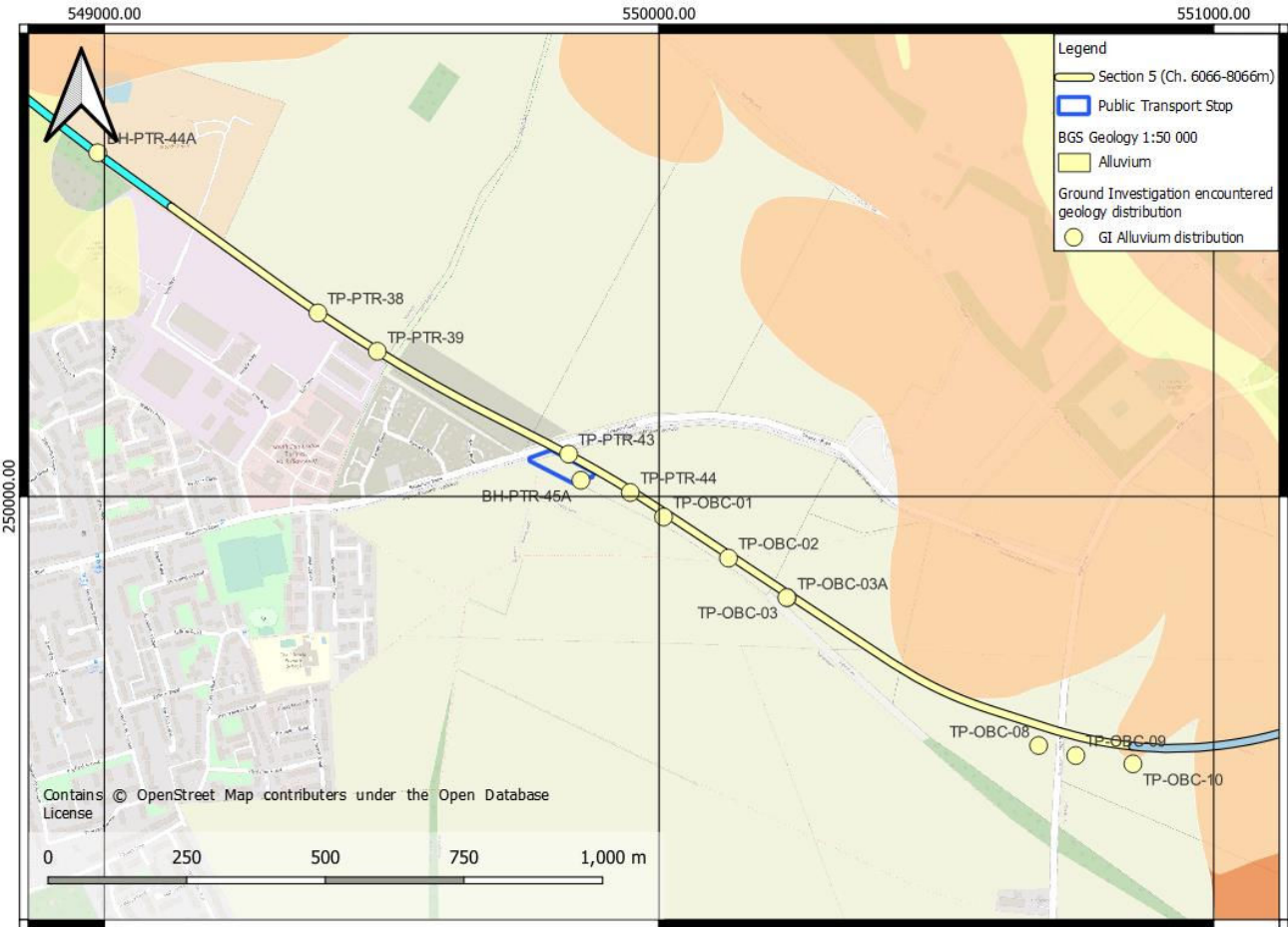


Figure 5-16 - Distribution of Alluvium/Head Deposits (undifferentiated) along Route Section 5, from the Tetra Tech ground investigation compared to BGS records along the preferred route alignment

Bedrock: Holywell Nodular Chalk Formation (HNK)

The Holywell Nodular Chalk Formation (HNK) was encountered in 22no borehole locations along Section 5. The lateral boundary between the HNK and the ZZCH was observed between locations TP-PTR-39 and TP-PTR-40, as shown in Figure 5-17, which confirms the BGS mapping records.

Typically, the formation comprised chalk increasing in CIRIA engineering grade with depth, from Dm and B3. Structureless chalk was dominantly found along the section.

Structureless chalk (Grade Dm and Grade Dc) was encountered from approximately 0.3m bgl to 4.7m bgl. Grade Dm chalk, typically found between 0.3 to 2.2m bgl, comprised structureless light grey CHALK composed of gravelly SILT with variable sand content and it was also recovered as silty gravelly yellowish off-white chalk SAND. Gravel is subrounded fine to coarse, weak chalk with occasional flint. Occasional pockets of fine to medium orangish brown sand. Grade Dc chalk, typically encountered below 1m bgl, comprised a structureless CHALK composed of white sub-rounded, fine to coarse and light brown, slightly sandy silty GRAVEL with low to cobble content. Gravel is very weak, low-density with occasional brown staining. Rare fine to medium, sub-angular to sub-rounded gravel of flint. Shell fragments were also noted in TP-OBC-08 (1.9-4.0m bgl) and infilled fractures with clay were noted in BH-PTR-45A between 2.0 and 2.2m bgl.

Grade B3 and B4 chalk was encountered in BH-PTR-45A and TP-PTR-43, respectively. Grade B3 chalk was encountered from 4.7m bgl and grade B4 chalk was noted from 1.4m bgl. The chalk comprised a very weak to weak, low to medium-density white shelly CHALK with two discernible discontinuity sets: 1) Joints are undulating rough partly open to closed, clean with black specks. Discontinuity 2) Bedding is close, undulating rough, partly open to closed clean with black specks. Orange-stained marl seams were observed in BH-PTR-45A from 9.1 to 10.2m bgl. Shell fragments of Inoceramus Crippssi were noted throughout TP-PTR-43.

A weathered horizon of the Holywell Nodular Chalk Formation was encountered in TP-OBC-09 at 0.45-1.8m bgl and TP-OBC-03A between 0.9-1.0m bgl described as a whitish beige sandy gravelly SILT and a medium dense light grey, silty gravelly, fine to medium SAND, respectively.

Bedrock: Zig Zag Chalk Formation (ZZCH)

The Zig Zag Chalk Formation (ZZCH) was encountered in four boreholes along Section 5 to the full depth of the ground investigation, which is consistent with BGS records, as shown in Figure 5-17.

Typically structureless chalk was encountered in trial pit locations and structured chalk was encountered in rotary core locations, where there is little disturbance. The boundary with the younger Holywell Nodular Chalk Formation was encountered in BH-PTR-45A at a depth of 10.20m bgl distinguished by clean and smooth joints with no staining.

Structureless chalk (Grade Dm and Grade Dc) was encountered from approximately 0.4 to 1.65m bgl. Grade Dm chalk was encountered between 0.4 to 3.0m bgl and comprised a structureless CHALK composed of white, very sandy, gravelly SILT and a Structureless CHALK composed of orangish white, silty, gravelly, fine to medium SAND. Grade Dc chalk, typically encountered below 1.4m bgl, comprised Structureless CHALK with zones of structured chalk composed a structureless CHALK composed of white, slightly sandy, silty GRAVEL with low cobble content.

Grade A2 chalk was encountered in BH-PTR-45A at a depth of 10.2m bgl. This comprised a very weak, low-density, pale greyish white CHALK. Joints are irregular closed clean, undulating smooth with no staining and no distinguishable bedding planes.

Minimum typical and maximum fracture spacing can be found on the engineering logs in the Tetra Tech Factual report [4].

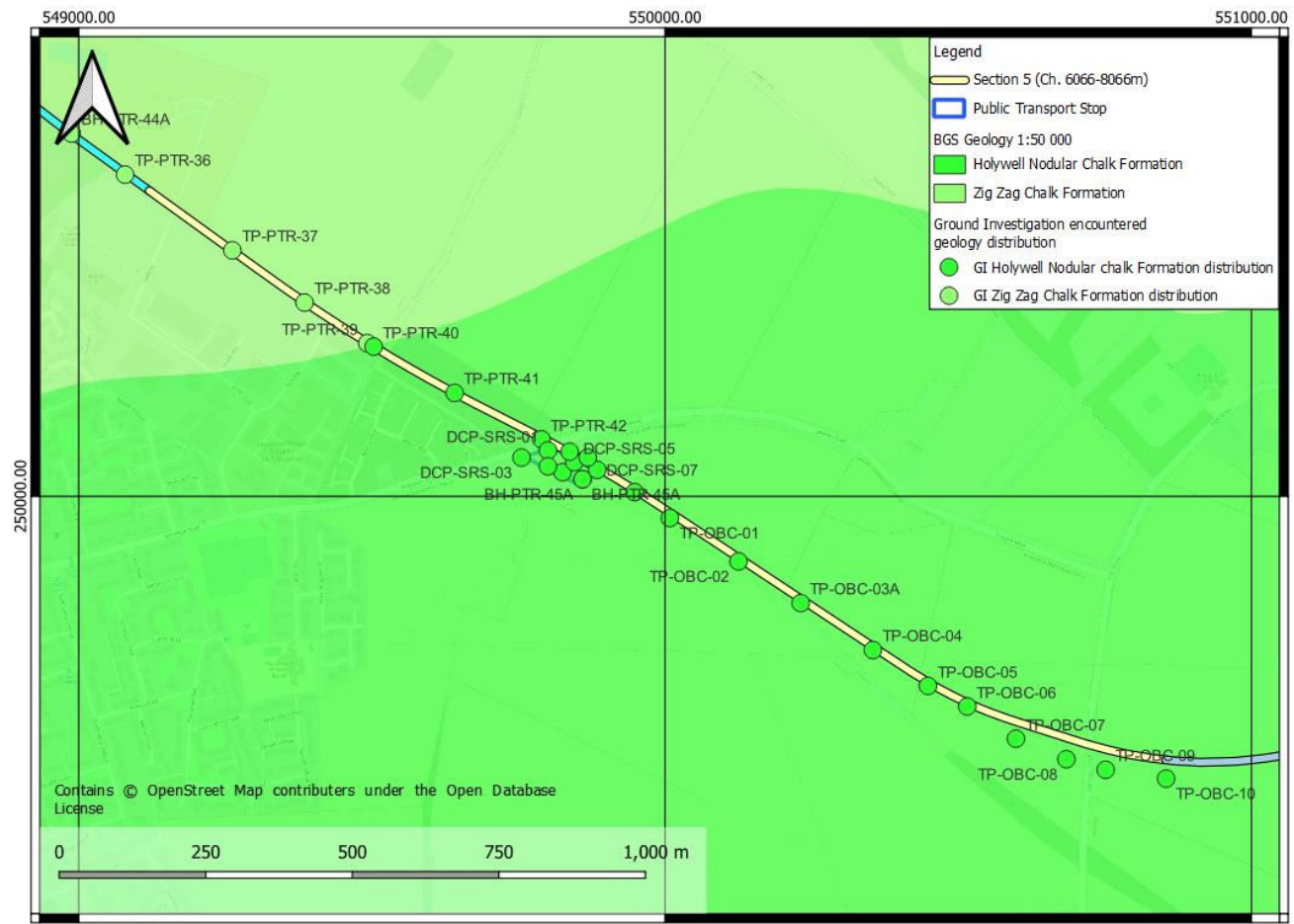


Figure 5-17 - Distribution of the Holywell Nodular and Zig Zag Chalk Formation along Route Section 5, from the Tetra Tech ground investigation compared to BGS records along the preferred route alignment

5.4.6. Route Section 6

The section of Route Section 6 includes the preferred alignment route from High Street to the Travel Hub site near the A11. The section is described in Table 1-4 and in Section 1.2. The relevant drawings, including exploratory hole locations, and cross sections are provided in Appendix B.

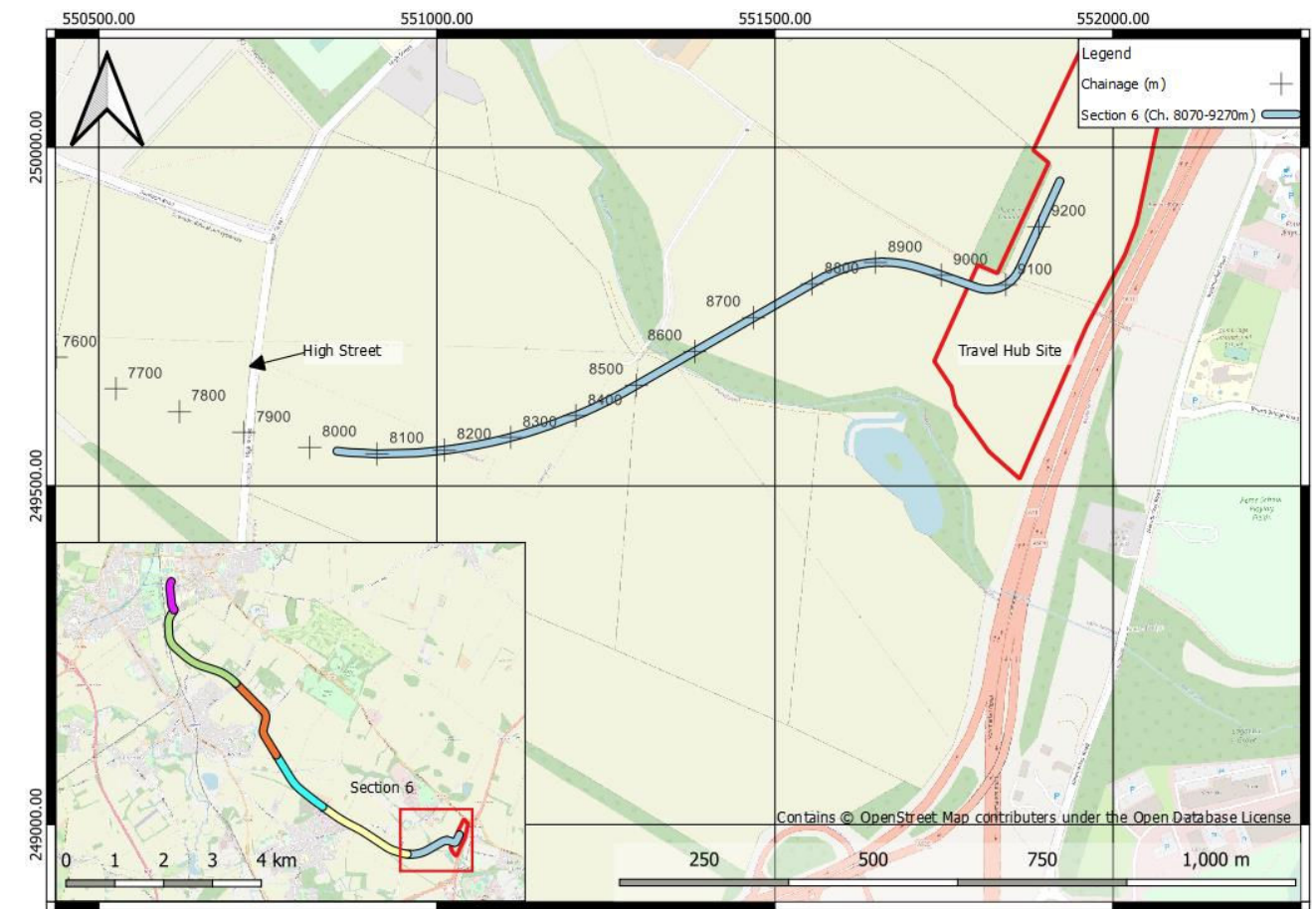


Figure 5-18 – Route Section 6 interpretation area

The exploratory hole at the lowest elevation is BH-OBC-09, located northeast of the River Granta, at 25.2 m AOD. The exploratory hole at the highest elevation is TP-OBC-12, located to the west of the section, at 31.31m AOD.

The strata encountered in Route Section 6 is presented in Table 5-21 including the thickness range (m), Upper-level Range (mAOD and m bgl) and Basal Level Range (mAOD). Where the base of the stratum was not encountered, this is recorded as not proven.

Table 5-21 – Route Section 6 (GM6) strata summary

Strata/Formation		Holes Encountered	Top of Stratum Depth (m bgl) range [average]	Top of Stratum Elevation (m OD) range [average]	Base of Stratum Depth (m bgl) range [average]	Base of Stratum Elevation (m OD) range [average]	Thickness (m) range [average]
Topsoil		BH-OBC-01 to BH-OBC-16; CPT-OBC-01 to CPT-OBC-04; TP-OBC-10; TP-OBC-12; TP-OBC-13; TP-PTR-56	0.0	25.2 to 31.3 [26.4]	0.2 to 0.7 [0.4]	24.8 to 30.8 [25.9]	0.2 to 0.7 [0.4]
Artificial Deposits	Made Ground	BH-PBC-10	0.0	25.5	0.4	25.1	0.4

Strata/Formation		Holes Encountered	Top of Stratum Depth (m bgl) range [average]	Top of Stratum Elevation (m OD) range [average]	Base of Stratum Depth (m bgl) range [average]	Base of Stratum Elevation (m OD) range [average]	Thickness (m) range [average]
Superficial Deposits	Alluvium (undifferentiated)	BH-OBC-03 to BH-OBC-09; CPT-OBC-02; CPT-OBC-03; TP-OBC-10; BH-OBC-11; TP-PTR-56	0.6 to 0.6 [0.4]	24.8 to 28.4 [25.5]	0.8 to 2.0 [1.2]	23.6 to 27.0 [24.7]	0.4 to 1.7 [0.8]
	River Terrace Deposits (undifferentiated)	BH-OBC-01 to BH-OBC-16; CPT-OBC-01; CPT-OBC-04; TP-OBC-12; TP-OBC-13	0.2 to 1.8 [0.7]	23.6 to 30.8 [25.5]	0.8 to 4.5 [2.9]	21.1 to 27.3 [23.4]	0.3 to 3.6 [2.1]
Bedrock	Holywell Nodular Chalk Formation	BH-OBC-01 to BH-OBC-16; TP-OBC-10; TP-PTR-56	0.7 to 4.4 [2.6]	21.1 to 26.9 [23.5]	3.0 to 23.3 [19.6]	2.01 to 25.7 [25.7]	1.0 to 20.4 [14.3]
	Zig Zag Chalk Formation	BH-OBC-02 to BH-OBC-16;	18.0 to 23.3 [20.0]	2.0 to 7.5 [5.6]	30.0 to 30.5 [30.4]	-5.29 to -3.56 [-4.8]	7.2 to 12.5 [10.4]

Notes

*thickness not proven. Strata thicknesses were not proven in all exploratory holes. Some thicknesses and depths given represent termination of exploratory holes within a stratum. Interpreted strata thicknesses are presented in the geological sections.

Topsoil

Topsoil is recorded in all 23no. exploratory holes positions along Route Section 6. The topsoil is predominantly fine-grained, comprising silt and clay, however coarse-grained material was encountered in BH-PBC-13, BH-OBC-15 and CPT-OBC-12, described as Grass over brown, slightly gravelly, fine SAND. The maximum thickness of the topsoil is 0.65m recorded in BH-OBC-14, however, generally was 0.3 to 0.4m thick.

Table 5-22 - Topsoil – Route Section 6 typical thicknesses and engineering description

Stratum	Typical Thicknesses range (m)	Typical Engineering Description
Topsoil	0.3 to 0.65 (generally, 0.3 to 0.4)	Grass over dark brown, sandy, gravelly CLAY/clayey sandy SILT with abundant rootlets. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse flint and chalk and rare brick.

Artificial Deposits: Made Ground (MGR)

Made ground was encountered in a single borehole location, BH-OBC-10 from ground level to 0.40m bgl. Made Ground comprised a Firm, brown, gravelly, very sandy SILT with rootlets. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse flint. However, it is likely that this is attributed to topsoil due to the lack of anthropogenic material.

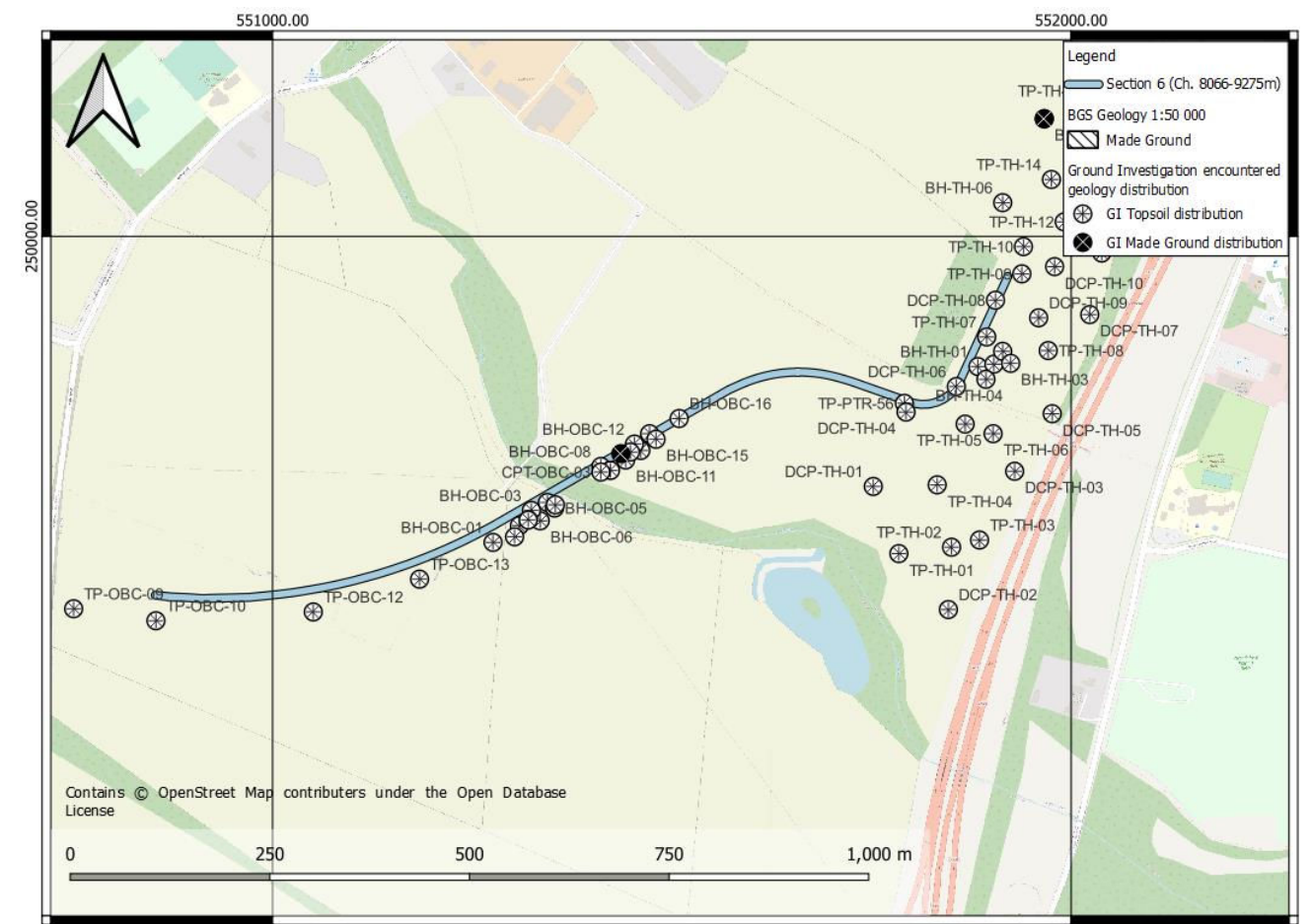


Figure 5-19 - Topsoil and Made Ground distribution along Route Section 6, from the Tetra Tech ground investigation

Superficial Deposits: Alluvium (ALV)

Alluvium was encountered in 12no. exploratory holes along Section 6 to a maximum depth of 2.0m bgl (BH-PTR-45). Alluvium broadly matched BGS records, as shown in Figure 5-20. The distribution of Alluvium is associated with lower lying areas in proximity to the River Granta. The stratum is predominantly fine-grained (seven locations) with coarse grained soils encountered in five locations (BH-OBC-06, BH-OBC-07, TP-OBC-10, BH-OBC-11, TP-PTR-56). The maximum proven thickness was recorded at 1.7m (TP-PTR-56) located to the southern extent of Two Acre Plantation. The Alluvium overlaid bedrock chalk and the base was proven in all locations. Table 5-23 summarises the alluvial deposits encountered.

Table 5-23 - Alluvial deposits – Route Section 6 typical thicknesses and engineering description

Formation/Stratum	Typical Thicknesses range (m)	Typical Engineering Description
Alluvium (fine grained)	0.35-1.37	Soft orangish brown gravelly very sandy / silty, CLAY. Gravel is subangular to subrounded, fine to coarse flint.
Alluvium (coarse grained)	0.4-1.7	Medium dense orange brown, silty slightly gravelly fine to coarse SAND. Gravel is subangular to rounded, fine to coarse flint; and, Dense orangish brown slightly clayey SAND and fine to medium, angular to rounded flint GRAVEL.

Superficial Deposits: River Terrace Deposits (RTD)

River Terrace Deposits was recorded in 19no. exploratory holes along Route Section 6 with a maximum thickness of 3.6m in TP-OBC-13. The distribution of RTD broadly matches BGS records, as shown in Figure 5-20. summarises the alluvial deposits encountered.

Table 5-24 - River Terrace Deposits – Route Section 6 typical thicknesses and engineering description

Formation/Stratum	Typical Thicknesses range (m)	Typical Engineering Description
River Terrace Deposits (undifferentiated)	0.3 to 3.6	<p>Medium dense orange brown, gravelly, medium to coarse SAND. Gravel is angular to subangular, fine to coarse flint; and,</p> <p>Medium dense brownish orange very sandy fine to coarse, angular to subrounded flint GRAVEL.</p> <p>Stiff brownish orange slightly sandy slightly gravelly CLAY. Sand is fine to medium. Gravel is sub-angular to rounded flint.</p>

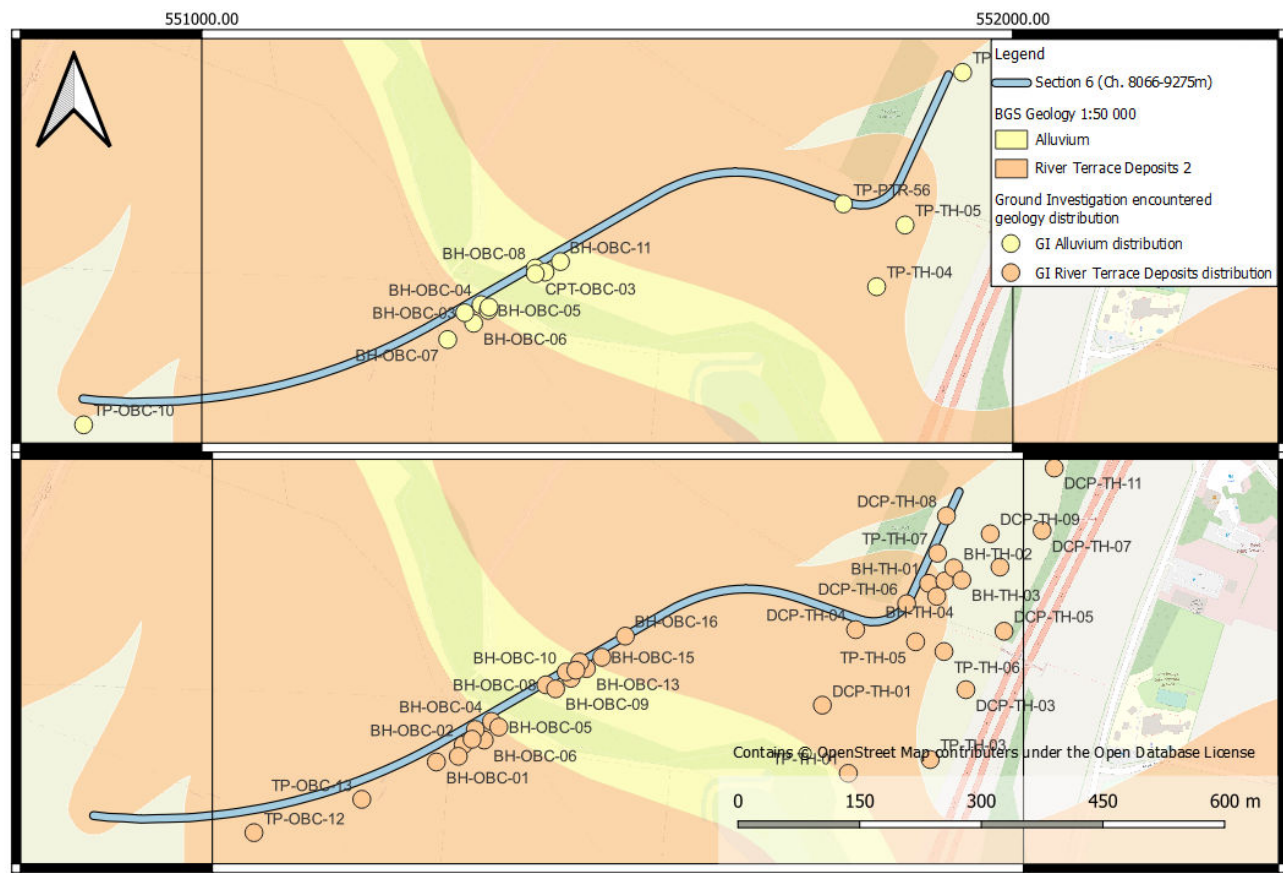


Figure 5-20 - Distribution of Alluvium (top) and River Terrace Deposits (bottom) along Route Section 6, from the Tetra Tech ground investigation compared to BGS records along the preferred route alignment

Bedrock: Holywell Nodular Chalk Formation (HNK)

The Holywell Nodular Chalk Formation (HNK) was encountered in a 18no exploratory holes along Section 6. The stratigraphic boundary between the HNK and the ZZCH was observed in 14no. locations BH-OBC-02 to BH-PBC-15, as shown in Figure 5-21. The distribution of the chalk generally confirms BGS mapping records.

Typically, the formation comprised chalk increasing in grade with depth from structureless to structured.

Structureless chalk (Grade Dm and Grade Dc) was encountered from approximately 0.65m bgl to 13.25m bgl. Grade Dm chalk, typically found between 0.7 to 7.7m bgl, comprised structureless CHALK composed of cream slightly gravelly SILT, often orange stained. Gravel is angular to subangular fine to medium very weak low-density chalk. Rare angular fine to coarse flint. Grade Dc chalk, typically encountered below 2m bgl, comprised a structureless white CHALK composed of silty GRAVEL. Gravel is subrounded to angular, fine to coarse, weak low-density chalk.

Inoceramid and mytiloid shell fragments were noted throughout the structured chalk in BH-OBC-02, BH-OBC-05 BH-OBC-08, BH-OBC-11, BH-OBC-13 and BH-OBC-16. These are thought to be part of the Holywell Mytiloid Grit Beds which is indicative of the upper boundary of the Holywell Nodular Chalk Formation, having the highest detrital shell beds.

The Plenus Marl Member (Grade B3) was noted in BH-OBC-05, BH-OBC-06 and BH-OBC-09 at depth of 17.35 to 19.4m bgl, representing the lower boundary of the formation. The Melbourne Rock Member was noted in BH-OBC-05, -06, -07, -08, -10, -14 and -15 at tops depths between 14.2m and 17.3m bgl.

Grade C (Grade C4 to C3) was encountered in 12no. exploratory holes. Grade C chalk was encountered from 6.0m bgl to 22.03m bgl, with the majority of the chalk being classed as Grade C3 encountered from 6.0m bgl. The chalk comprised a very weak, low to medium-density brown speckled white shelly gritty CHALK. Shells comprise fractured and disarticulated mytilids with other unidentified bivalves and brachiopods. Discontinuity 1) Joints are inclined, subvertical, closed to partially open, rough, undulating, clean with light brown staining some with a grey clay smearing. Discontinuity 2) Bedding is close to moderately wide with brecciated fine chalk gravel infill, rough, undulating, clean with light brown staining some with a grey clay smearing.

Grade B (Grade B5 to B3) was encountered in 12no. exploratory holes. Grade B chalk was encountered from 10.66m bgl to 23.3m bgl, with the majority of the chalk being classed as Grade B3 encountered from 11.66m bgl. Chalk comprised a weak, medium to high-density, slightly gritty occasional brown speckled white CHALK with some mytilid and other shell fragments including other unidentified bivalves and brachiopods. Two discernible discontinuity sets were noted: 1). Joints inclined to subvertical, closed and partially open, clean undulating rough with orange staining and occasionally green/black smeared. Discontinuity 2). Bedding closed and partially open, clean undulating rough with orange staining.

Bedrock: Zig Zag Chalk Formation (ZZCH)

The Zig Zag Chalk Formation (ZZCH) was encountered in 14no. boreholes along Section 6 to the full depth of the ground investigation, which is consistent with BGS records, as shown in Figure 5-21. The stratigraphic boundary was encountered in all locations from 18.0m bgl to the full depth of the ground investigation. ZZCK was recorded at a depth of 7.0m-8.0m bgl in BH-OBC-06, however on further review the log showed to have significant shell fragments (Mytiloids and brachiopods) as well as the HNK being recorded stratigraphically below the section. Therefore, it is likely that this is attributed to the HNK and is not part of the ZZCH sequence and has been removed from the assessment below and the depth ranges in .

Typically, the ZZCH was encountered as structured chalk throughout, from CIRIA Engineering Grades C to A.

Grade C3 chalk was encountered in BH-OBC-11 and BH-OBC-14 from a depth of 21.1m bgl and 24.4m bgl, respectively. Grade C3 chalk comprised a weak, low to medium-density, light grey CHALK with occasional trace fossil burrows, orange staining and frequent marl beds. Discontinuities were closed and open, occasionally clean but also with silt and gravel infill. Localised zones (30 to 100mm diameter / thick) of weak, low-density fine to coarse gravel (brecciated zones) was noted in BH-OBC-14 at 24.4m to 28.5m bgl.

Grade B chalk (B4 to B2) was encountered from 18.91m bgl to >30.0m bgl and comprised a very weak to weak low to medium-density white CHALK with some wispy griotte marls with occasional pyritization of relict trace fossil burrows. Discontinuity 1) Joints are undulating rough, close, clean. Discontinuity 2) Bedding is close, undulating rough, closed to partially open, clean with black staining, often stained orange and black speckling.

Grade A chalk (A4 to A2) was encountered from 18.0m bgl to >30.5m bgl, and comprised a very weak, medium-density greyish white CHALK with occasional pale grey zoophycos trace marks and wispy grey marls throughout, occasional pyritization of trace fossil burrows. Discontinuity set 1) Joints are closed and clean. Discontinuity 2) Bedding is close to medium, closed and clean

Minimum typical and maximum fracture spacing can be found on the engineering logs in the Tetra Tech Factual report [4].

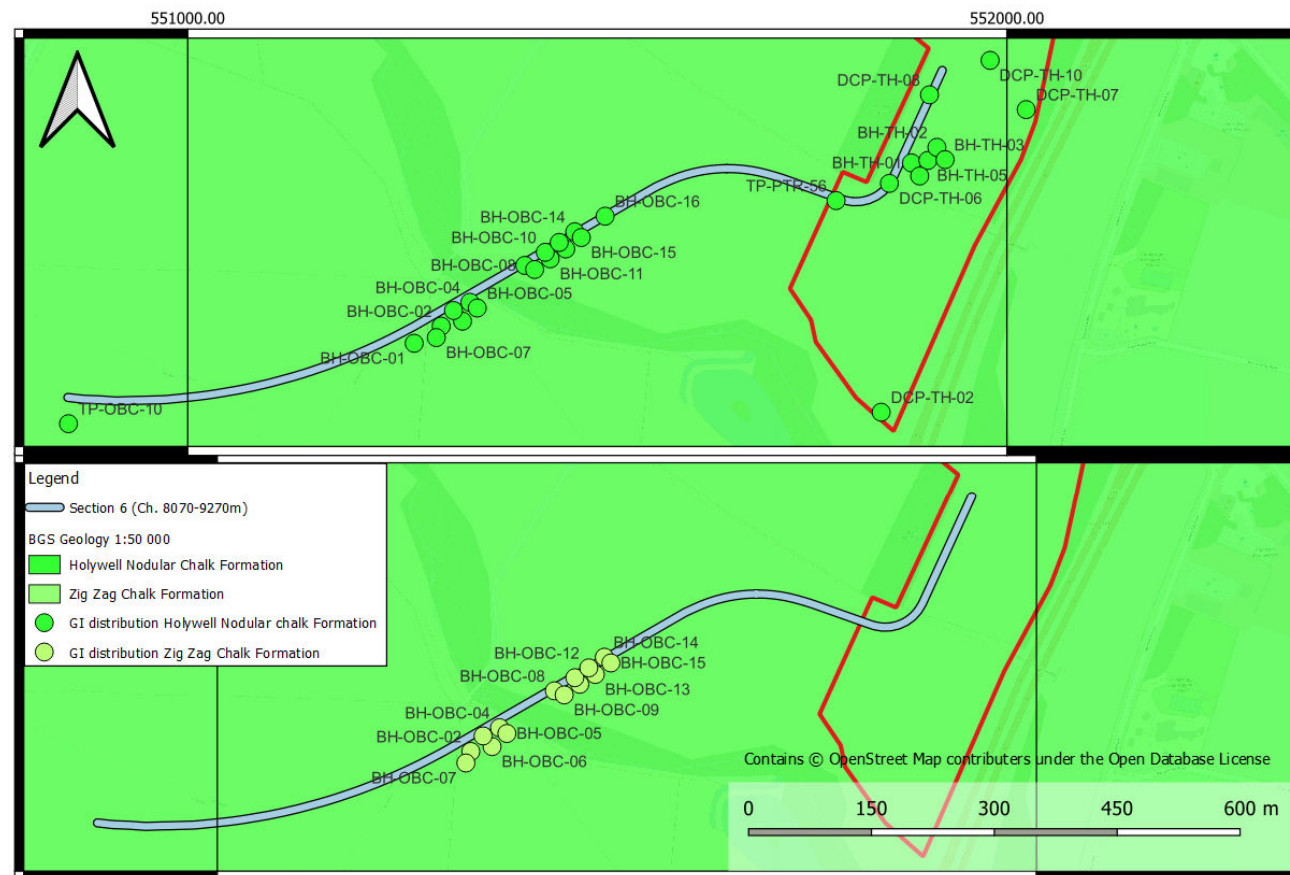


Figure 5-21 - Distribution of the Holywell Nodular Chalk (top) and Zig Zag Chalk (bottom) Formation along Route Section 6, from the Tetra Tech ground investigation

5.4.7. Travel Hub Site

The Travel Hub Site includes the area to the west of the A11. The section is described in Table 1-4 and in Section 1.2. The relevant drawings, including exploratory hole locations, and cross sections are provided in Appendix B.

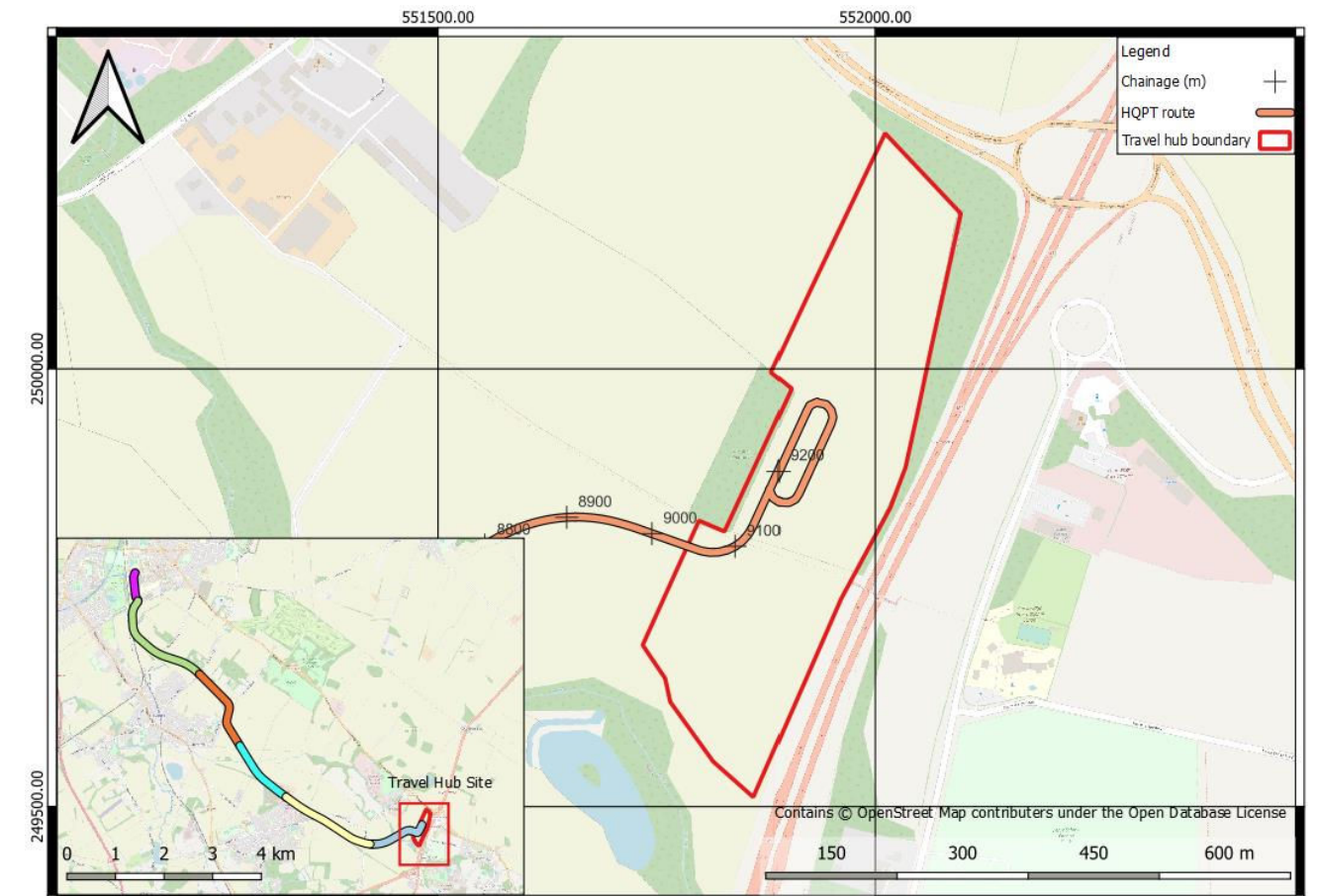


Figure 5-22 - Travel Hub interpretation area

The exploratory hole at the lowest elevation is DCP-TH-01, located at the southwest of the TH site, at 26.7m AOD. The exploratory hole at the highest elevation is TP-TH-08, located in the centre of the TH site, to the eastern boundary, at 34.8m AOD.

The strata encountered in the Travel Hub Site is presented in Table 5-25 including the thickness range (m), Upper-level Range (mAOD and m bgl) and Basal Level Range (mAOD). Where the base of the stratum was not encountered, this is recorded as not proven.

Table 5-25 - Travel Hub Site (GM7) strata summary

Strata/Formation		Holes Encountered	Top of Stratum Depth (m bgl) range [average]	Top of Stratum Elevation (m OD) range [average]	Base of Stratum Depth (m bgl) range [average]	Base of Stratum Elevation (m OD) range [average]	Thickness (m) range [average]
Topsoil		BH-TH-01 to BH-TH-10; DCP-TH-01 to DCP-TH-02 DCP-TH-11; TP-TH-01 to TP-TH-15	0.0	26.7 to 34.8 [30.4]	0.2 to 0.8 [0.4]	26.3 to 34.5 [29.9]	0.2 to 0.8 [0.4]
Artificial Deposits	Made Ground	BH-TH-07	0.4	33.1	0.5	33.0	0.1
Superficial Deposits	Alluvium (undifferentiated)	TP-TH-04 TP-TH-05 TP-TH-09	0.15 to 0.5 [0.3]	28.2 to 29.9 [28.9]	0.7 to 1.8 [1.1]	27.7 to 28.6 [28.1]	0.5 to 1.3 [0.8]
	River Terrace Deposits (undifferentiated)	BH-TH-01 to BH-TH-10; DCP-TH-01 to DCP-TH-11; TP-TH-01; TP-TH-03; TP-TH-05 to TP-TH-08; TP-TH-13 DCP-TH-03; DCP-TH-06; DCP-TH-07	0.2 to 0.8 [0.4]	26.3 to 34.5 [30.0]	0.5 to 2.8 [1.4]	25.7 to 33.5 [29.0]	0.2 to 2.4 [1.0]
	Lowestoft Formation	BH-TH-08; BH-TB-09	1.2 to 1.5	33.0 to 33.3 [33.2]	2.0 to 2.3 [2.2]	32.0 to 32.5 [32.3]	0.8 to 1.0 [0.9]
Bedrock	New Pit/Holywell Nodular Chalk Formation	BH-TH-02 to BH-TH-09A; TP-TH-01 to TP-TH-15	0.3 to 8.2 [2.4]	21.3 to 33.7 [28.2]	3.0 to 12.5 [5.2]	16.5 to 3.8 [25.4]	0.2 to 6.4 [2.8]
	Holywell Nodular Chalk Formation	BH-TH-01 to BH-TH-10; DCP-TH-02; DCP-TH-06 to DCP-TH-08; DCP-TH-10	0.5 to 2.8 [1.4]	26.7 to 32.3 [29.1]	1.1 to 12.5 [6.0]	16.6 to 29.4 [24.4]	0.5 to 10.7 [4.7]

Notes

*thickness not proven. Strata thicknesses were not proven in all exploratory holes. Some thicknesses and depths given represent termination of exploratory holes within a stratum. Interpreted strata thicknesses are presented in the geological sections.

Topsoil

Topsoil is recorded in 37no. positions in the Travel Hub site. The topsoil is predominantly fine-grained, comprising silt and clay, however coarse-grained material was encountered in a number of locations. The maximum thickness of the topsoil is 0.8m recorded in DCP-TH-11, however, generally was 0.3 to 0.4m thick.

Table 5-26 - Topsoil – Travel Hub Site typical thicknesses and engineering description

Stratum	Thicknesses range (m)	Typical Engineering Description
Topsoil	0.2 to 0.8 (generally between 0.3 and 0.4)	Crop over brown slightly gravelly sandy SILT/sandy CLAY. Sand is fine. Gravel is angular to subrounded, fine to coarse flint; Dark brown gravelly clayey SAND. Gravel is sub-angular to sub-rounded, fine to coarse flint and chalk.

Artificial Deposits: Made Ground (MGR)

Made ground was encountered in a single borehole location, BH-TH-07, located in the northwest of the TH site from ground level to 0.40m bgl. Made Ground comprised a medium dense yellowish brown clayey gravelly fine to coarse SAND. Gravel is sub-angular to sub-rounded, fine to coarse chalk and rare flint. However, it is likely that this is attributed to topsoil due to the lack of anthropogenic material.

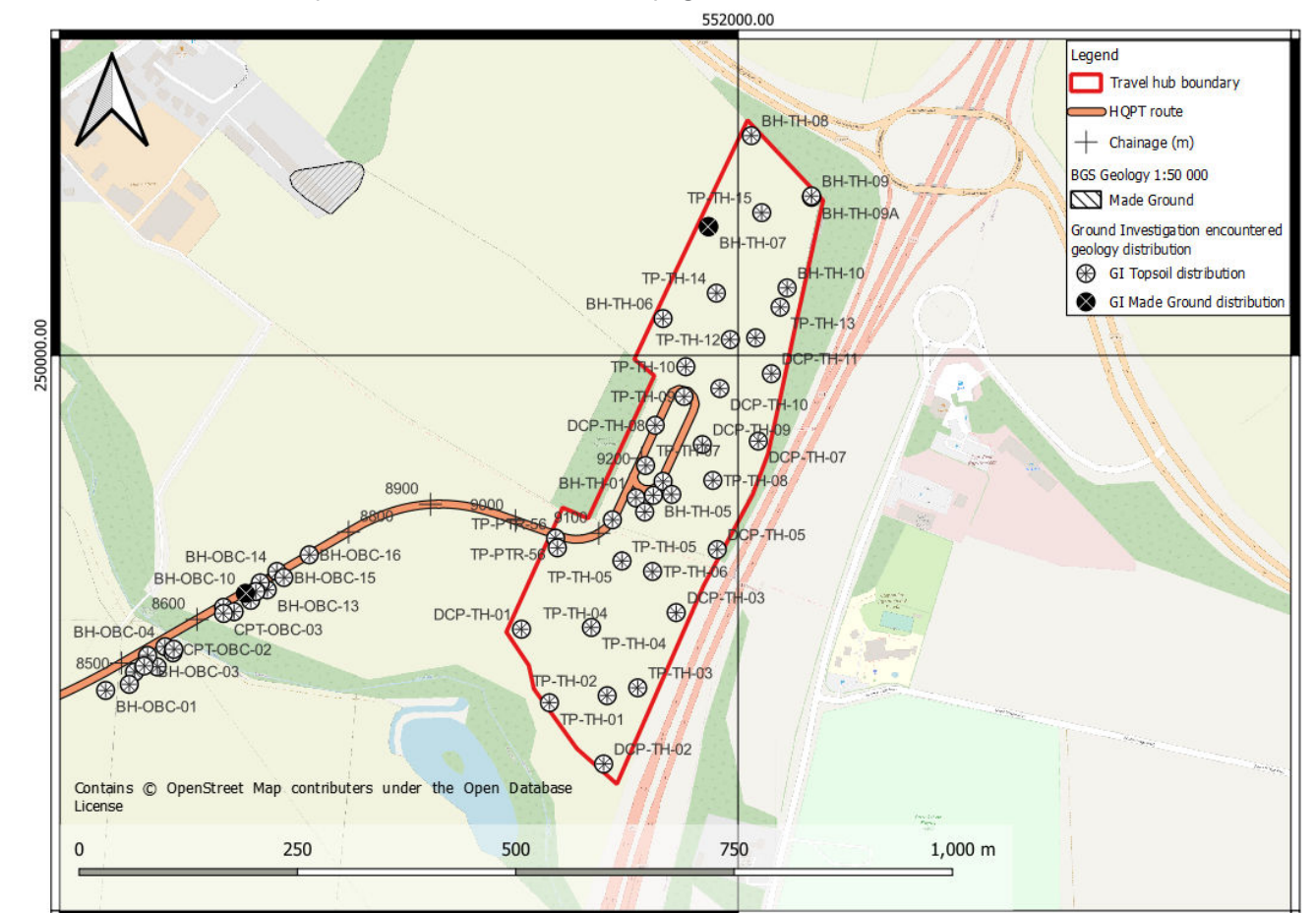


Figure 5-23 - Topsoil and Made Ground distribution at the Travel Hub Site, from the Tetra Tech ground investigation

Superficial Deposits: Alluvium (ALV)

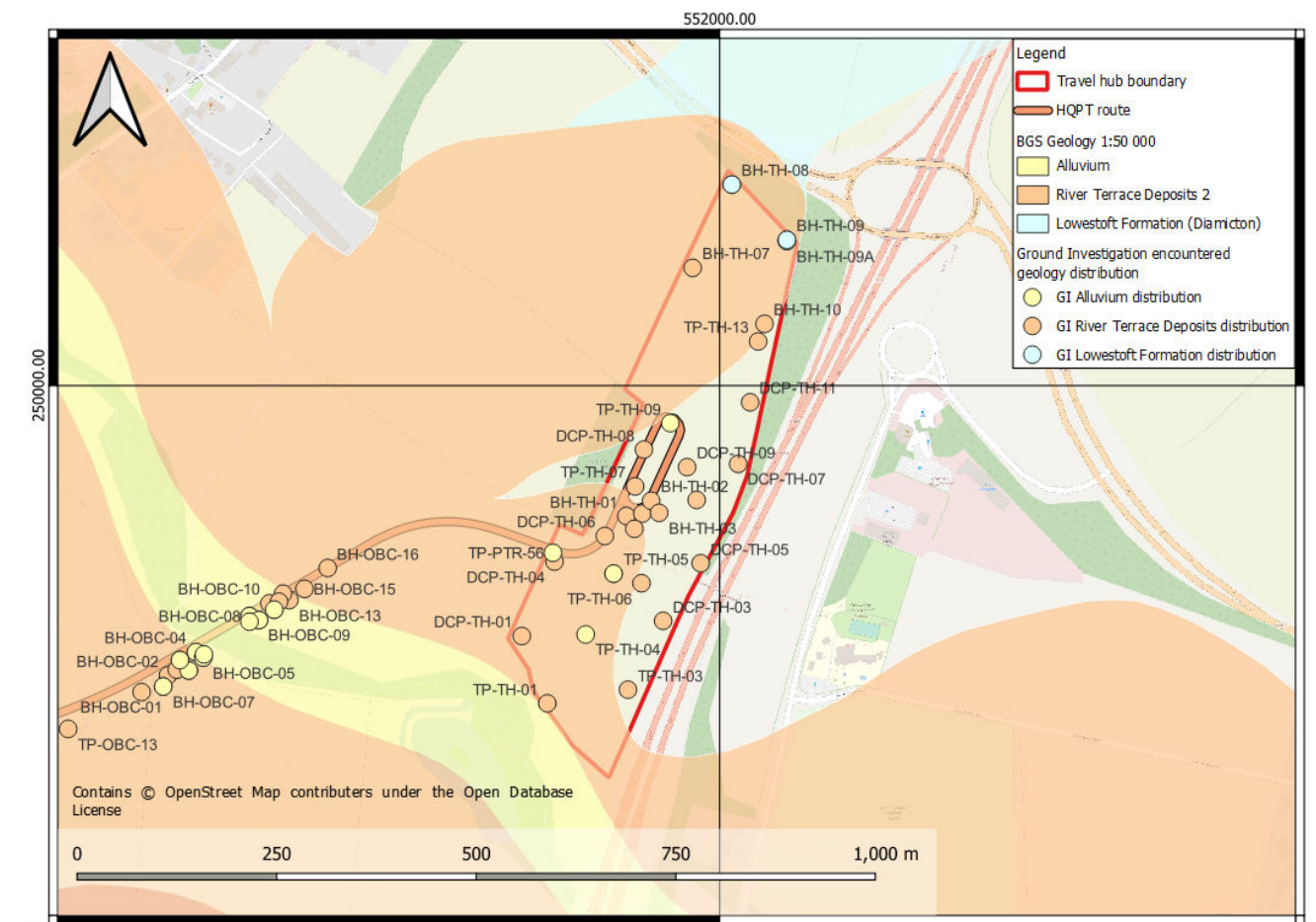
Alluvium was encountered in three exploratory holes within the TH site with a maximum thickness of 1.3m (TP-TH-09). Alluvium slightly differs from BGS records, as shown in Figure 5-24. The stratum is predominantly fine-grained. The Alluvium overlaid bedrock chalk and the base was proven in all locations. summarises the alluvial deposits encountered.

Formation/Stratum	Typical Thicknesses range (m)	Typical Engineering Description
Alluvium (fine grained)	0.5 to 1.3	Firm, orangish brown very sandy very silty, gravelly CLAY. Sand is fine to medium. Gravel is sub-angular to sub-rounded, fine to coarse flint.

River Terrace Deposits was recorded in 24no. exploratory holes in the Travel Hub Site with a maximum thickness of 2.43m in BH-TH-04.

Formation/Stratum	Typical Thicknesses range (m)	Typical Engineering Description
River Terrace Deposits (undifferentiated)	0.2 to 2.4	Firm orangish brown slightly gravelly sandy SILT/sandy CLAY. Sand is fine to coarse. Gravel is angular, fine to medium flint and occasional chalk; and, Medium dense yellowish brown, gravelly, clayey SAND. Sand is fine to medium. Gravel is fine to coarse, sub-angular to sub-rounded flint and chalk.

Formation/Stratum	Typical Thicknesses range (m)	Typical Engineering Description
Lowestoft Formation	0.8 to 1.0	<p>Stiff (friable) light brown mottled grey, sandy, gravelly, silty CLAY. Sand is fine and medium. Gravel is fine to coarse, sub-angular to rounded chalk and flint.</p> <p>Medium dense (friable) white mottled brown very clayey angular to subangular, fine to medium, very weak to weak, low-density chalk GRAVEL</p>



Grade B chalk (B3) was encountered from 7.5m to 12.0m bgl, in BH-TH-04, and comprised a very weak to weak, low-density white CHALK with rare inoceramid and mytilid fragments. Discontinuity 1). Joints are slightly

undulating, rough, closed, clean with rare speckling. Discontinuity 2). Bedding is close, slightly undulating, rough, closed to open, clean with rare speckling

Grade2 A2 was encountered from 8.17m to 10.5m bgl, and comprised an extremely weak to weak, low-density white CHALK with rare shell fragments. Discontinuity1) Joints are undulating, closed and clean with brown specks. Discontinuity 2) Bedding is close to medium, undulating, closed and clean.

Minimum typical and maximum fracture spacing can be found on the engineering logs in the Tetra Tech Factual report [4].

Bedrock: Holywell Nodular Chalk Formation (HNK)

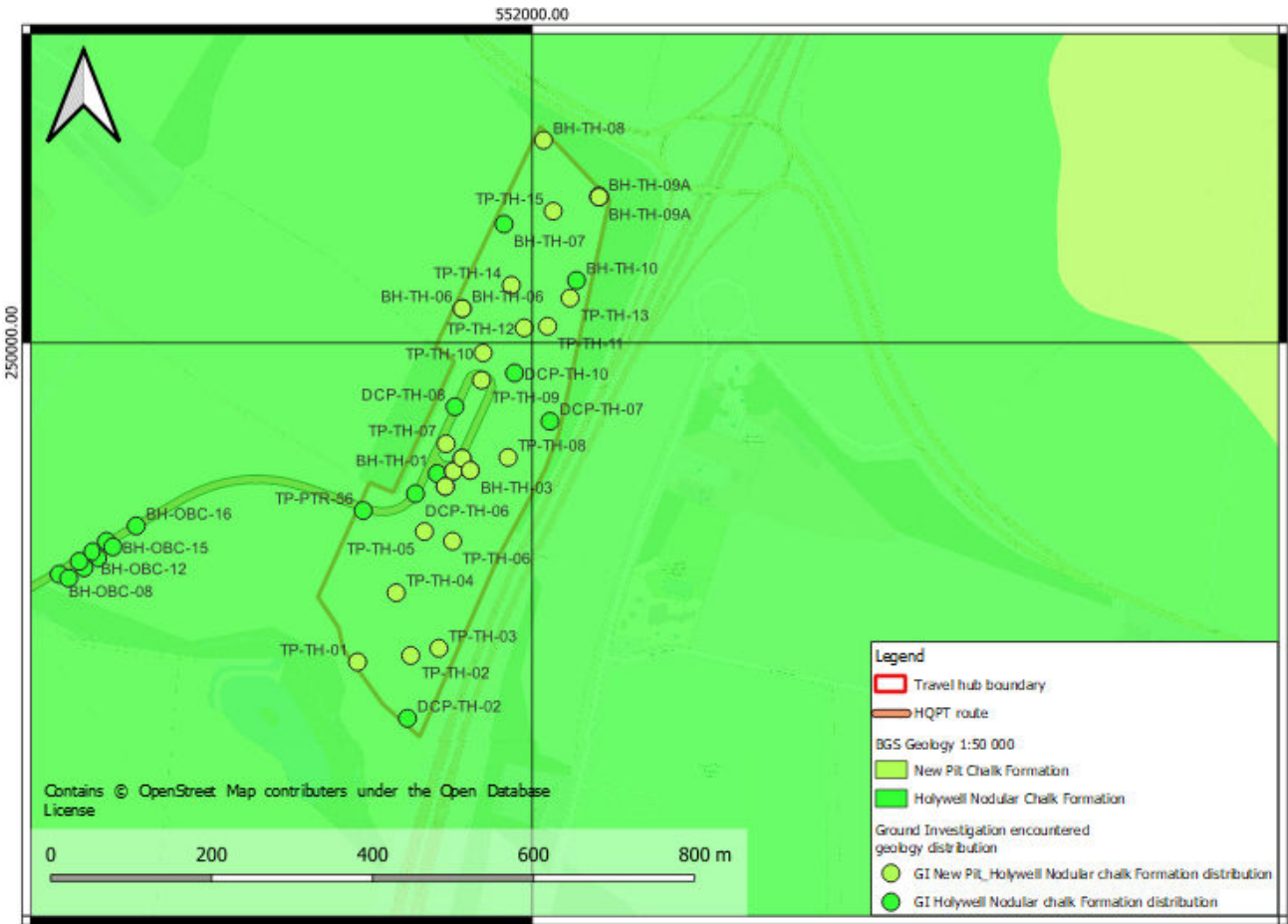
The Holywell Nodular Chalk Formation (HNK) was encountered in a 15no exploratory holes within the Travel Hub Site. Typically, the formation comprised chalk increasing in CIRIA Engineering Grade with depth from structureless to structured.

Structureless chalk (Grade Dm and Grade Dc) was encountered from approximately 0.48m bgl to 4.65m bgl. Grade Dm chalk, typically found between 0.5 to 3.2m bgl, comprised structureless white CHALK composed of gravelly SILT. Gravel is extremely weak to weak, low-density chalk and angular to sub-rounded, fine to coarse flint. Grade Dc chalk, typically encountered below 2m bgl to approximately 4.65m bgl, comprised a structureless white CHALK composed of silty GRAVEL. Gravel is subrounded to angular, fine to coarse, weak low-density chalk.

Grade C4 chalk was encountered in BH-TH-05 and BH-TH-07 between 3.0-6.0m bgl. The chalk comprised an extremely weak to weak, low-density white CHALK with rare small shell fragments. Two discernible discontinuities were recorded: Discontinuity 1) Joints are subvertical, open, clean with black speckling and orange staining, slightly undulating, slightly rough with occasional comminuted chalk. Discontinuity 2) Bedding inclined, open, clean with black speckling and orange staining, slightly undulating.

Grade B (Grade B5 to B3) was encountered in six borehole locations (BH-TH-01, -02, -06, 07, -09A and -10). Grade B chalk was encountered from 2.0m to 9.0m bgl, with the majority of the chalk being classed as Grade B4. Chalk comprised an extremely weak, low-density white CHALK with black speckles. Discernible structure: Discontinuity 1) Joints are inclined, open, clean with black speckling and orange staining, slightly undulating, slightly rough. Discontinuity 2) Bedding is inclined, open, clean with black speckling and orange staining, slightly undulating, slightly rough.

Grade A chalk (A3 to A2) was recorded in BH-TH-01 from 6.54m to 12.0m bgl. Chalk comprised an extremely weak to very weak, low-density white CHALK with rare shell fragments and occasional faint relict fossil burrows. Discontinuity 1) Joints are slightly undulating, rough, closed, clean with rare black specks. Discontinuity 2) Bedding is close, slightly undulating, rough, closed, clean with rare black specks.



Location ID	Depth strike (m bgl)	Elevation strike (m AOD)	Depth standing after 20 mins (m bgl)	Elevation standing after 20 mins (m AOD)	Stratum/ Formation
BH-PTR-09	2.6	11.3	0.89	13.01	ALV
BH-PTR-10	1.8	12.18	0.86	13.12	ALV
BH-PTR-11	2	12.52	0.91	13.61	WMCH
BH-PTR-12	2.9	12.56	2.1	13.36	WMCH
BH-PTR-12	7.1	8.36	3.35	12.11	WMCH
BH-PTR-13	2.7	14.24	1.32	15.62	ZZCH
BH-PTR-14	4	14.61	2.92	15.69	ZZCH
TP-PTR-03	2.5	14.27	2.2	14.57	WMCH
TP-PTR-04	2.9	14.2	2.9	14.2	WMCH
TP-PTR-05	2.8	14.06	2.75	14.11	WMCH
TP-PTR-06	2.9	14.27	2.9	14.27	ZZCH
TP-PTR-07	3	14.31	3	14.31	ZZCH
TP-PTR-09	3	15.59	2.8	15.79	ZZCH
TP-PTR-10	3.5	15.02	3.3	15.22	ZZCH
TP-PTR-08	2.8	14.75	2.8	17.55	ZZCH

Table 5-31 - Groundwater strikes during ground investigation in Section 3

Location ID	Depth strike (m bgl)	Elevation strike (m AOD)	Depth standing after 20 mins (m bgl)	Elevation standing after 20 mins (m AOD)	Stratum/ Formation
BH-PTR-18	4.5	15.86	4.37	15.99	ZZCH
TP-PTR-28	3	16.69	2.95	16.74	ZZCH
TP-PTR-29	3.5	15.98	3.5	15.98	ZZCH

Table 5-32 - Groundwater strikes during ground investigation in Section 4

Location ID	Depth strike (m bgl)	Elevation strike (m AOD)	Depth standing after 20 mins (m bgl)	Elevation standing after 20 mins (m AOD)	Stratum/ Formation
BH-BP-01	1.2	16.96	1.1	17.06	ALV
BH-PTR-19	1.7	17.01	1.62	17.09	ALV
BH-PTR-19	3.2	15.51	2.35	16.36	RTD
BH-PTR-20	0.8	17.56	0.55	17.81	ALV
BH-PTR-20	6.4	11.96	2.2	16.16	RTD
BH-PTR-21	1.3	17.11	1.15	17.26	RTD
BH-PTR-22	2.9	15.58	1.83	16.65	ALV
BH-PTR-23	0.9	17.4	0.75	17.55	MGR
BH-PTR-23	13.6	4.7	3.2	15.1	ZZCH
BH-PTR-24	0.8	17.55	0.75	17.6	MGR
BH-PTR-24	2.7	15.65	1.06	17.29	ALV
BH-PTR-24A	0.85	17.5	0.79	17.56	ALV

Location ID	Depth strike (m bgl)	Elevation strike (m AOD)	Depth standing after 20 mins (m bgl)	Elevation standing after 20 mins (m AOD)	Stratum/ Formation
BH-PTR-24A	12.8	5.55	1.91	16.44	ZZCH
BH-PTR-25	0.7	17.62	0.31	18.01	ALV
BH-PTR-26	0.8	17.63	0	18.43	ALV
BH-PTR-26	2.7	15.73	1.34	17.09	ALV
BH-PTR-27	0.7	17.67	0.55	17.82	ALV
BH-PTR-28	0.8	17.46	0.6	17.66	ALV
BH-PTR-29	1.2	16.14	1	16.34	RTD
BH-PTR-30	1.15	16.23	1	16.38	RTD
BH-PTR-31	1.1	16.1	1.1	16.1	ALV
BH-PTR-32	1.9	15.37	1.9	15.37	ALV
BH-PTR-33	1.2	16.27	0.86	16.61	ALV
BH-PTR-33	18	-0.53	18	-0.53	ZZCH
BH-PTR-35	2.1	16.31	1.86	16.55	RTD
BH-PTR-36	0.9	17.52	1.1	17.32	ALV
BH-PTR-37	0.9	17.71	0.71	17.9	RTD
BH-PTR-38	2.6	16.35	1.99	16.96	ALV
BH-PTR-39	0.8	17.98	0.65	18.13	MGR
BH-PTR-40	2.4	17.06	2.35	17.11	ALV
BH-PTR-40	8.7	10.76	7.56	11.9	ZZCH
BH-PTR-41	7.5	12.33	7.37	12.46	ZZCH
BH-PTR-42	6	14.29	6	14.29	ZZCH
BH-PTR-43B	5.7	14.74	5.7	14.74	ZZCH
CPT-PTR-05	1.1	17.27	1	17.37	ALV
TP-BP-01	1.23	16.97	1.2	17	RTD
TP-BP-04	1.5	16.33	1.4	16.43	RTD
TP-PTR-36	2.3	18.52	2.3	18.52	ZZCH
BH-PTR-28A	1.3	16.96	1.3	16.96	ALV
BH-PTR-32B	1.2	16.07	1	16.27	ALV
BH-PTR-39A	2.1	16.73	2.1	16.73	ALV
BH-PTR-39B	2	16.84	2	16.84	ALV

Table 5-33 - Groundwater strikes during ground investigation in Section 5

Location ID	Depth strike (m bgl)	Elevation strike (m AOD)	Depth standing after 20 mins (m bgl)	Elevation standing after 20 mins (m AOD)	Stratum/ Formation
BH-PTR-45A	6.8	20.05	6.2	20.65	HCK
TP-PTR-37	3	19.65	3	19.65	ZZCH

Table 5-34 - Groundwater strikes during ground investigation in Section 6

Location ID	Depth strike (m bgl)	Elevation strike (m AOD)	Depth standing after 20 mins (m bgl)	Elevation standing after 20 mins (m AOD)	Stratum/ Formation
BH-OBC-01	4.1	22.61	3.72	22.99	HCK
BH-OBC-02	2.7	22.83	1.95	23.58	RTD
BH-OBC-03	2.6	22.9	1.95	23.55	HCK
BH-OBC-04	1	24.46	0.86	24.6	ALV
BH-OBC-05	2.8	22.61	2.71	22.7	RTD
BH-OBC-06	3.1	22.45	1.7	23.85	RTD
BH-OBC-07	3.8	22.52	2.75	23.57	HCK
BH-OBC-08	1.25	23.96	1.25	23.96	RTD
BH-OBC-09	1.3	23.89	1.05	24.14	ALV
BH-OBC-10	1.6	23.86	1.25	24.21	RTD
BH-OBC-11	1.9	23.51	1.55	23.86	RTD
BH-OBC-12	1.4	24.34	1.15	24.59	RTD
BH-OBC-13	1.9	23.79	1.61	24.08	HCK
BH-OBC-14	2.4	24.04	1.7	24.74	HCK
BH-OBC-15	2.3	24.17	2.15	24.32	RTD
BH-OBC-16	3.9	23.45	3.9	23.45	HCK

Table 5-35 - Groundwater strikes during ground investigation at the Travel Hub Site

Location ID	Depth strike (m bgl)	Elevation strike (m AOD)	Depth standing after 20 mins (m bgl)	Elevation standing after 20 mins (m AOD)	Stratum/ Formation
BH-TH-01	8.8	20.2	8.15	20.85	HCK
BH-TH-02	6.7	22.8	6.11	23.39	HCK
BH-TH-03	7.5	21.94	5.3	24.14	HCK
BH-TH-04	7.5	21.4	6.43	22.47	HCK
BH-TH-05	7.5	21.82	6.15	23.17	HCK

5.5.2. Groundwater monitoring

A total of 38no. exploratory holes were installed, of which nine had dual monitoring pipes targeting shallow and deep strata. Installation details are noted in Section 3.2.11 of the Tetra Tech Report and noted on exploratory boreholes. Spot monitoring rounds were conducted over nine visits summarised in Section 4.3.1 in the Tetra Tech Report.

Groundwater charts for the monitoring visits for each exploratory hole are presented in Appendix C.21.

Table 5-36 - Summary of groundwater monitoring results

Location		Section	Groundwater depth (m bgl)								Targeted Geology
			10/05/2021	17/05/2021	03/06/2021	17/10/2021	13/11/2021	18/12/2021	09/01/2022	27/02/2022	
BH-PTR-02 D	2		1.23	1.04	1.31	1.03	1.04	0.85	1.06	0.95	WMCH
BH-PTR-02 S	2		1.1	0.96	2.36	0.86	0.9	1.05	0.95	0.88	WMCH
BH-PTR-03A	2		1.1	0.89	1.06	1.16	1.22	0.98	0.91	0.87	ALV
BH-PTR-04	2		0.9	0.62	0.78	0.8	0.81	0.76	0.64	0.52	ALV/WMCH
BH-PTR-07	2		0.54	0.5	0.6	0.36	0.36	0.58	0.61	0.62	WMCH
BH-PTR-08 D	2		0.54	0.56	0.67	0.24	0.37	0.78	0.68	0.65	WMCH
BH-PTR-08 S	2		0.57	0.61	0.73	0.39	0.42	0.79	0.76	0.68	WMCH
BH-PTR-10	2		0.54	0.52	0.64	0.26	0.42	0.73	0.65	0.62	ALV/WMCH
BH-PTR-12	2		1.92	1.99	2.08	1.73	1.78	2.11	2.01	1.97	WMCH
BH-PTR-13	2		1.97	2.02	2.15	5.04	2.44	2.68	2.23	2.13	ZZCH
BH-PTR-14	2		3.68	3.71	3.86	4.15	4.19	4.48	3.97	3.87	ZZCH
BH-PTR-15	3		Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	ZZCH
BH-PTR-16	3		Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	HCK
BH-PTR-18	3		3.85	4.03	4.16	Dry	Dry	Dry	Dry	Dry	ZZCH
BH-BP-01	4		-*	1.05	1.24	1.2	1.18	1.29	n/a	2.6	ALV
BH-PTR-19	4		2.32	2.36	2.5	2.82	2.85	3.07	2.46	2.34	RTD
BH-PTR-21	4		1.66	1.64	1.76	1.77	1.8	1.97	1.63	1.54	RTD
BH-PTR-27	4		0.84	0.81	0.99	0.88	0.91	1.13	0.87	0.79	RTD
BH-PTR-30	4		1.01	0.99	1.15	1.4	2.32	1.38	1.07	0.99	ZZCH
BH-PTR-31	4		0.85	0.84	0.91	1.09	1.04	1.13	0.88	0.82	ZZCH
BH-PTR-33 D	4		0.94	1.04	1.16	1.21	1.16	1.29	1.02	0.97	ZZCH
BH-PTR-33 S	4		1.05	1.06	1.22	1.23	1.16	1.26	1.04	0.98	ALV/RTD
BH-PTR-35	4		1.67	1.62	1.73	1.58	1.44	1.56	1.43	1.36	RTD

Location	Section	Groundwater depth (m bgl)										Targeted Geology
		10/05/2021	17/05/2021	03/06/2021	17/10/2021	13/11/2021	18/12/2021	09/01/2022	27/02/2022	19/03/2022		
BH-PTR-36	4	0.13	0.92	1.13	0.93	0.65	0.74	0.69	0.69	0.6	ALV	
BH-PTR-39	4	0.56	0.62	0.78	0.76	0.63	0.91	0.61	0.61	0.56	ZZCH	
BH-PTR-41 D	4	1.36	1.26	1.52	1.54	1.43	1.65	1.32	1.32	1.28	ZZCH	
BH-PTR-41 S	4	1.41	1.43	1.53	1.69	1.5	1.56	1.31	1.31	1.28	MG	
BH-PTR-42 D	4	1.72	1.55	1.75	1.73	1.58	1.76	1.37	1.37	1.3	ZZCH	
BH-PTR-42 S	4	Dry	1.49	1.75	Dry	Dry	Dry	Dry	Dry	Dry	MG	
BH-PTR-43 D	4	1.41	1.54	1.52	1.77	1.49	1.65	1.01	1.01	0.85	ZZCH	
BH-PTR-43 S	4	1.42	1.4	1.49	1.76	1.54	1.45	1	1	0.81	MG	
BH-PTR-45	5	5.9	5.89	5.98	5.88	5.69	5.95	5.62	5.62	5.57	HCK	
BH-OBC-01	6	Dry	Dry	Dry	Dry	Dry	DRY	n/a	n/a	DRY	RTD	
BH-OBC-04 D	6	2.26	2.41	2.8	3.79	3.5	3.76	2.74	2.74	2.6	HCK	
BH-OBC-04 S	6	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	RTD	
BH-OBC-06	6	2.68	2.96	3.22	4.34	4.06	4.23	3.24	3.24	3.08	HCK	
BH-OBC-07	6	3.46	3.7	3.99	5.09	4.83	5	4.09	4.09	3.92	ZZCH	
BH-OBC-07	6	3.11	3.34	3.63	4.68	4.38	4.58	3.65	3.65	3.49	HCK	
BH-OBC-11 D	6	2.44	2.65	2.91	4.23	3.96	3.99	2.97	2.97	2.85	HCK	
BH-OBC-11 S	6	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	RTD	
BH-OBC-12	6	2.72	1.98	3.27	4.59	4.31	4.35	3.33	3.33	3.23	HCK	
BH-OBC-15	6	3.85	4.12	4.39	6.71	5.43	5.5	4.53	4.53	4.39	ZZCH	
BH-TH-01	Travel Hub	5.46	5.82	6.18	7.44	7.14	7.31	6.23	6.23	6.03	HNCK	
BH-TH-03	Travel Hub	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	RTD	

S = Shallow install, D = Deep install, n/a monitoring round not undertaken

5.6. Hydrogeological assessment

An initial assessment of expected groundwater levels per Ground Model is provided below. For ULS design, BS EN 1997 [18] requires that the design groundwater level shall represent the most unfavourable values that could occur during the design lifetime of the structure. Hence, for design, it is suggested the designer should consider groundwater levels could be higher than typical values described below.

In general, near-surface shallow groundwater levels (<1.0m bgl), which show evidence of fluctuating seasonally, are to be expected in Sections 2 and 3. Groundwater levels up to 1.5m bgl have been observed in Section 4, whereas deeper (>1.5m bgl) groundwater levels were encountered in monitoring in Sections 5, 6 and the Travel Hub site.

Groundwater charts for the monitoring visits are presented in Appendix C.21.

GM2 Groundwater

Based on the groundwater strikes encountered during the recent ground investigation, as presented in Table 5-30 and the cross sections in Appendix B, the typical groundwater level for the Section 2 area between chainage 0 and 500m is 1.6m bgl (12.3m AOD) within the Alluvium, 4.8m bgl (10.7m AOD) in the West Melbury Marly Chalk Formation and 3.1m bgl (14.7m AOD) in the Zig Zag Formation. It should be noted that localised perched groundwater may be present within the Made Ground.

Groundwater monitoring undertaken between May 2021 and March 2022, presented in Table 5-36, indicates that groundwater levels are between 0.2m to 2.4m bgl with an average of 0.8m bgl.

GM3 Groundwater

Based on the groundwater strikes encountered during the recent ground investigation, as presented in Table 5-31 the cross sections in Appendix B, groundwater was encountered within three exploratory holes with a typical groundwater level of 4.0m bgl (13.8m AOD) between chainage 500 and 2800m.

Groundwater monitoring undertaken between May 2021 and March 2022, presented in Table 5-36 indicates that groundwater levels are between 3.9m and 4.2m bgl with an average of 4.0m bgl.

GM4 Groundwater

Based on the groundwater strikes encountered during the recent ground investigation, as presented in Table 5-32 and the cross sections in Appendix B, the typical groundwater level for the Section 4 area between chainage 2800 to 4600m is 0.8m bgl (17.6m AOD) in the Made Ground, 1.4m bgl (16.9m AOD) within the Alluvium, 9.3m bgl (10.0m AOD) in the Zig Zag Formation. It should be noted that localised perched groundwater may be present within the Made Ground.

Groundwater monitoring undertaken between May 2021 and March 2022, presented in Table 5-36, indicates that groundwater levels are between 0.1m to 3.1m bgl with an average of 1.3m bgl.

CPT data undertaken across the River Granta (Ch. 4900 to 5150m) indicates a phreatic surface at 3.0m bgl (15.2m AOD) in the Alluvium and River Terrace Deposits. Two phreatic surfaces are encountered within the Holywell Nodular Chalk Formation, one at 22.7m AOD and one at 14.0m AOD. These have been assessed using porewater pressures and presented in Appendix C.9.3.

GM5 Groundwater

Based on the groundwater strikes encountered during the recent ground investigation, as presented in Table 5-33 and the cross sections in Appendix B, the typical groundwater level for the Section 5 area between chainage 4600 to 6066m is 6.8m (20.05m AOD) in the Holywell Nodular Chalk Formation and 3.0m bgl (19.65m AOD) in the Zig Zag Chalk Formation. It should be noted that localised perched groundwater may be present within the Made Ground.

Groundwater monitoring undertaken between May 2021 and March 2022, presented in Table 5-36, indicates that groundwater levels are typically 5.8m bgl.

GM6 Groundwater

Based on the groundwater strikes encountered during the recent ground investigation, as presented in Table 5-34 and the cross sections in Appendix B, the typical groundwater level for the Section 6 area between chainage 8066 to 9275m is 1.15m bgl (24.2m AOD) within the Alluvium, 2.2m bgl (23.4m AOD) in the River Terrace Deposits and 1.9m bgl (22.5m AOD) in the Holywell Nodular Chalk Formation. It should be noted that localised perched groundwater may be present within the Made Ground.

Groundwater monitoring undertaken between May 2021 and March 2022, presented in Table 5-36, indicates that groundwater levels are between 2.0m to 6.7m bgl with an average of 3.7m bgl.

CPT data undertaken across the River Granta (Ch. 8500-8700m) indicates a phreatic surface at 3.0m bgl (15.2mAOD) in the Alluvium and River Terrace Deposits. Two phreatic surfaces are encountered within the Holywell Nodular Chalk Formation, one at 22.7mAOD and one at 14mAOD. These have been assessed using porewater pressures and presented in Appendix C.9.3.

GM7 (Travel Hub Site) Groundwater

Based on the groundwater strikes encountered during the recent ground investigation, as presented in Table 5-35 and the cross sections in Appendix B, the typical groundwater level for the Travel Hub Site is 7.6m bgl (21.6m AOD) in the Holywell Nodular Chalk Formation. It should be noted that localised perched groundwater may be present within the Made Ground.

Groundwater monitoring locations in the Travel Hub site were all dry, which wells targeted the River Terrace Deposits and the New Pit/Holywell Modular Chalk Formation.

6. Geotechnical Material Properties

6.1. Introduction

Soil properties of the strata encountered have been derived from consideration of the laboratory testing, *in situ* testing and descriptions from the exploratory borehole logs. The parameters have been derived both directly from test results and indirectly through correlations, and by use of published, or typical values, where limited data sets, as described below. Where appropriate, and where there is sufficient data, characteristic values (defined below) have been presented for the various strata encountered. The main correlations and parameters derivation approaches are summarised below.

Characteristic geotechnical parameters have been derived using the results of the 2021 ground investigation and any relevant historical information. Data plots are provided in Appendix C, laboratory test results are found in Appendix D.

The results are plotted against depth for each geological unit to enable trends to be identified. Results have been plotted against depth and elevation. However, assessment has been made against depth to account for the elevation variation across the Scheme.

Characteristic values are defined in BSI BS EN 1997 [18] as:

- *The selection of characteristic values for geotechnical parameters shall be based on results and derived values from laboratory and field tests, complemented by well-established experience.*
- *The characteristic value of a geotechnical parameter shall be selected as a cautious estimate of the value affecting the occurrence of the limit state.*

Where there is a large variability of test results or insufficient test results to enable characteristic value derivation, representative average values and the range of results for the unit are stated. The values stated for classification tests (e.g. Atterberg Limits and Particle Size Distribution (PSD)) are representative values for the strata rather than characteristic values to be used for design.

Individual stratum geotechnical parameters are provided in Table 6-4 to Table 6-11. A summary of the characteristic geotechnical parameters to be used in detailed design are provided in Table 6-12.

6.2. Geotechnical Parameter Derivation

Classification Parameters for Index Properties

Classification and index tests do not provide engineering parameters directly but are used to classify soils, identify trends, strata changes, predict behaviour and apply empirical correlations to obtain estimates of undrained shear strength (c_u) and angle of shearing resistance (ϕ'). Atterberg limits have been plotted on an A-line plasticity chart for classification (Appendix C.2). Plasticity index has also been plotted against depth (Appendix C.1).

Particle Size Distribution

Wet sieving particle size distribution tests were carried out to determine the grading of coarse materials (≥ 0.063 mm). Sedimentation tests have been carried out on tested samples with $>15\%$ clay and silt to determine the particle size distribution of the fine fraction (the proportion of particles <0.063 mm). The results are plotted as grading curves for each geological unit (Appendix C.3).

Bulk, Dry and Unit Weight

Values of bulk and dry density have been determined from laboratory tests on undisturbed samples. The weight density is the total weight of the soil in a single unit of volume. The unit weight of soil can be calculated by multiplying the force of gravity (9.81 m/s^2) by the bulk density. In the absence of bulk and dry density test results, for fine and coarse soils above the groundwater table, suggested values for characteristic weight density are given in Figure 1 of BS 8004:2015 [24]. For fine and coarse soils below the groundwater table, the suggested values for characteristic weight density are given in Figure 2 of BS 8004:2015 [24].

Undrained Strength (Cohesive Materials):

The undrained shear strength (c_u) has been assessed using the following:

- Empirical correlations with standard penetration tests (SPT)

- Unconsolidated undrained triaxial compression tests;
- Empirical correlations with cone penetration tests (CPT).

The undrained shear strength results derived from each of the above tests are plotted against depth below ground level and m AOD for each geological unit (Appendix C.6 and C.9.1). A characteristic line is then drawn deterministically to derive undrained shear strength change with depth.

Correlations with SPT ‘N₆₀’ values and Plasticity Index (PI), in accordance with Stroud and Butler (1975) [25] has also been used to determine c_u:

$$c_u = f_1 \times N_{60}$$

where f₁ is a correlation factor, dependent on plasticity index (PI).

A conservative value of 4.5 has been assigned for the Alluvium, with an average plasticity index of 18%, and the Lowestoft Formation, with an average plasticity index of 13%.

Undrained Shear Strength from cone resistance

Undrained shear strength has been derived from cone resistance using the following equation from Lunne et al. (1997) [20]:

$$C_u = (qc - \sigma_v) \div Nk$$

Where Nk is a cone resistance factor. An Nk factor of 20 has been derived by plotting the cone resistance converted to undrained shear strength with data from SPTs and Unconsolidated Undrained (UU) triaxial [20].

Standard Penetration Testing

SPTs were carried out in rotary core and window sample boreholes. Where SPTs refused (>50 blows for less than 300 mm penetration), the results have been extrapolated to give an N value for the full test drive using the equation:

$$N = \frac{\text{blow during test drive}}{\text{penetration during test drive (mm)}} \times 300$$

Effective Strength (Cohesive Materials):

Where available, effective stress parameters for fine soils have been derived from consolidated undrained (CU) triaxial compression tests and shear boxes. In the absence of CU triaxial test data for fine soils the characteristic constant volume (also known as critical state) effective angle of shearing resistance (φ’_{cv,k}) has been derived using the correlation given in BS 8004:2015:

$$\phi_{cv,k} = 42^\circ - 12.5 \text{Log}_{10} I_p$$

Where I_p is the soil’s plasticity index and falls between 5% and 100%.

For fine soils in the absence of test data, the characteristic constant volume effective cohesion (c’_{cv,k}) has been taken as zero in accordance with BS 8004:2015 Section 4.3.1.4.9 [24].

Effective Strength (Granular Materials):

φ’ and c’ for granular material can be obtained directly from shear box testing.

φ’ for granular material can also be obtained indirectly from SPT ‘N₆₀’ values using Figure 36a in CIRIA Report C143 [26] (taken from Peck et al. 1974) [27].

In the absence of test data suitable for determining the critical state effective angle of shearing resistance (φ’_{cv,k}) for coarse soils the following correlation has been used as given in BS 8004:2015 and using Table 1:

$$\phi_{cv,k} = 30^\circ + \phi'_{ang} + \phi'_{PSD}$$

Where:

- φ’_{ang} is derived from the angularity of the particles; and
- φ’_{PSD} is derived from the soil’s Particle Size Distribution.

For coarse soils with a fines content less than 15%, the characteristic peak effective angle of shearing resistance (φ’_{pk,k}) has been derived from BS8004:2015:

$$\phi_{pk,k} = \phi'_{cv,k} + \phi'_{dil}$$

Where:

- φ’_{dil} is derived from the soil dilatancy.

If the fines content of the coarse soil exceeds 15 %, then φ’_{dil} has been assumed to be zero.

Consolidation

Consolidation test data have been plotted on three plots:

- Coefficient of volume compressibility (m_v) vs applied stress (Appendix C.13);
- Coefficient of consolidation (c_v) vs applied stress (Appendix C.14); and
- Void ratio vs stress (Appendix C.15).

Oedometer tests were scheduled on undisturbed samples at a range of depths. The results of the oedometer tests present coefficient of volume compressibility values (m_v) and coefficient of consolidation (c_v) against applied end pressure. A correlation developed by Stroud and Butler (1975) [25] using a f₂ factor, which is broadly associated with the Plasticity Index of the material, and the SPT N60 values, provides a coefficient of volume compressibility (m_v). A summary of the f₂ values is given in and the empirical correlation is given below.

Table 6-1 - f₂ values for fine grained soils [25]

Geological unit	Characteristic Plasticity Index (%)	F ₂ (Stroud and Butler, 1976)
Alluvium	15	670
River Terrace Deposits (fine)	17	600
Lowestoft Formation (Diamicton)	13	730

Coefficient of volume compressibility (m_v) is derived from correlation between SPT N60 and f₂ (Stroud, 1975):

$$m_v = \frac{1}{N_{60} \times \frac{f_2}{1000}}$$

The results of the consolidation tests and the empirically derived m_v values have been assigned a qualitative compressibility description based on Table 2.1 of Tomlinson (2001), reproduced as below.

Table 6-2 - Compressibility after Tomlinson (2001) Table 2.1

Qualitative description of compressibility	Coefficient of Volume Compressibility, m _v (m ² /MN)
Very Low	<0.05
Low	0.05-0.10
Medium	0.10-0.30
High	0.30-1.50
Very high	>1.50

Soil Stiffness (Cohesive Materials):

Soil stiffness is a function of stress, and strain levels. Mobilised (i.e., moderate to large strain) soil stiffness parameters (E’ and E_u) have been determined based on correlations. For cohesive soils, where loading conditions are such that consolidation occurs, stiffness values may be represented by consolidation parameters and correlated to c_u. Stiffness parameters are noted to have a relatively high degree of uncertainty, which should be considered in resulting estimates of ground or structure movement.

- m_v values, where E’ = 1/m_v. Statistical values given in this report consider m_v values from the entire range of stress increments and therefore should not be used for specific analyses;
- For predominately cohesive materials estimations of the drained Young’s modulus of elasticity (E’) have been correlated to the c_u with respect to the PI in accordance with Barnes (2010) [28] building on relationships provided by Stroud (1975) [29] and CIRIA 143 [26] using the relationships shown in below. Barnes offers a more conservative approach than a factor of 400 proposed by Stroud (E_u=400C_u)

Table 6-3 - Values for Drained Modulus of Elasticity based on PI (on large strains)

Plasticity Index (%)	E'/c _u
10-20	270
20-30	200
30-40	150
40-50	130
50-60	110

For predominately cohesive materials the undrained Young’s modulus of elasticity (E_u) have been calculated from the derived drained Young’s modulus (E’) based on equations of elasticity, in accordance with Tomlinson [30], using the following relationship:

$$E_u = \frac{E'}{0.6}$$

Soil Stiffness (Granular Materials):

E’ has been determined based on the following N₆₀ correlation provided by Stroud (1989) [26]:

$$\frac{E'}{N_{60}} = 1 \text{ (MPa)}$$

California Bearing Ratio

California Bearing Ratio (CBR) is a measure of the bearing value of subgrade. CBR values have been obtained by the following methods

- *In situ* CBR tests via plate load testing; and
- Correlation with dynamic cone penetration (DCP) testing data (to give *in situ* CBR values)
- Correlating with published literature (LR1132 [31] and LR889 [32]).

Plate load tests were carried out in 31no. trial pit locations, located along the proposed route alignment. Results of the plate load tests are presented in the Ground investigation Factual Report, Section 4.2.1 and Appendix E, by Tetra Tech [4] and also presented in Appendix C.12.

CBR values derived *in situ* DCP testing can be converted from typical mm/blow to a CBR value through the TRL standard relationship provided below [33].

$$Log10(CBR) = 2.43 - 1.057 \times Log10(mm/blow)$$

These values are considered short-term values, representative of the water conditions at the time of test as well as the test elevations. The DCP values presented in the subsequent section represent the typical mm/blow value for the stratum.

DCP tests were carried out in 104no. exploratory holes. Results of the tests are presented in the Ground investigation Factual Report, Appendix D, by Tetra Tech [4], and also presented in Appendix C.12. These were all located along the proposed access route to the site.

LR1132 [31] provides long term equilibrium CBR values for fine and coarse material. Estimated CBR values assume average construction conditions and a high water table (300 mm beneath formation level).

Long term equilibrium CBR values under road pavements in clays from Table C1 from LR1132 [31].

LR889 [32] suggests using undrained shear strength of cohesive soils to provide a preliminary CBR value using the equation proposed by Black and Lister (1979) [32]:

$$CBR = \frac{C_u}{23}$$

Rock Strength:

Point load testing and unconfined compressive strength has been carried out on suitable rock samples of the Chalk Group.

The following equation based on Bowden et al (1998) [34] can be used to convert corrected point load results to unconfined compressive strength (UCS):

$$UCS = I_{S(50)} \times K$$

Where K is the correlation factor referenced in Table 2 of Bowden et al (1998) [34]. K of <10 has been used for Chalk.

K is generally being between 10 and 20 for weaker rock (25MPa) however it is often less than 10 for rock of 5MPa strength or less.

Soil chemistry

Geotechnical chemical testing has been undertaken on disturbed soil samples and water samples in order to determine the aggressivity of the materials encountered on buried concrete. Depending on the material designation as greenfield or brownfield with pyrite present or absent, as defined within BRE Special Digest 1:2005 [35], Suite A to D tests (as defined in ICE UK Specification for Ground Investigation) were scheduled and undertaken by a UKAS accredited laboratory.

All stratum encountered during the ground investigation were deemed to have the potential to contain sulphur rich minerals. Previously undeveloped sites were classified as greenfield.

Depending on the anticipated aggressivity of the underlying geology, samples were either tested for just pH and water-soluble sulphate or, if assumed to be aggressive, they were also tested for acid soluble sulphate and total potential sulphate.

In accordance with BRE Special Digest 1:2005 [35] Concrete Design Sulphate (DS) values and the resultant Aggressive Chemical Environment for Concrete (ACEC) values have been derived based on sample size. If only a small (less than five) number of samples have been tested for sulphate, the highest measured sulphate concentration has been taken as the characteristic value. In a data set where there are five to nine results available for the location, the mean of the highest two of the sulphate tests results has been taken as the characteristic value. In a data set where there are 10 or more results available, the mean of the highest 20% of the sulphate test results has been taken as the characteristic value.

In accordance with BRE Special Digest 1 [35] water soluble sulphate results have been rounded to the nearest 100 mg/l and total potential sulphate values have been rounded to the nearest one decimal place. Where water soluble sulphate results are below 50 mg/l these have been rounded up 100 mg/l.

The characteristic values for pH have been determined by considering the values obtained from tests on soil and groundwater. For both soil and groundwater, the respective lowest measured values of pH have been taken if only a small number of samples have been tested. Otherwise the respective means of the lowest 20 % of the pH results have been taken. The characteristic value of the pH has been taken as the lowest of the pH determinations for the soil.

Total potential sulphate (TPS) has been calculated using total sulphate (TS) and guidance in Section C5.1.2 of Special Digest 1 [35] where TPS%SO4=3.0xTS%S.

6.3. Geotechnical Parameters

The tables below provide a summary of the results of laboratory testing undertaken on each of the strata encountered during the Tetra Tech 2021 ground investigation [4]. Representative and characteristic values have been determined where appropriate, using the rationale detailed in Section 6.2. Where no test results are available a dash (-) has been used to mark the cell as blank. As described in Section 0, the Made Ground, Alluvium, River Terrace Deposits have been classed as undifferentiated. It is understood that topsoil will be stripped prior to construction, therefore it has been omitted from the following sections.

6.3.1. Made Ground (Undifferentiated)

Table 6-4 - Geotechnical parameters for the Made Ground

Test type	Parameter	Units	Number of tests	Range	Representative value	Characteristic value	Comments	Graphs
Index properties	Moisture Content (W)	%	21	8.1 to 29	18	-	It should be noted that Atterberg test results are likely to be affected by sample bias, where samples with greater fine content are sent for Atterberg testing. This may attribute a higher coarse-grained content being encountered locally in the field. Results suggest that the majority of material encountered ranges from low to intermediate plasticity clay and is favourable towards the plastic limit. Three results recorded high plasticity clay (BH-PTR-42, TP-PTR-35, BH-PTR-42). The Modified Plasticity Index (Ip) is defined as the Plasticity Index (Ip) of the soil multiplied by the percentage of particles less than 425µm. A representative value of 86% particles passing 425µm has been determined from laboratory test results. Three results were recorded between 24-36% modified PI between 0.5-1.2m bgl, which is indicative of Medium Volume Change Potential (BH-PTR-42, TP-PTR-35, BH-PTR-42). The Modified Plasticity Index based on the majority of the samples plasticity index test result would be 13% and suggests low volume change potential.	C.2
	Liquid Limit (LL)	%	19	23 to 63	35	-		
	Plastic Limit (PL)	%	19	14 to 26	18	-		
	Plasticity Index (IP)	%	19	9 to 37	17	-		
	Modified Plasticity Index	%	19	7 to 36	15	13		
Classification (Particle Size Distribution, PSD)	Fines (<0.063mm)	%		17 to 36			Limited PSD where tests were undertaken in the Made Ground. The composition and engineering behaviour of Made Ground is likely varied locally. Due to the highly variable nature of the two PSD tests undertaken (Very gravely very sandy CLAY and a sandy GRAVEL) representative values have not been given. The samples suggest a high coarse grain fraction and a highly variable fines content. It should be noted that PSD test results are likely to be affected by sample bias, where more granular samples are sent for PSD testing and more cohesive samples are sent for Atterberg Limit classification. This may attribute a higher fines content being encountered locally. Due to the variability of the Made Ground the derivation of geotechnical parameters should be considered locally.	C.3 and C.4
	Sand	%		2 to 27				
	Gravel	%	3	0 to 37	Very gravely sandy CLAY	-		
	Cobbles	%		0				
Density testing	Bulk density	Mg/m ³	1	2.1	-	-	A single triaxial test was undertaken in the Made Ground. Due to the limited number of tests undertaken, a representative value is not given.	C.2
	Dry density	Mg/m ³	1	1.74	-	-		
	Unit weight (unsaturated)	kN/m ³	-	-	-	18		C.10
	Unit weight (saturated)	kN/m ³	-	-	-	18		
In-Situ tests	SPT N ₆₀	-	8	4 to 63	5	-	No apparent trend observed with depth, due to inherent variable composition and compressibility.	C.5
	Unconsolidated undrained triaxial test, Cu	kN/m ²	1	31	-	-	The derivation of undrained shear strength from SPT correlations suggest a wide range of values which can be expected in Made Ground due to varying source material and placement methods. There is no apparent trend that indicates a change of strength with depth. Due to the variability of Made Ground the derivation of geotechnical parameters locally should be considered. Representative values have not been given for triaxial tests due to the range of results and limited number of tests undertaken.	C.6
	Derived from SPTs, Cu	kN/m ²	7	18 to 284	50	25		
Effective Stress (Drained)	Characteristic constant volume (critical state) effective angle of shearing resistance, $\phi_{cv,k}$	degrees	-	-	-	Derive locally	With the absence of laboratory test results, the characteristic constant volume effective angle of shearing resistance can be determined, through a correlation with Plasticity Index, using the equation presented within BS 8004:2015 Section 4.3.1.4.8. Due to the variability of the Made Ground the derivation of geotechnical parameters should be considered locally.	C.7
	Characteristic constant volume (critical state) effective cohesion $c_{cv,k}$	degrees	-	-	-	0	A characteristic constant volume effective cohesion ($c_{cv,k}$) of 0kPa is provided in accordance with BS 8004:2015 Section 4.3.1.4.9.	
	Drained Stiffness, E'	MN/m ²	-	-	-	7	Utilising the relationship with Cu from Stroud, a representative PI values of 18% (E'/Cu of 270) and a undrained shear strength of 25kN/m ² have been used to calculate a E' of 9MN/m ² .	-
Stiffness	Youngs Modulus, Eu	MN/m ²	-	-	-	11		-

Test type	Parameter	Units	Number of tests	Range	Representative value	Characteristic value	Comments	Graphs
California Bearing Ratio (CBR)	CBR derived from plate load	%	11	0.2 to 17.3	1	1	The majority of plate tests yielded results between 0-2%. Due to the limited tests undertaken in the fine grained Made Ground, as well as its compositional variability, a conservative approach of 1% is recommended for design. Due to the variability of made ground the derivation of geotechnical parameters should be considered locally.	C.12
	CBR derived from DCP	%	7	4.5 to 13	4.5	-		
Environmental testing	Organic matter	%	3	0.3 to 2.4	0.5	-	The samples were chosen based on organic matter described in the engineer's description. A representative value has been based on three samples plotted very low/negligible organic content. A single sample (TP-BP-02) indicates a low organic content. The result may not be representative of Made Ground across the entire Scheme.	C.16
	pH	-	9	8.1 to 9.3	-	8.4		
Geochemical testing (concrete classification characteristic values (BRE DS1, 2005) Greenfield	SO ₄ 2:1 Soil Extract (to nearest 100mg/l)	mg/l	9	10 to 564.5	-	300	In a data set where there are 10 or more results available, the mean of the highest 20% of the sulphate test and Total Potential Sulphate (TPS) results (rounded to 100 mg/l) should be taken as the characteristic value and respective means of the lowest 20% of the pH results. In a data set where there are five to nine results available for the location, the mean of the highest two testing results should be used. Total Potential Sulphate was calculated using Section C5.1.2 of BRE SD1 were TS%S is multiplied by 3. Utilising BRE SD1 for concrete classification of a greenfield site (Table C1) based on a soil characteristic values of pH of 8.4 and SO4 2:1 of 300, a design class of DS-1 and an ACEC class of AC-1, for mobile groundwater. Given the TPS value of 2661% this corresponds to a value of DS-5 on Table C1. However, with reference to Step 8 in BRE SD1, a limitation can be applied if the sulphate class for the total potential sulphate is initially found to be Sulphate Class 5, but sulphate classes for groundwater and the water extracts tests are Sulphate Class 3 or less (as above). In this case, the Design Sulphate Class for the site location can be limited to DS-4.	-
	Acid SO ₄	%	9	261 to 1647	-	1100		
	Total Sulphur (TP%S)	%	18	0.01 to 1763	-	887		
	Total Potential Sulphate (TPS%S)	%	18	0.03 to 5289	-	2661		
	Groundwater	Mobile						
	DS Class	DS-1						
	ACEC Class	AC-4						

6.3.2. Alluvium and Head Deposits (Undifferentiated)

Table 6-5 - Geotechnical parameters for the Alluvium/Head Deposits (undifferentiated)

Test type	Parameter	Units	Number of tests	Range	Representative value	Characteristic value	Comments	Graphs
Index properties	Moisture Content (W)	%	80	9 to 78	20	-	It should be noted that Atterberg test results are likely to be affected by sample bias, where samples with greater fine content are sent for Atterberg testing. This may attribute a higher coarse-grained content being encountered locally in the field. Five samples were determined as non-plastic. Moisture content generally decreases with depth. Moisture contents over 40% (BH-BP-01, TP-BH-02, BH-PTR-28, BH-PTR-32, BH-PTR-39 and BH-PTR-41 with moisture contents between 42-78%) associated with decaying plant material and organic matter noted on the engineering logs. BH-PTR-39 and BH-BP-01 is attributed to a Peat layer. Therefore, these results have been excluded from the representative values for W, PL, LL and PI. Results suggest that the majority of material encountered ranges from low to intermediate plasticity clay and is favourable towards the plastic limit. Eight results recorded very to extremely high plasticity clay (BH-OBC-05, BH-PTR-20, BH-PTR-26, BH-PTR-32, BH-PTR-01, BH-OBC-05, BH-PTR-28, BH-BP-01). The Modified Plasticity Index (Ip) is defined as the Plasticity Index (Ip) of the soil multiplied by the percentage of particles less than 425µm. A representative value of 90% particles passing 425µm has been determined from laboratory test results. The eight very high plasticity results above results were recorded between 25-53% modified PI, which is indicative of Medium to Very High Volume Change Potential. The Modified Plasticity Index based on the majority of the samples plasticity index test result would be 12% and suggests low volume change potential. The majority of results (50 out of the 59 samples) indicated low volume change potential.	C.2 and C.1
	Liquid Limit (LL)	%	60	23 to 92	35	-		
	Plastic Limit (PL)	%	60	13 to 39	20	-		
	Plasticity Index (IP)	%	60	6 to 53	15	-		
	Modified Plasticity Index	%	60	6 to 53	12	-		
Classification (Particle Size Distribution, PSD) – fine grained fraction	Clay	%		6 to 38	20		Representative percentages are based on 15 PSD tests. The results of the PSD tests confirm the primarily fine nature of the material and are generally consistent with field observations. Representative percentages are based on 12 PSD tests of the coarser fraction of Alluvium. The results of the PSD tests confirm the primarily coarse nature of the material. Based on a low undrained shear strength, and in accordance with BS 8004:2015 Figure 1 for soils above the groundwater table, the unit weight is likely to range from c. 15.0 to 19.0 kN/m³ and a bulk density of 1.77Mg/m³. A characteristic value of 18 kN/m³ has been selected based on engineering judgement. Based on a low undrained shear strength, and in accordance with BS 8004:2015 Figure 2 for soils below the groundwater table, the unit weight is likely to range from c. 17.0 to 20.0 kN/m³. A characteristic value of 19 kN/m³ has been selected based on engineering judgement. A general increase with depth is noted, however a conservative approach has been undertaken as a line of best fit indicates an N60 of 7 would be suitable.	C.3 and C.4
	Silt	%		9 to 43	25			
	Sand	%	15	19 to 29	35	Sandy gravelly silty CLAY		
	Gravel	%		0 to 56	20			
	Cobbles	%		0	0			
	Clay	%		8 to 27	10			
	Silt	%		3 to 33	15			
	Sand	%	12	29 to 36	45	Slightly clayey silty gravelly SAND/sandy GRAVEL		
	Gravel	%		4 to 68	30			
	Cobbles	%		0	0			
Density testing	Bulk density	Mg/m³	7	1.24 to 2.27	1.81	-	Based on a low undrained shear strength, and in accordance with BS 8004:2015 Figure 1 for soils above the groundwater table, the unit weight is likely to range from c. 15.0 to 19.0 kN/m³ and a bulk density of 1.77Mg/m³. A characteristic value of 18 kN/m³ has been selected based on engineering judgement. Based on a low undrained shear strength, and in accordance with BS 8004:2015 Figure 2 for soils below the groundwater table, the unit weight is likely to range from c. 17.0 to 20.0 kN/m³. A characteristic value of 19 kN/m³ has been selected based on engineering judgement.	C.10
	Dry density	Mg/m³	7	0.5 to 2.05	1.35	-		
	Unit weight (unsaturated)	kN/m³	-	-	-	18		
	Unit weight (saturated)	kN/m³	-	-	-	18		
In-Situ tests	SPT N ₆₀	-	38	4 to 27	10	7	C.5	
	Unconsolidated undrained triaxial test, Cu	kN/m²	2	11 to 240	-	11	The undrained shear strengths obtained from both methods show that the material is highly variable. Correlations through SPTs, from the 2021 GI, suggest a higher cu than the triaxial results. The strength tests indicate that the material ranges from very low to high strength in accordance with BS EN ISO 14688-2:2017, Table 6. Due to the variable nature of the material, values given are to be used only as a guide and must be derived locally where possible. Cu was also derived from CPT testing in the Alluvium in proximity of the bridge sections. Typically, Cu values rose from approximately 25kN/m2 at 1m to 50kN/m2 in excess of 3m.	C.6 C.9.1
Derived from SPTs, Cu	kN/m²	35	18 to 90	-	35			

Test type	Parameter	Units	Number of tests	Range	Representative value	Characteristic value	Comments	Graphs
Effective Stress (Drained)	Characteristic constant volume (critical state) effective angle of shearing resistance, $\phi'_{cv,k}$	degrees	-	-	-	27	The characteristic constant volume effective angle of shearing resistance has been determined using the equation presented within BS 8004:2015 Section 4.3.14.8 using a representative Plasticity Index of 15%. The characteristic value given is also supported by Table 2 in BS 8004:2015.	C.7 C.9.2
	Characteristic constant volume (critical state) effective cohesion $c'_{cv,k}$	degrees	-	-	-	0	A characteristic constant volume effective cohesion ($c'_{cv,k}$) of 0 kPa is provided in accordance with BS 8004:2015 Section 4.3.14.9.	
	Angle of internal friction derived from CPT	degrees	-	33 to 44	-	36	Angle of internal friction was derived from in-situ CPT data from CPTs located in proximity to the bridge locations crossing the River Granta.	
	Drained Stiffness, E'	MN/m²	-	-	-	9	Utilising the relationship with Cu from Stroud, a representative PI values of 15% (E'/Cu of 270) and an undrained shear strength of 35kN/m² have been used to calculate a E' of 9MN/m².	-
Consolidation testing	Youngs Modulus, E_u	MN/m²	-	-	-	15		
	Coefficient of volume of compressibility, m_v (laboratory testing)	m²/MN	35	0.00096 to 3.4 (typically between 0.0021 to 3.4)	0.4	-	The design coefficient of volume compressibility should be determined at detailed design stage once loading has been confirmed.	C.13 C.14 C.15
California Bearing Ratio (CBR)	Coefficient of Consolidation, C_v (laboratory testing)	m²/yr	35	0.19 to 24	1.5	-	The laboratory testing results show the potential for high compressibility within the Alluvium.	
	CBR derived from plate load	%	11	0.4 to 17.9	-	2	No laboratory CBR tests were undertaken. Majority of DCP CBR tests are grouped between 10-20% CBR value when assessed with elevation and was significantly lower for plate load testing. The range of all CBR results suggest variability within the Alluvium tested. Using the field descriptions and classification test results, a correlation is seen between the engineering description of a silty CLAY and undrained shear strength (35kPa), using relationship within LR1132 and LR889. It is therefore considered that a CBR of 2% should be adopted for design.	C.12
Environmental testing	CBR derived from DCP	%	20	4.3 to 93	15	-	Due to the variability of the Alluvium the derivation of geotechnical parameters should be considered locally.	
	Organic matter	%	20	0.24 to 13.37	4	-	The samples were chosen based on organic matter described in the engineer's description. A representative value has been based on 19no. samples plotted very low and low organic content. A single sample (BH-PTR-40) indicates a medium organic content.	C.16
Geochemical testing (concrete classification characteristic values (BRE DS1, 2005) Greenfield	pH	-	30	7.8 to 9.5	8.5	8.1	Mobile groundwater has been adopted as a conservative approach.	-
	SO ₄ 2:1 Soil Extract (to nearest 100mg/l)	mg/l	31	10.09 to 761	-	500	In a data set where there are 10 or more results available, the mean of the highest 20% of the sulphate test and Total Potential Sulphate (TPS) results (rounded to 100 mg/l) should be taken as the characteristic value and respective means of the lowest 20% of the pH results.	
	Acid SO ₄	%	24	337 to 1599	-	700	Total Potential Sulphate was calculated using Section C5.1.2 of BRE SD1 were TS%S is multiplied by 3.	
	Total Sulphur (TP%S)	%	56	0.01 to 1610	-	833.5	Utilising BRE SD1 for concrete classification of a greenfield site (Table C1) based on a soil characteristic values of pH of 8.1 and SO4 2:1 of 500, a design class of DS-2 and an ACEC class of AC-2, for mobile groundwater.	
	Total Potential Sulphate (TPS%S)	%	56	0.03 to 4830	-	2500	Given the TPS value of 2500% this corresponds to a value of DS-5 on Table C1. However, with reference to Step 8 in BRE SD1, a limitation can be applied if the sulphate class for the total potential sulphate is initially found to be Sulphate Class 5, but sulphate classes for groundwater and the water extracts tests are Sulphate Class 3 or less (as above). In this case, the Design Sulphate Class for the site location can be limited to DS-4.	
	Groundwater	Mobile						
	DS Class	DS-2						
	ACEC Class	AC-4						

6.3.3. River Terrace Deposits (Undifferentiated)

The River Terrace Deposits have been assessed as Undifferentiated, as there is no clear distinction laterally or stratigraphically on the location of the fine- and coarse-grained strata. However, where testing was undertaken on both strata types, this has been separated out in the following table.

Table 6-6 - Geotechnical parameters for the River Terrace Deposits

Test type	Parameter	Units	Number of tests	Range	Representative value	Characteristic value	Comments	Graphs
Index properties – fine grained fraction	Moisture Content (W)	%	24	0.9 to 29	13	-	It should be noted that Atterberg test results are likely to be affected by sample bias, where samples with greater fine content are sent for Atterberg testing. This may attribute a higher coarse-grained content being encountered locally in the field. Five samples were determined as non-plastic. Moisture contents of <10% were recorded in BH-PTR-19, BH-PTR-24A, BH-PTR-30, BH-PTR-37 and TP-BH-01. From review of the engineering logs, the soils are attributed to sandy GRAVEL with a small fine-grained fraction of silt. Six samples were recorded as non-plastic (BH-PTR-19, BH-PTR-24A, BH-PTR-37, BH-OB-C-05, BH-PTR-30 and BH-PTR-22). Results suggest that the majority of material encountered ranges from low to intermediate plasticity clay and is favourable towards the plastic limit. A single sample was recorded at high plasticity silt (BH-PTR-28 at 3.0m bgl). The Modified Plasticity Index (Ip) is defined as the Plasticity Index (Ip) of the soil multiplied by the percentage of particles less than 425µm. A representative value of 76% particles passing 425µm has been determined from laboratory test results. The Modified Plasticity Index based on the majority of the samples plasticity index test result would be 13% and suggests low volume change potential. A single sample (BH-PTR-28 has a modified plasticity index of 22% indicative of a Medium Volume Change Potential silt.	C.1 C.2
	Liquid Limit (LL)	%	12	24 to 61	37	-		
	Plastic Limit (PL)	%	12	14 to 28	20	-		
	Plasticity Index (IP)	%	12	9 to 33	17	-		
	Modified Plasticity Index	%	12	5 to 22	13	-		
Classification (Particle Size Distribution, PSD) – coarse grained	Fines (<0.063)	%		3 to 14	10	Slightly clayey sandy GRAVEL	Representative percentages are based on 42no. PSD tests. The results of the PSD tests confirm the primarily coarse nature of the material.	C.3 C.4
	Sand	%	42	3 to 75	35			
	Gravel	%		11 to 94	55			
	Cobbles	%		23 to 28	0			
	Clay	%		5 to 31	15			
Classification (Particle Size Distribution, PSD) – fine grained	Silt	%		11 to 49	20	Very sandy gravelly silty CLAY	It should be noted that PSD testing indicates a high sand content compared to what was generally encountered in the field. This may be attributed to sample bias, where more granular samples are sent for PSD testing and more cohesive samples sent for Atterberg Limit classification.	C.3 C.4
	Sand	%	33	20 to 41	45			
	Gravel	%		0 to 43	20			
	Cobbles	%		0	0			
	Unit weight (unsaturated)	kN/m³	-	-	-			19
Density testing	Unit weight (saturated)	kN/m³	-	-	-	20	Based on a medium dense relative density Gravel from SPT N values (Table 10, BS5930), and in accordance with BS 8004:2015 Figure 1 for soils above the groundwater table, the unit weight is likely to range from c. 17.0 to 20.0 kN/m3. A characteristic value of 16 kN/m³ has been selected based on engineering judgement. Based on a medium dense relative density Gravel from SPT N values (Table 10, BS5930), and in accordance with BS 8004:2015 Figure 2 for soils below the groundwater table, the unit weight is likely to range from c. 19.0 to 22.0 kN/m3. A characteristic value of 18 kN/m³ has been selected based on engineering judgement.	C.10
	SPT N60	-	78	7 to 55	20	15		C.5
In-Situ tests	Unconsolidated undrained triaxial test, Cu	kN/m2	-	-	-	-	No laboratory tests were undertaken.	C.6 C.9.1
	Derived from SPT's, Cu	kN/m2	8	27 to 68	51	40	Cu values show a general decrease with depth. A Cu value of 40kN/m² indicates a medium strength material in accordance with Table 6 of BS EN ISO 14688-2:2018.	
Effective Stress (Drained)	Effective angle of internal friction derived from SPT 'N60' value (blows per 300 mm),ϕ'	degrees	71	29 to 41	32	43 (borrow pit area)	Limited shear box testing has been undertaken within the borrow pit area (TP-BH-01 to TP-BH-05). It is considered that the borrow pit has an angle of internal friction of 43° and the remainder of the site should adopt a more conservative value of 36°.	C.7 C.8
	Peak effective angle of internal friction derived from shear box testing ϕ p in borrow pit area	degrees	1	-	43	36 (remaining site)	The characteristic effective constant volume angle of friction has been determined using the equation presented within BS 8004:2015 Section 4.3.1.3.5 assuming sub-angular to sub-rounded particles and being	

Test type	Parameter	Units	Number of tests	Range	Representative value	Characteristic value	Comments	Graphs
Compaction testing	Characteristic constant volume (critical state) effective angle of shearing resistance, ϕ cv,k	degrees	-	-	36		medium to multi-graded.	
	Angle of internal friction derived from CPT	degrees	-	33 to 51	-	39	Angle of internal friction was derived from in-situ CPT data from CPT's located in proximity to the bridge locations crossing the River Granta.	
	Peak effective cohesion derived from shear box testing, c' p	kN/m²	1	-	-	0	Effective cohesion, c' (kPa), could be assumed to be 0 kPa for coarse soil.	
	Characteristic constant volume (critical state) effective cohesion, c' cv,k	kN/m²	-	-	-	0	A characteristic constant volume effective cohesion (c'cv,k) of 0 kPa is given in accordance with BS 8004:2015 Section 4.3.1.4.9 .	
	Optimum Water Content	%	5	8.3 to 9.5	9	-		C.11
California Bearing Ratio (CBR)	Maximum Dry Density	Mg/m³	5	2.07 to 2.12	2.1	-	-	
	Moisture Condition Value	-	15	1 to 14.5	8	10		
	CBR derived from plate load	%	-	-	-	-	No plate load tests undertaken.	C.12
	CBR derived from DCP	%	14	6 to 70		15	The range of CBR results suggest variability within the coarse River Terrace Deposits tested. Test results suggest a similar CBR value when considering the recommendations made in LR1132 for a poorly sorted sand (20 % CBR value). A conservative CBR value of 15% is proposed for preliminary design based on the DCP data.	
	Organic matter	%	1	0.6	-	-	One organic matter test was scheduled in exploratory hole TP-BP-02. The sample was chosen based on organic matter described in the engineer's description. The result may not be representative of undifferentiated River Terrace Deposits across the entire Scheme.	C.16
Aggregate testing	Los Angeles Abrasion tests	%	4	24 to 27	-	26	Undertaken in 'Borrow Pit' area.	-
	pH	-	10	8 to 8.8	-	8.1	Mobile groundwater has been adopted as a conservative approach.	-
	SO ₄ 2:1 Soil Extract (to nearest 100mg/l)	mg/l	10	14 to 703	-	700	In a data set where there are 10 or more results available, the mean of the highest 20% of the sulphate test and Total Potential Sulphate (TPS) results (rounded to 100 mg/l) should be taken as the characteristic value and respective means of the lowest 20% of the pH results.	
	Acid SO ₄	%	5	121 to 551	-	500	In a data set where there are five to nine results available for the location, the mean of the highest two testing results should be used.	
	Total Sulphur (TP%S)	%	10	0.01 to 1354	-	912.5	Total Potential Sulphate was calculated using Section C5.1.2 of BRE SD1 were TS%S is multiplied by 3. Utilising BRE SD1 for concrete classification of a greenfield site (Table C1) based on a soil characteristic values of pH of 8.1 and SO4 2:1 of 500, a design class of DS-2 and an ACEC class of AC-2, for mobile groundwater.	
Environmental testing	Total Potential Sulphate (TPS%S)	%	10	0.03 to 4062	-	2737.5	Given the TPS value of 2737.5% this corresponds to a value of DS-5 on Table C1. However, with reference to Step 8 in BRE SD1, a limitation can be applied if the sulphate class for the total potential sulphate is initially found to be Sulphate Class 5, but sulphate classes for groundwater and the water extracts tests are Sulphate Class 3 or less (as above). In this case, the Design Sulphate Class for the site location can be limited to DS-4.	
	Groundwater	Mobile						
	DS Class	DS-2						
	ACEC Class	AC-4						

6.3.4. Lowestoft Formation (Diamicton, Glacial Till)

Table 6-7 - Geotechnical parameters for the Lowestoft Formation (Diamicton Glacial Till)

Test type	Parameter	Units	Number of tests	Range	Representative value	Characteristic value	Comments	Graphs
Index properties	Moisture Content (W)	%	2	14 to 23	-	-	Plasticity Index results suggest the Lowestoft Formation encountered is a low plasticity clay of a low volume change potential. Representative values have not been given due to the range of results and limited number of tests undertaken. C.1	C.1 C.2
	Liquid Limit (LL)	%	2	30 to 34	-	-		
	Plastic Limit (PL)	%	2	17 to 21	-	-		
	Plasticity Index (IP)	%	2	9 to 17	-	-		
	Modified Plasticity Index	%	2	9 to 15	-	-		
Density testing	Unit weight	kN/m ³	-	-	-	20	Based on a high undrained shear strength, and in accordance with BS 8004:2015 Figure 1 for soils above the groundwater table, the unit weight is likely to range from c. 18.0 to 22.0 kN/m ³ . A characteristic value of 20 kN/m ³ has been selected based on engineering judgement.	C.10
In-Situ tests	SPT N ₆₀	-	3	21 to 37	27	20	A characteristic value has been based on three samples. There is an overall decrease in SPT values with depth to 2m bgl.	C.5
	Unconsolidated undrained triaxial test, Cu	kN/m ²	-	-	-	-	A characteristic value has been based on three samples. There is an overall decrease in Cu value with depth to 2m bgl. A characteristic value of 100Kpa has been assigned indicating a high strength material in accordance with Table 9 of BS5930:2015. No triaxial tests were undertaken.	C.6
Effective Stress (Drained)	Derived from SPTs, Cu	kN/m ²	3	95 to 122	122	100		
	Characteristic constant volume (critical state) effective angle of shearing resistance, $\phi_{cv,k}$	degrees	-	-	-	28	The characteristic constant volume effective angle of shearing resistance has been determined using the equation presented within BS 8004:2015 Section 4.3.1.4.8 using a average Plasticity Index of 13%. The characteristic value given is also supported by Table 2 in BS 8004:2015.	C.7
	Characteristic constant volume (critical state) effective cohesion $c_{cv,k}$	degrees	-	-	-	0	A characteristic constant volume effective cohesion ($c_{cv,k}$) of 0 kPa is provided in accordance with BS 8004:2015 Section 4.3.1.4.9 .	
Stiffness	Drained Stiffness, E'	MN/m ²	-	-	-	20	Utilising the relationship with Cu from Stroud, a representative PI values of 21% (E'/Cu of 200) and a undrained shear strength of 100kN/m ² have been used to calculate a E' of 20MN/m ² .	-
	Youngs Modulus, Eu	MN/m ²	-	-	-	33		
Consolidation testing	Coefficient of volume of compressibility, C _v	m ² /MN	-	0.04 to 0.07	-	0.06	The design coefficient of volume compressibility should be determined at detailed design stage once loading has been confirmed. Mv has been derived from SPTs using the empirical correlation between N60 and f2 given in Section 6.2. The results show that the unit has a low compressibility based on correlation with SPT testing data.	C.13
California Bearing Ratio (CBR)	CBR derived from laboratory testing	%	-	-	-	4	No laboratory or in-situ CBR tests were undertaken. Using the field descriptions and classification test results, a correlation is seen between the engineering description of a silty CLAY and undrained shear strength (100kPa), using relationship within LR1132 and LR889. It is therefore considered that a CBR of 4% should be adopted for design. Due to the variability of the Lowestoft Formation the derivation of geotechnical parameters should be considered locally.	C.12
Geochemical testing (concrete classification characteristic values (BRE DS1, 2005) Greenfield	pH	-	1	8.6	-	8.6	Mobile groundwater has been adopted as a conservative approach.	-
	SO ₄ 2:1 Soil Extract (to nearest 100mg/l)	mg/l	1	24.8	-	100	In a data set where there are less than 5 have been tested for water-soluble sulphate using the 2:1 water/soil extract test, the highest measured sulphate concentration (mg/l SO4) should be taken as the characteristic value(rounded to 100 mg/l) should be taken as the characteristic value and respective lowest of the pH results.	
	Acid SO ₄	%	1	410	-	400	Total Potential Sulphate was calculated using Section C5.1.2 of BRE SD1 were TS% S is multiplied by 3.	
	Total Sulphur (TP%S)	%	2	0.02 to 150	-	150	Utilising BRE SD1 for concrete classification of a greenfield site (Table C1) based on a soil characteristic values of pH of 8.6 and SO4 2:1 of 100, a design class of DS-1 and an ACEC class of AC-1, for mobile groundwater.	
	Total Potential Sulphate (TPS%S)	%	2	0.06 to 450	-	450	Given the TPS value of 450% this corresponds to a value of DS-5 on Table C1. However, with reference to Step 8 in BRE SD1, a limitation can be applied if the sulphate class for the total potential sulphate is initially found to be Sulphate Class 5, but sulphate classes for groundwater and the water extracts tests are Sulphate Class 3 or less (as above). In this case, the Design Sulphate Class for the site location can be limited to DS-4.	
	Groundwater	Mobile						
	DS Class	DS-1						
	ACEC Class	AC-4						

6.3.5. New Pit Chalk Formation/Holywell Chalk Formation (undifferentiated)

Table 6-8 - Geotechnical parameters for the New Pit Chalk Formation/Holywell Chalk Formation (undifferentiated)

Test type	Parameter	Units	Number of tests	Range	Representative value	Characteristic value	Comments	Graphs
Index properties	Moisture Content (W)	%	5	9.4 to 28	-	-	Plasticity Index results suggest the undifferentiated chalk encountered is a low to intermediate plasticity clay of a low volume change potential. Representative values have not been given due to the limited number of tests undertaken.	C.1 C.2
	Liquid Limit (LL)	%	3	25 to 35	-	-		
	Plastic Limit (PL)	%	3	15 to 24	-	-		
	Plasticity Index (IP)	%	3	9 to 18	-	-		
	Modified Plasticity Index	%	3	8 to 15	-	-		
Density testing	Bulk density	Mg/m ³	19	1.88 to 2.02	1.92	-	Laboratory results are consistent with typical chalk density set out in Table 4.2 of CIRIA C574. The weight density of soil can be calculated by multiplying the force of gravity (9.81 m/s ²) by the representative bulk density.	C.10
	Dry density	Mg/m ³	19	1.43 to 1.73	1.51	-		
	Unit weight	kN/m ³	-	-	-	19		
	SPT N ₆₀	-	16	23 to 43	30	25		
In-Situ tests							Based on the N60 plot there appears to be a trend of increasing strength with depth from 2m bgl to a maximum depth of 12.0 m bgl.	C.5
	Effective Stress (Drained) for structureless chalk						According to CIRIA guidance C574 the effective strength parameters of structureless chalks will not be less than those found by Clayton (1978) for remoulded chalks: c=0 and ϕ' =31° for Grey (formerly Lower) Chalk, c=0 and ϕ' =33° for other chalks. CIRIA C574 notes the increase in effective strength with time for remoulded chalk which leads to the increase ineffective cohesion c' from 0kPa to 10kPa. The characteristic values selected for the in situ structureless chalk are c=0 and ϕ' =33°.	-
Effective Stress (Drained) for structured chalk							According to CIRIA guidance C574 "moderately conservative" strength parameters for structured chalk have been found to be c=20 and ϕ' =39°, with "worst credible" parameters of c=0 and ϕ' =34°. From review of the engineering logs and in-situ testing, typically structured chalk (Grades A-C) are generally encountered >6.5m bgl in the proposed Travel Hub Site.	
	Youngs Modulus	GPa	-	-	-	2.5	Utilising the relationship between dry density (1.51Mg/m ³) and young's modulus as set out in CIRIA C574 (Figure 4.20).	-
California Bearing Ratio (CBR)	CBR derived from plate load	%	-	-	-	-	No plate load tests undertaken.	C.12
	CBR derived from DCP	%	9	9 to 53	-	15	The majority of CBR values are between 12-18% when assess with elevation. It is therefore recommended that a CBR value of 15% is adopted for preliminary design.	
Rock testing	Point load	MPa	21	0.04 to 8.05	-	0.08	In accordance with BS 5930 and Table 3.7 in CIRIA C574, the representative value of 1.39MPa is of a very weak rock.	C.17 C.18
	Uniaxial compressive strength, UCS	MPa	2	1.39 to 1.92	1.39	-		
Chalk testing	Saturated moisture content, SMC	%	17	21 to 33	29	-	Chalk has been classified using CIRIA C574 [28] which assess likely earthwork characteristics after Greenwood (1993) and Toombs and Snowdon (1997). Greenwood assesses the chalk to be low to medium density, with earthwork classes of CD, and CC which correlated to Table 5.5 within the CIRIA guidance. Toombs and Snowdon assess the chalk to be in Group B-D which correlated to Table 5.6 within the CIRIA guidance.	C.19 C.20
	Natural Moisture Content	%	19	12 to 32	28	30	Samples tested indicate that the majority of moisture contents are between 24-32% which is the upper limit of moisture content (using Table 5.8 in CIRIA C574) for practical purposes before a form of modification or stabilisation is needed [28]. Therefore, a conservative approach has been undertaken and a characteristic value of 30 is considered suitable for preliminary design.	
Geochemical testing (concrete classification characteristic values	pH	-	2	8.6 to 9.1	-	8.6	Mobile groundwater has been adopted as a conservative approach. In a data set where there are less than 5 have been tested for water-soluble sulphate using the 2:1 water/soil	-

Test type	Parameter	Units	Number of tests	Range	Representative value	Characteristic value	Comments	Graphs
(BRE DS1, 2005) Greenfield	SO ₄ 2:1 Soil Extract (to nearest 100mg/l)	mg/l	2	23 to 42	-	100	extract test, the highest measured sulphate concentration (mg/l SO ₄) should be taken as the characteristic value(rounded to 100 mg/l) should be taken as the characteristic value and respective lowest of the pH results.	
	Acid SO ₄	%	2	363 to 436	-	400	Total Potential Sulphate was calculated using Section C5.1.2 of BRE SD1 were TS%S is multiplied by 3. Utilising BRE SD1 for concrete classification of a greenfield site (Table C1) based on a soil characteristic values of pH of 8.6 and SO ₄ 2:1 of 100, a design class of DS-1 and an ACEC class of AC-1, for mobile groundwater.	
	Total Sulphur (TP%S)	%	4	0.02 to 270	-	20	Given the TPS value of 810% this corresponds to a value of DS-5 on Table C1. However, with reference to Step 8 in BRE SD1, a limitation can be applied if the sulphate class for the total potential sulphate is initially found to be Sulphate Class 5, but sulphate classes for groundwater and the water extracts tests are Sulphate Class 3 or less (as above). In this case, the Design Sulphate Class for the site location can be limited to DS-4.	
	Total Potential Sulphate (TPS%S)	%	4	0.06 to 810	-	810		
	Groundwater	Mobile						
	DS Class	DS-1						
	ACEC Class	AC-4						

6.3.6. Holywell Chalk Formation

Table 6-9 - Geotechnical parameters for the Holywell Chalk Formation

Test type	Parameter	Units	Number of tests	Range	Representative value	Characteristic value	Comments	Graphs
Index properties	Moisture Content (W)	%	8	9.8 to 33	-	-	Plasticity Index results suggest the Holywell Nodular Chalk Formation encountered is a intermediate plasticity silt of a low volume change potential. Representative values have not been given due to the limited number of tests undertaken.	C.1 C.2
	Liquid Limit (LL)	%	5	35 to 49	-	-		
	Plastic Limit (PL)	%	5	21 to 27	-	-		
	Plasticity Index (IP)	%	5	11 to 28	-	-		
	Modified Plasticity Index	%	5	8.8 to 27	-	-		
Density testing	Bulk density	Mg/m³	67	1.78 to 2.12	1.97	-	Laboratory results are consistent with typical chalk density set out in Table 4.2 of CIRIA C574. The weight density of soil can be calculated by multiplying the force of gravity (9.81 m/s²) by the representative bulk density.	C.10
	Dry density	Mg/m³	67	1.43 to 1.86	1.60	-		
	Unit weight	kN/m³	-	-	-	19		
In-Situ tests	SPT N ₆₀	-	121	3 to 68	20	20	Based on the N60 plot there appears to be a trend of increasing strength with depth, from 1m bgl to a maximum depth of 22.0 m bgl. At 11m bgl N60 values increase further where the majority of N values at >25, which is accordance with CIRIA C574 indicates the presence of structured chalk.	C.5
	Characteristic critical state effective angle of shearing resistance $\phi_{cv,k}$	degrees	-	-	-	33	According to CIRIA guidance C574 the effective strength parameters of structureless chalks will not be less than those found by Clayton (1978) for remoulded chalks: $c=0$ and $\phi' = 31^\circ$ for Grey (formerly Lower) Chalk, $c=0$ and $\phi' = 33^\circ$ for other chalks.	
Effective Stress (Drained) for structureless chalk	Characteristic constant volume (critical state) effective cohesion $c_{cv,k}$	kN/m²	-	-	-	0	CIRIA C574 notes the increase in effective strength with time for remoulded chalk which leads to the increase ineffective cohesion c' from 0kPa to 10kPa. The characteristic values selected for the in situ structureless chalk are $c=0$ and $\phi'=33^\circ$.	-
	Characteristic critical state effective angle of shearing resistance $\phi_{cv,k}$	degrees	-	-	-	34	According to CIRIA guidance C574 "moderately conservative" strength parameters for structured chalk have been found to be $c=20$ and $\phi' = 39^\circ$, with "worst credible" parameters of $c=0$ and $\phi' = 34^\circ$.	
	Characteristic constant volume (critical state) effective cohesion $c_{cv,k}$	kN/m²	-	-	-	0	From review of the engineering logs and in-situ testing, typically structured chalk (Grades A-C) is generally encountered from >3m bgl in the proposed Travel Hub Site and from >6m bgl along Section 6.	
Stiffness	Youngs Modulus	GPa	-	-	-	5	Utilising the relationship between dry density (1.60Mg/m³) and young's modulus as set out in CIRIA C574 (Figure 4.20). Youngs Modulus of intact chalk and relationship with porosity.	-
California Bearing Ratio (CBR)	CBR derived from plate load	%	3	4.5 to 5.4	4.5	15% (structured) 4.5% (weathered)	Limited plate load tests were undertaken in the formation and are much lower than expected for chalk. Utilising guidance in CIRIA C574 a relationship with moisture content can be used. Moisture contents for the strata range from 13-25%. Using a conservative 25% water content, and Figure 4.2 in C574 a CBR value of 15% seems appropriate. Section 5.9.1 of C574 infers that a design value of 2% shall be adopted where weathered in-situ chalk is encountered, however plate load testing on Grade D chalk suggests a slightly higher reading of 4.5%.	C.12
	CBR derived from DCP	%	23	2.2 to 135	25		The majority of CBR values are between 15-40% when assess with depth. It is therefore recommended that a CBR value of 25% is adopted for preliminary design. Chalk classification testing shows a low to medium density chalk of Grade A-D.	
Rock testing	Point load (PLT)	MPa	108	0.02 to 0.35	-	0.12	In accordance with BS 5930 and Table 3.7 in CIRIA C574, the characteristic value of 1.2MPa, based on the empirical relationship between PLT and UCS [34], is of a very weak rock.	C.17 C.18
	Uniaxial compressive strength, UCS derived from relationship with PLT	MPa	-	0.2 to 3.5	-	1.2		
Chalk testing	Saturated moisture content, SMC	%	67	17 to 33	26	-	Chalk has been classified using CIRIA C574 [28] which assess likely earthwork characteristics after Greenwood (1993) and Toombs and Snowdon (1997). Greenwood assesses the chalk to be low to high density, with	C.19

Test type	Parameter	Units	Number of tests	Range	Representative value	Characteristic value	Comments	Graphs
Geochemical testing (concrete classification characteristic values (BRE DS1, 2005) Greenfield	Natural Moisture Content	%	67	8.8 to 32	23	28	earthwork classes of CD, CC and CB which correlated to Table 5.5 within the CIRIA guidance. Toombs and Snowdon assess the chalk to be in Group A-C which correlated to Table 5.6 within the CIRIA guidance. Samples tested indicate that the majority of moisture contents less than 22% indicating that these chalks will generally be stable when crushed (using Table 5.8 in CIRIA C574). However, 38no. samples returned moisture contents between 23-32% which is the upper limit of moisture content for practical purposes before a form of modification or stabilisation is needed [28]. Therefore, a conservative approach has been undertaken and a characteristic value of 28 is considered suitable for preliminary design.	C.20
	pH	-	8	8.3 to 8.9	-	8.3	Mobile groundwater has been adopted as a conservative approach. In a data set where there are 10 or more results available, the mean of the highest 20% of the sulphate test and Total Potential Sulphate (TPS) results (rounded to 100 mg/l) should be taken as the characteristic value and respective means of the lowest 20% of the pH results.	-
	SO ₄ 2:1 Soil Extract (to nearest 100mg/l)	mg/l	9	16 to 426	-	200	In a data set where there are five to nine results available for the location, the mean of the highest two testing results should be used for SO4 2:1 and TPS, and the lowest 20% of pH results.	-
	Acid SO ₄	%	7	396 to 565	-	400	Total Potential Sulphate was calculated using Section C5.1.2 of BRE SD1 were TS%S is multiplied by 3. Utilising BRE SD1 for concrete classification of a greenfield site (Table C1) based on a soil characteristic values of pH of 8.3 and SO4 2:1 of 200, a design class of DS-1 and an ACEC class of AC-1, for mobile groundwater.	-
	Total Sulphur (TP%S)	%	16	0.01 to 267	-	222.3	Given the TPS value of 667% this corresponds to a value of DS-5 on Table C1. However, with reference to Step 8 in BRE SD1, a limitation can be applied if the sulphate class for the total potential sulphate is initially found to be Sulphate Class 5, but sulphate classes for groundwater and the water extracts tests are Sulphate Class 3 or less (as above). In this case, the Design Sulphate Class for the site location can be limited to DS-4.	-
	Total Potential Sulphate (TPS%S)	%	16	0.03 to 579	-	667		
	Groundwater	Mobile						
	DS Class	DS-1						
	ACEC Class	AC-4						

6.3.7. Zig Zag Chalk Formation

Table 6-10 - Geotechnical parameters for Zig Zag Chalk Formation

Test type	Parameter	Units	Number of tests	Range	Representative value	Characteristic value	Comments	Graphs
Density testing	Bulk density	Mg/m ³	152	1.82 to 2.34	2.05	-	Laboratory results are consistent with typical chalk density set out in Table 4.2 of CIRIA C574. The weight density of soil can be calculated by multiplying the force of gravity (9.81 m/s ²) by the representative bulk density.	C.10
	Dry density	Mg/m ³	152	1.44 to 2.11	1.72	-		
	Unit weight	kN/m ³	-	-	-	20		
In-Situ tests	SPT N ₆₀	-	161	3 to 100	25	20	Based on the N60 plot there appears to be a trend of increasing strength with depth from 1m bgl to a maximum depth of 30.0 m bgl. At 16m bgl N60 values increase further where the majority of N values at >25, which is accordance with CIRIA C574 indicates the presence of structured chalk.	C.5
	Characteristic critical state effective angle of shearing resistance ϕ' cv,k	degrees	-	-	-	31	According to CIRIA guidance C574 the effective strength parameters of structureless chalks will not be less than those found by Clayton (1978) for remoulded chalks: $c'=0$ and $\phi' =31^{\circ}$ for Grey (formerly Lower) Chalk, $c'=0$ and $\phi' =33^{\circ}$ for other chalks.	-
	Characteristic constant volume (critical state) effective cohesion c' cv,k	kN/m ²	-	-	-	0	CIRIA C574 notes the increase in effective strength with time for remoulded chalk which leads to the increase in ineffective cohesion c' from 0kPa to 10kPa. The characteristic values selected for the in situ structureless chalk are $c'=0$ and $\phi'=31^{\circ}$.	-
Effective Stress (Drained) for structured chalk	Characteristic critical state effective angle of shearing resistance ϕ' cv,k	degrees	-	-	-	34	According to CIRIA guidance C574 "moderately conservative" strength parameters for structured chalk have been found to be $c'=20$ and $\phi' =39^{\circ}$ with "worst credible" parameters of $c'=0$ and $\phi' =34^{\circ}$.	-
	Characteristic constant volume (critical state) effective cohesion c' cv,k	kN/m2	-	-	-	0	From review of the engineering logs and in-situ testing, typically structured chalk (Grades A-C) are generally encountered > 10m bgl.	-
	Youngs Modulus	GPa	-	-	-	10	Utilising the relationship between dry density (1.72Mg/m ³) and young's modulus as set out in CIRIA C574 (Figure 4.20). Youngs Modulus of intact chalk and relationship with porosity.	-
California Bearing Ratio (CBR)	CBR derived from plate load	%	7	0.3 to 41.4	1		The majority of testing results in this formation yielded results of <1% attributed to Grade Dm chalk and highly weathered material. This is slightly less than Section 5.9.1 of C574 where the section states that a design value of 2% shall be adopted where weathered in-situ chalk is encountered.	C.12
	CBR derived from DCP	%	43	6.3 to 70	16	10 (structured) 1 (weathered)	Utilising guidance in CIRIA C574 a relationship with moisture content can be used. Majority of moisture contents for the strata range from 15-27%. Using a conservative 27% water content, and Figure 4.2 in C574 a CBR value of 10-15% seems appropriate. The majority of CBR values are between 10-20% when assessed with depth. It is therefore recommended that a CBR value of 10% is adopted for preliminary design.	
							Chalk classification testing shows a low to high density chalk of Grade A-D.	
Rock testing	Point load	MPa	267	0.01 to 0.14	-	0.15	In accordance with BS 5930 and Table 3.7 in CIRIA C574, the characteristic value of 2.3MPa is of a very weak rock.	C.17 C.18
	Uniaxial compressive strength, UCS	MPa	47	0.65 to 5.44	-	2.3		
	Chalk crushing value	-	6	3.1 to 4.0	-	3.5	-	-
Chalk testing	Saturated moisture content, SMC	%	105	10 to 33	23	-	Chalk has been classified using CIRIA C574 [28] which assess likely earthwork characteristics after Greenwood (1993) and Toombs and Snowdon (1997). Greenwood assesses the chalk to be low to very high density, with earthwork classes of CD, CC, CB and CA which correlated to Table 5.5 within the CIRIA guidance. Toombs and Snowdon assess the chalk to be in Group A-C which correlated to Table 5.6 within the CIRIA guidance.	C.19 C.20
	Natural Moisture Content	%	157	2 to 29	19	25	Samples tested indicate that the majority of moisture contents less than 22% indicating that these chalks will generally be stable when crushed (using Table 5.8 in CIRIA C574). However, 48no. samples returned moisture contents between 22-29% which is the upper limit of moisture content for practical purposes before a form of modification or stabilisation is needed [36]. Therefore, a conservative approach has been undertaken and a characteristic value of 25 is considered suitable for preliminary design.	

