A57 Link Roads

TR010034

9.71 Supplementary Ground Investigation Report

Rule 8(1)(k)

Planning Act 2008

Infrastructure Planning (Examination Procedure) Rules 2010

March 2022

Infrastructure Planning

Planning Act 2008

The Infrastructure Planning (Examination Procedure) Rules 2010

A57 Link Roads

Development Consent Order 202[x]

9.71 Supplementary Ground Investigation Report

Rule Number:	Rule 8(1)(k)
Planning Inspectorate Scheme Reference	TR010034
Application Document Reference	TR010034/EXAM/9.71
Author:	A57 Link Roads Project Team, National Highways and Atkins

Version	Date	Status of Version
Rev 1.0	March 2022	Deadline 7

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Status of this Report

This report provides a Supplementary Ground Investigation Report as requested by the Examining Authority for the A57 Link Roads Examination in their second Written Question 10.1. To inform the examination this report provides the results of the supplementary ground investigations undertaken in 2021 but it is acknowledged that some sections are not fully complete and as such should be treated as preliminary. A final report will be prepared at detailed design stage.

1. Introduction

1.1. Report scope and objectives

1.1.1. This addendum is prepared with HA Standard CD622 – Managing Geotechnical Risk and addresses the ground investigation aspects of the proposed A57 link roads. A full summary of the previous four phases of ground investigation and other geotechnical studies can be found the main Arcadis GIR [1]. Since production of the main Arcadis GIR an additional phase of GI has been undertaken (Phase 5 completed in 2021). The Phase 5 GI is still ongoing as 4 no. boreholes have yet to be drilled adjacent to the UU aqueduct due to ongoing access negotiations with United Utilities. The results of this additional investigation will be discussed in the relevant Geotechnical Design Report due to the sensitive nature of the information.

1.1.2. This addendum will:

- Where necessary, update any desk study information that has been made available since the current PSSR [2] which was undertaken by Arcadis in 2017.
- Compare and contrast the new and existing in situ and laboratory soils and rock testing data, comment on the range of parameters, and update the characteristic parameters if necessary;
- Provide geological long sections;
- Where necessary, update the text within the Arcadis GIR [1], primarily based on the Phase 5 GI;
- Provide text on the current construction proposals where these have been updated;
- Present a generic quantitative risk assessment (GQRA) to assess potential risks to human health and controlled waters for the proposed end use using the ground investigation data obtained for Atkins during the 2021 ground investigation. Compare and contrast risk assessment results with those previously undertaken within the Arcadis GIR [1];
- Present a preliminary ground gas risk assessment following on from post fieldwork monitoring;
- Produce a preliminary waste characterisation assessment;
- Develop a conceptual site model (CSM) identifying potential contaminant sources, pathways and receptors;
- Where the construction sequence is known, particularly with respect to earthworks, particular source areas will be identified and discussed with respect to reuse of materials;
- Update the geotechnical risk register.

1.1.3. The text in the Arcadis report will prevail unless an update is provided in this addendum.

1.1.4. Due to the size of the project and number of individual design elements within it, an Engineering Assessment (as defined by CD622) has not been presented within this report. As the detailed design is currently ongoing, this will be discussed in each of the individual Geotechnical Design Reports.

1.2. Project description

1.2.1. Current scheme proposals include construction of a new link road between the M67 Junction 4 and the A57 at Woolley Bridge, providing a bypass to the villages of Mottram in Longdendale and Hollingworth in the Metropolitan Borough of Tameside, Greater Manchester. The link road will comprise a dual carriageway approximately 1.8 km length from the M67 Junction, passing to the north of Mottram village within a new 130 m long underpass before ending at Mottram Junction. Thereafter the link road continues as single carriageway for approximately 1.3 km, crossing the River Etherow before re-joining the A57 south of Woolley Bridge. The term 'study area' used within this report refers to the red line boundary (DCO boundary) and a 250 m buffer zone. The red line boundary and associated buffer zone are shown within Appendix A.

1.2.2. Several structures are required along the route at locations where the proposed alignment intersects existing highways, public rights of way and watercourses. The main structures proposed are:

- Old Mill Farm Underpass;
- Roe Cross Road Bridge;
- Mottram Underpass;
- Carrhouse Lane Underpass;
- River Etherow Bridge Crossing.

1.2.3. Earthworks are required to carry the new link road across the undulating topography and several incised glacial valleys including that of the River Etherow. An indication of the proposed alignment and topography to be traversed is shown on the Geotechnical long sections presented in Appendix A to this report.

1.2.4. Four previous phases of ground investigation (GI) have been carried out in relation to the proposed scheme. However, successive changes to scope and route alignment mean that many of the past investigation locations no longer fall within the current scheme footprint.

1.2.5. The main Arcadis GIR covers a previous version of the alignment. Since this project stage the alignment has been amended slightly and the key changes are:

- Roe Cross Link Road has been removed from the scheme;
- Mottram Moor Roundabout has been changed to a signal controlled junction;
- Mottram underpass has been moved towards the east, and Roe Cross Road is to be supported by a separate bridge structure.

- The southern wing wall at the western side of Mottram underpass has been extended.

1.3. Geotechnical category

1.3.1. The geotechnical category remains as Category 3. Refer to the Arcadis GIR [1] for further details.

1.4. Limitations

1.4.1. Atkins is responsible for selecting and summarising the data supplied by the client or other parties but cannot be held accountable for any mistakes or inaccuracies or the completeness of third-party data on which it has relied. As with any point data, ground conditions can only be inferred between test locations and as such localised conditions on site may vary between point locations and groundwater/ ground gas conditions may differ from those encountered during monitoring periods. Therefore, this report cannot guarantee against unexpected ground conditions occurring between the sampling points.

1.4.2. This report presents the preliminary findings of geo-environmental and geotechnical ground investigation and risk assessment to inform the client about potential contamination and geotechnical hazards & constraints relating to developing the site to a transportation end use. Once details of the design (e.g. layout, levels loadings, etc) is known, further development-specific ground investigation and assessment may be required by the Client/Developer/ Contractor to inform design. Constraints relating to ecology, heritage, flooding/drainage, utilities, air quality and noise are beyond the remit of this report.

1.4.3. Ground gas and groundwater conditions are based on observations made at the time of the Atkins designed 2021 ground investigation and monitoring programme, and may be subject to variation due to atmospheric, seasonal or other effects. The Conceptual Site Model (CSM) developed and Generic Quantitative Risk Assessment (GQRA) carried out for human health has been based on using screening criteria for a public open space land use scenario. Any changes to the proposed development may require revision of the CSM and reassessment of the risk assessment findings if the final development differs substantially from these assumptions.

1.4.4. This report does not advise on measures to deal with asbestos. Detailed advice should be sought from a specialist contractor.

1.4.5. 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. Previous reports

2.1.1. A list of previous studies related to past schemes within the site area can be found in Table 2-1, as per Arcadis Preliminary Sources Study Report [2]..

Table 2-1 – Summary of previous studies within the site area [2]

NH GDMS Report Number	Scheme Title	Report Title	Report Category	Publication Year
23410	A57 Mottram-Tintwistle Bypass, Greater Manchester/Derbyshire	Geophysical survey	Archaeological	2000
24466	A57/A628 Mottram Tintwistle Bypass	Stage 2 Commission, Desk Study Addendum	Geotechnical	2002
24467	A57/A628 Mottram Tintwistle Bypass	Annex A to Preliminary Sources Study, 2003	Geotechnical	2003
24468	A57/A628 Mottram Tintwistle Bypass	Stage 2 Commission, Dewatering During Mottram Tunnel Construction	Geotechnical	2003
24464	A57/A628 Mottram Tintwistle Bypass	Stage 2 Commission, Dewatering During Mottram Tunnel Construction, Assessment of Potential Settlement	Geotechnical	2003
24465	A57/A628 Mottram Tintwistle Bypass	Stage 2 Commission, Ground Investigation No. 1, Interpretative Report	Geotechnical	2003
26569	A628 Eastbound MP 12/7 Slope Instability	Preliminary Sources Study Report & Annex A	Geotechnical	2012
26826	A628 Eastbound MP12/7 Slope	A628 Eastbound MP12/7 Slope GIR & GDR	Geotechnical	2013
22373	A628 Enterclough North Retaining Wall Cutting Failure	Preliminary Sources Study Report	Geotechnical	2008
10615	A57/A628 Trunk Road, Mottram, Hollingworth, Tintwistle Bypass	Geotechnical Desk Study, 1990	Geotechnical	1990
24294	A57/A628 Mottram to Tintwistle Bypass and A628/A616 Route Restraint Measures	Annex A to Preliminary Sources Study, 2005	Geotechnical	2005
27087	A628 MP8/2 Slope Instability	Ground Investigation Report	Geotechnical	2013
26619	A628 Eastbound MP 8/3 Slope Instability	Ground Investigation Report	Geotechnical	2012
26822	A628 Westbound MP7/8 Slope	A628 Westbound MP7/8 Slope Instability GIR & GDR	Geotechnical	2012

NH GDMS Report Number	Scheme Title	Report Title	Report Category	Publication Year
12866	A628 Salters's Brook Bridge South-West Retaining Wall Stabilisation	Preliminary Sources Study and Geotechnical Design Report	Geotechnical	2001
26224	A628 Salter's Brook Bridge, East Bound Carriageway, Cutting Slope Defect	A628 Salter's Brook Bridge, East Bound Carriageway, Cutting Slope Defect Geotechnical Design Report	Geotechnical	2011
26823	A628 Westbound MP7/9 Slope Instability	A628 Westbound MP7/9 Slope Instability GIR & GDR	Geotechnical	2012
27766	A628 Westbound MP7/8 Slope Instability	Geotechnical Feedback Report	Geotechnical	2014
27508	A628 Westbound MP7/9 Slope Instability	Geotechnical Feedback Report	Geotechnical	2013
24320	A628 Salter's Brook Bridge, East Bound Carriageway, Cutting Slope Defect	Ground Investigation Report	Geotechnical	2010
-	A57 Transpennine Upgrade.	Ground Investigation Report (HE551473-ARC-TPU-RP-CE-3199) (Arcadis, 2018)	Geotechnical	2018
-	A57 Link Roads	Ground Investigation scoping Report (HE551473-BBA-SGT-A57_AL_SCHEME-RP-CE-000002_ (Atkins, 2021)	Geotechnical	2021
30928	A57 Link Roads	Preliminary Sources Study Report (HE551473-ARC-HGT-ZZZ-RP-GE-2001)	Geotechnical	2017
-	A57/A628 Trans-Pennine upgrade Programme	Geotechnical Statement of Intent (HE550691-ARC-GEN-TP01-RP-GE-1022)	Geotechnical	2016

2.2. Topography

2.2.1. Ordnance survey maps and topographical LIDAR information is referenced in the Arcadis GIR [1].

2.3. Geological maps and memoirs

2.3.1. There are no changes noted to the geological maps and memoirs. The information provided in the Arcadis PSSR [2] and GIR [1] is considered to be complete.

2.4. Aerial photographs

2.4.1. There are several additional aerial photographs available on Google Earth since the last review of aerial photographs in 2006. The most recent available photograph is dated 2020, however there have been no significant changes along the alignment with respect to geotechnical and geoenvironmental considerations since the Arcadis GIR.

2.5. Records of mines and mineral deposits

2.5.1. The route alignment has changed since the Arcadis GIR [1] and PSSR [2] was written and therefore the location of coal mining features relevant to the site has changed. Atkins purchased a CON29M Coal Mining Report for the new site area from the Coal Authority in January 2021. The report is presented in Appendix B.

2.5.2. The report states that there are four mine entries within, or within 20 m of the site boundary. The positions of the shafts are shown in the report presented in Appendix B. Three of the shafts are located to the north of the A57 Hyde Road between Mottram roundabout and Mottram in Longdendale village. Two of these (Coal Authority reference 398395-002 and 398395-003) are to the west of Hurstclough Brook and one (398395-004) is situated to the east of the brook.

2.5.3. As discussed in the Arcadis PSSR Section 4.8.1.1 shafts 398395-002 and 398395-003 are thought to be ventilation shafts of the Longdendale aqueduct tunnel and therefore are not associated with coal mining. It was considered by within the report that shafts 398395-002 and 398395-003 may be the same shaft, recorded twice due to a cartographic error. However, if shaft 398395-002 is a separate shaft and associated with mining, it is located some distance from the alignment and therefore the risk of damage to the proposed works is considered low.

2.5.4. Shaft 398395-004 is also considered to be a ventilation shaft for the aqueduct.

2.5.5. Shafts 398395-002 and 398395-004 can be seen on aerial photographs of the site and have also been observed during site walkovers. It is believed that the tunnel was constructed in c.1850.

2.5.6. The fourth shaft (399395-007) is located to the south of A57 Mottram Moor and to the east of Mottram in Longdendale village. There are no records of any of the shafts having been treated.

2.5.7. The position of shaft 399395-007, thought to be associated with coal mining, is greater than 20 m from the proposed infrastructure and therefore the risk of damage to the proposed works is considered low. A proposed footpath was diverted at this location to avoid the shaft. However, there remains a risk of unrecorded mine entries being present within the site boundary and the risk that the coordinates are incorrect.

2.5.8. The shallow coal mining risk has been identified to be at low risk as per previous scheme reporting.

2.6. Archaeological and historical investigations

Historical land use

2.6.1. The site history has been reviewed in the Arcadis PSSR (Arcadis, 2017). The route alignment has since changed; however, a full desk based assessment has been undertaken by Atkins and is presented in the Cultural Heritage Desk-Based

Assessment Report (ref. HE551473-BBA-EGN-A57_AL_SCHEME-RP-LE-060512) [4].

2.6.2. The Desk-Based Assessment has identified that there is one scheduled monument, two conservation areas, two grade II listed buildings and 45 grade II listed buildings located within a 1.0 km study area around the scheme. Of these assets, only one, Mottram in Longdendale Conservation Area is partly located within the Development Consent Order (DCO) boundary. Tintwistle Conservation Area, which is situated circa 1.7 km from the DCO boundary, has also been included following consultation with Peak District National Park. No World Heritage Sites, registered battlefields or registered parks and gardens are situated within the 1.0 km study area.

2.6.3. In addition to the designated heritage assets identified, 105 non-designated heritage assets and a total of seventeen findspots have been identified within a 500 m study area around the scheme.

2.6.4. Assessment of the potential for unknown archaeological remains to be present within the DCO boundary has identified:

- High potential for remains of Mesolithic and Neolithic date;
- Moderate potential for remains of Romano-British date;
- Low to moderate potential for remains dating to the Bronze Age, Early Medieval and Medieval periods;
- Low potential for the presence of remains dating to the Palaeolithic; and
- Unknown potential for the presence of remains dating to the Iron Age.

2.6.5. Further information can be found in the Cultural Heritage Desk-Based Assessment Report [4]. Based on this report, an archaeological watching brief was undertaken during excavation of the inspection pits during the Phase 5 ground investigation.

2.7. Flooding

2.7.1. The flood risk designations and areas have not changed since the Arcadis GIR [1] was written. Refer to the Arcadis reports for further details [1], [2].

2.8. Hydrology and hydrogeology

2.8.1. There are two main watercourses visible on the topographical maps of the area:

- The River Etherow - which passes through the eastern extents of the scheme in a north to south direction. A series of reservoirs connected to the river are located approximately 1.5km to the north east of the site.
- Hurstclough Brook - which passes through the western extents of the scheme in a north to south direction from Roe Cross Road (north of Mottram in Longdendale village) to the A57 (between Mottram roundabout and Mottram in Longdendale village).

2.8.2. The aquifer designation maps suggest that the Glacial Till underlying the site is a Secondary (undifferentiated) aquifer [5]. The Alluvium and head deposits are mapped as Secondary A aquifers [5]. The Millstone Grit bedrock throughout the area is also designated as a Secondary A aquifer [5]. Detailed discussion of the groundwater flow regime is given in section 6.2. The study area is not within a groundwater Source Protection Zone [6]. The study area is within an area of medium to low groundwater vulnerability [7].

2.8.3. There are no registered Environment Agency groundwater abstractions (licensed) within the study area. There are five private abstractions (recorded by Tameside MBC) from spring, surface and groundwater (borehole) located within the study area and some additional private spring, well and borehole abstractions within a 1 km radius identified through the surface water features survey. The closest abstraction is located at Mottram Old Hall, within approximately 75 m of the closest red line boundary. According to the Environment Agency's Approach to Groundwater Protection "All abstractions, including private water supplies, that are used for drinking water supply or food production purposes are by default in an SPZ1 or SPZ2.". It also states that all groundwater abstractions intended for human consumption or food production have a default SPZ1 with a minimum radius of 50 m. However, as the abstraction is located 75 m north of the red line boundary and over 150 m from where any major works are due to be undertaken, this is unlikely to be affected. This has been discussed in further detail within the hydrogeological risk assessment within appendix 13.2 of the Environmental Statement [6].

2.8.4. The Environment Agency indicates that there are 14 discharge consents to controlled waters within the scheme, 13 of which are operated by a water company and relate to the sewerage network.

2.9. Previous ground investigations

2.9.1. According to the Arcadis GIR [1] a series of historical ground investigations have been undertaken in the site area. A full list of the previous investigations is provided in Table 2-2 below:

Table 2-2 – Summary of existing ground investigation [1]

Ground Investigation	Reasoning	Details
Rock Mechanics (1966)	GI survey along the north and south sides of the Longdendale Valley of River Etherow	29 rotary boreholes and 10 trial pits
Georesearch (1976)	Unknown	Unknown
Norwest Holst (1978)	Unknown	111 boreholes (rotary and cable percussive) and 16 hand and mechanically excavated trial pits
Norwest Holst (1994)	Ground investigation due to A57 (T) and A618 junction improvements and realignment of the A57(T)	10 boreholes (rotary and cable percussive)
Soil Mechanics Ltd (1994)	For the A57/A68 Mottram to Tintwistle Bypass	157 boreholes (rotary and cable percussive) and 70 mechanically excavated trial pits
Soil Mechanics Ltd (1995)	Unknown	75 boreholes
Geotechnics (2002)	Unknown	Unknown
Norwest Holst Soil Engineering Ltd (2003)	Supplementary GI in area of Mottram in Longdendale village to further characterise geology and groundwater regime of the cut and cover underpass	25 rotary and cable percussive boreholes and 2 mechanically excavated trial pits
Mott Macdonald Geotechnical Interpretive Report (2005)	Summary and interpretation of existing Ground Investigations	Relevant intrusive investigations to date of issue
Fugro Engineering Services Ltd (2005)	For the A57/A68 Mottram to Tintwistle Bypass	57 boreholes (rotary and cable percussive) and 75 mechanically excavated trial pits
Hyder Geotechnical Interpretive Report (2006)	Summary of existing Ground Investigations	Relevant intrusive investigations to date of issue
Geophysical Survey (2007)	Investigate shallow geological structure beneath Mottram in Longdendale village	10 survey lines with both seismic refraction and resistivity tomography
Arcadis – Socotec (2018)	Target sections of the route alignment not fully investigated during earlier ground investigations	31 boreholes (rotary and cable percussive) and 22 mechanically excavated trial pits In situ testing

2.10. Environmental setting

2.10.1. The following Environmental Setting of the scheme has been summarised from the information presented within the Geology and Soils Chapter (Chapter 9) of the Environmental Statement [6]. The study area referenced below includes the red line boundary and a buffer zone of 250 m.

Site history

2.10.2. The earliest maps (circa 1881) show that the study area lies within agricultural land with a number of farmsteads and established roads throughout the study area. The town of Mottram is shown to the south, Roe Cross to the north and Hollingworth to the east. Notable features within the study area at this time include a quarry near Roe Cross (250 m north) and Mottram Old Mill (Woollen) with several other mills and quarries present within the study area.

2.10.3. In 1910, a small gasworks is mapped adjacent to Woolley Lane on the south western edge of Hollingworth (10 m south of red line boundary). A Bleach Works, associated tanks and Mersey Mills are located adjacent to River Etherow to the east (20 m from red line boundary). Light industry (including Wadding Manufactory) is indicated to the north in Lower Roe Cross.

2.10.4. In 1950, additional industrial activities (Rhodes Mill (disused) and Longdendale (Works)) are shown to the east of the study area near Woolley Bridge and the Bleach Works. A sewage works can be seen approximately 300 m to the south of the red line boundary in Longdendale.

2.10.5. By 1983, residential development in Mottram and Hollingworth has significantly increased. The industry to the north in Lower Roe Cross is no longer shown. A garage is located in the vicinity of the gasworks which is no longer indicated.

2.10.6. Previous GIs along with the supplementary GI have targeted these identified potential sources of contamination.

Contemporary trade directory entries

2.10.7. The Envirocheck Environmental Database included within the Arcadis PSSR, indicates there are potentially 40 trade entries in the study area with the majority located to the east in the area of Hollingworth and Hadfield. A number of the trades are indicated to be located within the red line boundary. There is a small cluster of entries associated with Mottram which relate to car dealerships, garage services and blind manufacturers. It also records the presence of six fuel stations within the study area, four are indicated adjacent to the red line boundary with the closest being 50 m from the areas of any major earthworks.

Pollution incidents

2.10.8. Environment Agency consultation in 2018 provided a list of pollution incidents within the study area. There are 28 recorded incidents dating between June 2001 and January 2018. For those impacts to Land and Water, the categories were either No Impact (Category 4) or Minor Impact (Category 3) with pollutants involved ranged from firefighting runoff, oils, crude sewage and diesel.

2.10.9. Liaison with Tameside MBC indicated that the Environmental Protection Unit is aware of a single pollution incident taking place within the site boundary since consultation was undertaken in 2018. The incident is located over 500 m from any major proposed earthworks. This involved a diesel spillage due to a road traffic incident, with fuel leaking into soils and possible watercourse. The quantity of fuel leaked was not significant and only localised impacts were anticipated.

Landfill sites

2.10.10. Table 2-3 details the landfill sites recorded within the study area as summarised in the Arcadis GIR [1] (TR010034/APP/7.6) and prior PSSR.

Table 2-3 – Summary of landfill sties within the study area

Landfill	Dates	Type of Waste	Distance from Red Line Boundary
Land adjacent to Woolley Lane Gas Works	Nov 1993 – Jan 1996	Inert	Within and adjacent to north eastern scheme boundary (Mottram Moor junction) approximately 225 m from earthworks.
Carrhouse Lane	No information provided	No information provided	Within the scheme (Carrhouse Farm underpass) approximately 50 m east of earthworks.
Disused Railway Line	Dec 1990 – Oct 1991	Inert	100m east of scheme (from River Etherow Crossing/Brookfield junction).
Melandra Road Waste Disposal Site	Dec 1977 – Dec 1981	Inert, Industrial, Commercial, Household and Liquid/Sludge	100m south east of scheme

2.10.11. Liaison was undertaken with the Environment Agency in relation to Carrhouse Lane Landfill as part of the 2021 GI. The Environment Agency's records suggest that filling took place prior to 1974, therefore records regarding the landfill may be scarce or in-exact.

Previous ground investigation results

2.10.12. A summary of the chemical testing of soils and groundwater previously undertaken within the study area as part of the Arcadis GI [1] in 2018 is provided in Table 2-4. The Arcadis GIR [1] indicates that potentially elevated concentrations of Dibenz(ah)anthracene and lead were encountered above the Generic Assessment Criteria (GAC) for human health (public open space (residential)) within soil samples analysed. Exceedances of a number of poly-aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPH) and heavy metals were recorded within groundwater samples analysed in comparison to published freshwater Environmental Quality Standards (EQS) and/or UK Drinking Water Standards (DWS). Exceedances within soil samples were located within the area of the Mottram Underpass and the River Etherow approach embankments. Controlled waters exceedances were located across the site within areas where earthworks are due to be undertaken.

2.10.13. Asbestos was not recorded in any of the samples analysed from across the entire scheme, however there is potential for in-ground asbestos containing materials to be present due to historic land uses within the study area. Approximately 11 samples from the 2018 GI were collected from Made Ground across the scheme.

Table 2-4 – Summary of soil and groundwater GAC exceedances from previous phases of GI

Section of scheme	Soil - Human Health Exceedances	Groundwater - Controlled Waters Exceedances
M67 Junction 4 to Old Mill Farm Underpass (A)	None recorded	None recorded
Old Mill Farm Underpass (B)	None recorded	None recorded
Western Cutting (C)	None recorded	BH403 (Glacial Till) – zinc, benzo(a)pyrene, benzo(b)fluoranthene BH404 (Glacial Till) – benzo(a)pyrene, TPH, benzo(ghi)perylene, benzo(k)fluoranthene, indeno(123)pyrene BH406 (Bedrock & Glacial Till) - TPH
Mottram Underpass (D)	Dibenz(ah)anthracene exceedance BH411 at 0.30 m bgl	BH413 (Bedrock & Glacial Till) - TPH
Eastern Cutting (E)	None recorded	BH418 (Glacial Till) – zinc, chromium VI BH421 (Sandstone & Siltstone) – zinc,
Longdendale Aqueduct (F)	None recorded	None recorded
Mottram Moor Signal Controlled Junction (G)	None recorded	BH422 (Glacial Till) – zinc, chromium III, TPH
Carrhouse Farm Underpass (H)	None recorded	None recorded
River Etherow Crossing and Brookfield Junction (I)	None recorded	None recorded
Eastern Embankments (J)	Lead exceedance BH427 at 0.20 m bgl	None recorded
TPH = Total Petroleum Hydrocarbons		

2.10.14. Overall, the Arcadis GIR [1] (TR010034/APP/7.6) concluded that the two minor exceedances of the GAC for lead and dibenz(ah)anthracene were unlikely to pose an unacceptable risk to human health for the scheme. Exceedances were considered not representative of “site wide contamination”.

2.10.15. Minor exceedances of the GAC in groundwater were identified in the Arcadis GIR [1]. The onsite or offsite source of these exceedances is unknown. It was concluded by the Arcadis GIR (TR010034/APP/7.6) that the concentrations within the overlying Made Ground and Natural Deposits do not indicate a significant source of contamination and do not pose an unacceptable risk to either the scheme or controlled waters within influencing distance of the site.

2.10.16. Ground gas monitoring was undertaken in the following boreholes:

- Western Cutting BH401 and BH406

- Eastern Cutting BH421
- Mottram Moor Signal Controlled Junction BH422.

2.10.17. Arcadis undertook ground gas monitoring on three occasions between 26/06/2018 and 25/07/2018. A “worst case” scenario, informed by readings during low and falling atmospheric pressure, was not achieved on any of the three visits. A summary of the findings of the ground gas monitoring undertaken are presented below:

- Carbon Dioxide concentrations ranged from <0.1 % v/v to 1.3 % v/v
- Methane concentrations ranged from <0.1 % v/v to 0.7 % v/v
- Hydrogen Sulphide was consistently measured below the method detection limit (MDL) of the instrument utilised
- Carbon Monoxide concentrations ranged from <0.1 ppm to 19.0 ppm
- Maximum steady state flow rates ranged from 0.2 l/hr to 4.2 l/hr.

2.10.18. Arcadis concluded that the site could be classified as Characteristic Situation 1 (CS1) and that no gas protection measures were necessary.

2.11. Initial conceptual site model

Introduction

2.11.1. Primary guidance for assessing and managing risks posed by land contamination is presented in Land Contamination: Risk Management (LCRM) published by the Environment Agency on 8 October 2020. LCRM provides a technical framework (and signposts other key guidance) for identifying and remediating contamination through the application of a risk management process. The question of whether a 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 exactly what risk would be unacceptable.

2.11.2. A preliminary conceptual site model (PCSM) describes the relationship between potential sources of contamination (resulting from both on and off-site historical and recent activities) and receptors to the potential contamination.

2.11.3. As part of the PCSM development, three elements are identified and assessed:

- Source of contamination and associated contaminants
- Receptors – human beings, controlled waters (surface water/groundwater), ecological systems and property, to that contamination
- Pathways between the sources and receptors.

2.11.4. 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.

Table 2-5 – Summary of previously identified sources, pathways and receptors by Arcadis

Sources	Pathways	Receptors
Historical landfills 100+ m from excavation areas Roe Cross Quarry 250 m north of red line boundary Mottram Woollen Mill approximately 50 m from excavation areas Gas works 200 m from red line boundary Mill and bleach works; and Sewage works approximately 100 m east of earthworks	Direct contact including ingestion or dermal contact with contaminated soils and windblown dust. Surface runoff from disturbed ground. Direct contact or ingestion with contaminated runoff/ groundwater. Inhalation of contamination in dust, vapour or gas. Leaching from Made Ground into controlled waters or aquifers. Generation and migration of ground gas and vapours via permeable strata or preferential pathways along engineered structures (services or piles).	Human Health including future highways users, general public utilising public open space nearby residents, schools and commercial properties. Controlled waters including superficial deposits, classified as Secondary Undifferentiated and Secondary A Aquifers and the soil geology of Millstone Grit Group classified as a Secondary A Aquifer; and surface water receptors including the River Etherow, Hurtsclough Brook, ponds and drainage channels.

- Two minor exceedances for Lead and Dibenz(ah)anthracene were recorded within soils when analysed against the public open space (residential) generic assessment criteria. This appears to be localised contamination and not site-wide. No asbestos was detected in the soils samples tested. As the scheme will mostly comprise hardstanding and/or vegetation, it is considered that this is sufficient to sever any potential pathway. Based on these results a significant risk to human health is not anticipated.
- Minor groundwater exceedances have been identified along the entire route. It is unknown whether the overlying localised areas of Made Ground or an offsite source of contamination is the source of the elevated concentrations in the groundwater samples. Elevated concentrations of metals, PAHs & TPH are considered to be minor and therefore are unlikely to pose an unacceptable to either the scheme or controlled waters within close vicinity of the site. Where materials are to be reused onsite, consideration should be given to protection of surface waters from leachable heavy metals and further assessment may be required to verify that soils are suitable for reuse.
- The limited available data indicates that the potential risk of ground gas is considered to be low. However, given the potential landfill sources and the proposed confined spaces (underpasses) there may be an acute risk to construction / maintenance workers within the area of BH404.
- Based on initial soil analysis results, materials are likely to be chemically suitable for reuse on the scheme, subject to further detailed design taking into account the proposed use of the material. A Materials Management Plan (MMP) or environmental permit will be required to legally re-use soils on the scheme. The majority of excavated onsite materials, if in excess to re-use requirements, are likely to be classed as non-hazardous with a portion being likely suitable for classification as inert, subject to the results of Waste Acceptance Criteria (WAC) testing.

3. Field and Laboratory Studies

3.1. Geomorphological/geological mapping and topographic survey

3.1.1. Refer to section 4.3 in Arcadis GIR [1].

Geological maps

3.1.2. Refer to section 3.2 in Arcadis GIR [1].

3.2. 2021 Ground investigation

3.2.1. A supplementary GI was proposed by Arcadis and designed by Atkins, with the purpose to provide information specific to the current scheme and aid in the design process. The scope and investigation philosophy is discussed in the Atkins GISR [3]. This most recent phase of GI (Phase 5) aimed to confirm the ground conditions encountered during previous investigations and to provide supplementary data to ensure areas of geotechnical risk are understood and appropriately managed. Table 4-1 discusses the additional Phase 5 GI in each section and the associated geotechnical design proposed in that area. Table 3-1 includes the areas specifically targeted in relation to potential land contamination.

Table 3-1 – Justification for supplementary GI locations – contaminated land

Location	Requirements	Exploratory Hole
Within vicinity of Carrhouse Lane landfill (potential source of contamination). To gather data within area between scheme and suspected landfill location which was not previously investigated.	Soil samples, groundwater and ground gas.	BH541
Exploratory holes located within an area of a number of contemporary trade directories. Previous GIs recorded a marginal dibenz(ah)anthracene exceedance within a soil sample and minor TPH exceedances within groundwater samples collected within this area. Due to the creation of an enclosed space within the proposed underpass which passes adjacent to the contemporary trade directories, further gas monitoring required. Further data is required to improve understanding of ground conditions.	Soil samples and groundwater samples. Ground gas (BH510 & BH513).	BH510 BH511 BH512 BH513 BH514 BH515
Previous GI recorded a soil lead exceedance within this area of the scheme. Further samples required to improve understanding of ground conditions.	Soil sample and groundwater sample.	BH546

Location	Requirements	Exploratory Hole
Exploratory holes located along proposed deep cuttings. Require deeper samples of soil due to the potential reuse of material across the scheme. Previous GIs recorded heavy metal exceedances within groundwater. More recent samples will be obtained from this area to inform risk assessment.	Soil samples and groundwater samples	BH517 BH520 BH527 BH528
Previous GIs recorded exceedances of PAHs and TPH in this area within the groundwater. Arcadis concluded these GAC exceedances did not pose an unacceptable risk; however, further samples are required to confirm this.	Soil and groundwater	BH504 BH503 or TP502
To aid in the analysis of risk posed to controlled waters receptors and the calculation of bioavailable concentrations.	Surface Water Samples	River Etherow (upstream, centre and downstream)

Description of fieldwork

3.2.2. The ground investigation was completed by SOCOTEC UK Ltd in 2021. The aim of the ground investigation was to confirm, and supplement the existing information regarding, the geological, hydrogeological and geo-environmental characteristics across the site (see Table 3-1). Appendix A contains geological long-sections with the ground investigation data presented.

3.2.3. The 2021 Phase 5 ground investigation followed four previous phases of GI for this scheme; therefore, it was designed to:

- Fill gaps in existing information (such as where current alignment differed from previous);
- Provide data to inform land contamination assessments – as outlined within Table 3-1 above;
- Provide data to inform hydrogeological modelling;
- Investigate areas of the site in which access was not previously available. This includes the eastern cutting at the end of Mottram underpass, amongst others (further outlined below); and
- Supplement information at the location of proposed structures to provide an EC7 compliant ground investigation; and
- Investigate risks identified within the main Arcadis GIR – including features described as possible landslips (Appendix H).

3.2.4. The investigation comprised:

- 17 cable percussive boreholes (CP) to depths of up to 22.85 m bgl;
- 16 cable percussive boreholes with rotary follow on (CP+RC) to depths of up to 27.80 m bgl;
- 14 dynamic sampling boreholes with rotary follow on (DS+RC), to depths up to 30.40 m bgl;
- 3 window sampling (WS) boreholes to depths of up to 8.00 m bgl;
- 9 trial pits to depths up to 3.80 m bgl;
- 15 cone penetration tests (CPTs) to depths up to 14.32 m bgl;
- Survey of the location and elevation of each exploratory hole;
- Installation of groundwater monitoring wells within a selection of the exploratory holes and the subsequent monitoring of groundwater levels;
- Installation of vibrating wire piezometers within a selection of the exploratory holes and the subsequent monitoring of pore pressures;
- Completion of in situ testing, including:
  - Standard penetration tests (SPTs);
  - Soakaway tests;
  - Geophysical logging;
  - In situ falling and rising head permeability tests;
  - High pressure dilatometer tests (HPDTs);
  - Abstraction and recharge pumping tests;
  - Photo-ionisation detection (PID);
- Undertaking soil and groundwater sampling; and
- Completion of geotechnical and geo-environmental laboratory testing.

3.2.5. In addition to the investigation scoped in the GISR [3], Table 3-2 describes the amendments made during the 2021 investigation from the original scope and the reasons why they were completed.

Table 3-2 – 2021 Investigation Amendments

Change Type	Location	Exploratory Hole	Comments
Relocation			
	Roe Cross Road Bridge	BH505	Due to access issues to the initial location
		BH508	5.0m from original location due to proximity to existing wall
		BH509	Due to proximity to existing wall
	Mottram Underpass	BH510	Due to access issues to the initial location
		BH512	Due to access issues to the initial location
		BH513	Moved to the front garden of the house due to access issues
		BH514	Due to access issues to the initial location
		BH523	Relocated to scheduled location of TR501
	Mottram showground	BH526	To avoid sloping ground
		BH527	To avoid sloping ground
		BH550	To avoid sloping ground
	Carrhouse Lane	BH532	Moved to be on alignment
		BH533	Due to overhead power lines
		BH535	To avoid sloping ground
Change in drilling method			
CP+RC to DS+RC (Cable percussion with rotary follow on to dynamic sampling with rotary follow on)soft	Mottram Underpass	BH510	Requested by the contractor due to lack of available CP rigs on site
		BH511	
		BH512	
		BH513	
		BH514	
CP+RC to DS+RC	Mottram showground	BH516	Requested by the contractor due to lack of available CP rigs on site
RC only to DS+RC	Mottram showground	BH520	Suggested by the contractor for better recovery on superficial material
CP+RC to DS+RC	Mottram showground	BH521	Requested by the contractor due to lack of available CP rigs on site
CP+RC to DS+RC	Mottram showground	BH523	Due to access issues for the CP rig
RC only to DS+RC	Mottram showground	BH527	Suggested by the contractor for better recovery on superficial material
CP to WS (WS505)	Carrhouse Lane	BH534	Due to access issues for the CP and RC rig

Change Type	Location	Exploratory Hole	Comments
CP to WS (WS504)	Carrhouse Lane	BH537	Due to access issues for the CP and RC rig
CP to CP+RC	Mottram showground	BH549	Due to unexpected shallow rockhead
CP+RC to DS+RC	Mottram showground	BH550A	Requested by the contractor due to lack of available CP rigs on site
CP to CP+RC	Mottram showground	BH551	Due to unexpected shallow rockhead
Change in scheduled depth			
Scheduled depth extended to 17.0mbgl	Old Mill Farm Underpass	BH501	To reach bedrock
Scheduled depth extended for extra 5.0m to 30.0mbgl	Mottram Underpass	BH514	To get further information on the fault zone
Drill 5.0m further to 30.0mbgl	Mottram showground	BH521	To get further information from scheduled geophysics test
Drill to 13.50mbgl instead of 15.0mbgl	Mottram showground	BH525	Requested by the contractor due to water flushing issues
Scheduled depth of 15.0mbgl extended to 22.6mbgl	Carrhouse Lane	BH544	To reach bedrock
Drill 2.0m further to 27.0mbgl	River Etherow	BH547	To monitor artesian conditions within bedrock
20.0m CP to 10.0m CP+RC	Mottram showground	BH549	Due to unexpected shallow rockhead
20.0m CP to 10.0m CP+RC	Mottram showground	BH551	Due to unexpected shallow rockhead
Added boreholes			
	Roe Cross Road Bridge	BH506A	To assist design of the new retaining wall
	Mottram Underpass	BH514A	To get further information on the fault zone
	River Etherow	BH547A	To monitor groundwater level within cohesive Glacial Till
	River Etherow	BH547B	To monitor groundwater level within granular Glacial Till
Omitted boreholes			
	Old Mill Farm Underpass	BH504	Due to inaccessible position
Added in-situ tests			
Two additional HPDT tests	Mottram Underpass	BH514	To get further information on the fault zone

In situ test results

3.2.6. A program of geotechnical in situ testing was carried out during the ground investigation, in accordance with BS 5930 (2015), BS EN 1997-2 (2007) and BS EN ISO 22475-1 (2006). The in situ testing is detailed in Table 3-3 and presented in the factual GI report [8].

Table 3-3 – Geotechnical analysis summary – in situ tests

Determinand	Number of tests
Standard Penetration Tests (SPTs)	321
Geologging	10
High pressure dilatometer	6
Falling and rising head tests	11
Soakaway tests	4
Abstraction pump test	1
Recharge pump test	1

Geophysical studies

3.2.7. Catsurveys Ltd. was appointed to undertake a 3D Radar survey in accordance with CS 229 requirements. The survey was completed between February and April 2021 and the main objective was to determine the location of buried services within the site boundary.

3.2.8. The results are reported in 190382-CAT-XX-XX-RP-SR-1093-00001.

3.2.9. In June 2021, SOCOTEC carried out three lines of Electrical Resistivity Tomography (ERT) to confirm the location of an aqueduct known to be within a valley inside the site boundaries [9]. The study was inconclusive, as there was found no clear evidence of the aqueduct at the expected depth.

3.2.10. Further details can be found in the geophysical survey, provided in Appendix C.

Monitoring

3.2.11. Gas and groundwater installations and subsequent monitoring were also undertaken during the ground investigation. Further details can be found in section 6 of this report.

Laboratory testing

3.2.12. A program of laboratory testing was carried out on soil and rock samples taken during the ground investigation, in accordance with BS 5930 (2015), BS EN 1997-2 (2007) and BS EN ISO 22475-1 (2006). The testing was scheduled by Atkins and was carried out by the UKAS Accredited ‘SOCOTEC Laboratory’. The geotechnical laboratory testing on soil and rock samples is detailed in Table 3-4, with full results in the factual GI report [8].

Table 3-4 – Geotechnical analysis summary laboratory tests

Determinand	Number of samples tested
Moisture content determination	156
Atterberg limit determination	112
Particle size distribution (PSD) tests	49
Dry density / moisture content relationship (light compaction – 2.5kg rammer)	4
Moisture content value (MCV)	8
Consolidated undrained triaxial compression test	27
Unconsolidated undrained triaxial compression test	38
Determination of strength by direct shear (small shearbox apparatus)	1
Unconfined compression of soil	3
Shear strength by Pilcon hand vane	156
Shear strength by lab vane	1
Index properties of rock	1
Slake durability index	5
Indirect tensile strength by the Brazil test	17
One dimensional consolidation test (oedometer)	10
Point load tests (each test comprised an axial and diametral test)	54
Uniaxial compressive strength (UCS) of rock	7
BRE SD1 sulphate suite tests	23
Organic matter	3

Soil and soil-derived leachate sampling

3.2.13. Forty-one geo-environmental soil samples were selected by Atkins for chemical analysis based on ground conditions encountered during the ground investigation.

3.2.14. Laboratory certificates of the results are presented in the factual GI report [8]. Selected soil samples were scheduled for soil analysis comprising the determinants listed in Table 3-5.

Table 3-5 – Soil analysis summary

Determinant	Number of samples tested
Metals (Arsenic, Boron, Cadmium, Chromium, Chromium (Hexavalent), Copper, Mercury, Nickel, Lead, Selenium, Zinc, Vanadium)	41
Inorganics (pH, Sulphate, Sulphide, Cyanide Total, Cyanide Free, Cyanide complex and organic matter)	41
Speciated polycyclic aromatic hydrocarbons 16 (PAHs)	41
phenol	41
Asbestos screen	41
Total petroleum hydrocarbons (TPH) criteria working group (CWG) with aliphatic/aromatic separation and carbon banding	7
Volatile organic compounds (VOCs)	4
Semi-volatile organic compounds (SVOCs)	4
Polychlorinated Biphenyls (PCBs)	1

3.2.15. Selected soil samples were scheduled for soil derived leachate analysis comprising the determinants listed in Table 3-6.

Table 3-6 – Leachate analysis summary

Determinant	Number of samples tested
Metals (Arsenic, Boron, Cadmium, Chromium (total), Hexavalent Chromium, Copper, Lead, Mercury, Nickel, Selenium and Zinc).	14
Inorganics (pH, Nitrate, Nitrite, Chloride, Ammonia, Sulphate)	14
16 EPA Speciated Polycyclic Aromatic Hydrocarbons	14
Cyanide (total)	14
Phenols (total monohydric)	14

Groundwater sampling

3.2.16. Thirty-four groundwater monitoring wells were sampled by a SOCOTEC engineer using low flow sampling methods on three occasions:

- 14 to 16 June 2021;
- 28 June to 1 July 2021; and
- 12 to 14 July 2021.

3.2.17. The groundwater monitoring record sheets are presented in the factual GI report [8]. Laboratory certificates of the results are also presented within the factual GI report [8]. The samples were sent to the laboratory for chemical analysis according to Table 3-7.

Table 3-7 – Groundwater analysis summary

Determinand	Number of samples tested (over three rounds of sampling)
Metals (Arsenic, Boron, Cadmium, Chromium (total), Hexavalent Chromium, Copper, Iron, Lead, Mercury, Nickel, Selenium, Vanadium and Zinc).	81
Inorganics (pH, Phosphorous, Thiocyanate)	81
Chemical Oxygen Demand, Biochemical Oxygen Demand, Electrical Conductivity, Redox Potential, Alkalinity, Total Organic Carbon	81
Chloride, Ammonia (Free), Ammonium, Ammoniacal Nitrogen, Nitrite, Nitrate, Sulphate, Sulphide	81
Calcium, Potassium, Magnesium Nitrogen, Sodium	81
Cyanide (total), Cyanide Free, Cyanide complex	81
Suspended Solids	19
Speciated PAH 16	66
Phenols	81
Speciated TPH CWG with aliphatic/aromatic separation and carbon banding	38
VOCs and SVOCs	38

Surface water sampling

3.2.18. Two surface water samples (upstream and downstream) were collected from the River Etherow to the east of the scheme on the 21 April 2021 by a SOCOTEC engineer. Laboratory certificates of the results are also presented within the factual GI report [8]. The samples were sent to the laboratory and scheduled for a range of determinands as outlined in Table 3-8 below.

Table 3-8 – Surface water testing suite

Determinand	Number of samples tested
Metals (Arsenic, Boron, Cadmium, Chromium (total), Hexavalent Chromium, Copper, Iron, Lead, Mercury, Nickel, Selenium, Vanadium and Zinc).	2
Inorganics (pH, Phosphorous, Thiocyanate)	2
Chemical Oxygen Demand, Biochemical Oxygen Demand, Electrical Conductivity, Redox Potential, Alkalinity, Total Organic Carbon	2
Chloride, Ammonia (Free), Ammonium, Ammoniacal Nitrogen, Nitrite, Nitrate, Sulphate, Sulphide	2
Calcium, Potassium, Magnesium Nitrogen, Sodium	2
Cyanide (total), Cyanide Free, Cyanide complex	2
Speciated PAH 16	2
Phenols	2

Description of tests

3.2.19. Descriptions of the tests are presented in the factual GI report [8] in accordance with BS 5930 (2015), BS EN 1997-2 (2007) and BS EN ISO 22475-1 (2006).

Factual data

3.2.20. The factual data is presented in the factual GI report [8]. The report presents the factual records of the fieldwork, monitoring and laboratory testing. The information is also presented as digital data as defined in AGS format.

Ground gas and groundwater monitoring

3.2.21. Socotec carried out ground gas and groundwater level monitoring on three occasions over six weeks, using a calibrated GA5000 and dip meter. Ground gas monitoring was specified to supplement the data previously gathered by Arcadis in 2018 and to gather data in areas where data was previously not available. Refer to Table 3-1 for justification of selected boreholes for ground gas monitoring. Methane, carbon dioxide, carbon monoxide, hydrogen sulphide, nitrogen, oxygen and gas flow rate were recorded along with groundwater levels. The atmospheric pressure at the site ranged from 992 mb to 1005 mb during the monitoring visits. The monitoring dates and the atmospheric pressure trends in the days prior to the visits, together with the pressure measured during the visits are detailed in Table 3-9 below.

3.2.22. As with monitoring undertaken as part of the 2018 ground investigation, no visits were undertaken during low and/or falling pressure. CL:AIRE TB17: Ground Gas Monitoring and Worst Case Conditions August 2018. TB17 states “flow resulting from barometric pressure change is only significant where there is a large enough reservoir of gas and an open/highly permeable pathway”; the former of which has not been encountered on site.

Table 3-9 – Atmospheric pressure conditions during ground gas monitoring

Monitoring Round	Date	Pressure	Trend*
1	18/06/2021	994 to 1002	Fluctuating
2	30/06/2021 & 02/07/2021	992 to 1002	Fluctuating
3	14/07/2021 & 15/07/2021	1001 to 1005	Rising

*Data collected from online sources

4. Ground Summary

4.1. General

4.1.1. This addendum presents the ground conditions and material descriptions, split into the same sections presented in the Arcadis GIR [1]. There have been some minor changes to the scheme (and therefore chainages) and therefore Table 2 from the Arcadis GIR [1] is updated in the Table 4-1 below.

4.1.2. The major changes are:

- Roe Cross Link Road has been removed from the scheme;
- Mottram Moor Roundabout has been changed to a signal controlled junction;
- The southern wing wall at the western side of Mottram underpass has been extended; and
- Mottram underpass has moved towards the east, and Roe Cross Road is to be carried by a bridge structure.

Table 4-1 – Scheme section breakdown

Scheme section and chainage extents	Structure	Structural chainage extents	Proposed geotechnical works	Additional phase 5 GI boreholes (along proposed alignment)
Section 1 CH0 – 810	Western Embankments	CH0 – 730	Embankment construction	TP501, BH501, BH503
	Old Mill Farm Underpass	CH540	Precast concrete underpass and associated earthworks	BH502
	Mottram Underpass Western Approach Cutting	CH730 – 810	Cutting construction	BH505
Section 2 CH810 – 1100	Mottram Underpass West Wing Walls	CH810 – 860	Secant piled walls forming wing walls	BH506, BH506A, BH507
	Roe Cross Road Bridge	CH860 – 880	Secant piled walls propped by bridge deck	BH508, BH509
	Mottram Underpass	CH880 – 1050	Secant piled walls propped by bridge deck	BH510, BH511, BH512, BH513, BH514, BH514A, BH516
	Mottram Underpass East Wing Walls	CH1050 – 1100	Secant piled walls forming wing walls	BH515, BH517
Section 3 CH1100 – 1510	Mottram Underpass Eastern Cutting	CH1100 – 1510	Cutting construction	BH518, BH519, BH519A, BH520, BH521, BH522, BH523, BH524, BH524A, BH525, BH526, BH527, BH527A, BH549, BH550, BH550A

Scheme section and chainage extents	Structure	Structural chainage extents	Proposed geotechnical works	Additional phase 5 GI boreholes (along proposed alignment)
Section 4 CH1510 – 3116	Embankment spanning across the assumed location of the Longdendale Aqueduct	CH1510 – 1710	Embankment	BH528, BH529, BH530, BH531, BH532[1]
	Mottram Moor Crossroads Junction	v	Earthworks construction	BH533, BH535, BH536, BH537, BH538, TP502, TP503, WS501, WS503, WS504, WS505
	Eastern Embankments	CH1820 – 2970	Earthworks construction	BH539, BH540, BH541, BH542, BH543, BH544, BH545, TP504, CPT501, CPT502, CPT502A, CPT503, CPT503A, CPT504, CPT505, CPT506, CPT507, CPT508, CPT508A
	Carrhouse Lane Underpass	CH2230	Precast concrete underpass and associated earthworks	
	River Etherow Bridge and approach embankments	CH2970 – 3020	Piled bridge abutments. Embankments to be constructed on piled rafts.	BH546, BH547, BH547A, BH547B, BH548, CPT509, CPT510, CPT511, CPT512

[1]BH528 to BH532 not yet drilled before the completion of the present report

4.1.3. This section of the addendum will refer back to the main GIR [1] for the general material descriptions. Where appropriate, it will add information relating to the Phase 5 GI, particularly where the Phase 5 GI reports information that differs from that presented in the main GIR.

4.2. Section 1

Topsoil and Made Ground

4.2.1. This material is discussed in report sections 5.3.3, 5.3.10, 5.3.13-16 & 5.3.23 of the Arcadis GIR [1]. The Phase 5 GI encountered topsoil across this Section, and it was found to comprise a very soft to firm, slightly sandy, silty CLAY in line with the previous findings.

4.2.2. Made Ground is also recorded within the Section. The Phase 5 GI described the material in line with the reporting in the main Arcadis GIR.

Alluvium

4.2.3. Alluvial material is discussed in report sections 5.3.6-7 & 5.3.24 of the Arcadis GIR [1]. The Phase 5 GI described the material in line with the Phase 1 to 4 findings, however the maximum encountered thickness of the unit appears larger in the 2021 GI measuring 3.2 m in BH501.

Glacial Till

4.2.4. Glacial Till is discussed in report sections 5.3.4-5, 5.3.11, 5.3.17-21 & 5.3.25-28 of the Arcadis GIR [1].

4.2.5. Glacial Till was encountered within each exploratory hole position along this Section of the scheme underlying the Topsoil and Made Ground. The Glacial Till is generally described as soft to firm slightly sandy (rarely laminated) CLAY with occasional bands of granular material described as loose to medium dense SAND. The Phase 5 GI did not present any data different to that previously recorded and reported within the Arcadis GIR.

Millstone Grit Group

4.2.6. Bedrock is discussed in report sections 5.3.8-9, 5.3.12, 5.3.22 & 5.3.29-32 of the Arcadis GIR [1]. Bedrock was not encountered in BH501 and BH502 up to a maximum depth of 17.0 m bgl [187.92 m AOD], however sandstone was encountered within BH503 at 22.5 m bgl [182.1 m OD]. This is consistent with Phases 1 to 4 of GI where rock was not encountered up to a maximum depth of 16.80 m bgl [192.93 m AOD].

4.2.7. Within the Mottram Underpass Western Approach Cutting (CH730 – CH810) bedrock is encountered only within the exploratory holes BH210 and BH211, at levels between approximately 192.0 m AOD and 187.0 m AOD [between 18.6 and 22 m bgl]. Only one Phase 5 GI exploratory hole (BH505) was carried out in this area, which recorded no bedrock presence up to a depth of 20.45 m bgl [190.96 m AOD], in line with the previous GI findings.

4.3. Section 2

Topsoil and Made Ground

4.3.1. Topsoil and Made Ground is discussed in report sections 5.3.35-37 of the Arcadis GIR [1]. Section 2 is mainly located within Mottram Village. Made Ground is generally encountered within the residential area and highways. The Topsoil is present in the surrounding areas and gardens of the residential areas. The Phase 5 GI encountered topsoil within the first 0.5 m (BH514A) of material from the surface, and it was found to comprise a very soft to firm slightly sandy, silty CLAY in line with previous findings.

4.3.2. Made Ground is also recorded within the Section. The Phase 5 GI described the material to comprise fine to coarse sand and gravel with a range of man-made materials including concrete, bricks and hardcore. This description along with the depths and thicknesses of the material were found to be in line with previous findings.

Alluvium

4.3.3. Alluvial material for Section 2 is not discussed within the Arcadis GIR (Arcadis, 2018), however a 0.1 m thin layer was recorded during the previous phase of GI within BH411. Only a single additional exploratory hole containing Alluvium was recorded during the Phase 5 GI (BH508) which contained a 0.8 m layer of the alluvial material. This material is described as soft, slightly sandy silty CLAY.

4.3.4. Both of these exploratory hole locations are found within the western regions of Section 2, very close to the Section 1 boundary where Alluvium is commonly recorded.

Glacial Till

4.3.5. The Topsoil, Made Ground and Alluvium is underlain by cohesive Glacial Till which is discussed in report sections 5.3.38-44 of the Arcadis GIR [1] . This material is recorded as becoming thinner from west to east, and from north to south. The material appears to change in both geological description, and depths encountered across the length of the Section; therefore, descriptions will be split into 3 sub-sections: Western Wing Walls, Underpass and Eastern Wing Walls.

4.3.6. The Glacial Till within the Western Wing Walls is the thickest within Section 2. The Arcadis GIR (Arcadis, 2018) previously reported that till is recorded up to a depth of 192.67 m AOD (22.50 m bgl within BH212) which is in line with the Phase 5 GI findings (193.42 m AOD or 17.30 m bgl within BH506A).

4.3.7. Continuing from the Western Wing Walls, the Phase 5 GI recorded that the Glacial Till thickness reduces towards the east within the proposed Mottram Underpass site. In line with previous GI recordings, it is recorded to a depth of 14.80 m bgl (197.89 m AOD) within BH510 on the western side of the underpass, and a depth of 1.90 m bgl (207.56 m AOD) within BH516 on the eastern side of the underpass. The long section in Appendix A shows the variation of glacial till thickness along the length of the underpass. The change in thickness of till is related to the presence of the geological fault, rather than a linear change along the underpass.

4.3.8. The till recorded during the Phase 5 GI within the Eastern Wing Walls is thinner than the western and central parts of the underpass in line with previous findings, with some exploratory holes not recording any till material (BH515).

4.3.9. The cohesive Glacial Till recorded in the Phase 5 GI is generally described as soft to stiff, slightly sandy occasionally gravelly CLAY with gravel of various lithologies in line with previous findings. Five locations in this area described some layers of till, up to 2.6m thick, as ‘laminated’, and this coincided with a strength description of firm to very stiff. Additionally, the Phase 5 GI also recorded granular lenses which were briefly mentioned within the Arcadis GIR [1]. The granular lenses were recorded as having a maximum thickness of 2.0 m (BH510) and mostly comprise loose to dense, occasionally clayey, fine to coarse SAND also generally in line with previous findings, except for the looser material which was not reported within previous findings.

Millstone Grit

4.3.10. Bedrock is discussed in report sections 5.3.45-50 of the Arcadis GIR [1]. Report sections 5.3.51-63 of the Arcadis GIR [1] also form part of this bedrock assessment, however these sections specifically refer to the zones of tectonic deformation which is discussed below.

4.3.11. The bedrock comprises sandstone, siltstone and mudstone of the Millstone Grit Group and generally underlies the Glacial Till, although within some areas of Section 2, it is recorded as being at or close to the surface (BH515). The lithologies within this group predominately comprise mudstone with interbedded sandstone and siltstone.

4.3.12. A zone of high tectonic deformation is interpreted to extend between approximate chainage CH980 to CH1040 which has resulted in a significant weakening of the underlying bedrock. Many boreholes in the area note layers of material described as having “slickenside surfaces”, and in particular boreholes BH514 and BH514A are both recorded to contain thick (approximately 11 m) bands of material described as containing “slickenside surfaces” with the top of these units being recorded at depths between 12.50 and 13.25 m bgl (200.75 and 199.91 m AOD). This material is sometimes described as mudstone recovered as clay, or very weak and highly fractured mudstone. The presence of this material is highly indicative of the recorded faulting within the region, and potentially pinpoints the location of the highest zone of tectonic deformation. The bedrock surrounding this material is mostly recorded as highly weathered, extremely weak to weak mudstone.

4.3.13. In addition to these slickenside surfaces, there is material in other boreholes which presents a soil-like characteristic, interbedded with rock. This is noticeable within BH513 which possesses a soft to firm CLAY layer around a similar level to the slickenside surfaces within BH514 and BH514A. Additionally, the Rock Quality Designation (RQD) of the bedrock across this region is mainly recorded as being very poor (< 25%) and it is typically not observed to improve with depth suggesting that the zone of tectonic deformation extends below the maximum depth drilled. BH515 and BH517 supports this with very poor quality (<25% RQD) rock at depths of up to 24.7 m bgl and 15.0 m bgl respectively.

4.3.14. Zones of core loss were also recorded in BH408, BH45A, BH409 and BH412A. These reflect zones of poor quality rock, where the recovery of the rock was low, likely to be associated with the tectonic deformation and the fault.

Section 2 - Fault Zone

4.3.15. A key aim of the Phase 5 GI was to investigate the fault beneath the proposed Mottram Underpass in more detail. Following the investigation, geotechnical and geological interpretation was carried out to determine the extent of weathering caused by faulting, and geographically locate the zones which have seen high fault-weathering, moderate fault-weathering and slight fault-weathering.

4.3.16. The fault zone has already been previously assessed as part of the Arcadis GIR [1] within sections 5.3.51-63 of the report.

4.3.17. To identify the geographical location of the fault zone, the core mechanical properties were used as the main source of information, with the geological description acting as a secondary reference. The initial assessment of the fault material was based on the solid core recovery (SCR) data. Borehole strata with an SCR between 0%-15% was classified as “Highly Affected”, 15%-30% “Moderately Affected”, 30%-60% “Slightly to Un-affected” and then greater than 60%. The second stage of the assessment involved categorising each borehole (on the whole) based on the most common SCR categorisation along its depth and the geological description of the material. The results of this are presented in Appendix D.

4.3.18. The ground conditions within BH514 suggest that the fault is likely to be vertical or sub-vertical as the material found within the borehole consisted primarily of clay (described as fault gouge) which extended to the base of the borehole up to 30m bgl.

High Pressure Dilatometer (HPD) Testing

4.3.19. As part of the assessment of the fault material found within Section 2, a total of six high pressure dilatometer (HPD) tests were undertaken on boreholes identified to be within the zone of greatest faulting. The purpose of these tests was to identify the depth and extent of the faulting within the region, and provide an assessment into the stiffness and strength parameters of this faulted material. From the geological descriptions, the rock material found within the fault appears to present more soil based characteristics, with soft to firm clay being recorded interbedded with the more competent, and less weathered rock. Report section 5.13 discusses the HPD test results.

4.4. Section 3

Topsoil and Made Ground

4.4.1. Topsoil and Made Ground is discussed in report sections 5.3.64-65 of the Arcadis GIR [1]. During the Phase 5 GI, Topsoil was encountered at the surface to 0.5 m bgl (BH519 and BH550). Previous ground investigations have highlighted that Topsoil may extend down to 2.2 m bgl (BH306A) however the Arcadis GIR (Arcadis, 2018) discussed that these slightly deeper and thicker horizons are more likely representative of the underlying superficial material (Glacial Till in this instance). The Phase 5 GI recorded Topsoil to generally comprise very soft to soft slightly sandy silty occasionally gravelly CLAY with rootlets in line with previous GI recordings. However the Phase 5 GI additionally described some of the topsoil material (BH523) to have an organic odour which may indicate that some horizons may behave like an organic peat deposit.

4.4.2. Made Ground was also recorded within the Section. The Phase 5 GI indicated the material to be consistent with that reported in the main Arcadis GIR [1] .

Glacial Till

4.4.3. Glacial Till within this Section of the site is discussed in report sections 5.3.66-74 of the Arcadis GIR [1]. This material is recorded to underlie the Topsoil and Made Ground. The Phase 5 GI also recorded till at the surface within some of the exploratory holes (BH527 and BH527A).

4.4.4. The Phase 5 GI recorded thicker Glacial Till (up to 7.75m in BH520) compared to previous GI recordings, however this hole was located at a higher ground level compared to previous investigation locations. This shows that the till / bedrock boundary appears to deepen from west to east which is in line with previous findings from the Arcadis GIR [1].

4.4.5. The Glacial Till generally comprises a firm to stiff, occasionally sandy/gravelly CLAY. There are thin shallow horizons of CLAY described as very soft or soft recorded within 8 of the 52 exploratory holes in the Section. The maximum thickness of the very soft to soft CLAY material is 1.6 m recorded within BH525.

4.4.6. Granular Glacial Till was encountered towards the western side of Section 3 (BH52, BH518 and BH520), at depths between 0.50 m bgl (BH52) and 5.95 m bgl (BH520) with a maximum thickness of 1.90 m (BH518). The granular Glacial Till generally comprises a medium dense to very dense gravelly clayey SAND in line with previous findings.

Millstone Grit Group

4.4.7. The bedrock for this Section of the site is discussed in report section 5.3.75-78 of the Arcadis GIR [1]. This bedrock comprises various lithologies. Arcadis records that mudstone is generally prominent within the western side of Section 3, however the Phase 5 investigation highlights that the most dominant lithology across all of Section 3 is sandstone with less frequent interbedded mudstones and siltstones.

4.4.8. The mudstone is consistently described in the Phase 5 GI to be extremely to moderately weak with fractures. Both the sandstone and siltstone are generally described as moderately strong to strong, with occasional weak to very weak horizons (BH521 and BH524A).

4.4.9. Generally, the RQD of the Section is Very Poor to Poor (0 – 50%) with the lowest quality of rock located on the western side of the Section, closest to the recorded fault and associated tectonic activity. Arcadis recorded that the RQD (%) usually increases with depth, however BH525, BH526 and BH549 show that the RQD can initially increase with depth but then later decrease. This decrease in RQD corresponds with the geological descriptions of interbedded units of medium strong / strong to moderately weak / weak.

4.5. Section 4

4.5.1. It should be noted that at the time of writing this report, the 4 no. exploratory holes planned between CH1500-1710 have not yet been drilled due to ongoing access negotiations with United Utilities. The results of this additional investigation will be discussed in the relevant Geotechnical Design Report due to the sensitive nature of the information.

Topsoil and Made Ground

4.5.2. Topsoil and Made Ground are discussed in report sections 5.3.79, 5.3.85-87, 5.3.92-93, 5.3.99-100 & 5.3.104-105 of the Arcadis GIR [1].

4.5.3. Topsoil recorded during the Phase 5 GI was generally described as soft to firm, slightly sandy, gravelly CLAY or gravelly, silty, very clayey SAND in line with previous findings.

4.5.4. During previous GIs, the topsoil was generally encountered at the surface across most of Section 4. The exception to this was Longdendale Aqueduct (CH1510 – 1710) where Made Ground was encountered at the ground surface. The Phase 5 GI also recorded that Made Ground is present within both the Mottram Moor Crossroads Junction area and River Etherow Bridge (BH533, BH544, BH546 and BH548). The depth of the Made Ground was also recorded to be deeper than previously encountered, recorded as 3.20 m bgl (116.14 m AOD) within BH547B around the proposed River Etherow Bridge. Made Ground was recorded as comprising either a gravelly loose to medium dense sometimes slightly clayey SAND or a soft to firm gravelly sandy CLAY / SILT in line with previous findings.

Section 4 - Superficial materials introduction

4.5.5. This Section (Section 4.5) provides the descriptions of the natural superficial deposits as classified by the Ground Investigation contractors from different phases of investigation, however when assigning geotechnical parameters the materials have been grouped by granular and cohesive.

4.5.6. This grouping has been completed to simplify the uncertainties associated with classification of superficial materials within Section 4 of the scheme, particularly around the River Etherow. The uncertainties have arisen from different geological classifications being assigned during different phases of GI by subsequent GI contractors. This means AGS data, and therefore the data presented in the long-sections shows superficial material varying between different phases of investigation. The classifications presented on the long-sections are not proposed to be changed, but it is noted that these should be examined more closely at detailed design, when it is recommended that a location or structure specific ground model is prepared.

4.5.7. When assigning geotechnical parameters in Section 5 of this report, the materials are grouped as “Superficial – cohesive” comprising materials classified as cohesive Alluvium, and cohesive Glacial Till and “Superficial – granular” comprising materials classified as granular Alluvium, granular Glacial Till and River Terrace Deposits.

Alluvium

4.5.8. The alluvial material found within Section 4 of the route is discussed in report section 5.3.106 of the Arcadis GIR [1].

4.5.9. Alluvium is predominantly cohesive, however horizons of granular Alluvium have also been recorded within the Section. Alluvial soils typically comprise very soft to firm, occasionally thinly laminated, variably sandy, variably gravelly CLAY. The granular horizons are recorded to comprise gravelly, slightly clayey SAND.

4.5.10. The Alluvium appears near the surface and is recorded to reach depths up to 15.80 m bgl (BH433) in the previous phases, while the Phase 5 GI only recorded a maximum depth of 2.50 m (TP505). However, the GIR produced by Arcadis highlighted that the underlying River Terrace Deposits (as mapped on BGS

GeoIndex) were not recorded in GI phases 1 to 4. It is therefore possible that the underlying granular Alluvium (below 2.50m bgl) may be incorrectly recorded in GI phases 1 to 4 and should actually be recorded as the River Terrace Deposits, as identified in Phase 5 GI (see report section 5).

4.5.11. The Phase 5 GI also recorded a 0.5 m and a 0.7 m thick horizon of alluvial peat deposits (in BH537 and WS504 respectively) near the surface. Slight organic odours had previously been recorded within Section 4 of the route, however this “Alluvium Peat” recorded within the Phase 5 GI by SOCOTEC is the first time that peat material has been recorded within this section.

Glacial Till

4.5.12. Glacial Till is recorded to underlie the Topsoil and Made Ground and is discussed in report sections 5.3.80, 5.3.88-89, 5.3.94-95, 5.3.100-102, 105 & 107 of the Arcadis GIR (Arcadis, 2018).

4.5.13. The till gradually thickens from CH1550 at the start of the Section to CH1795, increasing from 6.30 m in BH152 to a maximum thickness of 22.90 m in BH423. After CH1795, the till then begins to thin towards the proposed River Etherow Bridge site which then sees the till become overlain by Alluvium and River Terrace Deposits.

4.5.14. The Glacial Till is mainly described as cohesive, comprising soft to stiff but generally firm, fissured, slightly sandy, occasionally gravelly CLAY. Occasionally it is described as laminated. However, granular horizons of the till have been recorded, most commonly within the River Etherow Bridge area (BH545 – 548) but is occasionally found within other boreholes within the Section (BH533, BH536 and BH540). These granular horizons comprise loose to dense very gravelly SAND or very sandy GRAVEL.

Head Deposits

4.5.15. This material is discussed within report section 5.3.81 & 5.3.105-106 of the Arcadis GIR [1]. It is considered unlikely that head deposits would be as extensive towards the east, away from the break in slope of the valley sides as suggested within the Arcadis report and geological cross-sections. During the Phase 5 GI, no head deposits were recorded however the local presence of head deposits within Section 4 of the site should still be assumed.

4.5.16. Within the Arcadis GIR [1] possible relict slip planes were identified within observation pits to the south of Mottram Moor within the area of the proposed signal controlled Mottram Moor Junction. Initial designs indicate that if relict slips are present they will be dug out and replaced with engineered fill as part of the process of benching into the slopes. Gaining access to this part of the site from the landowner during the GI was difficult. During construction a watching brief will be undertaken by a suitably qualified engineer and excavation will be extended to a suitable depth below and slips.

River Terrace / Glacio-fluvial Deposits

4.5.17. River Terrace (or Glacio-fluvial) Deposits had not been conclusively or confidently recorded on site during the previous ground investigations and had only been hypothesised through consulting BGS mapping. This material is discussed within report section 5.3.108 of the Arcadis GIR [1]. The Phase 5 GI confirmed its presence with deposits recorded in BH546 to BH548 and BH547A. The deposits are only present within the proposed River Etherow Bridge site (CH2970 – CH3020) and the thickness ranges between 2.60 m (BH546) and 3.20 m (BH547A) at depths of 0.50m bgl to 4.00m bgl. The River Terrance Deposits generally comprise medium dense to dense clayey SAND and GRAVEL with occasional cobbles. BH547A recorded loose material, which was described to become medium dense through the 1.30 m layer.

Millstone Grit Group

4.5.18. The bedrock comprises various lithologies. The Arcadis GIR [1] records that the bedrock mainly comprises mudstone which is generally the case within the Phase GI 5, specifically within the River Etherow Bridge Site. However, thick interbedded horizons of sandstone and siltstone were additionally found across the whole Section. The mudstone is described in line with previous studies as extremely weak (BH538, BH540, BH542 and BH547B) to weak, with sub-horizontal, closely spaced discontinuities. The siltstone and sandstone are both described as being extremely weak to weak displaying similar sub-horizontal discontinuities also in line with previous findings.

4.6. Visual/olfactory evidence of contamination

4.6.1. A summary of the visual and/or olfactory evidence of contamination encountered during the ground investigation for each area is summarised in Table 4-2 below. Appendix A within the Arcadis GIR (Arcadis, 2018) identified a faint hydrocarbon odour within Made Ground between 1.20 and 1.70 m bgl at BH422 within Section 4. During the Atkins 2021 GI no further visual/olfactory evidence of contamination was identified within this Section (the nearest 2021 exploratory hole to BH422 is located approximately 55 m east).

4.6.2. Photo-ionisation detector (PID) screening for volatile organic compounds (VOCs) was conducted on environmental soil samples during the ground investigation. The photo-ionisation (PID) tests conducted in the field consistently measured at/or below the limit of detection (<0.1 ppm). It should also be noted that during drilling of BH514A a “gas” odour was noted by the drilling crew and supervising engineer.

Table 4-2 – Summary of visual/olfactory evidence of contamination

Section	Area of Section	Evidence of contamination	PID results (ppm)
1	Western Embankments	Brick and coal	<0.1
	Old Mill Farm Underpass	None recorded	<0.1
2	Mottram Underpass West Wing Walls	None recorded	<0.1 to 0.1
	Roe Cross Bridge	None recorded	<0.1
	Mottram Underpass	None recorded	<0.1
	Mottram Underpass East Wing Walls	None recorded	<0.1
3	Mottram Underpass Eastern Cutting	Slight organic odour noted within BH523 at 0.10 to 0.35 m bgl.	<0.1
4	Embankment or structure spanning across the assumed location of the Longdendale Aqueduct	None recorded	n/a
	Mottram Moor Crossroads Junction	Slight organic odour noted in TP503 between 0.70 and 1.80 m bgl Slight organic odour noted in BH537 between 0.20 and 0.70 m bgl where decomposing plant matter is noted. Strong organic odour noted within BH537 between 0.70 and 1.20 m bgl where peat is noted.	<0.1
	Eastern Embankments	Strong organic odour noted in BH544 at 1.20 to 1.70 m bgl	<0.1
	Carrhouse Lane Underpass	None recorded	<0.1
	River Etherow Bridge and approach embankments	None recorded	<0.1

4.7. Groundwater encountered during the 2021 GI

4.7.1. Groundwater encountered during excavation of trial pits and drilling of boreholes is summarised in Table 4-3 below. Groundwater monitoring is discussed in detail in section 6.2 and section 4.8.

Table 4-3 – Summary of groundwater strikes during the 2021 ground investigation

Section	Area of section	Exploratory Hole	Depth of Water Strike (m bgl)	Deposit	Water level after 20 min (m bgl)	Total Rise in 20 min (m)
1	Western Embankments	BH503	16.50 22.50	Clay (Till)	9.33 9.16	7.17 13.34
	Old Mill Farm Underpass	BH501	1.20 (seepage)	Clay (Till)	n/a	n/a
		BH502	1.20 (seepage)	Sand/clay (Till)	n/a	n/a
	Mottram Underpass Western Approach Cutting	BH505	9.00	Clay (Till)	8.26	0.74
2	Mottram Underpass West Wing Walls	BH506	13.00	Clay (Till)	12.00	1.0
		BH506A	4.20 (seepage)	Clay (Till)	n/a	n/a
		BH507	9.80 (damp)	Clay (Till)	n/a	n/a
	Mottram Underpass	BH511	4.20	Clay (Till)	2.10	2.10
		BH513	0.20 (perched)	Gravel	n/a	n/a
	Mottram Underpass East Wing Walls	BH515	0.00 to 1.20 (fast inflow)	Made Ground	n/a	n/a
3	Mottram Underpass Eastern Cutting	BH518	2.60	Clay /sand (Till)	2.12	0.48
		BH519A	4.50	sandstone	4.0	0.50
			14.0	sandstone	7.10	6.90
		BH520	1.20	Clay (Till)	0.90	0.30
			8.20	Clay (Till)	-0.60 (slow artesian)	8.80
			9.95	Clay (Till)	0.90	9.05
			11.20	Mudstone	-0.20 (artesian)	11.40
		BH521	13.50	sandstone	11.20	2.30
			28.50	sandstone	4.95	23.55
		BH522	1.20 (seepage)	Clay (Till)	n/a	n/a
			7.30	Clay (Till) /sandstone	1.97	5.33
		BH523	9.90	Mudstone	6.30	3.60

Section	Area of section	Exploratory Hole	Depth of Water Strike (m bgl)	Deposit	Water level after 20 min (m bgl)	Total Rise in 20 min (m)
		BH524A	2.00	Clay (Till)	0.90	1.10
			7.00	sandstone	6.20	0.80
			11.80	sandstone	2.20	9.60
		BH525	9.40	sandstone	3.48	5.92
		BH526	4.40	Clay (Till) /sandstone	2.15	2.25
			8.80	sandstone	4.56	4.24
			20.60	Siltstone	1.84	18.76
		BH527A	11.00	sandstone	2.90	8.10
			17.00	Siltstone	4.60	12.40
		BH550	0.50	Clay (Till)	0.30	0.20
4	Mottram Moor Crossroads Junction	BH535	0.60 (seepage)	Clay (Till)	n/a	n/a
			5.00	Clay (Till)	4.65	0.35
			7.50	Clay (Till)	6.47	1.03
			11.30	Clay (Till)	10.42	0.88
		BH536	5.50	Sand/clay (Till)	4.95	0.55
			8.00	Clay/sand (Till)	2.38	5.62
		BH538	0.20 (seepage)	Clay (Till)	n/a	n/a
			4.45	Clay (Till)	3.79	0.66
			16.70	Gravel/mudstone	13.75	2.95
	Eastern Embankments	BH539	9.40	Clay (Till)	8.47	0.93
			17.20	Clay /gravel (Till)	9.04	8.16
		BH540	3.50	Clay (Till)	3.07	0.43
			5.00	Clay (Till)	4.36	0.64
			9.50	Clay (Till)	8.10	1.40
			19.50	Clay /sand (Till)	11.55	7.95
		BH543	13.00	Clay /gravel (Till)	1.80	11.20
			20.50	sandstone	1.40	19.10
		BH544	12.50	Clay /gravel (Till)	1.50	11.00
			21.20	sandstone	1.40	19.80
		BH545	11.00	Clay /gravel (Till)	1.28	9.72
	River Etherow Bridge and	BH546	1.20 (seepage)	Clay /sand (Till)	n/a	n/a
			9.00	Clay/sand (Till)	0.50	8.50

Section	Area of section	Exploratory Hole	Depth of Water Strike (m bgl)	Deposit	Water level after 20 min (m bgl)	Total Rise in 20 min (m)
	approach embankments	BH547	1.80	Gravel (alluvium)	1.50	0.30
			3.00	Gravel (alluvium)	1.50	1.50
			8.00	Clay/gravel (Till)	-1.80 (artesian)	9.80
		BH547A	1.60	Sand (Topsoil)	1.49	0.11
			5.00	Clay (Till)	2.47	2.53
		BH547B	1.70	Made Ground	1.50	0.20
			7.90	Clay/sand (Till)	4.32	3.58
		BH548	8.45	Clay/gravel (Till)	-1.65 (artesian)	10.10

4.7.2. The Arcadis GIR [1] details groundwater levels during the ground investigation within Section 5 of the report. Full details are provided within the Socotec Factual Report [8]. Groundwater strikes ranged from 0.50 m bgl to 16.7 m bgl. Artisan conditions were encountered in 2018 within the following locations:

- BH417: 9.10 m bgl to -0.60 m bgl (Section 3);
- BH432: 8.80 m bgl to -1.0 m bgl (Section 4); and
- BH433: 8.5 m bgl to -10.0 m bgl (Section 4).

4.7.3. The location of artesian conditions coincides with where artesian conditions were encountered during the Atkins 2021 GI.

4.8. Groundwater levels and flow direction

4.8.1. Groundwater levels have been monitored in all groundwater monitoring wells installed during the 2021 ground investigation on three occasions during the monitoring period by a Socotec engineer. Details of groundwater levels monitored during the 2018 GI are provided within Section 5 of the Arcadis GIR [1]. Groundwater levels recorded within the Arcadis GIR are summarised in Table 4-4 below. Groundwater levels measured during the 2021 GI appear to support the levels recorded as part of the 2018 GI.

Table 4-4 – Arcadis GIR Groundwater Levels Summary

Section of Scheme	Groundwater Level	
1 – Western Embankments	Glacial Till: Between 1.00 m bgl and 8.00 m bgl Bedrock (mudstone and siltstone): Not measured	
1 – Old Mill Farm Underpass	Glacial Till: Ground surface (flooded) Bedrock (mudstone, siltstone and sandstone): Not measured	
1 - Mottram Underpass Western Approach Cutting	Glacial Till: Not measured Bedrock (alternating sandstone and siltstone): 14.8 m bgl to 15.30 m bgl	
2 - Mottram Underpass West Wing Walls, Mottram Underpass & Mottram Underpass East Wing Walls	West of fault zone Made Ground: <2.0 m bgl Glacial Till: Dry Bedrock (alternating sandstone and siltstone): 14 to 15 m bgl	East of fault zone Glacial Till: 6.00 m bgl Bedrock (highly disturbed and weathered mudstones, siltstones and sandstones): 13.00 m bgl to 1.00 m bgl
3 - Mottram Underpass Eastern Cutting	Granular Glacial Till: Dry Cohesive Glacial Till: Not measured Bedrock (siltstone and sandstone): ground level to 6.20 m bgl	
4 – Eastern Embankments & Mottram Moor Crossroads Junction	Glacial Till: 1.00 to 16.8 m bgl Glaciofluvial: 1.00 to 1.20 m bgl Bedrock (siltstone, mudstone and sandstone): Not measured	
4 - Carrhouse Farm Underpass	Glacial Till: Dry Bedrock (siltstone and mudstone): 2.0 to 3.4 m bgl	
4 - River Etherow Bridge and approach embankments	Glacial Till: Not measured Glaciofluvial Deposits: 1.00 to 1.20 m bgl Bedrock (siltstone and mudstone): Not measured	

4.8.2. The groundwater levels recorded during the Atkins 2021 GI are summarised in Table 4-5. It should be noted that monitoring rounds took place over multiple consecutive days with all the dates provided in the table below. Water monitoring was undertaken in a select number of boreholes prior to the commencement of the formal monitoring regime. These results have been provided within Table 4-6. Groundwater levels and their interpretation is discussed in detail in section 6.2. In addition to this, vibrating wire piezometers were installed in BH546, BH547, BH547B and BH548. Vibrating wire piezometer data is provided within the Socotec factual report [8].

Table 4-5 – Summary of groundwater levels during Socotec monitoring rounds

Section	Area of section	Exploratory Hole	Well Screen Range (m bgl)	Screened Deposits	Water Depth (m bgl)						
					20 to 21/05/21	14 to 16/06/21	18/06/21	28 to 30/06/21	02/07/21	12 to 13/07/21	15/07/21
1	Western Embankments	BH503	15.40 to 16.20	Clay (Till)	5.42	6.06	-	6.16	-	6.30	-
	Old Mill Farm Underpass	BH501	15.50 to 16.00	Clay (Till)	3.11	4.28	-	4.40	-	4.60	-
		BH502	2.50 to 3.50	Clay (Till)	0.33	0.76	-	0.70	-	0.45	-
	Mottram Underpass Western Approach Cutting	BH505	7.50 to 9.00	Clay (Till)	Dry	Dry	-	-	-	Dry	-
2	Mottram Underpass West Wing Walls	BH506	11.00 to 13.00	Clay (Till)	11.58	11.80	-	12.22	-	12.22	-
		BH506A (S)	3.20 to 4.00	Clay (Till)	-	1.15	-	1.00	-	0.60	-
		BH506A (D)	23.50 to 27.00	Siltstone and Sandstone	-	26.85	26.93	27.00	27.00	27.00	Dry
	Roe Cross Bridge	BH508	23.50 to 27.00	Sandstone, Siltstone and Mudstone	27.08	27.07	-	27.00	27.10	27.00	Dry
		BH509	12.00 to 13.00	Clay (Till)	8.08	11.91	-	7.10	-	7.10	-
	Mottram Underpass	BH510	21.50 to 24.70	Sandstone & Siltstone	22.22	Dry	Dry	Dry	-	No access	-
		BH511	9.00 to 10.00	Clay (Till)	1.62	5.39	-	5.43	-	5.49	-
		BH512	15.00 to 16.00	Siltstone and Sandstone	Dry	Dry	-	Dry	-	Dry	-
		BH513 (S)	8.20 to 9.00	Clay and Sand (Till)	-	3.30	-	3.42	-	-	3.30
		BH513 (D)	21.50 to 25.00	Sandstone and Siltstone	-	21.82	21.81	21.97	-	-	21.93
		BH514 (S)	5.20 to 6.00	Clay (Till)	1.33	3.76	-	3.54	-	3.15	-
		BH514 (D)	15.00 to 18.50	Sandstone and Clay	9.32	11.43	11.09	10.99	11.78	11.70	11.94
		BH516	21.00 to 24.00	Siltstone & Mudstone	0.45	0.50	0.28	1.10	0.50	0.45	-
	Mottram Underpass East Wing Walls	BH515 (S)	10.00 to 11.00	Sandstone & Siltstone	0.98	0.14	-	0.19	-	1.06	-
		BH515 (D)	14.70 to 15.70	Mudstone	0.10	0.07	-	0.06	-	0.07	-
		BH517	7.50 to 10.50	Sandstone	4.84	5.11	5.16	-	-	-	5.82
3	Mottram Underpass Eastern Cutting	BH518	14.00 to 24.00	Sandstone, Siltstone and Mudstone	-	2.88	-	-	-	-	7.28
		BH519A	13.00 to 15.00	Sandstone, Siltstone and Mudstone	4.09	-	-	-	-	-	-
		BH520	13.00 to 25.00	Sandstone, Siltstone and Mudstone	-	1.47	1.50	4.40	-	-	5.77
		BH521	20.00 to 30.00	Mudstone, sandstone and siltstone	-0.84*	-	-	-	-	-	-

Section	Area of section	Exploratory Hole	Well Screen Range (m bgl)	Screened Deposits	Water Depth (m bgl)						
					20 to 21/05/21	14 to 16/06/21	18/06/21	28 to 30/06/21	02/07/21	12 to 13/07/21	15/07/21
		BH522	5.50 to 7.50	Clay (Till) & Sandstone and Siltstone	-	3.98	5.54	-	-	-	7.15
		BH523	9.50 to 12.50	Mudstone, Sandstone and Siltstone	-	-	-	*	-	-	1.16
		BH524A	11.00 to 14.00	Sandstone, Siltstone and Mudstone	-	6.35	6.39	6.47	6.50	6.52	6.52
		BH525 (S)	3.00 to 5.50	Clay (Till), Mudstone and Sandstone	1.26	3.07	-	3.09	-	3.20	-
		BH525 (D)	8.50 to 12.50	Sandstone and Siltstone	-	1.24	1.23	1.46	1.73	1.08	1.22
		BH526	19.00 to 23.00	Sandstone and Siltstone	-	-	-	*	-	-	-
		BH527A	12.00 to 18.00	Sandstone & Siltstone	-	-	-	*	-	-	-0.50
		BH549	6.00 to 9.00	Sandstone and Siltstone	-	4.90	5.00	5.03	5.06	-	5.47
		BH550A	6.50 to 9.50	Sandstone and Siltstone	-	2.26	2.31	-	-	-	2.89
		BH551	5.50 to 8.50	Sandstone and Siltstone	-	5.60	5.58	-	-	-	6.05
4	Embankment or structure spanning across the assumed location of the Longdendale Aqueduct	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Mottram Moor Crossroads Junction	BH533	23.50 to 14.20	Clay (Till)	11.44	11.48	-	11.60	-	11.38	-
		BH535 (S)	5.00 to 7.50	Clay (Till)	-	4.63	-	4.70	-	4.30	-
		BH535(D)	10.50 to 11.50	Clay (Till)	-	9.07	-	9.65	-	8.40	-
		BH536 (S)	4.50 to 5.50	Clay & Sand (Till)	-	1.68	-	1.83	-	1.66	-
		BH536(D)	7.00 to 8.00	Clay (Till)	-	1.98	-	2.00	-	2.10	-
		BH538(S)	2.00 to 4.50	Clay (Till)	-	3.02	-	3.10	-	3.50	-
		BH538(D)	14.00 to 16.70	Clay & Gravel (Till)	-	13.43	-	13.41	-	13.50	-
	Eastern Embankments	BH539	8.00 to 9.50	Clay (Till)	-	-	-	-	-	0.85	-
		BH540	7.00 to 9.00	Clay (Till)	-	-	-	-	-	4.70	-
		BH542	13.00 to 14.80	Clay (Till)	-	-	-	-	-	Dry	-
		BH544(S)	5.00 to 5.50	Clay (Till)	-	-	-	-	-	1.54	-
		BH544(D)	12.50 to 15.50	Gravel (Till)	-	-	-	-	-	1.30	-
		BH545(S)	5.50 to 6.00	Clay (Till)	-	3.72	-	4.76	-	3.96	-

Section	Area of section	Exploratory Hole	Well Screen Range (m bgl)	Screened Deposits	Water Depth (m bgl)						
					20 to 21/05/21	14 to 16/06/21	18/06/21	28 to 30/06/21	02/07/21	12 to 13/07/21	15/07/21
		BH545(D)	22.00 to 23.00	Siltstone and Sandstone	-	0.57	-	0.60	-	0.57	-
	Carrhouse Lane Underpass	BH541	2.50 to 5.00	Clay (Till)	-	-	1.54	1.67	-	0.61	-
	River Etherow Bridge and approach embankments	BH547A	4.50 to 5.50	Clay (Till)	1.65	1.66	-	1.60	-	1.84	-

4.8.3. In table 4-5 above some of the monitoring was carried out within the timeframe of the pumping test at BH519A (24th of June to the 15th of July 2021). However, it is considered that sufficient groundwater monitoring data was collected out with this time frame to gain enough data on the natural groundwater levels in the area. The relationship between distance and drawdown is discussed within the pumping test factual report [10] . Additional Monitoring prior to onset of the formal monitoring regime was undertaken at the locations and dates outlined in Table 4-6 below.

Table 4-6 – Summary of additional groundwater monitoring undertaken

Section	Area of section	Exploratory Hole	Well Screen Range (m bgl)	Screened Deposits	Water Depth (m bgl)							
					22 to 26/02/21	08/03/21	17/03/21	23/03/21	24/03/21	29/03/21	07/04/21	16/04/21
1	Mottram Underpass Western Approach Cutting	BH505	7.50 to 9.00	Clay (Till)	-	-	-	Dry	Dry	-	-	-
2	Mottram Underpass West Wing Walls	BH506	11.00 to 13.00	Clay (Till)	-	-	-	11.24	11.05	-	-	-
	Roe Cross Bridge	BH508	24.00 to 27.00	Sandstone, Siltstone and Mudstone	-	-	-	25.79	26.09	-	-	-
		BH516	21.00 to 24.00	Siltstone & Mudstone	-	-	-	-	0.78	0.58	-	-
		BH517	7.50 to 10.50	Sandstone	-	-	-	-	-	-	4.84	-
3	Mottram Underpass Eastern Cutting	BH518	14.00 to 24.00	Sandstone, Siltstone and Mudstone	3.00 to 3.33	3.70	-	-	-	-	3.81	-
		BH519A	13.00 to 15.00	Sandstone, Siltstone and Mudstone	-	3.20	-	-	-	-	3.70	-
		BH520	13.00 to 25.00	Sandstone, Siltstone and Mudstone	0.02 to 0.71	0.60	-	-	-	-	-	-
		BH522	5.50 to 7.50	Clay (Till) & Sandstone and Siltstone	3.00 to 3.20	3.13	-	-	-	-	3.60	-
		BH524A	11.00 to 14.00	Sandstone, Siltstone and Mudstone	5.56 to 6.04	6.07	-	-	-	-	6.05	-
		BH525 (S)	3.00 to 5.50	Clay (Till), Mudstone and Sandstone	-	-	0.90	0.92	0.93	1	1.42	-
		BH525 (D)	8.50 to 12.50	Sandstone and Siltstone	-	-	0.20	-	-	-	-	-
		BH526	19.00 to 23.00	Sandstone and Siltstone	-	-3.50*						-
		BH527A	12.00 to 18.00	Sandstone & Siltstone	-	-0.66*	-	-	-	-	0.70	-
		BH549	6.00 to 9.00	Sandstone and Siltstone	4.50	4.51	-	-	-	-	4.55	-
		BH550A	6.50 to 9.50	Sandstone and Siltstone	-	2.06	-	-	-	-	1.97	-
		BH551	5.50 to 8.50	Sandstone and Siltstone	-	5.41	-	-	-	-	-	-
4	Mottram Moor Crossroads Junction											
		BH535 (S)	5.00 to 7.50	Clay (Till)	-	-	-	-	-	-	-	4.54

Section	Area of section	Exploratory Hole	Well Screen Range (m bgl)	Screened Deposits	Water Depth (m bgl)							
					22 to 26/02/21	08/03/21	17/03/21	23/03/21	24/03/21	29/03/21	07/04/21	16/04/21
		BH535(D)	10.50 to 11.50	Clay (Till)	-	-	-	-	-	-	-	6.47
		BH536 (S)	4.50 to 5.50	Clay & Sand (Till)	-	-	-	-	-	-	-	1.49
		BH536(D)	7.00 to 8.00	Clay (Till)	-	-	-	-	-	-	-	1.92
		BH538(S)	2.00 to 4.50	Clay (Till)	-	-	-	-	-	-	-	3.11
		BH538(D)	14.00 to 16.70	Clay & Gravel (Till)	-	-	-	-	-	-	-	13.07
	Eastern Embankments	BH539	8.00 to 9.50	Clay (Till)	-	-	-	-	-	-	-	0.52
		BH540	7.00 to 9.00	Clay (Till)	-	-	-	-	-	-	-	2.94
		BH542	13.00 to 14.80	Clay (Till)	-	-	-	-	-	-	-	Dry
		BH544(S)	5.00 to 5.50	Clay (Till)	-	-	-	-	-	-	-	1.26
		BH544(D)	12.50 to 15.50	Gravel	-	-	-	-	-	-	-	1.55
		BH545(S)	5.50 to 6.00	Clay (Till)	-	-	-	-	-	-	-	1.62
		BH545(D)	22.00 to 23.00	Siltstone and Sandstone	-	-	-	-	-	-	-	0.79
	Carrhouse Lane Underpass	BH541	2.50 to 5.00	Clay (Till)	-	-	-	-	-	-	-	1.52

* groundwater levels recorded at this location are artesian (above ground level) - the recorded level is limited by upstand of monitoring standpipe. Further discussion of artesian groundwater is given in section 6.2.3.

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4.9. Ground gas monitoring

4.9.1. Three rounds of ground gas monitoring have been undertaken by a Socotec engineer from the installed monitoring wells as part of the 2021 GI. The results are summarised in Table 4-7, with maximum (or for oxygen, minimum) concentrations and maximum steady state flows for each well taken from across the whole monitoring period presented. A ground gas risk assessment is presented within section 7.5. No ground gas monitoring was undertaken within Section 1 of the scheme due to the lack of potential sources, lack of proposed enclosed spaces and the presence of previous gas monitoring data.

4.9.2. Appendix A of the Arcadis GIR provides details on the ground gas monitoring undertaken. Three rounds of ground gas monitoring were undertaken in 2018 at the following locations BH401 and BH406 (Section 1), BH421 (Section 3) and BH422 (Section 4).

4.9.3. A summary of the findings of the ground gas monitoring undertaken are presented below:

- Carbon Dioxide concentrations ranged from <0.1 % v/v to 1.3 % v/v
- Methane concentrations ranged from <0.1 % v/v to 0.7 % v/v
- Hydrogen Sulphide was consistently measured below the method detection limit (MDL) of the instrument utilised
- Carbon Monoxide concentrations ranged from <0.1 ppm to 19.0 ppm
- Maximum steady state flow rates of 0.1 l/hr.

4.9.4. Concentrations of gases recorded during both phases of GI are similar for carbon dioxide (maximum concentrations are 1.3 % v/v (2018) and 1.7 % v/v (2021). The 2021 ground investigation recorded methane at or below the MDL of 0.1 % v/v in all exploratory holes and visits. The maximum recorded steady state flow rate was significantly higher during the 2021 ground investigation at 12.0 l/hr compared to 4.2 l/hr recorded in 2018.

Table 4-7 – Summary of ground gas results from the Socotec monitoring

Section	Area of section	Exploratory Hole	Flow (l/hr)		Methane (% v/v)		Carbon Dioxide (% v/v)		Oxygen (% v/v)		Max hydrogen sulphide (ppm)	Max carbon monoxide (ppm)`	Deposits Screened	Response zone flooded? (no. of visits)
			Max	Max Steady	Max	Max steady	Max	Max steady	Min	Min steady				
2	Mottram Underpass West Wing Walls	BH506A	0.1	0.1	<0.1	<0.1	0.3	0.2	20.5	20.5	2	1	Sandstone and Siltstone	N (3/3)
	Roe Cross Bridge	BH508	<0.1*	<0.1*	<0.1	<0.1	0.1	0.1	21.1	21.1	2	1	Sandstone, Mudstone and Siltstone	N (2/2)
	Mottram Underpass	BH510	0.1	0.1	<0.1	<0.1	0.1	<0.1	20.8	21.0	1	7	Sandstone and Siltstone	N (1/1)
		BH513	0.1	0.1	<0.1	<0.1	0.1	0.1	20.5	20.7	6	455[1,2]	Sandstone and Siltstone	Y (3/3)
		BH514A	21.0[3]	12.0	<0.1	<0.1	0.2	0.2	19.2	19.2	3	4	Clay	Y (3/3)
		BH516	0.2	0.2	<0.1	<0.1	0.1	<0.1	20.7	20.9	0	3	Siltstone and Mudstone	Y (2/2)
	Mottram Underpass East Wing Walls	BH517	0.1	0.1	<0.1	<0.1	0.1	0.1	21.3	21.4	0	2	Sandstone	Y (1/1)
3	Mottram Underpass Eastern Cutting	BH549	<0.1*	<0.1*	<0.1	<0.1	0.1	0.1	20.9	20.9	4	4	Sandstone	Y (1/2)
		BH551	<0.1*	<0.1*	<0.1	<0.1	0.1	0.1	21.4	21.5	0	2	Sandstone	N (1/1)
		BH550A	<0.1*	<0.1*	<0.1	<0.1	0.1	0.1	21.1	21.2	0	1	Sandstone	Y (1/1)
		BH524A	<0.1*	<0.1*	<0.1	<0.1	1.70	0.3	28.2	20.0	1	2	Sandstone, Siltstone and Mudstone	Y (2/2)
		BH520	<0.1*	<0.1*	<0.1	<0.1	0.1	0.1	21.5	21.6	0	6	Sandstone, Mudstone and Siltstone	Y (1/1)
		BH525	<0.1*	<0.1*	<0.1	<0.1	0.1	0.1	20.9	21.0	1	1	Sandstone, Mudstone and Siltstone	Y (3/3)
		BH522	0.1	0.1	<0.1	<0.1	0.1	0.1	21.7	21.7	0	1	Clay and Sandstone	Y (1/1)
4	Eastern Embankments	BH540	0.1	0.1	<0.1	<0.1	0.8	0.2	16.4	20.2	0	20[4]	Clay	Y (1/1)
		BH544 (D)	<0.1*	<0.1*	<0.1	<0.1	0.2	0.1	17.9	20.4	1	44[5]	Gravel	Y (1/1)
	Carrhouse Lane Underpass	BH541	2.5	2.5	0.1	<0.1	0.9	0.5	14.4	15.90	1	91[6]	Clay	Y (3/3)

[1] Other monitoring rounds recorded maximum concentrations of 93 ppm and 0.0 ppm
[2] Recorded high CO concentrations when response zones were flooded.
[3] Other monitoring rounds recorded maximum flow rates of 0.3 l/hr and 20.6 l/hr
[4] Recorded high CO concentrations when response zones were flooded.
[5] Recorded high CO concentrations when response zones were flooded.
[6] Recorded high CO concentrations when response zones were flooded.

5. Geotechnical Parameters

5.1.1. This section of the GIR addendum derives the characteristic geotechnical parameters for each stratum using the material descriptions, and available in situ and laboratory testing. The methods used are as outlined in report section 6.2 of the Arcadis GIR [1]. The published correlations used to derive initial properties from either the SPT N_{60}, plasticity index and UCS results are presented in Table 5-1 below and are considered applicable to the design work to be undertaken. These values have then been checked against available lab testing and published values for similar soil and rock types to derive the design geotechnical parameters.