Test type	Parameter	Units	Number of tests	Range	Representative value	Characteristic value	Comments	Graphs
Geochemical testing (concrete classification characteristic values (BRE DS1, 2005) Greenfield	pH	-	70	8 to 9.3	-	7.9	Mobile groundwater has been adopted as a conservative approach. In a data set where there are 10 or more results available, the mean of the highest 20% of the sulphate test and Total Potential Sulphate (TPS) results (rounded to 100 mg/l) should be taken as the characteristic value and respective means of the lowest 20% of the pH results. Total Potential Sulphate was calculated using Section C5.1.2 of BRE SD1 were T%S is multiplied by 3. Utilising BRE SD1 for concrete classification of a greenfield site (Table C1) based on a soil characteristic values of pH of 7.9 and SO4 2:1 of 400, a design class of DS-1 and an ACEC class of AC-1, for mobile groundwater. Given the TPS value of 957.7% this corresponds to a value of DS-5 on Table C1. However, with reference to Step 8 in BRE SD1, a limitation can be applied if the sulphate class for the total potential sulphate is initially found to be Sulphate Class 5, but sulphate classes for groundwater and the water extracts tests are Sulphate Class 3 or less (as above). In this case, the Design Sulphate Class for the site location can be limited to DS-4.	
	SO4 2:1 Soil Extract (to nearest 100mg/l)	mg/l	80	10 to 1123	-	400		
	Acid SO4	%	60	300 to 787	-	600		
	Total Sulphur (TP%S)	%	140	0.01 to 1180	-	308.9		
	Total Potential Sulphate (TPS%S)	%	140	0.03 to 3540	-	957.7		
	Groundwater	Mobile						
	DS Class	DS-1						
	ACEC Class	AC-4						

6.3.8. West Melbury Marly Chalk Formation

Table 6-11 - Geotechnical parameters for the West Melbury Marly Chalk Formation

Test type	Parameter	Units	Number of tests	Range	Representative value	Characteristic value	Comments	Graphs
Index properties	Moisture Content (W)	%	3	22 to 25	-	-	Plasticity Index results suggest the West Melbury Marly Chalk Formation encountered is a low to intermediate plasticity clay of a low volume change potential. Representative values have not been given due to the limited number of tests undertaken.	C.1 C.2
	Liquid Limit (LL)	%	2	29 to 37	-	-		
	Plastic Limit (PL)	%	2	19 to 20	-	-		
	Plasticity Index (IP)	%	2	9 to 18	-	-		
	Modified Plasticity Index	%	2	9 to 17	-	-		
Density testing	Bulk density	Mg/m³	12	1.97 to 2.35	2.13	-	Laboratory results are consistent with typical chalk density set out in Table 4.2 of CIRIA C574. The weight density of soil can be calculated by multiplying the force of gravity (9.81 m/s2) by the representative bulk density.	C.10
	Dry density	Mg/m³	12	1.65 to 2.08	1.83	-		
In-Situ tests	Unit weight	kN/m³	-	-	-	21	Based on the N60 plot there appears to be a trend of increasing strength with depth from 1m bgl to a maximum depth of 30.0 m bgl. At 8m bgl N60 values increase further where the majority of N values at >25, which is accordance with CIRIA C574 indicates the presence of structured chalk.	C.5
	SPT N ₆₀	-	55	3 to 74	30	20		
Effective Stress (Drained) for structureless chalk	Characteristic critical state effective angle of shearing resistance $\phi'_{cv,k}$	degrees	-	-	-	31	According to CIRIA guidance C574 the effective strength parameters of structureless chalks will not be less than those found by Clayton (1978) for remoulded chalks: c'=0 and ϕ' =31° for Grey (formerly Lower) Chalk, c'=0 and ϕ' =33° for other chalks. CIRIA C574 notes the increase in effective strength with time for remoulded chalk which leads to the increase in ineffective cohesion c' from 0kPa to 10kPa. The characteristic values selected for the in situ structureless chalk are c'=0 and ϕ' =31°.	-
	Characteristic constant volume (critical state) effective cohesion c' _{cv,k}	kN/m2	-	-	-	0		
	Characteristic critical state effective angle of shearing resistance $\phi'_{cv,k}$	degrees	-	-	-	34		
Effective Stress (Drained) for structured chalk	Characteristic constant volume (critical state) effective cohesion c' _{cv,k}	kN/m2	-	-	-	0	From review of the engineering logs and in-situ testing, typically structured chalk (Grades A-C) are generally encountered >5m bgl.	-
	Youngs Modulus	GPa	-	-	-	12.5	Utilising the relationship between dry density (1.83Mg/m³) and young's modulus as set out in CIRIA C574 (Figure 4.20). Youngs Modulus of intact chalk and relationship with porosity.	
California Bearing Ratio (CBR)	CBR derived from plate load	%	1	5.5	5.5	15 (structured) 2 (weathered)	Limited plate load tests were undertaken in the formation and are much lower than expected for chalk. Utilising guidance in CIRIA C574 a relationship with moisture content can be used. Moisture contents for the strata range from 12-25%. Using a conservative 25% water content, and Figure 4.2 in C574 a CBR value of 15% seems appropriate. Section 5.9.1 of C574 infers that a design value of 2% shall be adopted where weathered in-situ chalk is encountered. Chalk classification testing shows a medium to high density chalk of Grade A.	C.12
	CBR derived from DCP	%	3	20 to 33	20			
	Point load	MPa	38	0.01 to 0.5	-	0.09	In accordance with BS 5930 and Table 3.7 in CIRIA C574, the characteristic value of 2MPa is of a very weak rock.	
Rock testing	Uniaxial compressive strength, UCS	MPa	5	0.24 to 4.54	-	2	Chalk has been classified using CIRIA C574 [36] which assess likely earthwork characteristics after Greenwood (1993) and Toombs and Snowdon (1997). Greenwood assesses the chalk to be medium to very high density, with earthwork classes of CB and CA, which correlated to Table 5.5 within the CIRIA guidance. Toombs and Snowdon asses the chalk to be in Group A, which correlated to Table 5.6 within the CIRIA guidance. Samples tested indicate moisture contents less than 22% indicating that these chalks will generally be stable when crushed (using Table 5.8 in CIRIA C574).	C.17 C.18
	Natural Moisture Content	%	12	12 to 21	16	-		
Chalk testing	Saturated moisture content, SMC	%	7	14 to 24	19	-		C.19 C.20

Test type	Parameter	Units	Number of tests	Range	Representative value	Characteristic value	Comments	Graphs
Geochemical testing (concrete classification characteristic values (BRE DS1, 2006) Greenfield	pH	-	20	7.7 to 9.2	-	8.1	Mobile groundwater has been adopted as a conservative approach. In a data set where there are 10 or more results available, the mean of the highest 20% of the sulphate test and Total Potential Sulphate (TPS) results (rounded to 100 mg/l) should be taken as the characteristic value and respective means of the lowest 20% of the pH results. Total Potential Sulphate was calculated using Section C5.1.2 of BRE SD1 were TS%S is multiplied by 3. Utilising BRE SD1 for concrete classification of a greenfield site (Table C1) based on a soil characteristic values of pH of 8.1 and SO4 2:1 of 600, a design class of DS-2 and an ACEC class of AC-2, for mobile groundwater. Given the TPS value of 4656.8% this corresponds to a value of DS-5 on Table C1. However, with reference to Step 8 in BRE SD1, a limitation can be applied if the sulphate class for the total potential sulphate is initially found to be Sulphate Class 5, but sulphate classes for groundwater and the water extracts tests are Sulphate Class 3 or less (as above). In this case, the Design Sulphate Class for the site location can be limited to DS-4.	
	SO4 2:1 Soil Extract (to nearest 100mg/l)	mg/l	20	12 to 923	-	600		
	Acid SO4	%	20	414 to 2430	-	1800		
	Total Sulphur (TP%S)	%	40	0.02 to 2828	-	1552.3		
	Total Potential Sulphate (TPS%S)	%	40	0.06 to 8484	-	4656.8		
	Groundwater	Mobile						
	DS Class	DS-2						
	ACEC Class	AC-4						

6.4. Summary of Geotechnical Material Properties

Table 6-12 - Summary of geotechnical parameters

Test Type	Parameter	Units	Made Ground	Alluvium/Head Deposits (undifferentiated)	River Terrace Deposits	Lowestoft Formation	New Pit Chalk/Holywell Nodular Chalk Formation (undifferentiated)	Holywell Nodular Chalk Formation	Zig Zag Chalk Formation	West Melbury Marly Chalk Formation
Index properties – fine grained fraction	Moisture Content (W)	%	18	20	13	14 to 23*	9.4 to 28*	9.8 to 33*	-	22 to 25*
	Liquid Limit (LL)	%	35	35	37	30 to 34*	25 to 35*	35 to 49*	-	29 to 37*
	Plastic Limit (PL)	%	18	20	20	17 to 21*	15 to 24*	21 to 27*	-	19 to 20*
	Plasticity Index (IP)	%	17	15	17	9 to 17*	9 to 18*	11 to 28*	-	9 to 18*
Classification (Particle Size Distribution, PSD)	Modified Plasticity	%	15	12	13	9 to 15*	8 to 15*	8.8 to 27*	-	9 to 17*
	Clay	%	36	20	10	-	-	-	-	-
	Silt	%	-	25	-	-	-	-	-	-
	Sand	%	27	35	35	-	-	-	-	-
Density testing	Gravel	%	37	20	55	-	-	-	-	-
	Cobbles	%	0	0	0	-	-	-	-	-
	Bulk density	Mg/m³	-	1.81	-	-	1.92	1.97	2.05	2.13
	Dry density	Mg/m³	-	1.35	-	-	1.51	1.60	1.72	1.83
Total stress (undrained)	Unit weight (unsaturated)	kN/m³	18	18	19	20	19	19	20	21
	Unit weight (saturated)	kN/m³	18	18	20	20	-	-	-	-
	Undrained Shear Strength, Cu	kN/m²	25	35	-	100	-	-	-	-
	Effective angle of internal friction, φ'	degrees	-	-	32	-	-	-	-	-
Effective Stress (Drained)	Constant volume effective angle of shearing resistance, φ cv,k	degrees	Derive locally	27	36 43 (borrow pit area)	28	33	33	31 (structureless) 34 (structured)	31 (structureless) 34 (structured)
	Angle of internal friction derived from CPT	degrees	-	36	39	-	-	-	-	-
	Constant volume (critical state) cohesion, c' cv,k	kPa	0	0	0	0	0	0	0	0
	Drained Stiffness, E'	MN/m²	7	9	-	20	-	-	-	-
Stiffness	Youns Modulus, Eu	MN/m²	11	15	-	33	2.5GPa (intact chalk)	5GPa (intact chalk)	10GPa (intact chalk)	12.5GPa (intact chalk)
	Coefficient of volume of compressibility, Mv (laboratory testing)	m²/MN	Derive locally	0.4	-	0.06	-	-	-	-
	Coefficient of Consolidation, Cv (laboratory testing)	m²/yr	Derive locally	1.5	-	Derive locally	-	-	-	-
	California Bearing Ratio (CBR)	%	1	2	-	3	15	15 (un-weathered) 2 (weathered)	10 (un-weathered) 2 (weathered)	15 (un-weathered) 2 (weathered)
Compaction Testing	Maximum Dry Density (MDD)	Mg/m³	-	-	9	-	-	-	-	-
	Optimum Moisture Content (OMC)	%	-	-	2.1	-	-	-	-	-
	Moisture Condition Value (MCV)	-	-	-	10	-	-	-	-	-
	Los Angeles Abrasion tests	%	-	-	26	-	-	-	-	-
Aggregate testing										
Environmental testing	Organic matter	%	0.5	4	0.6	-	-	-	-	-

<div><div><div><div></div><div>ATKINS</div></div><div><div>SNC-LAVALIN</div><div>Member of the SNC-Lavalin Group</div></div></div><div><div><div></div><div>ATKINS</div></div><div><div>SNC-LAVALIN</div><div>Member of the SNC-Lavalin Group</div></div></div></div>										
Test Type	Parameter	Units	Made Ground	Alluvium/Head Deposits (undifferentiated)	River Terrace Deposits	Lowestoft Formation	New Pit Chalk/Holywell Nodular Chalk Formation (undifferentiated)	Holywell Nodular Chalk Formation	Zig Zag Chalk Formation	West Melbury Marly Chalk Formation
Rock testing	Point load	MPa	-	-	-	-	0.08	0.12	0.15	0.09
	Uniaxial compressive strength, UCS	MPa	-	-	-	-	1.39	1.2	2.3	2
Chalk testing	Saturated moisture content, SMC	%	-	-	-	-	29	26	23	16
	Rock natural moisture content	%	-	-	-	-	30	28	25	19
Concrete Classification (Greenfield)	Chalk crushing value	-	-	-	-	-	-	-	3.5	-
	DS Class	-	DS-1	DS-2	DS-2	DS-1	DS-1	DS-1	DS-1	DS-2
	ACEC Class (mobile water)	-	AC-4	AC-4	AC-4	AC-4	AC-4	AC-4	AC-4	AC-4

Notes:

Values presented in this table are characteristic unless denoted by an Asterix as detailed below. Where there is a large variability of test results or insufficient test results to enable characteristic value derivation, representative average values for the unit are stated. The values stated for classification tests (e.g. Atterberg Limits and Particle Size Distribution (PSD)) are representative values for the strata rather than characteristic values to be used for design. Where no representative or characteristic values are available a dash (-) has been used to mark the cell as blank. For ranges of available test results reference should be made to the individual parameter table for each stratum.

* Representative value

** Due to the inherently variable nature of the material, values given are to be used only as a guide and must be derived locally where possible.

*** The design coefficient of volume compressibility should be determined at detailed design stage once loading has been confirmed

6.5. Hydraulic Conductivity

6.5.1. BRE 365 Soakaway testing

As discussed in Section 4.3.5 of this report, soakaway infiltration testing was carried out in the Zig Zag Chalk Formation (Haverhill Road PT Stop) and in the Holywell Nodular Chalk Formation (Travel Hub site).

As shown in Table 6-13, seven of the 12no. test locations had three repeat fills undertaken over the investigation period. During these periods, the required 75% and 25% effective storage depth intercepts were reached such that the tests were considered to be successful and in full accordance with the recommended practise given in BRE Digest 365 [22]. In accordance with BRE Digest 365 the lowest of the three soil infiltration rates (*f*) for these locations has been taken as the design value and have been assessed in more detail within Sections 6.5.1.1 and 6.5.1.2 below.

Where infiltration testing failed to reach the effective 25% storage depth over the testing period (TP-HRS-03, TP-TH-06, TP-TH-14) or where infiltration testing was impacted by time constraints (TP-TH-07 and TP-TH-09), an infiltration rate (*f*) could not be calculated. Where three consecutive tests could not be undertaken due to the reasons stated above, soil infiltration rates (*f*) have been given based on two repeat tests. These rates, however, are not in full accordance with the recommended practise given in BRE Digest 365 and should not be used for design. Therefore, these rates have not been included as part of the assessment within Sections 6.5.1.1 and 6.5.1.2 below.

Table 6-13 - Summary of soil infiltration testing data

Location	Trial Pit ID	Effective Test Depth (m)		Unit (CIRIA Chalk Grade)	Soil infiltration rate (m/s)			
		T25%	T75%		Test 1	Test 2	Test 3	Design value (<i>f</i>)
Haverhill Road PT Stop	TP-HRS-03	>500ltrs added per test, 1m head not established in 2.90m deep trial pits due to high infiltration.		ZZCH (Dc)	NR	2.4 x10 ⁻³	3.82 x10 ⁻³	*2.4 x10 ⁻³
	TP-HRS-03A			ZZCH (Dc)	1.87 x10 ⁻³	2.02 x10 ⁻³	1.30 x10 ⁻³	1.30 x10 ⁻³
	TP-HRS-04			ZZCH (Dc)	1.52 x10 ⁻³	1.08 x10 ⁻³	1.00 x10 ⁻³	1.00 x10 ⁻³
Travel Hub site	TP-TH-02	2.00	2.75	HNCK (Dc)	5.05 x10 ⁻⁵	5.06 x10 ⁻⁵	4.79 x10 ⁻⁵	4.79 x10 ⁻⁵
	TP-TH-04	2.07	2.50	HNCK (Dc)	1.85 x10 ⁻⁵	2.38 x10 ⁻⁵	1.72 x10 ⁻⁵	1.72 x10 ⁻⁵
	TP-TH-06	2.35	2.85	HNCK (Dc)	T50%/3hr	1.19 x10 ⁻⁵	2.63 x10 ⁻⁵	*1.19 x10 ⁻⁵
	TP-TH-07	2.10	2.70	HNCK (Dc)	1.11 x10 ⁻⁵	1.13 x10 ⁻⁵	NT	*1.11 x10 ⁻⁵
	TP-TH-08	2.58	1.73	HNCK (Dc)	4.01 x10 ⁻⁵	4.33 x10 ⁻⁵	4.33 x10 ⁻⁵	4.01 x10 ⁻⁵
	TP-TH-09	2.10	2.70	HNCK (Dc)	T30%/3hr	T40%/3hr	NT	ND
	TP-TH-11	2.67	3.00	HNCK (Dc)	2.37 x10 ⁻⁴	2.32 x10 ⁻⁴	1.72 x10 ⁻⁴	1.72 x10 ⁻⁴
	TP-TH-13	2.48	3.03	HNCK (Dm)	1.69 x10 ⁻⁴	2.49 x10 ⁻⁴	2.32 x10 ⁻⁴	1.69 x10 ⁻⁴
	TP-TH-14	2.53	1.81	HNCK (Dm)	T50%/5hr	T65%/7hr	NT	ND

Notes

ZZCH – Zig Zag Chalk Formation, HNCK - Holywell Nodular Chalk Formation

NR – No head established, NT – Test not undertaken due to time constraints, ND – not determinable

*In accordance with BRE 365 the lowest of the three soil infiltration rates (*f*) for each location should be used as the design value*

*Not in full accordance with BRE 365 where three consecutive tests were not undertaken, or the test did not reach 25% effective storage depth. *f* values have been given based on two tests, therefore should only be used for information purposes at this stage.

6.5.1.1. Haverhill Road PT Stop

Two locations were undertaken in full accordance with the recommended practise given in BRE Digest 365 within the Harverhill Road PT Stop site (TP-TH-03A and TP-TH-04). Calculated soil infiltration design values of 1.30 x10⁻³ m/s (TP-HRS-03A) and 1.00 x10⁻³ m/s (TP-HRS-04) indicate borderline medium to high permeability and good drainage conditions after Carter (1991) [23].

6.5.1.2. Travel Hub Site

Five locations were undertaken in full accordance with the recommended practise given in BRE Digest 365 within the Travel Hub site (TP-TH-02, TP-TH-04, TP-TH-08, TP-TH-11, TP-TH-13). Calculated soil infiltration design values range from 1.72×10^{-5} m/s (TP-TH-04) and 1.72×10^{-4} m/s (TP-TH-11). Results shown that locations to the north and northeast of the site (TP-TH-11 and TP-TH-13) show faster soil infiltration rates of $\times 10^{-4}$ m/s indicating borderline medium permeability and good drainage conditions. Whereas slower soil infiltration rates of $\times 10^{-5}$ m/s are shown in the centre and south of the site (TP-TH-02, TP-TH-04 and TP-TH-08) indicating borderline low to medium permeability and good drainage conditions after Carter (1991) [23].

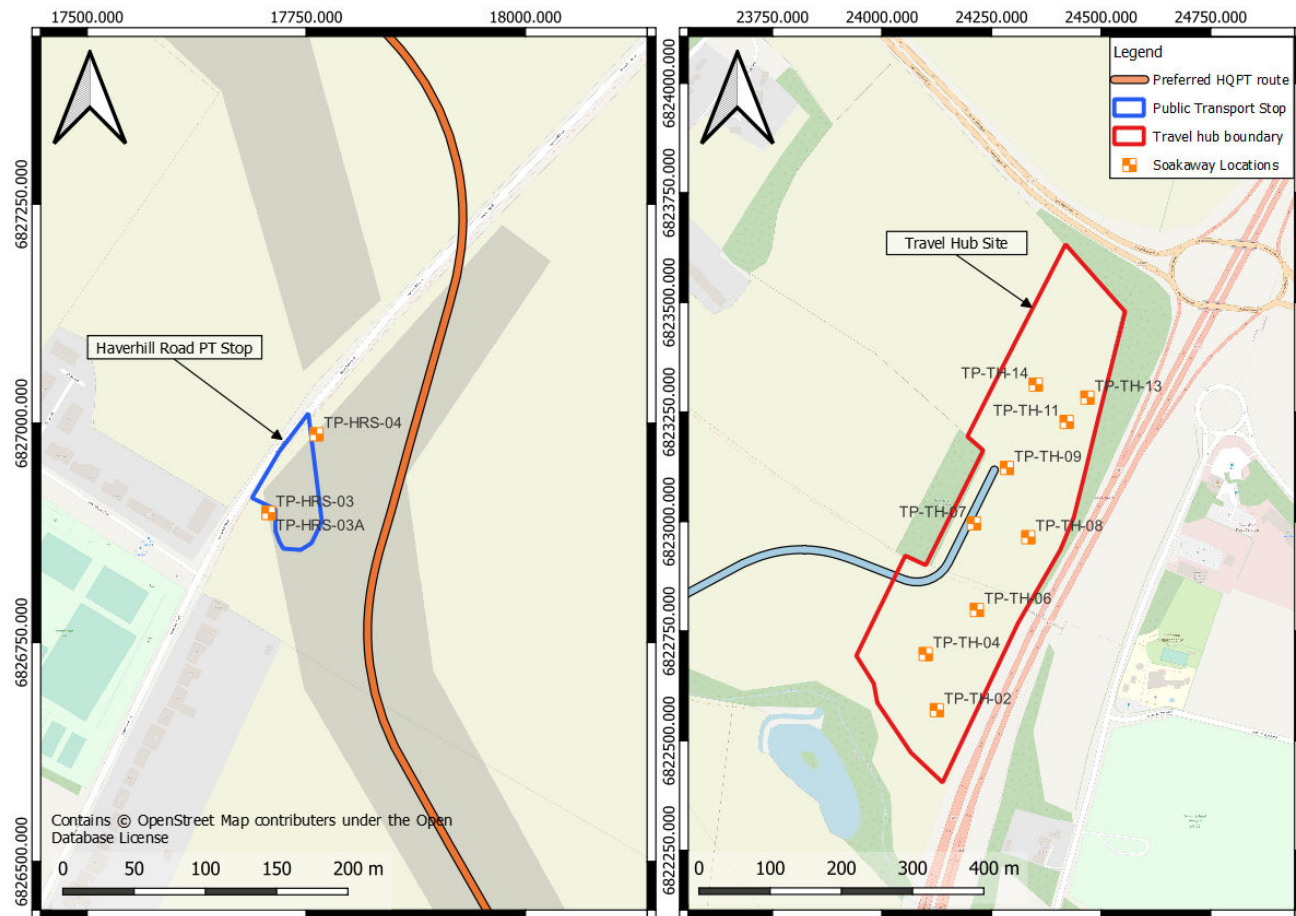


Figure 6-1 - Trial pit soakaway locations at the proposed Haverhill PT stop and the travel hub site

6.5.2. Downhole variable head testing

A single downhole falling head test was undertaken in BH-PTR-15 in the Zig Zag Chalk Formation between 1.7 to 3.0m bgl. The results are summarised below:

Table 6-14 - Summary of downhole permeability testing

Location/Section	Borehole ID	Casing Diameter (m)	Response Zone (m)	Target Formation	Soil Infiltration Rate (m/s)
3	BH-PTR-15	0.127	1.7 to 3.0	ZZCH	8.28×10^{-4}

7. Geotechnical Risk Register

7.1. Introduction and Rationale

Geotechnical risk is defined as the possibility of an adverse consequence arising from a ground hazard or circumstance.

The Geotechnical Risk Register takes into account the identified geotechnical constraints for the proposed works at the time, along with additional project details to ensure that all known significant geotechnical risks are identified, recorded, analysed and controlled. The geotechnical risks are discussed in terms of likelihood, severity and risk, as defined below:

- **Likelihood (L):** The perceived likelihood of the identified geotechnical hazard actually occurring (defined as a rating in Table 7-1.
- **Severity (S):** The perceived severity, in terms of capital cost, programme, safety, environment and reputation, of the occurrence of the identified geotechnical hazard on the identified receptor (s) (defined as a rating in Table 7-2.
- **Risk (R):** The perceived level of concern which should be assigned to the identified hazard, based on the likelihood of occurrence, and taking into account the perceived severity of the impact (defined as a risk number in Table 7-3.

The Geotechnical Risk Register is a semi-quantitative assessment based on engineering judgement. The classification of likelihood and severity used in this Geotechnical Risk Register are summarised in Table 7-1 and Table 7-2 respectively. The risk matrix uses the equation:

$$\text{Degree of Risk (R)} = \text{Likelihood (L)} \times \text{Severity (S)}$$

The explanation of the Degree of Risk is given in Table 7-3, which gives the assessed risk level and appropriate actions.

The hazards identified for this project are set out in the Geotechnical Risk Register. This is a 'live' document, which is to be updated regularly.

The Geotechnical Risk Register comprises an initial assessment of the risks identified, prior to the application of risk mitigation measures, and shows how the risks can be reduced by the application of the measures. It is assumed that future phases of site work will be under the control of a Principal Contractor appointed directly by Greater Cambridge Partnership during any ground investigation and construction phases of the works.

The Geotechnical Risk Register only includes geotechnical and geo-environmental risks. The mitigation measures considered are those that may be applied during design or construction, as appropriate, to mitigate the hazard identified. All risks should be reassessed during subsequent stages of the project as they may have changed since the issue of this report.

The overall risk ranking for each hazard is determined by the designer at both pre- and post-mitigation stage by considering the risk classification assigned to each risk aspect.

Following risk identification, assessment and the application of recommended mitigation/avoidance measures most risks can be revised and assessed as either "medium" or "low". In some cases, the risk may be reduced but a significant residual risk, i.e. Substantial or High Risk Classification, remains which must be managed.

The geotechnical risk register is presented in Table 7-5.

Table 7-1 - Likelihood Definitions

Scale	Likelihood	Chance
4	Probable	>50%
3	Likely	10% to 50%
2	Unlikely	1% to 10%
1	Negligible	<1%

Table 7-2 - Severity Definitions

Scale	Severity	Construction Impact	Operation/ Maintenance Impact	Environmental Impact	Safety
4	Very High	Construction unsustainable	Scheme operation unsustainable/deaths & serious injury	Major environmental incident – Threat to public health or safety	Unsustainable change of injury or illness
3	High	Significantly increased construction costs & operational difficulty	Increased scheme costs	Environmental incident triggers damage &/or nuisance prosecution and/or compensation	Increased chance of injury or illness
2	Low	Injury/Illness	Environmental incident triggers damage &/or nuisance prosecution and/or compensation	Third party environmental impact requiring management response to recover	Small chance of injury or illness
1	Very Low	Impact to costs/programme	Effect on scheme costs	Any environmental impact regarded as significant.	Negligible chance of injury or illness

Table 7-3 - Perceived Degree of Risk

Risk Number	Risk Ranking	Action Required
13 to 16	High (H)	Work must not start until risk has been reduced. If risk cannot be reduced, work should not begin.
9 to 12	Substantial (S)	Work must not start until risk has been reduced. Additional Resource required.
5 to 8	Medium (M)	Consider more cost-effective solutions or improvements at no extra cost.
1 to 4	Low (L)	None

Table 7-4 - Risk Matrix

Likelihood	Severity				
		1	2	3	4
	1	1	2	3	4
	2	2	4	6	8
	3	3	6	9	12
	4	4	M	12	16

Table 7-5 - CSET Geotechnical Risk Register.

Hazard Reference	Hazard	Location	Consequence	Phase of works affected	Initial Risk Level		Recommended mitigation measures	Residual Risk Level			
					Likelihood	Severity		Likelihood	Severity		
Geology and Geotechnics											
1	Ground conditions differ to those expected.	Site wide	Redesign required. Risk of programme delays Cost implications	Construction	3	2	1. GI carried out in accordance with relevant standards (BS5930, Eurocode 7). Interpretative ground models are provided in the GIR. 2. All reporting and geotechnical design should be undertaken in accordance with current standards and best practise and should take into account identified risks. 3. Geotechnical supervision to be present on-site during construction phase of works.	2	2	4	
2	Limited ground investigation along Option 1 route alignment, northeast and east of the proposed retirement facility.	Section 3, Ch. 3300-4100m	Uncertainty of design Risk of programme delays Cost implications	Construction	3	3	9	1. Limited ground investigation has been undertaken along Option 1 of the route options around the proposed retirement facility. The maximum distance of the deviation from the former preferred route is approx. 100m northeast. 2. Should proposed design change substantially or uncertainties regarding ground conditions, then a second phase of GI should be undertaken, targeting Option 1.	2	2	4
3	Mapped Alluvial deposits in GI, that differ from BGS mapping, are likely Head Deposits	Section 2, Section 3, Section 5	Uncertainty of design	Construction	3	3	9	1. Adequate GI and laboratory testing undertaken to inform material properties encountered on the scheme and engineering properties. 2. Assessment of engineering descriptions generally consistent with recorded Alluvium near BGS mapped deposits.	2	2	4
4	Presence of ground with shrink-swell potential (e.g. Alluvium, cohesive River Terrace Deposits, cohesive Lowestoft Formation)	Site wide	Redesign required. Post construction structural damage Risk of programme delays, long term maintenance	Construction and maintenance	3	2	6	1. Adequate GI and laboratory testing undertaken to inform material properties encountered on the scheme and engineering properties. 2. Groundwater level monitoring undertaken as part of the GI to inform fluctuation. 3. Mott MacDonald Report [6] indicates a very low hazard of shrink-swell clays in the Alluvium. However, the ground investigation results indicate a low to high volume change potential, the majority of results (50 out of the 59 samples) indicated low volume change potential. 4. The ground investigation results indicate low to high volume change in fine grained ALV, low volume change in fine grained RTD, and low volume change in LOFT. 5. All reporting and geotechnical design should be undertaken in accordance with current standards and best practise and should take into account identified risks. 6. Ground improvement to be designed and implementation if deemed necessary.	2	2	4
5	Presence of low strength and compressible ground conditions (e.g. Made Ground, Alluvium, Peaty material in the Alluvium near the River Granta along Section 4, cohesive River Terrace Deposits, Lowestoft Formation)	Site wide	Redesign required. Post construction structural damage Risk of programme delays, long term maintenance	Construction and maintenance	3	2	6	1. Adequate GI and laboratory testing undertaken to inform material properties encountered on the scheme and engineering properties. Exploratory holes (WLS+RC and CPT) have been targeted along areas where proposed bridge structures are to be constructed, crossing the River Granta, to investigate the nature of the Alluvium. 2. Undrained shear strengths of <50kN/m² were encountered within the majority of Alluvium across the scheme – indicating low to medium strength material (Table 9, BS 5930 [17]) 3. All reporting and geotechnical design should be undertaken in accordance with current standards and best practise and should take into account identified risks. 4. Should low strength material be encountered the use of ground improvement techniques may be required. 5. A competent contractor shall be employed to carry out the construction works. 6. Where unanticipated organic/peaty material layers are encountered at deep levels, a pile/concrete foundation installation technique is to take account and make allowance of this.	2	2	4

Hazard reference	Hazard	Location	Consequence	Phase of works affected	Initial Risk Level		Recommended mitigation measures		Residual Risk Level	
					Likelihood	Severity			Likelihood	Severity
							7. A geotechnical specialist to be present on site during construction phase of works in order to advise on any unforeseen ground conditions encountered and any potential redesigns required. 8. Additional verification of founding conditions, such as proof rolling of formation material, to be considered at design stage			
6	Risk of collapsible ground and landslips in Made Ground, Alluvium, River Terrace Deposits, Holywell Nodular Chalk and Zig Zag Chalk Formation	Site wide	Redesign required. Risk of injury to construction workers Post construction structural damage Risk of programme delays, long term maintenance	Construction and maintenance	2	3	6 1. Adequate GI and laboratory testing undertaken to inform material properties encountered on the scheme and engineering properties. 2. All reporting and geotechnical design should be undertaken in accordance with current standards and best practise and should take into account identified risks. 3. The Desk Based study [6] provided details of the risks of collapsible ground, where was determined to be very low for each given formation. 4. A competent contractor shall be employed to carry out the construction works. 5. Geotechnical supervision required to supervise excavation of materials. 6. No entry into excavations unless appropriately shored. 1. Adequate GI and laboratory testing undertaken to inform material properties encountered on the scheme and engineering properties. 2. Conservative values should be taken for geotechnical design. 3. Geotechnical design should be undertaken in accordance with current standards and best practise and should take into account identified risks.	1	2	2
7	Variable thicknesses and lithologies in the highly variable lithologies, such as Made Ground, Alluvium and the Lowestoft Formation.	Site wide	Causing instability and variable engineering properties of the soils. Structural implications. Risk of programme delays, cost implications	Construction and maintenance	3	2	6 1. Adequate GI undertaken to inform material properties, behaviour and anticipated distribution. 2. All works to be undertaken in accordance with current standards and best practice. 3. Where anticipated hard layers are encountered at shallow depth, appropriate pneumatic plant or localised blasting may be required for removal. The contractor should advise of the most appropriate technique where will be agreed with the Designer. 4. Walkover survey of route to identify areas of variable ground (e.g. shallow rock, glacial till, peat and organic clays) 5. Where anticipated hard layers are encountered at deep levels, pile foundation installation technique should take account and make allowances for this. Selection of conservative design parameters to allow for variable conditions.	2	2	4
8	Encountering hard layers, boulders and cobbles in the River Terrace Deposits and Chalk Group.	Site wide	Redesign required Risk of programme delays, cost implications	Construction	3	2	6 1. Adequate GI undertaken to inform material properties, behaviour and anticipated distribution. 2. All works to be undertaken in accordance with current standards and best practice. 3. Where anticipated hard layers are encountered at shallow depth, appropriate pneumatic plant or localised blasting may be required for removal. The contractor should advise of the most appropriate technique where will be agreed with the Designer. 4. Walkover survey of route to identify areas of variable ground (e.g. shallow rock, glacial till, peat and organic clays) 5. Where anticipated hard layers are encountered at deep levels, pile foundation installation technique should take account and make allowances for this. Selection of conservative design parameters to allow for variable conditions.	2	2	4
9	Excavation stability caused by running sand within the River Terrace Deposits, Lowestoft Formation and Alluvium.	Site wide	Programme delays, damage to equipment, injury or death.	Construction	3	3	9 1. Adequate GI undertaken to inform material properties, behaviour and anticipated distribution. 2. The Mott MacDonald Desk Study [6] indicates there is a low risk of running sands for Alluvium and very low for the remaining formations. 3. Excavation side stability measures will need to be taken into account for all excavations. Measures include dewatering, pumping, shoring and reducing the angle of the excavation sides.	2	3	6
10	Settlement of structures associated with excessive Made Ground located around the area of North Farm leading to Sawston Road	Section 4 and 5	Post construction structural damage Risk of programme delays, long term maintenance	Construction and maintenance	3	3	9 1. Adequate GI undertaken to inform material properties, behaviour and anticipated distribution. 2. Where necessary consider the risk appropriately in geotechnical design.	2	3	6
11	Differential Settlement of structures associated with highly compressible deposits e.g. Alluvium, cohesive River Terrace Deposits, Lowestoft Formation across the scheme, and peat	Site wide River Granta (Section 4, Ch. 5000m)	Post construction structural damage Risk of programme delays, long term maintenance	Construction and maintenance	3	3	9 1. Adequate GI undertaken to inform material properties, behaviour and anticipated distribution. 2. Where necessary consider the risk appropriately in geotechnical design.	2	3	6
12	Sensitive of cohesive material to moisture content Strength of cohesive superficial deposits (Alluvium, Fine grained River Terrace Deposits, Lowestoft Formation) ay change with moisture content	Site wide	Causing instability and variable engineering properties of the soils. Structural implications. Risk of programme delays, cost implications	Construction and maintenance	3	3	9 1. Adequate GI undertaken to inform material properties, behaviour and anticipated distribution. 2. Geotechnical design should be undertaken in accordance with current standards and best practise and should take into account identified	2	3	6

Hazard reference	Hazard	Location	Consequence	Phase of works affected	Initial Risk Level		Recommended mitigation measures		Residual Risk Level	
					Likelihood	Severity			Likelihood	Severity
			Implications				3. Geotechnical supervision required to supervise excavation of risks. materials.			
13	Presence of dissolution features within the chalk group and potential for near surface cavities within bedrock, leading to reduced rock strength, subsidence and collapse of structures and roads. Evidence of dissolution features noted in positions: BH-PTR-18, BH-TH-10, BH-PTR-45A, BH-TH-01, TP-TH-15, BH-TH-08, BH-OBC-10, BH-PTR-42	Section 3, 4, 5, 6 and Travel Hub site	Post construction structural damage Risk of programme delays, long term maintenance	Construction and maintenance	3	3	9 1. Obtaining further information from databases of locations of potential dissolution features by undertaking a Cavities Database Search. 2. The Mott MacDonald Desk Study indicates that risk from ground dissolution in the Chalk Group is Very Low. 3. A geotechnical specialist to be present on-site during construction phase of works in order to advise on any unforeseen ground conditions encountered and any potential redesigns required. All reporting and geotechnical design should be undertaken in accordance with current standards and best practise and should take into account identified risks. 5. CIRIA C574 Engineering in Chalk should be followed.	2	3	6
14	Settlement of proposed carriageway and potential voids beneath the carriageway caused by dissolution features within the Chalk Group	Site wide	Structural damage Risk of long-term maintenance costs, disruption and damage to reputation	Construction and maintenance	2	3	6 1. Adequate GI undertaken to inform material properties, behaviour and anticipated distribution. 2. Laboratory California Bearing Ratio (CBR) testing undertaken as part of the GI. Design pavement thickness to be determined in accordance with DMRB Highways Standards. 3. Plate Bearing tests to be undertaken in accordance with BS1377 Part 9 during construction to validate design CBR, at formation level. Should CBR achieved during construction validation testing to found lower than design CBR proposed, Client Engineer to be notified immediately. 4. Ground Improvement to be designed and implemented if deemed necessary, all potential voids to be infilled as required.	1	4	4
15	Unmapped folding and faulting of bedrock Chalk Group leading to area of increased weathering and low strength and potential groundwater/contamination pathways	Site wide	Redesign required Risk of programme delays, cost implications	Construction	2	3	6 1. GI carried out in accordance with relevant standards (BS5930, Eurocode 7). Interpretative ground models are provided in the GfR. 2. Should proposed design change substantially or uncertainties regarding ground conditions, then a second phase of GI should be undertaken. 3. All reporting and geotechnical design should be undertaken in accordance with current standards and best practise and should take into account identified risks. 4. Geotechnical supervision to be present on-site during construction phase of works.	2	2	4
16	Variable/poorly defined rockhead	Site wide	Risk of increased construction costs if rock is encountered at shallower depth than anticipated. Possible redesign required. Foundation issued or variable settlement	Construction and maintenance	2	3	6 1. GI carried out in accordance with relevant standards (BS5930, Eurocode 7). Interpretative ground models are provided in the GfR. 2. Should proposed design change substantially or uncertainties regarding ground conditions, then a second phase of GI should be undertaken. 3. All reporting and geotechnical design should be undertaken in accordance with current standards and best practise and should take into account identified risks. 4. Geotechnical supervision to be present on-site during construction phase of works.	2	2	4
17	Weathered rock within the Chalk Group	Side wide	Implication of piling in areas of non-intact rock and assumed zones of core loss from rotary boreholes in the Chalk Group as reported in the Tetra Tech Factual Report, [4] Redesign required Risk of programme delays, cost implications	Construction	3	3	9 1. Section of appropriately design parameters, construction control and appropriate geotechnical design.	2	3	6

Hazard reference	Hazard	Location	Consequence	Phase of works affected	Initial Risk Level		Recommended mitigation measures		Residual Risk Level	
					Likelihood	Severity			Likelihood	Severity
18	Piling in chalk leading to increased turbidity and creation of a potential pathway into the Principal Aquifer.	Proposed bridge structures	Environmental concerns Groundwater vulnerability Risk of programme delays Cost implications	Construction	3	3	9	1. Completion of a Piling Risk Assessment. 2. Hydrogeological mapping indicates the groundwater in the chalk is between 10mAOD to 20mAOD. 3. Geotechnical design should be undertaken in accordance with current standards and best practise and should take into account identified risks.	2	3
19	Frost susceptibility in chalk	Site wide	Structural damage Risk of long-term maintenance costs, disruption	Construction and maintenance	2	3	6	1. Adequate GI undertaken to inform material properties, behaviour and anticipated distribution. 2. All reporting and geotechnical design should be undertaken in accordance with current standards and best practise and should take into account identified risks. 3. CIRIA C574 Engineering in Chalk should be followed.	2	4
20	Aggressive Ground Conditions	Presence of Peat in Alluvium (around Ch. 5000m near River Granta) Presence of pyritised nodules and fossil burrows within the Chalk Group	Degradation and failure of any buried concrete elements over intended design life resulting in remedial works cost and disruption. Wear of concrete structures reducing the long-term design life of the structures.	Construction and maintenance	3	3	9	1. During recent GI, chemical testing was undertaken to establish aggressiveness to concrete. 2. Use appropriate concrete based on BRE Special Digest 1 (2005) concrete classes. Area/structure specific testing should be considered prior to construction. 3. Remedial methods such as lime treatment can be implemented to reduce pH of soil, if deemed necessary.	1	3
21	Ground conditions and geotechnical parameters not previously identified	Site wide	Programme delays, design changes, damage to equipment and reduced design life of structures.	Construction	2	3	6	1. GI and extensive laboratory testing carried out in accordance with relevant standards. Interpretative ground models are provided in the GIR. 2. Continual monitoring and logging of excavations during construction, with frequent liaison with an engineering geologist or geotechnical engineer.	2	2

Hydrogeology										
22	Shallow groundwater	Section 2 and Section 4	High groundwater level not considered in the design potentially causing failure or inadequate performance over design life resulting remedial works cost and disruption. Excavation during construction flooding due to high groundwater level resulting in delay and increased cost to construction works.	Construction	3	3	9	1. Groundwater information was obtained during the recent GI. 2. Available information to be considered during the design development, particularly in Section 2 where the majority of groundwater levels on return monitoring rounds where less than 1.0m bgl. and in Section 4 where the majority of groundwater levels on return monitoring rounds were less than 1.5m bgl. 1. Ground water measures to be undertaken during excavation and construction. Active dewatering should not be carried out unless agreed with the Client in advance. 1. Dewatering or pumping equipment to be available during construction of excavations. 2. Excavation side stability measures will need to be considered for all excavations. Measures include sheet pile cut-offs, shoring and reducing the angle of the excavation sides. 3. As per Section 2.6 of this report, much of the site is located in medium to high risk flooding areas associated with the River Granta. The contractor should be made aware of this so that they may plan their works accordingly.	2	3
23	Flooding of excavations	Site wide	Programme delays, damage to equipment and injury	Construction	3	3	9		2	3
24	Flotation of structures due to relatively high groundwater	Section 2 and Section 4	Leading to damage of structures and reduced design life of the structures.	Construction and Maintenance	2	3	6	1. Flotation measures will need to be taken into account during design, including the thickness and load of the base slabs and the fill surrounding any proposed shallow structures/infrastructure.	2	4

Hazard reference	Hazard	Location	Consequence	Phase of works affected	Initial Risk Level		Recommended mitigation measures		Residual Risk Level	
					Likelihood	Severity			Likelihood	Severity
25	Flooding caused by low lying topography and high water table and presence of surface water courses	Hobsons Brook River Granta	Redesign required. Risk of programme delays, cost implications	Construction and Maintenance	2	3	6	1. Comprehensive desk study, site investigation and detailed laboratory testing has been carried out to help identify and understand the seasonal variations in ground and surface water at the site. The desk study [6] indicates Flood Zone 2 and 3 within the site boundaries associated with groundwater flooding and surface water flooding, discussed in Section 2.6 of the GIR. 2. The Designer is to use this information to mitigate the risk of flooding to the project accordingly. 3. Hydrogeologist to be employed onsite during the construction phase to advise on any unforeseen groundwater conditions and to assist in any redesigns required. 4. Impacts of climate change and accidental groundwater conditions shall be taken forward in detailed design.	2	4
Structures										
26	Encountering existing buried foundations inhibiting excavation of trenches	Site wide	Risk of programme delays Cost implications Wear of equipment	Construction	2	3	6	1. Historical works encountered may need to be removed during the construction phase. 2. Contractor should remain vigilant when excavating in Made Ground across the site and be aware of the chance of unidentified obstructions. 3. Breakers should be employed on site for the excavation of the trench in order to break through encountered hard grounds. 1. Review detailed buried service plans. 2. A competent Contractor to CAT and Genny scan prior to and during any excavation to determine the location of any expected or unexpected buried services.	2	4
27	Buried services not identified on the available service plans	Site wide	Programme delays, damage of equipment or infrastructure, injury or death.	Construction	4	3	12	3. The Contractor should obtain from the Employer the latest statutory services plans and positively identify all services prior to commencing any excavations. 4. Any works undertaken in the vicinity of existing buried services shall be undertaken in accordance with the statutory undertakers requirements and the recommendations of HSG 47 'avoiding danger from underground services'.	3	9
28	Encountering Unexploded Ordnance	Site wide	Programme delays, damage of equipment, injury or death.	Construction	3	4	12	1. The Preliminary UXO Risk Assessment identified the potential for unexploded WWI and WWII ordnance to exist at the site, as being Likely. However, no UXO was encountered during the GI. 2. Brief all personnel involved with the intrusive works on the types of UXO that might be encountered, the associated risks of discovery and the actions to be taken if an UXO is encountered. 3. The presence of shallow bedrock, findings of recent GIs adjacent to the site and previous site development, suggest that the presence of unexploded ordnance is unlikely. 4. Contractor to remain vigilant during construction. 5. Have an UXO specialist, equipped with a hand-held magnetometer on site for the initial intrusive construction works, if deemed necessary by the Contractor. Both Preliminary and Detailed UXO Survey has been undertaken for the site as detailed within the Mott MacDonald Desk Study [6].	1	4

The Geo-Environmental risk register is set out in Atkins report (ref. GCP_5210174_A1307 Cambridge South East Transport_CLRA), which is appended to this report in Appendix E, discussing presence of contaminated land, groundwater and ground gas assessment.

8. Preliminary Engineering Assessment and Recommendations

8.1. Introduction

Geotechnical activities proposed as part of the scheme include:

- Bridge foundations (deep foundations)
- Retaining structures, retaining up to 1.5m of material in Section 1
- Earthworks - cuttings up to 1.5m, and embankments up to 6m
- Culverts
- Public Transport Stops
- Travel Hub Site to include 1,250 car park spaces, electric vehicle charging facilities, cycle parking spaces, bus shelters and drop off area

This section provides a preliminary assessment of the proposed geotechnical activities associated with the CSET preliminary design and highlights any risks that may be associated with these activities given the ground conditions local to their proposed locations. Reference has been made to the Mott MacDonald preliminary travel path corridor design [8] throughout. Bridge and structure location and descriptions, as well as reference to relevant drawings, have been set out in Mott MacDonald report Table 7.1 and detailed within this section.

Earthwork and retaining heights have been obtained from drawings produced by Mott MacDonald, drawing references 403394-MMD-HWA-00-DR-HW-0925-P2 to -0943-P2, which are included in Appendix A. A Geotechnical Design Report should be produced as part of detailed design and will need to consider the outcomes of this preliminary engineering assessment.

This section of the report should be read in conjunction with the cross and long sections provided as part of Appendix B. The relevant ground model numbers for each structure have been provided where necessary.

8.2. Bridge foundations

Four bridges are proposed along the scheme and are also proposed to be built on either spread footings or piled foundations. The choice of foundation type is dependent on space constraints, foundation loading and predicted overall and differential settlement.

The location of the bridges and anticipated geology is detailed within Table 8-1.

Table 8-1 - Summary of bridge locations and geotechnical considerations

Route Section	Description	Mott MacDonald structure number [8]	Chainage (m)	Anticipated strata (m bgl)	Relevant ground model (drawing number) in Appendix B
2	Single span bridge for active travel path – proprietary bridge solution	3	666 to 670	Made Ground (0.0 to 1.3) Alluvium (1.3 to 2.7) West Melbury Marly Chalk Formation (2.7 to >10.7)	5212868-ATK-VGT-WHL_AL_SCHME-DR-CE-00002
	Single span bridge crossing Hobsons Conduit – concrete composite bridge	4	874 to 917	Made Ground (0.0 to 0.5) Alluvium (0.5 to 2.5) West Melbury Marly Chalk Formation (2.5 to >16.5)	5212868-ATK-VGT-WHL_AL_SCHME-DR-CE-00003
4	Single span Stapleford Bridge over River Granta in Flood Zone 3 – multispan viaduct	6	4836 to 5057	Made Ground (0.0 to 1.0) Alluvium (1.0 to 3.5) River Terrace Deposits (3.5 to 6.0) Zig Zag Chalk Formation (6.0 to 28.0)	5212868-ATK-VGT-WHL_AL_SCHME-DR-CE-00010

Route Section	Description	Mott MacDonald structure number [8]	Chainage (m)	Anticipated strata (m bgl)	Relevant ground model (drawing number) in Appendix B
				West Melbury Marly Chalk Formation (>28.0)	
6	Bridge over River Granta	8	8468 to 8683	Made Ground (0.0 to 0.5) Alluvium (0.5 to 1.5) River Terrace Deposits (1.5 to 4.0) Holywell Nodular Chalk Formation (4.0 to 21.0) Zig Zag Chalk Formation (>21.0)	5212868-ATK-VGT-WHL_AL_SCHME-DR-CE-00017

The main overarching geotechnical considerations for all bridge foundation across the scheme are as follows:

- It is anticipated that the bridge foundations will be piled given the depth of Alluvium and compressible deposits (>2.5m thick).
- Lateral and vertical variability within the Alluvium; and within the geology of the Undifferentiated River Terrace Deposits, which is likely result in these units to be highly compressible and at risk of settlement;
- Drilling induced voids and running sands are likely to be encountered in the coarse-grained Alluvium and River Terrace Deposits, caused by high groundwater;
- Lateral and vertical variation, low strength, low to intermediate plasticity clay in Section 2, low to extremely high plasticity clay in Section 4 and low to very high plasticity clay in Section 6, and the potential for volume change within the Alluvium should all be considered during design (Low to medium volume change potential in Section 2, low to high volume change potential in Section 4 and low and high-volume change in Section 6);
- High groundwater <1-1.5m bgl along Section 2 and Section 4 from long term monitoring results;
- The weathering profile of the Chalk Group is likely to possess reduced shear strengths. Foundations are recommended to be avoided in structureless chalk. Piles design to be based on friction rather than end bearing where the CIRIA Engineering grade varies with depth;
- Dissolution features within the Chalk (BH-PTR-18 in Section 3, BH-PTR-42 in Section 4, BH-PTR-45A in Section 5, BH-OBC-10 in Section 6 and BH-TH01, -08, -10 and -15 in the Travel Hub site). The location of the potential dissolution features, noted from anecdotal evidence on engineering logs, is presented on a drawing within Appendix A;
- Ground Conditions should be assessed for the suitability of pile types. An options appraisal should be undertaken to determine the most suitable piling method;
- Piles may be favourable to reduce differential settlement across the bridge structure; and,
- All concrete should be designed to withstand extremely aggressive pH and sulphate conditions especially in areas containing peat and chalk with sulphide rich nodules.

8.3. Culverting of existing drains

Three existing drains along the scheme require to be culverted. The location of these, chainage and anticipated ground conditions based on the ground models set out in this report are detailed below.

Table 8-2 - Summary of proposed culvert locations and geotechnical considerations

Route Section	Description	Mott MacDonald structure number [8]	Chainage (m)	Anticipated strata (depth in m bgl)	Relevant ground model (drawing number)
2	Combined culvert – concrete culvert 2.0m wide x 1.0m wide x 45.0m long	2	666 to 670	Made Ground (0.0 to 1.3) Alluvium (1.3 to 2.7) West Melbury Marly Chalk Formation (2.7 to >10.7)	5212868-ATK-VGT-WHL_AL_SCHME-DR-CE-00002
4	Culverting of existing drain- concrete culvert 4.5m wide x 3.0m high x 32.0m length	5	4784 to 4789	Made Ground (0.0 to 1.0) Alluvium (1.0 to 3.5) River Terrace Deposits (3.5 to 6.0) Zig Zag Chalk Formation (6.0 to 28.0) West Melbury Marly Chalk Formation (>28.0)	5212868-ATK-VGT-WHL_AL_SCHME-DR-CE-00010
	Culverting of existing drain – concrete culvert 4.0m wide x 1.5m high x 31m length	7	5410 to 5414	Made Ground (0.0 to 0.5) Alluvium (0.5 to 2.5) River Terrace Deposits (2.5 to 4.25) Zig Zag Chalk Formation (>4.25)	5212868-ATK-VGT-WHL_AL_SCHME-DR-CE-00011

The variable nature of the ground at these locations are to be given consideration in a Geotechnical Design Report (GDR); the main consideration points are as follows:

- Variability within the Made Ground and Alluvium should be considered;
- Lateral and vertical variation, low strength, low to intermediate plasticity clay in Section 2 and low to extremely high plasticity clay in Section 4; and the potential for volume change within the Alluvium should all be considered during design (Low to medium volume change potential in Section 2 and low to high volume change potential in Section 4);
- High groundwater <1.5m bgl along Section 2 and Section 4 from long term monitoring results;
- Lateral and vertical variation within the Alluvium and River Terrace Deposits should be considered; and
- Any concrete should be designed to withstand extremely aggressive pH and sulphate conditions.

8.4. Retaining structures

Retaining walls are expected in the following locations, detailed in Section 11.4 of the Mott MacDonald Corridor Design Report [8]:

- Along the length of existing Multi-Storey Car Park to the south of Dame Mary Archer Way Road (Approximately 1m of fill to be retained);
- Earthworks or retaining wall to the north-west side of Francis Crick Avenue near the Cambridge South Station site;
- Tie in with earthworks and proposed retaining wall adjacent to Addenbrooke's Road (Approximately 1.5m of fill to be retained); and,
- Embankments up to 6m high are in located in areas of the proposed bridges that cross the River Granta in two locations.

Where anticipated earthworks height is limited, gravity wall or gabion retaining wall solutions are expected to be sufficient. Where the height of the anticipated earthworks is significant (up to 6m along some sections) alternative methods of gravity solutions, such as cantilever walls, counterfort walls or sheet piles could be adopted.

Design will need to consider stability and settlement, as well as area of anticipated high groundwater, and particularly in areas of soft ground, such as alluvium, increased wall width or founding depth may be required. Where there are limitations with regards to space, or ability to excavate, such as significant temporary excavation, other solutions such as reinforced earthworks or embedded or piled walls may be considered as an alternative.

8.5. Earthworks

The current design of the embankment and cuttings is based on having side slopes of 1:4 [8], which are shown in the general arrangements in Appendix A. A summary of the filling and cutting works is presented below:

- Section 2 - Earthworks – embankments up to 2.5m high and cuttings between 0.5-1.0m.
- Section 3 - Earthworks – embankments up to 1.0m high and cuttings up to 2.8m.
- Section 4 - Earthworks – embankments up to 5.1m high and cuttings up to 0.5m.
- Section 5 - Earthworks – filling works up to 0.5m.
- Section 6 - Earthworks – filling works up to 6.0m.

The anticipated stratum at formation level of proposed embankments and the cut slopes are as follows:

- Alluvium
- River Terrace Deposits
- Holywell Nodular Chalk Formation
- Zig Zag Chalk Formation

Embankment founding conditions along the route are variable. Where relatively soft ground, such as the Alluvium deposits occur, this presents a risk of settlement and or embankment instability. In these areas mitigation measures may be required, such as excavation and replace or ground improvement to ensure that the risk of settlement is appropriately mitigated. The more competent coarse grained River Terrace Gravel Deposits is expected to provide competent founding conditions.

Using the information contained within this report, it is anticipated that slope stability analysis at detailed design stage will allow those slopes to be steepened. This may also lead to currently proposed retaining solutions no longer being required at some locations following detailed design. Any changes to the proposed design should be included in a Geotechnical Design Report (GDR).

8.6. California Bearing Ratio for pavements subgrade

Currently the preliminary design CBR for the scheme is 3%, as set out in the Mott MacDonald Travel Path Corridor Report [8] and discussed in Section 6 of their report detailing proposed thicknesses of subgrades. A design life of 40 years has been assumed as per CD 226 – Design for New Pavement Construction [37]. However Characteristic CBR values have now been assessed and are presented in the Geotechnical Parameter tables of Section 5-11 of this report.

Caution should be adopted when using the in-situ test results for the derivation of preliminary CBR values, due to the potential for seasonal influence to affect the results. Surface stiffnesses may either increase or decrease due to changes in the in-situ moisture content (the investigation was undertaken during summer 2021).

Also, where assessing Made Ground materials, the presence of larger particles (coarse gravel and cobbles); which were noted in the material description, could affect the test results by indicating a false high value.

Once pavement levels have been finalised the design CBR value will need to be determined from available testing and with reference to published literature, taking consideration of the seasonal and in situ moisture conditions at the time of construction. Removal of vegetation and exposure of the subgrade as part of construction may also result in a potential increase in moisture, which may also lead to a decrease in surface stiffness.

Where poor subgrade conditions occur, mitigation such as increased pavement thickness, capping, or local dig out, could be considered.

As with all such schemes, during construction, the formation (founding level) of all pavements must be inspected by the geotechnical site representative to confirm the pavement design assumptions. CBR testing will also be required to verify Design CBR values using direct field CBR test methods. Where the result of any in-situ CBR test is below that of the design CBR a redesign will be required, potentially incorporating improvement measures. Note, if values obtained are higher, a reduction in pavement thickness should not be undertaken.

It is recommended that further CBR/Plate Bearing tests are carried out prior to the construction phase in order to target specific areas of the scheme proposed for carriageway widening that were not targeted during the 2021 ground investigation [4].

8.7. Soils infiltration rates

As discussed in Section 6.5, infiltration testing was carried out in the out in the Zig Zag Chalk Formation (Haverhill Road PT Stop) and in the Holywell Nodular Chalk Formation (Travel Hub site).

Table 8-3 - Summary of soil infiltration rates

Stratum	Location	Design soil infiltration rate (m/s)
Zig Zag Chalk Formation	Haverhill Road PT Stop	1.00x10 ⁻³
Holywell Nodular Chalk Formation	Travel Hub site	1.69x10 ⁻⁴ (north and northeast) 1.72x10 ⁻⁵ (centre and southeast)

In accordance with BRE 365 [22] the lowest of the three soil infiltration rates (*f*) for each location should be used as the design value, as shown in Table 6-13. Should final soakaway locations change during detailed design then consideration should be given to confirmation of the ground conditions and soil infiltration at that new location.

Guidance in CIRIA 574 Engineering in Chalk recommends that soakaways in low density chalk are located at least 10m away from any foundations and roads unless solution features are deemed to be prevalent within an area. In areas where dissolution features are expected, soakaways should be avoided so as not to induce erosion and thereby trigger a collapse. Water pipes and foul and surface water drains should be constructed with flexible pipes and joints. If the requirement for soakaways is unavoidable, they should be sited at least 20m away from any foundations.

The location of soakaway test exploratory locations and the locations of potential dissolution features is presented in Appendix A.4. The figure shows that evidence of dissolution features was noted in areas where soakaway testing was undertaken, summarised below:

- Section 3 in BH-PTR-18 which is in proximity to Haverhill Public Transport Stop and located approximately 70southeast of TP-HRS-03A
- Travel hub Site in BH-TH-15 (located 100m northeast of TP-TH-14), BH-TH-10 (located 25m north of TP-TH-13) and BH-TH-01 (located 40m southeast of TP-TH-07).

Given the low-grade classification of the chalk in the soakaway locations (Table 6-13), further works will be required to fully assess the risk of solution features to structures which is discussed in Section 8.10.

8.8. Site won material for re-use (earthworks)

In accordance with the guidance and material properties required for acceptability, as presented within the Specification for Highways Works (SHW) Series 600 [38], materials encountered on site have been classified according to their potential suitability for re-use as site-won fill.

All re-use of site-won material will be undertaken under a Materials Management Plan (MMP), reviewed and submitted by a Qualified Person (QP), with appropriate re-use criteria developed for determining the chemical suitability of the excavated materials.

Based on geotechnical testing available of classification tests the class of materials is summarised below for each strata in Table 8-4.

Table 8-4 - Summary of earthworks class to SHW (Series 600)

Stratum	Class (SHW Series 600) [38]	General Material Description
Alluvium (fine grained)	2A&B	Wet and dry cohesive fill
Alluvium (coarse grained)	2C	Stony cohesive fill
River Terrace Deposits (fine grained)	2A&B	Wet and dry cohesive fill
River Terrace Deposits (coarse grained)	1B	Uniformly graded granular

Stratum	Class (SHW Series 600) [38]	General Material Description
		material
Chalk Group	3	Chalk

Table 8-5 - Summary of earthworks class for Chalk Group from CIRIA C574 [36]

Stratum	Greenwood (1993) classification	Toombs and Snowden (1997)	Method of Compaction (Figure 5.8 CIRIA C574)
New Pit/ Holywell Nodular Chalk Formation	CB, CC, CD	B-D	4
Holywell Nodular Chalk Formation	CB, CC, CD	A-D	1,4
Zig Zag Chalk Formation	CA, CB, CC, CD	A-C	1
West Melbury Marly Chalk Formation	CA, CB,	A	1

Grading curves for suitability of fill material is presented in Appendix C (C.4).

Suitable site-won materials may also be re-used as ‘Landscape 4’ Class 4 and ‘Topsoil’ Class 5.

It is anticipated that on-site processing will be required to render certain site-won fill suitable for re-use. This will be undertaken under appropriate environmental permitting where applicable.

The potential for re-use of site-won material will also depend on the manner in which excavations are formed. Unless segregation of different materials can be undertaken at source, it is likely that re-use of fill will be limited by the various constituent materials at any location.

The potential for re-use of site-won fill material will also vary seasonally and comparison of the potential for re-use based on moisture content recorded at the time of the 2021 GI should take into consideration seasonal effects.

For the use of chalk in earthworks, reference should be made with Section 5 of CIRIA 574 – Engineering in Chalk. The chalk for this scheme has been classified based on moisture content and dry density, which plots can be found within Appendix C (C.19), where most chalks tested are between low to high density and Grades A-D, which is summarised in Table 8-5.

With reference to the classification schemes proposed in CIRIA C574 and Manual of Contract Documents for Highways Works (MCHW) Volume 1, Series 600 – Earthworks, the results of the IDD and SMC testing, the chalk deposits are indicated to be greater than 30% of the excavation and are classified as Class 3 in Table 6/1 of the MCHW 1. The laboratory testing data and the field descriptions indicates the shallow chalk to be Groups A, B and D (utilising Figure 5.7 in CIRIA C574), therefore the compaction method required, in Figure 5.8 of CIRIA C574, is recommended to be Method 1 (for Groups A and B) and Method 4 (for Group D) in Table 6/4 of the Specification for Highways Works (SHW).

A review of the range of OMC’s against natural in situ water contents for the River Terrace Deposits exhibit that, on average, both the natural moisture contents and OMC were similar.

The maximum dry density of the River Terrace Deposits ranges between 2.07 to 2.11Mg/m³, with a moisture condition value (MCV) range of 1 to 14.5.

Once development levels and excavation volumes have been confirmed, and should re-use be required, validation testing should be undertaken in accordance with the guidelines provided within SHW Series 600 and the re-use criteria developed for the MMP, to confirm these preliminary classifications. Should validation testing find that site-won materials are unsuitable for the proposed use (both geotechnically and geo-environmentally), import of suitable engineering fill will be required.

8.9. Ground Aggressivity

Using the guidance provided in BRE SD1 [35], the following classifications have been given to each strata type:

Table 8-6 - Summary of ground aggressivity

Stratum	Design Class	ACEC (mobile water)
Made Ground	DS-1	AC-4
Alluvium /Head Deposits (undifferentiated)	DS-2	AC-4
River Terrace Deposits	DS-2	AC-4
Lowestoft Formation	DS-1	AC-4
New Pit/ Holywell Nodular Chalk Formation	DS-1	AC-4
Holywell Nodular Chalk Formation	DS-1	AC-4
Zig Zag Chalk Formation	DS-1	AC-4
West Melbury Marly Chalk Formation	DS-2	AC-4

High sulphate concentrations were encountered within all formations attributed to the presence of sulphate rich minerals such as pyrite and high organic content, which increases the ACEC classification of the concrete.

8.10. Summary and considerations

The ground conditions across the site are variable. However, the proposed geotechnical activities are relatively simple and as such the ground conditions are not considered to present exceptional geotechnical risk.

It is recommended that prior to detailed design a site walkover by an engineering geologist should be undertaken to further assess the geomorphology of the site.

The following however should be considered carefully at geotechnical design stage:

- The variability of the thickness of Made Ground across the scheme (Route Section 4 and 5);
- Potential soft layers and variable thickness of Alluvium across the scheme (Route Section 4 and 6);
- Potential for volume change within the Alluvium/Head Deposits (undifferentiated) and Lowestoft Formation;
 - The majority of samples from the Tetra Tech Report indicate a Low Volume Change for the Alluvium/Head Deposits. A High Volume Change Potential should be adopted for the Lowestoft Formation as limited samples were undertaken.
- The Alluvium and Head Deposits have the potential to be highly compressible and may be at risk of settlement;
- Presence of peat and organic rich soils within Alluvium in proximity to the River Granta, northwest of North Farm, and within the ‘Borrow Pit’ area in Route Section 4;
- The variability of the interbedded fine and coarse layers, both laterally and vertically, within the River Terrace Deposits and the Alluvium/Head Deposits (undifferentiated);
- Elevated sulphate levels detected sporadically across the Scheme, linked to aggressivity of the ground conditions, Alluvium containing organic matter and pyritised fossils identified throughout the Chalk Group;
- Near-surface shallow groundwater levels (<1.0m bgl) are to be expected in Sections 2 and 3. Groundwater levels up to 1.5m bgl are expected in Route Section 4, whereas deeper (>1.5m bgl) groundwater levels were encountered in monitoring in Route Sections 5, 6 and the Travel Hub site;
- Management of perched water/groundwater will therefore likely be required;
- Consideration should be given to running sands and high groundwater within the coarse-grained Alluvium and the River Terrace Deposits;

- Weathering profiles within the Chalk Group need to be considered during design, structureless chalk is usually encountered within the first 2.0 to 5.0m with CIRIA Engineering Grade increasing with depth;
- Dissolution features may be present in Route Sections 3, 4, 5, 6 and the northwest and northeast of the Travel Hub site identified by preliminary assessment of the DTM Lidar model and the Tetra Tech engineering logs;
 - It is recommended that further information is obtained from databases of the location of dissolution features by undertaking a Cavities Database Search.
 - It is recommended that a detailed site walkover is undertaken, following detailed assessment of DTM Lidar information and the Cavities Database Search, by an experienced Engineering Geologist comprising a geomorphological mapping exercise with particular consideration on assessing land movement and dissolution features.
 - Should areas of risk of dissolution features be identified during the walkover, an initial non-intrusive geophysical survey can be undertaken in areas highlighted from the walkover.
 - Following the assessment of the geophysical data and where possible dissolution features are identified, an intrusive targeted ground investigation by Super Heavy Dynamic Probing (SHDP) may be undertaken.
- River Terrace Deposits (fine grained) and Alluvium/Head Deposits (undifferentiated) may be classified as ‘General (Wet & Dry) Cohesive Fill’ Class 2A/B, River Terrace Deposits may be classed as ‘Uniformly graded granular fill’ Class 1B and Chalk is classes as Class 3;
- All site-won materials for reusability will require drying prior to placement;
- All site-won materials will be reused under a suitable Material Management Plan (MMP) – reviewed and submitted by a Qualified Person (QP) – with related re-use criteria;
- Infiltration rates determined for the Holywell Nodular Chalk Formation and the Zig Zag Chalk Formation may not be representative across the whole Scheme as soakaway testing only undertaken in Sections 3 (Haverhill Public Transport Stop) and the Travel Hub Site;
- Guidance in CIRIA 574 Engineering in Chalk recommends that soakaways in low density (Grade D) chalk are located at least 10m away from any foundations and roads. In areas where dissolution features are expected, soakaways should be avoided or if the requirement for soakaways is unavoidable, they should be sited at least 20m away from any foundations.
- Should final soakaway locations change during detailed design, then consideration should be given to confirmation of the ground conditions and soil infiltration at any new locations;
- Interactions with existing structures is likely to occur in Section 1 of the scheme and through North Farm in Route Section 4;
- The interpretation of the ground conditions and the derivation of geotechnical parameters across the Scheme for design has been undertaken based on technical principles and standards of engineering practice. Due to the inherently variable nature of the stratum encountered engineering judgement should be considered at a localised scale; and,
- An options appraisal should be undertaken to determine most suitable piling method.

9. References

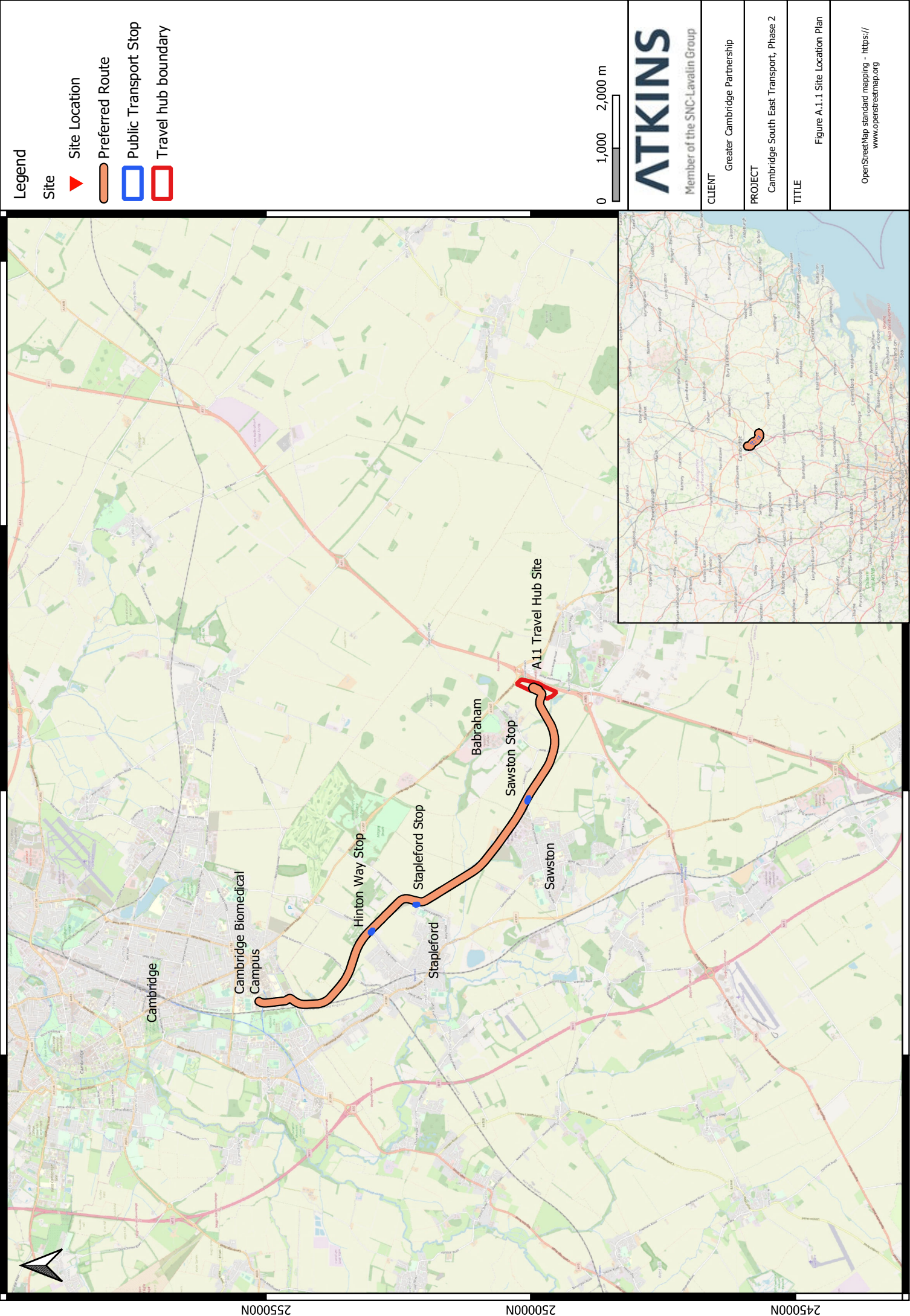
- [1] British Geological Survey, "Geoindex Onshore," British Geological Survey, 2020. [Online]. Available: <https://mapapps2.bgs.ac.uk/geoindex/home.html>. [Accessed 01 August 2022].
- [2] British Geological Survey, *1:50 000 Series Solid and Drift Geology Map (England and Wales Sheet 205, Saffron Walden)*, Nottingham: Keyworth: British Geological Survey, 2002.
- [3] Mott MacDonald Ltd, "Cambridge South East Transport - Phase 2, Ground Investigation Specification, 403394-MMD-HWA-00-RP-HW-0462," Mott MacDonald Ltd, Norwich, October 2020.
- [4] Tetra Tech, "Cambridge South East Transport - Phase 2, Factual Ground Investigation Report, B024522," Tetra Tech, London, April 2022.
- [5] Highways England, "CD 622 Managing Geotechnical Risk," Highways England, London, 2020.
- [6] Mott MacDonald Ltd, "A1307 Cambridge South East Transport - Phase 2, Geotechnical and Geo-Environmental Preliminary Risk Assessment, 403394-MMD-TGE-00-RP-GE-0248," Mott MacDonald Ltd, Norwich, December 2019.
- [7] Greater Cambridge Partnership, "Cambridge South East Transport – Phase 2, Project Update," July 2020. [Online]. Available: <https://www.greatercambridge.org.uk/asset-library/Sustainable-Transport/Public-Transport/Cambridge-South-East-Transport/Documents-2020/CSET-PH-2-project-update-July-2020.pdf>. [Accessed 23 September 2022].
- [8] Mott MacDonald Ltd, "Cambridge South East Transport Phase 2, High Quality Public Transport and Active Travel Path Corridor Design, 403394-MMD-HWA-00-RP-HW-0846 | P01," Mott MacDonald Ltd, Norwich, May 2021.
- [9] Greater Cambridge Partnership, "Cambridge South East Transport," 2022. [Online]. Available: <https://www.greatercambridge.org.uk/sustainable-transport-programme/public-transport-schemes/cambridge-south-east-transport>. [Accessed 23 September 2022].
- [10] B. P. Moorlock, S. Boreham, M. A. Woods and M. G. Sumbler, "Geology of the Saffron Walden district - a brief explanation of the geological map 1:50,000 Sheet 205 Saffron Walden (England and Wales)," British Geological Society, Keyworth, Nottingham, 2003.
- [11] British Geological Survey, "The BGS Lexicon of Named Rock Units [online]," Keyworth, Nottingham, 2020. [Online]. Available: <https://www.bgs.ac.uk/technologies/the-bgs-lexicon-of-named-rock-units/>. [Accessed 08 August 2022].
- [12] Newbury Geological Study Group, "Guide to the Chalk Group of Southern England," [Online]. Available: <http://www.ngsg.org.uk/ChalkGuide.pdf>. [Accessed 08 August 2022].
- [13] Cambridge Geological Society, "Cambridge Geological Society: Cambridgeshire Local Geology," [Online]. Available: <http://www.cambsgeology.org/>. [Accessed 08 August 2022].
- [14] B. C. Worassam and J. H. Taylor, *Geology of the Country around Cambridge*, London: Her Majesty's Stationary Office, 1969.
- [15] British Geological Survey, *Hydrogeological Map of the area between Cambridge and Maidenhead*, London: NERC, 1984.
- [16] Tetra Tech, *Cambridge Constraints Plan 23.3.21*, 2021.
- [17] BSI Standards Publication, *BH 5930:2015A1:2020 Code of Practice for ground investigations*, BSI Standards Publication, 2015.
- [18] BSI, "BS EN 1997-2: 2007 Eurocode 7 - Geotechnical Design Part 2: ground investigation and testing," BSI, 2007.
- [19] *BS EN ISO 22475-1: 2006 Geotechnical investigation and testing - sampling methods and groundwater measurements*, 2006.

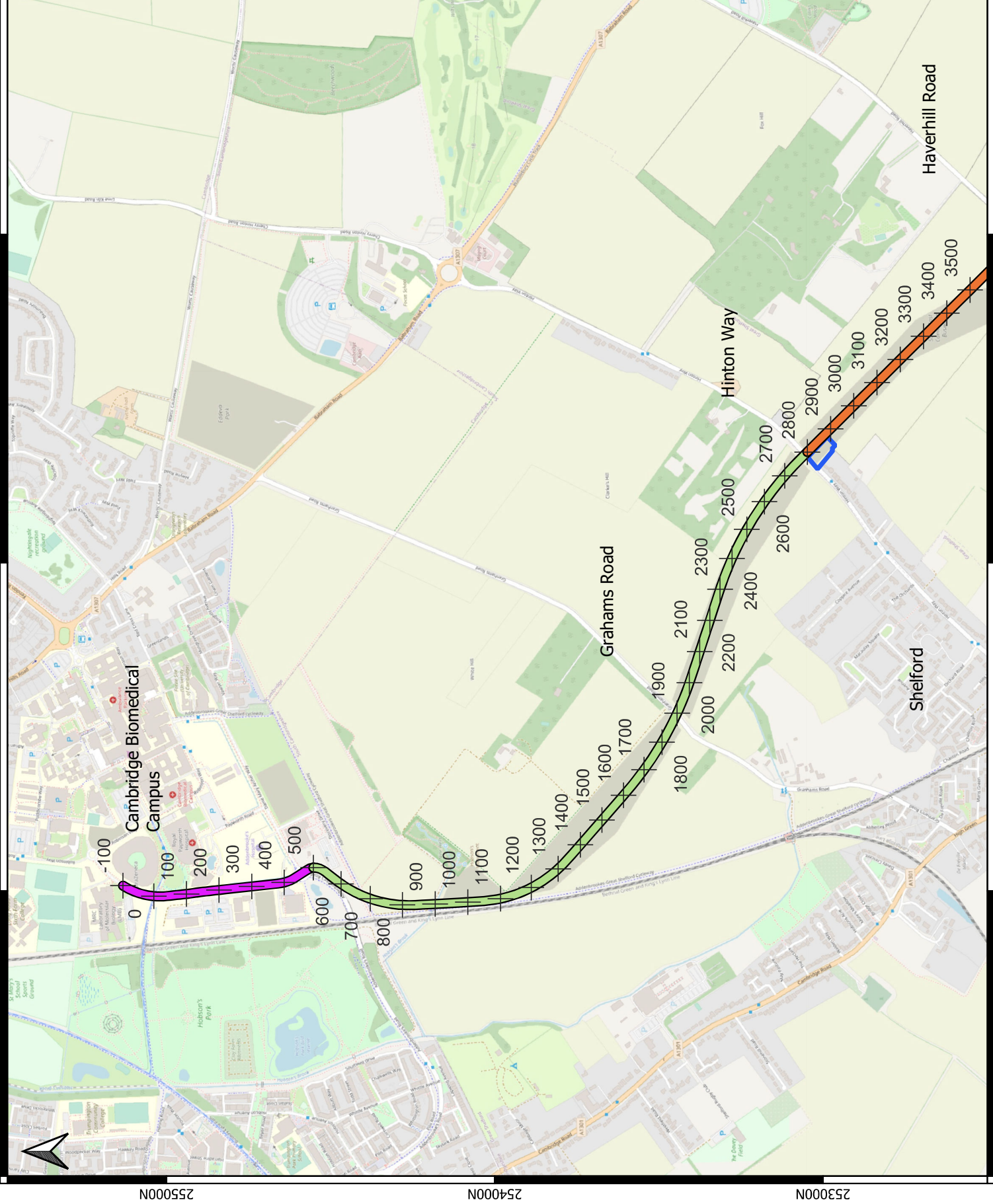
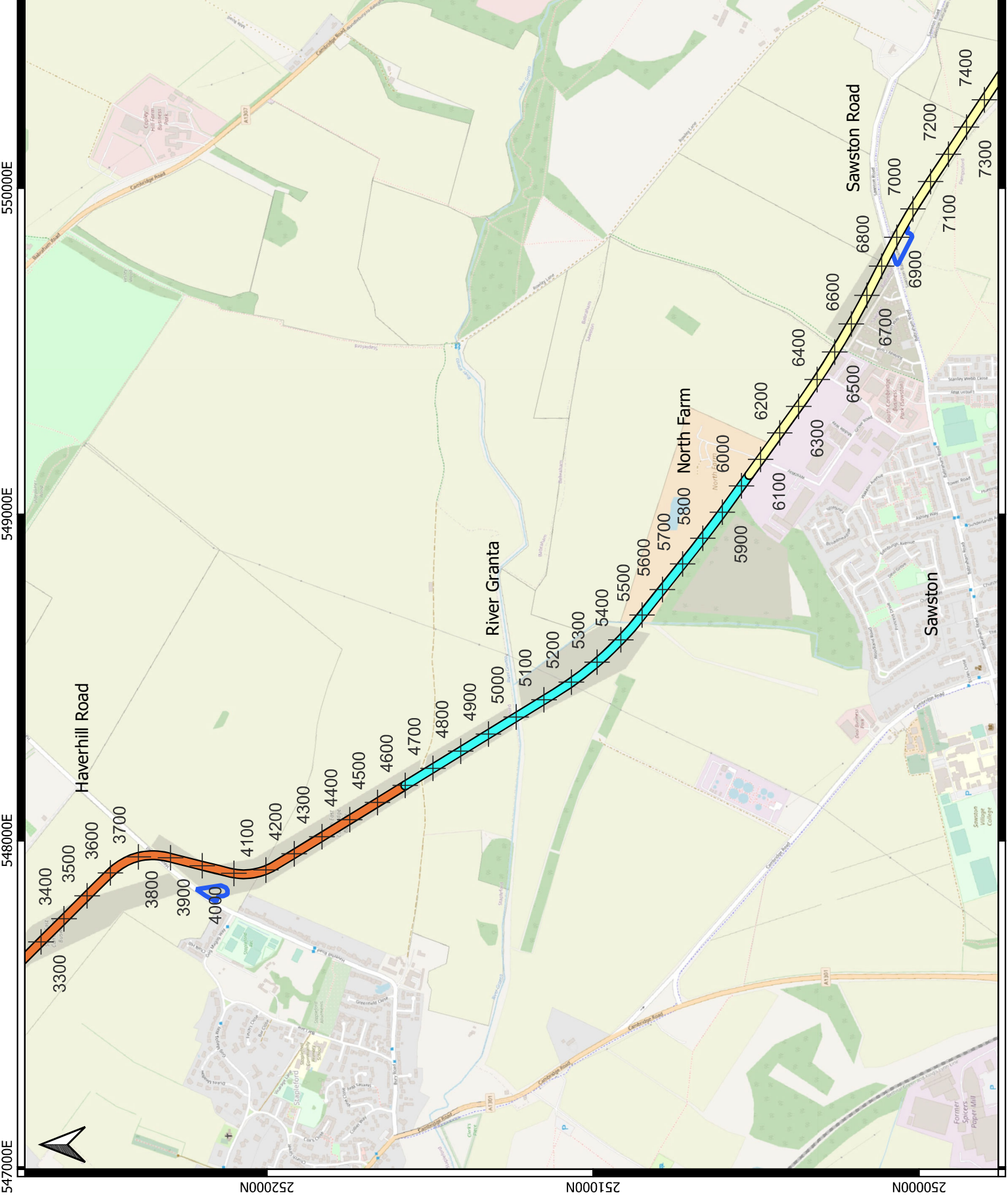
- [20] T. Lunne, P. K. Robertson and J. M. Powell, *Cone Penetration Testing in Geotechnical Practice*, New York: Blackie Academic, 1997.
- [21] P. K. Robertson, "Soil Classification using cone penetration test," *Canadian Geotechnical Journal*, vol. 27, no. 1, pp. 151-158, 1990.
- [22] BRE Special Digest 365, "Soakaway Design," BRE Press, 2016.
- [23] M. Carter and S. Bentley, *Correlations of soil properties*, London: Penetech Press Publishers, 1991.
- [24] British Standards Institute, "BS 8002:2015 Code of Practice for Earth retaining Structures," British Standards Institute, London, 2015.
- [25] M. A. Stroud and F. G. Butler, "The Standard Penetration Test and the Engineering Properties of Glacial Deposits' from the proceedings of the Midlands Soil Mechanics and Foundation Engineering Society 21st - 23rd April 1975 at the University," in *Proc. Midlands Soil Mechanics and Foundation Engineering Society*, Birmingham, 1975.
- [26] CIRIA, "The Standard Penetration Test (SPT): Methods and Use (Report 143)," CIRIA, London, 1995.
- [27] R. B. Peck, W. E. Hanson and T. H. Thornburn, *Foundation Engineering*, John Wiley and Sons, 1974.
- [28] G. E. Barnes, *Soil Mechanics: Principles and Practice*, 2010.
- [29] M. A. Stroud, "The standard penetration test in insensitive clays and soft rocks,," in *Proceedings of the European Symposium on Penetration Testing*, 1975.
- [30] M. J. Tomlinson, *Foundation Design and Construction 7th Edition*, Edinburgh: Pearson Education Ltd, 2001.
- [31] W. D. Powell, F. J. Potter, H. C. Mayhew and M. E. Nunn, "TRRL Laboratory Report 1132," Transport and Road Research Laboratory, Department of Transport, 1984.
- [32] W. a. L. N. Black, "The strength of clay fill subgrades: its prediction in relation to road performance. Department of Environment, Department of Transport, TRRL Report LR889, Crowthorne, Berks., 1979.
- [33] Highways England, *CS 229 Data for pavement assessment, Design Manual for Roads and Bridges, Revision 0*, Highways England, 2020.
- [34] A. J. Bowden, J. Lamont-Black and S. Ulyott, "Point load testing of weak rocks with particular reference to chalk," *Quarterly Journal of Engineering Geology and Hydrogeology*, vol. 31, pp. 95-103, 1998.
- [35] BRE, *BRE Special Digest 1:2005 Concrete in Aggressive Ground*, 2005.
- [36] CIRIA, *C574 Engineering In Chalk*, CIRIA, 2002.
- [37] Highways England, "CD 225 - Design for new pavement foundations," Highways England, London, 2020.
- [38] Standards for Highways, "Manual of contract documents for highways works Volume 1, Specification for Highways Works, Series 600, Earthworks".
- [39] Environment Agency, "Flood map for planning," Environment Agency, 2020. [Online]. Available: <https://flood-map-for-planning.service.gov.uk/confirm-location?easting=450548&northing=206022&placeOrPostcode=oxford>. [Accessed 21 04 2020].
- [40] Landmark Information Group, "Envirocheck Report Ref. 128766156_1_1," Landmark Information Group, Reading, 2017.
- [41] Public Health England, "UK maps of radon," Public Health England, 2020. [Online]. Available: <https://www.ukradon.org/information/ukmaps>. [Accessed 27 April 2020].

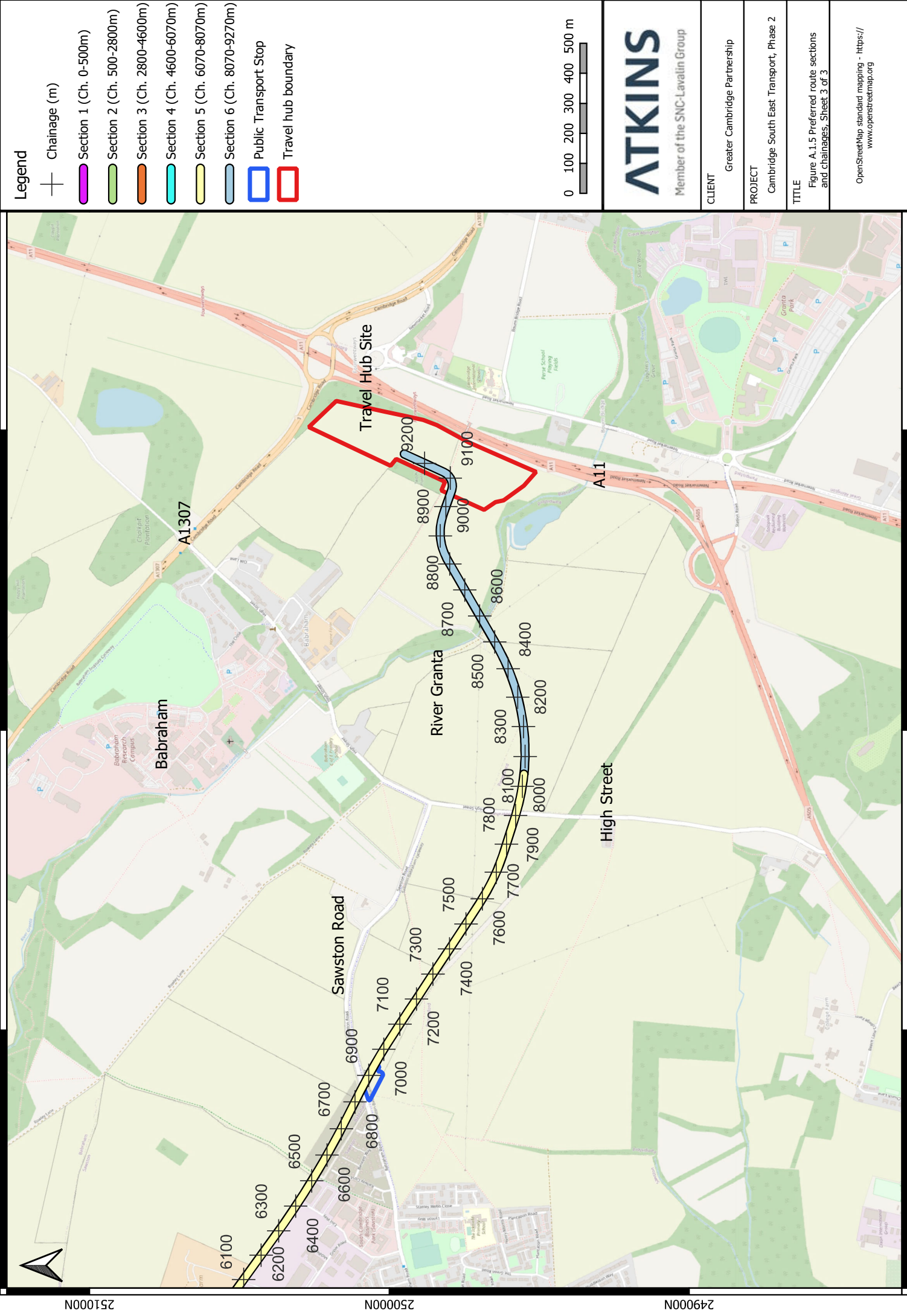
Appendices

Appendix A. Drawings

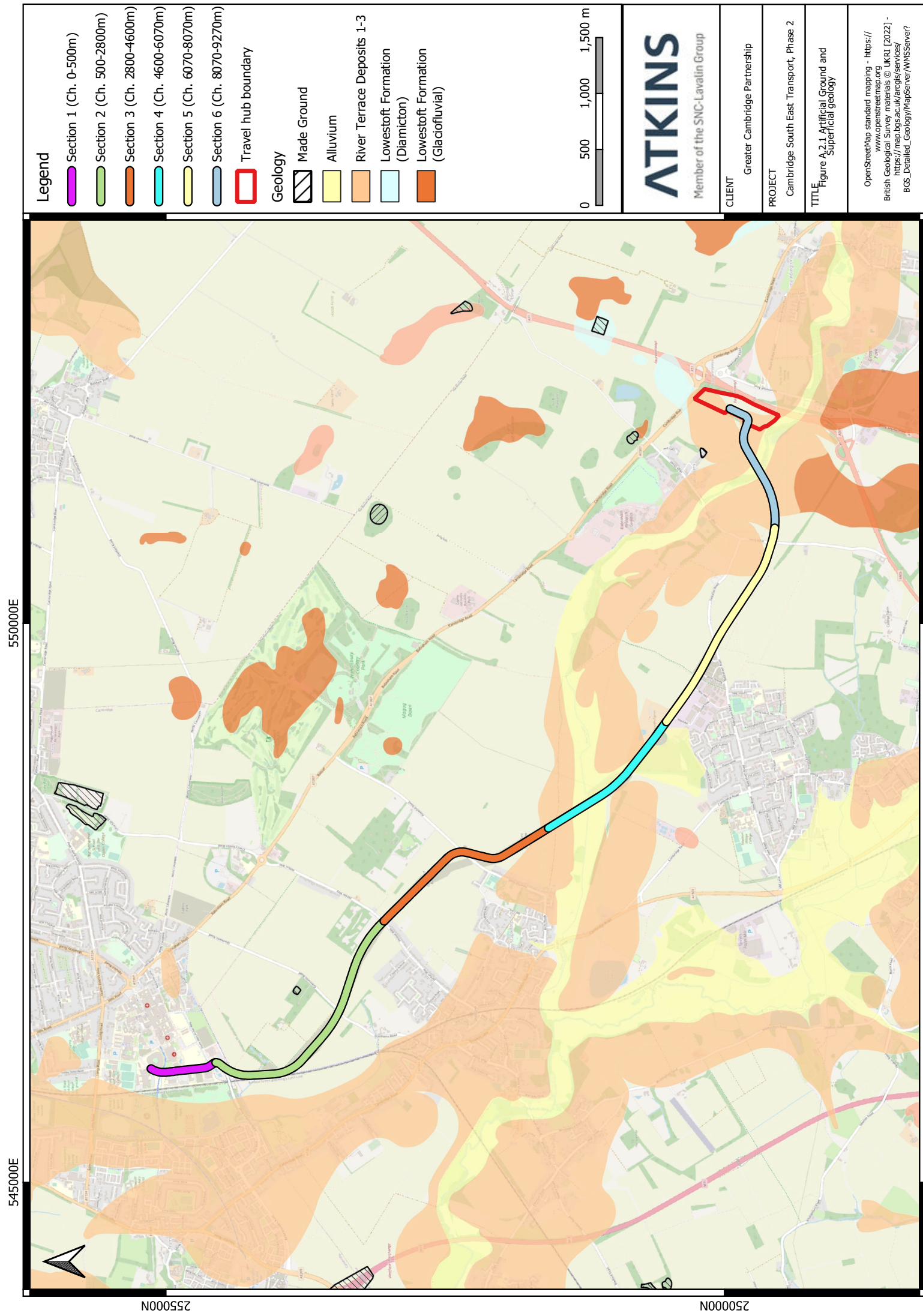
A.1. Scheme Location

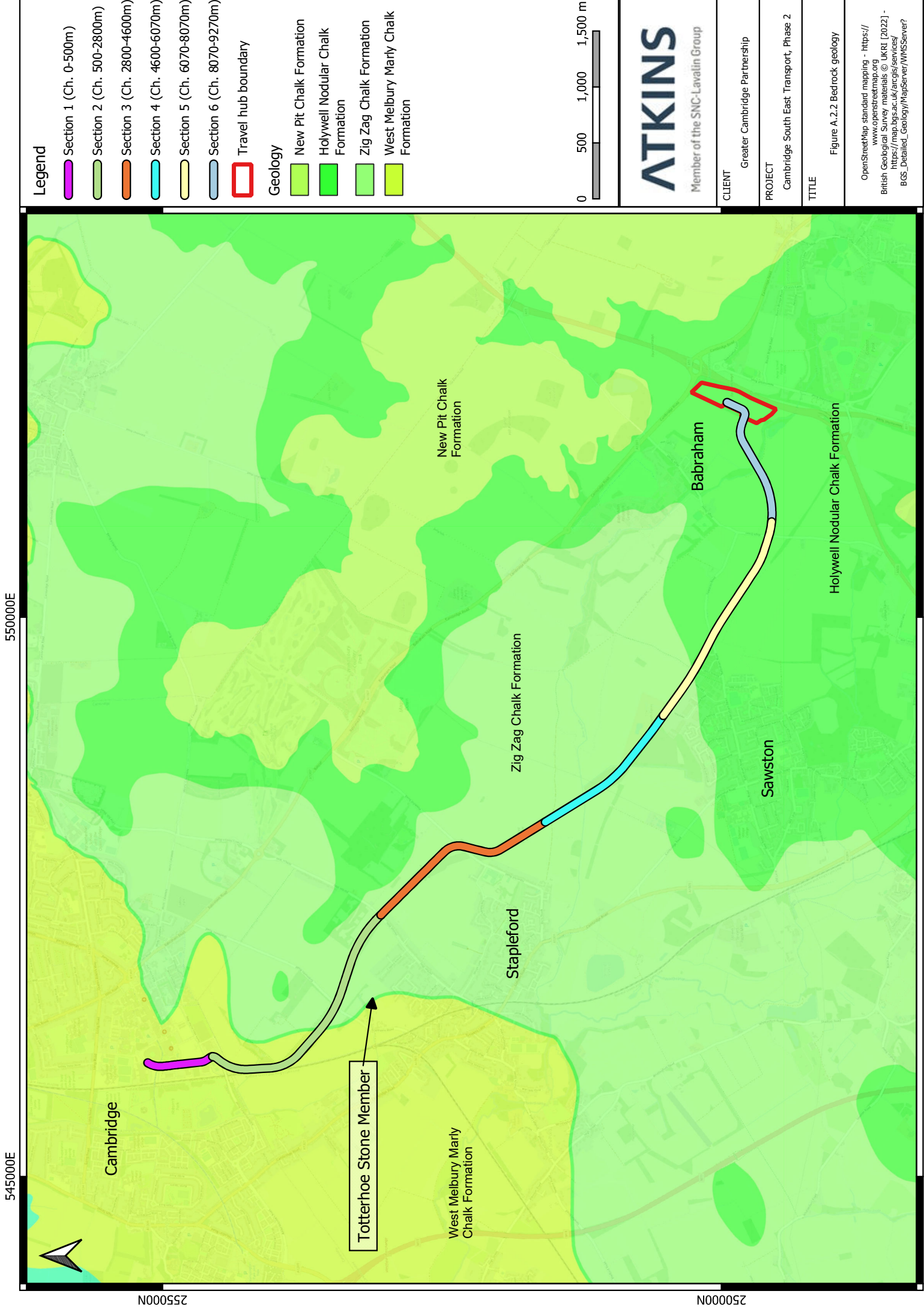
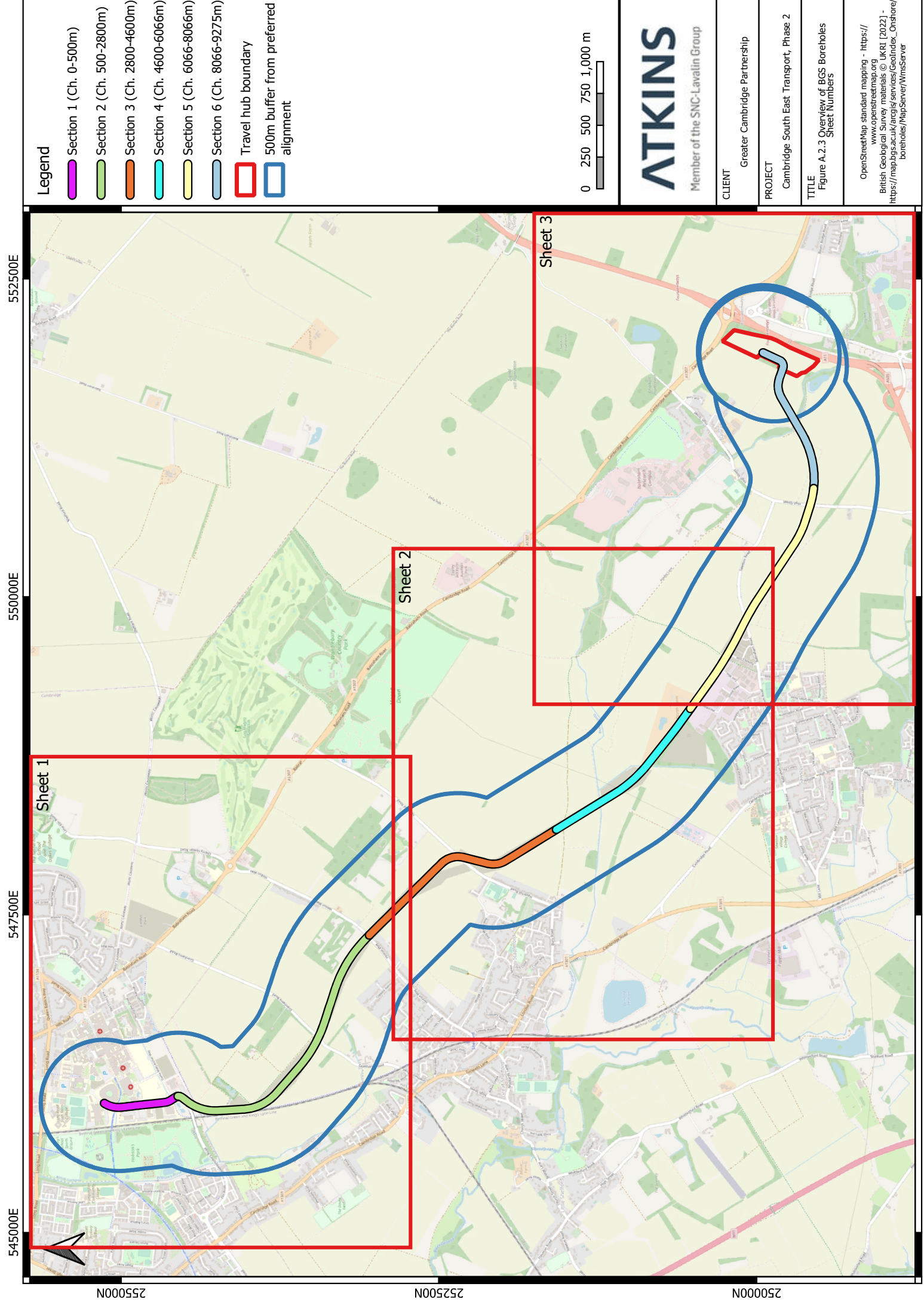


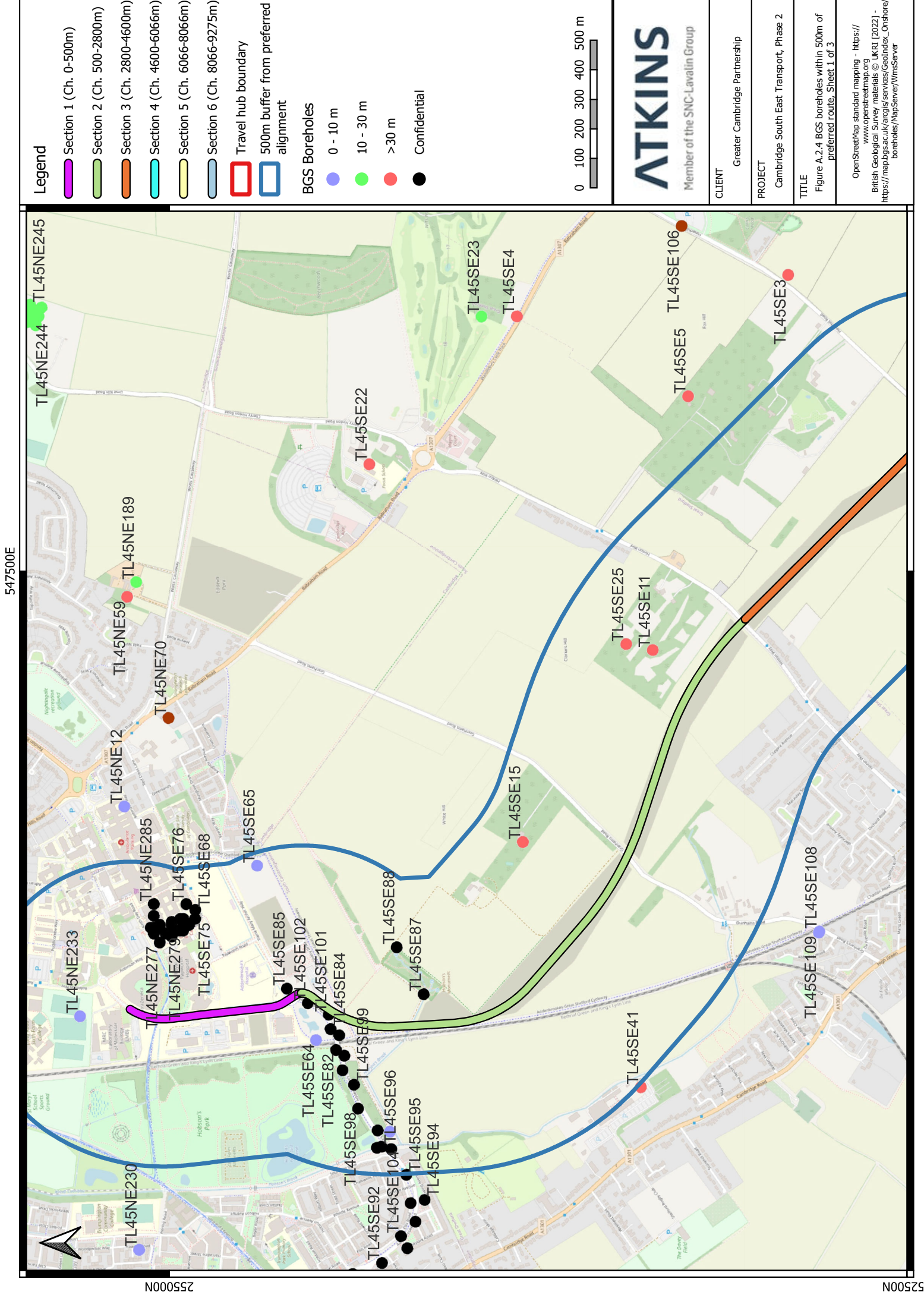
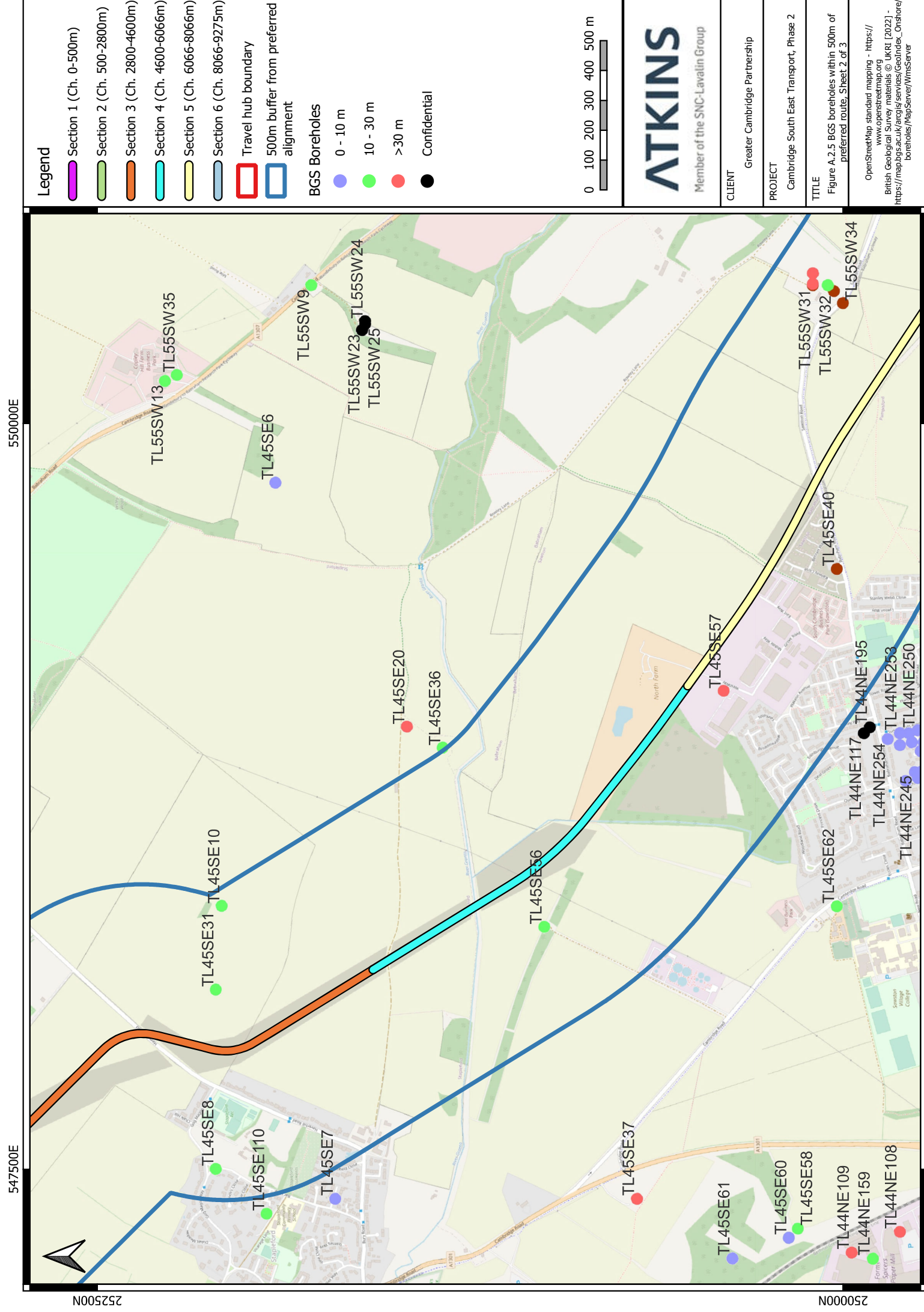




A.2. BGS Geology and borehole records

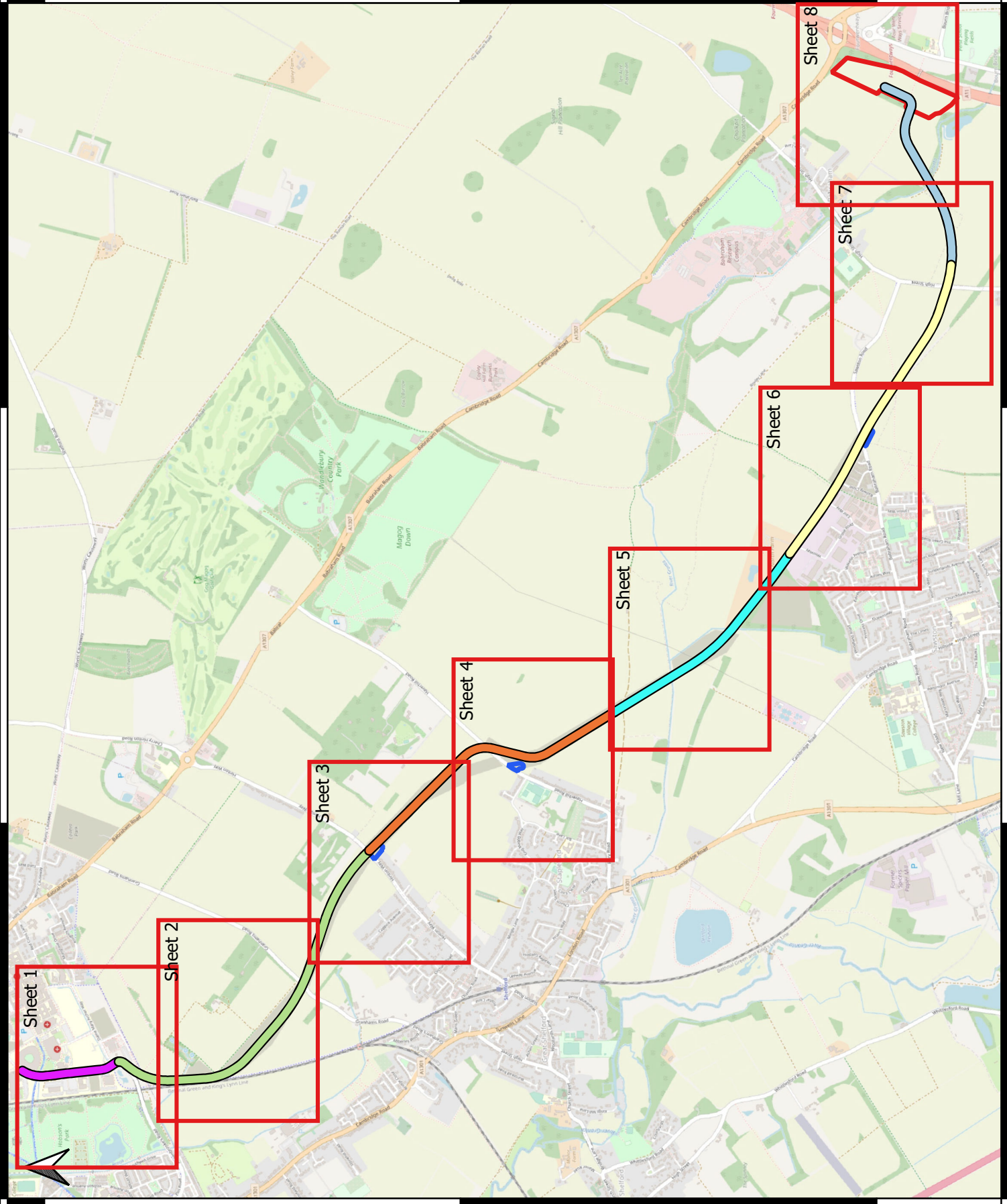






550000E

547500E



Legend

- Section 1 (Ch. 0-500m)
- Section 2 (Ch. 500-2800m)
- Section 3 (Ch. 2800-4600m)
- Section 4 (Ch. 4600-6066m)
- Section 5 (Ch. 6066-8066m)
- Section 6 (Ch. 8066-9275m)
- Travel hub boundary
- Public Transport Stop

0 250 500 750 1,000 m

ATKINS
Member of the SNC-Lavalin Group

CLIENT
Greater Cambridge Partnership

PROJECT
Cambridge South East Transport, Phase 2

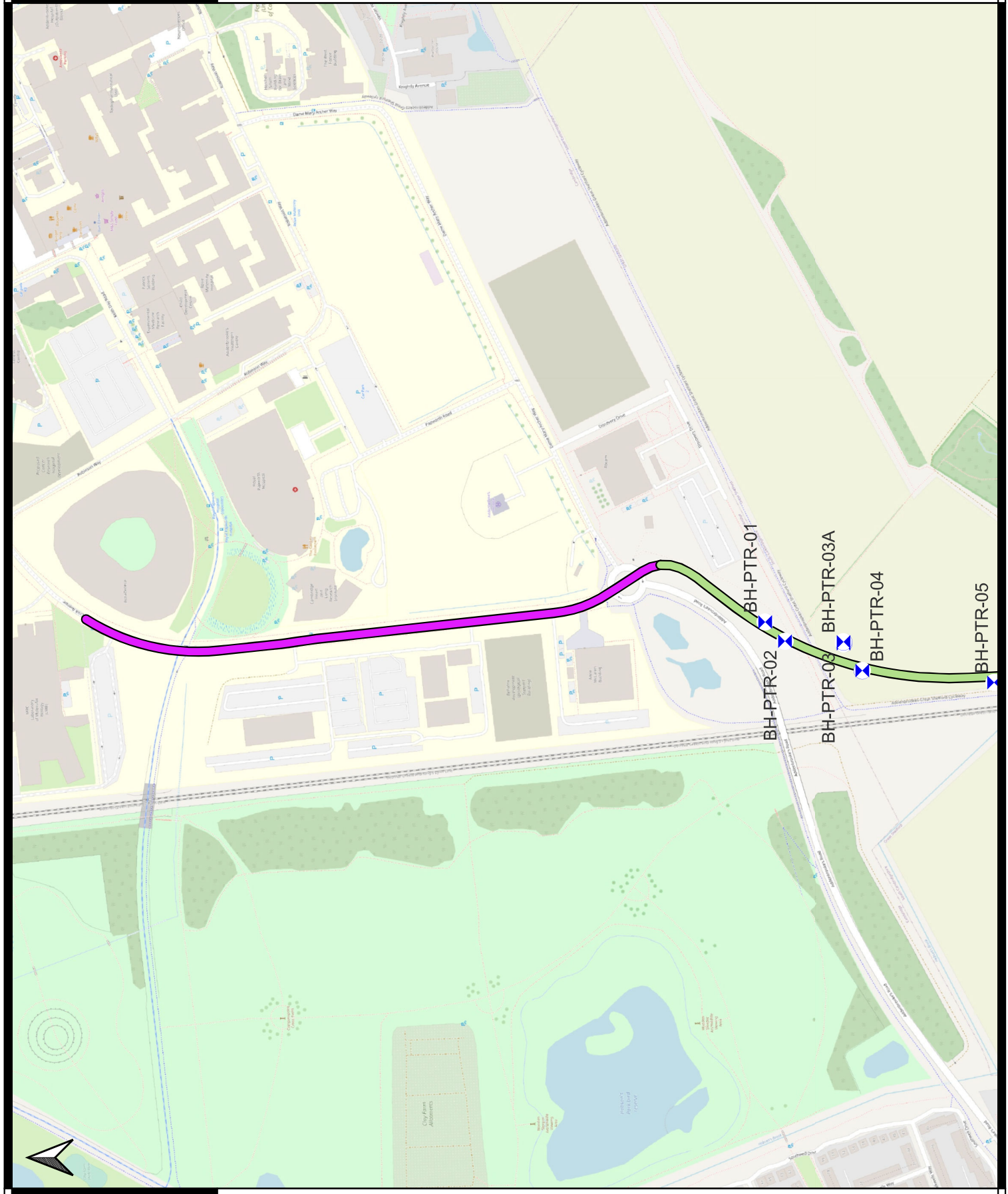
TITLE
Figure A3.1 Overview of Tetra Tech ground investigation sheet numbers

OpenStreetMap standard mapping - <https://www.openstreetmap.org>

255000N

252500N

250000N



Legend

- Section 1 (Ch. 0-500m)
- Section 2 (Ch. 500-2800m)
- Section 3 (Ch. 2800-4600m)
- Section 4 (Ch. 4600-6066m)
- Section 5 (Ch. 6066-8066m)
- Section 6 (Ch. 8066-9275m)
- Travel hub boundary
- Public Transport Stop
- Ground Investigation - Exploratory Locations
- Windowless Sample
- Rotary Core
- Trial Pit
- Cone Penetration Tests
- Dynamic Cone Penetrometer

0 50 100 150 m

ATKINS
Member of the SNC-Lavalin Group

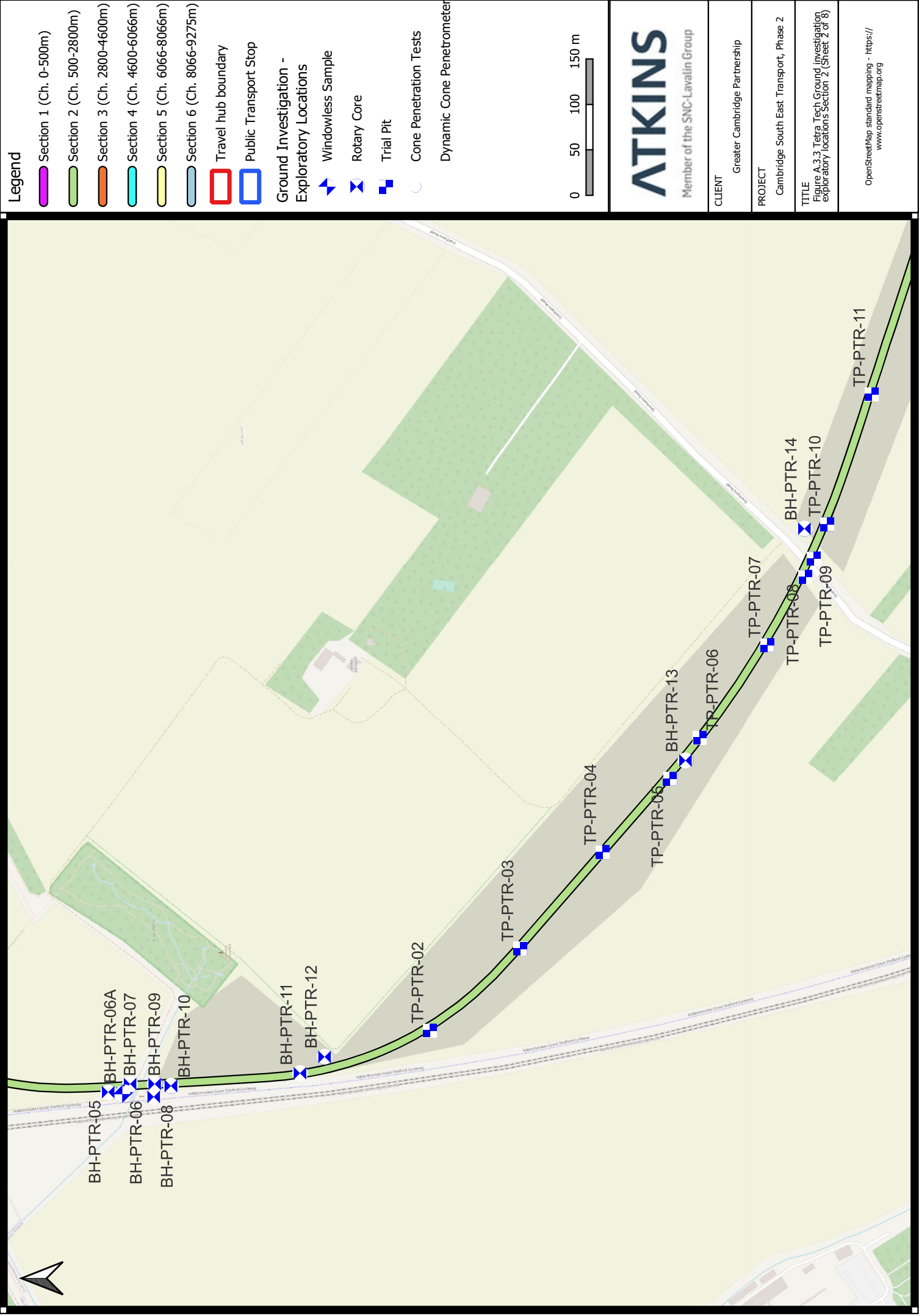
CLIENT
Greater Cambridge Partnership

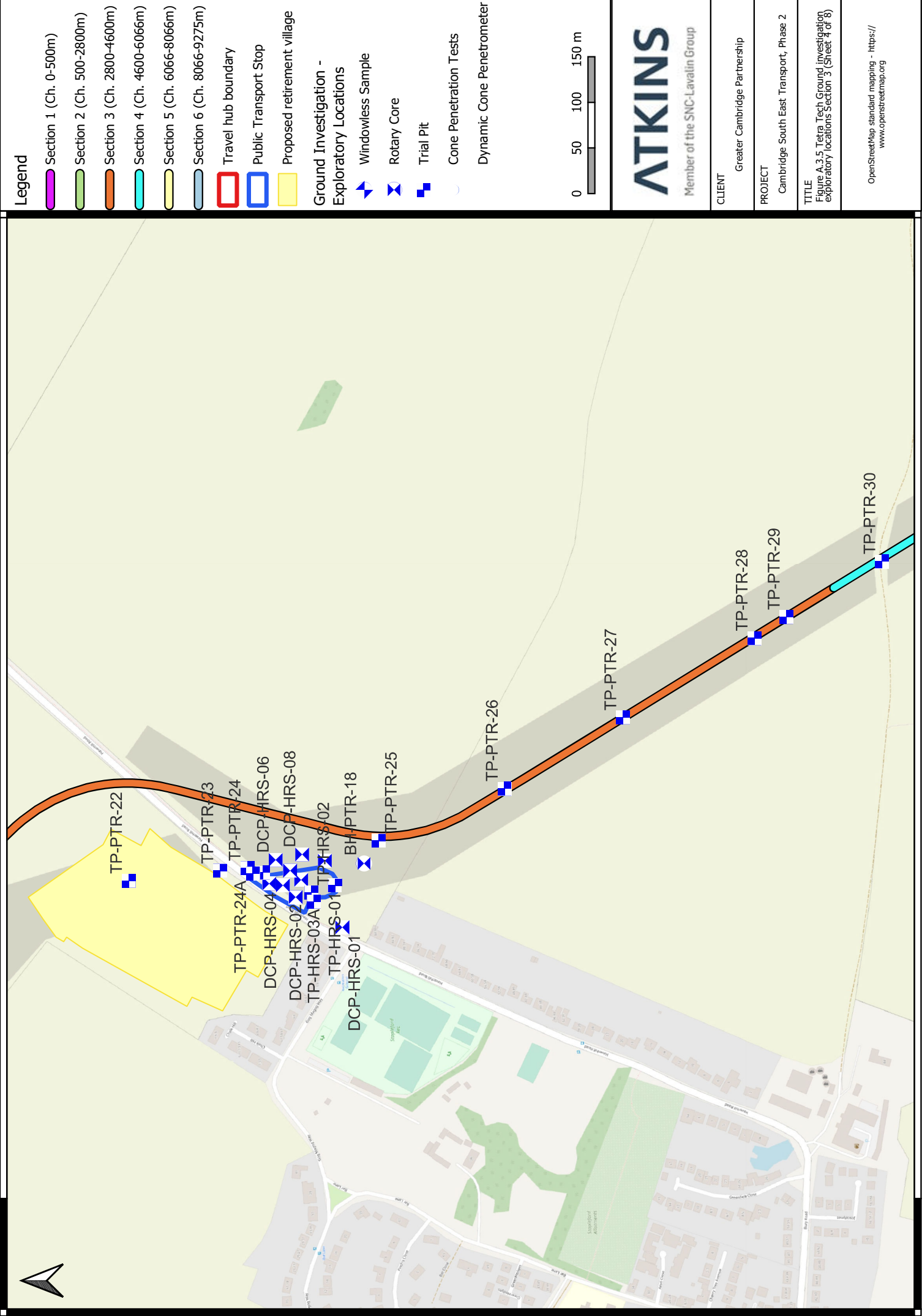
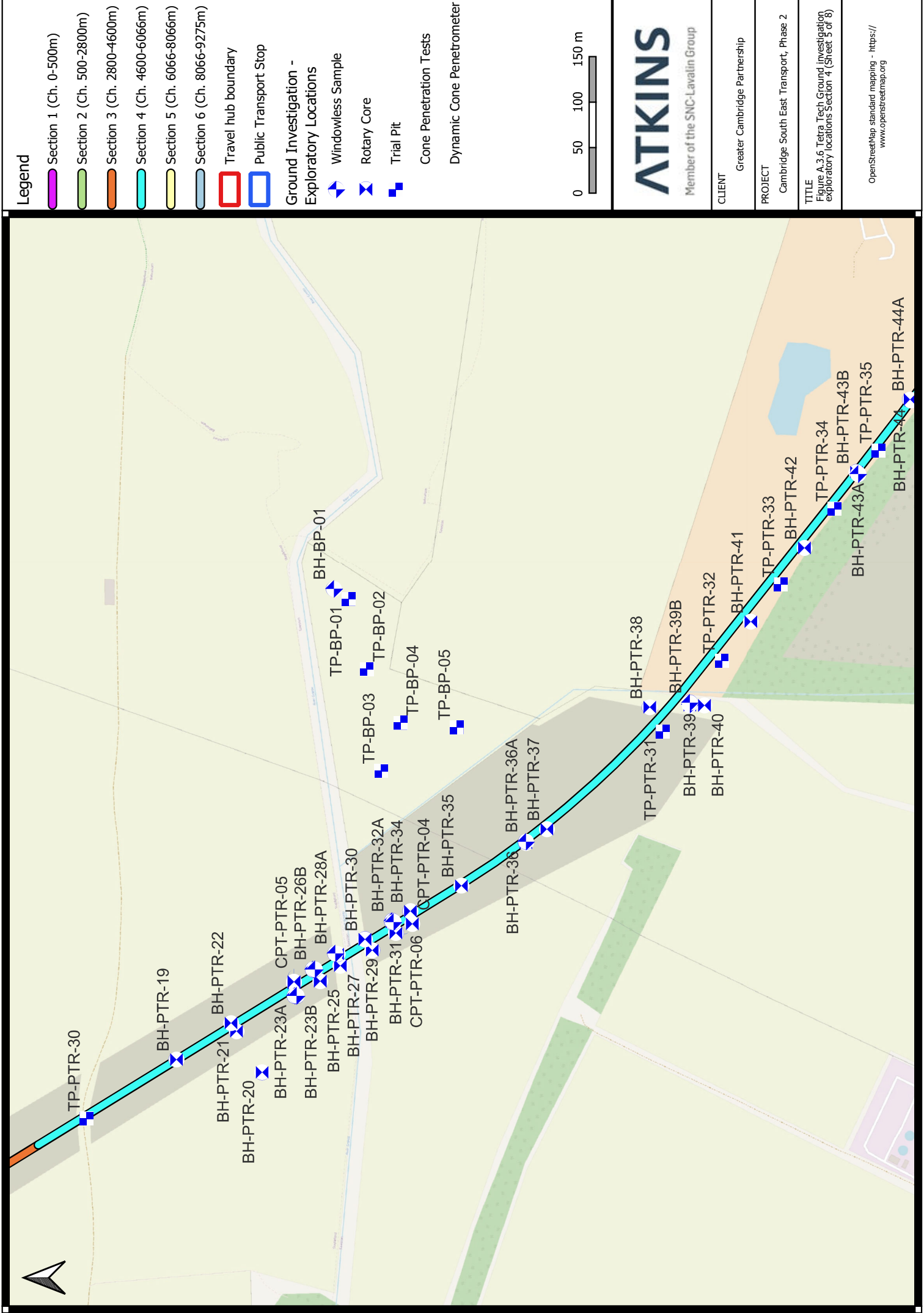
PROJECT
Cambridge South East Transport, Phase 2

TITLE
Figure A3.2 Tetra Tech ground investigation exploratory locations Section 1 (Sheet 1 of 6)

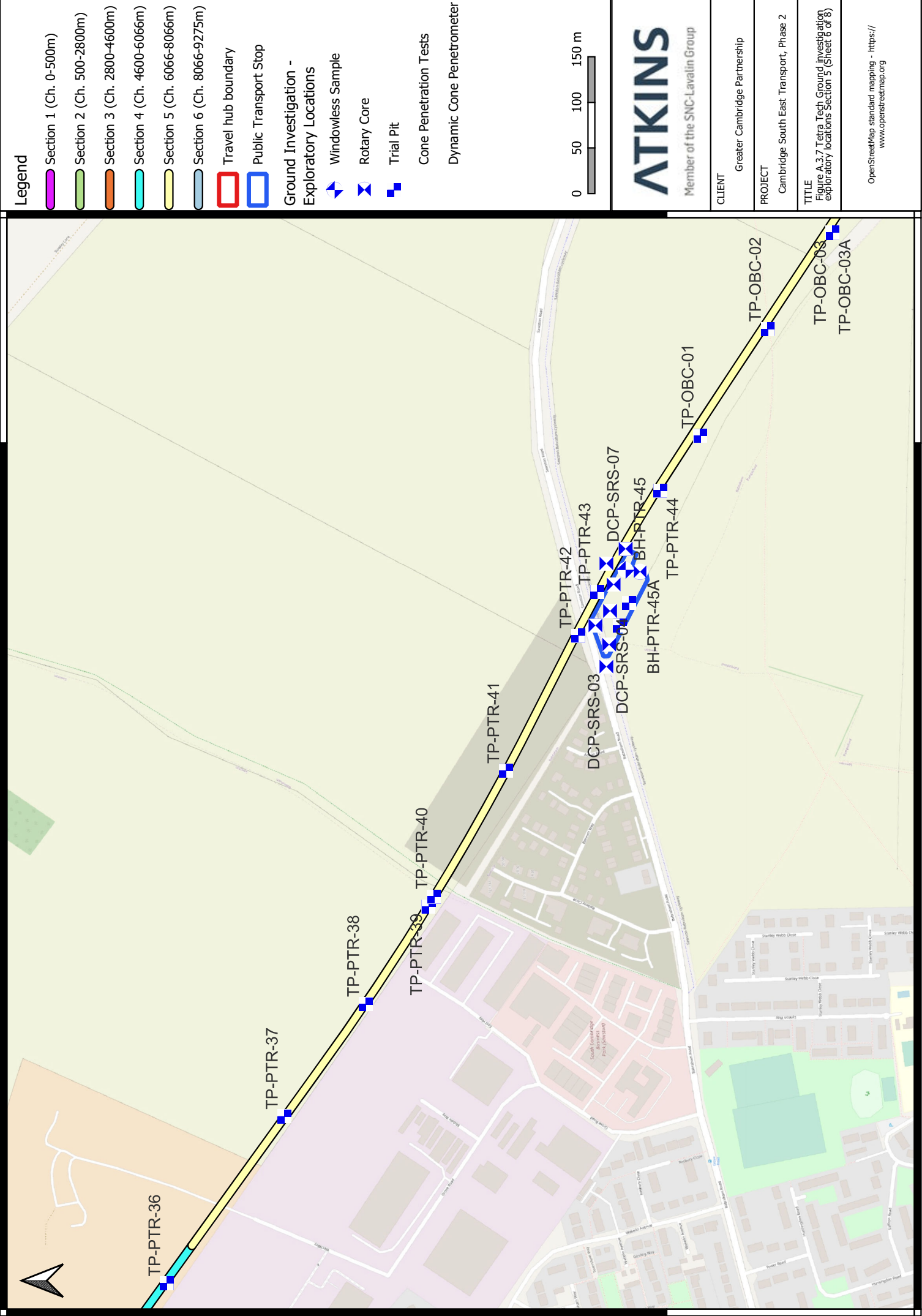
OpenStreetMap standard mapping - <https://www.openstreetmap.org>

255000N

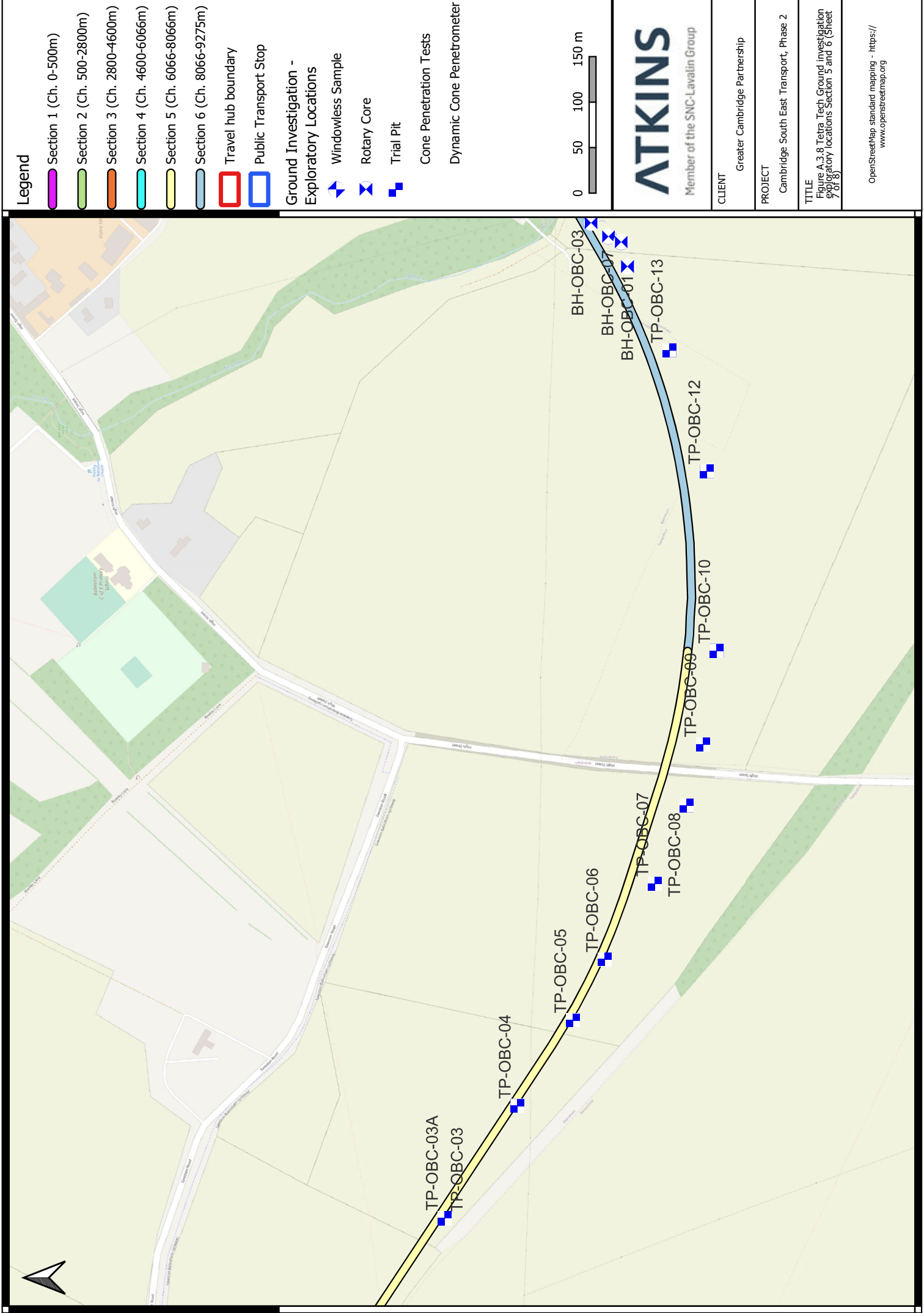




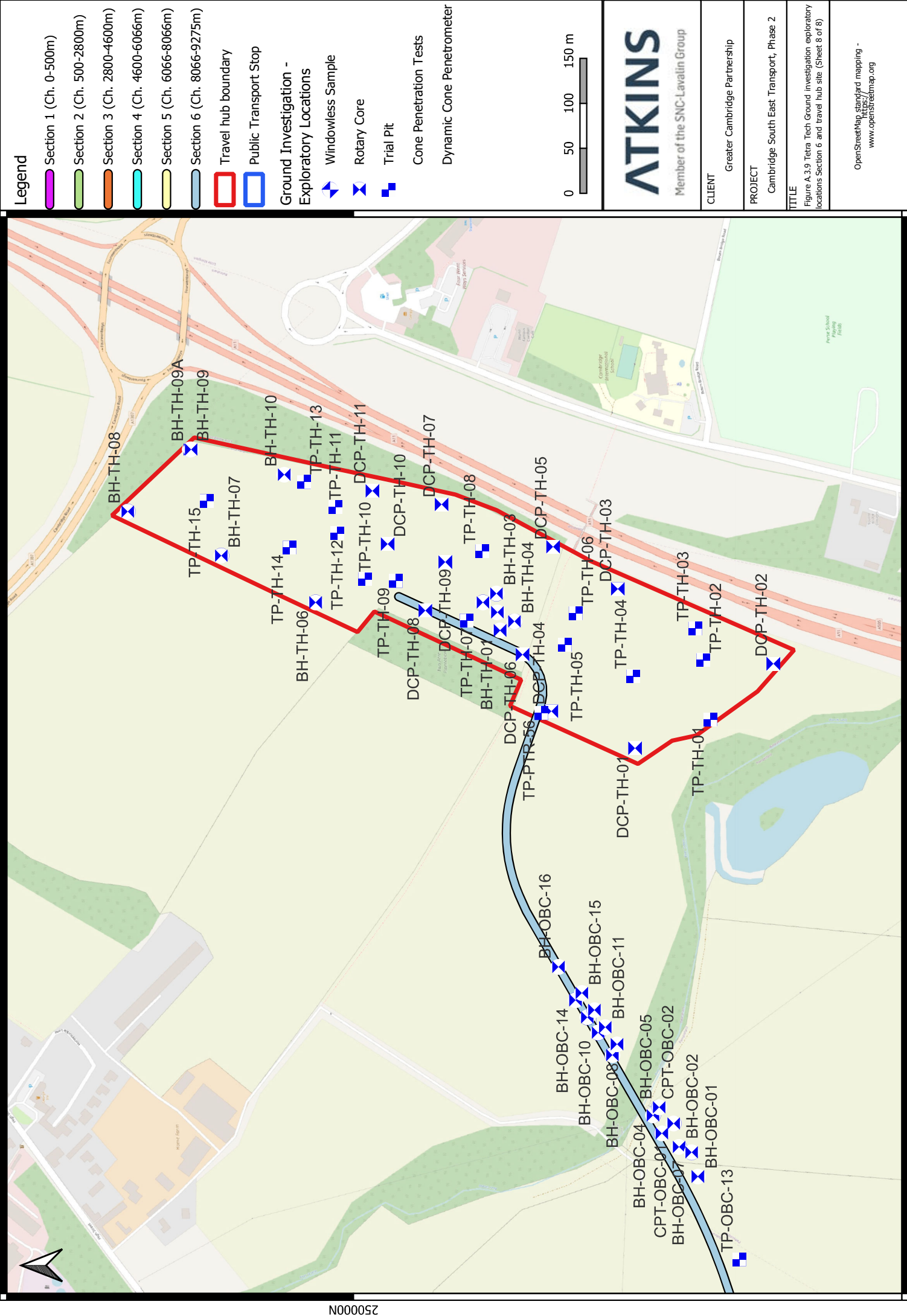
550000E



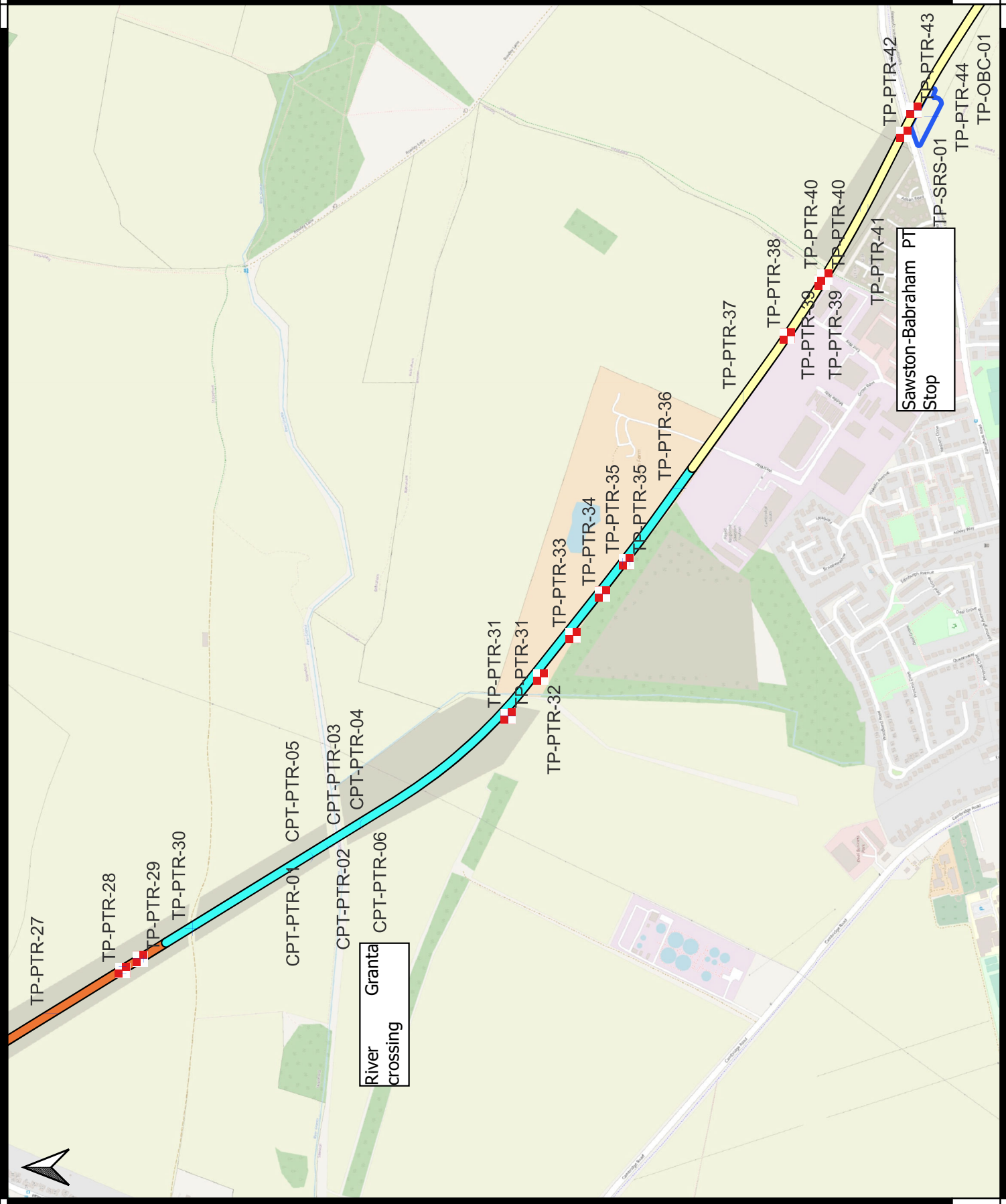
250000N



250000N

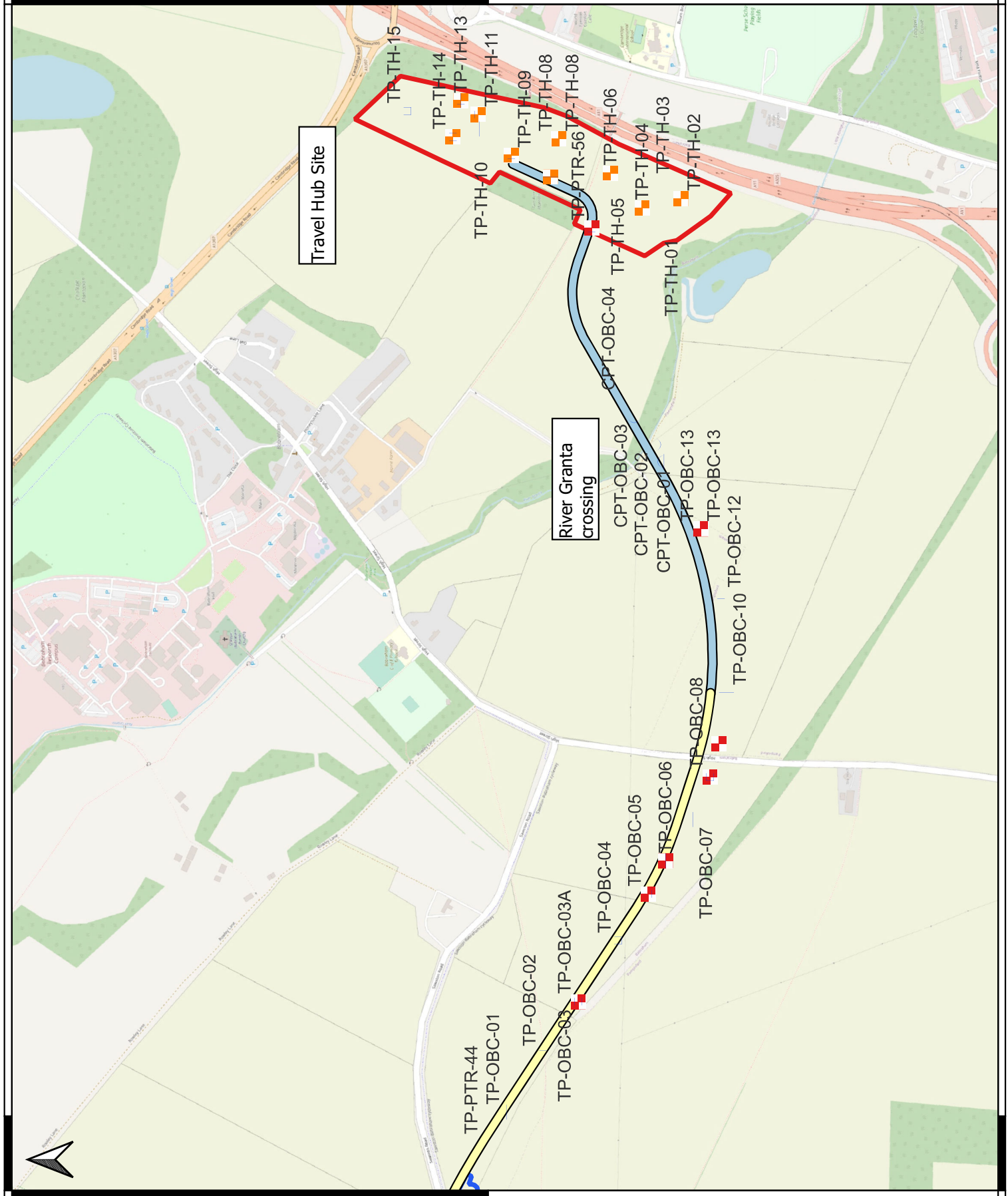


550000E



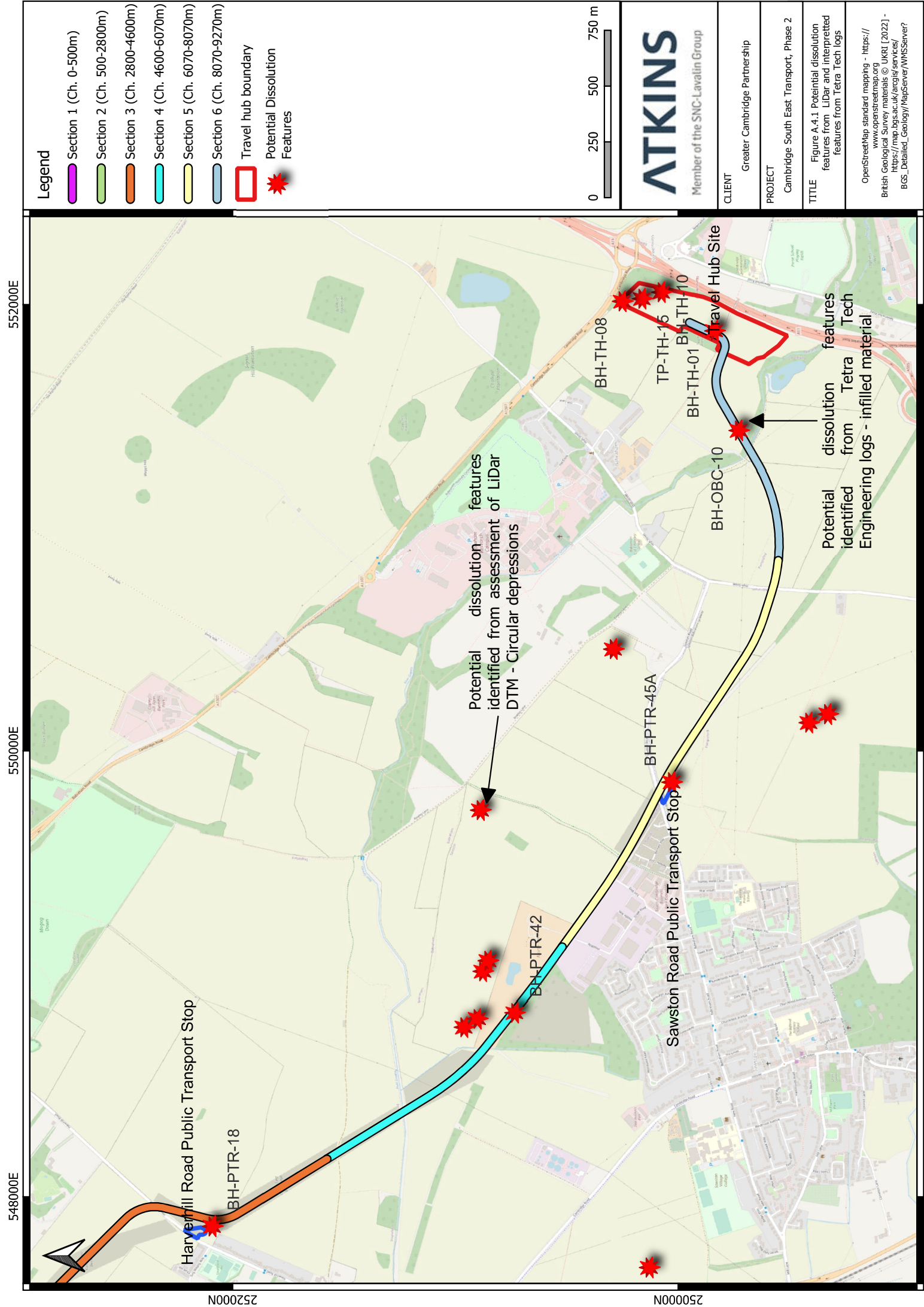
250000N

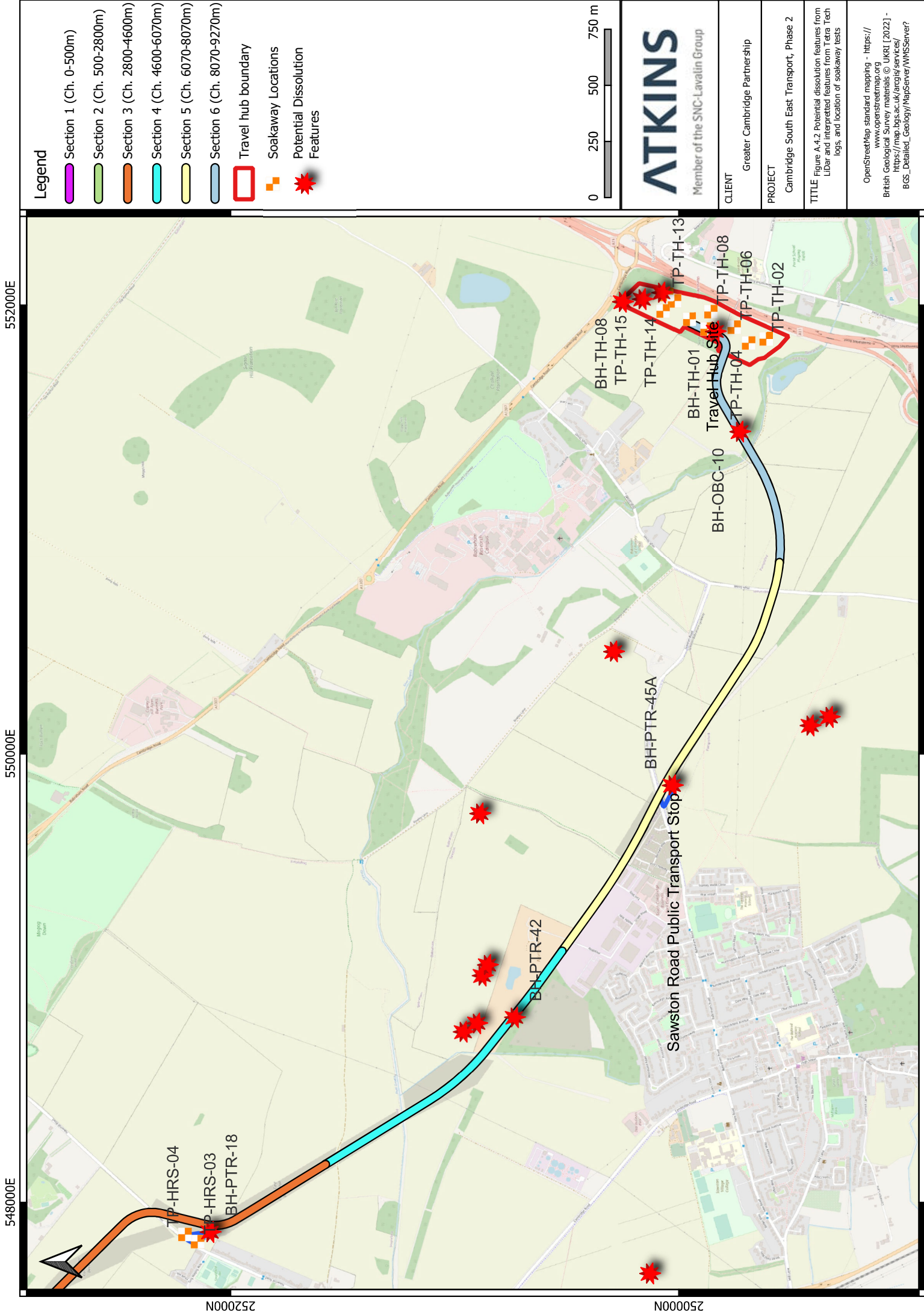
550000E



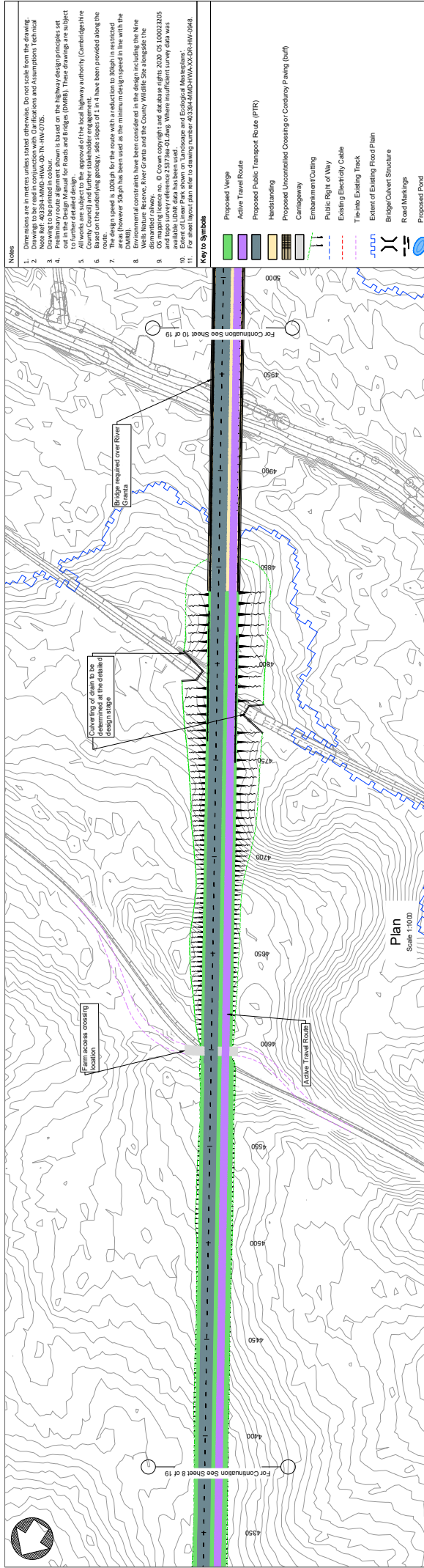
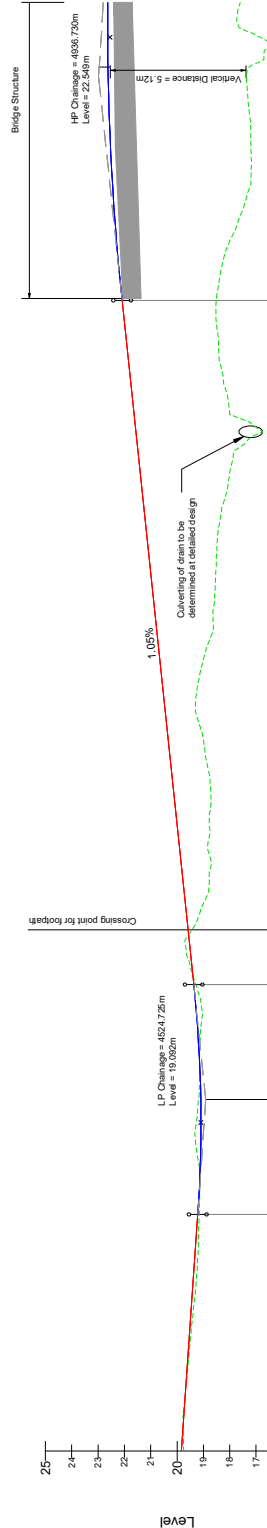
250000N

A.4. Dissolution features in Chalk





A.5. Mott MacDonald route alignment drawings

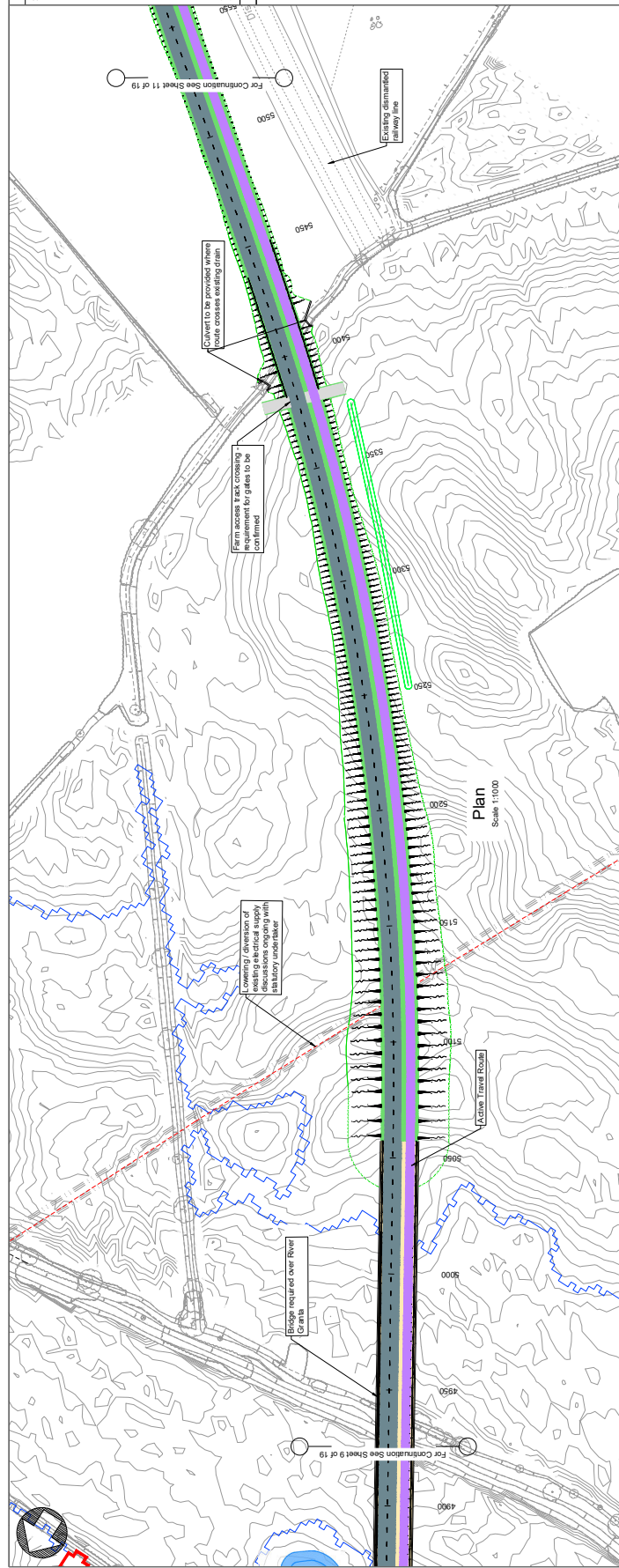
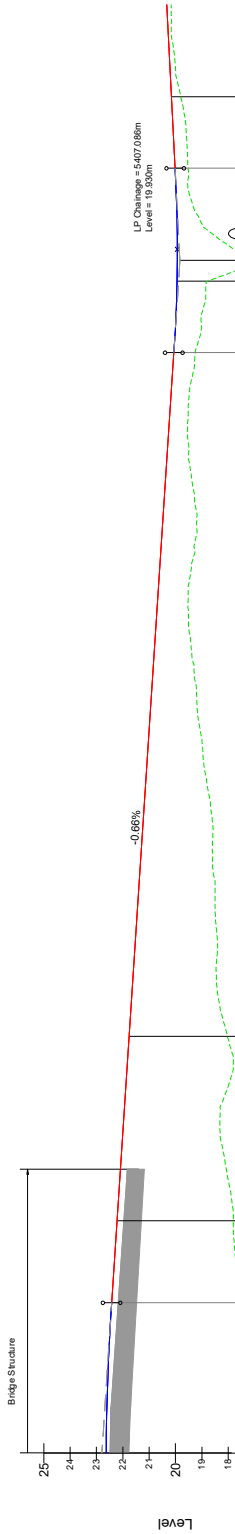


	Horizontal Geometry										Vertical Geometry									
Chainage	L=670.724										G=+0.697% K=450,000 L=182.285									
	R=10000.000 K=150,000 L=417.627										G=-1.048% K=450,000 L=259.742									
Existing Levels	44.00,000	44.10,000	44.20,000	44.30,000	44.40,000	44.50,000	44.60,000	44.70,000	44.80,000	44.90,000	45.00,000	45.10,000	45.20,000	45.30,000	45.40,000	45.50,000	45.60,000	45.70,000	45.80,000	45.90,000
Proposed Levels	44.00,000	44.10,000	44.20,000	44.30,000	44.40,000	44.50,000	44.60,000	44.70,000	44.80,000	44.90,000	45.00,000	45.10,000	45.20,000	45.30,000	45.40,000	45.50,000	45.60,000	45.70,000	45.80,000	45.90,000

Long Section
Chainage 4400 to 4950
Scale: H=1:1000 V=1:100

© Moti MacDonald
This document is issued for the party which commissioned it and for specific purposes connected with the assigned project only. It should not be relied upon by any other party or used for any other purpose.

we accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose.

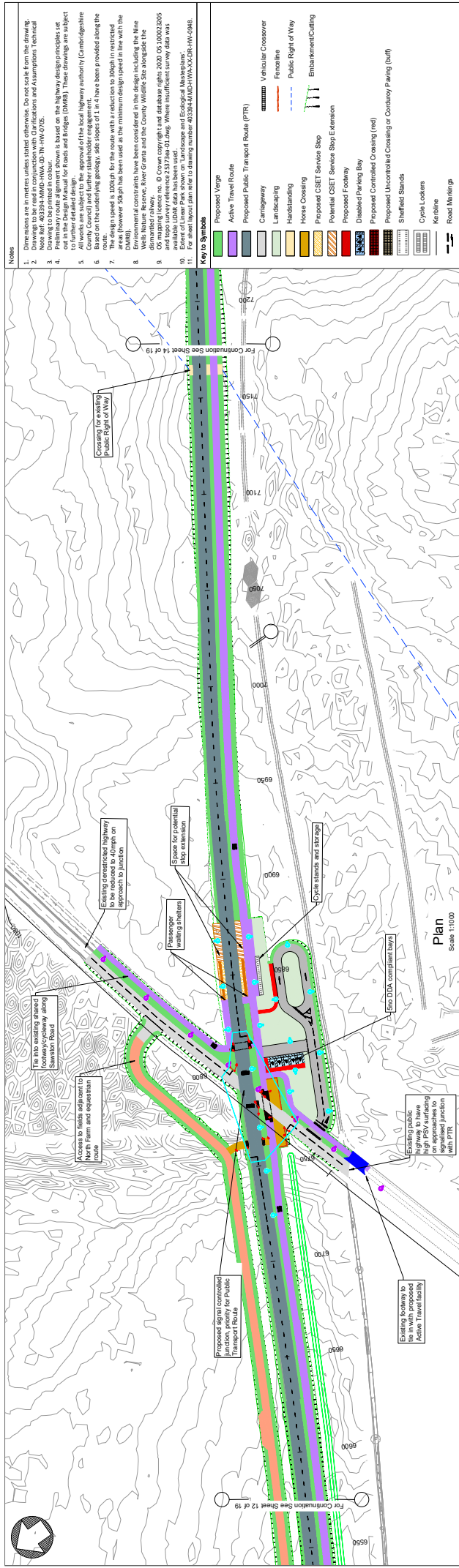
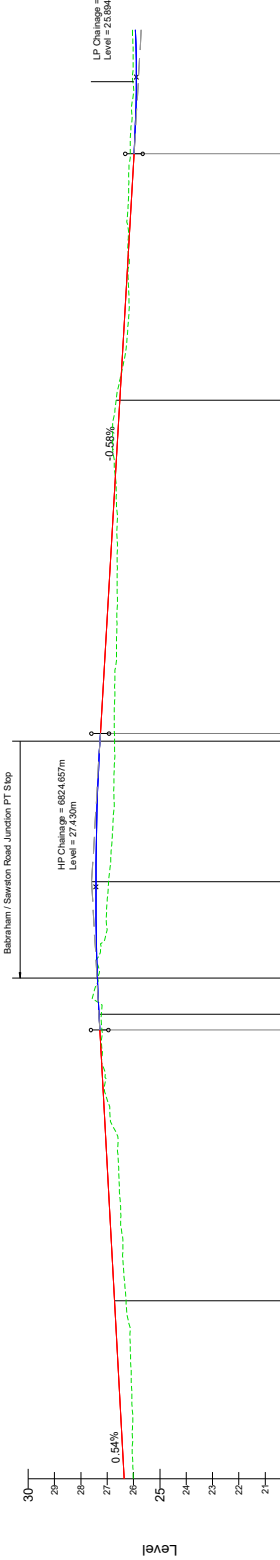
C:\Users\libl...
01/08/2015

Chainage	15	4950.000	4960.000	4970.000	4980.000	4990.000	5000.000	5010.000	5020.000	5030.000	5040.000	5050.000	5060.000	5070.000	5080.000	5090.000	5100.000	5110.000	5120.000	5130.000	5140.000	5150.000	5160.000	5170.000	5180.000	5190.000	5200.000	5210.000	5220.000	5230.000	5240.000	5250.000	5260.000	5270.000	5280.000	5290.000	5300.000	5310.000	5320.000	5330.000	5340.000	5350.000	5360.000	5370.000	5380.000	5390.000	5400.000	5410.000	5420.000	5430.000	5440.000	5450.000	5460.000	5470.000	5480.000	5490.000	5500.000																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													

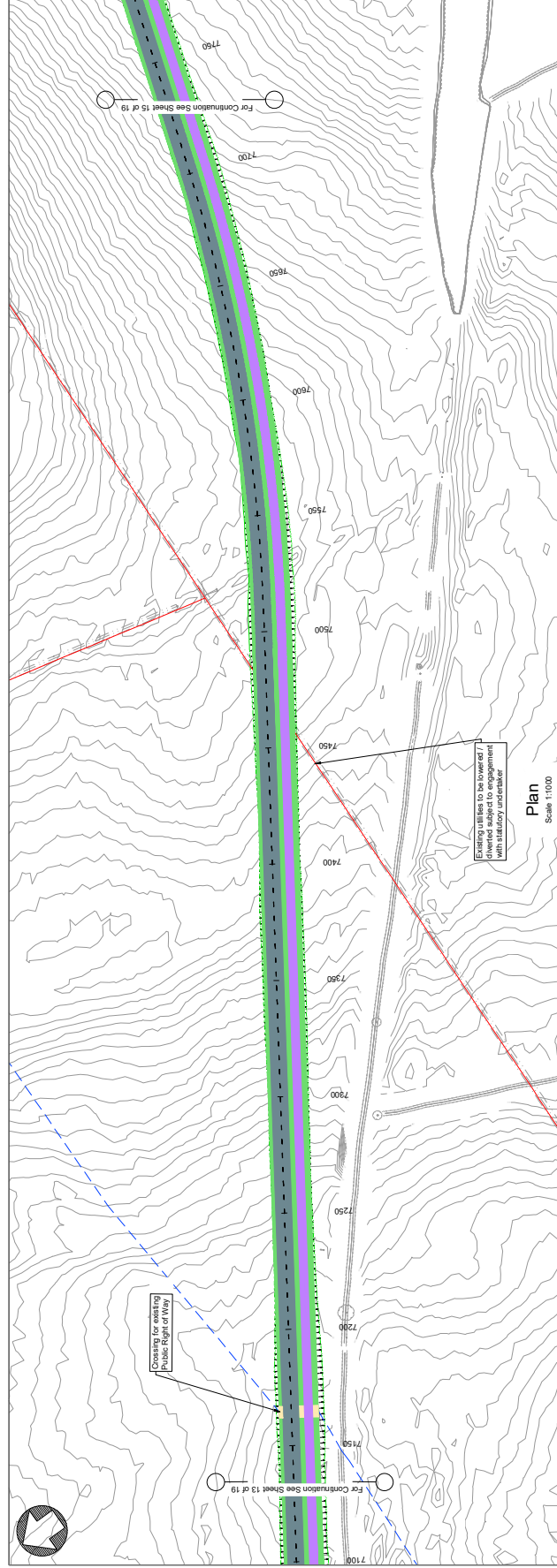
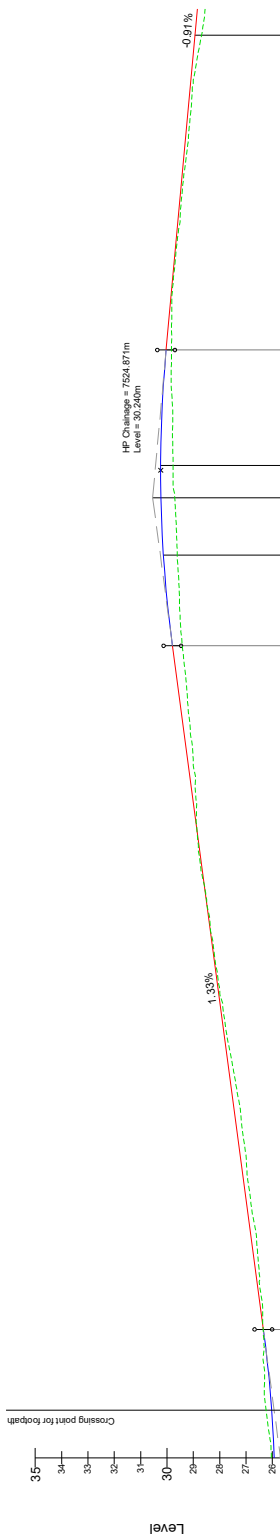
Long Section
Chainage 4950 to 5500

© 2006 Blackwell Publishing Ltd

What do
This do
We are

[illegible]

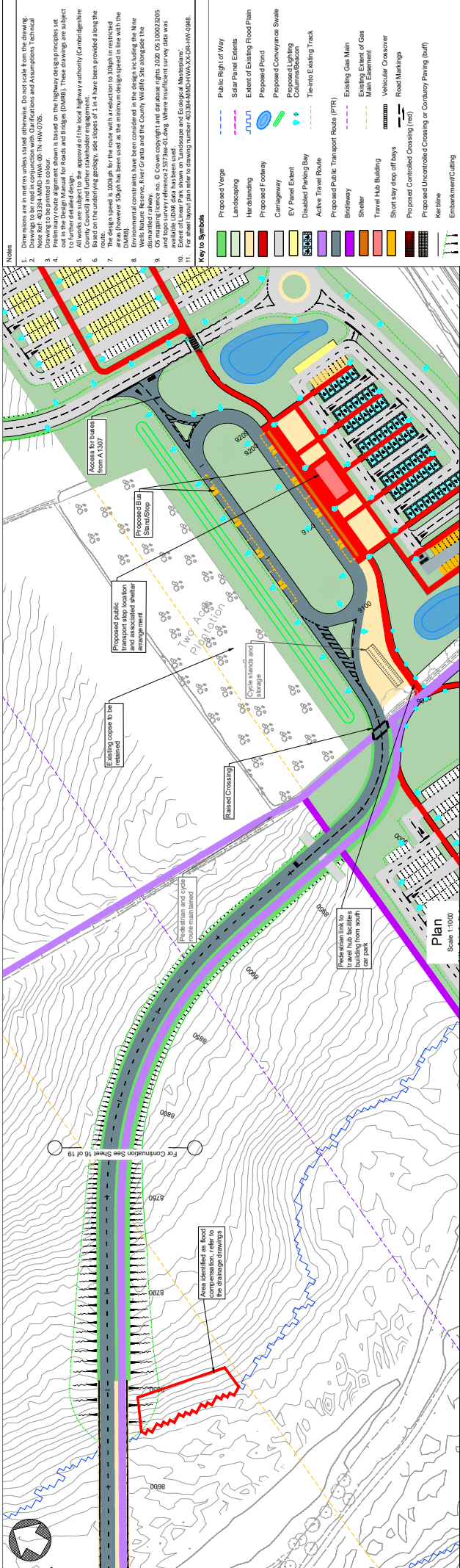
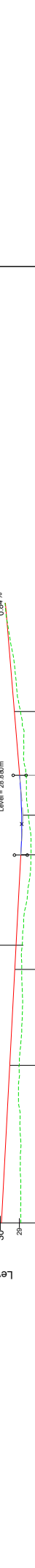
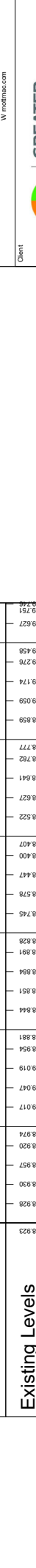
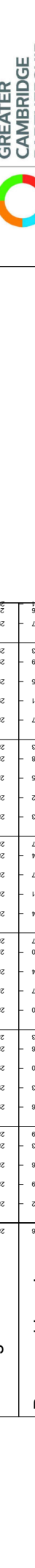
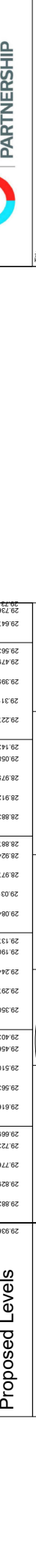
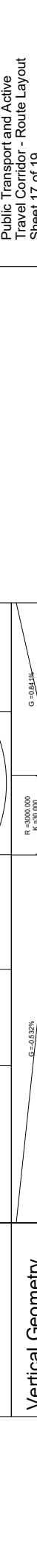
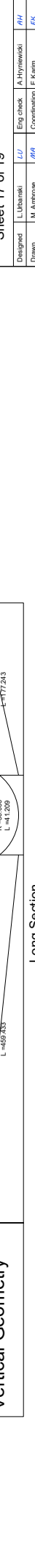
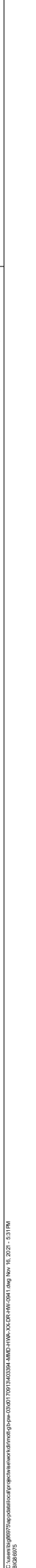
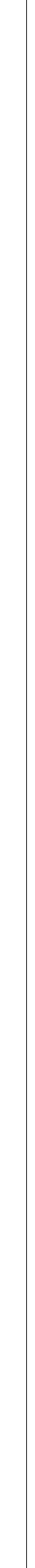
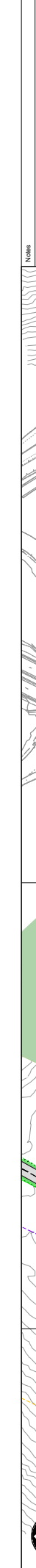
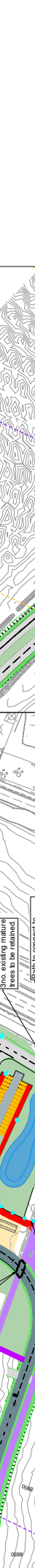
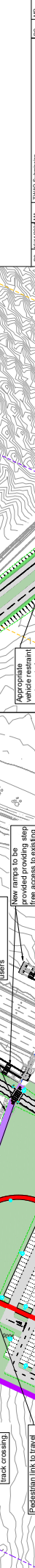
Long Section
Chainage 6600 to 7150
Scale: H=1:1000 V=1:100



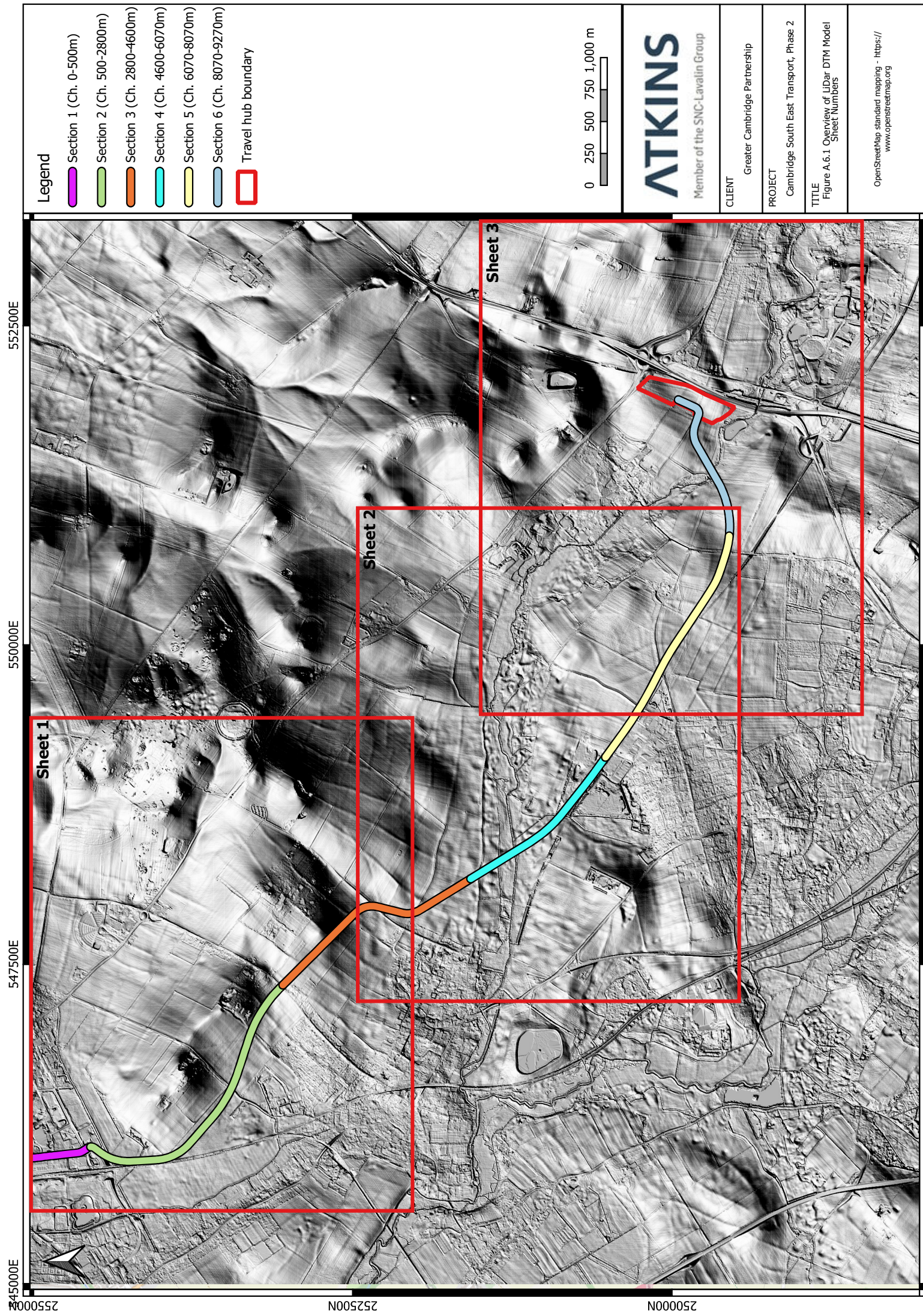
Chainage	Existing Levels	Proposed Levels	Horizontal Geometry	Vertical Geometry
25+000	25.928	25.972	<div><div><div>R=720.000 L=583.317</div><div>L=34.003</div></div><div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div></div>	<div><div>R=500.000 L=112.299</div><div>G=-0.814%</div></div>
25+040	26.134	26.194		
25+080	26.263	26.329		
25+120	26.356	26.400		
25+160	26.489	26.522		
25+200	26.595	26.622		
25+240	26.706	26.730		
25+280	26.888	26.898		
25+320	26.930	26.940		
25+360	26.955	26.965		
25+400	27.076	27.076	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
25+440	27.155	27.155		
25+480	27.236	27.236		
25+520	27.322	27.322		
25+560	27.422	27.422		
25+600	27.535	27.535		
25+640	27.668	27.668		
25+680	27.822	27.822		
25+720	27.990	27.990		
25+760	28.191	28.191		
25+800	28.347	28.347	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
25+840	28.544	28.544		
25+880	28.688	28.688		
25+920	28.800	28.800		
25+960	28.894	28.894		
26+000	28.940	28.940		
26+040	29.020	29.020		
26+080	29.154	29.154		
26+120	29.287	29.287		
26+160	29.420	29.420		
26+200	29.555	29.555	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
26+240	29.687	29.687		
26+280	29.820	29.820		
26+320	29.958	29.958		
26+360	30.099	30.099		
26+400	30.242	30.242		
26+440	30.386	30.386		
26+480	30.531	30.531		
26+520	30.676	30.676		
26+560	30.822	30.822		
26+600	30.968	30.968	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
26+640	31.117	31.117		
26+680	31.267	31.267		
26+720	31.418	31.418		
26+760	31.569	31.569		
26+800	31.721	31.721		
26+840	31.872	31.872		
26+880	32.024	32.024		
26+920	32.175	32.175		
26+960	32.326	32.326		
27+000	32.477	32.477	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
27+040	32.628	32.628		
27+080	32.779	32.779		
27+120	32.930	32.930		
27+160	33.081	33.081		
27+200	33.232	33.232		
27+240	33.383	33.383		
27+280	33.534	33.534		
27+320	33.685	33.685		
27+360	33.836	33.836		
27+400	33.987	33.987	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
27+440	34.138	34.138		
27+480	34.289	34.289		
27+520	34.440	34.440		
27+560	34.591	34.591		
27+600	34.742	34.742		
27+640	34.893	34.893		
27+680	35.044	35.044		
27+720	35.195	35.195		
27+760	35.346	35.346		
27+800	35.497	35.497	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
27+840	35.648	35.648		
27+880	35.799	35.799		
27+920	35.950	35.950		
27+960	36.101	36.101		
28+000	36.252	36.252		
28+040	36.403	36.403		
28+080	36.554	36.554		
28+120	36.705	36.705		
28+160	36.856	36.856		
28+200	37.007	37.007	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
28+240	37.158	37.158		
28+280	37.309	37.309		
28+320	37.460	37.460		
28+360	37.611	37.611		
28+400	37.762	37.762		
28+440	37.913	37.913		
28+480	38.064	38.064		
28+520	38.215	38.215		
28+560	38.366	38.366		
28+600	38.517	38.517	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
28+640	38.668	38.668		
28+680	38.819	38.819		
28+720	38.970	38.970		
28+760	39.121	39.121		
28+800	39.272	39.272		
28+840	39.423	39.423		
28+880	39.574	39.574		
28+920	39.725	39.725		
28+960	39.876	39.876		
29+000	40.027	40.027	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
29+040	40.178	40.178		
29+080	40.329	40.329		
29+120	40.480	40.480		
29+160	40.631	40.631		
29+200	40.782	40.782		
29+240	40.933	40.933		
29+280	41.084	41.084		
29+320	41.235	41.235		
29+360	41.386	41.386		
29+400	41.537	41.537	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
29+440	41.688	41.688		
29+480	41.839	41.839		
29+520	41.990	41.990		
29+560	42.141	42.141		
29+600	42.292	42.292		
29+640	42.443	42.443		
29+680	42.594	42.594		
29+720	42.745	42.745		
29+760	42.896	42.896		
29+800	43.047	43.047	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
29+840	43.198	43.198		
29+880	43.349	43.349		
29+920	43.500	43.500		
29+960	43.651	43.651		
30+000	43.802	43.802		
30+040	43.953	43.953		
30+080	44.104	44.104		
30+120	44.255	44.255		
30+160	44.406	44.406		
30+200	44.557	44.557	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
30+240	44.708	44.708		
30+280	44.859	44.859		
30+320	45.010	45.010		
30+360	45.161	45.161		
30+400	45.312	45.312		
30+440	45.463	45.463		
30+480	45.614	45.614		
30+520	45.765	45.765		
30+560	45.916	45.916		
30+600	46.067	46.067	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
30+640	46.218	46.218		
30+680	46.369	46.369		
30+720	46.520	46.520		
30+760	46.671	46.671		
30+800	46.822	46.822		
30+840	46.973	46.973		
30+880	47.124	47.124		
30+920	47.275	47.275		
30+960	47.426	47.426		
31+000	47.577	47.577	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
31+040	47.728	47.728		
31+080	47.879	47.879		
31+120	48.030	48.030		
31+160	48.181	48.181		
31+200	48.332	48.332		
31+240	48.483	48.483		
31+280	48.634	48.634		
31+320	48.785	48.785		
31+360	48.936	48.936		
31+400	49.087	49.087	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
31+440	49.238	49.238		
31+480	49.389	49.389		
31+520	49.540	49.540		
31+560	49.691	49.691		
31+600	49.842	49.842		
31+640	49.993	49.993		
31+680	50.144	50.144		
31+720	50.295	50.295		
31+760	50.446	50.446		
31+800	50.597	50.597	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
31+840	50.748	50.748		
31+880	50.899	50.899		
31+920	51.050	51.050		
31+960	51.201	51.201		
32+000	51.352	51.352		
32+040	51.503	51.503		
32+080	51.654	51.654		
32+120	51.805	51.805		
32+160	51.956	51.956		
32+200	52.107	52.107	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
32+240	52.258	52.258		
32+280	52.409	52.409		
32+320	52.560	52.560		
32+360	52.711	52.711		
32+400	52.862	52.862		
32+440	53.013	53.013		
32+480	53.164	53.164		
32+520	53.315	53.315		
32+560	53.466	53.466		
32+600	53.617	53.617	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
32+640	53.768	53.768		
32+680	53.919	53.919		
32+720	54.070	54.070		
32+760	54.221	54.221		
32+800	54.372	54.372		
32+840	54.523	54.523		
32+880	54.674	54.674		
32+920	54.825	54.825		
32+960	54.976	54.976		
33+000	55.127	55.127	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
33+040	55.278	55.278		
33+080	55.429	55.429		
33+120	55.580	55.580		
33+160	55.731	55.731		
33+200	55.882	55.882		
33+240	56.033	56.033		
33+280	56.184	56.184		
33+320	56.335	56.335		
33+360	56.486	56.486		
33+400	56.637	56.637	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
33+440	56.788	56.788		
33+480	56.939	56.939		
33+520	57.090	57.090		
33+560	57.241	57.241		
33+600	57.392	57.392		
33+640	57.543	57.543		
33+680	57.694	57.694		
33+720	57.845	57.845		
33+760	57.996	57.996		
33+800	58.147	58.147	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
33+840	58.298	58.298		
33+880	58.449	58.449		
33+920	58.600	58.600		
33+960	58.751	58.751		
34+000	58.902	58.902		
34+040	59.053	59.053		
34+080	59.204	59.204		
34+120	59.355	59.355		
34+160	59.506	59.506		
34+200	59.657	59.657	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
34+240	59.808	59.808		
34+280	59.959	59.959		
34+320	60.110	60.110		
34+360	60.261	60.261		
34+400	60.412	60.412		
34+440	60.563	60.563		
34+480	60.714	60.714		
34+520	60.865	60.865		
34+560	61.016	61.016		
34+600	61.167	61.167	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
34+640	61.318	61.318		
34+680	61.469	61.469		
34+720	61.620	61.620		
34+760	61.771	61.771		
34+800	61.922	61.922		
34+840	62.073	62.073		
34+880	62.224	62.224		
34+920	62.375	62.375		
34+960	62.526	62.526		
35+000	62.677	62.677	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
35+040	62.828	62.828		
35+080	62.979	62.979		
35+120	63.130	63.130		
35+160	63.281	63.281		
35+200	63.432	63.432		
35+240	63.583	63.583		
35+280	63.734	63.734		
35+320	63.885	63.885		
35+360	64.036	64.036		
35+400	64.187	64.187	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>	<div><div>R=500.000 L=559.555</div><div>G=+3.32%</div></div>
35+440	64.338	64.338		
35+480	64.489	64.489		
35+520	64.640	64.		

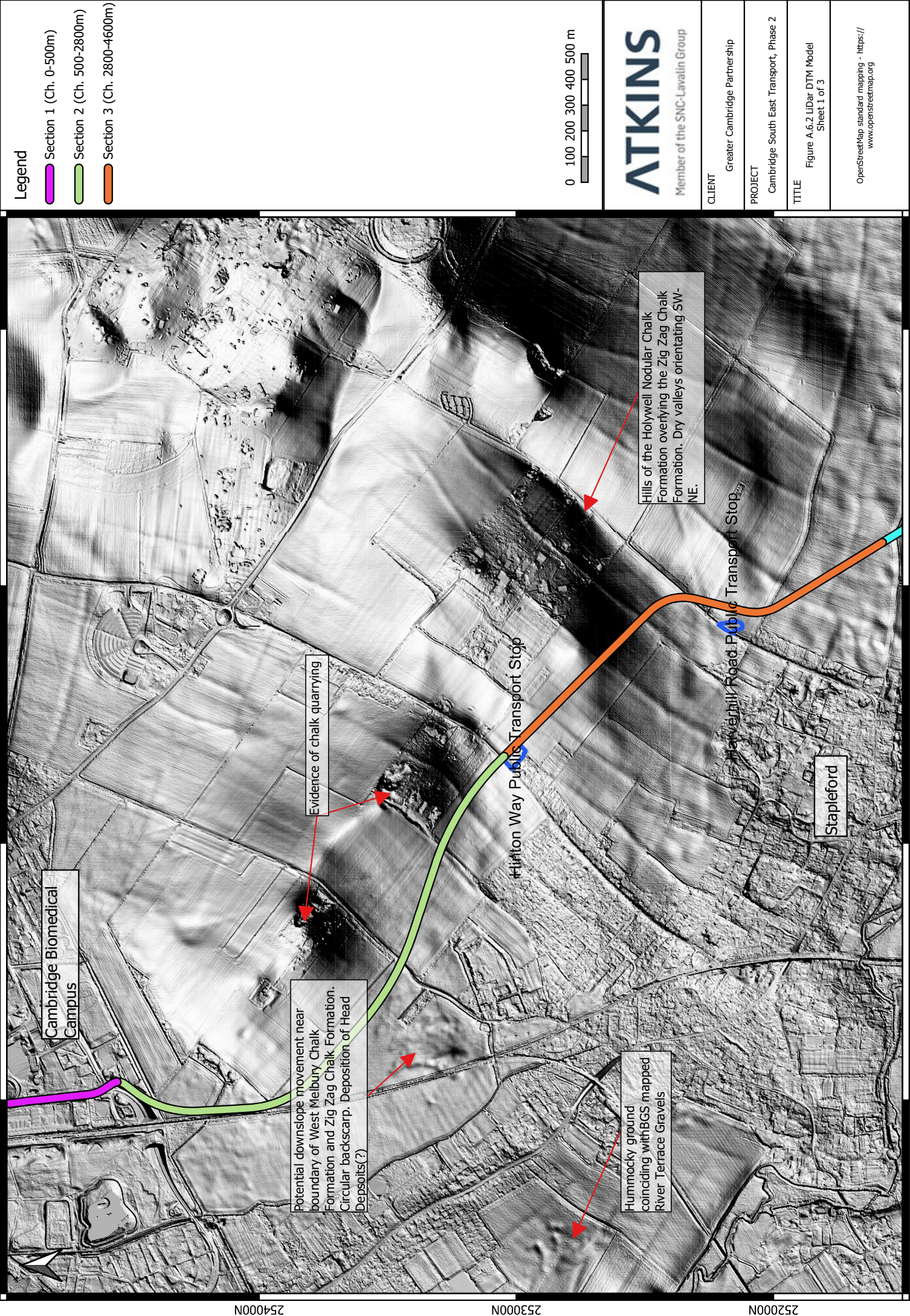
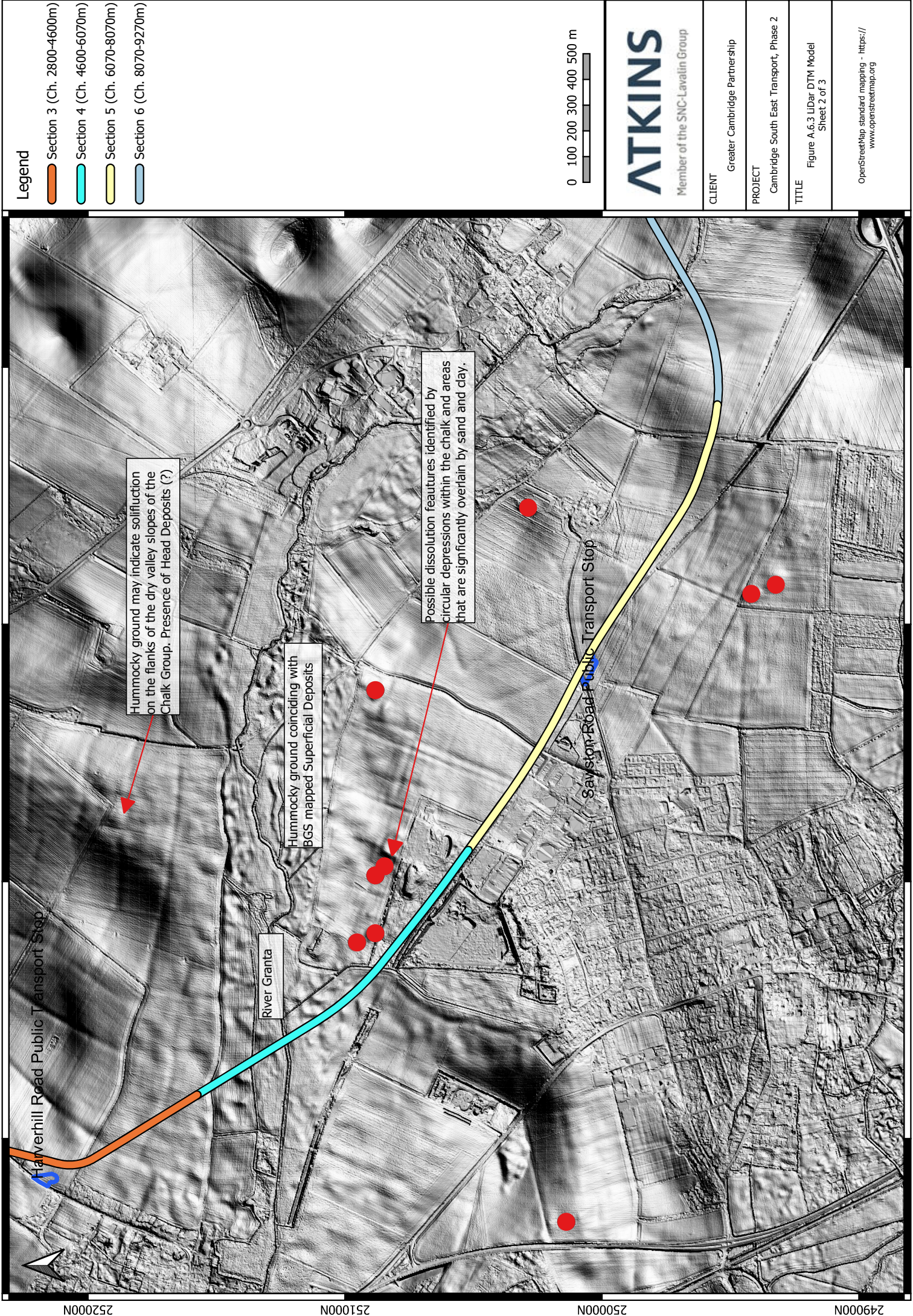
Long Section
Chainage 7150 to 7700

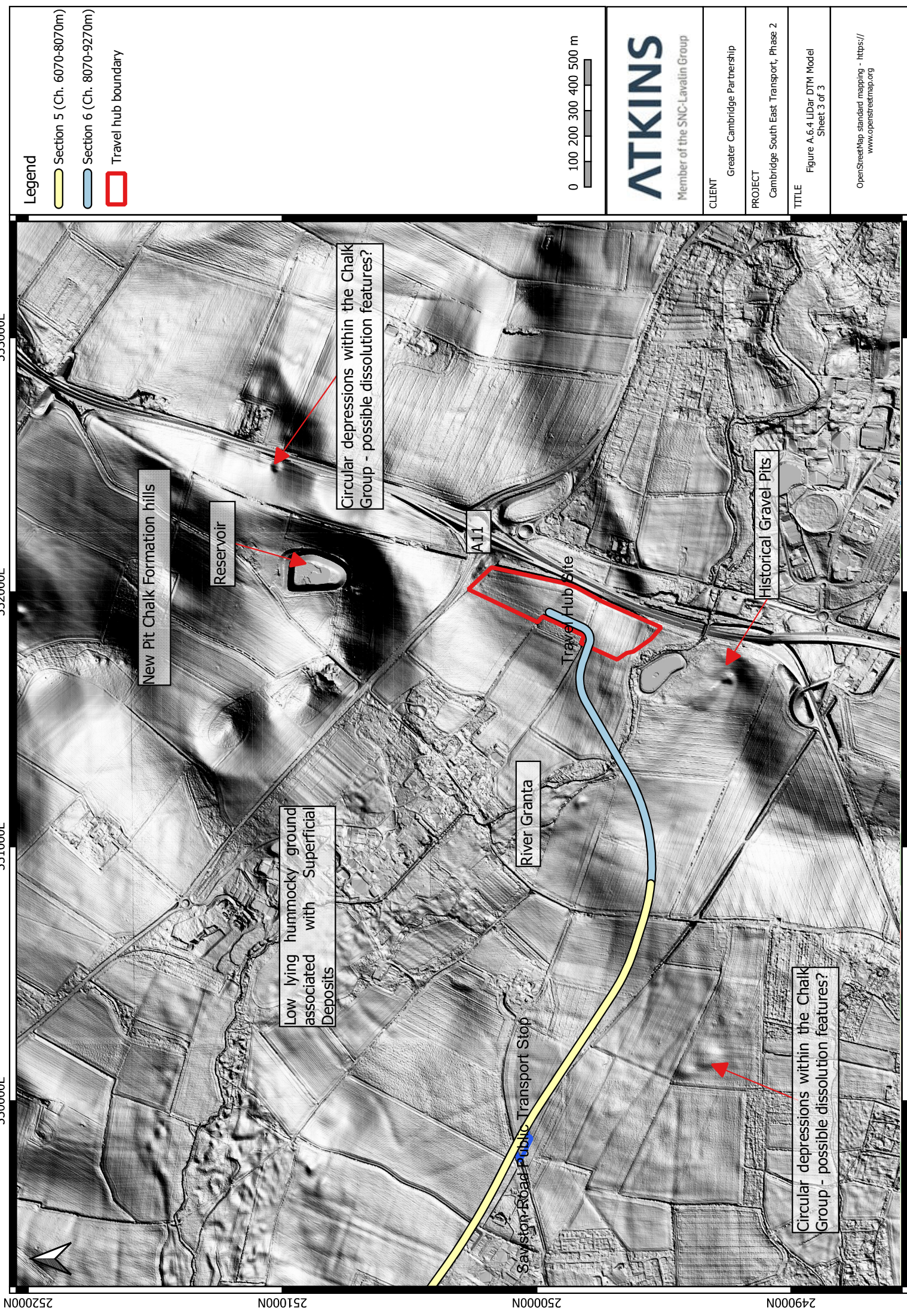




A.6. LiDAR (Geomorphology)





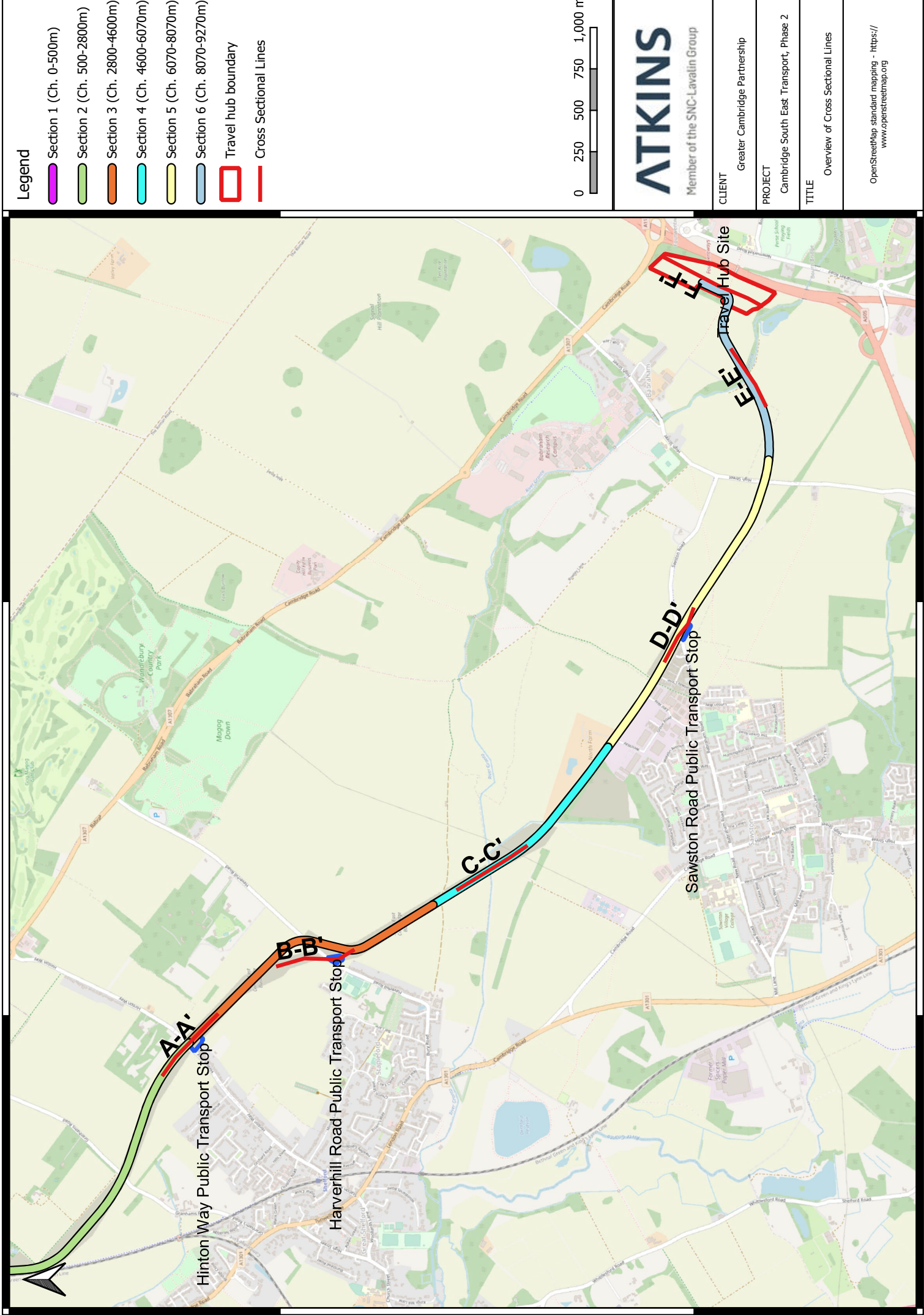


Appendix B. Ground Models

B.1. OpenGround Cross Sections

550000E

547500E



252500N

250000N

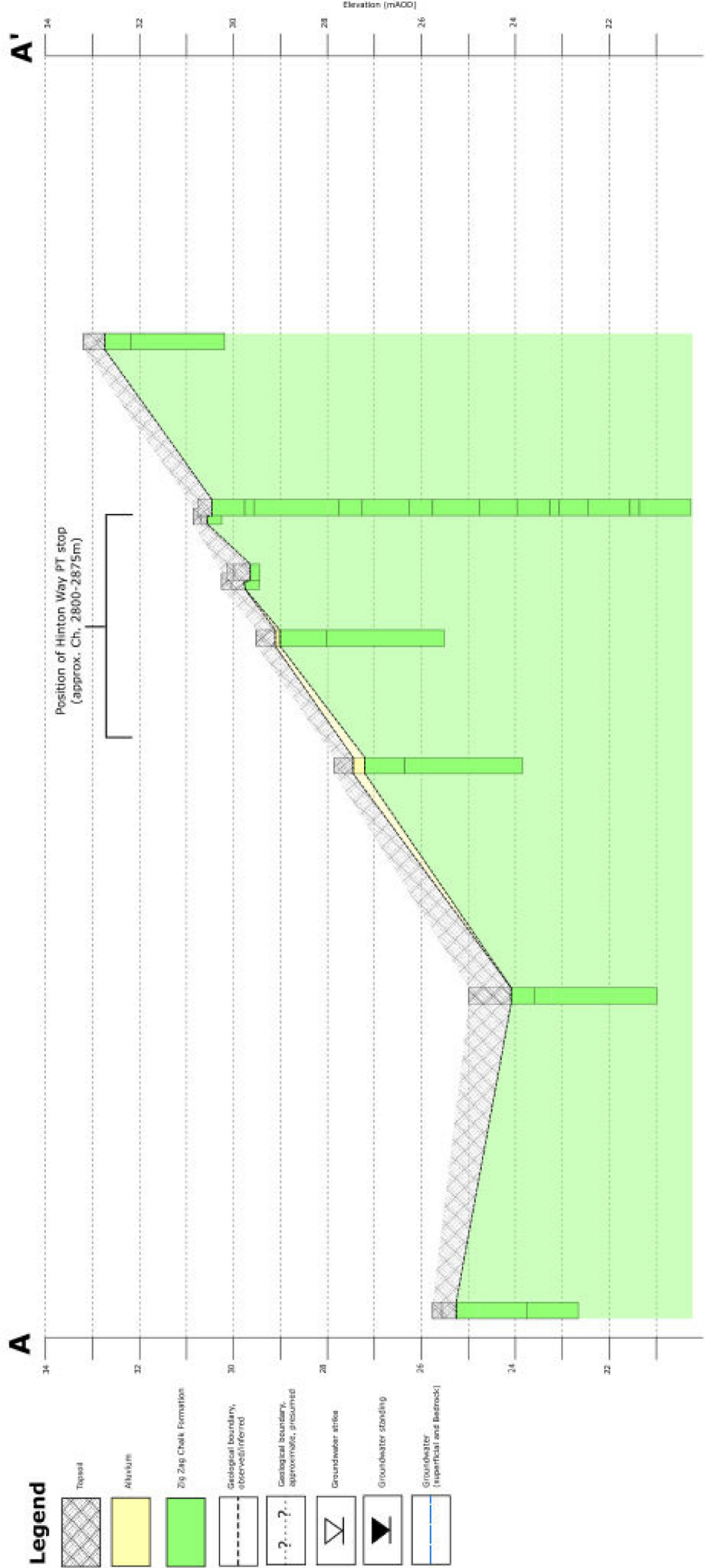
- Legend**
- Section 1 (Ch. 0-500m)
 - Section 2 (Ch. 500-2800m)
 - Section 3 (Ch. 2800-4600m)
 - Section 4 (Ch. 4600-6070m)
 - Section 5 (Ch. 6070-8070m)
 - Section 6 (Ch. 8070-9270m)
 - Travel hub boundary
 - Cross Sectional Lines



ATKINS
Member of the SNC-Lavalin Group

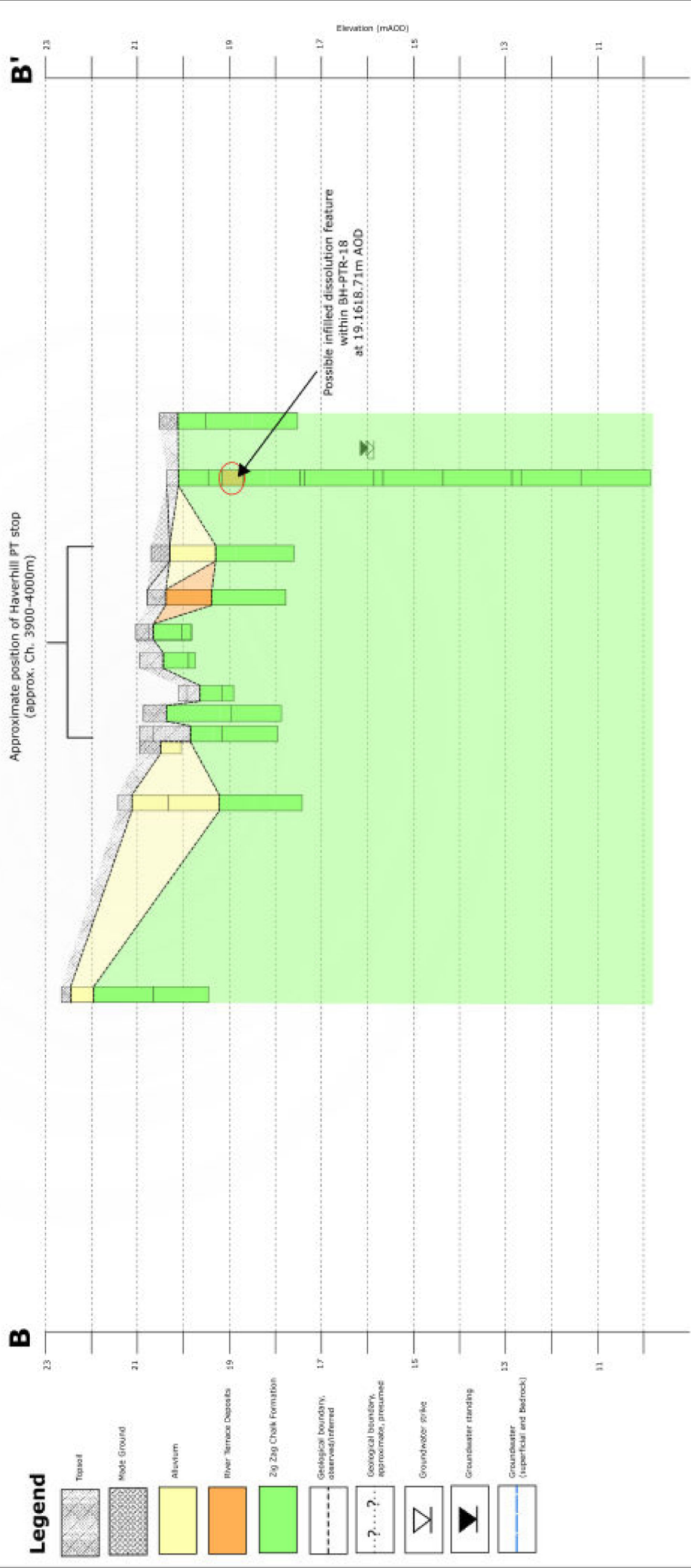
CLIENT	Greater Cambridge Partnership
PROJECT	Cambridge South East Transport, Phase 2
TITLE	Overview of Cross Sectional Lines
OpenStreetMap standard mapping - https://www.openstreetmap.org	

Project ID 20210761	Client Greater Cambridge Partnership	ATKINS Member of the SNC-Lavalin Group	Horizontal Scale 1:2330	Vertical Scale 1:123
Project Title Cambridge South East Transport, Phase 2	Engineer Atkins	Cross Section A-A': Hinton Way PT Stop Ch.2550-3050m		



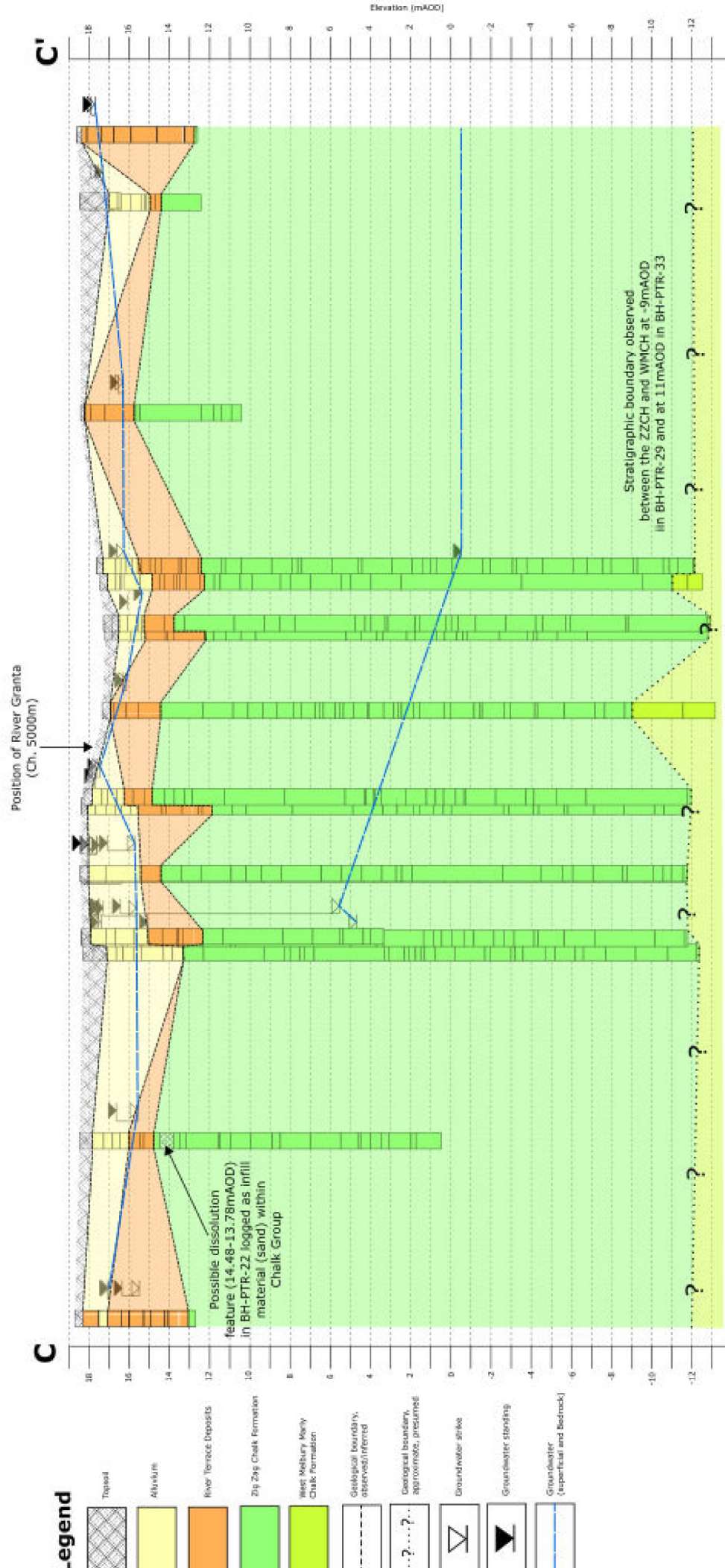
- NOTES:**
- Do not scale from this drawing
 - All dimensions are in metres unless otherwise stated.
 - This drawing is to be read in conjunction with the Cambridge South East Transport, Phase 2 Ground Investigation Report.
 - This geological cross section represents one possible interpretation of the ground investigation, other possible interpretations may exist. For detailed information regarding stratigraphy and material types, reference should be made to the individual exploratory hole records and the GIR.
 - The superficial deposits (Alluvium and Made Ground /Topsoil) may be highly variable on a small scale.
 - This cross section has been prepared from the Tetra Tech ground investigation undertaken in 2021.
 - This geological cross section has been interpreted from all available information and data.

Project ID	Client		Cross Section B-B': Haverhill PT Stop (Ch. 3500-4050m)	
20210761	Greater Cambridge Partnership		Member of the SMC-Lavalin Group	
Project Title	Engineer		Horizontal Scale	Vertical Scale
Cambridge South East Transport, Phase 2	Atkins		1:2973	1:123



- NOTES:**
1. Do not scale from this drawing
 2. All dimensions are in metres unless otherwise stated.
 3. This drawing is to be read in conjunction with the Cambridge South East Transport, Phase 2 Ground Investigation Report.
 4. This geological cross section represents one possible interpretation of the ground investigation, other possible interpretations may exist. For detailed information regarding stratigraphy and material types, reference should be made to the individual exploratory hole records and the GIR.
 5. The superficial deposits (Made Ground, Alluvium and River Terrace Deposits) may be highly variable on a small scale.
 6. This cross section has been prepared from the Tetra Tech ground investigation undertaken in 2021.
 7. This geological cross section has been interpreted from all available information and data.

Project ID	Client		Cross Section C-C': River Granta Ch.4800-5300m	
20210761	Greater Cambridge Partnership		Member of the SMC-Lavalin Group	
Project Title	Engineer		Horizontal Scale	Vertical Scale
Cambridge South East Transport, Phase 2	Atkins		1:2352	1:289

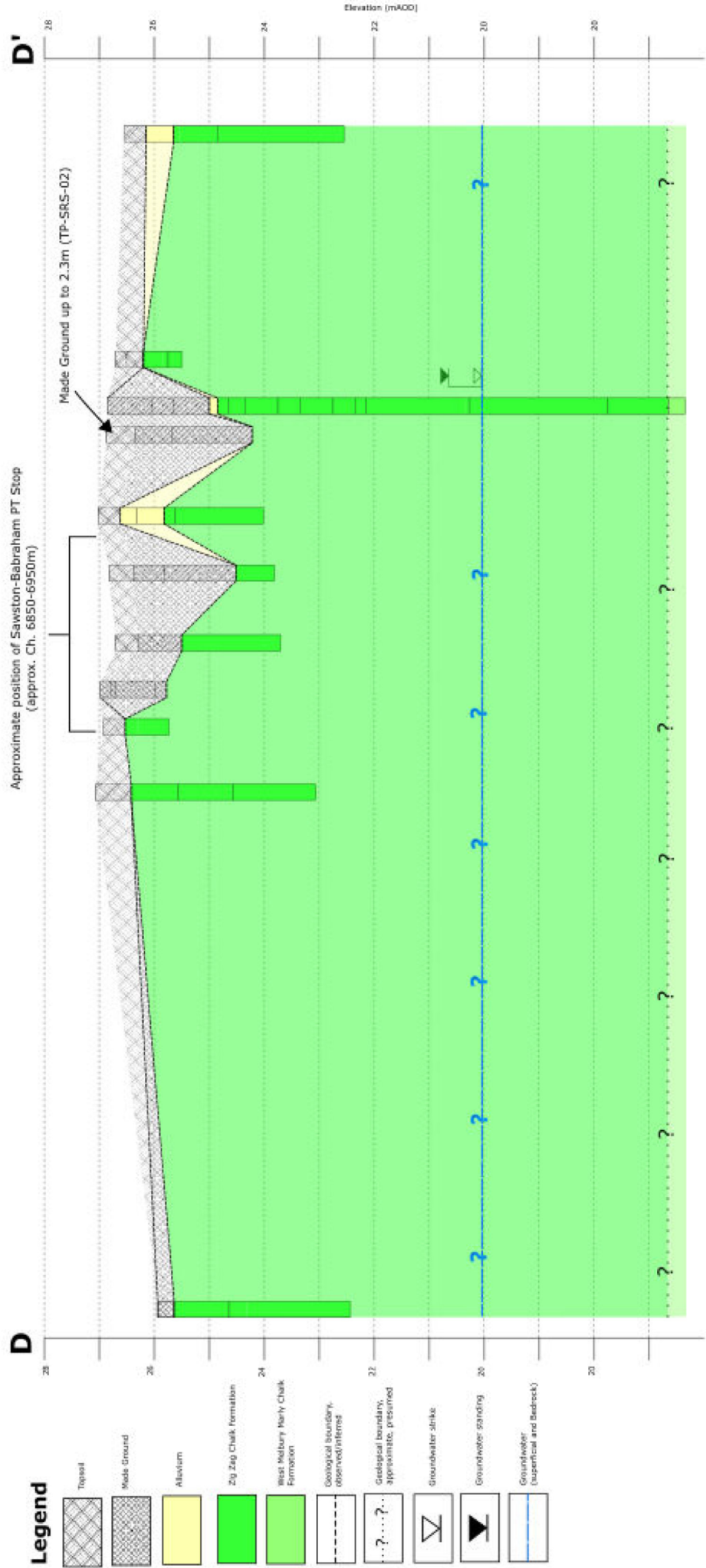


- NOTES:**
1. Do not scale from this drawing
 2. All dimensions are in metres unless otherwise stated.
 3. This drawing is to be read in conjunction with the Cambridge South East Transport, Phase 2 Ground Investigation Report.
 4. This geological cross section represents one possible interpretation of the ground investigation, other possible interpretations may exist. For detailed information regarding stratigraphy and material types, reference should be made to the individual exploratory hole records and the GIR.
 5. The superficial deposits (Alluvium and River Terrace Deposits) may be highly variable on a small scale.
 6. This cross section has been prepared from the Tetra Tech ground investigation undertaken in 2021.
 7. This geological cross section has been interpreted from all available information and data.

Project ID	Client	Cross Section D-D': Sawston-Babraham PT Stop (Ch. 6650-7025m)	
20210761	Greater Cambridge Partnership		
Project Title	Engineer	Horizontal Scale	Vertical Scale
Cambridge South East Transport, Phase 2	Atkins	1:1870	1:105

ATKINS

Member of the SNC-Lavalin Group

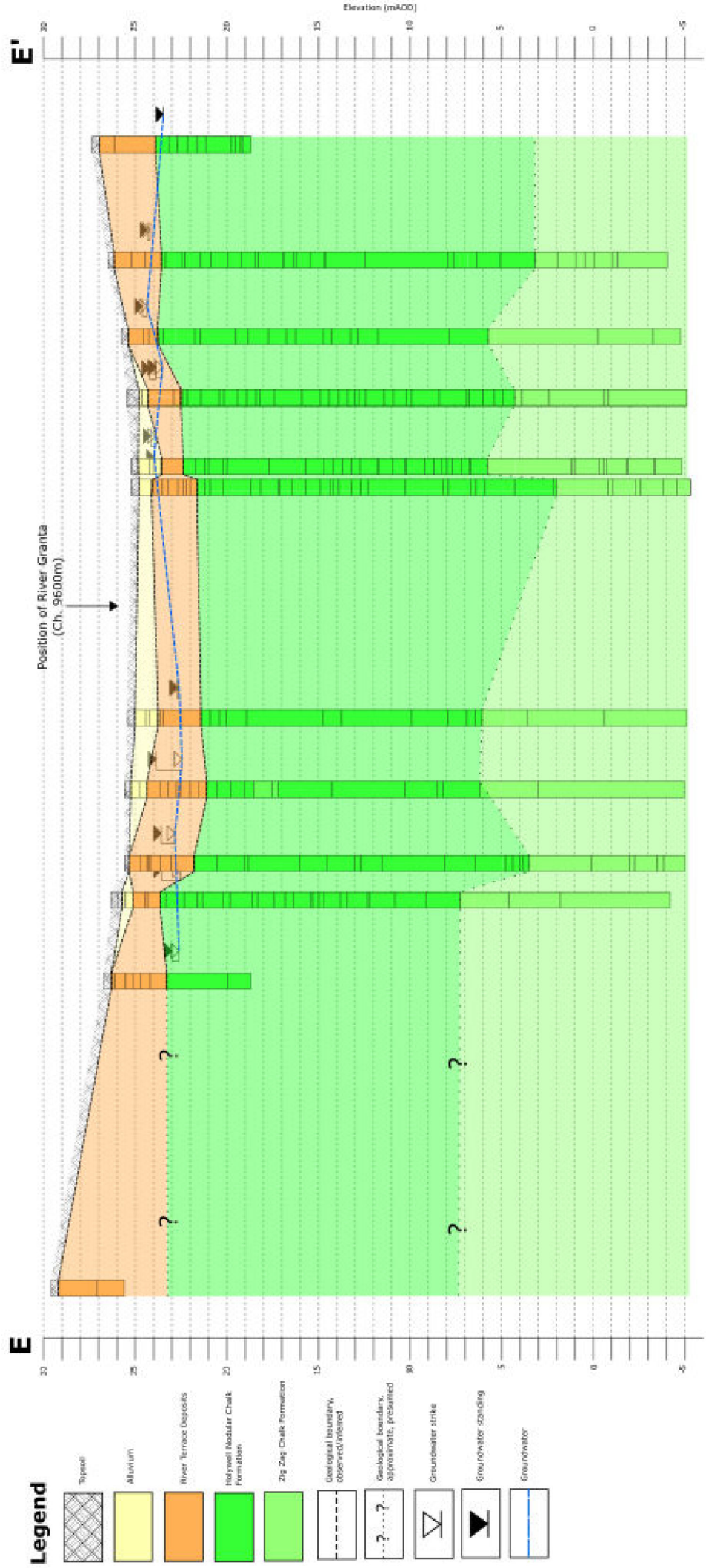


- NOTES:**
1. Do not scale from this drawing
 2. All dimensions are in metres unless otherwise stated.
 3. This drawing is to be read in conjunction with the Cambridge South East Transport, Phase 2 Ground Investigation Report.
 4. This geological cross section represents one possible interpretation of the ground investigation, other possible interpretations may exist. For detailed information regarding stratigraphy and material types, reference should be made to the individual exploratory hole records and the GIR.
 5. The superficial deposits (Made Ground and Alluvium) may be highly variable on a small scale.
 6. This cross section has been prepared from the Tetra Tech ground investigation undertaken in 2021.
 7. This geological cross section has been interpreted from all available information and data.