5.1.2. The parameter derivation assessment has considered the entire Phase 1 to 5 GI datasets, and where appropriate, the data has been split to show Phases 1 to 4, separately from Phase 5. Where the selected design parameters in this addendum vary significantly from those presented in the main GIR, this is discussed. It is possible that at detailed design stage, a subset of data may be taken, and a specific design value derived for that element of design. This is particularly relevant for rock, where the testing data ranges widely, and a lower bound characteristic value has been presented in this report. The wide range of results comes about partly from a varied weathering profile of the rock, but also because of the type of testing that has been used to derive parameters. Point load tests and UCS tests suffer from a sampling bias to select the more competent rock samples to be tested, therefore these tests report higher strength than a correlated SPT test. For the purposes of this report, a lower bound value has been derived considering all available data for each material. It is recommended that for particular design elements, a specific ground model is developed, and the local data is interrogated to verify or revise the parameters presented. Where the detailed design uses a design value that differs from that presented in this document, this will be described in the GDR.

5.1.3. For the purposes of this report, the rock weathering profiles have been grouped, because preliminary analysis of the assigned weathering descriptions showed very little consistency throughout the data. In line with guidance from CIRIA 143 [11] and CIRIA 181 [12] a UCS of 0.6 MPa has been identified as the lower bound limit for a weak rock, this corresponds to an approximate SPT N_{60} value of 60 (see the below table). For SPT N_{60} values less than 60, soil parameters will be assigned, as described in Table 5-1.

Table 5-1 – Summary of published relationships for the derivation of soil and rock properties

Geotechnical Parameter	Published correlation	Comments and sources
Bulk and Dry Density (kg/m^3)	Figure 1 and Figure 2 of BS 8004:2015 to derive dry and bulk density respectively	Where no bulk and dry density testing is available, BS 8004:2015 (British Standards Institute, 2015) can be used to estimate density based on material descriptions
Undrained shear strength (kPa)	$c_u = 4.5 \times N_{60}$	A single correlation factor of 4.5 was used in deriving c_u from SPT N for cohesive materials. In some cases, this may be slightly conservative. Relationship and factor based on Fig 3, CIRIA 143 (after Stroud, 1974) (CIRIA, 1995)
Drained Young's Modulus for fine grained soils (MPa)	$E' = 0.76 \times E_u$	CIRIA 143, assuming a drained and undrained Poisson's Ratio of 0.15 and 0.5 respectively means that the conversion factor is 0.76 (CIRIA, 1995)
Drained Young's Modulus for granular soils (MPa)	$E' = 2 \times N_{60}$	Min of $E' = 2 \times N_{60}$ given pg.81, CIRIA 143 (CIRIA, 1995)
Drained Young's Modulus for weathered rock (MPa)	$E' = 1 \times N_{60}$	Range for mudstone 0.5-2, pg.91, CIRIA 143 (CIRIA, 1995). In this case, a conversion factor of 1 was used.
Undrained Young's Modulus (MPa)	$E_u = 1 \times N_{60}$	CIRIA 143 (CIRIA, 1995)
Coefficient of compressibility for fine-grained soils (m^2/MN)	$m_v = \frac{1}{f_2 \times \mathrm{N}}$	The m_v parameter can be derived from SPT 'N' values using the method in CIRIA Report 143 (CIRIA, 1995) where by $m_v = f_2$ N, where f_2 is chosen for a given value of plasticity index
Constant volume angle of shearing resistance for fine-grained soils (°)	$\varphi' = 42 - 12.5 \times \log_{10} I_p$	BS 8004:2015 (British Standards Institution, 2015). A dilation angle of 2° will be added to constant volume angle to obtain peak angle.
Peak angle of shearing resistance for granular soils (°)	$\varphi' = 27.1 + 0.3 \times N_{60} - 0.00054[N_{60}]^2$	Peak φ' for granular soils, Wolff, 1989 (Wolff, 1989) These values have been compared with the guidance in BS 8004:2015 (British Standards Institution, 2015) for the derivation of φ' and shown to have suitable correlation
Uniaxial Compressive Strength of weathered rock (kPa or MPa)	$UCS = 10 \times N_{60}\ (kPa)$ $UCS = (17.5\ or\ 20) \times Is_{50}$ (MPa) **Used for graphical representation*	CIRIA 143 (CIRIA, 1995). The use of the SPT-N_{60} data is considered to be more appropriate as this takes into account the behaviour of the materials rock mass, opposed to the rock material. For mudstones, an Is_{50} conversion factor of 17.5 was adopted; for siltstone and sandstones, 20 was adopted.

5.2. Topsoil

5.2.1. Design parameters for Topsoil have not been determined as it is not expected to be used in earthwork fill and will be suitable for reuse only as Class 5 Topsoil material complying with the Specification for Highway Works, Series 0600 [16].

5.3. Made Ground

5.3.1. A summary of the available data gathered for Made Ground is provided in Table 5-2 to Table 5-7, with the characteristic values for each Section presented within report section 5.15. As noted in report section 4, Made Ground was encountered at the surface in areas within close proximity to infrastructure and transportation links and was variable in composition and depth, with both granular and cohesive deposits present. For the purposes of design, it was decided that the Made Ground in Section 1 of the site is mainly composed of cohesive material, thus cohesive geotechnical parameters are presented. Made Ground in Sections 2 and 3 of the site mainly comprises granular material, therefore granular geotechnical parameters are presented. For Section 4 of the site, the high variability of the material can be observed through the testing, with both cohesive and granular Made Ground present. Therefore, no material parameters have been derived for the Made Ground within Section 4 and a location specific ground model and parameter assessment should be undertaken for relevant element design.

Classification

5.3.2. The results from classification testing on the Made Ground is presented within Table 5-2 below. Where available, the bulk density has been provided through the appropriate testing. In the case where no density data is provided, the unit weight has been derived through the correlation between descriptions, compositions, and BS 8002:2015 [13]. From the descriptions in report sections 4.2.1, 4.3.1, 4.4.1 & 4.5.1, a characteristic unit weight of 18 kN/m^3 is recommended. However, due to the high variability of Made Ground across the site, unit weights should be reviewed upon location specific design.

Table 5-2 – Summary of classification testing of Made Ground

Section	Phase of GI	Moisture Content	Liquid Limit	Plastic Limit	Plasticity Index		Bulk Density	PSD[1]
		%	%	%	%		Mg/m^3	
					Testing Results	Characteristic value (%)		
	Phases 1-4	15 – 62 [33] {4}	27 – 120 [59] {4}	15 – 87 [39] {4}	12 – 33 [20] {4}		1.73 – 2.17 [1.95] {2}	-
1	Phase 5	-	-	-	-	20	-	-
	TOTAL	**15 – 62 [33] {4}**	**27 – 120 [59] {4}**	**15 – 87 [39] {4}**	**12 – 33 [20] {4}**		**1.73 – 2.17 [1.95] {2}**	**-**

Section	Phase of GI	Moisture Content	Liquid Limit	Plastic Limit	Plasticity Index		Bulk Density	PSD[1]
		%	%	%	%		Mg/m³	
					Testing Results	Characteristic value (%)		
2	Phases 1-4	23 [23] {1}	31 [31] {1}	12 [12] {1}	19 [19] {1}	N/A[2]	2.1 [2.1] {1}	{6}
	Phase 5	13 – 27 [18] {3}	-	-	-		-	-
	TOTAL	**13 – 27 [20] {4}**	**31 [31] {1}**	**12 [12] {1}**	**19 [19] {1}**		**2.1 [2.1] {1}**	**{6}**
3	Phases 1-4	-	-	-	-	N/A[2]	-	-
	Phase 5	11 – 18 [15] {2}	44 [44] {1}	20 [20] {1}	24 [24] {1}		-	-
	TOTAL	**11 – 18 [15] {2}**	**44 [44] {1}**	**20 [20] {1}**	**24 [24] {1}**		**-**	**-**
4	Phases 1-4	17 – 37 [24] {9}	33 – 38 [35] {6}	14 – 23 (1 = NP) [20] {7}	14 – 15 [14] {6}	Not enough data[3]	-	-
	Phase 5	14 – 16 [15] {3}	25 [25] {1}	14 [14] {1}	11 [11] {1}		-	-
	TOTAL	**14 – 37 [22] {12}**	**25 – 38 [33] {7}**	**14 – 23 (1 = NP) [19] {8}**	**11 – 15 [14] {7}**		**-**	**-**

[…] – Average of the test results. For Plastic Limit, Non-Plastic (NP) will not be included in the average
{…} – Number of test results
[1]PSD results are presented graphically within Appendix E
[2]No characteristic value provided as Made Ground in Section 2 and Section 3 is a granular material
[3]No characteristic value can be obtained due to high variability in available data and the non-uniform nature of the material

SPT

5.3.3. The results from the SPTs on the Made Ground across all Sections of the site are presented within Table 5-3 below. Due to the relatively limited amount of SPT data, a single characteristic N_{60} value has been derived for each Section.

Table 5-3 – Summary of SPT results on Made Ground

Section	Phase of GI	No. SPT Refusals (N>50)	SPT Results (N_{60})1	Chosen Characteristic N_{60} Value2
1	Phases 1-4	3	5 – 50 [25] {13}	10
	Phase 5	-	3 [3] {1}	
	TOTAL	3	3 – 50 [23] {14}	
2	Phases 1-4	3	4 – 50 [26] {18}	25
	Phase 5	1	N>50 {1}	
	TOTAL	4	4 – 50 [26] {19}	
3	Phases 1-4	-	-	Not enough data
	Phase 5	-	22 [22] {1}	
	TOTAL	-	22 [22] {1}	
4	Phases 1-4	-	5 [5] {1}	Not enough data[3]
	Phase 5	-	9 – 31 [14] {6}	
	TOTAL	-	5 – 31 [13] {7}	

[…] – Average of the test results

{…} – Number of Tests carried out including the refused N>50 tests

[1]Values present maximum and minimum values from testing and do not include the extrapolated N_{60} value from the refused SPT results where N>50

[2]Characteristic values have been interpreted from graphical representation (See Appendix E)

[3]No characteristic value can be obtained due to high variability in available data and the non-uniform natural of the material

Effective angle of shearing resistance

5.3.4. The effective angle of shearing resistance for the cohesive Made Ground has been derived through the correlation from the plasticity index in BS 8004:2019 [14]. The granular Made Ground has been derived through the correlation from the SPT 'N_{60}' value presented in Wolff, 1989 [15], refer to Table 5-1.

5.3.5. The characteristic angle of shearing resistance value of the Made Ground within each Section is presented within Table 5.4 and Table 5.5 below. A cohesion (c') value of 0 kPa is recommended for conservatism.

Table 5-4 – Summary of the effective angle of shearing resistance of cohesive Made Ground

Section	Phase of GI	Peak Angle of Shearing Resistance, φ' (°)	
		Empirically Derived from plasticity index	Chosen Characteristic Value
1	Phases 1-4	26+2 dilatancy	28

Table 5-5 – Summary of the effective angle of shearing resistance of granular Made Ground

Section	Phase of GI	Peak Angle of Shearing Resistance, φ' (°)	
		Empirically Derived from SPT N60	Chosen Characteristic Value
2	Phases 1-4	33	28[1]
	Phase 5		
	TOTAL		
3	Phases 1-4	Not enough data	Not enough data
	Phase 5		
	TOTAL		
4	Phases 1-4	Data highly variable	Data highly variable
	Phase 5		
	TOTAL		

[1]Due to the non-uniform nature of the material, the empirically derived angle of shearing resistance was reduced to provide a more conservative characteristic value.

Undrained shear strength

5.3.6. The undrained shear strength of the Made Ground has been determined from unconsolidated undrained triaxial test data and correlation from the associated SPT 'N_{60}' characteristic value. The data is presented below within Table 5-6. The data is also presented graphically Appendix E.

5.3.7. Due to the limited amount of both triaxial and SPT data, it cannot be determined if the undrained shear strength increases with depth, therefore only a single, conservative value has been provided for each Section.

Table 5-6 – Summary of the undrained shear strength of Made Ground

Section	Phase of GI	Undrained Shear Strength, c_u (kPa)		
		Unconsolidated undrained triaxial tests[1]	Empirically derived from SPT 'N_{60}' Value	Chosen Characteristic Value
1	Phases 1-4	13 – 32 [19] {4}	45	35
	Phase 5	-		
	TOTAL	13 – 32 [19] {4}		
2	Phases 1-4	38 [38] {1}	N/A[2]	Not enough data
	Phase 5	-		
	TOTAL	38 [38] {1}		

[…] – Average of the test results

{…} – Number of Tests carried out

[1]Values are presented as the minimum and maximum values obtained during testing

[2]No characteristic value provided as Made Ground in Section 2 is predominantly a granular material

Compressibility and stiffness

5.3.8. Direct testing of the compressibility and stiffness of the Made Ground has not been undertaken. Correlations from the SPT 'N_{60}' (Table 5-3) have been used to determine the stiffness parameters presented in Table 5-7 below.

Table 5-7 – Summary of the stiffness and compressibility of Made Ground

Section	Undrained Young's Modulus, E_u	Drained Young's Modulus, E'
	MPa	MPa
1	10.0	8.0
2	N/A1	30.02
3	N/A1	Not enough data

[1]No characteristic value provided as Made Ground in Section 2 and 3 is a granular material

[2] Due to the non-uniform nature of the material, the empirically derived drained Young's Modulus was reduced to provide a more conservative characteristic value.

5.3.9. The coefficient of volume compressibility (mv) derived from SPT values is presented in Appendix E in graphical format. Due to the complex nature of its variability with depth, a single design parameter or relationship with depth has not been determined.

5.4. Alluvium (Cohesive)

5.4.1. A summary of the available data gathered for cohesive Alluvium is provided in Table 5-8 to Table 5-12, with the characteristic values for each Section presented within report section 5.15. As noted in Section 4, cohesive Alluvium was mainly encountered within Sections 1 and 4 of the site. It should be noted that there has been some recorded testing on Alluvium within Section 2, however the amount of data is very limited therefore the geotechnical parameters for this material will only be derived for Sections 1 and 4.

Classification

5.4.2. The results from the classification testing on the cohesive Alluvium are presented within Table 5-8 – Summary of classification testing of cohesive Alluvium below. Where available, the bulk unit weight has been provided through the appropriate testing. In the case where no density data is provided, the unit weight has been derived through the guidance in BS 8002:2015 [13]. From the descriptions in report sections 4.2.2, 4.3.2 & 4.5.3, a unit weight of 17 kN/m^3 is recommended. However, due to the high variability of cohesive Alluvium across the site, unit weights should be reviewed upon location specific design.

Table 5-8 – Summary of classification testing of cohesive Alluvium

Section	Phase of GI	Moisture Content	Liquid Limit	Plastic Limit	Plasticity Index		Bulk Density	(PSD)[1]
		%	%	%	%		Mg/m^3	
					Testing Results	Characteristic Value		
1	Phases 1-4	20 – 25 [23] {2}	22 – 35 [29] {2}	17 (1 = NP) [17] {2}	18 [18] {1}	Not enough data	1.96 [1.96] {1}	-
	Phase 5	13 – 15 [14] {2}	-	-	-		-	-
	TOTAL	**13 – 25 [18] {4}**	**22-35 [29] {2}**	**17 (1 = NP) [17] {2}**	**18 [18] {1}**		**1.96 [1.96] {1}**	**-**
2	Phases 1-4	-	-	-	-	Not enough data	-	-
	Phase 5	17 [17] {1}	-	-	-		-	-
	TOTAL	**17 [17] {1}**	**-**	**-**	**-**		**-**	**-**

Values present maximum and minimum values from testing. NP is Non-Plastic

[…] – Average of the test results. For Plastic Limit, Non-Plastic (NP) will not be included in the average

{…} – Number of test results

[1]PSD results are presented graphically within Appendix E

SPT

5.4.3. The results from the SPTs on the cohesive Alluvium across all the available Sections of the site are presented within Table 5-9 – Summary of SPT results on cohesive Alluvium below. Due to the relatively limited amount of SPT data, it could not be confidently determined if there was an increase in blows with depth, therefore only a single characteristic N_{60} value has been derived for each Section.

Table 5-9 – Summary of SPT results on cohesive Alluvium

Section	Phase of GI	No. SPT Refusals (N>50)	SPT Results (N_{60})[1]	Characteristic N_{60} Value[2]
1	Phases 1-4	-	-	10
	Phase 5	-	4 – 19 [12] {3}	
	TOTAL	**-**	**4 – 19 [12] {3}**	

[…] – Average of the test results

{…} – Number of Tests carried out including the refused N> 50 tests

[1]Values present maximum and minimum values from testing and do not include the extrapolated N_{60} value from the refused SPT results where N> 50

[2]Characteristic values have been interpreted from graphical representation (See Appendix E)

Effective angle of shearing resistance

5.4.4. As no triaxial tests were undertaken on the cohesive Alluvium material, the effective angle of shearing resistance has been derived through the correlation from the plasticity index in BS 8004:2019 [14], refer to Table 5-1. It was deemed inappropriate to consider the dilatancy of cohesive Alluvium therefore only the constant volume angle of shearing resistance is provided.

5.4.5. The characteristic angle of shearing resistance for the cohesive Alluvium within the applicable Sections is presented within Table 5-10 below. A drained cohesion (c') value of 0 kPa is recommended for conservatism.

Table 5-10 – Summary of the effective angle of shearing resistance of cohesive Alluvium

Section	Phase of GI	Constant Volume Angle of Shearing Resistance, φ' (°)	
		Empirically derived from Plasticity Index	Chosen Characteristic Value
1	Phases 1-4	Not enough data	Not enough data (Note Arcadis GIR (Arcadis, 2018) reports value of 26 degrees based on one plasticity index value of 18%)
	Phase 5		
	TOTAL		

Undrained shear strength

5.4.6. The undrained shear strength of the cohesive Alluvium has been determined from the unconsolidated undrained triaxial test data and correlations from each Section's associated SPT 'N_{60}' characteristic value. The data is presented below within Table 5-11. The data is also presented graphically within Appendix E.

5.4.7. Due to the limited amount of both triaxial and SPT data, it cannot be determined if the undrained shear strength increases with depth, therefore only a single, conservative value has been provided for each Section.

Table 5-11 – Summary of the undrained shear strength of cohesive Alluvium

Section	Phase of GI	Undrained Shear Strength, c_u (kPa)		
		Derived from Undrained Unconsolidated Triaxial Tests[1]	Empirically derived from SPT 'N_{60}' Value	Chosen Characteristic Value
1	Phases 1-4	110 [110] {1}	45	45
	Phase 5	-		
	TOTAL	**110 [110] {1}**		

Z – Increase per metre depth
[…] – Average of the test results
{…} – Number of data points
[1]Values are presented as the minimum and maximum values obtained during testing

Compressibility and stiffness

5.4.8. Direct testing of the stiffness of the cohesive Alluvium have not been undertaken. Correlations between the SPT 'N_{60}' (Table 5-9) values have been used to determine the stiffness parameters. For the compressibility parameters, a number of oedometer tests have been carried out. The results from the consolidation tests have been compared to the correlated values derived from SPT 'N_{60}' values and the plasticity index. The derived parameters and testing results are presented in Table 5-12 below.

Table 5-12 – Summary of the stiffness and compressibility of the cohesive Alluvium

Section	Undrained Young's Modulus, E_u (MPa)	Drained Young's Modulus, E' (MPa)	Coefficient of Volume Compressibility, m_v (m²/MN)		
			Oedometer Testing Results[1]	SPT 'N_{60}' and Plasticity Index Correlated Value	Chosen Characteristic Value
1	10	8	{1}	Not enough data	See **Error! Reference source not found.**

{…} – Number of Oedometer Tests carried out
[1]Values from the oedometer tests have been determined from graphical representation of the data presented within Appendix E

5.5. Alluvium (Granular)

5.5.1. A summary of the available data gathered for granular Alluvium is provided in Table 5-13 to Table 5-16 with the characteristic values for each Section presented within report section 5.15. As noted in Section 4, granular Alluvium was mainly encountered within Sections 1 and 4 of the site.

Classification

5.5.2. The results from the classification testing on the granular Alluvium is presented within Table 5.13 below. Where possible, the bulk densities have been provided through the appropriate testing. In the case where no density data is available, the unit weight has been derived through the correlation between descriptions, compositions, and BS 8002:2015 [13]. From the descriptions in report sections 4.2.2 & 4.5.3, a characteristic unit weight of 18 kN/m^3 is recommended.

Table 5-13 – Summary of classification testing of granular Alluvium

Section	Phase of GI	Moisture Content	Liquid Limit	Plastic Limit	Plasticity Index		Bulk Density	PSD[1]
		%	%	%	%		Mg/m^3	
					Testing Results	Characteristic Value		
1	Phases 1-4	16 [16] {1}	25 [25] {1}	NP [-] {1}	-	N/A	2.12 [2.12] {1}	-
	Phase 5	-	-	-	-		-	-
	TOTAL	**16 [16] {1}**	**25 [25] {1}**	**NP [-] {1}**	**-**		**2.12 [2.12] {1}**	**-**

Values present maximum and minimum values from testing. NP is Non-Plastic
[…] – Average of the test results. For Plastic Limit, Non-Plastic (NP) will not be included in the average
{…} – Number of test results
[1]PSD results are presented graphically within Appendix E

SPT

5.5.3. The results from the SPTs on the granular Alluvium across all the available Sections of the site are presented within Table 5-14 below. Due to the relatively limited amount of SPT data, it could not be confidently determined if there was an increase in blows with depth, therefore only a single characteristic N_{60} value has been derived where an adequate number of tests have been carried out.

Table 5-14 – Summary of SPT results on granular Alluvium

Section	Phase of GI	No. SPT Refusals (N>50)	SPT Results (N_{60} Value)	Characteristic N_{60} Value
1	Phases 1-4	-	-	Not enough data
	Phase 5	-	7 [7] {1}	
	TOTAL	**-**	**7 [7] {1}**	

[…] – Average of the test results
{…} – Number of Tests carried out including the refused N>50 tests

Effective angle of shearing resistance

5.5.4. The effective angle of shearing resistance has been derived through the correlation from the SPT 'N_{60}' value presented in Wolff, 1989 [15], refer to Table 5-1. If no data was available for the material, the angle of shearing resistance has been correlated from the geological description and composition in accordance with BS 8004:2015 [14].

5.5.5. The characteristic angle of shearing resistance value of the granular Alluvium within each Section is presented within Table 5-15 below.

Table 5-15 – Summary of the effective angle of shearing resistance of granular Alluvium

Section	Phase of GI	Peak Angle of Shearing Resistance, φ' (°)	
		Empirically derived from SPT Results	Chosen Characteristic Value
1	Phases 1-4	Not enough data	30[1]
	Phase 5		
	TOTAL		

[1]Value has been derived through geological description and composition of the material in accordance with BS 8004:2015 (British Standards Institution, 2015)

Compressibility and stiffness

5.5.6. Direct testing of the stiffness of the granular Alluvium has not been undertaken. Correlations between of the SPT 'N_{60}' (Table 5-14) have been used to determine the stiffness parameters. A single oedometer test is recorded to have been carried out on material defined as granular Alluvium, as this type of test and resulting parameters are not applicable to granular material this result has been disregarded. The derived parameters are presented in Table 5-16 below.

Table 5-16 – Summary of the stiffness and compressibility of the granular Alluvium

Section	Drained Young's Modulus, E' (MPa)
1	Not enough data

5.6. Glacial Till (Cohesive)

5.6.1. A summary of the available data gathered for cohesive Glacial Till is provided in Table 5-17 – Summary of classification testing of cohesive Glacial Till

5.6.2. to Table 5-21, with the characteristic values for each Section presented within report section 5.154.

Classification

5.6.3. The results from the classification testing on the cohesive Glacial Till is presented within Table 5-17 below. Where available, the bulk density has been provided through the appropriate testing. In the case where no density data is available, the unit weight has been derived through the correlation between descriptions, compositions, and BS 8002:2015 [13]. From the descriptions in report sections 4.2.3, 4.3.3, 4.4.2 & 4.5.3, a unit weight of 18 kN/m^3 is recommended. However, due to the high variability of cohesive Glacial Till across the site, unit weights should be reviewed upon location specific design.

Table 5-17 – Summary of classification testing of cohesive Glacial Till

Section	Phase of GI	Moisture Content	Liquid Limit	Plastic Limit	Plasticity Index		Bulk Density		PSD[1]
		%	%	%	%		Mg/m^3		
					Testing Results	Characteristic Value	Testing Results	Characteristic Value	
	Phases 1-4	9 – 30 [15] {135}	19 – 51 [30] {126}	9 – 25 (5 = NP) [14] {124}	8 – 27 [16] {119}		2.03 – 2.38 [2.19] {79}		{9}
1	Phase 5	10 – 21 [15] {15}	21 – 42 [33] {10}	13 – 20 [16] {10}	8 – 23 [17] {10}	17	-	2.20	{3}
	TOTAL	**9 – 30 [15] {150}**	**19 – 51 [30] {136}**	**9 – 25 (5 = NP) [15] {134}**	**8 – 27 [16] {129}**		**2.03 – 2.38 [2.19] {79}**		**{12}**
	Phases 1-4	8 – 47 [16] {115}	20 – 55 [30] {120}	10 – 24 (5 = NP) [15] {118}	4 – 31 [15] {113}		1.70 – 2.33 [2.17] {45}		{14}
2	Phase 5	7 – 27 [15] {48}	24 – 45 [32] {25}	12 – 25 [17] {25}	8 – 20 [16] {25}	16	-	2.20	{13}

Section	Phase of GI	Moisture Content	Liquid Limit	Plastic Limit	Plasticity Index		Bulk Density		PSD[1]
		%	%	%	%		Mg/m^3		
					Testing Results	Characteristic Value	Testing Results	Characteristic Value	
	TOTAL	**7 – 47 [16] {163}**	**20 – 55 [30] {145}**	**10 – 25 (5 = NP) [15] {143}**	**4 – 31 [15] {138}**		**1.70 – 2.33 [2.17] {45}**		**{27}**
3	Phases 1-4	13 – 42 [18] {49}	24 – 110 [34] {48}	12 – 25 [17] {48}	5 – 96 [17] {48}	17	1.88 – 2.19 [2.10] {10}	2.10	{8}
	Phase 5	6 – 35 [18] {28}	24 – 63 [35] {20}	14 – 27 [18] {20}	8 – 36 [16] {20}		-		{4}
	TOTAL	**6 – 42 [18] {77}**	**24 – 110 [34] {68}**	**12 – 27 [18] {68}**	**5 – 96 [16] {68}**		**1.88 – 2.19 [2.10] {10}**		**{12}**

Values present maximum and minimum values from testing. NP is Non-Plastic
[…] – Average of the test results. For Plastic Limit, Non-Plastic (NP) will not be included in the average
{…} – Number of test results
[1]PSD results are presented graphically within Appendix E

SPT

5.6.4. The results from the SPTs on cohesive Glacial Till across the site are presented within Table 5-18 below.

Table 5-18 – Summary of SPT results on cohesive Glacial Till

Section	Phase of GI	No. SPT Refusals (N>50)	SPT Results (N_{60})[1]	Characteristic N_{60} Relationship[2]
1	Phases 1-4	1	5 – 50 [22] {60}	0 –20m: 10 + 1z 20 – 25m: 30
	Phase 5	1	9 – 44 [19] {27}	
	TOTAL	**2**	**5 – 50 [21] {87}**	
2	Phases 1-4	10	7 – 48 [21] {90}	0 – 6m: 12 6 – 22m: 12 + 2z
	Phase 5	-	4 – 49 [24] {68}	
	TOTAL	**10**	**4 – 49 [22] {157}**	
3	Phases 1-4	2	9 – 41 [20] {16}	0 – 2m: 10 2 - 8m: 10 + 2.5z

Section	Phase of GI	No. SPT Refusals (N>50)	SPT Results (N_{60})[1]	Characteristic N_{60} Relationship[2]
	Phase 5	1	4 – 50 [17] {26}	
	TOTAL	**3**	**4 – 50 [18] {42}**	

Z – Increase per metre depth

[…] – Average of the test results

{…} – Number of Tests carried out including the refused N>50 tests

[1]Values present maximum and minimum values from testing and do not include the extrapolated N_{60} value from the refused SPT results where N>50

[2]Characteristic values have been interpreted from graphical representation (See Appendix E)

Effective angle of shearing resistance

5.6.5. The effective angle of shearing resistance has been derived through the analysis of consolidated undrained triaxial tests conducted on the material. Additionally, these values have been compared with the correlated values from the plasticity index in BS 8004:2019 [14], refer to Table 5-17.

5.6.6. The characteristic angle of shearing resistance for the cohesive Glacial Till within each Section is presented within Table 5-19 below. A drained cohesion (c') value of 0 kPa is recommended for conservatism.

Table 5-19 – Summary of the effective angle of shearing resistance of cohesive Glacial Till

Section	Phase of GI	Peak Angle of Shearing Resistance, φ' (°)			
		Derived from Triaxial Test		Empirically derived from Plasticity Index	Chosen Characteristic Value
1	Phases 1-4	{28} (4)	30	27+2	30
	Phase 5	{9}			
	TOTAL	**{37} (4)**			
2	Phases 1-4	{37} (4)	29	27+2	29
	Phase 5	{3} (3)			
	TOTAL	**{40} (7)**			
3	Phases 1-4	{9} (1)	31	27+2	30
	Phase 5	{6}			
	TOTAL	**{15} (1)**			

{…} – Number of data points
(…) – Number of tests removed from the data analysis and parameter derivation due to anomalous values

Undrained shear strength

5.6.7. The undrained shear strength of the cohesive Glacial Till has been determined from the unconsolidated undrained triaxial test data and correlations from each Section's associated SPT 'N_{60}' characteristic value. The data is presented below within Table 5-20.

Table 5-20 – Summary of the undrained shear strength of cohesive Glacial Till

Section	Phase of GI	Undrained Shear Strength, c_u (kPa)		
		Derived from Undrained Unconsolidated Triaxial Tests[1]	Empirically derived from SPT 'N_{60}' Relationship	Chosen Characteristic Relationship[2]
1	Phases 1-4	12 – 149 [65] {128}	0 – 20 m: 45 + 4.5z 20 – 25m: 135	0 – 7m: 50 7 – 22mbgl: 50 + 4.5z
	Phase 5	22 – 120 [70] {7}		
	TOTAL	**12 – 149 [65] {135}**		
2	Phases 1-4	6 – 120 [59] {88}	0 – 6 m: 54 6-22 m: 54 + 9z	0 – 6 m: 60 6 – 22 m: 60 + 10z
	Phase 5	9 – 75 [39] {16}		
	TOTAL	**6 – 120 [56] {104}**		
3	Phases 1-4	39 – 160 [85] {21}	0 – 2m: 45 2 – 8 m: 45 + 11.25z	0 – 2m: 40 2 – 8 m: 40 + 20z
	Phase 5	40 [40] {1}		
	TOTAL	**39 – 160 [83] {22}**		

Z – Increase per metre depth
[…] – Average of the test results
{…} – Number of data points
[1]Values are presented as the minimum and maximum values obtained during testing

Compressibility and stiffness

5.6.8. Direct testing of the stiffness of the cohesive Glacial Till have not been undertaken. Correlations between the plasticity index (Table 5-17) and SPT 'N_{60}' (Table 5-18) have been used to determine the stiffness parameters. For the compressibility, a number of oedometer tests have been carried out. The results from the consolidation tests have been compared to the correlating values derived through SPT 'N_{60}' values and the plasticity index. The derived parameters and testing results are presented in Table 5-21 below.

Table 5-21 – Summary of the stiffness and compressibility of cohesive Glacial Till

Section	Undrained Young's Modulus, E_u (MPa)	Drained Young's Modulus, E' (MPa)	Coefficient of Volume Compressibility, m_v (m²/MN)		
			Oedometer Testing Results[1]	SPT 'N_{60}' and Plasticity Index Correlated Relationship	Chosen Characteristic Value
1	0 – 20m: 10 + 1z 20 – 25m: 30	0 –20m: 7.6 + 0.762z 20 – 25m: 22.8	{43}	0 –20m: 0.17 - 0.0055z 20 – 25m: 0.06	See Appendix E
2	0 – 6m: 12 6 – 22m: 12 + 2z	0 – 6m: 9 6 – 22 m: 9 + 1.5z	{5}	0 – 6 m: 0.14 6 – 22 m: 0.14 – 0.0063z	See Appendix E
3	0 – 2m: 10 2 - 8m: 10 + 2.5z	0 – 2m: 7.6 2 - 8m: 7.6 + 1.9z	{3}	0 – 2m: 0.17 2 - 8m: 0.17 – 0.017z	See Appendix E

Z – Increase per metre depth
{…} – Number of Oedometer Tests carried out
[1]Values provided from the Oedometer Tests are represented graphically within Appendix E

5.6.9. The coefficient of volume compressibility (m_v) derived from oedometer testing is presented in Appendix E in graphical format. Due to the complex nature of its variability with depth, a single design parameter or relationship with depth has not been determined.

5.7. Glacial Till (Granular)

5.7.1. A summary of the available data gathered for granular Glacial Till is provided in Table 5-22 to Table 5-25, with the characteristic values for each Section presented within report section 5.154. Granular Glacial Till is generally found across the whole site, however the material within each Section is highly variable with both geographical position and depth. Therefore, characteristic geotechnical parameters for this material may present a range or varying values with depth. A location specific ground model and parameters should be undertaken to review granular Glacial Till information in detail.

Classification

5.7.2. The results from the classification testing on the granular Glacial Till are presented within Table 5-22 below. Generally, the plasticity index testing of granular material is not appropriate as it is a non-plastic material, therefore a characteristic plasticity index is not usually derived, however in this case, there has been some testing on the material. It is likely that the sample collected for testing would be the cohesive parts of the overall granular material, therefore it would not be suitable in this case to provide a characteristic value for the plasticity index. There was no density testing of the material, therefore the unit weight has been derived through the correlation between descriptions, compositions, and BS 8002:2015 [13]. From the descriptions in report sections 4.2.3, 4.3.3, 4.4.2 & 4.5.3, a characteristic unit weight of 18 kN/m^3 is recommended. However, due to the high variability of granular Glacial Till across the site, unit weights should be reviewed upon location specific design.

Table 5-22 – Summary of classification testing of Glacial Till (Granular)

Section	Phase of GI	Moisture Content	Liquid Limit	Plastic Limit	Plasticity Index		Bulk Density	PSD[1]
		%	%	%	%		Mg/m^3	
					Testing Results	Characteristic Value		
1	Phases 1-4	17 [17] {1}	25 [25] {1}	(1 = NP) [-] {1}	-	N/A	-	-
	Phase 5	-	-	-	-		-	-
	TOTAL	**17 [17] {1}**	**25 [25] {1}**	**(1 = NP) [-] {1}**	**-**		**-**	**-**
2	Phases 1-4	15 [15] {1}	32 [32] {1}	23 [23] {1}	9 [9] {1}	N/A	-	{1}
	Phase 5	9 – 13 [11] {2}	33 – 36 [35] {2}	16 – 17 [17] {2}	17 – 19 [18] {2}		-	-
	TOTAL	**9 – 15 [12] {3}**	**32 – 36 [34] {3}**	**16 – 23 [19] {3}**	**9 – 19 [15] {3}**		**-**	**{1}**
3	Phases 1-4	-	-	-	-	N/A	-	{1}
	Phase 5	15 [15] {1}	-	-	-		-	{2}
	TOTAL	**15 [15] {1}**	**-**	**-**	**-**		**-**	**{3}**

Values present maximum and minimum values from testing. NP is Non-Plastic

[…] – Average of the test results. For Plastic Limit, Non-Plastic (NP) will not be included in the average

{…} – Number of test results

[1]PSD results are presented graphically within Appendix E. It should be noted that some of the results presented within the tables are not representative of granular material and are likely to have been incorrectly classified as granular Glacial Till instead of cohesive Glacial Till.

SPT

5.7.3. The results from the SPTs on the granular Glacial Till across all the available Sections of the site are presented within Table 5-23 below. Due to the relatively limited amount of SPT data, it could not be confidently determined whether there was an increase in blows with depth, therefore only a single characteristic N_{60} value has been derived for each Section.

Table 5-23 – Summary of the SPT results on Glacial Till (Granular)

Section	Phase of GI	No. SPT Refusals (N>50)	SPT Results (N_{60})[1]	Characteristic N_{60} Value[2]
1	Phases 1-4	-	8 – 19 [13] {7}	13
	Phase 5	-	-	
	TOTAL	**-**	**8 – 19 [13] {7}**	
2	Phases 1-4	1	15 [15] {2}	20
	Phase 5	1	8 – 50 [25] {7}	
	TOTAL	**2**	**8 – 50 [23] {9}**	
3	Phases 1-4	-	-	25
	Phase 5	2	13 – 31 [21] {5}	
	TOTAL	**2**	**13 – 31 [21] {5}**	

[…] – Average of the test results

{…} – Number of Tests carried out including the refused N> 50 tests

[1]Values present maximum and minimum values from testing and do not include the extrapolated N_{60} value from the refused SPT results where N> 50

[2]Characteristic values have been interpreted from graphical representation (See Appendix E)

Effective angle of shearing resistance

5.7.4. The effective angle of shearing resistance has been derived through the correlation from the SPT 'N_{60}' value presented in Wolff, 1989 [15] refer to Table 5-1. The characteristic angle of shearing resistance value of the granular Glacial Till within each Section is presented within Table 5.24 below.

Table 5-24 – Summary of the effective angle of shearing resistance of Glacial Till (Granular)

Section	Phase of GI	Peak Angle of Shearing Resistance, φ' (°)	
		Empirically derived from SPT N_{60} Value	Chosen Characteristic Value
1	Phases 1-4	31	31
	Phase 5		
	TOTAL		
2	Phases 1-4	33	33
	Phase 5		
	TOTAL		
3	Phases 1-4	34	34
	Phase 5		
	TOTAL		

Compressibility and stiffness

5.7.5. Direct testing of the stiffness of the granular Glacial Till have not been undertaken. Correlations with SPT 'N_{60}' (Table 5-23 – Summary of the SPT results on Glacial Till (Granular)

5.7.6. have been used to determine the stiffness parameters. The derived parameters and testing results are presented in Table 5-25 below.

Table 5-25 – Summary of the stiffness and compressibility of Glacial Till (Alluvium)

Section	Drained Young's Modulus, E' (MPa)
1	26
2	40
3	50

5.8. Section 4 – Cohesive Superficial Material

5.8.1. As previously discussed in report section 4.5.2, due to the uncertainty of the material classifications within Section 4 of the scheme, it was deemed appropriate to combine all the geotechnical testing from the cohesive material in this section of the scheme and provide a single set of characteristic geotechnical parameters. A summary of the available data gathered for Section 4 – cohesive superficial material is provided in Table 5-26 to Table 5-30 , with the characteristic values presented within report section 5.15. As Section 4 covers the largest chainage length within the scheme (CH1510 – 3116), this resulted in a larger range of results within the geotechnical testing. Characteristic values for this material have been derived through assessing the whole dataset, however the geotechnical properties of the material may vary through Section 4 of the scheme, particularly around the

River Etherow. Parameters should be reviewed during the detailed design stage, focussing on the specific areas of proposed works within Section 4.

Classification

5.8.2. The results from the classification testing on the Section 4 – cohesive superficial material is presented within Table 5-26 below. From the descriptions in report sections 4.5.3 and 4.5.4 a unit weight of 18 kN/m3 is recommended.

Table 5-26 – Summary of classification testing of Section 4 – Cohesive Superficial Material

Section	Phase of GI	Moisture Content	Liquid Limit	Plastic Limit	Plasticity Index		Bulk Density		PSD[1]
		%	%	%	%		Mg/m^3		
					Testing Results	Characteristic Value	Testing Results	Characteristic Value	
4	Phases 1-4	3 – 55 [19] {96}	25 – 71 [38] {86}	11 – 32 (1 = NP) [19] {85}	11 – 39 [19] {85}	17	-	2.10	{33}
	Phase 5	9 – 36 [20] {75}	28 – 66 [38] {40}	15 – 30 [19] {40}	8 – 36 [19] {40}		-		{11}
	TOTAL	**3 – 55 [19] {171}**	**25 – 71 [37] {126}**	**11 – 32 (1 = NP) [19] {125}**	**8 – 39 [19] {125}**		**-**		**{44}**

Values present maximum and minimum values from testing. NP is Non-Plastic
[…] – Average of the test results. For Plastic Limit, Non-Plastic (NP) will not be included in the average
{…} – Number of test results
[1]PSD results are presented graphically within Appendix E

SPT

5.8.3. The results from the SPTs on Section 4 – cohesive superficial material across the site are presented within Table 5-27 below.

Table 5-27 – Summary of SPT results on Section 4 – Cohesive Superficial Material

Section	Phase of GI	No. SPT Refusals (N>50)	SPT Results (N_{60})[1]	Characteristic N_{60} Relationship[2]
4	Phases 1-4	1	5 – 46 [21] {44}	0 - 7m: 10 7 – 22m: 10 + 1.2z
	Phase 5	3	4 – 50 [17] {82}	
	TOTAL	**4**	**4 – 50 [19] {126}**	

Z – Increase per metre depth
[…] – Average of the test results
{…} – Number of Tests carried out including the refused N>50 tests
[1]Values present maximum and minimum values from testing and do not include the extrapolated N_{60} value from the refused SPT results where N>50
[2]Characteristic values have been interpreted from graphical representation (See Appendix E)

Effective angle of shearing resistance

5.8.4. The effective angle of shearing resistance has been derived through the analysis of consolidated undrained triaxial tests conducted on the material. Additionally, these values have been compared with the correlated values from the plasticity index in BS 8004:2019 [14], refer to Table 5-26.

5.8.5. The characteristic angle of shearing resistance for the Section 4 – cohesive superficial material is presented within Table 5-28 below. A drained cohesion (c') value of 0 kPa is recommended for conservatism.

Table 5-28 – Summary of the effective angle of shearing resistance of Section 4 – Cohesive Superficial Material

Section	Phase of GI	Peak Angle of Shearing Resistance, φ' (°)			
		Derived from CU Triaxial Test		Empirically derived from Plasticity Index	Chosen Characteristic Value
4	Phases 1-4	{12} (4)	29	27+2	29
	Phase 5	{12}			
	TOTAL	**{24} (4)**			

{…} – Number of data points
(…) – Number of tests removed from the data analysis and parameter derivation due to anomalous values

Undrained shear strength

5.8.6. The undrained shear strength of the Section 4 – cohesive superficial material has been determined from the unconsolidated undrained triaxial test data and correlations from the associated SPT 'N_{60}' characteristic value. The data is presented below within Table 5-29.

Table 5-29 – Summary of the undrained shear strength of Section 4 - Cohesive Superficial Material

Section	Phase of GI	Undrained Shear Strength, c_u (kPa)		
		Derived from Undrained Unconsolidated Triaxial Tests[1]	Empirically derived from SPT 'N_{60}' Relationship	Chosen Characteristic Relationship[2]
4	Phases 1-4	20 – 86 [53] {12}	0 - 7m: 45 7 – 22m: 45 + 5.4z	0 - 7m: 45 7 – 22m: 45 + 5.4z
	Phase 5	26 – 160 [75] {27}		
	TOTAL	**26 – 160 [68] {39}**		

Z – Increase per metre depth
[…] – Average of the test results
{…} – Number of data points
[1]Values are presented as the minimum and maximum values obtained during testing

Compressibility and stiffness

5.8.7. Correlations between the plasticity index (Table 5-25) and SPT 'N_{60}' (Table 5-27) have been used to determine the stiffness parameters. For the compressibility, a number of oedometer tests have been carried out. The results from the consolidation tests have been compared to the correlated values derived through SPT 'N_{60}' values and the plasticity index. The derived parameters and testing results are presented in Table 5-30 below.

Table 5-30 – Summary of the stiffness and compressibility of Section 4 - Cohesive Superficial Material

Section	Undrained Young's Modulus, E_u (MPa)	Drained Young's Modulus, E' (MPa)	Coefficient of Volume Compressibility, m_v (m²/MN)		
			Oedometer Testing Results[1]	SPT 'N_{60}' and Plasticity Index Correlated Relationship	Chosen Characteristic Value
4	0 - 7m: 10 7 – 22m: 10 + 1.2z	0 - 7m: 7.6 7 – 22m: 7.6 + 0.9z	{29}	0 - 7m: 0.18 7 – 22m: 0.18 - 0.008z	See **Error! Reference source not found.**

Z – Increase per metre depth
{…} – Number of Oedometer Tests carried out
[1]Values provided from the Oedometer Tests are represented graphically within Appendix E

5.8.8. The coefficient of volume compressibility (m_v) derived from oedometer testing is presented in Appendix E in graphical format. Due to the complex nature of its variability with depth, a single design parameter or relationship with depth has not been determined.

5.9. Section 4 – Granular Superficial Material

5.9.1. As previously discussed in report section 4.5.2, due to the uncertainty of the material classifications within Section 4 of the scheme, it was deemed appropriate to combine all the geotechnical testing from the granular material in this section of the scheme and provide a single set of characteristic geotechnical parameters. A summary of the available data gathered for Section 4 – granular superficial material is provided in Table 5-31 to Table 5-34, with the characteristic values presented within report section 5.15. As Section 4 covers the largest chainage length within the scheme (CH1510 – 3116), this resulted in a larger range of results within the geotechnical testing. Characteristic values for this material have been derived through assessing the whole dataset, however the geotechnical properties of the material are likely to vary along Section 4 of the scheme. Parameters should be reviewed during the detailed design stage, focussing on the specific areas of proposed works within Section 4

Classification

5.9.2. The results from the relevant classification testing on the Section 4 - granular superficial material are presented within Table 5-31 below. Generally, the plasticity index testing of granular material is not appropriate as it is a non-plastic material, therefore a characteristic plasticity index is not usually derived, however in this case, there has been some testing on the material. It is likely that the sample collected for testing would be the cohesive parts of the overall granular material, therefore it would not be suitable in this case to provide a characteristic value for the plasticity index. There was no density testing of the material, therefore the unit weight has been derived through the correlation between descriptions, compositions, and BS 8002:2015 [13]. From the descriptions in report sections 4.5.2, 4.5.3, 4.5.4, 4.5.5 & 4.5.6, a characteristic unit weight of 18 kN/m3 is recommended.

Table 5-31 – Summary of classification testing of Section 4 - Granular Superficial Material

Section	Phase of GI	Moisture Content	Liquid Limit	Plastic Limit	Plasticity Index		Bulk Density		PSD[1]
		%	%	%	%		Mg/m^3		
					Testing Results	Characteristic Value	Testing Results	Characteristic Value	
4	Phases 1-4	0.3 – 14 [7] {2}	29 [29] {1}	16 [16] {1}	13 [13] {1}	N/A	-	2.10	{17}
	Phase 5	9 - 18 [14] {4}	25 [25] {1}	16 [16] {1}	9 [9] {1}		-		{11}
	TOTAL	**0.3 – 18** **[12]** **{6}**	**25 – 29** **[27]** **{2}**	**16** **[16]** **{2}**	**9 – 13** **[11]** **{2}**		**-**		**{28}**

SPT

5.9.3. The results from the SPTs on the granular superficial material in Section 4 are presented in Table 5-32 below. Due to the variation in SPT N_{60} value with depth, it could not be confidently determined whether there was an increase in blows with depth, therefore only a single characteristic N_{60} value has been derived.

Table 5-32 – Summary of the SPT results on Section 4 – Granular Superficial Material

Section	Phase of GI	No. SPT Refusals (N>50)	Extrapolated SPT Results (N_{60})[1]	Characteristic N_{60} Value[2]
4	Phases 1-4	5	6 - 42 [25] {26}	15
	Phase 5	17	4 – 48 [23] {40}	
	TOTAL	**22**	**4 – 48 [24] {66}**	

[…] – Average of the test results

{…} – Number of Tests carried out including the refused N> 50 tests

[1]Values present maximum and minimum values from testing and do not include the extrapolated N_{60} value from the refused SPT results where N> 50

[2]Characteristic values have been interpreted from graphical representation (See **Error! Reference source not found.**)

Effective angle of shearing resistance

5.9.4. The effective angle of shearing resistance has been derived through the correlation from the SPT 'N_{60}' value presented in Wolff, 1989 [15], refer to Table 5-1

5.9.5. The characteristic angle of shearing resistance value of the Section 4 - granular superficial material is presented within Table 5-33 below.

Table 5-33 – Summary of the effective angle of shearing resistance of Section 4 – Granular Superficial Material

Section	Phase of GI	Peak Angle of Shearing Resistance, φ' (°)	
		Empirically derived from SPT N_{60} Value	Chosen Characteristic Value
4	Phases 1-4	31	31
	Phase 5		
	TOTAL		

Compressibility and stiffness

5.9.6. Direct testing of the stiffness of the Section 4 – granular superficial material has not been undertaken. Correlations with the SPT 'N_{60}' (Table 5-32) value have been used to determine the stiffness parameters. The derived parameters and testing results are presented in Table 5-34 below.

Table 5-34 – Summary of the stiffness and compressibility of Section 4 - Granular Superficial Material

Section	Drained Young's Modulus, *E'* (MPa)
4	30

5.10. Millstone Grit Group – Mudstone

5.10.1. A summary of the available data gathered for Mudstone is provided in Table 5-35 to Table 5-38. Geotechnical parameters have been derived for Sections 2 to 4, in Section 1 there was inadequate data to derive parameters.

Classification

5.10.2. The results from the classification testing on the mudstone is presented within Table 5-35 below. Generally, moisture content, plasticity index and PSD testing on bedrock material is not usually undertaken. In this case, it is likely that Sections of rock which have been highly weathered to a residual clay material have been classified and tested as a soil to obtain the residual characteristics. For this assessment, the results of the tests will be reported, but there will be no geotechnical parameters derived from the results. From the descriptions in report sections 4.2.4, 4.3.4, 4.3.5, 4.4.3 & 4.5.7, a characteristic unit weight of 21 kN/m³ for the mudstone is recommended in line with BS 8002:2015 [13].

Table 5-35 – Summary of classification testing of mudstone

Section	Phase of GI	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Bulk Density	PSD**
2	Phases 1-4	3.4 [3.4] {1}	25 – 34 [30] {2}	15 – 19 [17] {2}	10 – 15 [13] {2}	-	{1}
	Phase 5	-	-	-	-	-	-
	TOTAL	**3.4 [3.4] {1}**	**25 – 34 [30] {2}**	**15 – 19 [17] {2}**	**10 – 15 [13] {2}**	**-**	**{1}**
3	Phases 1-4	7.5 – 24 [17] {4}	27 – 36 [33] {4}	11 – 20 [17] {4}	12 – 22 [16] {4}	-	-
	Phase 5	14 [14] {1}	36 [36] {1}	20 [20] {1}	16 [16] {1}	-	-
	TOTAL	**7.5 – 24 [16] {5}**	**27 – 36 [33] {5}**	**11 – 20 [17] {5}**	**12 – 22 [16] {5}**	**-**	**-**

Values present maximum and minimum values from testing. NP is Non-Plastic.

[…] – Average of the test results. For Plastic Limit, Non-Plastic (NP) will not be included in the average.

{…} – Number of test results

**PSD results are presented graphically within Appendix E

SPT

5.10.3. The results from the SPT on the mudstone across all the available Sections of the site are presented within Table 5-36. SPT N values greater than 50 are included within the assessment of the rock material. Due to the relatively limited amount of SPT data, it could not be confidently determined whether there was an increase in blows with depth, therefore only a single characteristic N_{60} value has been derived for each Section.

Table 5-36 – Summary of the SPT results on mudstone

Section	Phase of GI	Extrapolated SPT Results (N_{60})*	Characteristic N_{60} Value**
1	Phases 1-4	54 – 187 [121] {2}	*No Value Provided (Insufficient Data)*
	Phase 5	-	
	TOTAL	**54 – 187 [121] {2}**	
2	Phases 1-4	31 – 189 [87] {18}	55
	Phase 5	94 – 175 [135] {2}	
	TOTAL	**31 – 189 [92] {20}**	
3	Phases 1-4	41 – 176 [120] {3}	50
	Phase 5	50 - 64 [57] {2}	
	TOTAL	**41 – 176 [95] {5}**	
4	Phases 1-4	32 - 144 [73] {4}	40
	Phase 5	24 – 95 [52] {5}	
	TOTAL	**24 – 144 [62] {9}**	

*Values present maximum and minimum values from testing and include the extrapolated N_{60} value from the refused SPT results where N> 50

**Characteristic values are conservative values interpreted from graphical representation (See Appendix E)

[…] – Average of the test results

{…} – Number of Tests carried out including the refused N> 50 tests

Undrained shear strength & uniaxial compressive strength

5.10.4. The uniaxial compressive strength of the mudstone has been obtained directly and derived through testing results and empirical relationships, and is presented in Table 5-37 below.

Table 5-37 – Summary of the uniaxial compressive testing of mudstone

Section	Point Load Test Data, $I_{s\,(50)}$ (MPa)	Uniaxial Compressive Strength, UCS (MPa)				Undrained shear strength (kPa)***
		UCS from Testing	UCS derived from Point Load Testing	UCS derived from N_{60}	Characteristic UCS	Derived from characteristic SPT 'N'
1	0.1 – 2.6 [0.67] {20}	31.4 [31.4] {1}	2 – 5.2 [3.14] {20}	0. 54 – 1.87 [1.21] {2}	-	*No Value Provided (Insufficient Data)*
2	0.01 – 12.3 [1.47] {197}	0.94 – 44.1 [25.8] {21}	0.2 – 246 [29.4] {197}	0.31 – 1.89 [0.92] {20}	1.5 (for depths >10mBGL)	275 (depths 0-10mBGL)
3	0.01 – 5.9 [1.35] {113}	14.2 - 74.3 [36] {21}	0.2 – 118 [27] {113}	0.41 – 1.76 [0.95] {5}	-	250
4	0.1 – 9.0 [1.23] {37}	-	2 – 180 [24.6] {37}	0.24 – 1.44 [0.62] {9}	-	200

*Values present maximum and minimum values from testing and empirically derived UCS values
**Characteristic values are conservative values interpreted from graphical representation. (See Appendix E)
***Undrained shear strength is derived from SPT 'N' value using a conversion factor of 5
[…] – Average of the test results
{…} – Number of Tests carried out

5.10.5. Noting that soil parameters have been derived where characteristic SPT N_{60} values <60

Stiffness

5.10.6. The soil stiffness parameters derived from SPT values are presented in Table 5-38 below. Report section 5.13 discusses HPD testing that was undertaken in two boreholes and reports the stiffness characteristics for those tests.

Table 5-38 – Summary of the stiffness of mudstone

Section	Drained Young's Modulus, *E*' (MPa)
2	55
3	50
4	40

5.11. Millstone Grit Group – Siltstone

5.11.1. A summary of the available data gathered for Siltstone is provided in Table 5-39 to Table 5-42. Due to a lack of information, parameters were only derived for Sections 2 to 4.

Classification

5.11.2. The results of the classification testing on the siltstone are presented within Table 5-39 below. Generally, moisture content, plasticity index and PSD testing on bedrock material is not usually undertaken. In this case, it is likely that sections of rock which have been weathered to a residual clay or silt material have been classified and tested as a soil to obtain the residual parameters. For this assessment, the results of the tests will be reported, but there will be no geotechnical parameters derived from the results. From the descriptions in report sections 4.2.4, 4.3.4, 4.3.5, 4.4.3 & 4.5.7, a characteristic unit weight of 21 kN/m³ for the siltstone is recommended in line with BS 8002:2015 [13].

Table 5-39 – Summary of classification testing of siltstone

Section	Phase of GI	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Bulk Unit Weight	PSD
2	Phases 1-4	8.7 – 14 [12] {3}	27 – 32 [30] {3}	16 – 23 [20] {3}	6 – 16 [10] {3}	1.94 [1.94] {1}	-
	Phase 5	-	-	-	-	-	
	TOTAL	**8.7 – 14 [12] {3}**	**27 – 32 [30] {3}**	**16 – 23 [20] {3}**	**6 – 16 [10] {3}**	**1.94 [1.94] {1}**	**-**
3	Phases 1-4	14 – 21 [17] {6}	28 – 33 [31] {6}	16 – 23 [19] {6}	7 – 17 [12] {6}	-	{1}
	Phase 5	-	-	-	-	-	-
	TOTAL	**14 – 21 [17] {6}**	**28 – 33 [31] {6}**	**16 – 23 [19] {6}**	**7 – 17 [12] {6}**	**-**	**{1}**

Values present maximum and minimum values from testing. NP is Non-Plastic.
[…] – Average of the test results. For Plastic Limit, Non-Plastic (NP) will not be included in the average
{…} – Number of test results

SPT

5.11.3. The results from the SPT on the siltstone across all the available sections of the site are presented within Table 5-40 below.

Table 5-40 – Summary of the SPT results on siltstone

Section	Phase of GI	Extrapolated SPT Results (N_{60})*	Characteristic N_{60} Value**
1	Phases 1-4	200 [200] {1}	*No Value Provided (Insufficient Data)*
	Phase 5	-	
	TOTAL	**200 [200] {1}**	
2	Phases 1-4	50 – 178 [112] {17}	75
	Phase 5	42 – 226 [147] {3}	
	TOTAL	**42 – 226 [117] {20}**	
3	Phases 1-4	52 – 200 [111] {13}	80
	Phase 5	-	
	TOTAL	**52 – 200 [111] {13}**	
4	Phases 1-4	46 – 163 [132] {7}	120
	Phase 5	81 – 150 [127] {5}	
	TOTAL	**46 – 163 [130] {12}**	

*Values present maximum and minimum values from testing and include the extrapolated N_{60} value from the refused SPT results where N>50

**Characteristic values are conservative values interpreted from graphical representation. (See Appendix E)

[…] – Average of the test results

{…} – Number of Tests carried out including the refused N> 50 tests

Uniaxial compressive strength

5.11.4. The uniaxial compressive strength of the siltstone has been obtained directly and derived through testing results and empirical relationships, and is presented in Table 5-41 below.

Table 5-41 – Summary of the uniaxial compressive testing of siltstone

Section	Point Load Test Data, $I_{s\,(50)}$ (MPa)	Uniaxial Compressive Strength, UCS (MPa)			
		UCS from Testing	UCS derived from Point Load Testing	UCS derived from N_{60}	Characteristic UCS
1	0.7 [0.7] {1}	-	1.4 [1.4] {1.4}	2.00 [2.00] {1}	*No Value Provided (Insufficient Data)*
2	0.14 – 3.8 [1.16] {87}	4.06 – 76.9 [40.0] {5}	2.8 – 76 [23.2] {87}	0.42 – 2.26 [1.17] {20}	0.75
3	0.07 – 6.06 [2.53] {53}	36.9 – 79.8 [54.3] {5}	1.4 – 258 [50.6] {53}	0.52 – 2.00 [1.10] {13}	0.8 (0-10mBGL) 10 (>10mBGL)
4	0.17 – 9.03 [3.4] {20}	-	0.34 – 180.6 [68] {20}	0.46 – 1.63 [1.30] {12}	1.2 (0-25 mBGL) 10 (>25mBGL)

*Values present maximum and minimum values from testing and empirically derived UCS values
**Characteristic values are conservative values interpreted from graphical representation. (See Appendix E)
[…] – Average of the test results
{…} – Number of Tests carried out

Stiffness

5.11.5. The derived stiffness parameters are presented in Table 5-42 below. Report section 5.13 discusses HPD testing that was undertaken in two boreholes and reports the stiffness characteristics for those tests.

Table 5-42 – Summary of the stiffness of siltstone

Section	Drained Young's Modulus, E' (MPa)
2	75
3	80
4	120

5.12. Millstone Grit Group – Sandstone

5.12.1. A summary of the available data gathered for sandstone is provided in Table 5-43 to Table 5-45. It was deemed appropriate that the characteristic values within Sections 2 to 4 would be derived, and Section 1 would not be considered due to a small amount of available data.

Classification

5.12.2. There was no classification testing of the sandstone. From the descriptions in report sections 4.2.4, 4.3.4, 4.3.5, 4.4.3 & 4.5.7, a characteristic unit weight of 21 kN/m³ for the sandstone is recommended in line with BS 8002:2015 [13].

SPT

5.12.3. The results from the SPTs on the sandstone across all the available Sections of the site are presented within Table 5-43 below.

Table 5-43 – Summary of the SPT results on sandstone

Section	Phase of GI	Extrapolated SPT Results (N_{60})*	Characteristic N_{60} Value**
1	Phases 1-4	50 – 56 [53] {2}	*No Value Provided (Insufficient Data)*
	Phase 5	82 – 151 [117] {2}	
	TOTAL	**50 – 151 [85] {4}**	
2	Phases 1-4	50 - 130 [73] {10}	60
	Phase 5	157 [157] {1}	
	TOTAL	**50 – 157 [80] {11}**	
3	Phases 1-4	54 – 103 [72] {3}	60
	Phase 5	51 – 139 [90] {6}	
	TOTAL	**51 – 139 [84] {9}**	
4	Phases 1-4	60 – 180 [101] {4}	60
	Phase 5	200 [200] {1}	
	TOTAL	**60 – 200 [121] {5}**	

*Values present maximum and minimum values from testing and include the extrapolated N_{60} value from the refused SPT results where N>50

**Characteristic values are conservative values interpreted from graphical representation. (See Appendix E)

[…] – Average of the test results

{…} – Number of Tests carried out including the refused N> 50 tests

Uniaxial compressive strength

5.12.4. The uniaxial compressive strength of the sandstone has been obtained directly and derived through testing results and empirical relationships, and is presented in Table 5-44 below.

Table 5-44 – Summary of the uniaxial compressive testing of sandstone

Section	Point Load Test Data, $I_{s\,(50)}$ (MPa)	Uniaxial Compressive Strength, UCS (MPa)			
		UCS from Testing	UCS derived from Point Load Testing	UCS derived from N_{60}	Characteristic UCS
1	0.2 – 6.5 [2.05] {12}	50.1 [50.1] {1}	4 – 130 [41] {12}	0.50 – 1.51 [0.85] {4}	*No Value Provided (Insufficient Data)*
2	0.02 – 7.7 [2.08] {181}	14.4 – 130 [56.8] {21}	0.4 – 154 [41.7] {181}	0.50 – 1.57 [80] {11}	0.6
3	0.1 – 7.7 [2.7] {95}	17.3 – 85.6 [53.1] {15}	2 – 154 [54] {95}	0.51 – 1.57 [0.84] {9}	0.6 (0-10mBGL) 5 (>10mBGL)
4	0.02 – 5.47 [2.33] {16}	42.5 – 100 [75.7] {4}	0.4 – 109.4 [46.6] {16}	0.60 – 2.00 [1.21] {5}	0.6 (0-10 mBGL) 2 (10-25 mBGL) 10 (>25mBGL)

*Values present maximum and minimum values from testing and empirically derived UCS values
**Characteristic values are conservative values interpreted from graphical representation. (See Appendix E)
[…] – Average of the test results
{…} – Number of Tests carried out

Stiffness

5.12.5. The derived parameters are presented in Table 5-45 below. Report section 5.13 discusses HPD testing that was undertaken in two boreholes and reports the stiffness characteristics for those tests.

Table 5-45 – Summary of the stiffness of sandstone

Section	Drained Young's Modulus, E' (MPa)
2	60
3	60
4	60

5.13. High Pressure Dilatometer Testing

5.13.1. High Pressure Dilatometer (HPD) testing was completed in two boreholes at the proposed Mottram underpass location. The results are presented in detail in the factual GI report [17] and summarised in Table 5-46 below. As these test results are particular to the fault location, their results are not representative of the entire Section 2 area, and are not presented as such. The HPD results should be used where appropriate within the underpass detailed design.

Table 5-46 – Summary of HDP Results [8]

Test Number	Borehole ID	Depth	Material tested	Reported Shear Modulus (G(i))	Reported Undrained Young's Modulus	Reported undrained shear strength
		m BGL		MPa	MPa	kPa
1	BH514	13.6	Mudstone	10	30	312
2		15.1	Clay (Fault gouge)	15	45	725
3		16.5	Siltstone	21	63	573
4		19.6	Mudstone	17	51	592
5	BH516	19.2	Mudstone	93	279	2422
6		21.1	Siltstone	117	351	-

5.14. Cone Penetrometer Testing

5.14.1. During the Phase 5 Ground Investigation, a total of 15 cone penetrometer tests (CPTs) were undertaken. The tests were undertaken to investigate the soft deposits around the River Etherow. The type of test that was undertaken was static piezocone testing (CPTu).

5.14.2. Detailed interpretation of the CPT results will be required for the specific element of design they are relevant to. The results are presented in the factual GI report [8].

5.15. Characteristic geotechnical parameters

5.15.1. The recommended characteristic values for the encountered geological strata across the site are summarised in this Section. It should be noted that the characteristic parameters have been derived for guidance only. A location specific ground model with corresponding geotechnical parameters given below should be reviewed prior to undertaking any design in accordance with BS EN 1997-1 [18] to ensure values applicable to the design situation are selected.

Section 1

Table 5-47 – Characteristic geotechnical parameters for the superficial geology in Section 1

Parameter	Unit	Made Ground (Cohesive)	Alluvium (Cohesive)	Alluvium (Granular)	Glacial Till (Cohesive)	Glacial Till (Granular)
Unit weight (γ_B)	kN/m³	18	17	18	18	18
Peak angle of shearing resistance (φ')	°	28	Insufficient data	30	30	31
Drained cohesion (c')	kPa	0	0	0	0	0
Undrained shear strength (c_u)	kPa	35	45	N/A	0 -7m = 50 7 – 22m: 50 + 4.5z	N/A
Coefficient of volume compressibility (m_v)	m²/MN	See **Error! Reference source not found.**	See **Error! Reference source not found.**	N/A	See **Error! Reference source not found.**	N/A
Undrained elastic modulus (E_u)	MPa	10	10	N/A	0 – 20m: 10 + 1z 20 – 25m: 30	N/A
Drained stiffness (E')	MPa	8	8	Insufficient Data	0 –20m: 7.6 + 0.762z 20 – 25m: 22.8	26

Z – Increase per metre depth

Table 5-48 – Characteristic geotechnical parameters for the bedrock geology in Section 1

Parameter	Unit	Mudstone	Siltstone	Sandstone
Unit weight (γB)	kN/m3	21	21	21
Uniaxial Compressive Strength	MPa	Insufficient Data	Insufficient Data	Insufficient Data
Drained stiffness (E')	MPa	Insufficient Data	Insufficient Data	Insufficient Data

Section 2

Table 5-49 Characteristic geotechnical parameters for the superficial geology in Section 2

Parameter	Unit	Made Ground (Granular)	Glacial Till (Cohesive)	Glacial Till (Granular)
Unit weight (γB)	kN/m3	18	18	18
Peak angle of shearing resistance (φ')	°	28	29	33
Drained cohesion (c')	kPa	0	0	0
Undrained shear strength (cu)	kPa	N/A	0 – 6 m: 54 6 – 22 m: 54 + 9z	N/A
Coefficient of volume compressibility (mv)	m2/MN	N/A	See **Error! Reference source not found.**	N/A
Undrained elastic modulus (Eu)	MPa	N/A	0 – 6m: 12 6 – 22m: 12 + 2z	N/A
Drained stiffness (E')	MPa	30	0 – 6m: 9 6 – 22 m: 9 + 1.5z	40

Z – Increase per metre depth

Table 5-50 – Characteristic geotechnical parameters for the bedrock geology in Section 2

Parameter	Unit	Mudstone	Siltstone	Sandstone
Unit weight (γB)	kN/m3	21	21	21
Undrained shear strength (cu)	kPa	0 – 10m: 275	-	-
Uniaxial Compressive Strength	MPa	10 – 40m: 1.5	0.75	0-10m: 0.6 >10m: 5
Drained stiffness (E')	MPa	55	75	60

Section 3

Table 5-51 – Characteristic geotechnical parameters for the superficial geology in section 3

Parameter	Unit	Made Ground (Granular)	Glacial Till (Cohesive)	Glacial Till (Granular)
Unit weight (γB)	kN/m3	18	18	18
Peak angle of shearing resistance (φ')	°	Insufficient Data	30	34
Drained cohesion (c')	kPa	0	0	0
Undrained shear strength (cu)	kPa	N/A	0 – 2m: 40 2 – 8 m: 40 + 20z	N/A
Coefficient of volume compressibility (mv)	m2/MN	N/A	See **Error! Reference source not found.**	N/A
Undrained elastic modulus (Eu)	MPa	N/A	0 – 2m: 10 2 - 8m: 10 + 2.5z	N/A
Drained stiffness (E')	MPa	Insufficient Data	0 – 2m: 7.6 2 - 8m: 7.6 + 1.9z	50

Z – Increase per metre depth

Table 5-52 – Characteristic geotechnical parameters for the bedrock geology in Section 3

Parameter	Unit	Mudstone	Siltstone	Sandstone
Unit weight (γB)	kN/m3	21	21	21
Undrained shear strength (cu)	kPa	250	-	-
Uniaxial Compressive Strength	MPa	-	0 – 10m: 0.8 >10m: 10	0 – 10m: 0.6 >10m: 5
Drained stiffness (E')	MPa	50	80	60

Section 4

Table 5-53 – Characteristic geotechnical parameters for the superficial geology in Section 4

Parameter	Unit	Section 4 - Cohesive Superficial Material	Section 4 - Granular Superficial Material
Unit weight (γ_B)	kN/m³	18	18
Peak angle of shearing resistance (φ')	°	29	31
Drained cohesion (c')	kPa	0	0
Undrained shear strength (c_u)	kPa	0 - 7m: 45 7 – 22m: 45 + 5.4z	N/A
Coefficient of volume compressibility (m_v)	m²/MN	See **Error! Reference source not found.**	N/A
Undrained elastic modulus (E_u)	MPa	0 - 7m: 10 7 – 22m: 10 + 1.2z	N/A
Drained stiffness (E')	MPa	0 - 7m: 7.6 7 – 22m: 7.6 + 0.9z	30

Z – Increase per metre depth

Table 5-54 – Characteristic geotechnical parameters for the bedrock geology in Section 4

Parameter	Unit	Mudstone	Siltstone	Sandstone
Unit weight (γB)	kN/m3	21	21	21
Undrained shear strength (cu)	kPa	200	-	-
Uniaxial Compressive Strength	MPa	-	0 – 25m: 1.2 >25m: 10	0 – 10m: 0.6 10 - 25m: 2 >25m: 10
Drained stiffness (E')	MPa	40	120	60

5.16. Aggressive Chemical Environment for Concrete (ACEC)

5.16.1. The results from the pH and sulphate testing undertaken within the Phase 5 ground investigation is presented within Table 5-55. Testing and the Design Sulphate and ACEC class for each of the materials recorded on site was conducted in accordance with BRE SD1 guidance [19.]

Table 5-55 – Summary of BRE Sulphate and pH testing by geology

Material	Water soluble sulphate, 2:1 water/soil extract (mg/l SO4)	Total potential sulphate (%)	pH	Design Sulphate (DS) / Aggressive Chemical Environment for concrete (AC) Class
Topsoil	<10 – 19 {3}	0.093 – 0.100 {3}	6.9 – 9.0 {6}	DS-1 / AC-1
Made Ground	<10 – 27 {6}	<0.010 – 0.095 {6}	7.7 – 8.9 {7}	DS-1 / AC-1
Alluvium (Cohesive)	<10 {1}	0.023 {1}	8.0 - 8.5 {3}	DS-1 / AC-1*
Alluvium (Granular)	-	-	-	N/A
Glacial Till (Cohesive)	<10 – 47 {14}	0.011 – 0.140 {14}	6.4 – 8.9 {27}	DS-1 / AC-1
Glacial Till (Granular)	-	-	7.9 – 8.4 {1}	DS-1 / AC-1
Section 4 – Cohesive Superficial Material	<10 – 270 {7}	0.015 – 0.150 {7}	6.4 - 8.8 {21}	DS-1 / AC-1
Section 4 – Cohesive Superficial Material	<10 {3}	<0.010 - 0.050 {3}	7.1 – 9.7 {3}	DS-1 / AC-1
Millstone Grit Group - Mudstone	-	-	8.1 – 8.5 {4}	N/A
Millstone Grit Group - Siltstone	-	-	8.1 – 9.4 {4}	N/A
Millstone Grit Group - Sandstone	-	-	7.6 – 8.7 {13}	N/A

{…} – Number of Tests carried out

*based on only one sample and therefore may not be true reflection of the bulk material. Therefore please refer back to the BRE Sulphate and ACEC classification stated within the Arcadis GIR (Arcadis, 2018).

5.16.2. The recommended classification for all the materials with of the available testing from the 2021 GI is DS-1 / AC-1. These results are broadly in line with the findings of the Arcadis GIR [1], where differences exist, the designer should consider the testing which is available closest to the structure being designed.

5.16.3. For the materials which do not have a BRE Sulphate and ACEC classification from the Phase 5 ground investigation, the designer should adopt the class originally stated within the Arcadis GIR [1].

5.16.4. In addition to the materials in Table 5-55, peat material (from BH537) recorded high total sulphate of 0.74%, which would be categorised as DS-3. However, peat was only encountered in two boreholes across the entire site, and if encountered during construction will be considered an Unsuitable (Class U) material and will be excavated and replaced.

6. Groundwater

6.1. Introduction

6.1.1. The main water-bearing units along the route are the Millstone Grit and superficial Alluvium and River Terrace Deposits around the River Etherow. These are classified as Secondary A Aquifers, which are defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of baseflow to rivers. The Glacial Till which overlies the Millstone Grit is a low permeability unit, dominated by clays, classified as Secondary (undifferentiated) aquifers.

6.1.2. A full discussion of the previous groundwater conceptualisation is provided within the 2018 GIR and is not repeated herein. This section summarises new information gathered during the 2021 GI and puts this in context of the existing conceptual understanding of groundwater flow and behaviour along the planned route.

6.1.3. Further information on the impact of the scheme on the regional groundwater regime have been provided within the hydrogeological risk assessment in appendix 13.2 of the Environmental Statement [6].

6.2. Observed groundwater levels and inferred flow behaviour

Groundwater level monitoring

6.2.1. Three rounds of groundwater monitoring were carried out by Socotec following the completion of drilling, in addition to monitoring associated with the pumping test. Groundwater levels were recorded by manual dip in all boreholes fitted with monitoring installations. Vibrating wire piezometers were installed at four boreholes (BH546, BH547, BH547B and BH548) in the area of the River Etherow bridge.

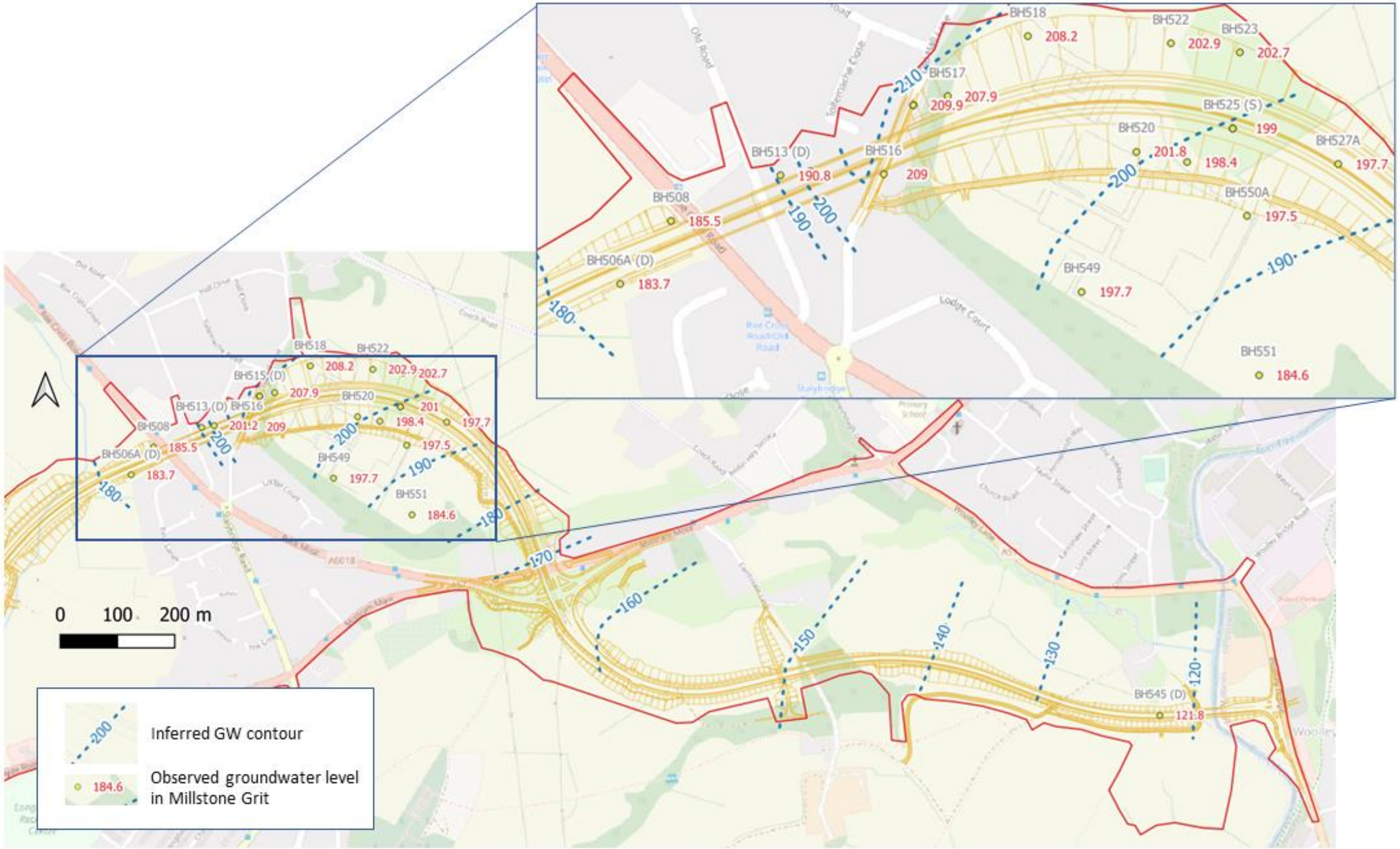
6.2.2. Groundwater dataloggers were installed in thirteen monitoring wells within the showground area during the 2021 GI and ten dataloggers will remain in situ across the area of the Mottram underpass and eastern cutting for one year in order to record seasonal variation in groundwater levels. At the time of writing this data was not yet available. Groundwater monitoring data is included in full in the factual report [8]. This section summarises the observed groundwater levels and head gradients in the four sections of the route.

6.2.3. A pumping test was carried out between the 24th of June and the 15th of July 2021. The impact of this pumping test on the groundwater levels recorded at the wells has been discussed further in section 6.4.2 below. Further detail on the impact of the pumping test can be found within the WJ Pumping Test Factual Report [10].

Overall groundwater flow direction

6.2.4. Overall groundwater flow along the route is to the south-east, towards the River Etherow. There is a flow divide in the vicinity of Old Hall Lane and groundwater flow to the west of Old Hall Lane is to the south-west, towards Hurstclough Brook. The flow divide is likely to be associated with the Mottram fault zone and that the topography of the site falls towards the southwest of Mottram. This is discussed further in section 6.2.3.2.

6.2.5. Inferred groundwater flow contours, based on data collected during the July 12-15 monitoring round, is shown in Figure 6.1. These are similar to groundwater contours presented in the 2018 GIR showing groundwater flow direction correlating with topography, with a steeper hydraulic gradient in the Mottram showground area, and shallower gradient closer to the River Etherow. The following sections summarise observed groundwater behaviour in the four sections of the route. Geological cross-sections in Appendix E show the maximum groundwater levels recorded at boreholes along the route.



Observed groundwater levels are shown in red, and inferred contours in m AOD in blue dash

Figure 6.1 – Inferred groundwater contours (m AOD) within the Millstone Grit based on monitoring data collected between 12 and 15 July 2021

6.2.6. Groundwater monitoring demonstrates that there are upwards vertical head gradients between the Millstone Grit and the overlying Glacial Till, and between different units of the Millstone Grit, along all parts of the route to the east of Mottram. In two areas of the site piezometric levels within the Millstone Grit were identified as artesian during the ground investigation – in section 2 to the east of Old Hall Lane and in the area around the River Etherow bridge in section 4 – these are discussed in further detail in sections 6.2.3.3 and 6.2.3.4. It is likely that this behaviour is present at depth within the Millstone Grit throughout the scheme to the east of the Mottram fault zone, but only encountered in the boreholes which penetrated deepest into bedrock.

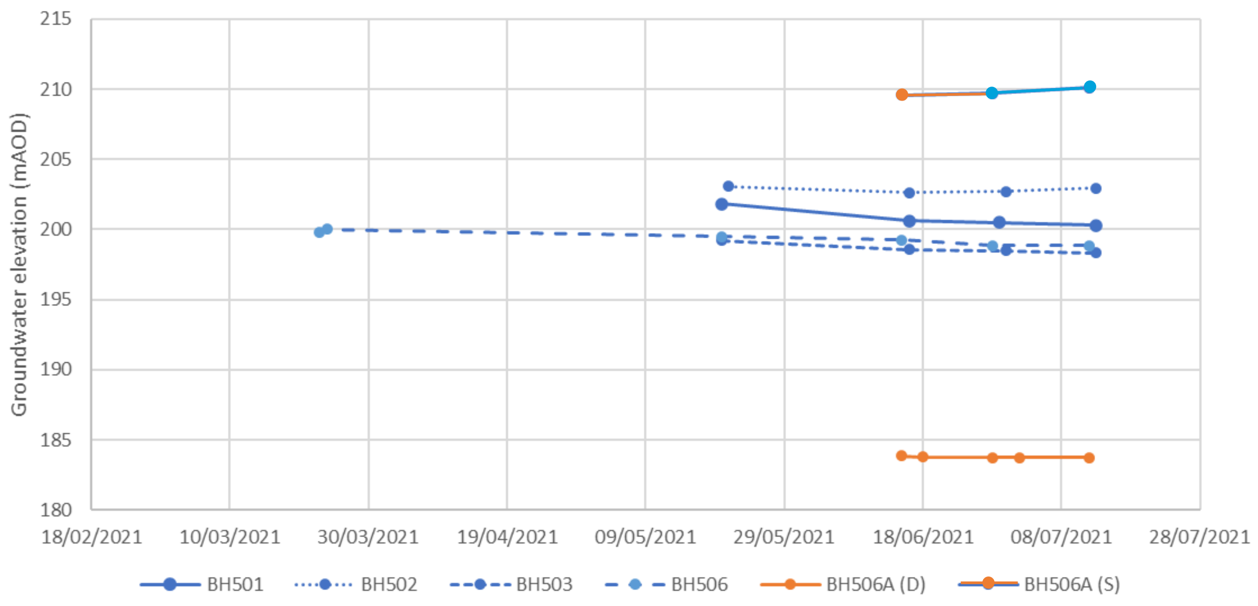
Groundwater behaviour

Section 1: CH0 – 810

6.2.7. Groundwater levels within this section are shown on Figure 6.2. Boreholes installed in Glacial Till are shown in blue, and those installed in Millstone Grit shown in orange.

6.2.8. This section is to the west of the Mottram fault zone and associated flow divide, and groundwater flow appears to be towards the south-west, in the direction of Hurstclough Brook.

6.2.9. Groundwater levels within the Millstone Grit are below the rockhead surface, therefore any groundwater in the overlying Glacial Till is likely to be perched lenses. These lenses may have lateral connectivity to some degree, and connectivity with the Brook, as well as providing limited recharge to the underlying Millstone Grit. Groundwater within the Millstone Grit is unlikely to have any connectivity with the Brook at this location due to the thickness of overlying till. Groundwater levels and inferred flow direction within bedrock do imply that groundwater is likely discharging to the Hurstclough Brook in its lower reaches down gradient. Groundwater levels in this area are approximately 15 m lower than those in equivalent strata to the east of the fault zone. This is likely due to the fact that the fault zone is a barrier to flow and blocking recharge from up-gradient in the area of Millstone Grit outcrop to the north of the scheme around Hollingworth hall Moor.



Boreholes installed in Glacial Till are shown in blue, and those installed in Millstone Grit shown in orange. BH506A is at CH830 but is the furthest west location installed in Millstone Grit and has been included here to demonstrate the relationship between water levels in the Millstone Grit and the overlying Glacial Till in this area

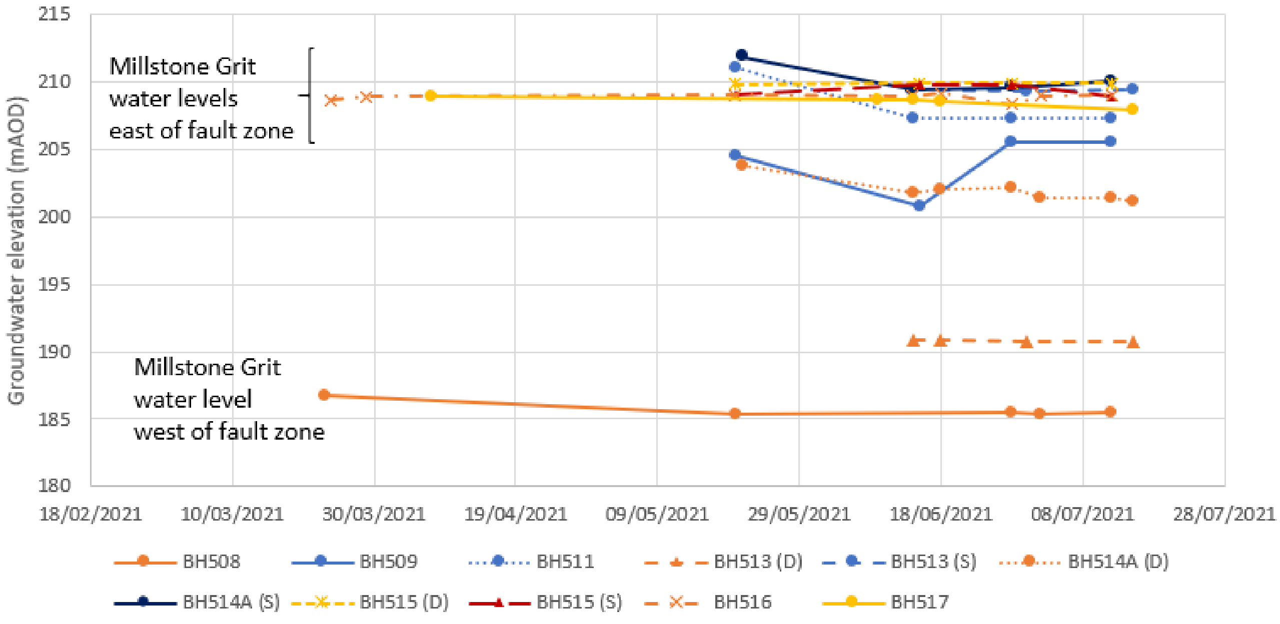
Figure 6.2 – Observed groundwater levels in boreholes in Section 1

Section 2: CH810 – 1100 (encompassing Mottram fault zone)

6.2.10. Groundwater levels within this section are shown on Figure 6.3. Boreholes installed in Glacial Till are shown in blue, and those installed in Millstone Grit shown in orange.

6.2.11. At the western end of the underpass groundwater conditions are as described in section 4.3 with thick Glacial Till overlying Millstone Grit with groundwater below bedrock head. At the eastern end of this section groundwater levels within the Millstone Grit are sub-artesian, with a very thin covering of Glacial Till which acts as a confining layer. This difference in behaviour is a result of the Mottram fault zone which runs NW-SE through the underpass (see section 0for further discussion). The only location where groundwater within the Millstone Grit is observed below rockhead is at BH517, which has a shallower installation depth than surrounding boreholes.

6.2.12. Based on observations during a pumping test, the 2018 GI concluded that the fault zone was acting as a barrier to flow within the Millstone Grit - that groundwater was likely flowing preferentially parallel with the fault, towards the south-east, but not across the fault. This conclusion is corroborated by observed groundwater levels within the Millstone Grit on either side of the fault during the 2021 groundwater monitoring. Piezometric levels within the Millstone Grit were approximately 15 m lower on the western side of the fault zone compared to the east, even when comparing boreholes with screen depths at similar elevations. For example, BH508 and BH516 are both installed at approximately 185-189 m AOD. During the July monitoring round, water levels within BH508 were at 185.51 m AOD, compared to BH516 where water levels were at 209.01 m AOD. To create such a steep hydraulic gradient across the fault zone the permeability within the Millstone Grit across the fault in the west-east direction must be extremely low. At shallow depths the juxtaposition of shallow low permeability Glacial Till against the sandstone, siltstone and mudstones of the Millstone Grit will also act as a barrier to flow.

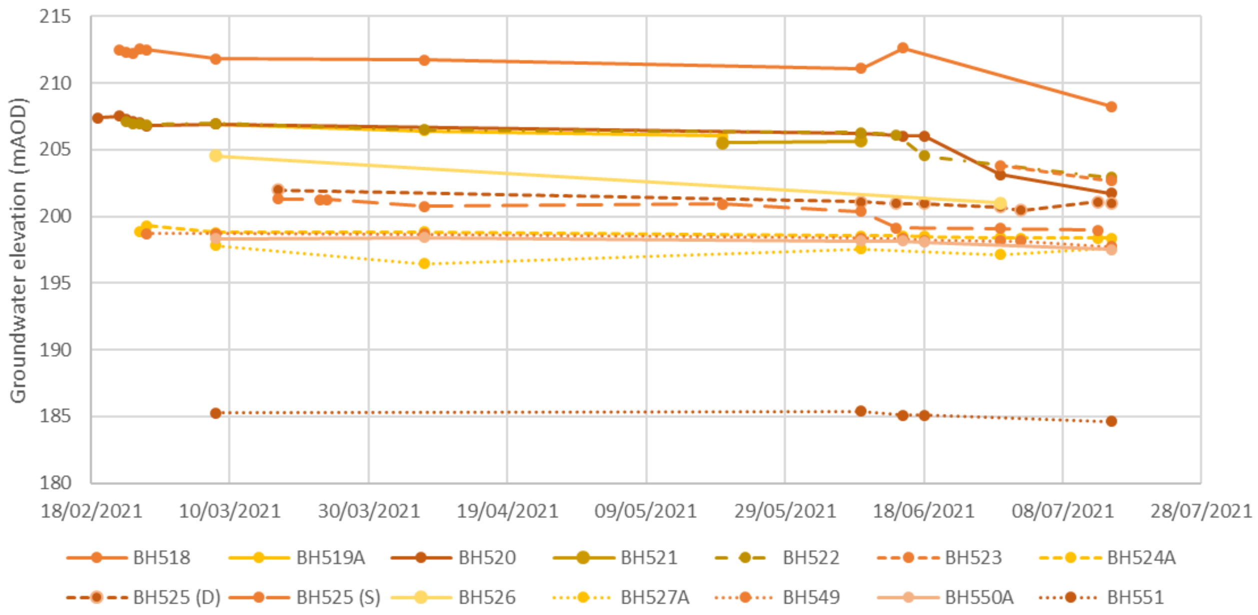


Boreholes installed in Glacial Till are shown in blue, and those installed in Millstone Grit shown in orange/yellow/red

Figure 6.3 – Observed groundwater levels in boreholes in Section 2

<u>Section 3: CH1100 – 1510</u>

6.2.13. Groundwater levels within this section are shown on Figure 6.4. All monitoring wells are installed within the Millstone Grit, with the exception of BH522 and BH525(S) which are installed partly in the Millstone Grit and partly within the Glacial Till.



Boreholes installed in Millstone Grit shown in orange/yellow

Figure 6.4 – Observed groundwater levels in boreholes in section 3

6.2.14. Groundwater flow is generally to the south-east towards the River Etherow. Groundwater levels within the Millstone Grit in this section are close to ground level and correlate closely with topography. The variation shown in Figure 6.4 is due to where on the slope the monitoring well is located.

6.2.15. Groundwater within the Millstone Grit in this section is confined by the overlying Glacial Till; piezometric levels are above the top of the bedrock aquifer. The Millstone Grit is also a self-confining aquifer, and piezometric levels have been observed to increase with depth into the aquifer, creating upward hydraulic gradients. For example, groundwater levels recorded at BH525S&D and the calculated vertical gradients are summarised in Table 6-1 – Vertical head gradients recorded within BH525. High vertical gradients demonstrate that the Millstone Grit has a relatively low vertical hydraulic conductivity, likely as a result of mudstone and siltstone horizons.

Table 6-1 – Vertical head gradients recorded within BH525

Date	Obs GWL - BH525S (m AOD)	Obs GWL - BH525D (m AOD)	Calculated upwards gradient
17/03/2021	201.29	201.99	0.11
09/06/2021	200.38	201.11	0.11
14/06/2021	199.12	200.95	0.29
29/06/2021	199.1	200.73	0.26[1]
13/07/2021	198.99	201.11	0.33[1]

Based on vertical distance between centre of screened sections of 6.4 m
[1]During pumping test

6.2.16. At BH521, BH523, BH526 and BH527 piezometric groundwater levels were shown to be above ground level (artesian) during groundwater monitoring, as shown in Table 6-2. This behaviour was also observed at depth in this area during the 2018 ground investigation. With the exception of BH523, wells showing artesian groundwater levels have particularly deep screened sections compared to surrounding boreholes. The observed vertical hydraulic gradients suggest that it is likely that elevated groundwater pressures are present at depth throughout this area, but have only been identified as “artesian” at monitoring locations which penetrate to the greatest depth within the Millstone Grit aquifer. Groundwater levels at BH523 are similar to surrounding locations, but this location is in a natural topographical depression so the groundwater level is artesian because of a deviation in topography rather than in groundwater behaviour.

Table 6-2 – Monitoring wells where artesian groundwater was recorded

BH ID	Screen top (m AOD)	Screen bottom (m AOD)	Ground level (m AOD)	Maximum recorded GWL (m AOD)	Max. recorded artesian head (m AGL)
BH521	185.7	174.3	204.7	205.64	0.94
BH523	195.31	190.81	203.81	Unknown – recorded only as “artesian”	-
BH526	183.03	175.13	201.03	204.53*	3.5
BH527	186.15	179.15	197.15	197.81	0.66

Water levels at this location only recorded during one monitoring visit due to access issues

6.2.17. Artesian groundwater is encountered in the deepest wells and in those locations where the current ground surface is lower compared to the surrounding ground, for example at BH523.

Section 4: CH1510 – 3116 (encompassing River Etherow Bridge)

6.2.18. Groundwater levels within this section are shown on Figure 6.5. Boreholes installed in Glacial Till are shown in blue, and those installed in Millstone Grit shown in orange.

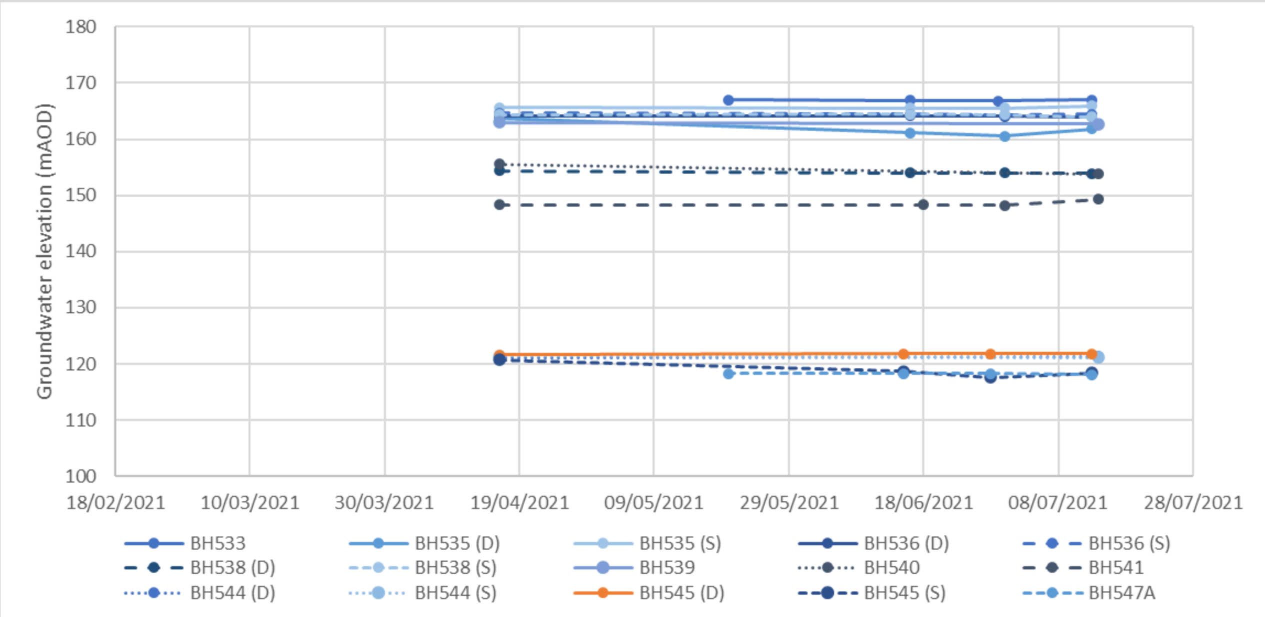


Figure 6.5 – Observed groundwater levels in boreholes in section 4

6.2.19. Groundwater flow is generally to the south-east towards the River Etherow throughout this section. Groundwater level data within the Millstone Grit is only available in the vicinity of the River Etherow - all other boreholes in this section were installed with monitoring screens within the Glacial Till. It is assumed that the Till acts as a confining layer to groundwater within the underlying Millstone Grit throughout this section. The range in groundwater levels in Figure 6.5 is a result of the regional hydraulic and topographic gradient towards the river – monitoring wells closer to the River Etherow have lower groundwater elevations than those upgradient.

6.2.20. Artesian groundwater levels were recorded in the vicinity of the River Etherow bridge as described in Table 6-3. These locations were monitored with vibrating wire piezometers (VWP) and are not included in Figure 6.5 – Observed groundwater levels in boreholes in section 4

6.2.21. , which is based on manual dip data from standpipe boreholes. The highest groundwater pressures were at BH547, at 25 m depth within the Millstone Grit. Artesian pressures were also identified within superficial deposits overlying the Millstone Grit within sand units of the Glacial Till. It is likely that artesian pressures in these units are supported by groundwater levels within the underlying Millstone Grit, and confined by overlying clay units within the Glacial Till.

Table 6-3 – Summary of observed artesian groundwater conditions close to the River Etherow

BH ID	VWP depth (m AOD)	Geology at install depth	Ground level (m AOD)	Maximum recorded GWL (m AOD)	Max. recorded artesian head (m AGL)
BH546	105.78	Glacial Till (sand)	120.28	122.00	1.72
BH547	94.43	Millstone Grit (mudstone)	119.93	123.84	3.91
BH547B	105.34	Glacial Till (sand)	119.84	120.80	0.96
BH548	106.58	Glacial Till (gravel)	120.08	121.80	1.72

6.2.22. In both BH547B and BH548 artesian groundwater levels were only recorded at the start of the monitoring period, and groundwater pressures dropped consistently throughout the monitoring according to the VWP data [8]. The behaviour at these locations was different to the other boreholes in this area which show responses to recharge and do not show any consistent decline in water pressures. Atkins consider that the trend observed in BH547B and BH548 may not be representative of groundwater pressures within the aquifer, and instead may be a result of a poor seal within the borehole that is allowing groundwater to drain.

6.2.23. Artesian groundwater within the confined Millstone Grit results in a strong upward vertical head gradient in this area. This suggests that the vertical hydraulic conductivity of the certain layers within the Millstone Grit and the overlying clay is extremely low.

6.3. In-situ permeability testing

6.3.1. Eleven falling and rising head tests were carried out at nine locations in the vicinity of Mottram underpass and eastern cutting as summarised in Table 6-4. Atkins have evaluated the results and comments have been included in the table relating to the assessed validity of the results.