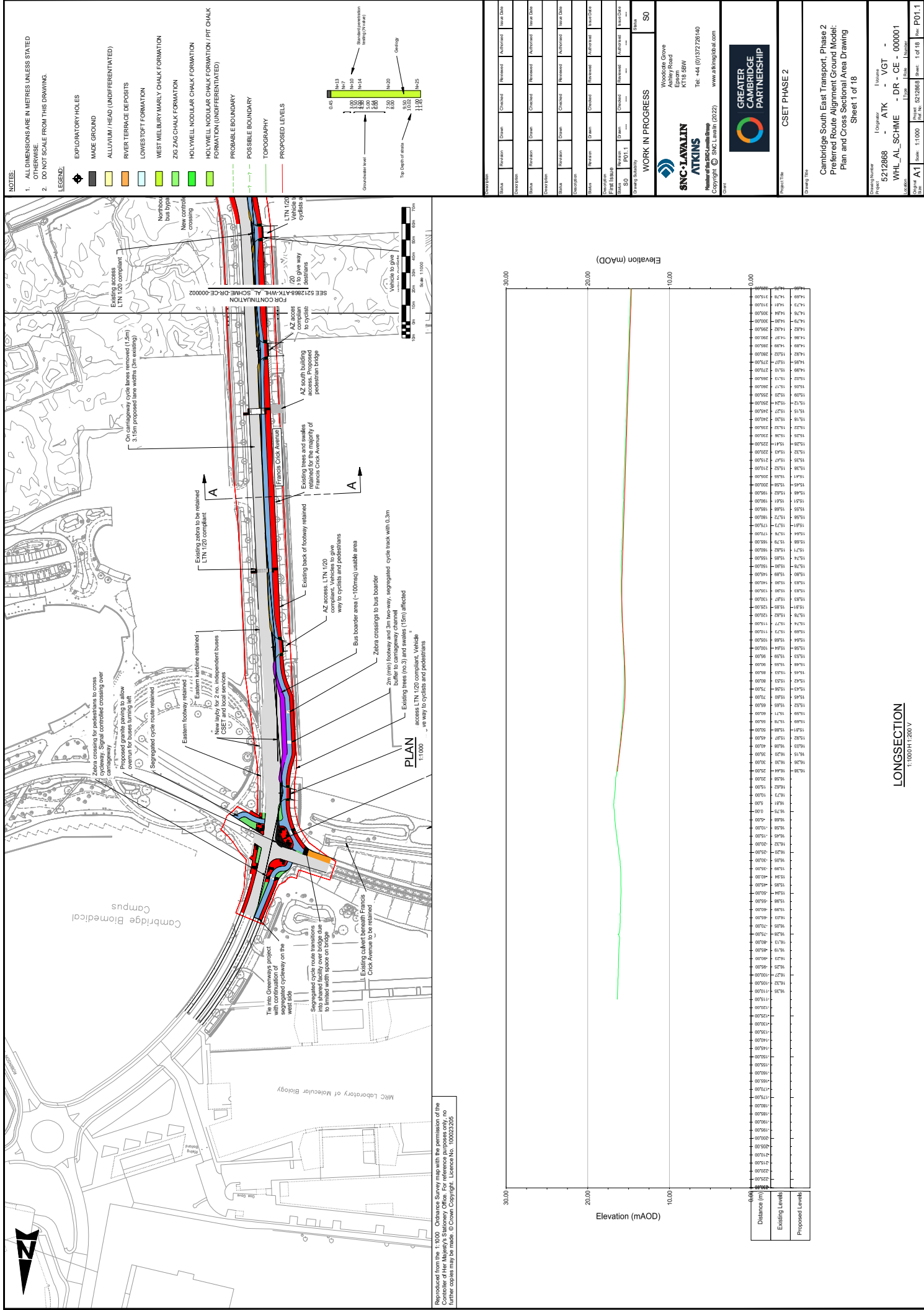
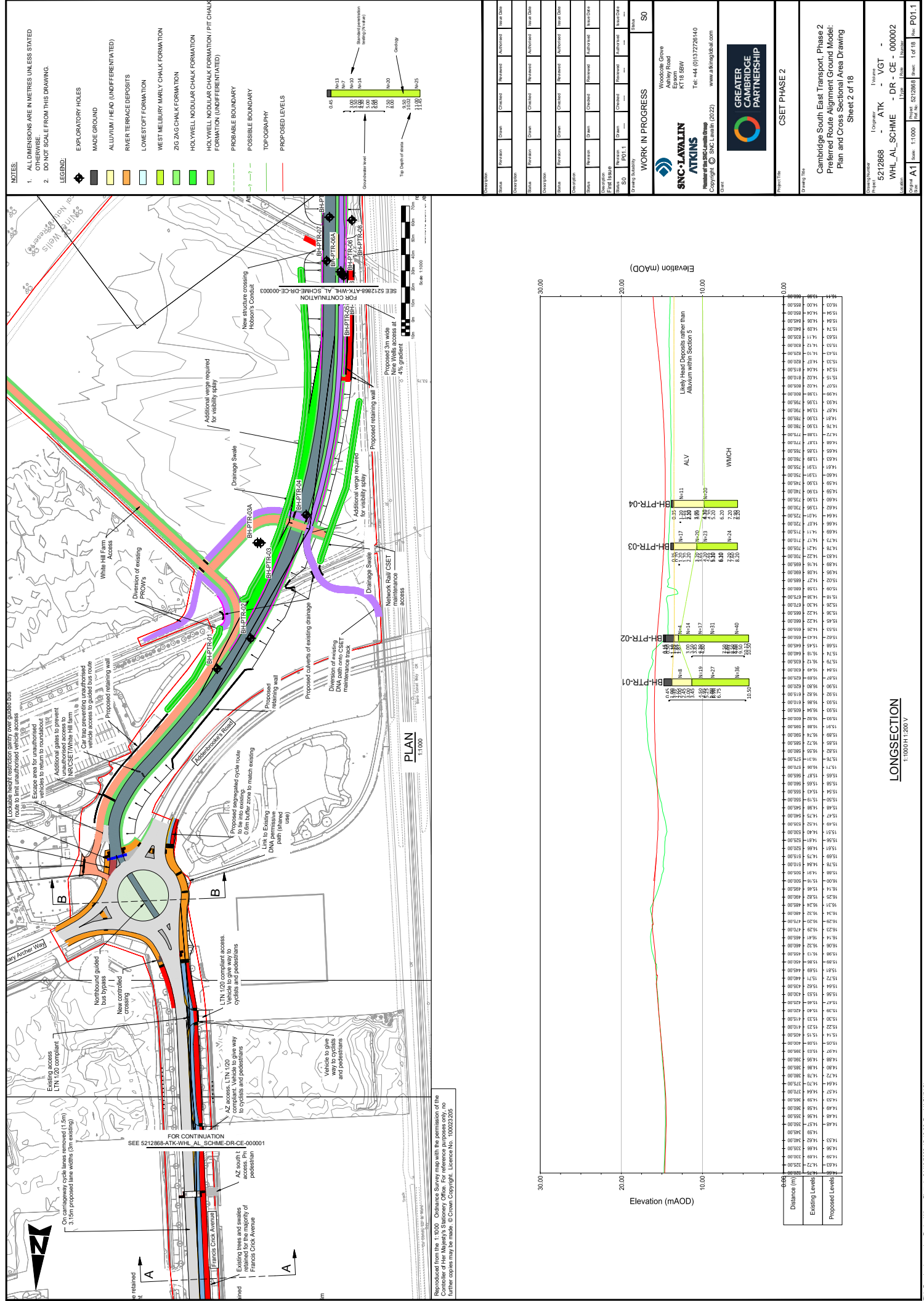
Project ID	Client	Cross Section E-E': River Granta Ch.8350-8750m	
20210761	Greater Cambridge Partnership		
Project Title	Engineer	Horizontal Scale	Vertical Scale
Cambridge South East Transport, Phase 2	Atkins	1:1933	1:315

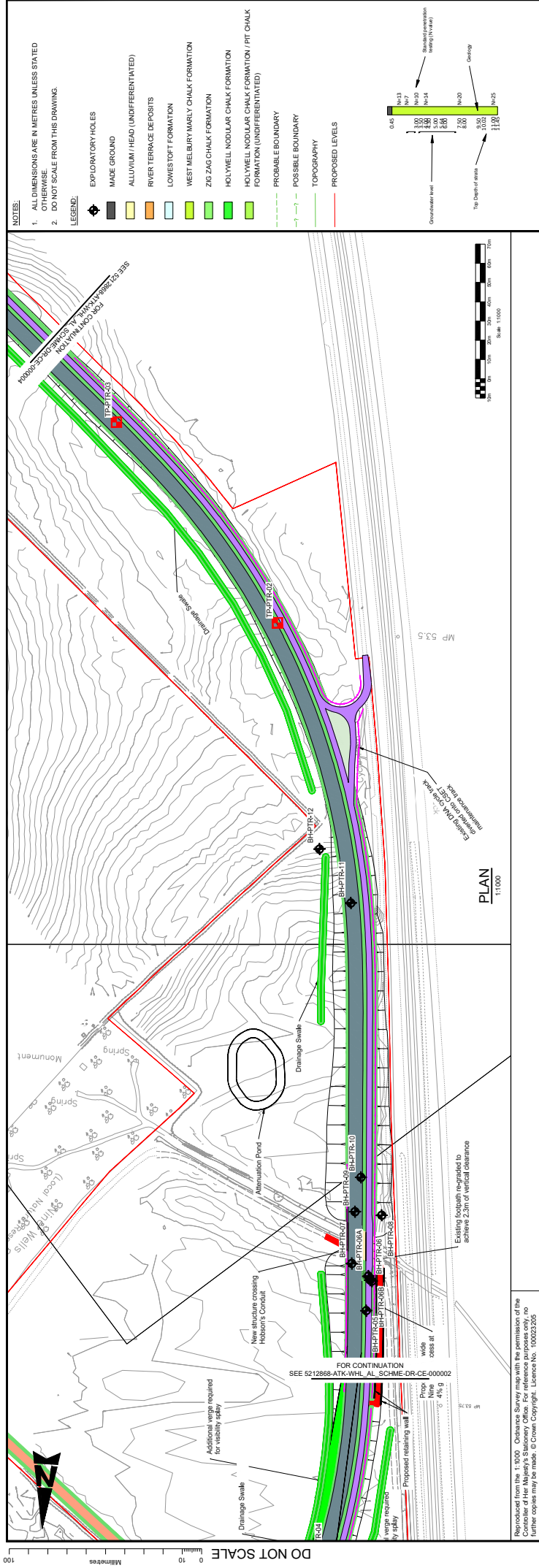
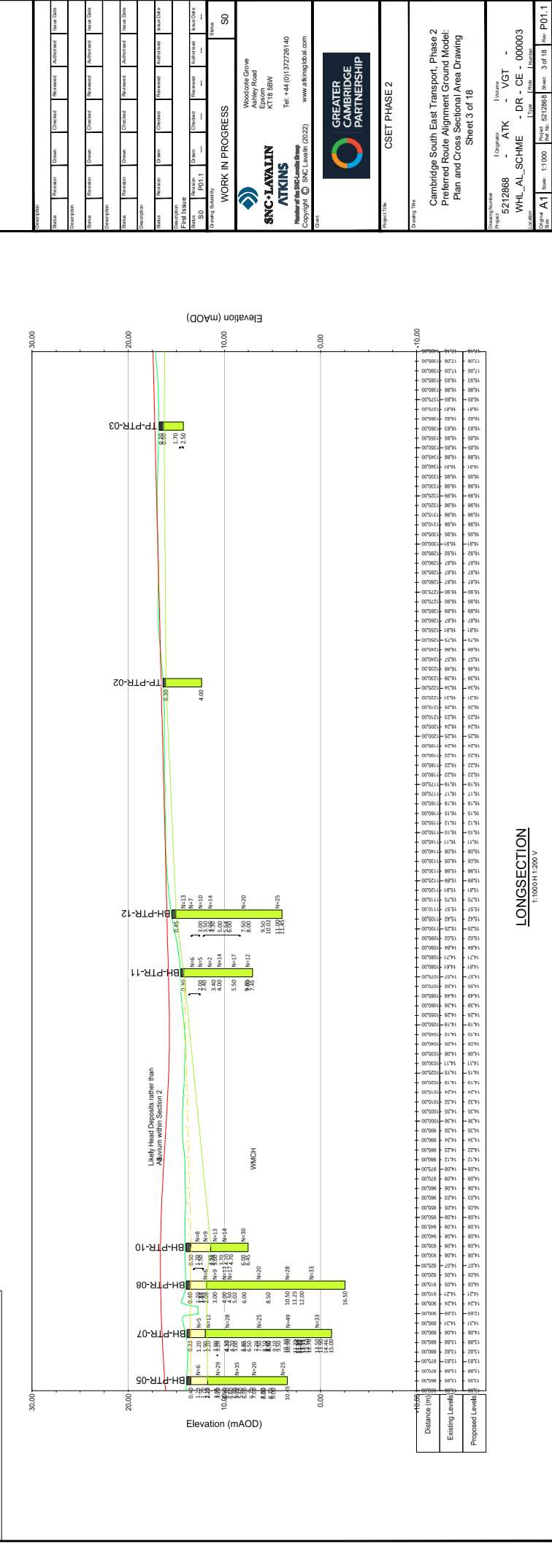
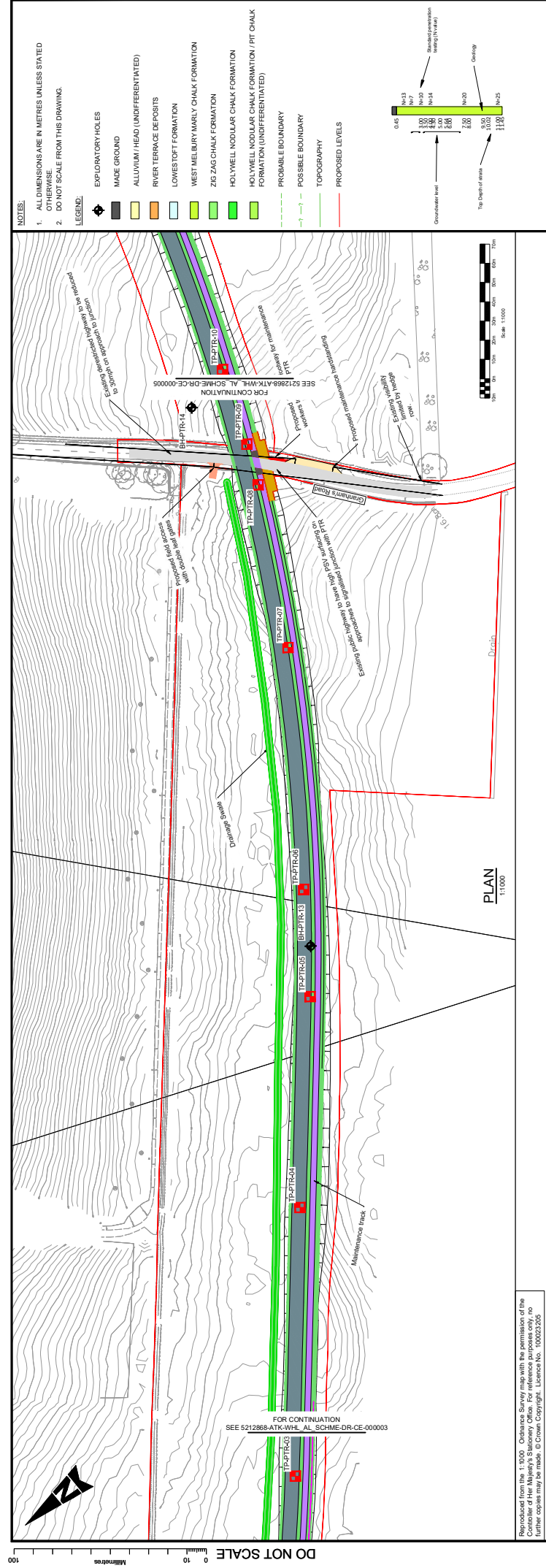
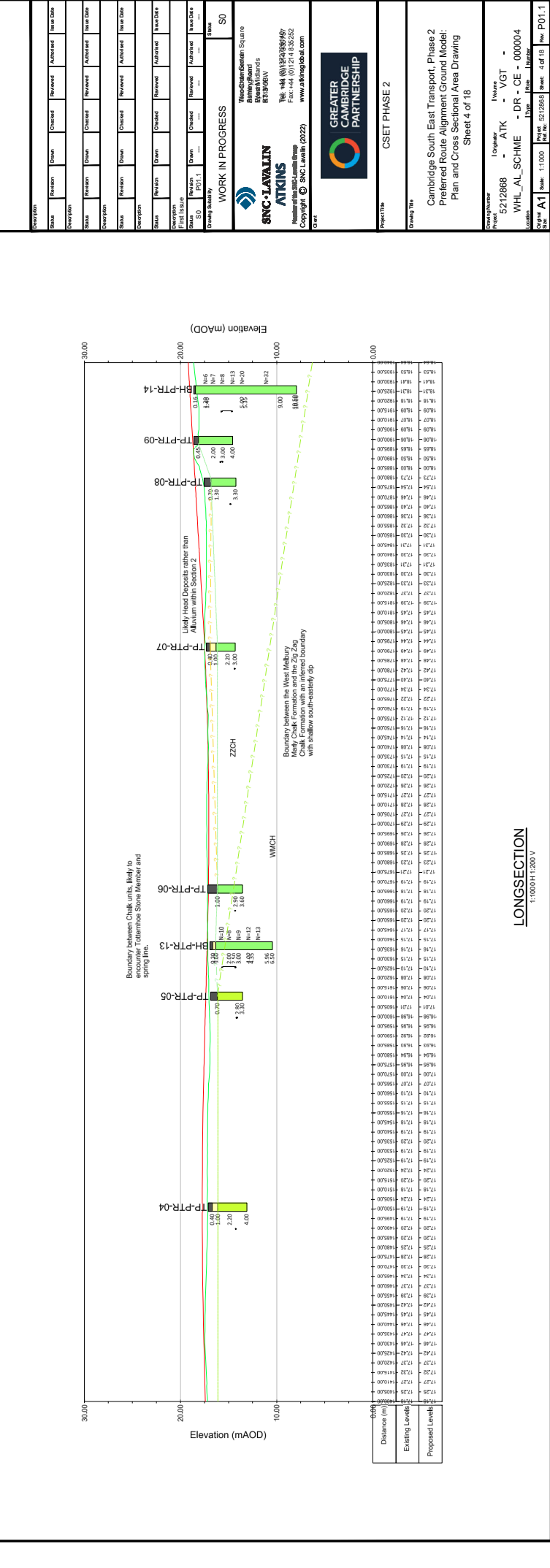
ATKINS

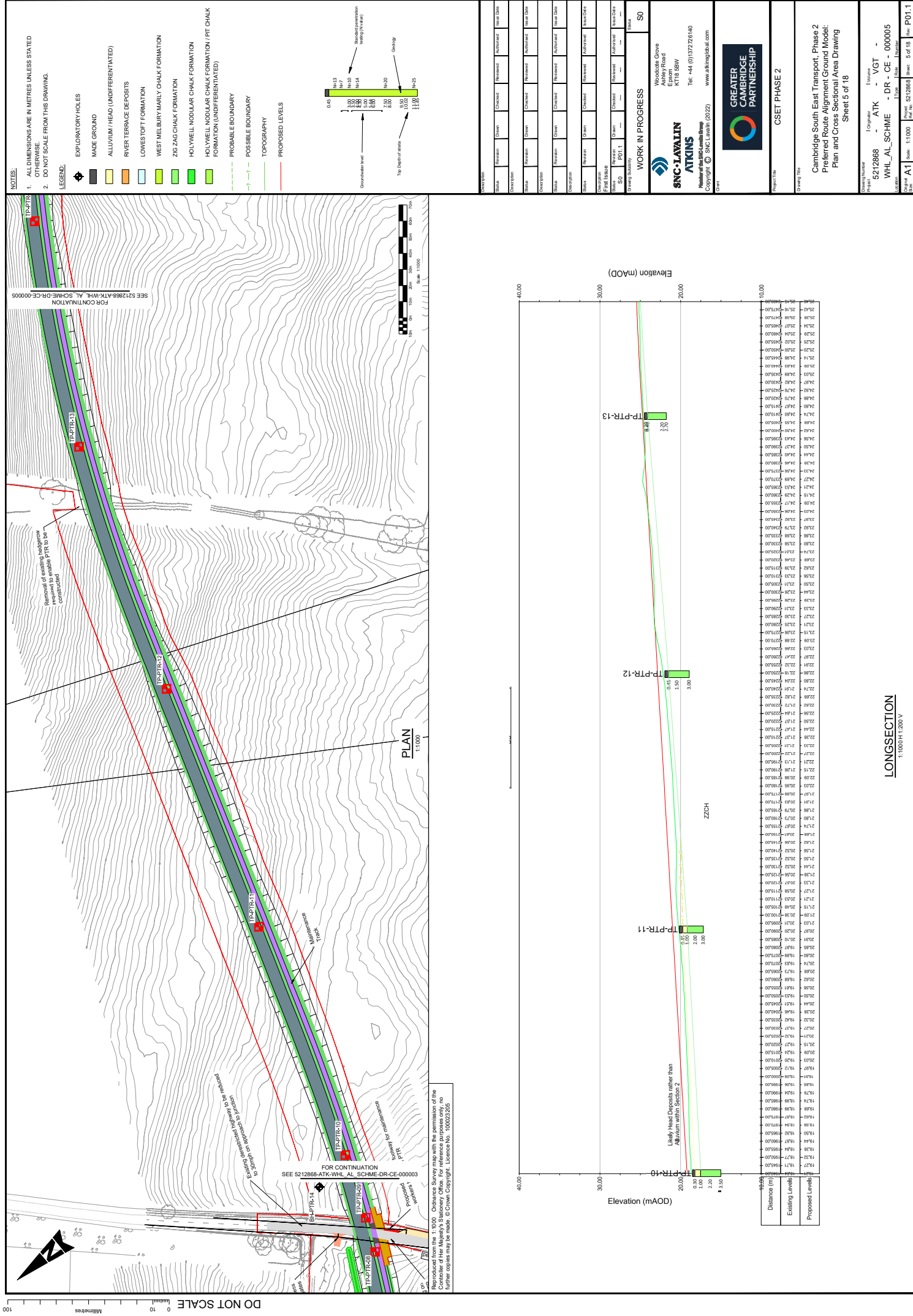
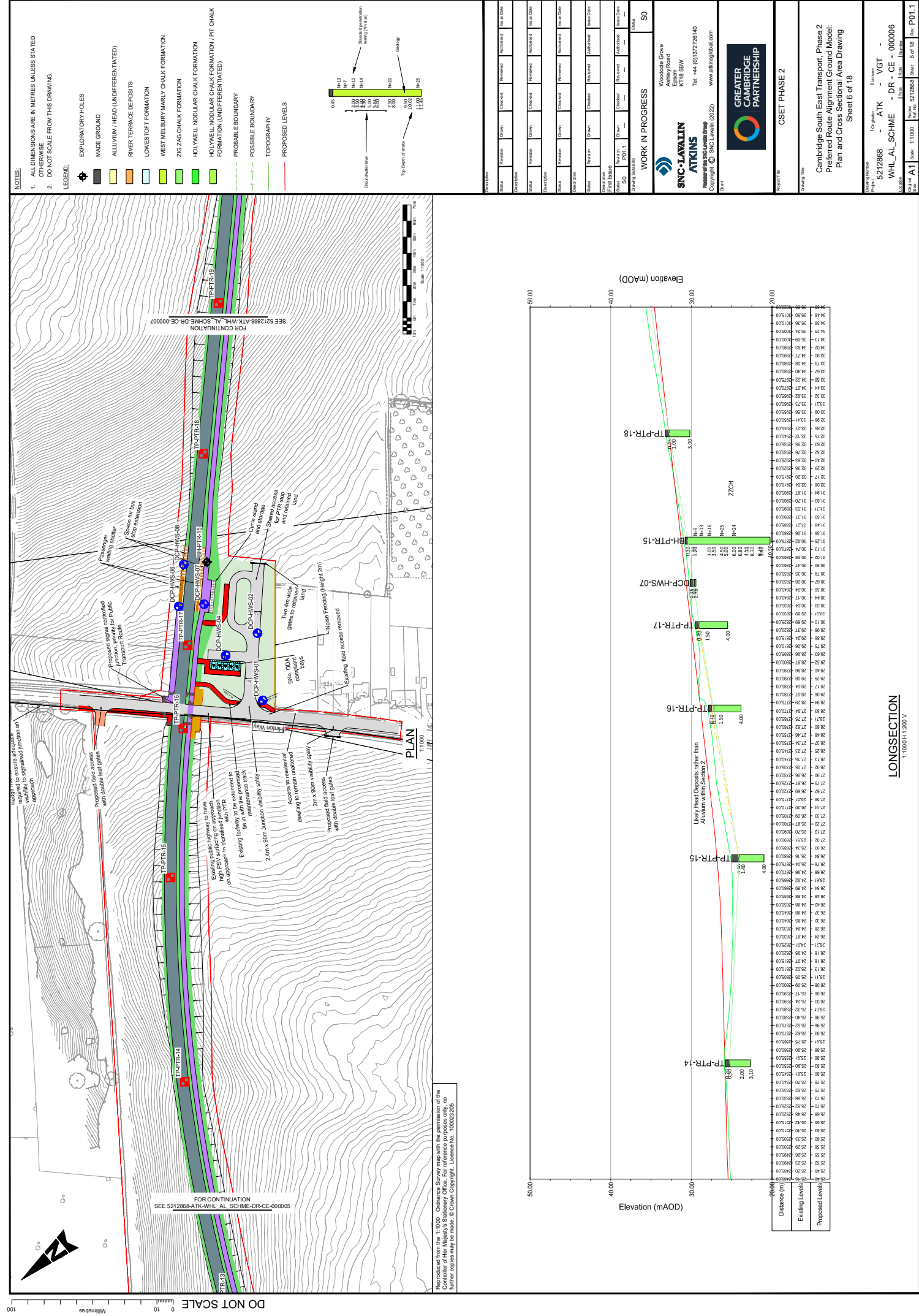
Member of the SNC-Lavalin Group

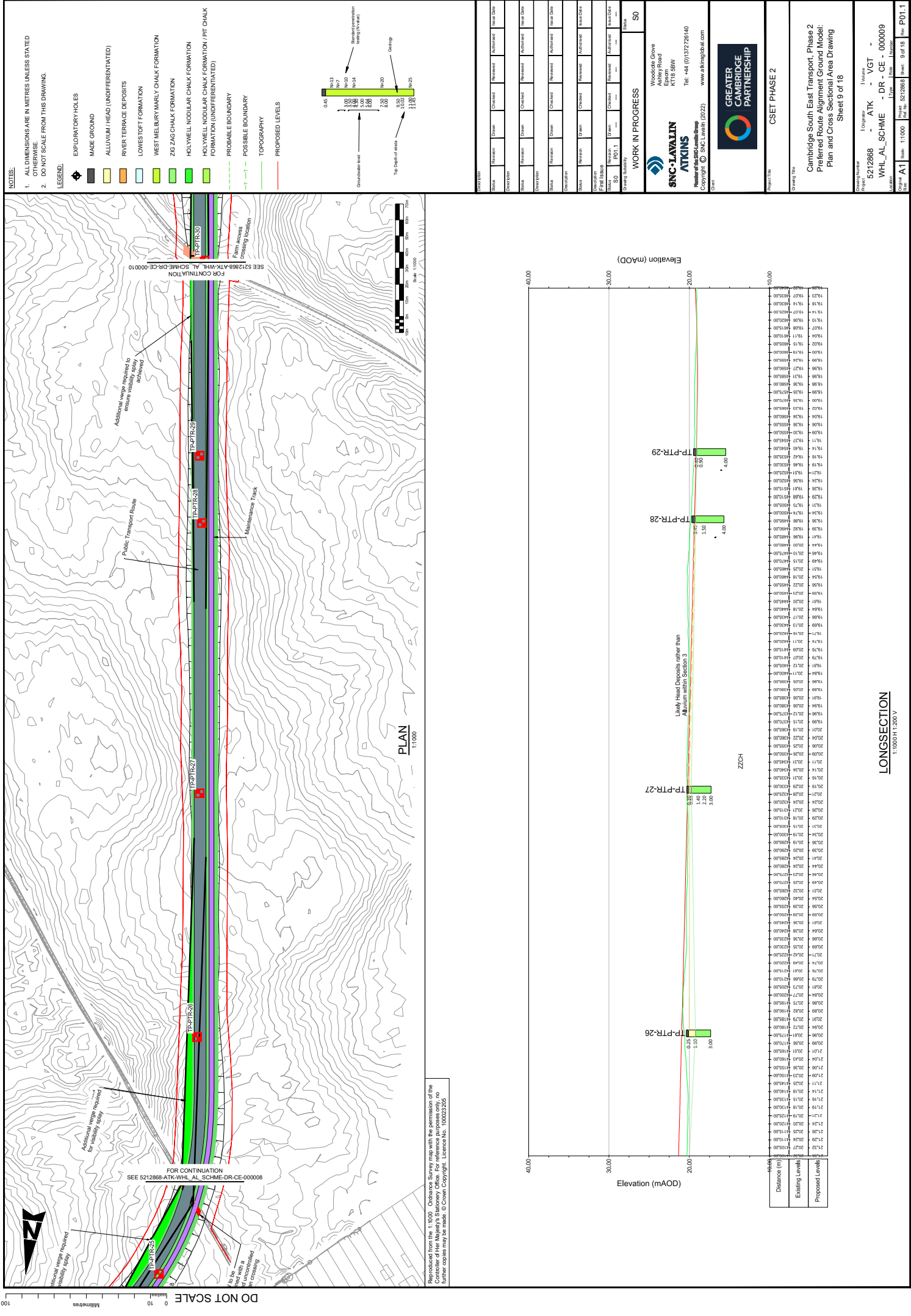
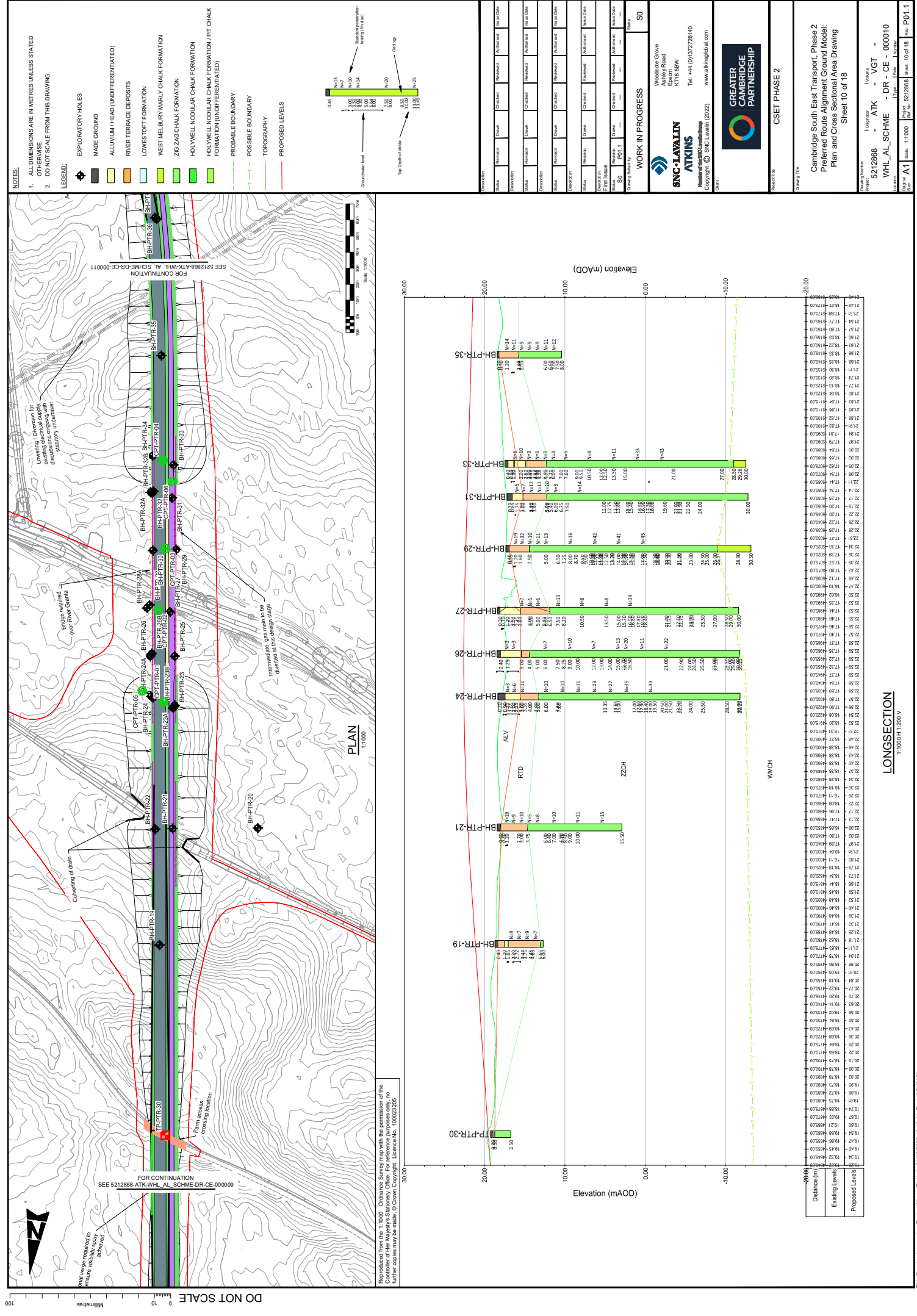


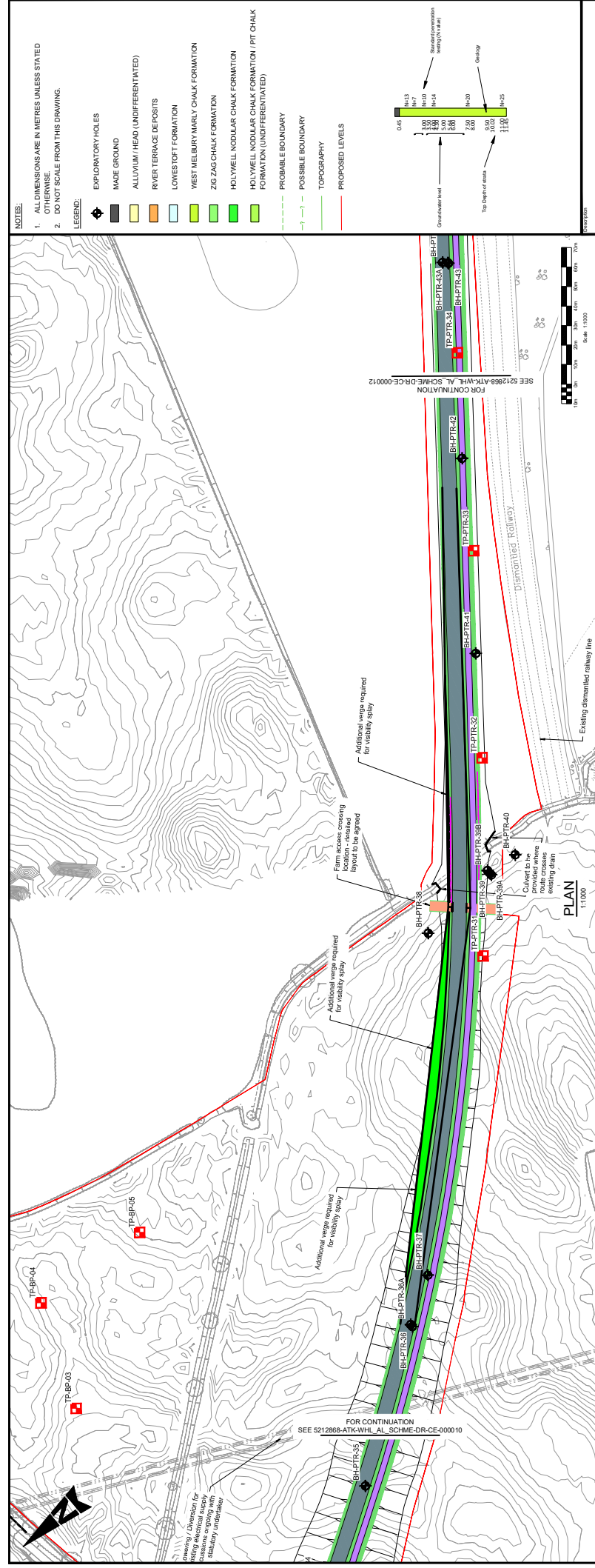
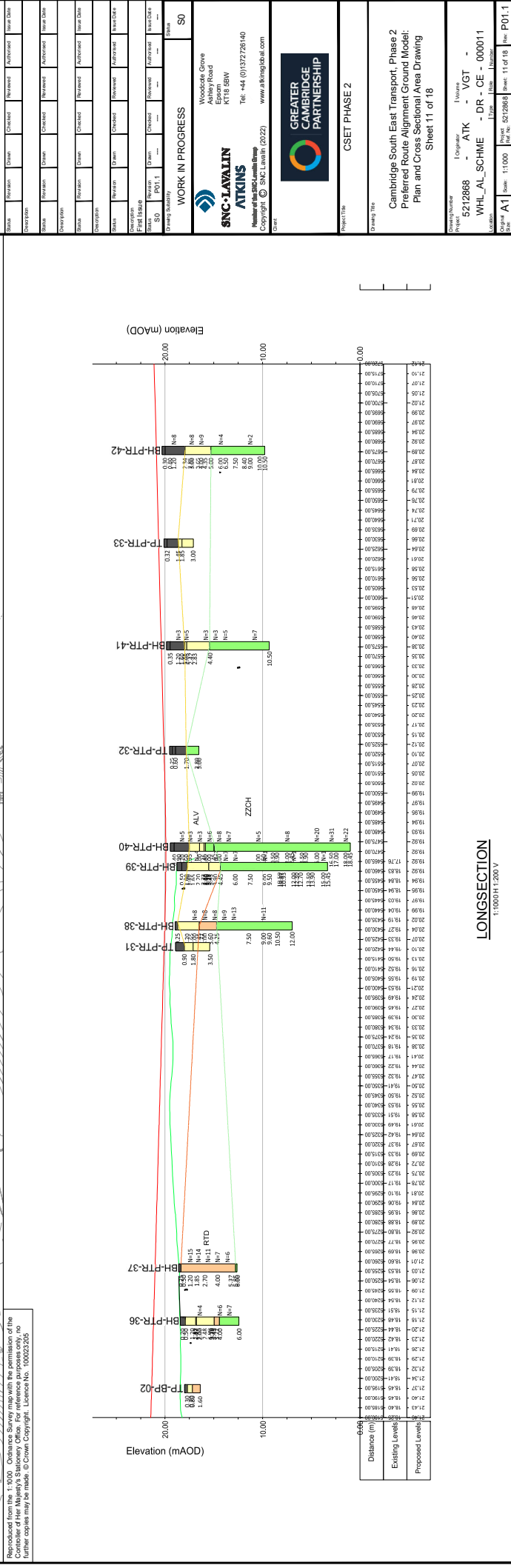
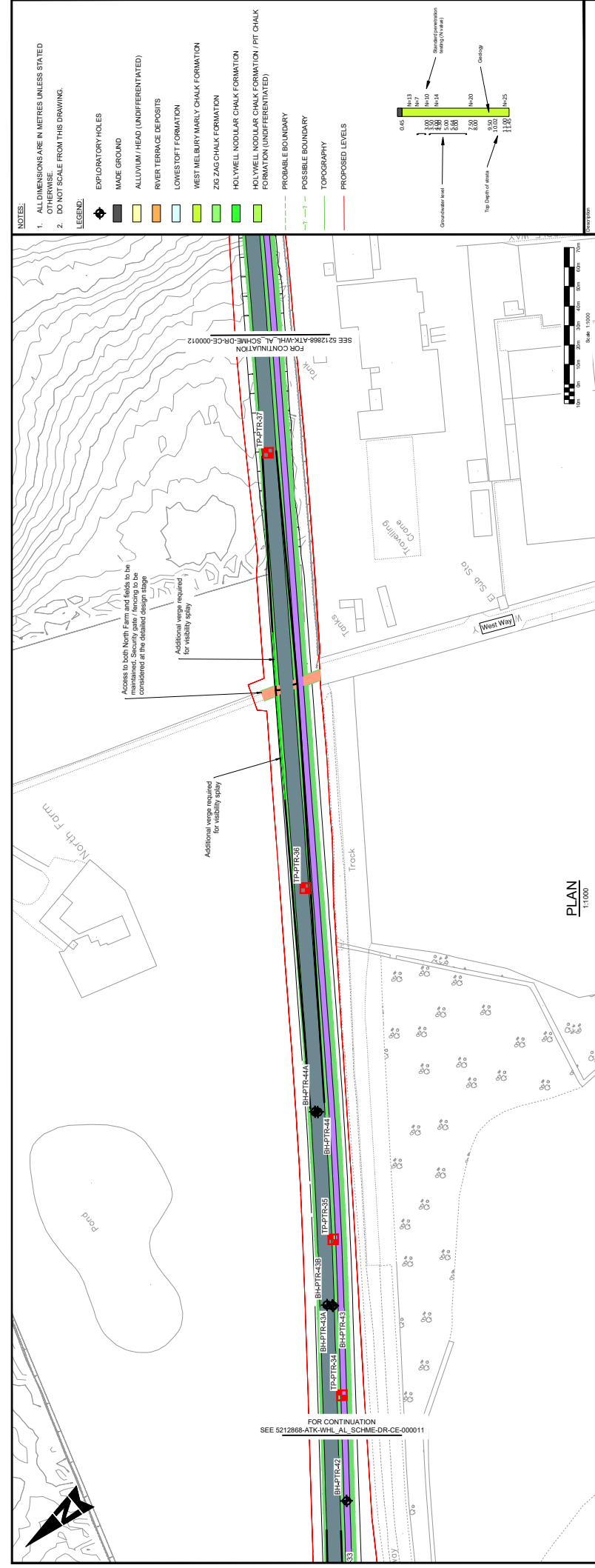
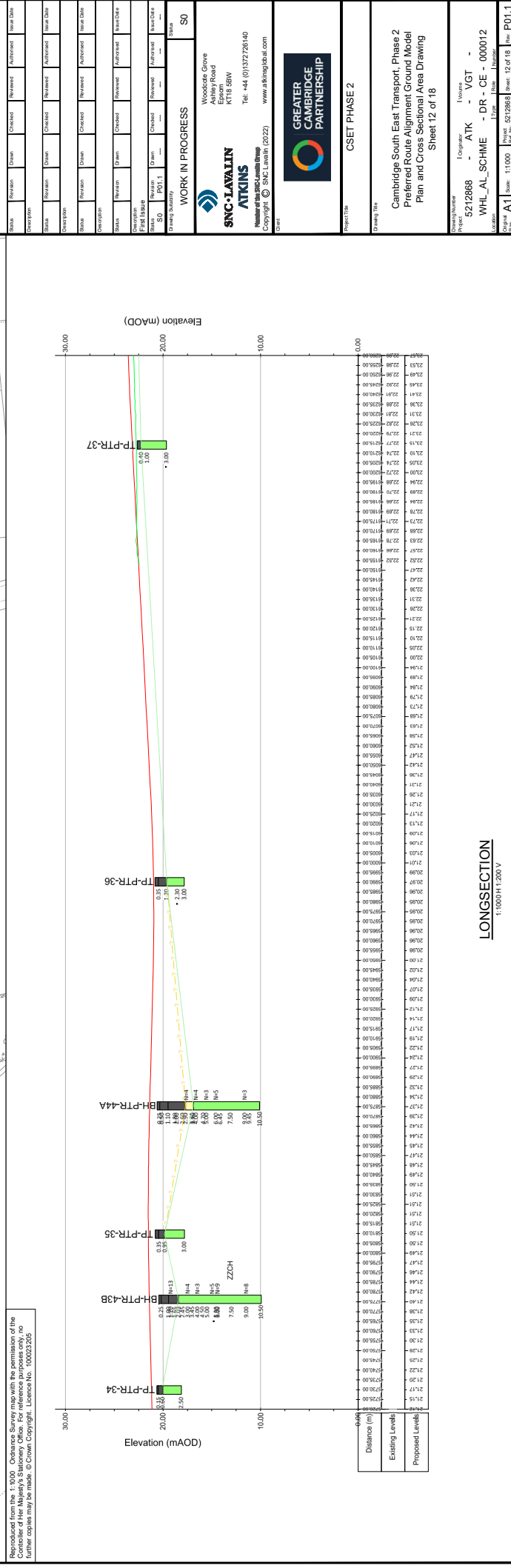
- NOTES:**
1. Do not scale from this drawing
 2. All dimensions are in metres unless otherwise stated.
 3. This drawing is to be read in conjunction with the Cambridge South East Transport, Phase 2 Ground Investigation Report.
 4. This geological cross section represents one possible interpretation of the ground investigation, other possible interpretations may exist. For detailed information regarding stratigraphy and material types, reference should be made to the individual exploratory hole records and the GIR.
 5. The superficial deposits (Alluvium and River Terrace Deposits) may be highly variable on a small scale.
 6. This cross section has been prepared from the Tetra Tech ground investigation undertaken in 2021.
 7. This geological cross section has been interpreted from all available information and data.

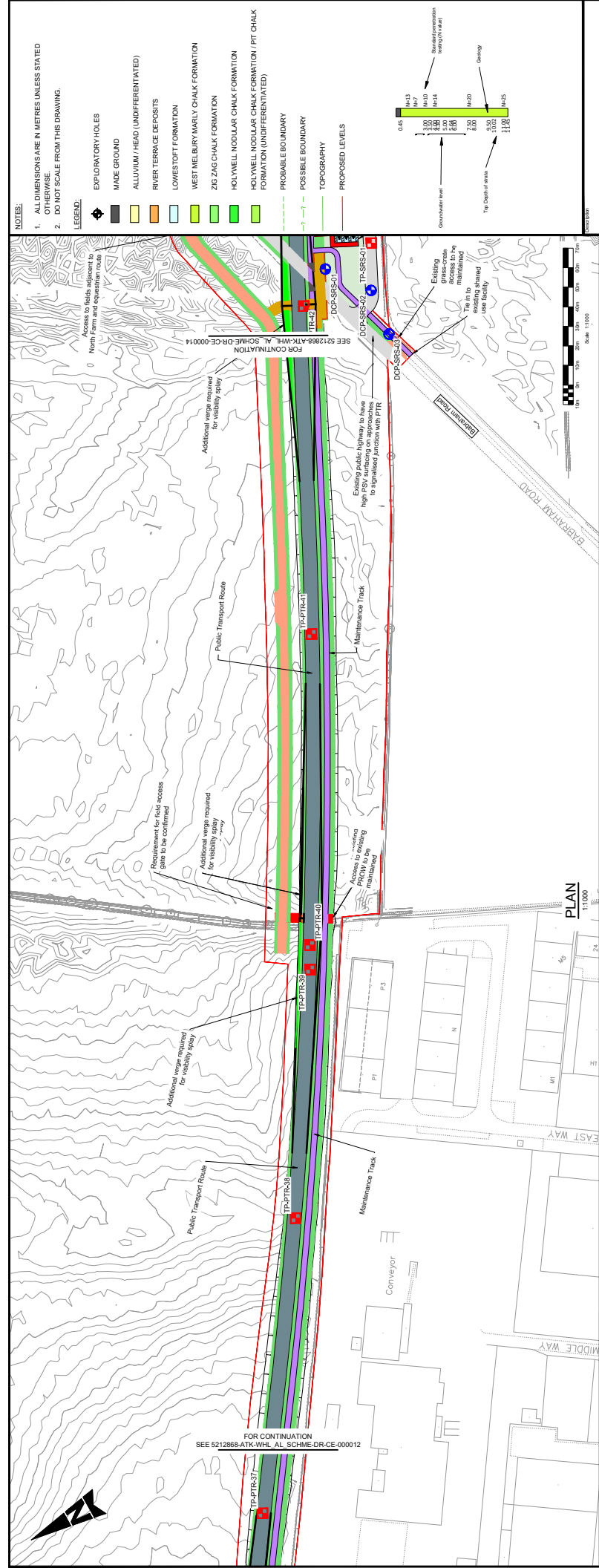
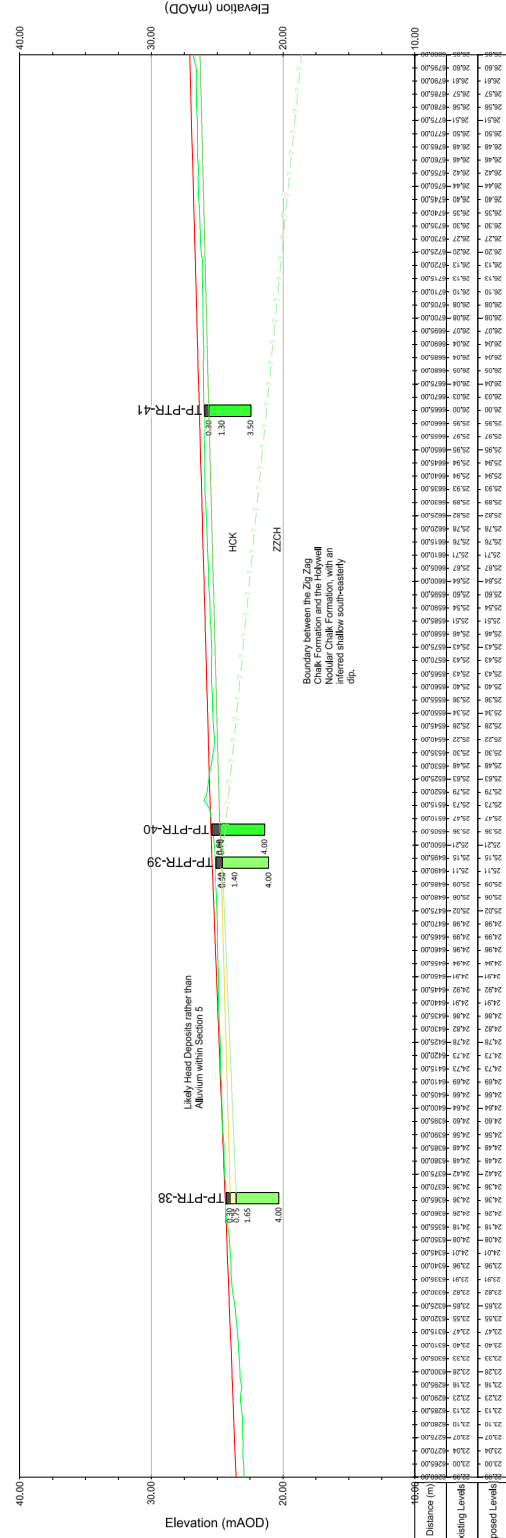




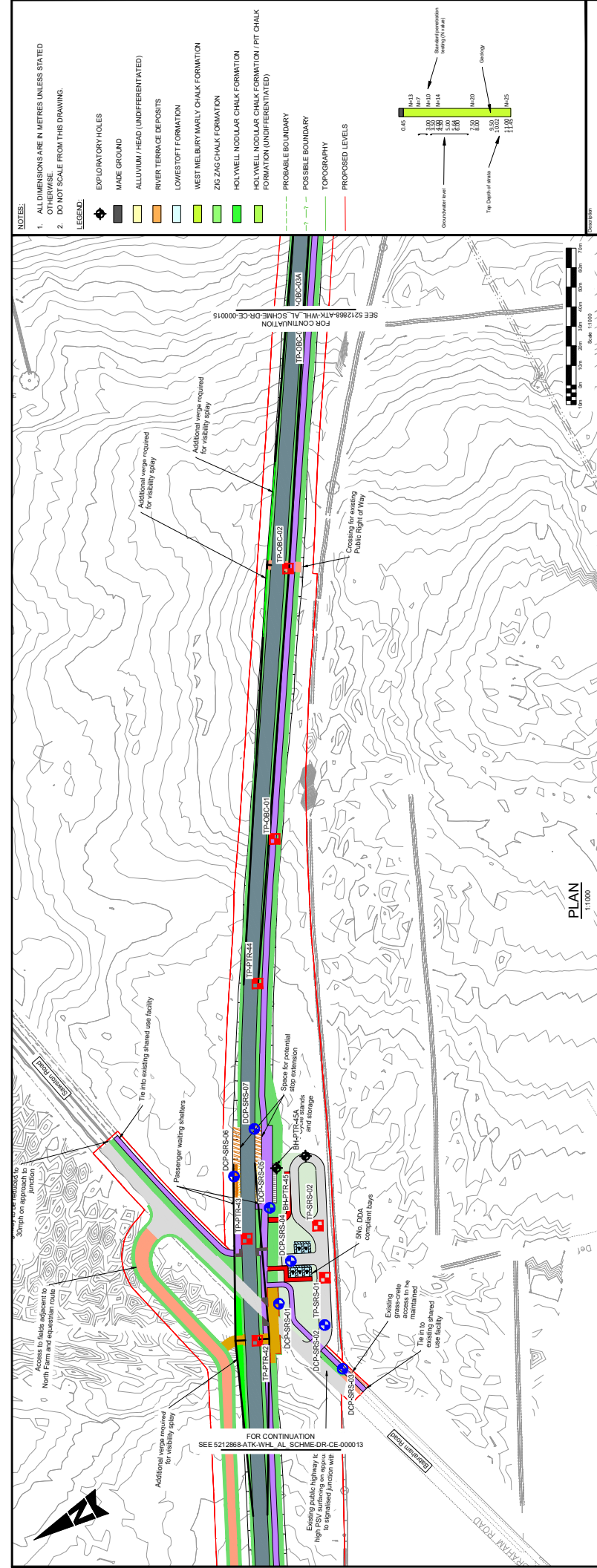
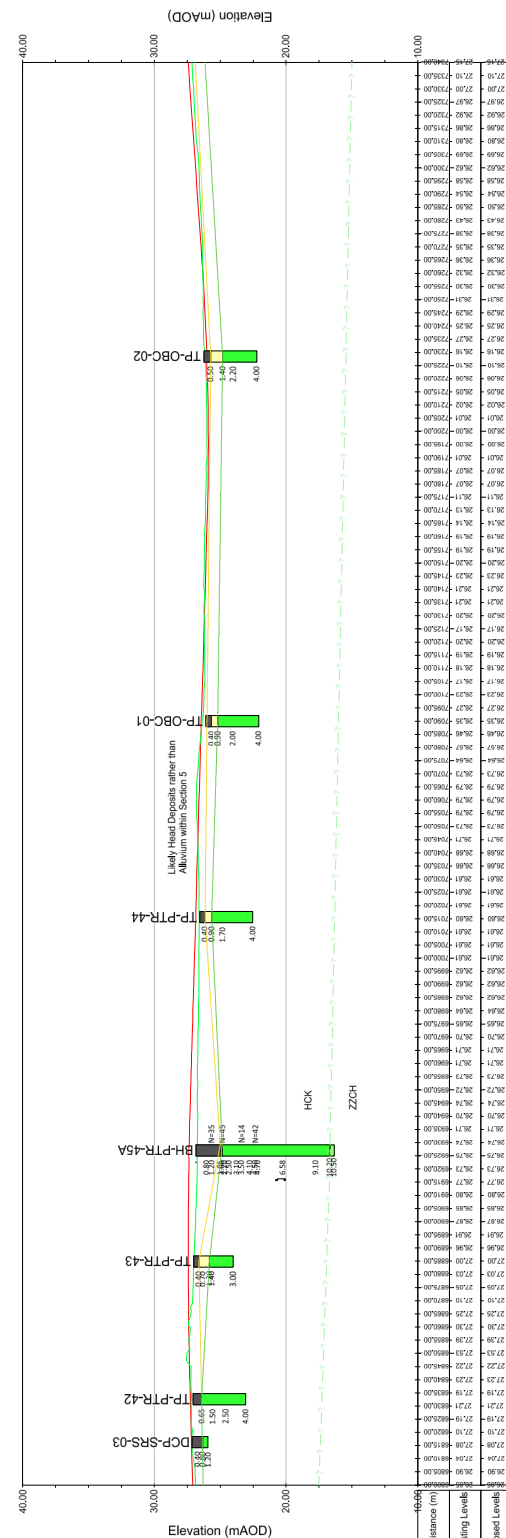




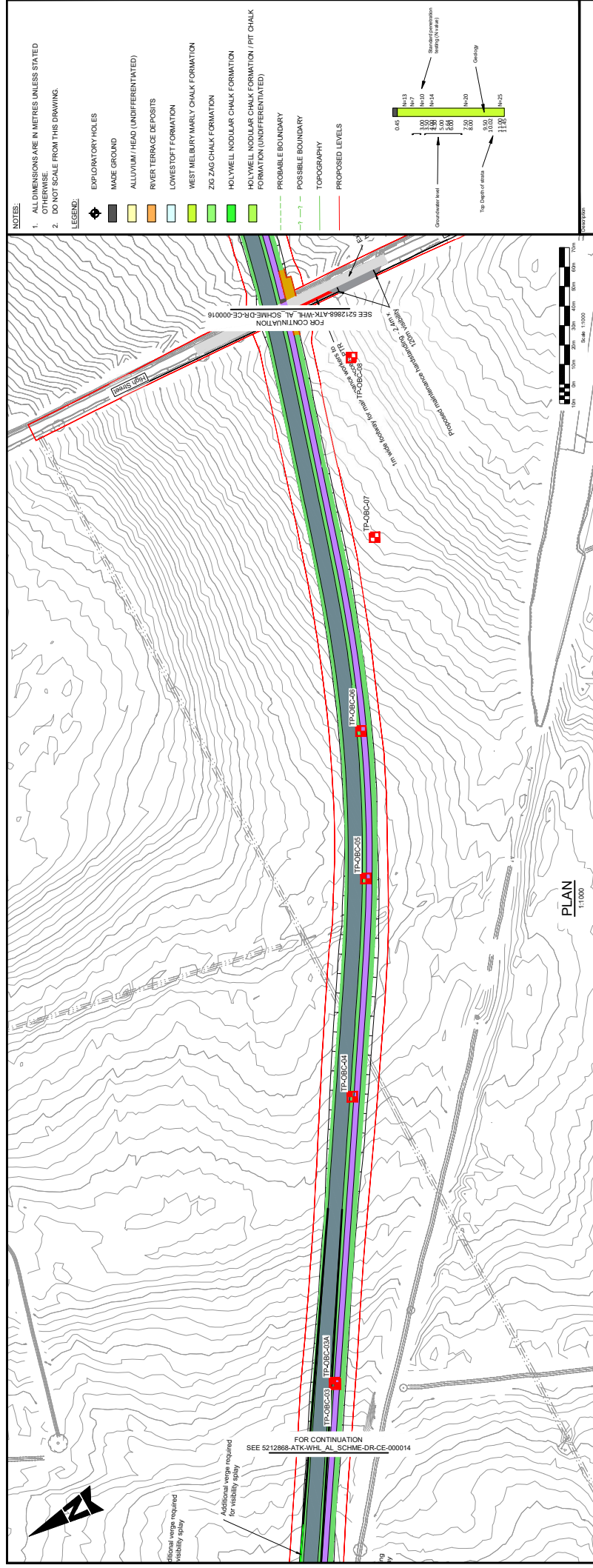
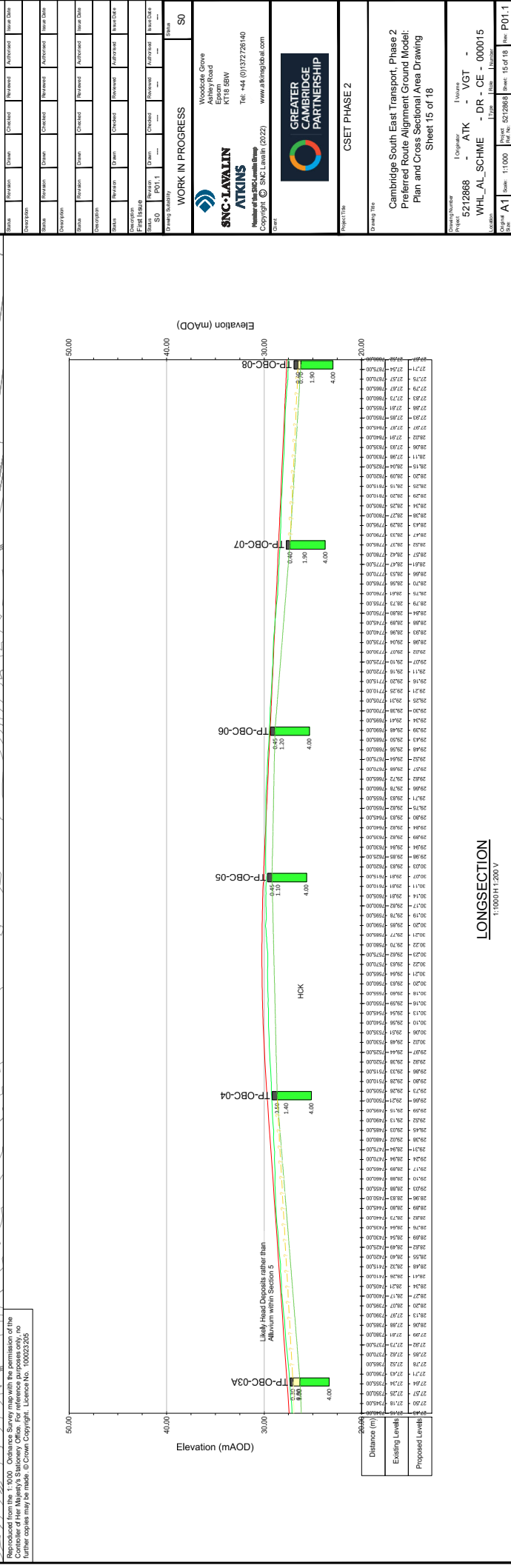
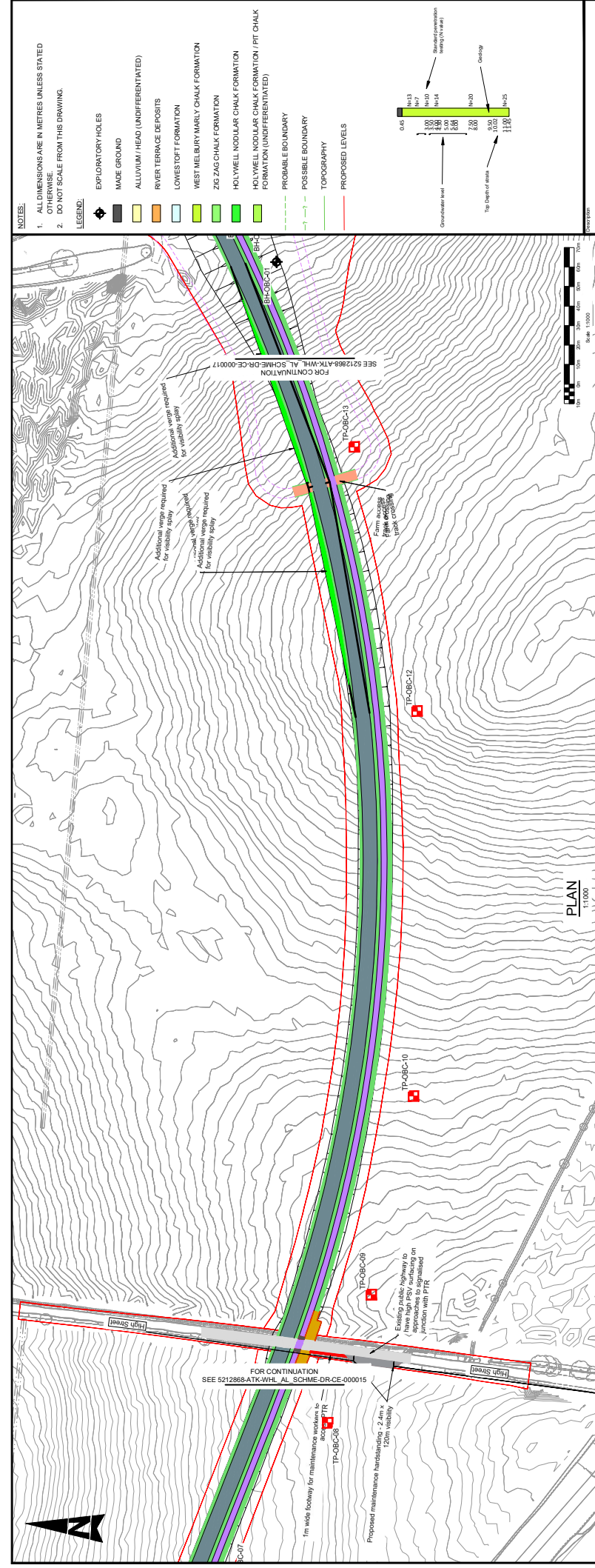
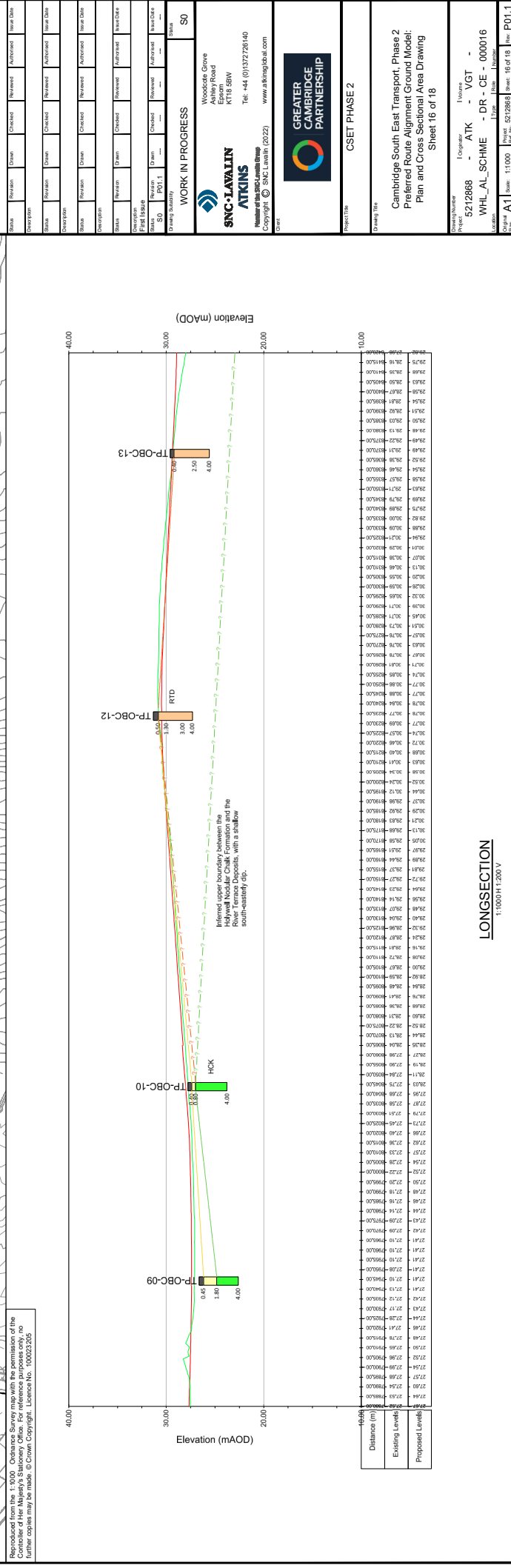




This Drawing is saved on ProjectWise. Plotted: 24/10/2022 16:39:17 By: VASH8151

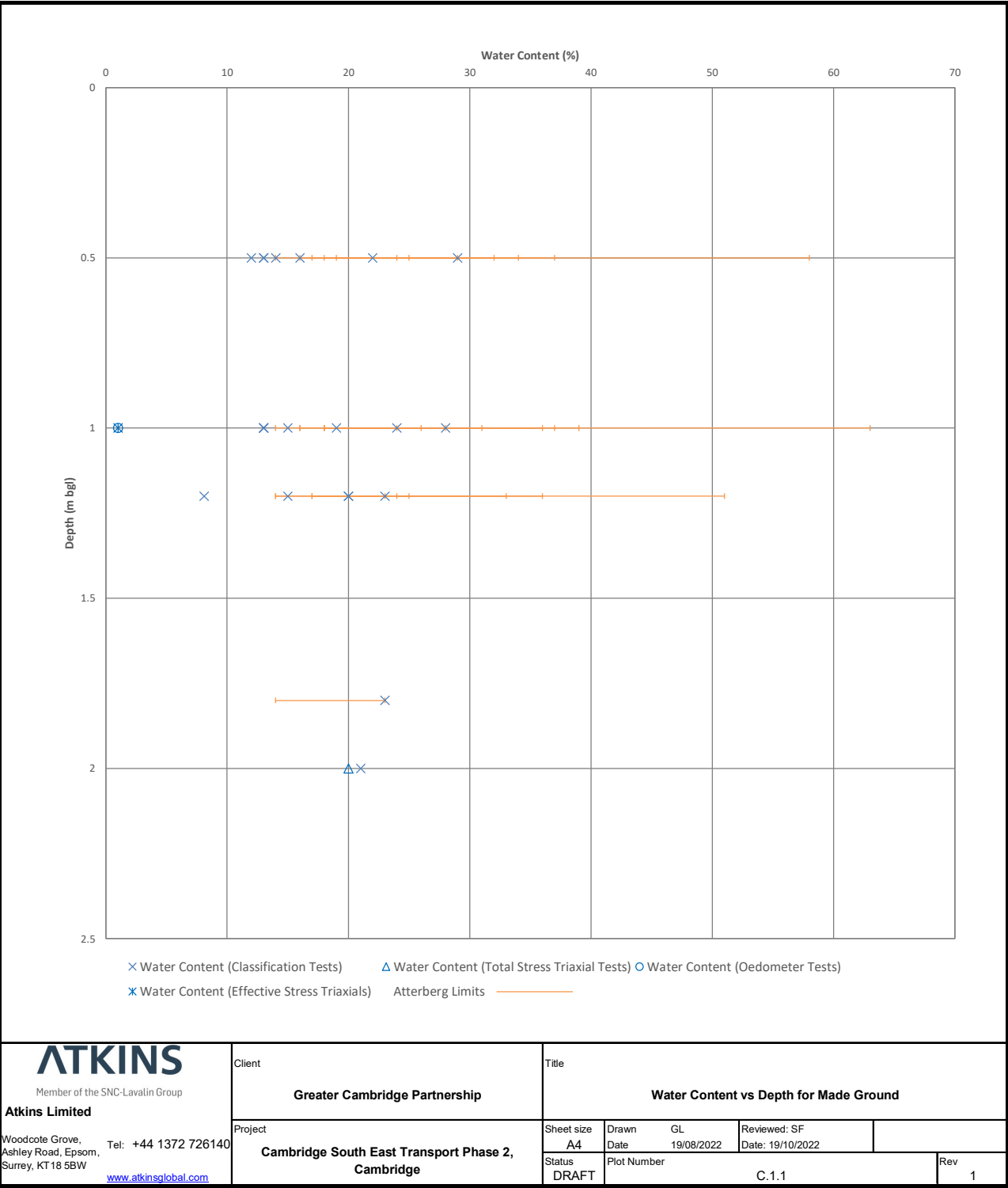


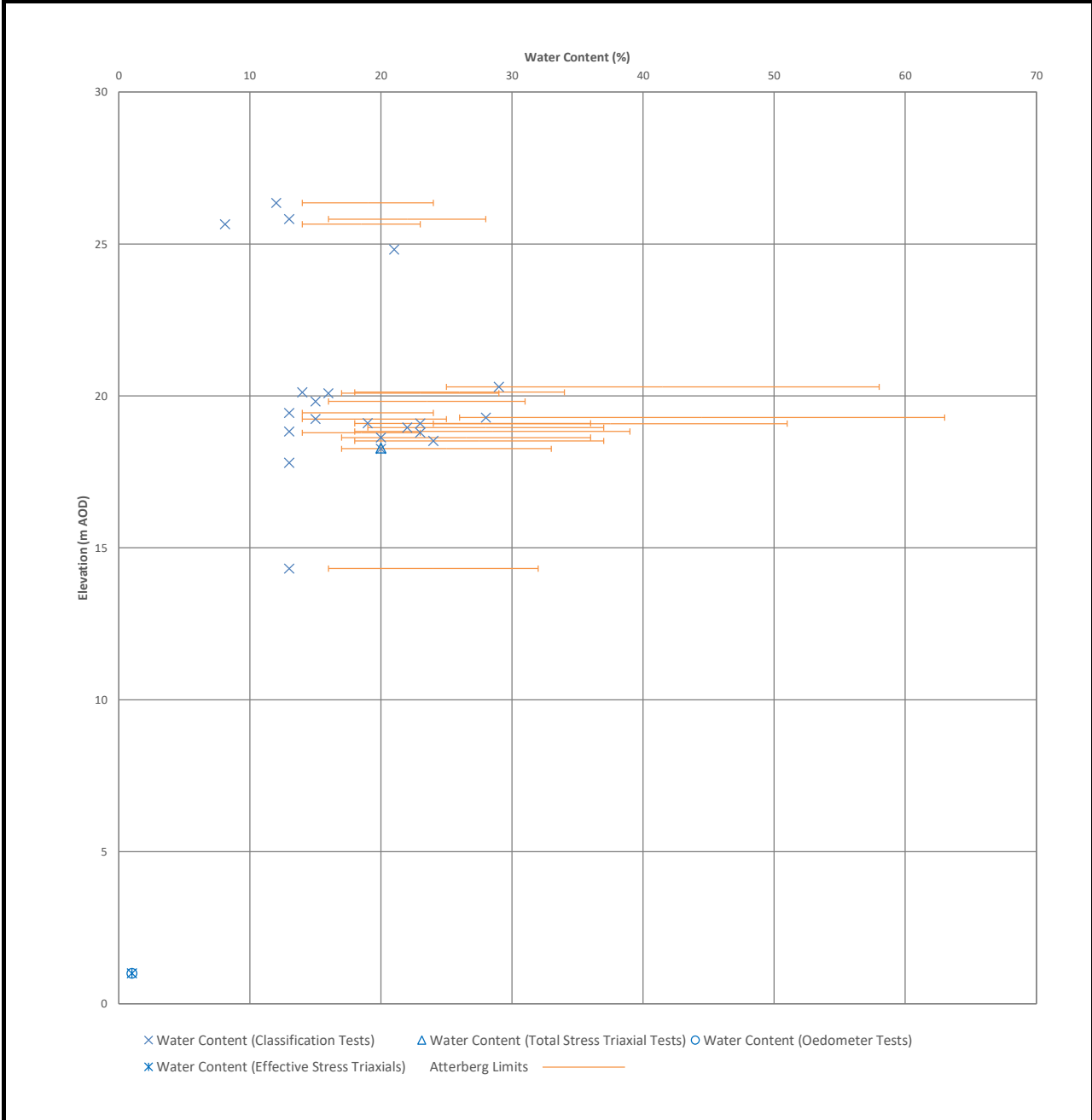
This Drawing is saved on ProjectWise. Plotted: 24/10/2022 16:45:43 By: VASH8151



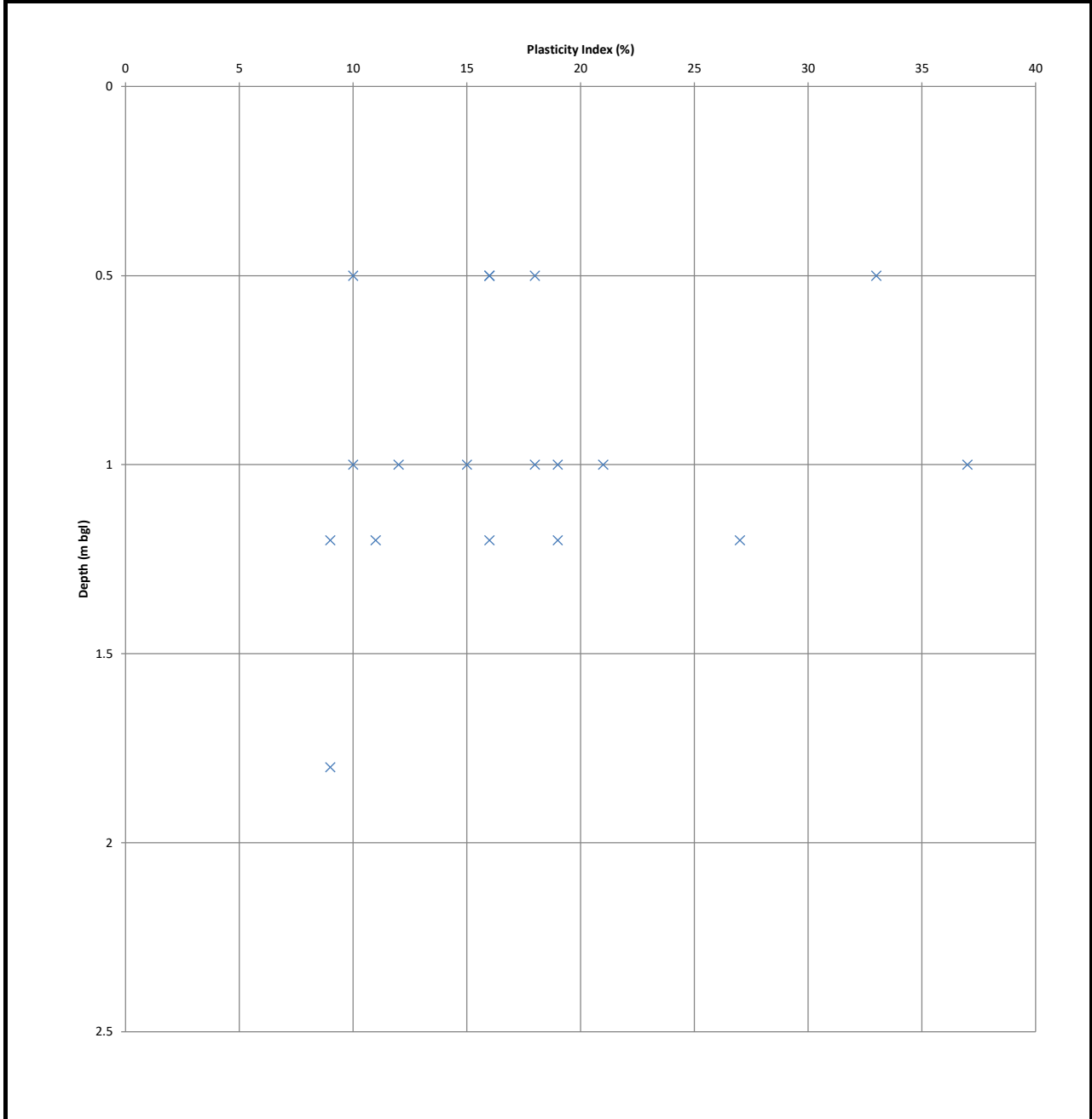
Appendix C. Geotechnical Plots

C.1. Water content and index properties

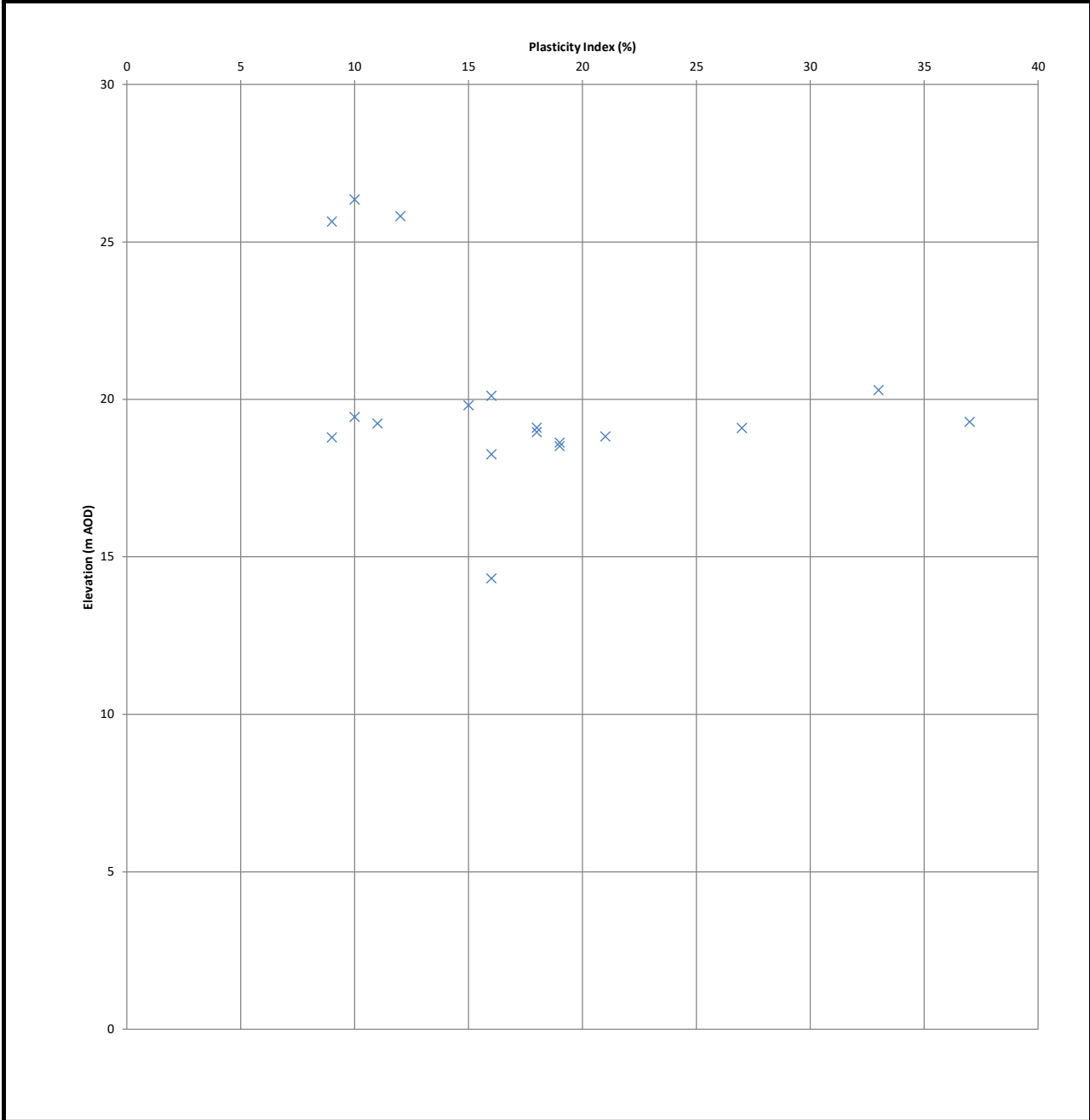




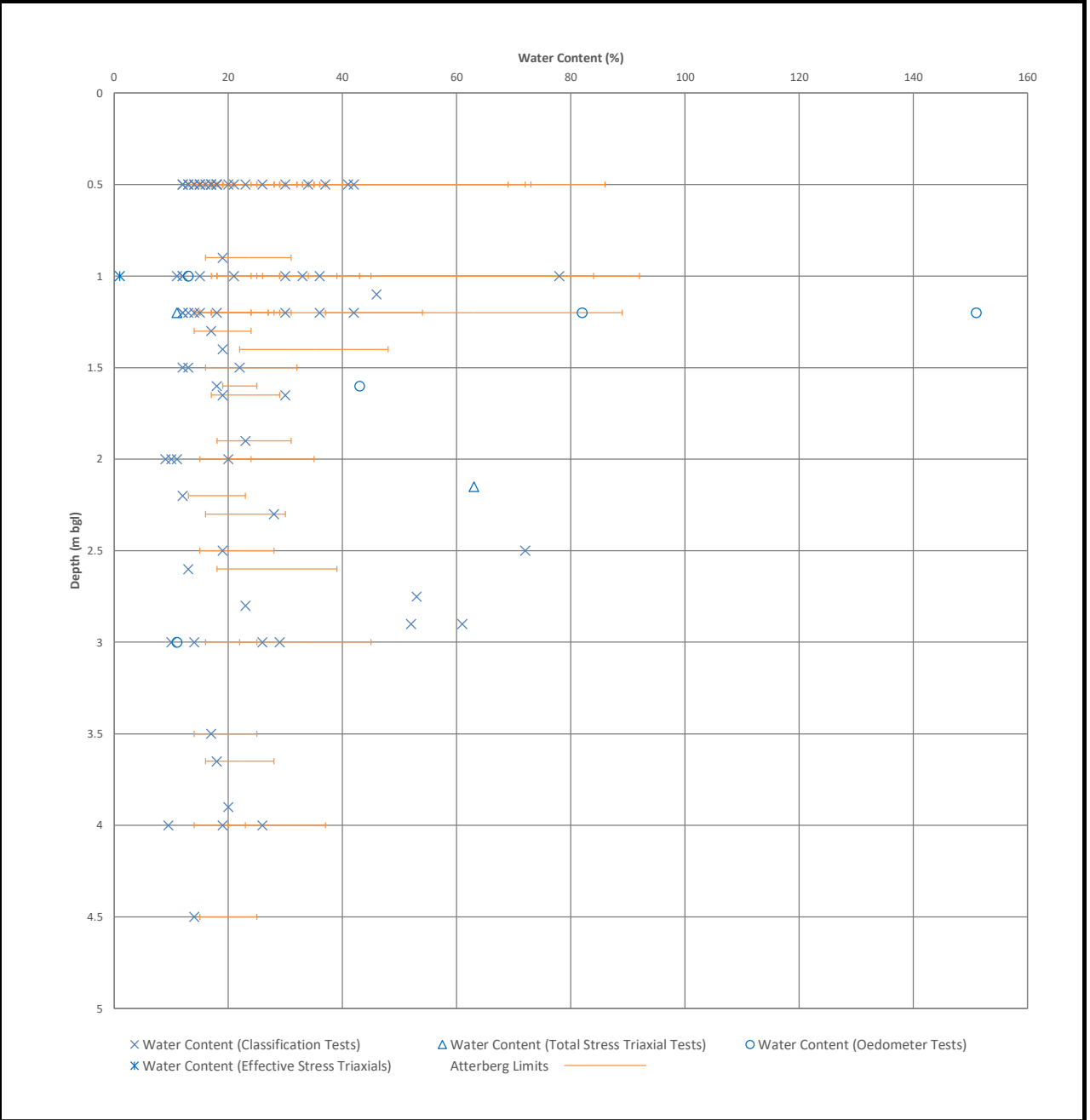
ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Tel: +44 1372 726140 www.atkinsglobal.com	Client Greater Cambridge Partnership		Title Water Content vs Elevation for Made Ground				
	Project Cambridge South East Transport Phase 2, Cambridge		Sheet size A4	Drawn Date	GL 19/08/2022	Reviewed: SF Date: 19/10/2022	
			Status DRAFT	Plot Number C.1.2			Rev 1



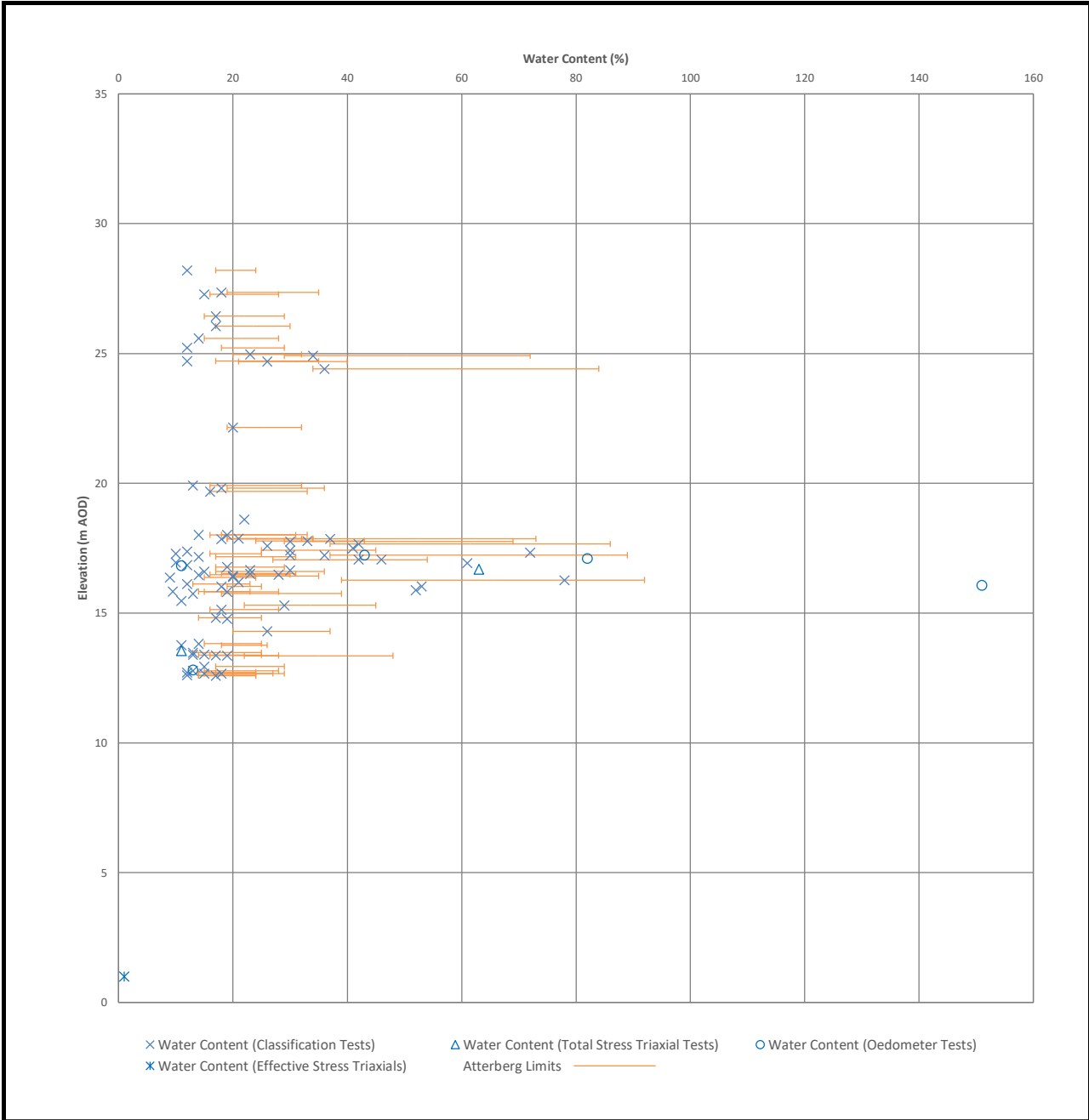
ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Tel: +44 1372 726140 www.atkinsglobal.com	Client Greater Cambridge Partnership		Title Plasticity Index vs Depth for Made Ground				
	Project Cambridge South East Transport Phase 2, Cambridge		Sheet size A4	Drawn Date	GL 19/08/2022	Reviewed: SF Date: 19/10/2022	
			Status DRAFT	Plot Number C.1.3			Rev 1



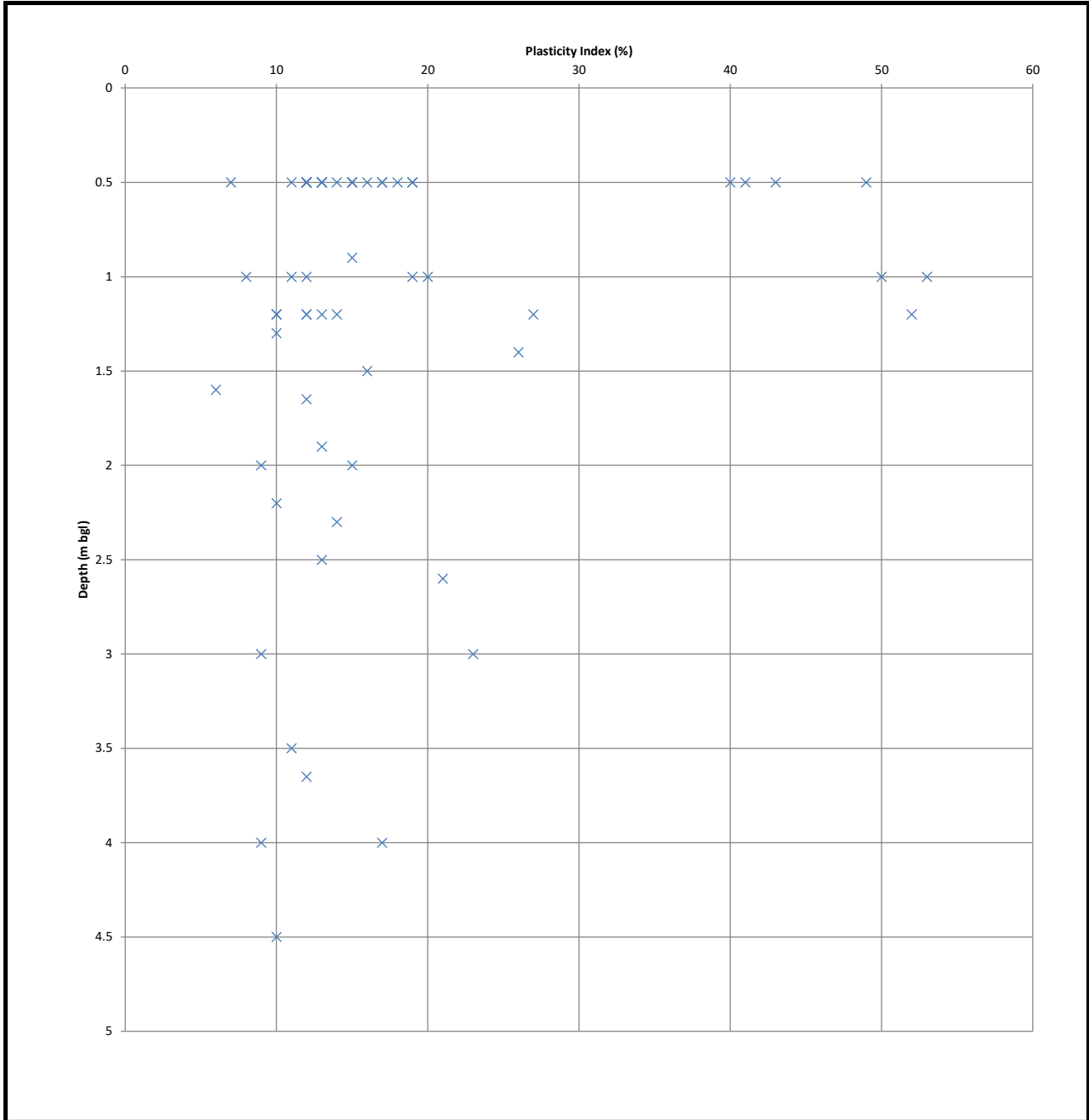
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client		Title					
	Greater Cambridge Partnership		Plasticity Index vs Elevation for Made Ground					
	Project		Sheet size	Drawn	GL	Reviewed: SF		
	Cambridge South East Transport Phase 2, Cambridge		A4	Date	19/08/2022	Date: 19/10/2022		
Status			Plot Number			C.1.4	Rev	1
		DRAFT						



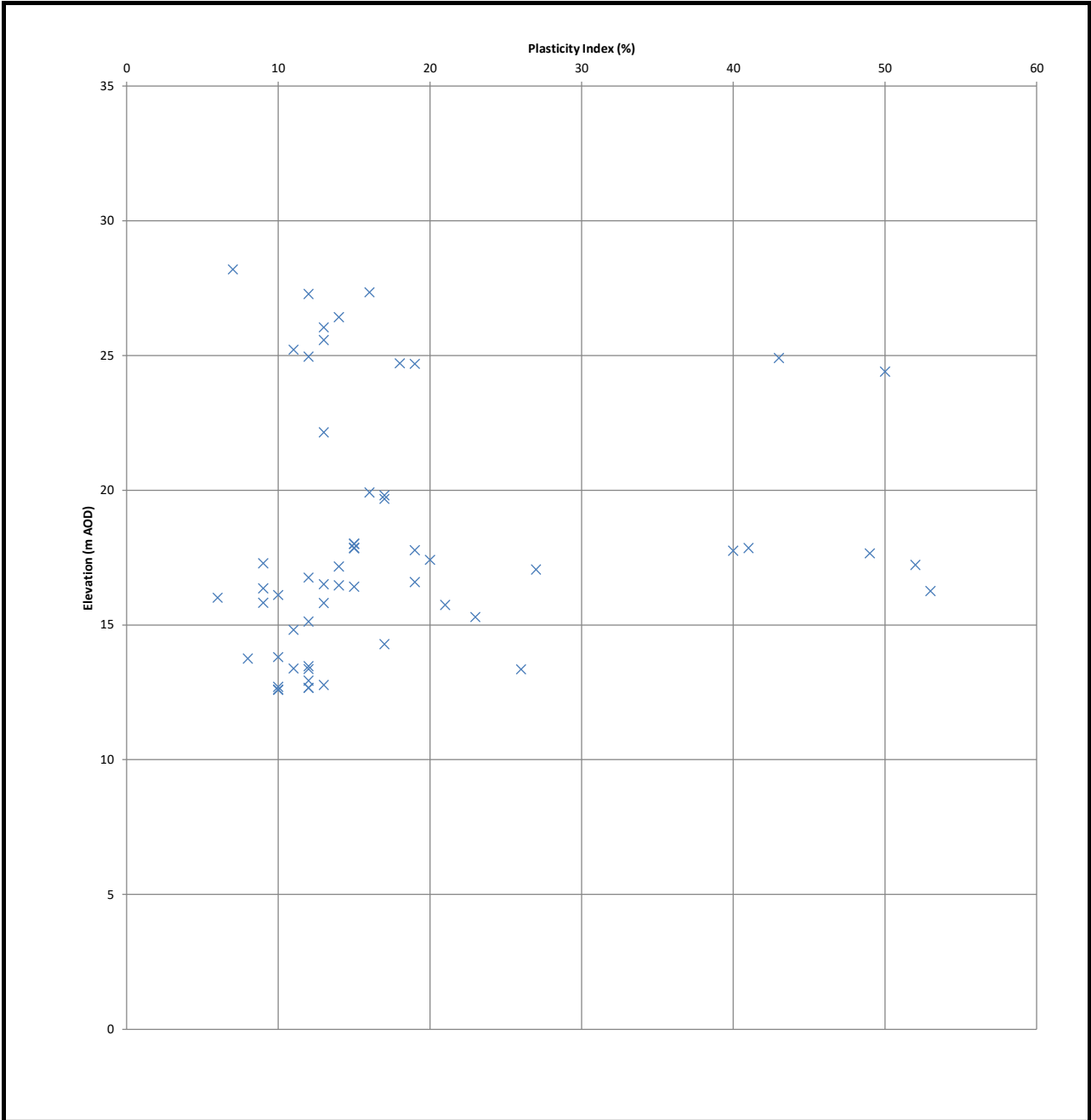
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT 18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client		Title			
	Greater Cambridge Partnership		Water Content vs Depth for Alluvium/Head Deposits (Undifferentiated)			
	Project		Sheet size	Drawn	GL	Reviewed: SF
	Cambridge South East Transport Phase 2, Cambridge		A4	Date	19/08/2022	Date: 19/10/2022
		Status	Plot Number			Rev
		DRAFT	C.1.5			1



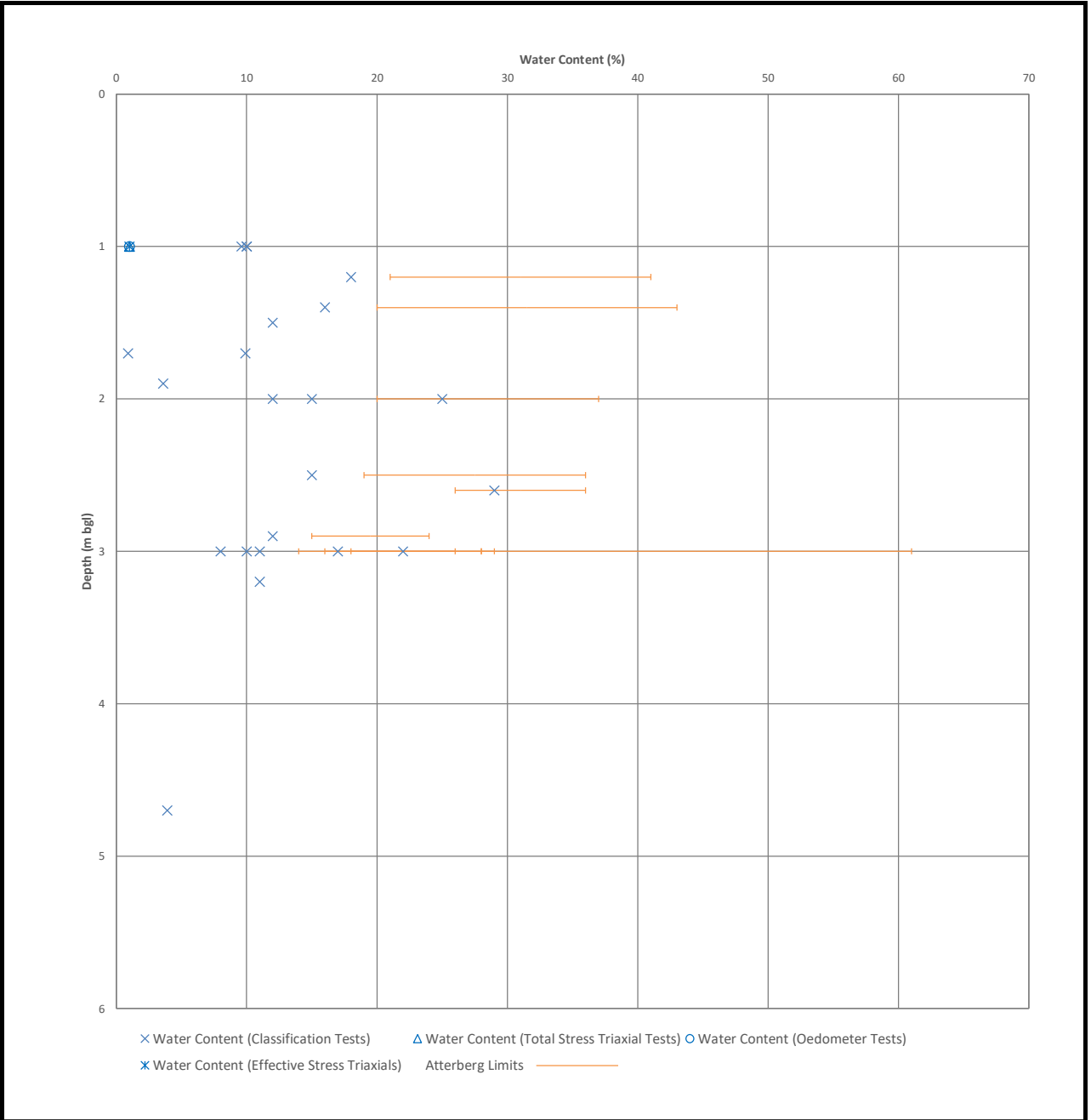
ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Tel: +44 1372 726140 www.atkinsglobal.com	Client Greater Cambridge Partnership		Title Water Content vs Elevation for Alluvium/Head Deposits (Undifferentiated)				
	Project Cambridge South East Transport Phase 2, Cambridge		Sheet size A4	Drawn Date	GL 19/08/2022	Reviewed: SF Date: 19/10/2022	
			Status DRAFT	Plot Number C.1.6			Rev 1



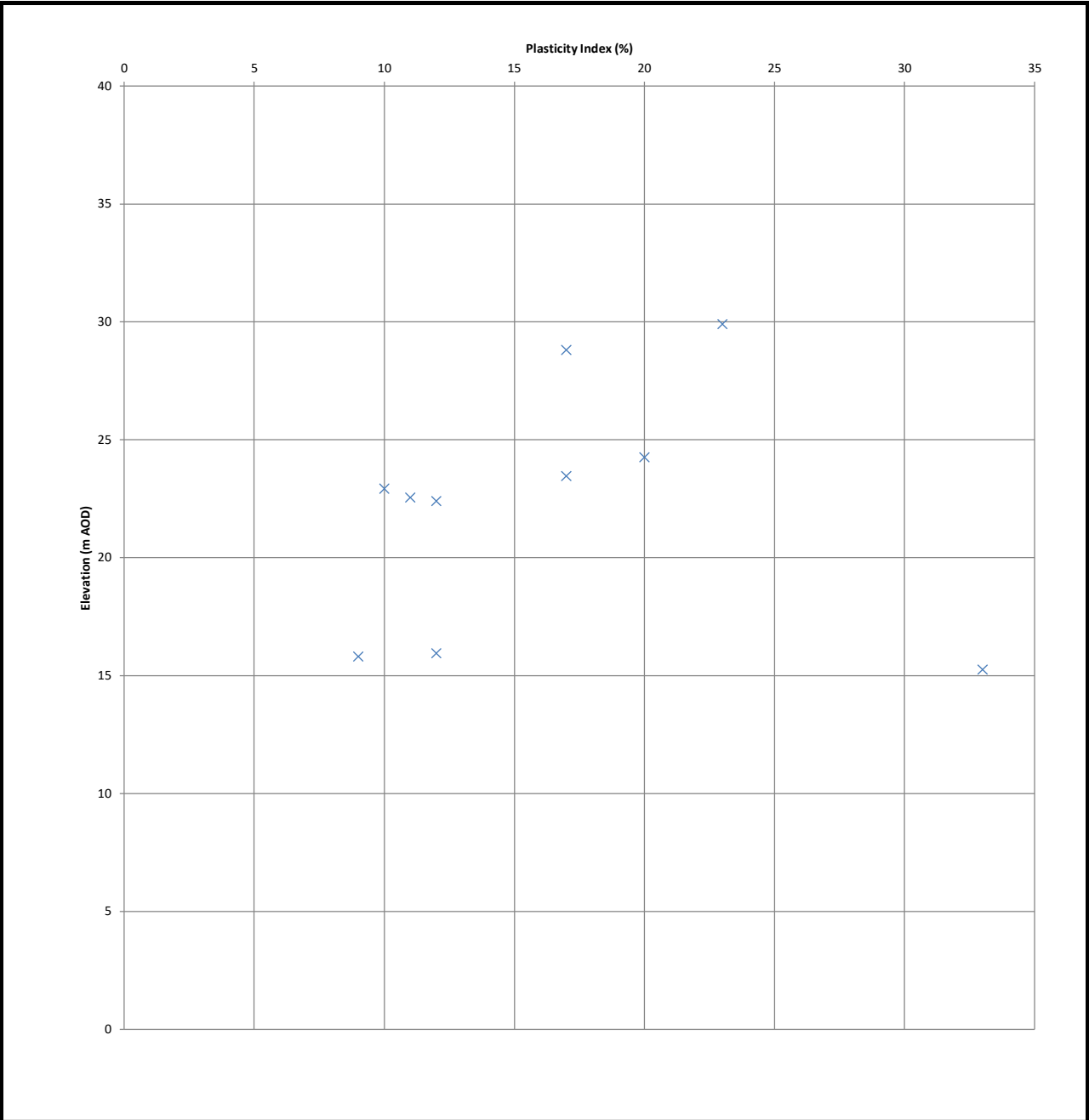
ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW Tel: +44 1372 726140 www.atkinsglobal.com	Client Greater Cambridge Partnership		Title Plasticity Index vs Depth for Alluvium/Head Deposits (Undifferentiated)				
	Project Cambridge South East Transport Phase 2, Cambridge		Sheet size A4	Drawn Date	GL 19/08/2022	Reviewed: SF Date: 19/10/2022	
			Status DRAFT	Plot Number C.1.7			Rev 1



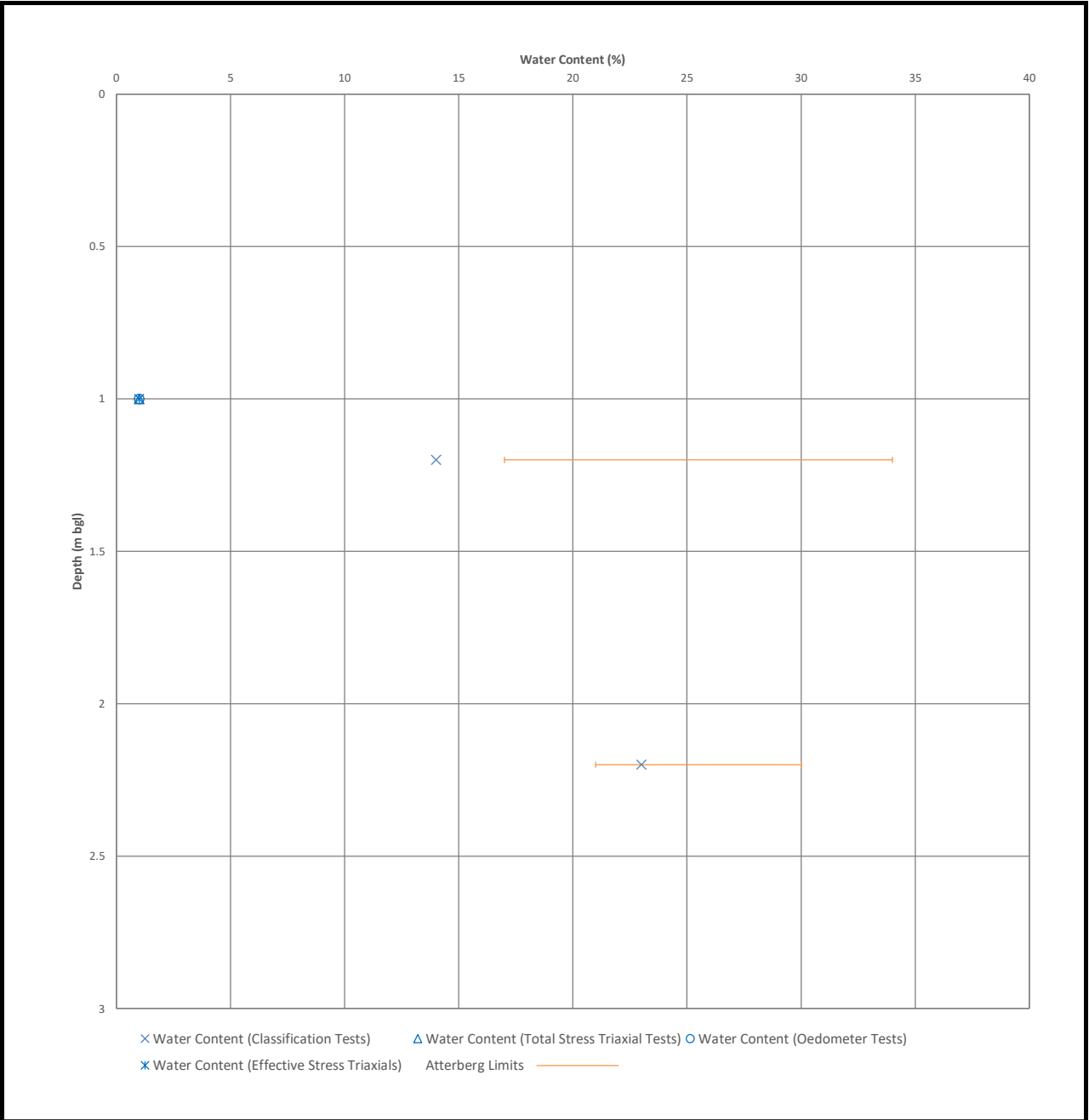
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client		Title					
	Greater Cambridge Partnership		Plasticity Index vs Elevation for Alluvium/Head Deposits (Undifferentiated)					
	Project		Sheet size	Drawn	GL	Reviewed: SF		
Cambridge South East Transport Phase 2, Cambridge			A4	Date	19/08/2022	Date: 19/10/2022		
		Status	Plot Number		Rev			
		DRAFT	C.1.8		1			



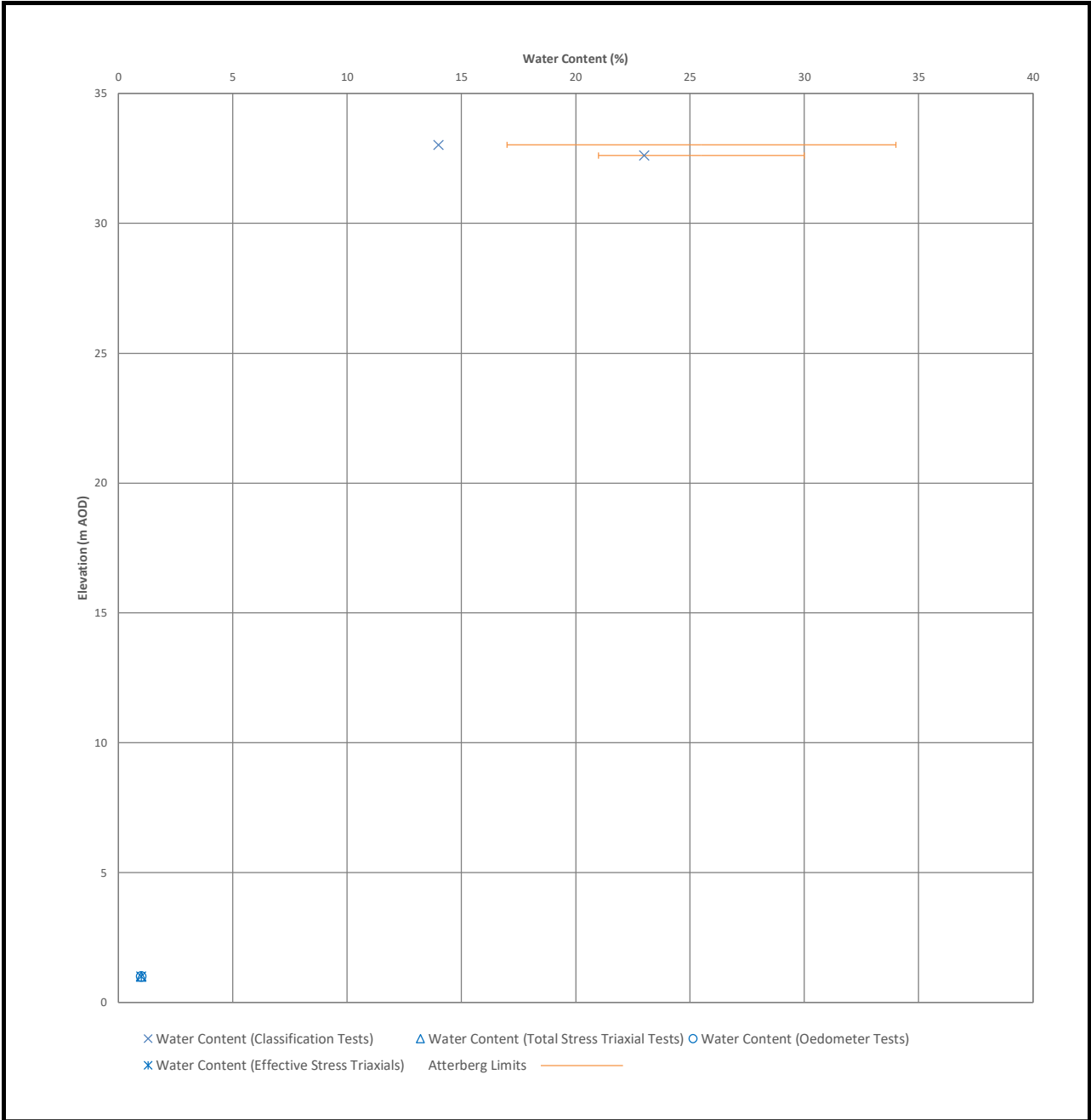
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client		Title					
	Greater Cambridge Partnership		Water Content vs Depth for River Terraced Deposits (undifferentiated)					
	Project		Sheet size	Drawn	GL	Reviewed: SF		
Cambridge South East Transport Phase 2, Cambridge			A4	Date	19/08/2022	Date: 19/10/2022		
		Status	Plot Number		Rev			
		DRAFT	C.1.9		1			



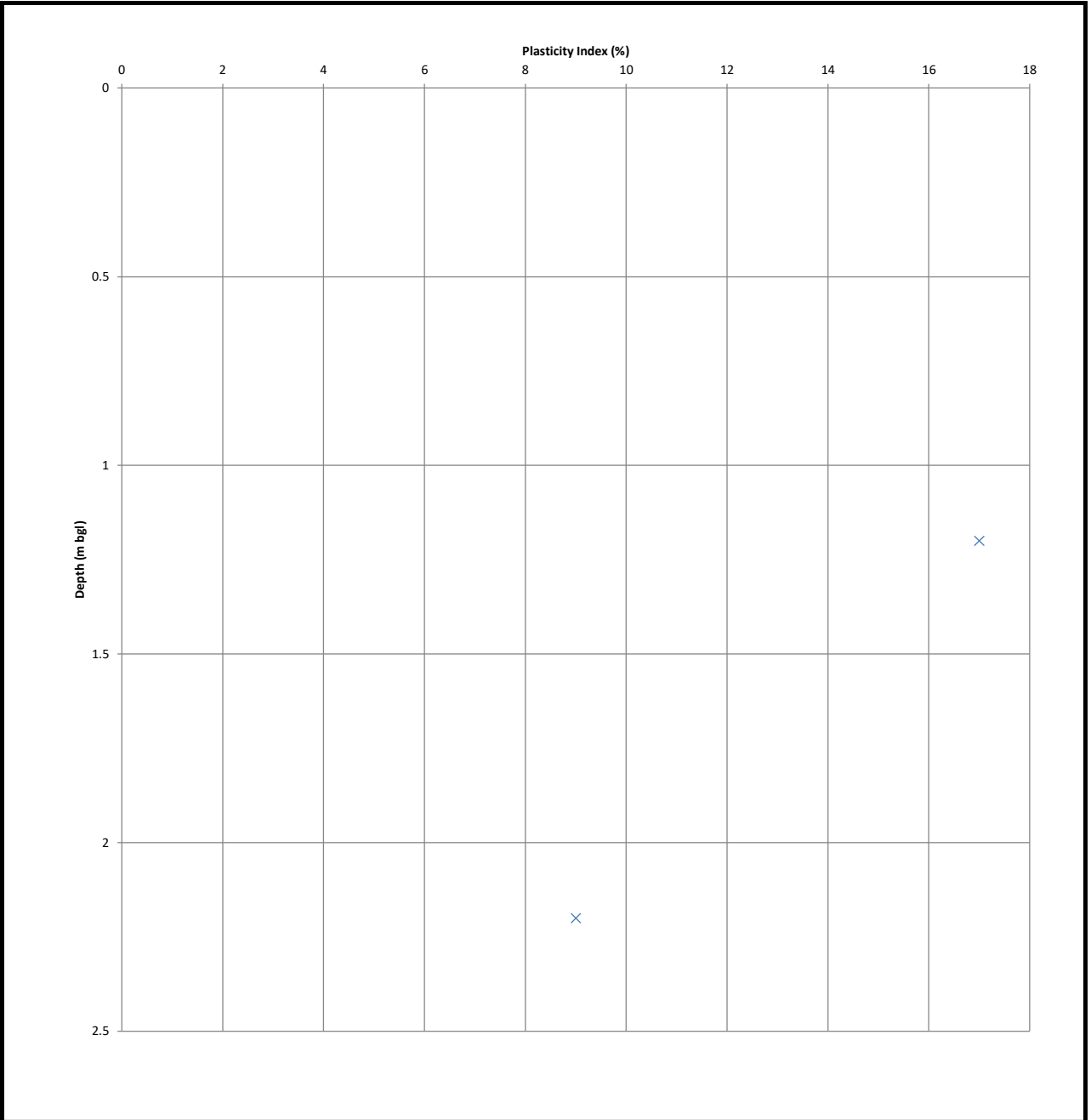
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT 18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client		Title						
	Greater Cambridge Partnership		Plasticity Index vs Elevation for River Terraced Deposits (undifferentiated)						
	Project		Sheet size		Drawn	GL	Reviewed: SF		
	Cambridge South East Transport Phase 2, Cambridge		A4		Date	19/08/2022	Date: 19/10/2022		
			Status		Plot Number			Rev	
		DRAFT		C.1.12			1		



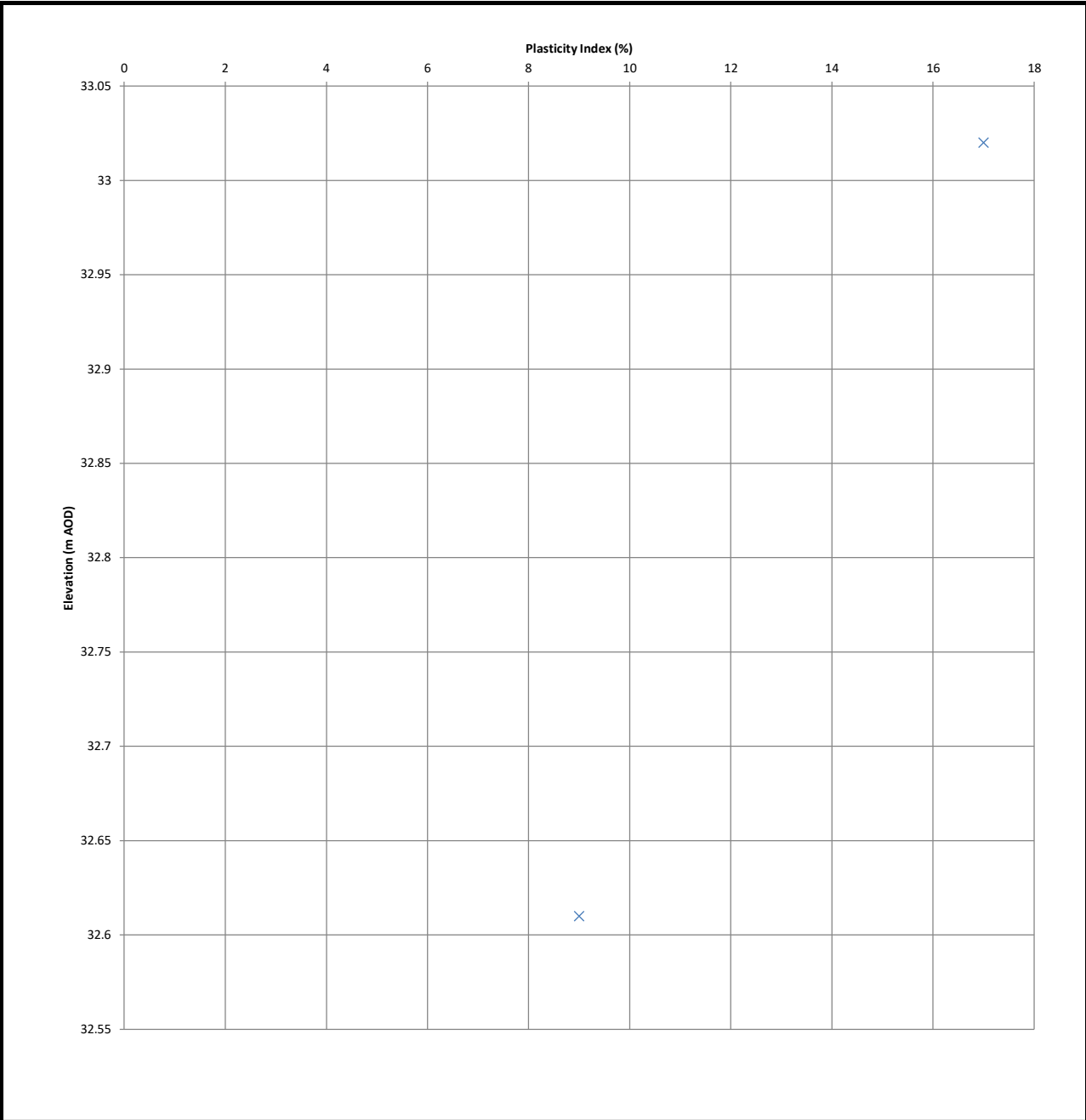
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT 18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client		Title				
	Greater Cambridge Partnership		Water Content vs Depth for Lowestoft Formation				
	Project		Sheet size	Drawn	GL	Reviewed: SF	
	Cambridge South East Transport Phase 2, Cambridge		A4	Date	19/08/2022	Date: 19/10/2022	
Status			Plot Number			Rev	
		DRAFT	C.1.13			1	



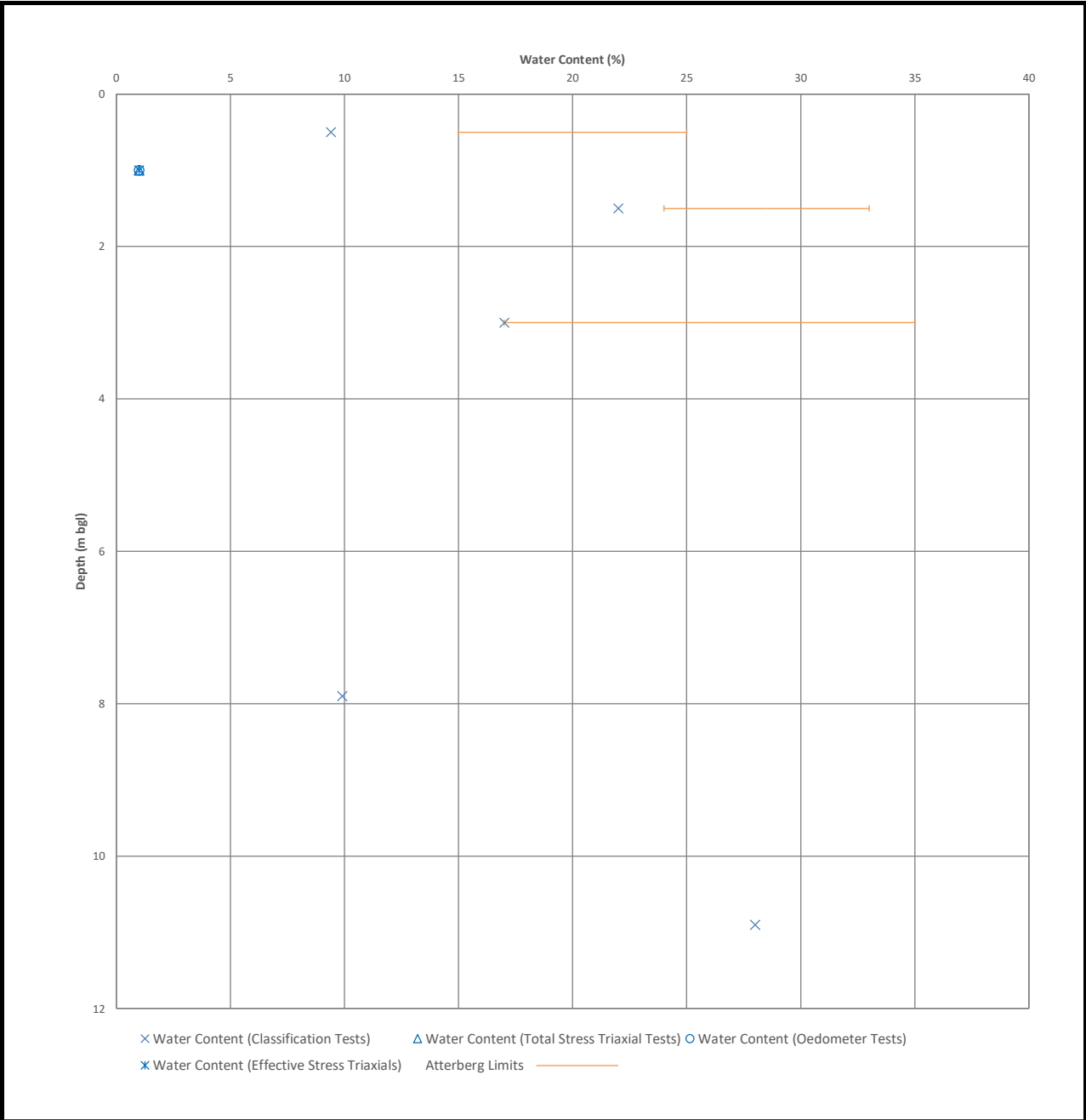
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client	Title					
	Greater Cambridge Partnership	Water Content vs Elevation for Lowestoft Formation					
	Project	Sheet size	Drawn	GL	Reviewed: SF		
Cambridge South East Transport Phase 2, Cambridge		A4	Date	19/08/2022	Date: 19/10/2022		
		Status	Plot Number			Rev	1
		DRAFT	C.1.14				



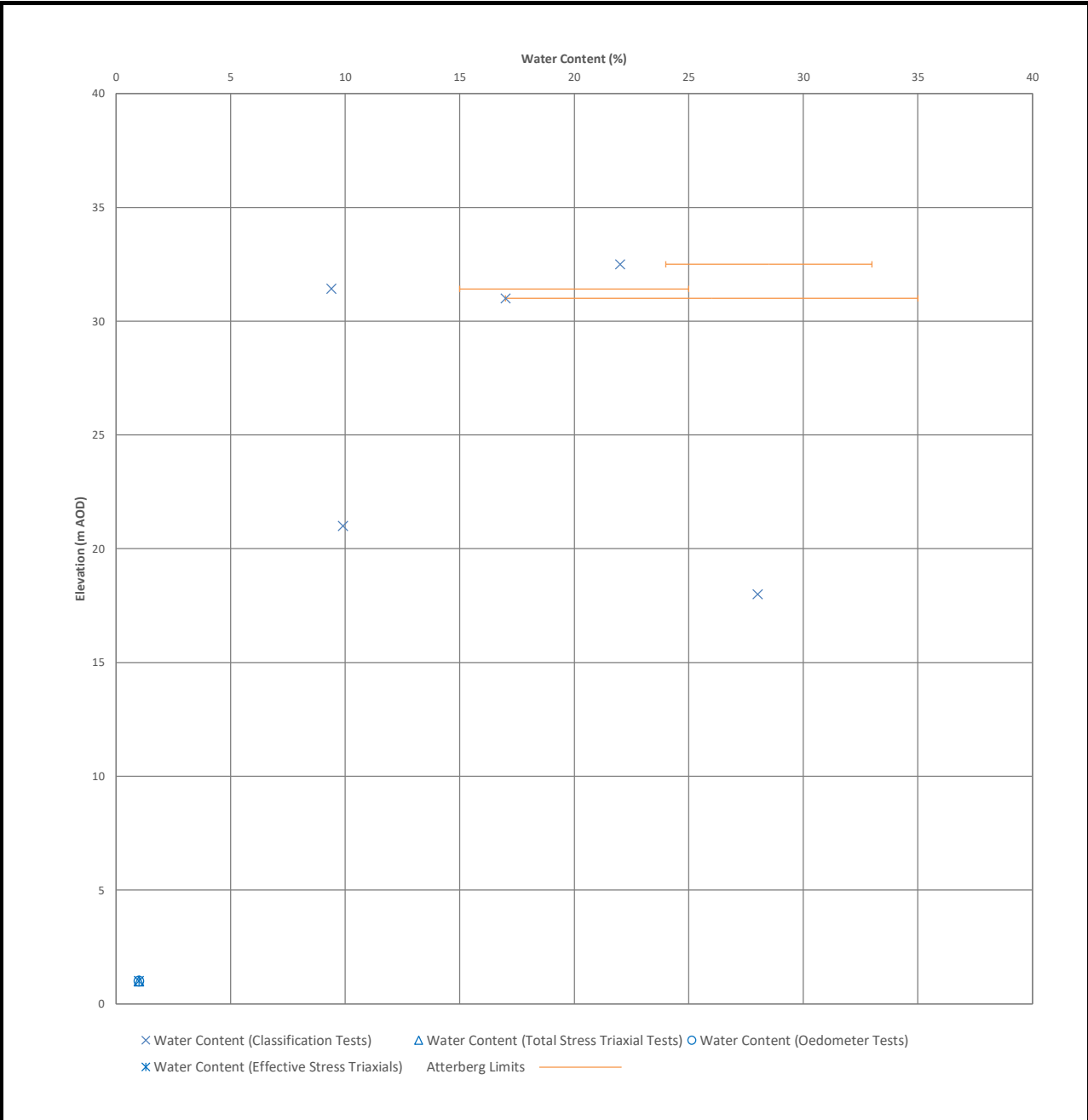
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client	Title					
	Greater Cambridge Partnership	Plasticity Index vs Depth for Lowestoft Formation					
	Project	Sheet size	Drawn	GL	Reviewed: SF		
Cambridge South East Transport Phase 2, Cambridge		A4	Date	19/08/2022	Date: 19/10/2022		
		Status	Plot Number			Rev	1
		DRAFT	C.1.15				



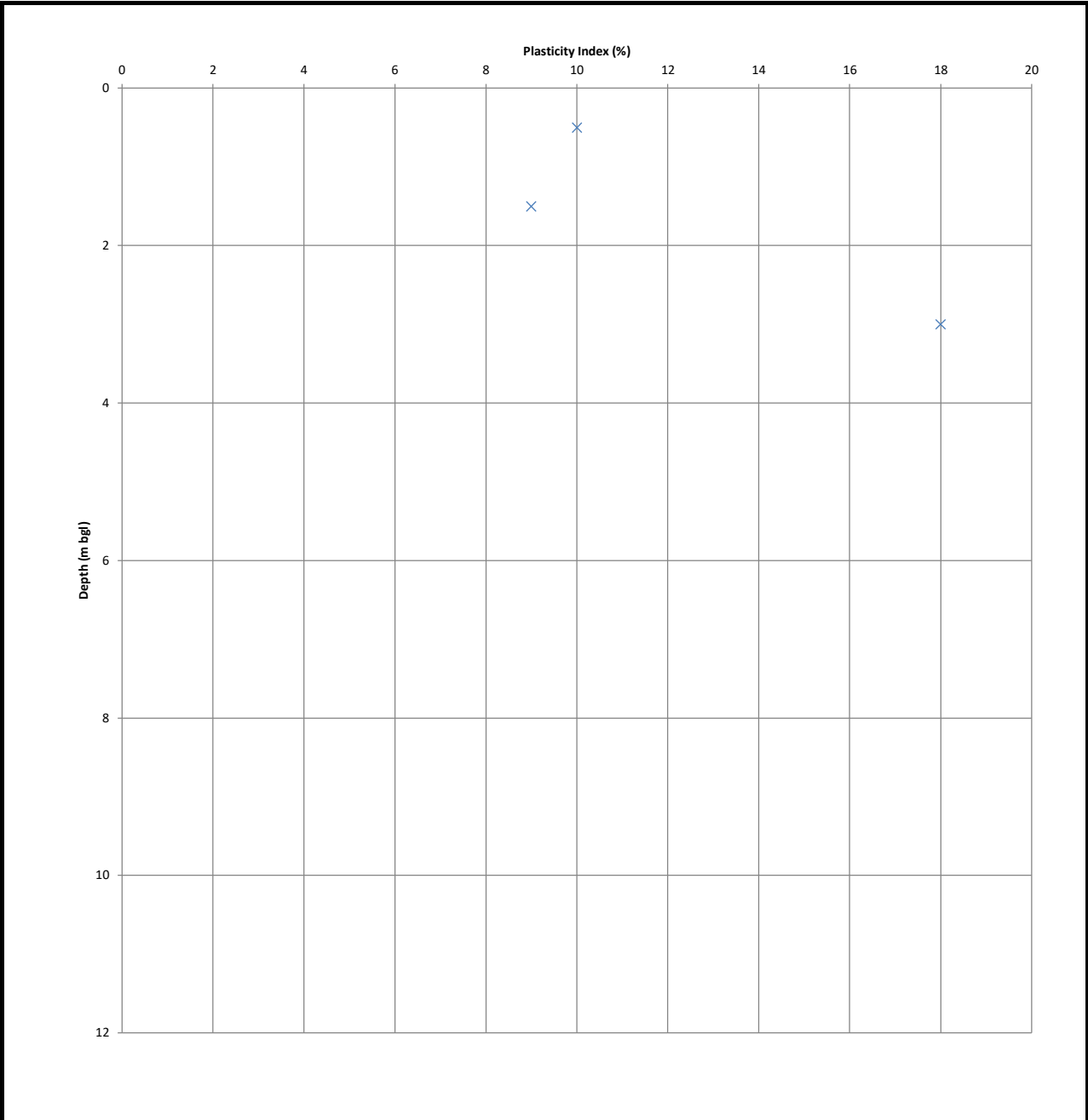
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT 18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client		Title				
	Greater Cambridge Partnership		Plasticity Index vs Elevation for Lowestoft Formation				
	Project		Sheet size	Drawn	GL	Reviewed: SF	
	Cambridge South East Transport Phase 2, Cambridge		A4	Date	19/08/2022	Date: 19/10/2022	
Status			Plot Number			Rev	
		DRAFT	C.1.16			1	



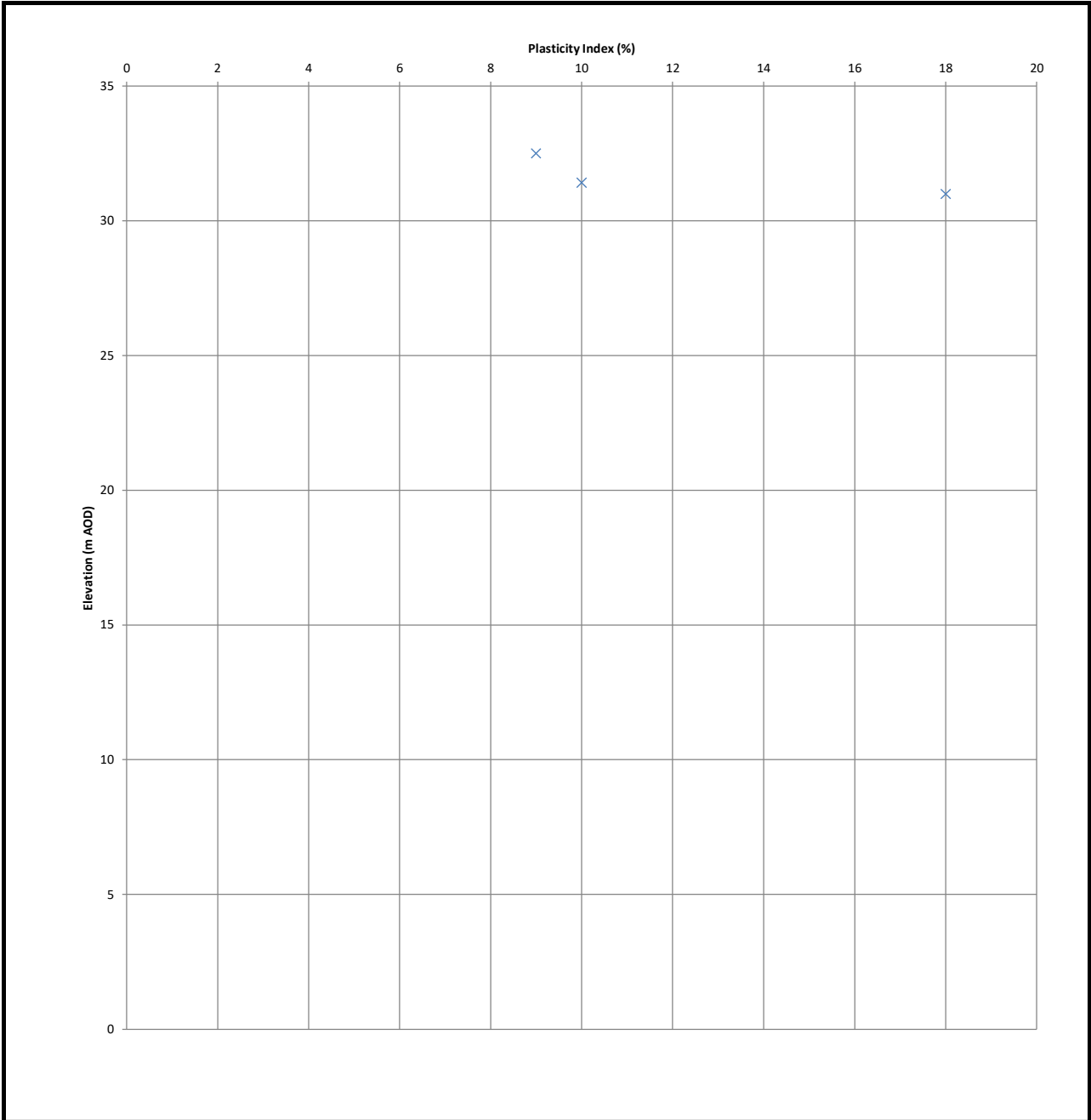
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT 18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client		Title					
	Greater Cambridge Partnership		Water Content vs Depth for Holywell Nodular Chalk Formation and New Pit Chalk Formation (Undifferentiated)					
	Project		Sheet size	Drawn	GL	Reviewed: SF		
	Cambridge South East Transport Phase 2, Cambridge		A4	Date	19/08/2022	Date: 19/10/2022		
Status			Plot Number			Rev		
DRAFT			C.1.17			1		



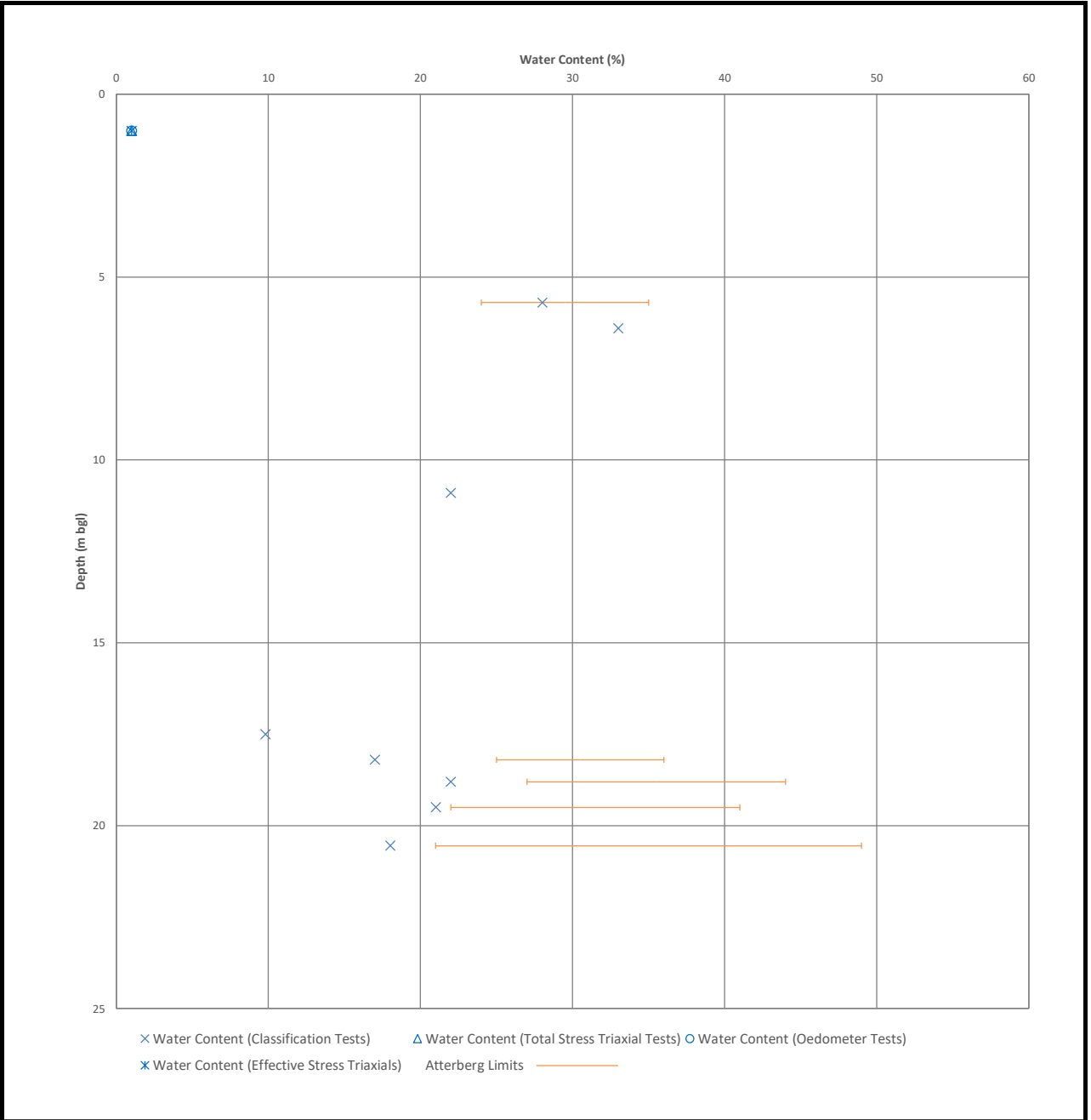
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT 18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client		Title				
	Greater Cambridge Partnership		Water Content vs Elevation for Holywell Nodular Chalk Formation and New Pit Chalk Formation (Undifferentiated)				
	Project		Sheet size	Drawn	GL	Reviewed: SF	
	Cambridge South East Transport Phase 2, Cambridge		A4	Date	19/08/2022	Date: 19/10/2022	
		Status	Plot Number			C.1.18	Rev
		DRAFT					1