6.3.2. A number of locations may be unrepresentative of the geological conditions at the specific locations. Not including these locations, the calculated permeabilities range from 2.4×10^{-9} m/s to 3.6×10^{-6} m/s, equivalent to 2×10^{-4} to 0.3 m/d. The Arcadis 2018 ground investigation recorded permeabilities between 4.6×10^{-10} m/s to 5.5×10^{-5} m/s (Arcadis, 2018), so the 2021 values lie within a similar range. Results of the tests also align with published values and so are considered reasonable for the screened geology.

Table 6-4 – Results of in situ permeability testing

BH ID	Screen (mbgl)	Geology at install depth	Route section	Calculated permeability (m/s)	Comments
BH515(D)	14.7 - 16.0	Millstone Grit (mudstone)	2	9.3E-08	(Rising head)
BH515(S)	10.0 - 11.5	Millstone Grit (sandstone)	2	2.4E-09	(Rising head)
BH518	14.0 - 24.0	Millstone Grit (mudstone, siltstone and sandstone)	3	1.6E-07	Slower later response used for permeability rather than rapid initial response unlike other tests. (Falling head)
BH520	13.0 - 25.0	Millstone Grit (mudstone, siltstone and sandstone)	3	Not Calculated	Permeability value was not calculated because there was only 30% recovery after a 60min test. (Falling head)
BH522	5.6 - 7.6	Glacial Till and Millstone Grit (sandstone)	3	1.5E-06	Very small (0.19m) differential head developed during testing and therefore results may not be representative. (Falling head)
BH524A	11.0 - 14.0	Millstone Grit (mudstone, siltstone and sandstone)	3	8.6E-07	(Falling head)
BH525(D)	9.5 - 12.4	Millstone Grit (mudstone, siltstone and sandstone)	3	3.6E-06	(Falling head)
BH525(S)	3.0 - 5.5	Glacial Till and Millstone Grit (mudstone and sandstone)	3	1.3E-07	Slower later response used for permeability rather than rapid initial response unlike other tests. (Falling head)
BH549	6.0 - 9.0	Millstone Grit (siltstone and sandstone)	3	4.9E-06	Very rapid initial response taken for permeability. Comment on test that response zone was not fully saturated during test which means that initial response may be a result of gravel pack response and be an overestimate of permeability of the screened geology. (Falling head)
BH550A	6.5 - 9.5	Millstone Grit (siltstone and sandstone)	3	1.6E-07	(Falling head)
BH551	5.5 - 8.5	Millstone Grit (siltstone and sandstone)	3	1.7E-07	(Falling head)

6.4. Pumping test

Introduction

6.4.1. Atkins commissioned WJ Groundwater to carry out a pumping test within the Millstone Grit to allow derivation of hydraulic parameters, and an abstraction-recharge test in the Millstone Grit to assess the feasibility of recharging groundwater back into the ground during the operation of the scheme (WJ UK, 2021). The test was carried out in the area of the eastern cutting, within the Mottram showground to the east of the Mottram fault zone.

6.4.2. During the 2018 GI Arcadis carried out a pumping test at BH414, on the eastern edge of the Mottram fault zone. Although hydraulic parameters were derived from this test, there were problems with pump failure and difficulties maintaining flow rates which may have affected the validity of the derived values. The 2018 test did demonstrate that there was little hydraulic connectivity across the Mottram fault zone. The 2021 pumping test was designed to verify derived hydraulic parameters.

Test pumping

Borehole construction and groundwater level monitoring

6.4.3. BH519A was chosen as the abstraction borehole and installed with a long screen within the Millstone Grit. During the recharge test water was recharged into BH521. WJ Groundwater installed continuous monitoring equipment at the pumping well, recharge well and five other boreholes in the showground area during the test, recording at a minimum of 15-minute intervals. The remaining wells in the vicinity were monitored by continuous monitoring equipment installed by Socotec, recording at 4 hourly intervals. All monitoring wells have the full screen depth within the Millstone Grit, with the exception of BH522 which is screened through the base of the Glacial Till and into the top of the Millstone Grit.

6.4.4. Table 6-5 summarises the locations and installation details of the abstraction and all monitoring points used to inform the analysis of the pumping test data.

Table 6-5 – Monitoring during pumping test works

BH ID	Response zone (m AOD)	Response strata	Distance to pumped well	Monitoring frequency
BH519A (pumped well)	185.1 – 198.1	Millstone Grit: mudstone/siltstone/sandstone	N/A	15 minutes[1]
BH520	182.5 – 194.5	Millstone Grit: mudstone/siltstone/sandstone	60.7	4 hourly
BH518	191.5 – 201.5	Millstone Grit: mudstone/siltstone/sandstone	89.5	15 minutes
BH521	174.3-185.7	Millstone Grit: mudstone/siltstone/sandstone	90.2	15 minutes
BH517	203.2 – 207.2	Millstone Grit: sandstone	93.5	15 minutes
BH524A	193.9-194.4	Millstone Grit: mudstone/siltstone/sandstone	99.9	4 hourly

BH ID	Response zone (m AOD)	Response strata	Distance to pumped well	Monitoring frequency
BH549	193.1– 198.2	Millstone Grit: sandstone/siltstone	110.2	4 hourly
BH522	202.5-204.5	Glacial Till & Millstone Grit: sandstone/siltstone	118.8	15 minutes
BH525D	189.8-193.8	Millstone Grit: sandstone/siltstone	135.4	4 hourly
BH550A	190.2-194.9	Millstone Grit: sandstone/siltstone	154.1	15 minutes
BH523	190.8-195.3	Millstone Grit: mudstone/siltstone/sandstone	158.0	4 hourly
BH527A	179.2-186.2	Millstone Grit: sandstone	215.1	4 hourly
BH551	180.5-186.2	Millstone Grit: sandstone/siltstone	231.4	15 minutes

[1]Monitoring intervals at the pumped well were more frequent at the start of each test

Boreholes from the 2018 GI shown in blue

Figure 6.6 – Pumped well (BH519A) and surrounding monitoring wells

6.4.5. Groundwater level monitoring commenced on 21 June 2021, three days before the step test started and continued until 29 July 2021, 14 days following the end of the abstraction-recharge test. Dates of the phases of test pumping are supplied in Table 6-6. Further information on the impact of the pumping test on the surrounding wells can be found within the WJ Pumping test factual report (WJ UK, 2021).

Discharge arrangements

6.4.6. Abstracted water was piped to a baffled weir tank and then discharged to soakaway within the wooded area at approximate OS NGR E399462 N396130. The soakaway was dug into the clay of the Glacial Till and it is thought unlikely that it would recharge the underlying Millstone Grit aquifer within the time period of the test.

Pumping rates and observed drawdown

Pumped well

6.4.7. Table 6-6 shows the pumping rates and drawdown at the pumped well during each phase of the test pumping. The initial target pumping rate for the constant rate test was 1 l/s, however this could not be maintained throughout the 7-day period without the water level falling beneath the pump invert and therefore the abstraction rate dropped to 0.9 l/s by the end of the test. Decreasing yields are commonly identified during abstraction from the Millstone Grit so this behaviour is not unusual [20].

6.4.8. The target flow rate for the abstraction recharge test was 0.5 l/s with the intention to increase the flow where possible. Water was observed seeping out of the ground close to the recharge well during the test, so the flow was not increased any further.

6.4.9. Drawdown in the pumped well during this test was less than observed during the 2018 pumping test for similar flow rates. The borehole construction for the pumping well in the 2018 test was similar to that in the 2021 test, so it is unlikely that this difference is due to differences in well losses. It is more likely due to the proximity of the fault zone, a flow barrier, to the pumped well in the 2018 test. BH519A is more than 200 m from the fault zone so the influence from the fault zone is negligible considering the estimated radius of influence of approximately 250 m (see section 0). BH519A is located out with the area that has been identified as high to moderate impact from the Mottram fault within appendix B.

Table 6-6 – Abstraction rates and observed drawdown at the abstraction well BH519A during pumping test works

Date	Activity	Duration	Target flow rate (l/s)	Flow rate achieved (l/s)	End drawdown (m)
24 June 2021	Step test – step 1	100 minutes	0.25	0.24	1.65
	Step test – step 2	100 minutes	0.50	0.50	4.41
	Step test – step 3	100 minutes	0.75	0.75	8.32
	Step test – step 4	100 minutes	1.00	1.00	13.51
	Step test – step 5	100 minutes	1.25	1.19	18.32
	Step test recovery	100 minutes	-	-	1.12
28 June 2021 – 05 July 2021	Constant Rate test	7 days	1.00	0.9 – 1.0	18.40

Date	Activity	Duration	Target flow rate (l/s)	Flow rate achieved (l/s)	End drawdown (m)
05 July 2021 – 12 July 2021	Recovery monitoring	7 days	-	-	1.72
12 July 2021 – 15 July 2021	Abstraction-recharge test	3 days	0.5	0.51	5.84[1]
15 July 2021 – 29 July 2021	Recovery monitoring	14 days[2]		-	1.83[2]

[1]Calculated against rest water level on 12 July 2021 prior to start of abstraction-recharge test
[2]Recovery monitoring in the pumped well did continue until 29 July 2021; however, drawdown values presented here are from 19 July 2021, after 4 days recovery. The pump and rising main were removed on 19 July 2021 and water levels were then recorded as falling for the remainder of the period (see Figure 6-7). No further manual dips were taken so the data from the remainder of the recovery period cannot be validated

Monitoring wells

6.4.10. Figure 6.7 reproduced from WJ Groundwater 2021 [10] shows the groundwater level response in the abstraction well and monitoring wells monitored by WJ throughout the test period. The observed drawdown at the end of the constant rate and abstraction recharge tests at all monitoring wells are summarised in Table 6-7. Less drawdown is seen during the abstraction-recharge test than during the constant rate test, this will be due to a combination of the lower pumping rate and the recharge of abstracted water. At several wells the drawdown response was negligible in both tests.

6.4.11. In Figure 6.7 BH518 shows unusual behaviour between the end of the constant rate test and the start of the abstraction-recharge test – water levels begin to recover before the end of the constant rate test and then show unusual variability before the abstraction recharge test starts. This behaviour is not seen at any other locations and is believed to be due to surface water ingress at BH518. A rainfall event began overnight on 04 July immediately before the switch off of the test which matches with the time of the recovery of water levels at this location. As such, data from BH518 should be treated with caution.

Table 6-7 – Observed drawdown in monitoring wells during the constant rate and abstraction recharge tests

BH ID	Response zone (m AOD)	Response strata	Distance to pumped well	End drawdown (m)	
				CRT	ART
BH520	182.5 – 194.5	Millstone Grit: mudstone/siltstone/sandstone	60.8	4.50	1.25
BH518	191.5 – 201.5	Millstone Grit: mudstone/siltstone/sandstone	89.5	0.51[1]	0.43
BH521 (recharge well)	174.3-185.7	Millstone Grit: mudstone/siltstone/sandstone	90.2	4.32	-7.72[3]
BH517	203.2 – 207.2	Millstone Grit: sandstone	93.5	0.12	-0.02
BH524A	193.9-194.4	Millstone Grit: mudstone/siltstone/sandstone	99.9	0.11	-0.04

BH ID	Response zone (m AOD)	Response strata	Distance to pumped well	End drawdown (m)	
				CRT	ART
BH549	193.1– 198.2	Millstone Grit: sandstone/siltstone	110.2	0.08	-0.01
BH522	202.5-204.5	Glacial Till & Millstone Grit: sandstone/siltstone	118.8	2.76	0.35
BH525D	189.8-193.8	Millstone Grit: sandstone/siltstone	135.4	0.47	-0.06
BH550A	190.2-194.9	Millstone Grit: sandstone/siltstone	154.02	0.05	0.02
BH523	190.8-195.3	Millstone Grit: mudstone/siltstone/sandstone	158.0	2.00	0.44
BH527A	179.2-186.2	Millstone Grit: sandstone	215.1	0.14[2]	0.01
BH551	180.5-186.2	Millstone Grit: sandstone/siltstone	231.4	0.02	0.03

[1]Maximum drawdown based on minimum water level which was recorded at 18:15 on 04/07/2021. Heavy rainfall began overnight on 04 July which results in increasing water levels in BH518 immediately before test switch off due suspected surface water ingress in this borehole
[2]Maximum drawdown based on reading at 20:00 on 04 July
[3]Increased water levels at recharge well during recharge test, hence negative drawdown

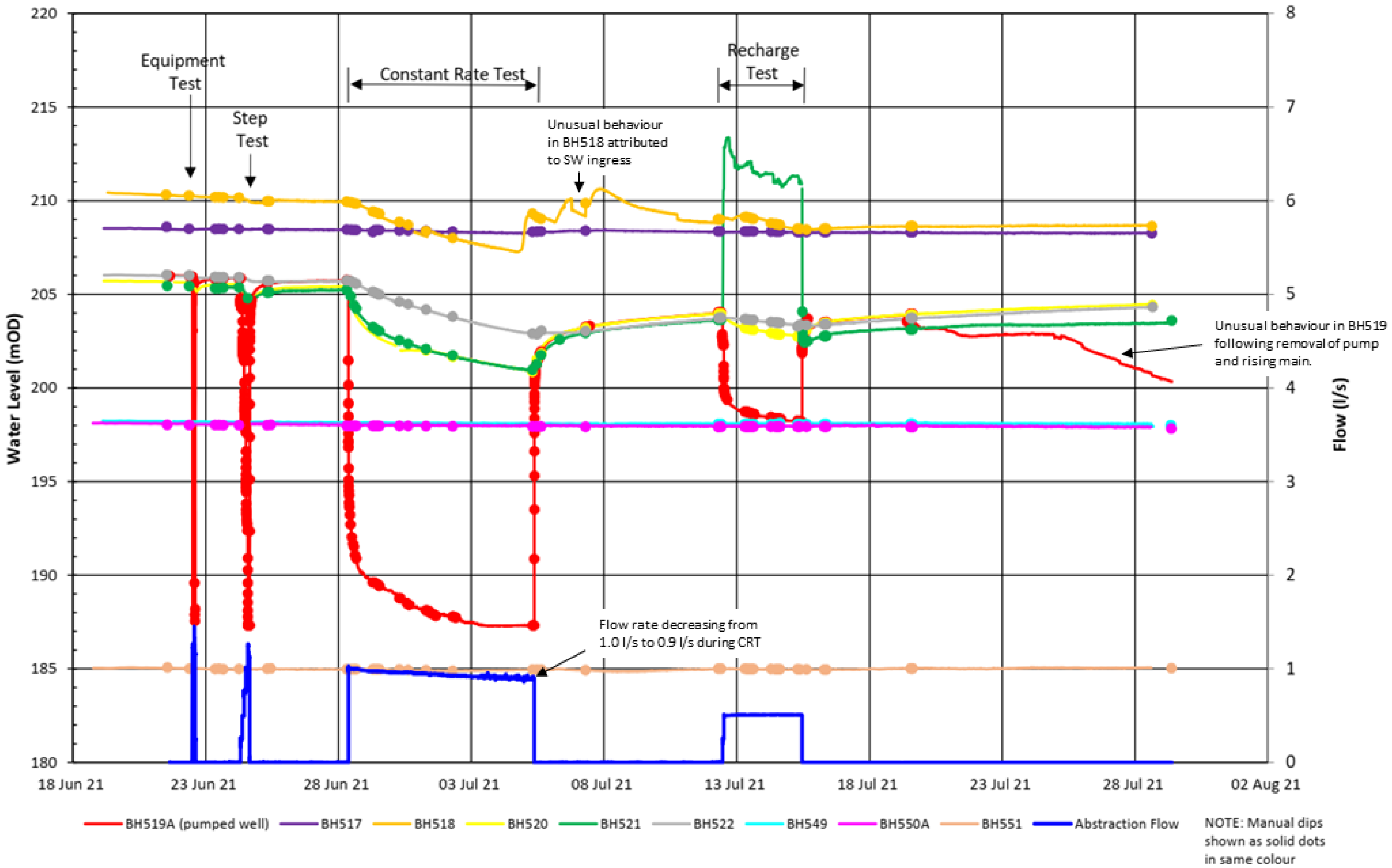


Figure 6.7 – Drawdown and abstraction rate during pumping test works (adapted from WJ Groundwater 2021 [10])

Abstraction-recharge test

6.4.12. The recharge well, BH521, is the deepest well in the showground and was observed to have artesian groundwater levels during the pre-test monitoring. As a result a sealed pressure cap had to be applied to the headworks during the recharge test to enable water to be recharged into the well. The pressure was monitored throughout the test and remained at approximately 0.65 bar. During the recharge test water was observed seeping out of the ground approximately 2 m from the recharge well. This is likely a result of the artesian water pressures at the recharge well, and seepage occurring through sandy horizons within the overlying till.

Water quality monitoring

6.4.13. Samples from groundwater were taken during the constant rate test and tested against a standard suite F as well as for total suspended solids. The results have been screened alongside all other groundwater monitoring data and are discussed in section 7.3.

6.4.14. In-line water quality parameters were also recorded throughout the test and are included in the WJ pumping test factual report. The range of values recorded are summarised in Appendix F.

Spring monitoring

6.4.15. Several water “issues” are marked on Ordnance Survey mapping in the vicinity of the Mottram Showground. The majority of these were dry during the test, with the exception of the stream to the east of Old Hall Lane at 399250 396055, and a pipe outlet at approximately 399602 396015, both marked on Figure 6.6. It is assumed that these are discharges are from groundwater. Daily visual observations were recorded at both locations to check for any potential reduction in flow during the constant rate test. None was observed.

Pumping test analysis

Step Test

6.4.16. Drawdown during the step test is shown in Appendix F, taken from WJ Groundwater 2021 report [10]. The drawdown, flow rate and calculated specific capacity during each step is summarised in Table 6-8.

6.4.17. Atkins has analysed the step test using the Eden-Hazel [21] method as presented in Appendix F. Transmissivity derived from this analysis is 9.42 m^2/d.

Table 6-8 – Observed drawdown and flow rates and calculated specific capacity for the step test

Step	Flow rate (l/s)	End drawdown (m)	Flow rate achieved (l/s)	Specific capacity (l/s/m)
Step test – step 1	0.24	1.65	0.24	0.15
Step test – step 2	0.50	4.41	0.50	0.11
Step test – step 3	0.75	8.32	0.75	0.09
Step test – step 4	1.00	13.51	1.00	0.07
Step test – step 5	1.19	18.32	1.19	0.07

During step 5 the target pumping rate could not be achieved without the water level dropping below the pump intake

Constant Rate Test

Pumped borehole – Theis (1946) recovery analysis

6.4.18. Transmissivity can be estimated from the pumped well using the Theis recovery method. In this method measured drawdown at the pumped source is plotted against time since the start of pumping (t) over time since the end of pumping (t'). The gradient of the line is a function of transmissivity. Theis (1946) recovery analysis using the abstraction borehole data is shown in Figure 6.8 and gives a transmissivity of 9.94 m2/d. This value is based on the flow rate at the end of the constant rate test of 0.9 l/s. Estimates of storage cannot be obtained from recovery data or from pumped well data in general.

6.4.19. In this method the early recovery data generally does not fit the straight-line: on Figure 6.8 – Theis recovery analysis on pumped well

6.4.20. the first 10 minutes of recovery does not follow a straight line. This is because the initial recovery within the borehole is recovery of drawdown attributed to well losses and storage in the well, rather than true representation of aquifer recovery.

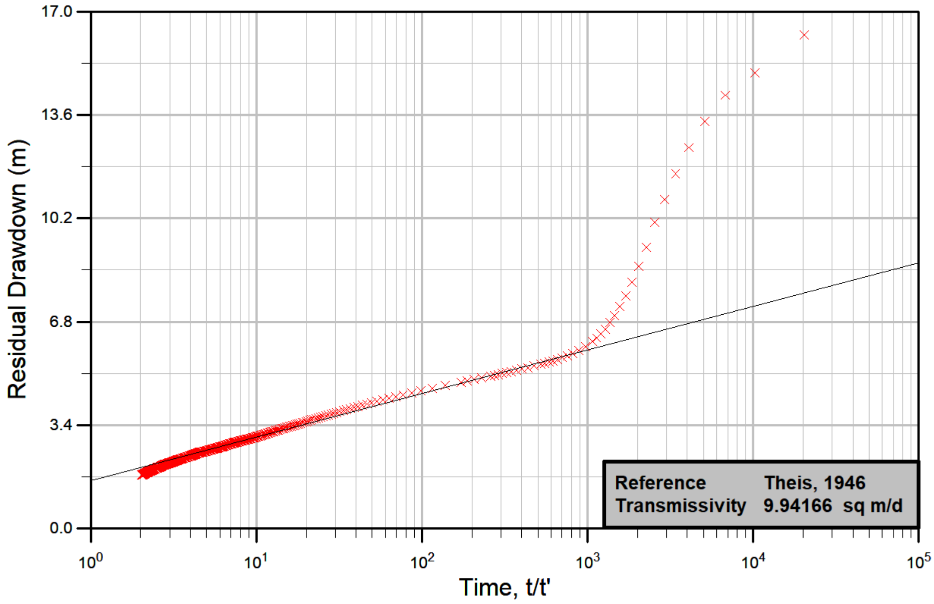


Figure 6.8 – Theis recovery analysis on pumped well

Observation boreholes - Thiem distance-drawdown

6.4.21. Observed steady-state drawdown from all of the monitoring wells was compiled to carry out a Thiem distance-drawdown analysis, as shown in . It is clear that the degree of drawdown response is not uniform across the monitoring wells, likely because flow is dominated by fracture flow and, to a lesser degree, flow in granular sandstone horizons, therefore the response is dependent on the well screen intersecting flowing fractures, and connectivity between sandstone layers.

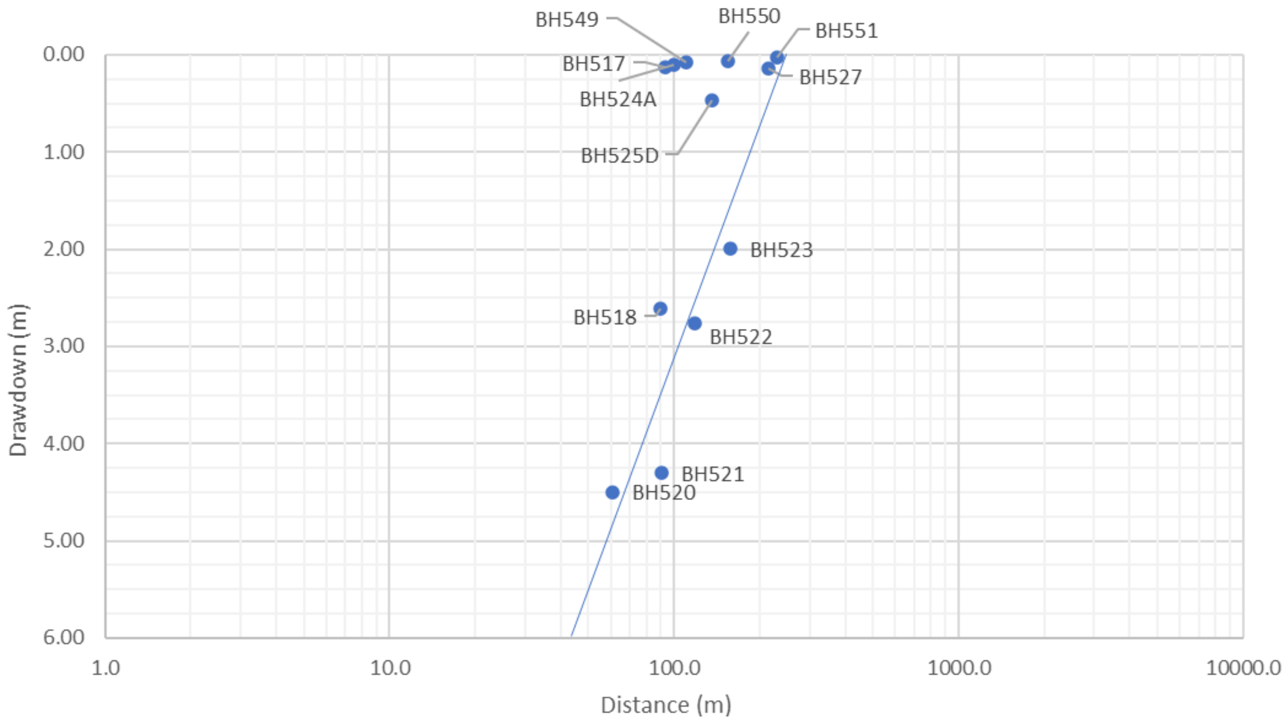


Figure 6.9 – Thiem distance drawdown

6.4.22. Wells of equivalent distance show very different responses, for example BH525D and BH523 are at similar distances but show very different drawdown responses, as do BH524A and BH518. For the latter pair this may be a result of the longer screen section at BH518, which intercepts a greater thickness of sandstone than at BH524A. This is not the case for BH525D and BH523 which both have 3 m screen sections, both installed in similar thickness of sandstone. It is likely that BH523 intercepts more flowing fractures than BH525D. It is also possible that the discharge of groundwater to ground is influencing groundwater levels at BH525D as this location is closest to, and down gradient from, the soakaway.

6.4.23. Elevation of the screen depth is not a clear control on connectivity either - BH522 and BH517 have screened sections at similar depths, shallower than the pumping well, but BH522 shows a much greater response despite being at a greater distance.

6.4.24. The two closest, long-screened wells, BH521 and BH520, show the greatest drawdown response. This is likely due to these wells intercepting the greatest number of flowing fractures (as a result of long screen sections) and hence showing connectivity with the pumped well.

6.4.25. The transmissivity derived from the distance-drawdown plot in Figure 6.9 based on the Thiem analysis is 3.58 m^2/d based on the average flow rate during the test of 0.94 l/s. The radius of influence for this pumping rate is approximately 250 m, but as has been demonstrated the heterogeneity of the aquifer and fracture network may mean that observed drawdown within this radius is not uniform.

Observation boreholes – Theis (1935)

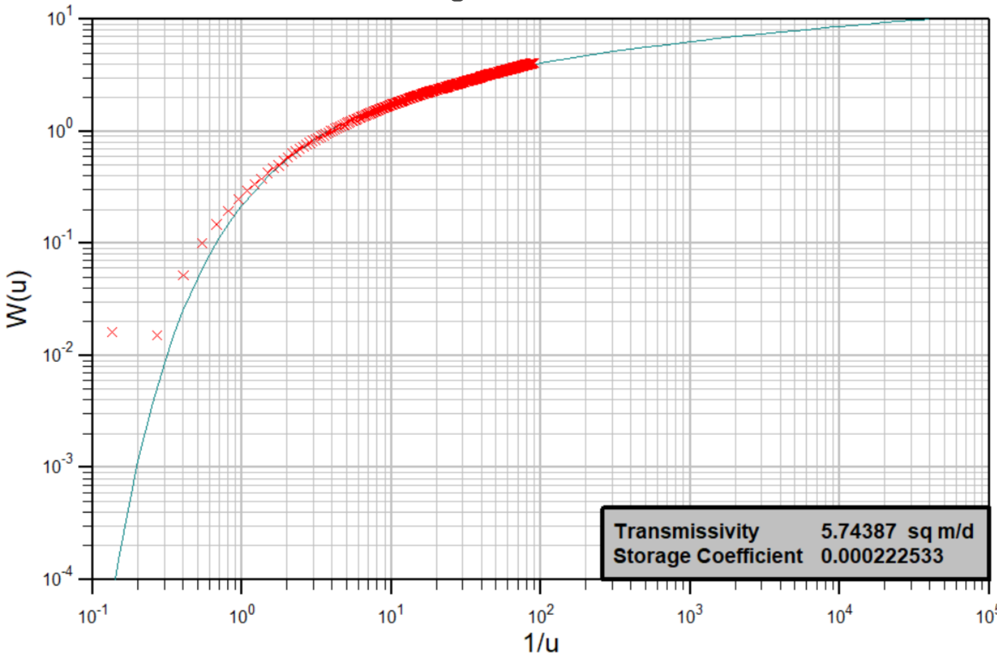
6.4.26. Theis (1935) analysis can be used to analyse the drawdown data from observation boreholes to give estimates of transmissivity and storativity. The Theis analysis is appropriate for confined aquifers, as in this case.

6.4.27. Figure 6.10 to Figure 6.14 show the Theis analysis for the monitoring wells in the vicinity of the pumped well. Only those that gave a good curve fit with a notable drawdown response (>0.25 m) are shown here, analysis of other monitoring wells with a lesser response is included in Appendix F .

6.4.28. As the pumping rate declined through the test the average pumping rate of 0.94 l/s was used for the derivation of hydraulic parameters in this analysis unless stated otherwise. Sensitivity analysis showed that the difference in derived T and S values for the start and end pumping rates was small and therefore using the average was a reasonable assumption.

BH521

At BH521 slightly different derived parameters were obtained by matching early and late time data, as shown in Figure 6.10 and



6.4.29. Figure 6.11. These figures give a range of T and S at this location based on the appropriate flow rate for the part of the curve that matches well to the type curve.

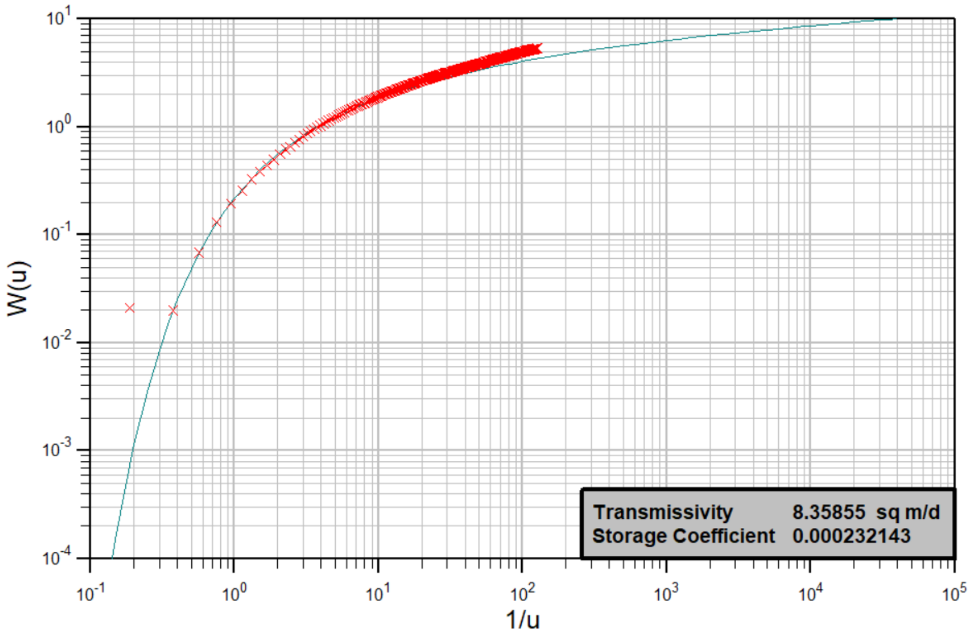


Figure 6.10 – Theis analysis at BH521 based on initial pumping rate of 1.0 l/s

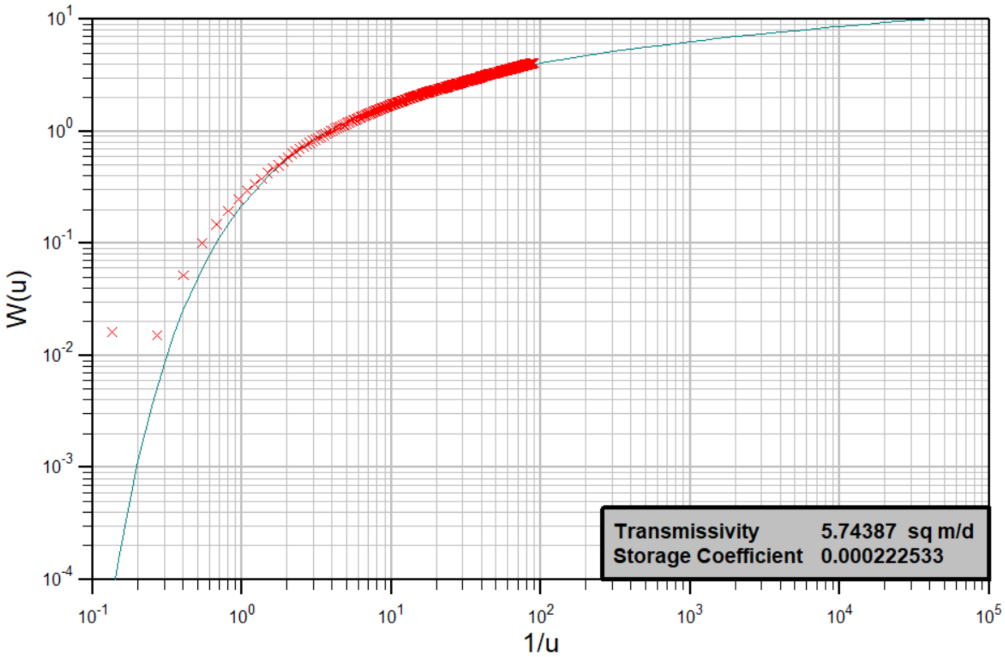


Figure 6.11 – Theis analysis at BH521 based on final pumping rate of 0.9 l/s

BH523

6.4.30. BH523 shows a delayed response and early time data does not match well to the type curve. The derived parameters are based on match to late time data.

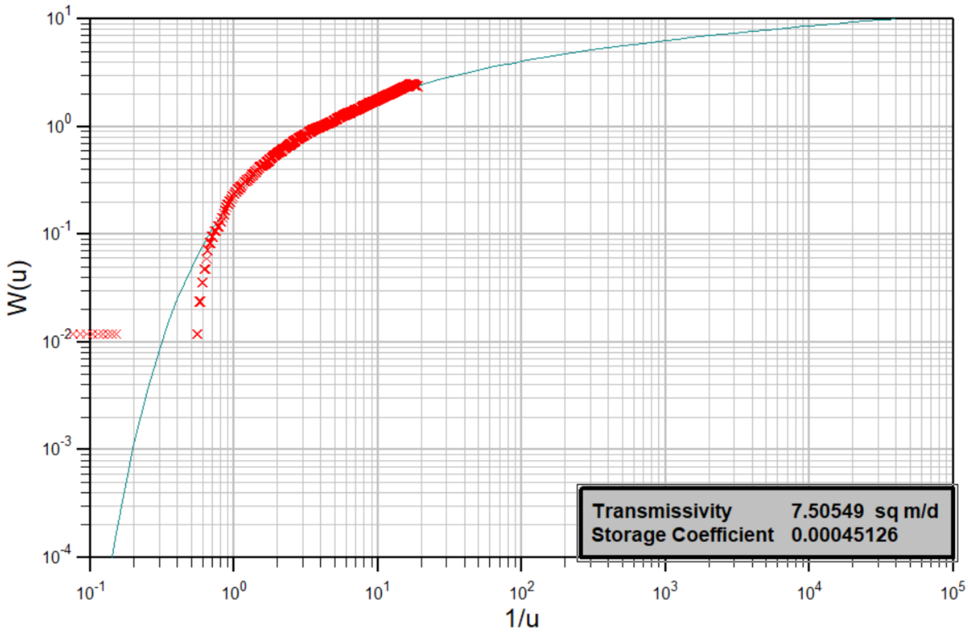


Figure 6.12 – Theis analysis at BH523 using average pumping rate of 0.94 l/s

BH518

6.4.31. Unusual behaviour was observed at BH518 during the constant rate test, attributed to surface water ingress at this location. This can be seen in Figure 6.13. Curve matching has been done based on the overall trend and a good match can still be obtained.

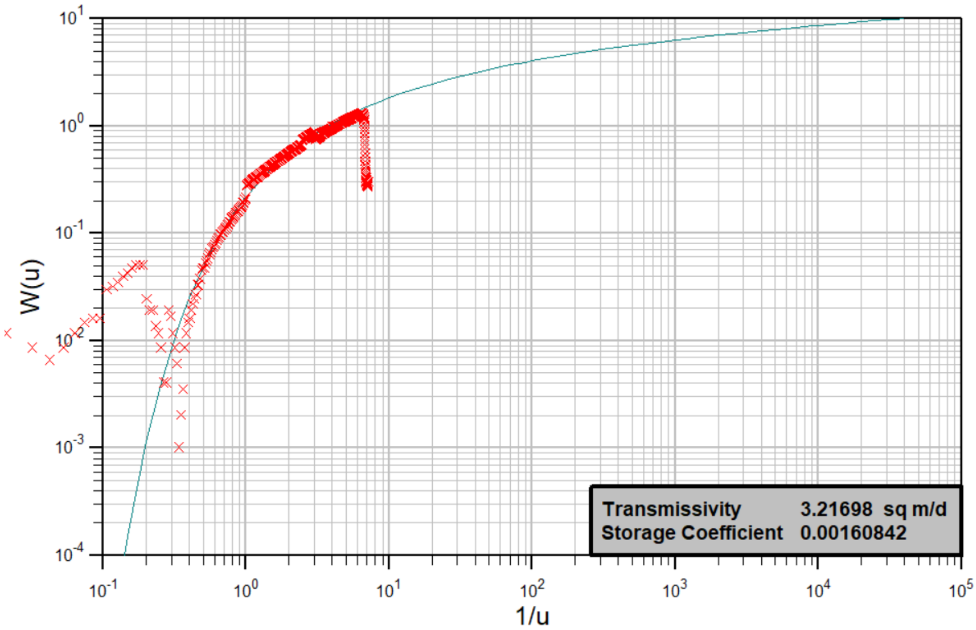


Figure 6.13 – Theis analysis at BH518 using average pumping rate of 0.94 l/s

BH520

6.4.32. This borehole was not being monitored at the start of the test, so the early time drawdown data was not available. Monitoring started three days into the constant rate test at this location. For the analysis in Figure 6.14 the data from the recovery period has been used (effectively negative drawdown) based on the assumption that the behaviour during recovery would be equivalent to the behaviour at the start of the test just that drawdown is reducing with time, rather than increasing. A good curve match has been achieved using this approach.

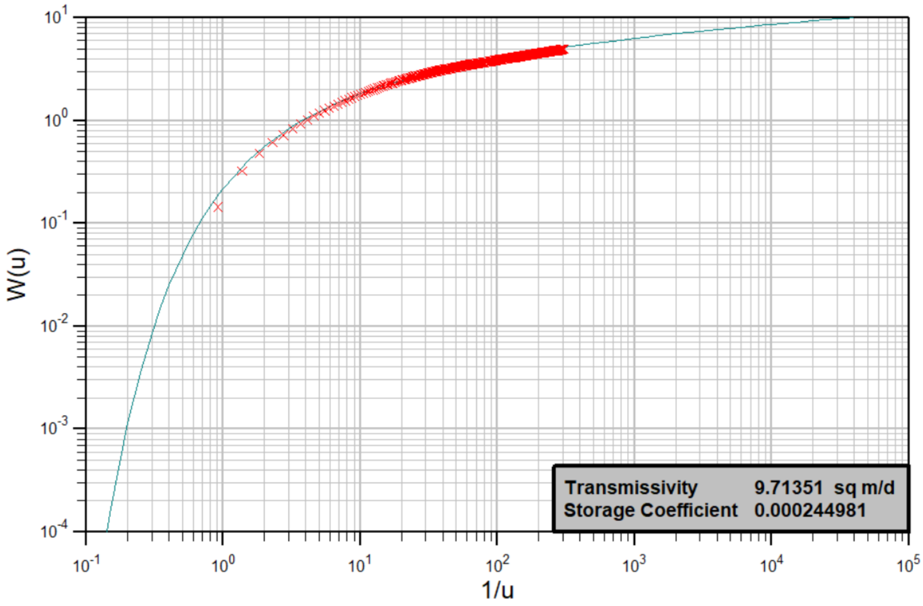


Figure 6.14 – Theis analysis using recovery data at BH520 based on final pumping rate of 0.9 l/s

Summary of derived parameters

6.4.33. Table 6-9 summarises the derived parameters from the analysis of the constant rate test. The conversion of transmissivity to hydraulic conductivity has been based on an assumed aquifer thickness of 30 m. The boreholes monitored during the test are all within the top 30 m of the aquifer, and given the likelihood of low vertical hydraulic conductivity, it is unlikely that the pumped well received significant flow contributions from beneath this depth. As none of the monitoring wells were dewatered below rockhead during the test the derived storage coefficients are assumed to be storativity rather than specific yield.

Table 6-9 – Derived parameters from the analysis of the constant rate test

Analytical method	Transmissivity (m^2/d)	Hydraulic conductivity (m/d)	Storativity (-)
Thiem distance-drawdown	3.58	0.12	N/A
Theis (1946) recovery – pumped well	9.94	0.33	N/A
Theis (1935) – BH521	5.74 – 8.36	0.19 – 0.28	0.00022 – 0.00024
Theis (1935) – BH523	7.51	0.25	0.00045
Theis (1935) – BH518	3.22	0.11	0.00161
Theis (1935) – BH520	9.71	0.32	0.00024
Geometric mean	6.34	0.21	0.00040

6.4.34. The pumping test carried out in 2018 (Arcadis, 2018) derived observed hydraulic conductivities of between 2.3×10-7 and 7.2 ×10-5 m/s, equivalent to 0.02 – 6.22 m/d, and storage values of 0.0002-0.0003. Hydraulic conductivities derived from this analysis lie in the middle of this range, and storage values show a slightly broader range but of the same order.

6.4.35. Hydraulic parameters derived here are considered a good representation of bulk aquifer values due to the long screen depths in the pumping well and several of the response wells, and the quality of the curve matching.

Abstraction-recharge test

6.4.36. The abstraction recharge test was undertaken to give a preliminary idea of the feasibility of recharging groundwater into the aquifer. No formal analysis has been carried out on the data from the abstraction-recharge test.

6.4.37. The test demonstrated that recharging of groundwater into the Millstone Grit can cause groundwater flooding at surface. Background water levels at this location were at or just above ground level prior to the pumping test starting, so recharge here increased piezometric levels to be above ground, and this may have resulted in the observed groundwater flooding. It is also possible that a poor seal in the upper part of the well may have been the cause of groundwater flooding via direct leakage into the Glacial Till and direct increase of groundwater levels within the Till.

7. Contaminated Land Risk Assessment

7.1. Introduction

7.1.1. A full discussion of the previous GQRA is provided within the 2018 GIR and is not repeated herein. This section summarises new information gathered during the 2021 GI and puts this in context of the existing conceptual understanding of potential contamination across the site.

7.1.2. Refer to Section 2.11 for details outlining the structure of a conceptual site model.

7.1.3. The general approach to the risk assessment reported here follows the principles given in LC:RM [22] , in that decisions regarding contamination risk on a site is assessed in stages:

i. Tier 1 preliminary risk assessment - typically a desk study and site walkover inspection with an assessment of risk considering the likelihood and severity of the potential consequences associated with the potential source-pathway-receptor (S-P-R) linkage(s).

ii. Tier 2 generic quantitative risk assessment (GQRA) - a review of site investigation and monitoring data, the development of an updated CSM with an assessment of risk using precautionary Generic Assessment Criteria (GACs) and confirmation of relevant potential contaminant linkage(s) that represent minimal or tolerable risk.

iii. Tier 3 detailed quantitative risk assessment (DQRA) - an assessment of risk based on the use of detailed ground investigation and monitoring data to develop a detailed CSM and derive Site Specific Assessment Criteria (SSACs) for the relevant potential contaminant linkage(s) to identify the likelihood of unacceptable risk.

7.1.4. The following sections detail the approaches to the GQRA (Tier 2) for assessing the potential impacts in relation to human health and controlled waters following completion of the Tier 1 assessments conducted as part of the Arcadis PSSR and Atkins 2021 Environmental Statement. The proposed underpasses at the Scheme have been identified as a potential receptor for gas migration on-site therefore a gas risk assessment has been undertaken.

7.2. Human health generic quantitative risk assessment

7.2.1. A GQRA has been carried out to assess the potential long-term risks to human health receptors in relation to future site use as a road scheme and the identified key contaminants of concern.

7.2.2. Construction/maintenance workers involved with site maintenance may have direct contact with soils, however, this cannot be formally assessed through this GQRA because the mode and duration of exposure (acute/short-term) are different to the scenarios used in determining GAC (chronic/long-term). It is considered that risks to maintenance ground workers would be managed by their Employers with the use of appropriate working methods informed by robust risk assessment and implementation of health and safety procedures.

Soils assessment

Methodology

7.2.3. In order to identify potential Contaminants of Concern (CoC), soil analytical data have been screened against Atkins's soil screening values (SSVs) or Category 4 Screening Levels (C4SLs), [23] collectively termed "generic assessment criteria" ("GAC"), derived to be protective of chronic risks to human health.

7.2.4. Atkins has produced SSVs based on minimal toxicological risk [24] 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 [25].

7.2.5. Based on the ratio of genotoxic PAHs to benzo(a)pyrene, the surrogate marker approach for genotoxic PAHs as set out in the C4SL Project Methodology [23] has been adopted.

7.2.6. Due to the proposed end-use being a road (with families waiting on the roadside verge if their vehicle breaks down) and the underpasses being beneath the Made Ground, the exposure of the public to Made Ground and any VOC vapours that might be emanating from the Made Ground is likely to be low. Based on the nature of the development, the GACs selected are those for public open space (park), which consider inhalation, ingestion and dermal contact with the soil/dust and inhalation of vapours originating from soils (outdoors).

7.2.7. The Ground Investigation designed by Atkins included 41 soil samples with SOM values ranging from 0.48% to 24.0%. The result of 24.0 % SOM was recorded within a sample collected from BH537 within peat. Therefore, this concentration has been disregarded when calculating the geometric mean SOM of 1.62%. Therefore, it is considered appropriate to assess the site based on a conservative 1% SOM.

7.2.8. For arsenic, benzene, benzo(a)pyrene, cadmium, hexavalent chromium and lead the CL:AIRE derived C4SL (based on a low level of toxicological concern) for the public open space (park) land use at 6% SOM has been selected as the assessment criterion. In May 2021 CL:AIRE also released C4SL values for vinyl chloride, tetrachloroethene (PCE) and trichloroethene (TCE). It should be noted that CL:AIRE has not derived C4SL for a 1% SOM.

7.2.9. At the time of writing this report the SGV for mercury has been withdrawn and therefore the S4UL has been adopted.[7]

7.2.10. For all other constituents, where available, the SSV has been selected.

7.2.11. Due to the nature of acute risk from cyanide, the SSV for cyanide has been based on the potential for an adult to ingest a bolus of soil contaminated with free cyanide.

7.2.12. Due to the nature of risk from asbestos an SSV cannot be derived using CLEA. Therefore, for generic quantitative risk assessment the limit of detection at the laboratory has been selected as the assessment criterion for asbestos.

7.2.13. The following assumptions have been made during selection of GACs and when screening the data:

- The main risk driving pathways in the top 1 m of soil are the direct pathways that include dermal contact, ingestion and inhalation of non-volatile and volatile contaminants in soil and inhalation of soil-derived dust. During the investigation soil samples were collected from across the site with depths ranging between 0.15 m bgl to 4.20 m bgl. Soils from all depths have been considered as part of this assessment, as following the proposed earthworks across the scheme, soils could end up within the upper 1 m of ground.
- The main risk driving pathway below 1 m bgl is inhalation of volatile contaminants.
- No free phase hydrocarbons were identified on the site during the ground investigation. Therefore, the combined assessment criterion (rather than the saturation limits) given by the CLEA model have been used for the relevant PAHs and TPHs;
- Human health GQRA comprises comparison of chemical analysis results for soil samples against appropriate GAC to assess the risk associated with the unsaturated soil source. Concentrations of contaminants which fall below the relevant GACs are considered unlikely to represent an unacceptable risk. Those contaminants that exceed their respective GACs are termed Contaminants of Concern (CoC) and may require further assessment.

7.2.14. A total of 41 soil samples from the Atkins 2021 investigation were screened against GAC and the full set of screening results are presented in the SOCOTEC Factual Report. Soil samples ranged in depth from 0.15 m bgl to 4.20 m bgl and consisted of Topsoil, Made Ground and Superficial Deposits.

7.2.15. The following samples were listed as deviating by the laboratory due to the sample age exceeding the stability time:

- BH505 at 0.20 m bgl
- BH535 at 0.50 m bgl
- BH515 at 1.20 m bgl
- BH536 at 0.40 m bgl
- BH510 at 0.50 m bgl
- TP503 at 0.90 m bgl

7.2.16. However, it should be noted that no visual/olfactory evidence of contamination was noted within these locations during the ground investigation.

7.2.17. However, it should be noted that no visual/olfactory evidence of contamination was noted within these locations during the ground investigation.

<u>Soil data screening</u>

7.2.18. Assessment of the soil chemical data from the Atkins investigation against GAC for public open space (park) with 1% SOM and 6% SOM for C4SLs identified two marginal GAC exceedances of Benzo(a)pyrene.

Table 7-1 – Summary of soil exceedance results

Determinand	GAC (mg/kg)	Min value (mg/kg)	Max Value (mg/kg)	No. of GAC Exceedances	Locations of Exceedances and Depth (m bgl)
Benzo(a)pyrene	21.4	2.1	25	2	TP505 at 0.50 BH511 at 0.20

7.2.19. A number of determinands where no GAC is available were recorded above the laboratory method detection limit (MDL), the majority of which were either TPH heavy end fractions and PAHs, or contaminants that are generally considered to pose minimal risk to human health (e.g. boron, sulphate). However, the PAHs and TPH fractions for which GAC have been derived are generally representative of the overall risk posed by these compounds to human health and as the majority of all the TPH/PAHs were recorded below GAC/MDL the overall risk pose by these contaminants are unlikely to pose an unacceptable risk to end-users. A summary has been provided in table 8-2 below. It should be noted that no GAC is currently available for complex and total cyanide. All concentrations of complex cyanide were measured below the MDL of 0.5 mg/kg, however, concentrations of up to 3.2 mg/kg were measured above the MDL of 0.5 mg/kg for total cyanide. All concentrations of complex cyanide were recorded below the GAC for free cyanide (34 mg/kg) and are therefore not considered to pose an unacceptable risk to human health.

7.2.20. Mercury concentrations are recorded below the S4UL of 240 mg/kg with the maximum concentration recorded being 0.35 mg/kg.

Table 7-2 – Determinands with no GAC and concentrations above MDL

Determinand	MDL (mg/kg)	Maximum Value (mg/kg)	No. of samples >MDL
Boron	0.4	1.3	16
Total Cyanide	0.5	3.2	7
Sulphide	0.5	25	41
Sulphate	100	7400	40
Acenaphthylene	0.1	10	4
Phenanthrene	0.1	25	7
Total of 16 PAHs	2	130	8
Total Aliphatic Hydrocarbons	5	68	2
Aromatic TPH >C16-C21	1	39	1
Total Aromatic Hydrocarbons	5	290	2
Total Petroleum Hydrocarbons	10	360	2
2-Methylnaphthalene	0.5	1.8	1

Determinand	MDL (mg/kg)	Maximum Value (mg/kg)	No. of samples >MDL
Acenaphthylene	0.5	0.6	1
Dibenzofuran	0.5	3.0	1
Phenanthrene (VOC)	0.5	40	3
Carbazole	0.5	3.0	2

Asbestos screening

7.2.21. A total of 41 samples collected during Atkins 2021 investigation from Topsoil (seven samples), Made Ground (six samples) and natural superficial deposits (27 samples) were submitted for asbestos analysis (presence and type). Minimal Made Ground was recorded across the site, however when Made Ground was encountered, samples were collected and analysed for asbestos. Potential asbestos containing materials were not reported during the course of the ground investigation and asbestos was not detected in the soil samples screened at the laboratory.

Human health risk assessment conclusions

7.2.22. Exceedances recorded within soil samples highlighted above, are deemed to be marginal GAC exceedances, within the same order of magnitude of the GAC and are therefore considered unlikely to pose an unacceptable risk to human health or the road scheme end-users (the public).

7.2.23. BH511 is located within the area of the proposed Mottram Underpass and therefore material is likely to be removed during construction. The sample, collected from 0.20 m bgl, was from within the Made Ground which consisted of brick and concrete. No visual/olfactory evidence of contamination was encountered during the drilling of BH511. The construction of the underpass is likely to be via a cut/cover system. It is assumed that topsoil, Made Ground and Till will likely be excavated, segregated and stockpiled and then replaced (subject to meeting re-use criteria). BH511 is located within a currently residential area adjacent to Old Road.

7.2.24. The sample collected from within TP505 at 0.50 m bgl was from natural sand and gravel) with no evidence of contamination noted during the excavation of the trial pit. TP505 was undertaken in the east of the Scheme, in the location of the proposed attenuation pond. It is likely that material will be required to be excavated. If material is to be reused on site it is recommended this material be utilised within the proposed highway boundary. However, if material is to be placed within temporary works areas which are to be returned to their former uses, further sampling and detailed risk assessments may need to be undertaken.

7.2.25. No asbestos was detected in any of the samples analysed.

7.2.26. The risk assessment undertaken within the Arcadis GIR compared soil data against the GAC for Public Open Space (Residential) (1 % SOM). A single lead exceedance was identified within BH427 (Section 4) and a single Dibenz(ah)anthracene exceedance within BH411 at 0.30 m bgl (Section 2). Both exceedances were considered to be marginal, within the same order of magnitude of the GAC, and were considered unlikely to pose an unacceptable risk to human health. It should be noted that if compared against the GAC for public open space (parks) which has been utilised within the Atkins 2021 assessment, no exceedances of the human health GAC would be recorded. Asbestos was not identified within samples analysed as part of the 2018 GI.

7.2.27. Based on the investigation data used and the assumption that exposure to the underlying soils will be minimal (due to presence of hardstanding/topsoil), risks to human receptors from inhalation, ingestion and dermal contact with dusts/soils are therefore considered to be low. However, it is advised that material which is excavated from areas where exceedances have been identified is reused within the highways boundary. If it is to be reused within areas of temporary works, further sampling and subsequent risk assessments may be required.

Groundwater-derived vapour risk assessment

7.2.28. Atkins has derived a set of Water Screening Values (WSV), using the Risk-Based Corrective Action (RBCA) Toolkit Model (GSI Environmental Inc), to allow assessment of the risk posed to human health from inhalation of vapours derived from VOCs that may be present in groundwater. The WSVs are based on a groundwater body present at 1 m bgl within a sandy soil and are available for commercial and residential receptors for a range of the most typical volatile contaminants. In the absence of WSVs for a road end-use, the residential screening values have been selected to provide an indication of risks from VOCs in groundwater that if exceeded could then be taken forward for further consideration.

7.2.29. With respect to potential risks to human health from groundwater, the only relevant pathways are considered to be via vapour migration and the inhalation of indoor and outdoor vapours. Therefore, only those organic contaminants with the potential to volatilise have been considered in the assessment.

7.2.30. The modelling used to develop assessment criteria estimates the concentration of contaminant in the soil vapour phase which may have derived from a water source. At the vapour saturation limit, the concentration of contaminant in the vapour phase cannot increase. In some cases, the calculated assessment criteria exceed the vapour saturation limit, in such instances, theoretically, the vapour concentration will never be high enough to cause an unacceptable risk to human health for that given scenario. Those contaminants for which this is the case do not have a WSV.

7.2.31. No WSV exceedances were recorded within groundwater samples collected from the site and together with an absence of VOC sources on-site, it is unlikely that VOCs in groundwater would pose an unacceptable risk to human health of end-users.

7.3. Controlled waters generic quantitative risk assessment

Introduction

7.3.1. The controlled waters GQRA has been undertaken to assess the potential risks posed to the identified controlled waters receptors from the migration of contaminants originating from current on-site sources, in the unsaturated zone soils and dissolved in groundwater. To assess the potential risks to the identified receptors, a comparison of soil leachate and groundwater concentrations against pertinent Water Quality Standards (WQS) has been undertaken.

7.3.2. The following samples were listed as deviating by the laboratory due to the sample age exceeding the stability time:

- BH515 (15/06/2021)
- BH518 (15/06/2021)
- BH520 (15/06/2021)
- BH524A (15/06/2021)
- BH550A (15/06/2021)
- BH551 (15/06/2021)
- BH549 (15/06/2021)
- BH547(15/06/2021)
- BH545 (15/06/2021)
- BH538 (16/06/2021)
- BH536 (16/06/2021)
- BH501 (16/06/2021)
- BH502 (16/06/2021)
- BH503 (16/06/2021)
- BH511 (14/06/2021)
- BH535 (16/06/2021)
- BH520 (29/06/2021)
- BH524A (29/06/2021)
- BH525 (D) (29/06/2021)
- BH525 (S) (29/06/2021)
- BH549 (29/06/2021)
- BH501 (29/06/2021)
- BH547A (28/06/2021)
- BH545 (D) (28/06/2021)
- BH509 (28/06/2021)
- BH506 (S) (28/06/2021)
- BH514A (28/06/2021)
- BH511 (28/06/2021)
- BH515 (S) (28/06/2021)
- BH515 (D) (28/06/2021)
- BH516 (28/06/2021)

7.3.3. Although deviations were recorded within a number of samples, three sampling rounds were undertaken across the scheme and every monitoring well had at least one sampling round where no deviations were recorded. In samples which are listed above, in the rounds where no deviations were recorded organic contaminants for which the stability time was exceeded, were recorded below the GAC and/or the MDL of the determinand. No visual/olfactory evidence of contamination was recorded within the exploratory hole locations during the ground investigation where deviations were recorded.

Methodology

7.3.4. Controlled waters GQRA comprises comparison of chemical analysis results for the soil-derived leachate and groundwater samples collected from the site against appropriate water quality standards (WQS). Concentrations of contaminants which fall below the relevant WQS are not considered to represent an unacceptable risk. Those contaminants that exceed their respective WQS are termed contaminants of concern (CoC) and may require further assessment.

7.3.5. WQS selection depends on the controlled waters receptors identified at the site. There are two main watercourses identified from the topographical maps of the area, The River Etherow which flows through the eastern extents of the study area in a north to south direction and Hurtsclough Brook which flows through the western extents of the scheme in a north to south direction.

7.3.6. The Alluvium, River Terrace Deposits and bedrock underlying the scheme are classified as a Secondary A aquifers, while the Glacial Till is a Secondary Undifferentiated Aquifer. The closest groundwater abstraction is located 75 m north west of the red line boundary (over 150 m from where any major works are due to take place).

7.3.7. On the basis of the above, to assess the potential risks to the identified receptors, soil-derived leachate and groundwater samples have been compared against both the drinking water standards presented in “The Water Supply (Water Quality) Regulations (England and Wales) 2016” [16], and the freshwater environmental quality standards (EQS) presented in “The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015” (WFD Directions 2015) [27].

7.3.8. Benzo(a)pyrene has been used as the indicator species for most of the PAH. There are no UK DWS or EQS for petroleum hydrocarbon fractions, therefore the old UK DWS of 10 ug/l has been utilised to assess total petroleum hydrocarbons *in lieu* of an EQS and the WHO drinking water values for indicator TPH fractions to assess risks posed to groundwater (that is abstracted locally for human consumption).

Results

Soil-derived leachate assessment - DWS

7.3.9. Fourteen soil-derived leachate samples were analysed from exploratory hole locations during the recent ground investigation. Four samples collected from Made Ground, six samples from clay deposits, three from sand and one from peat. Concentrations of soil-derived leachate from the Atkins 2021 investigation that exceed the DWS screening value are presented in Table 7-3. The location of the maximum concentration is in **bold.** Full results of the assessment are presented in the factual GI report [8].

Table 7-3 – Soil derived leachate screening - DWS

Determinand	Unit	GAC (DWS)	Max. Conc.	Number of Exceedances/Number of samples	Locations of Exceedances (max conc location indicated in bold)
pH	pH units	6.5 to 9.5	9.7	1/14	**BH547 at 0.40 m bgl**
Cyanide (Total)	mg/l	0.05	0.07	1/14	**BH511 at 0.20 m bgl**
Arsenic	mg/l	0.01	0.028	1/14	**BH541 at 0.40 m bgl**
Lead	mg/l	0.01	0.022	2/14	**BH541 at 0.40 m bgl** BH510 at 0.50 m bgl
Phenol	Mg/l	0.05	0.055	1/14	**WS537 at 0.80 m bgl**

Soil-derived leachate assessment - EQS

7.3.10. The results of the soil-derived leachate screening against EQS are summarised in Table 7-4. Full results of the assessment are present in the factual GI report [8].

Table 7-4 – Soil derived leachate screening – EQS

Determinand	Unit	GAC	Max. Conc.	Number of Exceedances/Number of samples	Locations of Exceedances (max conc location indicated in bold)
pH	pH Units	6.0 to 9.0	9.7	1/14	**BH547 at 0.40 m bgl**
Nitrite	mg/l	0.01	0.19	11/14	WS537 at 0.80 m bgl BH516 at 0.50 m bgl BH533 at 0.50 m bgl BH538 at 0.50 m bgl BH547 at 0.40 m bgl BH527A at 0.20 m bgl BH519 at 0.50 m bgl BH518 at 0.20 m bgl BH510 at 0.50 m bgl TP503 at 0.90 m bgl **BH514A at 0.30 m bgl**
Copper	mg/l	0.001	0.019	13/14	WS537 at 0.80 m bgl BH511 at 0.20 m bgl BH516 at 0.50 m bgl BH533 at 0.50 m bgl BH508 at 0.50 m bgl BH547 at 0.40 m bgl BH541 at 0.40 m bgl BH527A at 0.20 m bgl BH519 at 0.50 m bgl BH518 at 0.20 m bgl **BH510 at 0.50 m bgl** TP503 at 0.90 m bgl BH514A at 0.30 m bgl
Nickel	mg/l	0.004	0.02	1/14	**BH514A at 0.30 m bgl**
Lead	mg/l	0.0012	0.022	5/14	BH547 at 0.40 m bgl **BH541 at 0.40 m bgl** BH518 at 0.20 m bgl BH510 at 0.50 m bgl BH514A at 0.30 m bgl
Zinc	mg/l	0.0123	0.028	3/14	WS537 at 0.80 m bgl BH547 at 0.40 m bgl **BH541 at 0.40 m bgl**
Mercury	Mg/l	0.00007	0.00059	1/14	**BH518 at 0.20 m bgl**

Groundwater assessment - DWS

7.3.11. Eighty-one groundwater samples from monitoring wells and two surface water samples were collected as part of the 2021 investigation. The results of the groundwater and surface water screening against DWS are summarised in Table 7-5and full results of the assessment are presented in the factual GI report [8]. It should be noted that no exceedances of the DWS were recorded within the surface water samples scheduled.

Table 7-5 – Groundwater screening – DWS (2021)

Determinand	Unit	DWS	Max. Conc.	Number of Exceedances/Number of samples	Locations of Exceedances (max conc location indicated in bold)
pH	pH	6.5-9.5	6.4	1/81	**BH509**
Chloride	mg/l	250	12000	5/81	BH513; **2 x BH509**; 2 x BH506(S)
Total Ammonia as N	Mg/l	0.39	0.59	2/81	**BH514A**, BH519A
Ammonium	mg/l	0.5	4.1	41/81	3 x BH536 (D); 3 x BH503; 3 x BH519A; BH520; 2 x BH547A; BH545(D); **2 x BH509;** BH506(S); 3 x BH514A; 2 x BH515(S); 2 x BH515(d); 2 x BH501; BH513; 3 x BH515; 2 x BH511; BH518; 2 x BH535(S); 2 x BH535(D); BH539; BH502; 536(S); BH516; BH506A(S);
Ammoniacal Nitrogen	mg/l	0.39	3.2	43/81	3 x BH536 (D); 3 x BH503; 3 x BH519A; BH520; 2 x BH547A; BH545(D); **2 x BH509;** BH506(S); 3 x BH514A; 4 x BH515(S); 3 x BH515(D); 2 x BH516; 2 x BH501; BH513; 2 x BH511; BH518; BH549; 2 x BH535(S); 2 x BH535(D); BH539; BH502; BH536(S); BH506A(S).
Nitrite	mg/l	0.5	4.4	8/81	BH516; BH518; BH520; BH550A; BH547; BH545; **BH541;** BH540.
Sulphate	mg/l	250	410	2/81	**2 x BH535(D)**
Cyanide (Total)	mg/l	0.05	0.1	1/81	**BH535**
Sodium	mg/l	200	5200	5/81	**2 x BH509**; BH506(S); BH535; BH539
Arsenic	mg/l	0.01	0.03	2/81	**BH539;** BH502
Iron	mg/l	0.2	53	9/81	**2 x BH509;** 2 x BH506(S); BH501; BH535; BH536; BH539; BH544 (S).
Manganese	mg/l	0.05	2.8	1/81	**BH519A**

Determinand	Unit	DWS	Max. Conc.	Number of Exceedances/Number of samples	Locations of Exceedances (max conc location indicated in bold)
Nickel	mg/l	0.02	0.095	3/81	**2 x BH509;** BH539.
Lead	mg/l	0.01	0.13	2/81	**BH539;** BH544 (S).
Selenium	mg/l	0.01	0.017	2/81	**BH506(S);** BH539.
1,2-Dichloroethane	mg/l	0.003	0.0039	1/38	**BH541.**
1,2-Dibromoethane	mg/l	0.0004	0.017	3/38	**BH520;** BH525(S); BH549.

Groundwater Assessment - EQS

7.3.12. The results of the groundwater screening against freshwater EQS are summarised in Table 7-6. Full results of the assessment are present in Appendix G.

Table 7-6 – Groundwater screening – EQS (2020)

Determinand	Unit	EQS	Max. Conc.	Number of Exceedances/Number of samples	Locations of Exceedances (max conc location indicated in bold)
pH	pH Units	6-9	9.4	1/81	**BH516.**
Chloride	mg/l	250	12000	5/81	BH513; **2 x BH509;** 2 x BH506(S);
Total Ammonia as N	Mg/l	0.2	0.59	11/81	2 x BH516, BH502, BH501, BH535(S), BH536(S), BH515(D), BH515(S), BH511, **BH514A(D),** BH519A
Ammonium	mg/l	0.26	4.1	61/81	2 x BH536 (D); BH541; 2 x BH513; 3 x BH502; 3 x BH503; 3 x BH519A; 2 x BH520; 3 x BH525(S); 2 x BH547A; 2 x BH545(D); **2 x BH509;** BH506(S); 3 x BH514A; 3 x BH511; 4 x BH515(S); 3 x BH515(d); 2 x BH501; BH513; 2 x BH516; BH517; BH518; 2 x BH524A; BH551; BH549; BH547; 2 x BH535 (S); 2 x BH535 (D); 3 x

Determinand	Unit	EQS	Max. Conc.	Number of Exceedances/Number of samples	Locations of Exceedances (max conc location indicated in bold)
					BH536 (S); BH540; BH539; BH506A(S);
Ammoniacal Nitrogen	mg/l	0.2	3.2	63/81	2 x BH536 (D); BH541; 2 x BH513 x BH502; 3 x BH503; 3 x BH519A; BH520; 3 x BH525(S); 2 x BH547A; BH545(D); **2 x BH509;** BH506(S); 3 x BH514A; 3 x BH511; 4 x BH515(S); 3 x BH515(d); 2 x BH516; 2 x BH536; 2 x BH501; BH513; BH517; BH518; BH520; 2 x BH524A; BH551; BH549; BH547; 2 x BH545; 2 x BH535(S); 2 x BH535(D); BH540; BH539; BH536(S); BH516; BH506A(S);
Nitrite	mg/l	0.01	4.4	49/81	2 x BH536 (D); **2 x BH541;** BH513; 2 x BH513; 2 x BH502; BH503; 2 x BH519A; 2 x BH520; BH525(S); BH547A; BH545(D); 2 x BH509; BH506(S); BH514A; 2 x BH511; 3 x BH515(d); 3 x BH516; 2 x BH514A; 2 x BH515 (S); BH518; 3 x BH524A; BH550A; BH551; BH549; BH547; BH545; BH535; BH538; BH540; Upstream; Downstream; BH525(D); BH536(S);

Determinand	Unit	EQS	Max. Conc.	Number of Exceedances/Number of samples	Locations of Exceedances (max conc location indicated in bold)
Sulphate	mg/l	400	410	1/81	**BH535**
Cyanide (Free)	mg/l	0.001	0.09	1/81	**BH535**
Cadmium	mg/l	0.00008	0.0019	13/81	2 x BH513; BH525(D); 2 x BH549; BH509; BH517; BH525; **BH551;** BH541; BH539; BH544 (D); BH544 (S)
Chromium	Mg/l	0.0047	0.023	5/81	BH515, **BH539**, Upstream, Downstream, H525(D)
Copper	mg/l	0.001	0.17	35/81	BH536 (D); 2 x BH541; BH520; 2 x BH524A; 3 x BH525(S); BH547A; BH509; BH506(S); 3 x BH516; 2 x BH538; BH513; 3 x BH515; 2 x BH514A; BH535; BH540; **BH539;** BH544 (D); BH544 (S); Upstream; 2 x BH519A ; Downstream; BH525(D); BH536(S).
Iron	mg/l	1	53	5/81	**2 x BH509;** BH501; BH539; BH544 (S)
Manganese	mg/l	0.123	2.8	1/81	**BH519A**
Nickel	mg/l	0.004	0.095	11/81	**2 x BH509;** BH506(S); BH516; BH502; BH541; BH540; BH539; BH544 (S); BH535(D); BH506A(S).
Lead	mg/l	0.0012	0.13	2/81	**BH539;** BH544 (S)
Zinc	mg/l	0.0123	0.23	24/81	2 x BH513; 4 x BH519A; BH520; 2 x BH525(D); 2 x BH509; BH506(S); BH517; 2 x BH525; BH551; BH549; BH541; BH540;

Determinand	Unit	EQS	Max. Conc.	Number of Exceedances/Number of samples	Locations of Exceedances (max conc location indicated in bold)
					BH539; BH544 (D); BH544 (S); Downstream; BH506A(S)

7.3.13. Concentrations of dichlorofluoromethane were recorded above the MDL of 0.001 mg/l with a maximum concentration of 0.0039 mg/l recorded within BH541. It should be noted that a GAC is currently not available for dichlorodifluoromethane.

7.4. Controlled waters discussion

7.4.1. The following CoC have been identified in relation to the Secondary A Aquifers (DWS):

- soil-derived leachate: pH, cyanide (total), arsenic, lead and phenol;
- groundwater: pH, chloride, ammonium, ammoniacal nitrogen, nitrite, sulphate, cyanide (total), sodium, arsenic, iron, manganese, nickel, lead, selenium, 1,2-Dichloroethane and 1,2-Dibromoethane.
- The following CoC have been identified in relation to the identified surface water features (EQS):
- soil-derived leachate: pH, nitrite, copper, nickel, lead and zinc;
- groundwater: pH, chloride, ammonium, ammoniacal nitrogen, nitrite, sulphate, cyanide (free), cadmium, copper, chromium, iron, manganese, nickel, lead and zinc.

7.4.2. Based on the results presented above, the recorded exceedances are scattered across the scheme with no discrete contamination hotspots identified. However, nitrite/ammonia/ammonium GAC exceedances are widespread in groundwater sampled from across the scheme.

7.4.3. Exceedances identified within leachate samples appear to be generally marginal, with all results within the same order of magnitude of the EQS or DWS.

7.4.4. Groundwater exceedances with the exception of chloride, 1,2-dibromoethane, nitrite, cadmium, copper and lead were considered to be marginal (within the same order of magnitude of either the EQS or DWS), and/or with only a few samples recording exceedances.

7.4.5. Chloride exceedances are recorded within five groundwater samples collected from three locations; BH513, BH509 and BH506(S). All three exploratory holes are located within Section 2 of the site in the vicinity of the proposed underpass. The source of elevated chloride concentrations within the area is unknown.

7.4.6. 1,2-dibromoethane was recorded above the DWS in three locations; BH520, BH525(S) and BH549. All three locations are located within Section 3 within the eastern cutting. BH520 and BH549 were installed within bedrock while BH525(S) was installed within the clay/bedrock. No visual/olfactory evidence of contamination was noted within the exploratory holes. Exploratory holes BH520, BH549 and BH525 are located within the current showground with no obvious historical sources of contamination on-site or within the vicinity (within 250 m of the site boundary).

7.4.7. Nitrite and ammonia/ammonium GAC exceedances were recorded primarily in areas of farmland/showground and are likely to be a result of decades of fertiliser application, a widespread and diffuse contamination source across the study area.

7.4.8. Soil leachate concentrations and/or occurrences (with the exception of copper) are considerably lower than those recorded within groundwater, indicating that contamination within groundwater is potentially from an off-site source.

7.4.9. The EQS for nickel, copper, lead, manganese and zinc relate to the bioavailable concentration, while the laboratory result refers to the total concentration. Comparing recorded total concentrations directly to "bioavailable EQS" will not provide a true indication of the risk potentially posed, as the fraction of the total concentration that is actually available for uptake is much less. Based on professional experience on numerous similar schemes, when the laboratory test results are converted to bioavailable concentrations (using water quality values from the receiving water and the "M-BAT" tool), the majority of the EQS exceedances disappear.

7.4.10. As part of the Arcadis GIR eight groundwater samples were tested to inform the risk to controlled waters and potential of groundwater beneath the site to be source or pathway of contamination. Exceedances of the EQS included zinc, chromium III, chromium VI, benzo(a)pyrene and TPH. Exceedances of the DWS included benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(123)pyrene and TPH. Exceedances were recorded within the Glacial Till or bedrock. The majority of exceedances recorded were considered by Arcadis to be marginal, with the exception of zinc which was recorded up to 722 ug/l. No soil leachate assessment was undertaken within the Arcadis GIR. TPH and PAH exceedances were generally recorded within the vicinity of Old Mill Underpass and Mottram underpass.

7.4.11. Although recorded during the 2018 Arcadis GI, no PAH or TPH exceedances were recorded within groundwater samples collected as part of the Atkins 2021 GI. Further heavy metal exceedances were recorded during the Atkins 2021 ground investigation compared to those recorded during the Arcadis 2018 GI, however, the majority of these are still considered to be marginal.

7.4.12. Overall, the majority of the contaminant concentrations were recorded below GAC/MDL and of those that were recorded above GAC many were either marginal exceedances or were recorded in less than five samples. Cadmium, copper, lead, nickel and zinc were recorded above GAC in 10 to 43 samples, however as discussed above it is likely the bioavailable concentrations are considerably lower. Nitrites/ammonia were recorded in excess of GAC in over half the groundwater samples, but these are likely to be associated with fertiliser application on farmland across the study area. Based on the above, it is unlikely the contaminants recorded in soil-leachate and groundwater samples on site would pose an unacceptable risk to controlled waters following completion of construction. However, dewatering is likely to be required during construction within Section 3 in the location of the cuttings, which is where a large proportion of the organic GAC exceedances were recorded. The potential risk posed to the controlled water bodies receiving the water abstracted during de-watering (and the associated dissolved contaminants) should be assessed further.

7.5. Ground gas risk assessment

7.5.1. The preliminary ground gas risk assessment has been undertaken in general accordance with BS 8485:2019 code of practice for design of protective measures for methane and carbon dioxide ground gases for new buildings (British Standards Institute, 2019). Although the proposed scheme does not include the construction of any new buildings, it includes an underpass and deep cuttings into which ground gas has the potential to migrate, and human receptors including road users and maintenance workers. BS8485 assessment process stresses the importance of considering the identified gas sources, geology, water levels and CSM, alongside gas monitoring data in deciding upon potential risk levels posed by ground gas. BS8485 also includes consideration of gas flow rates to generate a gas screening value, rather than relying on a gas threshold value in isolation and has been used to provide an initial indication of the risks ground gas recorded on site might pose.

7.5.2. BS8485:2019 states that hazardous gas flow rates (Qhg) should be calculated for methane and carbon dioxide for every borehole for each visit and suggests the Qhgs be presented alongside the gas monitoring results in a database (which is included in Appendix G). Qhg is calculated using the maximum gas concentration recorded (unless lower values can be justified) and the steady state flow rate using the below formula:

Qhg (l/hr) = flow rate (l/hr) x [gas concentration (%) / 100]

7.5.3. 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.

7.5.4. BS8485:2019 indicates that a decision must be made to determine whether the maximum Qhg in the dataset is appropriate to represent the site (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".

7.5.5. The GSV considered representative for the site 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 BS8485:2019. The GSVs and CS are presented in (which is based on Table 2 in BS8485:2019).

7.5.6. Adopting a GSV based on peak flow measurements (i.e., those measured initially after the gas tap is opened) might result in a disproportionately high gas hazard prediction and assignment of an over-precautionary GSV and Characteristic Situation (CS), leading to overly conservative gas protection measures being incorporated into the development.

Table 7-7 – Site characteristic GSV and associated characteristic situation

CS	Hazard Potential	Site Characteristic GSV (l/hr)	Additional Factors
1	Very Low Risk	<0.07	Typical methane <1 % and/or carbon dioxide <5 %. Otherwise consider increase to Characteristic Situation 2.
2	Low Risk	<0.7	Borehole air flow rate not to exceed 70 l/hr. Otherwise consider increase to Characteristic Situation 3.
3	Moderate Risk	<3.5	-
4	Moderate to High Risk	<15	Quantitative risk assessment required to evaluate scope of protective measure.
5	High Risk	<70	-
6	Very High Risk	>70	-

7.5.7. BS8485:2019 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 (Health and Safety Executive, 2011) 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.
- Hydrogen sulphide: 5 ppm for the long-term exposure limit of and 10 ppm for the short-term exposure limit.

Risk assessment

Hydrogen sulphide and carbon monoxide

7.5.8. Hydrogen sulphide was consistently measured below the WEL of 5 ppm for long term exposure, with a single exceedance of 6 ppm recorded within BH513 on one occasion. All hydrogen sulphide concentrations measured were below the short-term exposure limit of 10 ppm. All hydrogen sulphide concentrations recorded within the Arcadis GIR were measure at or below 1 ppm.

7.5.9. Carbon Monoxide concentrations were generally recorded below the WEL of 30 ppm with the exception of those outlined below:

- 91 ppm recorded within BH541;
- 93, 79.4 and 455 ppm recorded within BH513 (during all three visits undertaken); and
- 44 ppm recorded BH544(D).

7.5.10. During the Arcadis 2018 GIR carbon monoxide concentrations were noted to range between <1.0 and 19 ppm, with no locations exceeding the WEL of 30 ppm. Several carbon monoxide concentrations recorded during the recent 2021 GI are noted to be higher than those recorded previously. Elevated concentrations (>30 ppm) were recorded in boreholes with response zones targeting natural deposits (clay, gravel and sandstone/siltstone) and where the response zones were flooded during monitoring visits. It should be noted that during the drilling of BH513, a “gas” odour was noted by the drilling crew and supervising engineer. However, no visual evidence of contamination was noted. Groundwater GAC exceedances of both chloride and ammonium were noted in samples collected from BH513, which may be related to the odour interpreted by site staff as a “gas” odour.

7.5.11. Elevated carbon monoxide concentrations (BH513, BH541 and BH544(D)) were recorded within wells which had consistently flooded response zones, which would suggest carbon monoxide has disassociated from groundwater and collected into the small artificial void created by the sealed well. BH513, which recorded the highest carbon monoxide concentration is at the location of the underpass, however carbon monoxide was not recorded above 7 ppm in other boreholes located along the underpass alignment that also screen the bedrock (BH508 and BH510, which were unflooded, BH516 and BH517). Although “worst case” atmospheric conditions may not have been encountered, CL:AIRE TB17: Ground Gas Monitoring and Worst Case Conditions, August 2018 states “flow resulting from barometric pressure change is only significant where there is a large enough reservoir of gas and an open/highly permeable pathway”; the former of which has not been encountered on site. Overall, carbon monoxide and hydrogen sulphide are unlikely to pose an unacceptable risk to future site users due to limited exposure times and natural air flow through the underpass portals is likely to dilute ground gas concentrations to insignificant levels.

<u>Methane and carbon dioxide</u>

7.5.12. The Qhg of each monitoring well on each visit has been calculated and is presented within the database in Appendix G. A summary using the maximum concentrations and maximum steady state flow rates for each well is presented in Table 7-8.

Table 7-8 – Preliminary ground gas risk assessment

Section	Area of section	Exploratory Hole	Flow (l/hr) Max Steady	Methane (% v/v) Max	Carbon Dioxide (% v/v) Max	Qhg calculated for each well*	Deposits Screened
2	Mottram Underpass West Wing Walls	BH506A	0.1	<0.1	0.3	0.0003	Sandstone and Siltstone
	Roe Cross Bridge	BH508	<0.1**	<0.1	0.1	0.0001	Sandstone, Mudstone and Siltstone
	Mottram Underpass	BH510	0.1	<0.1	0.1	0.0001	Sandstone and Siltstone
	Mottram Underpass	BH513	0.1	<0.1	0.1	0.0001	Sandstone and Siltstone
	Mottram Underpass	BH514A	12.0	<0.1	0.2	0.024	Clay
	Mottram Underpass	BH516	0.2	<0.1	0.1	0.0002	Siltstone and Mudstone
	Mottram Underpass East Wing Walls	BH517	0.1	<0.1	0.1	0.0001	Sandstone
3	Mottram Underpass Eastern Cutting	BH549	<0.1**	<0.1	0.1	0.0001	Sandstone
	Mottram Underpass Eastern Cutting	BH551	<0.1**	<0.1	0.1	0.0001	Sandstone
	Mottram Underpass Eastern Cutting	BH550A	<0.1**	<0.1	0.1	0.0001	Sandstone
	Mottram Underpass Eastern Cutting	BH524A	<0.1**	<0.1	1.70	0.0017	Sandstone, Siltstone and Mudstone
	Mottram Underpass Eastern Cutting	BH520	<0.1**	<0.1	0.1	0.0001	Sandstone, Mudstone and Siltstone
	Mottram Underpass Eastern Cutting	BH525	<0.1**	<0.1	0.1	0.0001	Sandstone, Mudstone and Siltstone
	Mottram Underpass Eastern Cutting	BH522	0.1	<0.1	0.1	0.0001	Clay and Sandstone
4	Eastern Embankments	BH540	0.1	<0.1	0.8	0.0008	Clay
		BH544 (D)	<0.1**	<0.1	0.2	0.0002	Gravel
	Carrhouse Lane Underpass	BH541	2.5	0.1	0.9	0.0225	Clay

Notes:

Shading indicates response zone completely flooded during all monitoring visits

*Maximum gas concentration combined within maximum steady state flow rate, recorded on any visit. Note that for the un-shaded rows, data from those visits in which the response well was completely flooded have not been used within this assessment.

**These concentrations were recorded as not detected in the field, therefore the LOD of the GA5000 has been used in the calculations

7.5.13. Following a review of barometric pressure trends on the lead up to the monitoring rounds undertaken, it appears no monitoring rounds were undertaken during a low/falling atmospheric pressure (where pressure fell to below 1000mb). However, the pressure data viewed online does not show the necessary detail (i.e. hourly readings) to be able to confirm whether this constitutes "worst case" conditions as described in CL:AIRE TB17: Ground Gas Monitoring and Worst Case Conditions August 2018. TB17 states "flow resulting from barometric pressure change is only significant where there is a large enough reservoir of gas and an open/highly permeable pathway"; the former of which has not been encountered on site.

7.5.14. During all three monitoring rounds a number of exploratory holes had flooded response zones on a few, or all, visits (grey shading in Table 7-8 above). BS 8485:2019 indicates that when a response zone is completely flooded the data may not be representative of the gas regime and such data should be treated with caution (and potentially discarded from further assessment).

7.5.15. Concentrations of methane were consistently measured at and/or below the LOD in all of the boreholes across all monitoring visits undertaken. Maximum carbon dioxide concentrations ranged from 0.1 % v/v to 1.7 % v/v. Maximum steady state flow rates within unflooded response zones were all recorded at/or below the LOD.

7.5.16. The ground gas risk assessment undertaken within the Arcadis GIR recorded maximum CO_2 concentrations of 1.3 % v/v, maximum methane concentrations of 0.7 % v/v and maximum steady state flow rates of 0.1 l/hr. Concentrations recorded during both phases of ground investigation appear to be similar, with slightly elevated concentrations of methane recorded during the Arcadis GI.

7.5.17. No potential sources of ground gas were identified during the ground investigation, other than pockets of peat. Peat was encountered during the investigation in localised areas, but was not present in any of the deposits spanned by the response zone of a well. The peat recorded within BH537 is located underneath a section of proposed new road with no buildings located within 100 m of this position. It is unlikely that ground gas is going to be produced at significant enough volumes to pose an unacceptable risk and that no new pathways are likely to be created during construction of the scheme.

7.5.18. No obvious sources of volatile contaminants were identified during the desk based review, ground investigation or during chemical analysis of soils and groundwater. VOCs/organics have been recorded within groundwater in five locations across the site, however, concentrations are unlikely to be sufficient to be a significant source organic vapours of gas.

7.5.19. In summary, an initial assessment undertaken in line with BS8485 risk assessment methodology indicates that the site is likely to be classified as "very low risk". Minimal sources of ground gas have been identified on site, none of which are likely to generate sufficient gas volumes to drive gas migration into the underpass or cuttings at concentrations likely to adversely impact health. This is supported by the recorded concentrations and flow rates. In addition, natural air flow through the underpass and cuttings is likely to dilute the ground gas that might be emitted from the bedrock to insignificant levels. The findings of this preliminary gas assessment suggest the overall ground gas risk for road users and maintenance workers of the scheme is low.

7.5.20. During construction the underpass and cutting excavations might be considered confined spaces and employers/contractors should undertake the usual risk assessments/precautions that are required for work in such conditions.

7.6. Revised conceptual model

7.6.1. The findings of the recent ground investigation and GQRA have been used to update the Initial CSM presented in section 2.11.

7.6.2. Under current health and safety legislation, construction and maintenance staff are required to carry out their own appropriate risk assessments and mitigation to protect their staff, other human receptors and the environment from potential contamination. Such risks must be adequately mitigated by law, specifically the Construction Design Management (CDM) Regulations (Health and Safety Statutory Executive, 2015), that require potential risks to human health and the environment from construction activities are appropriately identified and all necessary steps taken to eliminate/manage that risk. Therefore, construction/maintenance workers have been discounted as human receptors from the CSM.

Table 7-9 – Revised conceptual model

Sources	Receptors	Potential Pathway	Likelihood	Consequence	Risk
Potential contaminants in soil / groundwater on site originating from the following sources: Onsite: Made Ground Peat Offsite: Fuel station (50 m) Historical landfills (100+m) Melandra Road Waste Disposal Site (100 m) Roe Cross Quarry (250 m) Mottram Woollen Mill (50 m) Gas works (200 m) Mill and bleach works and Sewage works (100 m) **Contaminants identified during the GQRAs include:** **2021 Human Health:** Benzo(a)pyrene exceeded public open space (parks) GAC. **2018 Human Health**: lead and dibenz(ah)anthracene exceed the public open space (residential) GAC. No exceedances recorded if compared to public open space (parks) GAC. **2021 Controlled Waters:** pH, cyanide (total and free), arsenic, lead, copper, chloride, cadmium, chromium, ammonium, ammoniacal nitrogen, nitrite, sulphate, sodium, iron, manganese, nickel, selenium, zinc, phenol, 1,2-Dichloroethane and 1,2-Dibromoethane. **2018 Controlled Waters:** zinc, chromium (III & VI), benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, indeno(123)pyrene and TPH. **2021 Ground Gas**: CS1 **2018 Ground Gas**: CS2	On-site and off-site: public using road (and on verge if breakdown), off-site and occupiers of residential and non-residential properties, farm workers and users of show ground (including after temporary works areas are returned to current landowners)	Inhalation, ingestion and dermal contact with contaminants in soil and soil-derived dust/fibres and groundwater.	Low	Mild	**Low Risk** The extent of land within the new highways boundary is likely to be covered with hardstanding and/or vegetation which would limit exposure to potential contaminants in soils and limit dust generation. Road users and pedestrians utilising the site for limited exposure periods. Therefore, the potential for site users to come into contact with surface soils is very low. Excavation arisings will need to meet re-use criteria (that are specific to the end-use) before they are reused on site and/or in temporary works areas (e.g. construction compounds, access routes or above the new underpasses) in accordance with current regulations/guidance. If any water supply pipes require re-routing/relaying then an appropriate United Utilities Risk Assessment will need to be undertaken to assess the potential risks posed to water supply pipes and off site users.
		Inhalation of airborne asbestos fibres	Unlikely	Severe	**Moderate/Low Risk** No Asbestos containing materials were identified within the 41 samples tested as part of the Atkins GI. Also, asbestos was not identified during the Arcadis GI. As the site is likely to be covered in hardstanding and/or vegetation, it is unlikely that asbestos would be exposed at the surface, therefore reducing the likelihood of exposure to future site users. (The “severe” consequence automatically derives a moderate/low risk rating, although it is emphasised that no asbestos has been identified during works conducted to date.) **However, there is a potential for asbestos to be present in any areas of previously disturbed ground, including on farmland.** Staff involved in excavation of Made Ground should have an appropriate level of asbestos training and asbestos should be included in any test suites when re-using Made Ground. Advice should be sought from a specialist asbestos contractor if suspect materials are identified during construction.
		Migration & inhalation of ground and / or vapours from contaminants at the site.	Low	Mild	**Low Risk** No exceedances of the human health soils VOC or WSVs were recorded. PID concentrations within soils were generally measured at/or below the limit of detection (0.1 ppm). The majority of VOC/SVOCs were not recorded above MDL. There are no major sources of VOCs identified on-site. Fuel Stations located within 250 m of the red line boundary are considered unlikely to pose an unacceptable risk. Fuel stations are not located within the vicinity of areas where dewatering is likely to be required. Fuel stations are located in areas downgradient of major excavation areas and therefore it is unlikely that potentially contaminated groundwater will flow underneath the site. Following the preliminary gas assessment, the site has been classified as a CS1 as it presents a very low risk to future users/property. The desk study review and both ground investigations did not identify significant gas sources on-site or within 100 m of the main works areas and low concentrations of methane and carbon dioxide were recorded, which would suggest the gas generation potential is low. As no new buildings are proposed on-site and exposure times are likely to be low (site use as a

Sources	Receptors	Potential Pathway	Likelihood	Consequence	Risk
					road), it is unlikely that ground gas/vapours will pose an unacceptable risk as they would disperse into atmosphere. It is unlikely the proposed scheme or installation of new service trenches would significantly alter the current ground gas risk and it is unlikely the scheme would pose an unacceptable risk to nearby properties in relation to ground gas.
	Secondary A Aquifers (Alluvium, River Terrace Deposits and bedrock) River Etherow and Hurtsclough Brook	Leaching from unsaturated soils to shallow groundwater then migration of dissolved or separated non-aqueous phase contamination within groundwater. Lateral migration beneath the site to surface water receptors.	Likely	Mild	**Moderate/Low Risk** Based on GQRA, it is unlikely the contaminants recorded in soil-leachate and groundwater samples on site would pose an unacceptable risk to controlled waters following completion of construction. However, dewatering is likely to be required during construction within Section 3, which is where a large proportion of the organic GAC exceedances were recorded. The potential risk posed to the controlled water bodies receiving the water abstracted during de-watering (and the associated dissolved contaminants) should be assessed further.

8. Potential Reuse and Disposal of Materials

8.1. Material re-use – geo-environmental considerations

8.1.1. The re-use of excavation arisings on-site must be undertaken in accordance with either the Environmental Permitting Regulations 2006 (EPR) [28], or under the approach presented in the CL:AIRE Definition of Waste: Development Industry Code of Practice (CoP) Version 2 [29] which was published in March 2011 and is accepted as an alternative to the EPR. Since March 2010, Environmental Permit Exemptions (EPE) have been very restricted in their applicability to construction projects with only very small quantities falling within the EPE regime.

8.1.2. Under the CL:AIRE voluntary CoP [29], materials excavated on-site may be re-used on site providing they meet certain criteria, one of which is they must not pose an unacceptable risk to human health or the environment. The CoP regime requires that a 'Qualified Person', as defined under the CoP, reviews the proposed Materials Management Plan (MMP) and the supporting Risk Assessments, Remediation Strategy / Design Statement and communications with the relevant Regulatory authorities, prior to completion of and registration of the Declaration.

8.1.3. Following consideration of the GQRA findings, it is unlikely the contaminants recorded in soils and groundwater in the previous and recent investigations would pose an unacceptable risk to identified receptors following completion of the scheme. This is on the assumption that appropriate re-use criteria are selected/derived for the various future end-uses (e.g. highway, showground or farmland) and existing controlled waters receptors (e.g. materials re-used in the vicinity of surface waters).

8.1.4. Re-use of construction arisings should be undertaken in accordance with an approved MMP or environmental permit, with verification testing undertaken to confirm materials meet re-use criteria, all to be documented in a verification report.

8.2. Material re-use – geotechnical considerations

8.2.1. To be completed by BB.

8.3. Classification of materials for off-site disposal

CAT-WASTE assessment

8.3.1. To classify materials that may potentially be excavated across the site during construction works and require disposal off-site to a waste recycling of landfill facility, a number of steps are required as part of the WM3 Regulations [30] and the Waste Regulations. The initial steps are to identify:

i. if the materials are waste and whether classification is required;

ii. whether the waste is required to be classified at all;

iii. the relevant List of Waste (LoW) codes;

iv. the chemical composition of the material; and,

v. if the substances in the waste are 'hazardous substances' or 'Persistent Organic Pollutants'.

8.3.2. A preliminary waste assessment has been undertaken using the online Atkins/McArdle waste classification tool CAT-WASTE Soil [31]. CAT-WASTE Soil has been designed to cover the European Waste Catalogue code number 17 05 03 “soil and stones containing dangerous substances”. The assessment of chemical data to determine the potential non-hazardous / hazardous status has been developed with careful adherence to the relevant authoritative guidance.

8.3.3. CAT-WASTE Soil provides preliminary waste characterisation only and is based on the limited number of samples scheduled for analysis. Actual material to be removed off-site for disposal must be appropriately tested, classified and disposed of in agreement with the chosen waste operator (which will include WAC analysis if the waste has to go to a landfill).

8.3.4. Analytical results from 41 soil samples tested as part of the Atkins investigation were uploaded into CAT-WASTE Soil and the output of the tool is provided in Appendix G. All samples were classified as non-hazardous.

8.3.5. Arcadis also undertook a preliminary waste classification using HazWasteOnline. The chemical testing results for 84 samples were screened with 77 sample being classified as non-hazardous based on the determinands analysed. Seven samples were identified as potentially hazardous due to marginally elevated concentrations of Chromium VI.

8.3.6. Should any material from site be considered for off-site disposal, liaison with waste facility operators should be undertaken prior to disposal. Copies of the laboratory analysis undertaken on soil samples from site should be presented to the waste disposal / landfill operator(s) so that they can confirm their requirements.

8.3.7. Material that needs to be discarded (e.g. because of contamination / engineering properties, or surplus to the development requirements), including water which should be collected and disposed of as part of wheel washing operations, is waste and should be disposed of in accordance with the current relevant regulations. These include, but are not limited to, Duty of Care, the Landfill Regulations, the Hazardous Waste Regulations and Publication WM3.

8.4. Verification testing of imported material

8.4.1. The appointed contractor will be responsible for ensuring that any imported material required for the project is suitable for use on the site. This will include ensuring that that material does not contain contaminants which may impact on identified receptors. Material to be imported onto site should be agreed with a suitably qualified land contamination specialist and will require evidence from chemical testing of material and should meet the requirements of the Earthworks Specification and/or remediation strategy / design statement (i.e. test results should meet the import criteria or Threshold Values).

8.4.2. The minimum testing frequencies, to be considered by the appointed contractor, are recommended to be as advised in the YALPAG guidance [32] which in summary states:

Virgin quarried material	– 1 or 2 samples to confirm the inert nature of the material.
Greenfield/ Manufactured soils	– Minimum 3 samples or 1 per 250 m^3 (whichever is greater).
Brownfield/Screened Soils	– Minimum 6 or 1 per 100 m^3 (whichever is greater)

9. Conclusions and Recommendations

9.1. Geotechnical

9.1.1. The ground investigation undertaken in 2021 indicates results and ground conditions that are in line with the previous phases of investigations.

9.1.2. The following table notes differences in the design parameters between those recommended in the main Arcadis GIR and those presented within this Addendum. In particular the approach to derivation of the angle of shearing resistance was not defined between peak and constant volume values within the main GIR. This Addendum has defined and separated these different values for clarity.

Table 9-1 – Summary of significant parameter differences between Arcadis GIR and Atkins GIR Addendum

Section of the scheme	Material	Parameter	Arcadis main GIR value	Atkins addendum value	Comment
1	Glacial Till (cohesive)	Peak angle of shearing resistance	Western Embankments: 26°	30°	Arcadis GIR has not considered the difference between peak angle, and constant volume angle, therefore it is unknown which results were reported. Additionally, upon reviewing all available data from the various phases, the derived parameter has also been slightly increased.
		Undrained shear strength (Cu)	Varied *(Split across 4 sub-sections within section 1 of scheme)*	0-7mBGL = 50kPa 7-22mBGL = 50kPa +4.5z	Addendum has considered Section 1 in full, without splitting areas. Data from the additional Phase 5 GI shows a reduced increase in strength / stiffness with depth.
		Undrained Elastic Modulus (Eu)	Varied *(Split across 4 sub-sections within section 1 of scheme)*	0-20mBGL = 10MPa + 1z 20-25mBGL = 30MPa	
		Drained stiffness (E')	Varied *(Split across 4 sub-sections within section 1 of scheme)*	0-20mBGL = 7.6MPa + 0.762z 20-25mBGL = 22.8MPa	
	Glacial Till (granular)	Drained stiffness (E')	4m: 16MPa + 3.14z	26MPa	Addendum has not considered an increase in stiffness with depth as the limited data does not support this relationship.

Section of the scheme	Material	Parameter	Arcadis main GIR value	Atkins addendum value	Comment
2	Made Ground (granular)	Drained stiffness (E’)	10MPa	30MPa	More data obtained during Phase 5 GI, therefore more confidence in data.
	Glacial Till (granular)	Peak angle of shearing resistance (φ')	28°	33°	Arcadis GIR has not considered the difference between peak angle, and constant volume angle, therefore it is unknown which results were reported. Additionally, more data obtained during Phase 5 GI showed an increased angle compared to the Arcadis selected value.
		Drained stiffness (E’)	30MPa	40MPa	More data obtained during Phase 5 GI, therefore more confidence in data. Decided that stiffness value could be increased from Arcadis’ previously derived parameter.
3	Glacial Till (cohesive)	Peak angle of shearing resistance (φ')	26°	30°	Arcadis GIR has not considered the difference between peak angle, and constant volume angle, therefore it is unknown which results were reported. More data obtained during Phase 5 GI showed a decreased angle compared to Arcadis’.
	Glacial Till (granular)	Drained stiffness (E’)	40MPa	50MPa	More data obtained during Phase 5 GI, therefore more confidence in data. Decided that stiffness value could be increased from Arcadis’ previously derived parameter.

*Stiffness values based on SPT also display similar differences from the main GIR to this addendum.

9.1.3. Due to the amendments to the way in which superficial material was grouped in Section 4 of the scheme, the parameters in this section differ to those suggested by the Arcadis GIR (Arcadis, 2018). As previously mentioned, it is suggested that designers use the Section 4 parameters developed in this report as guidance and develop specific ground models for detailed design.