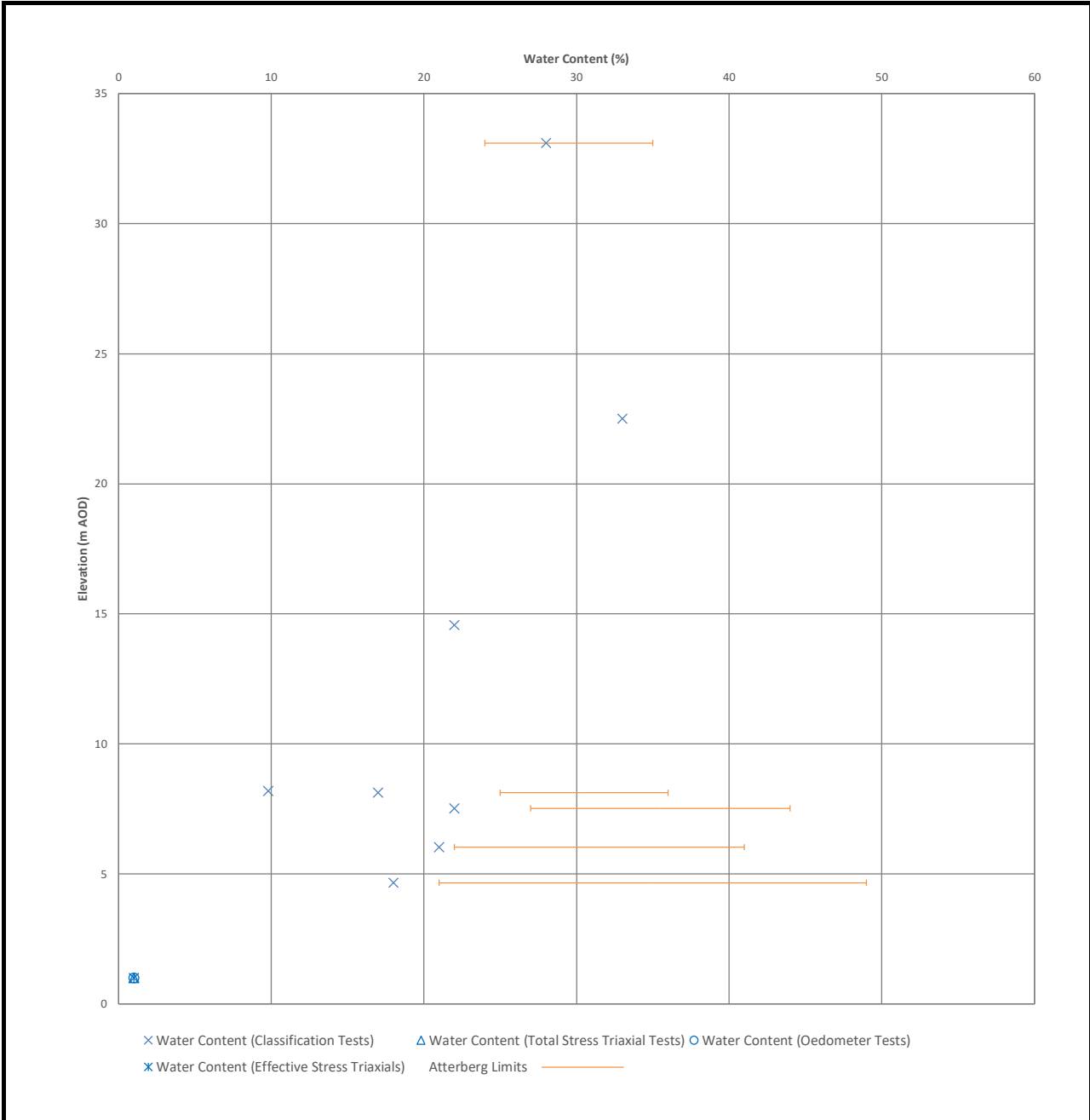
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT 18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client		Title				
	Greater Cambridge Partnership		Plasticity Index vs Depth for Holywell Nodular Chalk Formation and New Pit Chalk Formation (Undifferentiated)				
	Project		Sheet size	Drawn	GL	Reviewed: SF	
	Cambridge South East Transport Phase 2, Cambridge		A4	Date	19/08/2022	Date: 19/10/2022	
		Status	Plot Number			Rev	
		DRAFT	C.1.19			1	



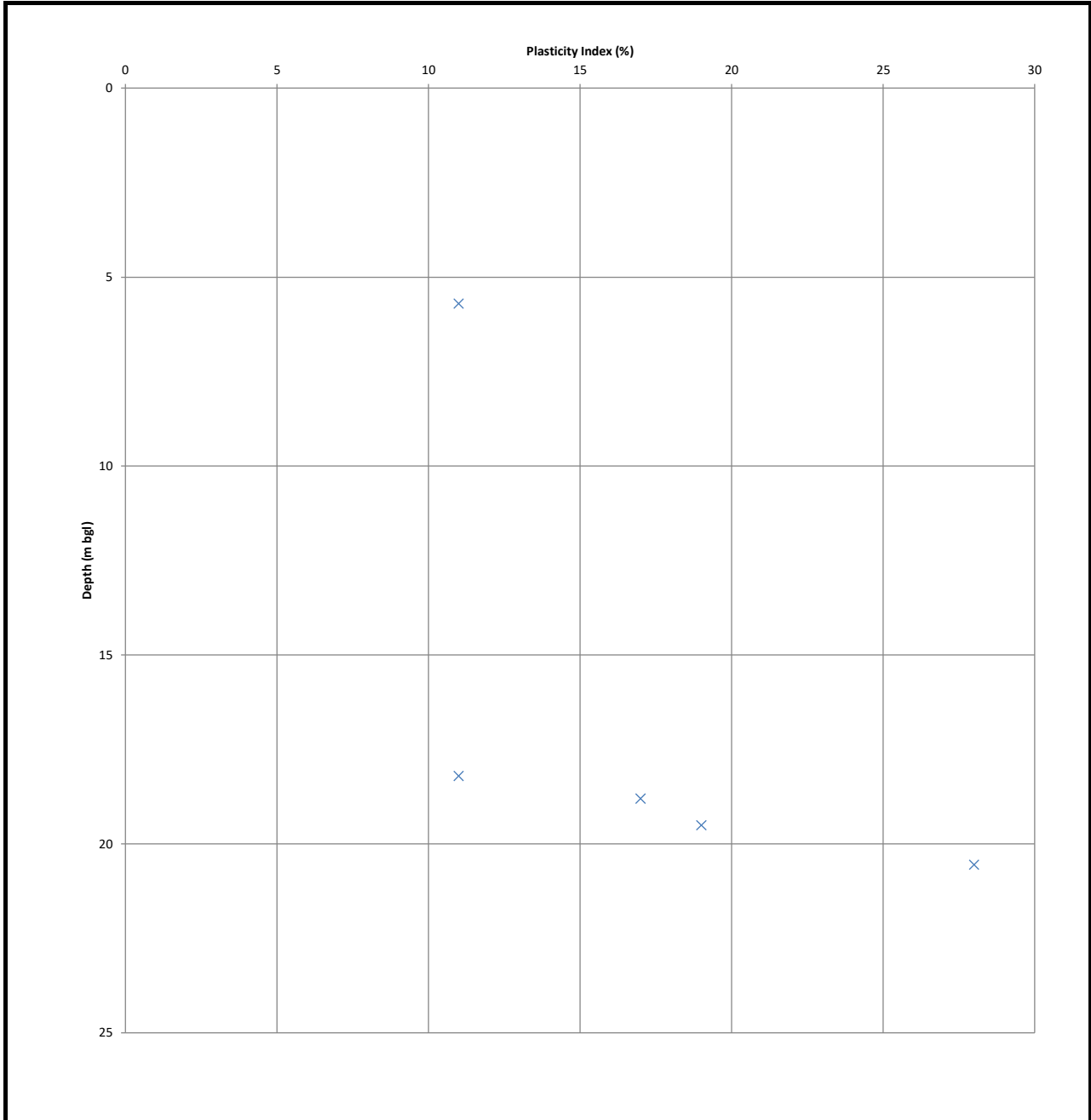
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client	Title					
	Greater Cambridge Partnership	Plasticity Index vs Elevation for Holywell Nodular Chalk Formation and New Pit Chalk Formation (Undifferentiated)					
	Project	Sheet size	Drawn	GL	Reviewed: SF		
Cambridge South East Transport Phase 2, Cambridge		A4	Date	19/08/2022	Date: 19/10/2022		
		Status	Plot Number			Rev	
		DRAFT	C.1.20			1	



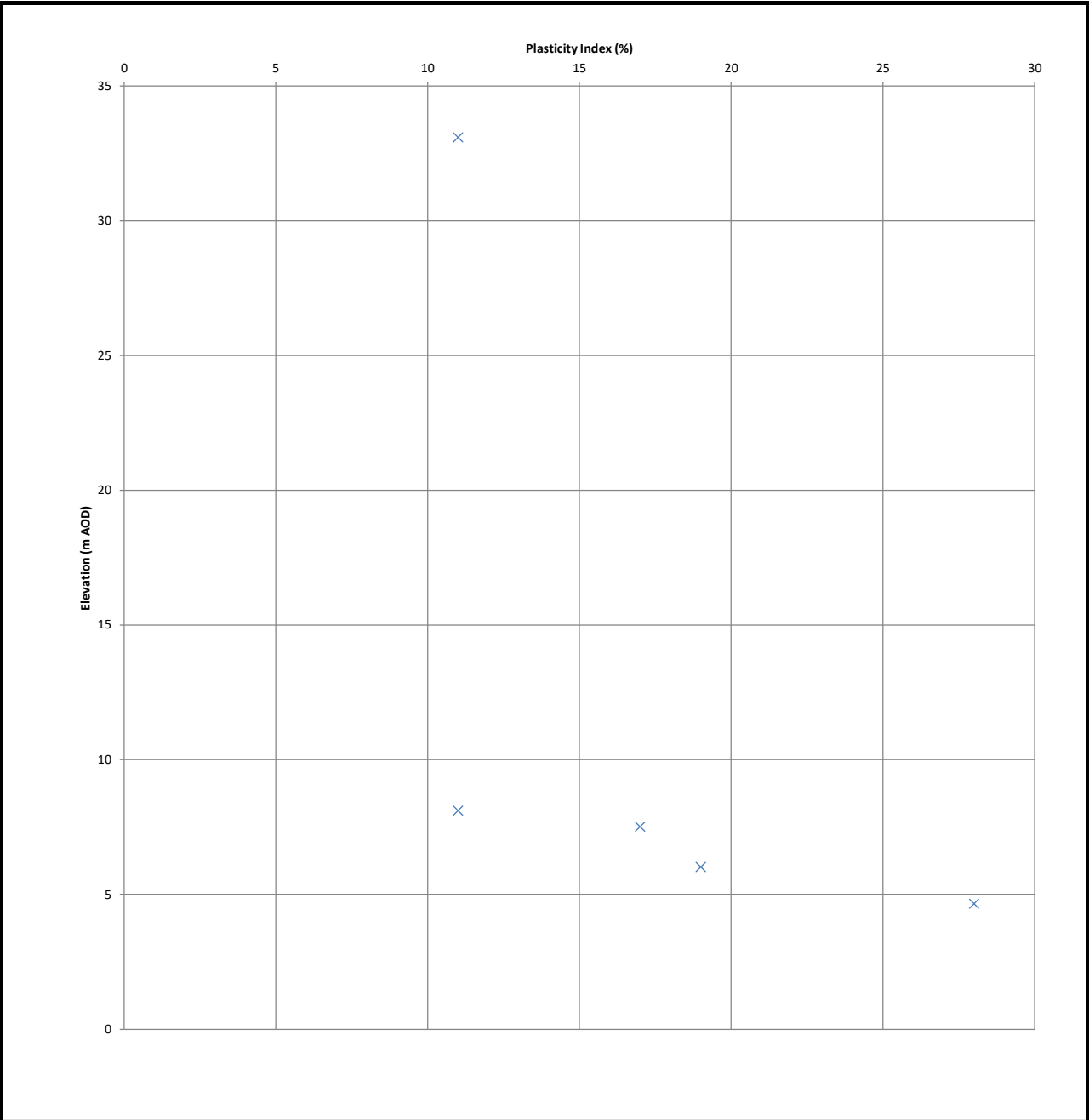
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client	Title					
	Greater Cambridge Partnership	Water Content vs Depth for Holywell Nodular Chalk Formation					
	Project	Sheet size	Drawn	GL	Reviewed: SF		
Cambridge South East Transport Phase 2, Cambridge		A4	Date	19/08/2022	Date: 19/10/2022		
		Status	Plot Number			Rev	
		DRAFT	C.1.21			1	



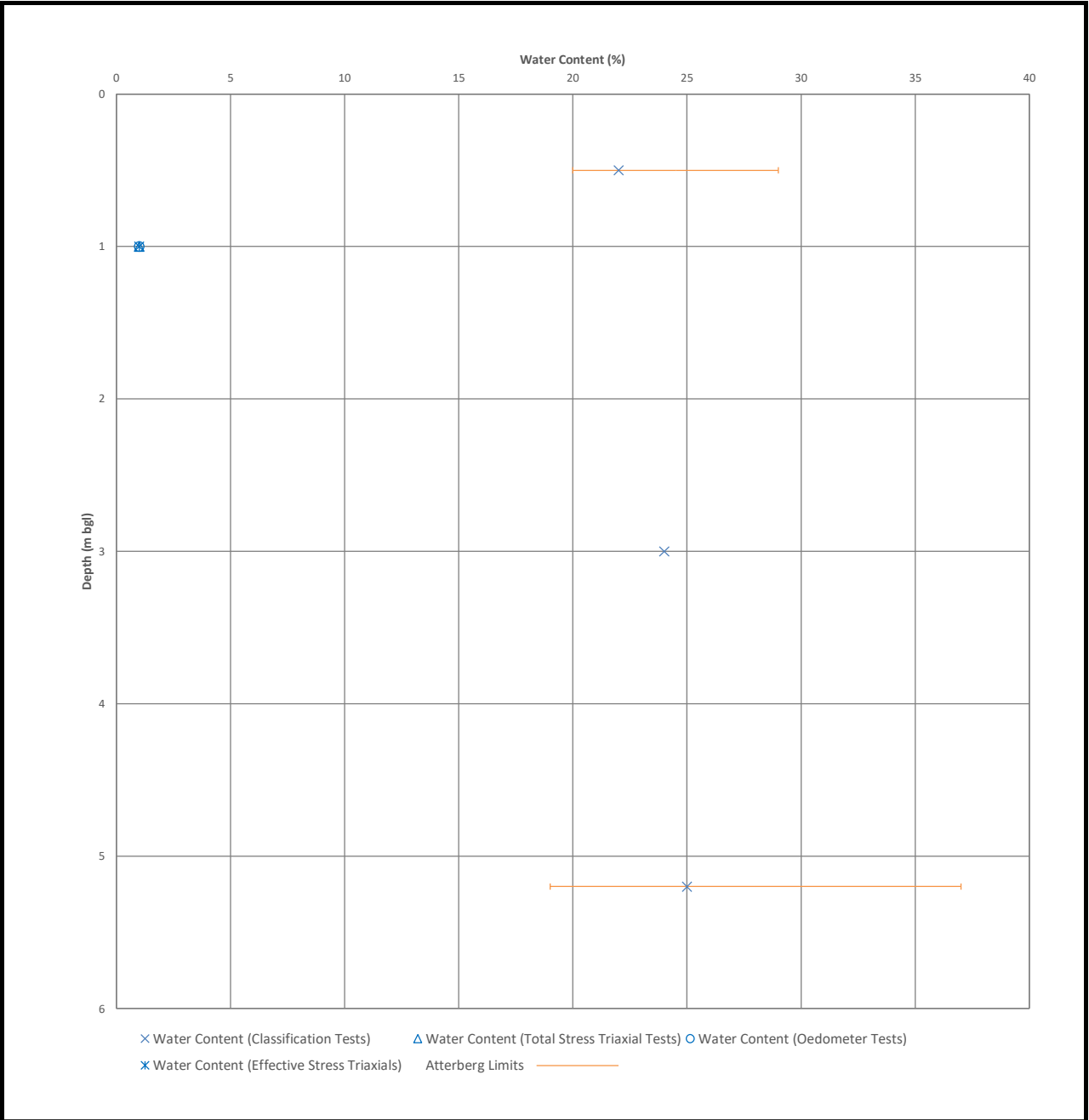
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client		Title				
	Greater Cambridge Partnership		Water Content vs Elevation for Holywell Nodular Chalk Formation				
	Project		Sheet size	Drawn	GL	Reviewed: SF	
	Cambridge South East Transport Phase 2, Cambridge		A4	Date	19/08/2022	Date: 19/10/2022	
		Status	Plot Number			C.1.22	Rev
		DRAFT					1



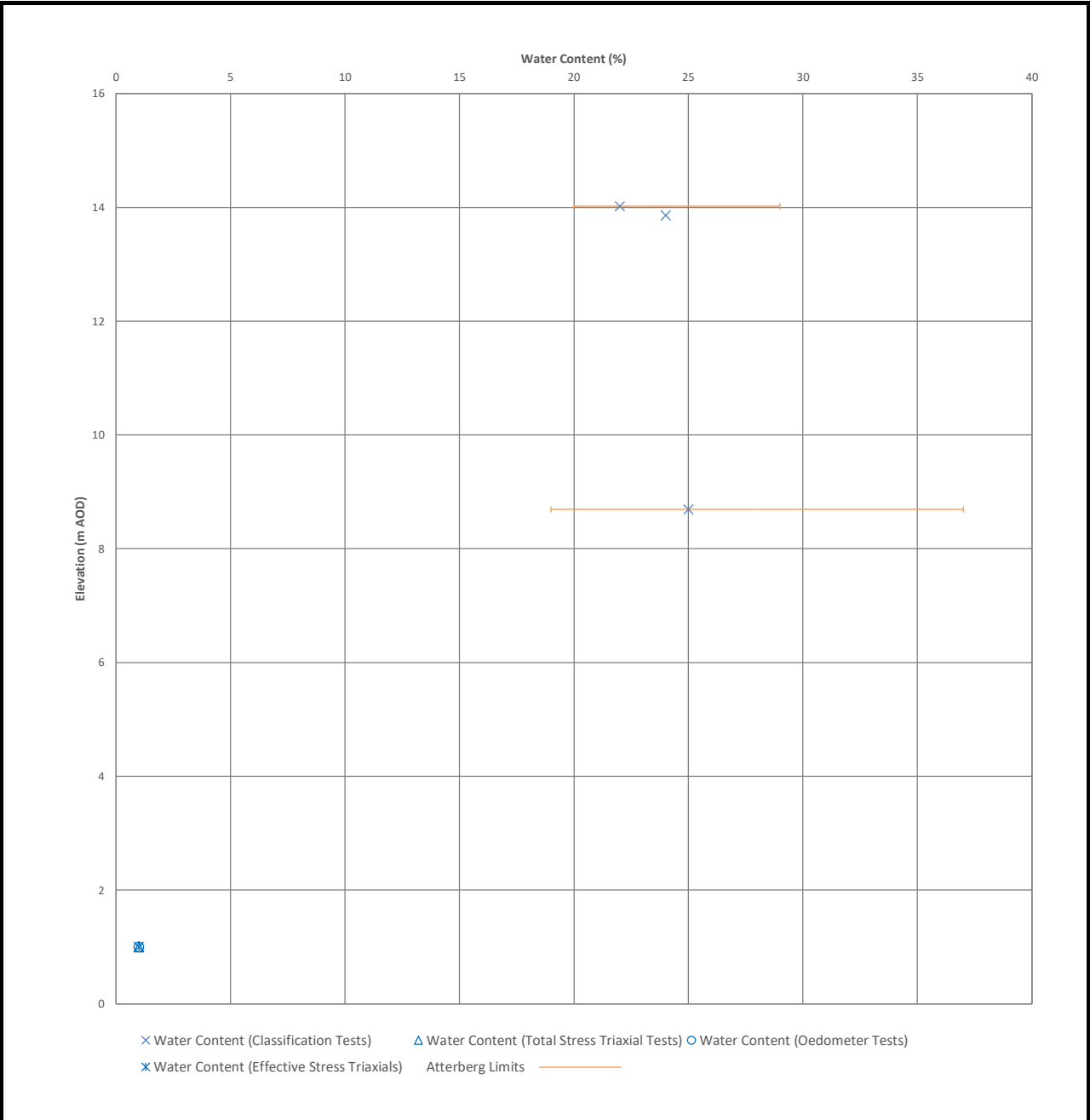
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client		Title				
	Greater Cambridge Partnership		Plasticity Index vs Depth for Holywell Nodular Chalk Formation				
	Project	Cambridge South East Transport Phase 2, Cambridge	Sheet size	Drawn	GL	Reviewed: SF	
			A4	Date	19/08/2022	Date: 19/10/2022	
Status	Plot Number			C.1.23		Rev	
DRAFT						1	



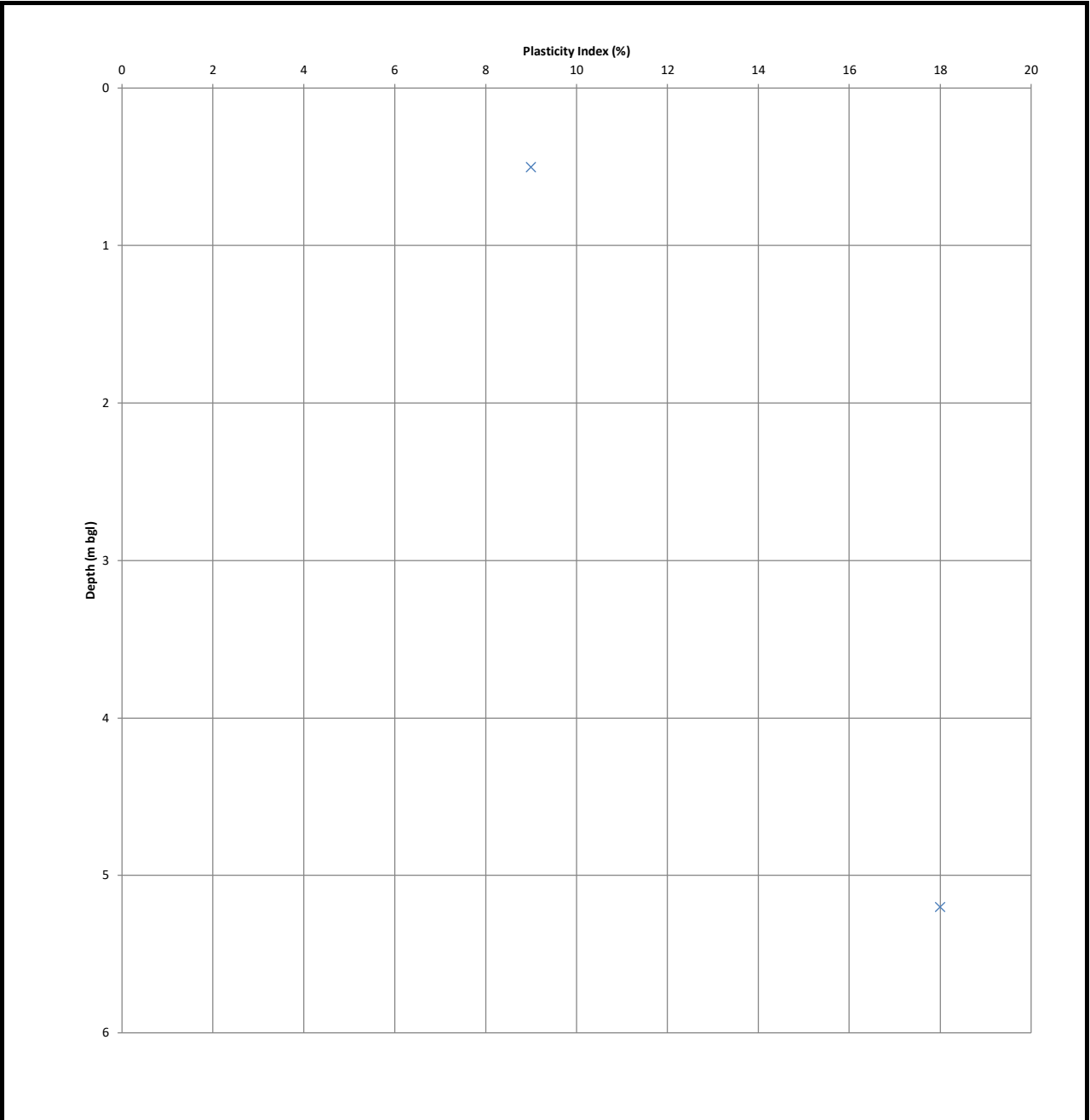
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client	Title				
	Greater Cambridge Partnership	Plasticity Index vs Elevation for Holywell Nodular Chalk Formation				
	Project	Sheet size	Drawn	GL	Reviewed: SF	
Cambridge South East Transport Phase 2, Cambridge		A4	Date	19/08/2022	Date: 19/10/2022	
		Status	Plot Number			Rev
		DRAFT	C.1.24			1



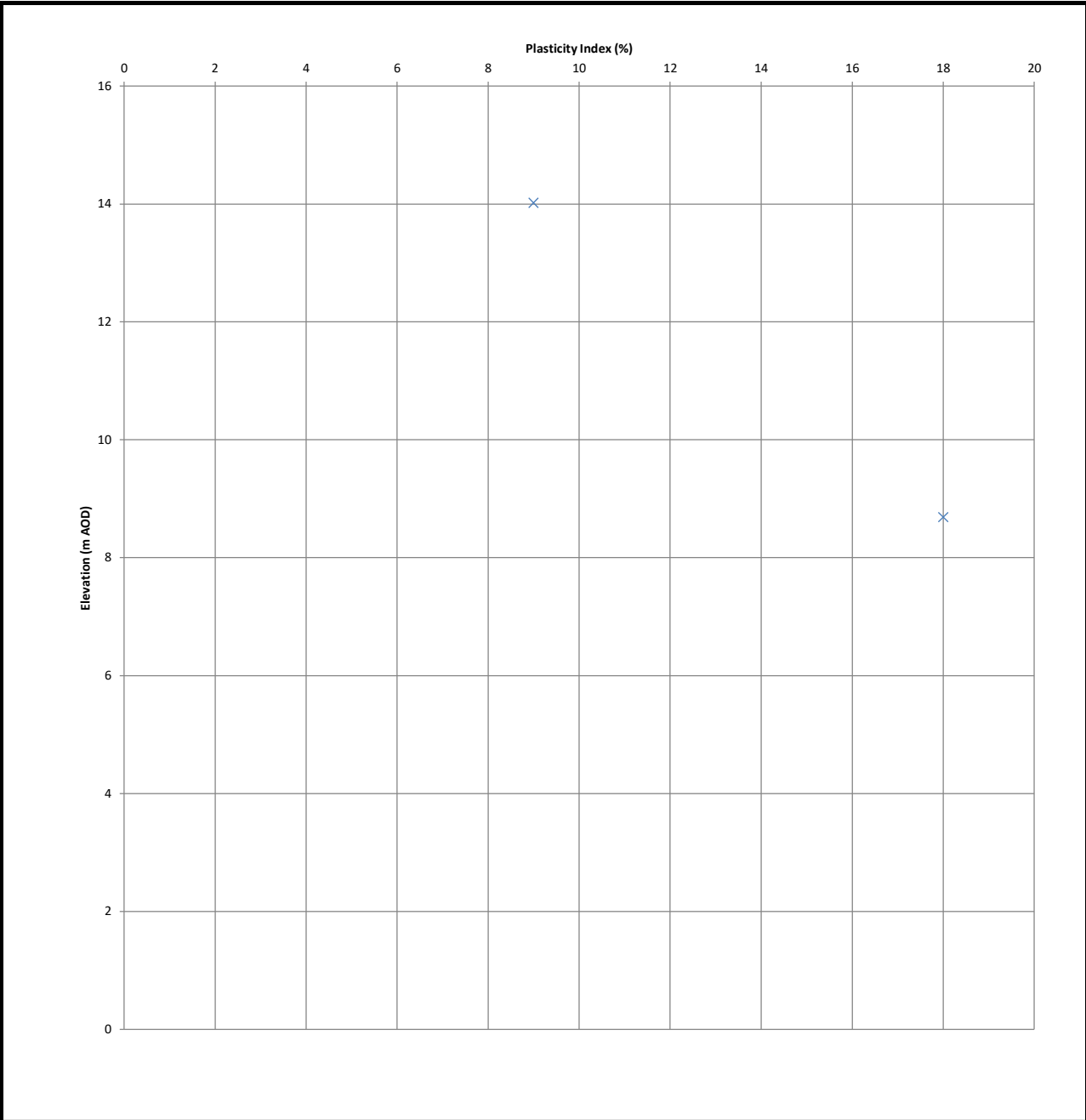
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client	Title				
	Greater Cambridge Partnership	Water Content vs Depth for West Melbury Marly Chalk Formation				
	Project	Sheet size	Drawn	GL	Reviewed: SF	
Cambridge South East Transport Phase 2, Cambridge		A4	Date	19/08/2022	Date: 19/10/2022	
		Status	Plot Number			Rev
		DRAFT	C.1.25			1



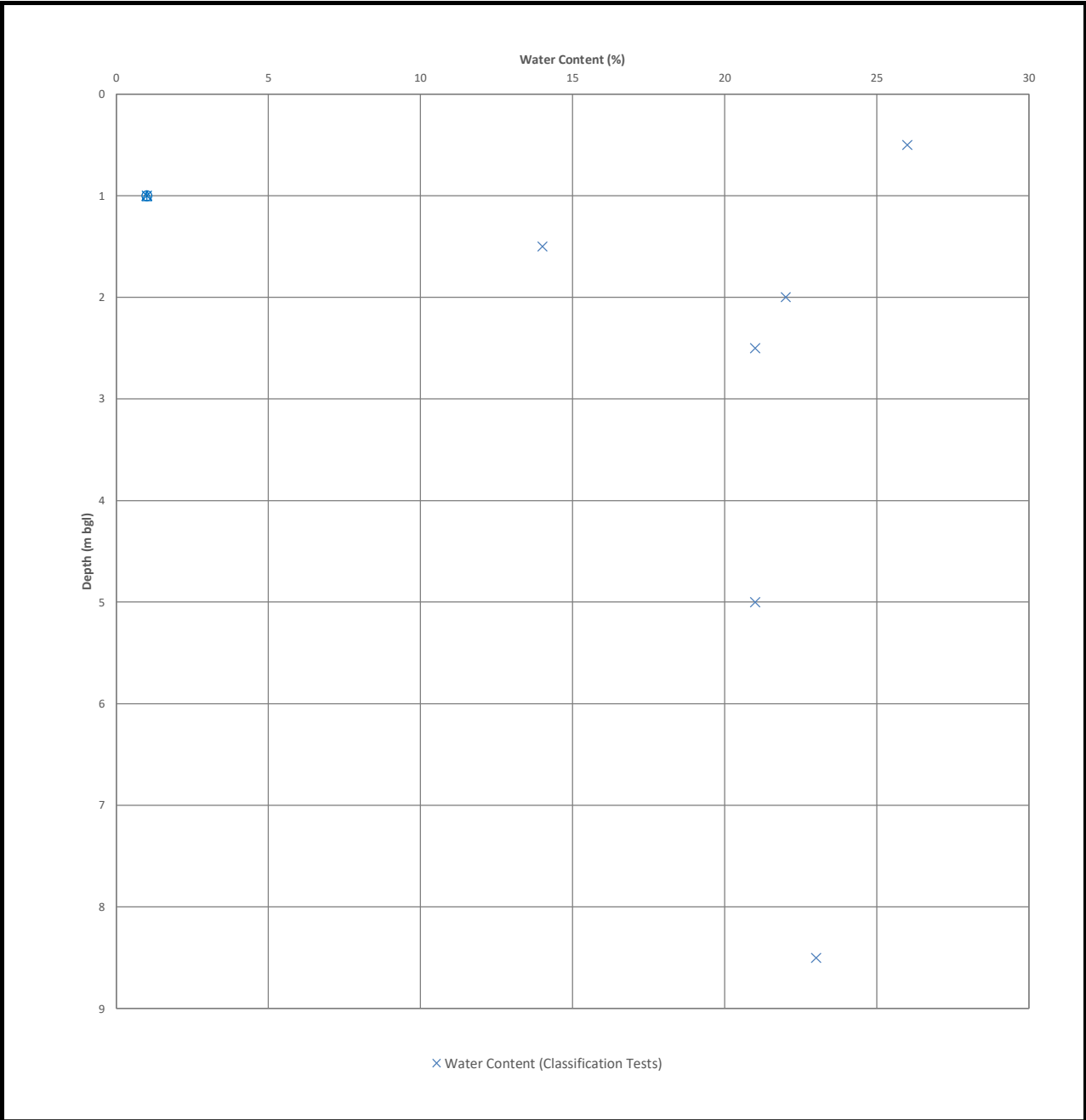
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client	Title				
	Greater Cambridge Partnership	Water Content vs Elevation for West Melbury Marly Chalk Formation				
	Project	Sheet size A4	Drawn Date	GL 19/08/2022	Reviewed: SF Date: 19/10/2022	
Cambridge South East Transport Phase 2, Cambridge		Status DRAFT	Plot Number C.1.26			Rev 1



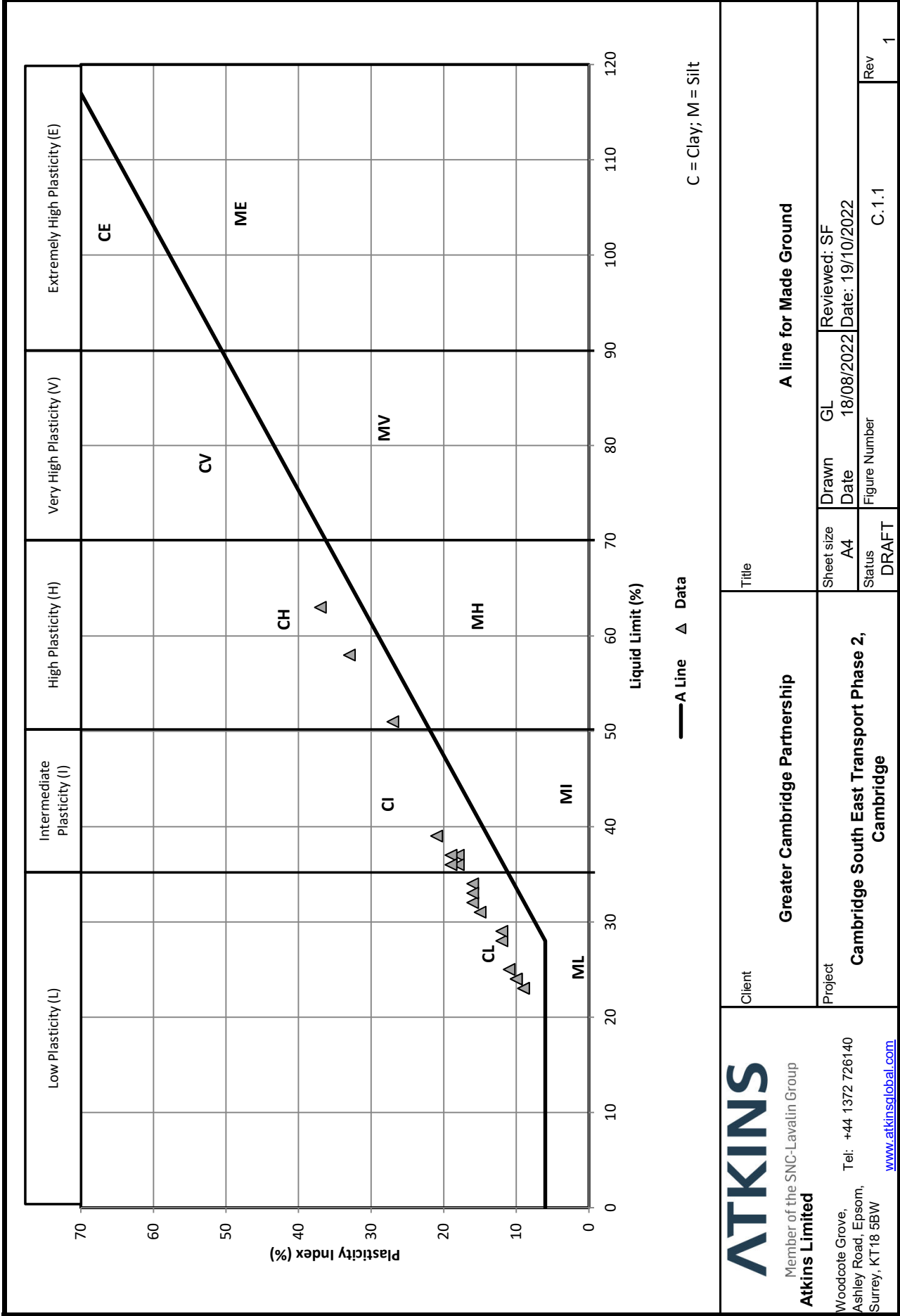
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client	Title				
	Greater Cambridge Partnership	Plasticity Index vs Depth for West Melbury Marly Chalk Formation				
	Project	Sheet size A4	Drawn Date	GL 19/08/2022	Reviewed: SF Date: 19/10/2022	
Cambridge South East Transport Phase 2, Cambridge		Status DRAFT	Plot Number C.1.27			Rev 1

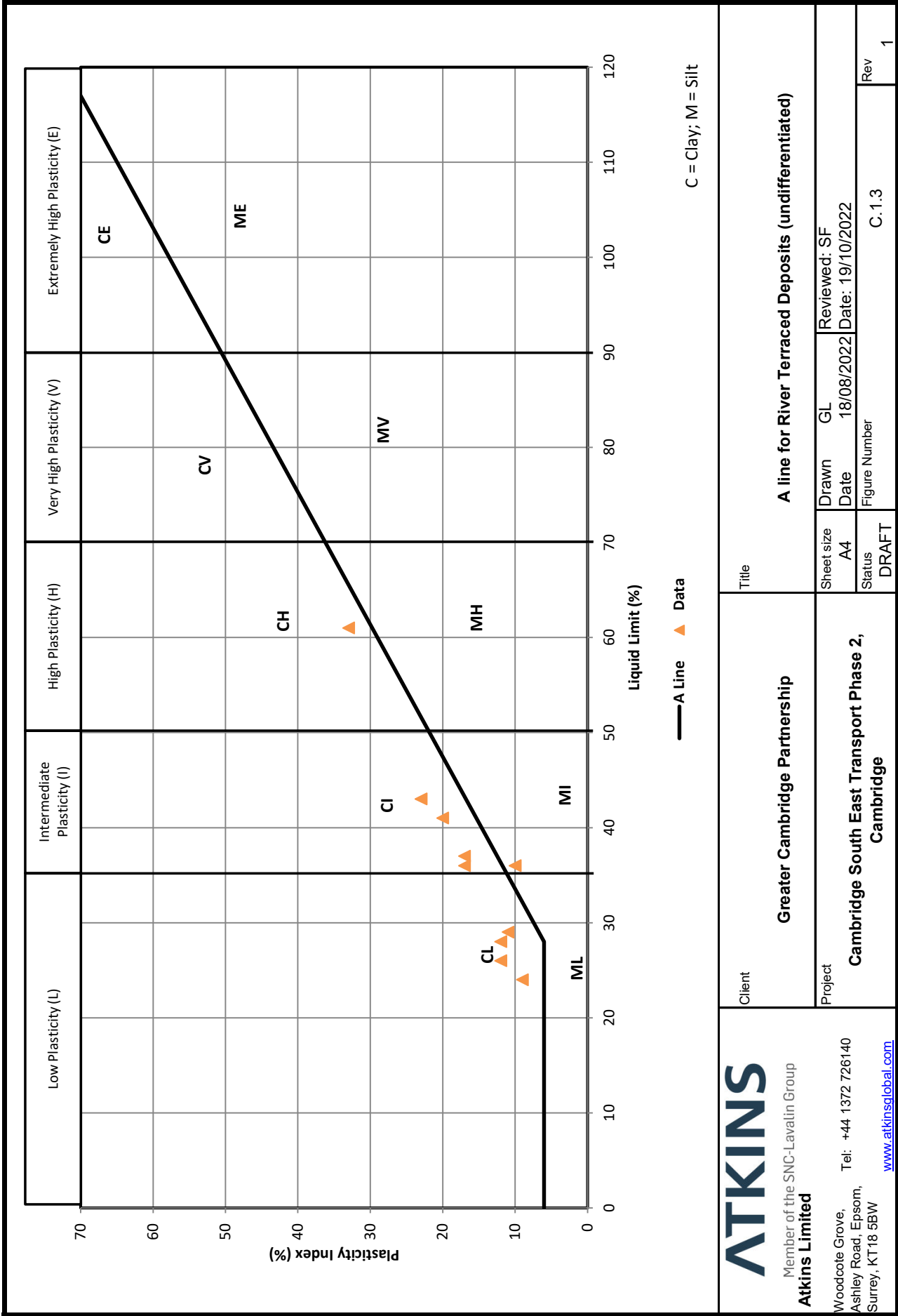


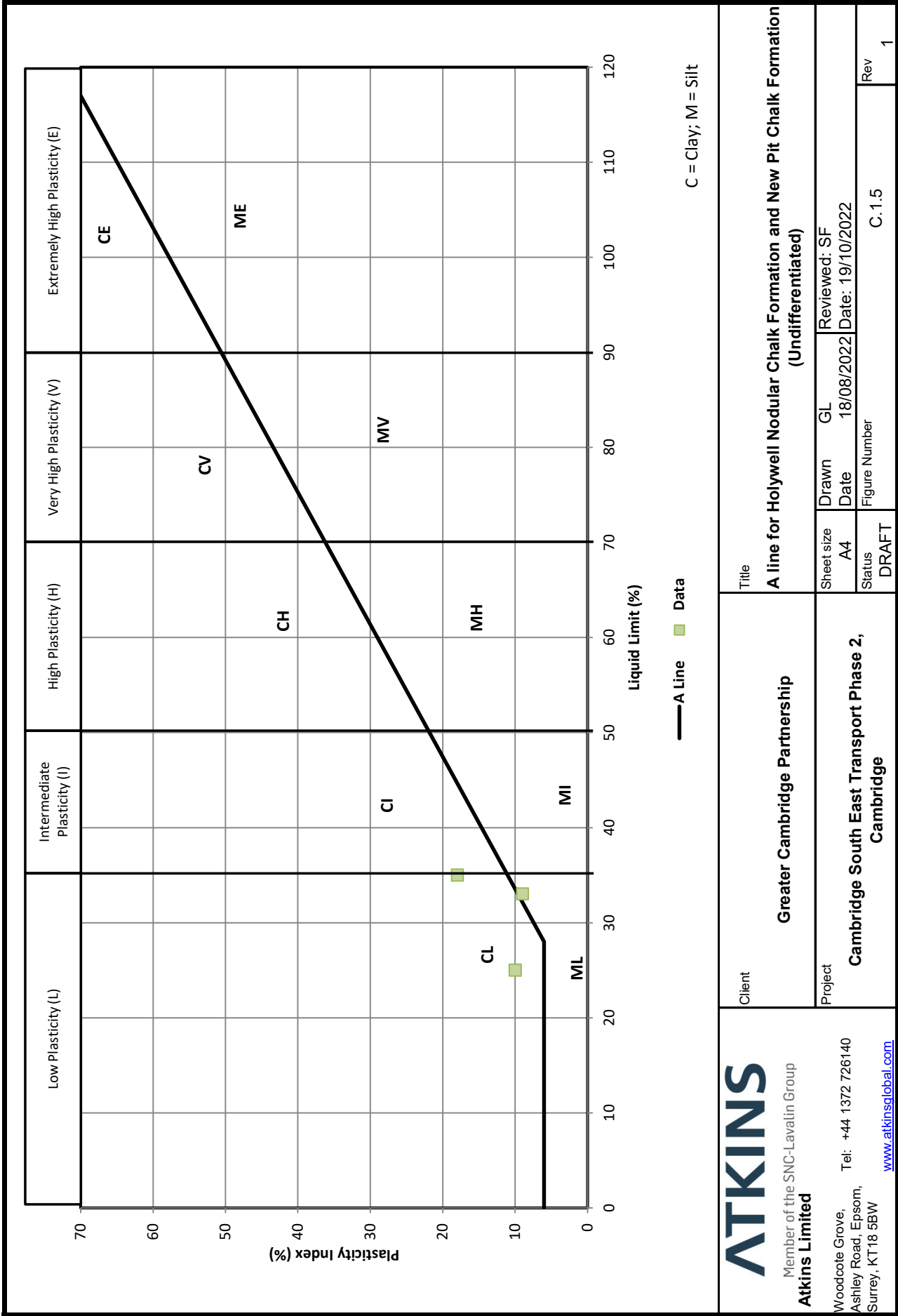
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT 18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client		Title				
	Greater Cambridge Partnership		Plasticity Index vs Elevation for West Melbury Marly Chalk Formation				
	Project	Cambridge South East Transport Phase 2, Cambridge	Sheet size	Drawn	GL	Reviewed: SF	
			A4	Date	19/08/2022	Date: 19/10/2022	
		Status	Plot Number			Rev	
		DRAFT	C.1.28			1	



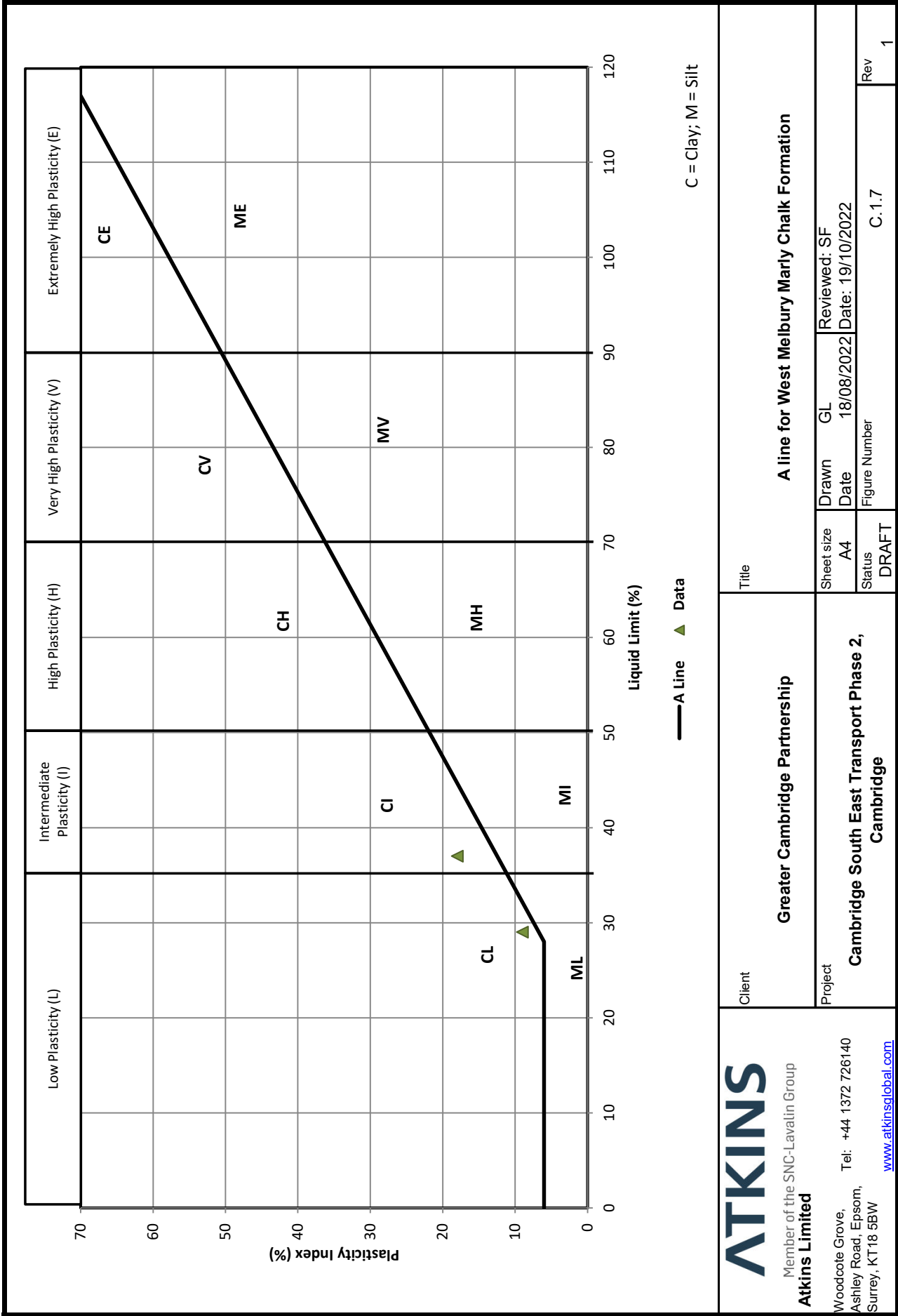
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT 18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client		Title				
	Greater Cambridge Partnership		Water Content vs Depth for Zig Zag Chalk Formation				
	Project	Cambridge South East Transport Phase 2, Cambridge	Sheet size	Drawn	GL	Reviewed: SF	
			A4	Date	19/08/2022	Date: 19/10/2022	
		Status	Plot Number	C.1.29		Rev	
		DRAFT				1	

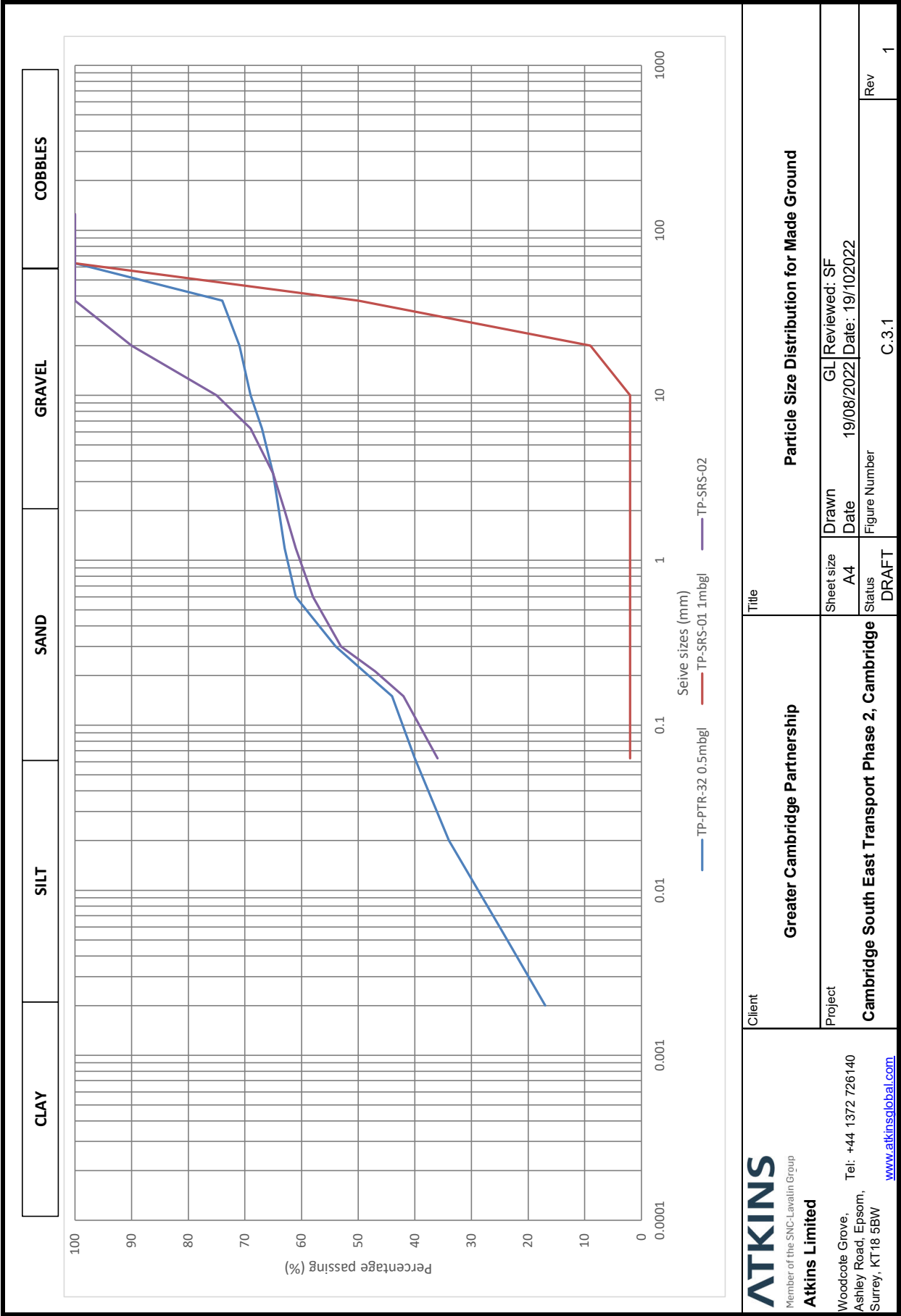
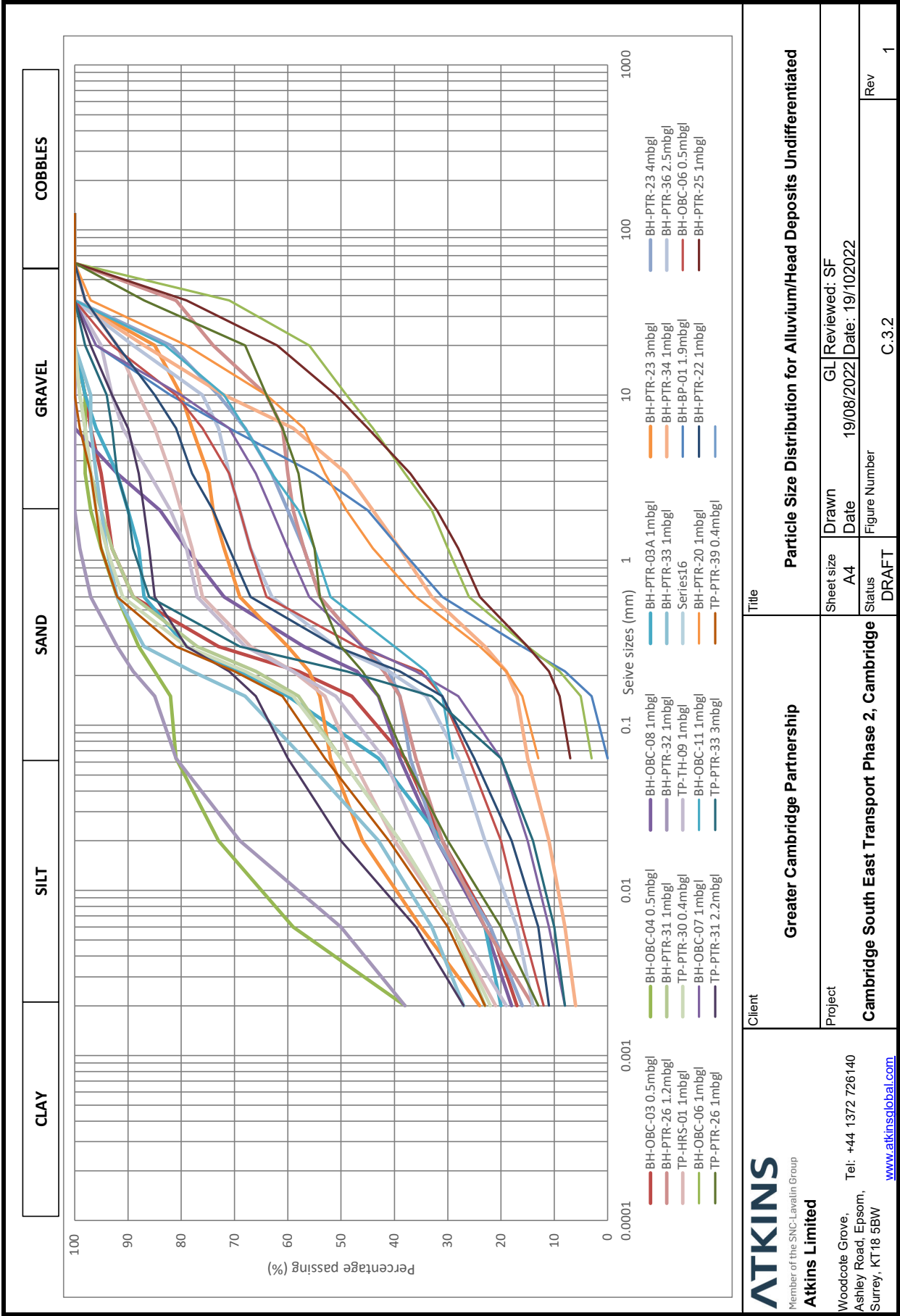


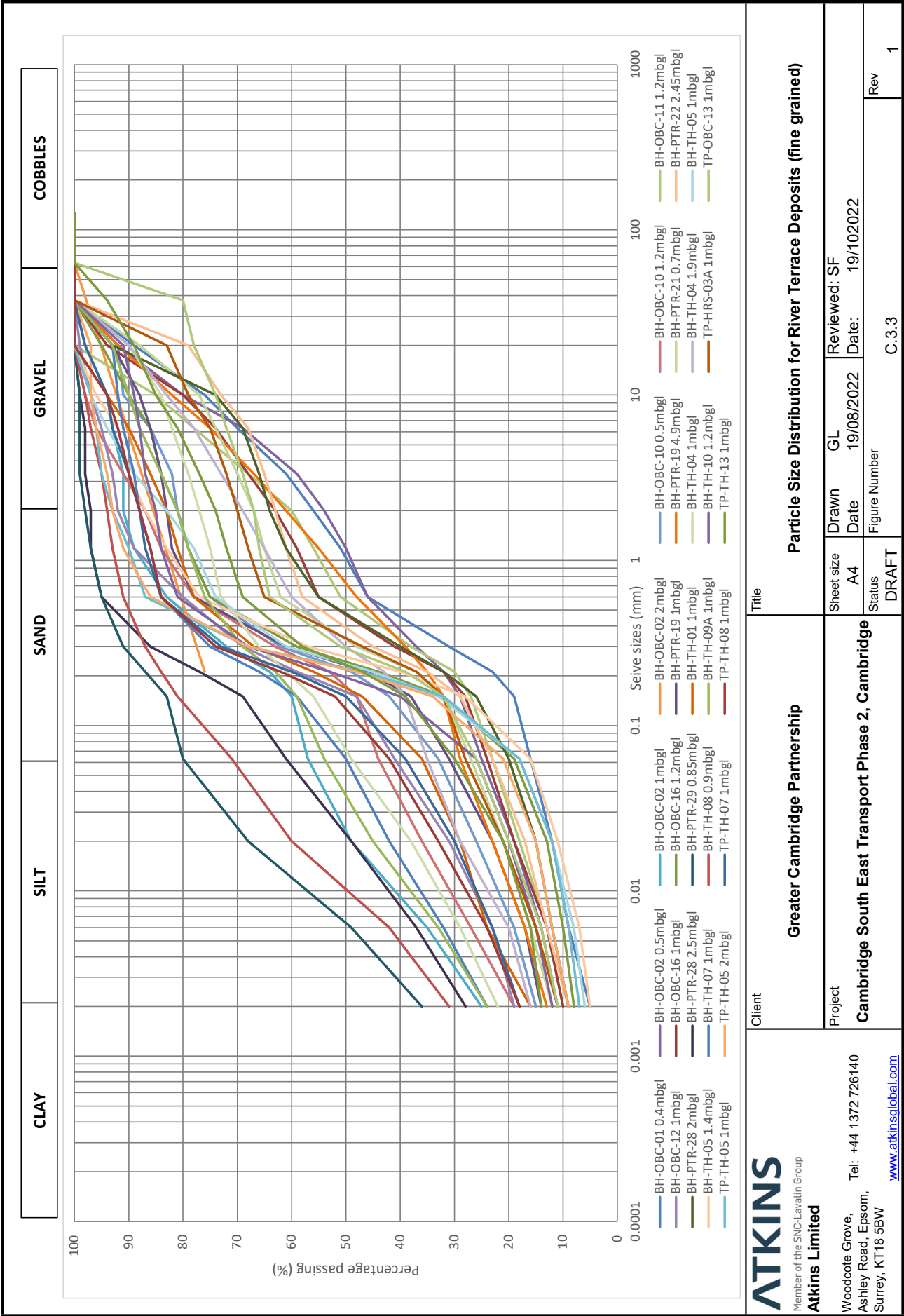
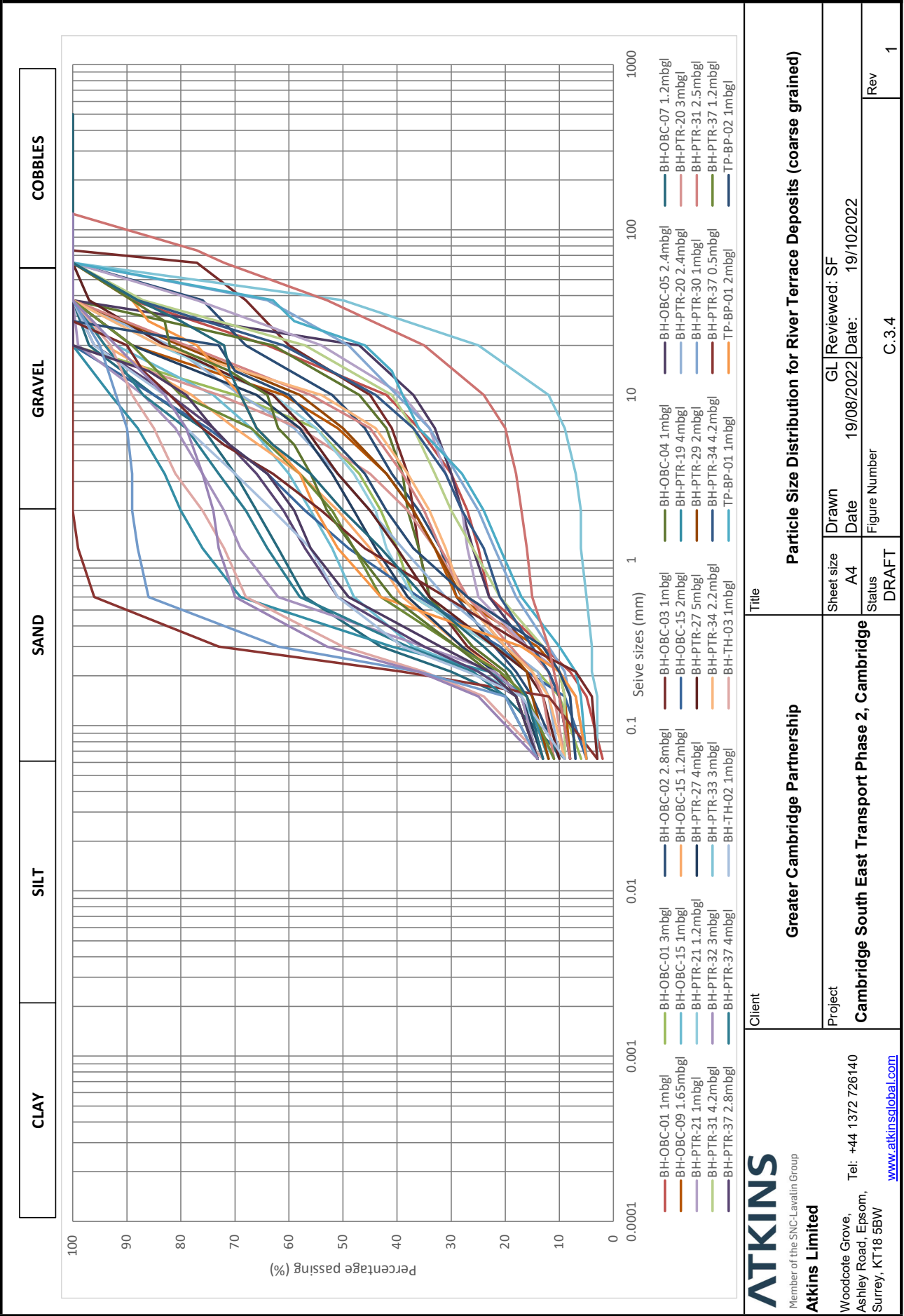




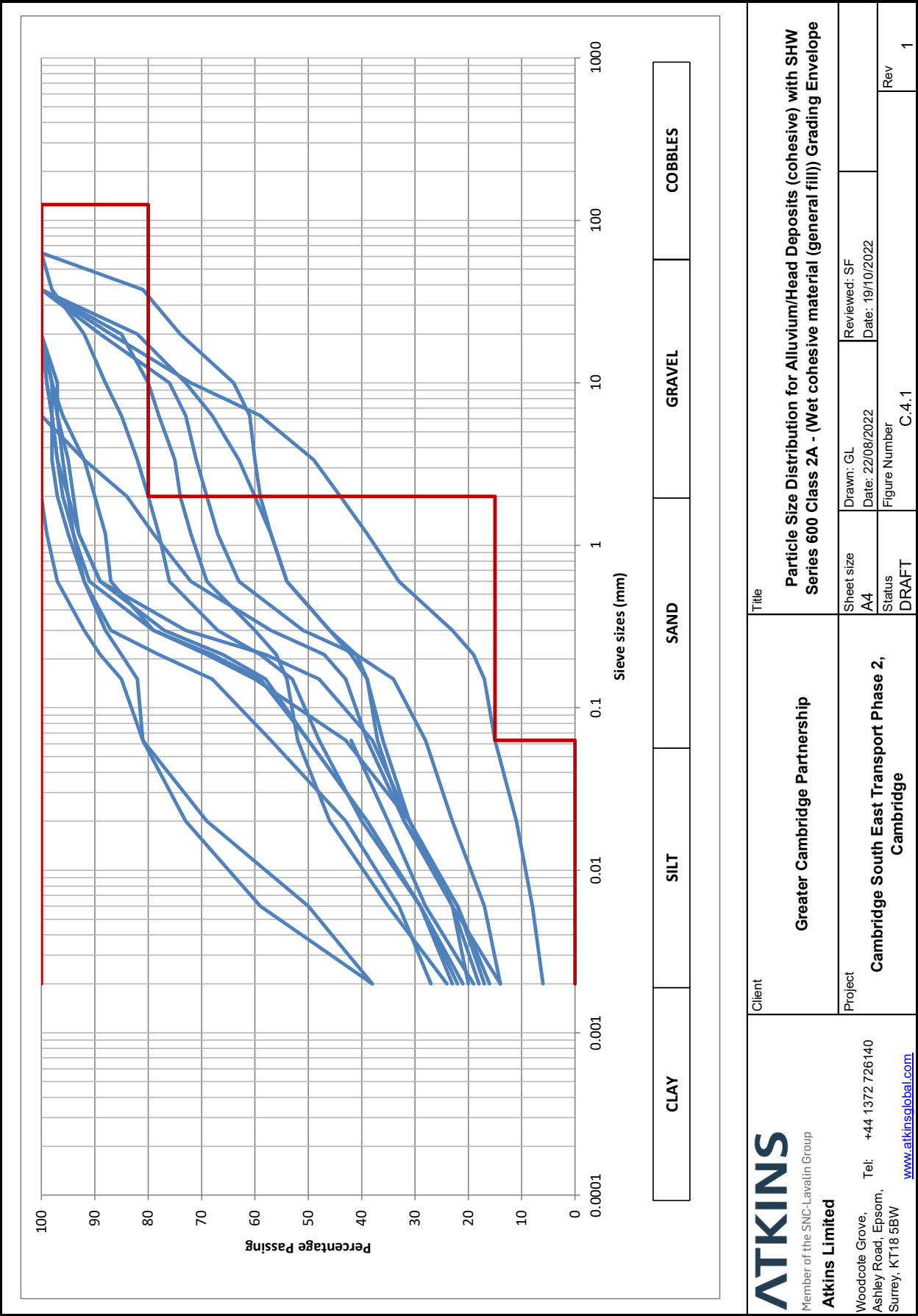
C.3. Particle Size Distribution



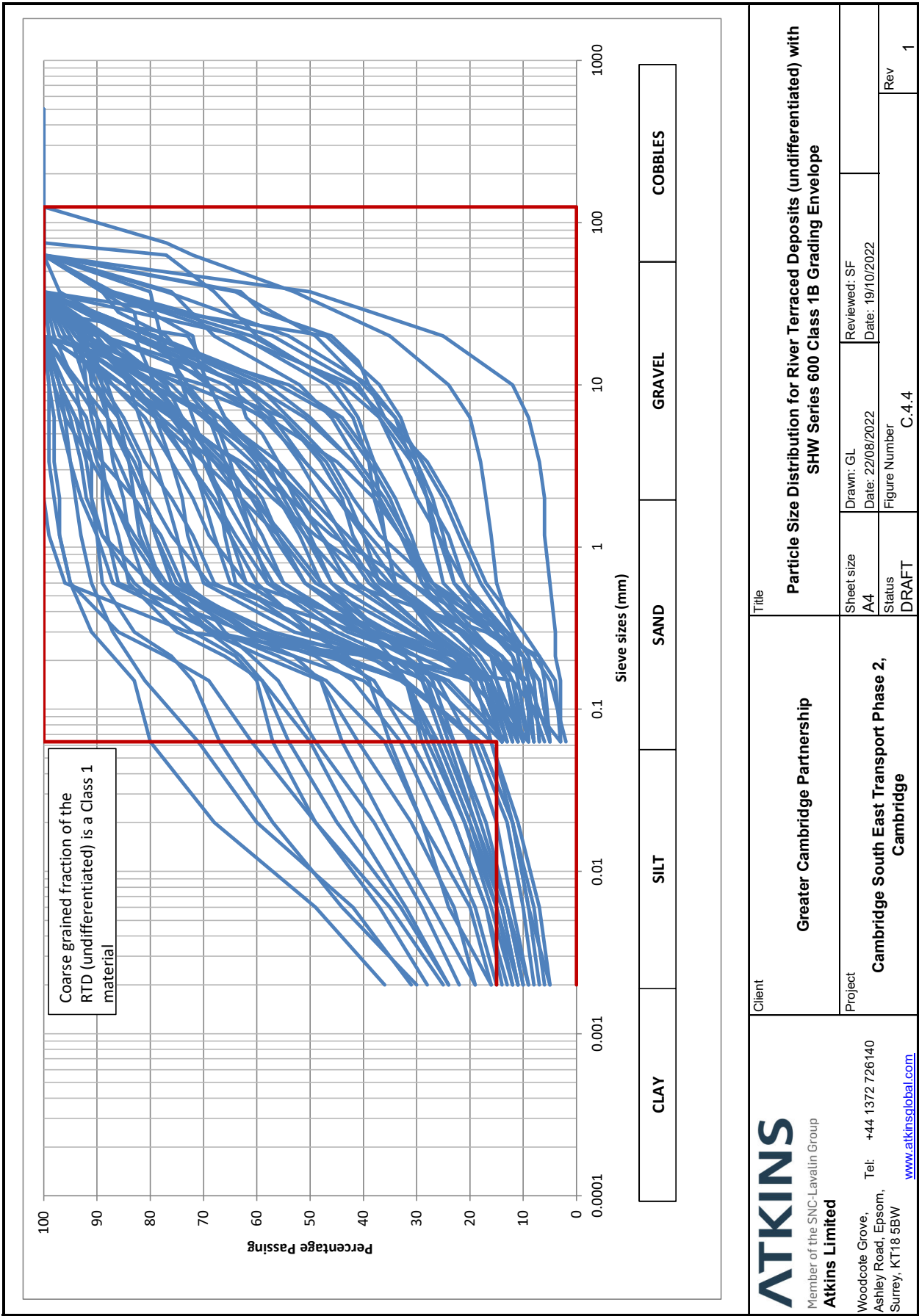


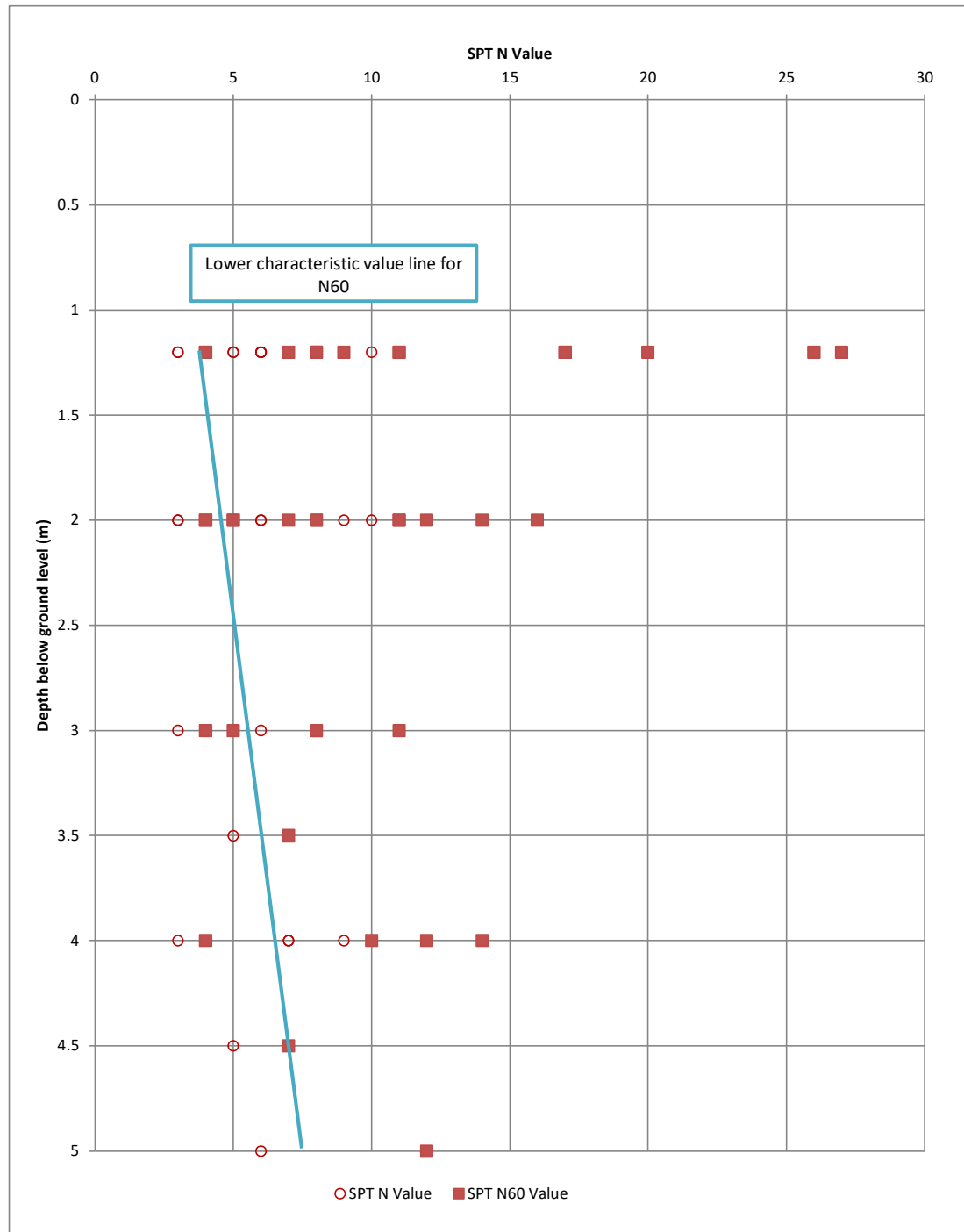


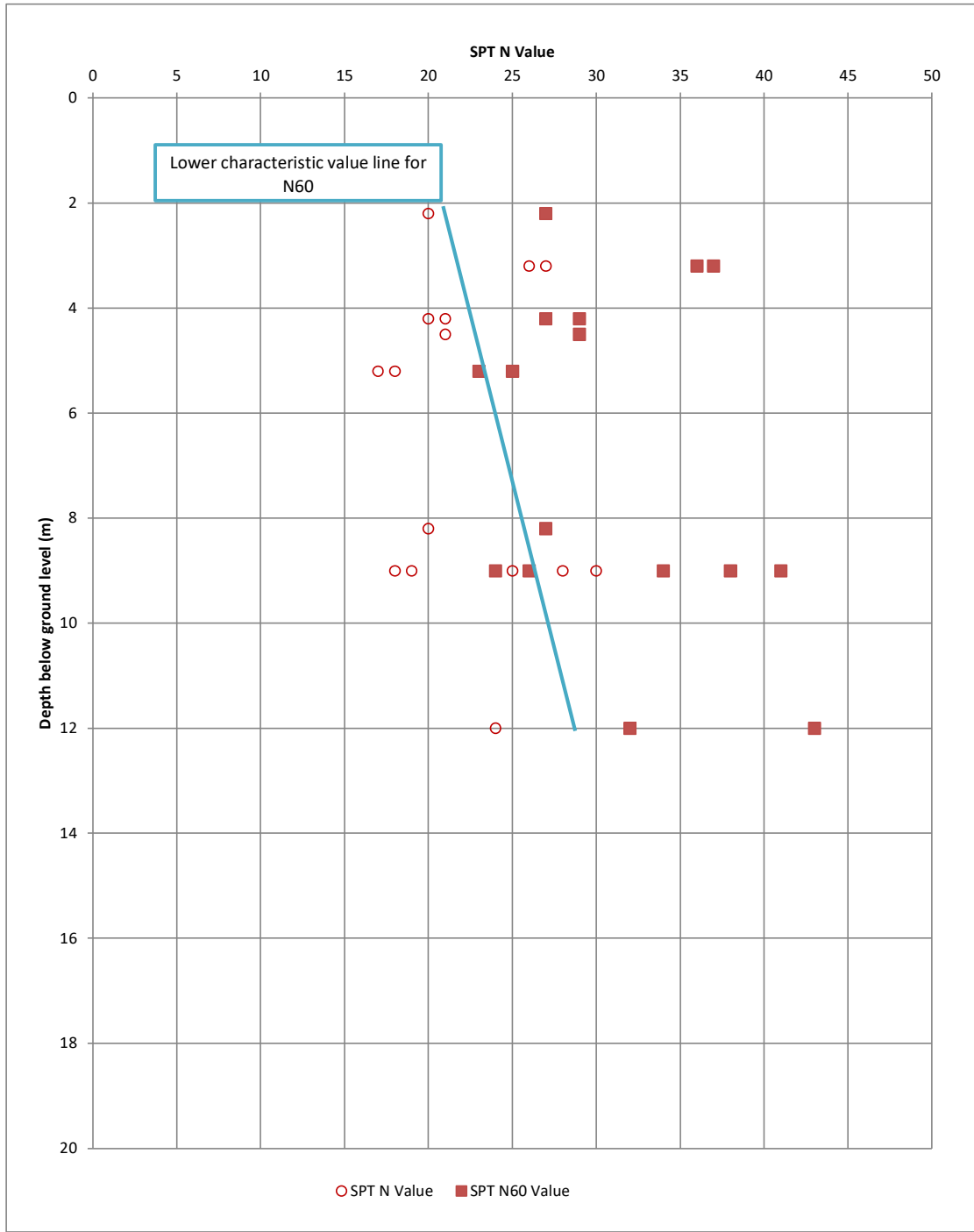
C.4. Particle Size Distribution for SHW Series 600



C.5. SPT N60 plots







Maximum Extrapolated N Value	200
------------------------------	-----

ATKINS
Member of the SNC-Lavalin Group
Atkins Limited
Woodcote Grove
Ashley Road
Epsom
KT18 5BW

Client
Greater Cambridge Partnership

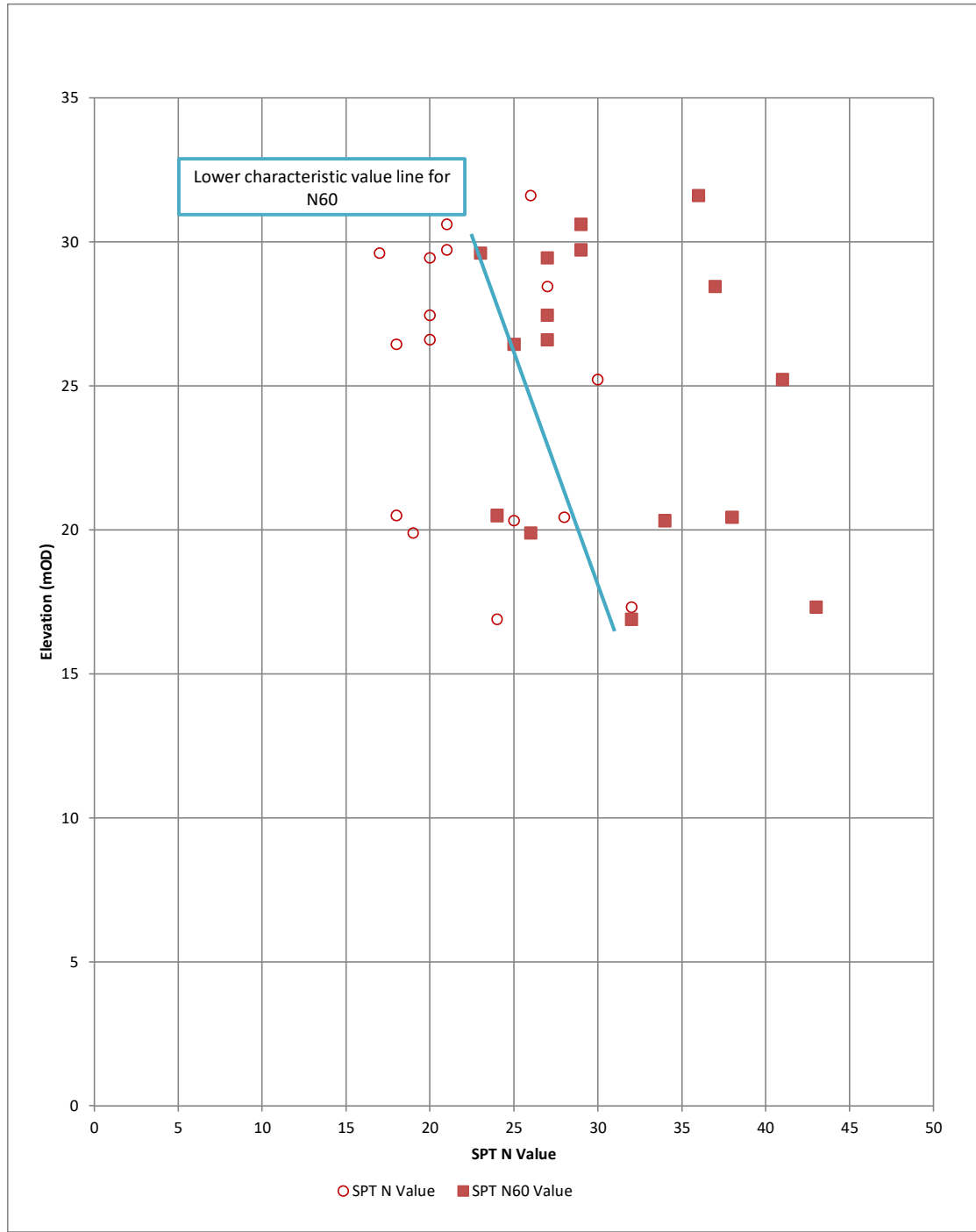
Project
Cambridge South East Transport Phase 2, Cambridge

Title
SPT N Value vs Depth for New Pit Chalk Formation/Holywell Nodular Chalk Formation (Undifferentiated)

Sheet size
A4
Status
DRAFT

Drawn: GL
Date: 19/08/2022
Figure Number
C.5.9

Reviewed: SF
Date: 19/10/2022
Rev
1



Maximum Extrapolated N Value	200
------------------------------	-----

ATKINS
Member of the SNC-Lavalin Group
Atkins Limited
Woodcote Grove
Ashley Road
Epsom
KT18 5BW

Client
Greater Cambridge Partnership

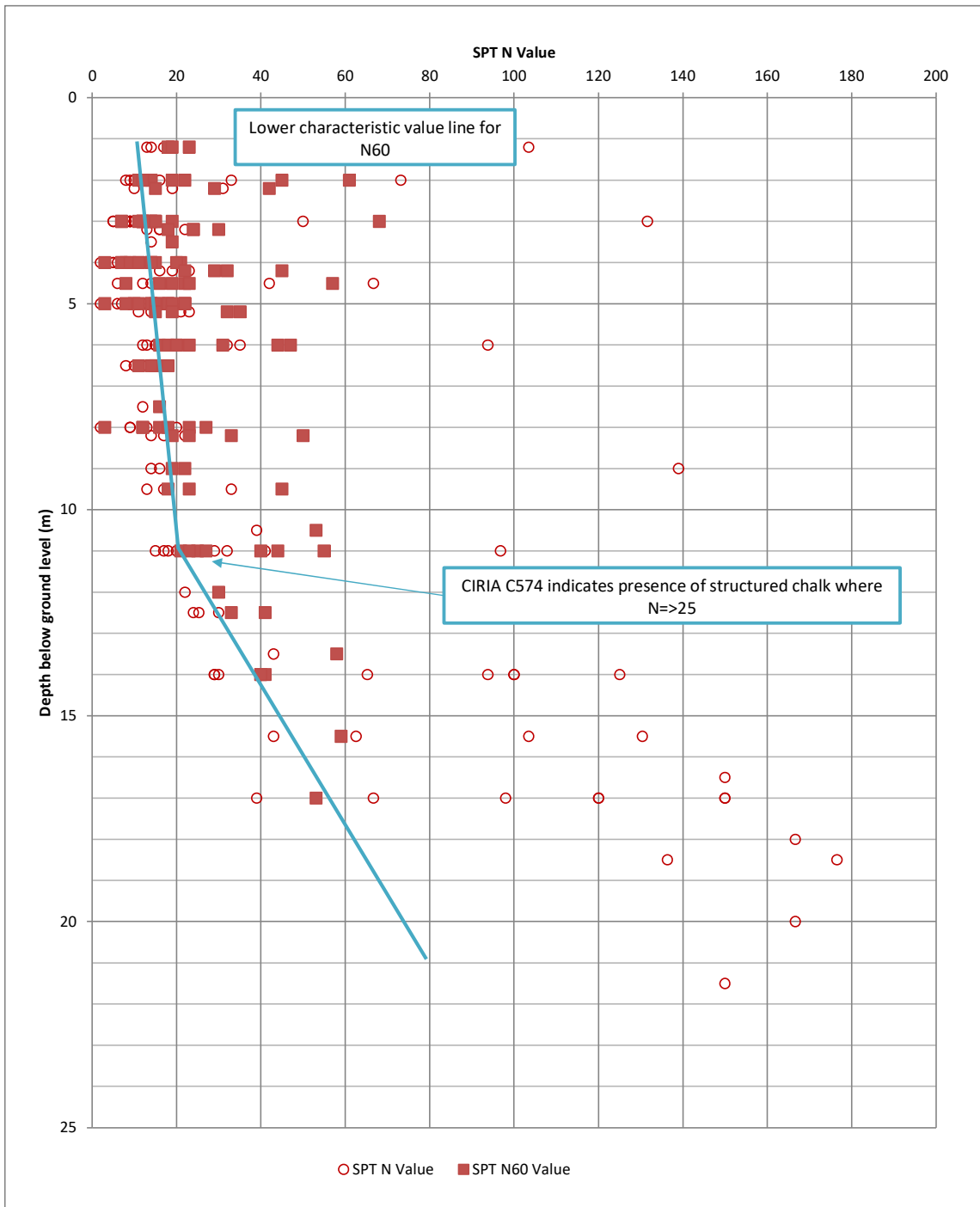
Project
Cambridge South East Transport Phase 2, Cambridge

Title
SPT N Value vs Elevation for New Pit Chalk Formation/Holywell Nodular Chalk Formation (Undifferentiated)

Sheet size
A4
Status
DRAFT

Drawn: GL
Date: 19/08/2022
Figure Number
C.5.10

Reviewed: SF
Date: 19/10/2022
Rev
1

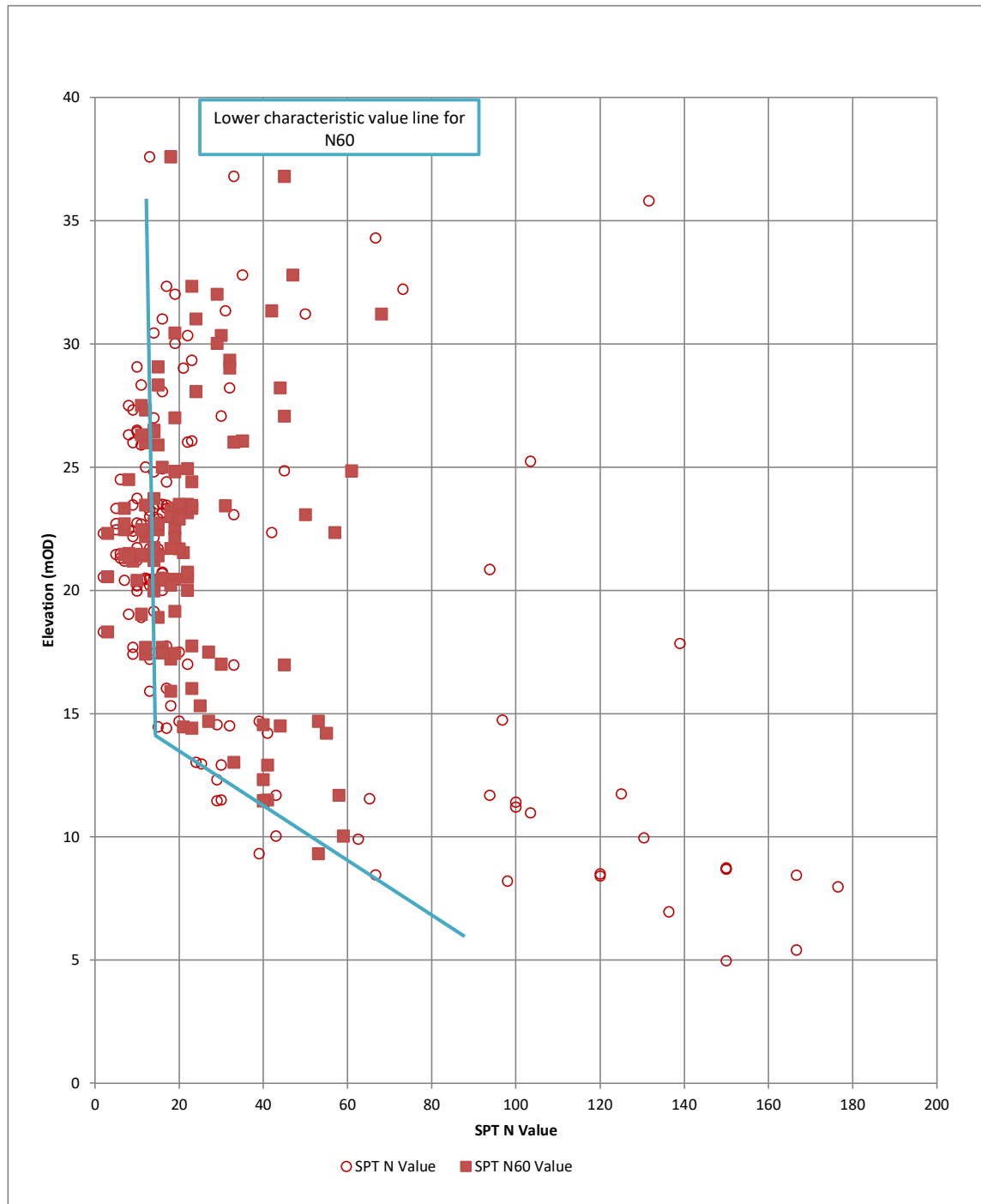


Maximum Extrapolated N Value	200
------------------------------	-----

ATKINS
Member of the SNC-Lavalin Group
Atkins Limited
Woodcote Grove
Ashley Road Epsom
KT18 5BW
Tel: (01372) 726140

Client	Greater Cambridge Partnership
Project	Cambridge South East Transport Phase 2, Cambridge

Title SPT N Value vs Depth for Holywell Nodular Chalk Formation		
Sheet size A4	Drawn: GL Date: 19/08/2022	Reviewed: SF Date: 19/10/2022
Status DRAFT	Figure Number C.5.11	Rev 1



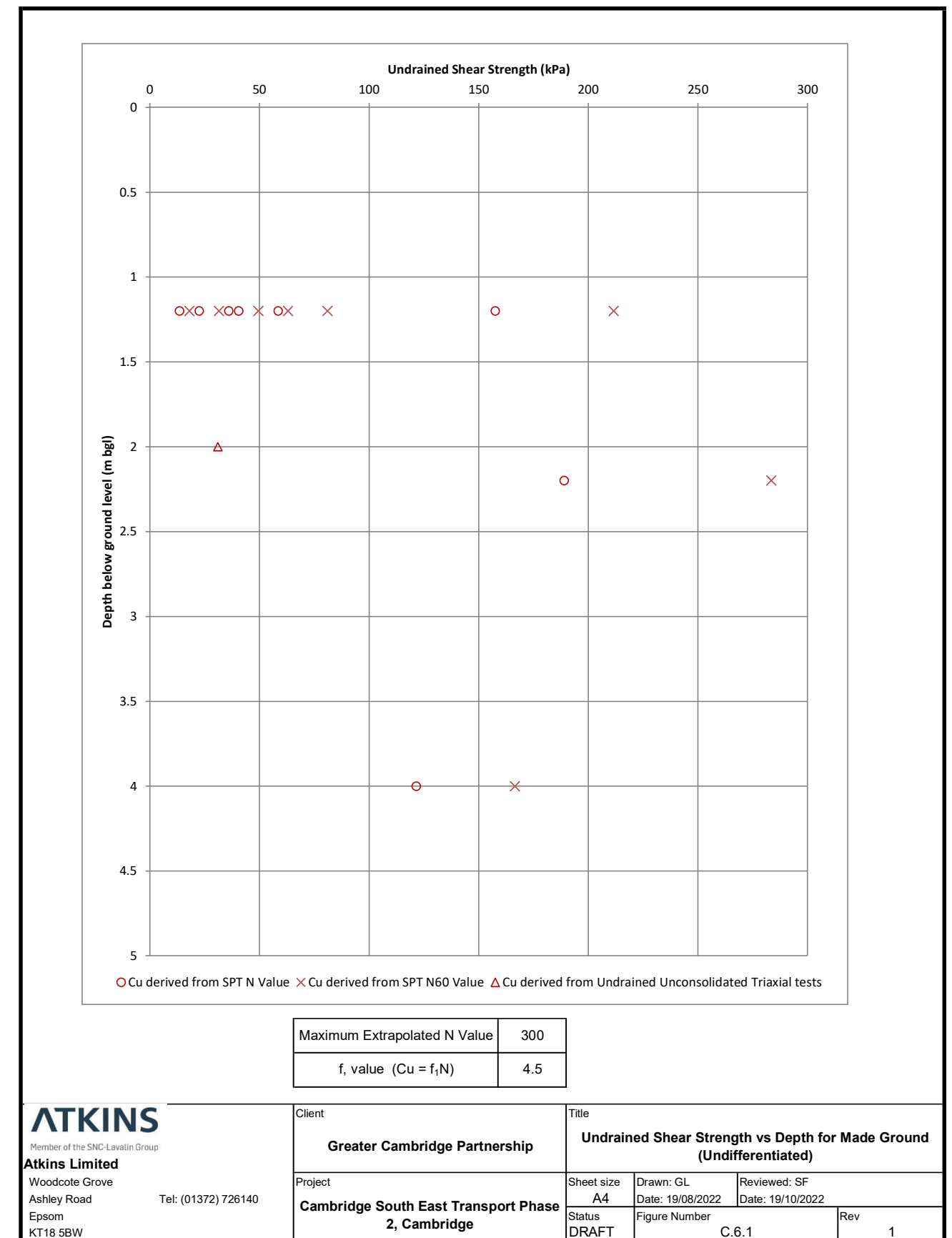
Maximum Extrapolated N Value	200
------------------------------	-----

ATKINS
Member of the SNC-Lavalin Group
Atkins Limited
Woodcote Grove
Ashley Road Epsom
KT18 5BW
Tel: (01372) 726140

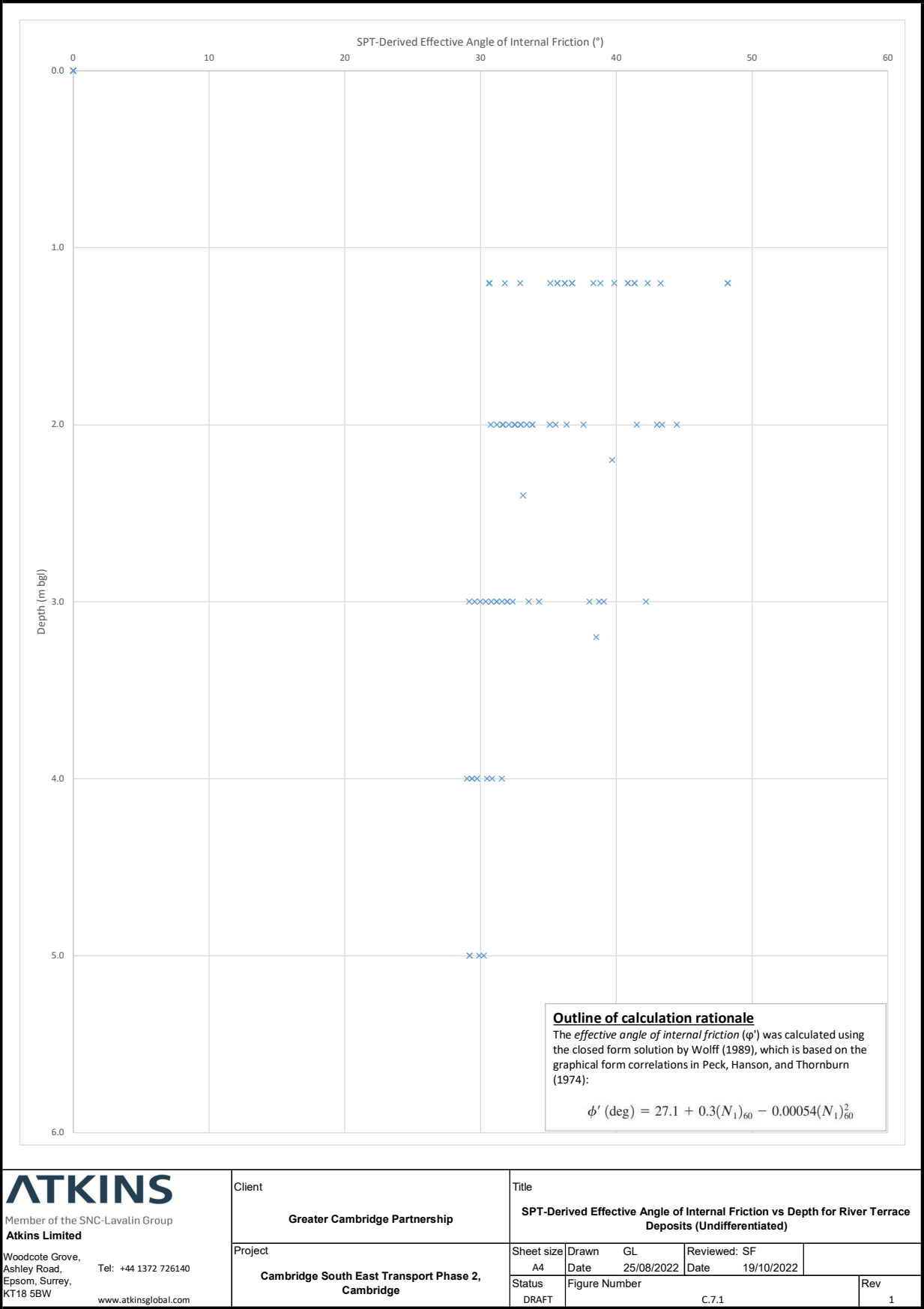
Client	Greater Cambridge Partnership
Project	Cambridge South East Transport Phase 2, Cambridge

Title SPT N Value vs Elevation for Holywell Nodular Chalk Formation		
Sheet size A4	Drawn: GL Date: 19/08/2022	Reviewed: SF Date: 19/10/2022
Status DRAFT	Figure Number C.5.12	Rev 1

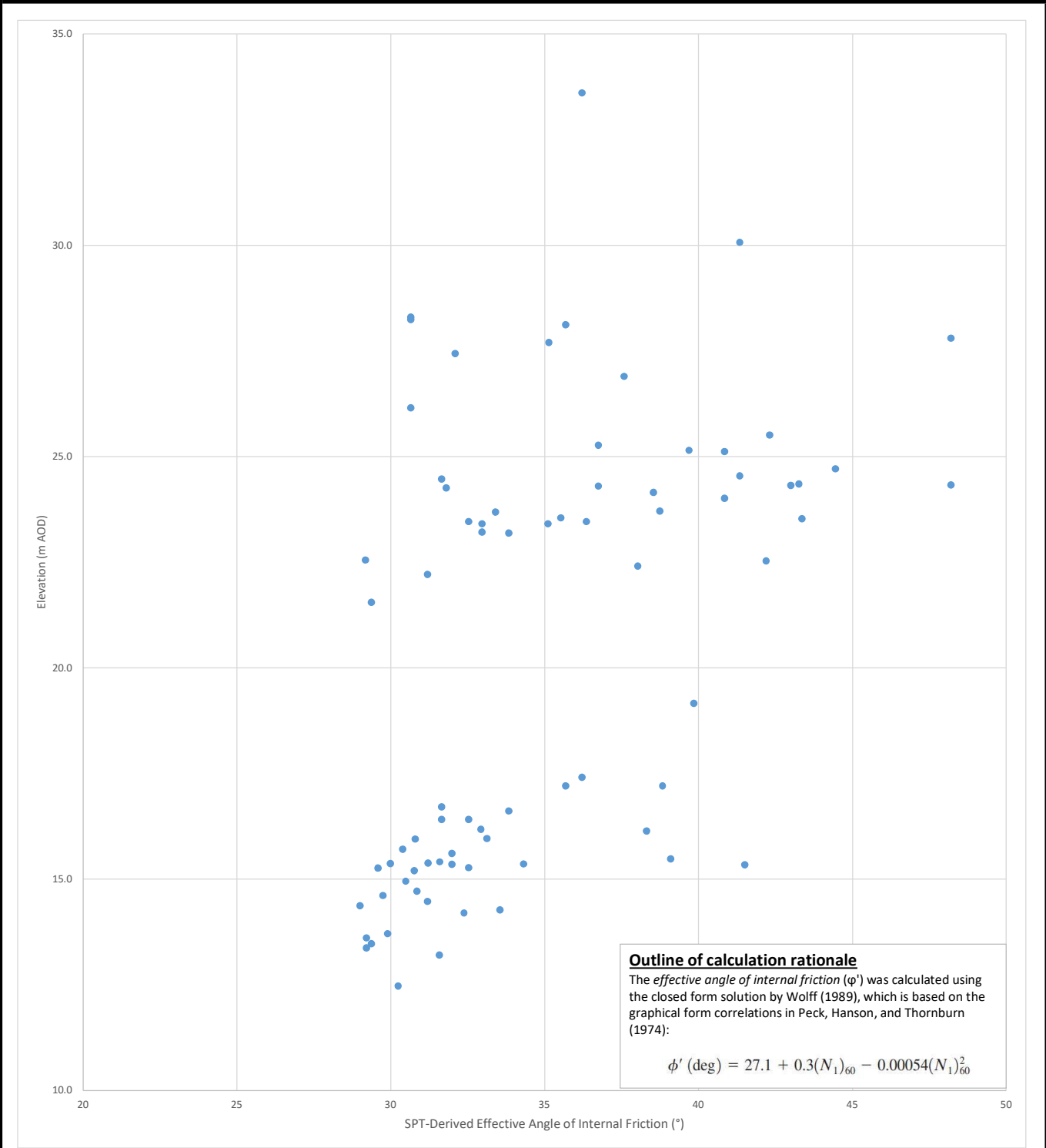
C.6. Undrained Shear Strength by SPT and UU



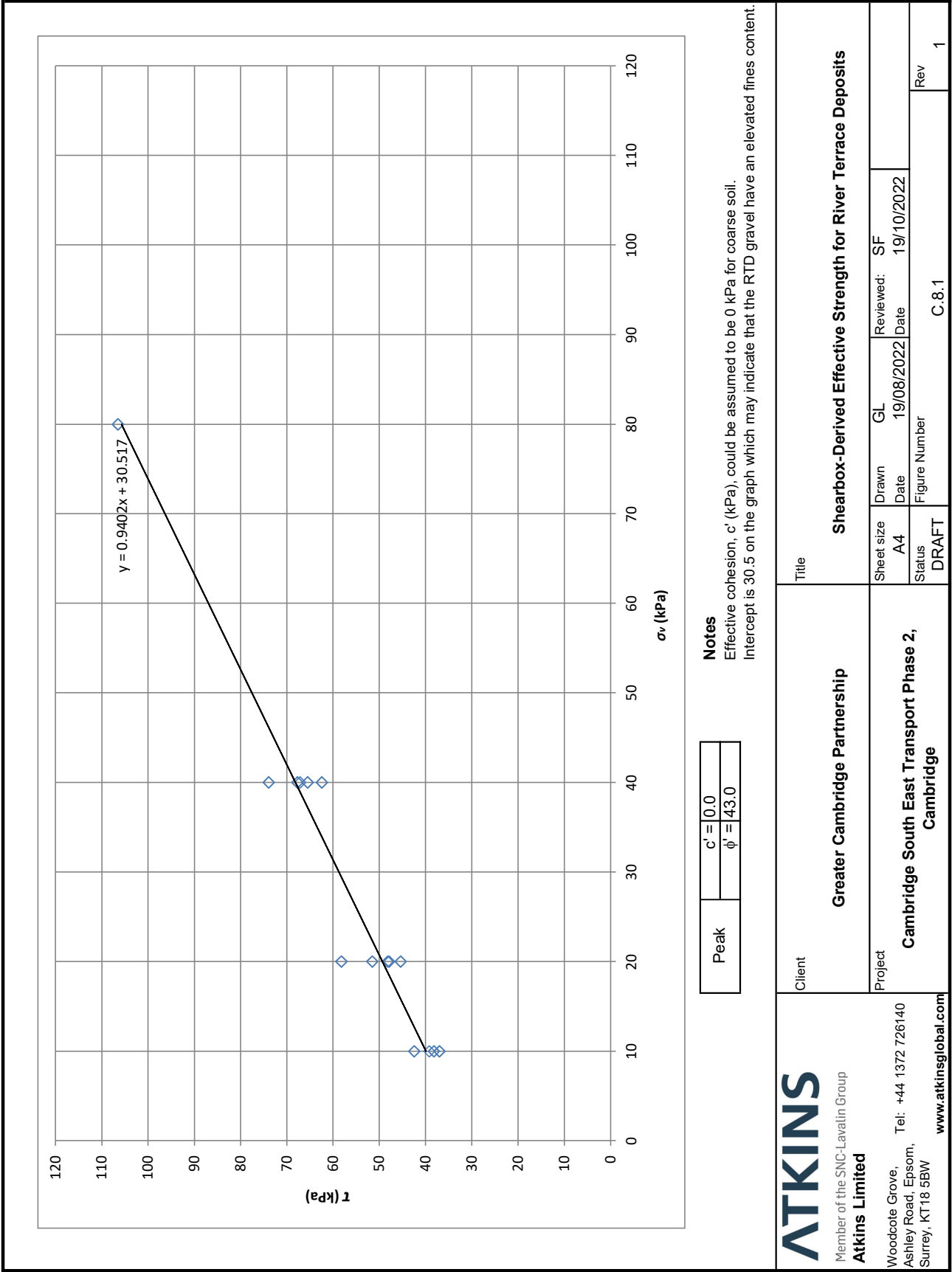
C.7. Effective angle of internal friction



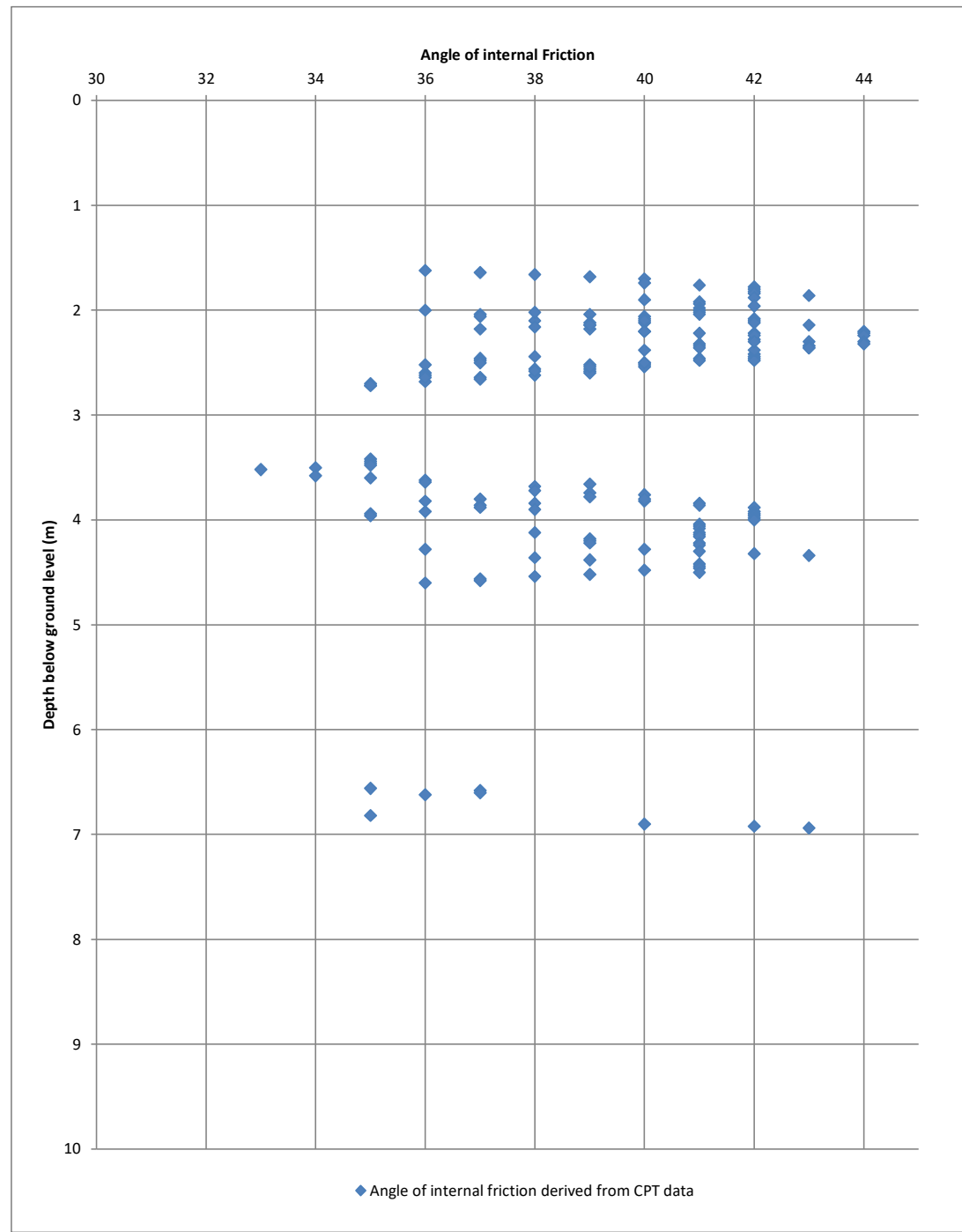
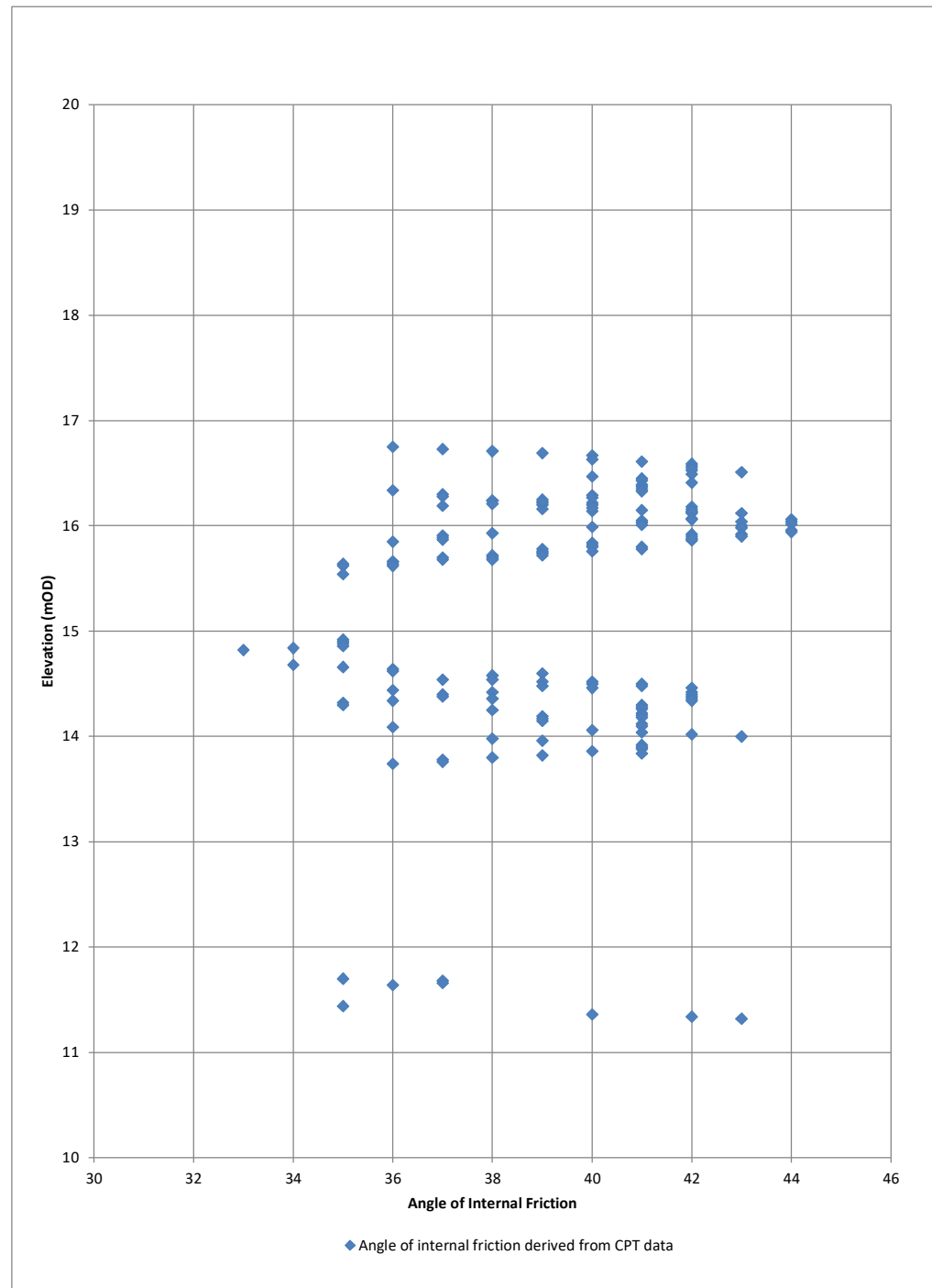
C.8. Effective Stress by Shear Box



<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW</div> <div>Tel: +44 1372 726140</div> <div>www.atkinsglobal.com</div>	Client		Title				
	Greater Cambridge Partnership		SPT-Derived Effective Angle of Internal Friction vs Elevation for River Terrace Deposits (Undifferentiated)				
	Project		Sheet size	Drawn	GL	Reviewed: SF	
	Cambridge South East Transport Phase 2, Cambridge		A4	Date	25/08/2022	Date	19/10/2022
			Status	Figure Number			Rev
		DRAFT	C.7.2			1	



- C.9. CPT derived parameters
 - C.9.1. Undrained Shear Strength
 - C.9.2. Angle of Internal Friction
 - C.9.3. Porewater Pressure



Notes

The effective friction angle for fine grained soils was calculated based on the Senneset et al. (1988, 1989) method by applying the approximate closed form solution by Mayne & Campanella (2005) as a direct function of the pore pressure parameter B_q and normalised tip resistance Q .

$$\phi' = 29.5^\circ B_q^{0.121} [0.256 + 0.336 B_q + \log Q]$$

ATKINS
Member of the SNC-Lavalin Group

Atkins Limited

Woodcote Grove
Ashley Road Epsom
KT18 5BW
Tel: (01372) 726140

Client

Greater Cambridge Partnership

Project

Cambridge South East Transport Phase 2, Cambridge

Title

CPT derived angle of internal friction vs. depth for Alluvium/Head Deposits (undifferentiated)

Sheet size

A4

Status

DRAFT

Drawn: GL

Date: 19/08/2022

Reviewed: SF

Date: 19/10/2022

Figure Number

C.9.1

Rev

1

ATKINS
Member of the SNC-Lavalin Group

Atkins Limited

Woodcote Grove
Ashley Road Epsom
KT18 5BW
Tel: (01372) 726140

Client

Greater Cambridge Partnership

Project

Cambridge South East Transport Phase 2, Cambridge

Title

CPT derived angle of internal friction vs. elevation for Alluvium/Head Deposits (undifferentiated)

Sheet size

A4

Status

DRAFT

Drawn: GL

Date: 19/08/2022

Reviewed: SF

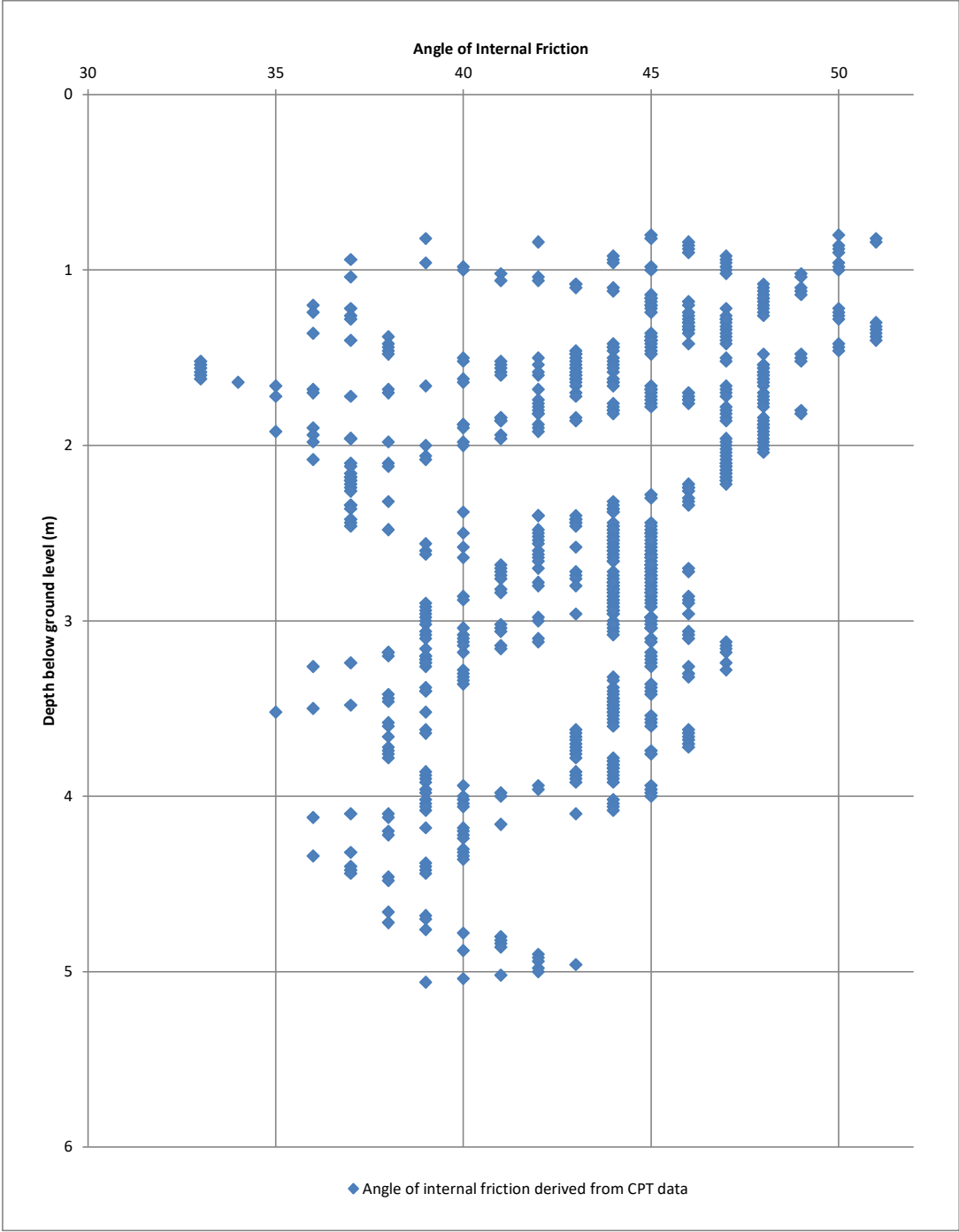
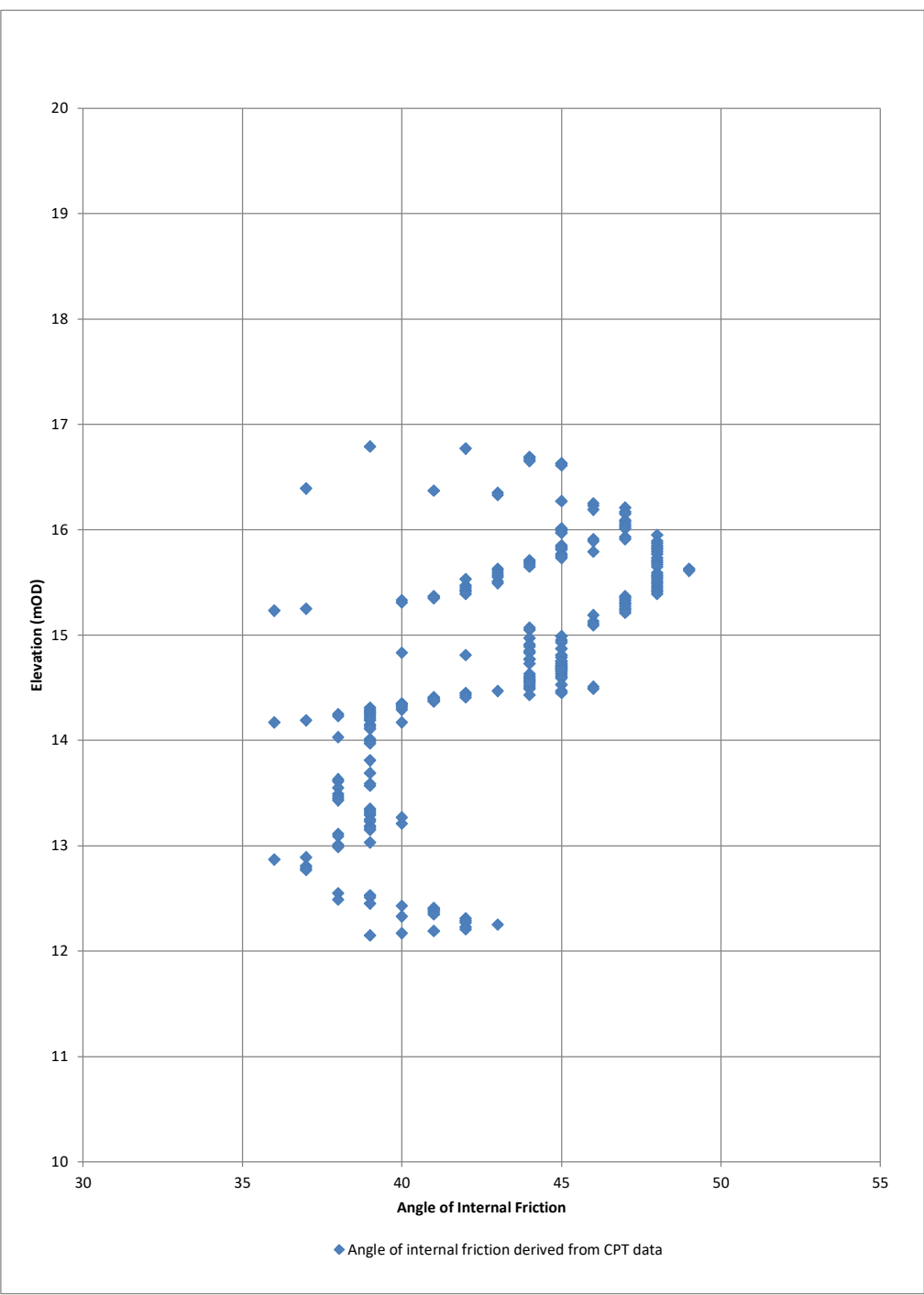
Date: 19/10/2022

Figure Number

C.9.2

Rev

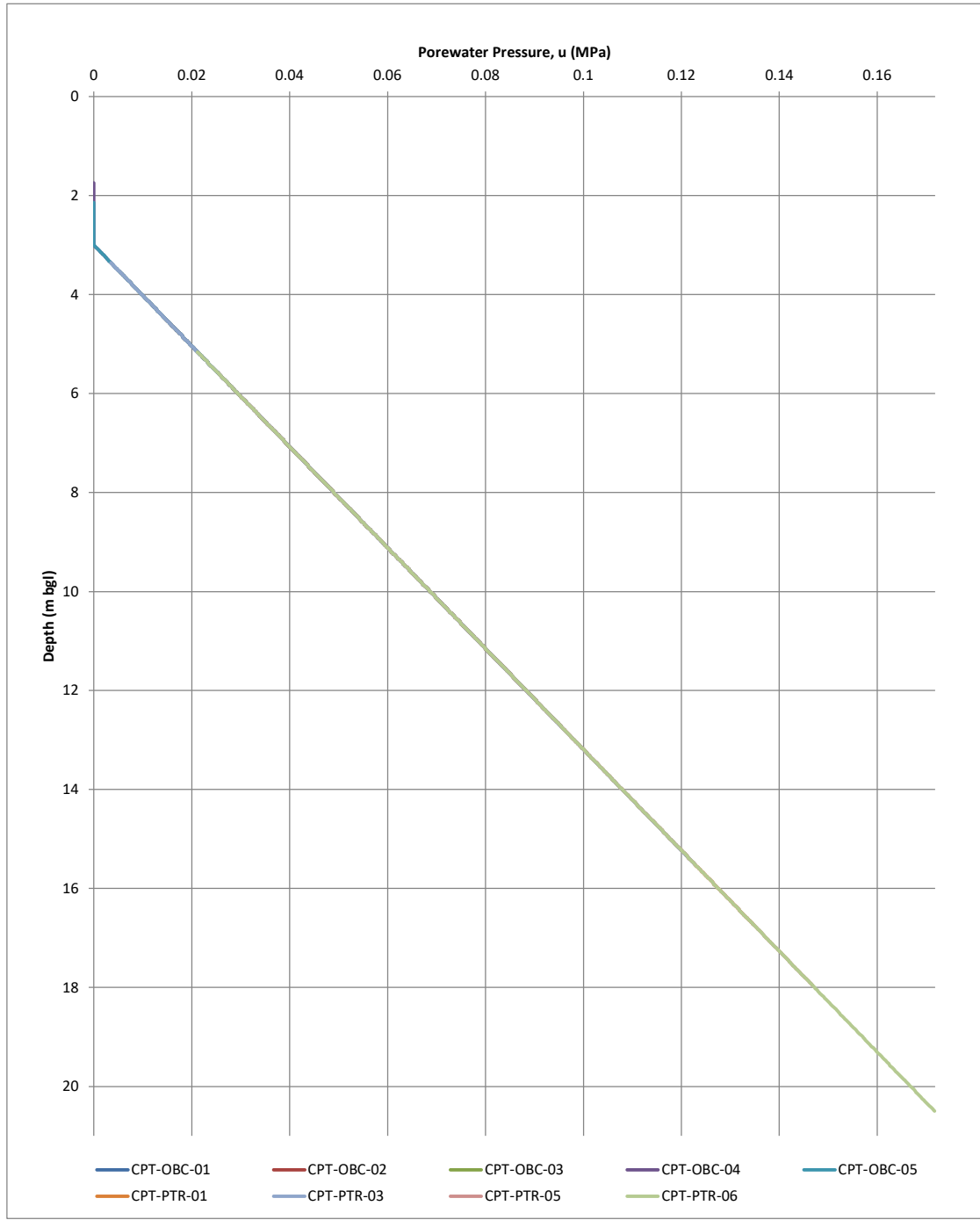
1



Notes The peak friction angle of granular materials was calculated using the Kulhawy and Mayne (1990) method. The relationship is based on a calibration chamber database from 24 sands of varying mineralogy. $\phi' = 17.6 + 11.0 \cdot \log(q_{t1})$

<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove</div> <div>Ashley Road</div> <div>Epsom</div> <div>KT18 5BW</div> <div>Tel: (01372) 726140</div>	Client		Title			
	Greater Cambridge Partnership		CPT derived angle of internal friction vs. depth for River Terrace Deposits			
	Project		Sheet size	Drawn: GL	Reviewed: SF	
			A4	Date: 19/08/2022	Date: 19/10/2022	
Cambridge South East Transport Phase 2, Cambridge	Status		Figure Number		Rev	
	DRAFT		C.9.7		1	

<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove</div> <div>Ashley Road</div> <div>Epsom</div> <div>KT18 5BW</div> <div>Tel: (01372) 726140</div>	Client		Title			
	Greater Cambridge Partnership		CPT derived angle of internal friction vs. elevation for River Terrace Deposits			
	Project		Sheet size	Drawn: GL	Reviewed: SF	
			A4	Date: 19/08/2022	Date: 19/10/2022	
Cambridge South East Transport Phase 2, Cambridge	Status		Figure Number		Rev	
	DRAFT		C.9.8		1	

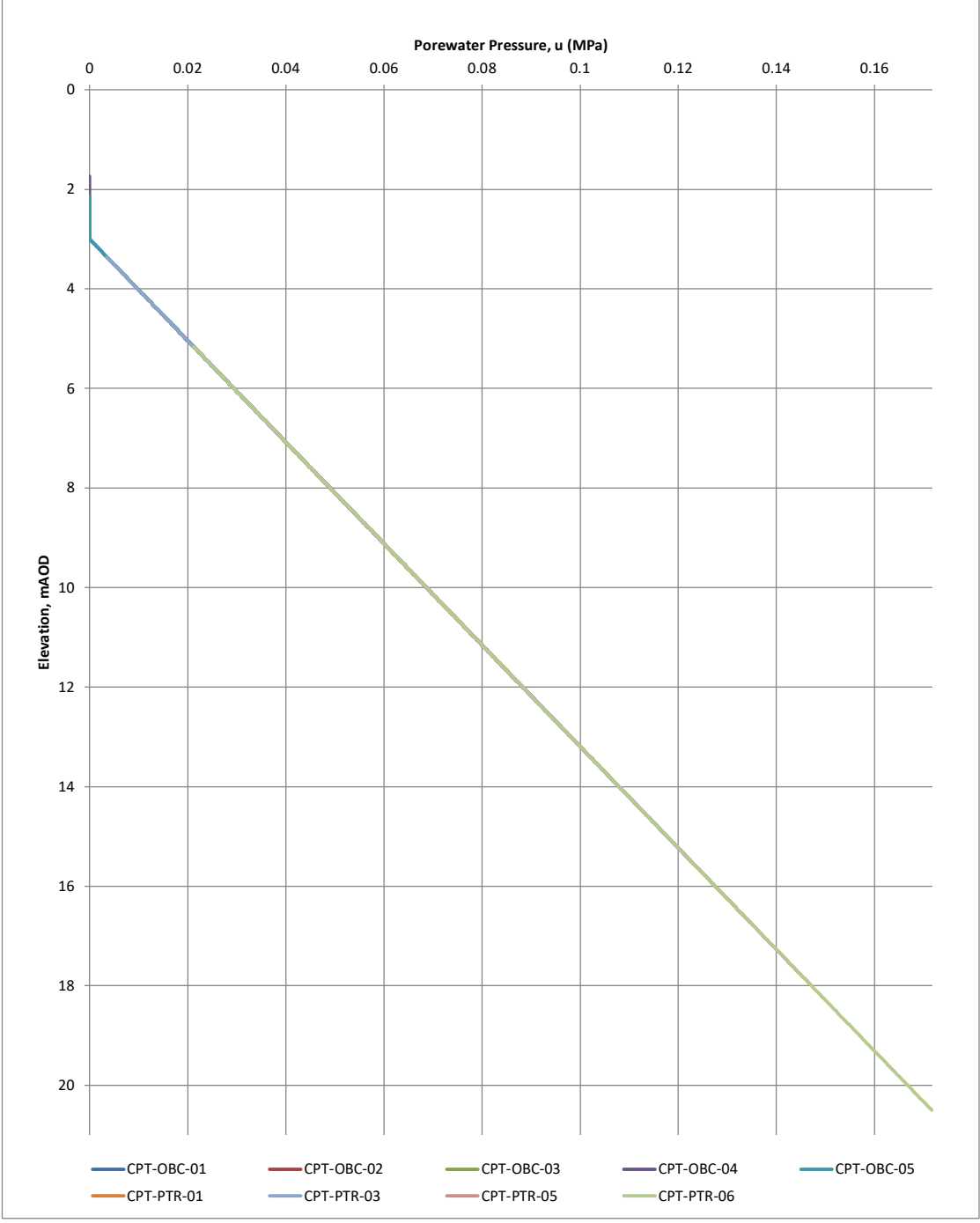


Notes: Porewater pressure was recorded within CPT-OBC-03, CPT-PTR-01, CPT-PTR-02 and CPT-PTR-05. Porewater pressures were recorded to be similar in all CPT locations, noted by the overlapping data points, and have been plotted on the graph above.