9.1.4. In addition to those items highlighted in **Error! Reference source not found.** above, t he strength and stiffness parameters selected for the rock encountered across the site varies significantly in this addendum when compared to the figures presented in the main GIR (Arcadis, 2018). This is due to two main reasons:

- Firstly, rock weathering descriptions were used to sub-group the rock in the Arcadis GIR. There were three different weathering grades (highly/moderately/slightly weathered) assigned to each rock type (mudstone, siltstone and sandstone) based on log description. Upon receipt of the 2021 data and further assessment, it was concluded that the separation by weathering grades was misleading and no significant difference was encountered between the grades to justify splitting them. Therefore, in this GIR addendum report, the rock has only been split by Section of the route and rock type (mudstone, siltstone and sandstone).
- Secondly, the design values assigned in this addendum report are very conservative based on the available data. This is due to variability of the rock, particularly close to the rockhead.

9.1.5. It is therefore recommended that during detailed design, location specific data is used, and design values amended as necessary for the element being designed.

9.2. Land contamination

9.2.1. Table 9-2 and the revised Conceptual Site Model (CSM) presented in section 8 comprise the decision record for this stage of risk assessment. The Land Contamination Risk Management (LCRM) guidance states that confirmed pollutant linkages become Relevant Contaminant Linkages (RCLs). For the purpose of this report, RPLs are considered those where the risk level in the revised CSM is higher than Moderate/Low and some form of mitigation before or during construction is considered likely to be required. All of the PCLs in the revised CSM are Moderate/Low or less, which indicates it is unlikely the contamination recorded on site to date will require remediation.

9.2.2. Table 9-2 is a summary of the key findings of the Arcadis and Atkins ground investigations/GQRAs with respect to land contamination and future recommended actions. The assessments within this report are based on the scheme as described in Section 1. As the design of the scheme evolves, the GQRA and CSM contained within this report should be reviewed and updated accordingly.

Table 9-2 – Land contamination constraints and recommendations

Item	Findings of Initial Assessments	Implications to scheme
Exposure of workforce to contaminants in soil/water	Substances including metals and organics have been recorded within soil and groundwater. Asbestos was not recorded in the samples tested.	The chemical test results from both investigations should be reviewed by future contractors to inform health and safety risk assessments for those workers likely to come into contact with Made Ground and/or groundwater. Due to the presence of Made Ground at the site, vigilance should be maintained during earthworks by appropriately experienced/trained staff in case asbestos is found. An asbestos specialist should be contacted if it is encountered during construction and advice sought on what mitigation measures are required to protect the workforce.
Re-use of site won arisings (Made Ground and natural deposits) within the site boundary	Overall, the risk assessments indicate site won arisings might be appropriate for re-use on the site as they are unlikely to pose an unacceptable risk to human health or controlled waters, depending on where they are used. For example where soils exceed open spaces GAC, these could be used within the fenceline of the new highway.	Re-use criteria should be selected/derived for the various different land uses (e.g., farmworkers on land that was used as a construction compound, or soils being placed within 50m of the river) and included within a design statement and/or earthworks specification. Material reuse must comply the requirements of a materials management plan or environmental permit (as well as the earthworks specification). Materials should be tested and compared to re-use criteria, with a verification report prepared to confirm compliance with the MMP, etc. The findings of this report and the selected re-use values should be issued to the contaminated land officers at the Local Council and Environment Agency for their approval, prior to submission of the MMP/permit.
Disposal of waste soils.	Preliminary waste characterisations indicate the majority of samples from across the site might be considered non-hazardous for off-site disposal. Arcadis identified seven samples that might be considered hazardous due to elevated Chromium III.	Further sampling/analysis and waste classification will be required. Additional WAC tests might also be required if the wastes are going to a landfill. It is recommended the client/contractor discuss lab results and soil descriptions with a variety of waste management /soil recycling operators to confirm options.
Discharge of groundwater that has been abstracted during construction works to de-water deep excavations	Various inorganic and organic contaminants have been recorded within groundwater at concentrations that exceed DWS and/or EQS.	The potential risk posed to the receiving water (whether groundwater or the river) from contaminants recorded within the zone of a groundwater body to be abstracted, should be assessed to ensure the dewatering activities do not pose an unacceptable risk to controlled waters.

Item	Findings of Initial Assessments	Implications to scheme
Piled foundations, drainage/service trenches (inadvertent creation of preferential pathways)		The potential to create preferential contaminant migration pathways between different groundwater bodies (e.g. alluvium and bedrock) or to a surface water should be considered in conjunction with design. Degree of risk will depend on the locations/type of a structure (and hence likelihood of pathway creation) and the contaminants recorded in the different groundwater bodies at that location. Piling risk assessments in accordance with Environment Agency guidance should be undertaken to further assess the above.
Ground Gas and vapour risks (from VOCs)	No exceedances of the human health volatile GACs/WSVs were recorded. Soil/groundwater vapour is unlikely to pose an unacceptable risk. Initial ground gas risk assessment indicates a very low risk.	The gas monitoring results and assessments indicate an overall low risk to end-users from ground gas. However, given the location of Carrhouse Lane landfill Arcadis considered there might be an acute risk to construction/maintenance workers in nearby excavations. As with any deep excavations, the potential for ground gas and/or low oxygen conditions should be considered within construction contractors' health and safety risk assessments. Peat was also recorded in several boreholes. Although thick, laterally extensive peat deposits are not anticipated, vigilance should be maintained during excavation of service trenches and if peat/putrescible/organic material is encountered then it is recommended that ground gas specialists are consulted to consider whether installation of clay stanks is required to minimise lateral gas migration.
Unexpected Contamination	N/A	As with any development there is the possibility of finding ground/gas/contamination conditions that vary from those recorded in the ground investigation. Construction team should be vigilant and if such is encountered, stop work in that area and seek advice from contamination specialists and inform the planning authority. Further sampling and assessment might be required to evaluate the risk.
Decommissioning monitoring wells	N/A	Prior to construction, all monitoring wells must be decommissioned in accordance with the Environment Agency's guidance "Good Practice for Decommissioning Redundant Boreholes and Wells" dated October 2012. This is essential to prevent the wells from inadvertently becoming preferential migration pathways for dissolved contaminants or gas. Inadequately sealed boreholes might also become a pathway by which artesian groundwater could flow into higher groundwater units and/or cause surface flooding.

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Appendices

Appendix A. Drawings

DO NOT SCALE

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GEOLOGY SECTION KEY

GEOL CODE	DESCRIPTION
ALVC	Alluvium Cohesive
ALVG	Alluvium Granular
ALVP	Alluvium Peat
GLTC	Glacial Till Cohesive
GLTG	Glacial Till Granular
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PEAT	Peat
TS	Topsoil
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MSGG-M-H	Millstone Grit Group Highly Weathered Mudstone
MSGG-M-M	Millstone Grit Group Moderately Weathered Mudstone
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MSGG-SND-M	Millstone Grit Group Moderately Weathered Sandstone
MSGG-SND-S	Millstone Grit Group Slightly Weathered Sandstone
MSGG-SS	Millstone Grit Group Slickenside Surface
	No Recovery

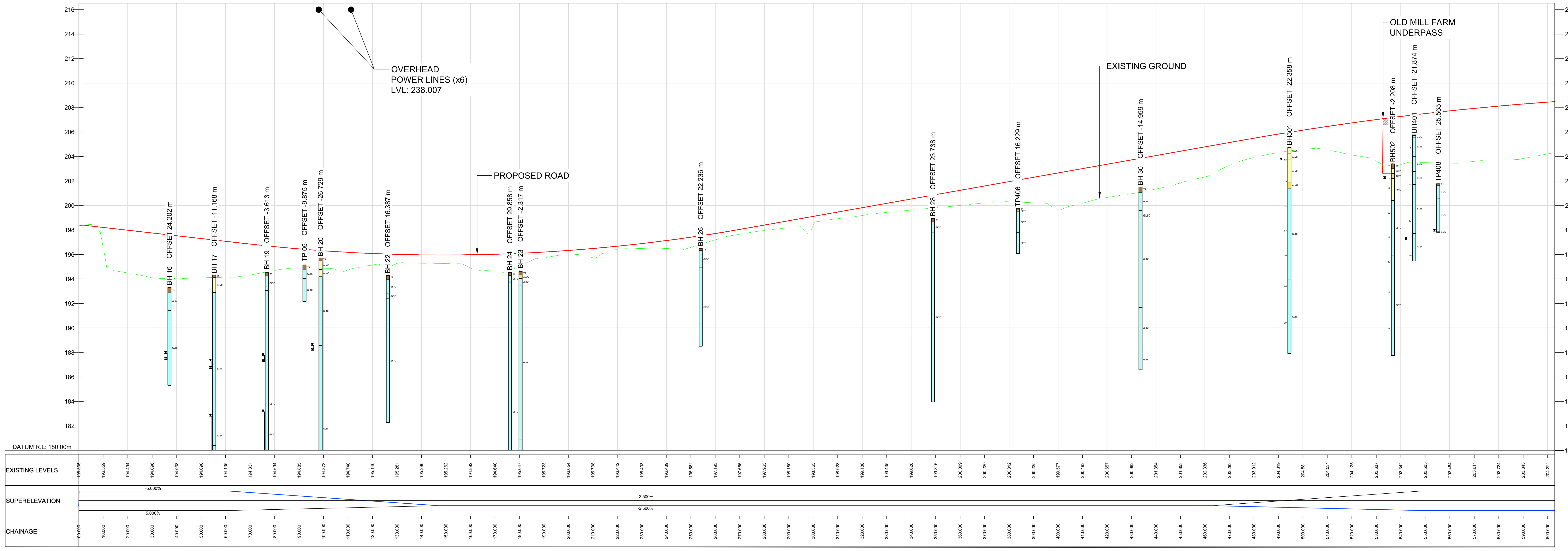
INSTALLATION RESPONSE ZONE

MAXIMUM MEASURED GROUNDWATER LEVEL WITHIN MONITORING INSTALLATION

GROUNDWATER STRIKE LEVEL

GROUNDWATER LEVEL AFTER 20 MINS

29 SPT N-VALUES (NUMBERS AT SIDE OF BH STICKS)



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HORIZONTAL SCALE

Scale 1:200
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VERTICAL SCALE

NOTES

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5. 30m BUFFER EACH SIDE OF THE ROAD CENTRE ALIGNMENT HAS BEEN USED FOR THE EXPLORATORY HOLES IN THE LONG SECTION.

PROPOSED HIGHWAY ALIGNMENT

EXISTING GROUND

PLAN KEY

HISTORICAL BOREHOLE LOCATION

HISTORICAL TRIAL PIT LOCATION

PHASE 5 BOREHOLE LOCATION

PHASE 5 TRIAL PIT LOCATION

PHASE 5 CONE PENETROMETER TEST

2450 ROAD ALIGNMENT CHAINAGE

SITE BOUNDARY

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
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Maintenance / Cleaning
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Use
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Decommissioning / Demolition
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Description	Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Issue to NH	S3	P01	CC	GDS	JJ	---	19/01/22
Revised based on NH comments	S4	C01	CC	GDS	MSR	MSR	17/03/22

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Status: S4

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Client: highways england

Project Title: A57 TPU

Drawing Title: A57 LINK ROADS GEOLOGICAL LONG SECTION ALL GI DATA SHEET 1 OF 8

Drawing Number
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GEOLOGY SECTION KEY

GEOL CODE	DESCRIPTION
ALVC	Alluvium Cohesive
ALVG	Alluvium Granular
ALVP	Alluvium Peat
GLTC	Glacial Till Cohesive
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	No Recovery

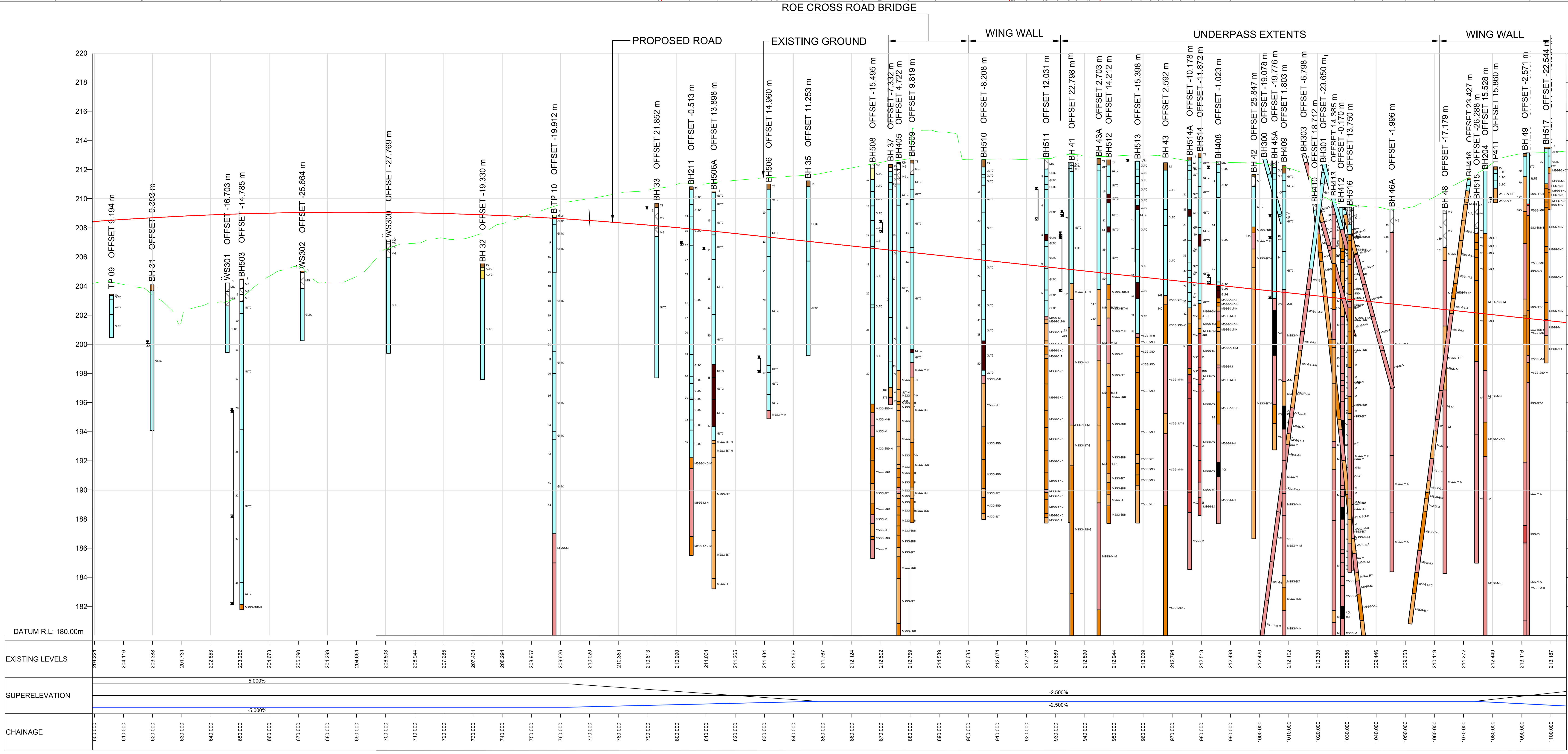
INSTALLATION RESPONSE ZONE

MAXIMUM MEASURED GROUNDWATER LEVEL WITHIN MONITORING INSTALLATION

GROUNDWATER STRIKE LEVEL

GROUNDWATER LEVEL AFTER 20 MINS

29 SPT N-VALUES (NUMBERS AT SIDE OF BH STICKS)



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5. 30m BUFFER EACH SIDE OF THE ROAD CENTRE ALIGNMENT HAS BEEN USED FOR THE EXPLORATORY HOLES IN THE LONG SECTION.

PROPOSED HIGHWAY ALIGNMENT
EXISTING GROUND

PLAN KEY

- HISTORICAL BOREHOLE LOCATION
- HISTORICAL TRIAL PIT LOCATION
- PHASE 5 BOREHOLE LOCATION
- PHASE 5 TRIAL PIT LOCATION
- PHASE 5 CONE PENETROMETER TEST
- ROAD ALIGNMENT CHAINAGE (2450)
- SITE BOUNDARY

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Decommissioning / Demolition
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
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Description: Issue to NH						
S3	P01	CC	GDS	JJ	---	19/01/22
Description: Revised based on NH comments						
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Drawing Title: A57 LINK ROADS GEOLOGICAL LONG SECTION ALL GI DATA SHEET 2 OF 8

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INSTALLATION RESPONSE ZONE

MAXIMUM MEASURED GROUNDWATER LEVEL WITHIN MONITORING INSTALLATION

GROUNDWATER STRIKE LEVEL

GROUNDWATER LEVEL AFTER 20 MINS

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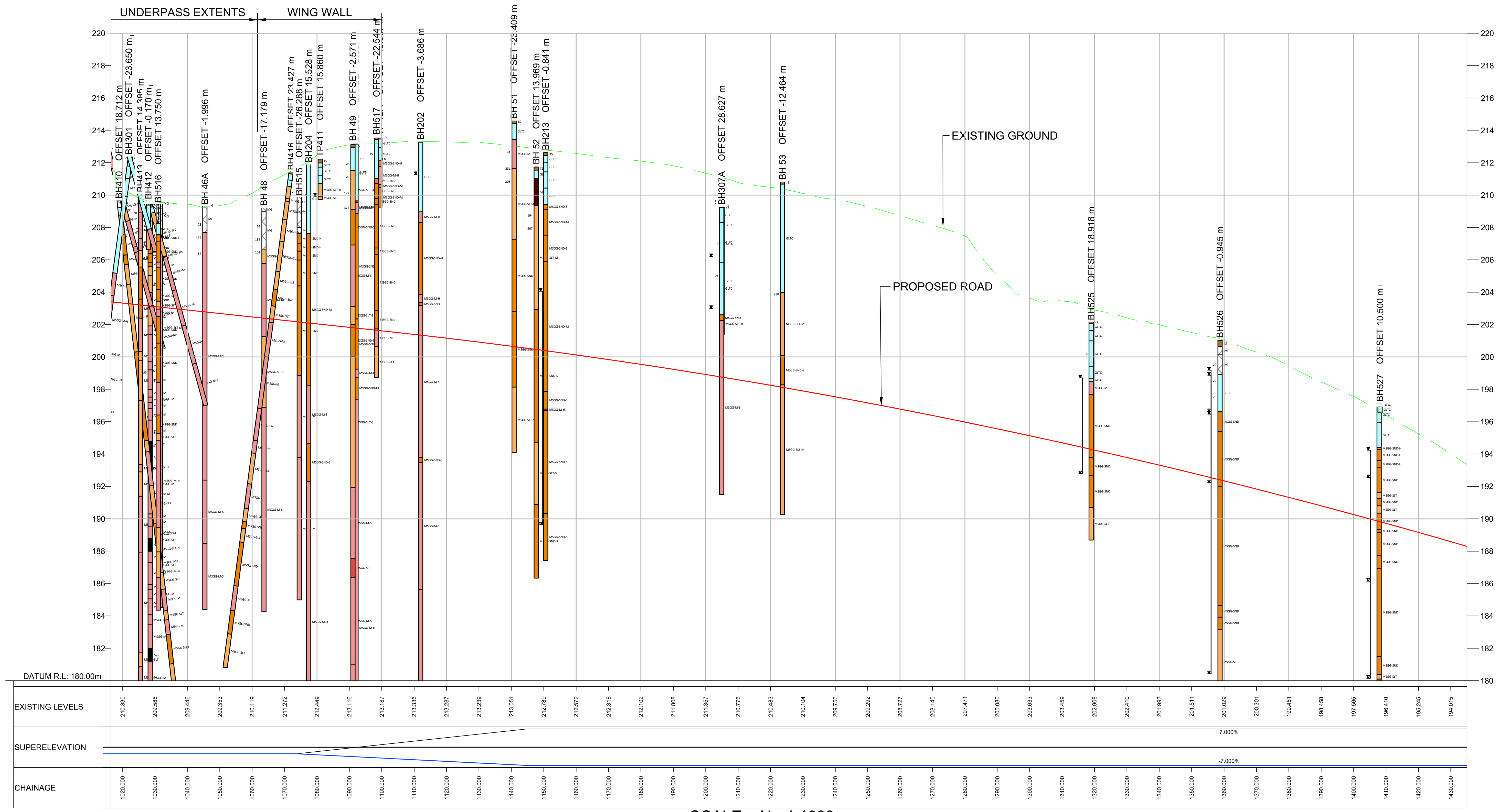

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PROPOSED HIGHWAY ALIGNMENT
EXISTING GROUND

PLAN KEY

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Revised based on NH comments	S4	C01	CC	GDS	MSR	MSR	17/03/22

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Project Title: A57 TPU

Drawing Title: A57 LINK ROADS GEOLOGICAL LONG SECTION ALL GI DATA SHEET 3 OF 8

Drawing Number: HE551473 - BBA - HGT - A57_AL_SCHEME - DR - CE - 000023
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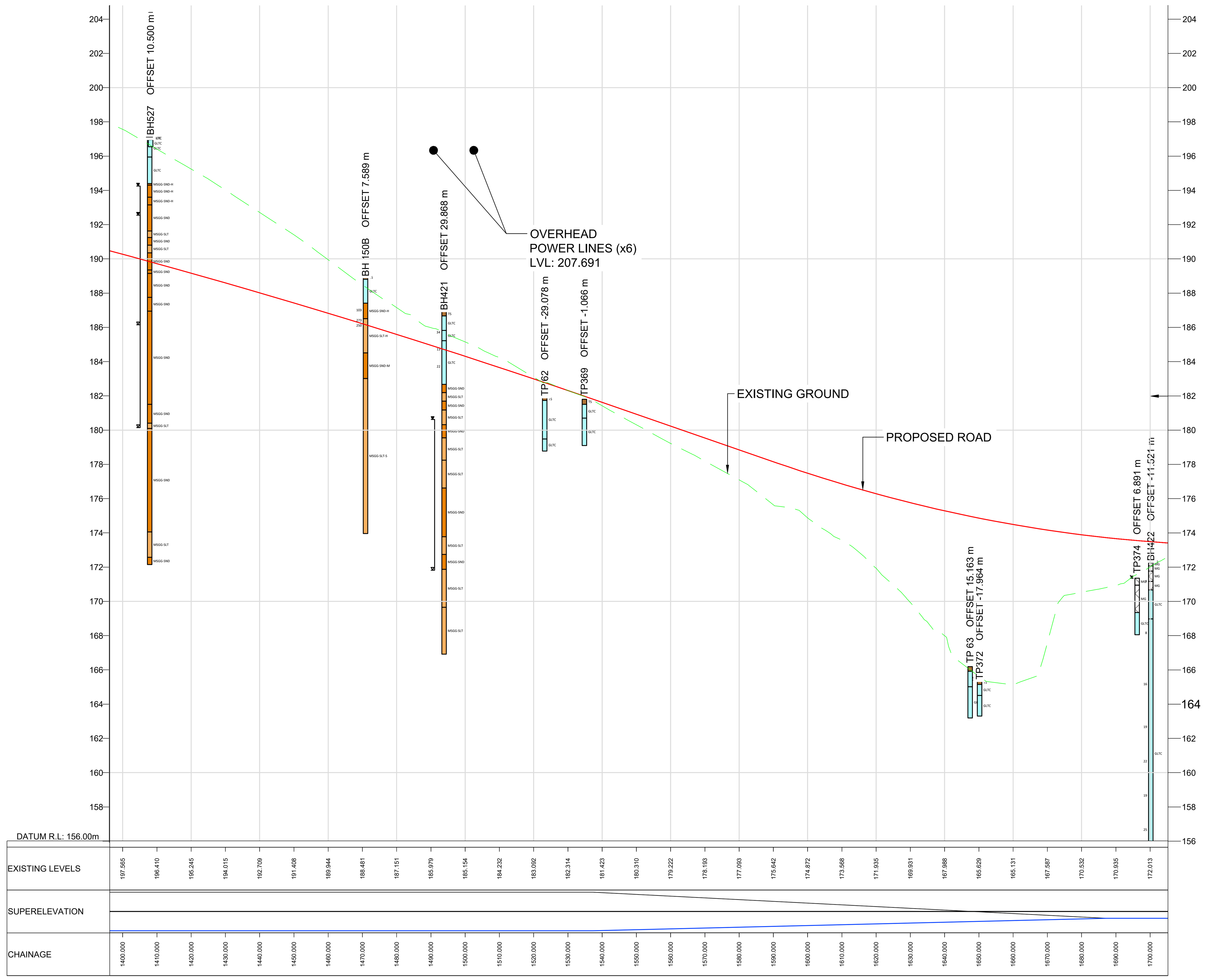
MSGG-SS	Millstone Grit Group Slickenside Surface
	No Recovery

INSTALLATION RESPONSE ZONE
MAXIMUM MEASURED GROUNDWATER LEVEL WITHIN MONITORING INSTALLATION
GROUNDWATER STRIKE LEVEL
GROUNDWATER LEVEL AFTER 20 MINS
29 SPT N-VALUES (NUMBERS AT SIDE OF BH STICKS)



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HORIZONTAL SCALE

VERTICAL SCALE

NOTES

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2. FOR DETAILS ON THE PHASE 5 EXPLORATORY HOLES AND KNOWN BURIED SERVICES & UTILITIES INFORMATION REFER TO THE A57 LINK ROADS GROUND INVESTIGATION SPECIFICATION HE551473-BBA-HGT-A57_AL_SCHEME-SP-CE-000001.
3. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWINGS HE551473-BBA-HGT-A57_AL_SCHEME--DR-CE-000001 TO 000008.
4. THE PHASE 5 EXPLORATORY HOLE POSITIONS ARE AS-BUILT SURVEY BY THE GI CONTRACTOR.
5. 30m BUFFER EACH SIDE OF THE ROAD CENTRE ALIGNMENT HAS BEEN USED FOR THE EXPLORATORY HOLES IN THE LONG SECTION.

PROPOSED HIGHWAY ALIGNMENT
EXISTING GROUND

PLAN KEY

HISTORICAL BOREHOLE LOCATION
HISTORICAL TRIAL PIT LOCATION
PHASE 5 BOREHOLE LOCATION
PHASE 5 TRIAL PIT LOCATION
PHASE 5 CONE PENETROMETER TEST
ROAD ALIGNMENT CHAINAGE
SITE BOUNDARY

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Maintenance / Cleaning
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Use
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Decommissioning / Demolition
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Issue to NH						
S3	P01	CC	GDS	JJ	---	19/01/22
Revised based on NH comments						
S4	C01	CC	GDS	MSR	MSR	17/03/22

Drawing Suitability: FOR STAGE APPROVAL
Status: S4

Designer: ATKINS
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Delivery Partner: ..\dms47377\BB@.png
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www.balfourbeatty.com

Client: highways england

Project Title: A57 TPU

Drawing Title: A57 LINK ROADS GEOLOGICAL LONG SECTION ALL GI DATA SHEET 4 OF 8

Drawing Number
Project: HE551473 - Originator: BBA - Volume: HGT -
Location: A57_AL_SCHEME - Type: DR - Role: CE - Number: 000024

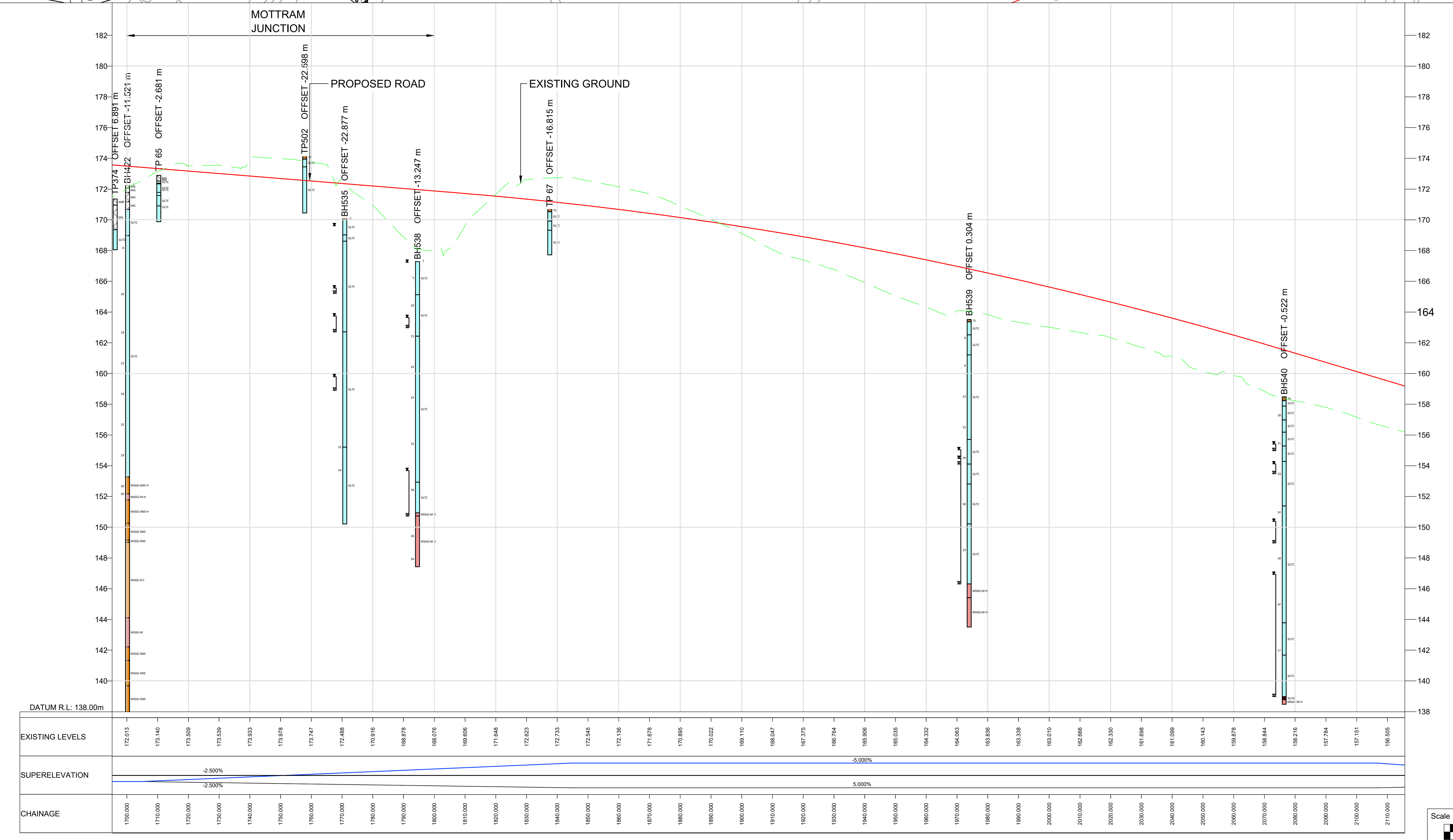
Original Size: A1 | Scale: AS SHOWN | Project Ref. No: 5186301 | Sheet: 4 of 8 | Rev: C01

DO NOT SCALE

GEOLOGY SECTION KEY

GEOL CODE	DESCRIPTION
ALVC	Alluvium Cohesive
ALVG	Alluvium Granular
ALVP	Alluvium Peat
GLTC	Glacial Till Cohesive
GLTG	Glacial Till Granular
MG	Made Ground
PEAT	Peat
TS	Topsoil
MSGG-M	Millstone Grit Group Mudstone
MSGG-M-H	Millstone Grit Group Highly Weathered Mudstone
MSGG-M-M	Millstone Grit Group Moderately Weathered Mudstone
MSGG-M-S	Millstone Grit Group Slightly Weathered Mudstone
MSGG-SLT	Millstone Grit Group Siltstone
MSGG-SLT-H	Millstone Grit Group Highly Weathered Siltstone
MSGG-SLT-M	Millstone Grit Group Moderately Weathered Siltstone
MSGG-SLT-S	Millstone Grit Group Slightly Weathered Siltstone
MSGG-SND	Millstone Grit Group Sandstone
MSGG-SND-H	Millstone Grit Group Highly Weathered Sandstone
MSGG-SND-M	Millstone Grit Group Moderately Weathered Sandstone
MSGG-SND-S	Millstone Grit Group Slightly Weathered Sandstone
MSGG-SS	Millstone Grit Group Slickenside Surface
	No Recovery

INSTALLATION RESPONSE ZONE
MAXIMUM MEASURED GROUNDWATER LEVEL WITHIN MONITORING INSTALLATION
GROUNDWATER STRIKE LEVEL
GROUNDWATER LEVEL AFTER 20 MINS
29 SPT N-VALUES (NUMBERS AT SIDE OF BH STICKS)



SCALE = H - 1:1000
V - 1:200

NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. FOR DETAILS ON THE PHASE 5 EXPLORATORY HOLES AND KNOWN BURIED SERVICES & UTILITIES INFORMATION REFER TO THE A57 LINK ROADS GROUND INVESTIGATION SPECIFICATION HE551473-BBA-HGT-A57_AL_SCHEME-SP-CE-000001.
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5. 30m BUFFER EACH SIDE OF THE ROAD CENTRE ALIGNMENT HAS BEEN USED FOR THE EXPLORATORY HOLES IN THE LONG SECTION.

PROPOSED HIGHWAY ALIGNMENT
EXISTING GROUND

PLAN KEY

HISTORICAL BOREHOLE LOCATION
HISTORICAL TRIAL PIT LOCATION
PHASE 5 BOREHOLE LOCATION
PHASE 5 TRIAL PIT LOCATION
PHASE 5 CONE PENETROMETER TEST
2450 ROAD ALIGNMENT CHAINAGE
SITE BOUNDARY

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Maintenance / Cleaning
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Use
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Decommissioning / Demolition
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description: Issue to NH						
S3	P01	CC	GDS	JJ	---	19/01/22
Description: Revised based on NH comments						
S4	C01	CC	GDS	MSR	MSR	17/03/22

Drawing Suitability: FOR STAGE APPROVAL
Status: S4

Designer: ATKINS
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www.balfourbeatty.com

Client: highways england

Project Title: A57 TPU

Drawing Title: A57 LINK ROADS GEOLOGICAL LONG SECTION ALL GI DATA SHEET 5 OF 8

Drawing Number
Project: HE551473 - Originator: BBA - Volume: HGT -
Location: A57_AL_SCHEME - Type: DR - Role: CE - Number: 000025

Original Size: A1 | Scale: AS SHOWN | Project Ref. No: 5186301 | Sheet: 5 of 8 | Rev: C01

This Drawing is saved on ProjectWise. Plotted: 17/03/2022 19:14:57 By: DESA1722

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Scale 1:1000

DO NOT SCALE

GEOLOGY SECTION KEY

GEOL CODE	DESCRIPTION
ALVC	Alluvium Cohesive
ALVG	Alluvium Granular
ALVP	Alluvium Peat
GLTC	Glacial Till Cohesive
GLTG	Glacial Till Granular
MG	Made Ground
PEAT	Peat
TS	Topsoil
MSGG-M	Millstone Grit Group Mudstone
MSGG-M-H	Millstone Grit Group Highly Weathered Mudstone
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MSGG-SLT-S	Millstone Grit Group Slightly Weathered Siltstone
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MSGG-SND-M	Millstone Grit Group Moderately Weathered Sandstone
MSGG-SND-S	Millstone Grit Group Slightly Weathered Sandstone
MSGG-SS	Millstone Grit Group Slickenside Surface
	No Recovery

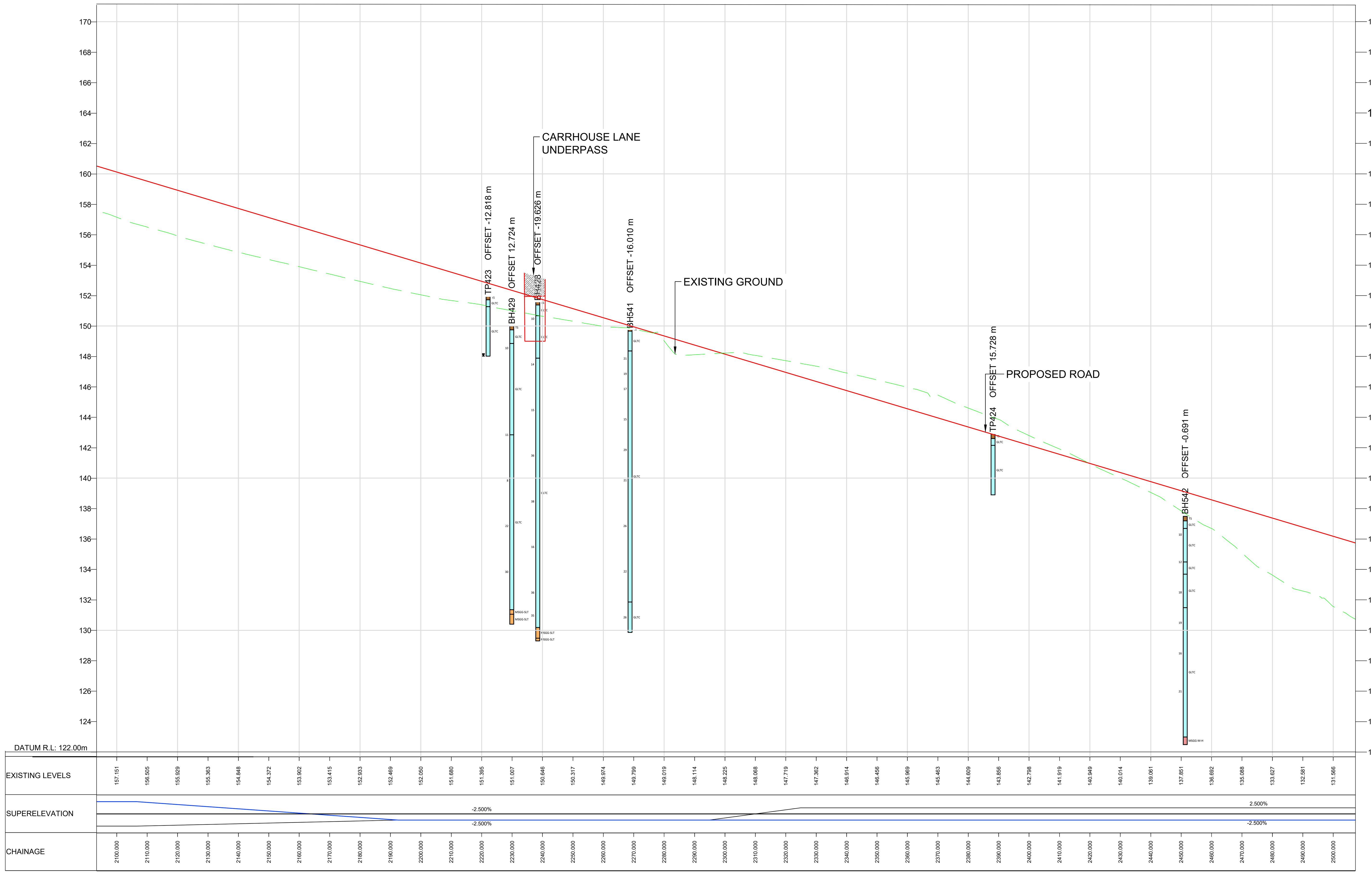
INSTALLATION RESPONSE ZONE

MAXIMUM MEASURED GROUNDWATER LEVEL WITHIN MONITORING INSTALLATION

GROUNDWATER STRIKE LEVEL

GROUNDWATER LEVEL AFTER 20 MINS

29 SPT N-VALUES (NUMBERS AT SIDE OF BH STICKS)



SCALE = H - 1:1000
V - 1:200

HORIZONTAL SCALE — Scale 1:1000

VERTICAL SCALE — Scale 1:200

NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. FOR DETAILS ON THE PHASE 5 EXPLORATORY HOLES AND KNOWN BURIED SERVICES & UTILITIES INFORMATION REFER TO THE A57 LINK ROADS GROUND INVESTIGATION SPECIFICATION HE551473-BBA-HGT-A57_AL_SCHEME-SP-CE-000001.
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PROPOSED HIGHWAY ALIGNMENT

EXISTING GROUND

PLAN KEY

HISTORICAL BOREHOLE LOCATION

HISTORICAL TRIAL PIT LOCATION

PHASE 5 BOREHOLE LOCATION

PHASE 5 TRIAL PIT LOCATION

PHASE 5 CONE PENETROMETER TEST

2450 ROAD ALIGNMENT CHAINAGE

SITE BOUNDARY

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Maintenance / Cleaning
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Use
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Decommissioning / Demolition
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Description						
Issue to NH						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
S3	P01	CC	GDS	JJ	---	19/01/22
Revised based on NH comments						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
S4	C01	CC	GDS	MSR	MSR	17/03/22

Drawing Suitability: FOR STAGE APPROVAL — Status: S4

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www.balfourbeatty.com

Client: highways england

Project Title: A57 TPU

Drawing Title: A57 LINK ROADS GEOLOGICAL LONG SECTION ALL GI DATA SHEET 6 OF 8

Drawing Number: HE551473 - BBA - HGT - A57_AL_SCHEME - DR - CE - 000026

Original Size: A1 — Scale: AS SHOWN — Project Ref. No: 5186301 — Sheet: 6 of 8 — Rev: C01

This Drawing is saved on ProjectWise. Plotted: 17/03/2022 19:19:36 By: DESA1722

DO NOT SCALE

Scale 1:1000

GEOLOGY SECTION KEY

GEOL CODE	DESCRIPTION
ALVC	Alluvium Cohesive
ALVG	Alluvium Granular
ALVP	Alluvium Peat
GLTC	Glacial Till Cohesive
GLTG	Glacial Till Granular
MG	Made Ground
PEAT	Peat
TS	Topsoil
MSGG-M	Millstone Grit Group Mudstone
MSGG-M-H	Millstone Grit Group Highly Weathered Mudstone
MSGG-M-M	Millstone Grit Group Moderately Weathered Mudstone
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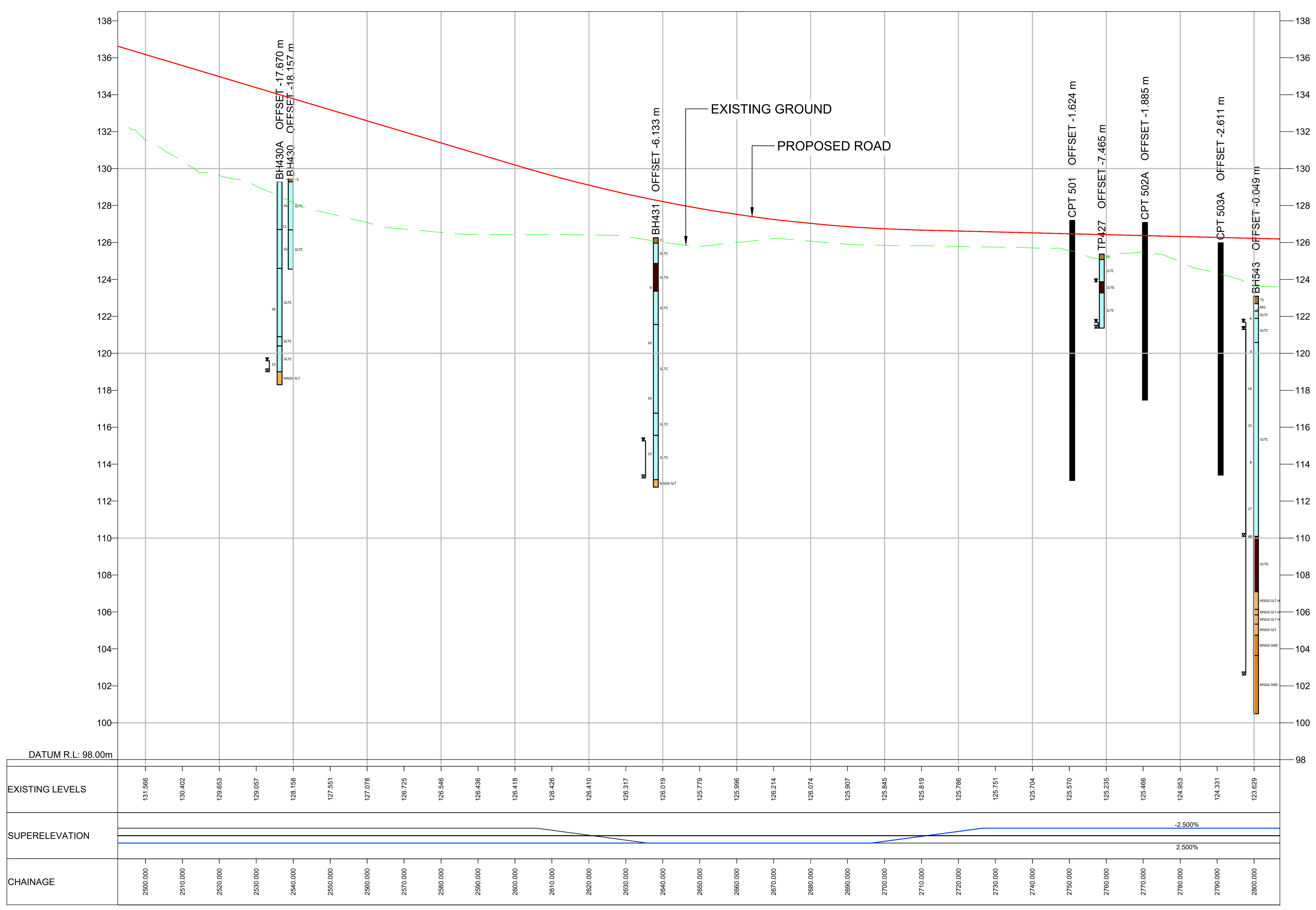
MSGG-SND-M	Millstone Grit Group Moderately Weathered Sandstone
MSGG-SND-S	Millstone Grit Group Slightly Weathered Sandstone
MSGG-SS	Millstone Grit Group Slickenside Surface
	No Recovery

INSTALLATION RESPONSE ZONE
MAXIMUM MEASURED GROUNDWATER LEVEL WITHIN MONITORING INSTALLATION
GROUNDWATER STRIKE LEVEL
GROUNDWATER LEVEL AFTER 20 MINS
29 SPT N-VALUES (NUMBERS AT SIDE OF BH STICKS)



SCALE = H - 1:1000
V - 1:200

HORIZONTAL SCALE (Scale 1:1000)

VERTICAL SCALE (Scale 1:200)

NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. FOR DETAILS ON THE PHASE 5 EXPLORATORY HOLES AND KNOWN BURIED SERVICES & UTILITIES INFORMATION REFER TO THE A57 LINK ROADS GROUND INVESTIGATION SPECIFICATION HE551473-BBA-HGT-A57_AL_SCHEME-SP-CE-000001.
3. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWINGS HE551473-BBA-HGT-A57_AL_SCHEME--DR-CE-000001 TO 000008.
4. THE PHASE 5 EXPLORATORY HOLE POSITIONS ARE AS-BUILT SURVEY BY THE GI CONTRACTOR.
5. 30m BUFFER EACH SIDE OF THE ROAD CENTRE ALIGNMENT HAS BEEN USED FOR THE EXPLORATORY HOLES IN THE LONG SECTION.

PROPOSED HIGHWAY ALIGNMENT
EXISTING GROUND

PLAN KEY

HISTORICAL BOREHOLE LOCATION
HISTORICAL TRIAL PIT LOCATION
PHASE 5 BOREHOLE LOCATION
PHASE 5 TRIAL PIT LOCATION
PHASE 5 CONE PENETROMETER TEST
ROAD ALIGNMENT CHAINAGE
SITE BOUNDARY

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Maintenance / Cleaning
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Use
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Decommissioning / Demolition
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Description	Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Issue to NH	S3	P01	CC	GDS	JJ	---	19/01/22
Revised based on NH comments	S4	C01	CC	GDS	MSR	MSR	17/03/22

Drawing Suitability: FOR STAGE APPROVAL
Status: S4

Designer: ATKINS
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Fax:+44 (0)1925 238500
www.atkinsglobal.com
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www.balfourbeatty.com

Client: highways england

Project Title: A57 TPU

Drawing Title: A57 LINK ROADS GEOLOGICAL LONG SECTION ALL GI DATA SHEET 7 OF 8

Drawing Number
Project: HE551473 - Originator: BBA - Volume: HGT - A57_AL_SCHEME - DR - CE - 000027
Location | Type | Role | Number

Original Size: A1 | Scale: AS SHOWN | Project Ref. No: 5186301 | Sheet: 7 of 8 | Rev: C01

DO NOT SCALE

GEOLOGY SECTION KEY

GEOL CODE	DESCRIPTION
ALVC	Alluvium Cohesive
ALVG	Alluvium Granular
ALVP	Alluvium Peat
GLTC	Glacial Till Cohesive
GLTG	Glacial Till Granular
MG	Made Ground
PEAT	Peat
TS	Topsoil
MSGG-M	Millstone Grit Group Mudstone
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MSGG-SND-M	Millstone Grit Group Moderately Weathered Sandstone
MSGG-SND-S	Millstone Grit Group Slightly Weathered Sandstone
MSGG-SS	Millstone Grit Group Slickenside Surface
	No Recovery

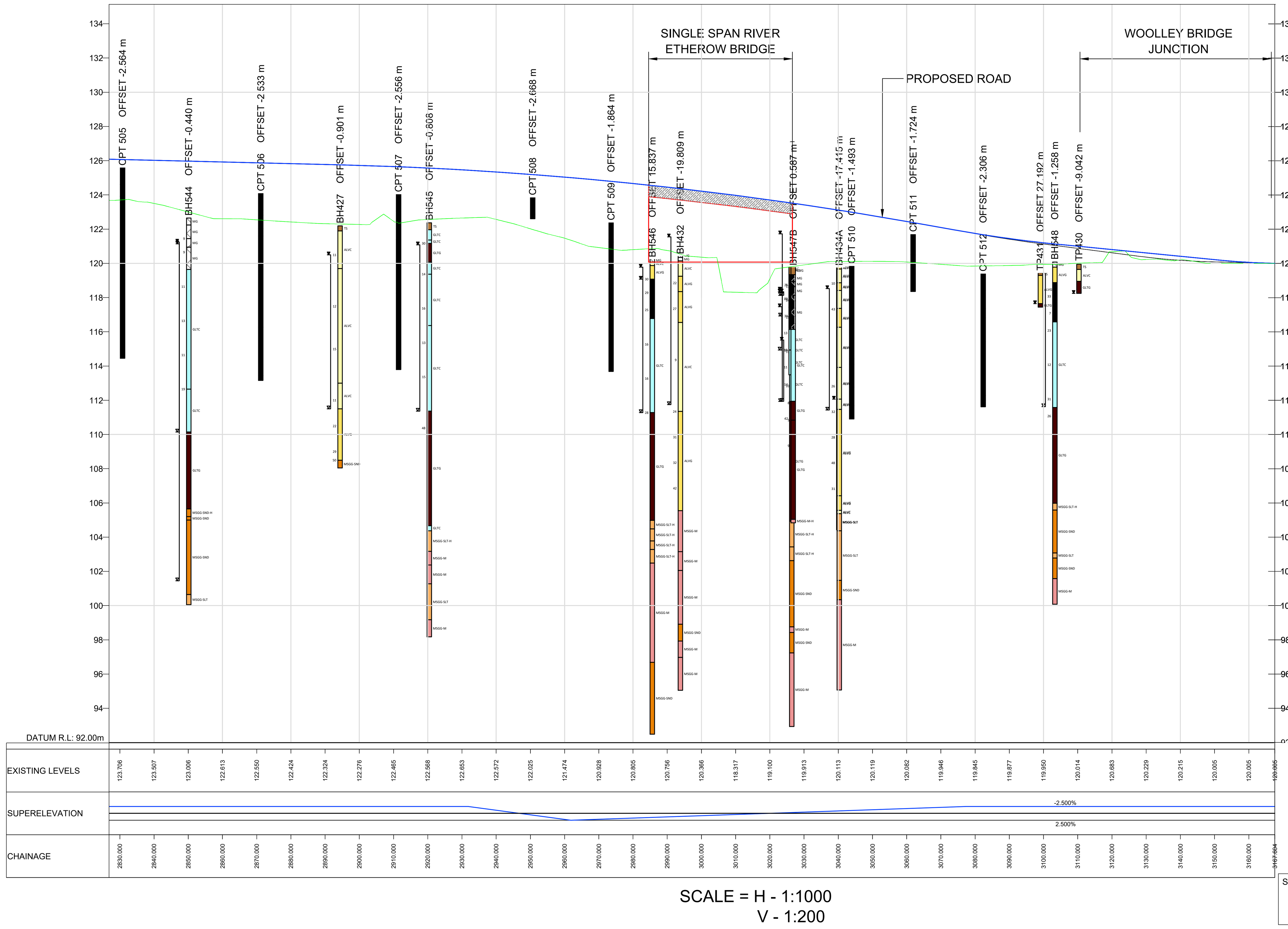
INSTALLATION RESPONSE ZONE

MAXIMUM MEASURED GROUNDWATER LEVEL WITHIN MONITORING INSTALLATION

GROUNDWATER STRIKE LEVEL

GROUNDWATER LEVEL AFTER 20 MINS

29 SPT N-VALUES (NUMBERS AT SIDE OF BH STICKS)



SCALE = H - 1:1000
V - 1:200

NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. FOR DETAILS ON THE PHASE 5 EXPLORATORY HOLES AND KNOWN BURIED SERVICES & UTILITIES INFORMATION REFER TO THE A57 LINK ROADS GROUND INVESTIGATION SPECIFICATION HE551473-BBA-HGT-A57_AL_SCHEME-SP-CE-000001.
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5. 30m BUFFER EACH SIDE OF THE ROAD CENTRE ALIGNMENT HAS BEEN USED FOR THE EXPLORATORY HOLES IN THE LONG SECTION.

PROPOSED HIGHWAY ALIGNMENT
EXISTING GROUND

PLAN KEY

HISTORICAL BOREHOLE LOCATION
HISTORICAL TRIAL PIT LOCATION
PHASE 5 BOREHOLE LOCATION
PHASE 5 TRIAL PIT LOCATION
PHASE 5 CONE PENETROMETER TEST
ROAD ALIGNMENT CHAINAGE
SITE BOUNDARY

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

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Maintenance / Cleaning
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Use
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Decommissioning / Demolition
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description: Issue to NH						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
S3	P01	CC	GDS	JJ	---	19/01/22
Description: Revised based on NH comments						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
S4	C01	CC	GDS	MSR	MSR	17/03/22

Drawing Suitability: FOR STAGE APPROVAL
Status: S4

Designer: ATKINS
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Spencer House, Dewhurst Road, Birchwood, Warrington, WA3 7PG
www.balfourbeatty.com

Client: highways england

Project Title: A57 TPU

Drawing Title:
A57 LINK ROADS
GEOLOGICAL LONG SECTION
ALL GI DATA
SHEET 8 OF 8

Drawing Number
Project: HE551473 - Originator: BBA - Volume: HGT -
Location: A57_AL_SCHEME - Type: DR - Role: CE - Number: 000028

Original Size: A1 | Scale: AS SHOWN | Project Ref. No: 5186301 | Sheet: 8 of 8 | Rev: C01

DO NOT SCALE

Scale 1:1000

GEOLOGY SECTION KEY

GEOL CODE	DESCRIPTION
ALVC	Alluvium Cohesive
ALVG	Alluvium Granular
ALVP	Alluvium Peat
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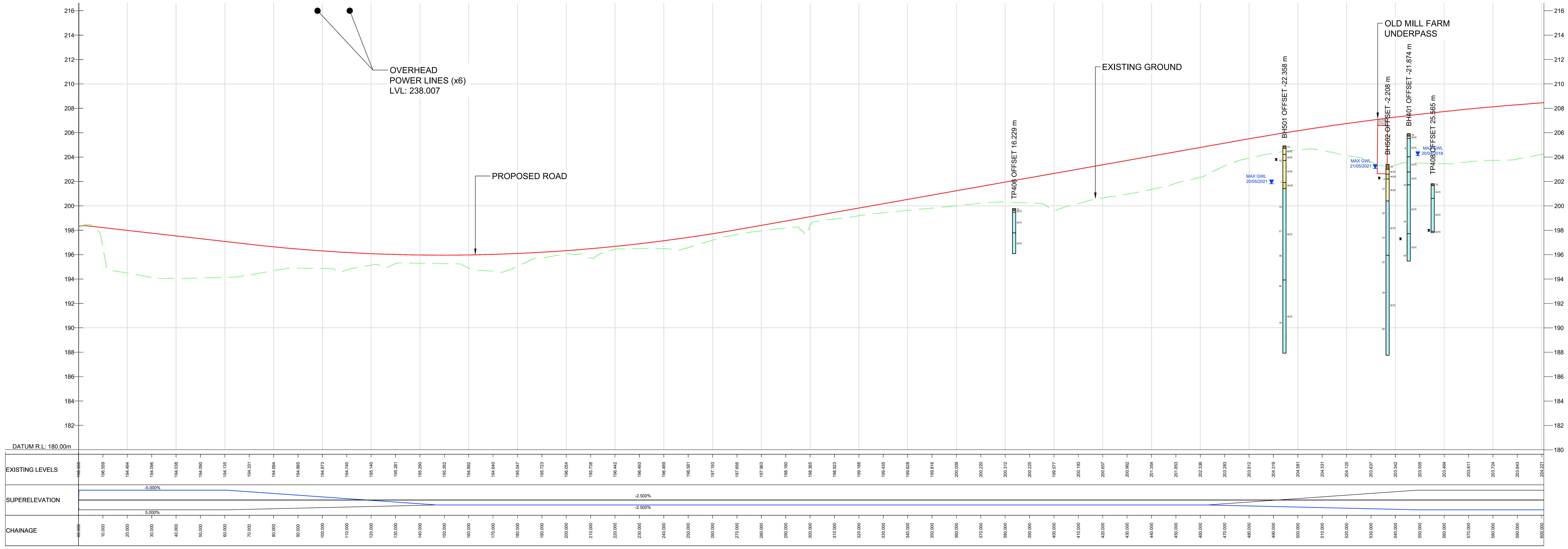
INSTALLATION RESPONSE ZONE

MAXIMUM MEASURED GROUNDWATER LEVEL WITHIN MONITORING INSTALLATION

GROUNDWATER STRIKE LEVEL

GROUNDWATER LEVEL AFTER 20 MINS

29 SPT N-VALUES (NUMBERS AT SIDE OF BH STICKS)



Scale 1:1000

HORIZONTAL SCALE

Scale 1:200

VERTICAL SCALE

SCALE = H - 1:1000
V - 1:200

NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
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PROPOSED HIGHWAY ALIGNMENT

EXISTING GROUND

PLAN KEY

HISTORICAL BOREHOLE LOCATION

HISTORICAL TRIAL PIT LOCATION

PHASE 4 BOREHOLE LOCATION

PHASE 4 TRIAL PIT LOCATION

PHASE 4 CONE PENETROMETER TEST

PHASE 5 BOREHOLE LOCATION

PHASE 5 TRIAL PIT LOCATION

PHASE 5 CONE PENETROMETER TEST

2450 ROAD ALIGNMENT CHAINAGE

SITE BOUNDARY

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

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Maintenance / Cleaning
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

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Description: Issue to NH						
S3	P01	CC	GDS	JJ	---	19/01/22
Description: Revised based on NH comments						
S4	C01	CC	GDS	MSR	MSR	17/03/22

Drawing Suitability: FOR STAGE APPROVAL
Status: S4

Designer: ATKINS
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Delivery Partner: Balfour Beatty
Spencer House, Dewhurst Road, Birchwood, Warrington, WA3 7PG
www.balfourbeatty.com

Client: highways england

Project Title: A57 TPU

Drawing Title: A57 LINK ROADS
GEOLOGICAL LONG SECTION
GI PHASES 4 & 5 DATA
SHEET 1 OF 8

Drawing Number
Project: HE551473 - Originator: BBA - Volume: HGT - Location: A57_AL_SCHEME - Type: DR - Role: CE - Number: 000031

Original Size: A1 | Scale: AS SHOWN | Project Ref. No: 5186301 | Sheet: 1 of 8 | Rev: C01

This Drawing is saved on ProjectWise. Plotted: 17/03/2022 18:52:39 By: BALM8905

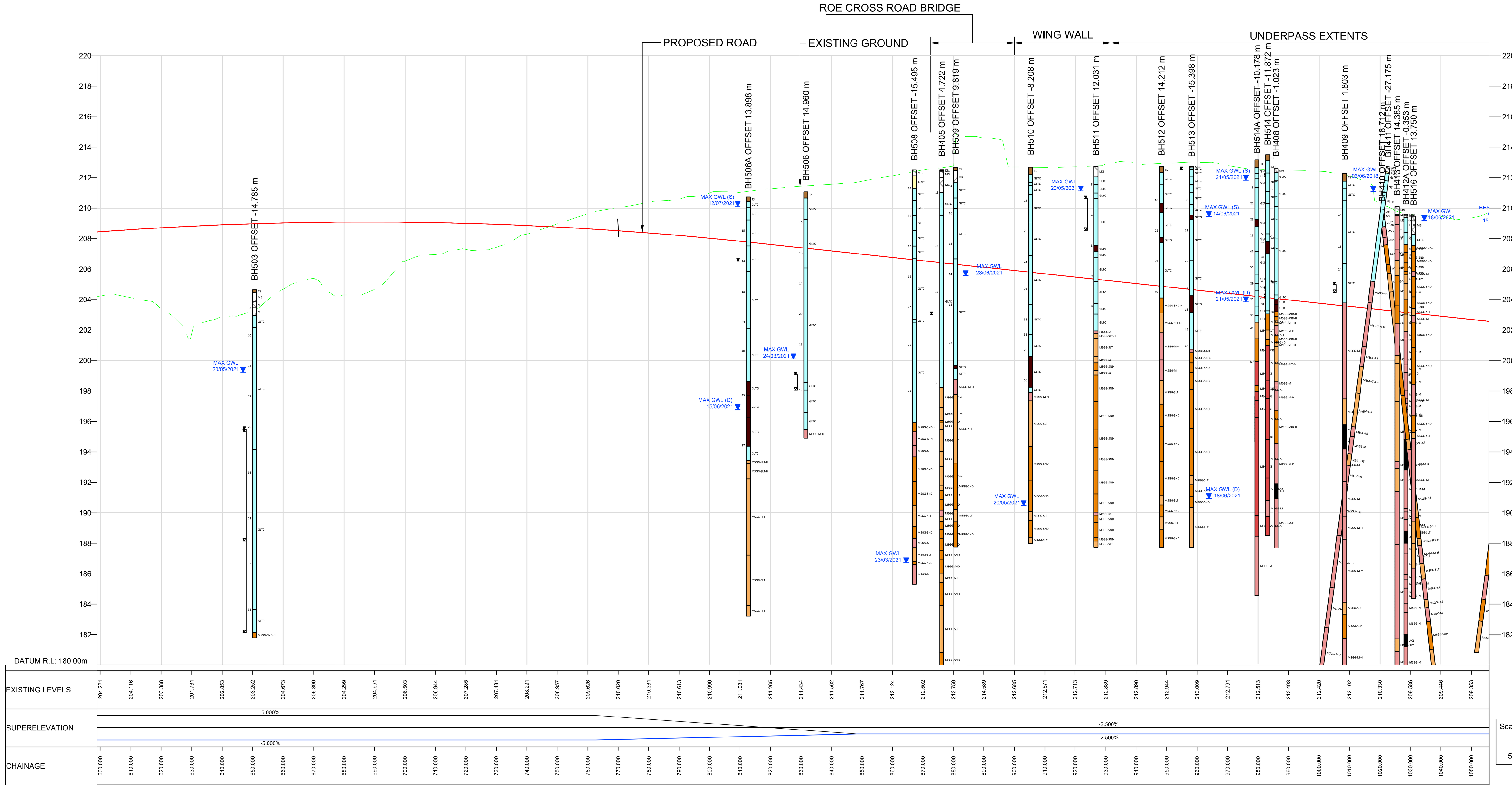
DO NOT SCALE

Scale 1:1000

GEOLOGY SECTION KEY

GEOL CODE	DESCRIPTION
ALVC	Alluvium Cohesive
ALVG	Alluvium Granular
ALVP	Alluvium Peat
GLTC	Glacial Till Cohesive
GLTG	Glacial Till Granular
MG	Made Ground
PEAT	Peat
TS	Topsoil
MSGG-M	Millstone Grit Group Mudstone
MSGG-M-H	Millstone Grit Group Highly Weathered Mudstone
MSGG-M-M	Millstone Grit Group Moderately Weathered Mudstone
MSGG-M-S	Millstone Grit Group Slightly Weathered Mudstone
MSGG-SLT	Millstone Grit Group Siltstone
MSGG-SLT-H	Millstone Grit Group Highly Weathered Siltstone
MSGG-SLT-M	Millstone Grit Group Moderately Weathered Siltstone
MSGG-SLT-S	Millstone Grit Group Slightly Weathered Siltstone
MSGG-SND	Millstone Grit Group Sandstone
MSGG-SND-H	Millstone Grit Group Highly Weathered Sandstone
MSGG-SND-M	Millstone Grit Group Moderately Weathered Sandstone
MSGG-SND-S	Millstone Grit Group Slightly Weathered Sandstone
MSGG-SS	Millstone Grit Group Slickenside Surface
	No Recovery

INSTALLATION RESPONSE ZONE
MAXIMUM MEASURED GROUNDWATER LEVEL WITHIN MONITORING INSTALLATION
GROUNDWATER STRIKE LEVEL
GROUNDWATER LEVEL AFTER 20 MINS
29 SPT N-VALUES (NUMBERS AT SIDE OF BH STICKS)



SCALE = H - 1:1000
V - 1:200

Scale 1:200 VERTICAL SCALE
Scale 1:1000 HORIZONTAL SCALE

NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. FOR DETAILS ON THE PHASE 5 EXPLORATORY HOLES AND KNOWN BURIED SERVICES & UTILITIES INFORMATION REFER TO THE A57 LINK ROADS GROUND INVESTIGATION SPECIFICATION HE551473-BBA-HGT-A57_AL_SCHEME-SP-CE-000001.
3. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWINGS HE551473-BBA-HGT-A57_AL_SCHEME--DR-CE-000001 TO 000008.
4. THE PHASE 5 EXPLORATORY HOLE POSITIONS ARE AS-BUILT SURVEY BY THE GI CONTRACTOR.
5. 30m BUFFER EACH SIDE OF THE ROAD CENTRE ALIGNMENT HAS BEEN USED FOR THE EXPLORATORY HOLES IN THE LONG SECTION.

PROPOSED HIGHWAY ALIGNMENT
EXISTING GROUND

PLAN KEY

HISTORICAL BOREHOLE LOCATION
HISTORICAL TRIAL PIT LOCATION
PHASE 4 BOREHOLE LOCATION
PHASE 4 TRIAL PIT LOCATION
PHASE 4 CONE PENETROMETER TEST
PHASE 5 BOREHOLE LOCATION
PHASE 5 TRIAL PIT LOCATION
PHASE 5 CONE PENETROMETER TEST
2450 ROAD ALIGNMENT CHAINAGE
SITE BOUNDARY

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Maintenance / Cleaning
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Use
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Decommissioning / Demolition
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description: Issue to NH						
Status S3	Revision P01	Drawn CC	Checked GDS	Reviewed JJ	Authorised ---	Issue Date 19/01/22
Description: Revised based on NH comments						
Status S4	Revision C01	Drawn CC	Checked GDS	Reviewed MSR	Authorised MSR	Issue Date 17/03/22

Drawing Suitability: FOR STAGE APPROVAL
Status: S4

Project Title: A57 TPU

Designer: ATKINS
Member of the SNC-Lavalin Group
Chadwick House, Birchwood Park, Warrington, WA3 6AE
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Delivery Partner: Balfour Beatty
Spencer House, Dewhurst Road, Birchwood, Warrington, WA3 7PG
www.balfourbeatty.com

Client: highways england

Drawing Title: A57 LINK ROADS GEOLOGICAL LONG SECTION GI PHASES 4 & 5 DATA SHEET 2 OF 8

Drawing Number: HE551473 - BBA - HGT - A57_AL_SCHEME - DR - CE - 000032

Original Size: A1 | Scale: AS SHOWN | Project Ref. No: 5186301 | Sheet: 2 of 8 | Rev: C01

This Drawing is saved on ProjectWise. Plotted: 17/03/2022 19:10:27 By: BALM8905

GEOLOGY SECTION KEY

GEOL CODE	DESCRIPTION
ALVC	Alluvium Cohesive
ALVG	Alluvium Granular
ALVP	Alluvium Peat
GLTC	Glacial Till Cohesive
GLTG	Glacial Till Granular
MG	Made Ground
PEAT	Peat
TS	Topsoil
MSGG-M	Millstone Grit Group Mudstone
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MSGG-M-M	Millstone Grit Group Moderately Weathered Mudstone
MSGG-M-S	Millstone Grit Group Slightly Weathered Mudstone
MSGG-SLT	Millstone Grit Group Siltstone
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MSGG-SLT-M	Millstone Grit Group Moderately Weathered Siltstone
MSGG-SLT-S	Millstone Grit Group Slightly Weathered Siltstone
MSGG-SND	Millstone Grit Group Sandstone
MSGG-SND-H	Millstone Grit Group Highly Weathered Sandstone
MSGG-SND-M	Millstone Grit Group Moderately Weathered Sandstone
MSGG-SND-S	Millstone Grit Group Slightly Weathered Sandstone
MSGG-SS	Millstone Grit Group Slickenside Surface
	No Recovery

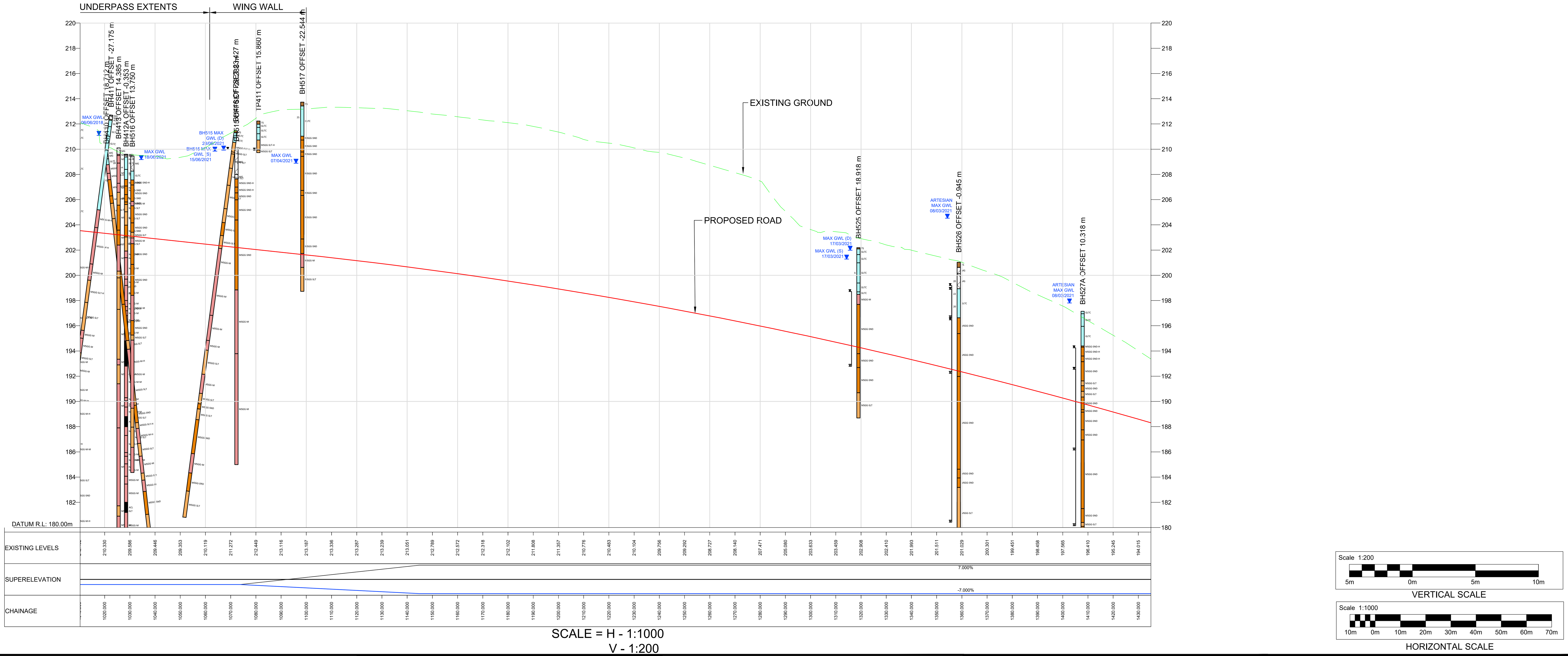
INSTALLATION RESPONSE ZONE

MAXIMUM MEASURED GROUNDWATER LEVEL WITHIN MONITORING INSTALLATION

GROUNDWATER STRIKE LEVEL

GROUNDWATER LEVEL AFTER 20 MINS

29 SPT N-VALUES (NUMBERS AT SIDE OF BH STICKS)



SCALE = H - 1:1000
V - 1:200

NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. FOR DETAILS ON THE PHASE 5 EXPLORATORY HOLES AND KNOWN BURIED SERVICES & UTILITIES INFORMATION REFER TO THE A57 LINK ROADS GROUND INVESTIGATION SPECIFICATION HE551473-BBA-HGT-A57_AL_SCHEME-SP-CE-000001.
3. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWINGS HE551473-BBA-HGT-A57_AL_SCHEME--DR-CE-000001 TO 000008.
4. THE PHASE 5 EXPLORATORY HOLE POSITIONS ARE AS-BUILT SURVEY BY THE GI CONTRACTOR.
5. 30m BUFFER EACH SIDE OF THE ROAD CENTRE ALIGNMENT HAS BEEN USED FOR THE EXPLORATORY HOLES IN THE LONG SECTION.

PROPOSED HIGHWAY ALIGNMENT

EXISTING GROUND

PLAN KEY

- HISTORICAL BOREHOLE LOCATION
- HISTORICAL TRIAL PIT LOCATION
- PHASE 4 BOREHOLE LOCATION
- PHASE 4 TRIAL PIT LOCATION
- PHASE 4 CONE PENETROMETER TEST
- PHASE 5 BOREHOLE LOCATION
- PHASE 5 TRIAL PIT LOCATION
- PHASE 5 CONE PENETROMETER TEST
- 2450 ROAD ALIGNMENT CHAINAGE
- SITE BOUNDARY

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Maintenance / Cleaning
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Use
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Decommissioning / Demolition
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Description	Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Issue to NH	S3	P01	CC	GDS	JJ	---	19/01/22
Revised based on NH comments	S4	C01	CC	GDS	MSR	MSR	17/03/22

Drawing Suitability: FOR STAGE APPROVAL — Status: S4

Project Title: A57 TPU

Designer: ATKINS — Member of the SNC-Lavalin Group
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Fax:+44 (0)1925 238500
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Delivery Partner: Balfour Beatty
Spencer House, Dewhurst Road, Birchwood, Warrington, WA3 7PG
www.balfourbeatty.com

Client: highways england

Drawing Title: A57 LINK ROADS GEOLOGICAL LONG SECTION GI PHASES 4 & 5 DATA SHEET 3 OF 8

Drawing Number: HE551473 - BBA - HGT - A57_AL_SCHEME - DR - CE - 000033

Original Size: A1 | Scale: AS SHOWN | Project Ref. No: 5186301 | Sheet: 3 of 8 | Rev: C01

DO NOT SCALE

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Scale 1:1000

GEOLOGY SECTION KEY

GEOL CODE	DESCRIPTION
ALVC	Alluvium Cohesive
ALVG	Alluvium Granular
ALVP	Alluvium Peat
GLTC	Glacial Till Cohesive
GLTG	Glacial Till Granular
MG	Made Ground
PEAT	Peat
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MSGG-M	Millstone Grit Group Mudstone
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MSGG-SLT	Millstone Grit Group Siltstone
MSGG-SLT-H	Millstone Grit Group Highly Weathered Siltstone
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MSGG-SLT-S	Millstone Grit Group Slightly Weathered Siltstone
MSGG-SND	Millstone Grit Group Sandstone
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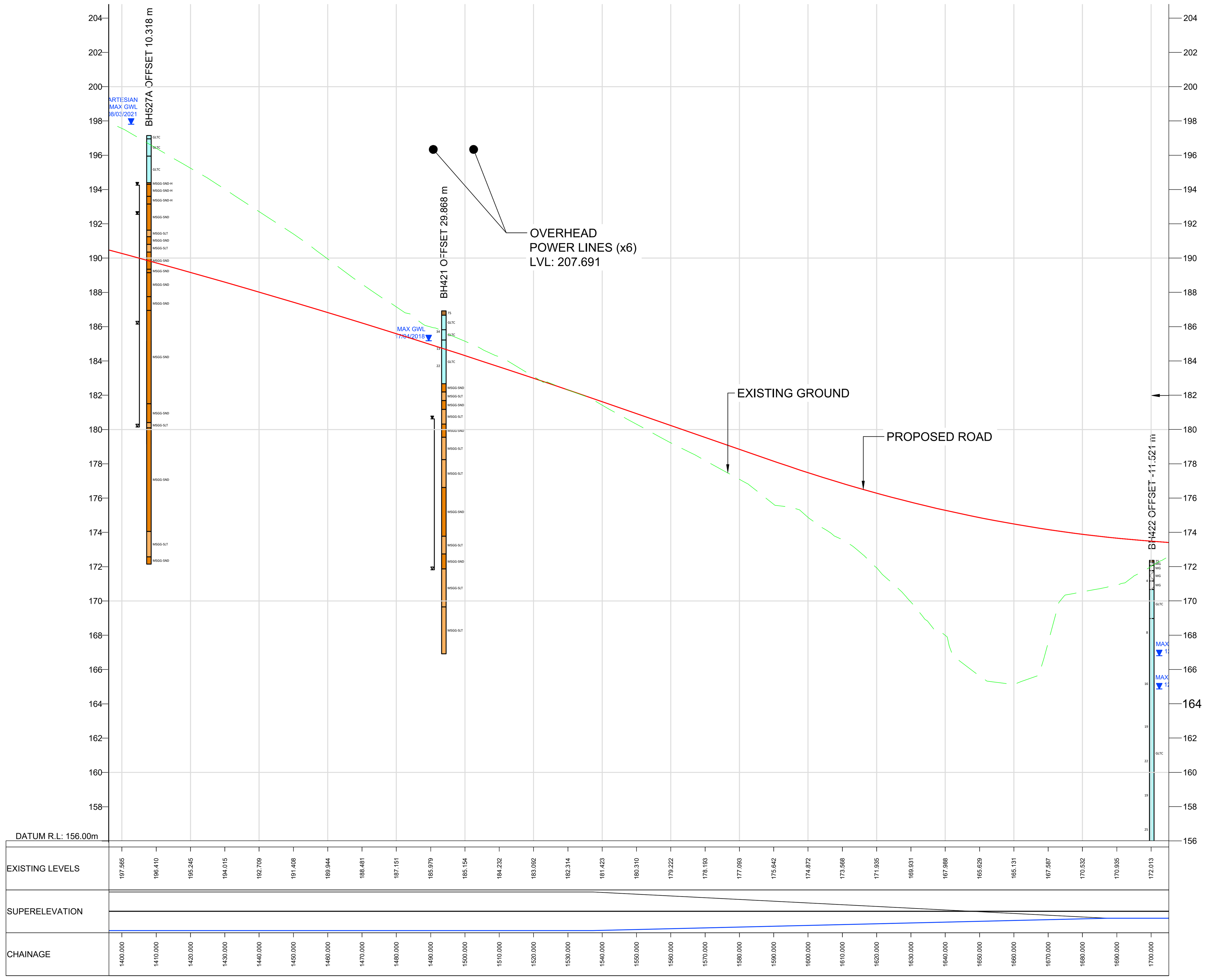
MSGG-SND-M	Millstone Grit Group Moderately Weathered Sandstone
MSGG-SND-S	Millstone Grit Group Slightly Weathered Sandstone
MSGG-SS	Millstone Grit Group Slickenside Surface
	No Recovery

INSTALLATION RESPONSE ZONE
MAXIMUM MEASURED GROUNDWATER LEVEL WITHIN MONITORING INSTALLATION
GROUNDWATER STRIKE LEVEL
GROUNDWATER LEVEL AFTER 20 MINS
29 SPT N-VALUES (NUMBERS AT SIDE OF BH STICKS)



SCALE = H - 1:1000
V - 1:200

Scale 1:1000
HORIZONTAL SCALE

Scale 1:200
VERTICAL SCALE

NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. FOR DETAILS ON THE PHASE 5 EXPLORATORY HOLES AND KNOWN BURIED SERVICES & UTILITIES INFORMATION REFER TO THE A57 LINK ROADS GROUND INVESTIGATION SPECIFICATION HE551473-BBA-HGT-A57_AL_SCHEME-SP-CE-000001.
3. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWINGS HE551473-BBA-HGT-A57_AL_SCHEME--DR-CE-000001 TO 000008.
4. THE PHASE 5 EXPLORATORY HOLE POSITIONS ARE AS-BUILT SURVEY BY THE GI CONTRACTOR.
5. 30m BUFFER EACH SIDE OF THE ROAD CENTRE ALIGNMENT HAS BEEN USED FOR THE EXPLORATORY HOLES IN THE LONG SECTION.

PROPOSED HIGHWAY ALIGNMENT
EXISTING GROUND

PLAN KEY

HISTORICAL BOREHOLE LOCATION
HISTORICAL TRIAL PIT LOCATION
PHASE 4 BOREHOLE LOCATION
PHASE 4 TRIAL PIT LOCATION
PHASE 4 CONE PENETROMETER TEST
PHASE 5 BOREHOLE LOCATION
PHASE 5 TRIAL PIT LOCATION
PHASE 5 CONE PENETROMETER TEST
2450 ROAD ALIGNMENT CHAINAGE
SITE BOUNDARY

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Maintenance / Cleaning
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Use
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Decommissioning / Demolition
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description: Issue to NH						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
S3	P01	CC	GDS	JJ	---	19/01/22
Description: Revised based on NH comments						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
S4	C01	CC	GDS	MSR	MSR	17/03/22

Drawing Suitability: FOR STAGE APPROVAL
Status: S4

Designer: ATKINS
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www.atkinsglobal.com
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Delivery Partner: Balfour Beatty
Spencer House, Dewhurst Road, Birchwood, Warrington, WA3 7PG
www.balfourbeatty.com

Client: highways england

Project Title: A57 TPU

Drawing Title: A57 LINK ROADS GEOLOGICAL LONG SECTION GI PHASES 4 & 5 DATA SHEET 4 OF 8

Drawing Number
Project | Originator | Volume | Location | Type | Role | Number
HE551473 - BBA - HGT - A57_AL_SCHEME - DR - CE - 000034

Original Size: A1 | Scale: AS SHOWN | Project Ref. No: 5186301 | Sheet: 4 of 8 | Rev: C01

This Drawing is saved on ProjectWise. Plotted: 17/03/2022 19:28:39 By: BALM8435

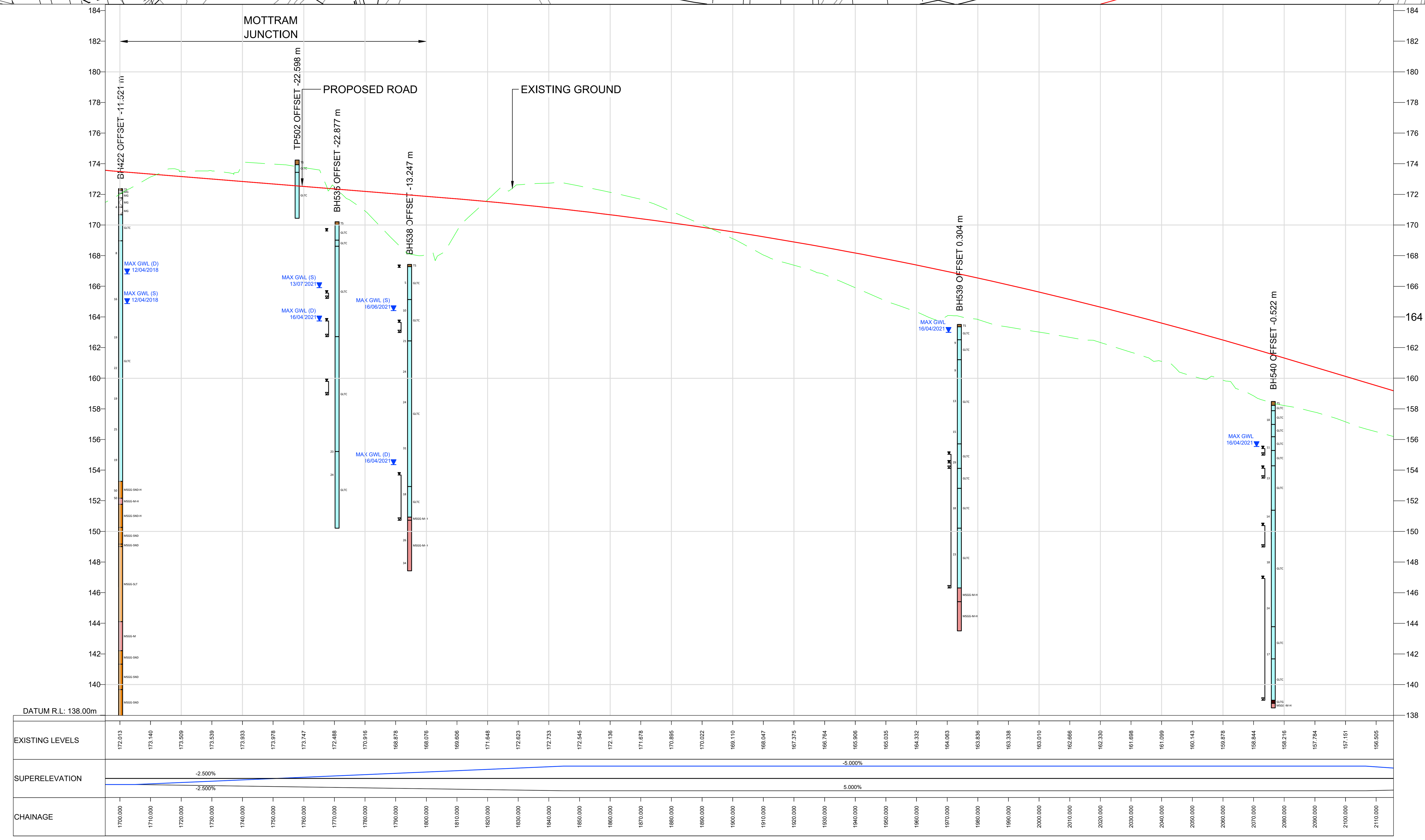
DO NOT SCALE

Scale 1:1000

GEOLOGY SECTION KEY

GEOL CODE	DESCRIPTION
ALVC	Alluvium Cohesive
ALVG	Alluvium Granular
ALVP	Alluvium Peat
GLTC	Glacial Till Cohesive
GLTG	Glacial Till Granular
MG	Made Ground
PEAT	Peat
TS	Topsoil
MSGG-M	Millstone Grit Group Mudstone
MSGG-M-H	Millstone Grit Group Highly Weathered Mudstone
MSGG-M-M	Millstone Grit Group Moderately Weathered Mudstone
MSGG-M-S	Millstone Grit Group Slightly Weathered Mudstone
MSGG-SLT	Millstone Grit Group Siltstone
MSGG-SLT-H	Millstone Grit Group Highly Weathered Siltstone
MSGG-SLT-M	Millstone Grit Group Moderately Weathered Siltstone
MSGG-SLT-S	Millstone Grit Group Slightly Weathered Siltstone
MSGG-SND	Millstone Grit Group Sandstone
MSGG-SND-H	Millstone Grit Group Highly Weathered Sandstone
MSGG-SND-M	Millstone Grit Group Moderately Weathered Sandstone
MSGG-SND-S	Millstone Grit Group Slightly Weathered Sandstone
MSGG-SS	Millstone Grit Group Slickenside Surface
	No Recovery

INSTALLATION RESPONSE ZONE
MAXIMUM MEASURED GROUNDWATER LEVEL WITHIN MONITORING INSTALLATION
GROUNDWATER STRIKE LEVEL
GROUNDWATER LEVEL AFTER 20 MINS
29 SPT N-VALUES (NUMBERS AT SIDE OF BH STICKS)



SCALE = H - 1:1000
V - 1:200

VERTICAL SCALE (Scale 1:200)

HORIZONTAL SCALE (Scale 1:1000)

NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. FOR DETAILS ON THE PHASE 5 EXPLORATORY HOLES AND KNOWN BURIED SERVICES & UTILITIES INFORMATION REFER TO THE A57 LINK ROADS GROUND INVESTIGATION SPECIFICATION HE551473-BBA-HGT-A57_AL_SCHEME-SP-CE-000001.
3. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWINGS HE551473-BBA-HGT-A57_AL_SCHEME--DR-CE-000001 TO 000008.
4. THE PHASE 5 EXPLORATORY HOLE POSITIONS ARE AS-BUILT SURVEY BY THE GI CONTRACTOR.
5. 30m BUFFER EACH SIDE OF THE ROAD CENTRE ALIGNMENT HAS BEEN USED FOR THE EXPLORATORY HOLES IN THE LONG SECTION.

PROPOSED HIGHWAY ALIGNMENT
EXISTING GROUND

PLAN KEY

HISTORICAL BOREHOLE LOCATION
HISTORICAL TRIAL PIT LOCATION
PHASE 4 BOREHOLE LOCATION
PHASE 4 TRIAL PIT LOCATION
PHASE 4 CONE PENETROMETER TEST
PHASE 5 BOREHOLE LOCATION
PHASE 5 TRIAL PIT LOCATION
PHASE 5 CONE PENETROMETER TEST
2450 ROAD ALIGNMENT CHAINAGE
SITE BOUNDARY

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Maintenance / Cleaning
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Use
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Decommissioning / Demolition
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Description	Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Issue to NH	S3	P01	CC	GDS	JJ	---	19/01/22
Revised based on NH comments	S4	C01	CC	GDS	MSR	MSR	17/03/22

Drawing Suitability: FOR STAGE APPROVAL
Status: S4

Designer: ATKINS
Member of the SNC-Lavalin Group
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www.atkinsglobal.com
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Delivery Partner: Balfour Beatty
Spencer House, Dewhurst Road, Birchwood, Warrington, WA3 7PG
www.balfourbeatty.com

Client: highways england

Project Title: A57 TPU

Drawing Title: A57 LINK ROADS GEOLOGICAL LONG SECTION GI PHASES 4 & 5 DATA SHEET 5 OF 8

Drawing Number: HE551473 - BBA - HGT - A57_AL_SCHEME - DR - CE - 000035

Original Size: A1 | Scale: AS SHOWN | Project Ref. No: 5186301 | Sheet: 5 of 8 | Rev: C01

This Drawing is saved on ProjectWise. Plotted: 17/03/2022 19:35:26 By: BALM8905

DO NOT SCALE

Millimetres 0 10 100

GEOLOGY SECTION KEY

GEOL CODE	DESCRIPTION
ALVC	Alluvium Cohesive
ALVG	Alluvium Granular
ALVP	Alluvium Peat
GLTC	Glacial Till Cohesive
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MG	Made Ground
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MSGG-SND-M	Millstone Grit Group Moderately Weathered Sandstone
MSGG-SND-S	Millstone Grit Group Slightly Weathered Sandstone
MSGG-SS	Millstone Grit Group Slickenside Surface
	No Recovery

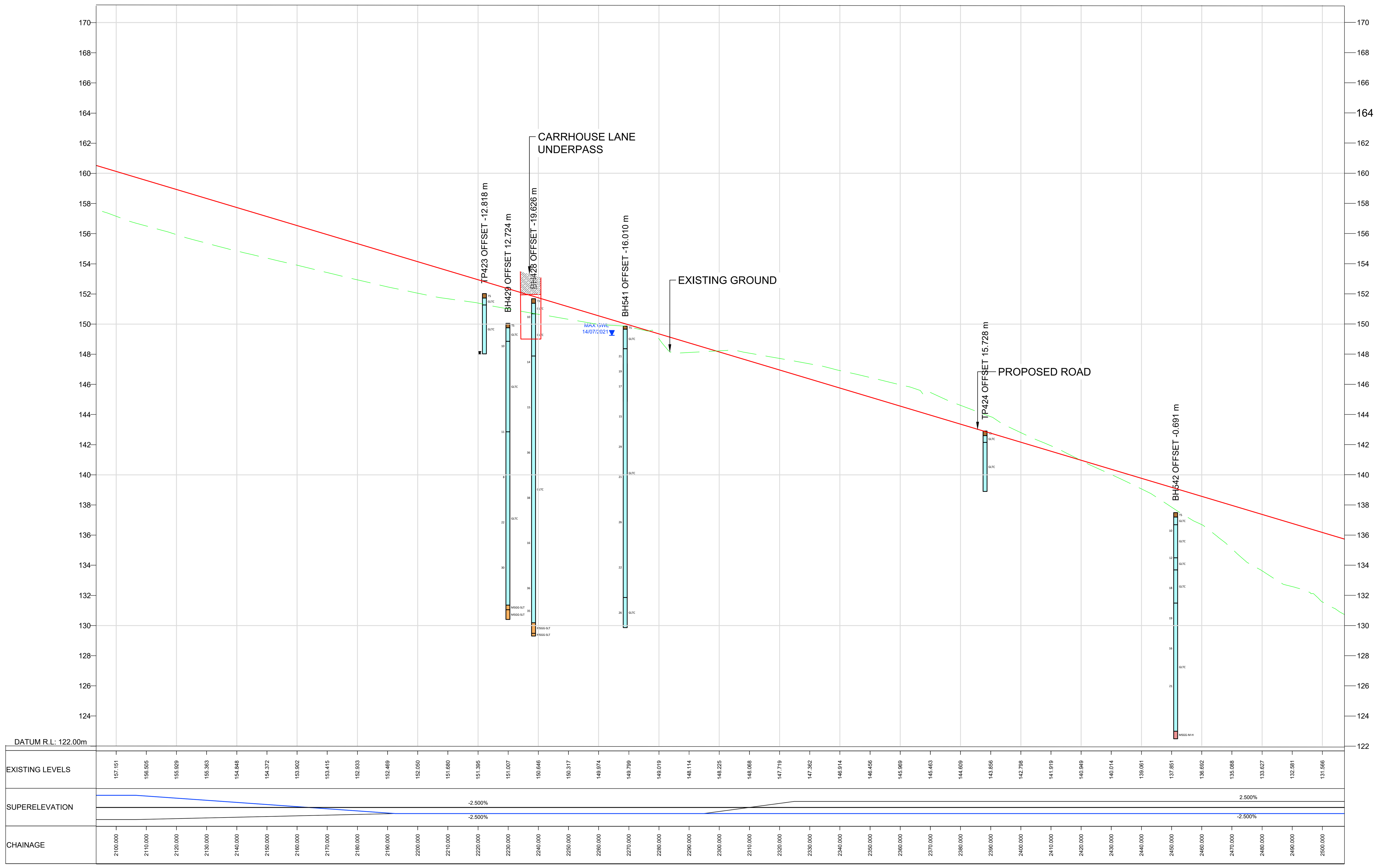
INSTALLATION RESPONSE ZONE

MAXIMUM MEASURED GROUNDWATER LEVEL WITHIN MONITORING INSTALLATION

GROUNDWATER STRIKE LEVEL

GROUNDWATER LEVEL AFTER 20 MINS

29 SPT N-VALUES (NUMBERS AT SIDE OF BH STICKS)



SCALE = H - 1:1000
V - 1:200

Scale 1:200
5m 0m 5m 10m
VERTICAL SCALE

Scale 1:1000
10m 0m 10m 20m 30m 40m 50m 60m 70m
HORIZONTAL SCALE

NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. FOR DETAILS ON THE PHASE 5 EXPLORATORY HOLES AND KNOWN BURIED SERVICES & UTILITIES INFORMATION REFER TO THE A57 LINK ROADS GROUND INVESTIGATION SPECIFICATION HE551473-BBA-HGT-A57_AL_SCHEME-SP-CE-000001.
3. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWINGS HE551473-BBA-HGT-A57_AL_SCHEME--DR-CE-000001 TO 000008.
4. THE PHASE 5 EXPLORATORY HOLE POSITIONS ARE AS-BUILT SURVEY BY THE GI CONTRACTOR.
5. 30m BUFFER EACH SIDE OF THE ROAD CENTRE ALIGNMENT HAS BEEN USED FOR THE EXPLORATORY HOLES IN THE LONG SECTION.

PROPOSED HIGHWAY ALIGNMENT

EXISTING GROUND

PLAN KEY

- HISTORICAL BOREHOLE LOCATION
- HISTORICAL TRIAL PIT LOCATION
- PHASE 4 BOREHOLE LOCATION
- PHASE 4 TRIAL PIT LOCATION
- PHASE 4 CONE PENETROMETER TEST
- PHASE 5 BOREHOLE LOCATION
- PHASE 5 TRIAL PIT LOCATION
- PHASE 5 CONE PENETROMETER TEST
- 2450 ROAD ALIGNMENT CHAINAGE
- SITE BOUNDARY

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Maintenance / Cleaning
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Use
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Decommissioning / Demolition
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Description: Issue to NH						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
S3	P01	CC	GDS	JJ	---	19/01/22
Description: Revised based on NH comments						
Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
S4	C01	CC	GDS	MSR	MSR	17/03/22

Drawing Suitability: FOR STAGE APPROVAL
Status: S4

Project Title: A57 TPU

Designer: ATKINS
Member of the SNC-Lavalin Group
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Delivery Partner: Balfour Beatty
Spencer House, Dewhurst Road, Birchwood, Warrington, WA3 7PG
www.balfourbeatty.com

Client: highways england

Drawing Title:
A57 LINK ROADS
GEOLOGICAL LONG SECTION
GI PHASES 4 & 5 DATA
SHEET 6 OF 8

Drawing Number
Project: HE551473 - Originator: BBA - Volume: HGT -
Location: A57_AL_SCHEME - Type: DR - Role: CE - Number: 000036

Original Size: A1 | Scale: AS SHOWN | Project Ref. No: 5186301 | Sheet: 6 of 8 | Rev: C01

Millimetres

DO NOT SCALE

GEOLOGY SECTION KEY

GEOL CODE	DESCRIPTION
ALVC	Alluvium Cohesive
ALVG	Alluvium Granular
ALVP	Alluvium Peat
GLTC	Glacial Till Cohesive
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PEAT	Peat
TS	Topsoil
MSGG-M	Millstone Grit Group Mudstone
MSGG-M-H	Millstone Grit Group Highly Weathered Mudstone
MSGG-M-M	Millstone Grit Group Moderately Weathered Mudstone
MSGG-M-S	Millstone Grit Group Slightly Weathered Mudstone
MSGG-SLT	Millstone Grit Group Siltstone
MSGG-SLT-H	Millstone Grit Group Highly Weathered Siltstone
MSGG-SLT-M	Millstone Grit Group Moderately Weathered Siltstone
MSGG-SLT-S	Millstone Grit Group Slightly Weathered Siltstone
MSGG-SND	Millstone Grit Group Sandstone
MSGG-SND-H	Millstone Grit Group Highly Weathered Sandstone
MSGG-SND-M	Millstone Grit Group Moderately Weathered Sandstone
MSGG-SND-S	Millstone Grit Group Slightly Weathered Sandstone
MSGG-SS	Millstone Grit Group Slickenside Surface
	No Recovery

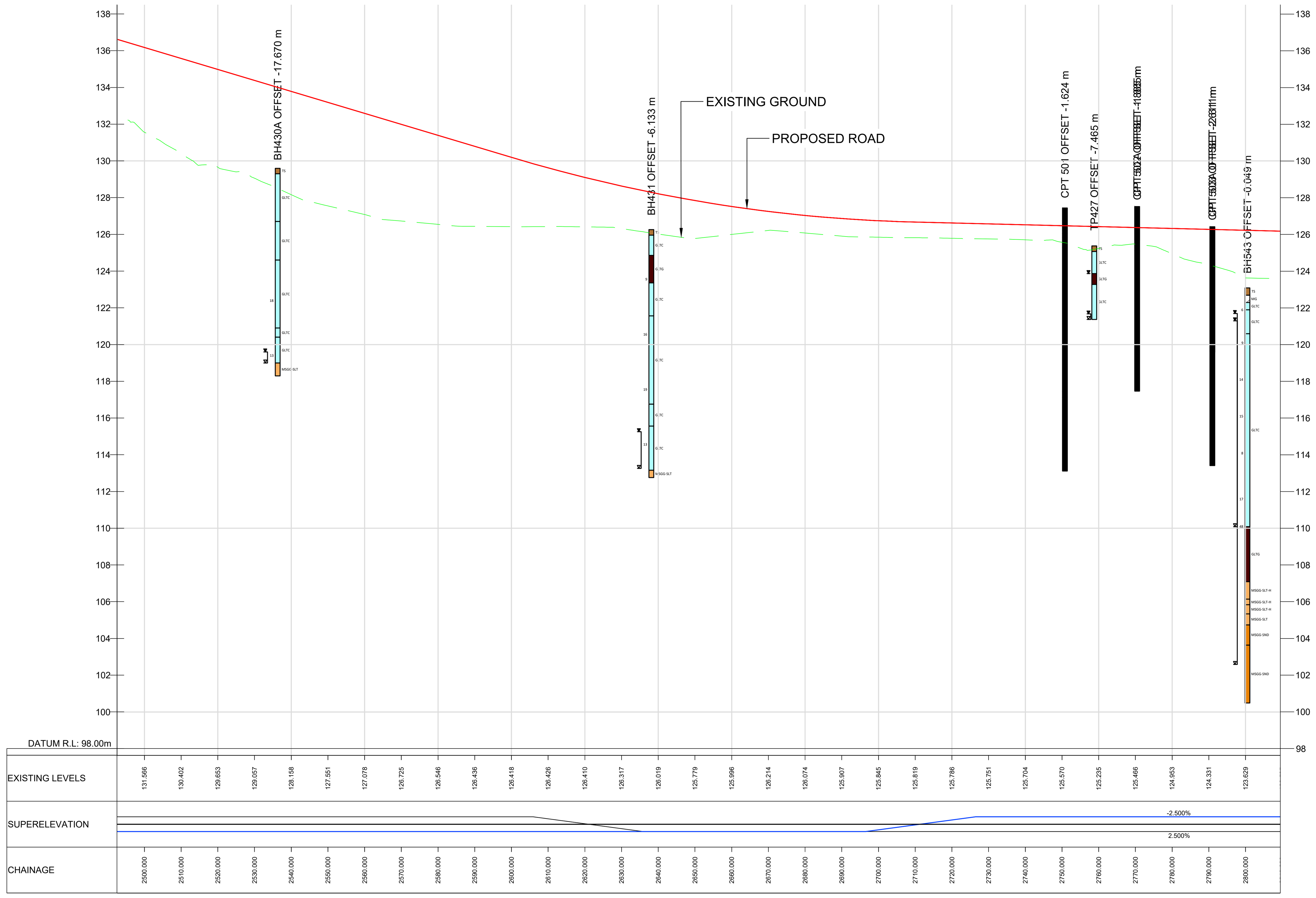
INSTALLATION RESPONSE ZONE

MAXIMUM MEASURED GROUNDWATER LEVEL WITHIN MONITORING INSTALLATION

GROUNDWATER STRIKE LEVEL

GROUNDWATER LEVEL AFTER 20 MINS

29 SPT N-VALUES (NUMBERS AT SIDE OF BH STICKS)



SCALE = H - 1:1000
V - 1:200

Scale 1:1000
HORIZONTAL SCALE

Scale 1:200
VERTICAL SCALE

NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. FOR DETAILS ON THE PHASE 5 EXPLORATORY HOLES AND KNOWN BURIED SERVICES & UTILITIES INFORMATION REFER TO THE A57 LINK ROADS GROUND INVESTIGATION SPECIFICATION HE551473-BBA-HGT-A57_AL_SCHEME-SP-CE-000001.
3. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWINGS HE551473-BBA-HGT-A57_AL_SCHEME--DR-CE-000001 TO 000008.
4. THE PHASE 5 EXPLORATORY HOLE POSITIONS ARE AS-BUILT SURVEY BY THE GI CONTRACTOR.
5. 30m BUFFER EACH SIDE OF THE ROAD CENTRE ALIGNMENT HAS BEEN USED FOR THE EXPLORATORY HOLES IN THE LONG SECTION.

PROPOSED HIGHWAY ALIGNMENT

EXISTING GROUND

PLAN KEY

- HISTORICAL BOREHOLE LOCATION
- HISTORICAL TRIAL PIT LOCATION
- PHASE 4 BOREHOLE LOCATION
- PHASE 4 TRIAL PIT LOCATION
- PHASE 4 CONE PENETROMETER TEST
- PHASE 5 BOREHOLE LOCATION
- PHASE 5 TRIAL PIT LOCATION
- PHASE 5 CONE PENETROMETER TEST
- ROAD ALIGNMENT CHAINAGE (2450)
- SITE BOUNDARY

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Maintenance / Cleaning
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Use
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Decommissioning / Demolition
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Description	Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Issue to NH	S3	P01	CC	GDS	JJ	---	19/01/22
Revised based on NH comments	S4	C01	CC	GDS	MSR	MSR	17/03/22

Drawing Suitability: FOR STAGE APPROVAL
Status: S4

Designer: ATKINS
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Delivery Partner: Balfour Beatty
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www.balfourbeatty.com

Client: highways england

Project Title: A57 TPU

Drawing Title: A57 LINK ROADS GEOLOGICAL LONG SECTION GI PHASES 4 & 5 DATA SHEET 7 OF 8

Drawing Number: HE551473 - BBA - HGT - A57_AL_SCHEME - DR - CE - 000037

Original Size: A1 | Scale: AS SHOWN | Project Ref. No: 5186301 | Sheet: 7 of 8 | Rev: C01

DO NOT SCALE

Scale 1:1000

GEOLOGY SECTION KEY

GEOL CODE	DESCRIPTION
ALVC	Alluvium Cohesive
ALVG	Alluvium Granular
ALVP	Alluvium Peat
GLTC	Glacial Till Cohesive
GLTG	Glacial Till Granular
MG	Made Ground
PEAT	Peat
TS	Topsoil
MSGG-M	Millstone Grit Group Mudstone
MSGG-M-H	Millstone Grit Group Highly Weathered Mudstone
MSGG-M-M	Millstone Grit Group Moderately Weathered Mudstone
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GROUNDWATER LEVEL AFTER 20 MINS

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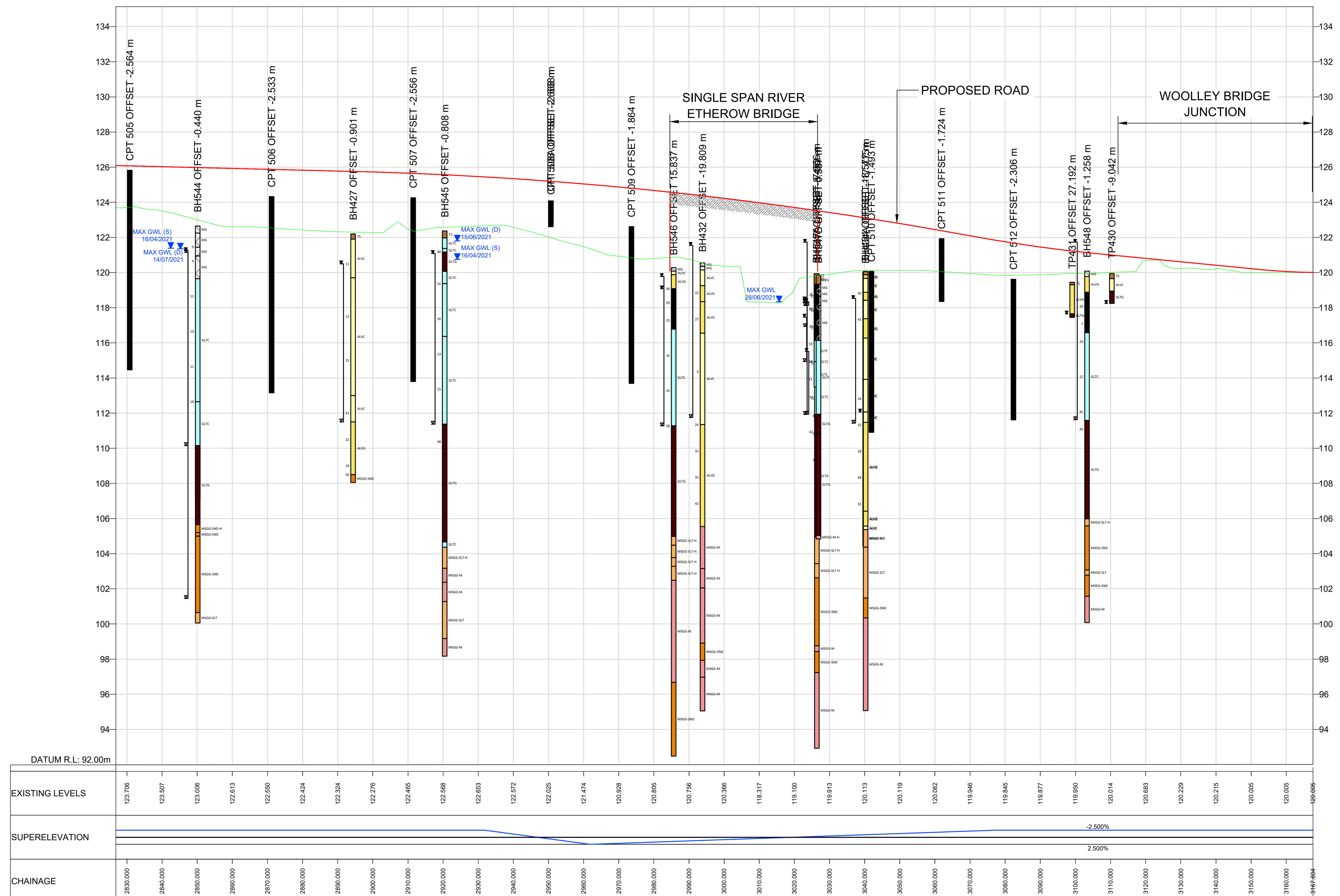

SCALE = H - 1:1000
V - 1:200

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Scale 1:200
VERTICAL SCALE

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PROPOSED HIGHWAY ALIGNMENT

EXISTING GROUND

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- PHASE 4 BOREHOLE LOCATION
- PHASE 4 TRIAL PIT LOCATION
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- PHASE 5 BOREHOLE LOCATION
- PHASE 5 TRIAL PIT LOCATION
- PHASE 5 CONE PENETROMETER TEST
- ROAD ALIGNMENT CHAINAGE
- SITE BOUNDARY

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Maintenance / Cleaning
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Use
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Decommissioning / Demolition
REFER TO HEALTH AND SAFETY RISK REGISTER DOCUMENT No:

Description	Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
Issue to NH	S3	P01	CC	GDS	JJ	---	19/01/22
Revised based on NH comments	S4	C01	CC	GDS	MG	MSR	17/03/22

Drawing Suitability: FOR STAGE APPROVAL — Status: S4

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www.atkinsglobal.com
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www.balfourbeatty.com

Client: highways england

Drawing Title:
A57 LINK ROADS
GEOLOGICAL LONG SECTION
GI PHASES 4 & 5 DATA
SHEET 8 OF 8

Drawing Number
Project: HE551473 - Originator: BBA - Volume: HGT -
Location: A57_AL_SCHEME - Type: DR - Role: CE - Number: 000038

Original Size: A1 | Scale: AS SHOWN | Project Ref. No: 5186301 | Sheet: 8 of 8 | Rev: C01

This Drawing is saved on ProjectWise. Plotted: 17/03/2022 19:34:08 By: DESA1722

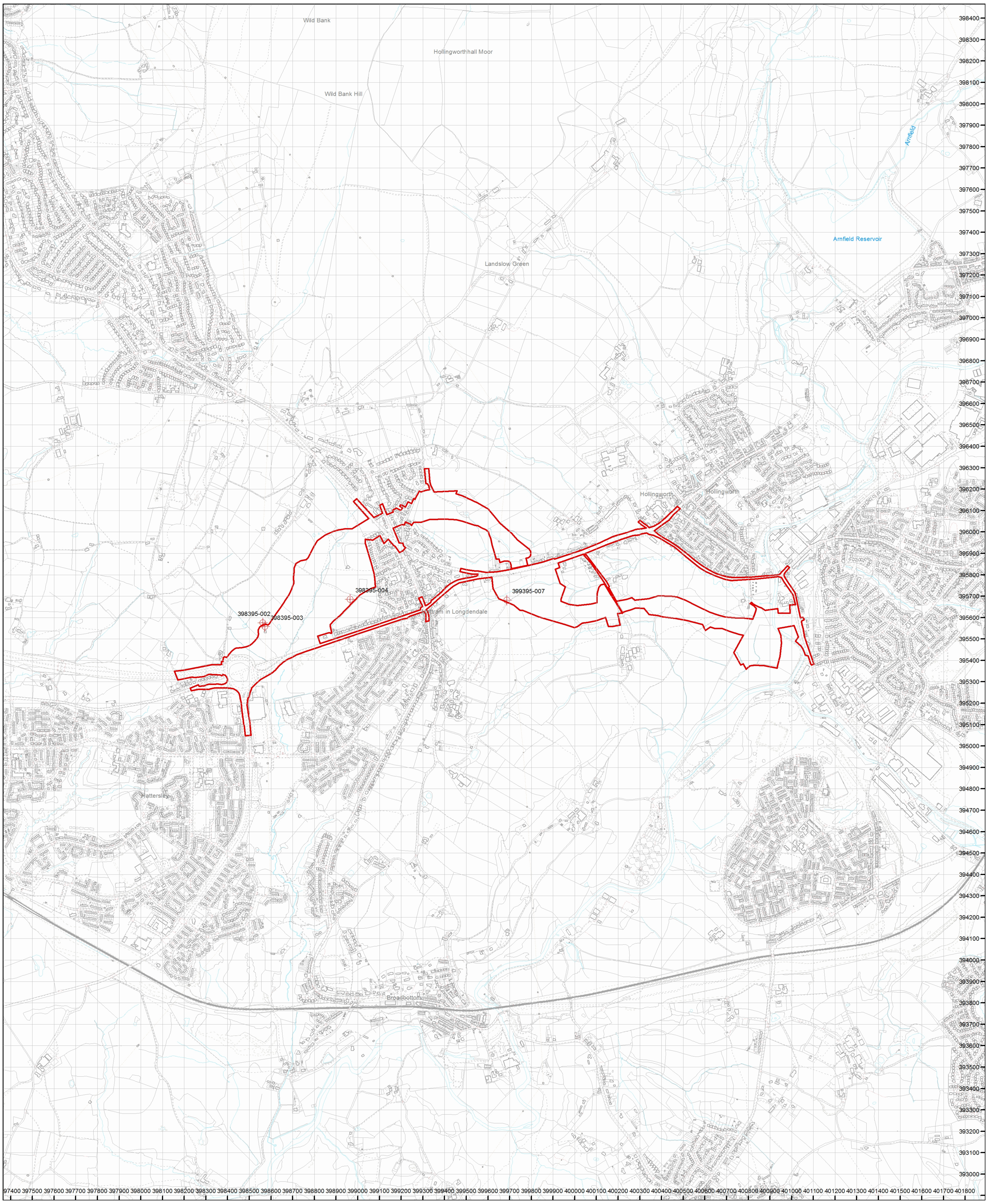
Appendix B. Coal Mining Factual Reports

Enquiry boundary

Key

Approximate position of enquiry boundary shown

Disused mineshaft



How to contact us

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+44 (0)1623 637 000 (International)

200 Lichfield Lane
Mansfield
Nottinghamshire
NG18 4RG

www.groundstability.com

@coalauthority

/company/the-coal-authority

/thecoalauthority

/thecoalauthority

The Coal Authority

CON29M

coal mining report

MOTTRAM IN LONGDENDALE, MOTTRAM IN LONGDENDALE, GREATER MANCHESTER

Known or potential coal mining risks

Further action

These additional reports can give further detail on the risks identified:

- Mine entry interpretive report
- Mine entry plan and data sheets

For more information please see our Further action reports on page 10

Professional opinion

According to the official mining information records held by the Coal Authority at the time of this search, evidence of, or the potential for, coal mining related features have been identified. In view of the coal mining circumstances we would recommend that any planned or future development should follow detailed technical advice before beginning work on site. Please see page 3 for further details on Future development.

Your reference:
Our reference: 71007510621001
Date: 4 January 2021

Client name: ATKINS

If you require any further assistance please contact our experts on:
0345 762 6848
groundstability@coal.gov.uk

The Law Society

Enquiry boundary

The map image is too large for this page and will be sent in a separate document

We can confirm that the location is
on the coalfield

This report is prepared in accordance with the latest Law Society's Guidance Notes 2018, the User Guide 2018 and the Coal Authority's Terms and Conditions applicable at the time the report was produced.

Accessibility

If you would like this information in an alternative format, please contact our communications team on 0345 762 6848 or email communications@coal.gov.uk.

Professional opinion

Mine entries

The enquiry boundary shows the approximate location of the disused mine entry/entries referred to in this report. Property owners have the benefit of statutory protection (under the Coal Mining Subsidence Act 1991). This contains provision for the making good, to the reasonable satisfaction of the owner, of physical damage caused by disused coal mine workings including disused coal mine entries. A leaflet setting out the rights and obligations of either the Coal Authority or other responsible persons under the 1991 Act can be obtained by visiting www.coal.gov.uk. Please note this Act is not valid where coal was worked or extracted by virtue of the grant of a gale in the Forest of Dean, or any other part of the Hundred of St. Briavels in the county of Gloucester.

If you wish to discuss the relevance of any of the information contained in this report, you should seek the advice of a qualified mining engineer or surveyor. If you or your advisor wishes to examine the source plans from which the information has been taken, these are available to view, at our Coal Authority head office in Mansfield. To book an appointment please call 01623 637 225. Should you or your advisor wish to carry out a physical investigation that may enter, disturb or interfere with any disused mine entry, prior permission must be sought from the owner. For coal mine entries, the owner will normally be the Coal Authority.

The Coal Authority, regardless of responsibility and in conjunction with other public bodies, provide an emergency, 24 hour call out facility in coalfield areas to assess the public safety implications of mining features (including disused mine entries). To report an emergency you can call 01623 646 333.

Future development

If development proposals are being considered, technical advice relating to both the investigation of coal and former coal mines and their treatment should be obtained before beginning work on site. All proposals should apply specialist engineering practice required for former mining areas. No development should be undertaken that intersects, disturbs or interferes with any coal or coal mines without first obtaining the permission of the Coal Authority. Developers should be aware that the investigation of coal seams, mine workings or mine entries may have the potential to generate and/or displace underground gases. Associated risks both to the development site and any neighbouring land or properties should be fully considered when undertaking any ground works. The need for effective measures to prevent gases migrating onto any land or into any properties, either during investigation or remediation work, or after development must also be assessed and properly addressed.

If you are looking to develop, or undertake works, within a coal mining development high risk area your Local Authority planning department may require a Coal Mining Risk Assessment to be undertaken by a qualified mining geologist or engineer. Should you require any additional information then please contact the Coal Authority on 0345 762 6848 or email cmra@coal.gov.uk.

Detailed findings

Information provided by the Coal Authority in this report is compiled in response to the Law Society's CON29M Coal Mining enquiries. The said enquiries are protected by copyright owned by the Law Society of 113 Chancery Lane, London WC2A 1PL.

1 Past underground coal mining

The property is not within a surface area that could be affected by any past recorded underground coal mining.

However the property is in an area where the Coal Authority believes there is coal at or close to the surface. This coal may have been worked at some time in the past. The potential presence of coal workings at or close to the surface should be considered, particularly prior to any site works or future development activity, as ground movement could still be a risk. Your attention is drawn to the Professional opinion sections of the report.

2 Present underground coal mining

The property is not within a surface area that could be affected by present underground mining.

3 Future underground coal mining

The property is not in an area where the Coal Authority has received an application for, and is currently considering whether to grant a licence to remove or work coal by underground methods.

The property is not in an area where a licence has been granted to remove or otherwise work coal using underground methods.

The property is not in an area likely to be affected from any planned future underground coal mining.

However, reserves of coal exist in the local area which could be worked at some time in the future.

No notices have been given, under section 46 of the Coal Mining Subsidence Act 1991, stating that the land is at risk of subsidence.

4 Mine entries

Within, or within 20 metres of, the boundary of the property there are 4 mine entries, the approximate positions of which are shown on the enquiry boundary plot. For reasons of clarity, mine entry symbols may not be drawn to the same scale as the plan.

There is no record of what steps, if any, have been taken to treat the mine entries.

This information is based on the information that the Coal Authority has at the time of this enquiry.

Based on the Coal Authority's knowledge of the mining circumstances at the time of this enquiry, there may be unrecorded mine entries in the local area that do not appear on Coal Authority records.

For an additional fee, the Coal Authority can provide a Mine Entry Interpretive Report. The report will provide a separate assessment for the mine entry/entries referred to in this report. It gives an opinion on the likelihood of mining subsidence damage caused from ground movement as a consequence of the mine entry/entries. It also gives details of the remedies available for subsidence damage where the mine entry was sunk in connection with coal mining.

Please note that it may not be possible to produce a report if the main building to the property cannot be identified from Coal Authority plans (ie for development sites and new build).

For further advice on how to order this additional information please visit www.groundstability.com.

5 Coal mining geology

The Coal Authority is not aware of any damage due to geological faults or other lines of weakness that have been affected by coal mining.

6 Past opencast coal mining

The property is not within the boundary of an opencast site from which coal has been removed by opencast methods.

7 Present opencast coal mining

The property does not lie within 200 metres of the boundary of an opencast site from which coal is being removed by opencast methods.

8 Future opencast coal mining

There are no licence requests outstanding to remove coal by opencast methods within 800 metres of the boundary.

The property is not within 800 metres of the boundary of an opencast site for which a licence to remove coal by opencast methods has been granted.

9 Coal mining subsidence

The Coal Authority has not received a damage notice or claim for the subject property, or any property within 50 metres of the enquiry boundary, since 31 October 1994.

There is no current Stop Notice delaying the start of remedial works or repairs to the property.

The Coal Authority is not aware of any request having been made to carry out preventive works before coal is worked under section 33 of the Coal Mining Subsidence Act 1991.

10 Mine gas

The Coal Authority has no record of a mine gas emission requiring action.

11 Hazards related to coal mining

The property has not been subject to remedial works, by or on behalf of the Coal Authority, under its Emergency Surface Hazard Call Out procedures.

12 Withdrawal of support

The property is not in an area where a notice to withdraw support has been given.

The property is not in an area where a notice has been given under section 41 of the Coal Industry Act 1994, cancelling the entitlement to withdraw support.

13 Working facilities order

The property is not in an area where an order has been made, under the provisions of the Mines (Working Facilities and Support) Acts 1923 and 1966 or any statutory modification or amendment thereof.

14 Payments to owners of former copyhold land

The property is not in an area where a relevant notice has been published under the Coal Industry Act 1975/Coal Industry Act 1994.

Statutory cover

Coal mining subsidence

In the unlikely event of any coal mining related subsidence damage, the Coal Authority or the mine operator has a duty to take remedial action in respect of subsidence caused by the withdrawal of support from land or property in connection with lawful coal mining operations.

When the works are the responsibility of the Coal Authority, our dedicated public safety and subsidence team will manage the claim. The house or land owner ("the owner") is covered for these works under the terms of the Coal Mining Subsidence Act 1991 (as amended by the Coal Industry Act 1994). Please note, this Act does not apply where coal was worked or gotten by virtue of the grant of a gale in the Forest of Dean, or any other part of the Hundred of St. Briavels in the county of Gloucester.

If you believe your land or property is suffering from coal mining subsidence damage and you need more information on what to do next, please use the following link to our website which sets out what your rights are and what you need to consider before making a claim.
www.gov.uk/government/publications/coal-mining-subsidence-damage-notice-form

Coal mining hazards

Our public safety and subsidence team provide a 24 hour a day, 7 days a week hazard reporting service, to help protect the public from hazards caused by past coal workings, such as a mine shaft or shallow working collapse. To report any hazards please call 01623 646 333. Further information can be found on our website: www.gov.uk/coalauthority.

Glossary

Key terms

adit - horizontal or sloped entrance to a mine

coal mining subsidence - ground movement caused by the removal of coal by underground mining

Coal Mining Subsidence Act 1991 - the Act setting out the duties of the Coal Authority to repair damage caused by coal mining subsidence

coal mining subsidence damage - damage to land, buildings or structures caused by the removal of coal by underground mining

coal seams - bed of coal of varying thickness

future opencast coal mining - a licence granted, or licence application received, by the Coal Authority to excavate coal from the surface

future underground coal mining - a licence granted, or licence application received, by the Coal Authority to excavate coal underground. Although it is unlikely, remaining coal reserves could create a possibility for future mining, which would be licensed by the Coal Authority

mine entries - collective name for shafts and adits

payments to owners of former copyhold land - historically, copyhold land gave rights to coal to the copyholder. Legislation was set up to allow others to work this coal, but they had to issue a notice and pay compensation if a copyholder came forward

shaft - vertical entry into a mine

site investigation - investigations of coal mining risks carried out with the Coal Authority's permission

stop notice - a delay to repairs because further coal mining subsidence damage may occur and it would be unwise to carry out permanent repairs

subsidence claim - a formal notice of subsidence damage to the Coal Authority since it was established on 31 October 1994

withdrawal of support - a historic notice informing landowners that the coal beneath their property was going to be worked

working facilities orders - a court order which gave permission, restricted or prevented coal mine workings

Further action reports

Mine entry interpretive report - assesses the risk of ground movement from mine entries in, or within 20 metres of, the property boundary. To order this report, use the same boundary as the CON29M report, then draw the building on the additional map screen.

For more information and to order this report please visit:
[redacted]

Mine entry plan and data sheets - give additional information on mine entries recorded on a piece of land. To order this report use the same boundary as the CON29M report and a member of our team will contact you to confirm the mine entries to include in this bespoke report.

For more information and to order this report please visit:
[redacted]

Appendix C. Geophysics Reports

Mottram

Geophysical Survey

Report on Electrical Resistivity Tomography Survey for Aqueduct identification

Carried out for:

United Utilities

July 2021

Report No: L1012-21/R0

Report No: L1012-21/R0

DATE: July 2021

Issue No Date	Status	Prepared by	Checked by	Approved by
Rev0		Danielle Kiefer (BSc, FGS)	Joe Milner (BSc, FGS)	Joe Milner (BSc, FGS)
July 2021	Final	[redacted]	[redacted]	[redacted]

CONTENTS

EXECUTIVE SUMMARY

On the 28th June 2021, SOCOTEC mobilised to the Mottram site to carry out 3 lines of Electrical Resistivity Tomography (ERT). The survey was required to confirm the location of an aqueduct believed to be 8 metres below the ground running through the base of a valley.

Survey Aims	• Identify location of an aqueduct.
Survey Objectives	• Undertake 3 lines of ERT survey. • Process the datasets to map variations in the subsurface. • Produce AutoCAD drawings highlighting results. • Produce a geophysical report highlighting findings.
Geophysical Techniques Used	• Electrical resistivity tomography survey (ERT).
Geophysical Investigation Findings	A restriction to the survey area due to Japanese Knotweed, a stream and limited areas of vegetation clearance meant the positioning of the survey lines was not as desired. All RMS errors were less than 5% suggesting the data were of good quality. A conductive body at depth has been identified in all 3 lines, most clearly in Lines 2 and 3, likely relating to a saturated body. There is no clear evidence of the aqueduct seen in the data at the expected depth.
Recommendations	It is recommended that geophysical anomalies are targeted intrusively for verification.

1 INTRODUCTION

In June of 2021 a geophysical survey was undertaken at the Mottram site by SOCOTEC. The survey was undertaken to identify the position of an aqueduct known to be within the valley, at a suspected depth of 8 metres below the ground. To meet the survey objectives Electrical Resistivity Tomography (ERT) surveys were undertaken in a series of 3 lines.

Figure 1: Photos taken on site showing the ERT line setup.

2 THE SITE

The site is centred on:

- National Grid Reference: SJ 99758 95901 (**Appendix A, Figure 1**)

Based on the information available from nearby boreholes the surrounding geology is mainly sandstone overlaid by clays. The clays were found in the upper 6-8 metres, with glacial till found from 4m down. The sandstone was noted as moderately weathered.

3 FIELDWORK

3.1 Scope of works

The scope of work was detailed to include the following aspects:

- Electrical Resistivity Tomography (ERT)

3.2 Fieldwork Activities

On the 28th June the survey team mobilised from the Deeside SOCOTEC offices and travelled to the Mottram Site. Survey works were undertaken during the day between the hours of 08:30 – 18:00. On completion of site works, the survey team demobilised from site and travelled back to the Deeside SOCOTEC office.

The following Equipment was used to complete the scope of works.

Portion of Survey	Type of Equipment	Item of Equipment
Surface positioning	RTK GPS System	Leica GS08 RTK GPS system with SmartNet corrections
Geophysical Survey	Resistivity meter + survey equipment	ABEM LS2 Terrameter 4 no. ERT Cables with 21 no. take outs 81 no. Electrodes
Other		Laptop computers, Safety equipment, PPE

Technical Information on the equipment used for the survey can be found in Appendix C.

The following personnel were mobilised to site to carry out the survey;

Elliott Richardson (MSc) Geophysicist
Harry Martin (MSc) Assistant Geophysicist

3.3 Fieldwork Observations

During the site walkover, an area of Japanese knotweed was identified. The areas affected by this were taken into account when positioning the ERT lines. There was also a stream identified at one end of the site which was fairly deep in places. See **Figure A2, Appendix A** for photos. The combination of these factors and the cleared area available to the site team meant a less than ideal positioning of the survey lines.

3.4 Positioning

A Leica GS08 RTK GPS system, with high precision corrections being obtained via the Leica SmartNet network corrections service, was utilised for site works. The Leica RTK GPS system was used to survey the coordinates and levels of the electrodes for the ERT survey.

3.5 Electrical Resistivity Tomography Survey

An ABEM LS2, computer controlled multichannel resistivity imaging system, was used to complete the Electrical Resistivity Tomography (ERT) survey works. The equipment is comprised of an ABEM LS2 Resistivity meter, 4 resistivity imaging cables each with 21 take outs, 5 metre separation and 81 electrodes.

All lines utilised the Dipole-Dipole array, due to their sensitivity to shallow surface horizontal variations. A schlumberger array was utilised over Line 1 as a quality check. All line information is shown in **Table 1.**

Line ID	Array Type	Inter-Electrode Separation (m)	Total Profile Length (m)
1	Dipole-Dipole	1.5	120
2	Dipole-Dipole	1.0	80
3	Dipole-Dipole	1.5	120

Table 1: Summary of resistivity profiles

3.5.1 **Electrical Resistivity Tomography Data Quality**

In general the data quality across the 3 lines were of good quality. All RMS errors were below the 5%, which is deemed to indicate good quality data. Any negative readings were removed at the initial raw data stage.

3.5.2 **Electrical Resistivity Tomography Processing**

The data were first exported from the ABEM system in a DAT format and combined with the topography data for the electrode positions collected on site. The file is then converted into the correct format using the ABEM Toolbox software, where any negative readings or readings with a high percentage variance were filtered out. This file was then imported into the software RES-2DINV for processing. Erroneously high apparent resistivity data detected were manually filtered within the RES-2DINV program. The program splits the sub-surface into a series of rectangular blocks and then determines the resistivity of the rectangular blocks that will produce an apparent resistivity pseudo section that agrees with the actual measurements. Inversion parameters in areas with high variations were optimised by making the blocks smaller and therefore reducing the effect of the high surface resistivity on the overall model. This process is repeated a number of times (iterations) to bring the model closer to the actual observed data.

The number of inversion iterations are summarised in **Table 2** and were chosen based on the point where subsequent iterations did not significantly reduce the root mean square (RMS) error**.** The inversion method chosen was the smoothness constrained least squares method. A mesh refinement algorithm was incorporated to better resolve high near surface resistivity variations. Good data is generally up to 5% RMS error.

Line Number	Number of Iterations	RMS Error (%)
1	6	1.8
2	7	2.5
3	4	1.7

Table 2: Inversion parameters for ERT model.

4 RESULTS

4.1 ERT Results

All pseudo-sections created from the inversion process are shown in drawings **L1012-21/02, Appendix B**. the data is presented on the same linear colour scale for all three lines to allow for direct comparison. The scale was chosen to best show the variations of resistivity through the entire depth of the results. The higher resistances seen at the surface are due to the constraints used on the colour scale, the resistances seen are common for that of shallow surface variations.

Within all 3 lines two defined layers can be seen in the results. The upper dark blue layers have a resistivity range of ~60-100 Ohm/m, likely relating to the clay layer seen in the boreholes. The second layer, with a range of ~150-200 Ohm/m, shown by greens in the drawing, is likely to relate to the sandstone layers.

Anomaly 1 is a low resistivity, conductive body at depth. This may relate to a saturated body of material or a water filled area. It is seen most clearly in Lines 2 and 3 and the location along the lines do correspond with one another.

From records it is believed that the aqueduct is approximately 8 metres deep, of brick construction with an arched roof and a diameter greater than 1 metre. The positing of Line 1 is unlikely to show any evidence of the aqueduct due to having the same orientation that we expect the aqueduct to have. The positioning of lines 2 and 3 were confined to the restrictions on site, due to the presence of Japanese knot weed and a running stream. Therefore the orientation and length of the survey lines are not ideally placed to allow us to have surveyed the area in its entirety. If the aqueduct in question was water filled at the time of the survey, due to the conductive bodies seen on site, the response we would expect to see in the data would match that of its surroundings. In general there is no clear evidence within the results of an aqueduct being present on site within the area surveyed.

5 SAFETY

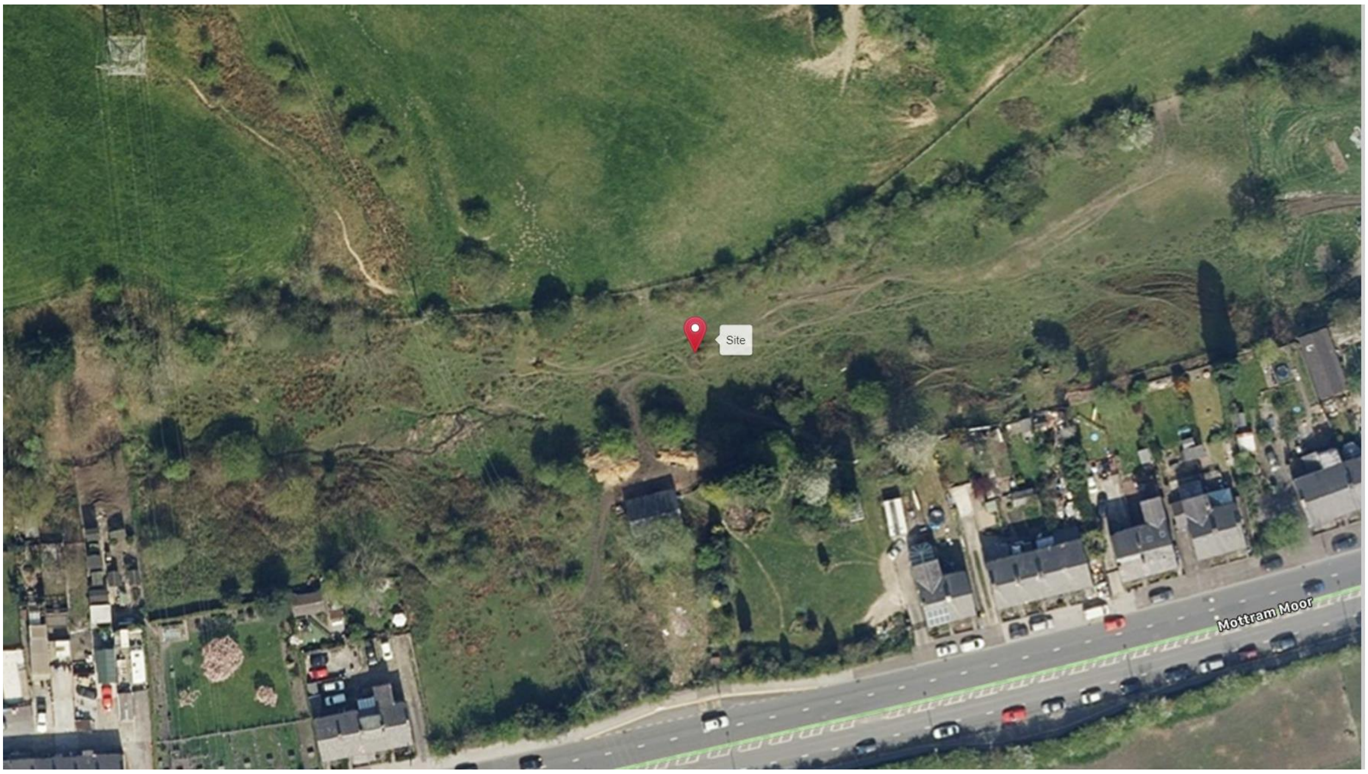
All SOCOTEC and BGS staff members were briefed on the project requirements by the project leader and undertook inductions by Severn Trent to the site specific hazards and site rules. Upon receipt of a daily toolbox talk, SOCOTEC staff members were briefed on the tasks to be undertaken on each shift.

All operations and procedures on site during the survey adhered to SOCOTEC Surveys method statement and control measures put in place as a result of carrying out a risk assessment. This can be found in the previous SOCOTEC document number L1012-21-RAMS.

APPENDIX A – FIGURES AND TABLES

Site Location Plan

National Grid Reference: - SJ 99758 95901



Notes:	Project	Mottram ERT Geophysical Survey	Figure
	Project No.	L1012-21	A1
	Carried out for	United Utilities	

Site Photos

Figure 1: Position of ERT lines across the site.

Figure 2: Picture showing how lines were orientated to fit through gaps in bushes and other vegetation.

Notes:	Project	Mottram ERT Geophysical Survey	Figure
	Project No.	L1012-21	A2
	Carried out for	United Utilities	

Site Photos

Figure 3: Pictures showing running water at the surface on site. The stream was quite deep in places.

Figure 4: Japanese knotweed was identified on site affecting the positioning of the ERT lines.

Notes:			Figure
	Project	Mottram ERT Geophysical Survey	A2
	Project No.	L1012-21	
	Carried out for	United Utilities	

APPENDIX B – DRAWINGS

Drawing Number	**Description**
L1012-21/01	Site Overview
L1012-21/02	ERT Results

Legend:

ERT LINES

UU WATER DISTRIBUTION NETWORK

Notes:

1) Co-ordinate System: OS National Grid (OSGB1936).

2) All levels are reduced to Ordnance Datum Newlyn (OD(N))

Scale: 1:200

0 2m 4m 8m 12m 16m

Rev.	Date	Changes	Checked	Approved	Details
0	July 21	-	JM	JM	Issued

Survey Date:	Surveyor:	Drawn By:
28/06/21	ER	DK

Client: United Utilities

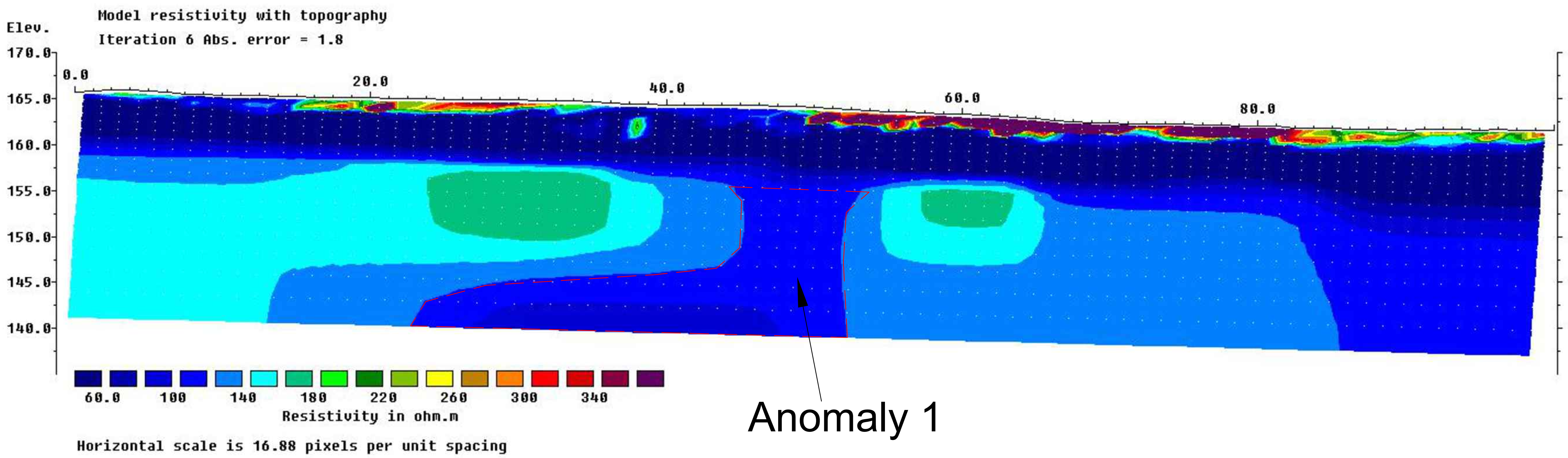
Contractor: SOCOTEC

Geotechnical House
18 - 19 Drome Road
Deeside Industrial Park, Deeside, Flintshire
CH5 2NY, United Kingdom
www.socotec.co.uk
surveys-geophysics@socotec.com
Tel: +44(0)1244 288200

Project: Mottram ERT Survey

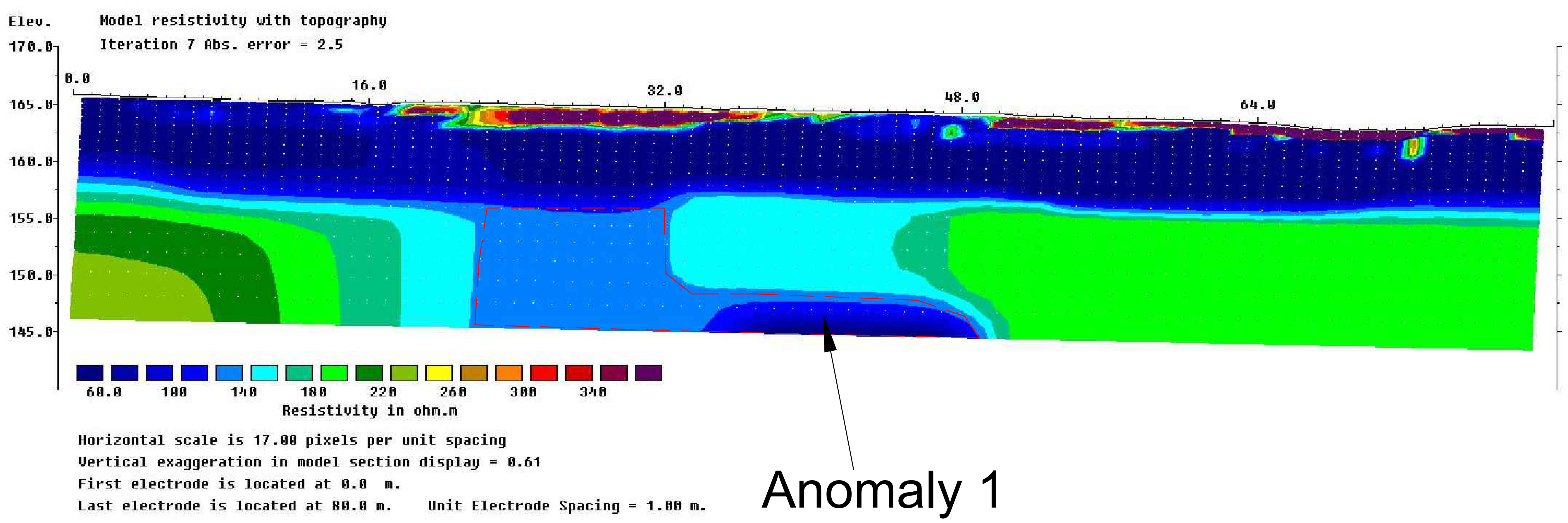
DWG: Site Overview L1012-21/01

Original Sheet Size:	Scale:	Rev.:
A1	1:200	0



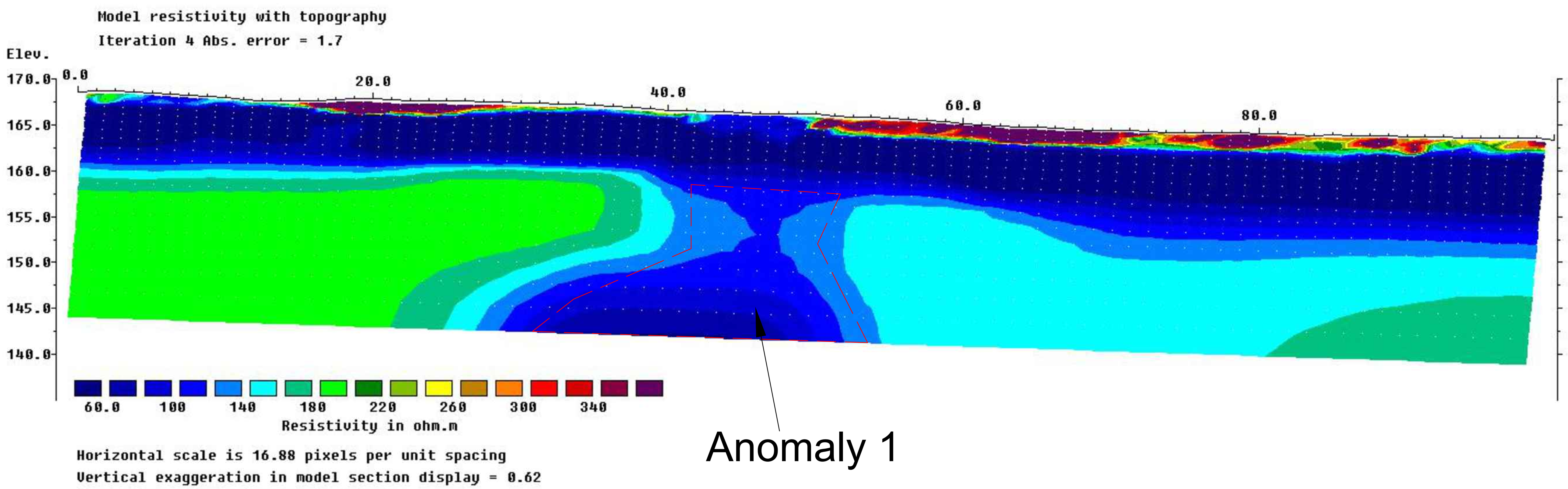
Horizontal scale is 16.88 pixels per unit spacing
Vertical exaggeration in model section display = 0.62
First electrode is located at 0.0 m.
Last electrode is located at 100.0 m. Unit Electrode Spacing = 1.25 m.

Line 1 ERT Results



Horizontal scale is 17.00 pixels per unit spacing
Vertical exaggeration in model section display = 0.61
First electrode is located at 0.0 m.
Last electrode is located at 80.0 m. Unit Electrode Spacing = 1.00 m.

Line 2 ERT Results

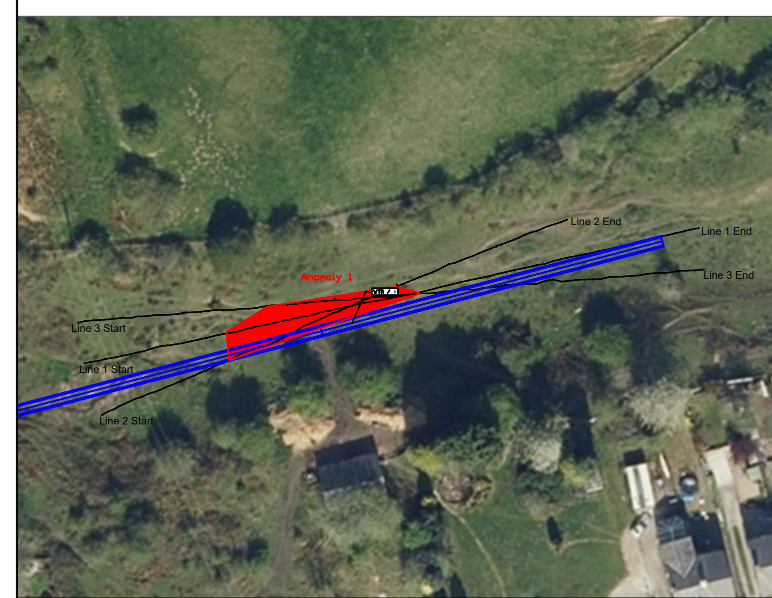


Horizontal scale is 16.88 pixels per unit spacing
Vertical exaggeration in model section display = 0.62
First electrode is located at 0.0 m.
Last electrode is located at 100.0 m. Unit Electrode Spacing = 1.25 m.

Line 3 ERT Results

Legend:

ERT LINES
UU WATER DISTRIBUTION NETWORK



Notes:
1) Co-ordinate System: OS National Grid (OSGB1936).
2) All levels are reduced to Ordnance Datum Newlyn (OD(N))

Scale: 1:200
0 2m 4m 8m 12m 16m

Rev.	Date	Changes	Checked	Approved	Details
0	July 21	-	JM	JM	Issued

Survey Date: 28/06/21
Surveyor: ER
Drawn By: DK

Client: United Utilities

Contractor: SOCOTEC
Geotechnical House
18 - 19 Drome Road
Deeside Industrial Park, Deeside, Flintshire
CH5 2NY, United Kingdom
www.socotec.co.uk
surveys-geophysics@socotec.com
Tel: +44(0)1244 288200

Project: Mottram ERT Survey

DWG: Lines 1 - 3 ERT Results
L1012-21/02

Original Sheet Size: A1
Scale: 1:200
Rev.: 0

APPENDIX C – TECHNICAL SPECIFICATIONS

GPS – Leica GS08
Leica Smartnet
ABEM LS2

Technical Information

Leica SmartNet
Commercial RTK Network for Great Britain

Leica SmartNet is a broadcast correction service introduced in 2006 as a partnership between Leica Geosystems and Ordnance Survey.

Leica SmartNet is enabled by the network of Ordnance Survey base stations to create a high density, high redundancy network which is able to deliver corrections at the centimetre level in RTK mode or sub-metre DGPS and with raw data for post processing. This network of base stations, known as OS Net, comprises around 90 permanent nationally deployed GPS reference stations.

Data from each of these base stations around the country is received over the Internet at a secure location in London Docklands where they are processed using Leica SpiderNet, Leica Geosystems advanced network calculation software. These data are then made available to users via GSM or GPRS cellphone technology.

Technical Information

Leica GS14 GNSS Receiver

GS14 is a high specification RTK GNSS Surveying Receiver, providing high accuracy, reliability and flexibility. The system consists of the Leica GNSS AS05 Antenna and the Leica GS14 GNSS Receiver with an internal Li-ion battery charger and ruggedized casing providing environmental protection to IP67 standards.

The GS14 Receiver is built to allow many setup options and connection to a variety of devices and data download facilities. Having Windows CE™ user interface and support software, together with Bluetooth™ wireless technologies, GSM, UMTS or radio options, it does not require external configuration or communication devices. This allows direct contact via the internet to control the system and to upload/download data.

GS14 GNSS Receiver Technical Data:

Weight and dimensions	
Weight (GS25)	0.93 kg
Dimension (GS25)	190 mm x 90 mm
Environmental Specifications	
Temperature, operating	-40° C to +65° C, compliance with ISO9022-10-08, ISO9022-11-special, MIL STD 810G –502.5-II, MIL STD 810G – 501.5-II
Temperature, storage	-40° C to +80° C, compliance with ISO9022-10-08, ISO9022-11-special, MIL STD 810G –502.5-I, MIL STD 810G – 501.5-I
Humidity	100%, compliance with ISO9022-13-06, ISO9022-12-04 and MIL STD 810G – 507.5-I
Proof against: water, sand and dust	IP68 according IEC60529 and MIL STD 810G - 506.5-I, MIL STD 810G – 510.5-I and MIL STD 810F – 512.5-I Protected against blowing rain and dust Protected against temporary submersion into water (max. depth 1.4 m)
Vibration	Withstands strong vibration during operating, compliance with ISO9022-36-08 and MIL STD 810G – 514.6-Cat.24
Drops	Withstands 1.0 m drop onto hard surfaces
Functional shock	40 g / 15-23 msec, compliance with MIL STD 810G – 516.6-I
Power & Electrical	
Supply voltage	Nominal 12V DC
Range	10.5 – 28V DC
Power consumption	Typically: 2.0 W
Internal power supply	Recharge & removable LI-Ion battery, 2.6 Ah / 7.4 V
External power supply	Rechargeable external NiMh battery 9 Ah / 12 V
Certifications	Compliance to: FCC, CE, PTCRB Local and operator specific approvals (as IC Canada, C-Tick Australia, Japan, China AT&T)

Antenna Technical Data:

GNSS technology	SmartTrack
Satellite signal tracking	GPS L1, L2, GLONASS
Ground plane	Built-In Ground plane
Dimensions (diameter x height)	170 mm x 62 mm 170 mm x 62 mm
Weight	0.93 kg
Temperature operating	-40° C to +65° C
Temperature storage	-40° C to +80° C
Humidity	100%
Protection against water, sand	IP68
drops & topple over	Withstands 1 m drop onto hard surfaces and survives topple over from a 2 m pole onto hard surfaces
Vibration	Withstands strong vibration during operating Compliance with ISO9022-36-08 and MIL-STD 810G – 514.6-Cat.24

Accuracy

Dependent upon number of satellites tracked, constellation geometry, observation time, ephemeris accuracy, ionospheric disturbance, multipath and resolved ambiguities.

Accuracy (rms) Code differential with DGPS/ RTCM	
DGPS / RTCM	Typically 25 cm (rms)
Accuracy (rms) with Real-Time (RTK)	
Standard of compliance	Compliance with ISO17123-8
Rapid static (phase) (Static mode after initialisation)	Horizontal: 8 mm + 1 ppm (rms) Vertical: 15 mm + 0.1 ppm (rms)
Kinematic (phase) (Moving mode after initialization)	Horizontal: 8 mm + 0.5 ppm (rms) Vertical: 15 mm + 0.5 ppm (rms)
Accuracy (rms) with Post Processing	
Static (phase) with long observations	Horizontal: 3 mm + 0.1 ppm (rms) Vertical: 3.5 mm + 0.4 ppm (rms)
Static and rapid static (phase)	Horizontal: 3 mm + 0.5 ppm (rms) Vertical: 5 mm + 0.5 ppm (rms)
Kinematic (phase)	Horizontal: 10 mm + 1 ppm (rms)

SOCOTEC

ABEM Terrameter LS 2

ABEM Terrameter LS 2 is a world leading resistivity/IP instrument which can be used for a wide range of applications. With its software licensing system, it is available in multiple configurations to best match your requirements.

General

- Casing rugged aluminium case meets IEC IP66
- Computer Embedded ARM 9, 400 MHz
- GPS Built-in GPS with support for GLONASS
- Display 8,4" Active TFT LCD, full colour, daylight visible
- I/O ports 2x KPT 32 pin for imaging
- AUX, Interconnect, USB A, RJ45 for LAN
- WLAN IEEE 802.11 b/g/n, built-in antenna
- 3G/GSM1 3G (UMTS/HSPA+) and GSM (GPRS/Edge), built-in antenna
- Measure modes Resistivity, SP, Resistivity and IP using 50 % duty cycle, resistivity and IP using 100 % duty cycle1
- Service point Accessible through Internet
- Memory capacity 16 GB, microSD card accessable from outside
- Power 12 V, 8 Ah internal battery, built-in charger
- Dimensions 39 x 21x32 cm (WxLxH)
- Weight 13.9 kg, 12.2 kg without internal battery

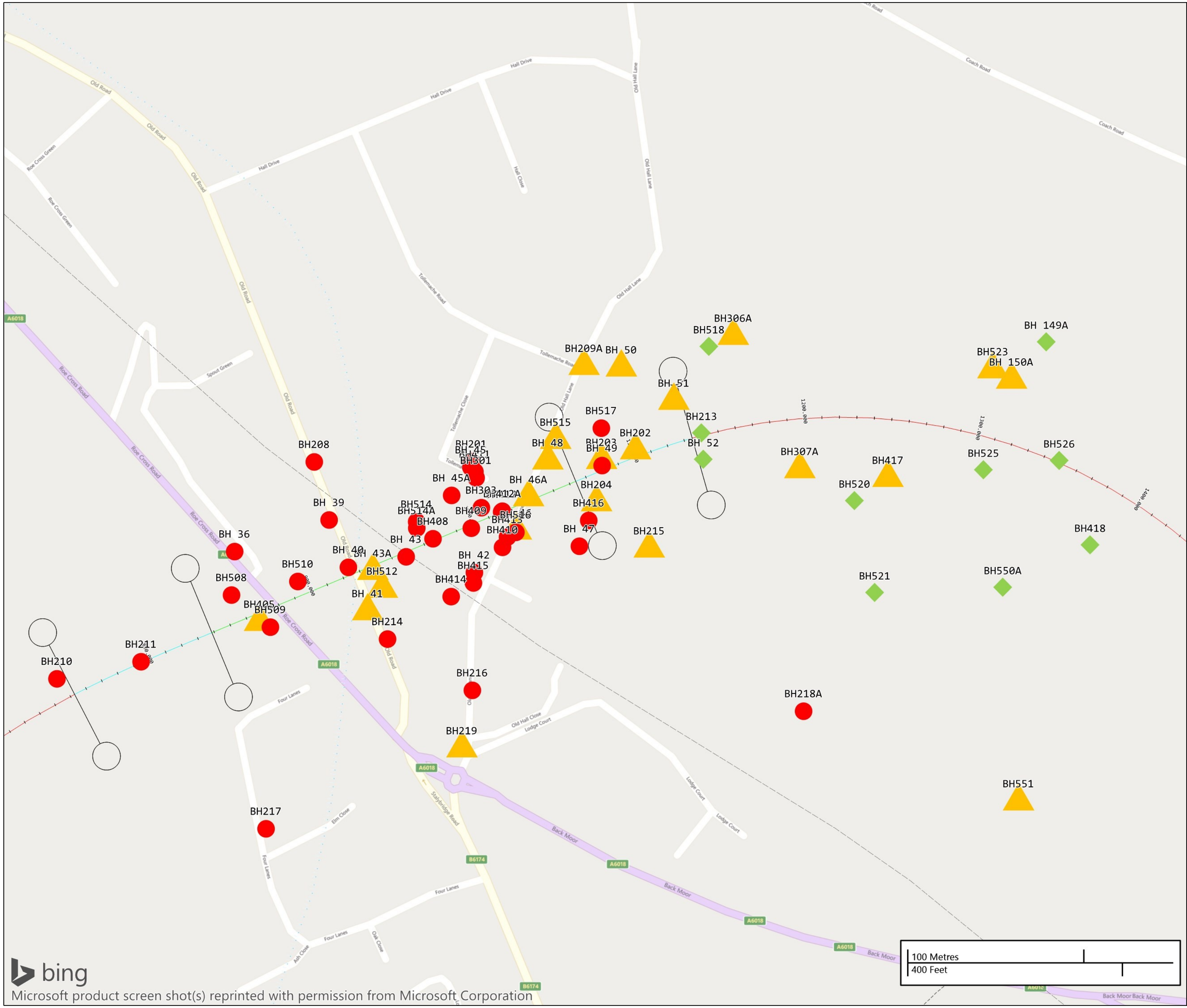
Multi-Electrode Survey Systems for 2D & 3D

- Number of electrodes - Up to 81, using internal electrode selector
  Up to 16384, using external electrode selectors
- Roll-along - Full coverage, both 2D and 3D
- Pre-installed array types - Multiple Gradient, Dipole-Dipole, Wenner, Schlumberger, Pole-Dipole and Pole-Pole
- Remote electrodes 2 remote electrodes in addition to inline electrodes
- Electrode test Estimates contact resistance on all electrodes currently in use

Transmitter

- Maximum output power Up to 250 W
- Current transmission Constant current transmitter
- Maximum output current Up to 2500 mA
- Maximum output voltage Up to ± 600 V, 1200 V peak to peak
- Current accuracy 0.2 %
- Current precision 0.1 %
- Instant polarity changer Yes
- Self diagnostics Monitoring of temperature and power dissipation
- Safety Easily accessible safety switch
- Full waveform recording Depending on model, built-in montoring of current and voltage output

Appendix D. Fault Boundary Assessment



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Scale

1:3000

Legend Key

- Highly Affected - SCR 0-15 Percent
- Moderately Affected - SCR 15-30 Percent
- Slightly Affected - SCR 30-60
- Fault Line
- Palaeo River Channel

Project Title

A57 Trans Pennine Upgrade

Client

Highways England

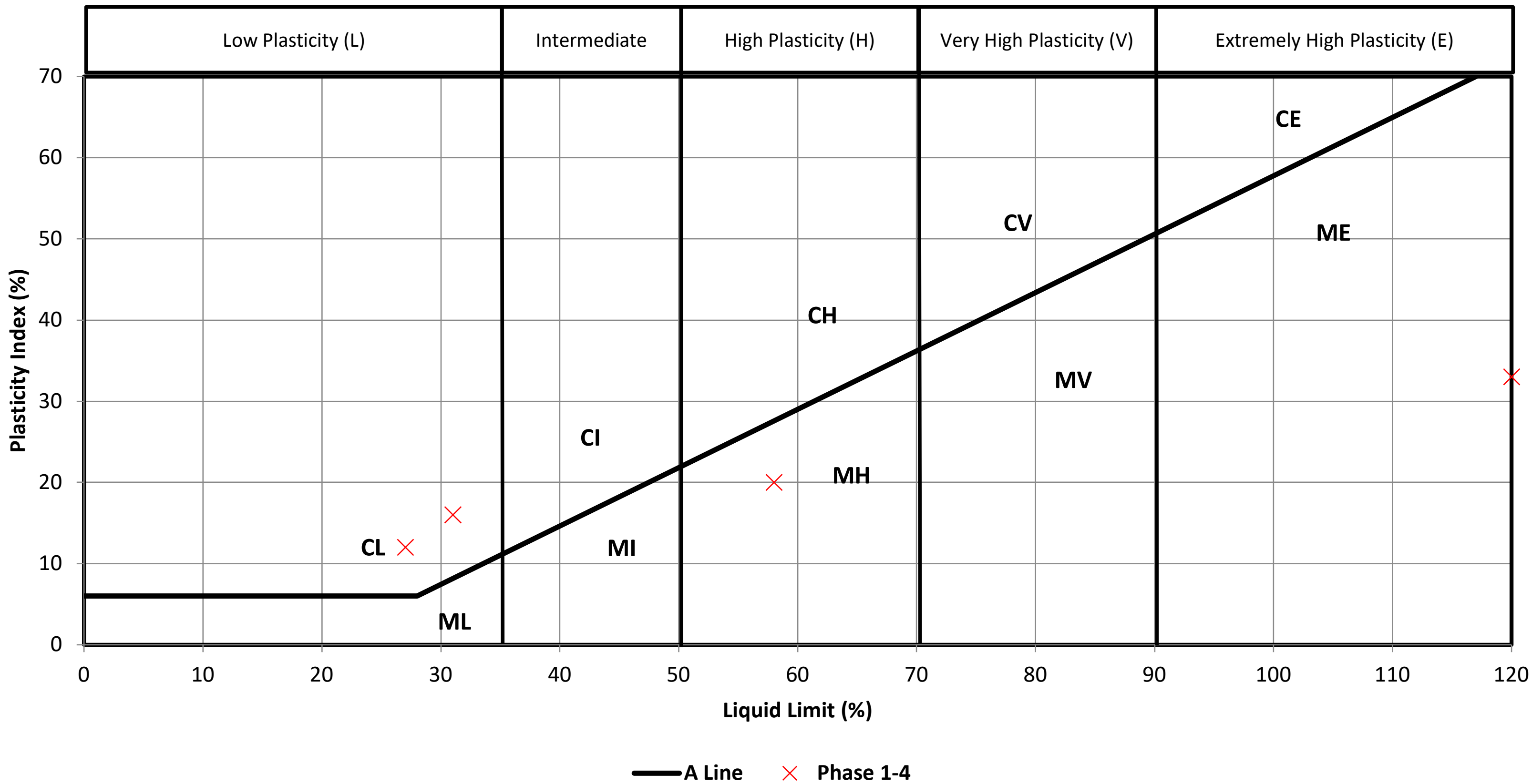
Engineer

Atkins

Site Plan

Appendix E. GI Parameter Plots

Section 1



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	**Highways England**	**A Line for Made Ground - Section 1**					
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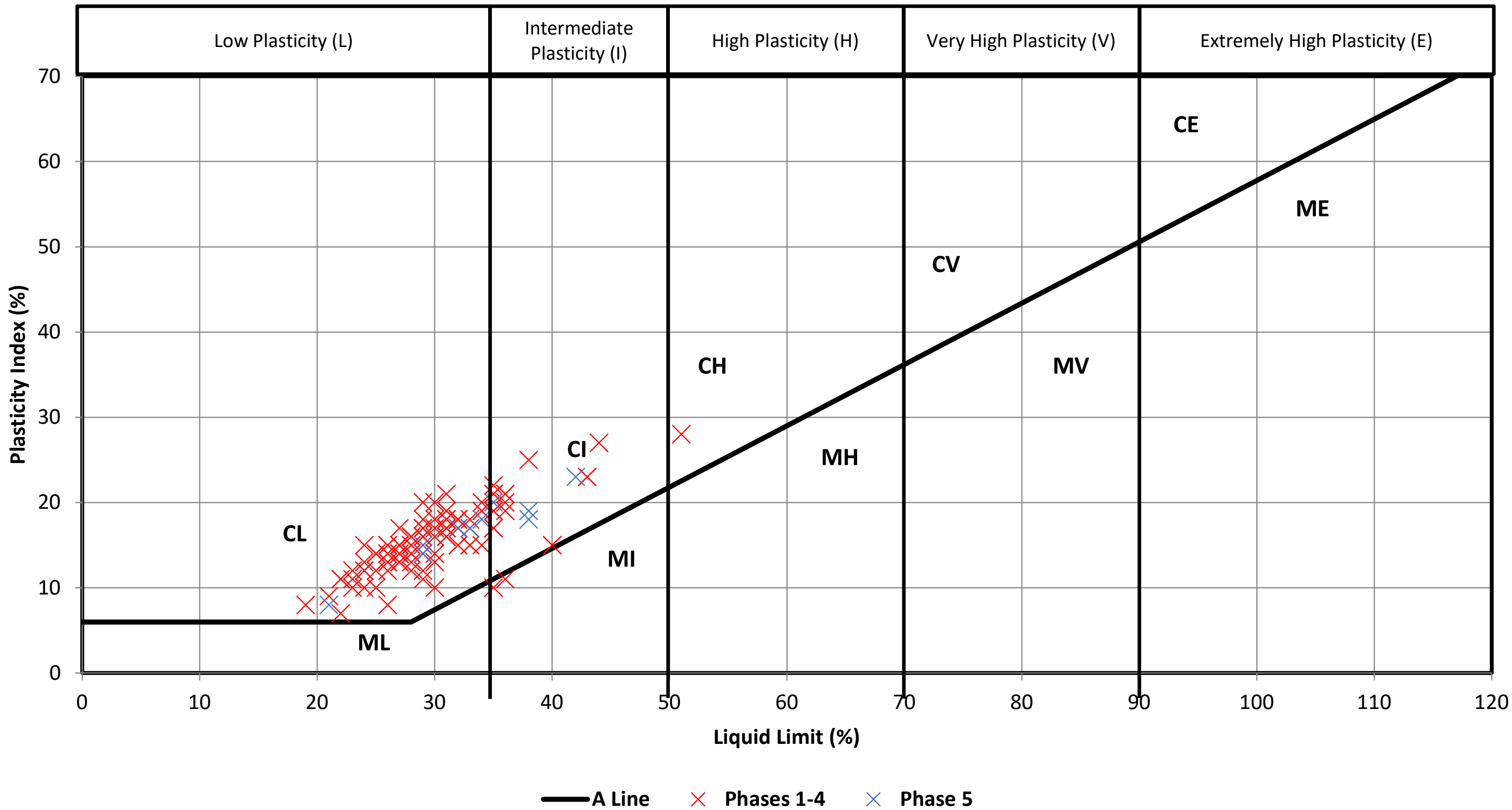
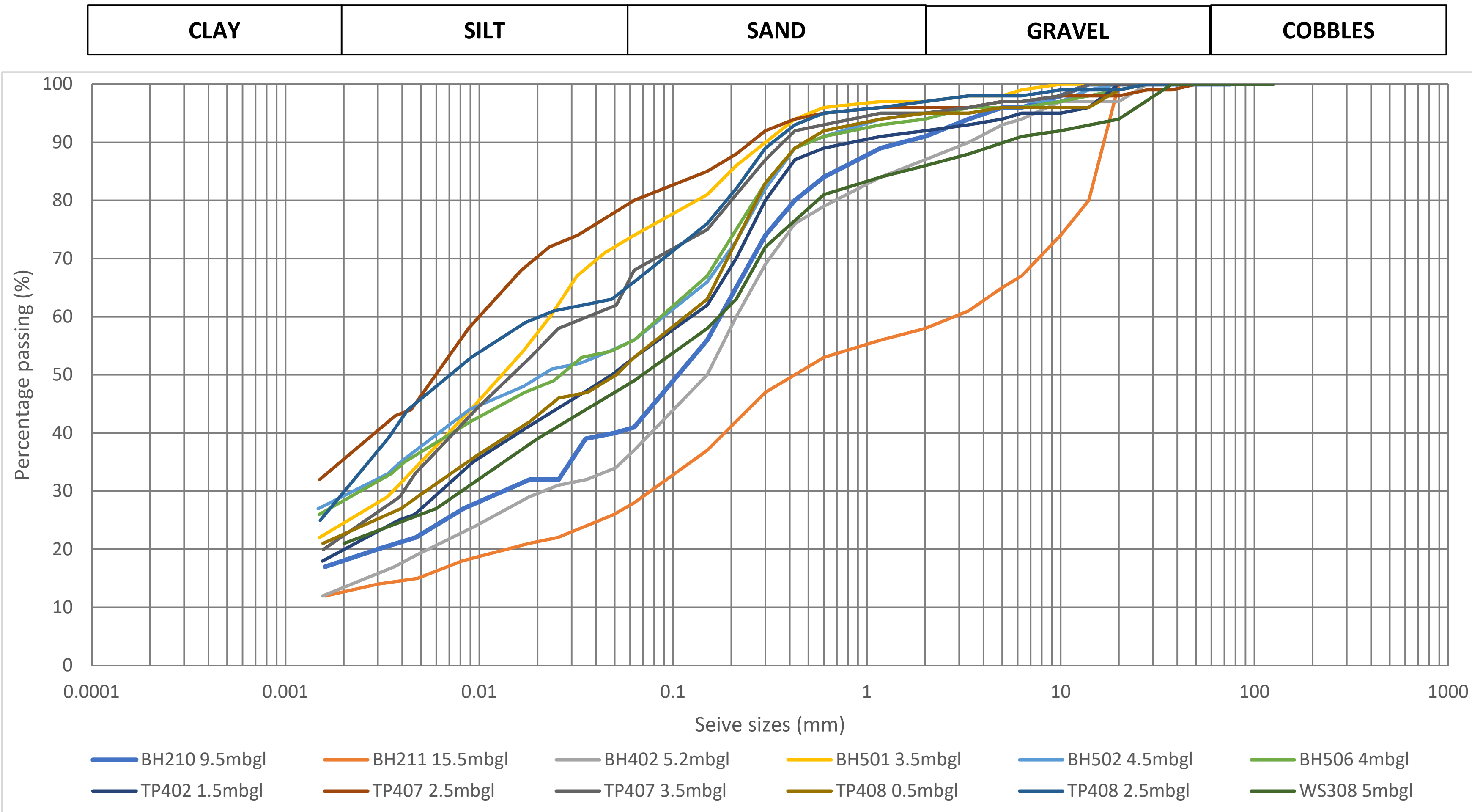
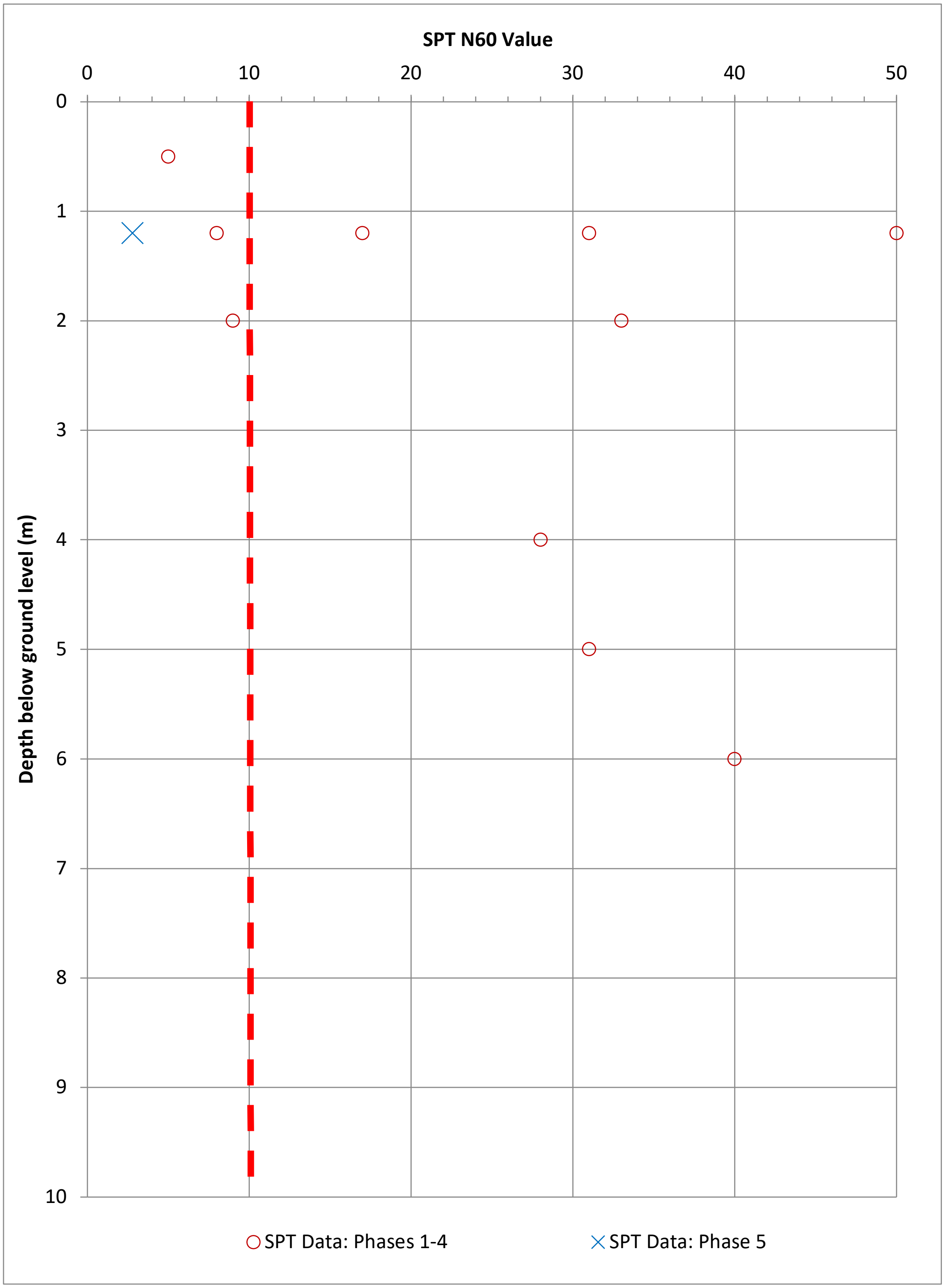
		Status	Figure Number			Rev P01	



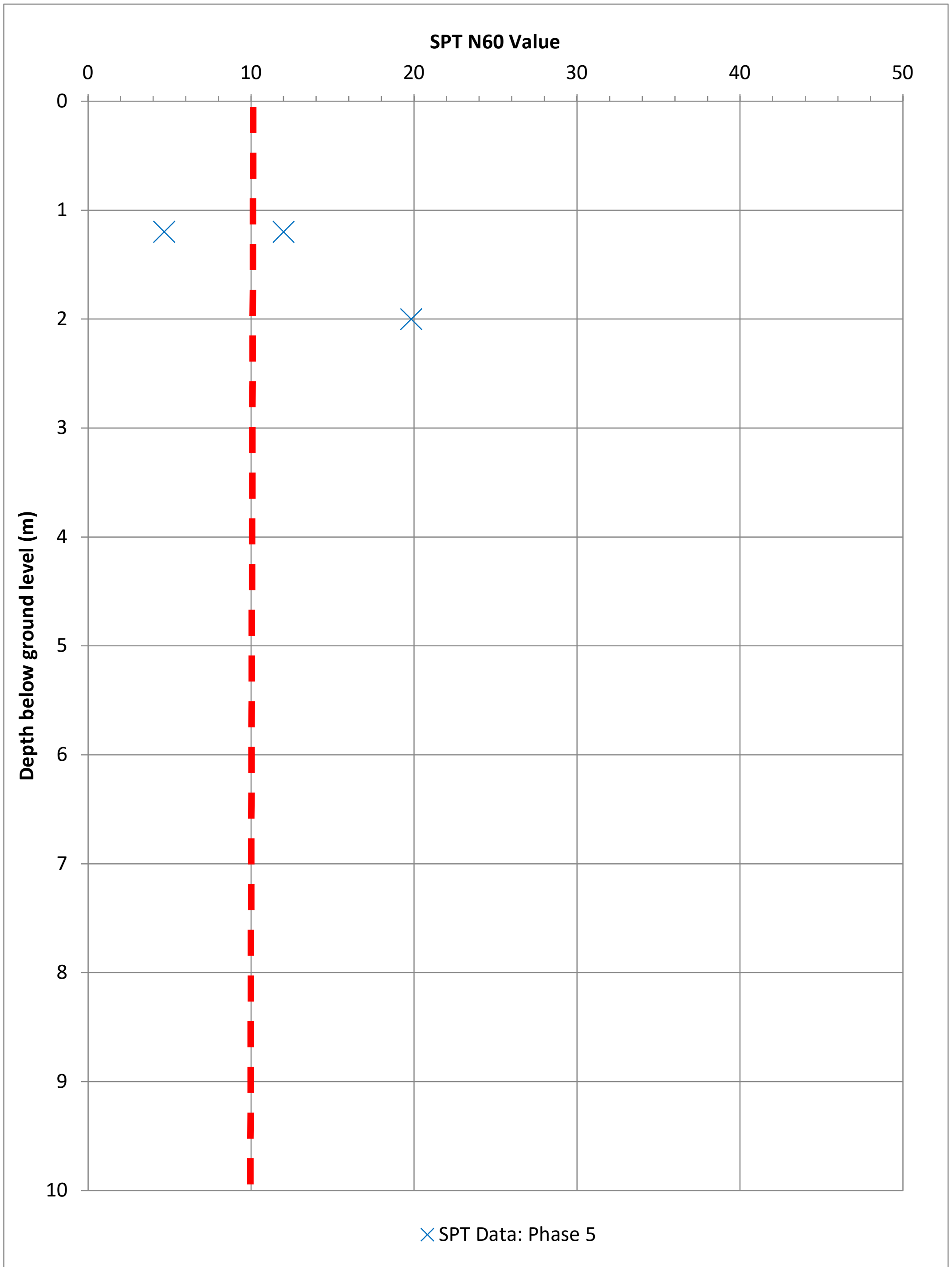
ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	**Highways England**	**A Line for Glacial Till (Cohesive) - Section 1**					
Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE Tel: +44 1925 238000 Fax: +44 1925 238500	Project **A57 Trans Pennine Upgrade**	Sheet size A4	Drawn TB Date 10/09/2021	Checked GDS Date 04/01/2022	Authorised JJ Date 04/01/2022		
		Status	Figure Number			Rev P01	



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	**Highways England**	**Particle Size Distribution for Glacial Till (Cohesive) - Section 1**			
Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE Tel: +44 1925 238000 Fax: +44 1925 238500	Project **A57 Trans Pennine Upgrade**	Sheet size A4	Drawn TB Date 10/09/2021	Checked GDS Date 04/01/2022	Authorised JJ Date 04/01/2022
		Status	Figure Number		Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited** Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Client **Highways England** Project **A57 Trans Pennine Upgrade**	Title **SPT N60 vs Depth for Made Ground - Section 1** Drawn: TB Date: 10/9/21 | Check: GDS Date: 4/1/22 | Review: JJ Date: 4/1/22 Figure Number | Rev P01



ATKINS
Member of the SNC-Lavalin Group
Atkins Limited
Chadwick House
Birchwood Park
Warrington Tel: (01372) 726140
WA3 6AE Fax: (01372) 740055

Client
Highways England

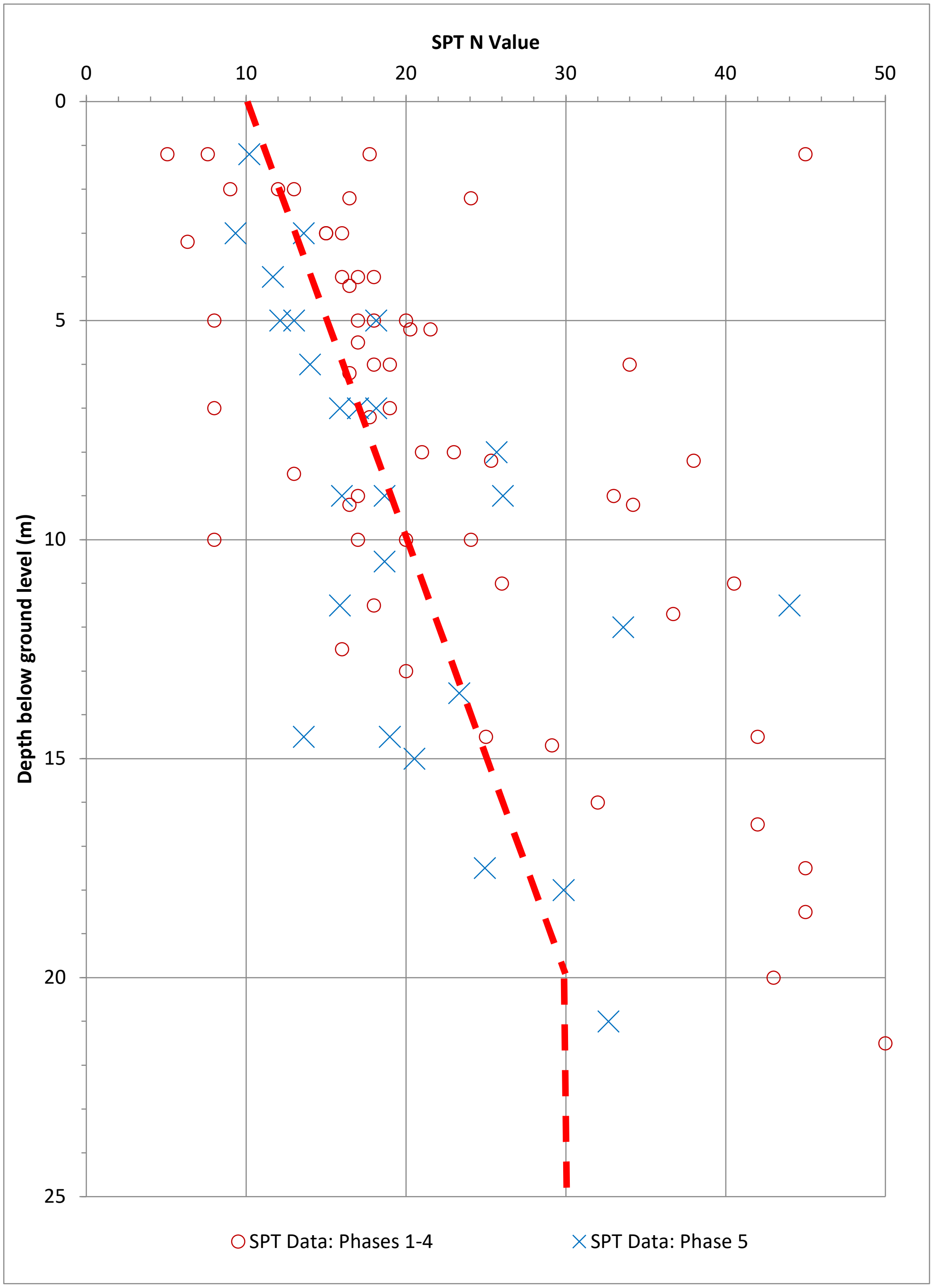
Project
A57 Trans Pennine Upgrade

Title
SPT N60 vs Depth for Alluvium (Cohesive) - Section 1

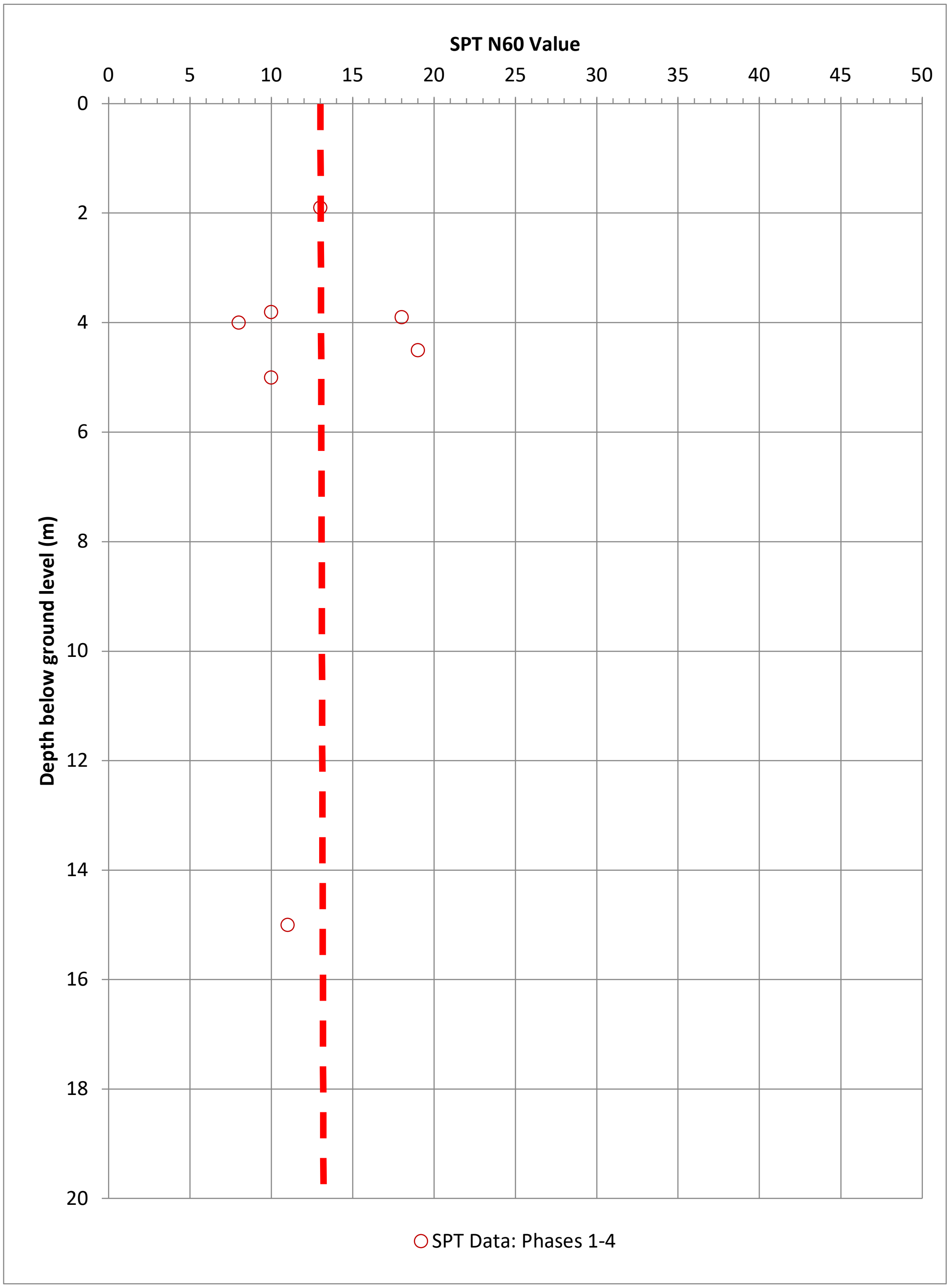
Drawn: TB | Check: GDS | Review: JJ
Date: 10/9/21 | Date: 4/1/22 | Date: 4/1/22

Figure Number

Rev
P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client **Highways England**	Title **SPT N60 vs Depth for Glacial Till (Cohesive) - Section 1**		
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
		Figure Number		Rev P01



ATKINS
Member of the SNC-Lavalin Group
Atkins Limited
Chadwick House
Birchwood Park
Warrington Tel: (01372) 726140
WA3 6AE Fax: (01372) 740055

Client	Title		
Highways England	**SPT N60 vs Depth for Glacial Till (Granular) - Section 1**		
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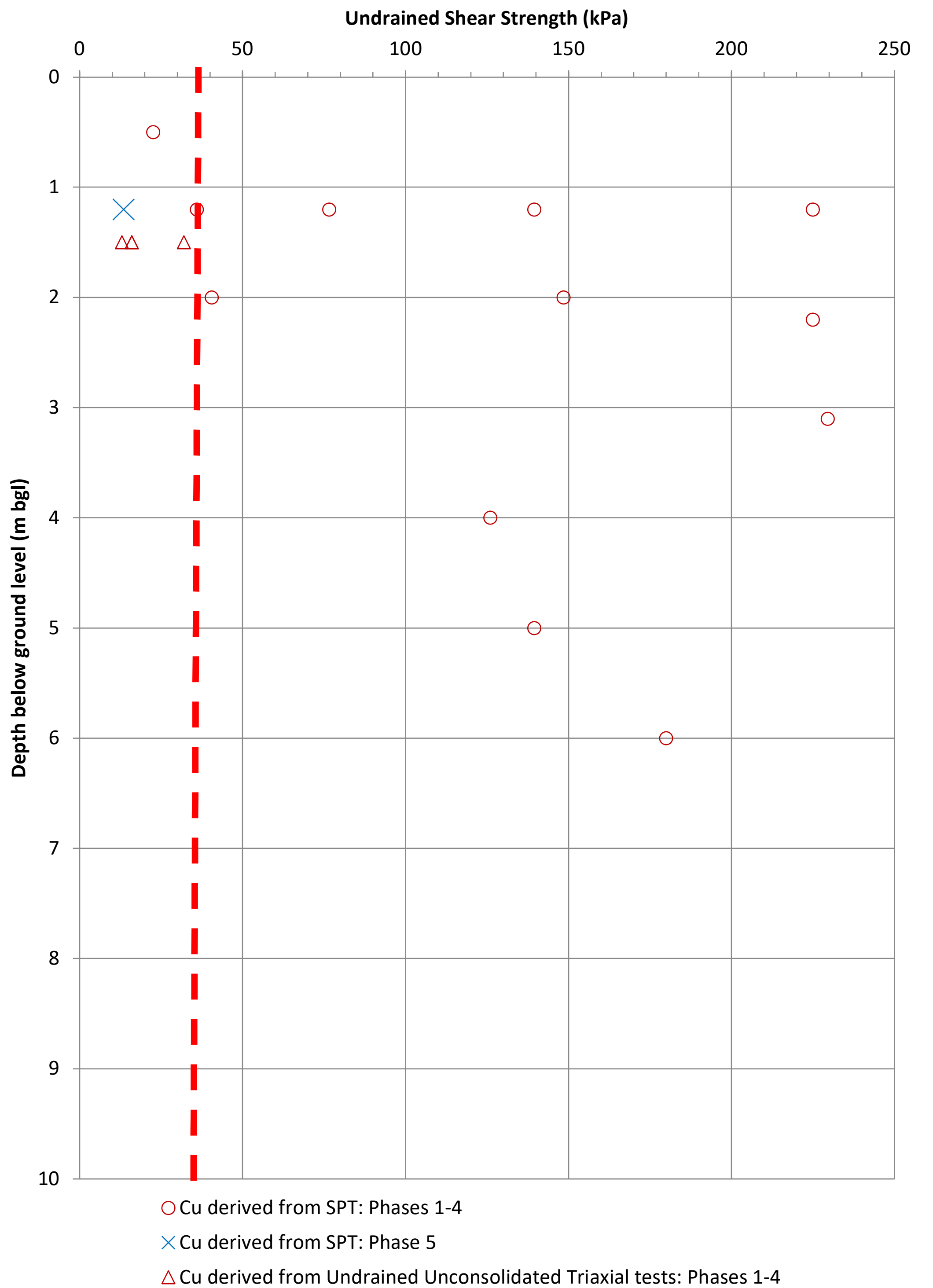
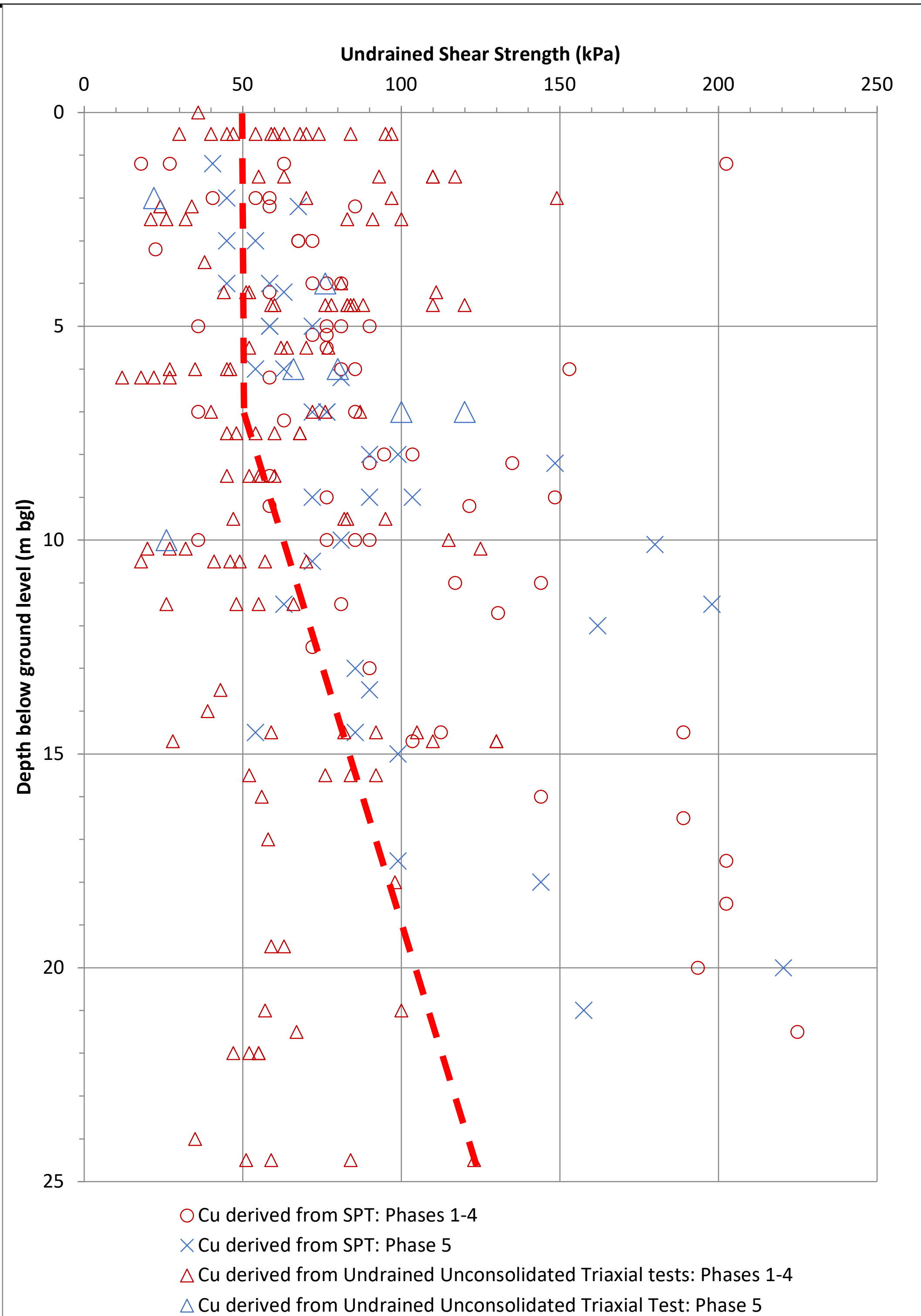
A57 Trans Pennine Upgrade	Figure Number		Rev P01



ATKINS Member of the SNC-Lavalin Group	Client **Highways England**	Title **Undrained Shear Strength vs Depth for Made Ground - Section 1**		
Atkins Limited Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
		Figure Number		Rev P01