ATKINS
Member of the SNC-Lavalin Group

Atkins Limited
Woodcote Grove
Ashley Road
Epsom
KT18 5BW
Tel: (01372) 726140

Client Greater Cambridge Partnership		Title CPT derived porewater pressure vs. depth for Holywell Nodular Chalk Formation		
Project Cambridge South East Transport, Phase 2, Cambridge	Sheet size A4	Drawn: GL Date: 19/08/2022	Reviewed: SF Date: 19/10/2022	
	Status DRAFT	Figure Number C.9.11	Rev 1	



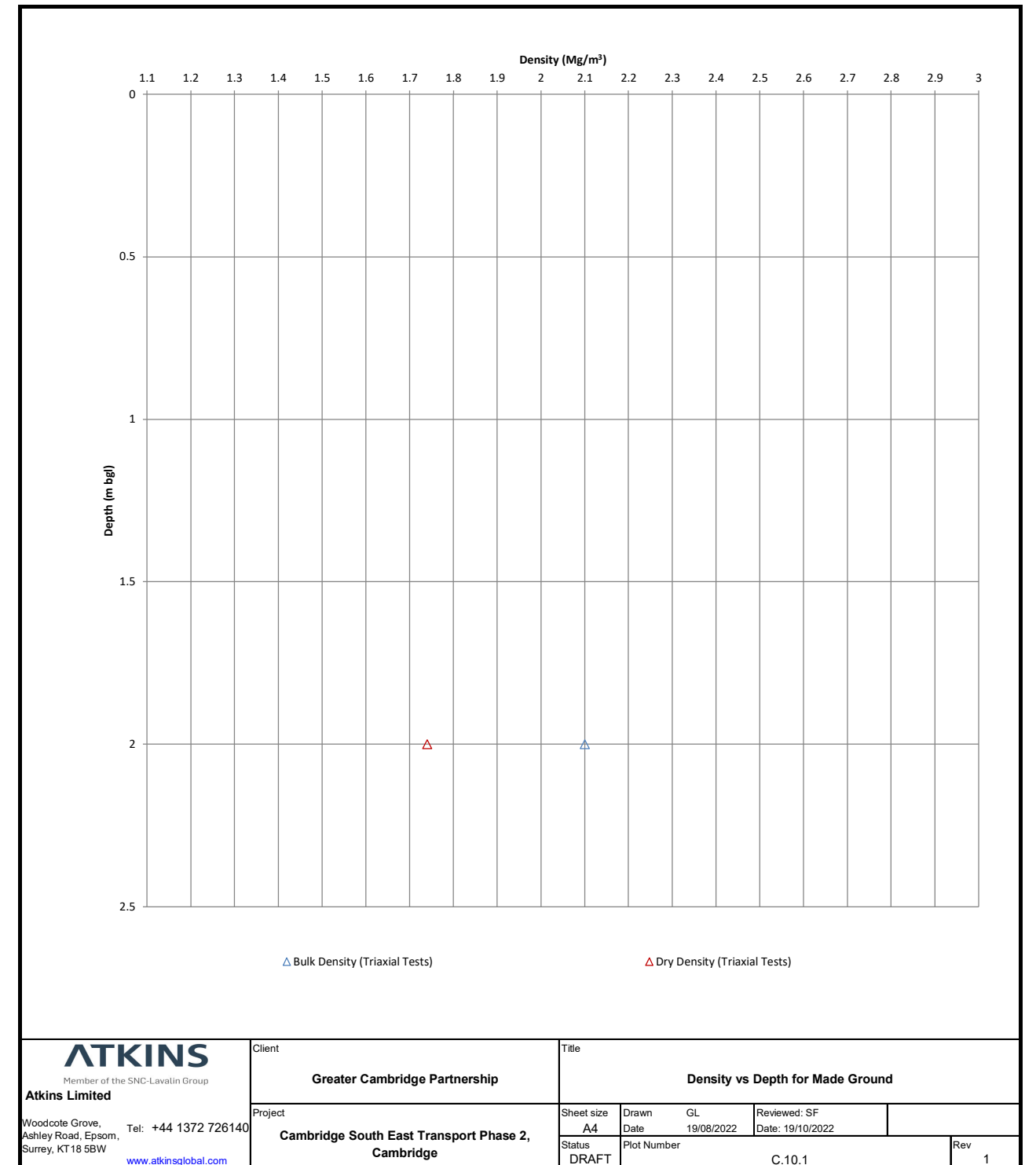
Notes: Porewater pressure was recorded within CPT-OBC-03, CPT-PTR-01, CPT-PTR-02 and CPT-PTR-05. Porewater pressures were recorded to be similar in all CPT locations, noted by the overlapping data points, and have been plotted on the graph above.

ATKINS
Member of the SNC-Lavalin Group

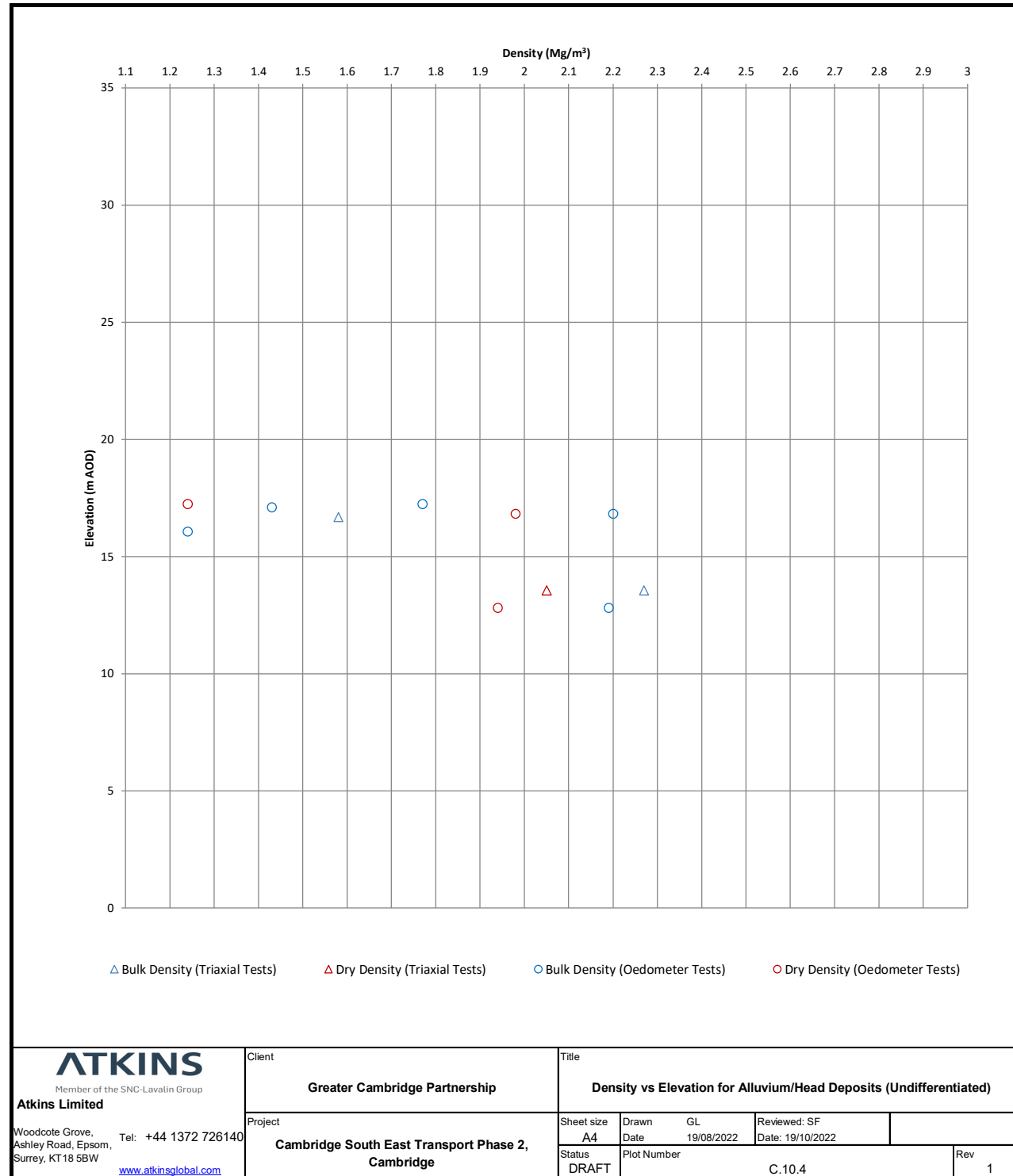
Atkins Limited
Woodcote Grove
Ashley Road
Epsom
KT18 5BW
Tel: (01372) 726140

Client Greater Cambridge Partnership		Title CPT derived porewater pressure vs. elevation for Holywell Nodular Chalk Formation		
Project Cambridge South East Transport, Phase 2, Cambridge	Sheet size A4	Drawn: GL Date: 19/08/2022	Reviewed: SF Date: 19/10/2022	
	Status DRAFT	Figure Number C.9.12	Rev 1	

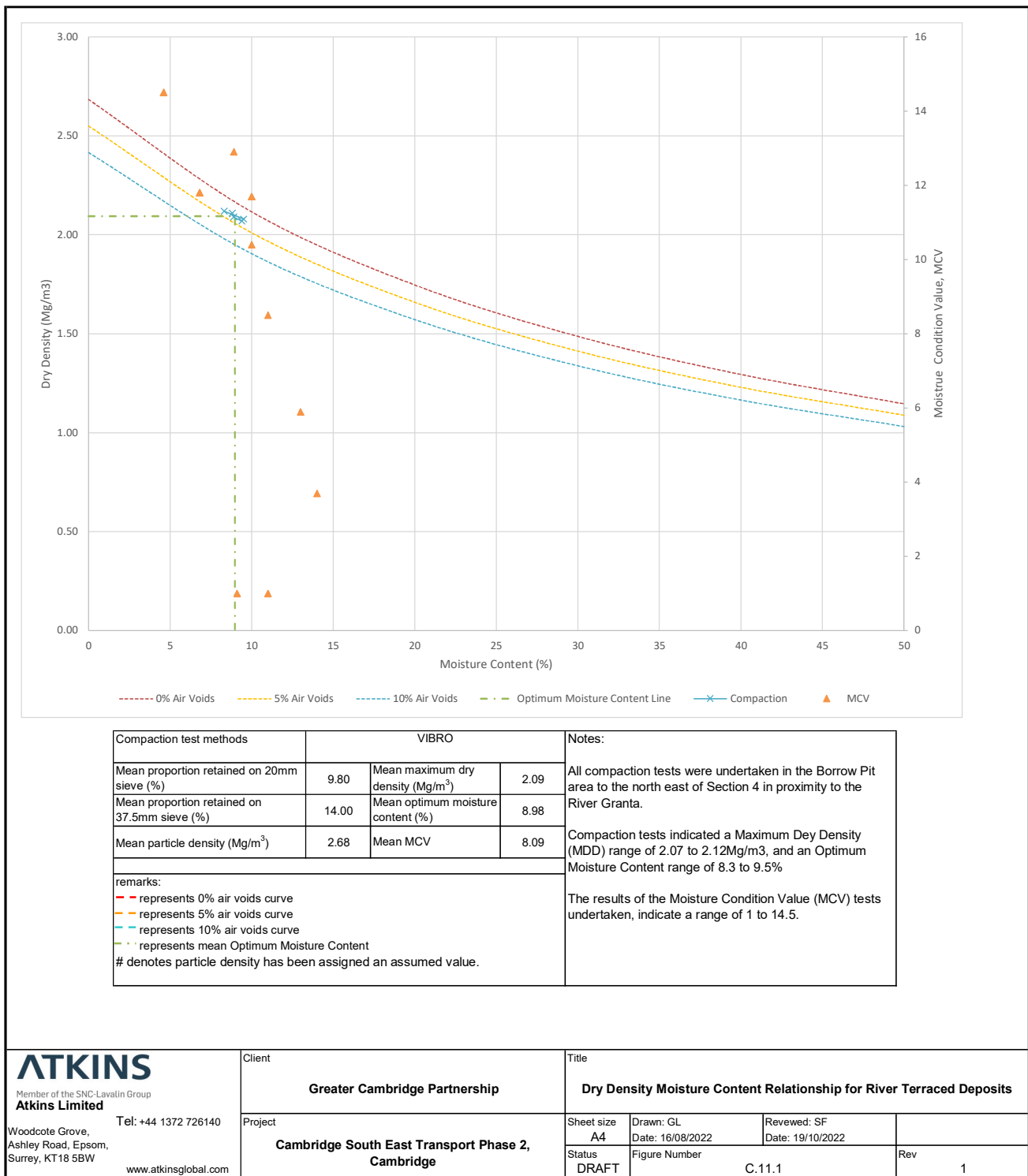
C.10. Density plots

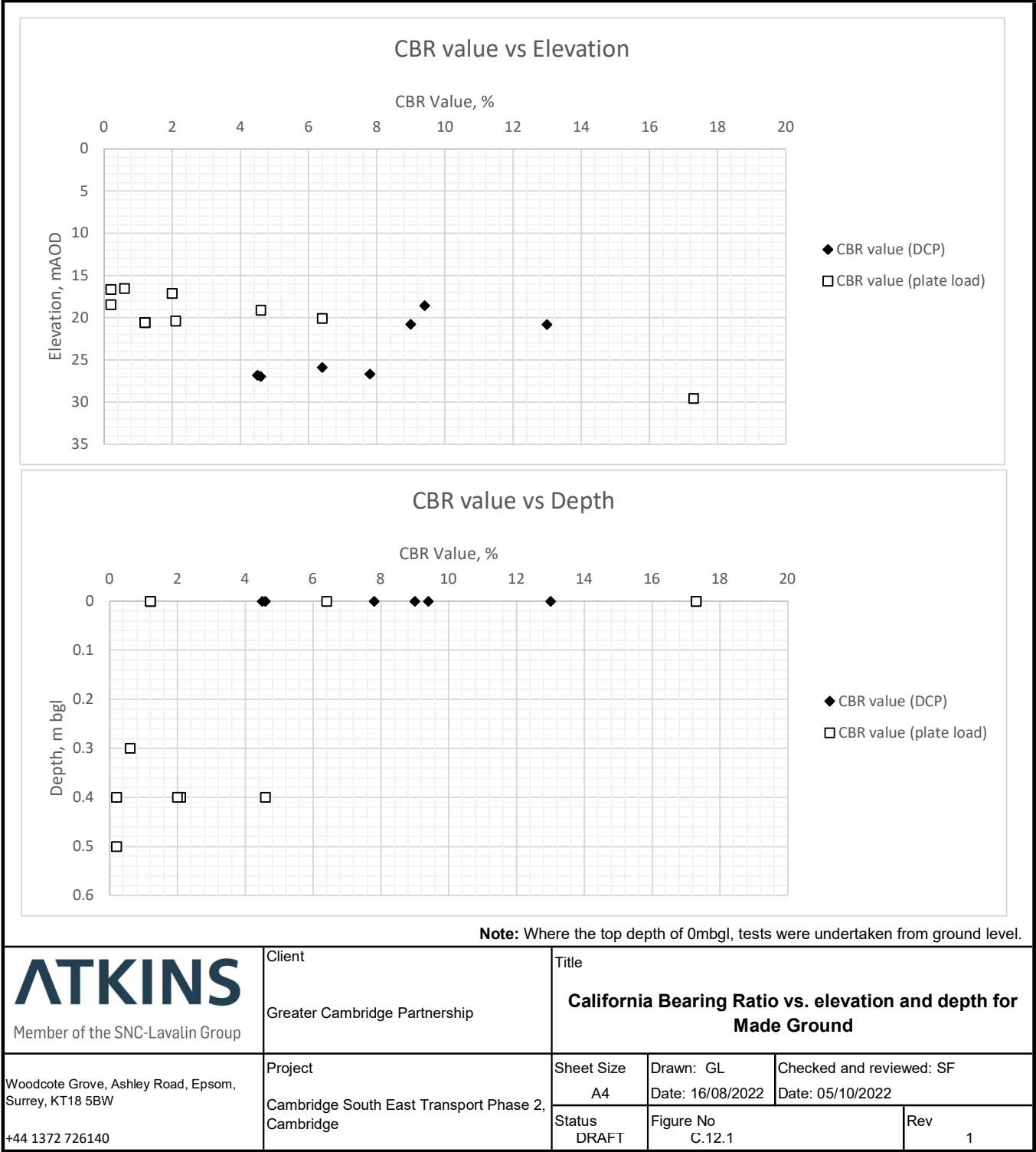


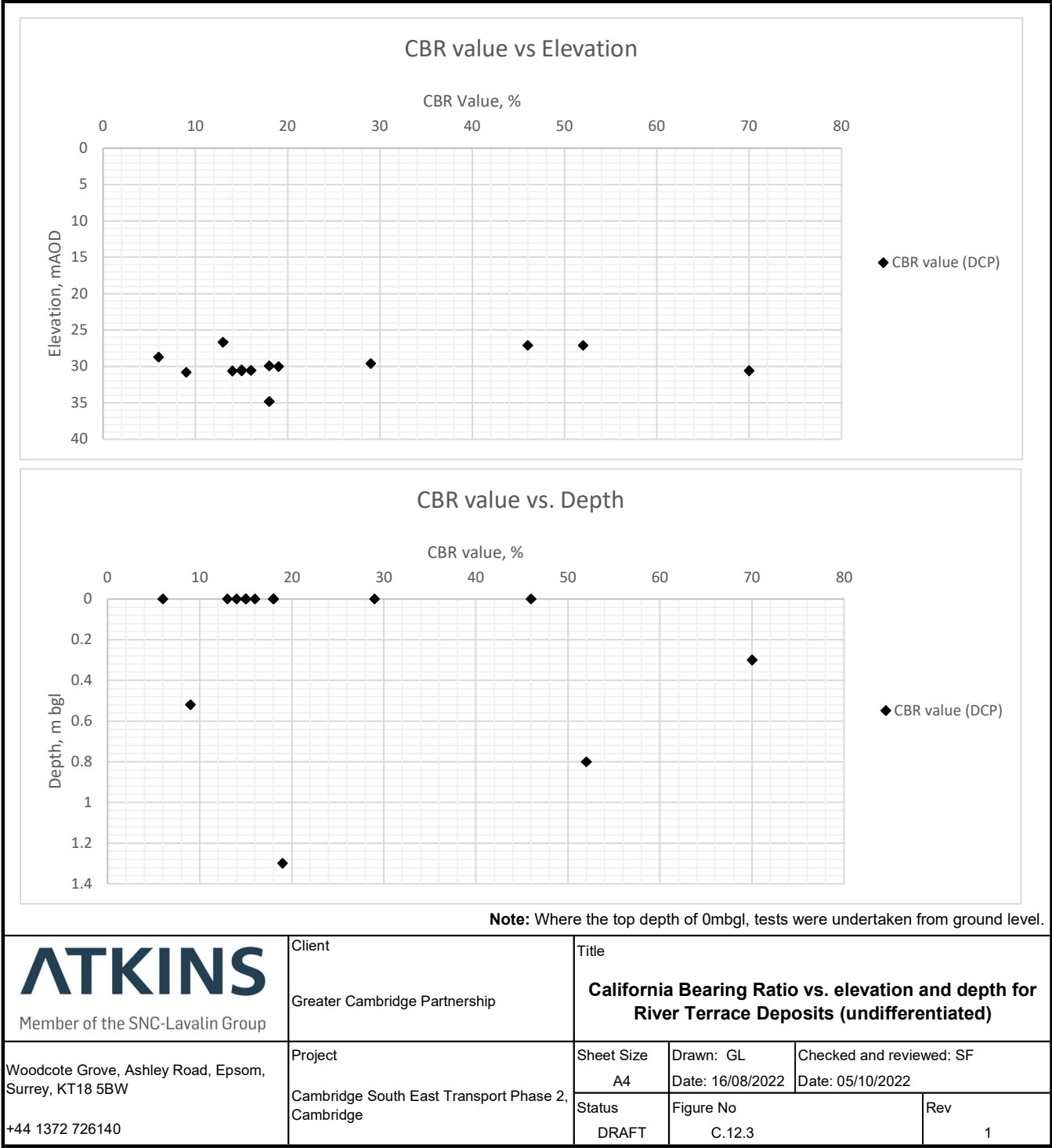
C.11. Dry Density and Moisture Content relationship (compaction)

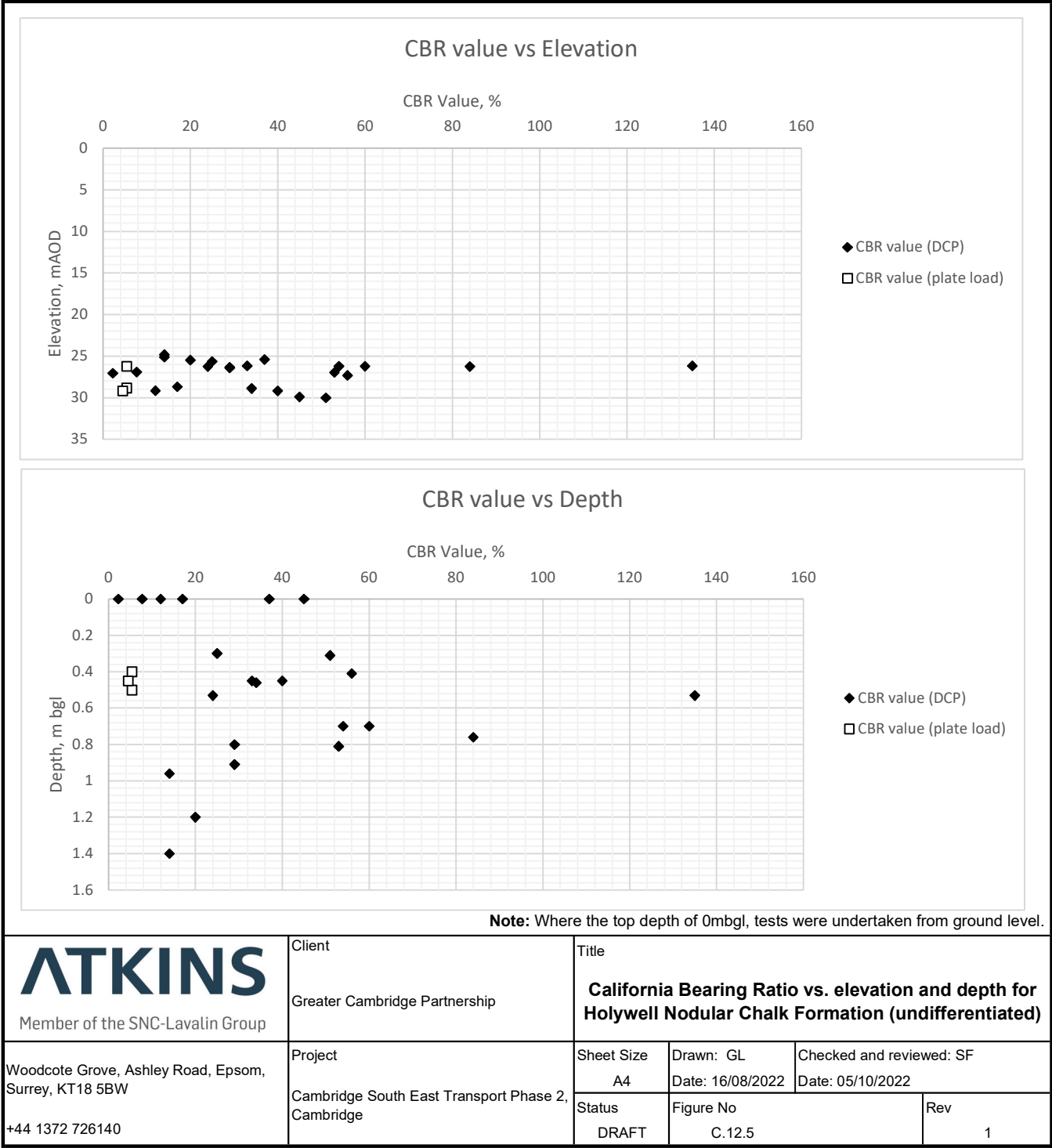
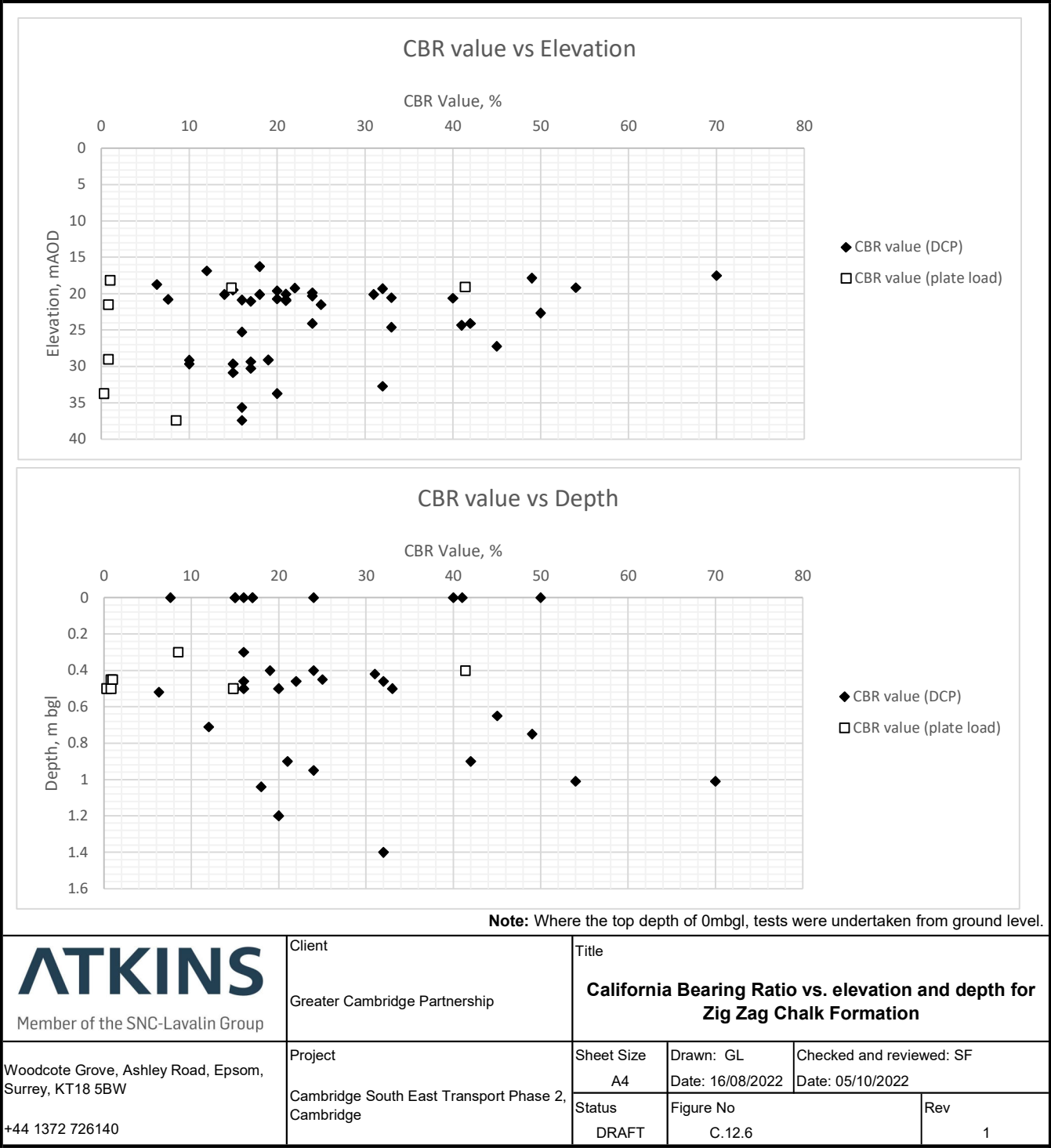


C.12. California Bearing Ratio

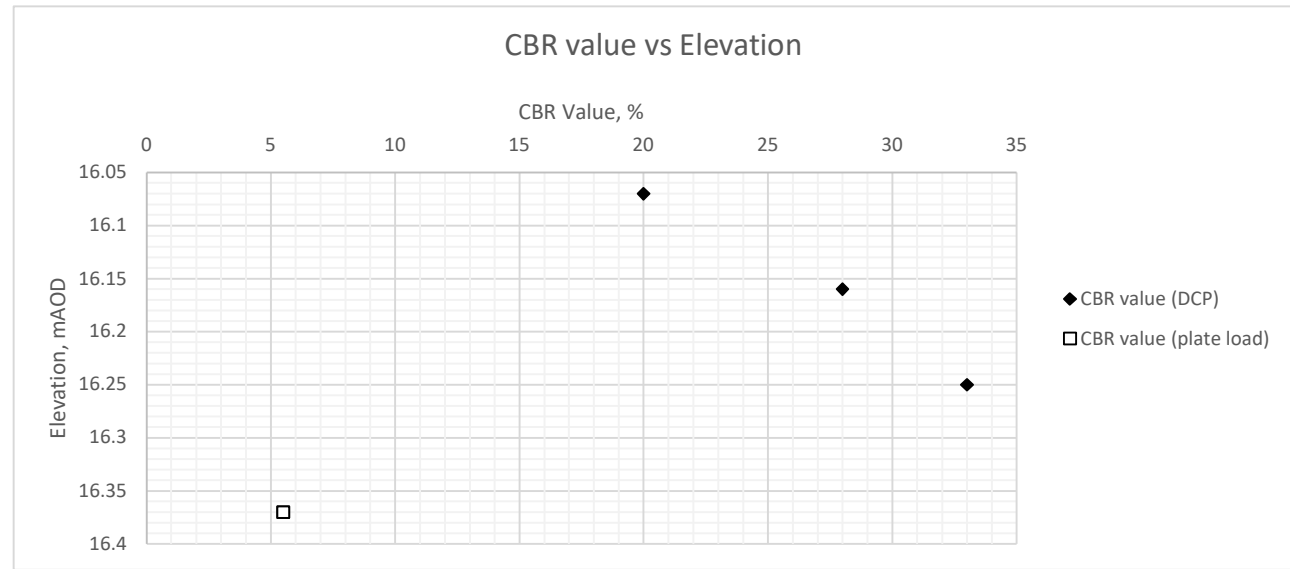
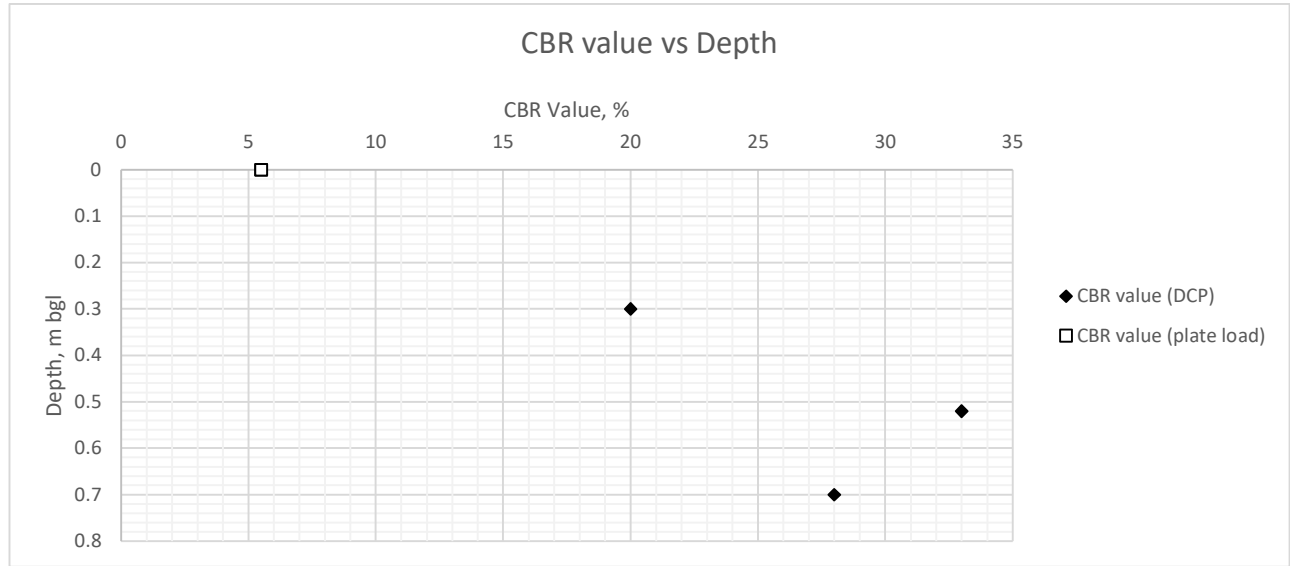






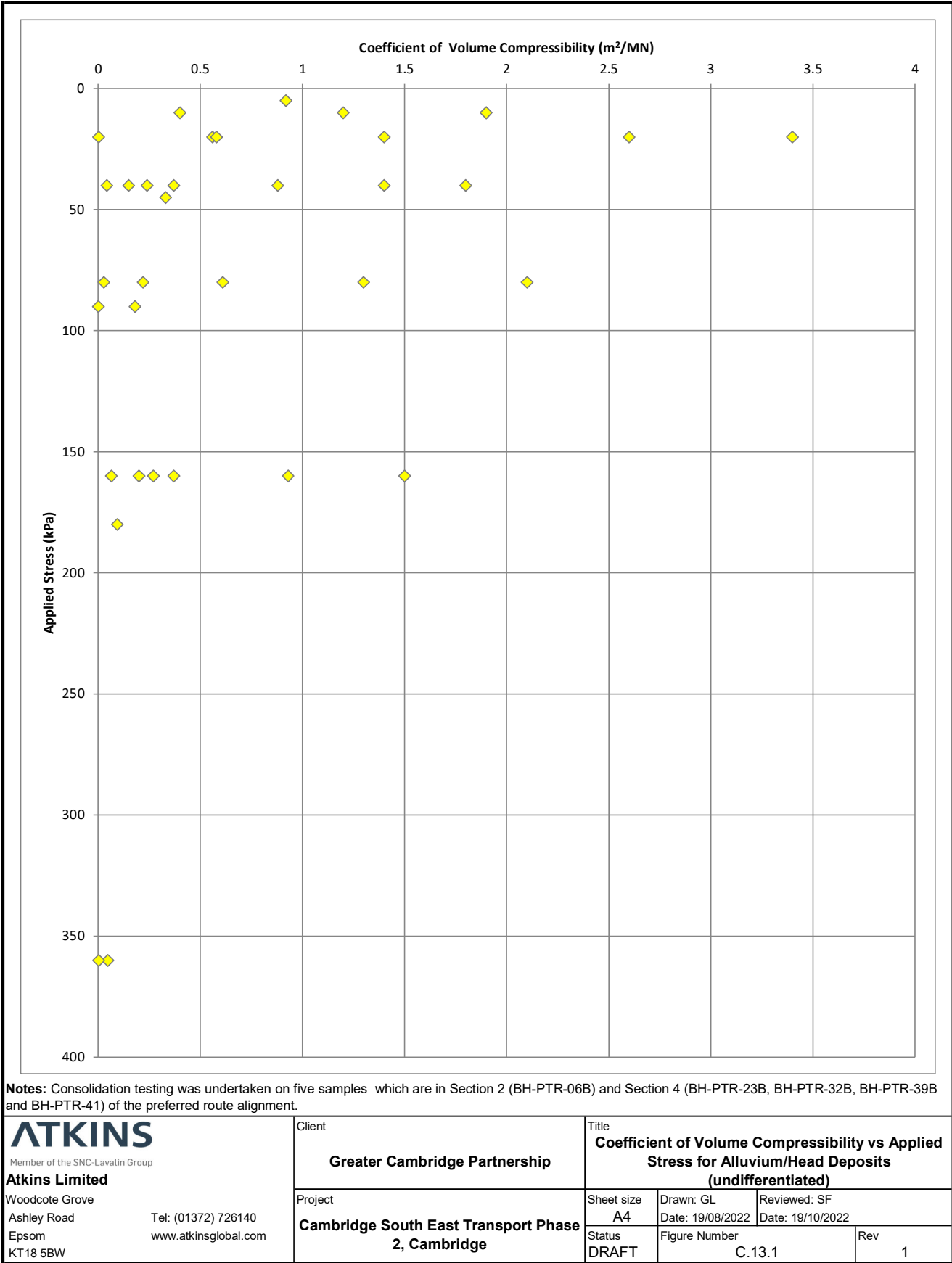


C.13. Coefficient of Compressibility vs. Applied Stress

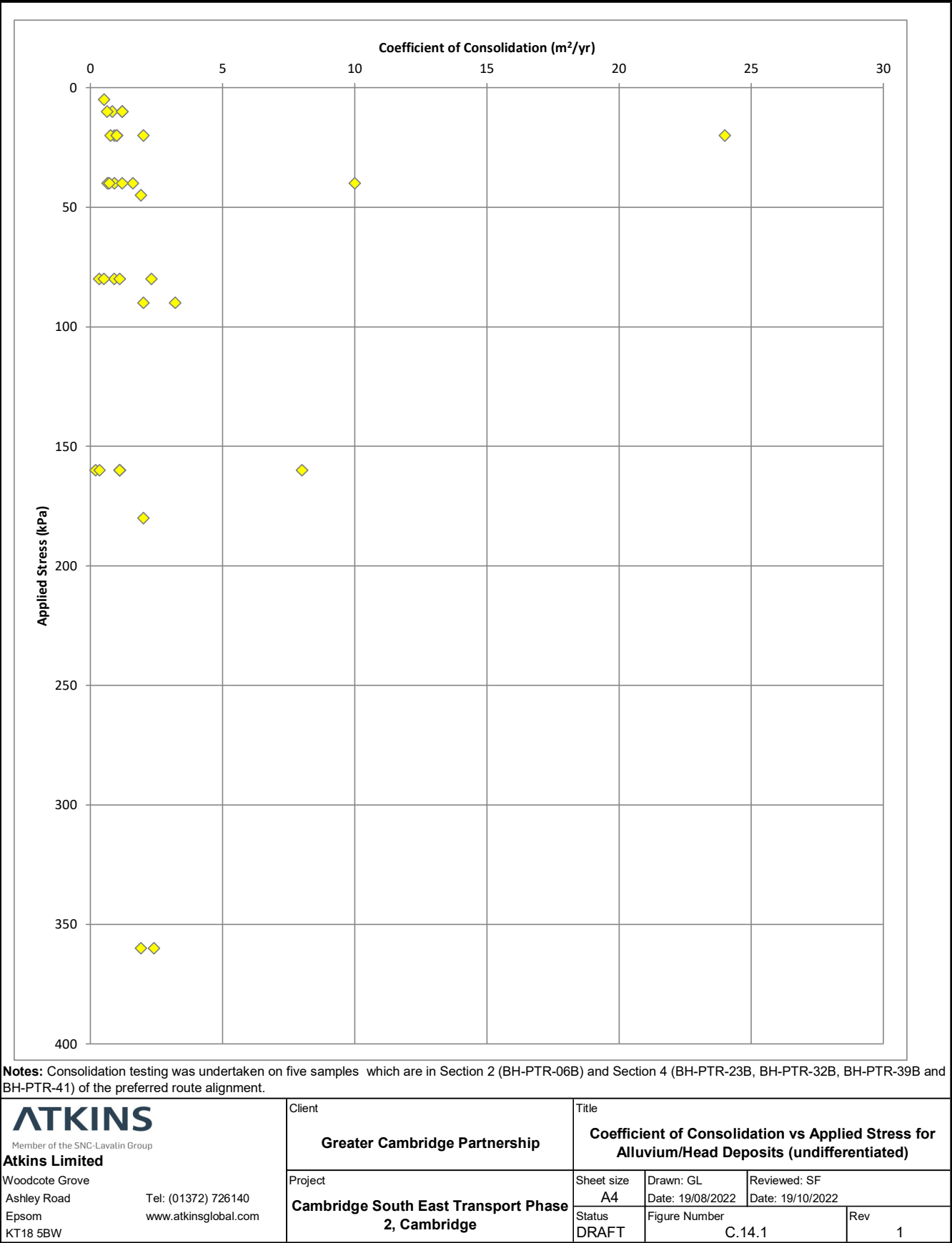


 <div>Member of the SNC-Lavalin Group</div>	Client	Title		
	Greater Cambridge Partnership	California Bearing Ratio vs. elevation and depth for West Melbury Marly Chalk Formation		
Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW +44 1372 726140	Project	Sheet Size	Drawn: GL	Checked and reviewed: SF
	Cambridge South East Transport Phase 2, Cambridge	A4	Date: 16/08/2022	Date: 05/10/2022
		Status	Figure No	Rev
		DRAFT	C.12.7	1

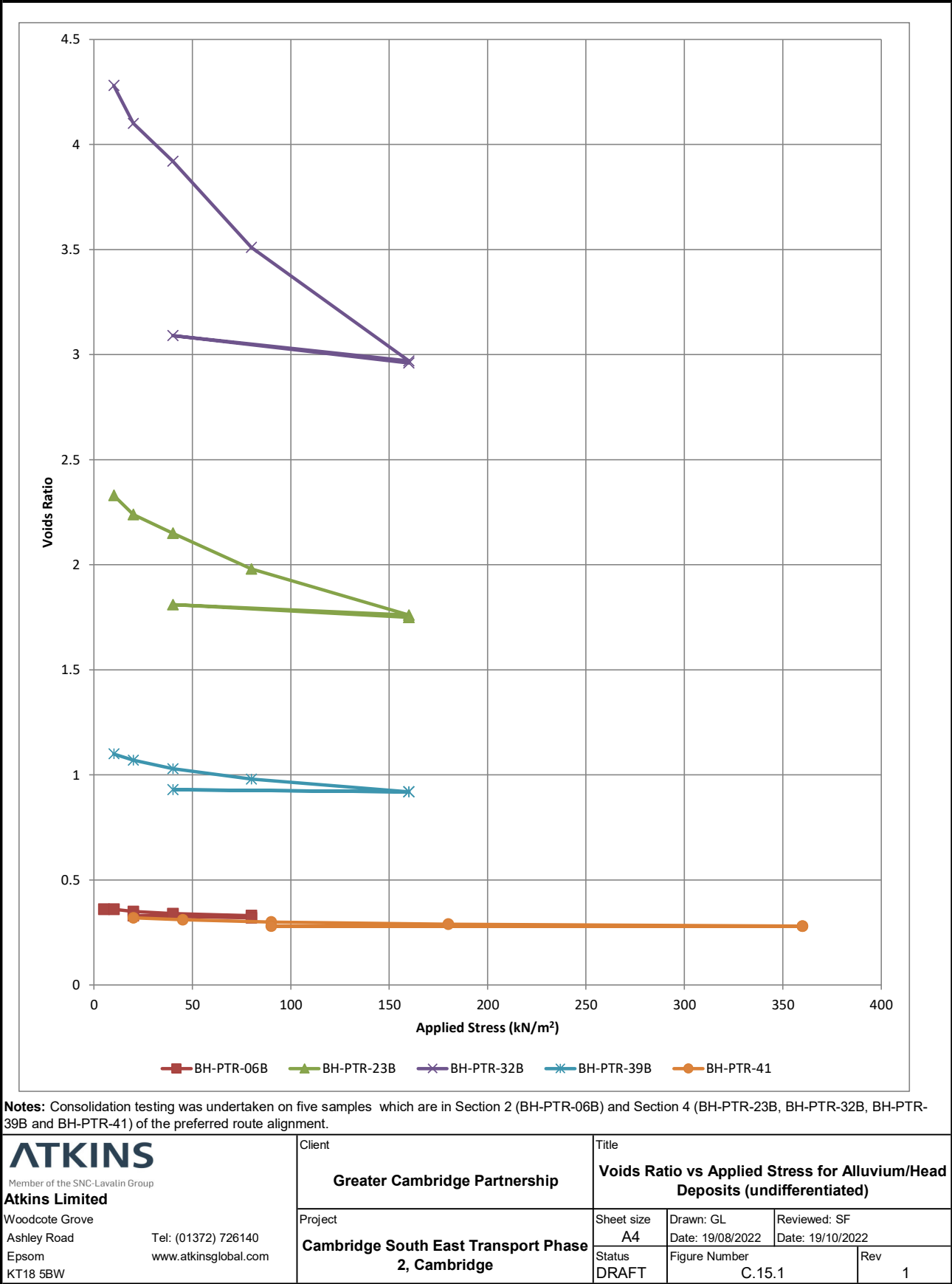
C.14. Coefficient of Consolidation vs. Applied Stress

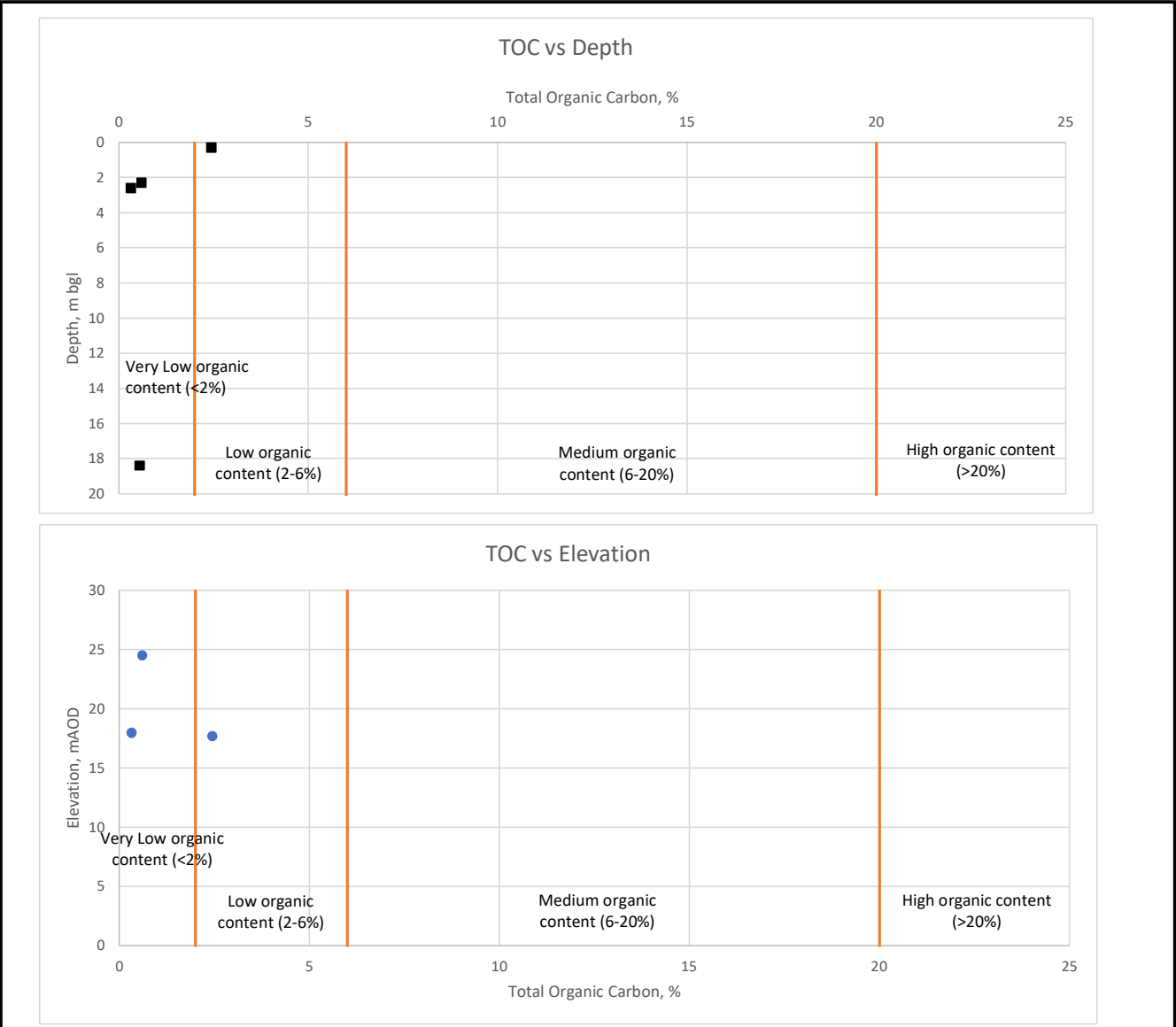


C.15. Applied Stress vs Voids Ratio

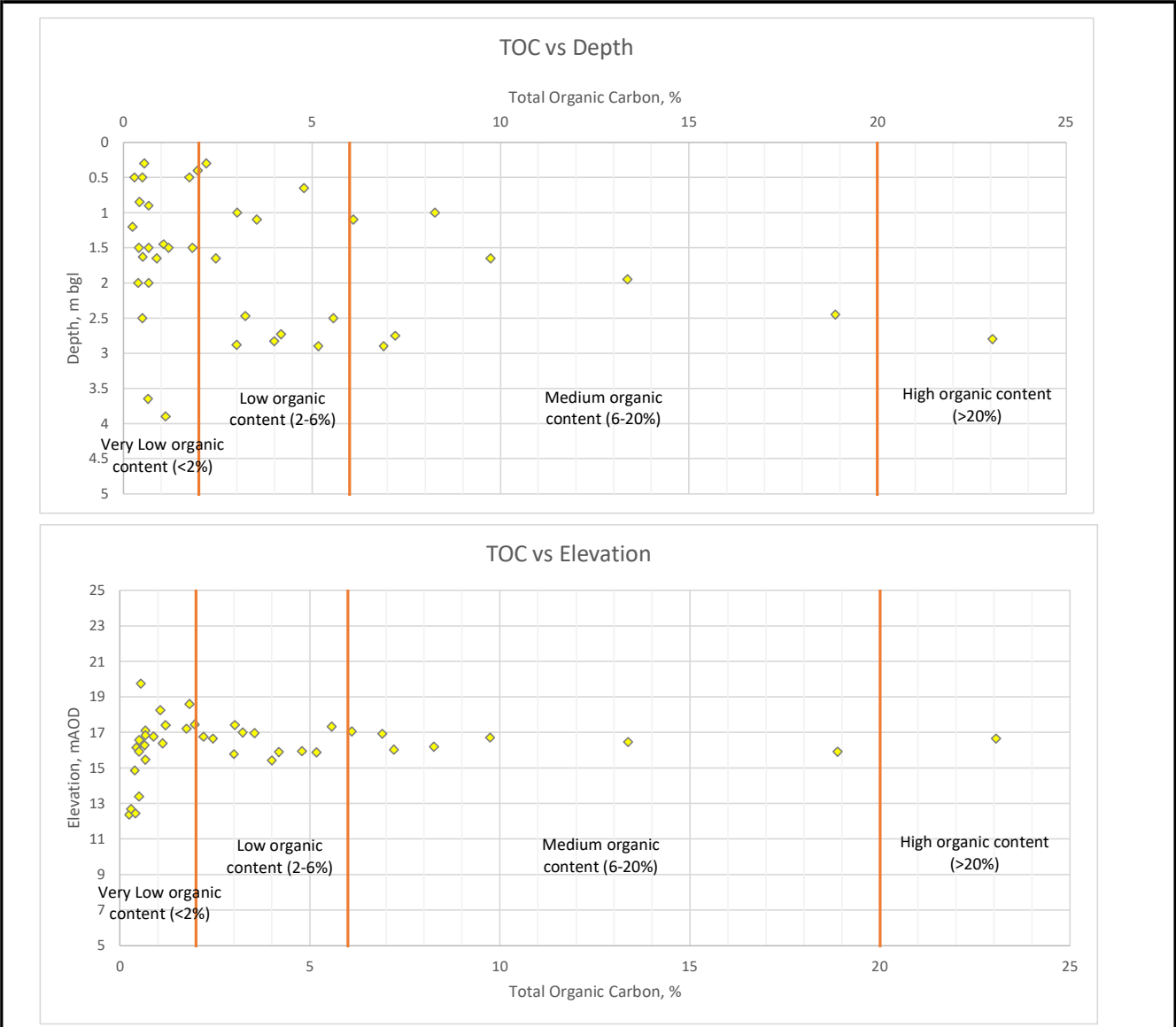


C.16. Organic matter



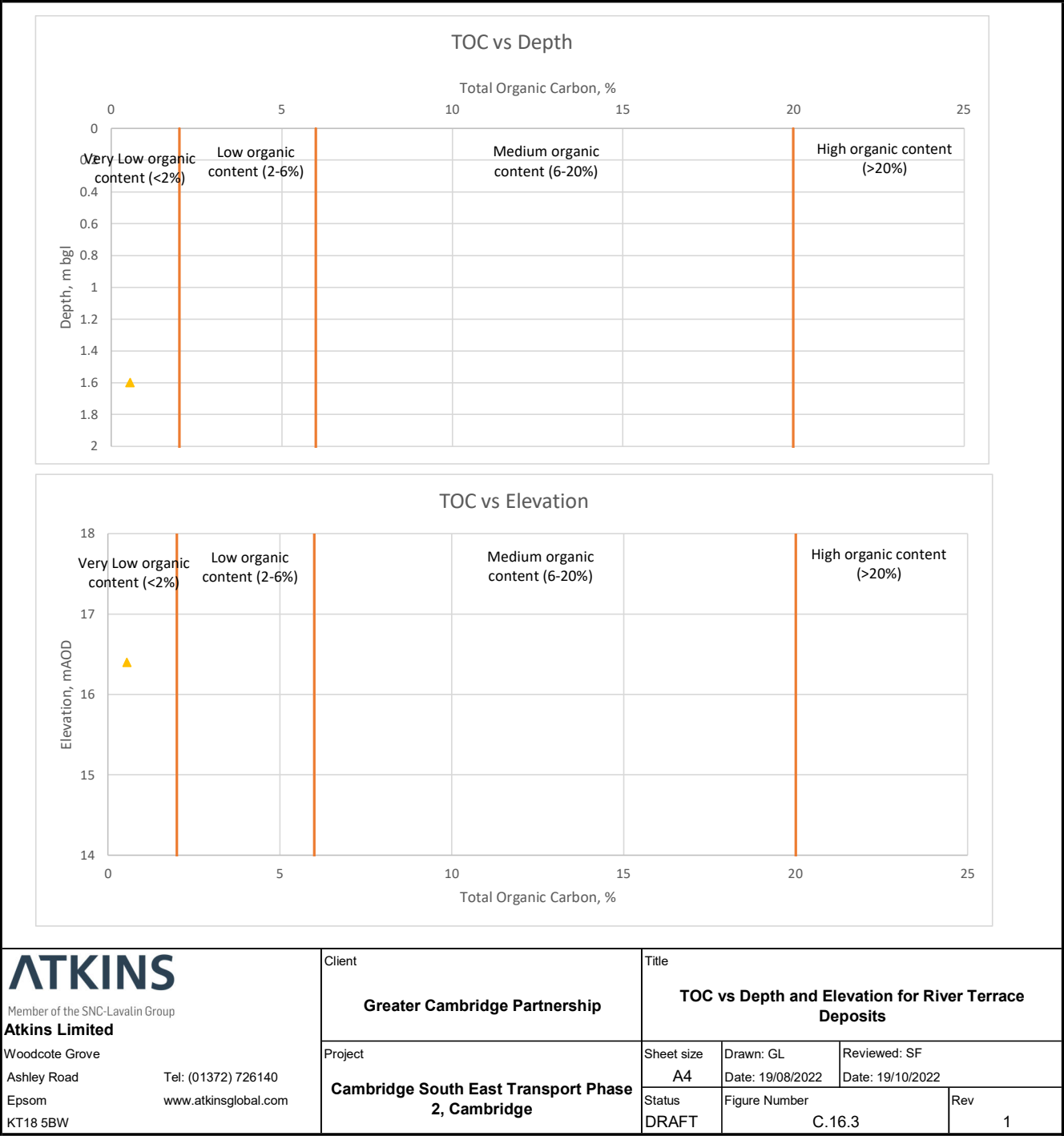


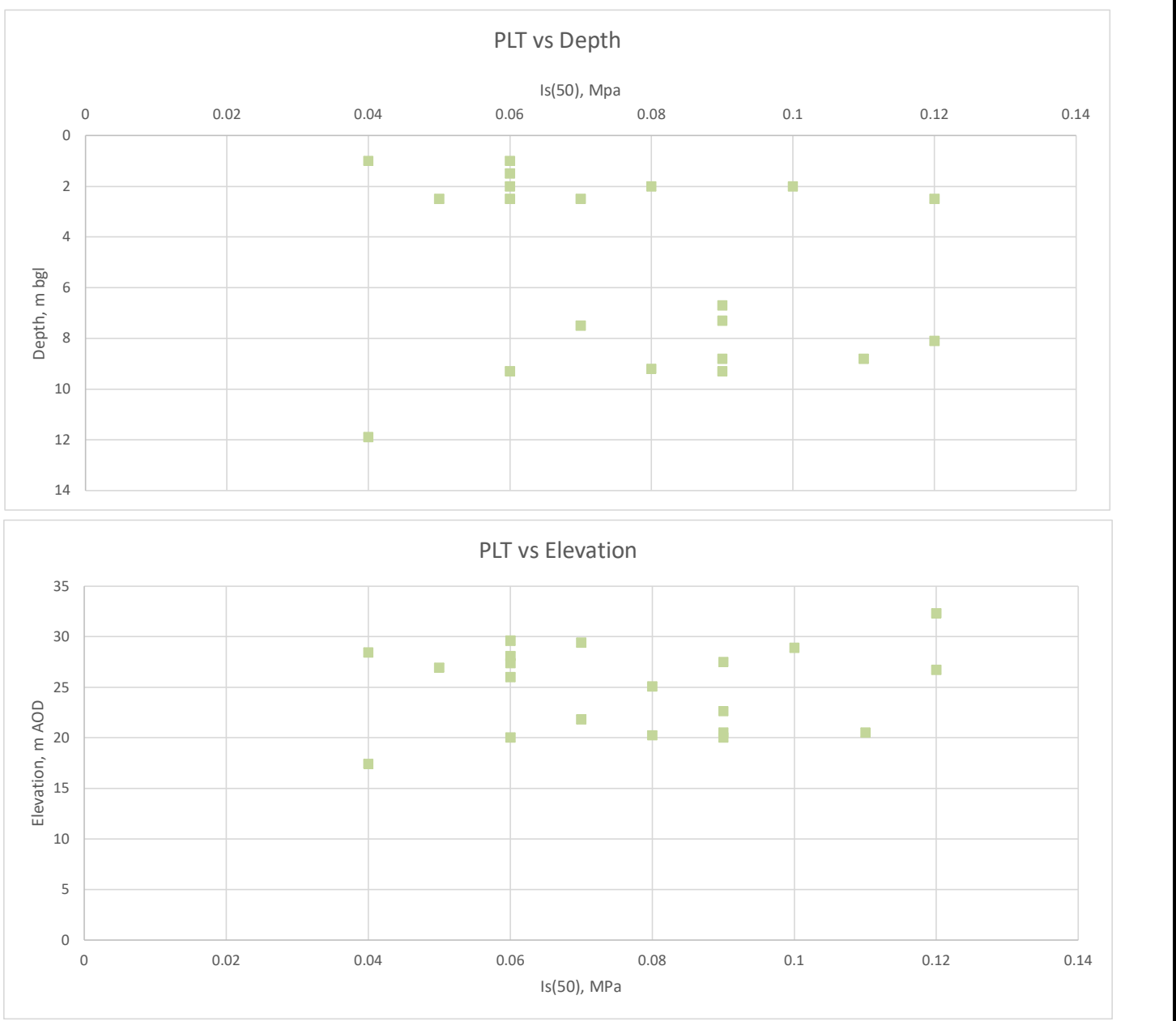
<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove</div> <div>Ashley Road</div> <div>Epsom</div> <div>KT18 5BW</div> <div>Tel: (01372) 726140</div> <div>www.atkinsglobal.com</div>	Client	Greater Cambridge Partnership			TOC vs Depth and Elevation for Made Ground		
	Project	Cambridge South East Transport Phase 2, Cambridge			Sheet size	Drawn: GL	Reviewed: SF
					A4	Date: 19/08/2022	Date: 19/10/2022
	Status	DRAFT			Figure Number	C.16.1	
	Rev					1	



<div>ATKINS</div> <div>Member of the SNC-Lavalin Group</div> <div>Atkins Limited</div> <div>Woodcote Grove</div> <div>Ashley Road</div> <div>Epsom</div> <div>KT18 5BW</div> <div>Tel: (01372) 726140</div> <div>www.atkinsglobal.com</div>	Client	Greater Cambridge Partnership			TOC vs Depth and Elevation for Alluvium/Head Deposits (Undifferentiated)		
	Project	Cambridge South East Transport Phase 2, Cambridge			Sheet size	Drawn: GL	Reviewed: SF
					A4	Date: 19/08/2022	Date: 19/10/2022
	Status	DRAFT			Figure Number	C.16.2	
	Rev					1	

C.17. Point Load Test Plots





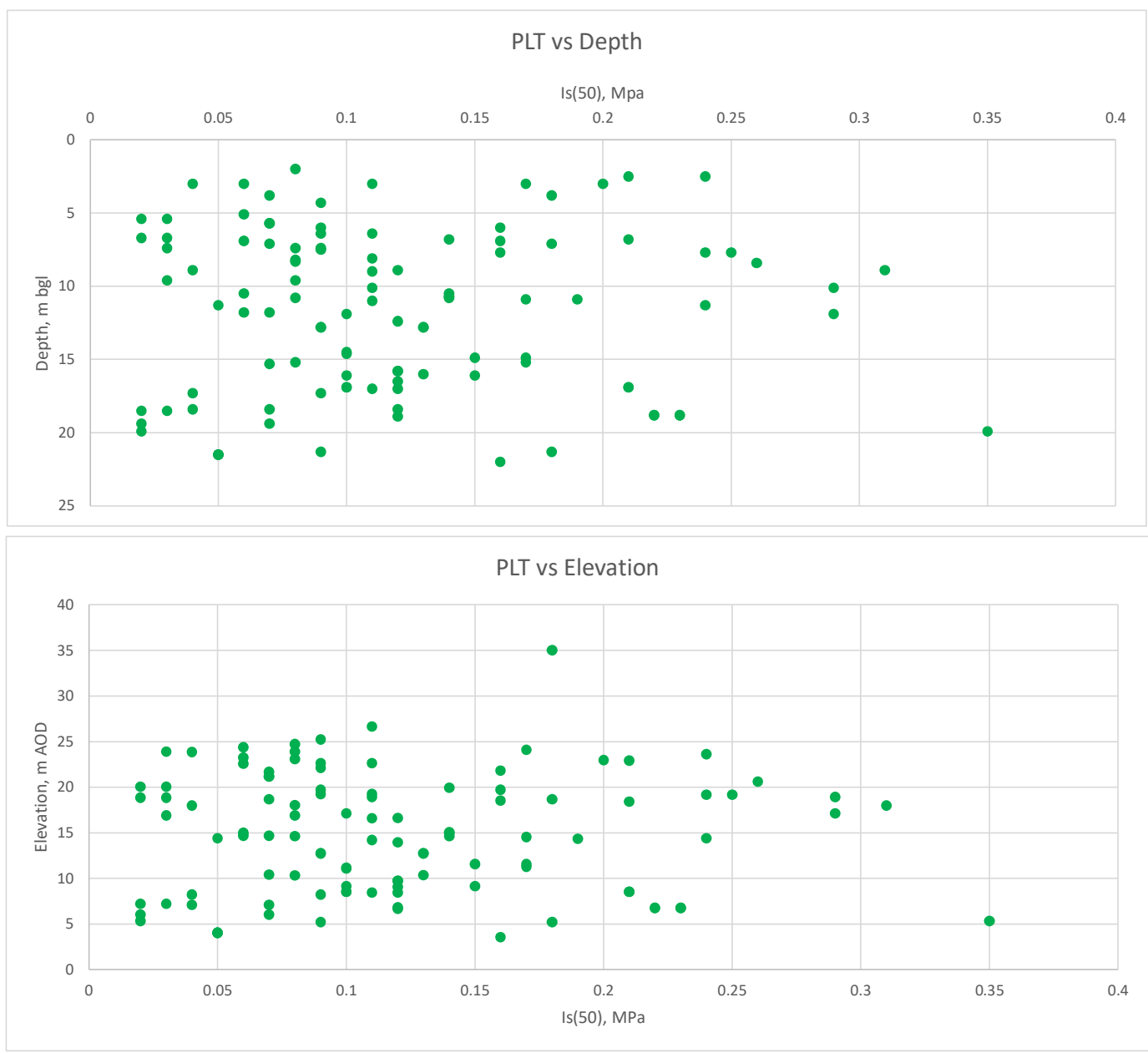
ATKINS

Member of the SNC-Lavalin Group
Atkins Limited

Woodcote Grove
Ashley Road
Epsom
KT18 5BW

Tel: (01372) 726140
www.atkinsglobal.com

Client		Title			
Greater Cambridge Partnership		Point Load Testing vs Depth and Elevation for Holywell nodular Chalk/Newpit Chalk Formation (undifferentiated)			
Project		Sheet size	Drawn: GL	Reviewed: SF	
		A4	Date: 19/08/2022	Date: 19/10/2022	
Cambridge South East Transport Phase 2, Cambridge		Status	Figure Number	Rev	
		DRAFT	C.17.1	1	



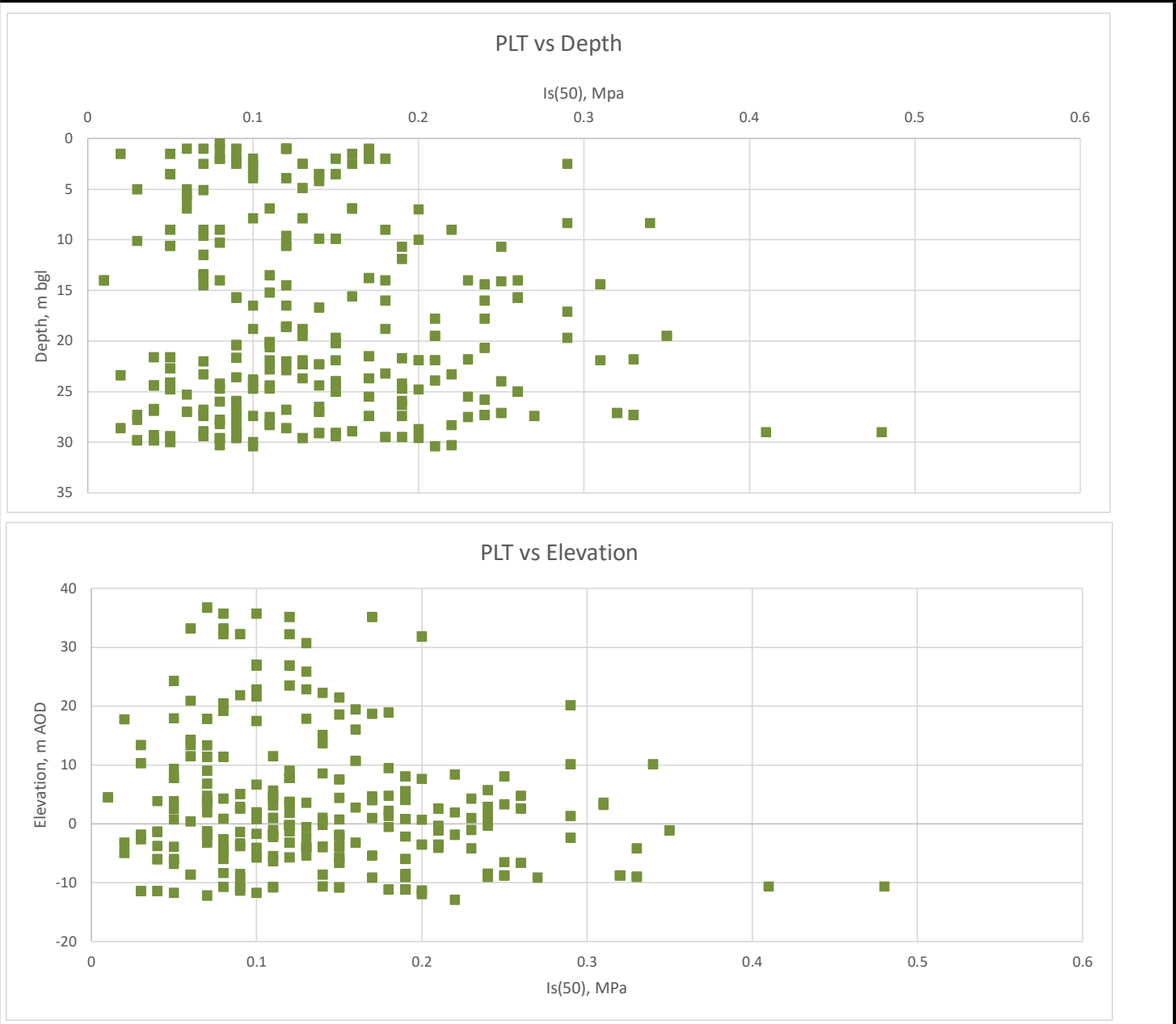
ATKINS

Member of the SNC-Lavalin Group
Atkins Limited

Woodcote Grove
Ashley Road
Epsom
KT18 5BW

Tel: (01372) 726140
www.atkinsglobal.com

Client		Title			
Greater Cambridge Partnership		Point Load Testing vs Depth and Elevation for Holywell Nodular Chalk Formation			
Project		Sheet size	Drawn: GL	Reviewed: SF	
		A4	Date: 19/08/2022	Date: 19/10/2022	
Cambridge South East Transport Phase 2, Cambridge		Status	Figure Number	Rev	
		DRAFT	C.17.2	1	



ATKINS

Member of the SNC-Lavalin Group

Atkins Limited

Woodcote Grove

Ashley Road

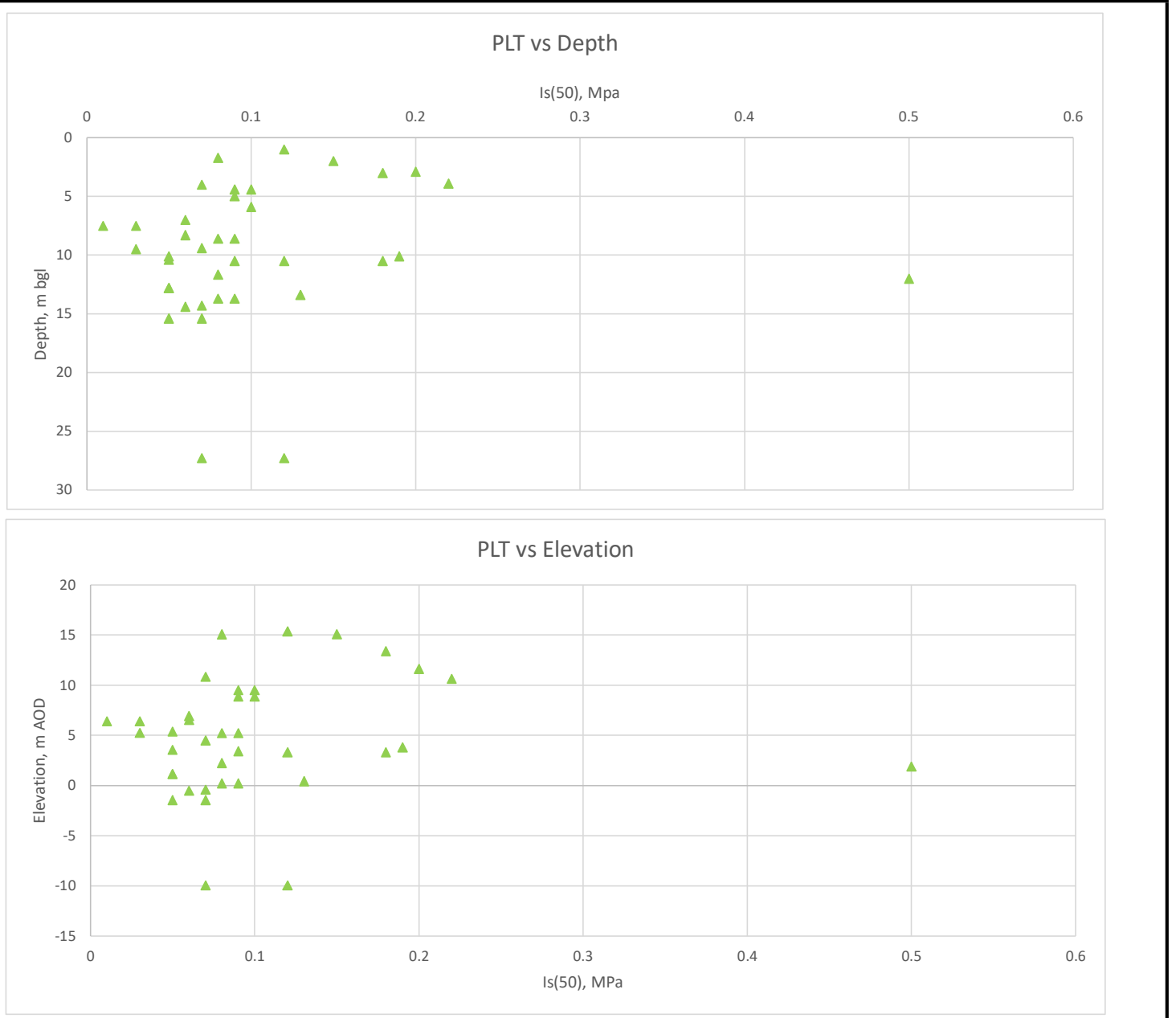
Epsom

KT18 5BW

Tel: (01372) 726140

www.atkinsglobal.com

Client	Title		
Greater Cambridge Partnership	Point Load Testing vs Depth and Elevation for Zig Zag Chalk Formation		
Project	Sheet size	Drawn: GL	Reviewed: SF
Cambridge South East Transport Phase 2, Cambridge	A4	Date: 19/08/2022	Date: 19/10/2022
	Status	Figure Number	Rev
	DRAFT	C.17.3	1



ATKINS

Member of the SNC-Lavalin Group

Atkins Limited

Woodcote Grove

Ashley Road

Epsom

KT18 5BW

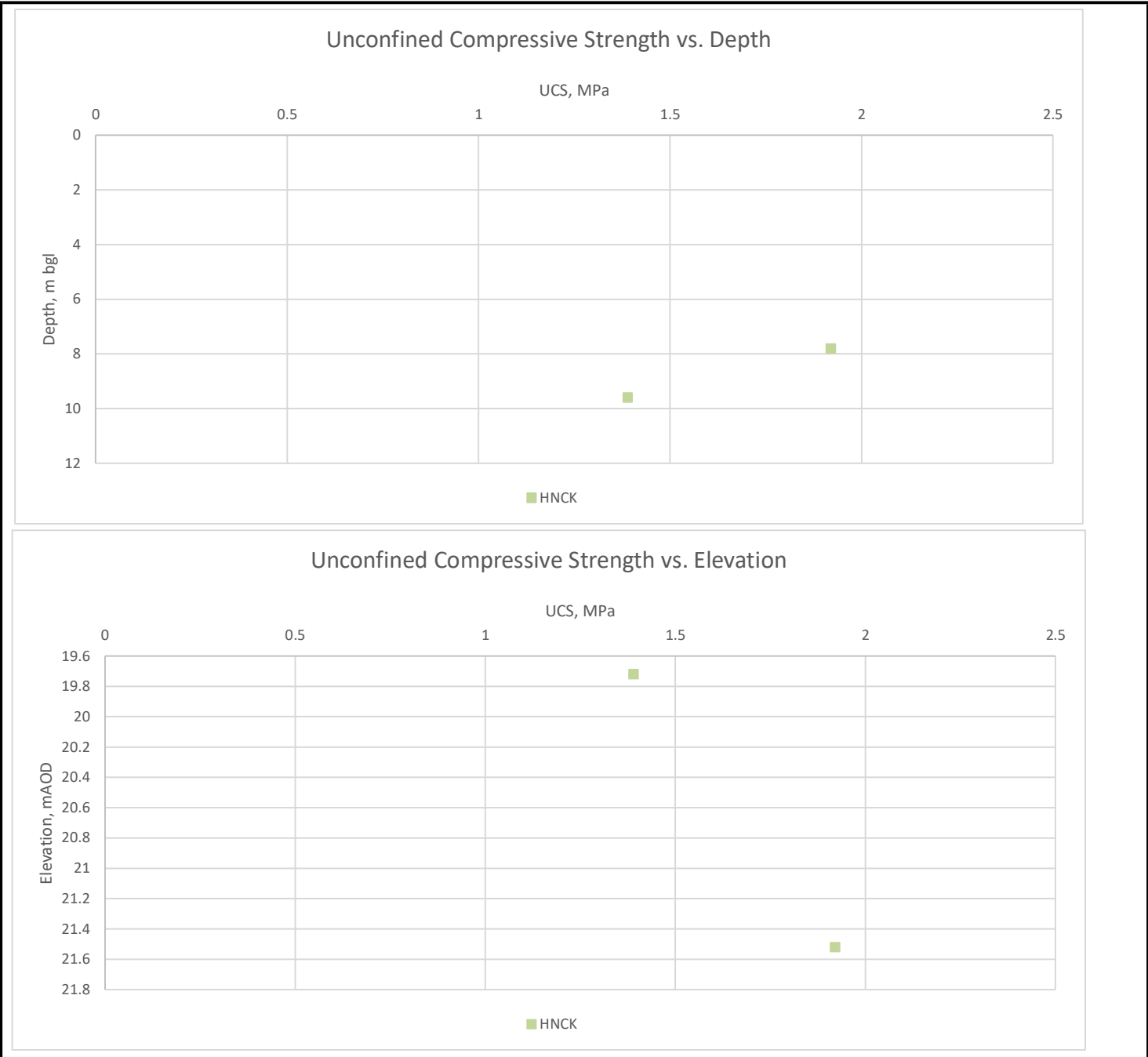
Tel: (01372) 726140

www.atkinsglobal.com

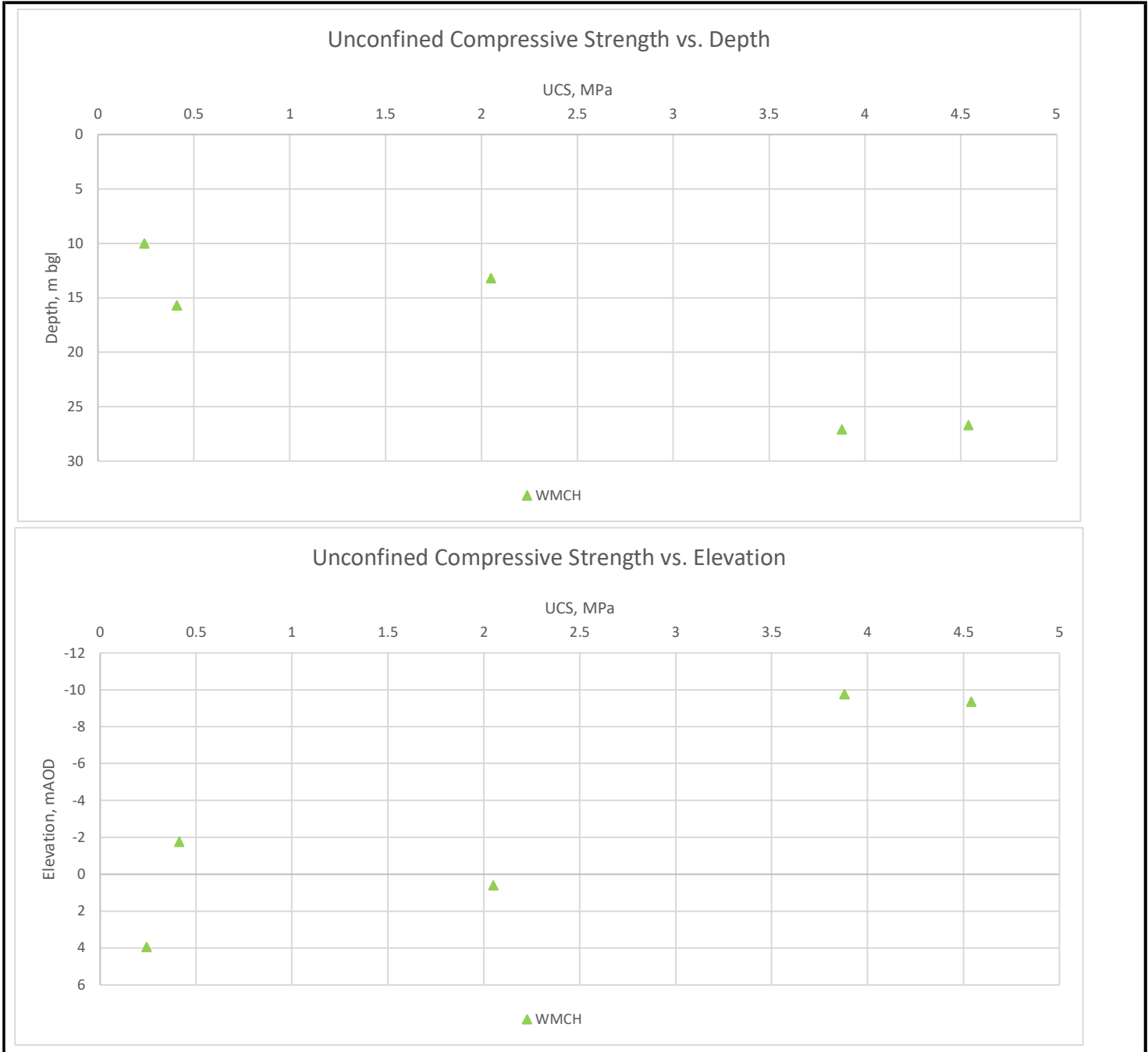
Client	Title		
Greater Cambridge Partnership	Point Load Testing vs Depth and Elevation for West Melbury Marly Chalk Formation		
Project	Sheet size	Drawn: GL	Reviewed: SF
Cambridge South East Transport Phase 2, Cambridge	A4	Date: 19/08/2022	Date: 19/10/2022
	Status	Figure Number	Rev
	DRAFT	C.17.4	1

C.18. UCS Plots



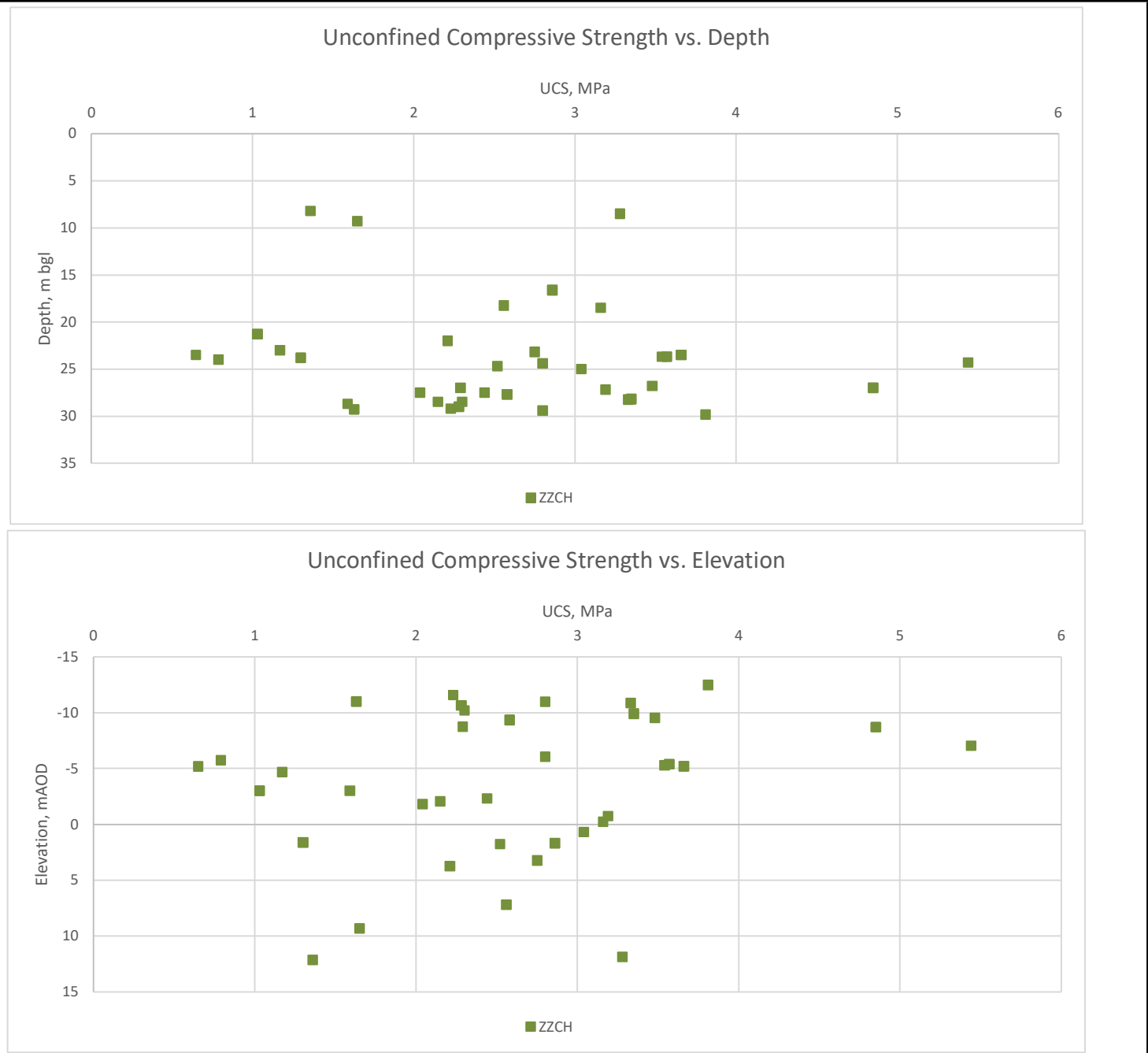


ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove Ashley Road Epsom KT18 5BW Tel: (01372) 726140 www.atkinsglobal.com	Client Greater Cambridge Partnership		Title UCS vs Depth and Elevation for New Pit Chalk Formation / Holywell Nodular Chalk Formation (Undifferentiated)		
	Project Cambridge South East Transport Phase 2, Cambridge		Sheet size A4	Drawn: GL Date: 19/08/2022	Reviewed: SF Date: 19/10/2022
			Status DRAFT	Figure Number C.18.1	Rev 1

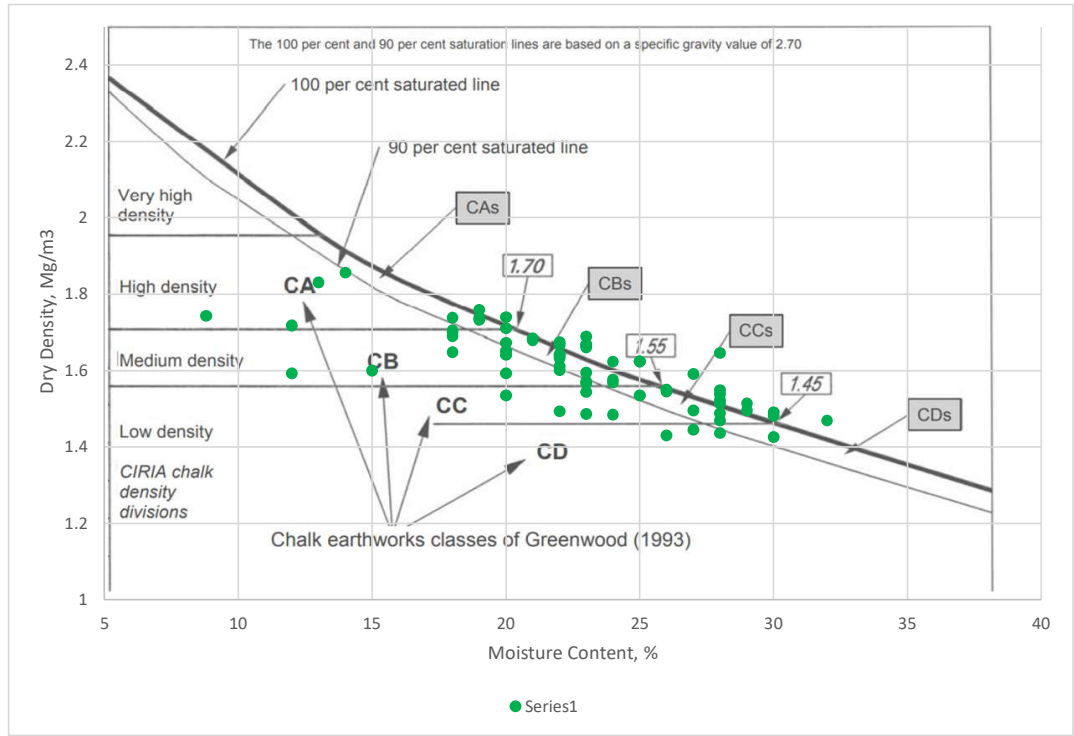
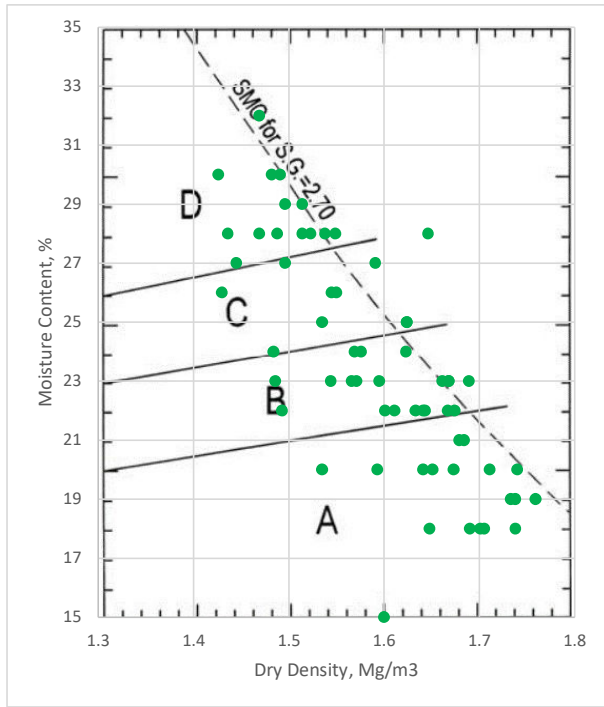


ATKINS Member of the SNC-Lavalin Group Atkins Limited Woodcote Grove Ashley Road Epsom KT18 5BW Tel: (01372) 726140 www.atkinsglobal.com	Client Greater Cambridge Partnership		Title UCS vs Depth and Elevation for West Melbury Marly Chalk Formation		
	Project Cambridge South East Transport Phase 2, Cambridge		Sheet size A4	Drawn: GL Date: 19/08/2022	Reviewed: SF Date: 19/10/2022
			Status DRAFT	Figure Number C.18.2	Rev 1

C.19. Chalk Classification charts



<div><div>Member of the SNC-Lavalin Group</div>Atkins Limited<div>Woodcote Grove</div><div>Ashley Road</div><div>Epsom</div><div>KT18 5BW</div></div> <div>Tel: (01372) 726140</div> <div>www.atkinsglobal.com</div>	Client		Title		
	Greater Cambridge Partnership		UCS vs Depth and Elevation for Zig Zag Chalk Formation		
	Project		Sheet size	Drawn: GL	Reviewed: SF
Cambridge South East Transport Phase 2, Cambridge		A4	Date: 19/08/2022	Date: 19/10/2022	
		Status	Figure Number	Rev	
		DRAFT	C.18.3	1	



Notes: Chalk classification after Greenwood, 1993 (top), proposed TL chalk classification chart after Toombs and Snowdon, 1997 (bottom)

ATKINS

Member of the SNC-Lavalin Group
Atkins Limited

Woodcote Grove
Ashley Road
Epsom
KT18 5BW

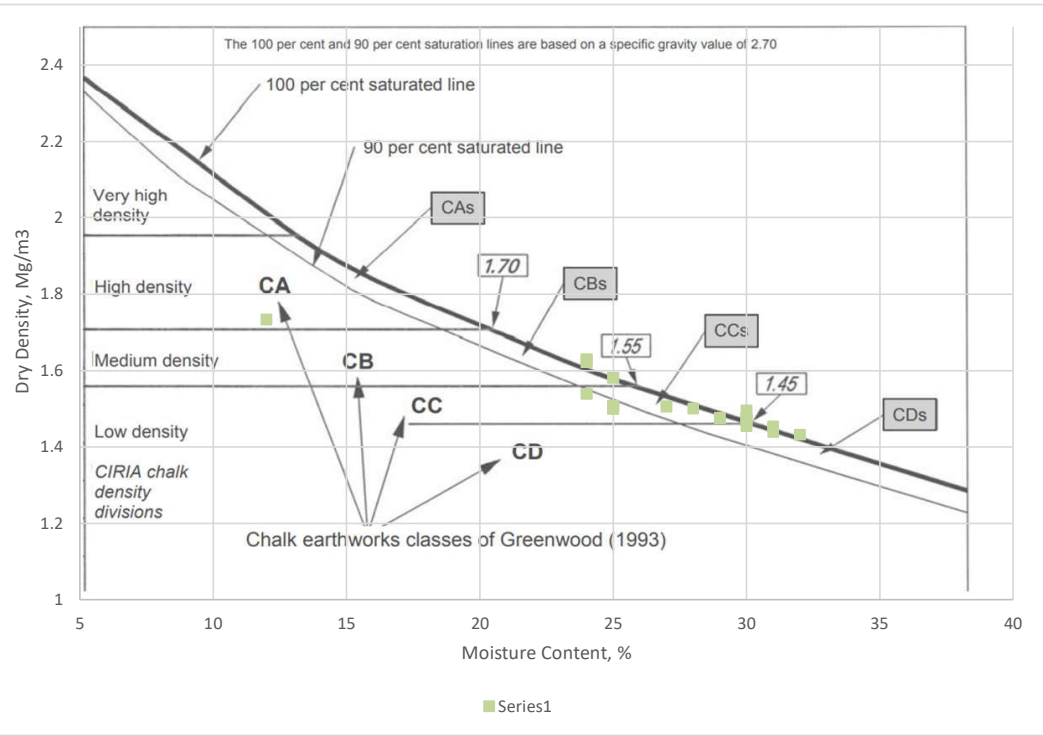
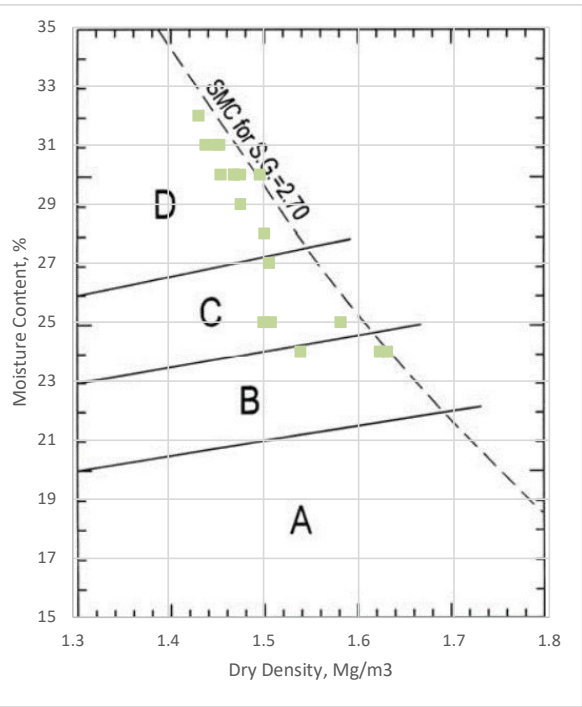
Tel: (01372) 726140
www.atkinsglobal.com

Client
Greater Cambridge Partnership

Project
Cambridge South East Transport Phase 2, Cambridge

Title
Moisture Content vs Dry Density for Holywell Nodular Chalk Formation

Sheet size A4	Drawn: GL Date: 19/08/2022	Reviewed: SF Date: 19/10/2022
Status DRAFT	Figure Number C.19.1	Rev 1



Notes: Chalk classification after Greenwood, 1993 (top), proposed TL chalk classification chart after Toombs and Snowdon, 1997 (bottom)

ATKINS

Member of the SNC-Lavalin Group
Atkins Limited

Woodcote Grove
Ashley Road
Epsom
KT18 5BW

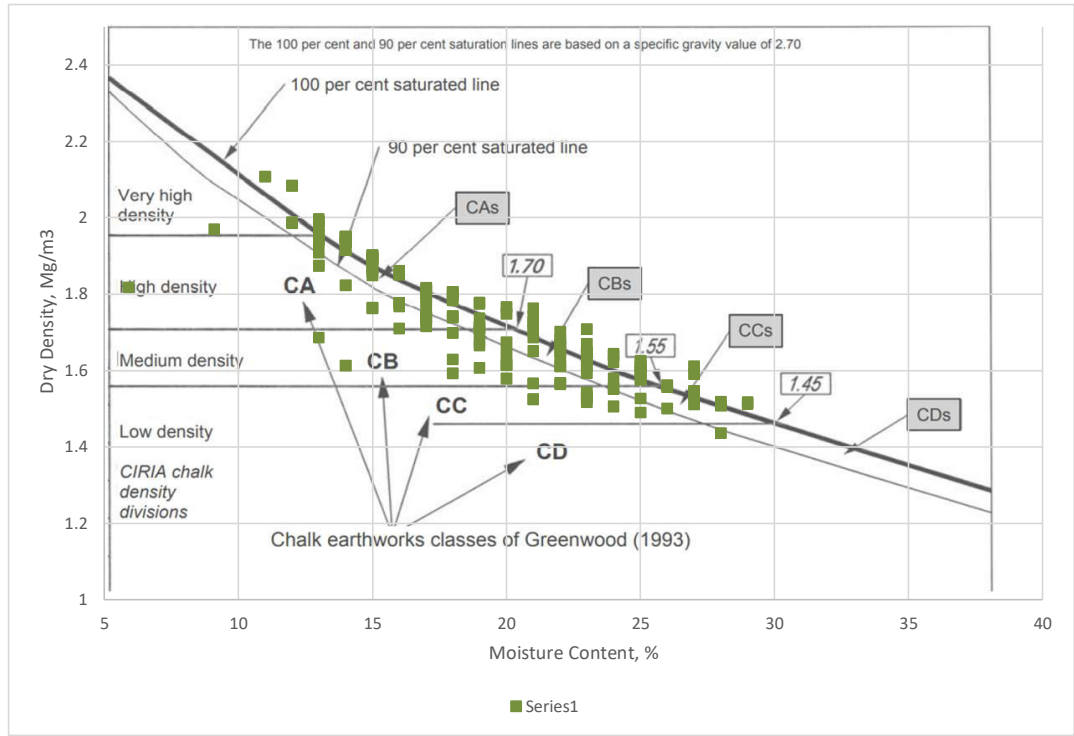
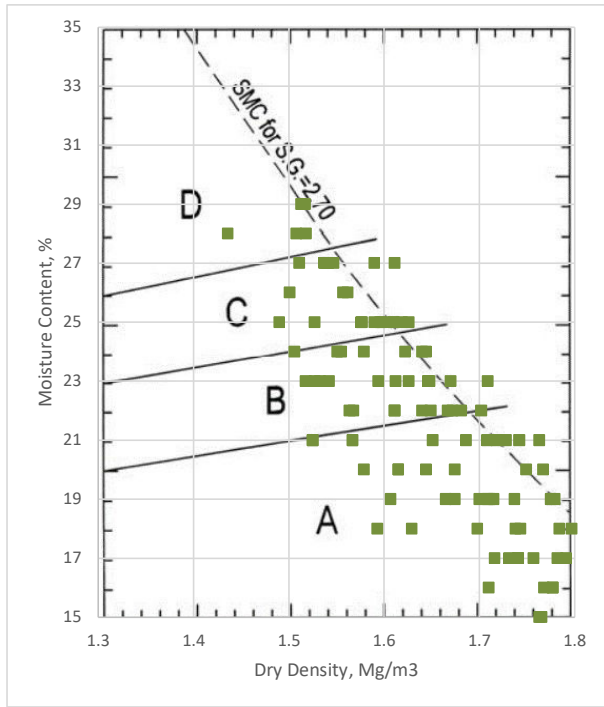
Tel: (01372) 726140
www.atkinsglobal.com

Client
Greater Cambridge Partnership

Project
Cambridge South East Transport Phase 2, Cambridge

Title
Moisture Content vs Dry Density for Holywell Nodular Chalk/New Pit Chalk Formation (undifferentiated)

Sheet size A4	Drawn: GL Date: 19/08/2022	Reviewed: SF Date: 19/10/2022
Status DRAFT	Figure Number C.19.2	Rev 1



Notes: Chalk classification after Greenwood, 1993 (top), proposed TL chalk classification chart after Toombs and Snowdon, 1997 (bottom)

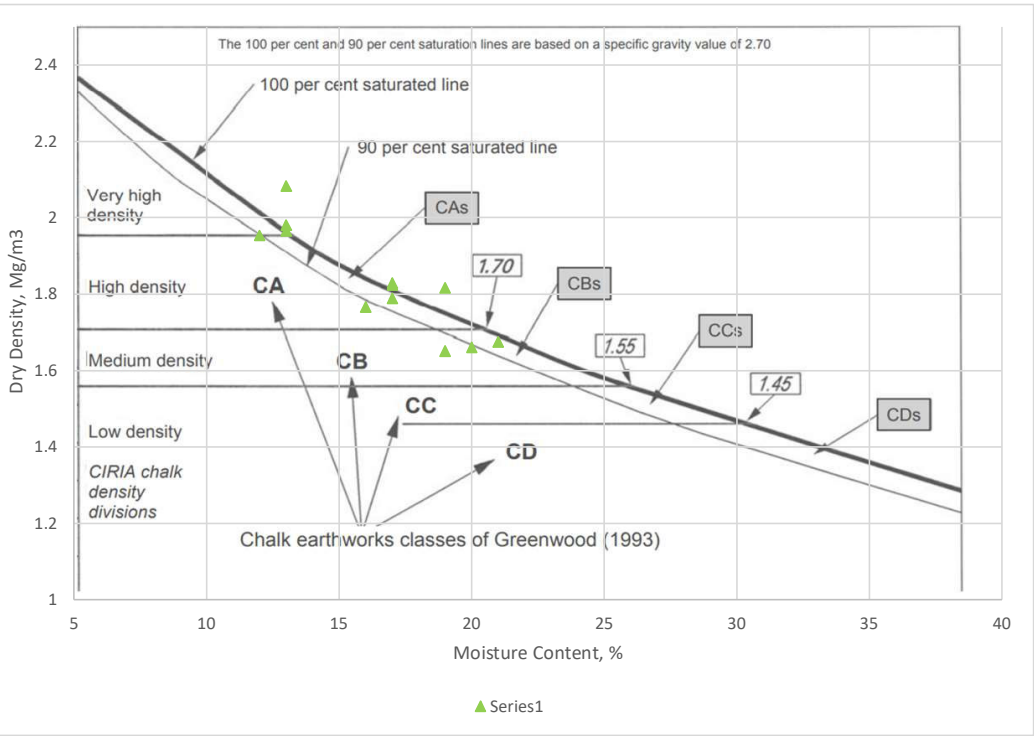
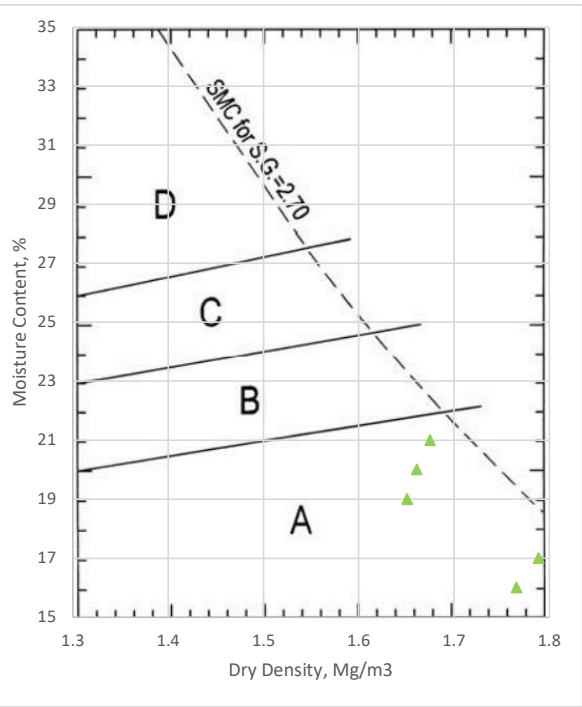
ATKINS

Member of the SNC-Lavalin Group
Atkins Limited
Woodcote Grove
Ashley Road
Epsom
KT18 5BW
Tel: (01372) 726140
www.atkinsglobal.com

Client
Greater Cambridge Partnership
Project
Cambridge South East Transport Phase 2, Cambridge

Title
Moisture Content vs Dry Density for Zig Zag Chalk Formation

Sheet size A4	Drawn: GL Date: 19/08/2022	Reviewed: SF Date: 19/10/2022
Status DRAFT	Figure Number C.19.3	Rev 1



Notes: Chalk classification after Greenwood, 1993 (top), proposed TL chalk classification chart after Toombs and Snowdon, 1997 (bottom)

ATKINS

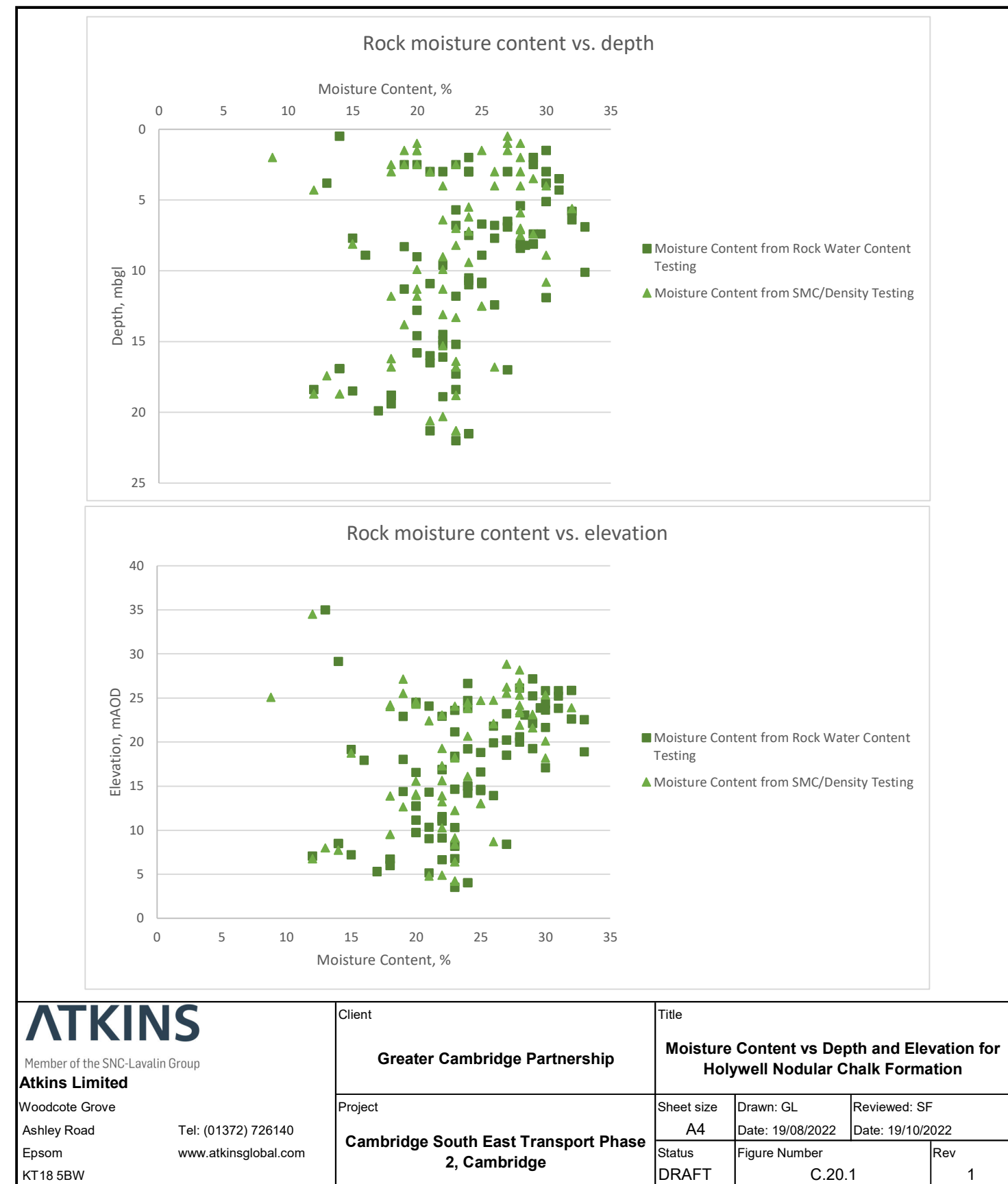
Member of the SNC-Lavalin Group
Atkins Limited
Woodcote Grove
Ashley Road
Epsom
KT18 5BW
Tel: (01372) 726140
www.atkinsglobal.com

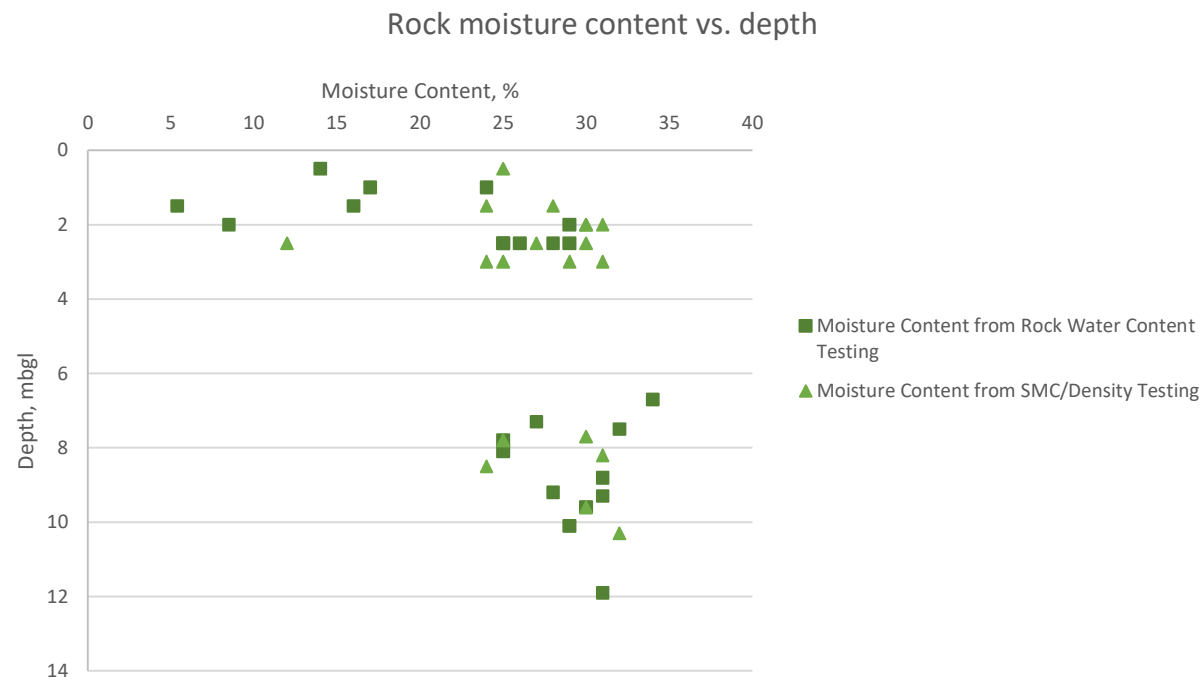
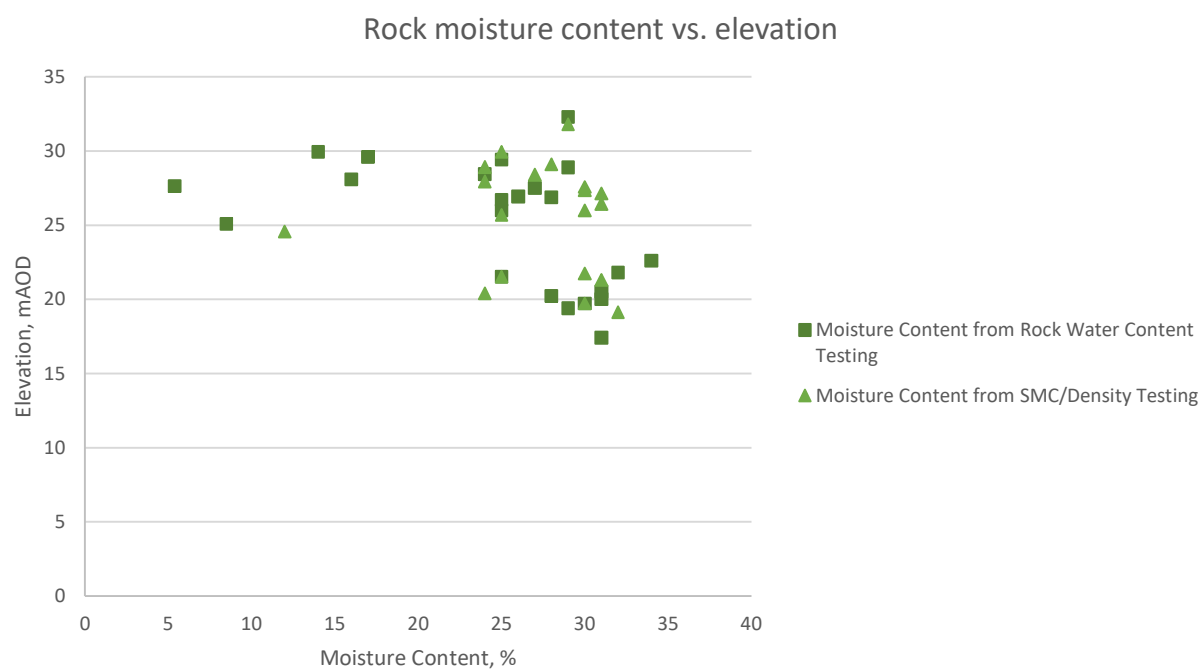
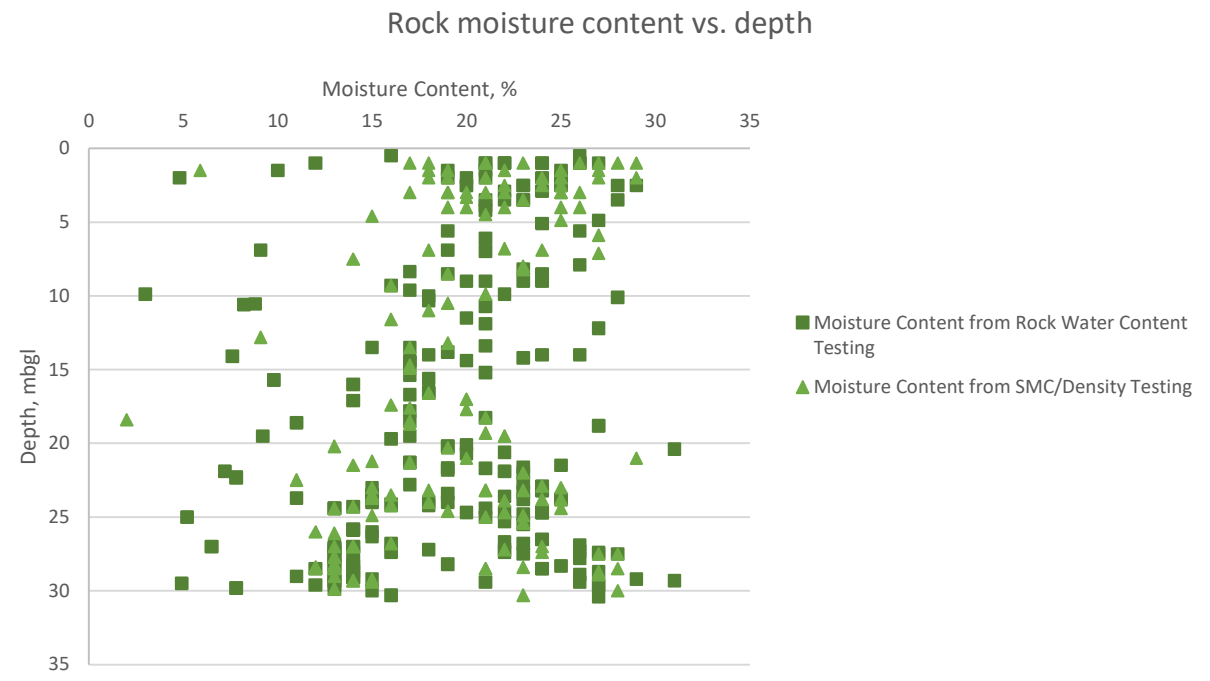
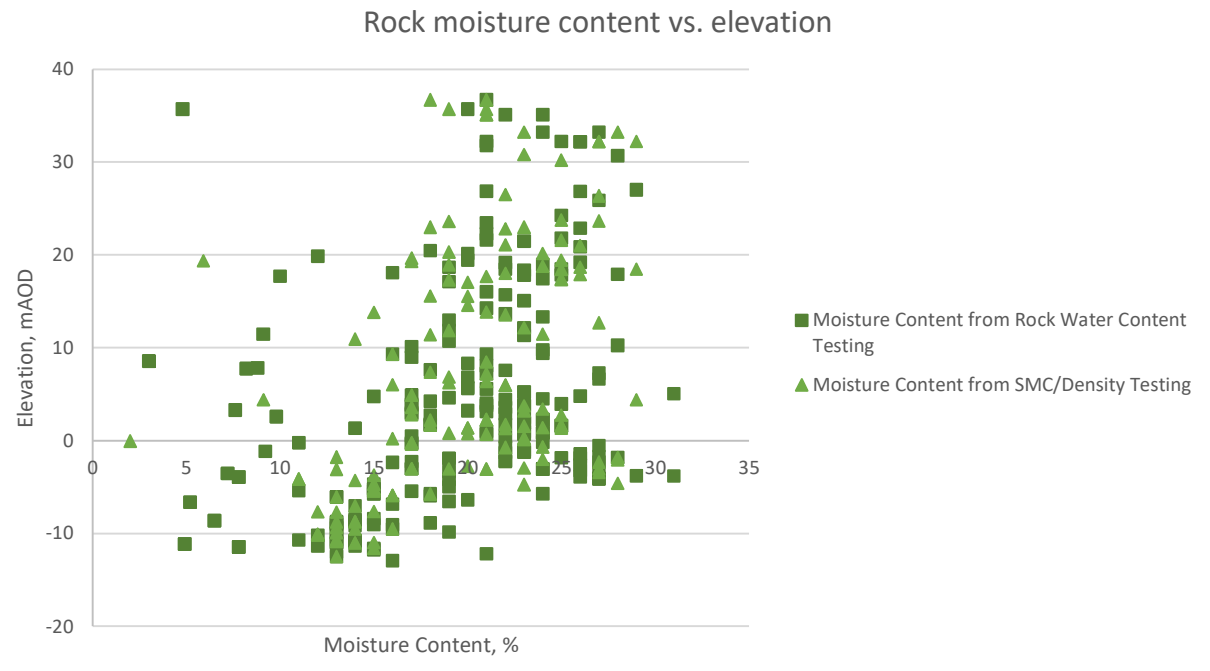
Client
Greater Cambridge Partnership
Project
Cambridge South East Transport Phase 2, Cambridge

Title
Moisture Content vs Dry Density for West Melbury Marly Chalk Formation

Sheet size A4	Drawn: GL Date: 19/08/2022	Reviewed: SF Date: 19/10/2022
Status DRAFT	Figure Number C.19.4	Rev 1

C.20. Rock water content plots





ATKINS

Member of the SNC-Lavalin Group

Atkins Limited

Woodcote Grove

Ashley Road

Epsom

KT18 5BW

Tel: (01372) 726140

www.atkinsglobal.com

Client

Greater Cambridge Partnership

Project

Cambridge South East Transport Phase 2, Cambridge

Title

Moisture Content vs Depth and Elevation for Holywell Nodular Chalk/New Pit Chalk Formation (undifferentiated)