ATKINS

Member of the SNC-Lavalin Group

Atkins Limited

Chadwick House

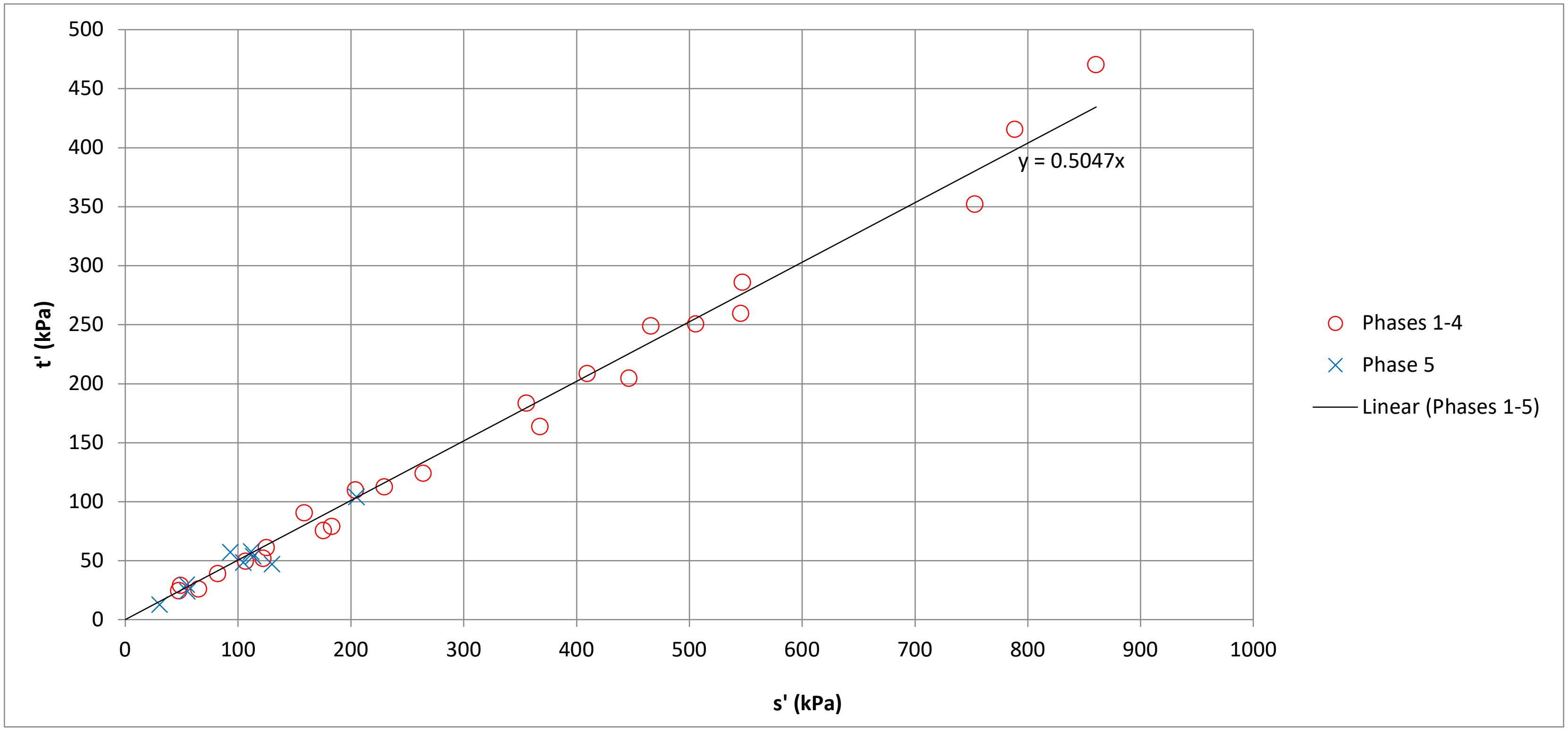
Birchwood Park

Warrington Tel: (01372) 726140

WA3 6AE Fax: (01372) 740055

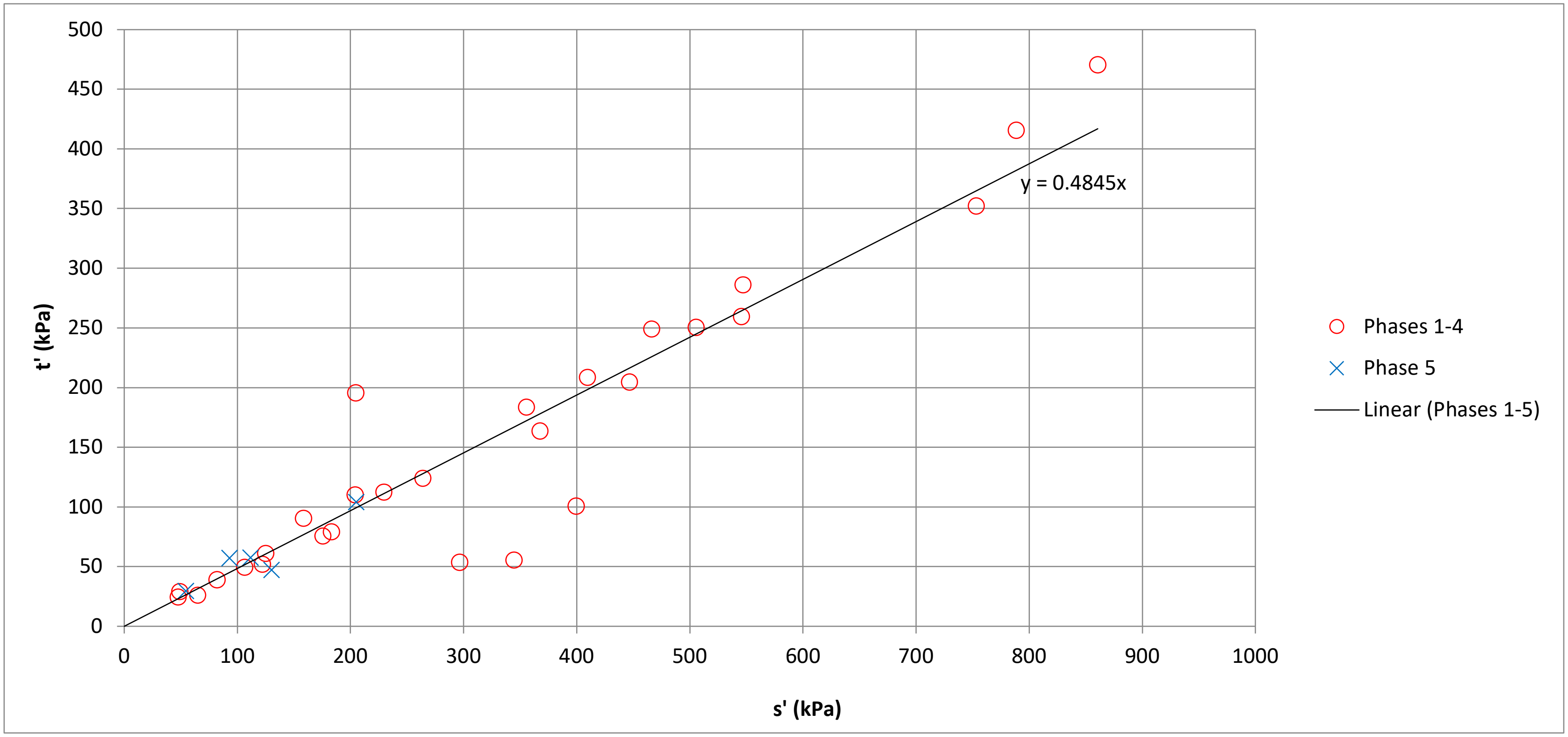
Client	Title
Highways England	**Undrained Shear Strength vs Depth for Glacal Till (Cohesive) - Section 1**

Project	Drawn: TB	Check: GDS	Review: JJ
	Date: 10/9/21	Date: 4/1/22	Date: 4/1/22
A57 Trans Pennine Upgrade	Figure Number		Rev P01



c' =	0
ϕ' =	30.5

ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	**Highways England**	**Triaxial-Derived Effective Strength for Glacial Till (Cohesive) - *Anomalous Results Removed* - Section 1**					
Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE Tel: +44 1925 238000 Fax: +44 1925 238500	Project **A57 Trans Pennine Upgrade**	Sheet size A4	Drawn TB	Date 09/09/2021	Checked GDS Date 04/01/2022	Authorised JJ Date 04/01/2022	
		Status	Figure Number				Rev P01



c' =	0
ϕ' =	29

ATKINS

Member of the SNC-Lavalin Group

Atkins Limited

Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE

Tel: +44 1925 238000

Fax: +44 1925 238500

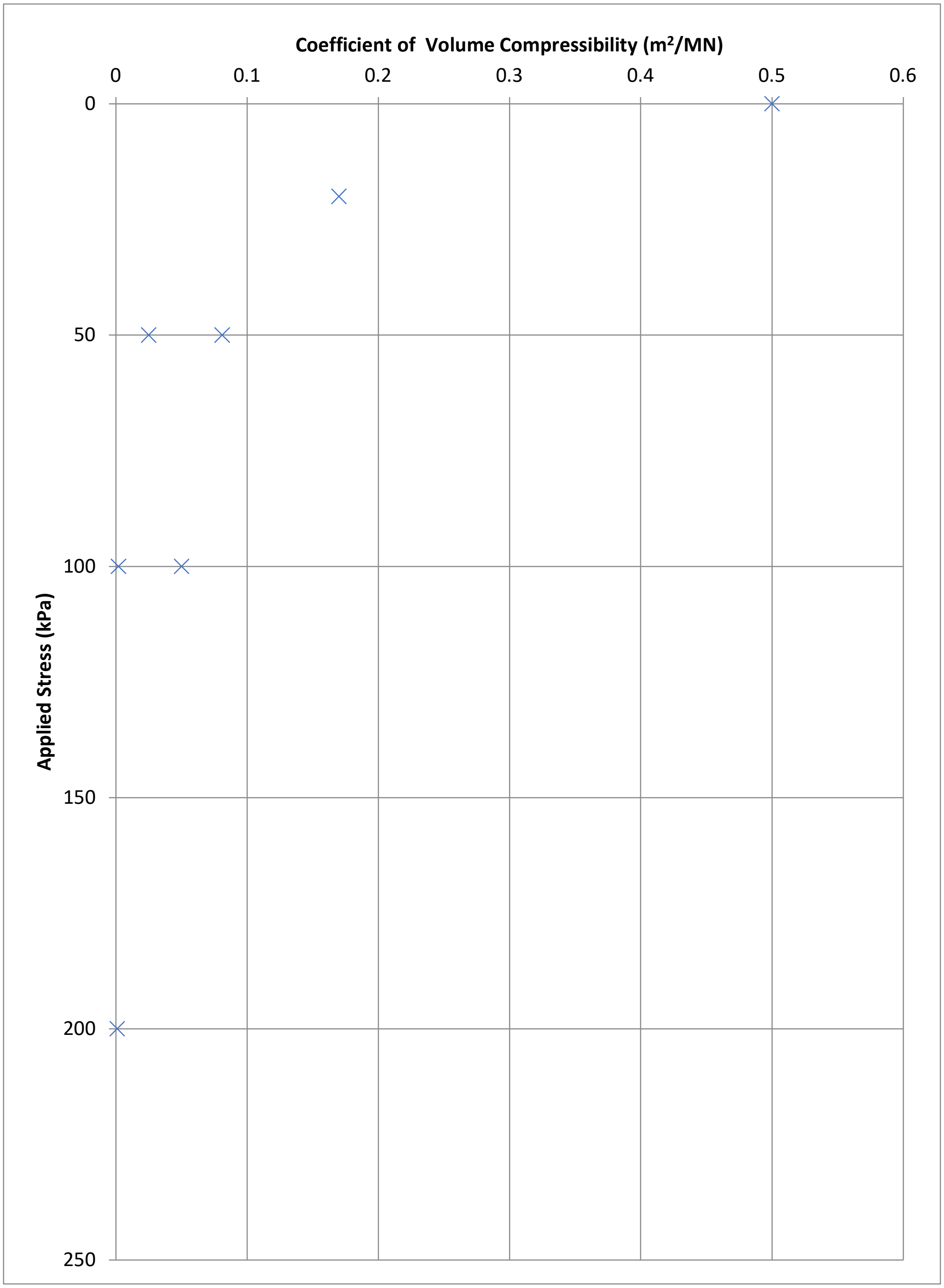
Highways England

Project

A57 Trans Pennine Upgrade

Triaxial-Derived Effective Strength for Glacial Till (Cohesive) - *All Results* - Section 1

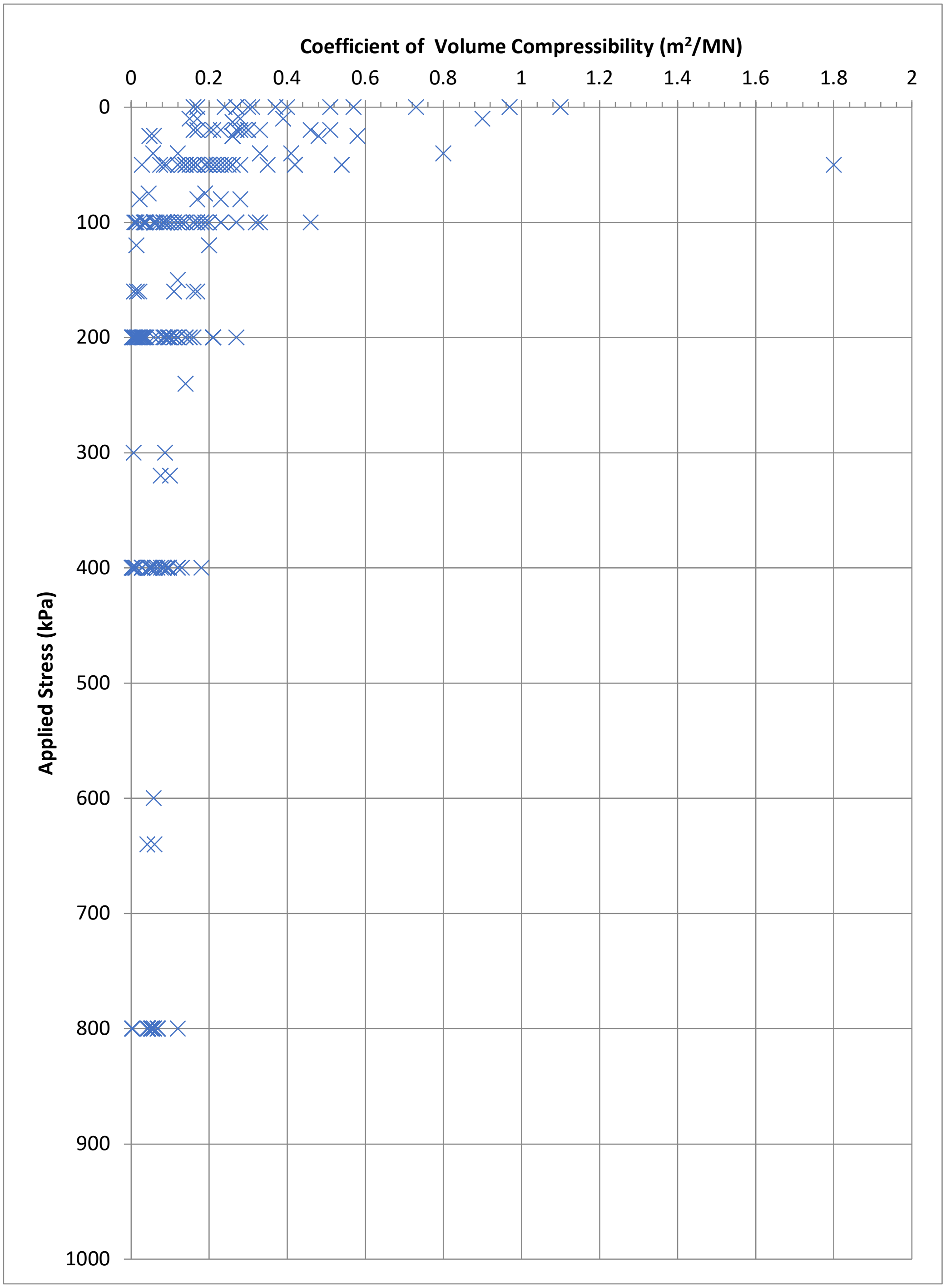
Sheet size	Drawn	TB	Checked	GDS	Authorised	JJ
A4	Date	09/09/2021	Date	04/01/2022	Date	04/01/2022
Status	Figure Number				Rev	P01



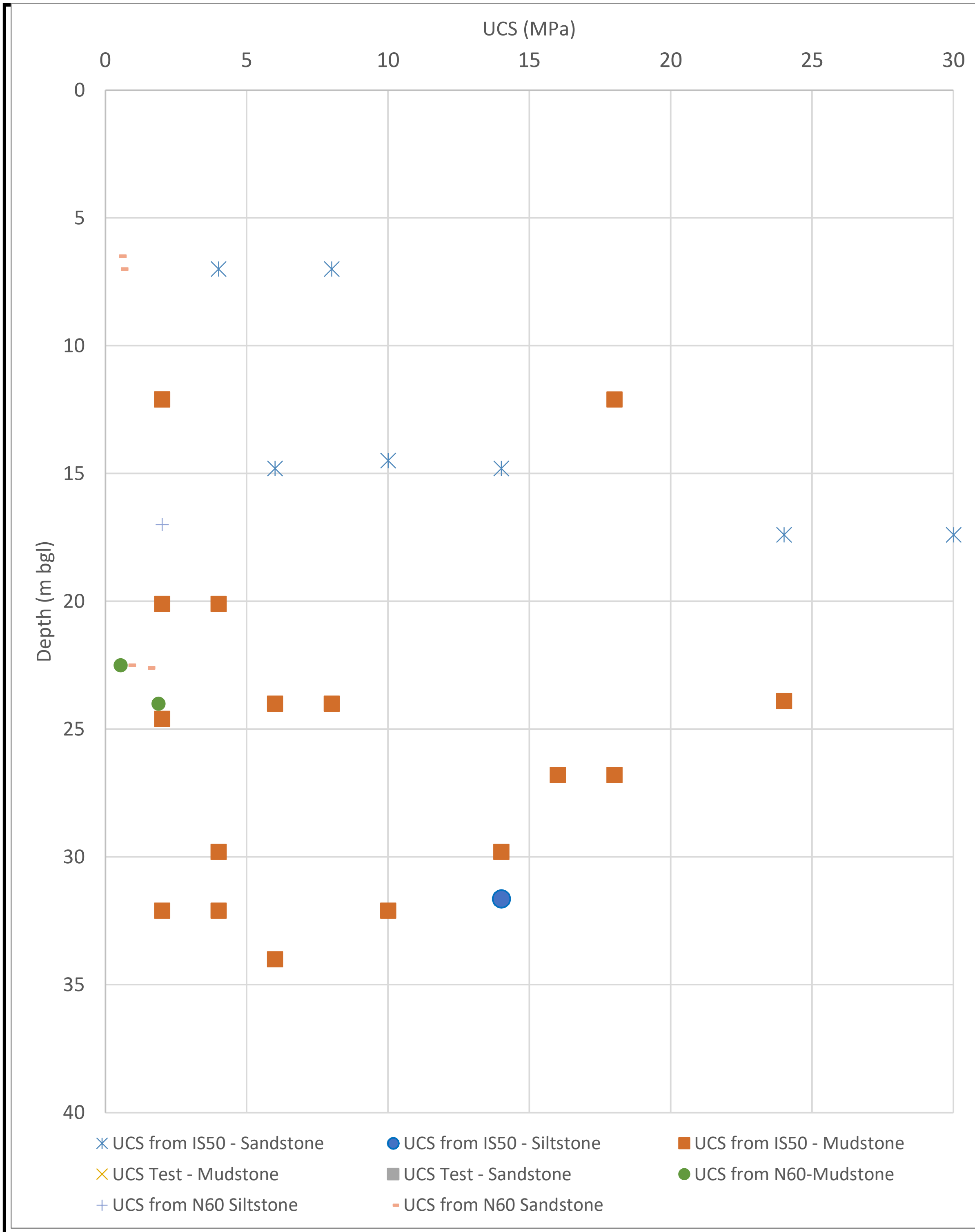
ATKINS
Member of the SNC-Lavalin Group

Atkins Limited
Chadwick House
Birchwood Park
Warrington Tel: (01372) 726140
WA3 6AE Fax: (01372) 740055

Client		Title
Highways England		**Coefficient of Volume Compressibility vs Applied Stress for Alluvium (Cohesive) - Section 1**
Project	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
A57 Trans Pennine Upgrade	Figure Number	Rev P01

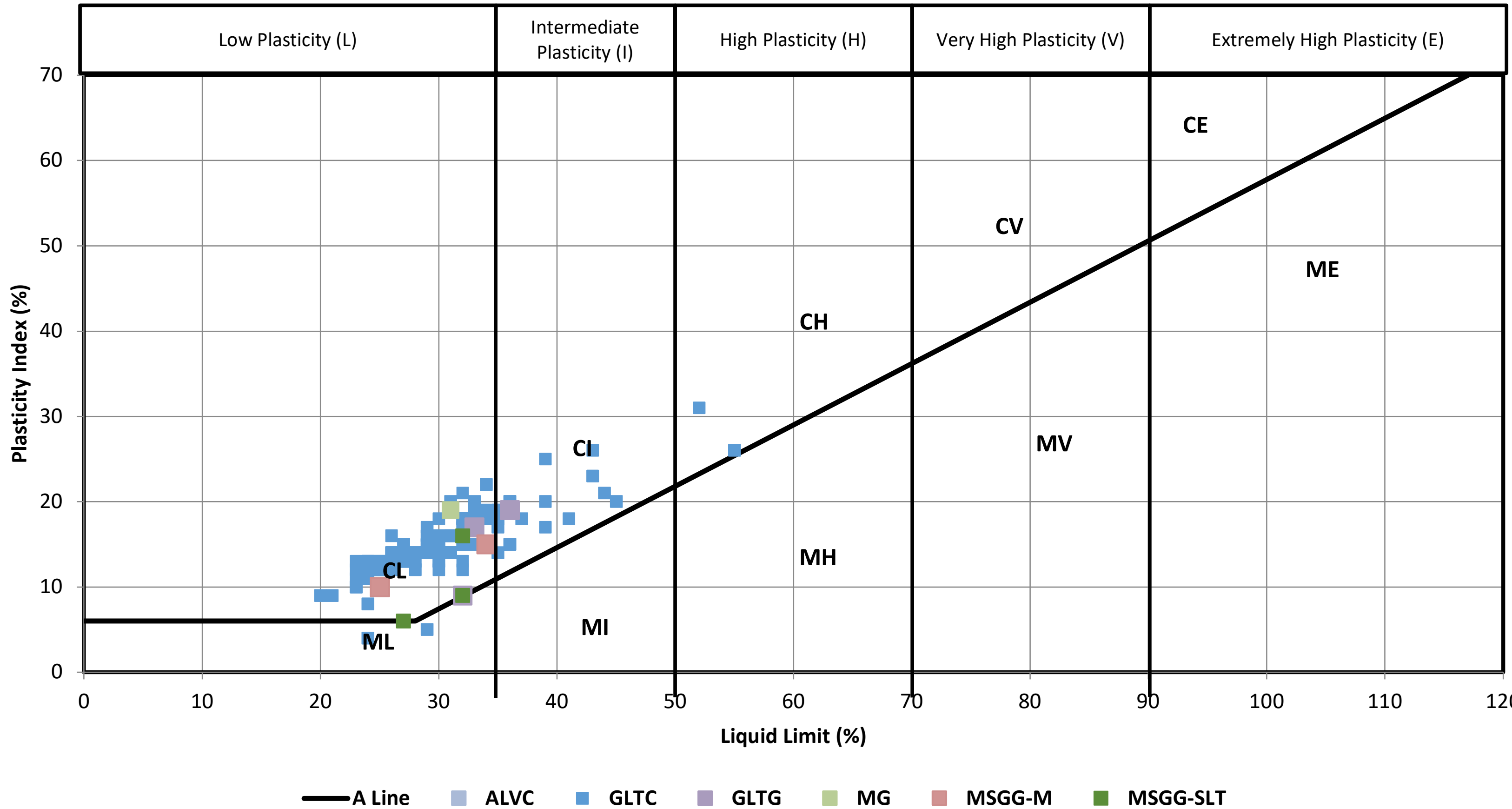


ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client **Highways England**	Title **Coefficient of Volume Compressibility vs Applied Stress for Glacial Till (Cohesive) - Section 1**		
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
		Figure Number		Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited** Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Client **Highways England**	Title **Uniaxial Compressive Strength for Bedrock Geology - Section 1**	
	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21 | Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
		Figure Number	Rev P01

Section 2



ATKINS

Member of the SNC-Lavalin Group

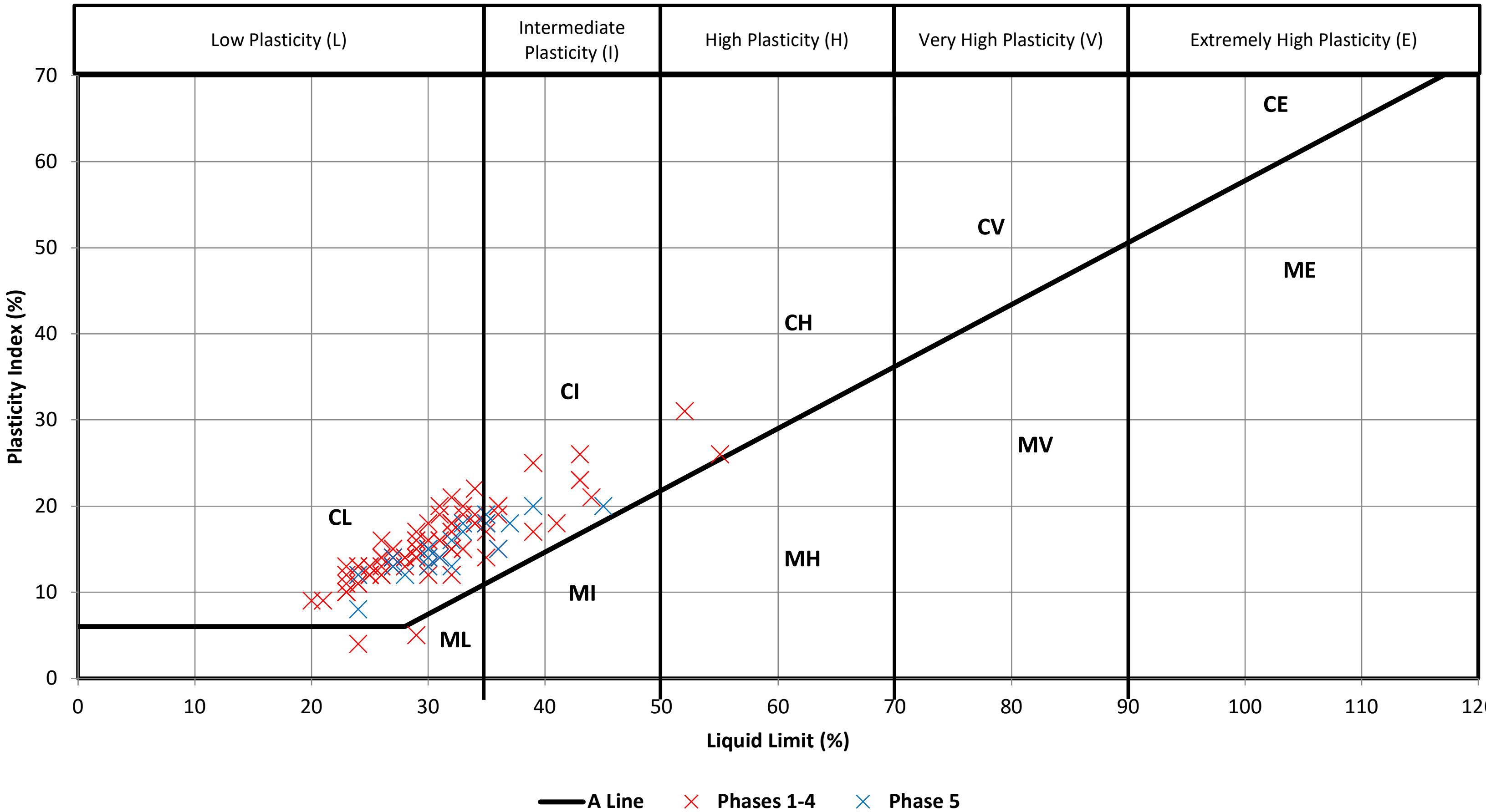
Atkins Limited

Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE

Tel: +44 1925 238000

Fax: +44 1925 238500

Highways England	**A Line for All Relevant Geology Types - Section 2**							
Project **A57 Trans Pennine Upgrade**	Sheet size A4	Drawn	TB	Checked	GDS	Authorised	JJ	
		Date	10/09/2021	Date	04/01/2022	Date	04/01/2022	
	Status	Figure Number					Rev P01	



Atkins Limited Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE Tel: +44 1925 238000 Fax: +44 1925 238500	**Highways England**	**A Line for Glacial Till (Cohesive) - Section 2**			
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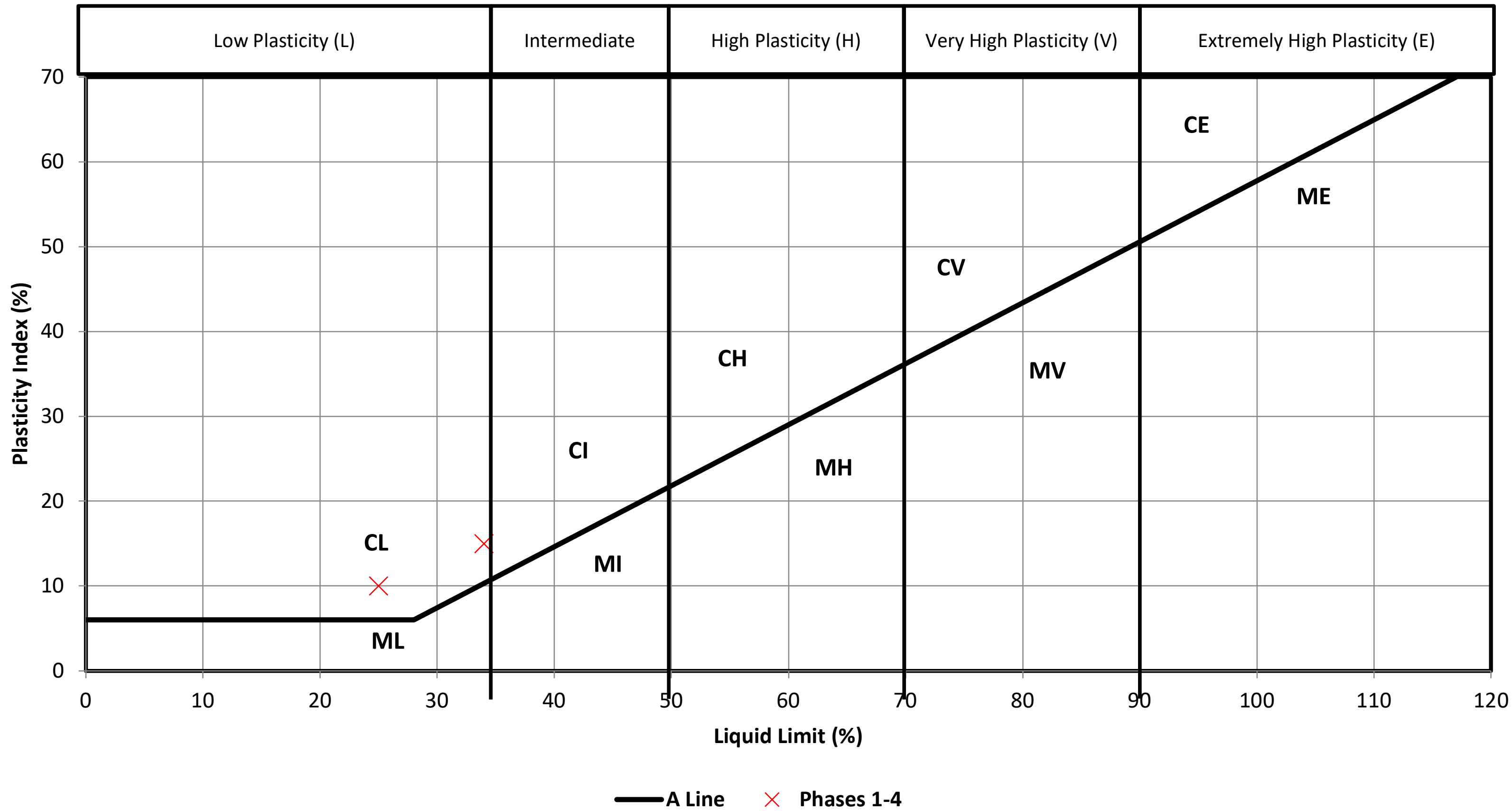

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Highways England	**A Line for Mudstone - Section 2**							
Project	Sheet size A4	Drawn	TB	Checked	GDS	Authorised	JJ	
A57 Trans Pennine Upgrade		Date	10/09/2021	Date	04/01/2022	Date	04/01/2022	
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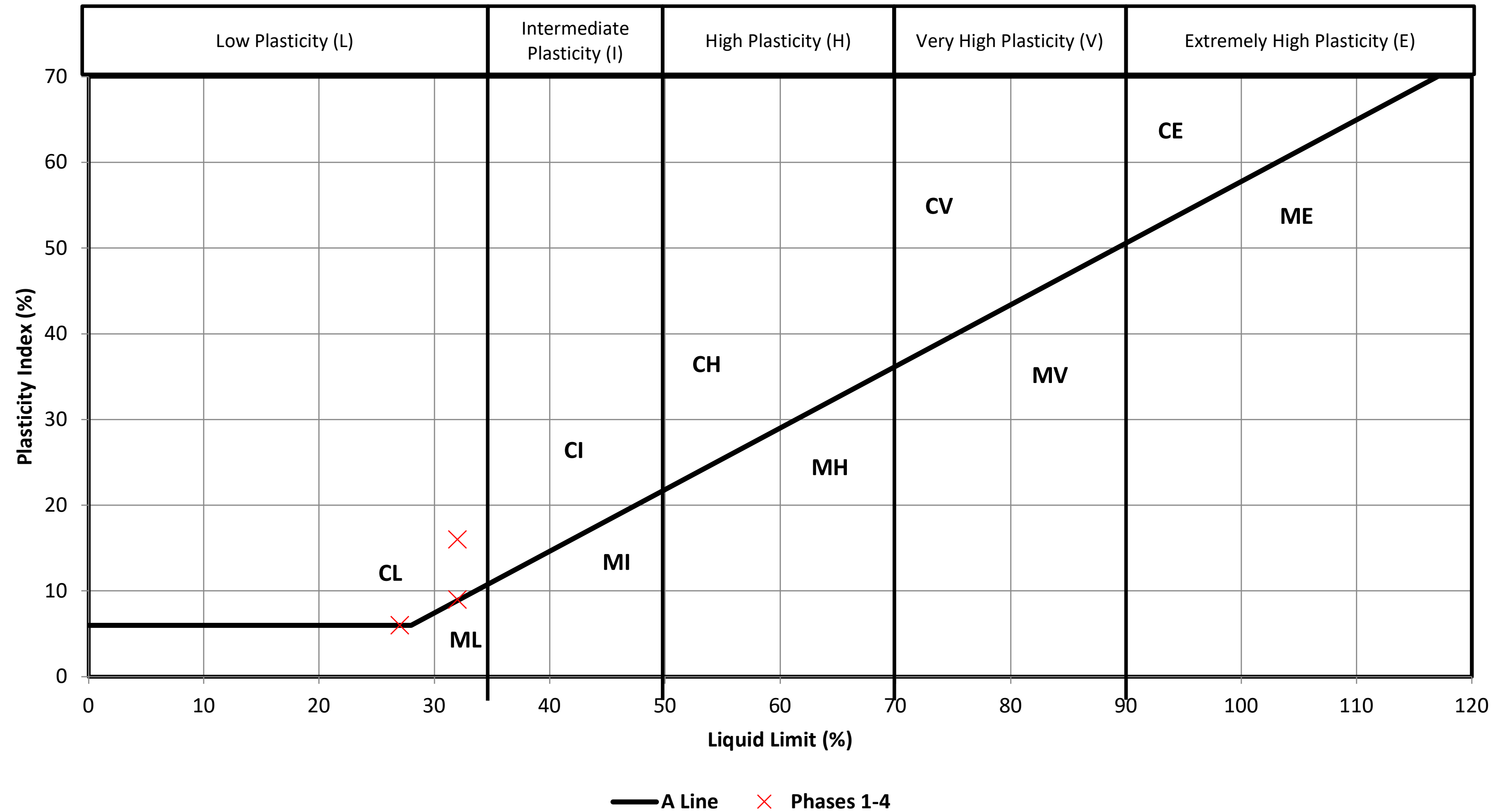

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A Line for Siltstone - Section 2

Project	Sheet size	Drawn	TB	Checked	GDS	Authorised	JJ	
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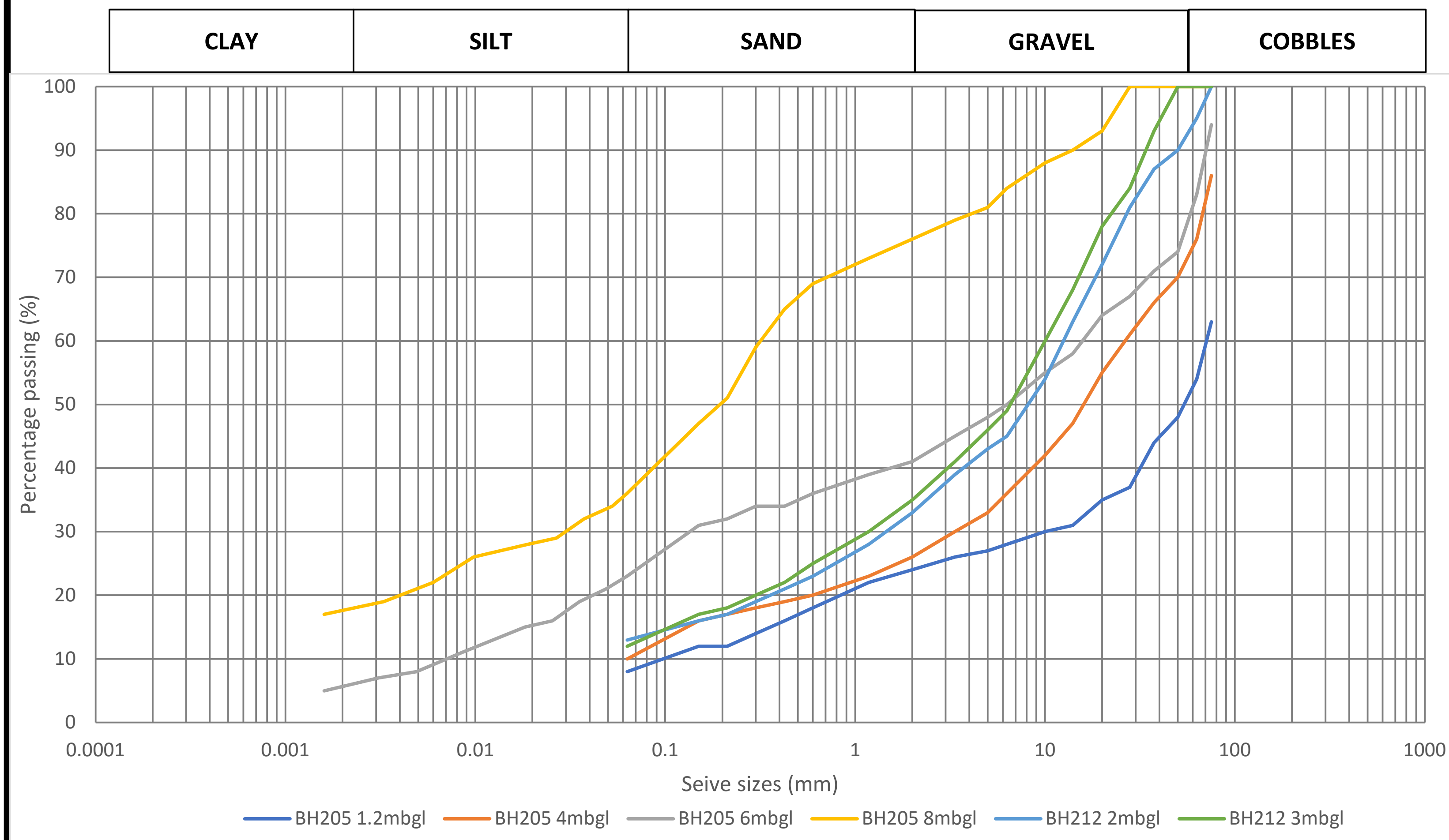

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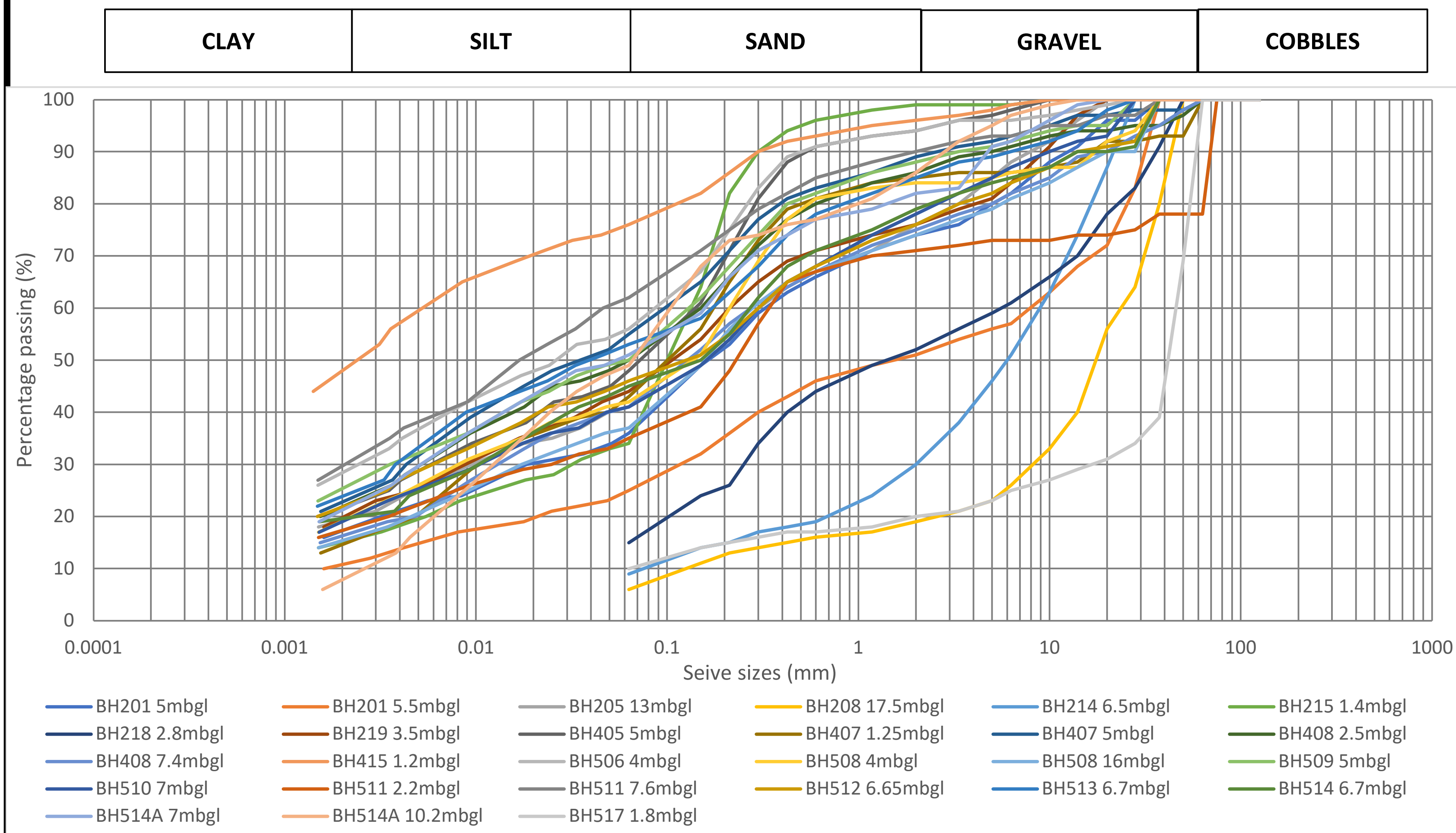
	Project **A57 Trans Pennine Upgrade**	Sheet size A4 · Drawn TB · Date 10/09/2021 · Checked GDS · Date 04/01/2022 · Authorised JJ · Date 04/01/2022 Status · Figure Number · Rev P01



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Particle Size Distribution for Glacial Till (Cohesive) - Section 2

Project

A57 Trans Pennine Upgrade

Sheet size	Drawn	TB	Checked	GDS	Authorised	JJ	
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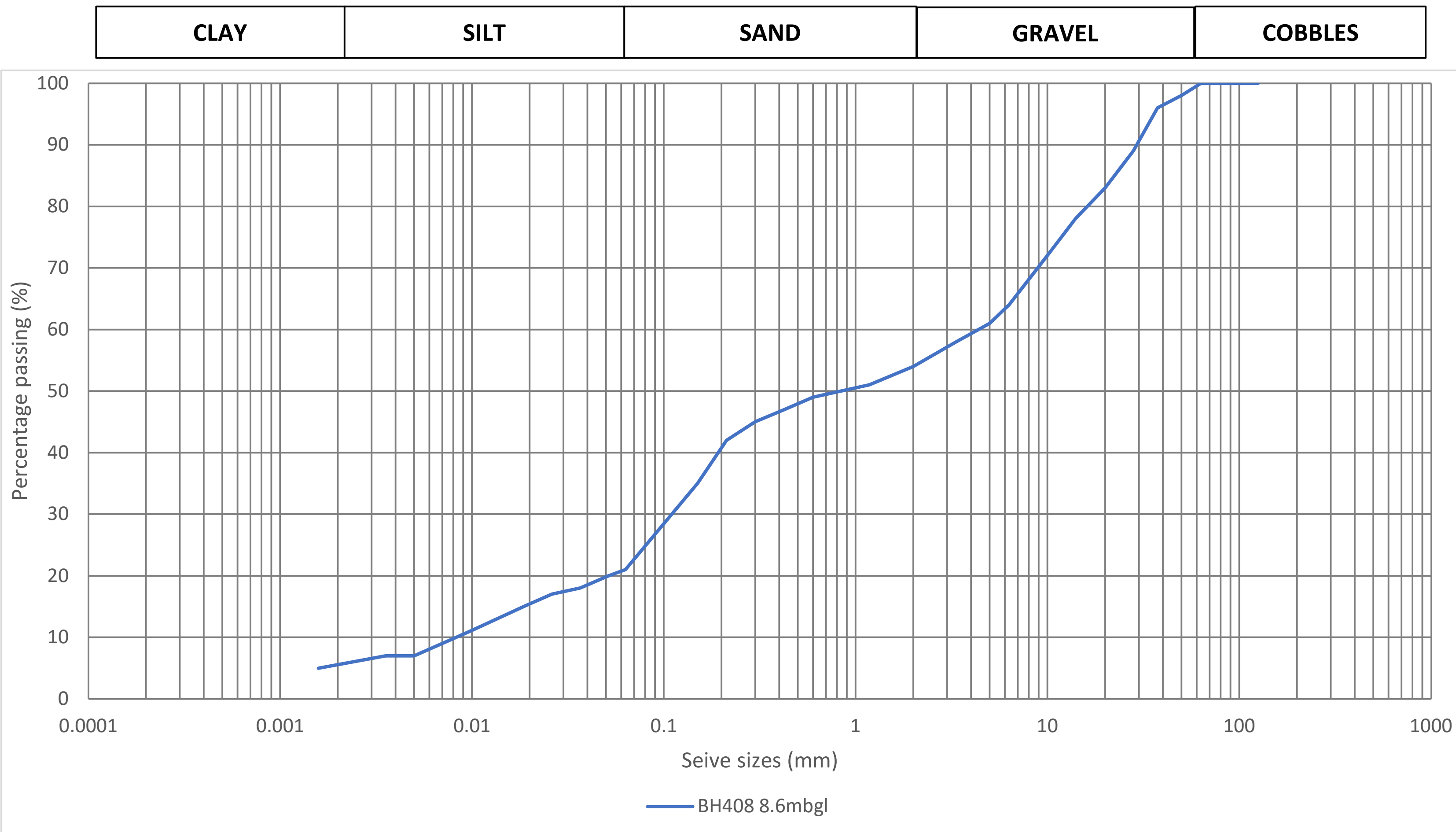
Status	Figure Number					Rev	P01



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Highways England	**Particle Size Distribution for Glacial Till (Granular) - Section 2**							
Project **A57 Trans Pennine Upgrade**	Sheet size A4	Drawn	TB	Checked	GDS	Authorised	JJ	
		Date	10/09/2021	Date	04/01/2022	Date	04/01/2022	
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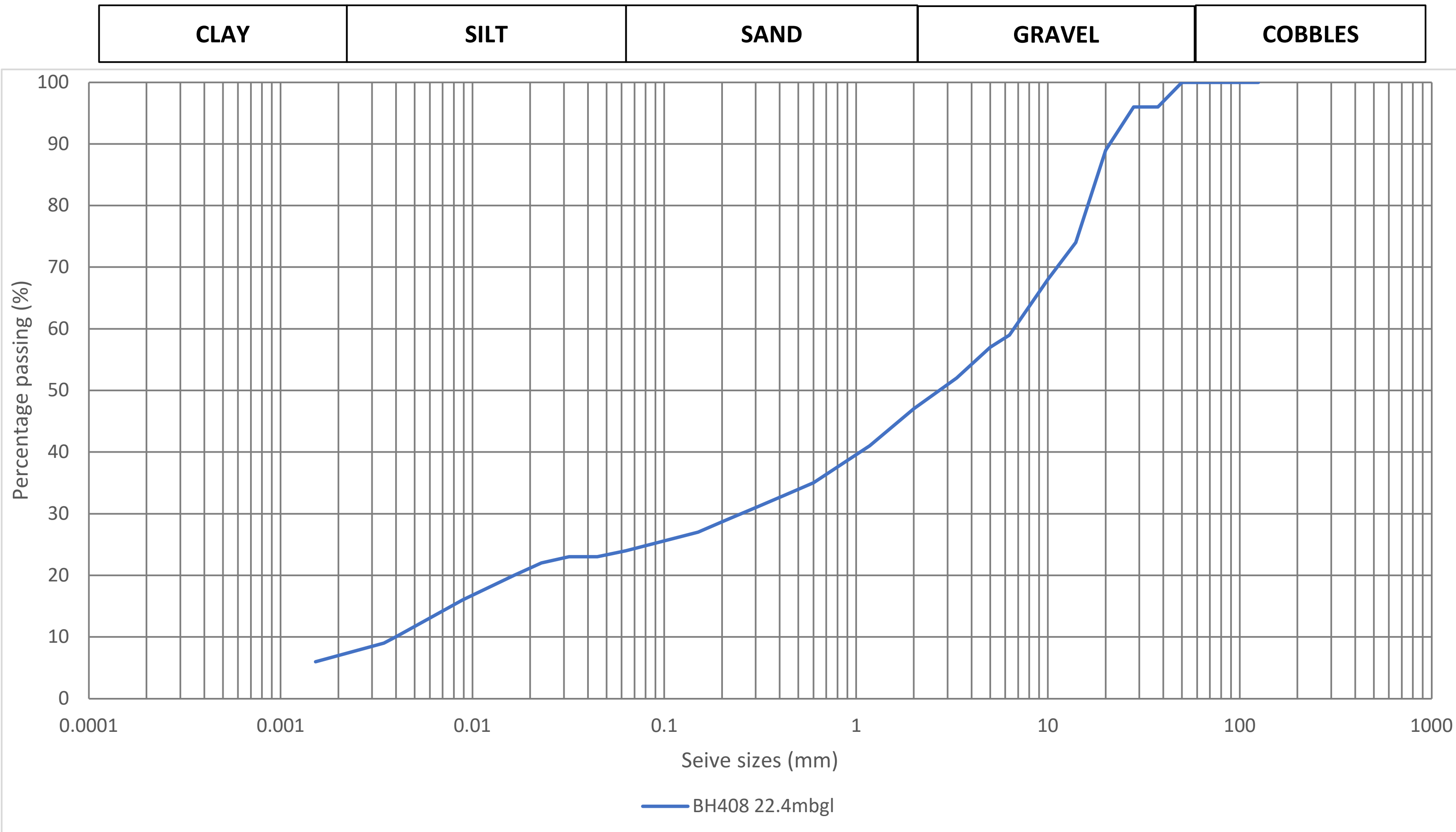
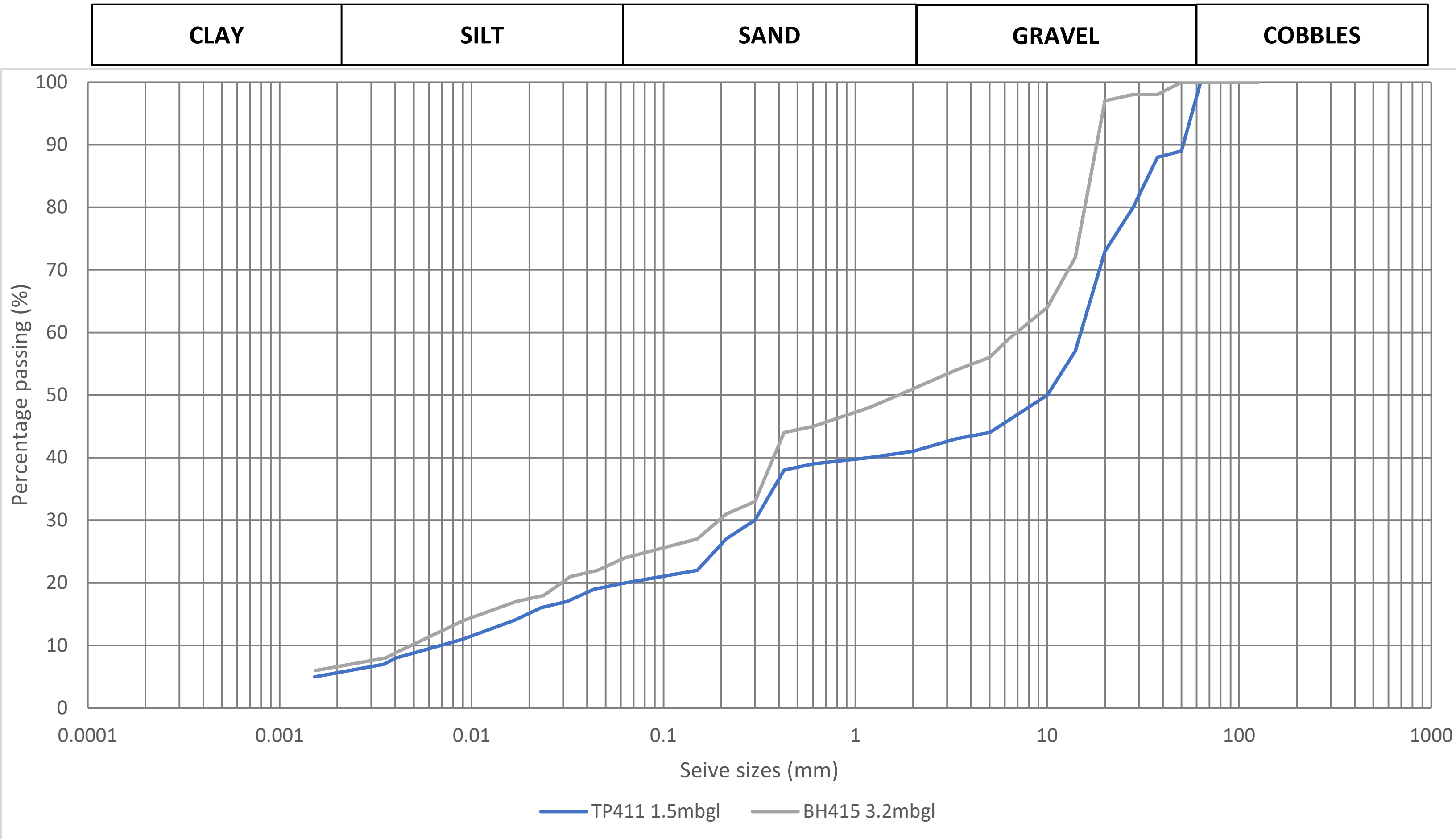


ATKINS Member of the SNC-Lavalin Group **Atkins Limited** Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE Tel: +44 1925 238000 Fax: +44 1925 238500	**Highways England**	**Particle Size Distribution for Mudstone - Section 2**
	Project **A57 Trans Pennine Upgrade**	Sheet size: A4 · Drawn: TB · Date: 10/09/2021 · Checked: GDS · Date: 04/01/2022 · Authorised: JJ · Date: 04/01/2022 Status · Figure Number · Rev: P01



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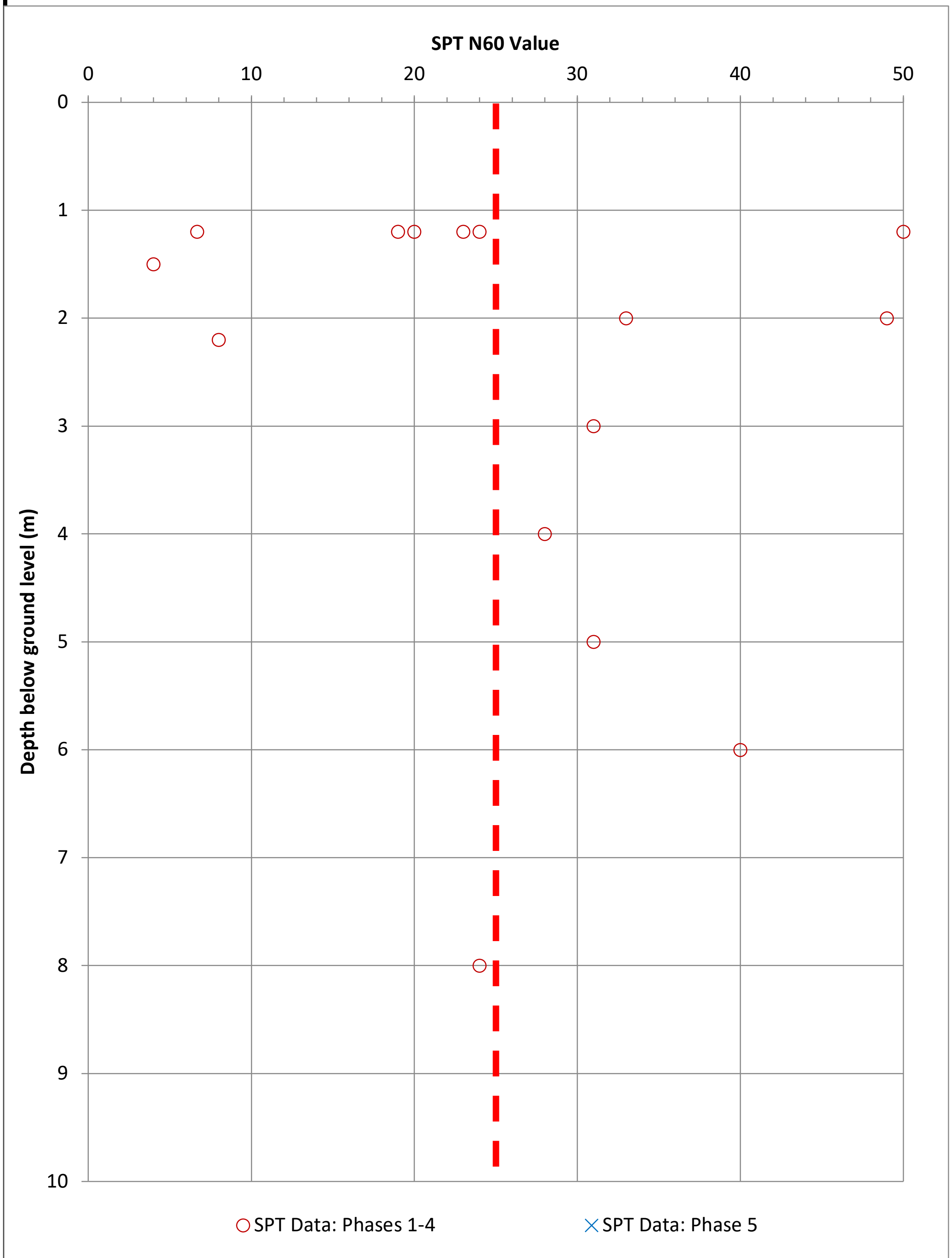
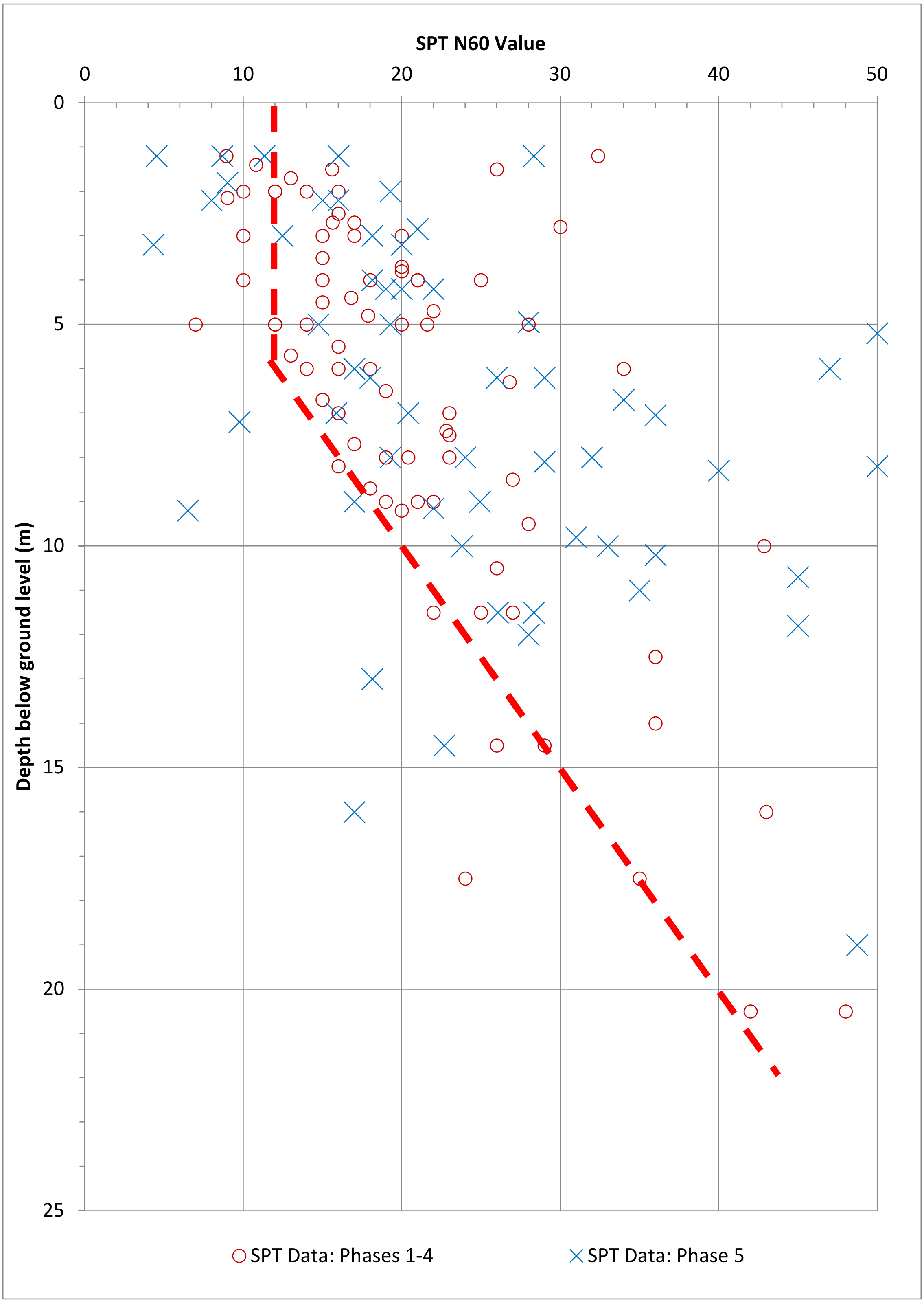
Project

A57 Trans Pennine Upgrade

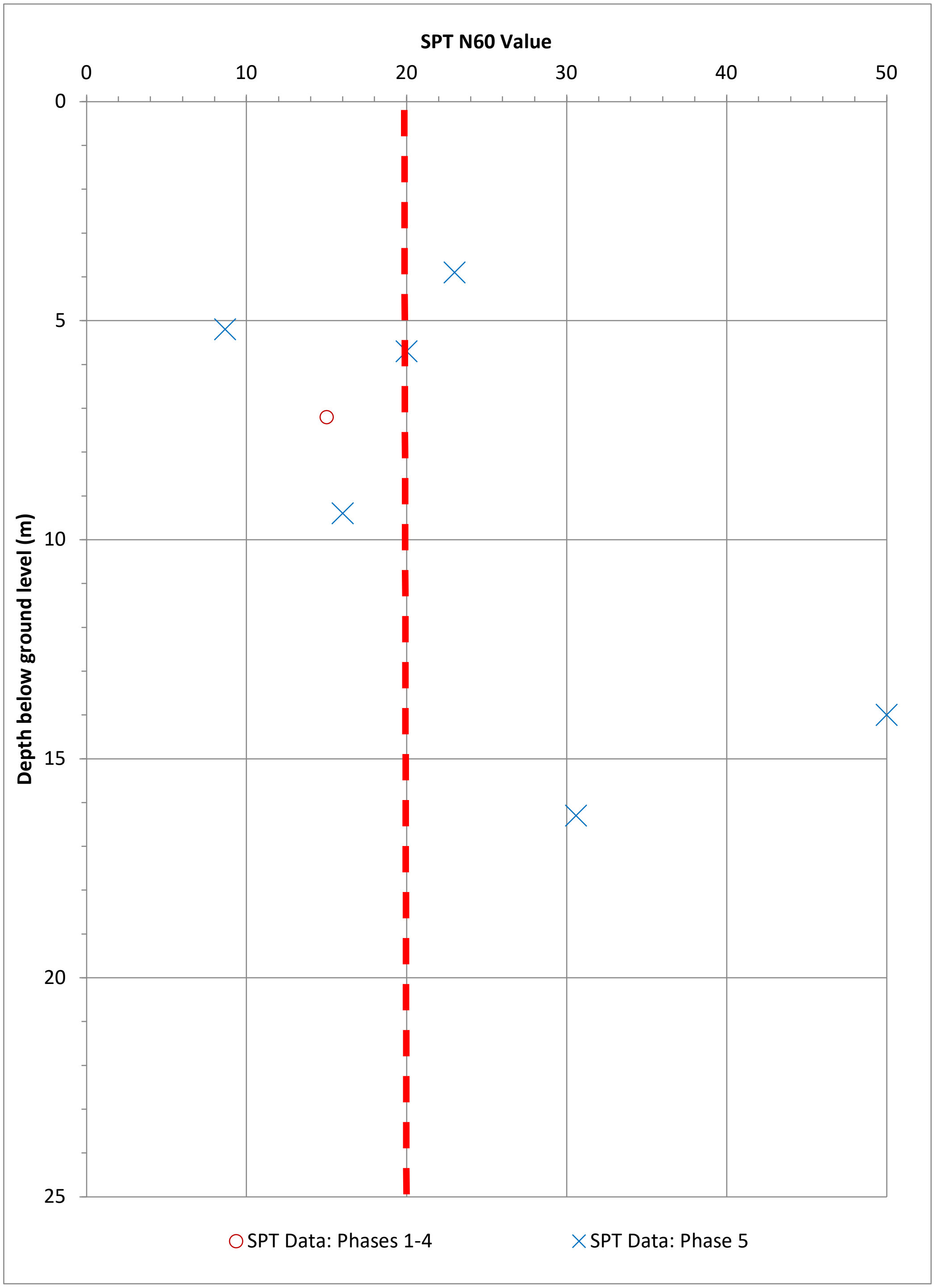
Sheet size A4	Drawn TB Date 10/09/2021	Checked GDS Date 04/01/2022	Authorised JJ Date 04/01/2022
Status	Figure Number		Rev P01



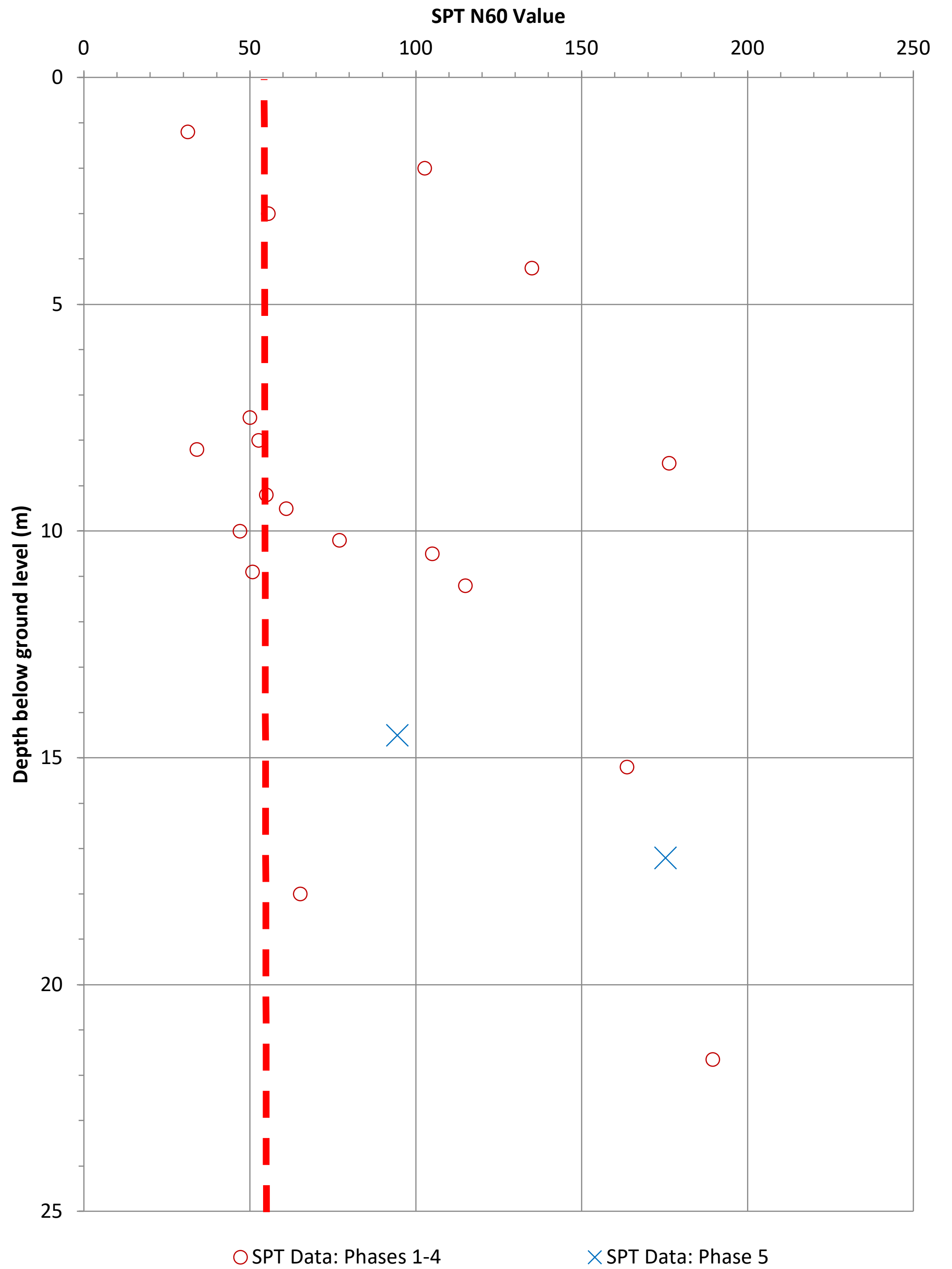
ATKINS Member of the SNC-Lavalin Group **Atkins Limited** Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Client **Highways England**	Title **SPT N60 vs Depth for Made Ground - Section 2**		
	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
		Figure Number		Rev P01



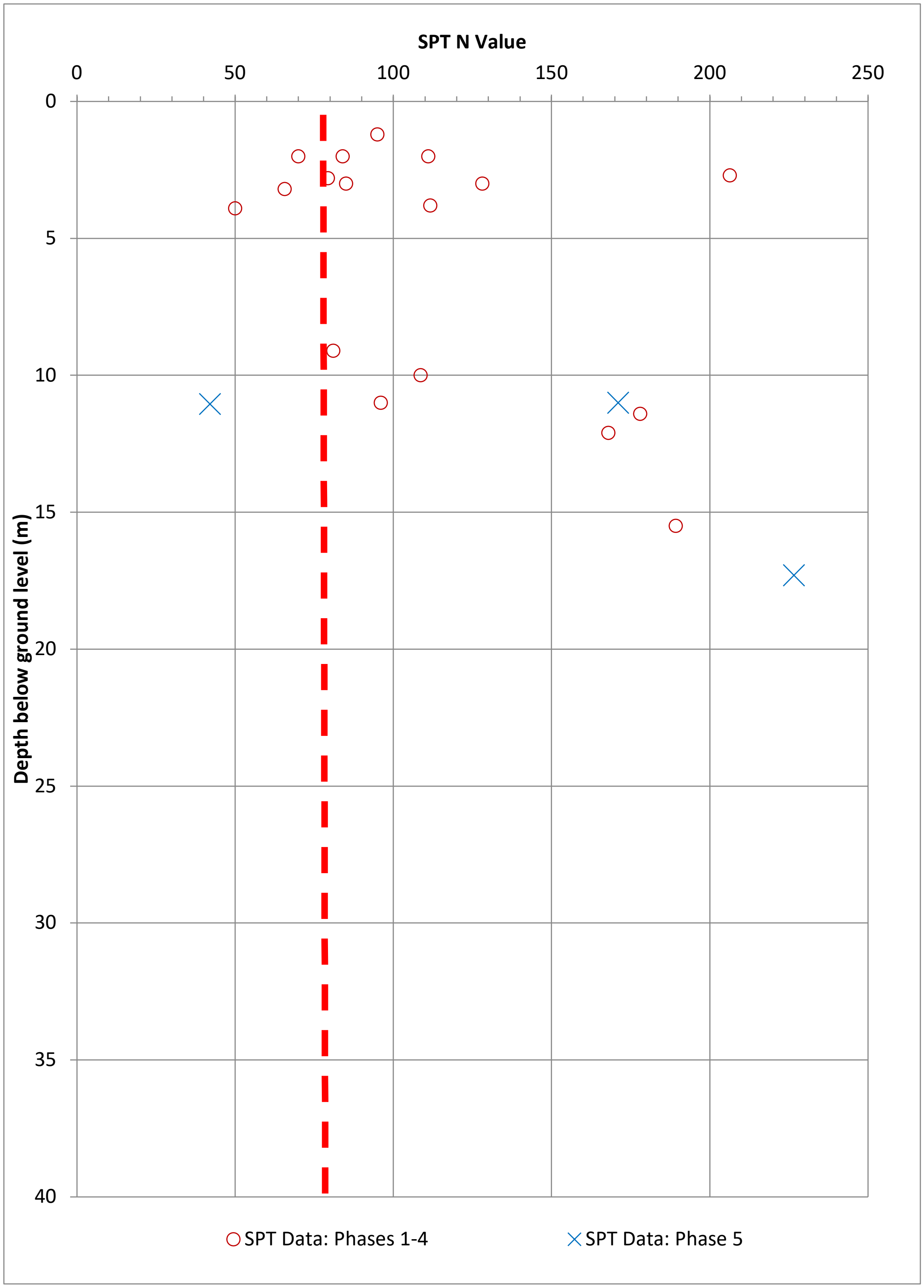
ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client **Highways England**	Title **SPT N60 vs Depth for Glacial Till (Cohesive) - Section 2**
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 4/3/22 · Check: GDS Date: 11/3/22 · Review: MG Date: 14/3/22 Figure Number · Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited** Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Client **Highways England**	Title **SPT N60 vs Depth for Glacial Till (Granular) - Section 2**		
	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
		Figure Number		Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client: **Highways England**	Title: **SPT N60 vs Depth for Mudstone - Section 2**		
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project: **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
		Figure Number		Rev P01



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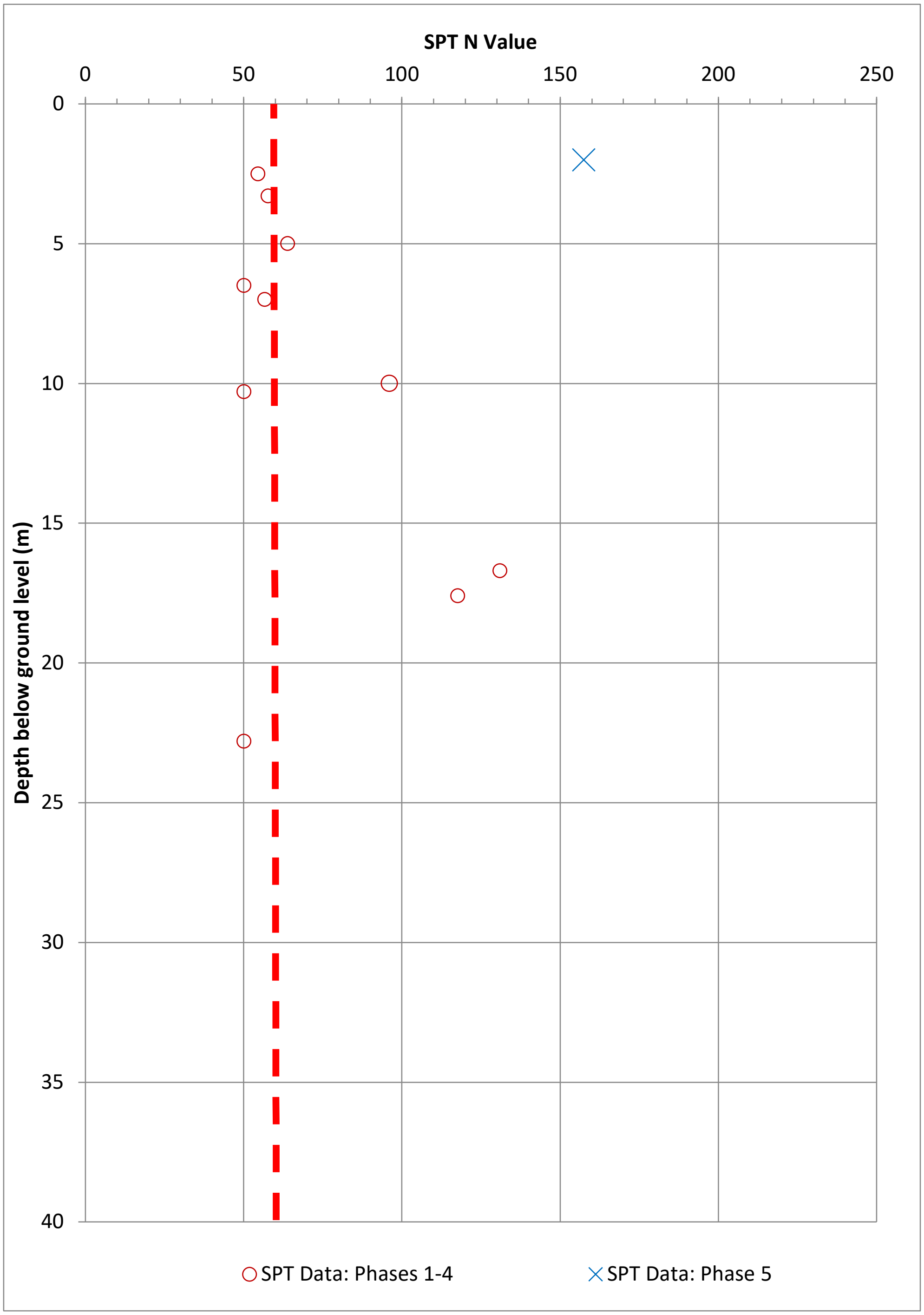
Project: **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
	Figure Number	Rev P01



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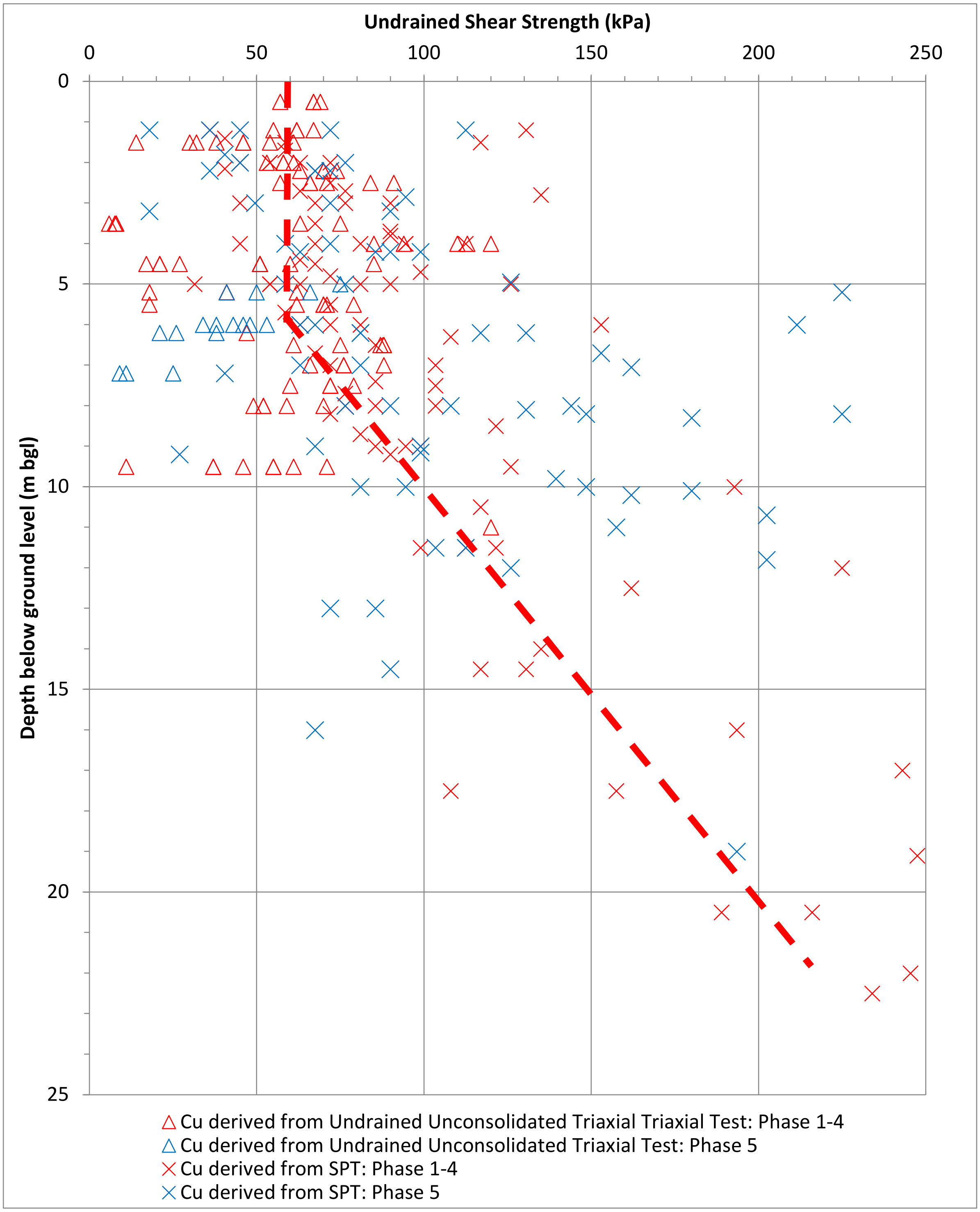
Atkins Limited	**Highways England**		**SPT N60 vs Depth for Sandstone - Section 2**	
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
		Figure Number		Rev P01



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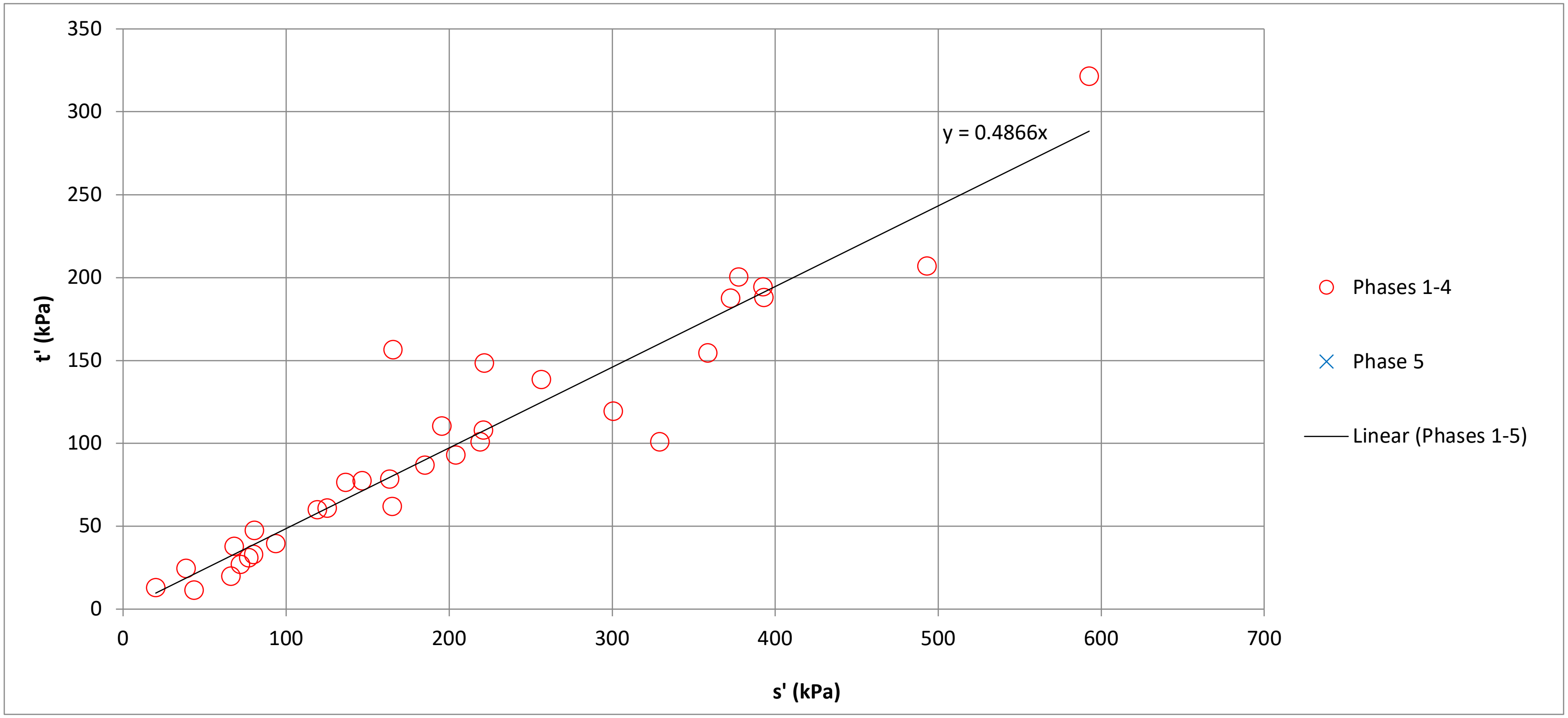
Client	Title		
Highways England	**Undrained Shear Strength vs Depth for Glacial Till (Cohesive) - Section 2**		
Project	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
A57 Trans Pennine Upgrade	Figure Number		Rev P01



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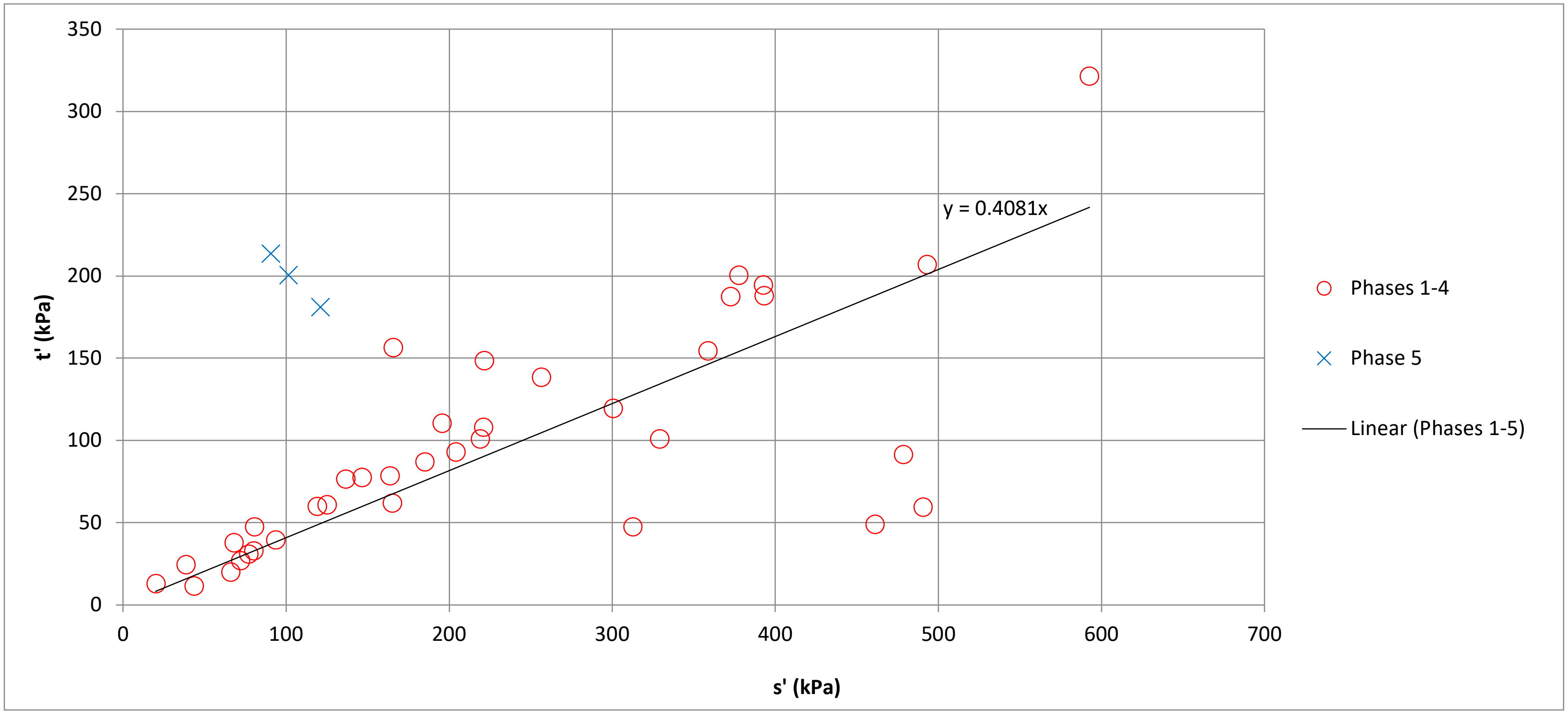
ATKINS Member of the SNC-Lavalin Group	Highways England	Triaxial-Derived Effective Strength for Glacial Till (Cohesive) - *Anomalous Results Removed* - Section 2						
Atkins Limited	Project	Sheet size	Drawn	TB	Checked	GDS	Authorised	JJ
Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE Tel: +44 1925 238000 Fax: +44 1925 238500	**A57 Trans Pennine Upgrade**	A4	Date	09/09/2021	Date	04/01/2022	Date	04/01/2022
		Status	Figure Number				Rev	P01



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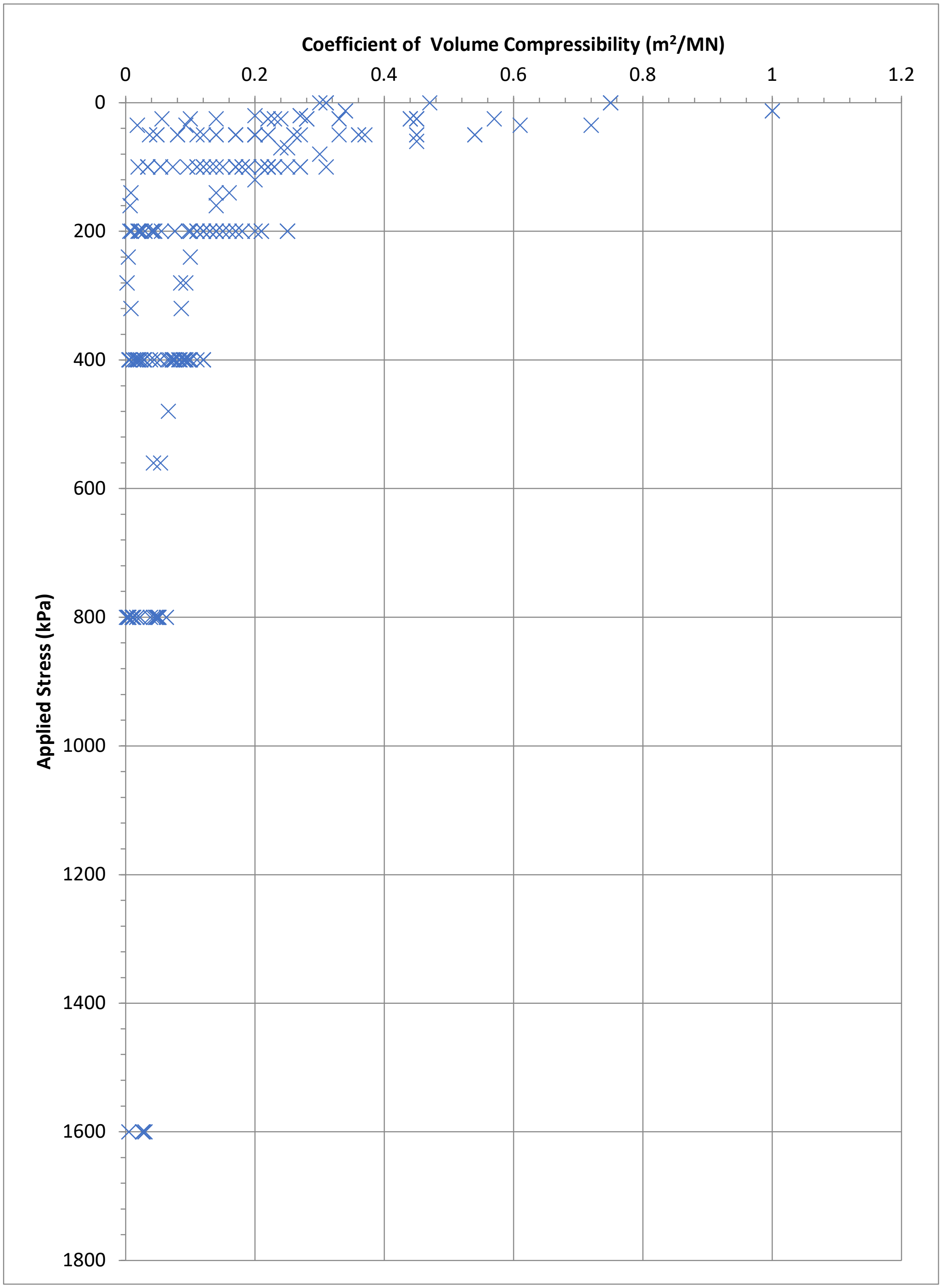
Highways England

Triaxial-Derived Effective Strength for Glacial Till (Cohesive) - *All Results* - Section 2

Project

A57 Trans Pennine Upgrade

Sheet size	Drawn	TB	Checked	GDS	Authorised	JJ
A4	Date	09/09/2021	Date	04/01/2022	Date	04/01/2022
Status	Figure Number				Rev	P01



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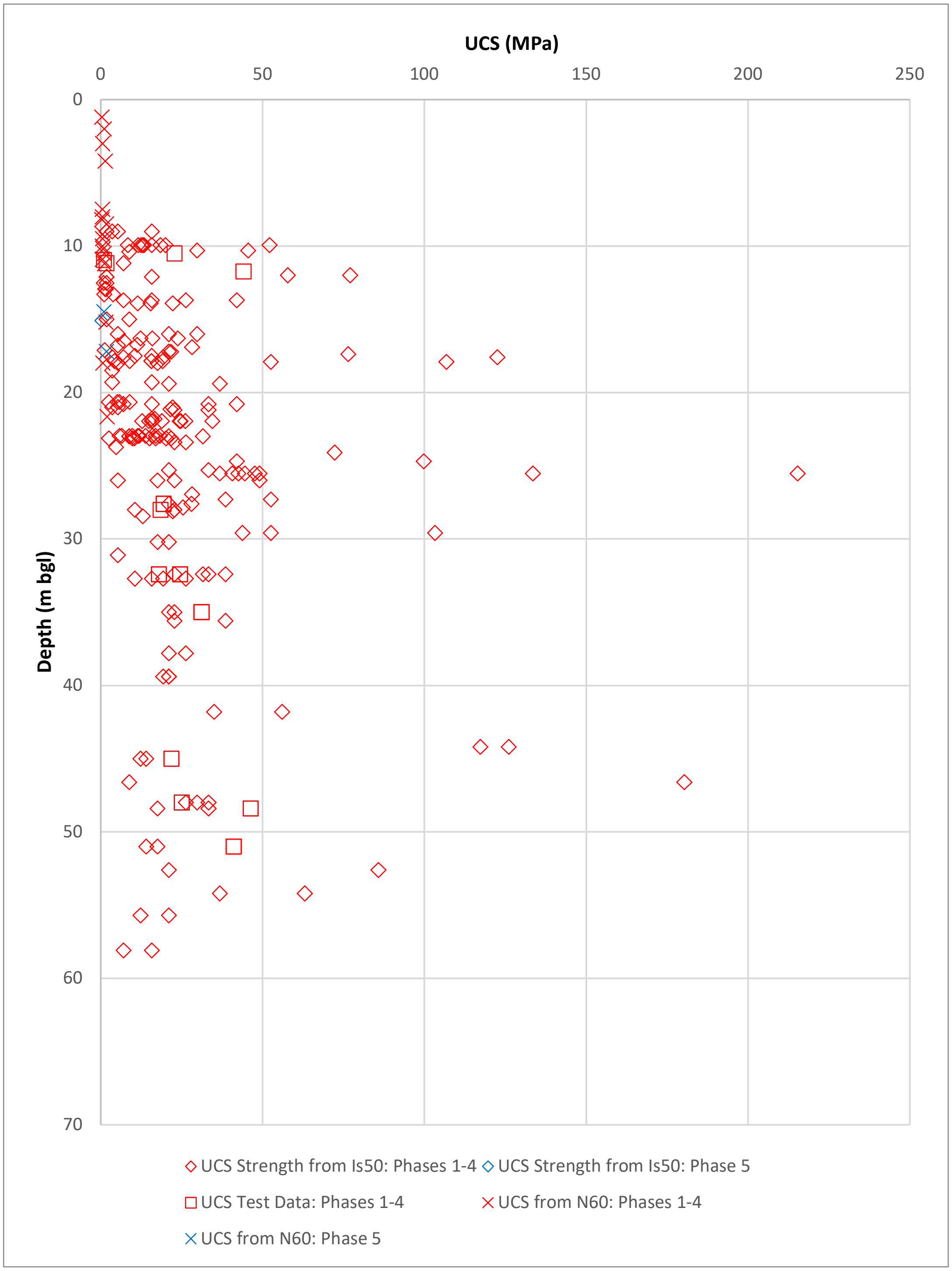
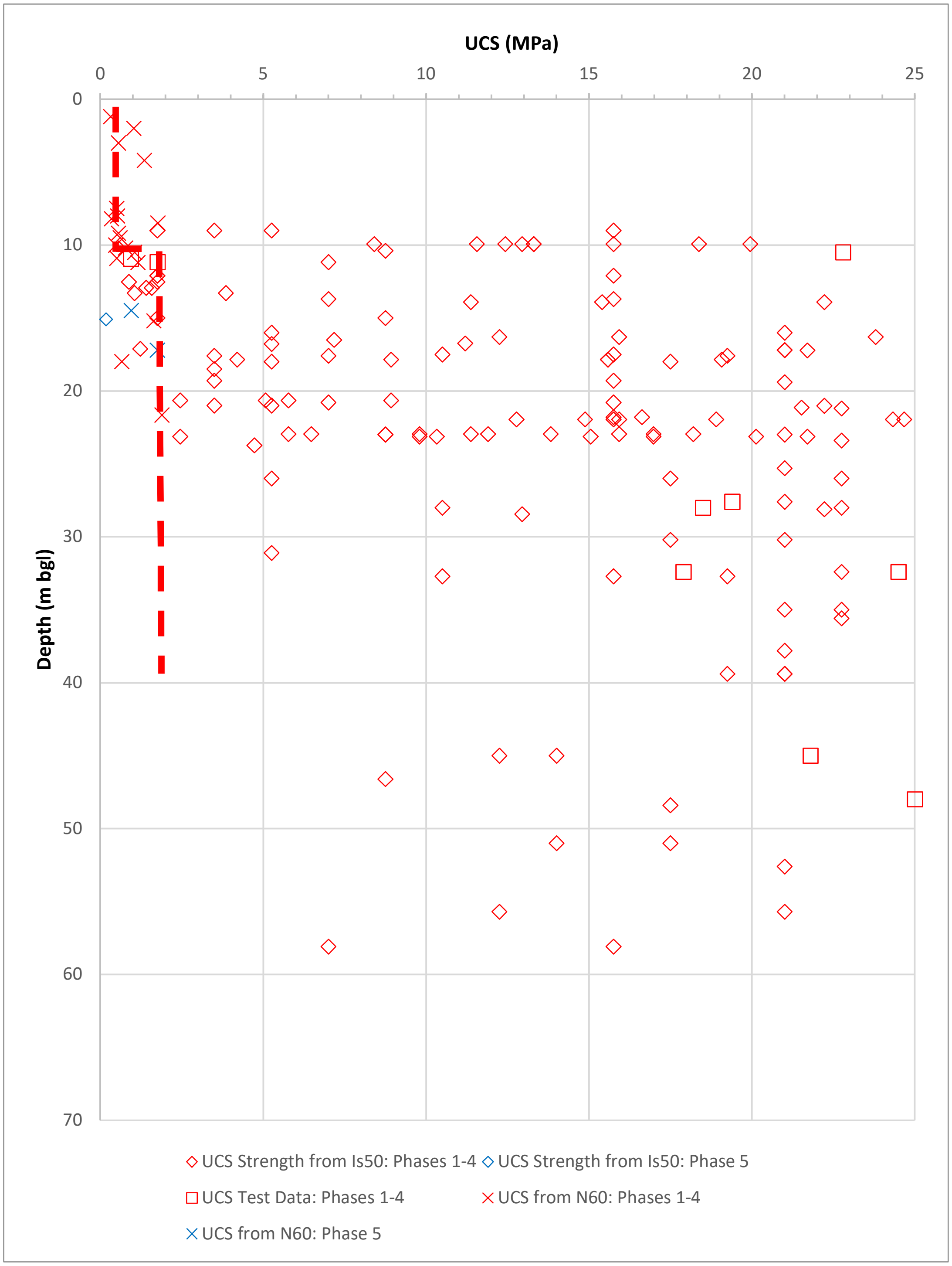
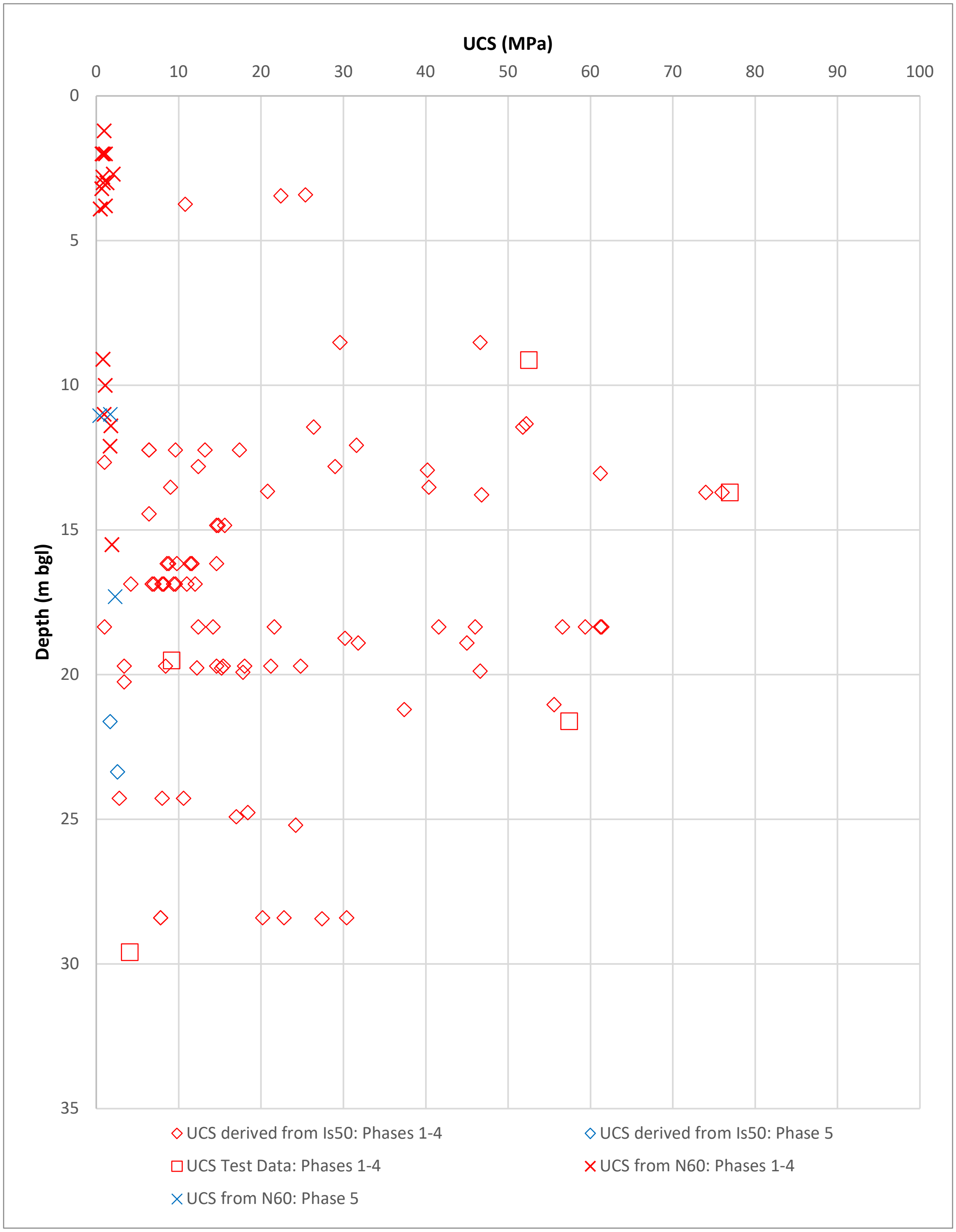
Client **Highways England**	Title **Coefficient of Volume Compressibility vs Applied Stress for Glacial Till (Cohesive) - Section 2**		
Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
	Figure Number		Rev P01



ATKINS Member of the SNC-Lavalin Group	Client	Title		
Atkins Limited	**Highways England**	**Uniaxial Compressive Strength vs Depth for Mudstone - Section 2**		
Chadwick House	Project	Drawn: TB	Check: GDS	Review: JJ
Birchwood Park		Date: 10/9/21	Date: 4/1/22	Date: 4/1/22
Warrington Tel: (01372) 726140	**A57 Trans Pennine Upgrade**	Figure Number		Rev
WA3 6AE Fax: (01372) 740055				P01



ATKINS Member of the SNC-Lavalin Group	Client	Title	
Atkins Limited	**Highways England**	**Uniaxial Compressive Strength vs Depth for Mudstone (UCS < 25MPa) - Section 2**	
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22
		Figure Number	Review: JJ Date: 4/1/22 Rev P01



ATKINS Member of the SNC-Lavalin Group	Client **Highways England**	Title **Uniaxial Compressive Strength vs Depth for Siltstone - Section 2**	
Atkins Limited Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
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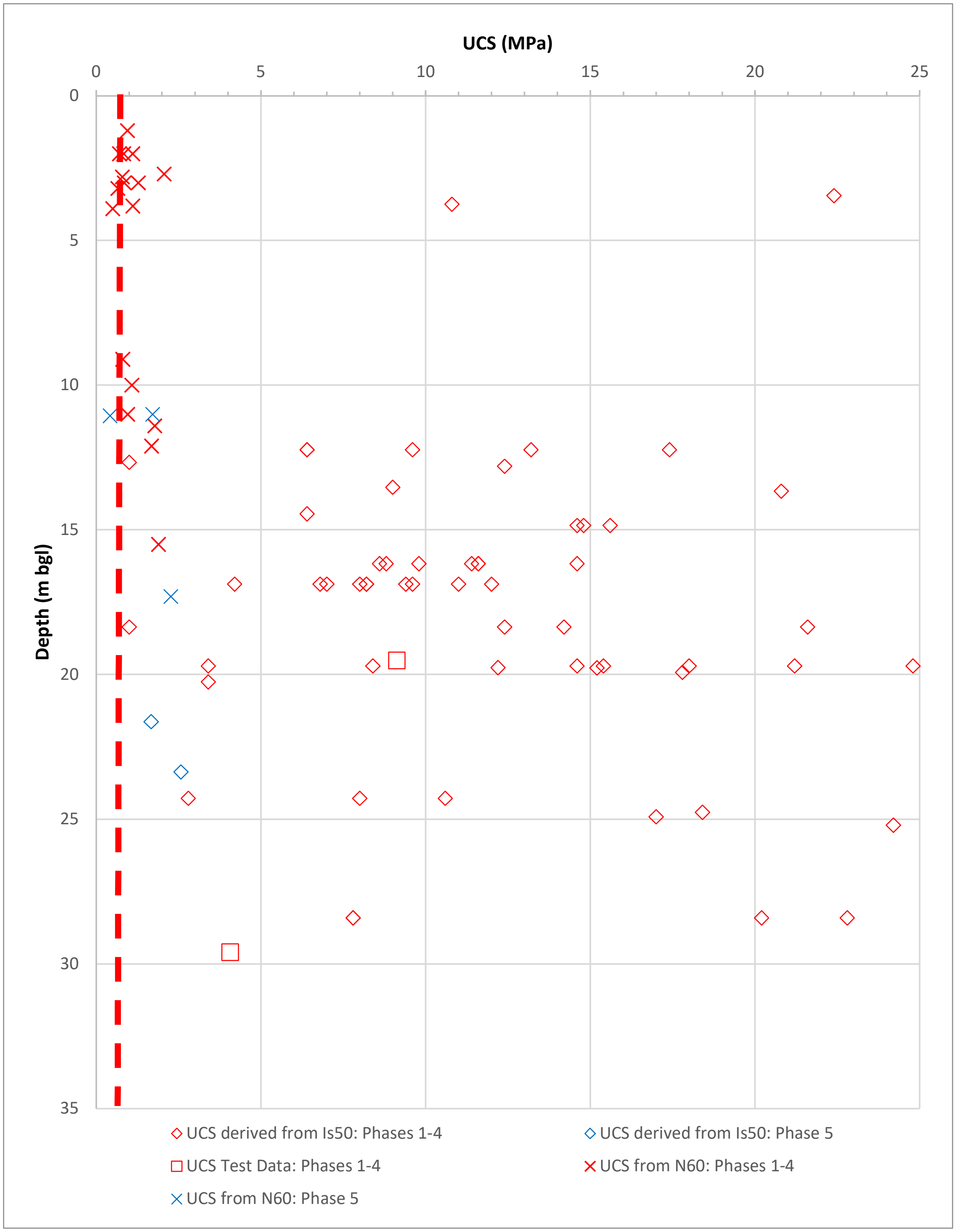
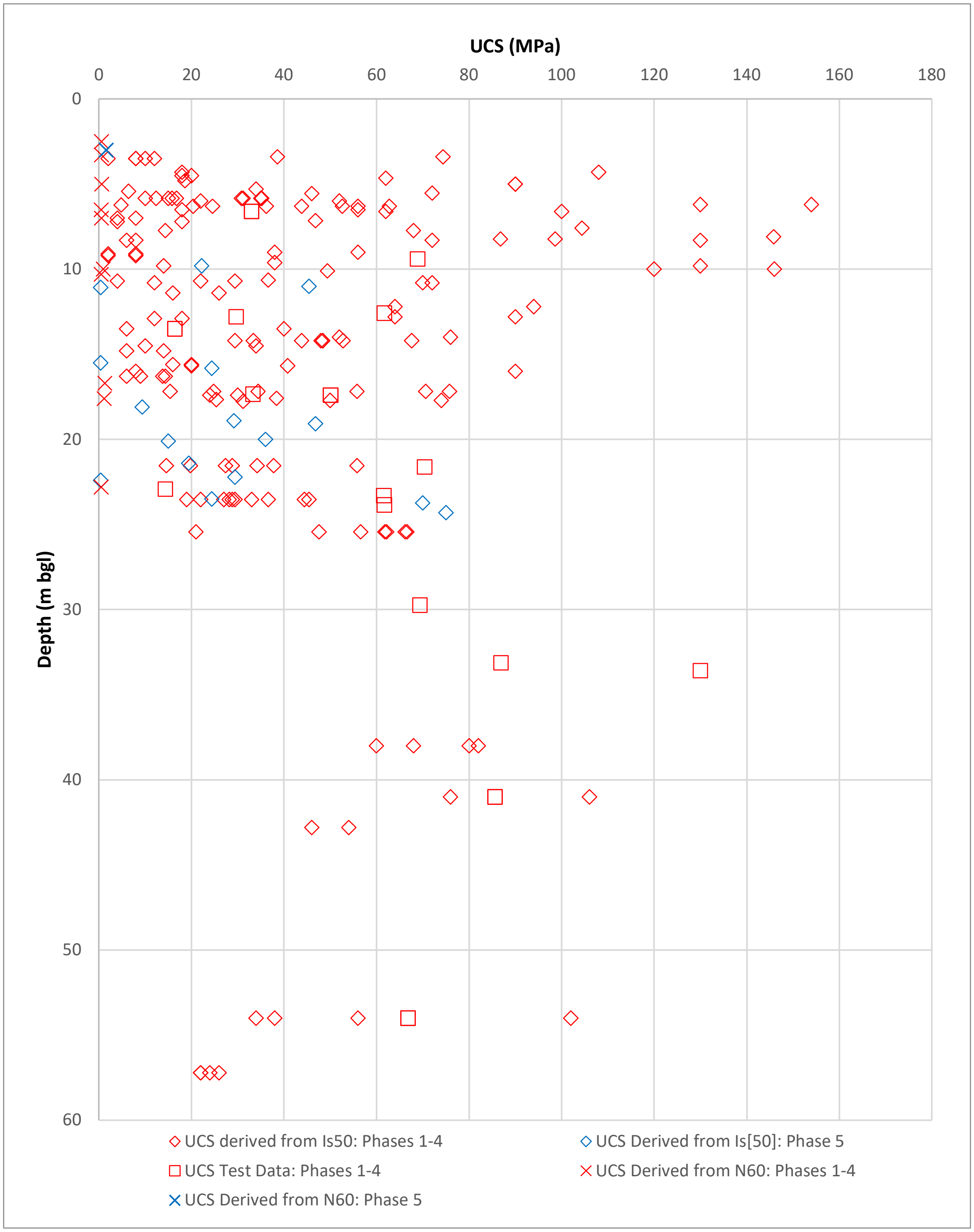


ATKINS Member of the SNC-Lavalin Group **Atkins Limited** Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Client **Highways England** Project **A57 Trans Pennine Upgrade**	Title **Uniaxial Compressive Strength vs Depth for Siltstone (UCS < 25MPa) - Section 2** Drawn: TB Date: 10/9/21 | Check: GDS Date: 4/1/22 | Review: JJ Date: 4/1/22 Figure Number | Rev P01



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Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
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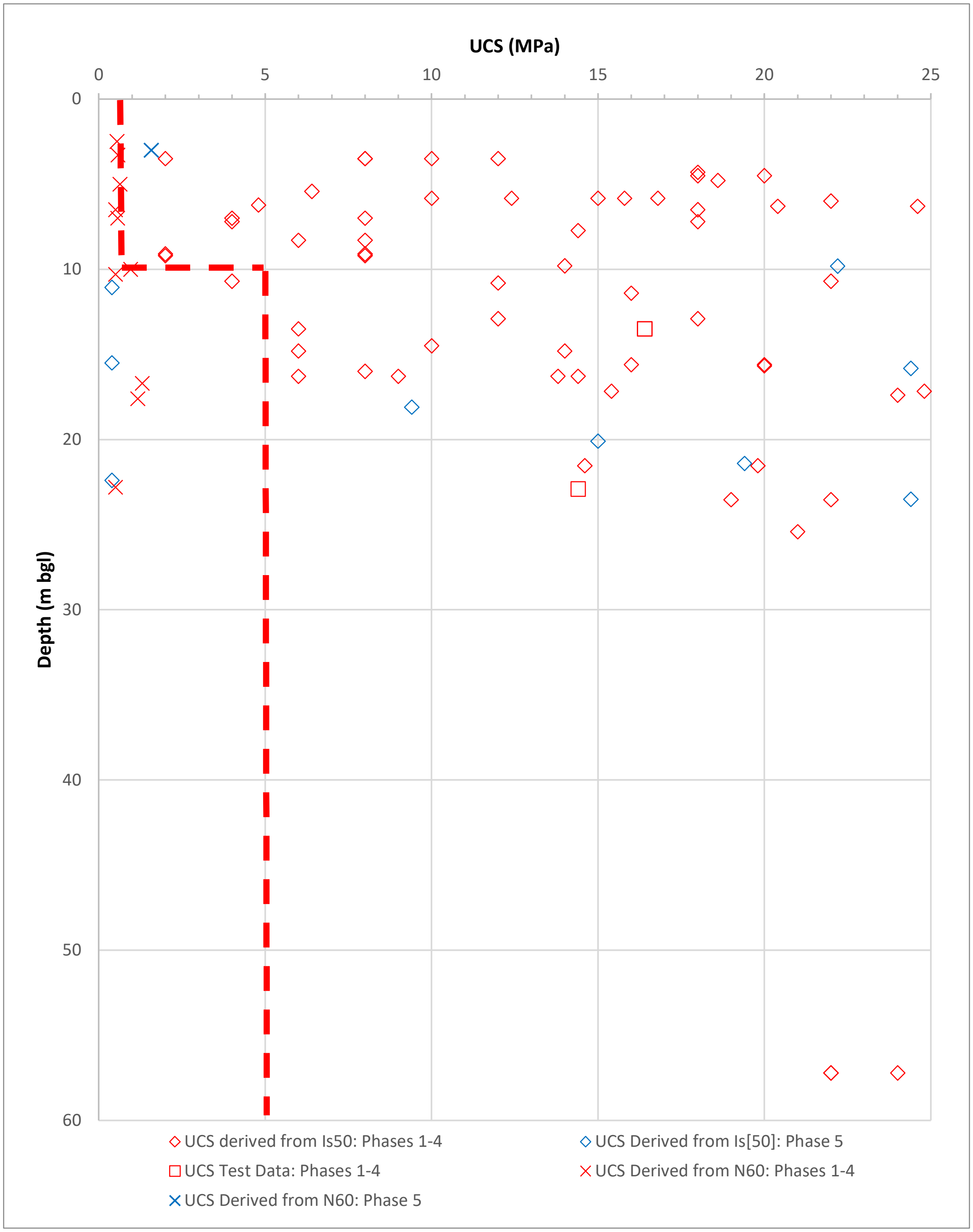

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Client	Title		
Highways England	**Uniaxial Compressive Strength vs Depth for Sandstone (UCS < 25MPa) - Section 2**		
Project	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
A57 Trans Pennine Upgrade	Figure Number		Rev P01

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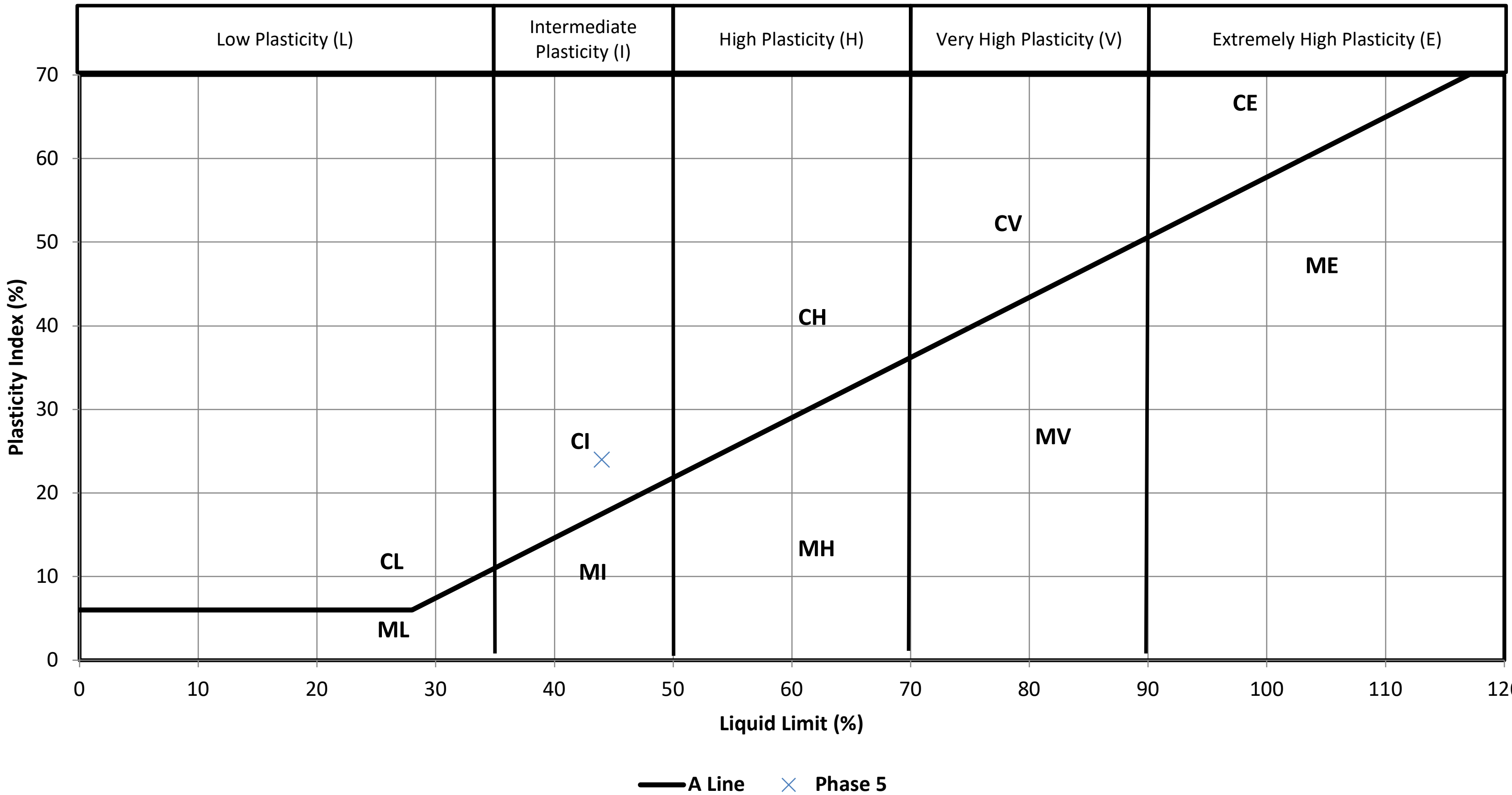
Section 3



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Highways England	A Line for Made Ground - Section 3			
Project: A57 Trans Pennine Upgrade	Sheet size: A4	Drawn: TB; Date: 10/09/2021	Checked: GDS; Date: 04/01/2022	Authorised: JJ; Date: 04/01/2022
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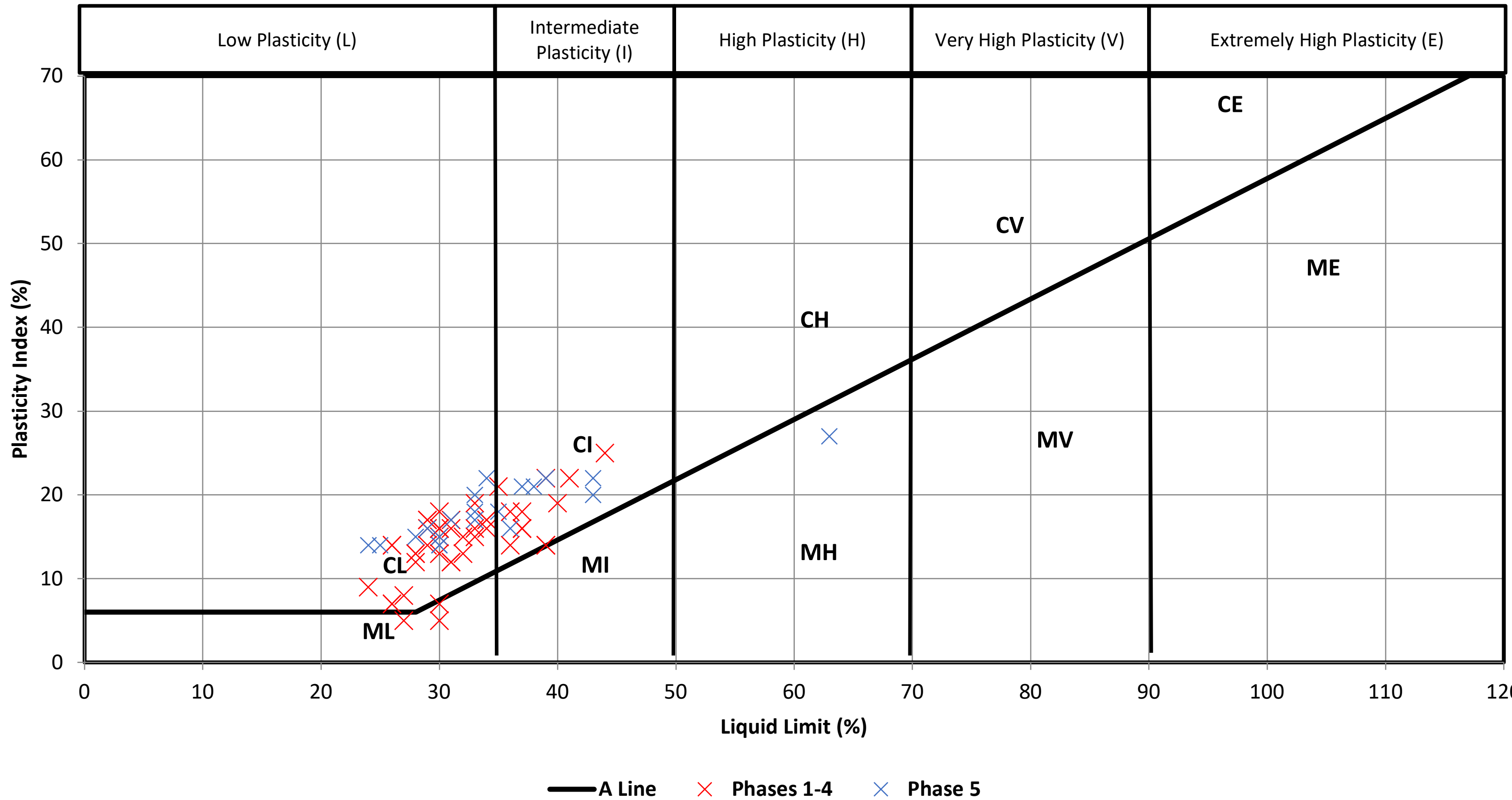
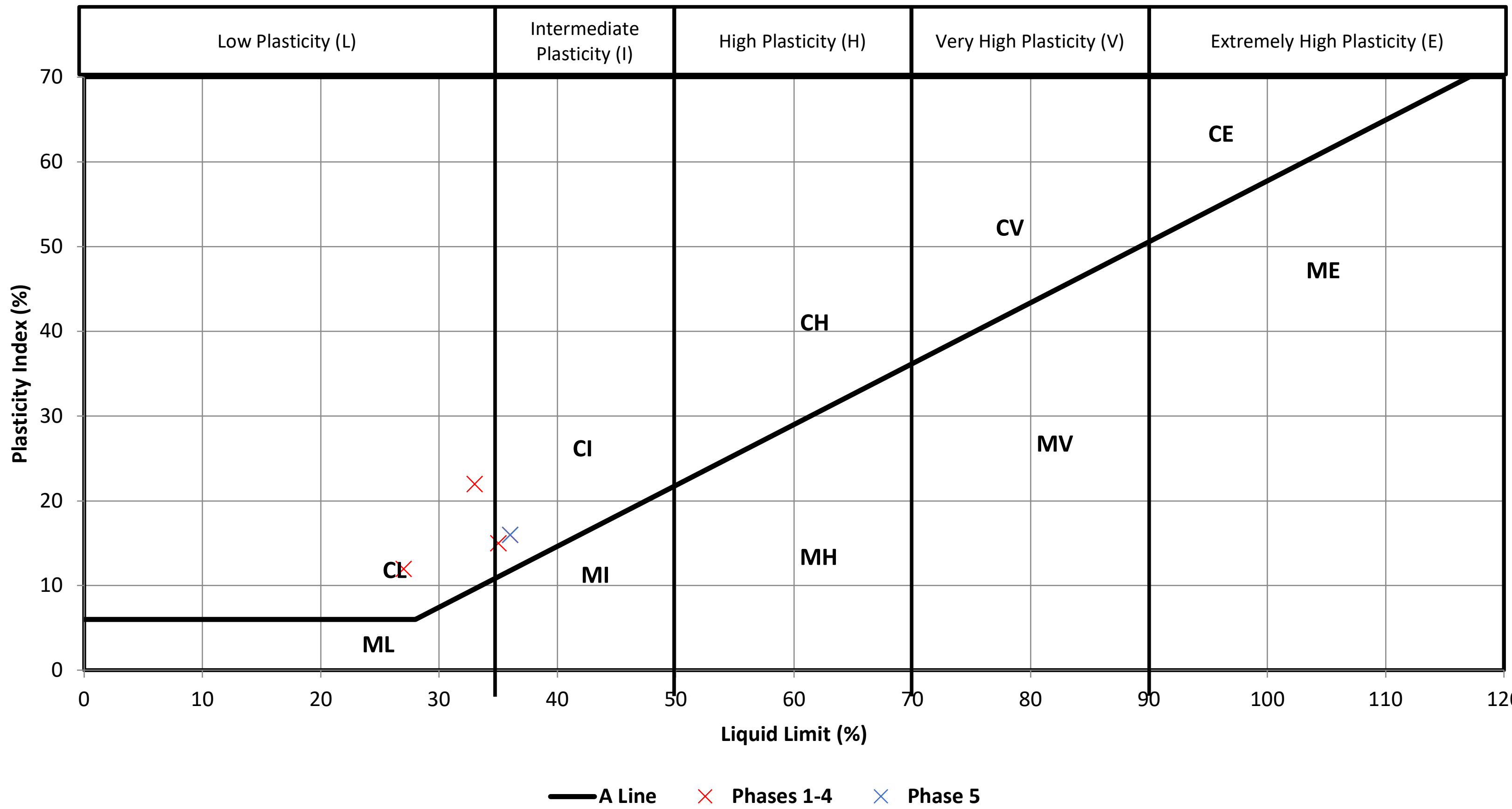
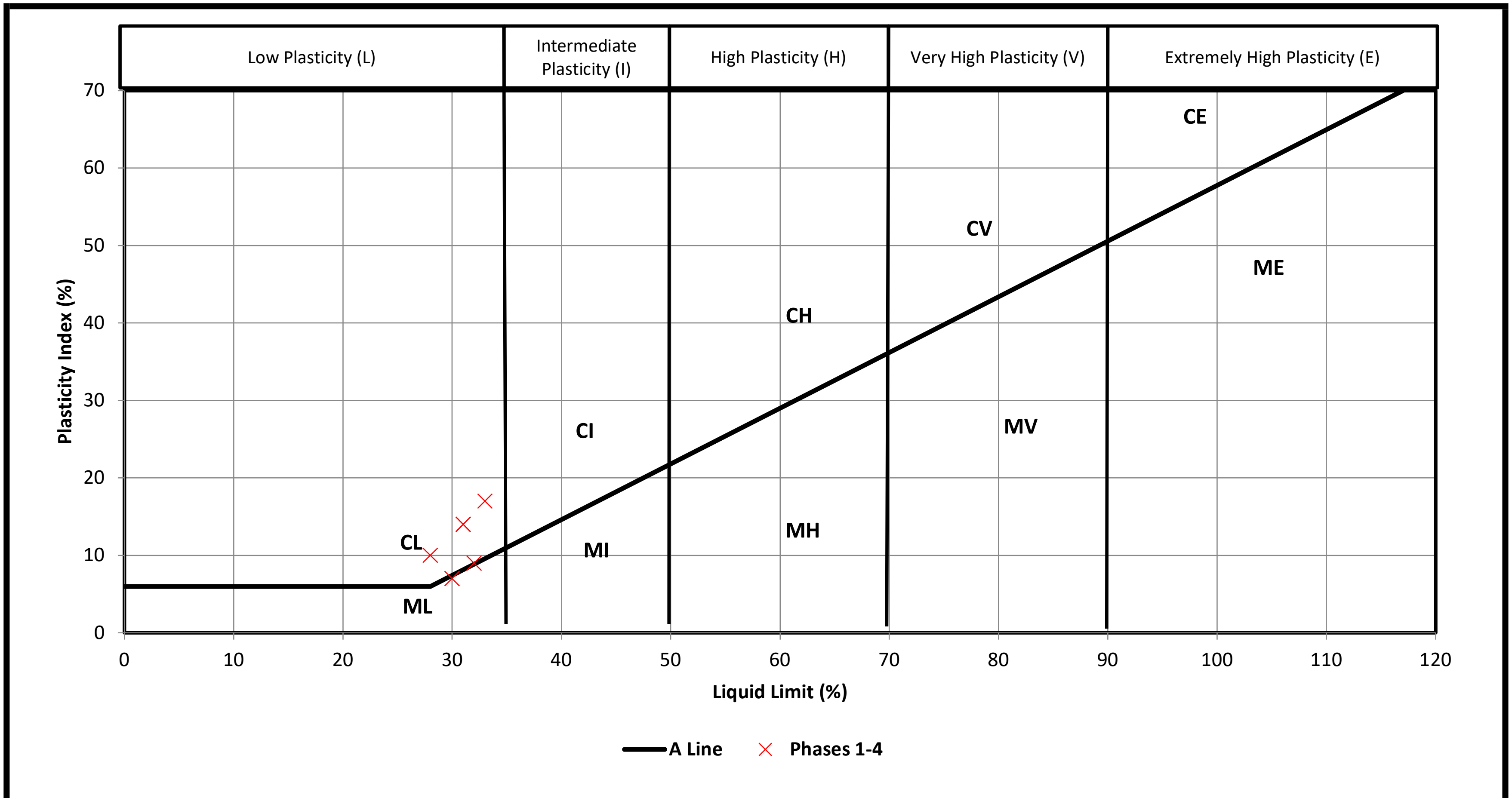


ATKINS Member of the SNC-Lavalin Group **Atkins Limited** Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE Tel: +44 1925 238000 Fax: +44 1925 238500	**Highways England**	**A Line for Glacial Till (Cohesive) - Section 3**
	Project **A57 Trans Pennine Upgrade**	Sheet size: A4 · Drawn: TB · Date: 10/09/2021 · Checked: GDS · Date: 04/01/2022 · Authorised: JJ · Date: 04/01/2022 Status · Figure Number · Rev: P01



ATKINS Member of the SNC-Lavalin Group	Highways England	A Line for Mudstone - Section 3						
Atkins Limited Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE Tel: +44 1925 238000 Fax: +44 1925 238500	Project: **A57 Trans Pennine Upgrade**	Sheet size A4	Drawn TB Date 10/09/2021		Checked GDS Date 04/01/2022		Authorised JJ Date 04/01/2022	
		Status	Figure Number				Rev P01	



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	**Highways England**	**A Line for Siltstone - Section 3**						
Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE Tel: +44 1925 238000 Fax: +44 1925 238500	Project **A57 Trans Pennine Upgrade**	Sheet size A4	Drawn	TB	Checked	GDS	Authorised	JJ
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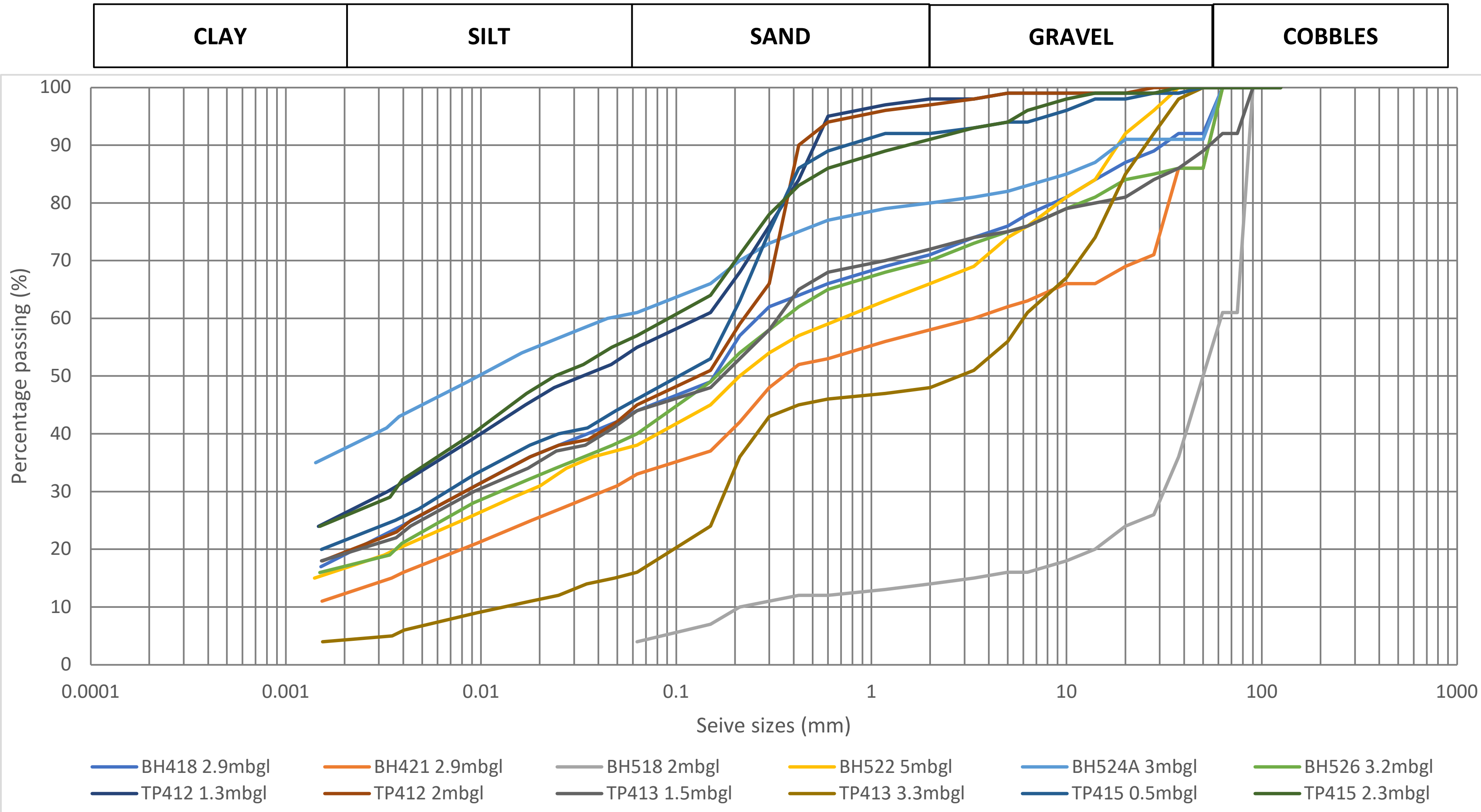

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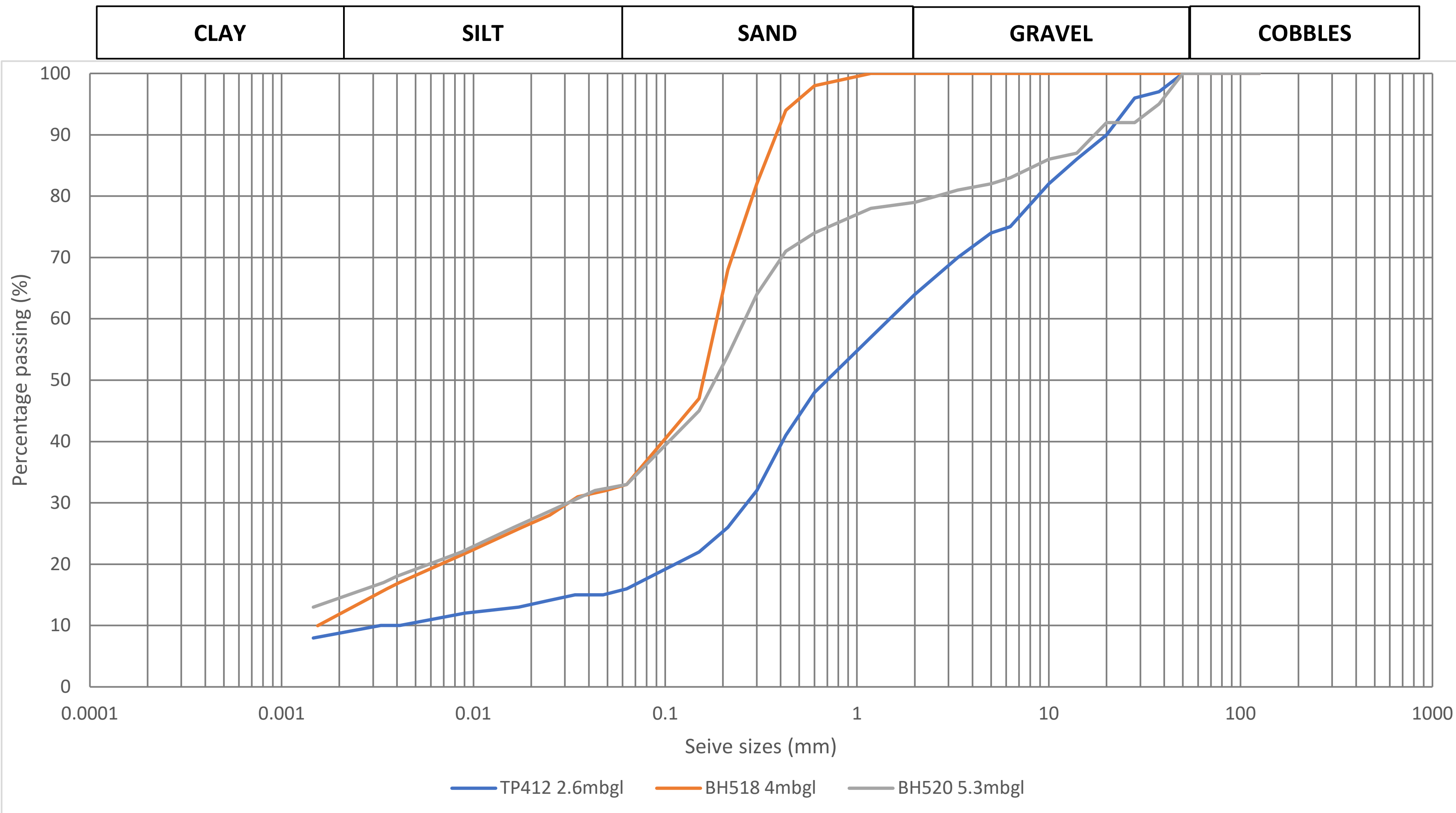
Particle Size Distribution for Glacial Till (Cohesive) - Section 3

Project

A57 Trans Pennine Upgrade

Sheet size	Drawn	TB	Checked	GDS	Authorised	JJ
A4	Date	10/09/2021	Date	04/01/2022	Date	04/01/2022
Status	Figure Number				Rev	P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Highways England	Particle Size Distribution for Glacial Till (Granular) - Section 3					
Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE Tel: +44 1925 238000 Fax: +44 1925 238500	Project **A57 Trans Pennine Upgrade**	Sheet size A4	Drawn TB Date 10/09/2021	Checked GDS Date 04/01/2022	Authorised JJ Date 04/01/2022		
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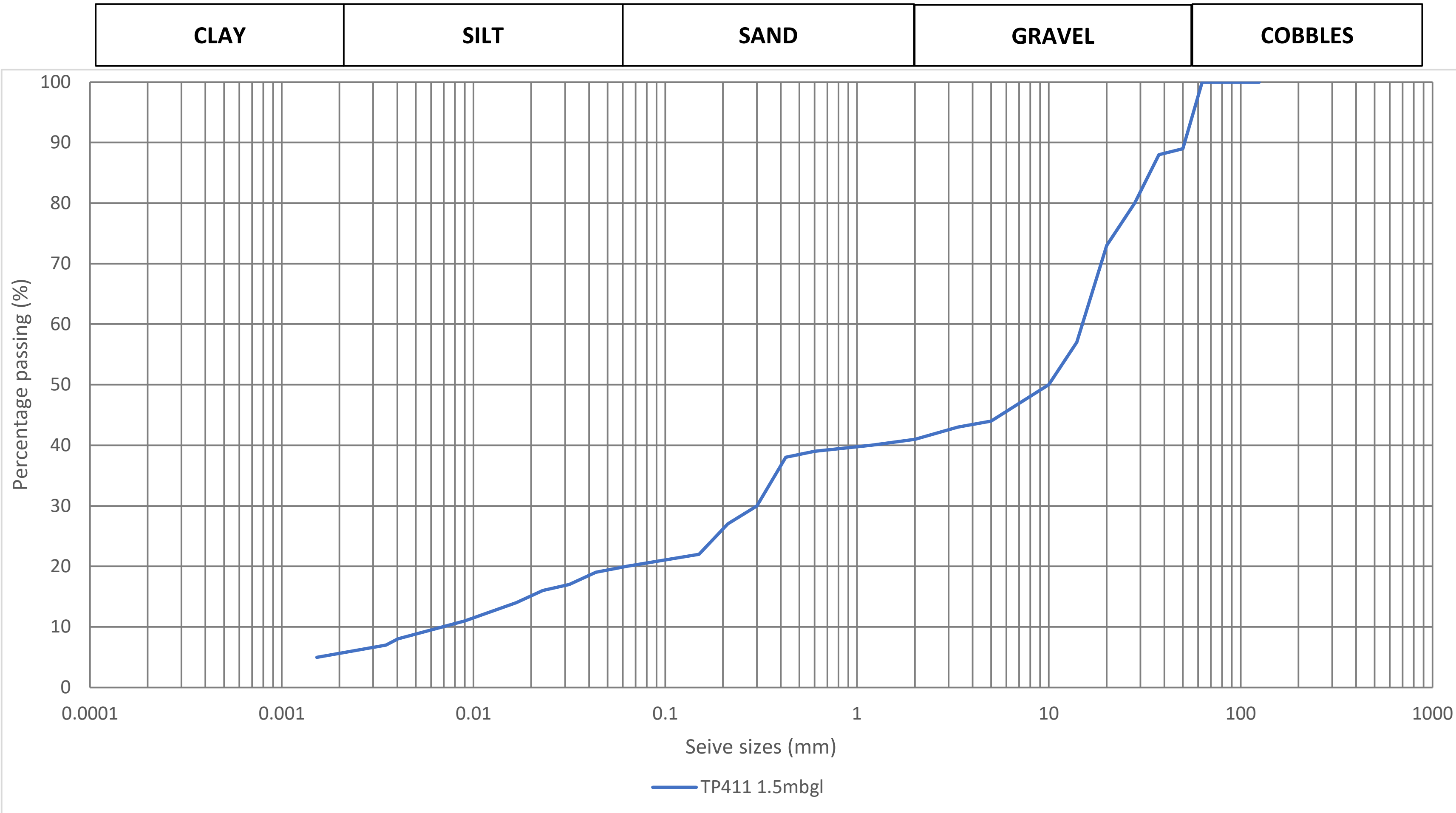

ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	**Highways England**	**Particle Size Distribution for Siltstone - Section 3**							
Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE Tel: +44 1925 238000 Fax: +44 1925 238500	Project **A57 Trans Pennine Upgrade**	Sheet size A4	Drawn	TB	Checked	GDS	Authorised	JJ	
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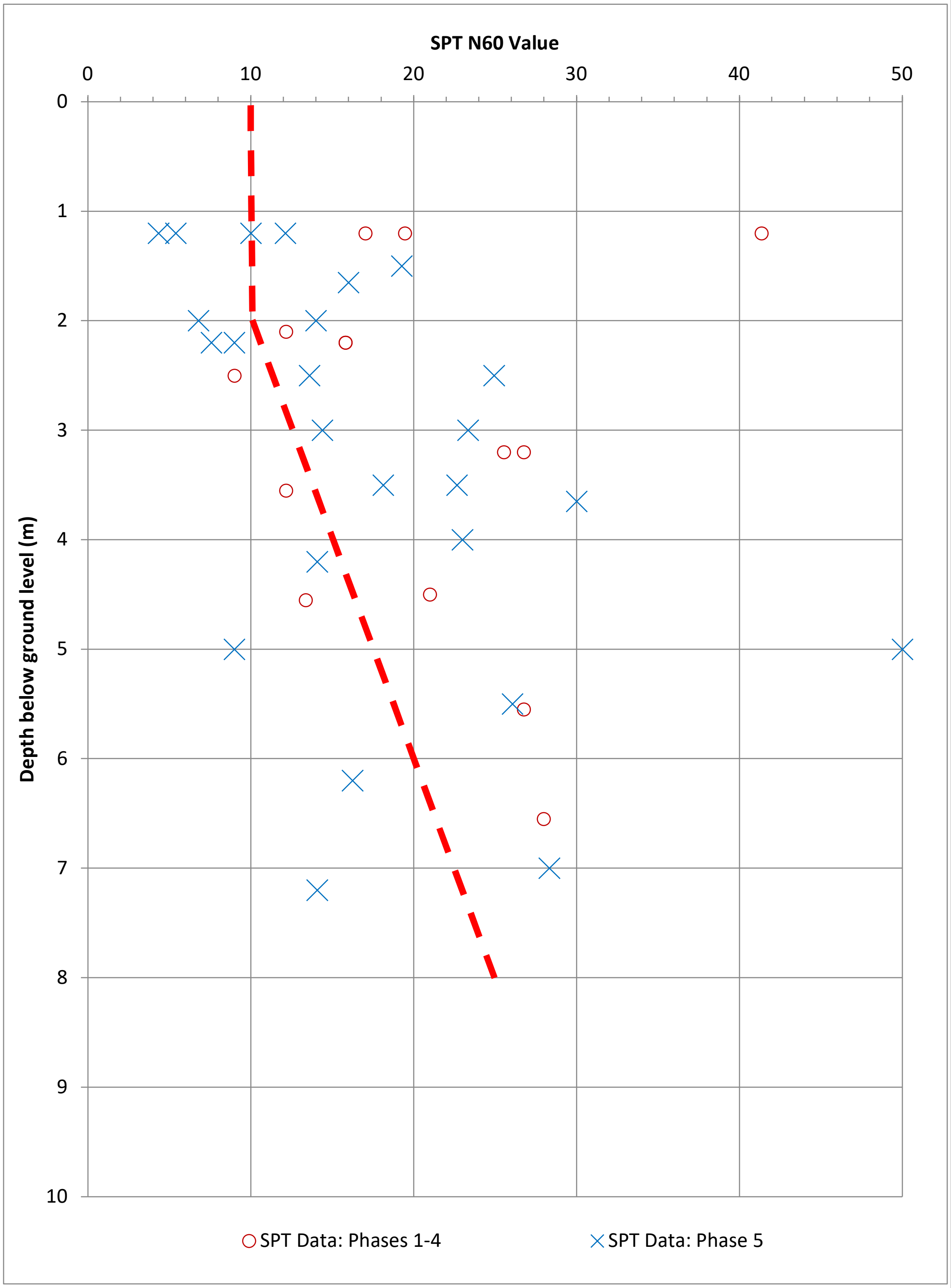

ATKINS Member of the SNC-Lavalin Group	Client **Highways England**	Title **SPT N60 vs Depth for Glacial Till (Cohesive) - Section 3**

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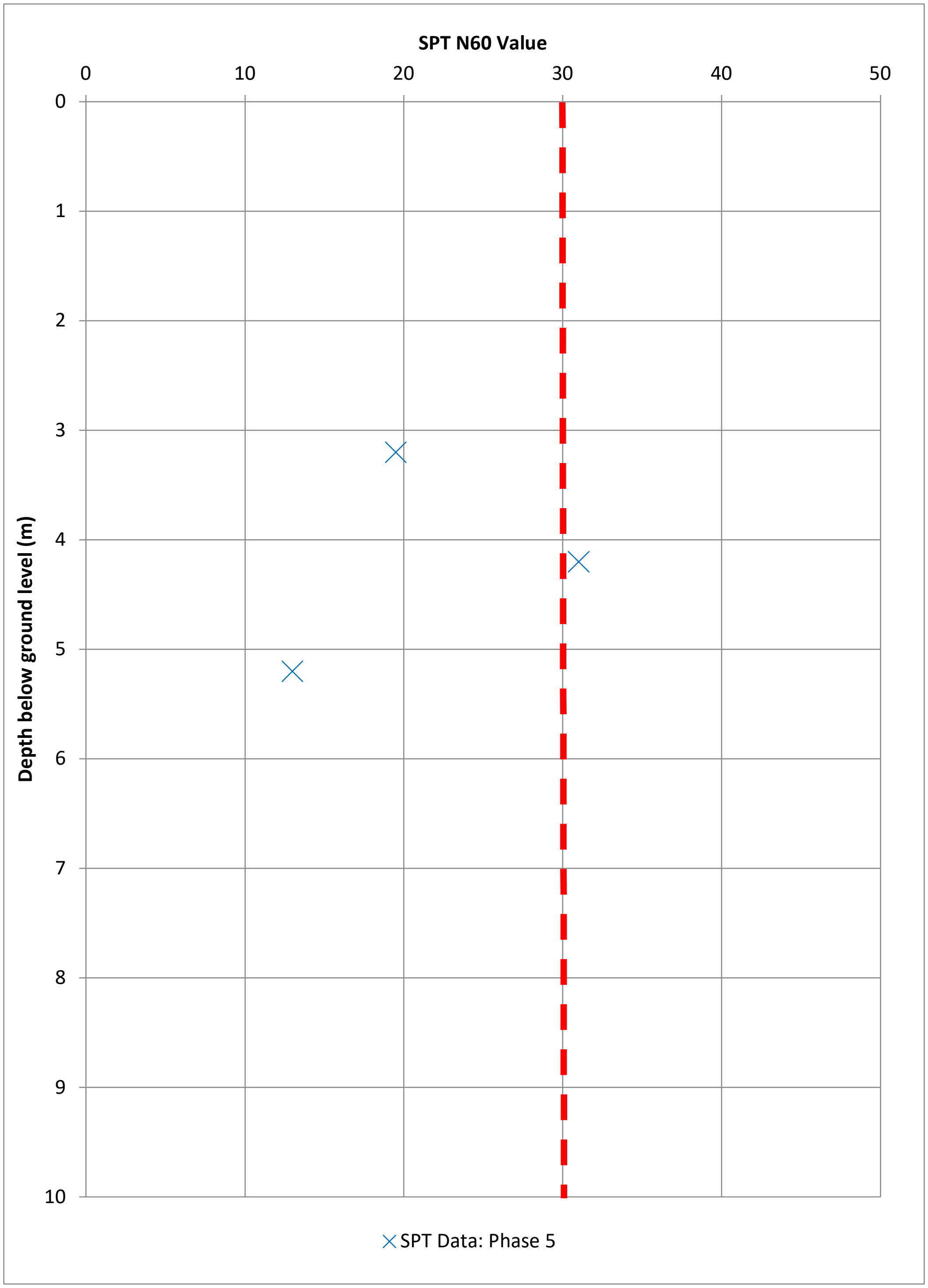
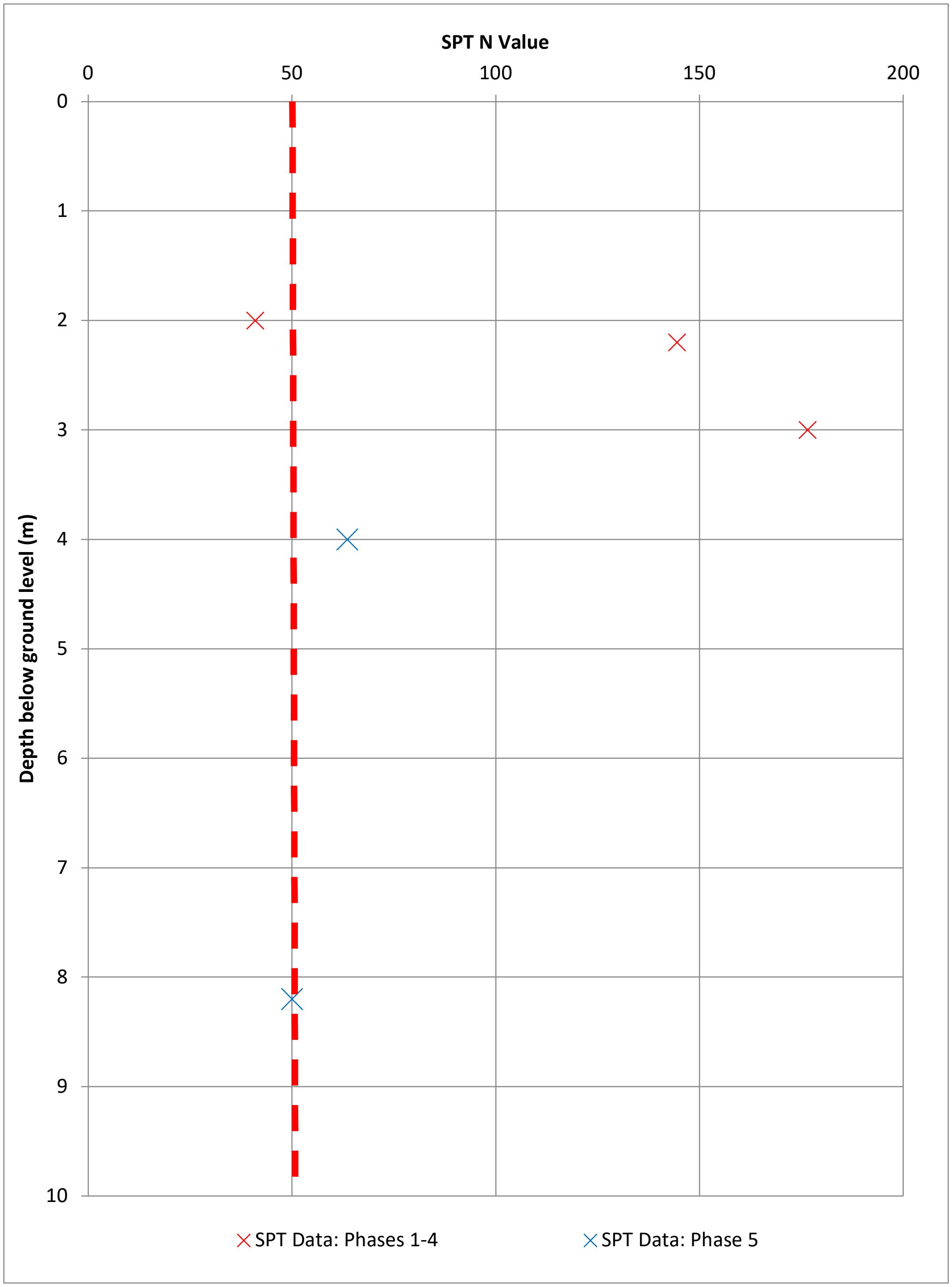
WA3 6AE Fax: (01372) 740055

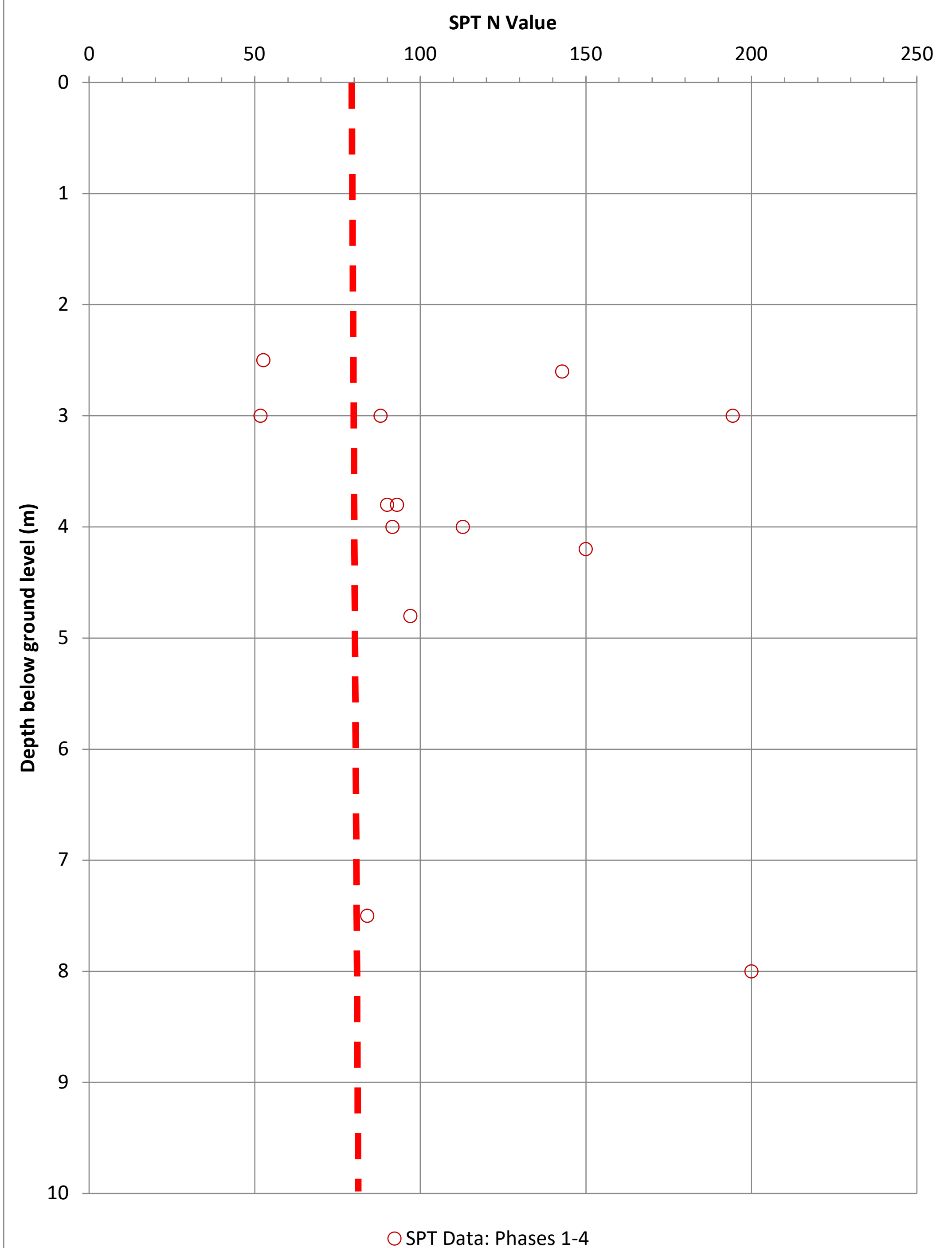
Project	Drawn: TB	Check: GDS	Review: JJ
A57 Trans Pennine Upgrade	Date: 10/9/21	Date: 4/1/22	Date: 4/1/22
	Figure Number		Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client **Highways England**	Title **SPT N60 vs Depth for Glacial Till (Granular) - Section 3**
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21 | Check: GDS Date: 4/1/22 | Review: JJ Date: 4/1/22 Figure Number | Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client **Highways England**	Title **SPT N60 vs Depth for Mudstone - Section 3**		
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
		Figure Number		Rev P01



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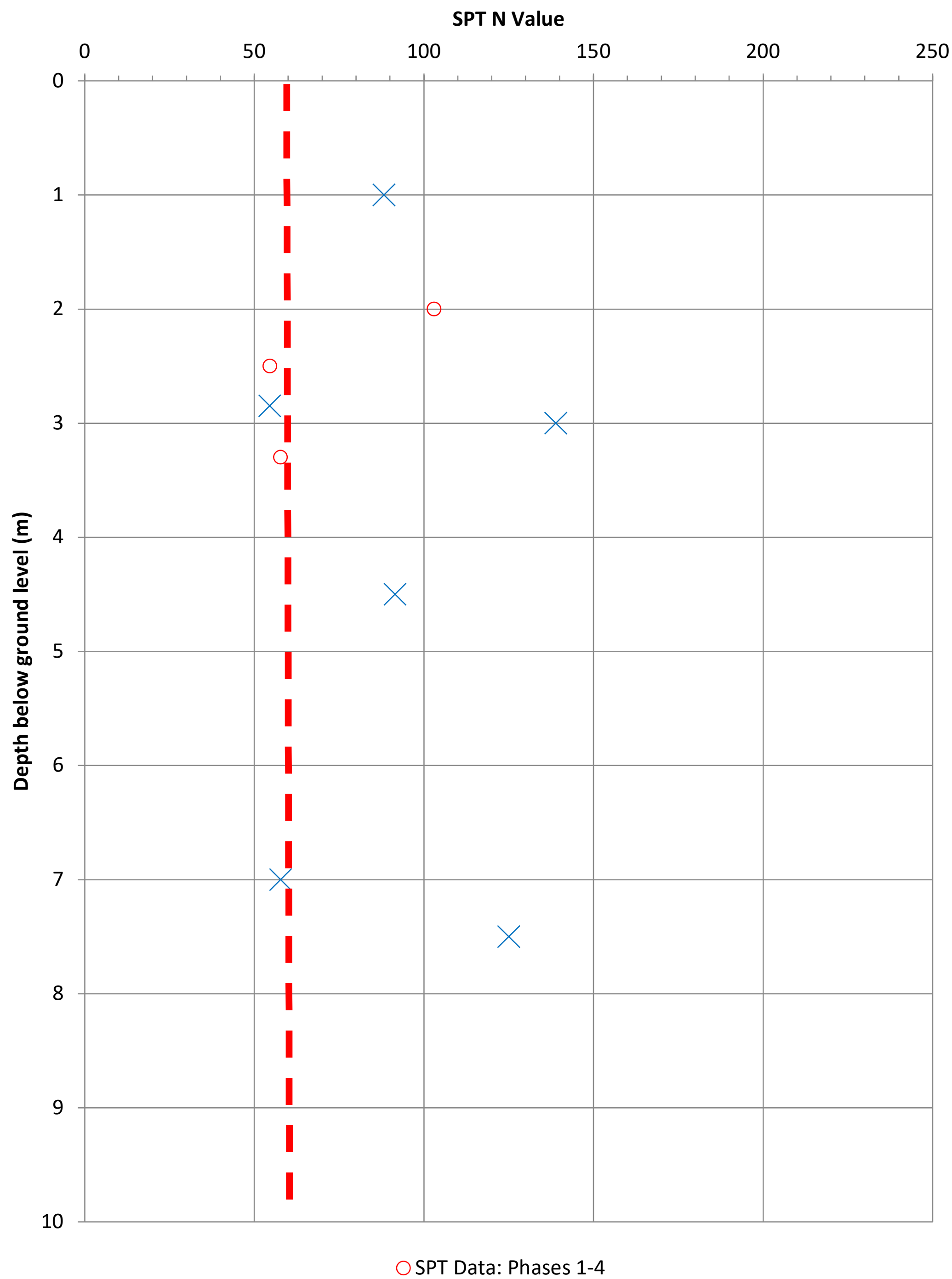
Client
Highways England

Title
SPT N60 vs Depth for Siltstone - Section 3

Project
A57 Trans Pennine Upgrade

Drawn: TB	Check: GDS	Review: JJ
Date: 10/9/21	Date: 4/1/22	Date: 4/1/22
Figure Number		Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited** Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Client **Highways England** Project **A57 Trans Pennine Upgrade**	Title **SPT N60 vs Depth for Sandstone - Section 3**	
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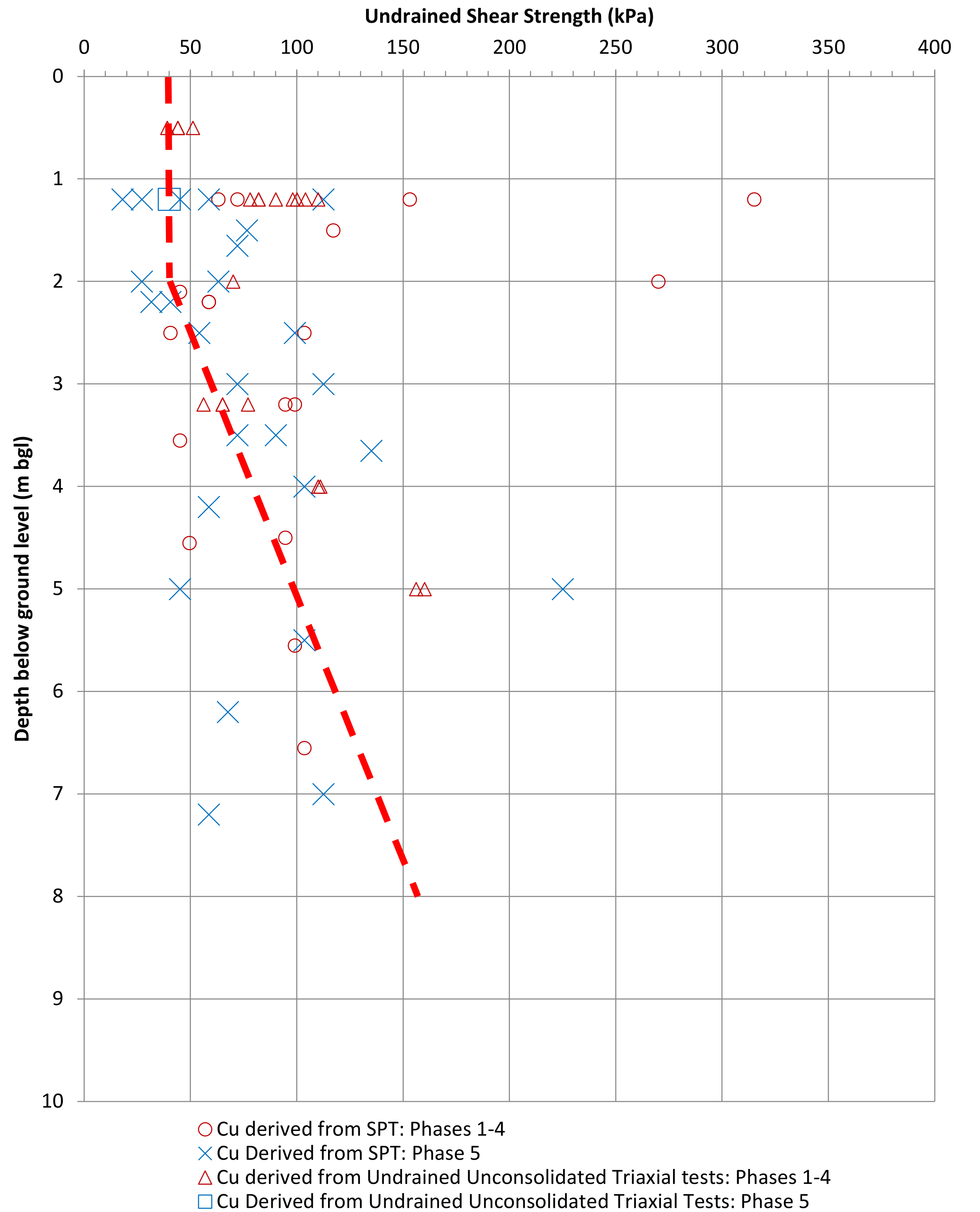
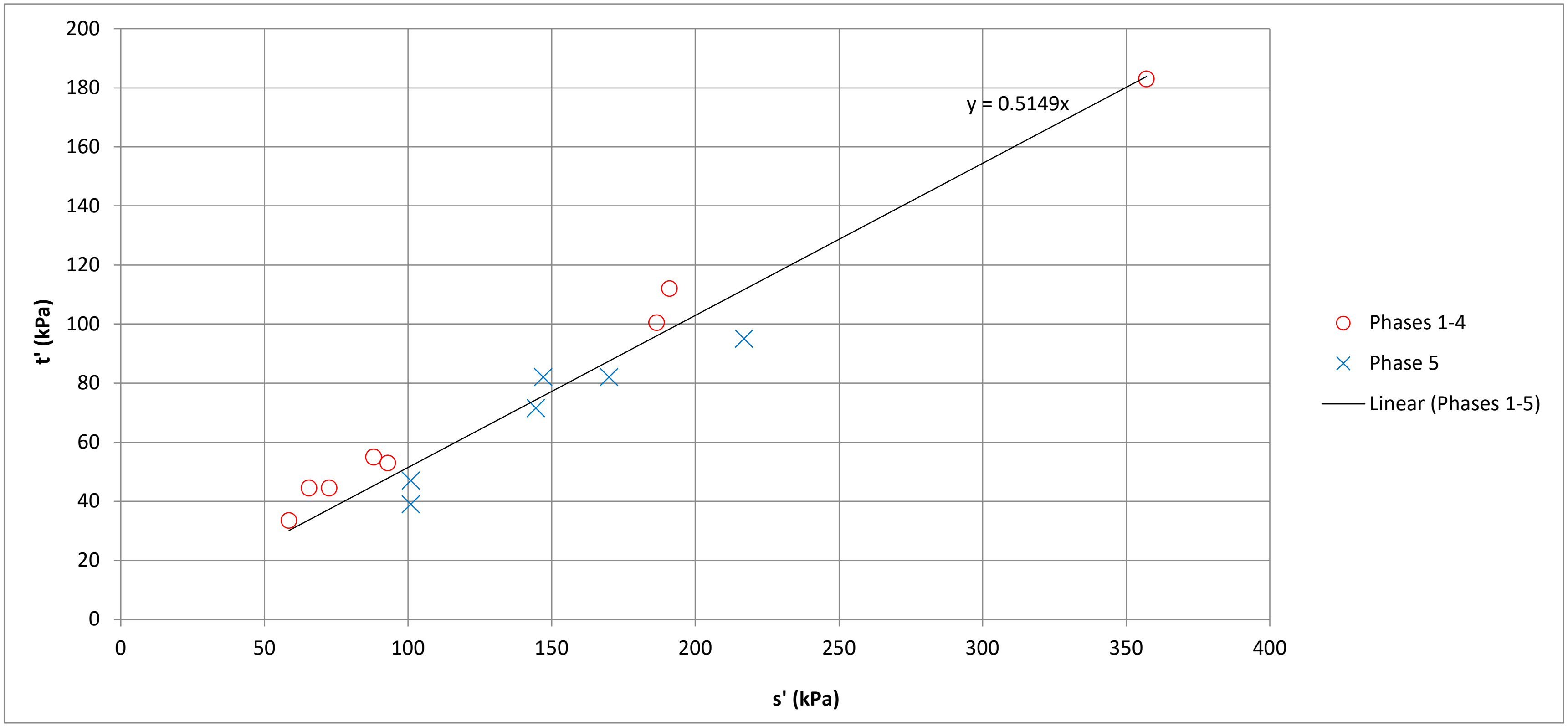
		Review: JJ Date: 4/1/22	
		Figure Number	Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client **Highways England**	Title **Undrained Shear Strength vs Depth for Glacial Till (Cohesive) - Section 3**		
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
		Figure Number		Rev P01



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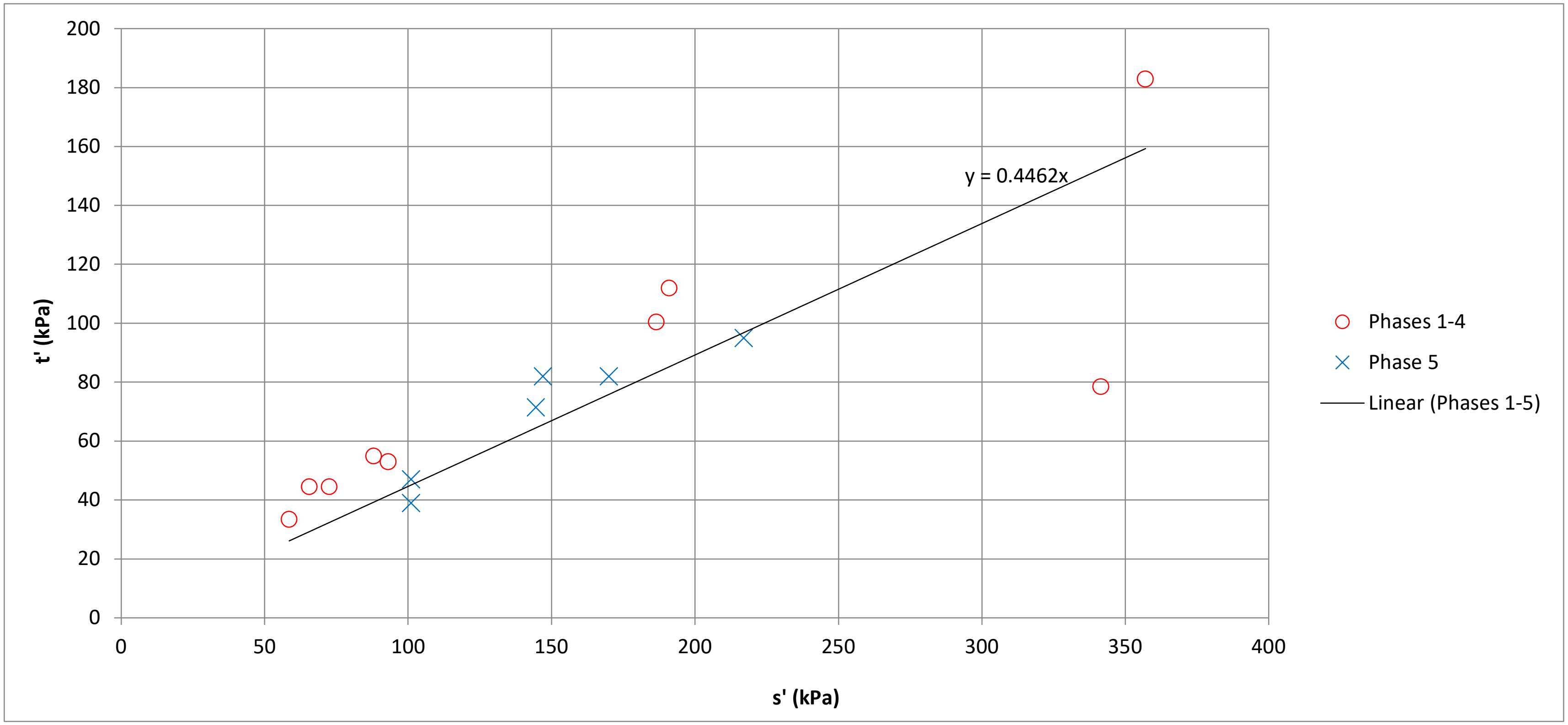
Triaxial-Derived Effective Strength for Glacial Till (Cohesive) - *Anomalous Results Removed* - Section 3

Project

A57 Trans Pennine Upgrade

Sheet size	Drawn	TB	Checked	GDS	Authorised	JJ	
A4	Date	10/09/2021	Date	04/01/2022	Date	04/01/2022	
Status	Figure Number					Rev	P01



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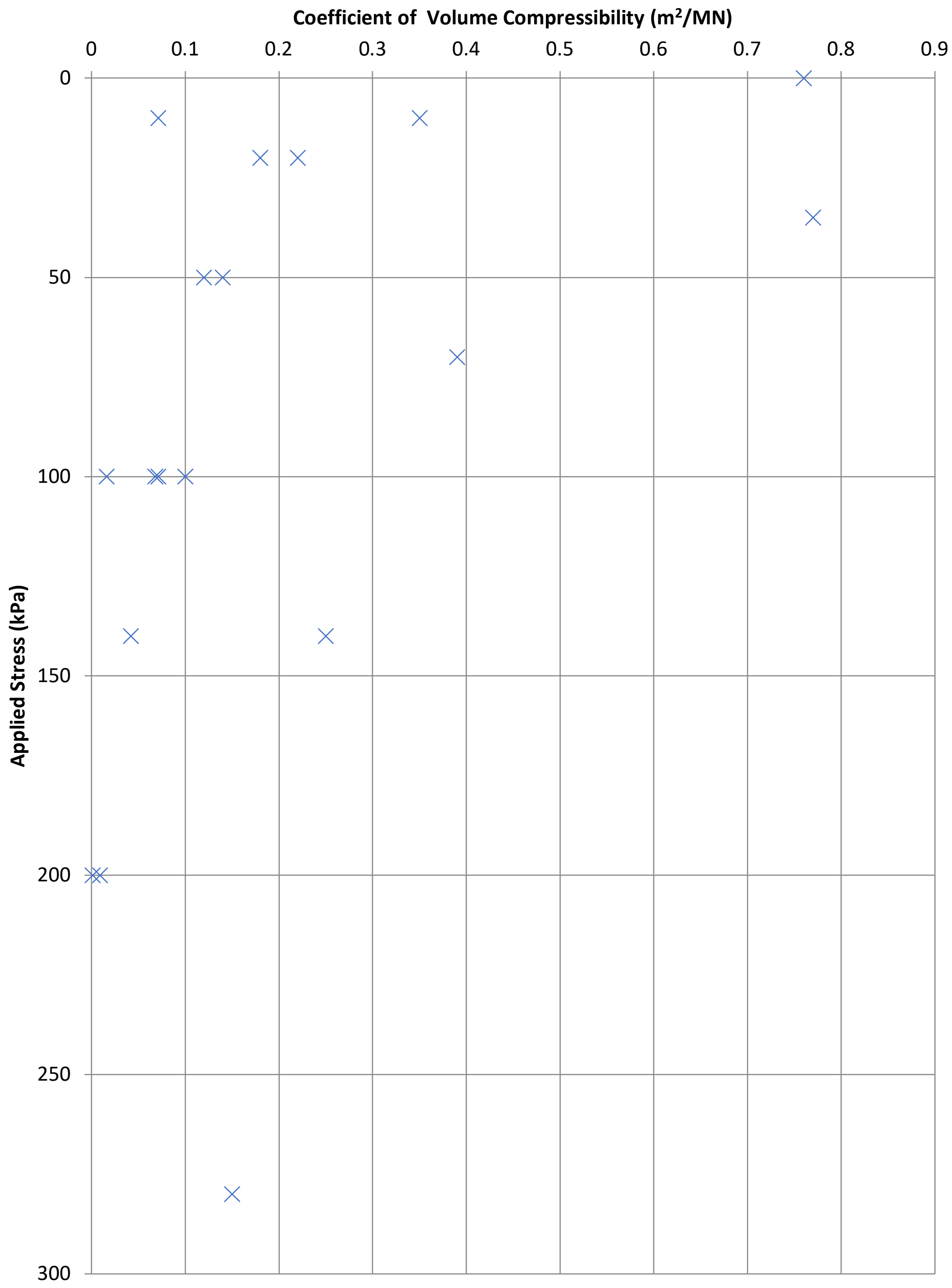
Triaxial-Derived Effective Strength for Glacial Till (Cohesive) - *All Results* - Section 3

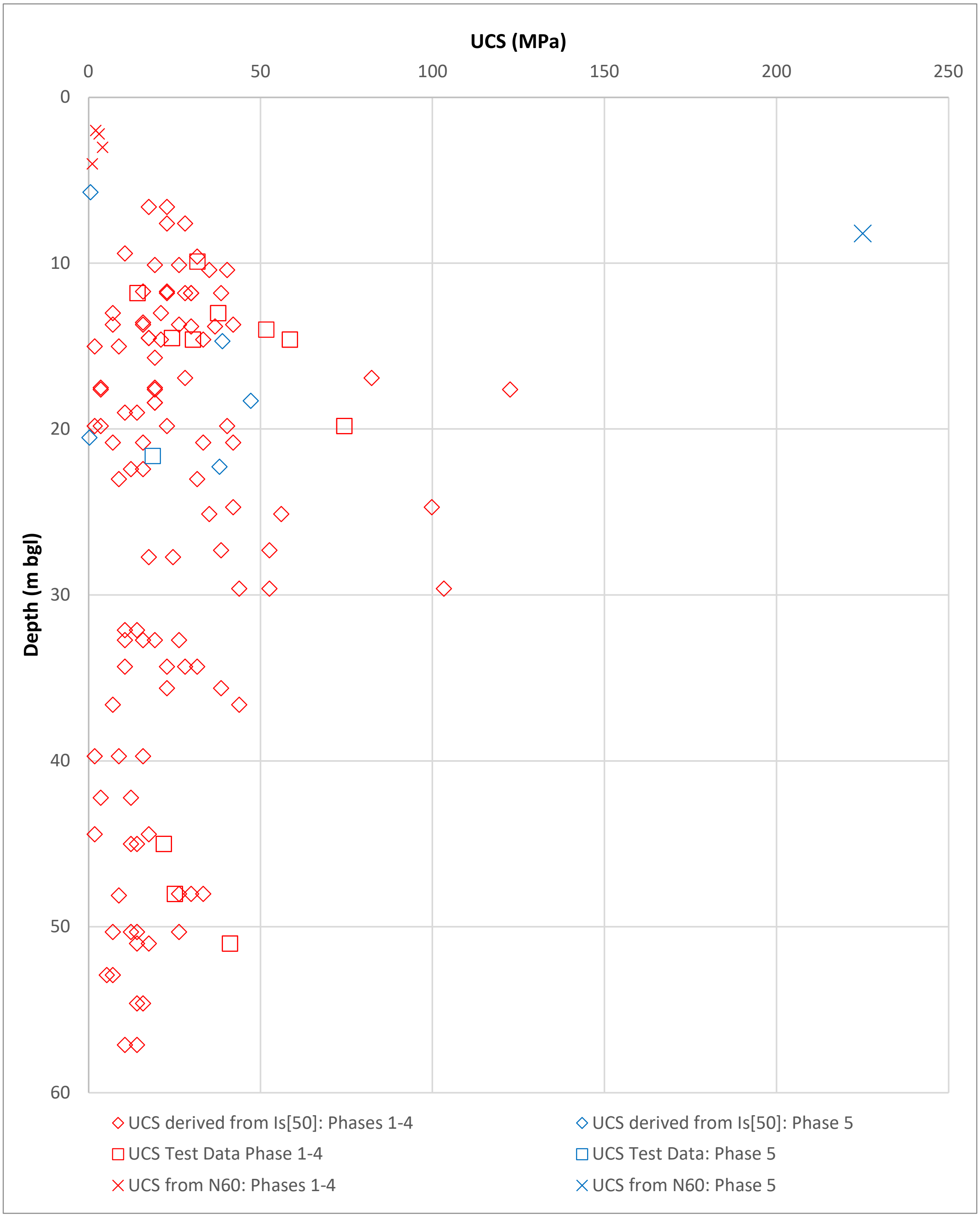
Project

A57 Trans Pennine Upgrade

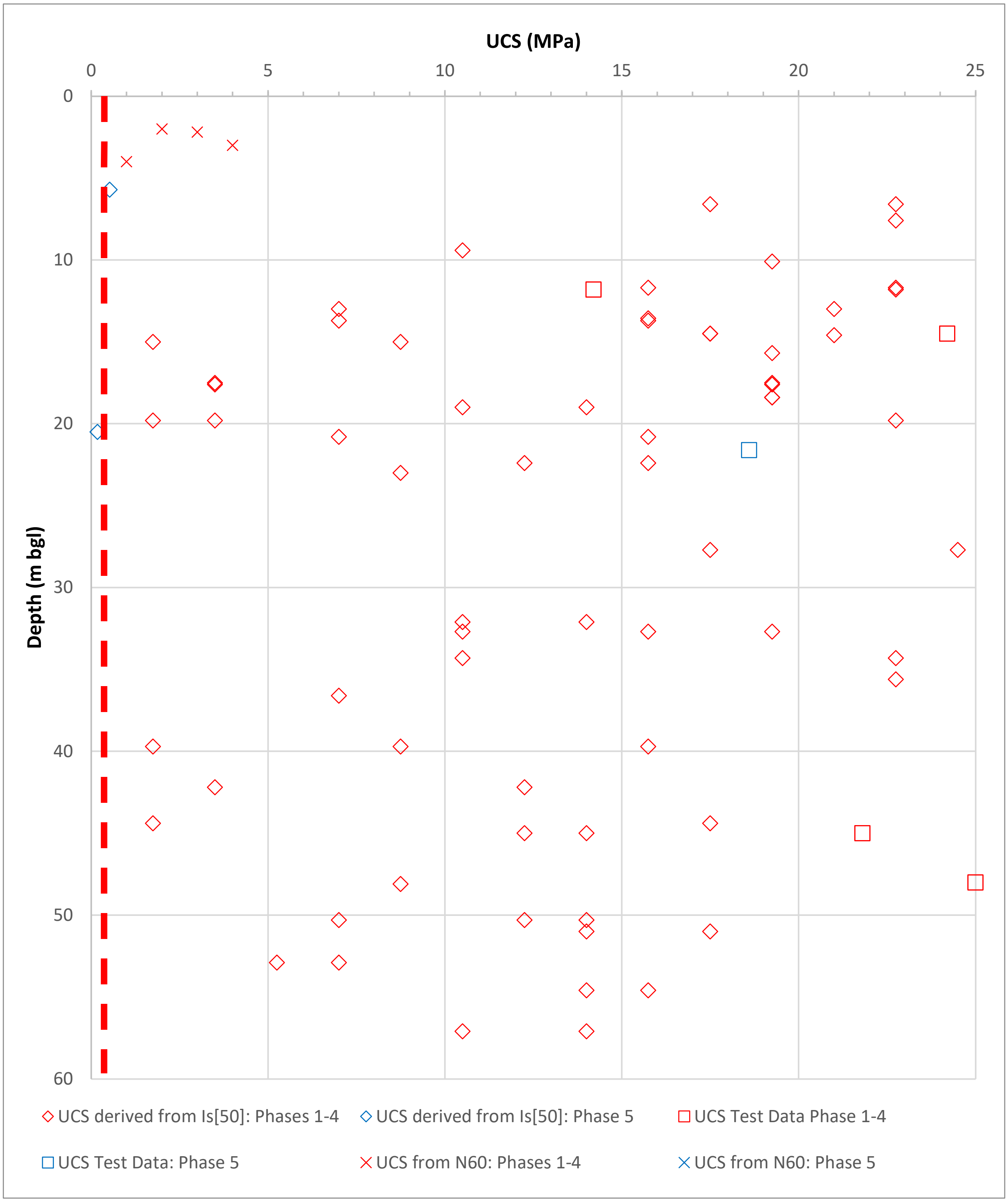
Sheet size	Drawn	TB	Checked	GDS	Authorised	JJ
A4	Date	10/09/2021	Date	04/01/2022	Date	04/01/2022
Status	Figure Number				Rev	P01



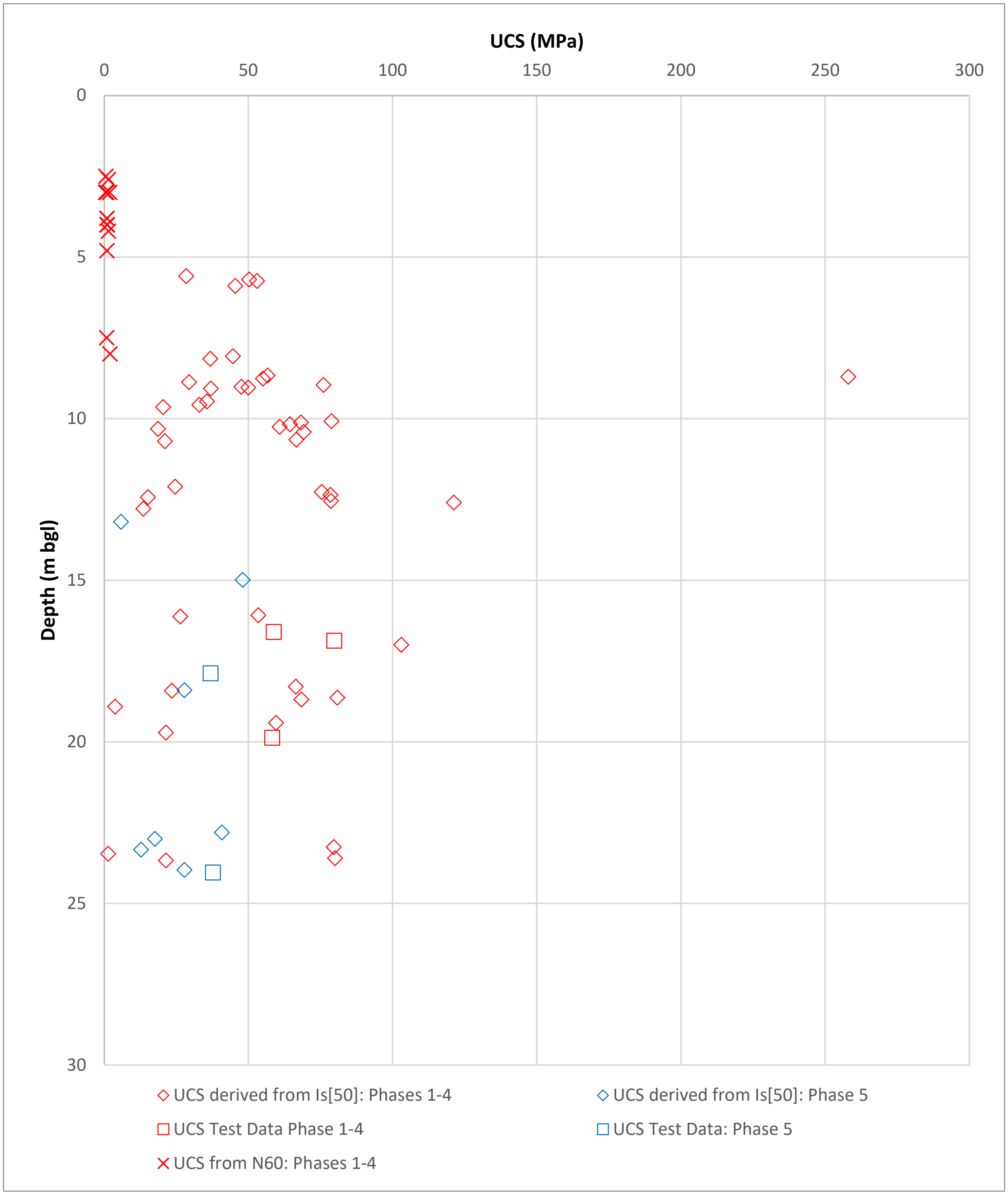
ATKINS Member of the SNC-Lavalin Group	Client **Highways England**	Title **Coefficient of Volume Compressibility vs Applied Stress for Glacial Till (Cohesive) - Section 3**	
Atkins Limited Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22
		Figure Number	Review: JJ Date: 4/1/22 Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client **Highways England**	Title **Uniaxial Compressive Strength vs Depth for Mudstone - Section 3**		
Chadwick House Birchwood Park	Project	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	**A57 Trans Pennine Upgrade**	Figure Number		Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client **Highways England**	Title **Uniaxial Compressive Strength vs Depth for Mudstone (UCS < 25MPa) - Section 3**		
Chadwick House Birchwood Park	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055		Figure Number		Rev P01



ATKINS Member of the SNC-Lavalin Group	Client		Title	
Atkins Limited	**Highways England**		**Uniaxial Compressive Strength vs Depth for Siltstone - Section 3**	
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
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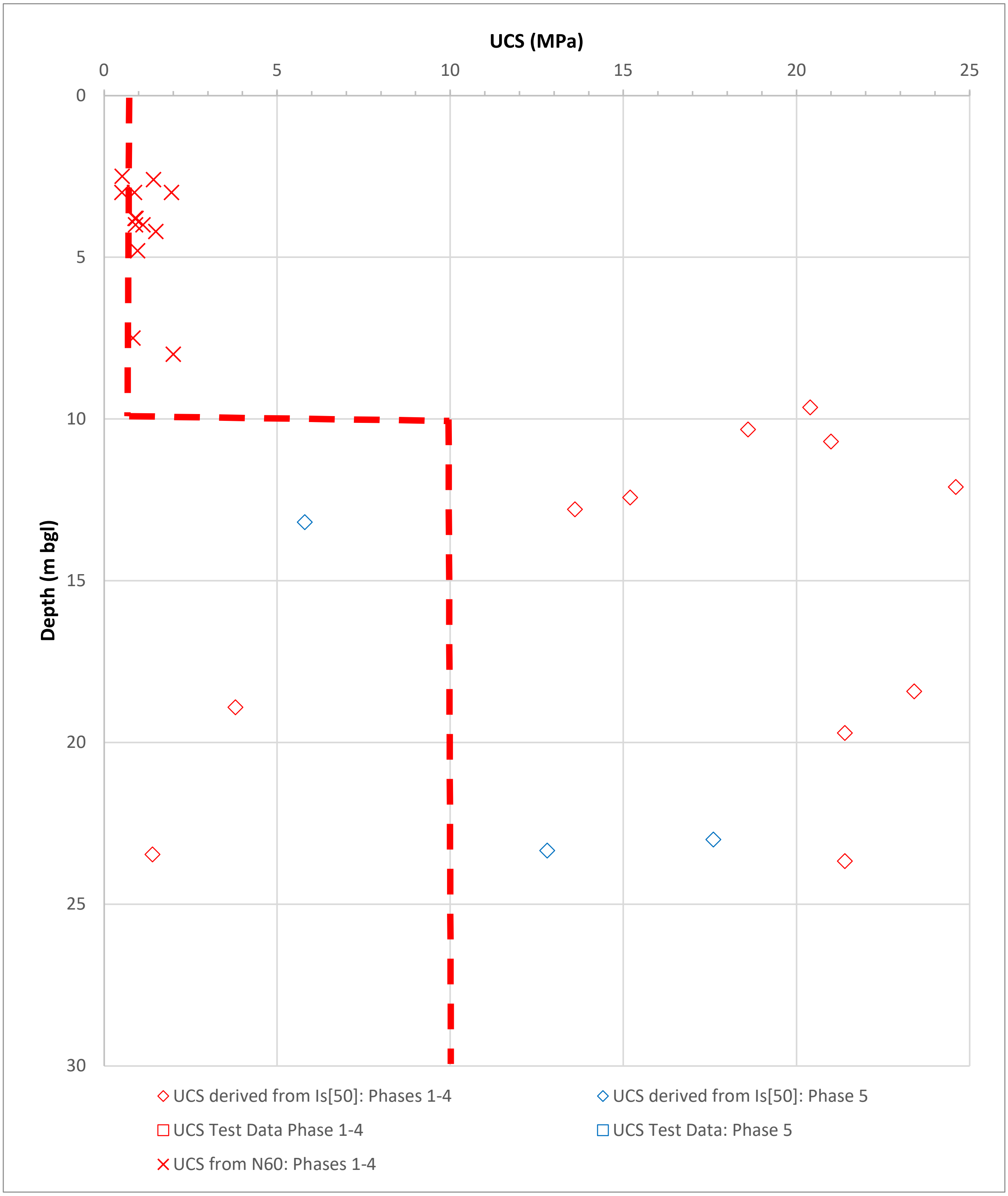