Sheet size

A4

Status

DRAFT

Drawn: GL

Date: 19/08/2022

Reviewed: SF

Date: 19/10/2022

Figure Number

C.20.2

Rev

1

ATKINS

Member of the SNC-Lavalin Group

Atkins Limited

Woodcote Grove

Ashley Road

Epsom

KT18 5BW

Tel: (01372) 726140

www.atkinsglobal.com

Client

Greater Cambridge Partnership

Project

Cambridge South East Transport Phase 2, Cambridge

Title

Moisture Content vs Depth and Elevation for Zig Zag Chalk Formation

Sheet size

A4

Status

DRAFT

Drawn: GL

Date: 19/08/2022

Reviewed: SF

Date: 19/10/2022

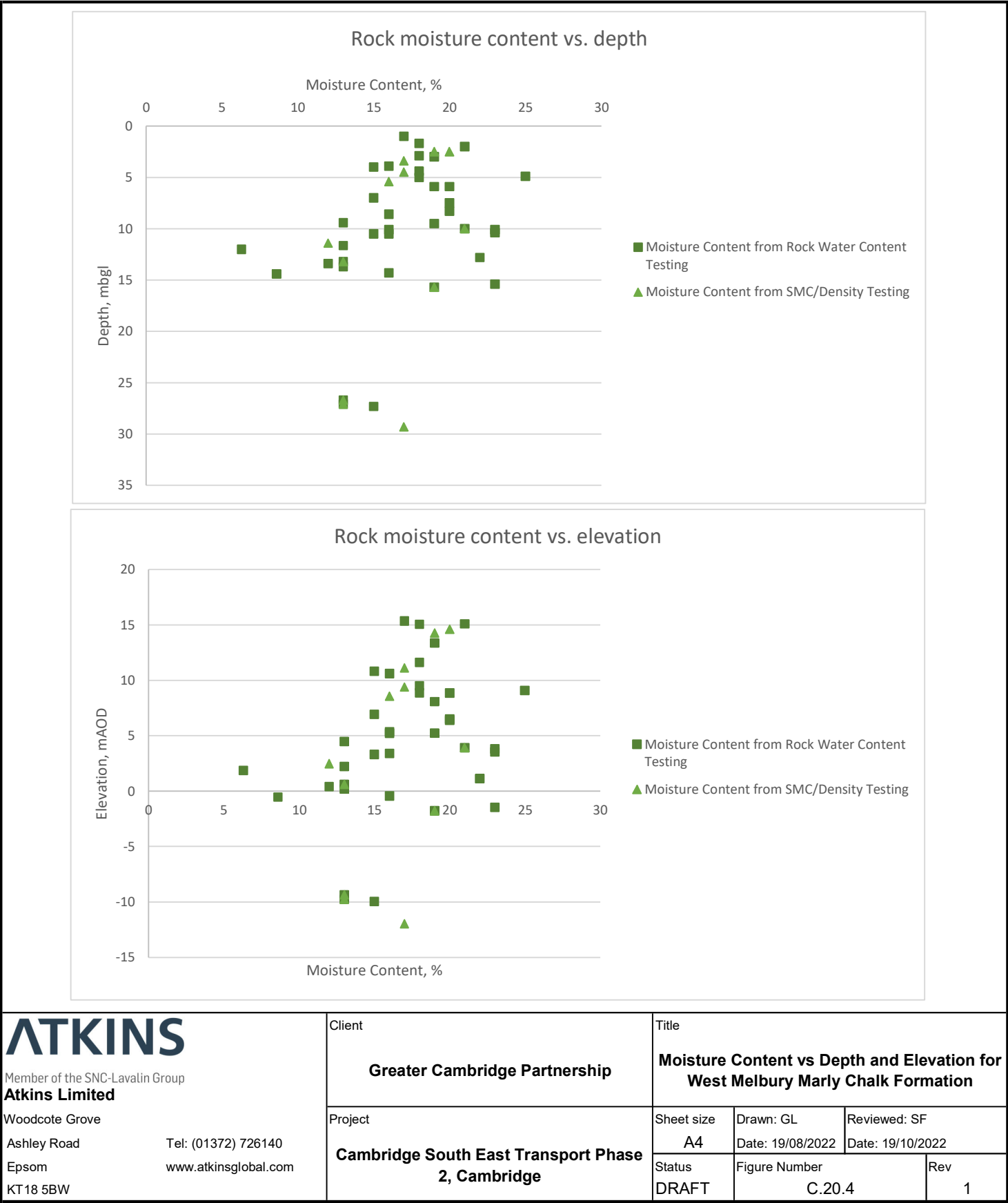
Figure Number

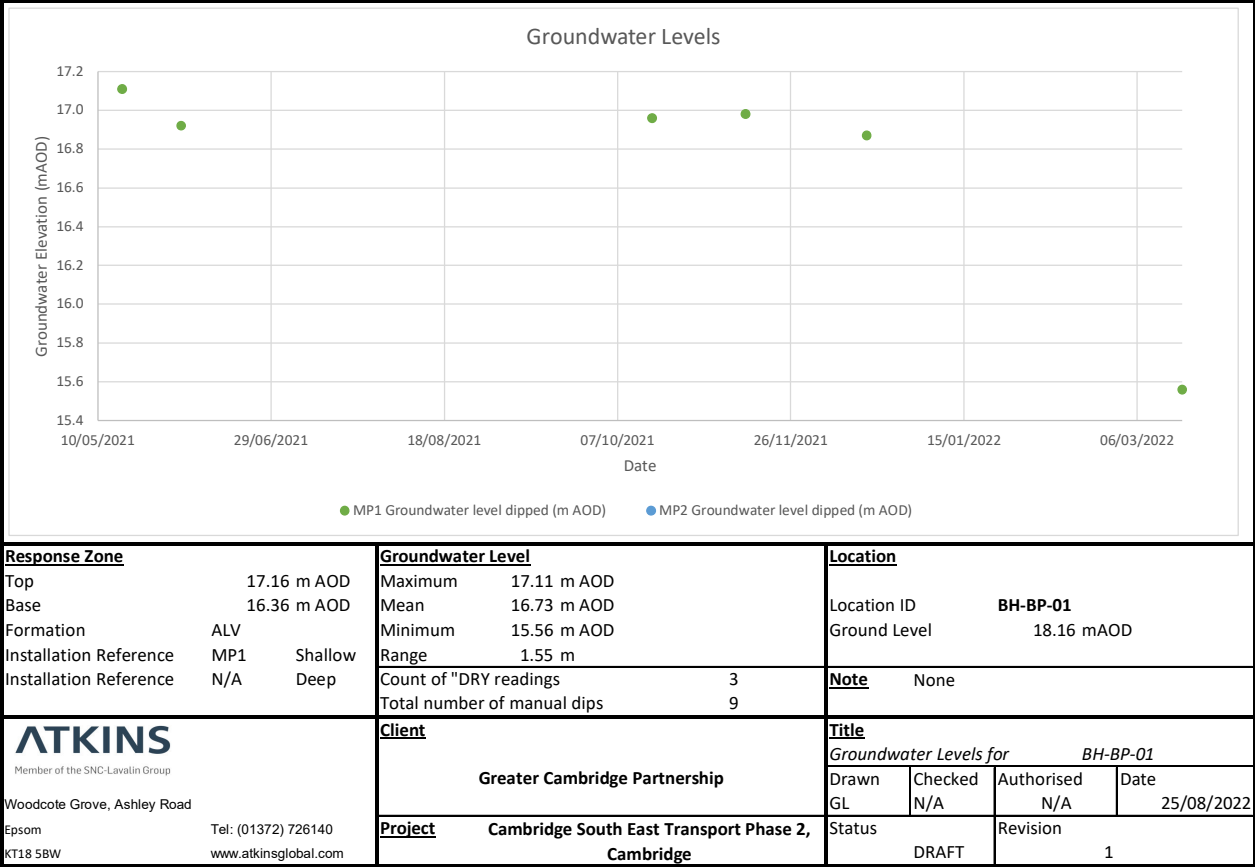
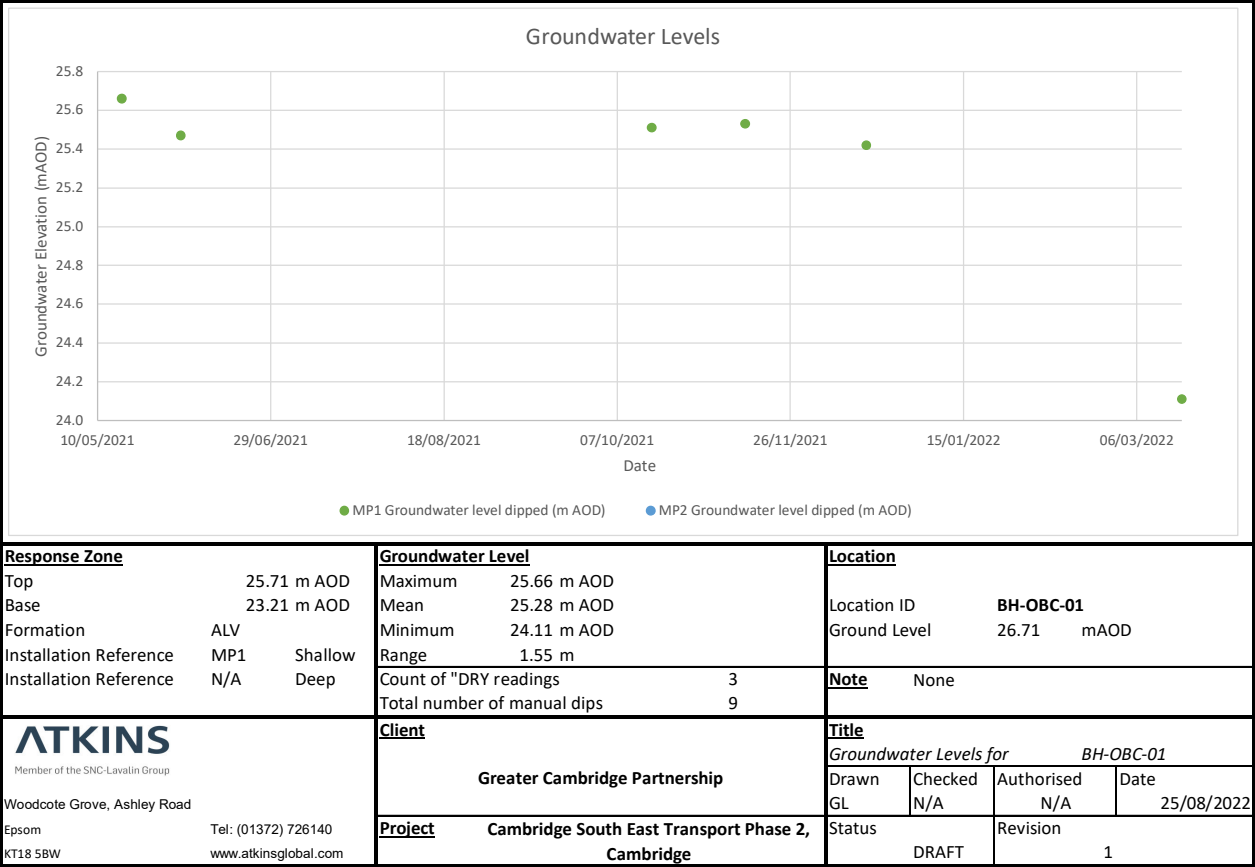
C.20.3

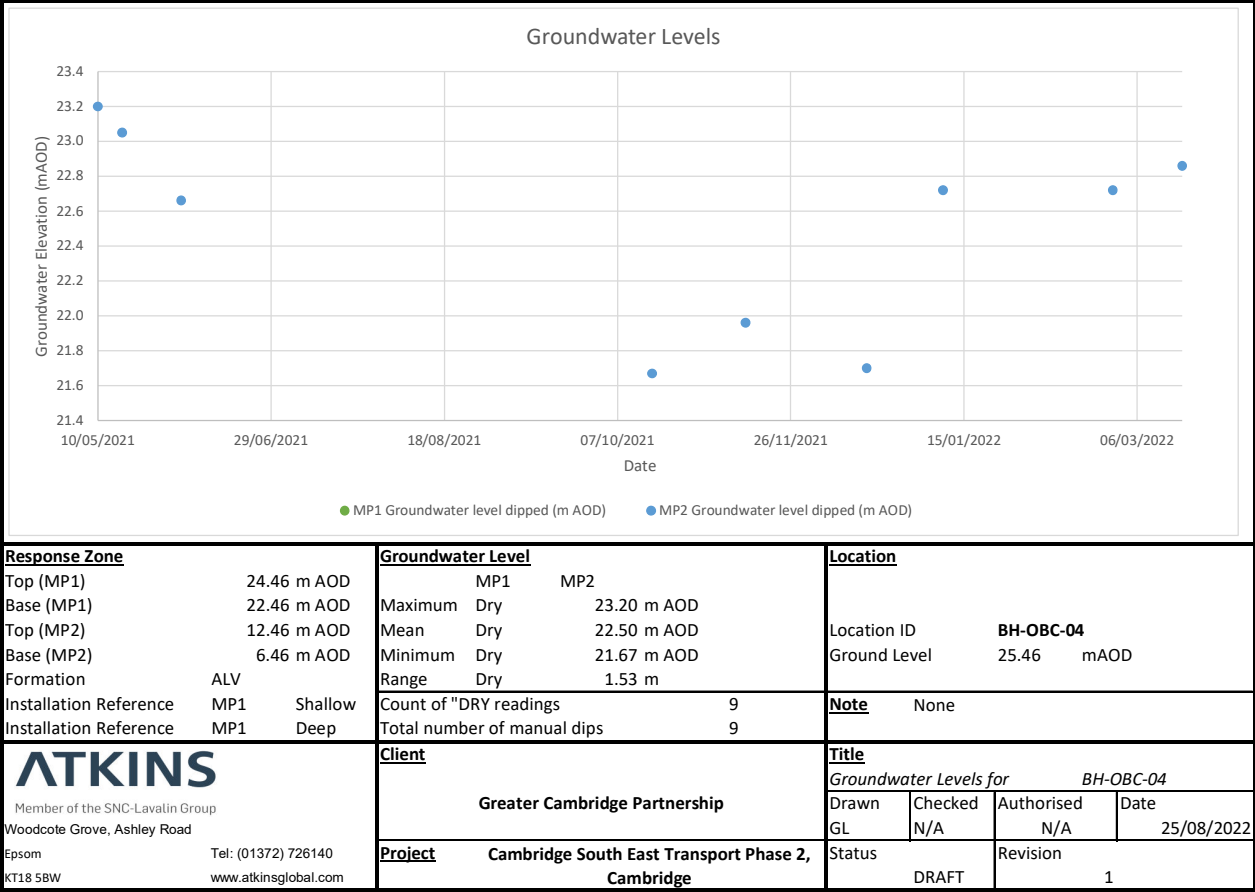
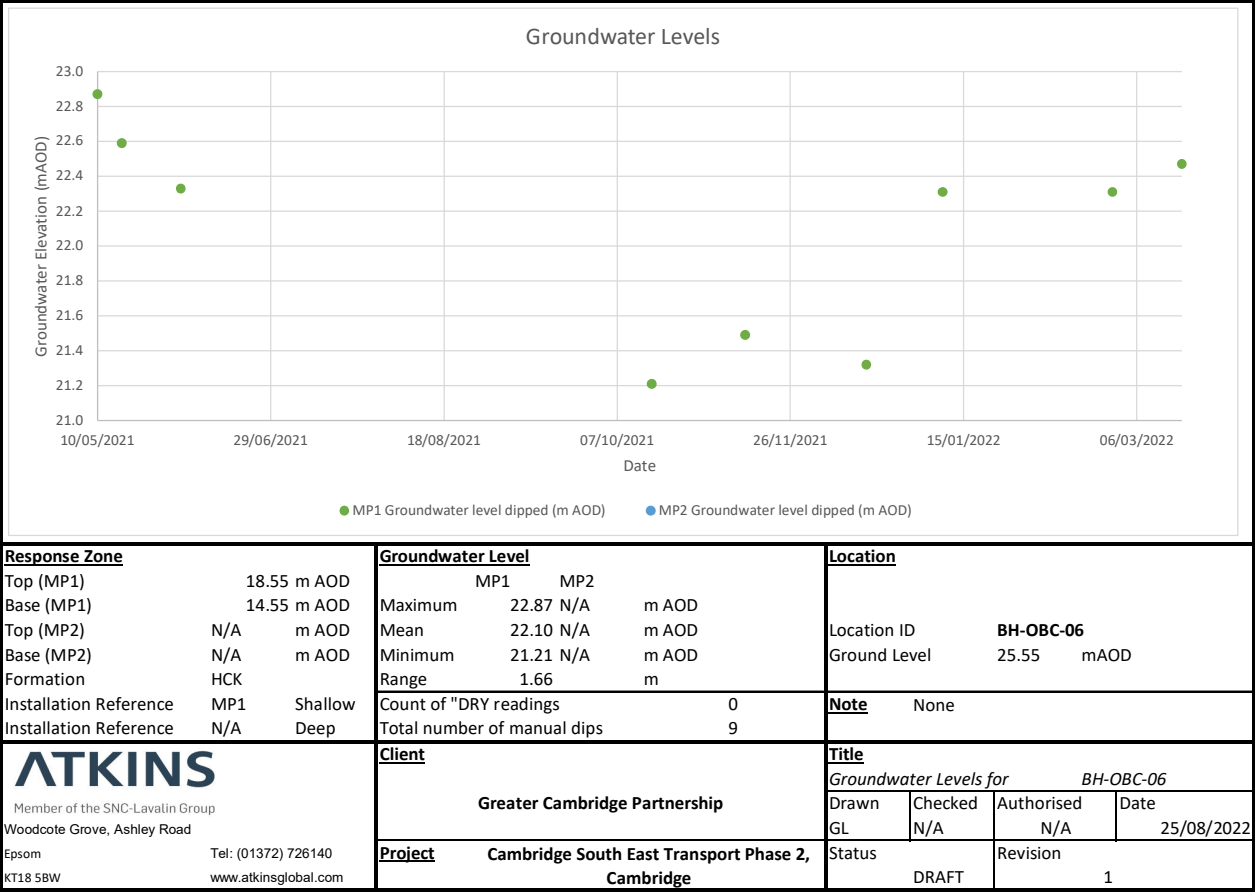
Rev

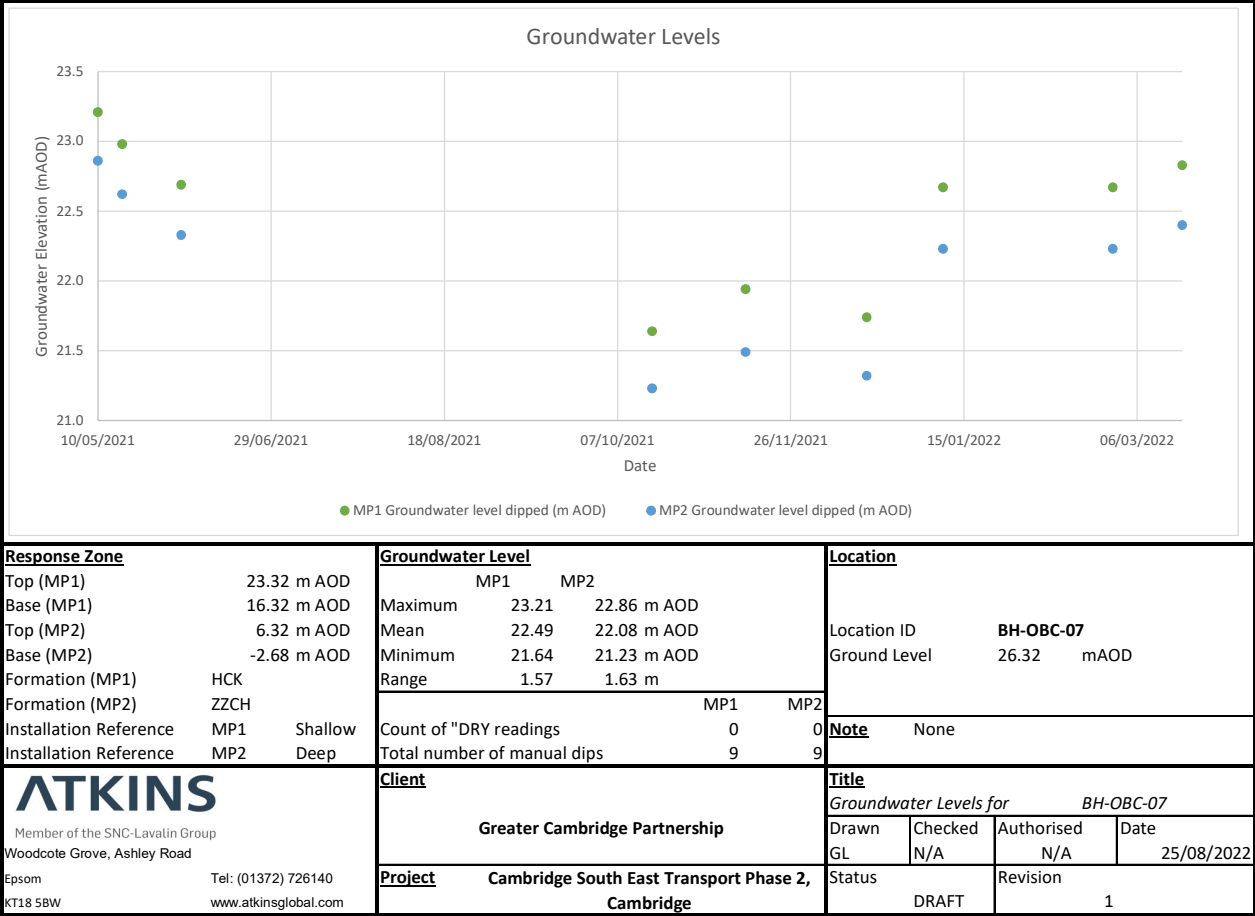
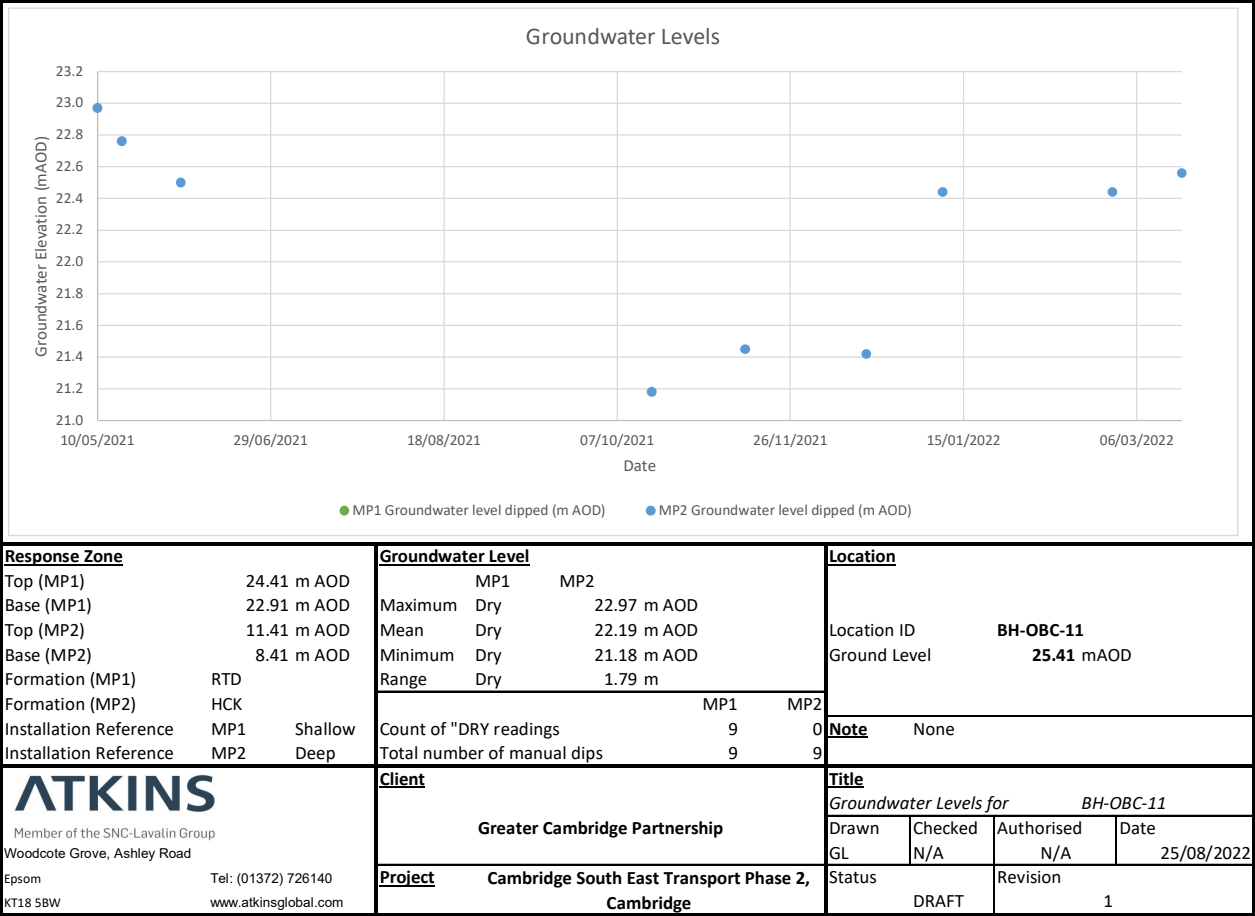
1

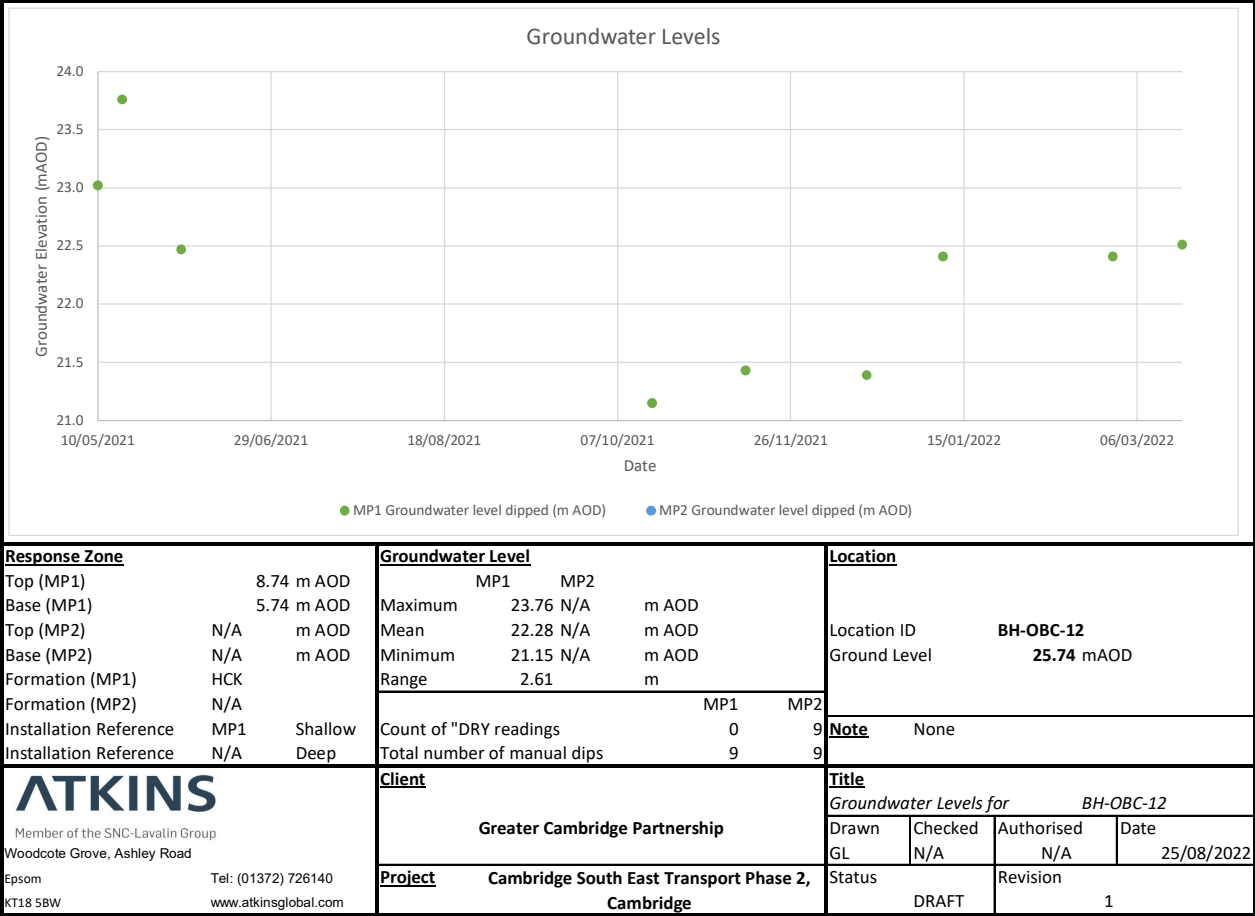
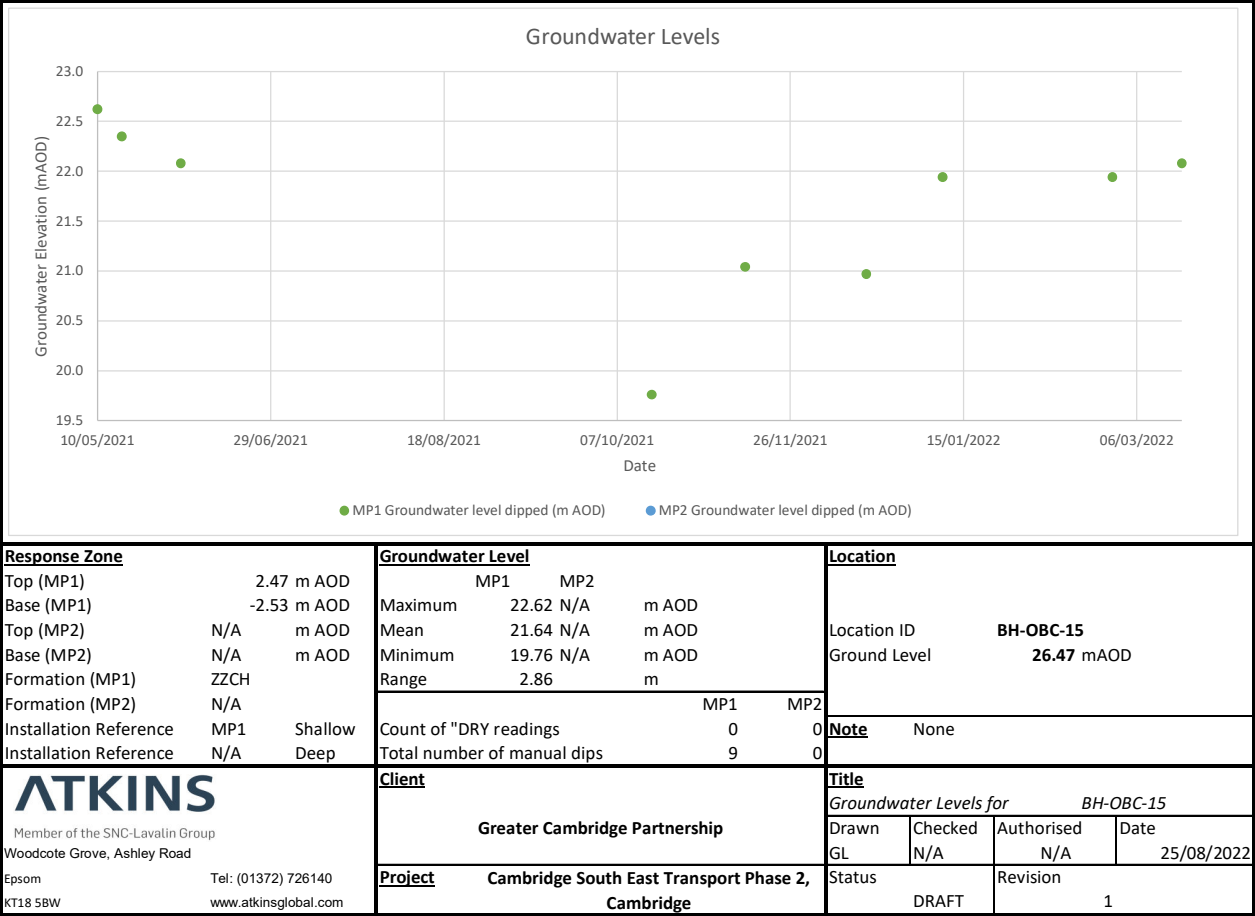
C.21. Groundwater Level Charts

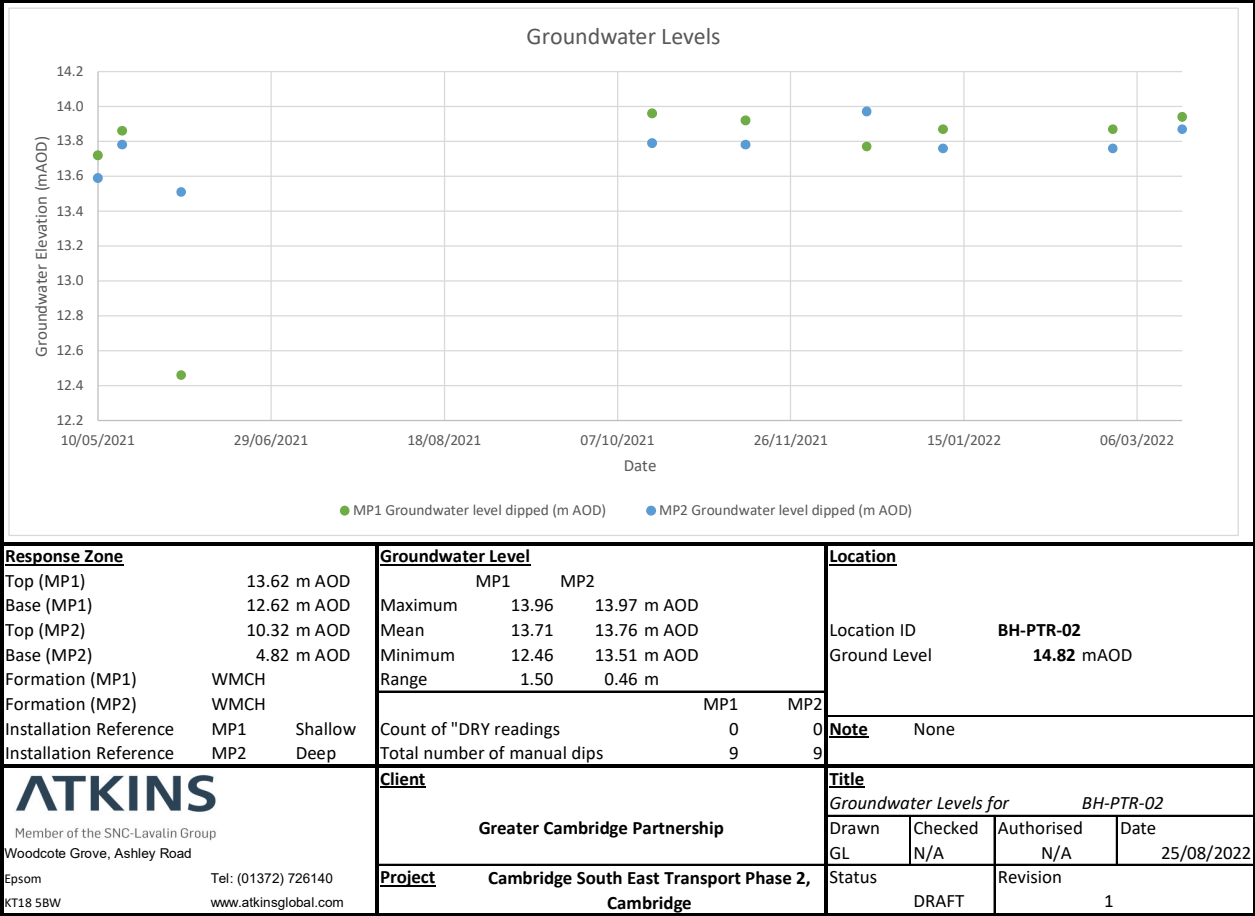
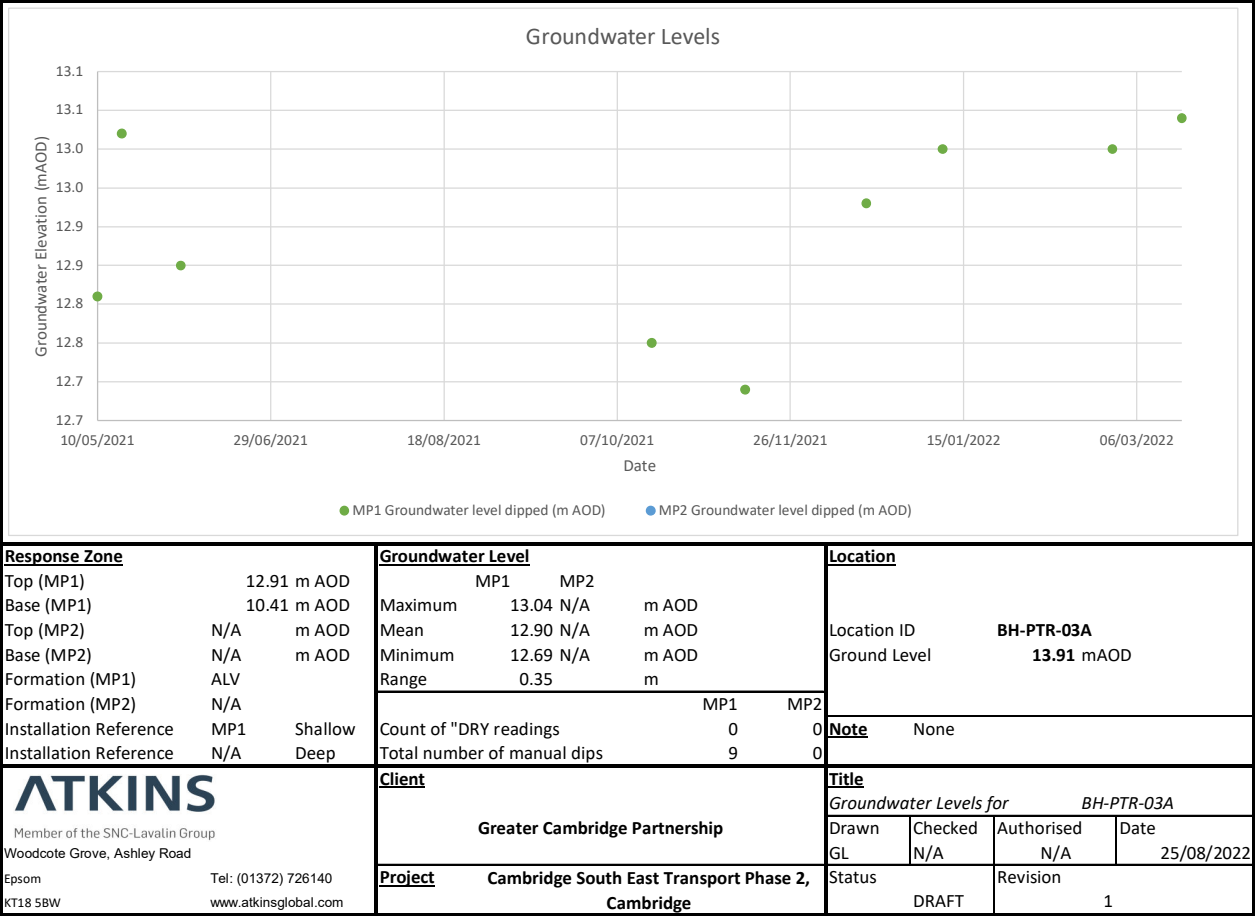


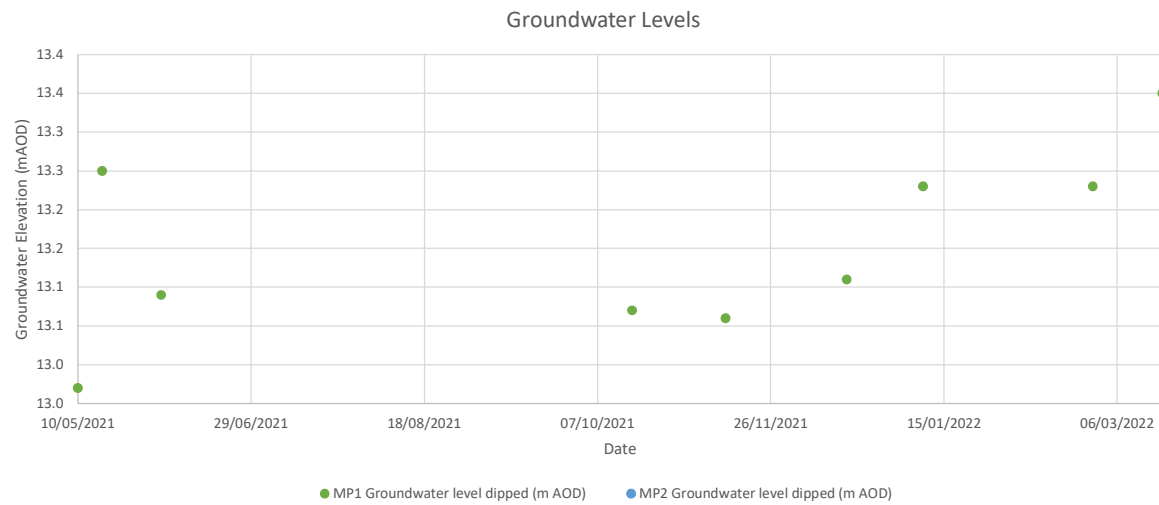




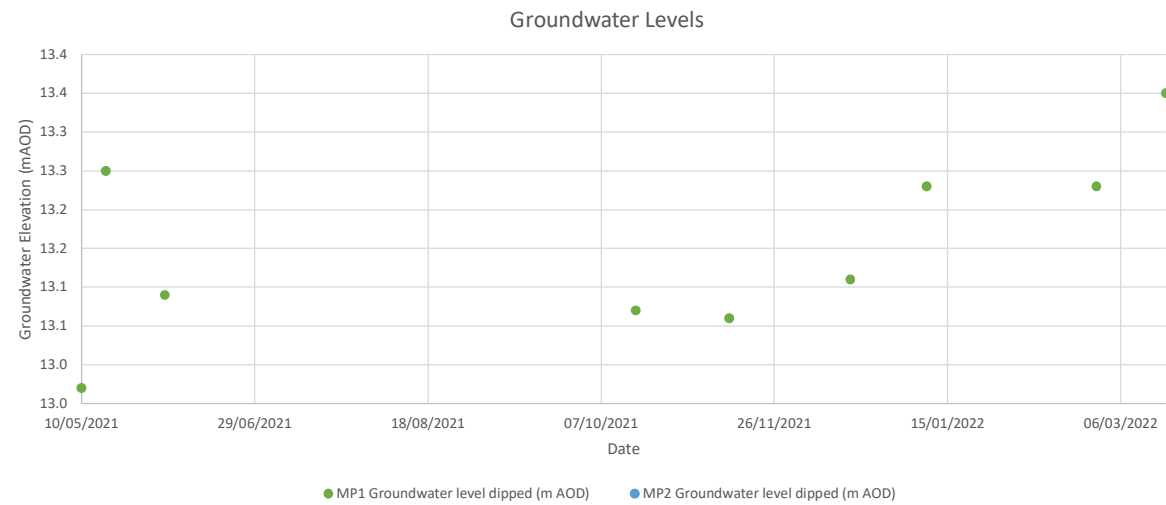




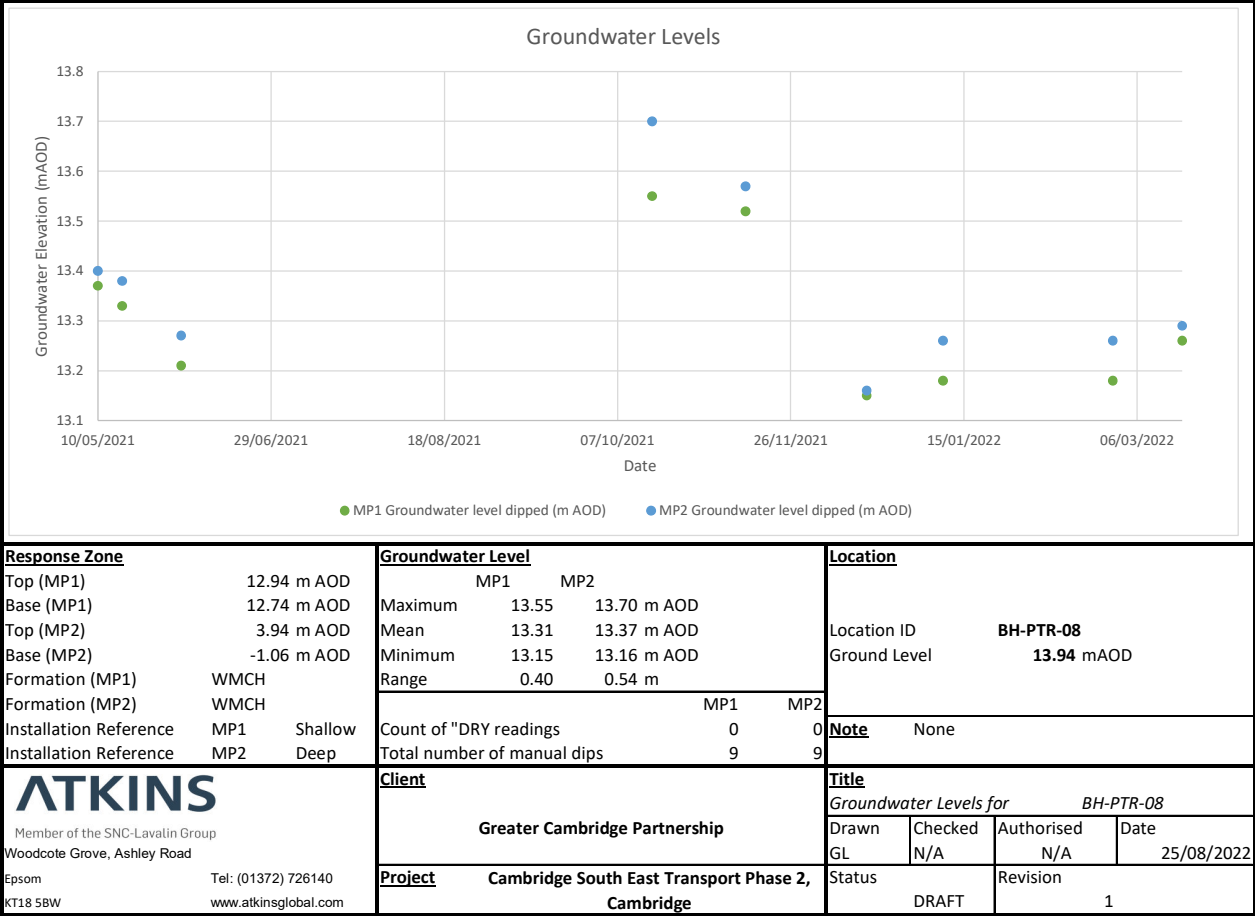
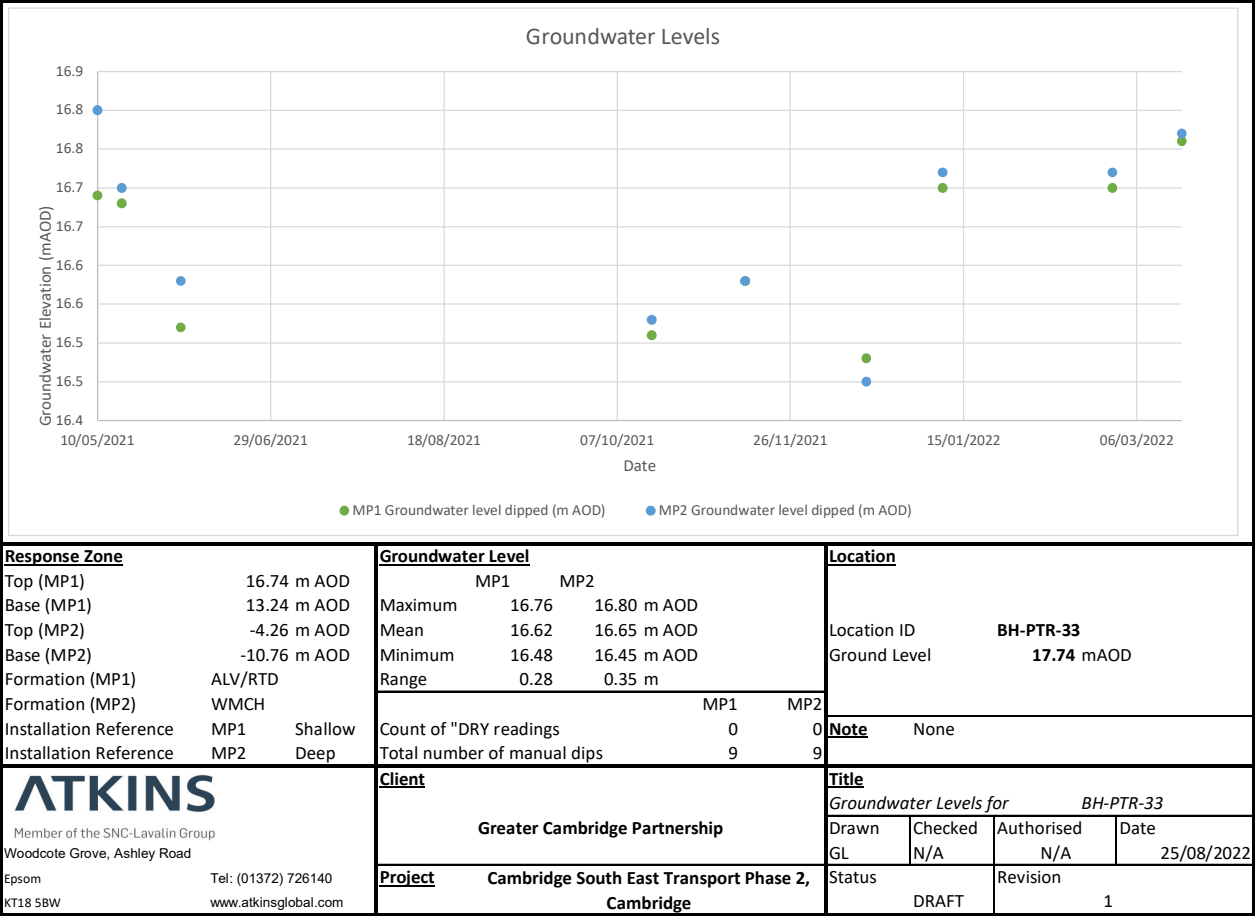


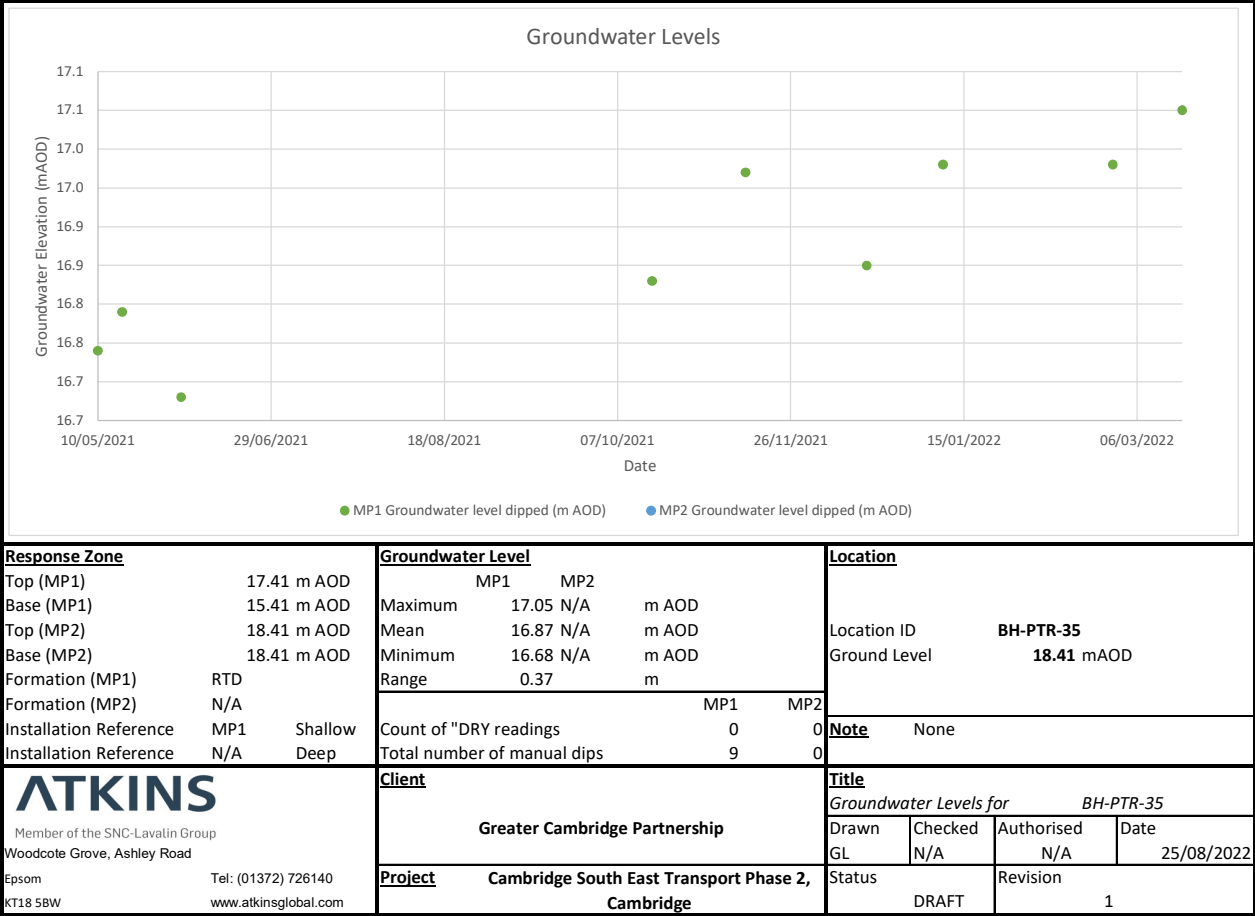
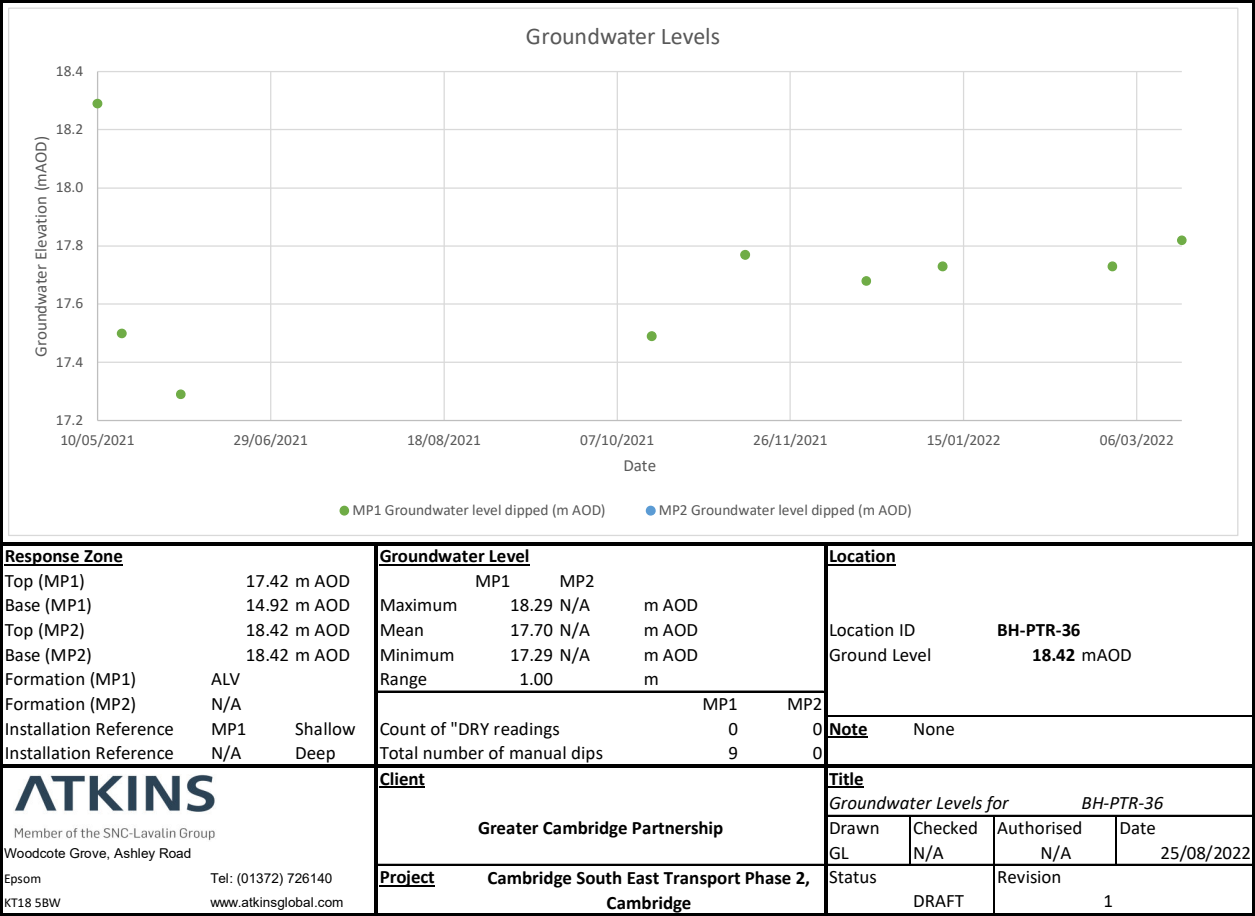


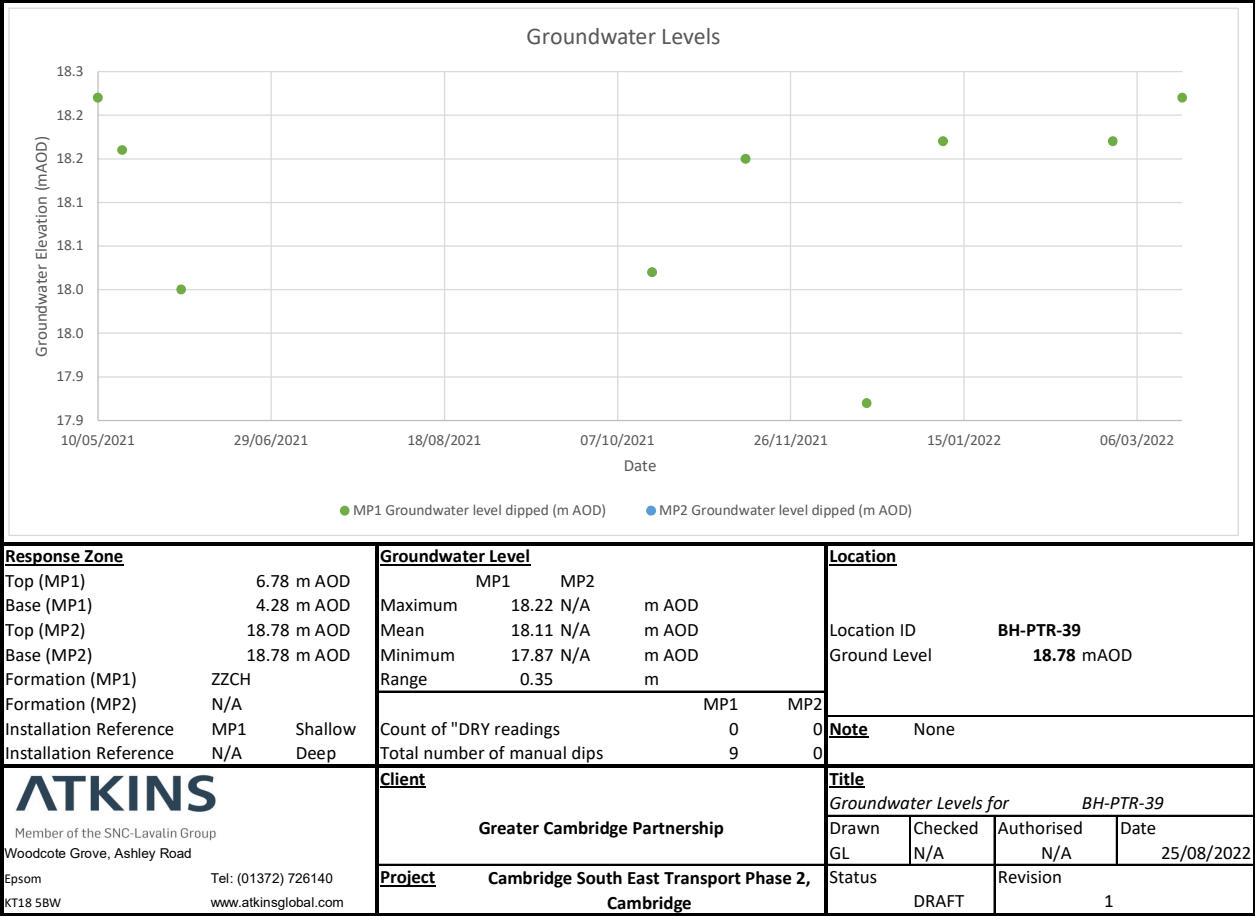
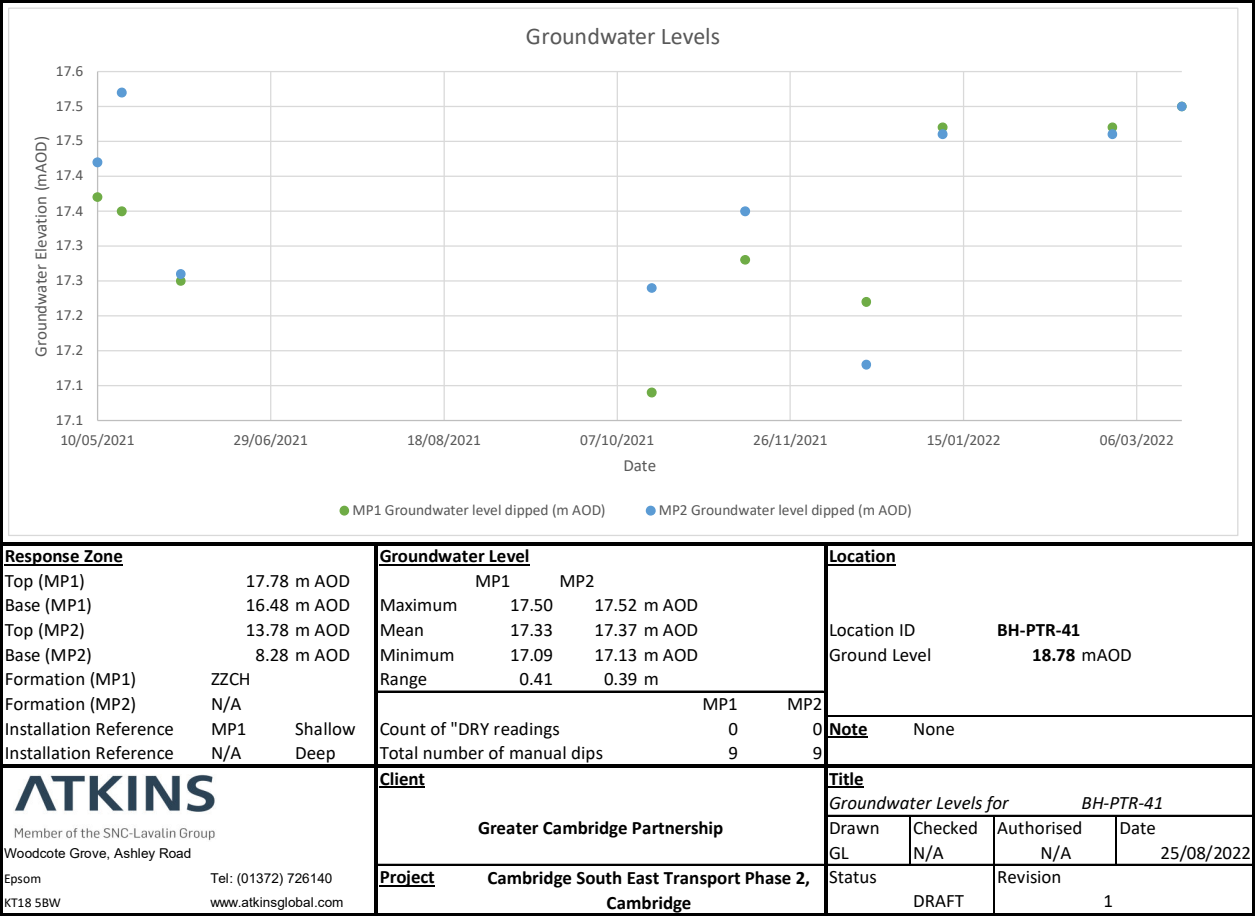
Response Zone			Groundwater Level			Location										
Top (MP1)	12.87	m AOD	MP1	MP2		Location ID Ground Level	BH-PTR-04 13.87 mAOD									
Base (MP1)	10.87	m AOD	Maximum	13.35	N/A				m AOD							
Top (MP2)	N/A	m AOD	Mean	13.15	N/A				m AOD							
Base (MP2)	N/A	m AOD	Minimum	12.97	N/A				m AOD							
Formation (MP1)	ALV/WMCH		Range	0.38					m							
Formation (MP2)	N/A			MP1	MP2											
Installation Reference	MP1	Shallow	Count of "DRY" readings	0	0	Note	None									
Installation Reference	N/A	Deep	Total number of manual dips	9	0											
<div><div>ATKINS</div><div>Member of the SNC-Lavalin Group</div><div>Woodcoke Grove, Ashley Road</div><div>Epsom Tel: (01372) 726140</div><div>KT18 5BW www.atkinsglobal.com</div></div>			<div><div>Client</div><div>Greater Cambridge Partnership</div></div>			<div><div>Title</div><div>Groundwater Levels for BH-PTR-04</div><table><tr><td>Drawn</td><td>Checked</td><td>Authorised</td><td>Date</td></tr><tr><td>GL</td><td>N/A</td><td>N/A</td><td>25/08/2022</td></tr></table></div>			Drawn	Checked	Authorised	Date	GL	N/A	N/A	25/08/2022
Drawn	Checked	Authorised	Date													
GL	N/A	N/A	25/08/2022													
			<div><div>Project</div><div>Cambridge South East Transport Phase 2, Cambridge</div></div>			<div><div>Status</div><div>DRAFT</div></div>		<div><div>Revision</div><div>1</div></div>								

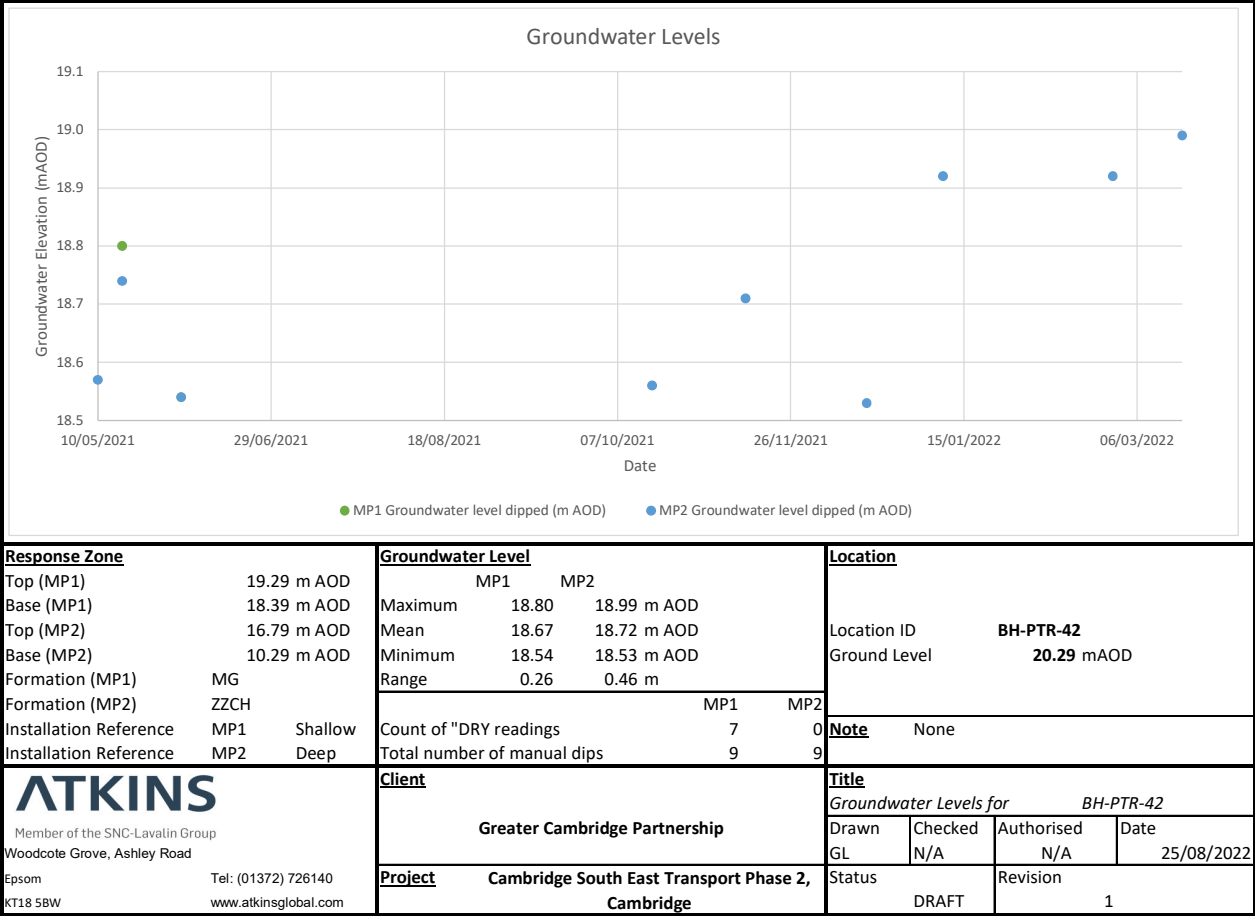
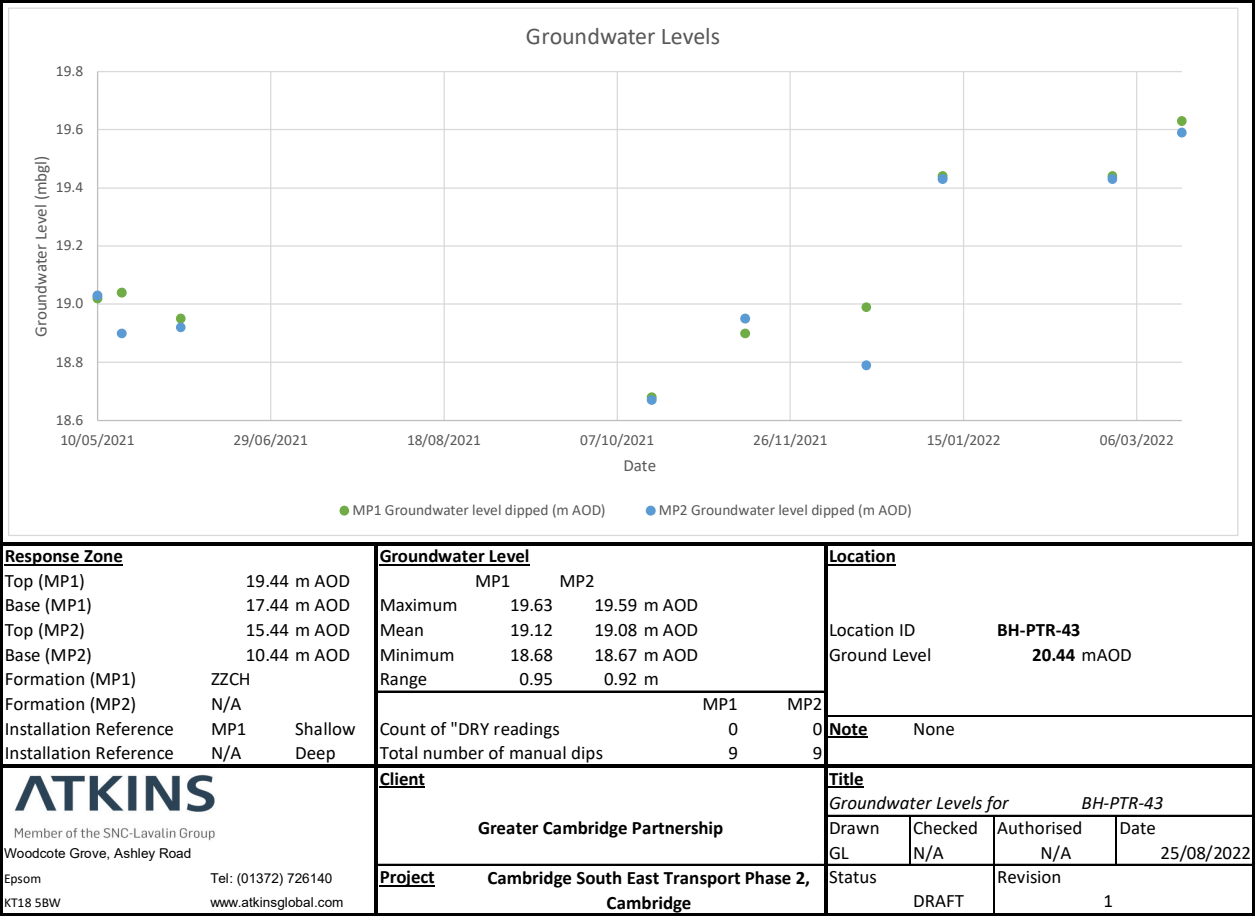


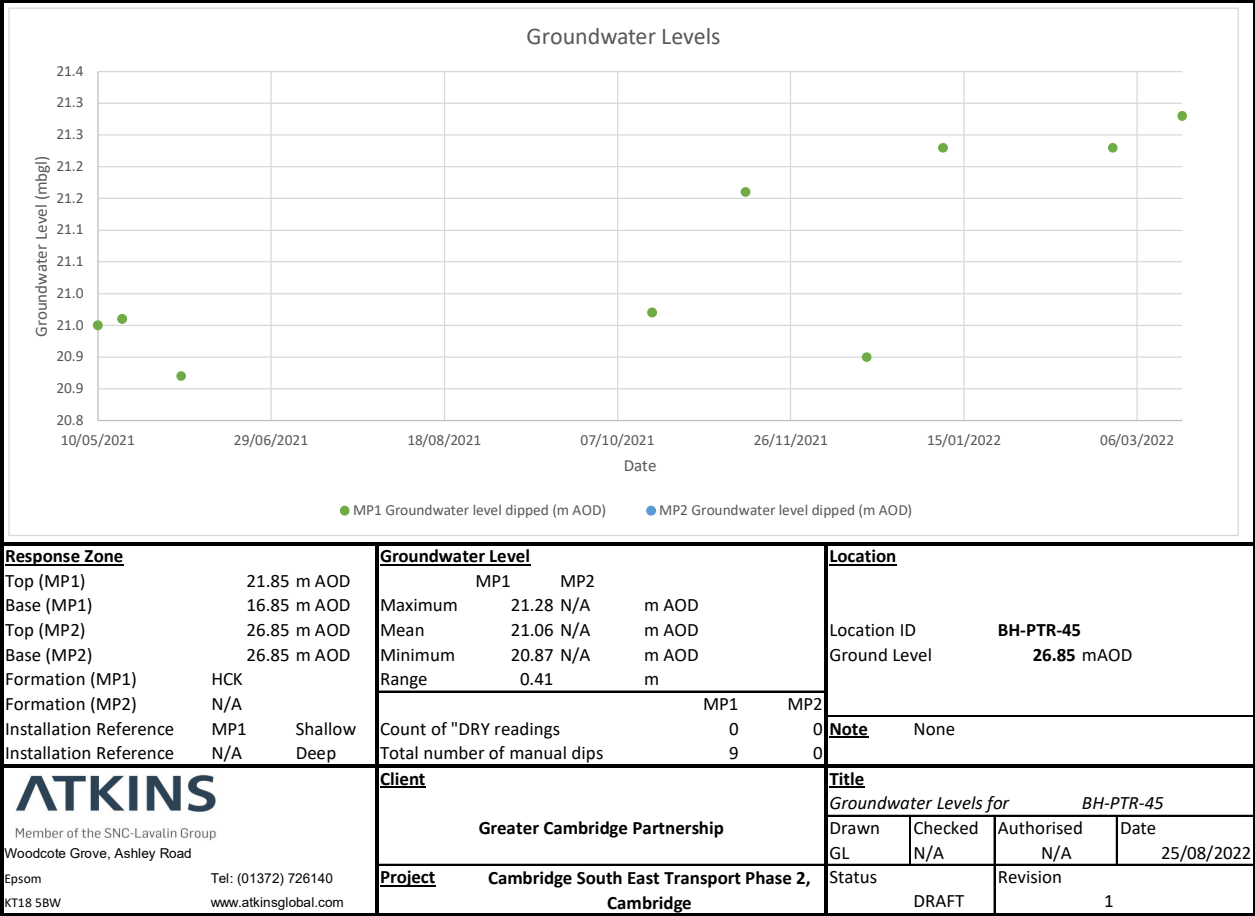
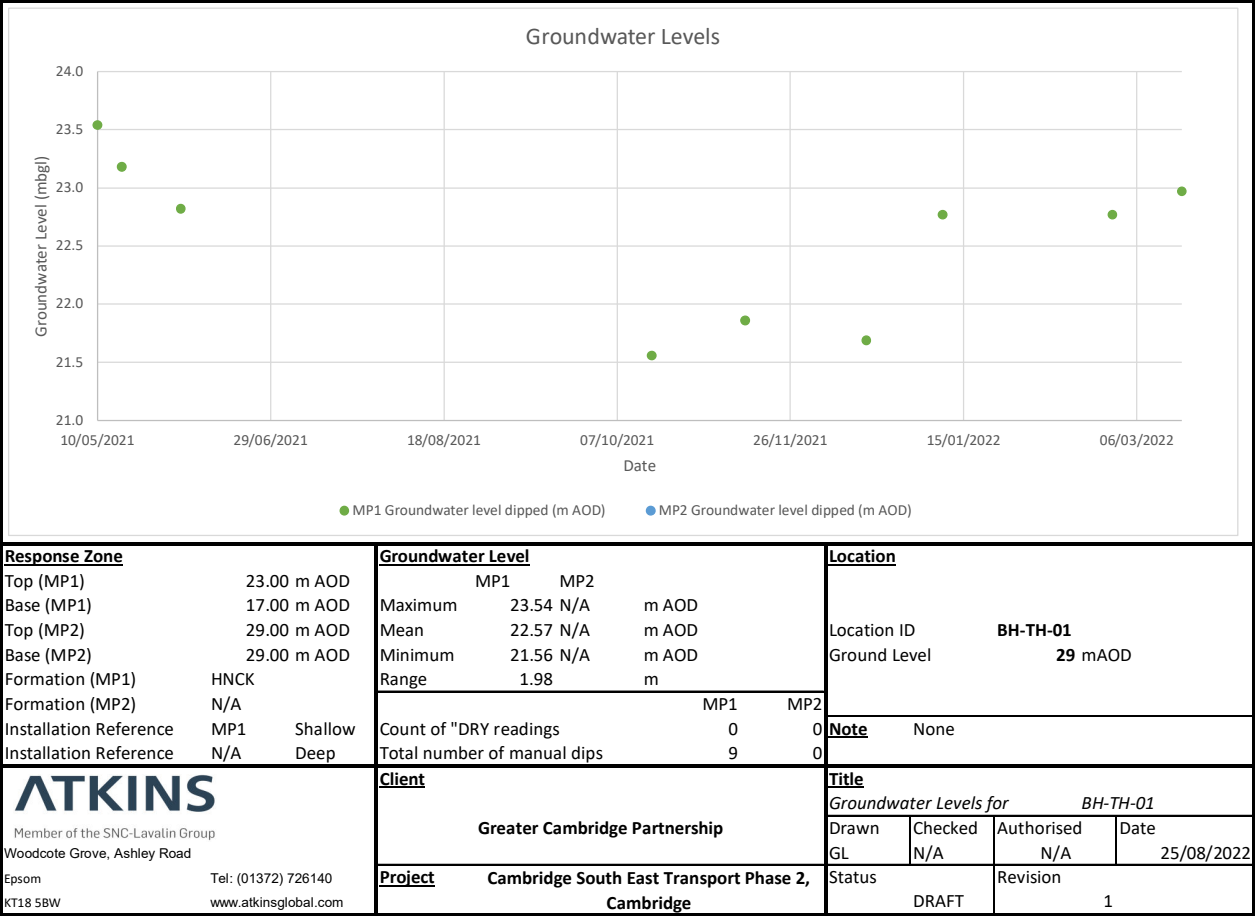
Response Zone			Groundwater Level			Location		
Top (MP1)	10.87	m AOD	MP1	MP2		Location ID BH-PTR-07 Ground Level 13.87 mAOD		
Base (MP1)	3.87	m AOD	Maximum	13.35	N/A			
Top (MP2)	N/A	m AOD	Mean	13.15	N/A			
Base (MP2)	N/A	m AOD	Minimum	12.97	N/A			
Formation (MP1)	WMCH		Range	0.38	m			
Formation (MP2)	N/A			MP1	MP2			
Installation Reference	MP1	Shallow	Count of "DRY readings	0	0	Note	None	
Installation Reference	N/A	Deep	Total number of manual dips	9	0			
ATKINS Member of the SNC-Lavalin Group Woodcote Grove, Ashley Road Epsom Tel: (01372) 726140 KT18 5BW www.atkinsglobal.com			Client Greater Cambridge Partnership			Title <i>Groundwater Levels for BH-PTR-07</i>		
			Project Cambridge South East Transport Phase 2, Cambridge			Drawn GL	Checked N/A	Authorised N/A
						Status DRAFT	Revision 1	Date 25/08/2022

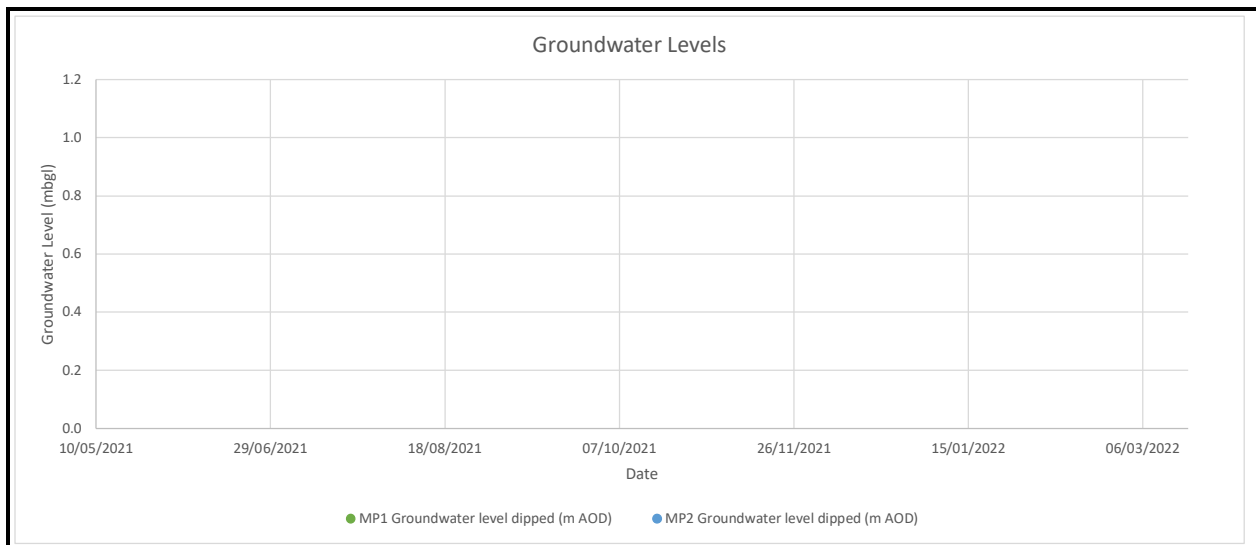




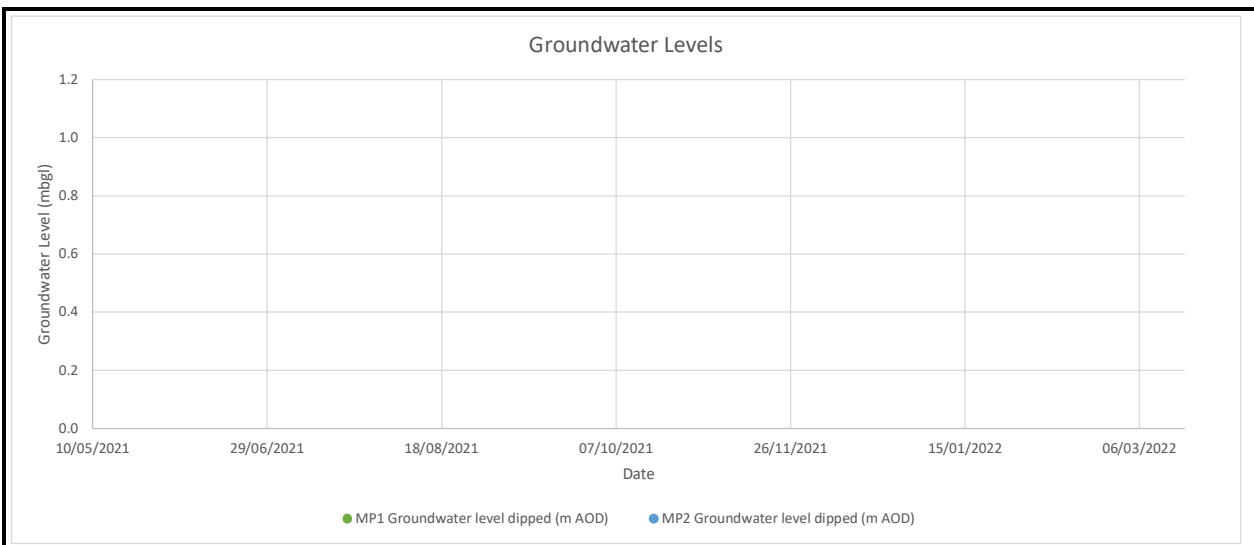




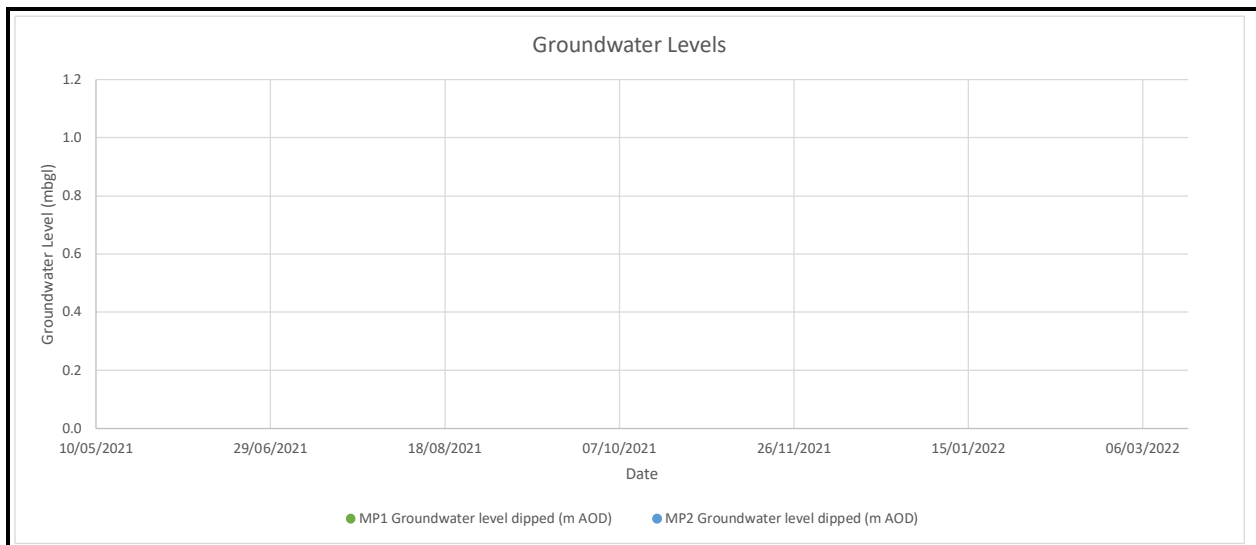




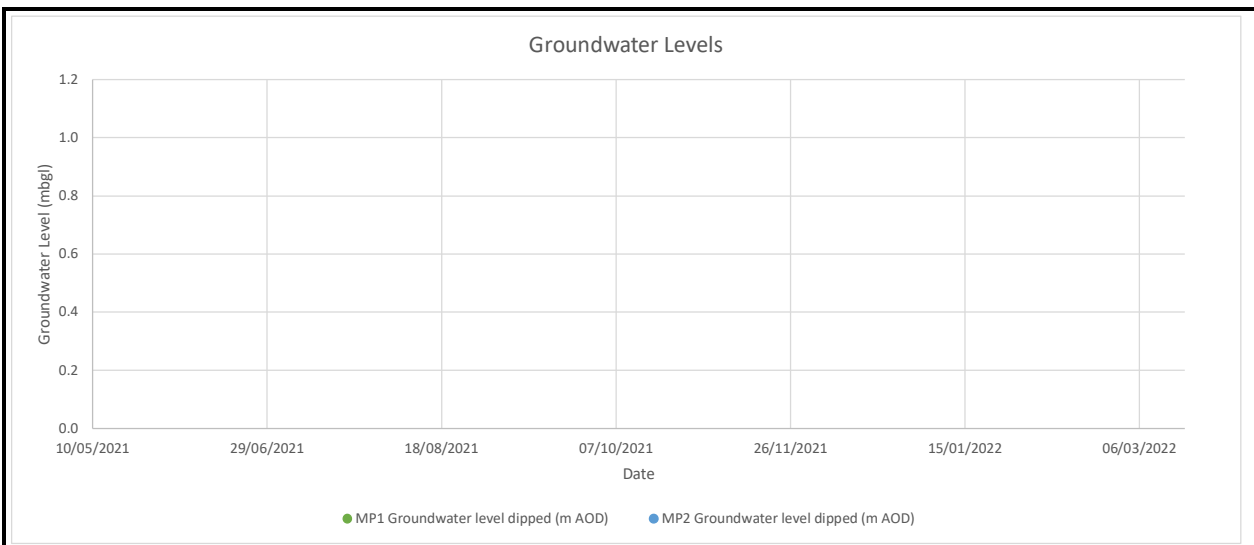
Response Zone		Groundwater Level				Location			
Top (MP1)	28.44 m AOD	MP1	MP2			Location ID Ground Level	BH-TH-03 29.44 m AOD		
Base (MP1)	25.94 m AOD	Maximum Dry	N/A	m AOD					
Top (MP2)	29.44 m AOD	Mean Dry	N/A	m AOD					
Base (MP2)	29.44 m AOD	Minimum Dry	N/A	m AOD					
Formation (MP1)	RTD	Range		m					
Formation (MP2)	N/A			MP1	MP2				
Installation Reference	MP1	Shallow		9	0	Note	None		
Installation Reference	N/A	Deep		9	0				
 <p>Member of the SNC-Lavalin Group</p> <p>Woodcote Grove, Ashley Road</p> <p>Epsom Tel: (01372) 726140</p> <p>KT18 5BW www.atkinsglobal.com</p>		Client				Title			
		Greater Cambridge Partnership				<i>Groundwater Levels for BH-TH-03</i>			
						Drawn	Checked	Authorised	Date
						GL	N/A	N/A	25/08/2022
		Project				Status		Revision	
		Cambridge South East Transport Phase 2, Cambridge							
						DRAFT		1	



Response Zone		Groundwater Level				Location			
Top (MP1)	28.32 m AOD	MP1	MP2			Location ID BH-TH-05 Ground Level 29.32 m AOD			
Base (MP1)	27.32 m AOD	Maximum	Dry	N/A	m AOD				
Top (MP2)	29.32 m AOD	Mean	Dry	N/A	m AOD				
Base (MP2)	29.32 m AOD	Minimum	Dry	N/A	m AOD				
Formation (MP1)	RTD	Range			m				
Formation (MP2)	N/A				MP1	MP2			
Installation Reference	MP1	Count of "DRY" readings			9	0	Note	None	
Installation Reference	N/A	Total number of manual dips			9	0			
ATKINS		Client				Title			
Member of the SNC-Lavalin Group		Greater Cambridge Partnership				<i>Groundwater Levels for BH-TH-05</i>			
Woodcote Grove, Ashley Road						Drawn	Checked	Authorised	Date
Epsom		Project Cambridge South East Transport Phase 2, Cambridge				GL	N/A	N/A	25/08/2022
Tel: (01372) 726140						Status	Revision		
KT18 5BW www.atkinsglobal.com						DRAFT		1	



Response Zone			Groundwater Level				Location			
Top (MP1)	30.65 m AOD		MP1		MP2		Location ID Ground Level	BH-TH-06 31.65 m AOD		
Base (MP1)	23.65 m AOD		Maximum	Dry	N/A	m AOD				
Top (MP2)	31.65 m AOD		Mean	Dry	N/A	m AOD				
Base (MP2)	31.65 m AOD		Minimum	Dry	N/A	m AOD				
Formation (MP1)	HCK		Range			m				
Formation (MP2)	N/A				MP1	MP2				
Installation Reference	MP1	Shallow	Count of "DRY" readings		9	0	Note	None		
Installation Reference	N/A	Deep	Total number of manual dips		9	0				
<div><p>Member of the SNC-Lavalin Group</p><p>Woodcote Grove, Ashley Road</p><p>Epsom Tel: (01372) 726140</p><p>KT18 5BW www.atkinsglobal.com</p></div>			Client				Title			
			Greater Cambridge Partnership				Groundwater Levels for <i>BH-TH-06</i>			
							Drawn	Checked	Authorised	Date
							GL	N/A	N/A	25/08/2022
			Project				Status			
Cambridge South East Transport Phase 2, Cambridge				DRAFT						
				Revision 1						



Response Zone		Groundwater Level				Location			
Top (MP1)	33.71 m AOD	MP1	MP2			Location ID BH-TH-08 Ground Level 34.81 m AOD			
Base (MP1)	30.81 m AOD	Maximum	Dry	N/A	m AOD				
Top (MP2)	34.81 m AOD	Mean	Dry	N/A	m AOD				
Base (MP2)	34.81 m AOD	Minimum	Dry	N/A	m AOD				
Formation (MP1)	RTD	Range			m				
Formation (MP2)	N/A			MP1	MP2				
Installation Reference	MP1	Count of "DRY" readings		9	0	Note	None		
Installation Reference	N/A	Total number of manual dips		9	0				
ATKINS Member of the SNC-Lavalin Group Woodcote Grove, Ashley Road Epsom Tel: (01372) 726140 KT18 5BW www.atkinsglobal.com		Client Greater Cambridge Partnership				Title <i>Groundwater Levels for BH-TH-08</i>			
						Drawn GL	Checked N/A	Authorised N/A	Date 25/08/2022
		Project Cambridge South East Transport Phase 2, Cambridge				Status DRAFT		Revision 1	

Appendix D. Tetra Tech Factual Report

Appendix E. Atkins Contaminated Land Risk Assessment Report

E.1. GCP_5210174_A1307 Cambridge South East Transport_CLRA

A1307 Cambridge South East Transport - Phase 2

Appendix E - Contaminated Land Risk Assessment

Greater Cambridge Partnership

September 2022

Notice

This document and its contents have been prepared and are intended solely as information for Greater Cambridge Partnership (GCP) and use in relation to the proposed Public Transport Route (PTR) that aims to improve transport links between Cambridge and towns and villages to the south-east.

Atkins Limited assumes no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

Document history

Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
1.0	Issue	CF	AD	MC	PH	05/09/22

Contents

Chapter	Page
1. Introduction	1
1.1. Report Objectives	1
1.2. Scope of Work	1
1.3. Overview of the Project	1
1.4. Limitations	5
2. Desk Based Review	7
3. Initial Conceptual Site Model	11
3.1. Introduction	11
3.2. Potential sources	12
3.3. Qualitative Risk Assessment	14
3.4. Initial Conceptual Site Model	14
4. Site Investigation Works	18
4.1. Scope of Investigation	18
4.2. Description of Works Undertaken	18
5. Ground Summary	21
5.1. Scheme Sections	21
5.2. Geology overview	21
5.1. Distribution of geological strata	21
5.2. Groundwater monitoring	23
5.3. Evidence of contamination	27
5.4. Ecological constraints	27
6. Human Health Generic Quantitative Risk Assessment	28
7. Ground Gas Risk Assessment	30
7.1. General	30
7.2. Methodology	30
7.3. Results	31
7.4. Discussion	34
8. Controlled Waters Generic Quantitative Risk Assessment	35
8.1. Groundwater Regime and Selection of Assessment Criteria	35
8.2. Screening	35
8.3. Results and Discussion	42
8.4. Conclusions and Recommendations	43
9. Refined Conceptual Site Model	44
10. Preliminary Waste Assessment	48
10.1. Classification of waste	48
10.2. Suitability for reuse	48
11. Conclusions and recommendations	49
11.1. Summary and Recommendations	49
12. References	51
Appendices	52
Appendix E.1 – Human Health Screening	53
Appendix E.2 Controlled Water Screening	54

Appendix E.3 CATWaste Soils Screening

55

Tables

Table 1-1 - Summary of the preferred travel route [1]	3
Table 1-2 - Summary of travel hub site [1]	3
Table 1-3 - Route sectioning and chainages	4
Table 2-1 – Summary of Mott Macdonald Preliminary Risk Assessment	7
Table 3-1 - Qualitative Risk Matrix	14
Table 3-2 - Risk Classifications	14
Table 3-3 - Initial Conceptual Site Model	15
Table 5-1 - Geology overview of the scheme	21
Table 5-2 - Summary of distribution of geology along the scheme	21
Table 5-3 - Summary of groundwater monitoring results	24
Table 5-4 – Visual and Olfactory Evidence of Contamination	27
Table 6-1 - Soil GAC exceedances (public open space (parks))	29
Table 7-1 - Ground Gas Assessment Summary	31
Table 8-1 - Soil leachate EQS exceedances	36
Table 8-2 - Soil leachate DWS exceedances	37
Table 8-3 - Groundwater EQS exceedances	38
Table 8-4 - Groundwater DWS exceedances	40
Table 8-5 - Comparison of Metal Soil-leachate and Groundwater Exceedances	42
Table 9-1 - Revised conceptual site model	45

1. Introduction

Atkins Limited has been commissioned by Greater Cambridge Partnerships (GCP) to produce a Contaminated Land Risk Assessment (CLRA) in support of the A1307 Cambridge South East Transport (CSET) Scheme.

A ground investigation (GI) was designed and specified by Mott MacDonald Ltd [1] and was undertaken in March and April 2021 by Tetra Tech [2].

This CLRA has been prepared to inform issues specific to land quality in the context of the proposed infrastructure improvement Scheme.

1.1. Report Objectives

The objectives of this report are to:

- Provide a land contamination assessment to identify potential risks to human health and controlled waters, together with potential recommendations for mitigation;
- Inform the potential for material reuse / waste disposal; and
- Identify geo-environmental risks to the project and recommendations for mitigation.

1.2. Scope of Work

The scope of the assessment was progressed to fulfil the objectives is outlined below:

- Review and summarisation of the Mott Macdonald Geotechnical and Geo-environmental Preliminary Risk Assessment produced in December 2019;
- Develop an Initial Conceptual Site Model (ICSM) to identify potentially unacceptable risks and constraints that may be associated with the Scheme.
- Review and summarisation of the Tetra Tech Factual Ground Investigation Report produced in March 2022;
- Complete Human Health and Controlled Waters Generic Quantitative Risk Assessments (GQRA), and;
- Undertake a waste and material reuse assessment to support future decision making.

1.3. Overview of the Project

The CSET aims to deliver a new High Quality Public Transport (HQPT) bus route and associated infrastructure alongside a proposed travel hub facility southeast of Cambridge, presented in Figure 1-1.

The Scheme will connect the existing guided busway at the Cambridge Biomedical Campus (CBC) along Francis Crick Avenue (FCA). The Scheme will run via Sawston, Stapleford and Great Shelford and connections will be provided to Babraham, Babraham Research Campus and Granta Park via the travel hub site.

The scheme aims to provide dedicated HQPT routes for transport into and out of Cambridge from the southeast, as well as additional transport capability for developments proposed within Greater Cambridge to mitigate the impact of future growth along the A1307 corridor [3].

The scheme comprises three key elements, summarised below:

1. New Travel Hub site off the A1307/A11 junction with vehicle parking facilities; and,
2. Construction of a new HQPT route between the proposed Travel hub Site and Cambridge with stops along the route;
3. New Active Travel Path (ATP) for pedestrians, cyclists and equestrians.

Initial concepts for the scheme included five different HQPT which ran between three different travel hub sites which were discussed in Mott MacDonald Geotechnical and Geo-Environmental Preliminary Risk Assessment report [4]. Since the scheme progressed a preferred travel route and travel hub site option (Option B) have been developed which is detailed and assessed within this report.

The current general arrangements for the route alignment and location of the travel hub site are provided on nineteen drawings produced by Mott MacDonald, drawing references 403394-MMD-

HWA-00-DR-HW-0925-P2 to 0943-P2. The overall scheme is provided on Mott MacDonald drawing reference 403394-MMD-HWA-00-DR-HW-0948-P2 titled 'Route Layout Plan' and in Figure 1-1, below.

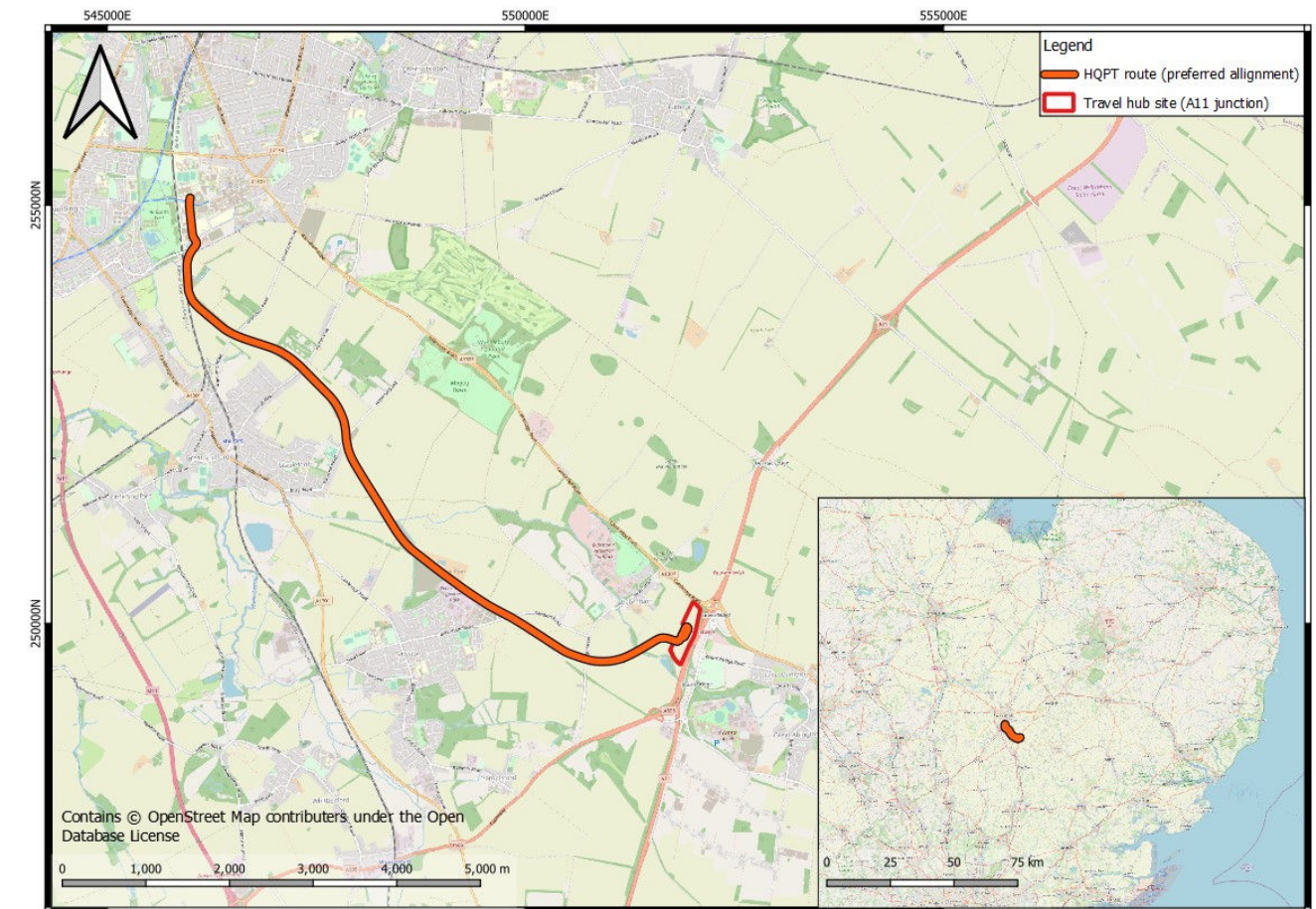


Figure 1-1 - Site location and preferred route alignment and travel hub location

1.3.1. Description of the Scheme Area and Route Alignment

Within this report, the 'scheme' refers to land along the linear route in orange and red as presented in Figure 1-1. Land away from the route and within 250 m is referenced herein as 'off site'.

The scheme lies to the southeast of Cambridge and to the southwest of the junction between the A1134 and A1307 within the county of Cambridgeshire. The northern end of the scheme will start at the Cambridge Biomedical Campus, which includes the headquarters of AstraZeneca where the route will be at-grade with the current busway. The route will primarily traverse agricultural land comprising arable fields segregated by hedgerows and treelines. The route passes adjacently through residential areas of Stapleford and Sawston to the west and southwest, and Babraham Research Campus to the north. The route will terminate at the proposed travel hub site, located southwest of the junction between the A1307 and the A11.

There is one main river system within the scheme extents, the River Granta transecting the scheme in two locations, the centre and south east located between the villages of Stapleford and Sawston and between Babraham and the Great Abingdon. Hobsons Brook, a spring fed stream sourced from Nine Wells Nature Reserve, transects the route south of Addenbrooke's Road. Other surface water features are also present along the scheme, including ponds, lakes, reservoirs and springs.

A summary of the preferred travel route and travel hub site are summarised in the tables below.

Table 1-1 - Summary of the preferred travel route [1]

Route Option	Start Grid Reference	End Grid Reference	Approximate Length (km)
Preferred Travel Route	55180, 249784	545981, 255038	9.3

Table 1-2 - Summary of travel hub site [1]

Travel Hub Option Location	Grid Reference (Centre point)	Approximate area (km ²)
Option B	551933, 249888	0.09

1.3.1.1. Known Alterations to Preferred Proposed Alignment - Retirement Village

A retirement village has recently been proposed by Axis Ltd located to the northeast of Stapleford, to the northwest of Haverhill Road named 'Stapleford Retirement Village' resulting in the requirement for a route re-alignment of the existing route.

Currently, there are two options proposed for the realignment of the HQPT which both cross Haverhill Road approximately 120 m northwest of the original alignment, named Option 1 and Option 2. These are presented in Figure 1-2 below. At this stage, Option 1 is the most likely route that the scheme will proceed with. Currently ground investigation has only been targeted at the initial alignment and no data is presented for the realignment options.

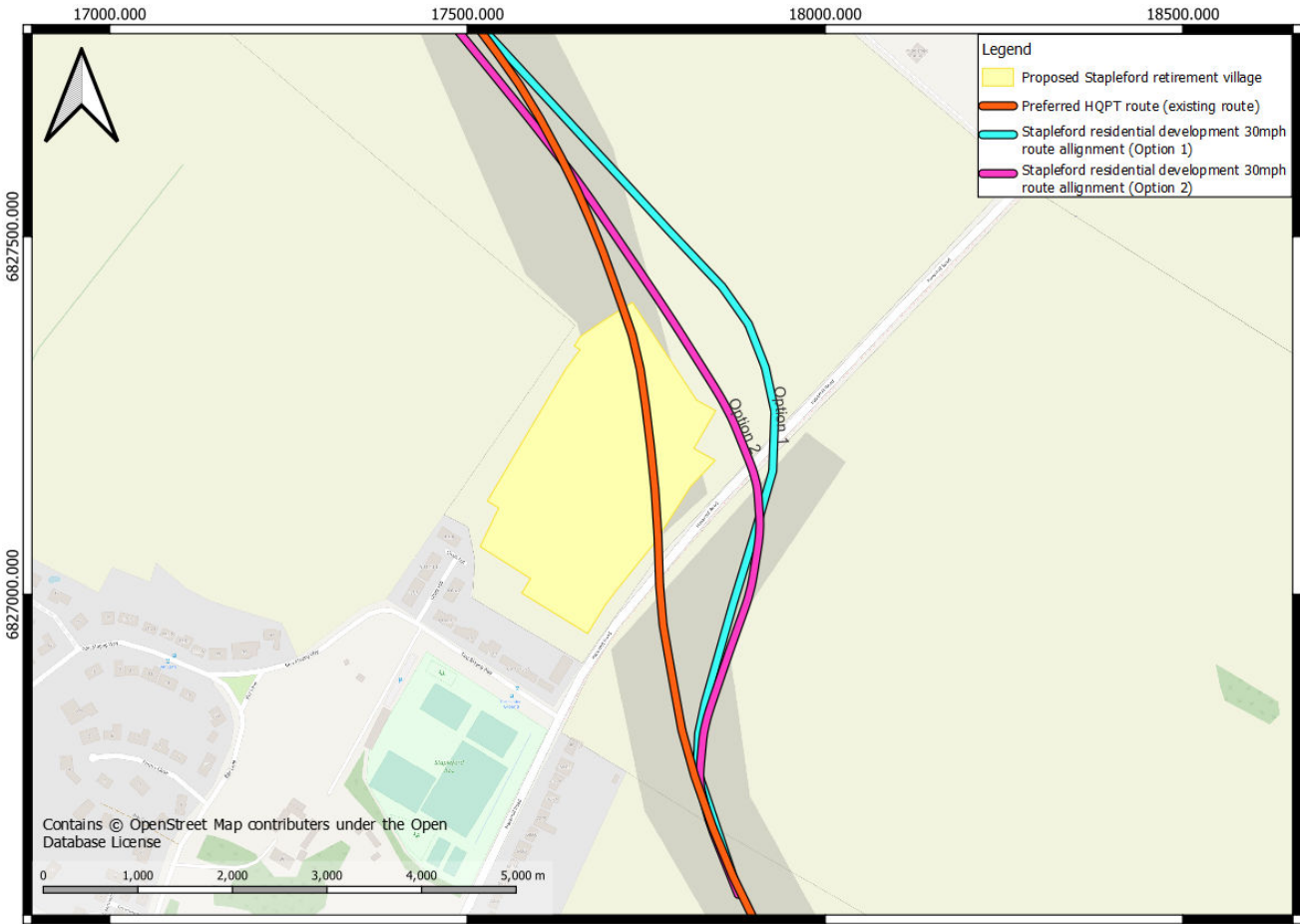


Figure 1-2 - Summary of route realignment options for Stapleford Retirement Village

1.3.1.2. Route Sections and Chainages

The route has been divided into six sections which will be assessed within this report. Current chainages are consistent with Atkins' re-design (detailed in full in Atkins Geotechnical GIR) and slightly differ to that set out within the Mott MacDonald Corridor Design Report [3]. The sections have been summarised in the Table 1-3 and presented in a schematic plan as Figure 1-3 below.

Table 1-3 - Route sectioning and chainages

Section	Location	Start Chainage (m)	End Chainage (m)
1	Cambridge Biomedical Campus to Dame Mary Archer Roundabout	0	500
2	Dame Mary Archer Roundabout to Hinton Way. Grahams Fields	500	2800
3	Hinton Way to public footpath leading from Bury Road	2800	4600
4	Public footpath to North Farm	4600	6066
5	West Way to High Street	6066	8066
6	High Street to A11 Travel Hub	8066	9275

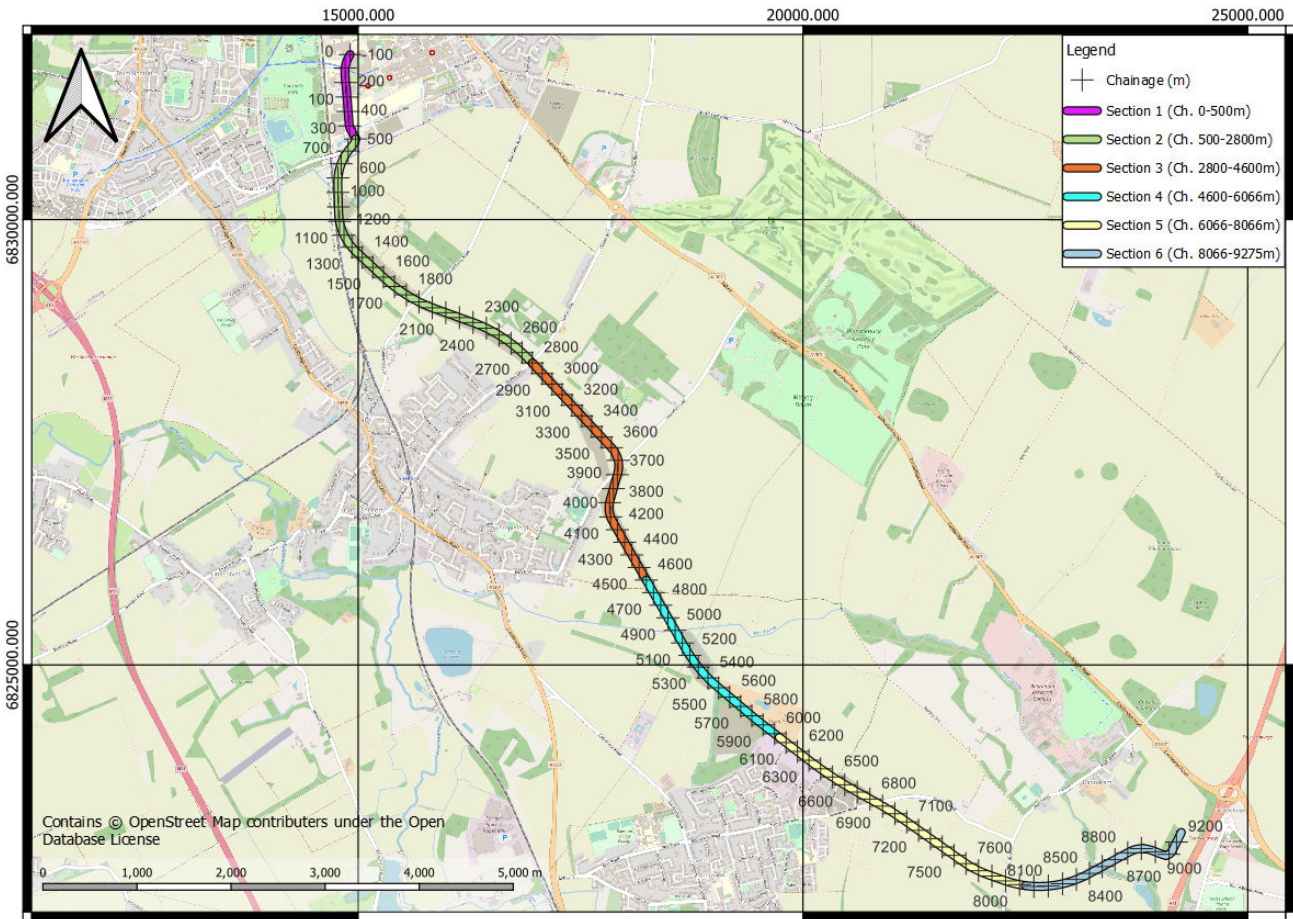


Figure 1-3 - Route sectioning along the preferred HQPT route

1.3.2. Description of the Proposed Scheme

The scheme comprised the following principal elements [3], a general arrangement plan for the proposed Scheme is presented as Figure 1-4:

4. A new HQPT route approximately 7.3m wide between the A11 Travel Hub and Cambridge Biomedical Campus (See Figure 1-1), the majority of which is to be a dedicated HQPT route, however to the north there is a segregated HQPT route section along Francis Crick Avenue;
5. A new Travel Hub site off the A1307 / A11 and associated ancillary infrastructure;
6. Construction of a new Active Travel Path (ATP) for cycling/walking facilities, running adjacent to the HQPT route between the A11 Travel Hub and a point south of Francis Crick Avenue;
7. Ancillary works including signal-controlled junctions, junction upgrades, tie-ins to existing infrastructure, lighting and landscaping;
8. Upgrades to Francis Crick Avenue to create segregated HQPT lanes along the road; and
9. Enhancements to the existing cycle provision (The DNA Cycle Path) between the ATP at the DNA Cycle Path tie in, and its junction with Francis Crick Avenue.

This report is prepared and written in the context of an agreed scope of work and should not be used in a different context. Furthermore, new information, improved practices and changes in legislation may necessitate a re-interpretation of the report in whole or in part after its original submission.

Due to the inherent variability of the ground conditions between exploratory hole positions, interpretations are subject to the limitations of only assessing a relatively small proportion of sub-surface conditions at the Scheme.

This report should be read in line with current legislation, statutory requirements and/or industry good practice applicable at the time of the works being undertaken. Any changes in this legislation, guidance or design may dictate the findings provided within this report to be reassessed.

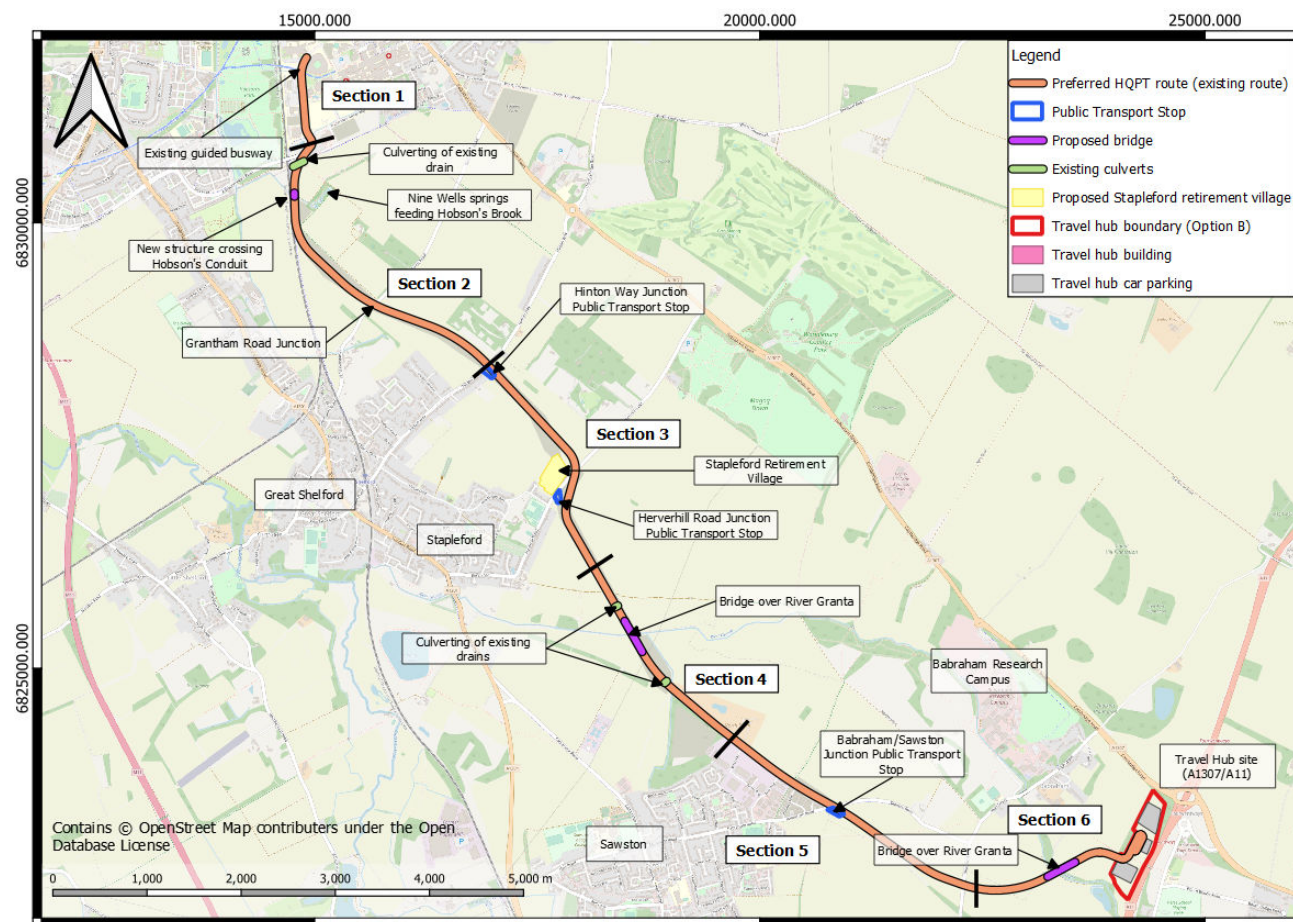


Figure 1-4 – Summary of general arrangement along preferred route alignment

1.4. Limitations

The findings and opinions conveyed in this report are based on information obtained from a variety of third-party sources, as detailed within Table 1-1, which Atkins understands are reliable. Nevertheless, Atkins cannot and do not guarantee the authenticity or reliability of the information. Furthermore, it is possible that the research carried out, whilst fully appropriate to meet the requirements of the brief, may not indicate the full extent of conditions across the Scheme and the existence of other information sources. Assuming such sources exist, their information could not have been used in the formulation of the findings and options presented in this report.

2. Desk Based Review

A summary of the historical and environmental setting extracted from the Mott Macdonald Geotechnical and Geo-environmental Preliminary Risk Assessment of the Scheme alongside other publicly available sources of information is presented in Table 2-1.

Table 2-1 – Summary of Mott Macdonald Preliminary Risk Assessment

Item	Description
Current Land Use	<p>Section 1</p> <p>The section is c.500 m trending north to south from the existing bus route (Ch. 0m) along Francis Crick Avenue to Cambridge Biomedical Campus, with an elevation of approximately 15mAOD along the route. The route lies to the east of Bellatrix development (Biological Support Building) and the west of Addenbrooke's Hospital.</p> <p>Section 2</p> <p>The section of the scheme is c.2500m long beginning at Dame Mary Archer roundabout to the south of Cambridge Biomedical Campus. The section connects the existing guided busway approximately 450 m north running along Francis Crick Avenue. The section aligns south to southeast crossing a drainage ditch and cycleway at Ch. 667 m and Hobson's Brook spring fed stream at Ch. 900 m, originating from Nine Wells Nature Reserve, located 80 m east of the route. The route runs parallel with Berthnal Green and King's Lynn Line until Ch. 1100 m where it diverts to the southeast across agricultural fields to Hinton Way. Elevation gradually increases from 15 m AOD at Dame Mary Archer roundabout to 30 m AOD at Hinton Way.</p> <p>Section 3</p> <p>The section is c. 1800 m long commencing at Hinton Way, located on a corridor between residential properties at an elevation of 30 m AOD. The route is orientated southeast for approximately 925 m towards Haverhill Road, southwest of Fox Hill, where elevations are between 38-40 m AOD, where it bears south to southeast towards the River Granta decreasing in elevation to 20 m AOD. The borough of Stapleford lies approximately 150 m east to the section.</p> <p>Section 4</p> <p>The section is c. 1466 m long and cross the River Granta at Ch. 5000 m at an elevation of approximately 19 m AOD. The section then bears to the southeast towards North Farm where elevation remains at 20 m AOD. The town of Sawston lies immediately to the south of the section.</p> <p>Section 5</p> <p>This section is c.2000 m long beginning at North Farm and ending at High Street. The route runs parallel with South Cambridge Business Park (Sawston) for approximately 770 m where it cross Sawston Road and Sawston-Babraham cycleway at Ch. 6870 m where the elevation gradually increases from 23 m AOD to 27 m AOD. The route bears to the southwest towards High Street, at elevation approximately 28 m AOD, located 80 m northeast of a northwest to southeast trending disused railway and approximately 370 m south of Church Farm.</p> <p>Section 6</p> <p>This section is c.1209 m long running northeast towards the A11 to the proposed travel hub site. The route crosses the River Granta</p>

	<p>Ch. 8564 m. The route traverse across agricultural fields, from High Street at approximately 30 m AOD elevation. The majority of the route lies at 27 m AOD, where it then increases to 32 m AOD at Two Acre Plantation (Ch. 9116 m).</p> <p>The travel hub site is located immediately to the southeast of Two Acre Plantation, west of the A11. The section is located approximately 400 m south of Babraham.</p>								
Key Historical Land Uses (potentially contaminative uses)	<p>The history of the site and surrounding area (within 500m of the site) has been reviewed and is discussed within the Mott MacDonald Desk Study.</p> <p>Earliest available mapping (1886) indicated that the site area comprises mainly agricultural farmland. The Great Eastern Railway is located to the southwest of the proposed route and orientates southeast to northwest from Great Abington to White Hill. The Great Eastern Railway is shown to be dismantled in 1973-1977. Old gravel pits are noted to the southeast of the alignment and a number of chalk pits are noted along the route. A spring is located at North Farm, Granham's Farm and Nine Springs.</p> <p>The towns of Babraham, Sawston and Stapleford are shown on mapping in early 1900. Cherry Hinton and Trumpington are shown on mapping in early 1900 with development increasing in 1960 with Addernbrookes Hospital noted in mapping in early 1970 to the north of the site. In 1996 the A11 is noted to be widened with a new alignment which crosses the River Granta. The Four Went Ways roundabout is shown in the south of the site, which joins the A1307 to the A11.</p>								
Topography	<p>Topographic mapping and LiDar shows that along the majority of the route elevation generally lies between 20 m AOD and 30 m AOD. Elevations between 30 m AOD to 40 m AOD are shown along Section 3 between chainages 2820 m and 3455 m.</p> <p>Elevation generally increases from the end of Section 1, south of Dame Mary Archer roundabout, from 13 m AOD to the beginning of Section 3, at 30 m AOD at Hinton Way. The highest elevation point is 38.8 m AOD recorded along Section 3 within agricultural fields. Ground level gently decreases towards Haverhill and further towards the River Granta at 17 m AOD. Along the remainder of the route the elevation further increases towards Sawston Road in Section 5, noted at 26 m AOD, and the travel hub site where ground levels are recorded up to 35 m AOD.</p>								
Published Geology	<p>A review of the published geology present at the Scheme is provided below based on information held by the BGS open geoscience online database [2], the Lexicon of Named Rock Units [10] and the BGS 1:50,000 published Geological Mapping Sheet 205 'Saffron Walden', with both the bedrock and superficial edition and the bedrock edition [4] [5]. No Made Ground, Artificial Ground or Landscaped Ground was reported by BGS according to the Mott Macdonald Assessment. There is one entry of Worked Ground situated 250 m north of Section 6.</p> <table> <tr> <td>Section 1</td><td>Superficial Deposits: None reported. Bedrock Deposits: White Chalk</td></tr> <tr> <td>Section 2</td><td>Superficial Deposits: None reported. Bedrock Deposits: White Chalk</td></tr> <tr> <td>Section 3</td><td>Superficial Deposits: None reported. Bedrock Deposits: White Chalk</td></tr> <tr> <td>Section 4</td><td>Superficial Deposits: None reported.</td></tr> </table>	Section 1	Superficial Deposits: None reported. Bedrock Deposits: White Chalk	Section 2	Superficial Deposits: None reported. Bedrock Deposits: White Chalk	Section 3	Superficial Deposits: None reported. Bedrock Deposits: White Chalk	Section 4	Superficial Deposits: None reported.
Section 1	Superficial Deposits: None reported. Bedrock Deposits: White Chalk								
Section 2	Superficial Deposits: None reported. Bedrock Deposits: White Chalk								
Section 3	Superficial Deposits: None reported. Bedrock Deposits: White Chalk								
Section 4	Superficial Deposits: None reported.								

	Bedrock Deposits: White Chalk
Section 5	Superficial Deposits: Alluvium and River Terrace Deposits are recorded across 50% of this section. Bedrock Deposits: White Chalk
Section 6	Superficial Deposits: Alluvium, River Terrace Deposits and Lowestoft Formation Bedrock Deposits: White Chalk
Travel Hub B	Superficial Deposits: Alluvium and River Terrace Deposits Bedrock Deposits: White Chalk
Hydrogeology	<p>The Environment Agency [5] classifies the underlying geological units as the following:</p> <ul style="list-style-type: none"> Alluvium: Secondary A aquifer River Terrace Deposits: Secondary A aquifer Lowestoft Formation: Secondary undifferentiated White Chalk: Principal Aquifer <p>The BGS hydrogeological map indicates that groundwater levels range from 19 m AOD in the northwest of the Scheme to 21 m AOD in the southeast.</p> <p>Two surface water abstractions are reported in Section 2, the first of which is 100 m east of the Scheme and the second 172 m east. Both abstractions are associated with agriculture spray and direct irrigation.</p> <p>One surface water abstraction is reported 164 m south west of Section 3. Two surface water abstractions are reported in Section 6 the closest of which is within the Scheme boundary at Babraham Farms.</p> <p>An Environment Agency Source Protection Zone (SPZs) II is mapped across Sections 5, 6 and the Travel Hub B. A SPZ III is also mapped in Section 5. No SPZs are mapped in Sections 1 – 4.</p>
Hydrology	<p>The northwest-southeast orientated River Granta transects the public transport route halfway along its length, between the villages of Stapleford and Sawston (section 5) and also between Babraham and the Great Abingdon (section 6). The river also flows to the immediate south of Travel Hub Option B. The roughly north-south trending Hobson's Brook is indicated approximately 380 m west of the scheme, in the scheme's north eastern extent.</p> <p>Springs are indicated on OS mapping in the northwest, originating in the Nine Wells Nature Reserve and immediately north of Great Shelford, proximal to Graham's Farm. Both springs are shown to join with Hobson's Brook.</p> <p>The Environment Agency Catchment Data Explorer [6] assigned the River Granta the following classifications in 2019:</p> <ul style="list-style-type: none"> Chemical: Fail Ecological: Moderate <p>No Environment Agency chemical data is available for Hobson's Brook</p>
Fuel Stations & Contemporary Trade Directory Entries	The Mott Macdonald report indicates there are two fuel station records within 250 m of the Scheme.
Contaminated Land Register and Notices	The Mott Macdonald Report indicates none within 500 m of the Scheme.

Pollution Incidents	The Mott Macdonald Report indicates there were no pollution incidents classified above minor recorded within 500 m of the Scheme.
Hazardous Substances	The Mott Macdonald Report indicates there are no Control of Major Accident Hazards (COMAH), The Notification of Installations Handling Hazardous Substances (NIHHS), explosive sites or planning hazardous consents recorded within 500 m of the Scheme.
Radon	The UK Radon Online Viewer indicate that the Scheme is within an area classified as being within a lower probability radon area; meaning that less than 1% of homes are above the action level.
Unexploded Ordnance	<p>A Preliminary Unexploded Ordnance (UXO) Risk Assessment was conducted by 6 Alpha Associates as part of the Mott Macdonald Report.</p> <p>The UXO assessment indicated that it was a high risk area. It was recommended that a Detailed UXO Report is undertaken for the site prior to any intrusive works being carried out.</p>
Sensitive Land Uses	The Mott Macdonald Report indicates there are no sensitive land uses (Ramsar sites, Sites of Special Scientific Interest, Special Area of Conservation, Special Protection Areas, National Parks, Local Nature Reserves and National Nature Reserves within 500 m of the Scheme.

3. Initial Conceptual Site Model

3.1. Introduction

Current legislation relating to contaminated land is contained within Part 2A of the Environmental Protection Act (EPA) 1990 [7]. Land contamination is also a material consideration under the Town and Country Planning Act 1990 [8] and is aligned with the requirements under Part 2A EPA 1990 [7] and the National Planning Policy Framework [9] which concern the future use of a site. The latter states that:

- The site should be suitable for its new use, taking account of ground conditions and land instability, including that from natural hazards or former activities, and pollution arising from previous uses;
- The development (proposed improvement works) is suitable for its location, i.e., unacceptable risks from pollution and land stability are prevented and that unacceptable risks to human health, buildings and the environment are mitigated; and
- Where a site is affected by contamination or land stability issues, responsibility for securing a safe development is with the developer and/or landowner.

In accordance with guidance provided in Land Contamination: Risk Management (LC:RM) [10] as published by the Environment Agency, human health, buildings and wider environmental receptors (such as controlled waters) and pathways have been identified, taking into consideration the proposed improvement works.

LC:RM provides a technical framework for identifying and remediating contamination through the application of a risk management process. The question of whether risk is unacceptable in any particular case involves not only scientific and technical assessments, but also appropriate criteria by which to judge the risk and conclude what risk would be unacceptable.

An Initial Conceptual Site Model (ICSM) has been developed based on the available information, to enable the assessment of the potential land contamination. An ICSM describes the relationship between potential sources of contamination and potential receptors to those sources. As part of the ICSM development, three elements are identified and assessed:

- Source of contamination and associated contaminants;
- Receptors to that contamination – human beings, controlled waters (surface water/groundwater), ecological systems and property; and
- Pathways between the sources and receptors.

Where all three elements are present or are likely to be present, they are described as potential contaminant linkages (PCLs), which can then be subjected to the risk assessment and risk management process.

The preliminary risk categorisations presented are based on an assessment of the potential consequence of each PCL occurring along with the likelihood that each PCL will occur. Potential contaminants that might be present have been identified through knowledge of historical land uses in the Study Area. The risk assessment has been undertaken in consideration of the proposed improvement works.

3.2. Potential sources

Based on the available information detailed in the Mott MacDonald [11] desk study the following sources of contamination have been identified:

At the Scheme (On-Site)

Historical and current potentially contaminative activities which could give rise to contaminants in, on, or under the ground comprise:

- Artificial Ground and associated contamination from past and current structures / infrastructure / historical mining / infilled pits.
- Potential asbestos from demolished historical structures within soil or associated with potentially infilled ground.
- Vehicles and trains using existing / historical infrastructure that may have resulted in fuel/oil spillages to ground.
- Large areas of the Scheme and surroundings are currently designated as agricultural fields so agricultural pesticides and sewage sludge may have been applied to the ground, with localised fuel fuel/oil spillages from agricultural machinery possible.
- Organics associated with the Alluvium deposits with the potential to produce ground gas.

Off-site

Contaminants from off-site sources which have the potential to impact the site include:

- Existing and historical infrastructure surrounding the site such as the Cambridge-London railway, disused railway and traffic using surrounding roads could be a potential source of hydrocarbons (e.g. via fuel and/or oil leaks)
- Numerous surrounding industries such as historical mining, farming, engineering works and depots, along with businesses such as fuel stations, garages, tyre dealers, cleaners and waste disposal services which are present in the surrounding area.
- Historical landfill sites in the wider area (up to 250 m from the route centreline)
- Sewage farms and pumping stations may result in contamination associated with chemicals associated with water purification.

3.2.1. Potential receptors

The following receptors have been identified at the site.

Human health

Potential human receptors are considered to comprise:

- Scheme users (users of the Travel Hub and public transport route) and
- Scheme users (construction / maintenance workers).
- Off site residents to the south west of Section 5 and off site residents in the planned retirement home in Stapleford
- Off site commercial workers to the east and west of Section 1.

Controlled waters

Potential controlled waters receptors are considered to comprise:

- Groundwater in the secondary A and principal aquifers associated with the superficial / bedrock deposits underlying the Scheme
- Surface water that intersect the Scheme – The River Granta and Hobson's Brook

Property and Services:

- Residential and commercial properties within 250 m of the Scheme
- Enclosed spaces associated with the infrastructure work (ie. borrow pits / maintenance pits)
- Services and Infrastructure (including piles and foundations)

It should be noted that under current health and safety legislation, construction and maintenance workers are required to carry out appropriate risk assessments and instigate appropriate mitigating

measures to protect themselves, other human receptors and the environment from contamination which may be present.

Such risks must be adequately mitigated by the measures required under current legislation, specifically the Construction Design Management (CDM) Regulations [12] which requires that potential risks to human health and the environment from construction activities are appropriately identified and all necessary steps taken to eliminate / manage that risk.

On this basis, it been assumed that personal protective equipment (PPE) and health and safety best practices will be adopted during the construction works and acute risks to construction workers / site visitors have therefore not been considered as part of this assessment.

3.2.2. Potential pathways

The potential pathways and receptors depend upon the current and proposed end use of the Scheme.

The Scheme comprises the creation of a HQPT Bus Route and associated infrastructure; there are no enclosed structures proposed along the route, however, ground gas and vapour pathways have been included as a precautionary measure on the basis the design may change in the future and to assess the risks to future receptors associated with the Travel Hub structure.

Human health

Human receptors could be exposed to potential contamination through the following pathways:

- Ingestion of contaminated soils, soil derived dust, surface water and groundwater;
- Inhalation of soil and soil derived dust / fibres;
- Inhalation of asbestos fibres;
- Dermal contact with soil, soil derived dust and groundwater;
- Ground gas / vapour migration and accumulation in enclosed structures followed by ignition and explosion or inhalation and asphyxiation.

Controlled waters

Controlled waters receptors may be affected by potential contamination by the following pathways:

- Leaching/ vertical migration of contaminants in soils to underlying groundwater
- Migration of groundwater
- Vertical migration of contaminants via preferential pathways such as via piles to deeper groundwater
- Vertical migration of contaminants via preferential pathways such as via piles to groundwater followed by lateral migration

Property

Property receptors may be affected by the following pathways:

- Direct contact of soils and groundwater with foundations / structures / services, (this is assessed within Atkins Geotechnical GIR);
- Ground gas migration and accumulation in enclosed structures followed by ignition and explosion.

3.3. Qualitative Risk Assessment

Table 3-1 below provides the qualitative risk matrix, based on CIRIA guidance [13], in which the likelihood or probability of each pollutant linkage being realised is ranked against the severity of the consequences. The result is the relative risk classification, the results of which can inform the due diligence process and allow prioritisation of any further assessments or the implementation of risk management measures.

Table 3-1 - Qualitative Risk Matrix

Risk Matrix		Severity of Consequence			
		Severe	Medium	Mild	Minor
Probability of pollutant linkage	High Likelihood	Very High Risk	High Risk	Moderate Risk	Moderate/Low Risk
	Likely	High Risk	Moderate Risk	Moderate/Low Risk	Low Risk
	Low Likelihood	Moderate Risk	Moderate/Low Risk	Low Risk	Very Low Risk
	Unlikely	Moderate/Low Risk	Low Risk	Very Low Risk	Very Low Risk

Definitions of the risk classifications presented in the guidance are given in Table 3-2 below.

Table 3-2 - Risk Classifications

Risk Classification	Definition
Very High Risk	There is a high probability that severe harm could arise to a designated receptor from an identified source, or there is evidence that severe harm to a designated receptor is currently happening.
High Risk	Harm is likely to arise to a designated receptor from an identified source.
Moderate Risk	It is possible that harm could arise to a designated receptor from an identified source. However, it is relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild.
Low Risk	It is possible that harm could arise to a designated receptor from an identified source, but it is likely that this harm, if realised, would at worst normally be mild.
Very Low Risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.

The individual sources, pathways and receptors identified in previous sections are judged against this risk matrix and professional judgement has been used to estimate the combination of probability of a pollutant linkage being realised and the consequence of the harm that might result in line with CIRIA C552 [13]. Details of the potential pollutant linkages and associated risks are recorded in Table 3-3.

3.4. Initial Conceptual Site Model

Details of the potential pollutant linkages and associated risks are recorded in the ICSM presented in Table 3-3.

Table 3-3 - Initial Conceptual Site Model

Source	Receptor	Pathway	Consequence	Probability	Classification of Risk
<p>At the Scheme:</p> <p>Artificial Ground and associated contamination from past and current structures / infrastructure / historical mining / infilled pits.</p> <p>Potential asbestos from demolished historical structures within soil. Vehicles and trains using existing infrastructure may have resulted in fuel/oil spillages to ground.</p> <p>Large areas of the Scheme and surroundings are currently designated as agricultural fields so agricultural pesticides and sewage sludge may have been applied to the ground, with localised fuel fuel/oil spillages from agricultural machinery possible.</p> <p>Organics associated with the Alluvium deposits with the potential to produce ground gas</p>	Human Health (At the Scheme) Scheme users (users of the Travel Hub and public transport route)	Inhalation, ingestion and dermal contact with contaminants in soil and soil-derived dust/fibres	Medium	Low Likelihood	Moderate/low
		Migration and accumulation of ground gases followed by inhalation or ignition causing asphyxiation and/or explosion	Medium	Low Likelihood	Moderate/low
		Inhalation of vapours from contaminated soil and / or water	Medium	Low Likelihood	Moderate/low
	Human Health (At the Scheme) Pedestrians accessing existing roads, footpaths and public rights of way	Inhalation, ingestion and dermal contact with contaminants in soil and soil-derived dust/fibres	Medium	Low Likelihood	Moderate/low
	Human Health (Off Site) Off site residents to the south west of Section 5, off site residents in the planned retirement home in Stapleford Off site commercial workers to the east and west of Section 1.	Inhalation, ingestion and dermal contact with contaminants in windblown soil-derived dust/fibres	Medium	Low Likelihood	Moderate/low
		Migration and accumulation of ground gases followed by inhalation or ignition causing asphyxiation and/or explosion	Medium	Low Likelihood	Moderate/low
		Inhalation of vapours from contaminated soil and / or water	Medium	Low Likelihood	Moderate/low
	Controlled Waters: Groundwater, the principal and secondary A aquifers associated with the superficial / bedrock deposits underlying the Scheme Surface waters that intersect the Scheme – The River Granta and Hobson's Brook	Leaching/ vertical migration of contaminants in soils to underlying groundwater	Medium	Low Likelihood	Moderate/low
		Migration of groundwater	Medium	Low Likelihood	Moderate/low
		Vertical migration of contaminants via preferential pathways such as via piles to deeper groundwater	Medium	Low Likelihood	Moderate/low
		Vertical migration of contaminants via preferential pathways such as via piles to groundwater followed by lateral migration	Medium	Low Likelihood	Moderate/low
	Property	Migration and accumulation of ground gases followed by ignition causing explosion	Medium	Low Likelihood	Moderate/low

<p>Off Site:</p> <p>Existing and historical infrastructure surrounding the site such as the Cambridge-London railway and disused railway and traffic using surrounding roads could be a potential source of hydrocarbons (e.g. via fuel and/or oil leaks)</p> <p>Numerous surrounding industries such as historical mining, farming, engineering works and depots, along with businesses such as fuel stations, garages, tyre dealers, cleaners and waste disposal services which are present in the surrounding area.</p> <p>Historical landfill sites within 250 m of the route centreline</p> <p>Sewage farms and pumping stations may result in contamination associated with</p>	Residential and commercial properties in the wider area Enclosed spaces associated with the infrastructure work (ie. borrow pits / maintenance pits Services and Infrastructure (including piles and foundations)				
	Human Health Scheme users (users of the Travel Hub and public transport route) Pedestrians accessing existing roads, footpaths and public rights of way	Inhalation, ingestion and dermal contact with contaminants in soil and soil-derived dust/fibres	Medium	Low Likelihood	Moderate/low
		Migration and accumulation of ground gases followed by inhalation or ignition causing asphyxiation and/or explosion	Medium	Low Likelihood	Moderate/low
		Inhalation of vapours from contaminated soil and / or water	Medium	Low Likelihood	Moderate/low
	Property Residential and commercial properties in the wider area Enclosed spaces associated with the infrastructure work (ie. borrow pits / maintenance pits) Services and Infrastructure (including piles and foundations)	Ground gas migration and accumulation in enclosed structures followed by ignition and explosion.	Medium	Low Likelihood	Moderate/low

4. Site Investigation Works

4.1. Scope of Investigation

Tetra Tech Ltd undertook a GI from 8th February – 5th May 2021 in line with a GI specification prepared by Mott Macdonald [1].

The scope of works progressed as per the Tetra Tech Ltd Factual Report is presented in Appendix C and summarised below;

- Sixteen window sample boreholes were progressed to depths of up to 5.45 m bgl;
- Seventy five dynamic sample boreholes with rotary core follow on to depths of up to 30.65 m bgl;
- Installation of 45 groundwater and ground gas monitoring standpipes where the following units were screened:
 - 23 screening the White Chalk
 - 10 cross strata boundaries (Made Ground into the Superficial Deposits or, Superficial Deposits into the White Chalk)
 - 11 screening the superficial Deposits
 - 1 screening Made Ground
- A total of 85 machine excavated trial pits were progressed to a depth of up to 4 m bgl;
- Progression of a monitoring regime comprising two groundwater monitoring rounds two and six weeks after the completion of the GI. Four ground gas monitoring rounds at weekly intervals following completion of the GI. and eight water level and quality monitoring visits were completed at monthly intervals following completion of the GI.

4.2. Description of Works Undertaken

4.2.1. Service Assessment

Statutory service plans were consulted prior to the site investigation and supplied to the contractor (Tetra Tech).

Service clearance was undertaken at each location in advance of the intrusive works by a specialist sub-contractor using non-intrusive Cable Avoidance Tool (CAT) and Signal Generator (Genny).

The service plans showed various statutory services in the vicinity of the proposed exploratory holes within Pemberton’s Track and Ground penetrating radar (GPR) was employed to aid service location along the Pemberton’s track and surrounding areas to provide options for alternative locations.

4.2.2. Unexploded Ordnance Survey (UXO)

A specialist engineer from Brimstone supervised hand pit excavation and drilling utilising a magnetometer at each GI location between NGR 547250, 253136 and 548106, 251667 (between TP-PTR15 and TP-PTR-28) where a desk based UXO Assessment indicated there was a high risk of encountering UXO.

4.2.3. Hand Excavated Pits

Hand excavated inspection pits were advanced to 1.20 m bgl using hand tools prior to the progression of any window sample or rotary core boreholes.

4.2.4. Drilling of Boreholes

Using percussive dynamic sampling and rotary coring techniques with core liners for sampling, boreholes were progressed from the hand excavated starter pits, using one of either a Beretta T41, T46, T59 or Massenza M13 to depths between 1.3 m and 30.65 m bgl.

Drilling works were undertaken by Tetra Tech and logged in accordance with BS 5930:2015 + A1:2020 [14] with logs presented in Appendix C.

4.2.5. Monitoring Well Installation

Gas and groundwater monitoring wells were installed in 45 boreholes, with the installations comprising 50 mm diameter high-density polyethylene (HDPE) standpipes. The wells were completed with 5 mm filter sand / gravel within the response zone and sealed with hydrated bentonite pellets above the response zone, end caps were placed at the base of pipework. The head works were completed using traffic-rated flush-mounted covers, locations fitted with gas bungs and taps. Boreholes were developed following installation through the utilisation of a bailer to surge the well.

A summary of well installation details is presented in the Tetra Tech Factual Report (Appendix C).

4.2.6. Environmental Sampling

Appropriate soil sampling and geological logging were progressed by Tetra Tech at each investigation location in general accordance with British Standard guidance documents BS5930:2015+A1:2020 [14] and BS10175:2011+A2:2017 [15].

Sampling was undertaken to obtain data, both laterally and vertically, across the Scheme in order to provide an indication of chemical conditions within the ground.

Preliminary screening for potential VOC vapours present within the unsaturated soils was undertaken using a PID (MiniRAE 3000 VOC detector), capable of measuring VOC concentrations in parts per million (ppm).

A total of one hundred and thirty eight soil samples (including one duplicate sample) were scheduled for the following analytical suite:

- asbestos screen (with quantification if asbestos positively identified);
- pH;
- electrical conductivity;
- moisture content;
- sulphate, sulphide, nitrite, nitrate, phosphorus and ammoniacal nitrogen;
- total, complex and free cyanide;
- total phenols;
- organic matter;
- metals and metalloids – arsenic, boron, barium, cadmium, total chromium, chromium (VI), copper, lead, mercury, nickel, selenium, vanadium and zinc;
- benzene, toluene, ethylbenzene and xylenes (BTEX);
- methyl-tert-butyl-ether (MTBE);
- speciated Polycyclic Aromatic Hydrocarbons (PAH): US EPA 16; and
- speciated Total Petroleum Hydrocarbons Criteria Working Group (TPH CWG) C5 – C44.

One hundred and forty one samples were scheduled for soil-derived leachate analysis for:

- pH;
- electrical conductivity;
- total nitrogen, sulphate, sulphide, chloride, nitrite, nitrate and ammoniacal nitrogen;
- total, complex and free cyanide;
- total phenol;
- metals and metalloids – arsenic, boron, cadmium, calcium, total chromium, chromium (VI), copper, lead, mercury, nickel, selenium, iron and zinc;
- BTEX;
- PAH: US EPA 16;
- TPH CWG C5 – C44; and
- Speciated phenols.

All analysis was undertaken by ALS Laboratories, with original laboratory certificates presented in Appendix C.

4.2.7. Groundwater Monitoring and Sampling

Four water level monitoring have been undertaken in the installed boreholes undertaken on 10 May 2021, 17 to 24 May 2021, 4 June 2021 and 17 October 2021.

Two rounds of groundwater sampling were progressed where samples were collected via low flow purging techniques, samples were collected on stabilisation of water quality parameters which were recorded with a YSI multi-parameter probe with dedicated pipework utilised at each location.

A total of fifty nine samples (including duplicates) were recovered and sent for analytical testing at ALS Laboratories, an UKAS and MCERTs accredited laboratory for the following suite of compounds:

- pH;
- total organic carbon (TOC);
- sulphate, sulphide, chloride, nitrate, ammoniacal nitrogen, ammonia (free), ammonium;
- total and free cyanide;
- total phenols;
- metals and metalloids – arsenic, cadmium, total chromium, chromium (VI), copper, lead, mercury, molybdenum, nickel, iron and zinc;
- BTEX;
- PAH: US EPA 16; and
- TPH CWG C5 – C44.

All analysis was undertaken by ALS Laboratories, with laboratory certificates presented in Appendix C

4.2.8. Ground Gas Monitoring

Ground gas monitoring was undertaken over four rounds between the 11th May and 4th of June 2021 using a Geotech GA5000 Infrared Gas Analyser.

The following parameters were measured at each location:

- flow rate (L/hr);
- peak and steady methane concentrations (% v/v);
- peak and steady carbon dioxide concentrations (% v/v);
- steady oxygen concentrations (%);
- steady hydrogen sulphide and carbon monoxide concentrations (ppm); and
- barometric pressure and relative pressure (mbar).

The results of the ground gas sampling are presented in the Tetra Tech Factual Report.

5. Ground Summary

5.1. Scheme Sections

An interpretation of the geology has been compiled using the typical ground profiles encountered across the scheme during the recent ground investigation by Tetra Tech (2021), supplemented with the results of available BGS historical logs.

The scheme has been split into six ground models (GM1 to GM6) based on the referred route sections: route section 1 to route section 6. The ground conditions across the Scheme are summarised below.

Full detail on the twenty cross sections and long sections as interpreted by Atkins is provided in the Atkins Geotechnical GIR [16].

5.2. Geology overview

The ground conditions encountered during the recent 2021 ground investigation generally confirm the geological succession expected at the Scheme based on available historical investigations and literature on the area.

The geological sequence, in approximate stratigraphic order is shown in Table 5-1.

Table 5-1 - Geology overview of the scheme

Type	Formation
-	Topsoil
Artificial	Made Ground
Superficial	Alluvium
	River Terrace Deposits
	Lowestoft Formation
Bedrock	Hollywell Nodular Chalk / Newpit Chalk Formation Undifferentiated
	Hollywell Nodular Chalk Formation
	Zig Zag Chalk Formation
	West Melbury Marly Chalk Formation

5.1. Distribution of geological strata

The geological strata in each area is summarised in .

Table 5-2 - Summary of distribution of geology along the scheme

Formation	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6 and Travel Hub
Topsoil	n/a	✓	✓	✓	✓	✓
Made Ground (	n/a	✓	-	✓	✓	-
Alluvium	n/a	✓	✓	✓	✓	✓
River Terrace Deposits	n/a	-	✓	✓	-	✓
Lowestoft Formation	n/a	-	-	-	-	✓
Hollywell Nodular Chalk / Newpit Chalk Formation Undifferentiated	n/a	-	-	-	-	✓
Hollywell Nodular Chalk Formation	n/a	-	-	-	✓	✓

Zig Zag Chalk Formation	n/a	✓	✓	✓	✓	✓
West Melbury Marly Chalk Formation	n/a	✓	-	✓*	-	-

Notes

Section 1 – no exploratory boreholes advanced in the section (n/a)

*Transitional strata change at depth

5.1.1. Topsoil

Most exploratory hole locations were commenced in arable fields and surface soils typically comprised predominantly fine soils with a lesser sand and gravel content below recently planted or established crops or grass. Occasional anthropogenic inclusions were noted in localised areas, including plastic, ceramic and concrete fragments.

5.1.2. Artificial deposits

Made Ground (MG)

Obvious signs of anthropogenic influence were noted to deeper levels in local areas, notably in North Farm (TP-PTR-32 to TP-PTR-37 inclusive, and BH-PTR-43A, BH-PTR-43B, BH-PTR-44, BH-PTR-44A and BH-PTR-45) where inclusions of brick, concrete, asphalt and fused ash, possibly associated with the former rail line, were noted to depths of up to 2.65 m bgl.

5.1.3. Superficial deposits

Alluvium (AL)

Alluvial soils were prevalent across the Scheme and generally thicker towards the river crossings and drainage ditches. The strata was highly variable in composition, and typically comprised low-consistency fine deposits, with organic rich and peat horizons, often with predominantly coarse pockets and layers. Shell fragments (possibly freshwater snails) and organic odours were also noted.

River Terrace Deposits (RTD)

The River Terrace Deposits were also noted in all areas of the Scheme, and typically comprised sandy flint gravel and to a lesser extent, layers of sand. Layers / pockets of fine deposits were also recorded, particularly towards the base of the unit, within the transition zone with the underlying chalk units, where pockets of light orangish brown clay or silt of chalk occur as remnants of the weathered chalk horizons.

Lowestoft Formation (LOFT)

The characteristically high-strength (stiff), predominantly fine, shallow deposits encountered below the River Terrace Deposits in the north of the Travel Hub area.

5.1.4. White Chalk Bedrock

Hollywell Nodular Chalk / Newpit Chalk Formation Undifferentiated (HNCK)

Chronological biomarker fossils and established marker beds (Glynbourne Tubular Flints and the Guns Gardens Main Marl) indicative of the transition zone between the Hollywell Nodular Chalk Formation and the Newpit Chalk Formation have been tentatively identified within chalk recovered from the Travel Hub boreholes. Therefore, although the anticipated youngest chalk unit in this area comprises the Hollywell Nodular Chalk Formation, these markers suggest that the Newpit Chalk Formation could also be present as the youngest / shallowest units and potentially outcrops further north / west as part of a structural low.

Hollywell Nodular Chalk Formation (HCK)

The presence of characteristically weak to strong, low to medium density, off-white to white chalk, with discrete marl seams and flaser marls that displayed high contrast with the chalk, generally coincided with the anticipated lateral extent and depth of the Hollywell Nodular Chalk Formation.

Established marker beds such as the Plenus Marls Member (interbedded chalk and marl), and the Melbourn Rock Member (hard off-white chalk with nodular chalk beds and flaser marls), along with biomarkers, were often found to occur at the anticipated base depth of this formation, the shallowing of which ties in with the southerly dipping succession. These characteristics were absent from BHs north of BH-PTR-16, where it has been assumed the underlying units outcrop in the northern portion of the Scheme.

Zig Zag Chalk Formation (ZZCH)

The Zig Zag Chalk Formation was encountered from ground level in the northern central area of the Scheme, and below the Hollywell Nodular Chalk Formation, and was characteristically off-white, becoming light or pale grey chalk, with rhythmic gradational marl seams, and frequent intraclastic zones, typically occurring as off-white chalk clasts in a grey, occasionally marly matrix.

West Melbury Marly Chalk Formation (WMCH)

The West Melbury Marly Chalk Formation was encountered from ground level in the north area of the Scheme, and below the Zig Zag Chalk Formation, and was characteristically grey, silty marl.

5.2. Groundwater monitoring

Groundwater depth across the site was recorded between 0.13 and 7.74 m bgl. Groundwater wells were installed in Sections 2 – 6 and the Travel Hub site.

Three boreholes screened Made Ground each of which was situated in Section 4 and groundwater was recorded at a depth of between 0.81 and 1.76 m bgl across the monitoring regime.

Groundwater Levels in the superficial deposits were recorded between 0.13 and 3.07 m bgl in Section 2 and 4, groundwater was not recorded in wells screening the same strata in Section 6 and the Travel Hub site.

The White Chalk was screened in 29 boreholes from Section 2 – 6 and the Travel Hub.

Groundwater level in the White Chalk ranged between 0.24 to 7.44 m bgl with the shallowest groundwater table identified in Section 2 depth to groundwater ranged between 0.24 and 5.04 m bgl.

A summary of groundwater levels recorded across four rounds of monitoring is presented in full in Table 5-3.

Table 5-3 - Summary of groundwater monitoring results

Location	Section	Ground water depth (m bgl)								Targeted Geology	
		10/05/2021	17/05/2021	03/06/2021	17/10/2021	13/11/2021	18/12/2021	09/01/2022	27/02/2022		19/03/2022
BH-PTR-02 D	2	1.23	1.04	1.31	1.03	1.04	0.85	1.06	1.06	0.95	WMCH
BH-PTR-02 S	2	1.1	0.96	2.36	0.86	0.9	1.05	0.95	0.95	0.88	WMCH
BH-PTR-03A	2	1.1	0.89	1.06	1.16	1.22	0.98	0.91	0.91	0.87	ALV
BH-PTR-04	2	0.9	0.62	0.78	0.8	0.81	0.76	0.64	0.64	0.52	ALV/WMCH
BH-PTR-07	2	0.54	0.5	0.6	0.36	0.36	0.58	0.61	0.61	0.62	WMCH
BH-PTR-08 D	2	0.54	0.56	0.67	0.24	0.37	0.78	0.68	0.68	0.65	WMCH
BH-PTR-08 S	2	0.57	0.61	0.73	0.39	0.42	0.79	0.76	0.76	0.68	WMCH
BH-PTR-10	2	0.54	0.52	0.64	0.26	0.42	0.73	0.65	0.65	0.62	ALV/WMCH
BH-PTR-12	2	1.92	1.99	2.08	1.73	1.78	2.11	2.01	2.01	1.97	WMCH
BH-PTR-13	2	1.97	2.02	2.15	5.04	2.44	2.68	2.23	2.23	2.13	ZZCH
BH-PTR-14	2	3.68	3.71	3.86	4.15	4.19	4.48	3.97	3.97	3.87	ZZCH
BH-PTR-15	3	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	ZZCH
BH-PTR-16	3	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	HCK
BH-PTR-18	3	3.85	4.03	4.16	Dry	Dry	Dry	Dry	Dry	Dry	ZZCH
BH-BP-01	4	-*	1.05	1.24	1.2	1.18	1.29	n/a	n/a	2.6	ALV
BH-PTR-19	4	2.32	2.36	2.5	2.82	2.85	3.07	2.46	2.46	2.34	RTD
BH-PTR-21	4	1.66	1.64	1.76	1.77	1.8	1.97	1.63	1.63	1.54	RTD
BH-PTR-27	4	0.84	0.81	0.99	0.88	0.91	1.13	0.87	0.87	0.79	RTD

Location	Section	Ground water depth (m bgl)									Targeted Geology
		10/05/2021	17/05/2021	03/06/2021	17/10/2021	13/11/2021	18/12/2021	09/01/2022	27/02/2022	19/03/2022	
BH-PTR-30	4	1.01	0.99	1.15	1.4	2.32	1.38	1.07	1.07	0.99	ZZCH
BH-PTR-31	4	0.85	0.84	0.91	1.09	1.04	1.13	0.88	0.88	0.82	ZZCH
BH-PTR-33 D	4	0.94	1.04	1.16	1.21	1.16	1.29	1.02	1.02	0.97	ZZCH
BH-PTR-33 S	4	1.05	1.06	1.22	1.23	1.16	1.26	1.04	1.04	0.98	ALV/RTD
BH-PTR-35	4	1.67	1.62	1.73	1.58	1.44	1.56	1.43	1.43	1.36	RTD
BH-PTR-36	4	0.13	0.92	1.13	0.93	0.65	0.74	0.69	0.69	0.6	ALV
BH-PTR-39	4	0.56	0.62	0.78	0.76	0.63	0.91	0.61	0.61	0.56	ZZCH
BH-PTR-41 D	4	1.36	1.26	1.52	1.54	1.43	1.65	1.32	1.32	1.28	ZZCH
BH-PTR-41 S	4	1.41	1.43	1.53	1.69	1.5	1.56	1.31	1.31	1.28	MG
BH-PTR-42 D	4	1.72	1.55	1.75	1.73	1.58	1.76	1.37	1.37	1.3	ZZCH
BH-PTR-42 S	4	Dry	1.49	1.75	Dry	Dry	Dry	Dry	Dry	Dry	MG
BH-PTR-43 D	4	1.41	1.54	1.52	1.77	1.49	1.65	1.01	1.01	0.85	ZZCH
BH-PTR-43 S	4	1.42	1.4	1.49	1.76	1.54	1.45	1	1	0.81	MG
BH-PTR-45	5	5.9	5.89	5.98	5.88	5.69	5.95	5.62	5.62	5.57	HCK
BH-OBC-01	6	Dry	Dry	Dry	Dry	Dry	DRY	n/a	n/a	DRY	RTD
BH-OBC-04 D	6	2.26	2.41	2.8	3.79	3.5	3.76	2.74	2.74	2.6	HCK

Location	Section	Ground water depth (m bgl)									Targeted Geology
		10/05/2021	17/05/2021	03/06/2021	17/10/2021	13/11/2021	18/12/2021	09/01/2022	27/02/2022	19/03/2022	
BH-OBC-04 S	6	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	RTD
BH-OBC-06	6	2.68	2.96	3.22	4.34	4.06	4.23	3.24	3.24	3.08	HCK
BH-OBC-07	6	3.46	3.7	3.99	5.09	4.83	5	4.09	4.09	3.92	ZZCH
BH-OBC-07	6	3.11	3.34	3.63	4.68	4.38	4.58	3.65	3.65	3.49	HCK
BH-OBC-11 D	6	2.44	2.65	2.91	4.23	3.96	3.99	2.97	2.97	2.85	HCK
BH-OBC-11 S	6	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	RTD
BH-OBC-12	6	2.72	1.98	3.27	4.59	4.31	4.35	3.33	3.33	3.23	HCK
BH-OBC-15	6	3.85	4.12	4.39	6.71	5.43	5.5	4.53	4.53	4.39	ZZCH
BH-TH-01	Travel Hub	5.46	5.82	6.18	7.44	7.14	7.31	6.23	6.23	6.03	HNCK
BH-TH-03	Travel Hub	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	RTD

S = Shallow install, D = Deep install, n/a monitoring round not undertaken

S = Shallow install, D = Deep install, n/a monitoring round not undertaken

5.3. Evidence of contamination

Visual and olfactory evidence of potential contamination identified during the ground investigation is presented in the table below. No PID reading recorded during the GI exceeded 0.1 ppm.

Table 5-4 – Visual and Olfactory Evidence of Contamination

Description of contamination	Location	Depth (m bgl)
Fused ash	BH-PTR-15	0 – 0.3
Ash	BH-PTR-40	0.90 – 1.20
Ash	BH-PTR-41	0.35 – 1.20
Ash	BH-PTR-42	1.20 – 2.34
Coal	BH-PTR-42	0.30 – 0.80
Ash	BH-PTR-43	0.25 – 1.30
Fused ash	BH-PTR-43A	0.25 – 1.30
Fused ash	BH_PTR-43B	0.25 – 1.00
Fused ash	BH_PTR-43B	1.00 – 1.20
Fused ash and coal fragments	BH_PTR-43B	1.65 – 2.03
Fused ash	BH-PTR-45	0.00 – 2.65
Fused ash	BH-PTR-45a	0.00 – 1.20
Ash	BH-TH-08	0.00 – 0.15
Ash	BH-PTR-40	0.90 – 1.20
Ash	BH-PTR-41	0.35 – 1.20
Fused ash	BH-PTR-42	1.20 – 2.34

5.4. Ecological constraints

For an assessment of the ecological constraints for the Scheme, refer to the ecological desk study carried out for this scheme by Soltys Brewster and Atkins [17].

6. Human Health Generic Quantitative Risk Assessment

A Generic Quantitative Risk Assessment (GQRA) of potential PCLs has been carried out using information from the Tetra Tech Factual Report (Appendix C) as summarised in this report.

The soil chemical data have been screened against their respective Generic Assessment Criteria (GAC) to assess the risks to the previously identified receptors. The outcome of this assessment is presented in the following sections.

6.1.1. Selection of Human Health Generic Assessment Criteria

Detailed guidance on human health risk assessment is provided in Science Report SR2 [18], SR3 [19] and the Contaminated Land Exposure Assessment (CLEA) Model. The GQRA for identified human receptors has compared soil concentration data with GAC.

Category 4 Screening Values (C4SLs), derived to be protective of chronic risks to human health have been published for six contaminants (benzo(a)pyrene, benzene, lead, arsenic, cadmium and chromium) by DEFRA [20]. C4SLs represent low risk levels, they are not representative of significant possibility of significant harm (SPoSH). If the C4SLs are not exceeded, land can be demonstrated as being in Category 4 and cannot be determined as contaminated land.

Atkins has produced soil screening values (SSVs) based on minimal toxicological risk for a variety of standard land uses at 1% soil organic matter (SOM) (sand soil type) and 6% SOM (sandy loam soil type) using CLEA v1.071 in accordance with Environment Agency guidance.

The proposed project involves the construction of public transport route and a new travel hub facility. Therefore, to undertake the assessment of the risk to associated receptors along the public transport route, soil samples have been screened against commercial end use SSVs and C4SLs where available (collectively referred to as GAC).

A further screening exercise has been progressed using Public Open Space (Park) GAC in order to be considerate of the exposure for current and future Scheme users comprising the travel hub users, active travel path, and off site local residents.

The presence of SOM is important in determining the fate and behaviour of a number of organic contaminants such as PAHs and chlorinated solvents. The mobility of these contaminants decreases with increasing SOM. Generally, the greater the SOM content the greater the sorptive capacity of the soil. Atkins' derived SSVs for a 1% SOM have been used to inform the GAC as the average SOM in soil samples was recorded at 0.31% across the Scheme.

Potential acute risks resulting from short term exposure of construction workers to contamination involved with the proposed development cannot be assessed using these GACs because they relate to the long-term (chronic) risk. Risks to construction workers should be managed by the contractor through their Construction Environmental Management Plans (CEMPs) and as a minimum should include the use of appropriate Personal Protective Equipment (PPE) and appropriate working methods.

Groundwater samples have not been screened against Atkins WSV in absence of any significant vapour sources identified within the CSM outlined in section 5.1.

6.1.2. Screening and Results

A total of 138 soil samples were analysed across the Scheme. All of these samples were collected from Made Ground or Superficial Deposits between the depths of 0.1 m and 4.0 m bgl.

Potential asbestos containing material was not identified during the GI, soil analytical results indicate that no asbestos fibres or ACM were identified during subsequent testing

The results of the Human Health screening are presented in Appendix E.1 Every sample screened against the commercial GAC recorded contaminant concentrations below the adopted screening criteria.

A summary of the soil GAC exceedances against the public open space screening criteria is provided in Table 6-1.

Table 6-1 - Soil GAC exceedances (public open space (parks))

Constituent	Units	Public open space (parks) GAC (mg/kg)	Number of samples	Minimum concentration	Maximum concentration	Number of exceedances	Location & Depth (m bgl)
Lead	mg/kg	1340	184	<0.7	2210	1	TP-PTR-33, 1.5m (section 5)

One soil sample collected from BH-PTR-33 at 1.5 m bgl recorded a concentration of lead that exceeds the adopted public open space (parks) end use soil GAC. The soil exceedance is within the same magnitude as the soil GAC.

The lead concentration reported to exceed the GAC is isolated and was identified at a depth of 1.5m bgl, within Section 5 of the public transport route, which is predominantly used for agricultural purposes. Given the depth of the exceedance and land use, public open space users are unlikely to become exposed. Moreover, the PTR will consist of hardstanding limiting the potential for direct contact with the underlying soil.

On the basis of the limited exceedances recorded during the screening process alongside the limited evidence of visual or olfactory contamination during the GI, the risk to human health receptors associated with the whole scheme development is considered to be low.

7. Ground Gas Risk Assessment

7.1. General

The following sources with the potential to generate hazardous ground gas were identified in the Conceptual Site Model:

At the Scheme

- Artificial Ground and associated contamination from past and current structures / infrastructure / historical mining / infilled pits.
- Organics associated with the Alluvium deposits with the potential to produce ground gas.

Off Site

- Numerous surrounding industries such as historical mining, farming, engineering works and depots, along with businesses such as fuel stations, garages, tyre dealers, cleaners and waste disposal services which are present in the surrounding area.
- Historical landfill sites within 250 m of the route centreline

The main risk associated with the identified off-site sources is deemed to be associated with the historical land and the subsequent migration of ground gas / vapours through preferential pathways to the Scheme.

7.2. Methodology

Ground Gas monitoring included recording weather conditions, barometric pressure and flow rate, together with concentrations of methane, carbon dioxide, carbon monoxide, hydrogen sulphide and oxygen at each monitoring location.

The preliminary ground gas risk assessment has been undertaken in general accordance with the methodology presented within the Construction Industry Research Information Association (CIRIA) C665 methodology [40] and BS 8485:2015 + A1:2019 [21].

BS8485 states that hazardous gas flow rates (Q_{hg}) should be calculated for methane and carbon dioxide for every borehole for each visit. A worse case Q_{hg} is calculated using the maximum gas concentration recorded (unless lower values can be justified) and the maximum steady state flow rate using the below formula:

$$Q_{hg} \text{ (l/hr)} = \text{flow rate (l/hr)} \times [\text{gas concentration (\%)} / 100]$$

The Gas Screening Value (GSV) is the flow rate of a specific hazardous gas considered to be representative of a site, following assessment of all borehole concentrations and gas flow rates, whilst taking account of other influencing factors. Such factors being, for example, whether a response zone was completed flooded (which can compromise gas data), the temporal/spatial nature of the data set, and the acute one-off nature of the risk.

BS8485 indicates that a decision must be made to determine whether the maximum Q_{hg} in the dataset is appropriate to represent the Scheme (and thereby be selected as the GSV), or whether maximum gas concentrations and maximum steady state flow rates should be combined from any borehole/visit to derive a "worst case GSV".

The GSV considered representative for the Scheme is then used to select a Characteristic Situation (CS), which is the ground gas regime assumed for design of gas protection measures for new buildings in accordance with BS8485.

Characteristic situations were calculated for individual exploratory holes using the maximum steady state flow and maximum recorded concentrations of carbon dioxide or methane.

BS8485 does not include an approach for assessing carbon monoxide or hydrogen sulphide. The relevant Workplace Exposure Limits (WELs) as outlined within the HSE EH40/2015 (2011) document [22] have been adopted for use in a preliminary assessment of carbon monoxide and hydrogen sulphide:

- carbon monoxide: 30 parts per million (ppm) for long-term (eight hours) exposure limit and 200 ppm for short-term (15 minutes) exposure limit; and
- hydrogen sulphide: 5 ppm for the long-term exposure limit and 10 ppm for the short-term exposure limit.

7.3. Results

Four rounds of gas monitoring were undertaken by Tetra Tech in May and June 2021. Gas monitoring records are provided within the ground investigation Factual Report [23].

Table 7-1 presents the calculated hazardous gas concentrations (Qhg) based on peak gas concentrations and maximum steady state gas flow rates collected during the monitoring visits.

Table 7-1 - Ground Gas Assessment Summary

Borehole ID	Steady Flow Rate (l/hr)	Steady Methane (%)	Steady Carbon Dioxide (%)	Max Qhg / GSV (l/hr)	Characteristic Situation	Response Zone	Response Zone Flooded
BH-BP-01	0.1	<0.1	0.7	0.0007	CS1	1.00 – 1.80	Alluvium
BH-OBC-01	0.1	0.1	2.3	0.0023	CS1	1.00 – 3.50	River Terrace Deposits
BH-OBC-04 D	0.1	<0.1	0.2	0.0002	CS1	13.00 – 19.00	White Chalk
BH-OBC-04 S	0.1	<0.1	0.9	0.0009	CS1	1.00 – 3.00	River Terrace Deposits
BH-OBC-06	0.1	<0.1	1.2	0.0012	CS1	7.00 – 11.00	White Chalk
BH-OBC-07 D	0.1	<0.1	1.2	0.0012	CS1	20.00 – 29.00	White Chalk
BH-OBC-07 S	0.1	<0.1	0.5	0.0005	CS1	14.00 – 17.00	White Chalk
BH-OBC-11 D	-10	<0.1	1.1	-0.11	CS1	1.00 – 2.50	White Chalk
BH-OBC-11 S	0.1	<0.1	3.7	0.0037	CS1	14.00 – 17.00	River Terrace Deposits
BH-OBC-12	0.1	<0.1	0.3	0.0003	CS1	17.00 – 20.00	White Chalk
BH-OBC-15	-8.6	0.1	1.2	-0.1032	CS2	24.00 – 29.00	White Chalk
BH-PTR-02 D	0.1	<0.1	2.1	0.0021	CS1	4.50 – 10.00	White Chalk
BH-PTR-02 S	17	<0.1	2.2	0.374	CS2	1.20 – 2.20	Alluvium & White Chalk
BH-PTR-03A	0.1	<0.1	0.1	0.0001	CS1	2.00 – 6.00	White Chalk
BH-PTR-04	0.1	<0.1	0.1	0.0001	CS1	2.00 – 6.00	Alluvium & White Chalk

Borehole ID	Steady Flow Rate (l/hr)	Steady Methane (%)	Steady Carbon Dioxide (%)	Max Qhg / GSV (l/hr)	Characteristic Situation	Response Zone	Response Zone Flooded
BH-PTR-07	0.1	0.1	0.1	0.0001	CS1	8.00 – 15.00	White Chalk
BH-PTR08 D	0.1	<0.1	0.1	0.0001	CS1	10.00 – 15.00	White Chalk
BH-PTR08 S	0.1	<0.1	0.1	0.0001	CS1	1.00 – 2.50	Alluvium & White Chalk
BH-PTR-10	0.1	<0.1	0.1	0.0001	CS1	1.00 – 5.00	Alluvium & White Chalk
BH-PTR-12	-0.1	<0.1	0.1	-0.0001	CS1	7.00 – 10.00	Alluvium & White Chalk
BH-PTR-13	-0.1	<0.1	0.8	-0.0008	CS1	1.50 – 6.00	White Chalk
BH-PTR-14	0.1	<0.1	1.2	0.0012	CS1	4.50 – 10.00	White Chalk
BH-PTR-16	0.1	<0.1	0.6	0.0006	CS1	1.00 – 3.50	White Chalk
BH-PTR-18	0.1	<0.1	0.2	0.0002	CS1	2.00 – 5.00	White Chalk
BH-PTR-19	0.1	<0.1	2.2	0.0022	CS1	1.50 – 5.00	River Terrace Deposits
BH-PTR-21	3.1	<0.1	2	0.062	CS1	1.00 – 4.00	River Terrace Deposits
BH-PTR-27	3.1	<0.1	0.7	0.0217	CS1	3.00 – 5.50	River Terrace Deposits
BH-PTR-30	-0.1	<0.1	0.1	-0.0001	CS1	15.00 – 22.00	White Chalk
BH-PTR-31	-20.6	<0.1	1.2	-0.2472	CS2	5.00 – 11.00	White Chalk
BH-PTR-33 D	1.4	<0.1	0.9	0.0126	CS1	22.00 – 28.50	White Chalk
BH-PTR-33 S	0.1	<0.1	1.3	0.0013	CS1	1.00 – 4.50	Alluvium & River Terrace Deposits
BH-PTR-35	3.1	<0.1	2.5	0.0775	CS1	1.00 – 3.00	River Terrace Deposits
BH-PTR-36	-0.1	<0.1	0.3	-0.0003	CS1	1.00 – 3.50	Alluvium
BH-PTR-39	-0.1	<0.1	0.7	-0.0007	CS1	12.00 – 14.50	White Chalk
BH-PTR-41 D	0.1	0.1	1.6	0.0016	CS1	5.00 – 10.50	White Chalk

Borehole ID	Steady Flow Rate (l/hr)	Steady Methane (%)	Steady Carbon Dioxide (%)	Max Qhg / GSV (l/hr)	Characteristic Situation	Response Zone	Response Zone Flooded
BH-PTR-41 S	0.1	0.1	4.3	0.0043*	CS1	1.00 – 2.30	Made Ground & Alluvium
BH-PTR-42 D	0.1	0.1	0.2	0.0002	CS1	3.50 – 10.00	Alluvium & White Chalk
BH-PTR-42 S	0.1	<0.1	1.4	0.0014	CS1	1.00 – 1.90	Made Ground
BH-PTR-43 D	0.1	<0.1	1.1	0.0011	CS1	5.00 - 10.00	White Chalk
BH-PTR-43 S	0.1	0.1	1.7	0.0017	CS1	1.00 – 3.00	Made ground and White Chalk
BH-PTR-45	-0.1	<0.1	2.2	-0.0022	CS1	5.00 – 10.00	White Chalk
BH-TH-01	0.1	0.1	0.9	0.0009	CS1	6.00 – 12.00	White Chalk
BH-TH-03	0.1	<0.1	0.3	0.0003	CS1	1.00 – 3.50	River Terrace Deposits & White Chalk
BH-TH-05	0.1	<0.1	0.5	0.0005	CS1	1.00 – 2.00	River Terrace Deposits
BH-TH-06	0.1	<0.1	0.7	0.0007	CS1	1.00 – 8.00	White Chalk
BH-TH-08	0.1	0.1	0.2	0.0002	CS1	1.0 – 4.00	River Terrace Deposits, Lowestoft Formation & White Chalk

7.4. Discussion

Four rounds of gas monitoring were undertaken by Tetra Tech in May and June 2021. Gas monitoring records are provided within the ground investigation Factual Report [23]. The gas monitoring carried out at the Scheme were recorded during a period of falling atmospheric pressure where levels fell below 1000 mb (Round three) and are as a result considered representative of worst case conditions.

Gas flow rates in all monitored locations were recorded between LOD (0.1 Litres per hour (l/hr)) and 20.50 l/hr with an average flow rate of 0.49 l/hr. Carbon dioxide concentrations ranged from 0.1 l/hr to 4.3 l/hr and methane concentrations were recorded between <0.1 l/hr and 2 l/hr.

Soil samples displayed relatively low levels of organic content with Total Organic Carbon recorded between 0.2 and 5.41% with an average level of 1.2%, this was supported by visual evidence recorded during the GI where Made Ground soils generally displayed low levels of organics.

The maximum concentration of CO was measured at 7 ppm with the majority of concentrations recorded below detection. Hydrogen sulphide levels were also recorded below LOD (1 ppm) in each location during each monitoring round.

A summary of the Qhgs, utilising the steady flow rates and gas concentrations of each monitoring well is provided in Table 7-1 where every location with the exception of BH-OBC-11 D, BH-OBC-15, BH-PTR-02, BH-PTR-31 and BH-PTR-35 (commensurate with a CS2) had a methane and CO2 levels commensurate with a CS1.

In addition, a 'worst case' check comprising the maximum recorded flow in any strata and maximum gas concentration has also been undertaken. The peak recorded carbon dioxide concentrations were recorded as 4.3%. The peak recorded concentration of methane was 0.1% on all monitoring rounds. The maximum flow rate of 20.50 l/hr was recorded at BH-PTR-31, this has been calculated alongside the peak concentrations and results in a worst case GSV for carbon dioxide is 0.88 and for methane 0.02 commensurate with a CS2 and CS1 respectively.

BS8485 indicates that a decision must be made to determine whether the maximum Qhg in the dataset is appropriate to represent the Scheme (and thereby be selected as the GSV), or whether maximum gas concentrations. Based on the proposed end use where at present no enclosed spaces are proposed along the route and the travel hub is determined to be a low risk Type C building in line with BS8485, the receptors are considered to be of low sensitivity. 27 of 31 boreholes monitored presented ground gas conditions commensurate with a CS1 indicating very low risk, moreover, of the four monitoring wells that were commensurate with a CS2 none were situated in the area of the proposed travel hub structure. On this basis, Atkins considers it appropriate to adopt this as representative of the Scheme's ground gas regime given the low organic content in Made Ground, gas monitoring results and lack of visual or olfactory evidence of organic contamination during the GI.

As a result, no ground gas mitigation measures are considered necessary within the future infrastructure project.

8. Controlled Waters Generic Quantitative Risk Assessment

A controlled waters GQRA for the identified PCLs has been carried out using information from the Tetra Tech 2022 ground investigation as summarised in this report.

8.1. Groundwater Regime and Selection of Assessment Criteria

The controlled waters GQRA has been designed to assess the potential risks posed to the identified controlled waters receptors from the migration of contaminants from identified on-site sources. To assess potential risks to the identified receptors, a comparison of soil leachate and groundwater against pertinent water quality standards (WQS) has been undertaken.

The screening criteria for controlled waters assessment are dependent on the nature of the key receptor(s).

Superficial deposits underlying the Scheme comprise Alluvium and River Terrace Deposits, classified as secondary A aquifers, and the Lowestoft formation, classified as a secondary undifferentiated aquifer. Bedrock underlying the Scheme comprises the various Chalk formations all of which are classified as a principal aquifer.

A number of surface water bodies are present at the Scheme including Hobson's Brook which intersects Section 1 while the River Granta intersects Sections 4 and 6.

Considering the hydrological and hydrogeological receptors identified as summarised soil leachate and groundwater monitoring data has been screened against Water Quality Standards (WQS) comprising Environmental Quality Standards for inland freshwater (EQS) [24], protective of aquatic life in surface water and Drinking Water Standards (DWS) [24] protective of groundwater as a resource.

The Environment Agency's Metal Bioavailability Tool has been utilised to adjust the EQS for manganese, lead, copper, nickel and based upon the pH, calcium and dissolved oxygen levels at the River Granta. In the absence of Environment Agency calcium testing at the River Granta, data from the River Cam have been utilised.

8.2. Screening

8.2.1. Soil-leachate Screening

Data from 141 soil-leachate samples collected from the Made Ground and superficial deposits between the depths of 0.1 m and 1.9 m bgl were screened against EQS and DWS values. Screening against EQS is presented in Table 8-1 and DWS in Table 8-2. Full screening is presented in Appendix E2.1.

8.2.2. Groundwater Screening

Data from 58 groundwater samples collected from the Scheme were screened against EQS and DWS values. Screening against EQS is presented in Table 8-3 and DWS in Table 8-4. Full screening is presented in Appendix E2.2

Table 8-1 - Soil leachate EQS exceedances

Constituent	Units	EQS (mg/l)	Number of samples	Minimum concentration	Maximum concentration	Number of exceedances	Location & Depth (m bgl)
Ammoniacal Nitrogen as N	mg/l	0.2	141	0.01	0.869	2	BH-PTR-44A, 2.2, Section 4; TP-PTR-33, 1.5, Section 4
Cadmium	mg/l	0.00025	141	<0.00008	0.000375	1	BH-PTR-16, 0.2, Section 3
Copper	mg/l	0.001	141	<0.0003	0.0142	42	BH-OBC-01, 0.1, Section 6; BH-OBC-11, 0.1, Section 6; BH-PTR-01, 0.5, Section 2; BH-PTR-02, 0.2, Section 2; BH-PTR-03A, 0.2, Section 2; BH-PTR-05, 0.1, Section 2; BH-PTR-06, 0.1, Section 2; BH-PTR-07, 0.2, Section 2; BH-PTR-12, 0.2, Section 2; BH-PTR-23, 0.2, Section 4; BH-PTR-24A, 0.5, Section 4; BH-PTR-25, 0.5, Section 4; BH-PTR-26, 0.3, Section 4; BH-PTR-28, 0.2, Section 4; BH-PTR-36, 0.2, Section 4; BH-PTR-40, 0.2, Section 4; BH-PTR-42, 1.4, Section 4; BH-PTR-42, 2.2, Section 4; BH-PTR-43, 0.2, Section 4; BH-PTR-43, 1, Section 4; BH-PTR-44A, 2.2, Section 4; BH-PTR-01, 0.2, TH; BH-PTR-07, 0.1, TH; CPT-PTR-06, 0.5, Section 4; DCP-HRS-08, 0.2, Havershill Road; DCP-SRS-02, 0.5, Sawston Road; DCP-SRS-02, 1, Sawston Road; DCP-TH-07, 0.2, TH; DCP-TH-11, 0.5, TH; TP-BP-02, 0.2, Borrow Pit Area; TP-BP-03, 0.5, Borrow Pit Area; TP-OBC-01, 0.2, Section 5; TP-OBC-02, 0.2, Section 5; TP-OBC-03, 0.1, Section 5; TP-OBC-05, 0.2, Section 5; TP-PTR-19, 0.1, Section 3; TP-PTR-20, 0.2, Section 3; TP-PTR-32, 0.5, Section 4; TP-PTR-42, 0.2, Section 5; TP-PTR-43, 0.5, Section 5; TP-PTR-44, 0.2, Section 5; TP-TH-12, 0.2, TH
Iron	mg/l	1	141	<0.019	1.4	1	TP-BP-04, 0.2, Borrow Pit Area
Lead	mg/l	0.0012	141	<0.0002	0.00698	6	BH-PTR-16, 0.2, Section 3; BH-PTR-36, 0.2, Section 4; BH-PTR-43, 1, Section 4; BH-PTR-44A, 2.2, Section 4; BH-TH-01, 0.2, TH; TP-PTR-14, 0, Section 2
Mercury	mg/l	0.00007	141	<0.00001	0.000115	1	BH-PTR-43, 1, Section 4
Nickel	mg/l	0.004	141	<0.0004	0.00954	2	BH-PTR-05, 0.1, Section 2; BH-PTR-44A, 2.2, Section 4
Zinc	mg/l	0.014	141	<0.001	0.328	16	BH-OBC-11, 0.1, Section 6; BH-OBC-15, 0.2, Section 6; BH-PTR-05, 0.1, Section 2; BH-PTR-12, 0.2, Section 2; BH-PTR-16, 0.2, Section 3; BH-PTR-21, 0.1, Section 4; BH-PTR-28, 0.2, Section 4; BH-PTR-41, 0.2, Section 4; BH-PTR-43, 0.2, Section 4; BH-PTR-43, 1, Section 4; BH-PTR-44A, 2.2, Section 4; BH-PTR-45A, 1.6, Section 5; TP-BP-04, 0.2, Section 5

02, 0.2, Borrow Pit Area; TP-BP-05, 0.1, Borrow Pit Area; TP-PTR-07, 0.1, Section 2; TP-PTR-14, 0, Section 2

Table 8-2 - Soil leachate DWS exceedances

Constituent	Units	DWS (mg/l)	Number of samples	Minimum concentration	Maximum concentration	Number of exceedances	Location & Depth (m bgl)
Ammoniacal Nitrogen as N	mg/l	0.39	141	0.01	0.869	2	BH-PTR-44A, 2.2, Section 4; TP-PTR-33, 1.5, Section 4
Arsenic	mg/l	0.01	141	<0.0005	0.0144	1	BH-PTR-44A, 2.2, Section 4
Iron	mg/l	0.2	141	<0.019	1.4	34	BH-OBC-01, 0.1, Section 6; BH-OBC-11, 0.1, Section 6; BH-PTR-01, 0.5, Section 2; BH-PTR-02, 0.2, Section 2; BH-PTR-06, 0.1, Section 2; BH-PTR-16, 0.2, Section 3; BH-PTR-21, 0.1, Section 4; BH-PTR-23, 0.2, Section 4; BH-PTR-24A, 0.5, Section 4; BH-PTR-26, 0.3, Section 4; BH-PTR-28, 0.2, Section 4; BH-PTR-36, 0.2, Section 4; BH-PTR-40, 0.2, Section 4; BH-PTR-41, 0.1, Section 4; BH-PTR-41, 0.2, Section 4; BH-PTR-43, 1, Section 4; BH-PTR-44A, 2.2, Section 4; BH-TH-01, 0.2, TH; CPT-PTR-06, 0.5, Section 4; DCP-HRS-08, 0.2, Havershill Road; DCP-TH-07, 0.2, TH; TP-BP-02, 0.2, Borrow Pit Area; TP-BP-02, 1, Borrow Pit Area; TP-BP-03, 0.5, Borrow Pit Area; TP-BP-04, 0.2, Borrow Pit Area; TP-HRS-02, 0, Havershill Stop; TP-OBC-02, 0.2, Section 5; TP-PTR-07, 0.1, Section 2; TP-PTR-13, 0.2, Section 2; TP-PTR-14, 0, Section 2; TP-PTR-19, 0.1, Section 3; TP-PTR-20, 0.2, Section 3; TP-PTR-32, 0.5, Section 4; TP-PTR-43, 0.5, Section 5
Manganese	mg/l	0.05	141	<0.003	0.0683	1	TP-PTR-33, 1.5, Section 4

Table 8-3 - Groundwater EQS exceedances

Constituent	Units	EQS (mg/l)	Number of samples	Minimum concentration	Maximum concentration	Number of exceedances	Location & Depth (m bgl)
Copper	mg/l	0.001	58	<0.0003	0.0142	35	BH-OBC-07, 24.5m, Section 6; BH-OBC-11, 15.5m, Section 6; BH-OBC-15, 27m, Section 6; BH-PTR-02, 1.7m, Section 2; BH-PTR-02, 7.25m, Section 2; BH-PTR-02, 1.7m, Section 2; BH-PTR-02, 5.3m, Section 2; BH-PTR-03, 4m, Section 2; BH-PTR-04, 2.5m, Section 2; BH-PTR-07, 7m, Section 2; BH-PTR-08, 2m, Section 2; BH-PTR-08, 1.3m, Section 2; BH-PTR-10, 3m, Section 2; BH-PTR-10, 3m, Section 2; BH-PTR-12, 8.5m, Section 2; BH-PTR-12, 8.5m, Section 2; BH-PTR-14, 7.5m, Section 2; BH-PTR-14, 7.5m, Section 2; BH-PTR-18, 4.4m, Section 3; BH-PTR-19, 3.5m, Section 4; BH-PTR-19, 3.25m, Section 4; BH-PTR-21, 3m, Section 4; BH-PTR-30, 18.5m, Section 4; BH-PTR-33, 3m, Section 4; BH-PTR-35, 3m, Section 4; BH-PTR-36, 2.3m, Section 4; BH-PTR-39, 13m, Section 4; BH-PTR-41, 7.5m, Section 4; BH-PTR-41, 1.7m, Section 4; BH-PTR-43, 2.5m, Section 4; BH-PTR-43, 7m, Section 4; BH-PTR-43, 2m, Section 4; BH-PTR-43, 7m, Section 4; BH-PTR-45, 7.5m, Section 5; BH-TH-01, 9m, TH
Iron	mg/l	1	58	<0.019	1.42	1	BH-PTR-07, 7m, Section 2
Lead	mg/l	0.0012	58	<0.0002	0.00439	7	BH-OBC-07, 24.5m, Section 6; BH-OBC-15, 27m, Section 6; BH-PTR-02, 1.7m, Section 2; BH-PTR-07, 7m, Section 2; BH-PTR-10, 3m, Section 2; BH-PTR-14, 7.5m, Section 2; BH-PTR-19, 3.25m, Section 4
Manganese	mg/l	0.123	58	<0.003	0.474	6	BH-PTR-02, 1.7m, Section 2; BH-PTR-07, 7m, Section 2; BH-PTR-14, 7.5m, Section 2; BH-PTR-43, 2.5m, Section 4; BH-PTR-43, 2m, Section 4; BH-PTR-43, 7m, Section 4

Page 39 of 60

2:
BH
BH
4:
4:
Se
Se
Se

Table 8-4 - Groundwater DWS exceedances

Constituent	Unit	GAC (mg/l)	No. of Samples	Min. Value	Max. Value	No. of Exceedances	Locations of Exceedances
Iron	mg/l	0.2	58	<0.019	1.42	9	BH-OBC-15, 27m (Section 6); BH-PTR-02, 1.7m (Section 2); BH-PTR-07, 7m (section 2); BH-PTR-08, 12m (section 2); BH-PTR-08, 11.5m (section 2); BH-PTR-10, 3m (section 2); BH-PTR-14, 7.5m (section 4); BH-PTR-19, 3.25m Section 5); BH-PTR-43, 2.5m (section 5)
Manganese	mg/l	0.05	58	<0.003	0.474	16	BH-PTR-02, 1.7m (Section 2); BH-PTR-03, 4m (Section 2); BH-PTR-07, 7m (Section 2); BH-PTR-08, 11.5m (Section 2); BH-PTR-10, 3m (Section 2); BH-PTR-14, 7.5m (section 4); BH-PTR-18, 4.4m (Section 5); BH-PTR-19, 3.25m (Section 5); BH-PTR-36, 2.3m (section 5); BH-PTR-41, 2.1m (section 5); BH-PTR-41, 1.7m (section 5); BH-PTR-43, 2.5m (section 5); BH-PTR-43, 7m (section 5); BH-PTR-43, 2m (section 5); BH-PTR-43, 7m (section 5)
Selenium	mg/l	0.01	58	<0.001	0.0187	2	BH-PTR-08, 2m (Section 2); BH-PTR-08, 1.3m (section 2).
Fluoride	mg/l	1.5	58	<0.5	2.73	1	BH-PTR-43, 7m (section 5)
Ammoniacal	mg/l	0.39	58	0.01	0.718	3	BH-PTR-35, 2m (section 5); BH-PTR-43, 2.5m (section 5); BH-PTR-43, 2m (section 5)

Nitrogen as N							
Sulphate as SO4	mg/l	250	58	15.3	895	4	BH-PTR-03, 4m (section 2); BH-PTR-03A, 4.9m (section 2); BH-PTR-43, 2.5m (section 5); BH-PTR-43, 2m (section 5).
Benzo(a) pyrene	mg/l	0.00001	58	<0.000002	0.000108	18	BH-OBC-06, 7.45m (section 6); BH-OBC-06, 7m (section 6); BH-PTR-02, 1.7m (section 2); BH-PTR-03A, 4.9m (section 2); BH-PTR-04, 2.5m (section 2); BH-PTR-08, 11.5m (section 2); BH-PTR-33, 3m (section 5); BH-PTR-36, 2.3m (section 5); BH-PTR-36, 2.75m (section 5); BH-PTR-41, 1.7m (section 5); BH-PTR-42, 6.75m (section 5); BH-PTR-42, 6.5m (section 5); BH-PTR-43, 2.5m (section 5); BH-PTR-43, 7m (section 5); BH-PTR-43, 2m (section 5); BH-PTR-43, 7m (section 5); BH-PTR-45, 7.5m (section 6)

8.3. Results and Discussion

Recorded concentrations of contaminants in soil-leachate and groundwater were recorded above both EQS and DWS. The potential risk these pose to controlled waters is discussed below.

8.3.1. Metals

A comparison of metal soil-leachate and groundwater exceedances at the Scheme is presented in Table 8-5.

Table 8-5 - Comparison of Metal Soil-leachate and Groundwater Exceedances

CoC	Leachate (mg/l)			Groundwater (mg/l)		
	No. of samples	No. of exceedances EQS	No. of exceedances DWS	No. of samples	No. of exceedances EQS	No. of exceedances DWS
Cadmium	141	3	0	58	0	0
Copper	141	42	0	58	35	0
Iron	141	1	34	58	1	9
Lead	141	6	0	58	7	0
Mercury	141	1	0	58	0	0
Nickel	141	2	0	58	12	0
Vanadium	141	1	0	58	0	0
Zinc	141	16	0	58	20	0
Arsenic	141	0	1	58	0	0
Manganese	141	0	1	58	6	16
Selenium	141	0	0	58	0	2

Soil-leachate exceedances of cadmium, mercury, vanadium and arsenic in Made Ground were isolated across the Scheme while corresponding groundwater concentrations were recorded below the adopted EQS and DWS. This indicates while there is a limited source of these contaminants and that there is unlikely to be a pathway to underlying groundwater.

While rare nickel and manganese exceedances were recorded against WQS in groundwater they were limited or absent from soil-leachate samples which indicates the groundwater concentrations may not be a result from sources of contamination at the Scheme. Exceedances of selenium were absent in soil-leachate and limited to 2 / 58 samples in groundwater indicating a low risk to controlled waters.

While groundwater exceedances of copper, zinc and lead have been identified across the Scheme, the concentrations were typically recorded within one order of magnitude of the adopted DWS or EQS criteria. Given the low level of the exceedances recorded across the Scheme and the limited corresponding values in soil-leachate (all within one order of magnitude of the adopted criteria, the risk to controlled waters from metals is considered to be low.

8.3.2. Organics

On completion of the screening exercise 18 of 58 samples recorded concentrations of Benzo(a)pyrene (BaP) above both the EQS and DWS criteria. The highest concentration was recorded within a sample taken from BH-PTR-43 at 0.000108 mg/l.

23 of 58 samples recorded fluoranthene above the adopted EQS criteria. Each exceedance with the exception of one were within the same order of magnitude as the EQS, with a sample taken from BH-PTR-43 recording a concentration of 0.0001 mg/l against the EQS of 0.00000017.

The Tetra Tech factual report notes Obvious signs of anthropogenic influence were noted to deeper levels in local areas, notably in North Farm (TP-PTR-32 to TP-PTR-37 inclusive, and BH-PTR-43A, BH-PTR-43B, BH-PTR-44, BH-PTR-44A and BH-PTR-45) where inclusions of brick, concrete, asphalt and fused ash, possibly associated with the former rail line, were noted to depths of up to 2.65m bgl.

Higher concentrations of both BaP and fluoranthene in soil and groundwater coincided with the location of North Farm at the boundary between Sections 4 and 5. It is considered plausible that the Made Ground recorded locally has resulted in the leaching and subsequent migration of the identified compounds to groundwater.

On the basis of the current dataset the risk to controlled water is considered to be low due to the low level of the exceedances against the adopted criteria.

8.4. Conclusions and Recommendations

Following completion of the GQRA, the overall risk posed to identified controlled water receptors is considered to be low.

However, as a precautionary measure it is recommended that a watching brief is implemented during future earthworks in the vicinity of North Farm. If unexpected contamination is encountered a geoenvironmental professional should be contacted to inform the next steps and consideration of the need for further risk assessment or localised remediation.

Additionally, given the sensitivity of the water environment (Principal Aquifers, SPZs and surface water bodies identified) it is recommended that a Piling Risk Assessment is undertaken to assess the risk that proposed piling activities may pose to controlled waters. All future materials management should be done in line with CL:AIRE guidance where Scheme specific criteria for the reuse of controlled water are derived and that these criteria are suitably protective of the identified receptors across the Scheme.

9. Refined Conceptual Site Model

The preliminary conceptual model for the Scheme was presented in Section 3 and has been updated based on the findings of the investigation and assessment detailed in Sections 6 to 8.

Table 9-1 presents the updated conceptual site model identifying the remaining relevant and significant contaminant linkages.

Table 9-1 - Revised conceptual site model

Source	Receptor	Pathway	Consequence	Probability	Classification of Risk	Comment
At the Scheme Artificial Ground and associated contamination from past and current structures / infrastructure / historical mining / infilled pits. Potential asbestos from demolished historical structures within soil. Vehicles and trains using existing infrastructure may have resulted in fuel/oil spillages to ground. Large areas of the site and surroundings are currently designated as agricultural fields so agricultural pesticides and sewage sludge may have been applied to the ground, with localised fuel fuel/oil spillages from agricultural machinery possible. Historical landfill sites within 250 m	Human Health (At the Scheme) On-site users (users of the Travel Hub and public transport route)	Inhalation, ingestion and dermal contact with contaminants in soil and soil-derived dust/fibres	Medium	Unlikely	Low	Screening of soil analytical results against a Public Open Space (Parks) end use indicated a low risk to human health from soils at the Scheme.
		Migration and accumulation of ground gases followed by inhalation or ignition causing asphyxiation and/or explosion	Medium	Unlikely	Low	Ground Gas data indicates the regime to be commensurate with a CS1 'very low risk'. Risk to human health receptors from ground gas or vapour is considered to be low.
		Inhalation of vapours from contaminated soil and / or water	Medium	Unlikely	Low	Screening of soil analytical results against a Public Open Space (Parks) end use indicated a low risk to human health from soils at the Scheme.
		Inhalation, ingestion and dermal contact with contaminants in soil and soil-derived dust/fibres	Medium	Unlikely	Low	Screening of soil analytical results against a Public Open Space (Parks) end use indicated a low risk to human health from soils at the Scheme.
	Human Health (at the Scheme) Pedestrians accessing existing roads, footpaths and public rights of way	Inhalation, ingestion and dermal contact with contaminants in windblown soil-derived dust/fibres	Medium	Unlikely	Low	Screening of soil analytical results against a Public Open Space (Parks) end use indicated a low risk to human health from soils at the Scheme.
		Migration and accumulation of ground gases followed by inhalation or ignition causing asphyxiation and/or explosion	Medium	Unlikely	Low	Ground Gas data indicates the regime to be commensurate with a CS1 'very low risk'. Risk to human health receptors from ground gas or vapour is considered to be low.
		Inhalation of vapours from contaminated soil and / or water	Medium	Unlikely	Low	Screening of soil analytical results against a Public Open Space (Parks) end use indicated a low risk to human health from soils at the Scheme.

of the route centreline Organics associated with the Alluvium deposits with the potential to produce ground gas	Controlled Waters: Groundwater, the principal and secondary A Aquifers associated with the superficial / bedrock deposits underlying the Scheme Surface waters that intersect the Scheme – The River Granta	Leaching/ vertical migration of contaminants in soils to underlying groundwater	Medium	Unlikely	Low	Soil leachate analytical results for metals, organics and inorganics indicate a low risk
		Migration of groundwater	Medium	Unlikely	Low	
		Vertical migration of contaminants via preferential pathways such as via piles to deeper groundwater	Medium	Low Likelihood	Moderate/low	GQRA concludes the risk to controlled water is low however, it is recommended that a Piling Risk Assessment is undertaken to assess the risk that proposed piling activities may pose to controlled waters.
		Vertical migration of contaminants via preferential pathways such as via piles to groundwater followed by lateral migration	Medium	Low Likelihood	Moderate/low	
Off Site Existing and historical infrastructure surrounding the site such as the Cambridge-London railway and disused railway and traffic using surrounding roads could be a	Property Residential and commercial properties in the wider area Enclosed spaces associated with the infrastructure work (ie. borrow pits / maintenance pits Services and Infrastructure (including piles and foundations)	Migration and accumulation of ground gases followed by ignition causing explosion	Medium	Unlikely	Low	Ground Gas data indicates the regime to be commensurate with a CS1 'very low risk'. Risk to property receptors from ground gas is considered to be low.
		Migration and accumulation of ground gases followed by inhalation or ignition causing asphyxiation and/or explosion	Medium	Unlikely	Low	Ground Gas data indicates the regime to be commensurate with a CS1 'very low risk'. Risk to human health receptors from ground gas or vapour is considered to be low.
		Migration and accumulation of ground gases followed by inhalation or ignition causing asphyxiation and/or explosion	Medium	Unlikely	Low	Screening of soil analytical results against a Public Open Space (Parks) end use indicated a low risk to human health from soils at the Scheme.
		Inhalation of vapours from contaminated soil and / or water	Medium	Unlikely	Low	

Ground Gas data indicates the regime to be commensurate with a CS1 'very low risk'. Risk to property receptors from ground gas is considered to be low.

Low

Unlikely

Medium

Ground gas migration and accumulation in enclosed structures followed by ignition and explosion.

Property
Residential and commercial properties in the wider area
Enclosed spaces associated with the infrastructure work (ie. borrow pits / maintenance pits)
Services and Infrastructure (including piles and foundations)

potential source of hydrocarbons (e.g. via fuel and/or oil leaks)
Numerous surrounding industries such as historical mining, farming, engineering works and depots, along with businesses such as fuel stations, garages, tyre dealers, cleaners and waste disposal services which are present in the surrounding area.
Historical landfill sites in the wider area >250 m from the route centreline
Sewage farms and pumping stations may result in contamination associated with chemicals associated with water purification.

10. Preliminary Waste Assessment

10.1. Classification of waste

Material that is surplus to requirements and where there is no clear strategy for reuse at the Scheme is classified as waste and should be disposed of in accordance with the Duty of Care as specified in the Landfill Regulations [25].

A preliminary waste assessment has been undertaken based on analysed concentrations of contaminants in 184 soil samples obtained during the ground investigation summarised in this report and using Atkins' on-line waste classification tool, CAT-WASTE SOIL [26]. The assessment was undertaken with TPH inputted as unknown hydrocarbon / oil with marker compound on the basis that this represents the most conservative approach.

The results of the CAT-WASTE SOIL assessment indicate that each screened sample would be classified as non-hazardous waste. Results of the CATWASTE assessment are presented in Appendix E.3.

This classification is a preliminary assessment based on point samples from locations across the Scheme. The actual material to be removed off-site for disposal, if any, must be appropriately classified and the classification agreed with the chosen landfill operator. Waste Acceptance Criteria testing may also be required to determine how the material will behave in landfill.

It is the responsibility of the waste producer to classify, treat, manage and dispose of waste appropriately and to ensure the chosen landfill is licensed to accept such material. In addition, note that individual landfill sites may have their own soil and soil leachate limits for waste acceptance as stipulated in their waste permit.

10.2. Suitability for reuse

Material can be reused at the Scheme if there is a genuine design requirement (and only the volume needed is used), it meets geotechnical criteria and it can be demonstrated that it does not pose an unacceptable risk to human health or the environment.

Future materials management should be done in line with CL:AIRE Definition of Waste Code of Practice where Scheme specific criteria for the reuse of materials are derived and that these criteria are suitably protective of the identified receptors across the Scheme. Appropriate sampling of the actual material excavated will be required and be the responsibility of the contractor with concentrations compared to appropriate reuse criteria to confirm suitability for reuse or otherwise, specific to the required end use.

11. Conclusions and recommendations

11.1. Summary and Recommendations

The objective of the report was to provide a land contamination assessment to identify potential risks to human health and controlled waters, together with recommendations for mitigation, inform reuse / waste requirements and identify geo-environmental risks to the project and recommendations for mitigation.

A summary of the assessments progressed, and any associated recommendations is outlined below.

11.1.1. Human Health Risk Assessment Conclusions

A total of 138 soil samples were analysed across the Scheme. All of these samples were collected the depths of 0.1 m and 4.0 m bgl.

Potential asbestos containing material was not identified during the GI, soil analytical results indicate that no asbestos fibres or ACM were identified during subsequent testing

One soil sample collected from BH-PTR-33 at 1.5 m bgl recorded a concentration of lead that exceeds the adopted public open space (parks) end use soil GAC. The soil exceedance is within the same magnitude as the soil GAC.

On the basis of the limited exceedances recorded during the screening process alongside the limited evidence of visual or olfactory contamination during the GI, the risk to human health receptors associated with the whole scheme development is considered to be low.

11.1.2. Ground Gas Risk Assessment Conclusions

Based on the proposed end use where at present no enclosed spaces are proposed along the route and the travel hub is determined to be a low risk Type C building in line with BS8485, the receptors are considered to be of low sensitivity. 27 of 31 boreholes monitored presented ground gas conditions commensurate with a CS1 indicating very low risk, moreover, of the four monitoring wells that were commensurate with a CS2 none were situated in the area of the proposed travel hub structure.

On this basis, Atkins considers it appropriate to adopt this as representative of the Scheme's ground gas regime given the low organic content in Made Ground, gas monitoring results and lack of visual or olfactory evidence of organic contamination during the GI. .

As a result, no ground gas mitigation measures are considered necessary within the future infrastructure project.

11.1.3. Controlled Water Risk Assessment Conclusions and Recommendations

Following completion of the GQRA, the overall risk posed to identified controlled water receptors is considered to be low.

However, as a precautionary measure it is recommended that a watching brief is implemented during future earthworks in the vicinity of North Farm. If unexpected contamination is encountered a geoenvironmental professional should be contacted to inform the next steps and consideration of the need for further risk assessment or localised remediation.

Additionally, given the sensitivity of the water environment (Principal Aquifers, SPZs and surface water bodies identified) it is recommended that a Piling Risk Assessment is undertaken to assess the risk that proposed piling activities may pose to controlled waters. All future materials management should be done in line with CL:AIRE guidance where Scheme specific criteria for the reuse of controlled water are derived and that these criteria are suitably protective of the identified receptors across the Scheme.

At this stage, it is recommended the Scheme's network of monitoring wells is protected and preserved for utilisation during future phases of work. However, prior to Scheme clearance/demolition the wells should be decommissioned in line with good practice Environment Agency Guidance [27].

11.1.4. Waste and Suitability for Reuse Conclusions and Recommendations

A preliminary waste assessment has been undertaken based on analysed concentrations of contaminants in 184 soil samples obtained during the ground investigation summarised in this report and using Atkins' on-line waste classification tool, CAT-WASTE SOIL [26].

The results of the CAT-WASTE SOIL assessment indicate that each screened sample would be classified as non-hazardous waste.

This classification is a preliminary assessment based on point samples from locations across the Scheme. The actual material to be removed off-site for disposal, if any, must be appropriately classified and the classification agreed with the chosen landfill operator. Waste Acceptance Criteria testing may also be required to determine how the material will behave in landfill.

Material can be reused at the Scheme if there is a genuine design requirement (and only the volume needed is used), it meets geotechnical criteria and it can be demonstrated that it does not pose an unacceptable risk to human health or the environment.

Future materials management should be done in line with CL:AIRE Definition of Waste Code of Practice where Scheme specific criteria for the reuse of materials are derived and that these criteria are suitably protective of the identified receptors across the Scheme. Appropriate sampling of the actual material excavated will be required and be the responsibility of the contractor with concentrations compared to appropriate reuse criteria to confirm suitability for reuse or otherwise, specific to the required end use.

12. References

- [1] Mott MacDonald Ltd, "Cambridge South East Transport - Phase 2, Ground Investigation Specification, 403394-MMD-HWA-00-RP-HW-0462," Mott MacDonald Ltd, Norwich, October 2020.
- [2] Tetra Tech, "Cambridge South East Transport - Phase 2, Factual Ground Investigation Report, B024522," Tetra Tech, London, April 2022.
- [3] Mott MacDonald Ltd, "Cambridge South East Transport Phase 2, High Quality Public Transport and Active Travel Path Corridor Design, 403394-MMD-HWA-00-RP-HW-0846 | P01," Mott MacDonald Ltd, Norwich, May 2021.
- [4] Mott MacDonald Ltd, "A1307 Cambridge South East Transport - Phase 2, Geotechnical and Geo-Environmental Preliminary Risk Assessment, 403394-MMD-TGE-00-RP-GE-0248," Mott MacDonald Ltd, Norwich, December 2019.
- [5] DEFRA, "Magic Maps," [Online]. Available: <https://magic.defra.gov.uk/>. [Accessed 04 October 2021].
- [6] Environment Agency, "Catchment Data Explorer," 2021. [Online]. Available: <https://environment.data.gov.uk/catchment-planning/>. [Accessed 04 October 2021].
- [7] UK Parliament, *Environmental Protection Act: Part 2A*, 1990.
- [8] UK Parliament, "Town and Country Planning Act," 1990a.
- [9] Department for Communities and Local Government, *National Planning Policy Framework*, Open Government, 2018.
- [10] Environment Agency, "Land contamination: risk management," 2020. [Online]. Available: <https://www.gov.uk/guidance/land-contamination-how-to-manage-the-risks>.
- [11] Mott Macdonald, "A1307 Cambridge South East Transport Phase 2," 2019.
- [12] Construction Industry Research and Information Association (CIRIA), "Contaminated Land Risk Assessment: A guide to good practice (C552)," 2001.
- [13] CIRIA, "Contaminated land risk assessment. A guide to good practice (C552)," 2001.
- [14] British Standards Institution, "BS5930:2015 + A1:2020 Code of Practice for Ground Investigations," 2020.
- [15] British Standards Institution, "BS10175:2011+A2:2017 Investigation of Potentially Contaminated Sites," 2017.
- [16] Atkins, "CSET Geotechnical GIR," 2022.
- [17] Soltys Brewster and Atkins, "Carmarthenshire Cycle Path and Bridges Preliminary Ecological Appraisal," Atkins, Bristol, 2019.
- [18] Environment Agency, "Human health toxicological assessment of contaminants in soil: Science Report SC050021/SR2," 2009.
- [19] Environment Agency, "Science Report SC050021/SR3: Updated Technical Background to the CLEA model," 2009.
- [20] DEFRA, "Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination," 2013.
- [21] (BSI) British Standards Institute, "BS 8485:2015 (Revised 2019). Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings.," 2019.
- [22] (HSE) Health and Safety Executive, "EH40/2005 Workplace Exposure Limits.," January 2020.
- [23] Tetra Tech , "Cambridge South East Transport - Phase 2. Factual Ground Investigation Report," Tetra Tech, 2021.
- [24] HMSO, "The Water Framework Directive (Standards and Classification) Direction (England and Wales)," 2015.
- [25] DEFRA, "Waste Duty of Care Code of Practice," 2016.
- [26] Atkins, "CatWasteSoil," 2019. [Online]. Available: www.catwastesoil.co.uk.
- [27] Environment Agency, "Good practice for decommissioning redundant boreholes and wells," October 2012.

Appendices

Appendix E.1 – Human Health Screening

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232	1233	1234	1235	1236	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246	1247	1248	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259	1260	1261	1262	1263	1264	1265	1266	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276	1277	1278	1279	1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1295	1296	1297	1298	1299	1300	1301	1302	1303	1304	1305	1306	1307	1308	1309	1310	1311	1312	1313	1314	1315	1316	1317	1318	1319	1320	1321	1322	1323	1324	1325	1326	1327	1328	1329	1330	1331	1332	1333	1334	1335	1336	1337	1338	1339	1340	1341	1342	1343	1344	1345	1346	1347	1348	1349	1350	1351	1352	1353	1354	1355	1356	1357	1358	1359	1360	1361	1362	1363	1364	1365	1366	1367	1368	1369	1370	1371	1372	1373	1374	1375	1376	1377	1378	1379	1380	1381	1382	1383	1384	1385	1386	1387	1388	1389	1390	1391	1392	1393	1394	1395	1396	1397	1398	1399	1400	1401	1402	1403	1404	1405	1406	1407	1408	1409	1410	1411	1412	1413	1414	1415	1416	1417	1418	1419	1420	1421	1422	1423	1424	1425	1426	1427	1428	1429	1430	1431	1432	1433	1434	1435	1436	1437	1438	1439	1440	1441	1442	1443	1444	1445	1446	1447	1448	1449	1450	1451	1452	1453	1454	1455	1456	1457	1458	1459	1460	1461	1462	1463	1464	1465	1466	1467	1468	1469	1470	1471	1472	1473	1474	1475	1476	1477	1478	1479	1480	1481	1482
---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------

SHEET INFORMATION		SHEET INFORMATION	
PROJECT INFORMATION		PROJECT INFORMATION	
PROJECT NAME	[Project Name]	PROJECT NAME	[Project Name]
CLIENT	[Client Name]	CLIENT	[Client Name]
LOCATION	[Location]	LOCATION	[Location]
DATE	[Date]	DATE	[Date]
DESIGN INFORMATION		DESIGN INFORMATION	
DESIGNER	[Designer Name]	DESIGNER	[Designer Name]
REVISION	[Revision Number]	REVISION	[Revision Number]
CALCULATION DATA		CALCULATION DATA	
PARAMETER	UNIT	VALUE	UNIT
1.1	m	1.2	m
2.1	m	2.2	m
3.1	m	3.2	m
4.1	m	4.2	m
5.1	m	5.2	m
6.1	m	6.2	m
7.1	m	7.2	m
8.1	m	8.2	m
9.1	m	9.2	m
10.1	m	10.2	m
11.1	m	11.2	m
12.1	m	12.2	m
13.1	m	13.2	m
14.1	m	14.2	m
15.1	m	15.2	m
16.1	m	16.2	m
17.1	m	17.2	m
18.1	m	18.2	m
19.1	m	19.2	m
20.1	m	20.2	m
21.1	m	21.2	m
22.1	m	22.2	m
23.1	m	23.2	m
24.1	m	24.2	m
25.1	m	25.2	m
26.1	m	26.2	m
27.1	m	27.2	m
28.1	m	28.2	m
29.1	m	29.2	m
30.1	m	30.2	m
31.1	m	31.2	m
32.1	m	32.2	m
33.1	m	33.2	m
34.1	m	34.2	m
35.1	m	35.2	m
36.1	m	36.2	m
37.1	m	37.2	m
38.1	m	38.2	m
39.1	m	39.2	m
40.1	m	40.2	m
41.1	m	41.2	m
42.1	m	42.2	m
43.1	m	43.2	m
44.1	m	44.2	m
45.1	m	45.2	m
46.1	m	46.2	m
47.1	m	47.2	m
48.1	m	48.2	m
49.1	m	49.2	m
50.1	m	50.2	m
51.1	m	51.2	m
52.1	m	52.2	m
53.1	m	53.2	m
54.1	m	54.2	m
55.1	m	55.2	m
56.1	m	56.2	m
57.1	m	57.2	m
58.1	m	58.2	m
59.1	m	59.2	m
60.1	m	60.2	m
61.1	m	61.2	m
62.1	m	62.2	m
63.1	m	63.2	m
64.1	m	64.2	m
65.1	m	65.2	m
66.1	m	66.2	m
67.1	m	67.2	m
68.1	m	68.2	m
69.1	m	69.2	m
70.1	m	70.2	m
71.1	m	71.2	m
72.1	m	72.2	m
73.1	m	73.2	m
74.1	m	74.2	m
75.1	m	75.2	m
76.1	m	76.2	m
77.1	m	77.2	m
78.1	m	78.2	m
79.1	m	79.2	m
80.1	m	80.2	m
81.1	m	81.2	m
82.1	m	82.2	m
83.1	m	83.2	m
84.1	m	84.2	m
85.1	m	85.2	m
86.1	m	86.2	m
87.1	m	87.2	m
88.1	m	88.2	m
89.1	m	89.2	m
90.1	m	90.2	m
91.1	m	91.2	m
92.1	m	92.2	m
93.1	m	93.2	m
94.1	m	94.2	m
95.1	m	95.2	m
96.1	m	96.2	m
97.1	m	97.2	m
98.1	m	98.2	m
99.1	m	99.2	m
100.1	m	100.2	m

As a result of

Appendix E.3 CATWaste Soils Screening

Soil Sample ID		Soil Sample Description		Soil Sample Location		Soil Sample Date		Soil Sample Type		Soil Sample Analysis		Soil Sample Results		Soil Sample Comments	
Soil Sample ID		Soil Sample Description		Soil Sample Location		Soil Sample Date		Soil Sample Type		Soil Sample Analysis		Soil Sample Results		Soil Sample Comments	
1001		1001-01		1001-01-01		1001-01-01-01		1001-01-01-01-01		1001-01-01-01-01-01		1001-01-01-01-01-01-01		1001-01-01-01-01-01-01-01	
1002		1002-01		1002-01-01		1002-01-01-01		1002-01-01-01-01		1002-01-01-01-01-01		1002-01-01-01-01-01-01		1002-01-01-01-01-01-01-01	
1003		1003-01		1003-01-01		1003-01-01-01		1003-01-01-01-01		1003-01-01-01-01-01		1003-01-01-01-01-01-01		1003-01-01-01-01-01-01-01	
1004		1004-01		1004-01-01		1004-01-01-01		1004-01-01-01-01		1004-01-01-01-01-01		1004-01-01-01-01-01-01		1004-01-01-01-01-01-01-01	
1005		1005-01		1005-01-01		1005-01-01-01		1005-01-01-01-01		1005-01-01-01-01-01		1005-01-01-01-01-01-01		1005-01-01-01-01-01-01-01	
1006		1006-01		1006-01-01		1006-01-01-01		1006-01-01-01-01		1006-01-01-01-01-01		1006-01-01-01-01-01-01		1006-01-01-01-01-01-01-01	
1007		1007-01		1007-01-01		1007-01-01-01		1007-01-01-01-01		1007-01-01-01-01-01		1007-01-01-01-01-01-01		1007-01-01-01-01-01-01-01	
1008		1008-01		1008-01-01		1008-01-01-01		1008-01-01-01-01		1008-01-01-01-01-01		1008-01-01-01-01-01-01		1008-01-01-01-01-01-01-01	
1009		1009-01		1009-01-01		1009-01-01-01		1009-01-01-01-01		1009-01-01-01-01-01		1009-01-01-01-01-01-01		1009-01-01-01-01-01-01-01	
1010		1010-01		1010-01-01		1010-01-01-01		1010-01-01-01-01		1010-01-01-01-01-01		1010-01-01-01-01-01-01		1010-01-01-01-01-01-01-01	
1011		1011-01		1011-01-01		1011-01-01-01		1011-01-01-01-01		1011-01-01-01-01-01		1011-01-01-01-01-01-01		1011-01-01-01-01-01-01-01	
1012		1012-01		1012-01-01		1012-01-01-01		1012-01-01-01-01		1012-01-01-01-01-01		1012-01-01-01-01-01-01		1012-01-01-01-01-01-01-01	
1013		1013-01		1013-01-01		1013-01-01-01		1013-01-01-01-01		1013-01-01-01-01-01		1013-01-01-01-01-01-01		1013-01-01-01-01-01-01-01	
1014		1014-01		1014-01-01		1014-01-01-01		1014-01-01-01-01		1014-01-01-01-01-01		1014-01-01-01-01-01-01		1014-01-01-01-01-01-01-01	
1015		1015-01		1015-01-01		1015-01-01-01		1015-01-01-01-01		1015-01-01-01-01-01		1015-01-01-01-01-01-01		1015-01-01-01-01-01-01-01	
1016		1016-01		1016-01-01		1016-01-01-01		1016-01-01-01-01		1016-01-01-01-01-01		1016-01-01-01-01-01-01		1016-01-01-01-01-01-01-01	
1017		1017-01		1017-01-01		1017-01-01-01		1017-01-01-01-01		1017-01-01-01-01-01		1017-01-01-01-01-01-01		1017-01-01-01-01-01-01-01	
1018		1018-01		1018-01-01		1018-01-01-01		1018-01-01-01-01		1018-01-01-01-01-01		1018-01-01-01-01-01-01		1018-01-01-01-01-01-01-01	
1019		1019-01		1019-01-01		1019-01-01-01		1019-01-01-01-01		1019-01-01-01-01-01		1019-01-01-01-01-01-01		1019-01-01-01-01-01-01-01	
1020		1020-01		1020-01-01		1020-01-01-01		1020-01-01-01-01		1020-01-01-01-01-01		1020-01-01-01-01-01-01		1020-01-01-01-01-01-01-01	
1021		1021-01		1021-01-01		1021-01-01-01		1021-01-01-01-01		1021-01-01-01-01-01		1021-01-01-01-01-01-01		1021-01-01-01-01-01-01-01	
1022		1022-01		1022-01-01		1022-01-01-01		1022-01-01-01-01		1022-01-01-01-01-01		1022-01-01-01-01-01-01		1022-01-01-01-01-01-01-01	
1023		1023-01		1023-01-01		1023-01-01-01		1023-01-01-01-01		1023-01-01-01-01-01		1023-01-01-01-01-01-01		1023-01-01-01-01-01-01-01	
1024		1024-01		1024-01-01		1024-01-01-01		1024-01-01-01-01		1024-01-01-01-01-01		1024-01-01-01-01-01-01		1024-01-01-01-01-01-01-01	
1025		1025-01		1025-01-01		1025-01-01-01		1025-01-01-01-01		1025-01-01-01-01-01		1025-01-01-01-01-01-01		1025-01-01-01-01-01-01-01	
1026		1026-01		1026-01-01		1026-01-01-01		1026-01-01-01-01		1026-01-01-01-01-01		1026-01-01-01-01-01-01		1026-01-01-01-01-01-01-01	
1027		1027-01		1027-01-01		1027-01-01-01		1027-01-01-01-01		1027-01-01-01-01-01		1027-01-01-01-01-01-01		1027-01-01-01-01-01-01-01	
1028		1028-01		1028-01-01		1028-01-01-01		1028-01-01-01-01		1028-01-01-01-01-01		1028-01-01-01-01-01-01		1028-01-01-01-01-01-01-01	
1029		1029-01		1029-01-01		1029-01-01-01		1029-01-01-01-01		1029-01-01-01-01-01		1029-01-01-01-01-01-01		1029-01-01-01-01-01-01-01	
1030		1030-01		1030-01-01		1030-01-01-01		1030-01-01-01-01		1030-01-01-01-01-01		1030-01-01-01-01-01-01		1030-01-01-01-01-01-01-01	
1031		1031-01		1031-01-01		1031-01-01-01		1031-01-01-01-01		1031-01-01-01-01-01		1031-01-01-01-01-01-01		1031-01-01-01-01-01-01-01	
1032		1032-01		1032-01-01		1032-01-01-01		1032-01-01-01-01		1032-01-01-01-01-01		1032-01-01-01-01-01-01		1032-01-01-01-01-01-01-01	
1033		1033-01		1033-01-01		1033-01-01-01		1033-01-01-01-01		1033-01-01-01-01-01		1033-01-01-01-01-01-01		1033-01-01-01-01-01-01-01	
1034		1034-01		1034-01-01		1034-01-01-01		1034-01-01-01-01		1034-01-01-01-01-01		1034-01-01-01-01-01-01		1034-01-01-01-01-01-01-01	
1035		1035-01		1035-01-01		1035-01-01-01		1035-01-01-01-01		1035-01-01-01-01-01		1035-01-01-01-01-01-01		1035-01-01-01-01-01-01-01	
1036		1036-01		1036-01-01		1036-01-01-01		1036-01-01-01-01		1036-01-01-01-01-01		1036-01-01-01-01-01-01		1036-01-01-01-01-01-01-01	
1037		1037-01		1037-01-01		1037-01-01-01		1037-01-01-01-01		1037-01-01-01-01-01		1037-01-01-01-01-01-01		1037-01-01-01-01-01-01-01	
1038		1038-01		1038-01-01		1038-01-01-01		1038-01-01-01-01		1038-01-01-01-01-01		1038-01-01-01-01-01-01		1038-01-01-01-01-01-01-01	
1039		1039-01		1039-01-01		1039-01-01-01		1039-01-01-01-01		1039-01-01-01-01-01		1039-01-01-01-01-01-01		1039-01-01-01-01-01-01-01	
1040		1040-01		1040-01-01		1040-01-01-01		1040-01-01-01-01		1040-01-01-01-01-01		1040-01-01-01-01-01-01		1040-01-01-01-01-01-01-01	
1041		1041-01		1041-01-01		1041-01-01-01		1041-01-01-01-01		1041-01-01-01-01-01		1041-01-01-01-01-01-01		1041-01-01-01-01-01-01-01	
1042		1042-01		1042-01-01		1042-01-01-01		1042-01-01-01-01		1042-01-01-01-01-01		1042-01-01-01-01-01-01		1042-01-01-01-01-01-01-01	
1043		1043-01		1043-01-01		1043-01-01-01		1043-01-01-01-01		1043-01-01-01-01-01		1043-01-01-01-01-01-01		1043-01-01-01-01-01-01-01	
1044		1044-01		1044-01-01		1044-01-01-01		1044-01-01-01-01		1044-01-01-01-01-01		1044-01-01-01-01-01-01		1044-01-01-01-01-01-01-01	
1045		1045-01		1045-01-01		1045-01-01-01		1045-01-01-01-01		1045-01-01-01-01-01		1045-01-01-01-01-01-01		1045-01-01-01-01-01-01-01	
1046		1046-01		1046-01-01		1046-01-01-01		1046-01-01-01-01		1046-01-01-01-01-01		1046-01-01-01-01-01-01		1046-01-01-01-01-01-01-01	
1047		1047-01		1047-01-01		1047-01-01-01		1047-01-01-01-01		1047-01-01-01-01-01		1047-01-01-01-01-01-01		1047-01-01-01-01-01-01-01	
1048		1048-01		1048-01-01		1048-01-01-01		1048-01-01-01-01		1048-01-01-01-01-01		1048-01-01-01-01-01-01		1048-01-01-01-01-01-01-01	
1049		1049-01		1049-01-01		1049-01-01-01		1049-01-01-01-01		1049-01-01-01-01-01		1049-01-01-01-01-01-01		1049-01-01-01-01-01-01-01	
1050		1050-01		1050-01-01		1050-01-01-01		1050-01-01-01-01		1050-01-01-01-01-01		1050-01-01-01-01-01-01		1050-01-01-01-01-01-01-01	
1051		1051-01		1051-01-01		1051-01-01-01		1051-01-01-01-01		1051-01-01-01-01-01		1051-01-01-01-01-01-01		1051-01-01-01-01-01-01-01	
1052		1052-01		1052-01-01		1052-01-01-01		1052-01-01-01-01		1052-01-01-01-01-01		1052-01-01-01-01-01-01		1052-01-01-01-01-01-01-01	
1053		1053-01		1053-01-01		1053-01-01-01		1053-01-01-01-01		1053-01-01-01-01-01		1053-01-01-01-01-01-01		1053-01-01-01-01-01-01-01	
1054		1054-01		1054-01-01		1054-01-01-01		1054-01-01-01-01		1054-01-01-01-01-01		1054-01-01-01-01-01-01		1054-01-01-01-01-01-01-01	
1055		1055-01		1055-01-01		1055-01-01-01		1055-01-01-01-01		1055-01-01-01-01-01		1055-01-01-01-01-01-01		1055-01-01-01-01-01-01-01	
1056		1056-01		1056-01-01		1056-01-01-01		1056-01-01-01-01		1056-01-01-01-01-01		1056-01-01-01-01-01-01		1056-01-01-01-01-01-01-01	
1057		1057-01		1057-01-01		1057-01-01-01		1057-01-01-01-01		1057-01-01-01-01-01		1057-01-01-01-01-01-01		1057-01-01-01-01-01-01-01	
1058		1058-01		1058-01-01		1058-01-01-01		1058-01-01-01-01		1058-01-01-01-01-01		1058-01-01-01-01-01-01		1058-01-01-01-01-01-01-01	
1059		1059-01		1059-01-01		1059-01-01-01		1059-01-01-01-01		1059-01-01-01-01-01		1059-01-01-01-01-01-01		1059-01-01-01-01-01-01-01	
1060		1060-01		1060-01-01		1060-01-01-01		1060-01-01-01-01		1060-01-01-01-01-01		1060-01-01-01-01-01-01		1060-01-01-01-01-01-01-01	
1061		1061-01		1061-01-01		1061-01-01-01		1061-01-01-01-01		1061-01-01-01-01-01		1061-01-01-01-01-01-01		1061-01-01-01-01-01-01-01	
1062		1062-01		1062-01-01		1062-01-01-01		1062-01-01-01-01		1062-01-01-01-01-01		1062-01-01-01-01-01-01		1062-01-01-01-01-01-01-01	
1063		1063-01		1063-01-01		1063-01-01-01		1063-01-01-01-01		1063-01-01-01-01-01		1063-01-01-01-01-01-01		1063-01-01-01-01-01-01-01	
1064		1064-01		1064-01-01		1064-01-01-01		1064-01-01-01-01		1064-01-01-01-01-01		1064-01-01-01-01-01-01		1064-01-01-01-01-01-01-01	
1065		1065-01		1065-01-01		1065-01-01-01		1065-01-01-01-01		1065-01-01-01-01-01		1065-01-01-01-01-01-01		1065-01-01-01-01-01-01-01	
1066		1066-01		1066-01-01		1066-01-01-01		1066-01-01-01-01		1066-01-01-01-01-01		1066-01-01-01-01-01-01		1066-01-01-01-01-01-01-01	
1067		1067-01		1067											

Site Name	GCP CSET
Location	GCP CSET
Site ID	5210174
Job Number	5210174
Date	9/2/2022
User Name	Mark.Boobyer@atkinsglobal.com
Company Name	Atkins

Hole ID	Sample Depth	Hazardous Waste Y/N	HP1	HP2	HP3	HP4	HP5	HP6	HP7	HP8	HP9
CPT-PTR-06	0.5	N	No	No	No	No	No	No	No	No	No
DCP-HRS-08	0.2	N	No	No	No	No	No	No	No	No	No
DCP-SRS-02	0.2	N	No	No	No	No	No	No	No	No	No
DCP-SRS-02	0.5	N	No	No	No	No	No	No	No	No	No
DCP-SRS-02	1	N	No	No	No	No	No	No	No	No	No
DCP-TH-02	0.2	N	No	No	No	No	No	No	No	No	No
DCP-TH-03	0.1	N	No	No	No	No	No	No	No	No	No
DCP-TH-04	0.5	N	No	No	No	No	No	No	No	No	No
DCP-TH-07	0.2	N	No	No	No	No	No	No	No	No	No
DCP-TH-11	0.5	N	No	No	No	No	No	No	No	No	No
TP-BP-01	1	N	No	No	No	No	No	No	No	No	No
TP-BP-02	0.2	N	No	No	No	No	No	No	No	No	No
TP-BP-02	0.5	N	No	No	No	No	No	No	No	No	No
TP-BP-02	1	N	No	No	No	No	No	No	No	No	No
TP-BP-03	0.2	N	No	No	No	No	No	No	No	No	No
TP-BP-03	0.5	N	No	No	No	No	No	No	No	No	No
TP-BP-03	1	N	No	No	No	No	No	No	No	No	No
TP-BP-04	0.2	N	No	No	No	No	No	No	No	No	No
TP-BP-05	0.1	N	No	No	No	No	No	No	No	No	No
TP-BP-05	0.5	N	No	No	No	No	No	No	No	No	No
TP-HRS-01	0.2	N	No	No	No	No	No	No	No	No	No
TP-HRS-02	0	N	No	No	No	No	No	No	No	No	No
TP-HRS-02	0.2	N	No	No	No	No	No	No	No	No	No
TP-HRS-04	0.1	N	No	No	No	No	No	No	No	No	No
TP-OBC-01	0.2	N	No	No	No	No	No	No	No	No	No
TP-OBC-02	0.2	N	No	No	No	No	No	No	No	No	No
TP-OBC-03	0.1	N	No	No	No	No	No	No	No	No	No
TP-OBC-04	0.1	N	No	No	No	No	No	No	No	No	No

This output data has been generated by the CAT-Waste Soil waste classification tool provided by Atkins Consultants Ltd and J.McArdle Contracts and should be read in conjunction with the standard Terms and Conditions

10:28 05/09/2022

Site Name	GCP CSET
Location	GCP CSET
Site ID	5210174
Job Number	5210174
Date	9/2/2022
User Name	Mark.Boobyer@atkinsglobal.com
Company Name	Atkins

Hole ID	Sample Depth	Hazardous Waste Y/N	HP1	HP2	HP3	HP4	HP5	HP6	HP7	HP8	HP9
TP-OBC-05	0.2	N	No	No	No	No	No	No	No	No	No
TP-OBC-06	1	N	No	No	No	No	No	No	No	No	No
TP-OBC-07	0.8	N	No	No	No	No	No	No	No	No	No
TP-OBC-08	0.5	N	No	No	No	No	No	No	No	No	No
TP-OBC-12	1.4	N	No	No	No	No	No	No	No	No	No
TP-OBC-13	0.2	N	No	No	No	No	No	No	No	No	No
TP-PTR-02	0.5	N	No	No	No	No	No	No	No	No	No
TP-PTR-04	0.1	N	No	No	No	No	No	No	No	No	No
TP-PTR-07	0.1	N	No	No	No	No	No	No	No	No	No
TP-PTR-07	0.5	N	No	No	No	No	No	No	No	No	No
TP-PTR-09	0.1	N	No	No	No	No	No	No	No	No	No
TP-PTR-11	1	N	No	No	No	No	No	No	No	No	No
TP-PTR-13	0.2	N	No	No	No	No	No	No	No	No	No
TP-PTR-14	0	N	No	No	No	No	No	No	No	No	No
TP-PTR-16	1	N	No	No	No	No	No	No	No	No	No
TP-PTR-18	0.2	N	No	No	No	No	No	No	No	No	No
TP-PTR-19	0.1	N	No	No	No	No	No	No	No	No	No
TP-PTR-20	0.2	N	No	No	No	No	No	No	No	No	No
TP-PTR-23	0.1	N	No	No	No	No	No	No	No	No	No
TP-PTR-24	0.2	N	No	No	No	No	No	No	No	No	No
TP-PTR-25	1	N	No	No	No	No	No	No	No	No	No
TP-PTR-26	0.5	N	No	No	No	No	No	No	No	No	No
TP-PTR-26	2	N	No	No	No	No	No	No	No	No	No
TP-PTR-27	0.5	N	No	No	No	No	No	No	No	No	No
TP-PTR-28	1	N	No	No	No	No	No	No	No	No	No
TP-PTR-30	0	N	No	No	No	No	No	No	No	No	No
TP-PTR-30	1	N	No	No	No	No	No	No	No	No	No
TP-PTR-31	0.2	N	No	No	No	No	No	No	No	No	No

This output data has been generated by the CAT-Waste Soil waste classification tool provided by Atkins Consultants Ltd and J.McArdle Contracts and should be read in conjunction with the standard Terms and Conditions

10:28 05/09/2022

Site Name	GCP CSET
Location	GCP CSET
Site ID	5210174
Job Number	5210174
Date	9/2/2022
User Name	Mark.Boobyer@atkinsglobal.com
Company Name	Atkins

Hole ID	Sample Depth	Hazardous Waste Y/N	HP1	HP2	HP3	HP4	HP5	HP6	HP7	HP8	HP9
TP-PTR-31	1	N	No	No	No	No	No	No	No	No	No
TP-PTR-32	0.5	N	No	No	No	No	No	No	No	No	No
TP-PTR-32	1	N	No	No	No	No	No	No	No	No	No
TP-PTR-33	0.2	N	No	No	No	No	No	No	No	No	No
TP-PTR-33	0.5	N	No	No	No	No	No	No	No	No	No
TP-PTR-33	1.5	N	No	No	No	No	No	No	No	No	No
TP-PTR-34	1	N	No	No	No	No	No	No	No	No	No
TP-PTR-36	0.5	N	No	No	No	No	No	No	No	No	No
TP-PTR-36	1	N	No	No	No	No	No	No	No	No	No
TP-PTR-37	0.5	N	No	No	No	No	No	No	No	No	No
TP-PTR-40	1	N	No	No	No	No	No	No	No	No	No
TP-PTR-42	0.2	N	No	No	No	No	No	No	No	No	No
TP-PTR-42	0.5	N	No	No	No	No	No	No	No	No	No
TP-PTR-43	0.5	N	No	No	No	No	No	No	No	No	No
TP-PTR-44	0.2	N	No	No	No	No	No	No	No	No	No
TP-PTR-44	1	N	No	No	No	No	No	No	No	No	No
TP-PTR-56	0.2	N	No	No	No	No	No	No	No	No	No
TP-SRS-01	0.5	N	No	No	No	No	No	No	No	No	No
TP-SRS-01	1.5	N	No	No	No	No	No	No	No	No	No
TP-SRS-02	1.1	N	No	No	No	No	No	No	No	No	No
TP-SRS-02	1.6	N	No	No	No	No	No	No	No	No	No
TP-SRS-02	2.5	N	No	No	No	No	No	No	No	No	No
TP-TH-01	0.2	N	No	No	No	No	No	No	No	No	No
TP-TH-03	0.35	N	No	No	No	No	No	No	No	No	No
TP-TH-06	0.2	N	No	No	No	No	No	No	No	No	No
TP-TH-12	0.2	N	No	No	No	No	No	No	No	No	No

This output data has been generated by the CAT-Waste Soil waste classification tool provided by Atkins Consultants Ltd and J.McArdle Contracts and should be read in conjunction with the standard Terms and Conditions

10:28 05/09/2022

Site Name	GCP CSET
Location	GCP CSET
Site ID	5210174
Job Number	5210174
Date	9/2/2022
User Name	Mark.Boobyer@atkinsglobal.com
Company Name	Atkins

Hole ID	Sample Depth	Hazardous Waste Y/N	HP10	HP11	HP12	HP13	HP14	HP15	HP16
CPT-PTR-06	0.5	N	No	No	No	No	No	No	No
DCP-HRS-08	0.2	N	No	No	No	No	No	No	No
DCP-SRS-02	0.2	N	No	No	No	No	No	No	No
DCP-SRS-02	0.5	N	No	No	No	No	No	No	No
DCP-SRS-02	1	N	No	No	No	No	No	No	No
DCP-TH-02	0.2	N	No	No	No	No	No	No	No
DCP-TH-03	0.1	N	No	No	No	No	No	No	No
DCP-TH-04	0.5	N	No	No	No	No	No	No	No
DCP-TH-07	0.2	N	No	No	No	No	No	No	No
DCP-TH-11	0.5	N	No	No	No	No	No	No	No
TP-BP-01	1	N	No	No	No	No	No	No	No
TP-BP-02	0.2	N	No	No	No	No	No	No	No
TP-BP-02	0.5	N	No	No	No	No	No	No	No
TP-BP-02	1	N	No	No	No	No	No	No	No
TP-BP-03	0.2	N	No	No	No	No	No	No	No
TP-BP-03	0.5	N	No	No	No	No	No	No	No
TP-BP-03	1	N	No	No	No	No	No	No	No
TP-BP-04	0.2	N	No	No	No	No	No	No	No
TP-BP-05	0.1	N	No	No	No	No	No	No	No
TP-BP-05	0.5	N	No	No	No	No	No	No	No
TP-HRS-01	0.2	N	No	No	No	No	No	No	No
TP-HRS-02	0	N	No	No	No	No	No	No	No
TP-HRS-02	0.2	N	No	No	No	No	No	No	No
TP-HRS-04	0.1	N	No	No	No	No	No	No	No
TP-OBC-01	0.2	N	No	No	No	No	No	No	No
TP-OBC-02	0.2	N	No	No	No	No	No	No	No
TP-OBC-03	0.1	N	No	No	No	No	No	No	No
TP-OBC-04	0.1	N	No	No	No	No	No	No	No

This output data has been generated by the CAT-Waste Soil waste classification tool provided by Atkins Consultants Ltd and J.McArdle Contracts and should be read in conjunction with the standard Terms and Conditions

10:28 05/09/2022

Site Name	GCP CSET
Location	GCP CSET
Site ID	5210174
Job Number	5210174
Date	9/2/2022
User Name	Mark.Boobyer@atkinsglobal.com
Company Name	Atkins

Hole ID	Sample Depth	Hazardous Waste Y/N	HP10	HP11	HP12	HP13	HP14	HP15	HP16
TP-OBC-05	0.2	N	No	No	No	No	No	No	No
TP-OBC-06	1	N	No	No	No	No	No	No	No
TP-OBC-07	0.8	N	No	No	No	No	No	No	No
TP-OBC-08	0.5	N	No	No	No	No	No	No	No
TP-OBC-12	1.4	N	No	No	No	No	No	No	No
TP-OBC-13	0.2	N	No	No	No	No	No	No	No
TP-PTR-02	0.5	N	No	No	No	No	No	No	No
TP-PTR-04	0.1	N	No	No	No	No	No	No	No
TP-PTR-07	0.1	N	No	No	No	No	No	No	No
TP-PTR-07	0.5	N	No	No	No	No	No	No	No
TP-PTR-09	0.1	N	No	No	No	No	No	No	No
TP-PTR-11	1	N	No	No	No	No	No	No	No
TP-PTR-13	0.2	N	No	No	No	No	No	No	No
TP-PTR-14	0	N	No	No	No	No	No	No	No
TP-PTR-16	1	N	No	No	No	No	No	No	No
TP-PTR-18	0.2	N	No	No	No	No	No	No	No
TP-PTR-19	0.1	N	No	No	No	No	No	No	No
TP-PTR-20	0.2	N	No	No	No	No	No	No	No
TP-PTR-23	0.1	N	No	No	No	No	No	No	No
TP-PTR-24	0.2	N	No	No	No	No	No	No	No
TP-PTR-25	1	N	No	No	No	No	No	No	No
TP-PTR-26	0.5	N	No	No	No	No	No	No	No
TP-PTR-26	2	N	No	No	No	No	No	No	No
TP-PTR-27	0.5	N	No	No	No	No	No	No	No
TP-PTR-28	1	N	No	No	No	No	No	No	No
TP-PTR-30	0	N	No	No	No	No	No	No	No
TP-PTR-30	1	N	No	No	No	No	No	No	No
TP-PTR-31	0.2	N	No	No	No	No	No	No	No

This output data has been generated by the CAT-Waste Soil waste classification tool provided by Atkins Consultants Ltd and J.McArdle Contracts and should be read in conjunction with the standard Terms and Conditions

10:28 05/09/2022

Site Name	GCP CSET
Location	GCP CSET
Site ID	5210174
Job Number	5210174
Date	9/2/2022
User Name	Mark.Boobyer@atkinsglobal.com
Company Name	Atkins

Hole ID	Sample Depth	Hazardous Waste Y/N	HP10	HP11	HP12	HP13	HP14	HP15	HP16
TP-PTR-31	1	N	No	No	No	No	No	No	No
TP-PTR-32	0.5	N	No	No	No	No	No	No	No
TP-PTR-32	1	N	No	No	No	No	No	No	No
TP-PTR-33	0.2	N	No	No	No	No	No	No	No
TP-PTR-33	0.5	N	No	No	No	No	No	No	No
TP-PTR-33	1.5	N	No	No	No	No	No	No	No
TP-PTR-34	1	N	No	No	No	No	No	No	No
TP-PTR-36	0.5	N	No	No	No	No	No	No	No
TP-PTR-36	1	N	No	No	No	No	No	No	No
TP-PTR-37	0.5	N	No	No	No	No	No	No	No
TP-PTR-40	1	N	No	No	No	No	No	No	No
TP-PTR-42	0.2	N	No	No	No	No	No	No	No
TP-PTR-42	0.5	N	No	No	No	No	No	No	No
TP-PTR-43	0.5	N	No	No	No	No	No	No	No
TP-PTR-44	0.2	N	No	No	No	No	No	No	No
TP-PTR-44	1	N	No	No	No	No	No	No	No
TP-PTR-56	0.2	N	No	No	No	No	No	No	No
TP-SRS-01	0.5	N	No	No	No	No	No	No	No
TP-SRS-01	1.5	N	No	No	No	No	No	No	No
TP-SRS-02	1.1	N	No	No	No	No	No	No	No
TP-SRS-02	1.6	N	No	No	No	No	No	No	No
TP-SRS-02	2.5	N	No	No	No	No	No	No	No
TP-TH-01	0.2	N	No	No	No	No	No	No	No
TP-TH-03	0.35	N	No	No	No	No	No	No	No
TP-TH-06	0.2	N	No	No	No	No	No	No	No
TP-TH-12	0.2	N	No	No	No	No	No	No	No

This output data has been generated by the CAT-Waste Soil waste classification tool provided by Atkins Consultants Ltd and J.McArdle Contracts and should be read in conjunction with the standard Terms and Conditions

10:28 05/09/2022

Site Name	GCP CSET
Location	GCP CSET
Site ID	5210174
Job Number	5210174
Date	9/2/2022
User Name	Mark.Boobyer@atkinsglobal.com
Company Name	Atkins

Hole ID	Sample Depth	Hazardous Waste Y/N	HP1	HP2	HP3	HP4	HP5	HP6	HP7	HP8	HP9
BH-OBC-01	0.1	N	No	No	No	No	No	No	No	No	No
BH-OBC-01	0.5	N	No	No	No	No	No	No	No	No	No
BH-OBC-03	0.5	N	No	No	No	No	No	No	No	No	No
BH-OBC-06	0.1	N	No	No	No	No	No	No	No	No	No
BH-OBC-07	0.5	N	No	No	No	No	No	No	No	No	No
BH-OBC-09	1	N	No	No	No	No	No	No	No	No	No
BH-OBC-10	0.1	N	No	No	No	No	No	No	No	No	No
BH-OBC-11	0.1	N	No	No	No	No	No	No	No	No	No
BH-OBC-14	0.2	N	No	No	No	No	No	No	No	No	No
BH-OBC-14	1	N	No	No	No	No	No	No	No	No	No
BH-OBC-15	0.2	N	No	No	No	No	No	No	No	No	No
BH-OBC-16	0.1	N	No	No	No	No	No	No	No	No	No
BH-PTR-01	0.5	N	No	No	No	No	No	No	No	No	No
BH-PTR-02	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-02	1	N	No	No	No	No	No	No	No	No	No
BH-PTR-03A	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-04	0.5	N	No	No	No	No	No	No	No	No	No
BH-PTR-05	0.1	N	No	No	No	No	No	No	No	No	No
BH-PTR-05	0.5	N	No	No	No	No	No	No	No	No	No
BH-PTR-06	0.1	N	No	No	No	No	No	No	No	No	No
BH-PTR-06	1	N	No	No	No	No	No	No	No	No	No
BH-PTR-07	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-08	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-09	0.5	N	No	No	No	No	No	No	No	No	No
BH-PTR-12	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-16	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-16	1	N	No	No	No	No	No	No	No	No	No
BH-PTR-18	0.2	N	No	No	No	No	No	No	No	No	No

This output data has been generated by the CAT-Waste Soil waste classification tool provided by Atkins Consultants Ltd and J.McArdle Contracts and should be read in conjunction with the standard Terms and Conditions

10:33 05/09/2022

Site Name	GCP CSET
Location	GCP CSET
Site ID	5210174
Job Number	5210174
Date	9/2/2022
User Name	Mark.Boobyer@atkinsglobal.com
Company Name	Atkins

Hole ID	Sample Depth	Hazardous Waste Y/N	HP1	HP2	HP3	HP4	HP5	HP6	HP7	HP8	HP9
BH-PTR-19	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-19	1	N	No	No	No	No	No	No	No	No	No
BH-PTR-20	0.5	N	No	No	No	No	No	No	No	No	No
BH-PTR-20	1	N	No	No	No	No	No	No	No	No	No
BH-PTR-21	0.1	N	No	No	No	No	No	No	No	No	No
BH-PTR-22	0	N	No	No	No	No	No	No	No	No	No
BH-PTR-23	0.1	N	No	No	No	No	No	No	No	No	No
BH-PTR-23	0.5	N	No	No	No	No	No	No	No	No	No
BH-PTR-24A	0.3	N	No	No	No	No	No	No	No	No	No
BH-PTR-24A	1	N	No	No	No	No	No	No	No	No	No
BH-PTR-25	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-25	1	N	No	No	No	No	No	No	No	No	No
BH-PTR-26	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-26	0.5	N	No	No	No	No	No	No	No	No	No
BH-PTR-28	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-29	0.1	N	No	No	No	No	No	No	No	No	No
BH-PTR-29	1	N	No	No	No	No	No	No	No	No	No
BH-PTR-31	0.5	N	No	No	No	No	No	No	No	No	No
BH-PTR-33	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-34	0.5	N	No	No	No	No	No	No	No	No	No
BH-PTR-36	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-38	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-39	0.1	N	No	No	No	No	No	No	No	No	No
BH-PTR-40	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-41	0.1	N	No	No	No	No	No	No	No	No	No
BH-PTR-41	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-41	0.5	N	No	No	No	No	No	No	No	No	No
BH-PTR-42	0.2	N	No	No	No	No	No	No	No	No	No

This output data has been generated by the CAT-Waste Soil waste classification tool provided by Atkins Consultants Ltd and J.McArdle Contracts and should be read in conjunction with the standard Terms and Conditions

10:33 05/09/2022

Site Name	GCP CSET
Location	GCP CSET
Site ID	5210174
Job Number	5210174
Date	9/2/2022
User Name	Mark.Boobyer@atkinsglobal.com
Company Name	Atkins

Hole ID	Sample Depth	Hazardous Waste Y/N	HP1	HP2	HP3	HP4	HP5	HP6	HP7	HP8	HP9
BH-PTR-42	0.5	N	No	No	No	No	No	No	No	No	No
BH-PTR-42	1.4	N	No	No	No	No	No	No	No	No	No
BH-PTR-42	1.9	N	No	No	No	No	No	No	No	No	No
BH-PTR-42	2.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-43	0.1	N	No	No	No	No	No	No	No	No	No
BH-PTR-43	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-43	1	N	No	No	No	No	No	No	No	No	No
BH-PTR-43B	1.6	N	No	No	No	No	No	No	No	No	No
BH-PTR-44	0.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-44	0.5	N	No	No	No	No	No	No	No	No	No
BH-PTR-44A	1.4	N	No	No	No	No	No	No	No	No	No
BH-PTR-44A	2.2	N	No	No	No	No	No	No	No	No	No
BH-PTR-44A	4	N	No	No	No	No	No	No	No	No	No
BH-PTR-45	0.5	N	No	No	No	No	No	No	No	No	No
BH-PTR-45	1	N	No	No	No	No	No	No	No	No	No
BH-PTR-45A	1.6	N	No	No	No	No	No	No	No	No	No
BH-PTR-45A	2.3	N	No	No	No	No	No	No	No	No	No
BH-TH-01	0.2	N	No	No	No	No	No	No	No	No	No
BH-TH-02	0.5	N	No	No	No	No	No	No	No	No	No
BH-TH-02	1	N	No	No	No	No	No	No	No	No	No
BH-TH-03	1	N	No	No	No	No	No	No	No	No	No
BH-TH-06	0.2	N	No	No	No	No	No	No	No	No	No
BH-TH-07	0.1	N	No	No	No	No	No	No	No	No	No
BH-TH-08	0.2	N	No	No	No	No	No	No	No	No	No
BH-TH-09A	0.2	N	No	No	No	No	No	No	No	No	No
BH-TH-10	0.2	N	No	No	No	No	No	No	No	No	No
CPT-OBC-01	0.1	N	No	No	No	No	No	No	No	No	No
CPT-OBC-02	0	N	No	No	No	No	No	No	No	No	No

This output data has been generated by the CAT-Waste Soil waste classification tool provided by Atkins Consultants Ltd and J.McArdle Contracts and should be read in conjunction with the standard Terms and Conditions

10:33 05/09/2022

Site Name	GCP CSET
Location	GCP CSET
Site ID	5210174
Job Number	5210174
Date	9/2/2022
User Name	Mark.Boobyer@atkinsglobal.com
Company Name	Atkins

Hole ID	Sample Depth	Hazardous Waste Y/N	HP1	HP2	HP3	HP4	HP5	HP6	HP7	HP8	HP9
CPT-OBC-02	0.6	N	No	No	No	No	No	No	No	No	No
CPT-OBC-04	0.2	N	No	No	No	No	No	No	No	No	No

Site Name	GCP CSET
Location	GCP CSET
Site ID	5210174
Job Number	5210174
Date	9/2/2022
User Name	Mark.Boobyer@atkinsglobal.com
Company Name	Atkins

Hole ID	Sample Depth	Hazardous Waste Y/N	HP10	HP11	HP12	HP13	HP14	HP15	HP16
BH-OBC-01	0.1	N	No	No	No	No	No	No	No
BH-OBC-01	0.5	N	No	No	No	No	No	No	No
BH-OBC-03	0.5	N	No	No	No	No	No	No	No
BH-OBC-06	0.1	N	No	No	No	No	No	No	No
BH-OBC-07	0.5	N	No	No	No	No	No	No	No
BH-OBC-09	1	N	No	No	No	No	No	No	No
BH-OBC-10	0.1	N	No	No	No	No	No	No	No
BH-OBC-11	0.1	N	No	No	No	No	No	No	No
BH-OBC-14	0.2	N	No	No	No	No	No	No	No
BH-OBC-14	1	N	No	No	No	No	No	No	No
BH-OBC-15	0.2	N	No	No	No	No	No	No	No
BH-OBC-16	0.1	N	No	No	No	No	No	No	No
BH-PTR-01	0.5	N	No	No	No	No	No	No	No
BH-PTR-02	0.2	N	No	No	No	No	No	No	No
BH-PTR-02	1	N	No	No	No	No	No	No	No
BH-PTR-03A	0.2	N	No	No	No	No	No	No	No
BH-PTR-04	0.5	N	No	No	No	No	No	No	No
BH-PTR-05	0.1	N	No	No	No	No	No	No	No
BH-PTR-05	0.5	N	No	No	No	No	No	No	No
BH-PTR-06	0.1	N	No	No	No	No	No	No	No
BH-PTR-06	1	N	No	No	No	No	No	No	No
BH-PTR-07	0.2	N	No	No	No	No	No	No	No
BH-PTR-08	0.2	N	No	No	No	No	No	No	No
BH-PTR-09	0.5	N	No	No	No	No	No	No	No
BH-PTR-12	0.2	N	No	No	No	No	No	No	No
BH-PTR-16	0.2	N	No	No	No	No	No	No	No
BH-PTR-16	1	N	No	No	No	No	No	No	No
BH-PTR-18	0.2	N	No	No	No	No	No	No	No

This output data has been generated by the CAT-Waste Soil waste classification tool provided by Atkins Consultants Ltd and J.McArdle Contracts and should be read in conjunction with the standard Terms and Conditions

10:33 05/09/2022

Site Name	GCP CSET
Location	GCP CSET
Site ID	5210174
Job Number	5210174
Date	9/2/2022
User Name	Mark.Boobyer@atkinsglobal.com
Company Name	Atkins

Hole ID	Sample Depth	Hazardous Waste Y/N	HP10	HP11	HP12	HP13	HP14	HP15	HP16
BH-PTR-19	0.2	N	No	No	No	No	No	No	No
BH-PTR-19	1	N	No	No	No	No	No	No	No
BH-PTR-20	0.5	N	No	No	No	No	No	No	No
BH-PTR-20	1	N	No	No	No	No	No	No	No
BH-PTR-21	0.1	N	No	No	No	No	No	No	No
BH-PTR-22	0	N	No	No	No	No	No	No	No
BH-PTR-23	0.1	N	No	No	No	No	No	No	No
BH-PTR-23	0.5	N	No	No	No	No	No	No	No
BH-PTR-24A	0.3	N	No	No	No	No	No	No	No
BH-PTR-24A	1	N	No	No	No	No	No	No	No
BH-PTR-25	0.2	N	No	No	No	No	No	No	No
BH-PTR-25	1	N	No	No	No	No	No	No	No
BH-PTR-26	0.2	N	No	No	No	No	No	No	No
BH-PTR-26	0.5	N	No	No	No	No	No	No	No
BH-PTR-28	0.2	N	No	No	No	No	No	No	No
BH-PTR-29	0.1	N	No	No	No	No	No	No	No
BH-PTR-29	1	N	No	No	No	No	No	No	No
BH-PTR-31	0.5	N	No	No	No	No	No	No	No
BH-PTR-33	0.2	N	No	No	No	No	No	No	No
BH-PTR-34	0.5	N	No	No	No	No	No	No	No
BH-PTR-36	0.2	N	No	No	No	No	No	No	No
BH-PTR-38	0.2	N	No	No	No	No	No	No	No
BH-PTR-39	0.1	N	No	No	No	No	No	No	No
BH-PTR-40	0.2	N	No	No	No	No	No	No	No
BH-PTR-41	0.1	N	No	No	No	No	No	No	No
BH-PTR-41	0.2	N	No	No	No	No	No	No	No
BH-PTR-41	0.5	N	No	No	No	No	No	No	No
BH-PTR-42	0.2	N	No	No	No	No	No	No	No

This output data has been generated by the CAT-Waste Soil waste classification tool provided by Atkins Consultants Ltd and J.McArdle Contracts and should be read in conjunction with the standard Terms and Conditions

10:33 05/09/2022

Site Name	GCP CSET
Location	GCP CSET
Site ID	5210174
Job Number	5210174
Date	9/2/2022
User Name	Mark.Boobyer@atkinsglobal.com
Company Name	Atkins

Hole ID	Sample Depth	Hazardous Waste Y/N	HP10	HP11	HP12	HP13	HP14	HP15	HP16
BH-PTR-42	0.5	N	No	No	No	No	No	No	No
BH-PTR-42	1.4	N	No	No	No	No	No	No	No
BH-PTR-42	1.9	N	No	No	No	No	No	No	No
BH-PTR-42	2.2	N	No	No	No	No	No	No	No
BH-PTR-43	0.1	N	No	No	No	No	No	No	No
BH-PTR-43	0.2	N	No	No	No	No	No	No	No
BH-PTR-43	1	N	No	No	No	No	No	No	No
BH-PTR-43B	1.6	N	No	No	No	No	No	No	No
BH-PTR-44	0.2	N	No	No	No	No	No	No	No
BH-PTR-44	0.5	N	No	No	No	No	No	No	No
BH-PTR-44A	1.4	N	No	No	No	No	No	No	No
BH-PTR-44A	2.2	N	No	No	No	No	No	No	No
BH-PTR-44A	4	N	No	No	No	No	No	No	No
BH-PTR-45	0.5	N	No	No	No	No	No	No	No
BH-PTR-45	1	N	No	No	No	No	No	No	No
BH-PTR-45A	1.6	N	No	No	No	No	No	No	No
BH-PTR-45A	2.3	N	No	No	No	No	No	No	No
BH-TH-01	0.2	N	No	No	No	No	No	No	No
BH-TH-02	0.5	N	No	No	No	No	No	No	No
BH-TH-02	1	N	No	No	No	No	No	No	No
BH-TH-03	1	N	No	No	No	No	No	No	No
BH-TH-06	0.2	N	No	No	No	No	No	No	No
BH-TH-07	0.1	N	No	No	No	No	No	No	No
BH-TH-08	0.2	N	No	No	No	No	No	No	No
BH-TH-09A	0.2	N	No	No	No	No	No	No	No
BH-TH-10	0.2	N	No	No	No	No	No	No	No
CPT-OBC-01	0.1	N	No	No	No	No	No	No	No
CPT-OBC-02	0	N	No	No	No	No	No	No	No

This output data has been generated by the CAT-Waste Soil waste classification tool provided by Atkins Consultants Ltd and J.McArdle Contracts and should be read in conjunction with the standard Terms and Conditions

10:33 05/09/2022

Site Name	GCP CSET
Location	GCP CSET
Site ID	5210174
Job Number	5210174
Date	9/2/2022
User Name	Mark.Boobyer@atkinsglobal.com
Company Name	Atkins

Hole ID	Sample Depth	Hazardous Waste Y/N	HP10	HP11	HP12	HP13	HP14	HP15	HP16
CPT-OBC-02	0.6	N	No	No	No	No	No	No	No
CPT-OBC-04	0.2	N	No	No	No	No	No	No	No

Charlotte Foster

Atkins Limited
The Hub
500 Park Avenue
Aztec West
Bristol
BS32 4RZ

Tel: +44 (0)1454 662000

Grace Larcombe

Atkins Limited
Woodcote Grove
Ashley Road
Epsom
KT18 5BWWoodcote Grove
Ashley Road
Epsom
KT18 5BW

Tel: +44 (0)1372 726140
Direct: +44 (0)1372 752 724
grace.larcombe@atkinsglobal.com