Member of the SNC-Lavalin Group **Atkins Limited** Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Client **Highways England**	Title **Uniaxial Compressive Strength vs Depth for Siltstone (UCS < 25MPa) - Section 3**	
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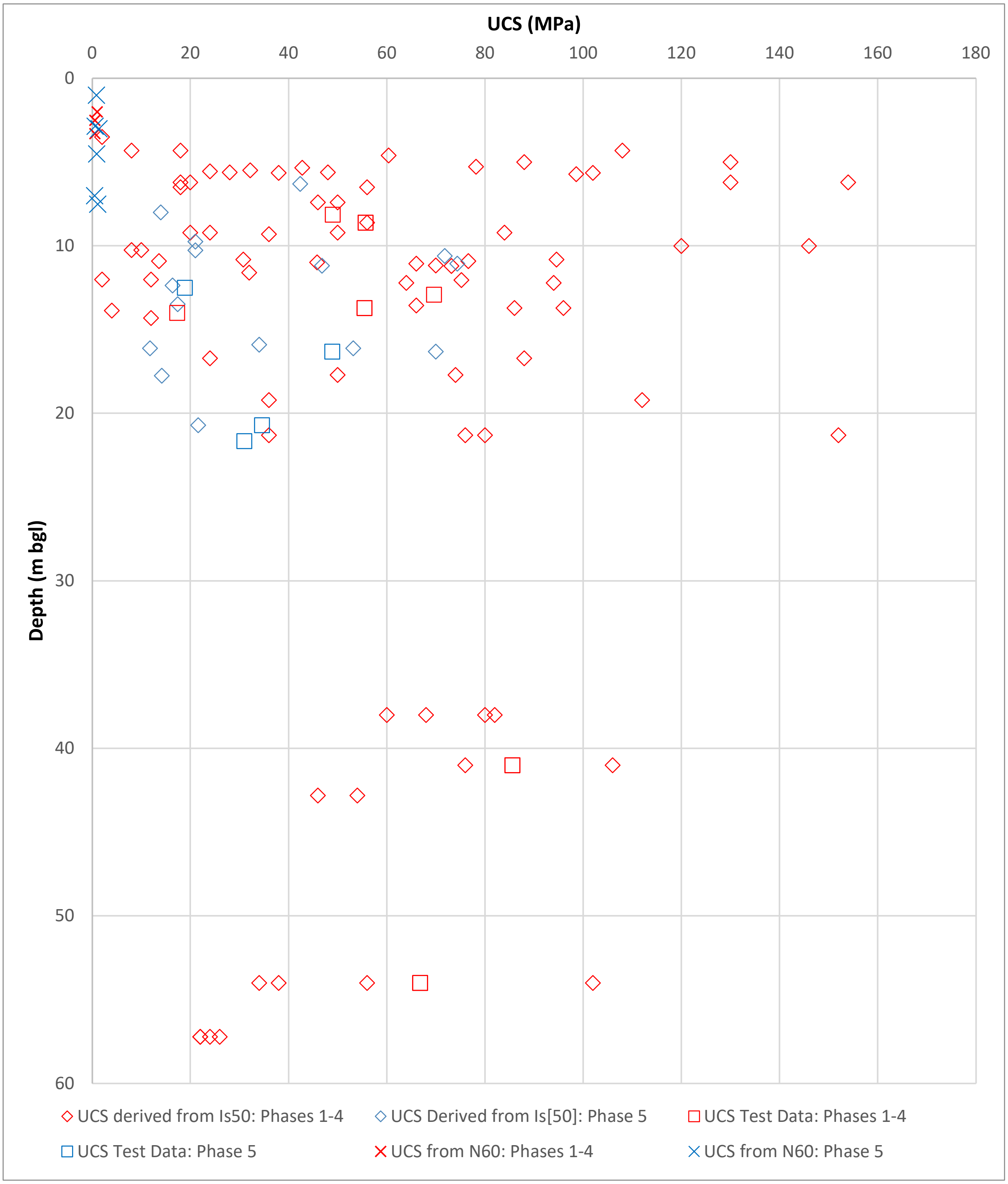
		Figure Number	Review: JJ Date: 4/1/22 Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited** Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Client **Highways England**	Title **Uniaxial Compressive Strength vs Depth for Sandstone - Section 3**
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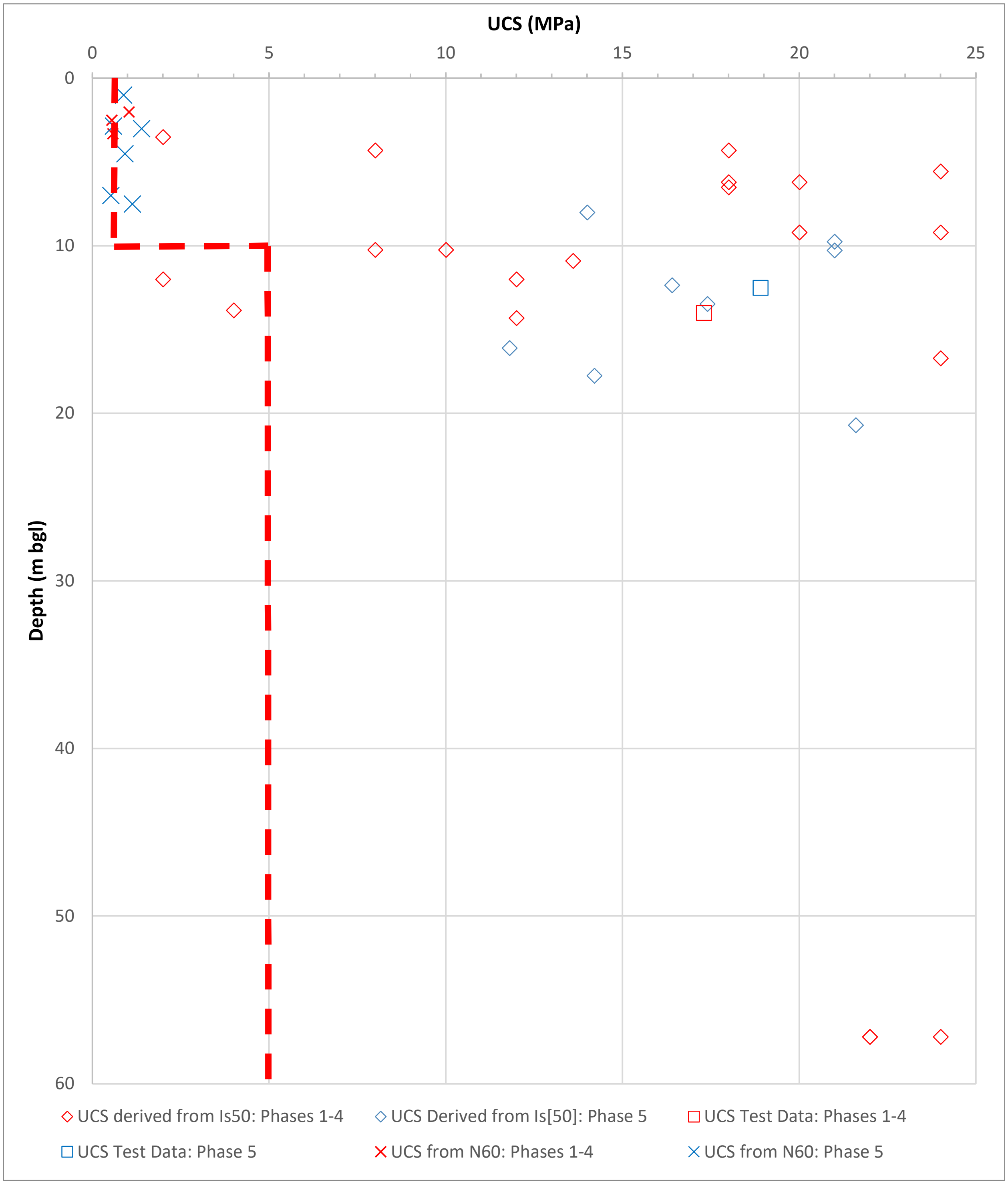

ATKINS Member of the SNC-Lavalin Group	Client **Highways England**	Title **Uniaxial Compressive Strength vs Depth for Sandstone (UCS < 25MPa) - Section 3**

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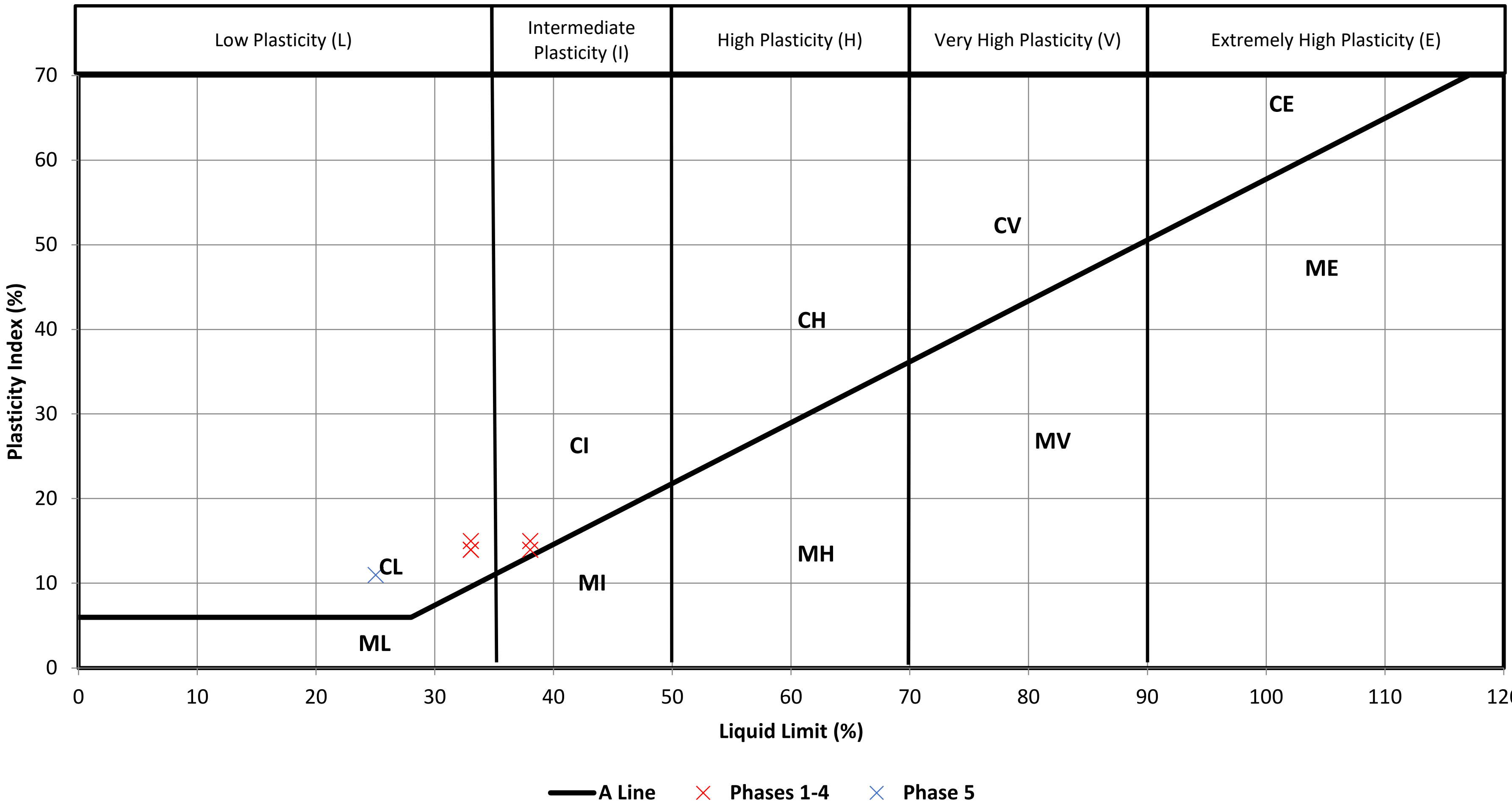
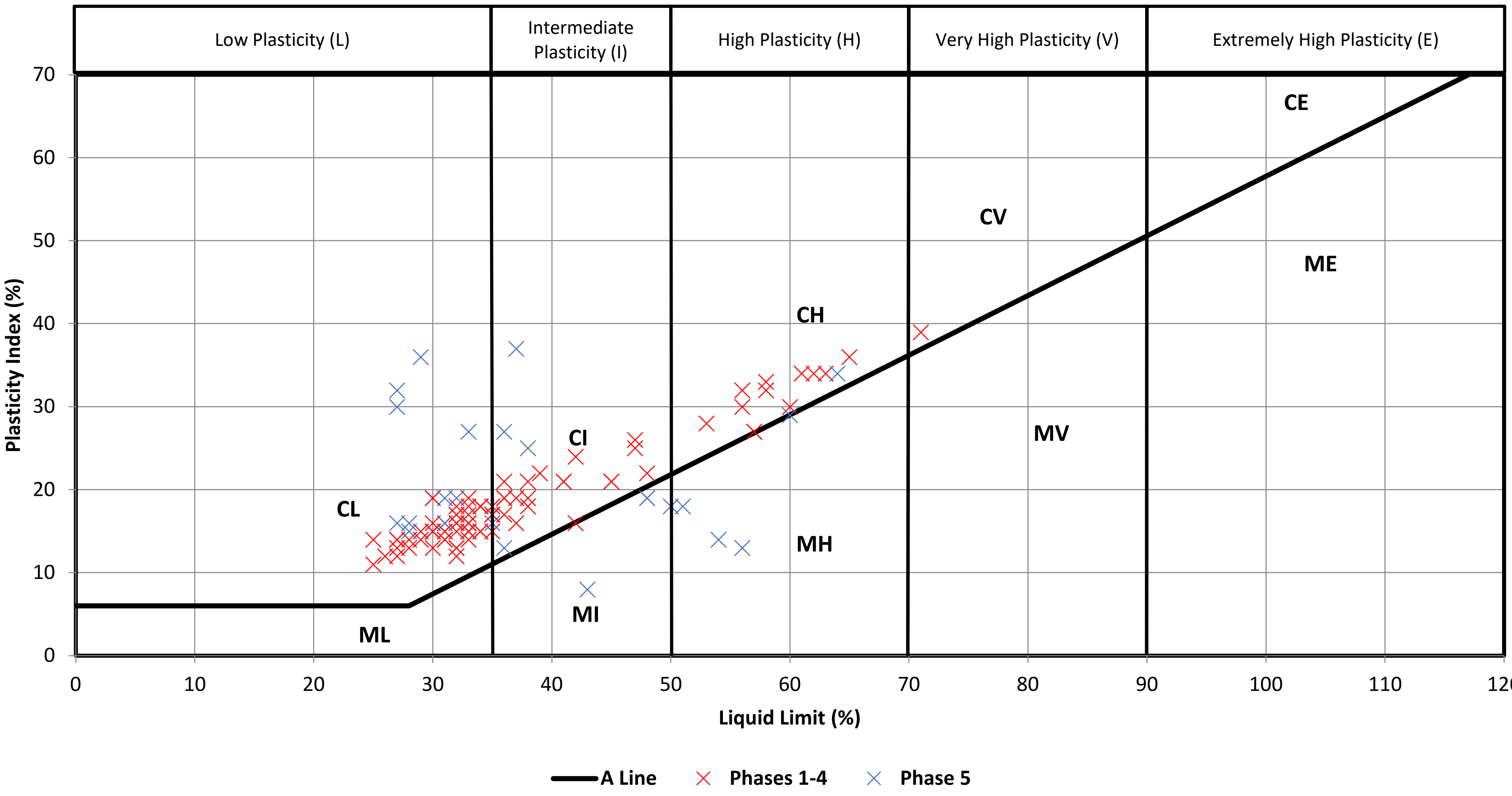
Project
A57 Trans Pennine Upgrade

Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
Figure Number		Rev P01

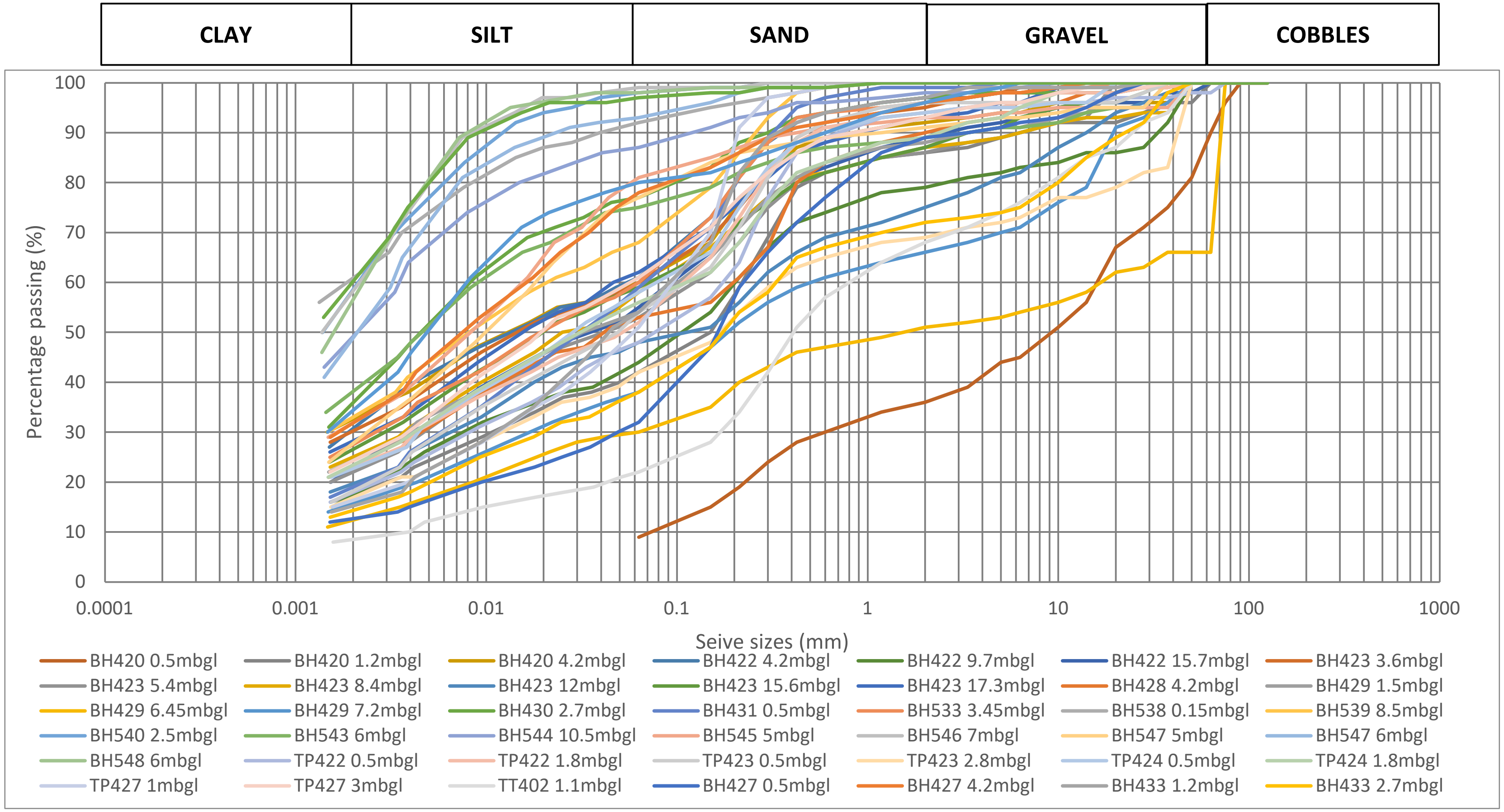
Section 4



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	**Highways England**	**A Line for Made Ground - Section 4**	
Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE Tel: +44 1925 238000 Fax: +44 1925 238500	Project **A57 Trans Pennine Upgrade**	Sheet size A4 / Drawn TB / Date 10/09/2021 / Checked GDS / Date 04/01/2022 / Authorised JJ / Date 04/01/2022	
		Status / Figure Number	Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	**Highways England**	**A Line for Cohesive Superficial Material - Section 4**						
Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE Tel: +44 1925 238000 Fax: +44 1925 238500	Project **A57 Trans Pennine Upgrade**	Sheet size A4	Drawn TB Date 04/03/2022		Checked GDS Date 11/03/2022		Authorised MG Date 14/03/2022	
		Status	Figure Number				Rev P01	



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Particle Size Distribution for Cohesive Superficial Material - Section 4

Project

A57 Trans Pennine Upgrade

Sheet size	Drawn TB	Checked GDS	Authorised MG
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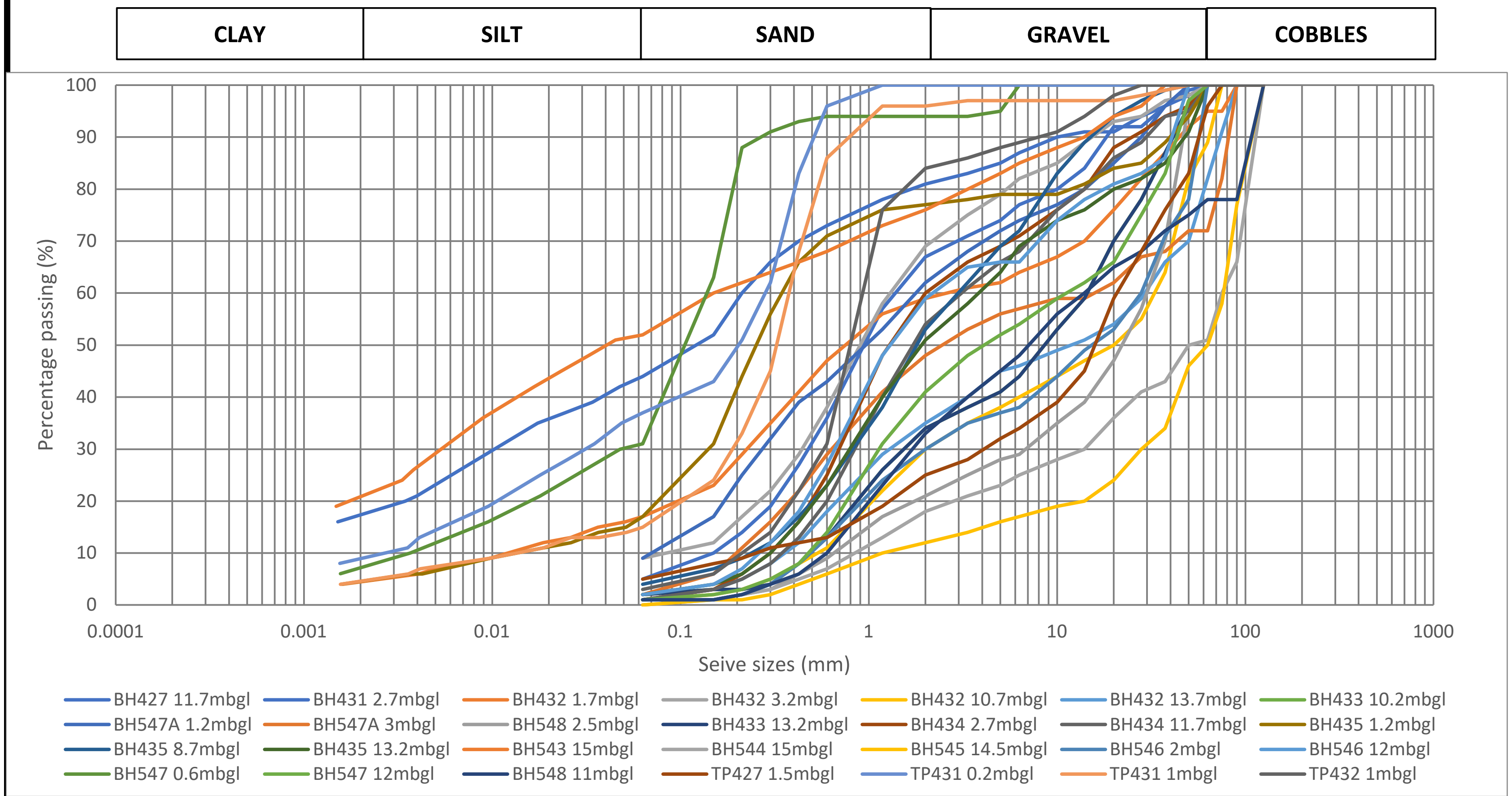
Status	Figure Number		Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited** Atkins, Chadwick House, Birchwood Park, Warrington, WA3 6AE Tel: +44 1925 238000 Fax: +44 1925 238500	**Highways England** Project **A57 Trans Pennine Upgrade**	**Particle Size Distribution Granular Superficial Material - Section 4**

Sheet size	Drawn	TB	Checked	GDS	Authorised	MG
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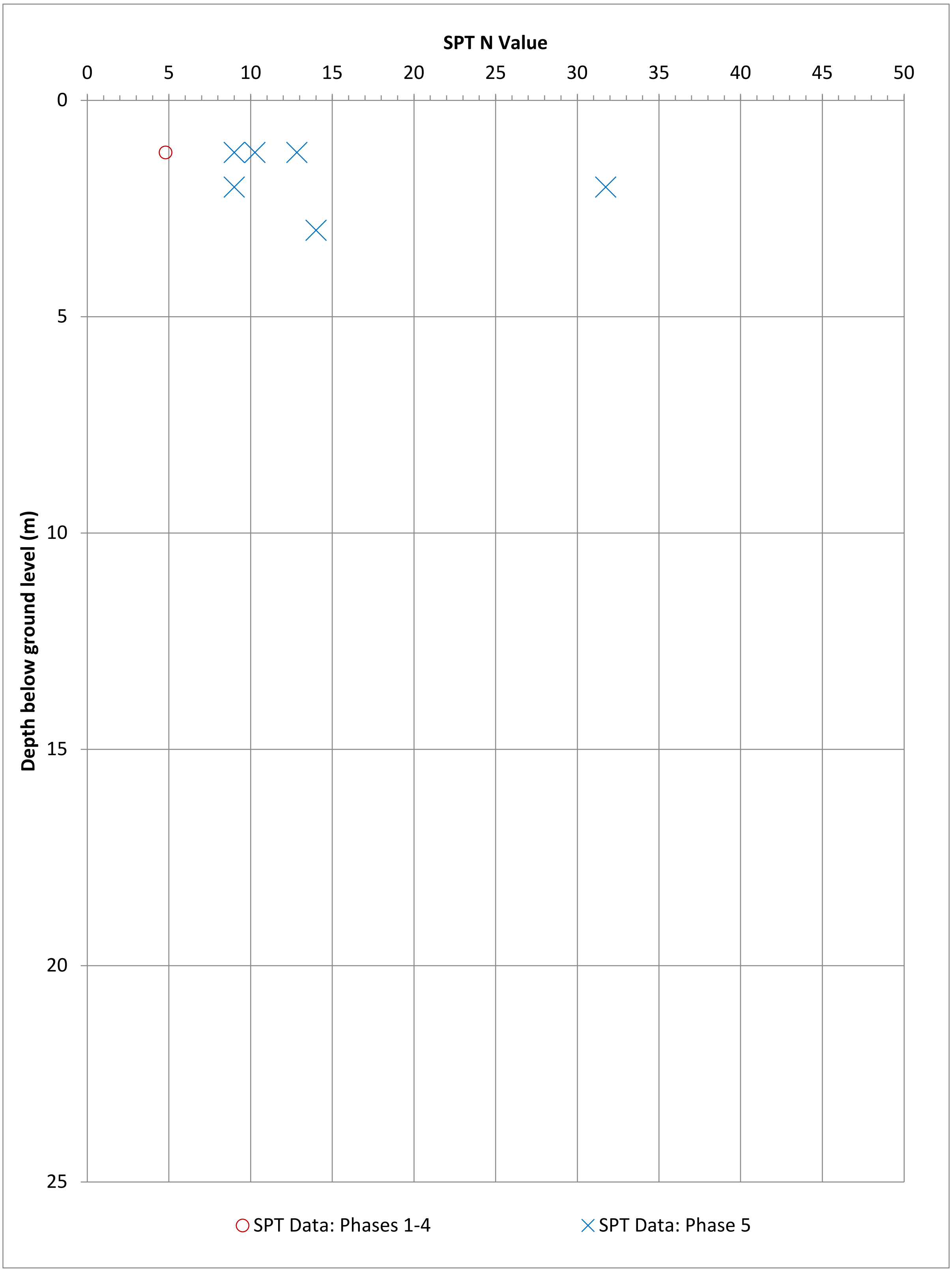
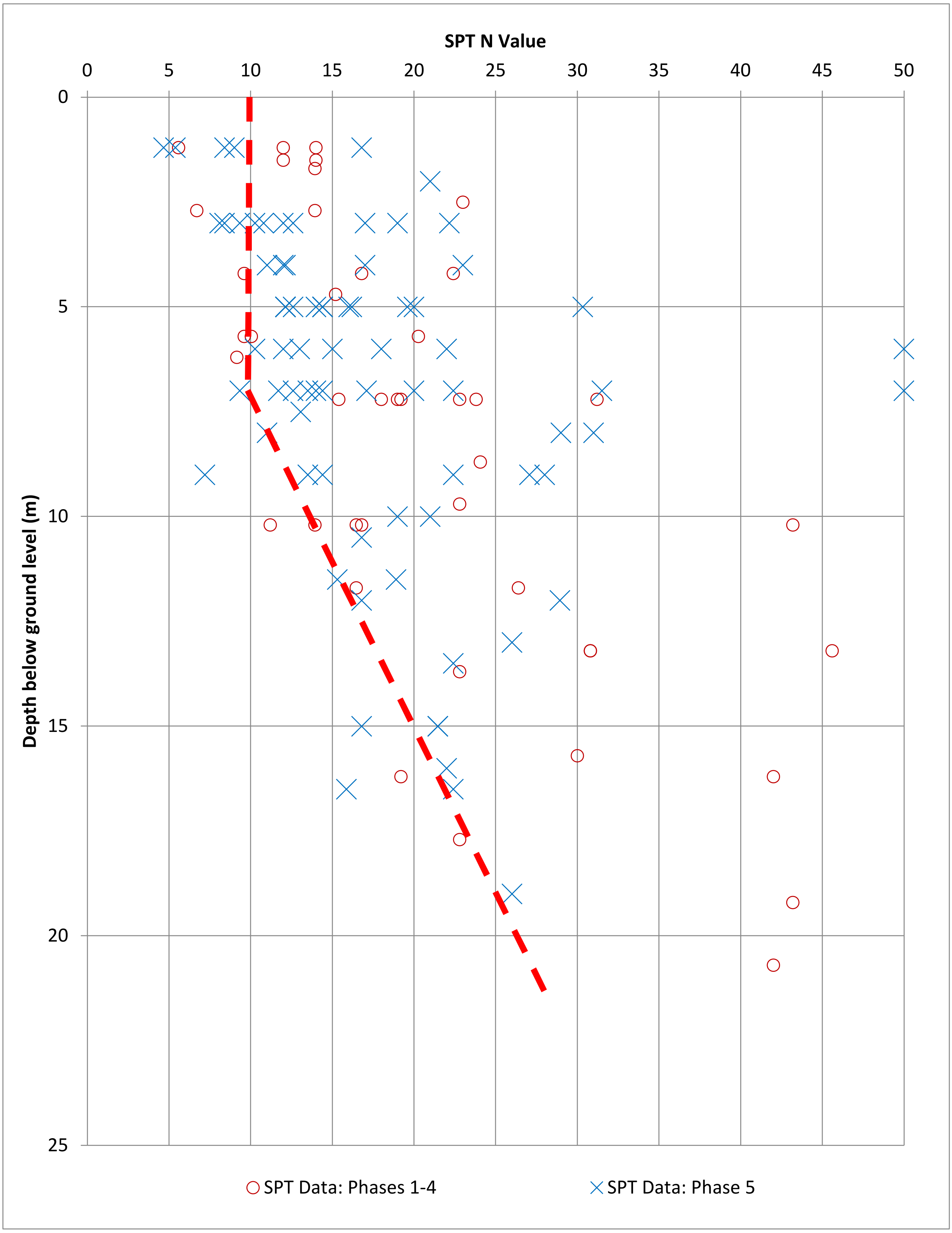
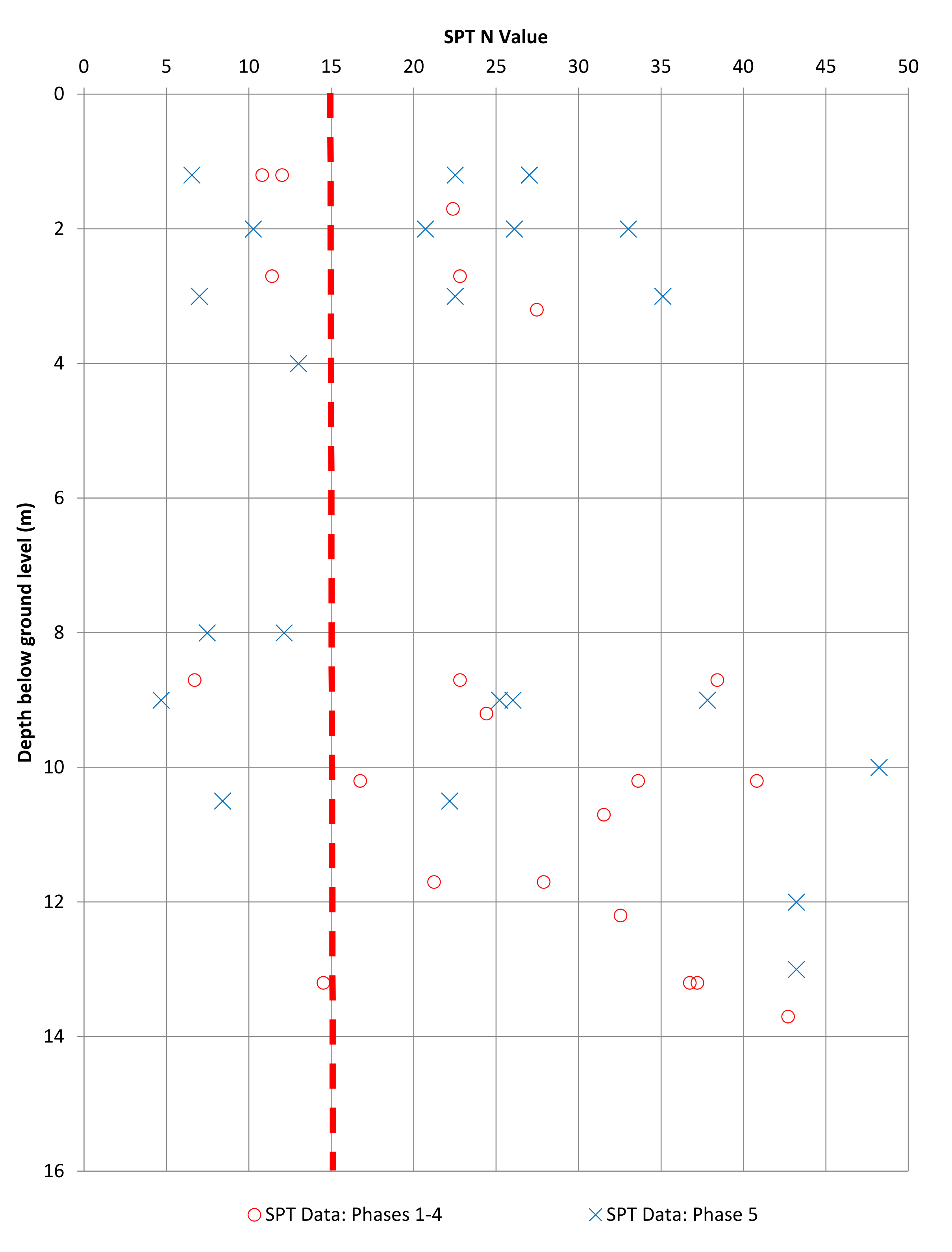
Status	Figure Number				Rev	P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client **Highways England**	Title **SPT N60 vs Depth for Made Ground - Section 4**		
Chadwick House Birchwood Park	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055		Figure Number		Rev P01



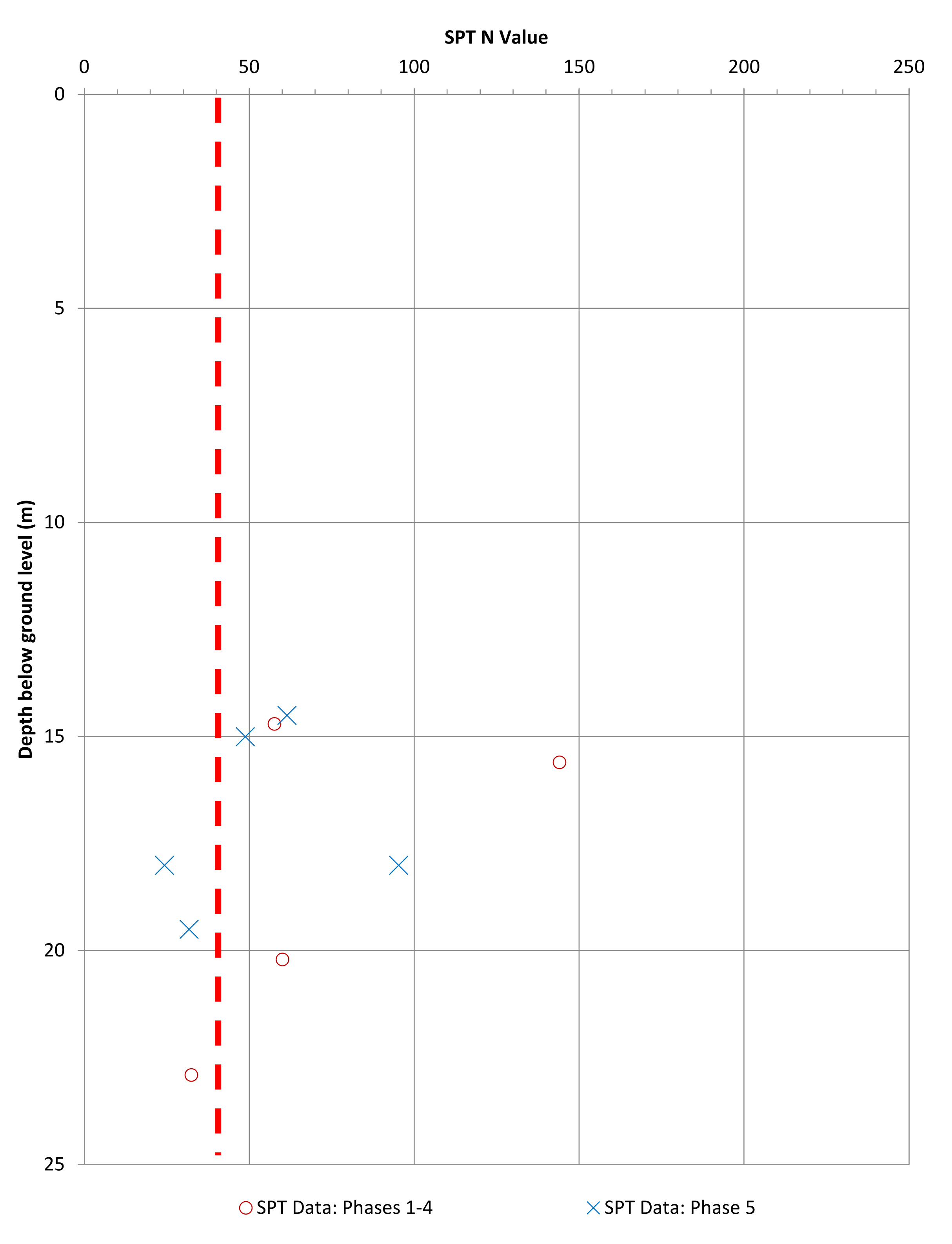
ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client **Highways England**	Title **SPT N60 vs Depth for Superficial Cohesive Material- Section 4**		
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 4/3/22	Check: GDS Date: 11/3/22	Review: MG Date: 14/3/22
		Figure Number		Rev P01



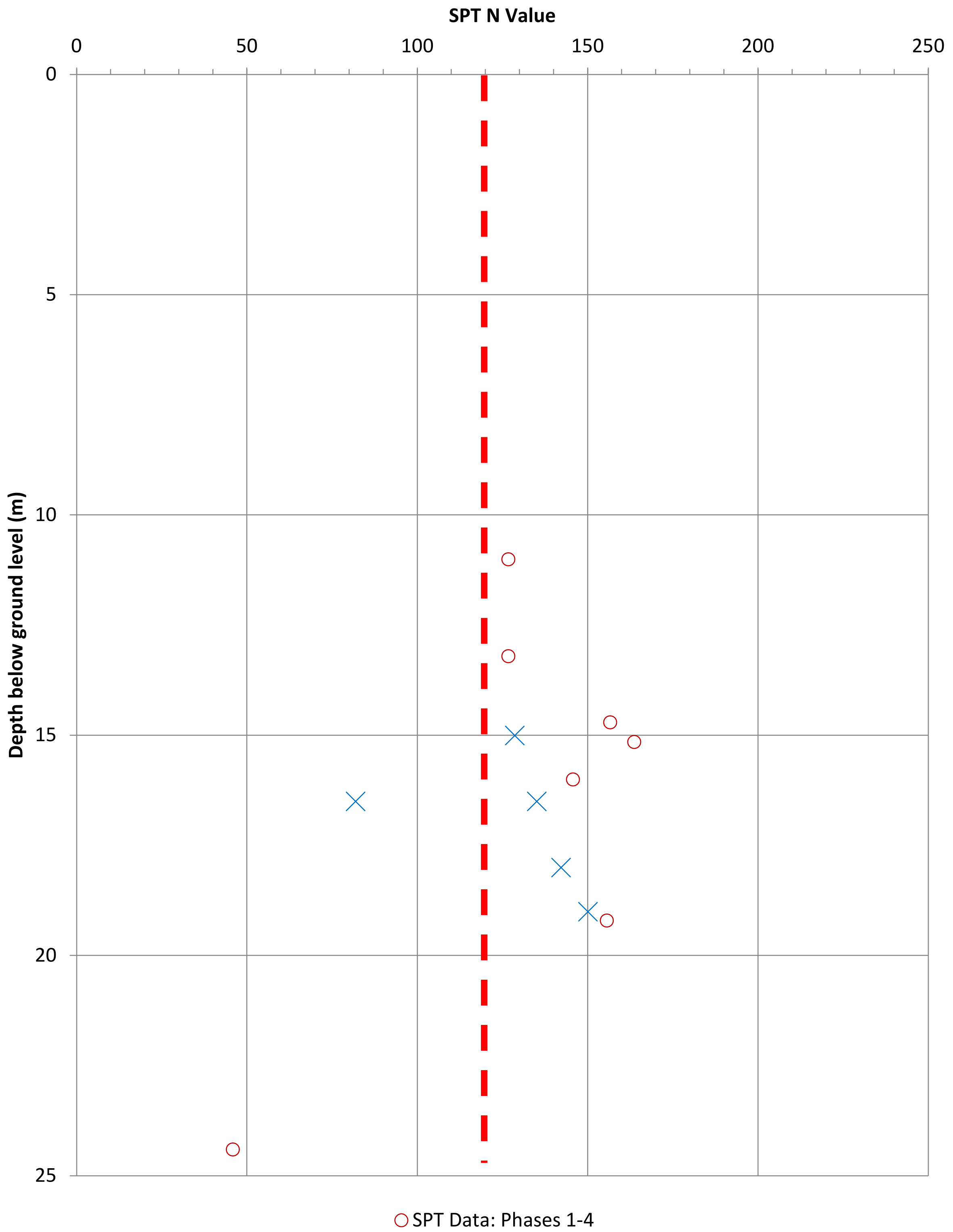
ATKINS Member of the SNC-Lavalin Group	Client	Title
Atkins Limited	**Highways England**	**SPT N60 vs Depth for Superficial Granular Material - Section 4**

Chadwick House
Birchwood Park
Warrington Tel: (01372) 726140
WA3 6AE Fax: (01372) 740055

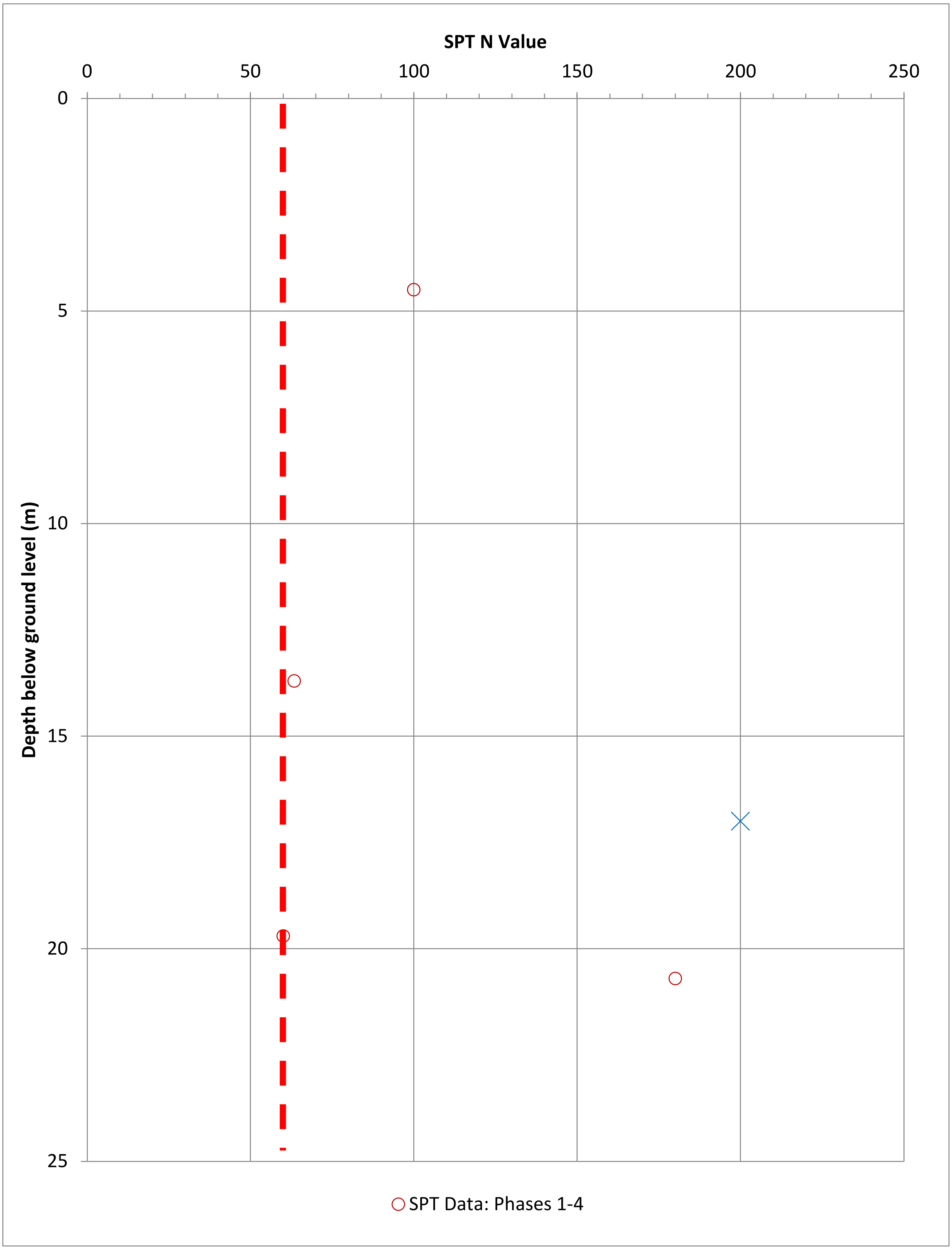
Project	Drawn: TB	Check: GDS	Review: MG
A57 Trans Pennine Upgrade	Date: 4/3/22	Date: 11/3/22	Date: 14/3/22
	Figure Number		Rev P01



ATKINS Member of the SNC-Lavalin Group	Client **Highways England**	Title **SPT N60 vs Depth for Mudstone - Section 4**
Atkins Limited Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21 Check: GDS Date: 4/1/22 Review: JJ Date: 4/1/22 Figure Number Rev P01

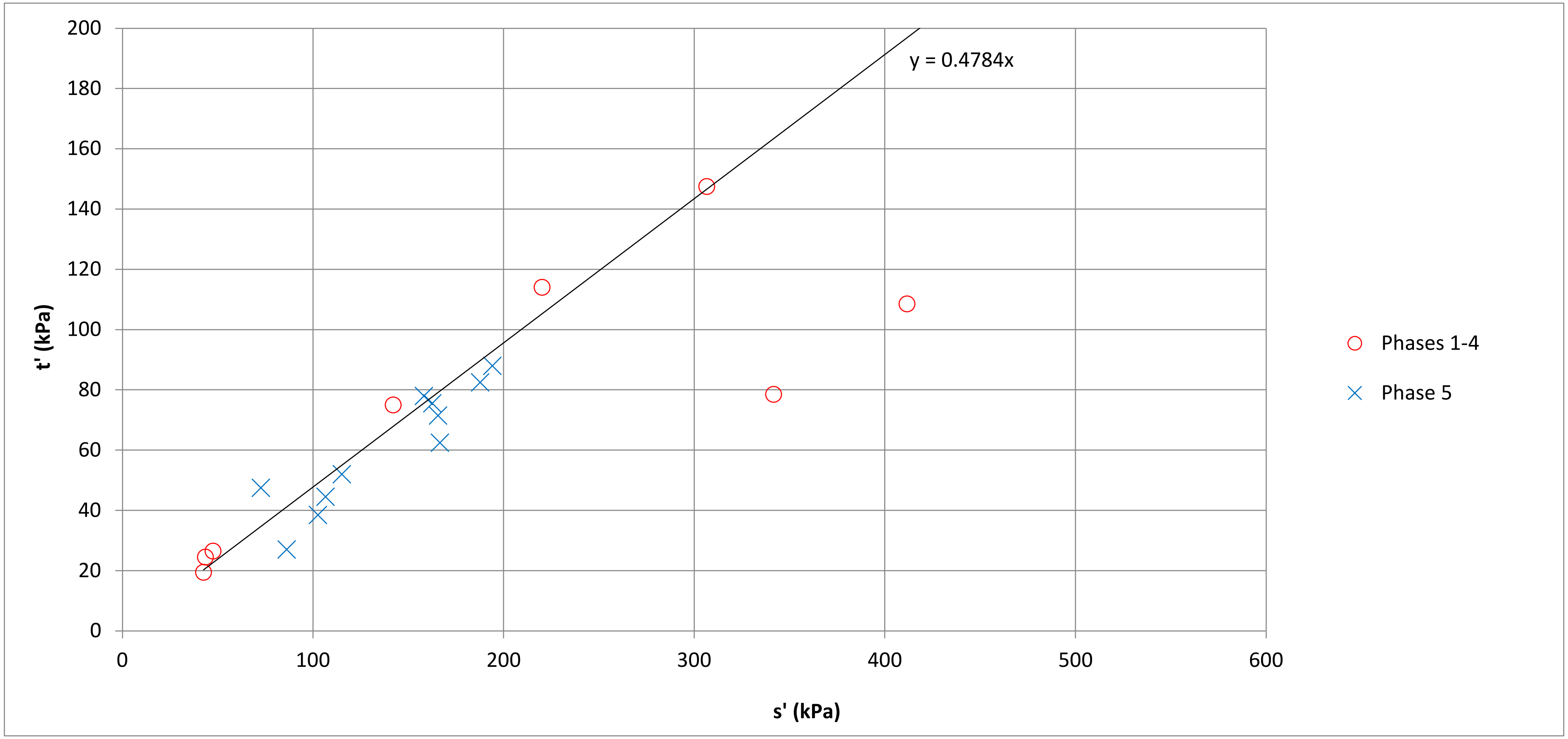


ATKINS Member of the SNC-Lavalin Group	Client	Title
Atkins Limited	**Highways England**	**SPT N60 vs Depth for Siltstone - Section 4**
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21 | Check: GDS Date: 4/1/22 | Review: JJ Date: 4/1/22 Figure Number | Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client **Highways England**	Title **SPT N60 vs Depth for Sandstone - Section 4**		
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
		Figure Number		Rev P01

ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client **Highways England**	Title **Undrained Shear Strength vs Depth for Cohesive Superficial Material - Section 4**
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 4/3/22 | Check: GDS Date: 11/3/22 | Review: MG Date: 14/3/22 Figure Number | Rev P01



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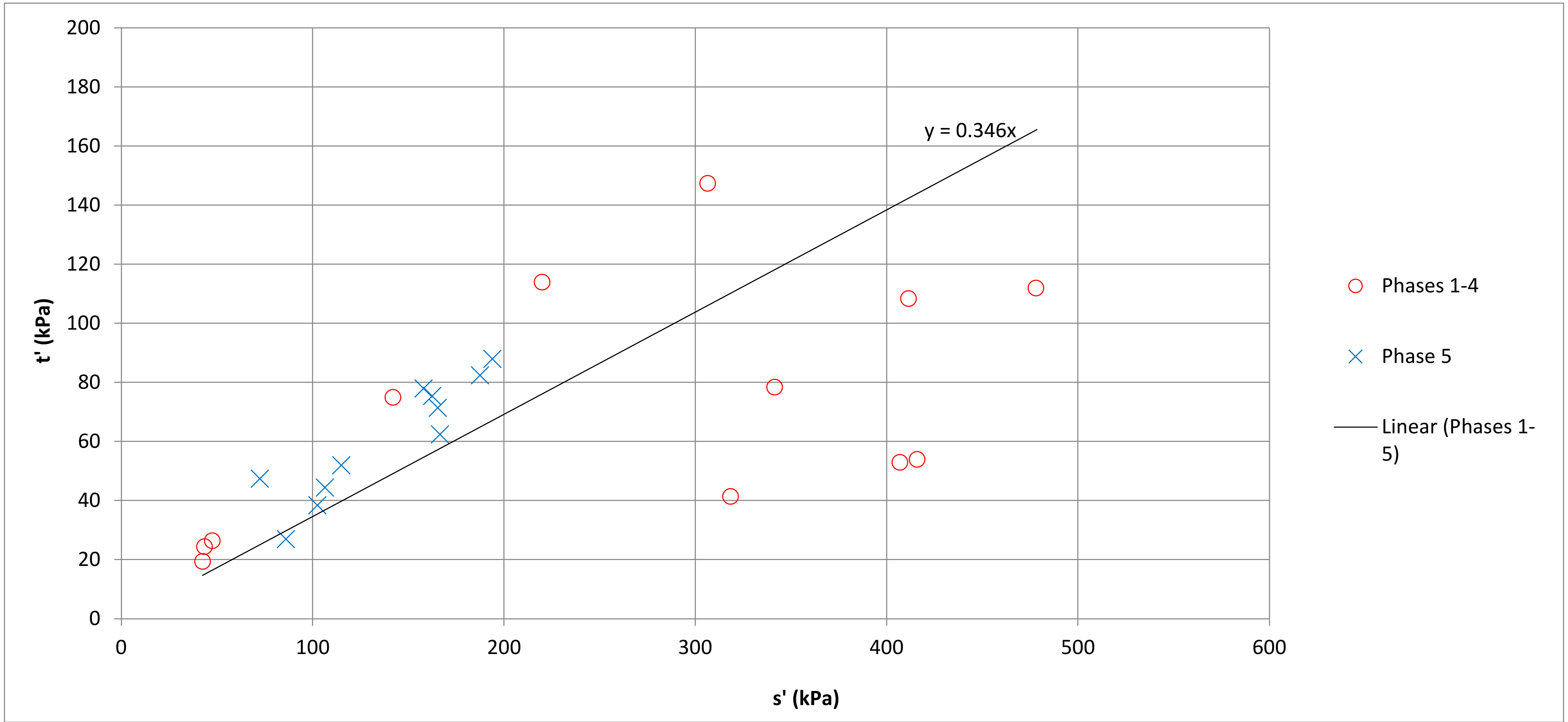
Triaxial-Derived Effective Strength for Cohesive Superficial Material - *Anomalous Results Removed* - Section 4

Project

A57 Trans Pennine Upgrade

Sheet size	Drawn	TB	Checked	GDS	Authorised	MG
A4	Date	04/03/2022	Date	11/03/2022	Date	14/03/2022
Status	Figure Number				Rev	P01



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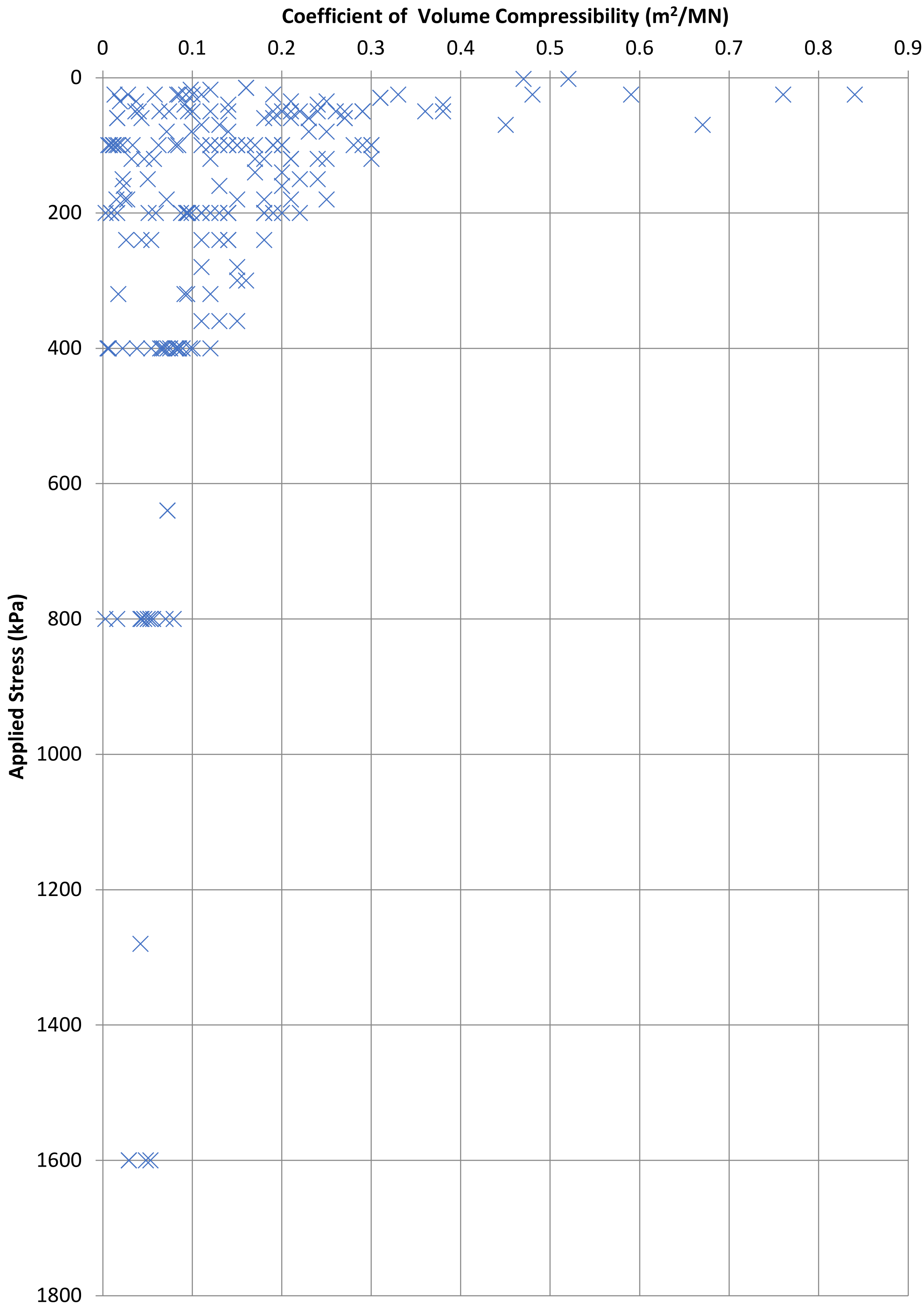
Highways England

Triaxial-Derived Effective Strength for Cohesive Superficial Material - *All Results* - Section 4

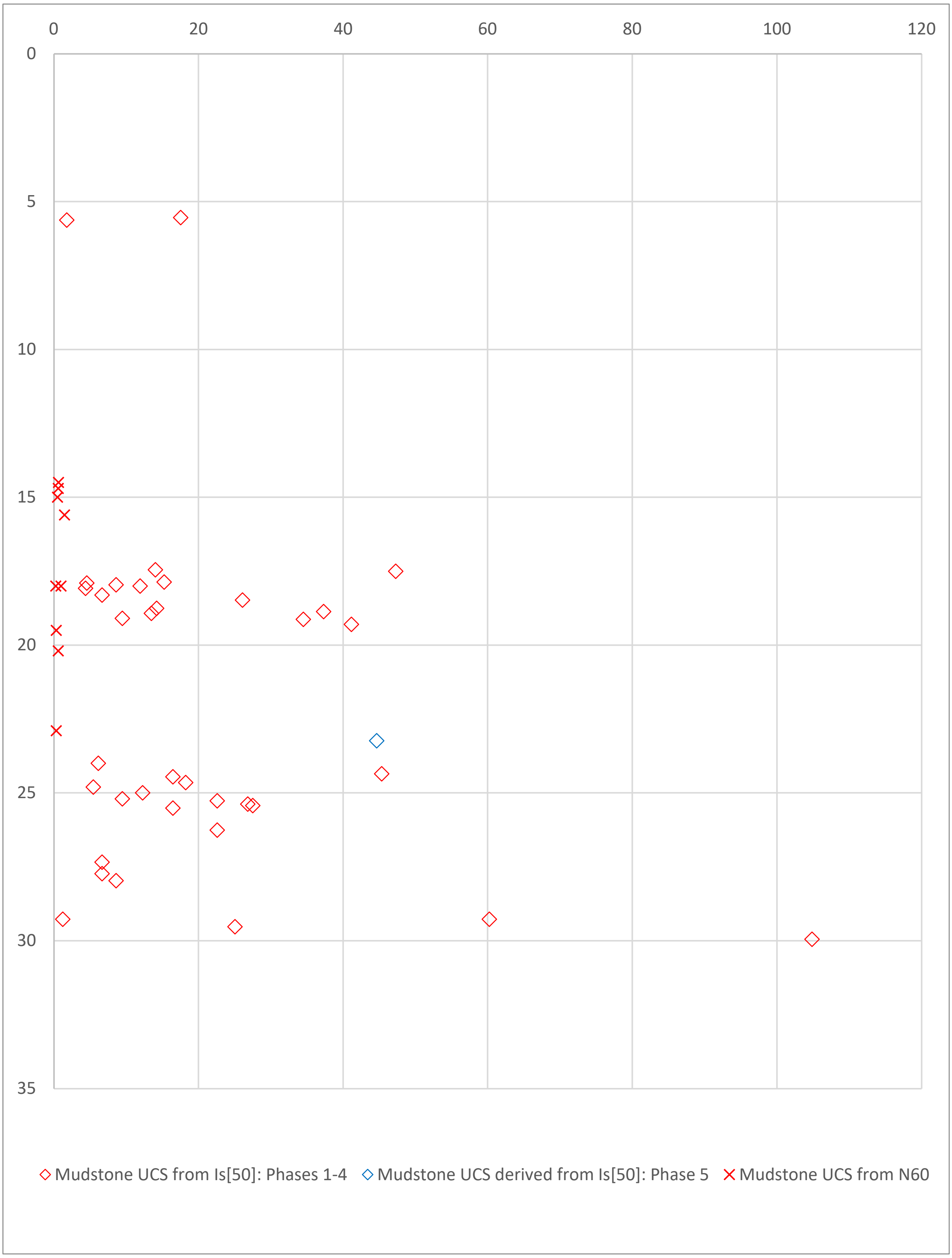
Project

A57 Trans Pennine Upgrade

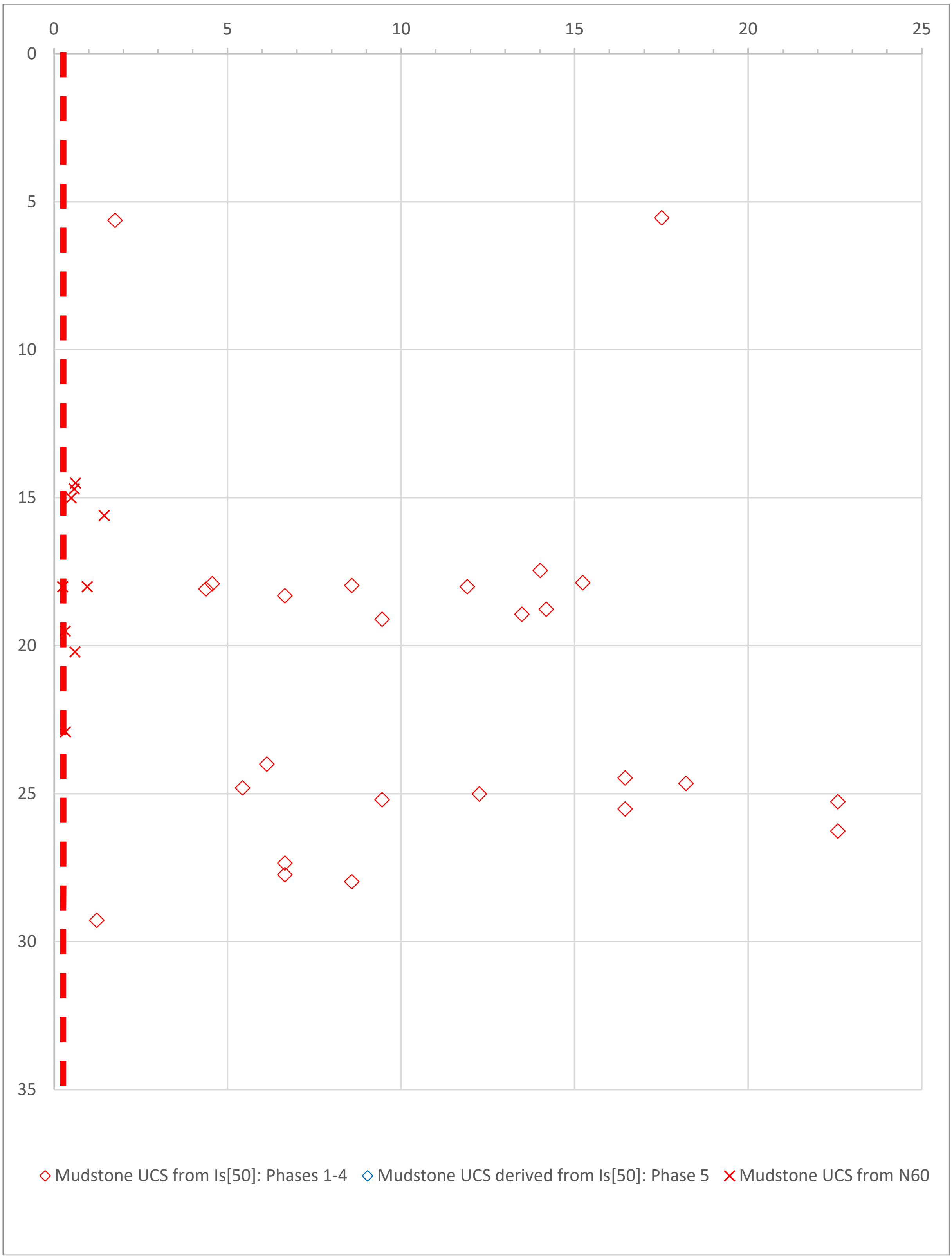
Sheet size	Drawn	TB	Checked	GDS	Authorised	MG
A4	Date	04/03/2022	Date	11/03/2022	Date	14/03/2022
Status	Figure Number				Rev	P01



Atkins Limited Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Client **Highways England**	Title **Coefficient of Volume Compressibility vs Applied Stress for Cohesive Superficial Material - Section 4**
	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 4/3/22 · Check: GDS Date: 11/3/22 · Review: MG Date: 14/3/22 Figure Number · Rev P01



ATKINS Member of the SNC-Lavalin Group	Client	Title
Atkins Limited	**Highways England**	**Uniaxial Compressive Strength vs Depth for Mudstone - Section 4**
Chadwick House	Project	Drawn: TB / Date: 10/9/21 — Check: GDS / Date: 4/1/22 — Review: JJ / Date: 4/1/22
Birchwood Park	**A57 Trans Pennine Upgrade**	Figure Number
Warrington Tel: (01372) 726140		Rev
WA3 6AE Fax: (01372) 740055		P01



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Warrington Tel: (01372) 726140
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Client

Highways England

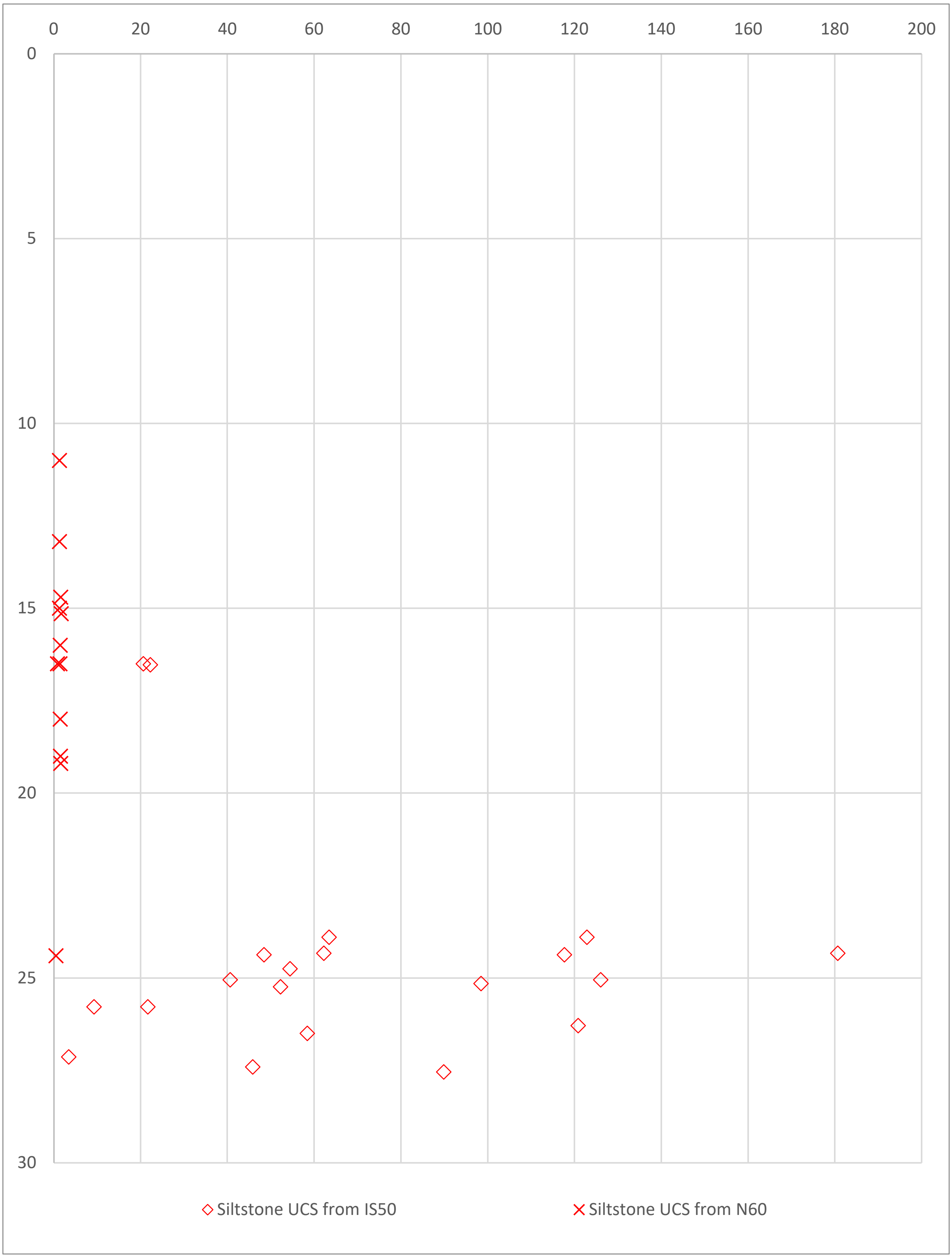
Title

Uniaxial Compressive Strength vs Depth for Mudstone (UCS < 25MPa) - Section 4

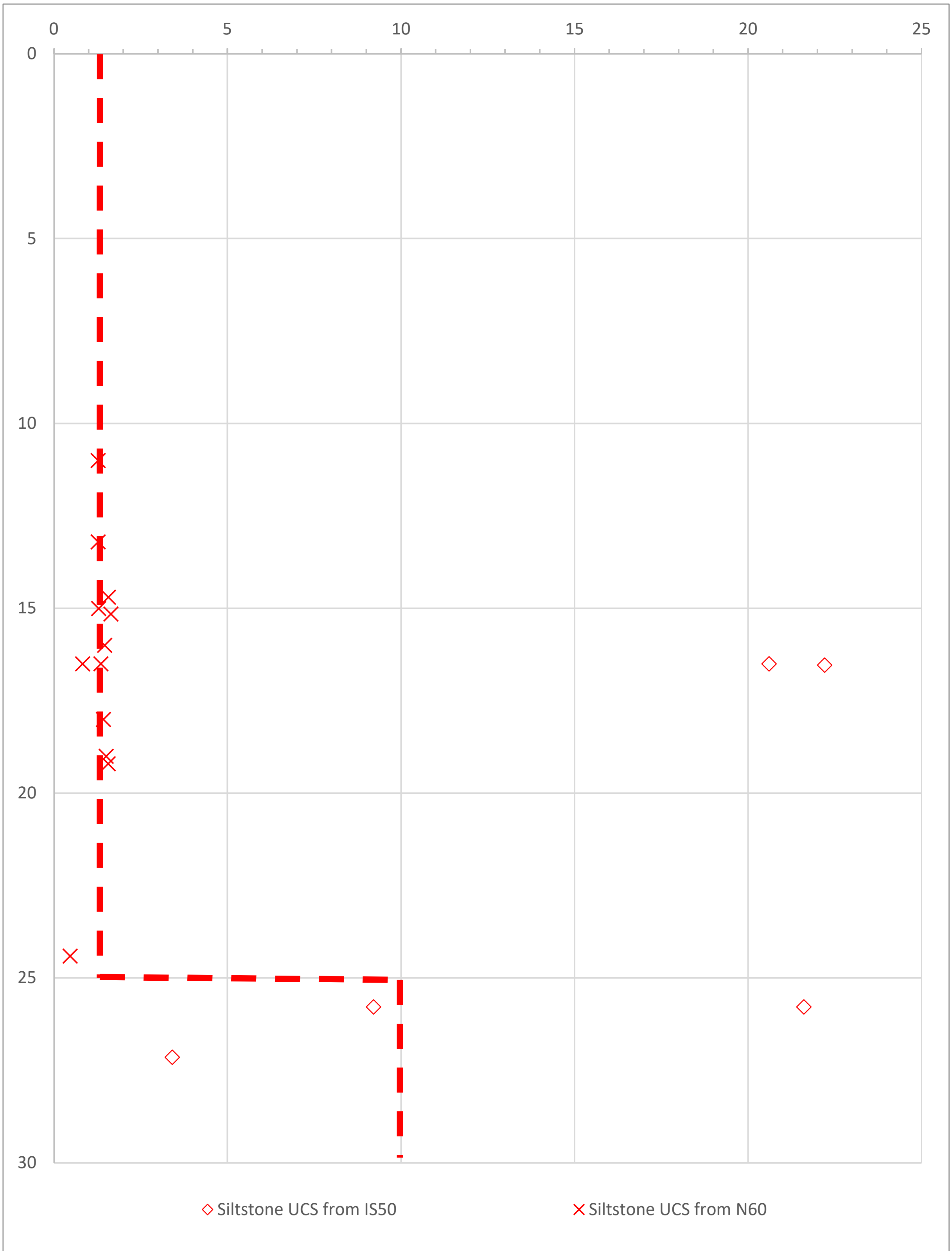
Project

A57 Trans Pennine Upgrade

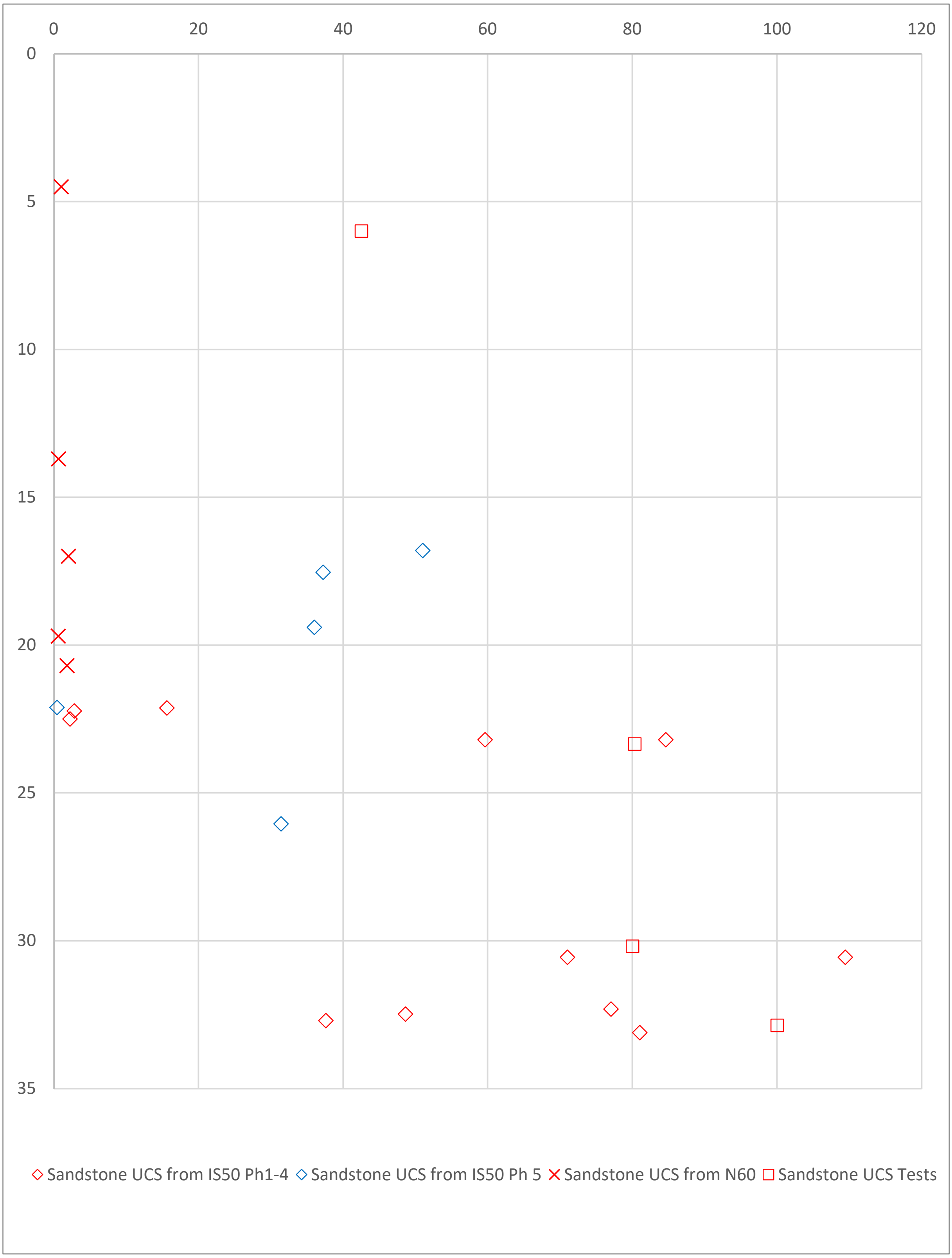
Drawn: TB	Check: GDS	Review: JJ
Date: 10/9/21	Date: 4/1/22	Date: 4/1/22
Figure Number		Rev P01



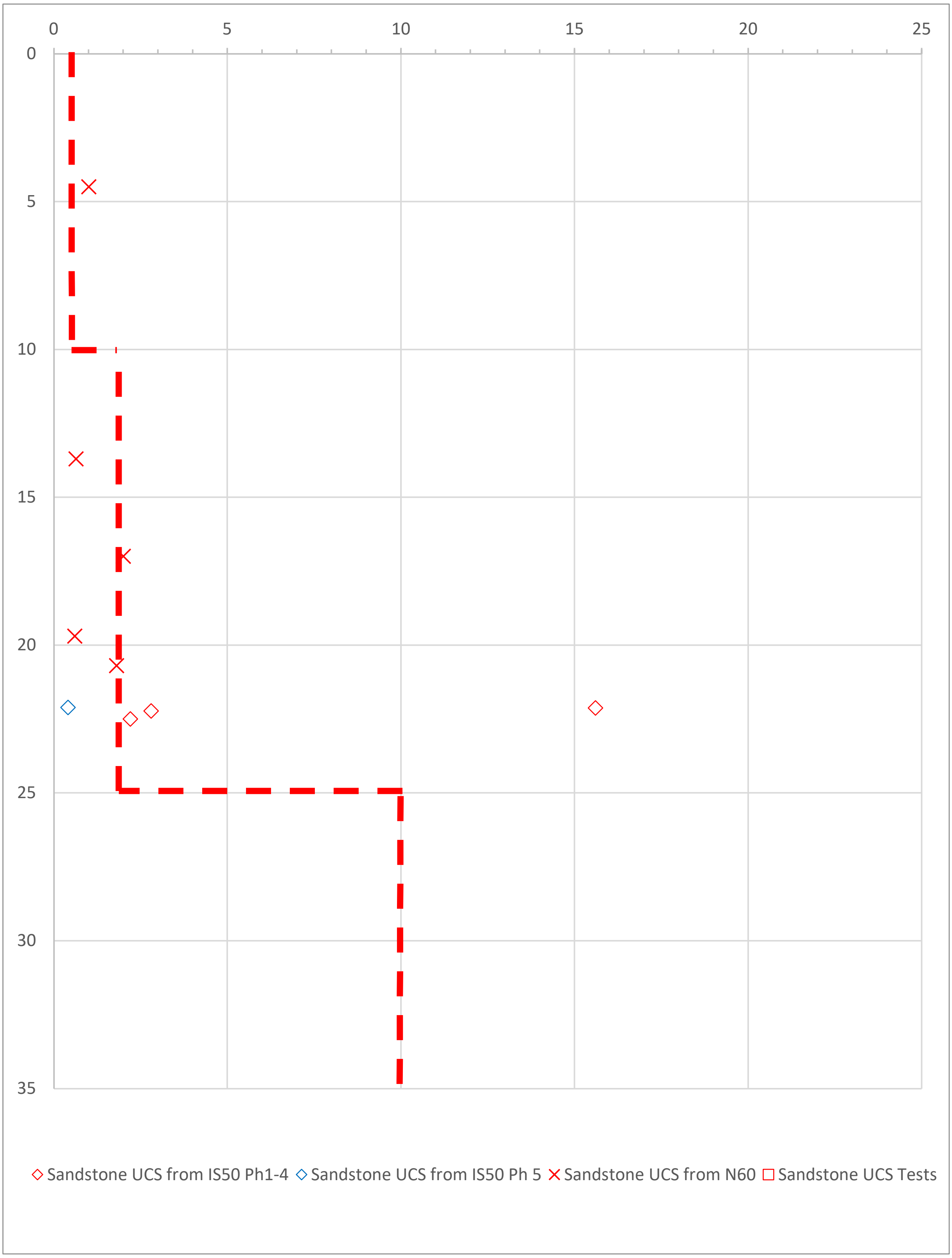
ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client **Highways England**	Title **Uniaxial Compressive Strength vs Depth for Sandstone - Section 4**
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21 Check: GDS Date: 4/1/22 Review: JJ Date: 4/1/22 Figure Number Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client **Highways England**	Title **Uniaxial Compressive Strength vs Depth for Siltstone (UCS < 25MPa) - Section 4**
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21 Check: GDS Date: 4/1/22 Review: JJ Date: 4/1/22 Figure Number Rev P01



ATKINS Member of the SNC-Lavalin Group **Atkins Limited** Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Client **Highways England** Project **A57 Trans Pennine Upgrade**	Title **Uniaxial Compressive Strength vs Depth for Sandstone - Section 4** Drawn: TB Date: 10/9/21 | Check: GDS Date: 4/1/22 | Review: JJ Date: 4/1/22 Figure Number | Rev P01

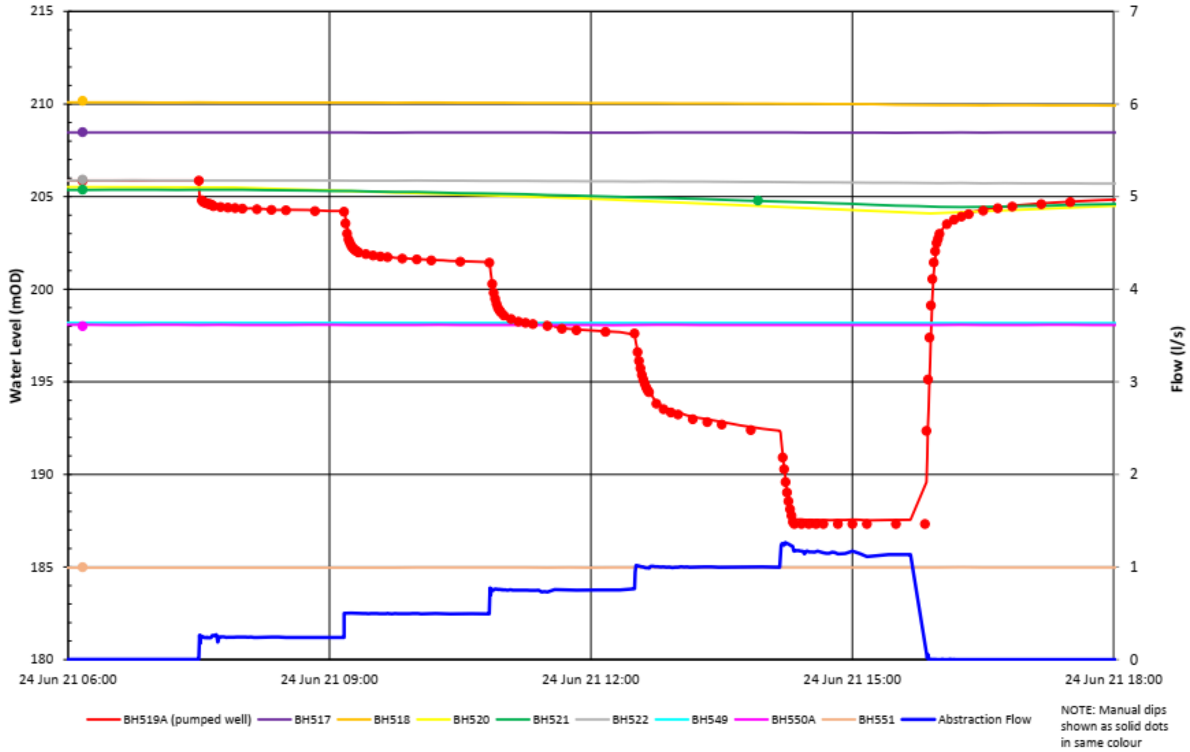


ATKINS Member of the SNC-Lavalin Group **Atkins Limited**	Client **Highways England**	Title **Uniaxial Compressive Strength vs Depth for Sandstone (UCS < 25MPa) - Section 4**		
Chadwick House Birchwood Park Warrington Tel: (01372) 726140 WA3 6AE Fax: (01372) 740055	Project **A57 Trans Pennine Upgrade**	Drawn: TB Date: 10/9/21	Check: GDS Date: 4/1/22	Review: JJ Date: 4/1/22
		Figure Number		Rev P01

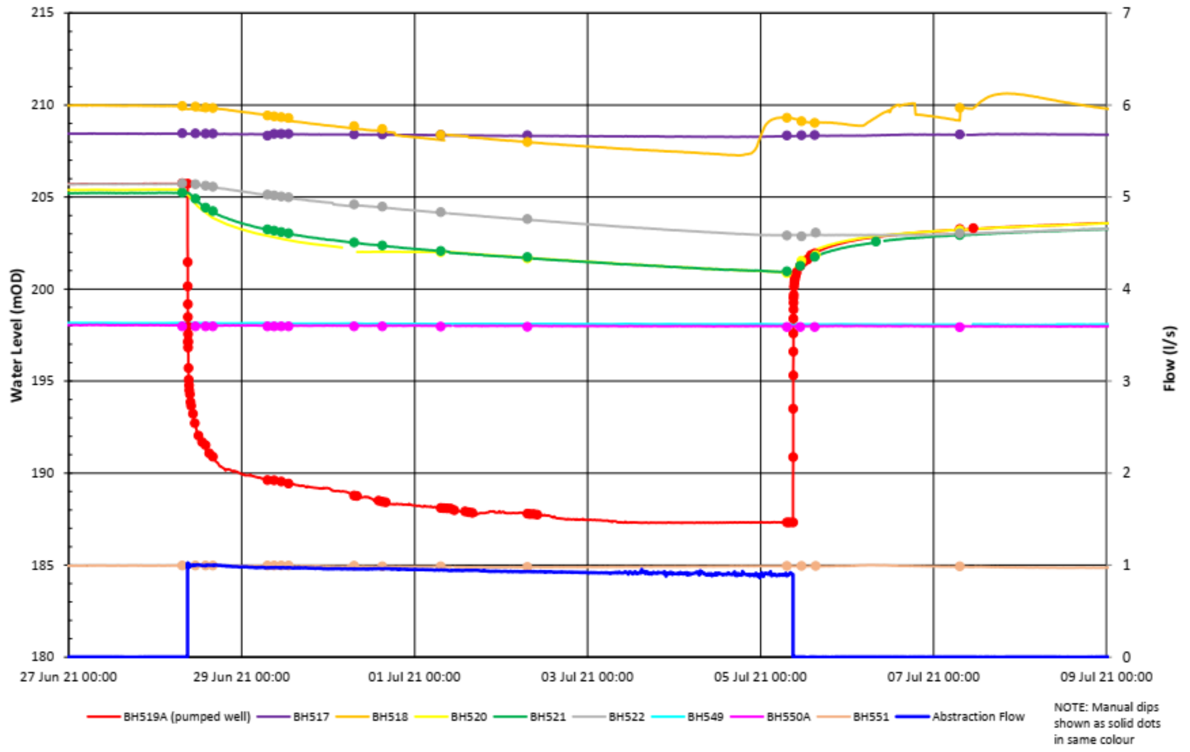
Appendix F. Groundwater Data

F.1 Pumping test water levels

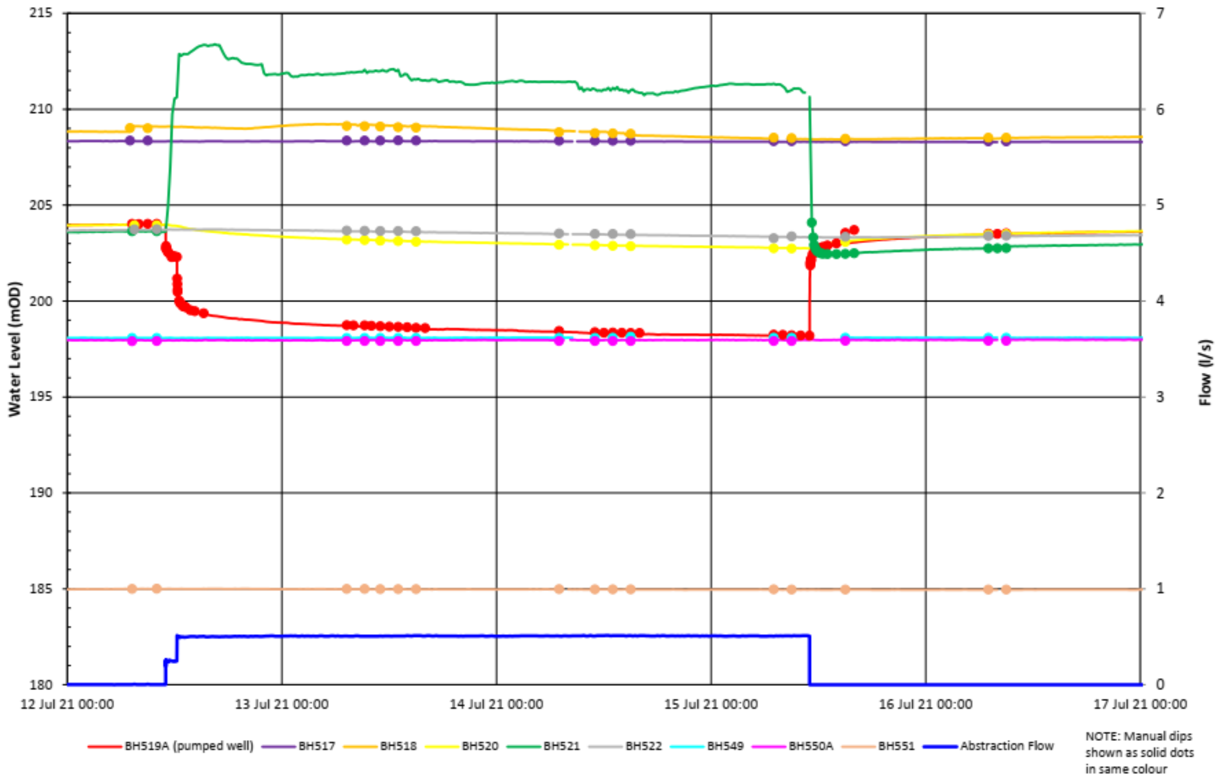
Step test drawdown (WJ GW ref)



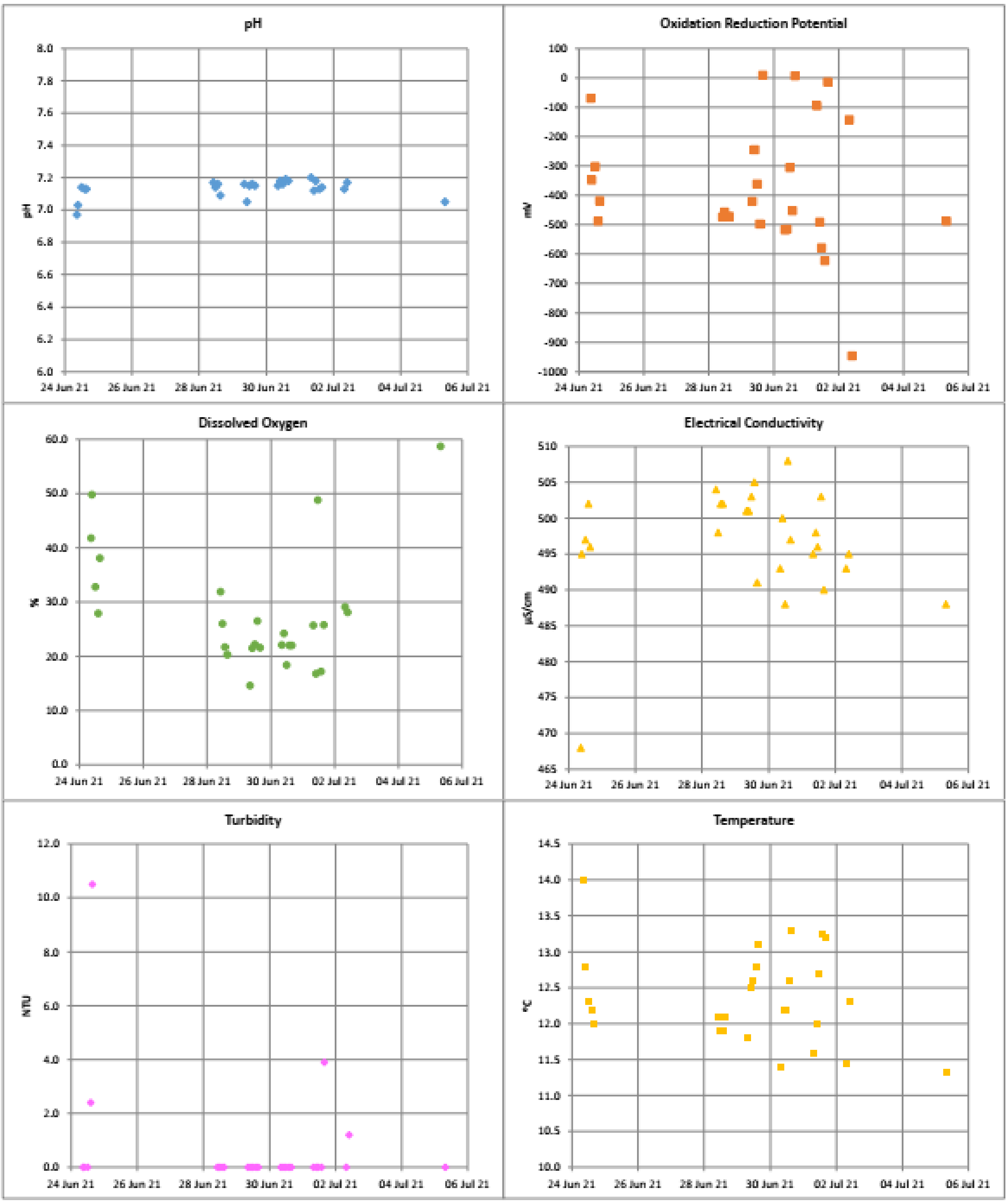
Constant rate test drawdown – continuous monitoring (WJ GW ref)



Water level during abstraction-recharge test (WJ GW ref)



Field water quality parameters (WJ GW ref)


pH
pH
Oxidation Reduction Potential
mV
Dissolved Oxygen
%
Electrical Conductivity
µS/cm
Turbidity
NTU
Temperature
°C
24 Jun 21
26 Jun 21
28 Jun 21
30 Jun 21
02 Jul 21
04 Jul 21
06 Jul 21

F.2 Step test analysis – Eden and Hazel (1973) (Eden & Hazel, 1973)

F.2.1 Well hydraulics theory is based on the assumption that laminar flow conditions exist in the aquifer during pumping. If the flow is laminar, drawdown in the borehole is directly proportional to the pumping rate. Upon entrance to a borehole the flow frequently becomes turbulent and under turbulent flow conditions this linear relationship no longer holds true. The specific capacity of the borehole, i.e. the ratio of discharge to steady drawdown, starts to decline as the turbulent flow losses become a greater proportion of the total head losses.

F.2.2 The purpose of a step-drawdown pumping test (‘step test’) is to define those elements of head loss attributable to laminar flow and those attributable to turbulent flow. This allows a prediction of total drawdown in the borehole for a particular discharge and pumping duration.

F.2.3 The Eden-Hazel method is based on the Jacob approximation for Theis (1935) and generates coefficients for linear and non-linear well losses which can be used to estimate transmissivity. The method is applicable for confined aquifers where the saturated thickness remains the same throughout the test.

F.2.4 In step 1 of the Eden-Hazel method the change in drawdown at each step is plotted against a function of the increased discharge for that step and previous steps. Best-fit lines are matched to the late stage data from each step. The intercept of these lines is a function of discharge at each step and the turbulent well losses at that discharge. In this test the best-fit lines matched better to the early pumping steps, as steady state drawdown was not fully achieved in the later pumping steps (Figure M-1).

F.2.5 In step 2, these intercepts are plotted against discharge to give an indication of specific capacity, this linear regression is used to derive the coefficients of linear and non-linear losses, which can then be used to estimate transmissivity (Figure M-2).

F.2.6 The estimated transmissivity can then be used to predict the drawdown response during the step test and compare this to the observed data. The predicted drawdown is shown in Figure M-3 this predicts greater drawdown than was observed in general but is a relatively good match.

F.2.7 The outputs from the Eden- Hazel (1973) analysis can be used to predict the drawdown in the borehole for pumping rates and pumping durations other than those followed during the step test. The predicted yield against drawdown relationship for a pumping period for 7 days is shown in Figure M-4. Predicted drawdown for a flow rate of 0.94 l/s is approximately 15 m. Observed drawdown during the constant rate test was 18.4 m so this is a slight underestimate.

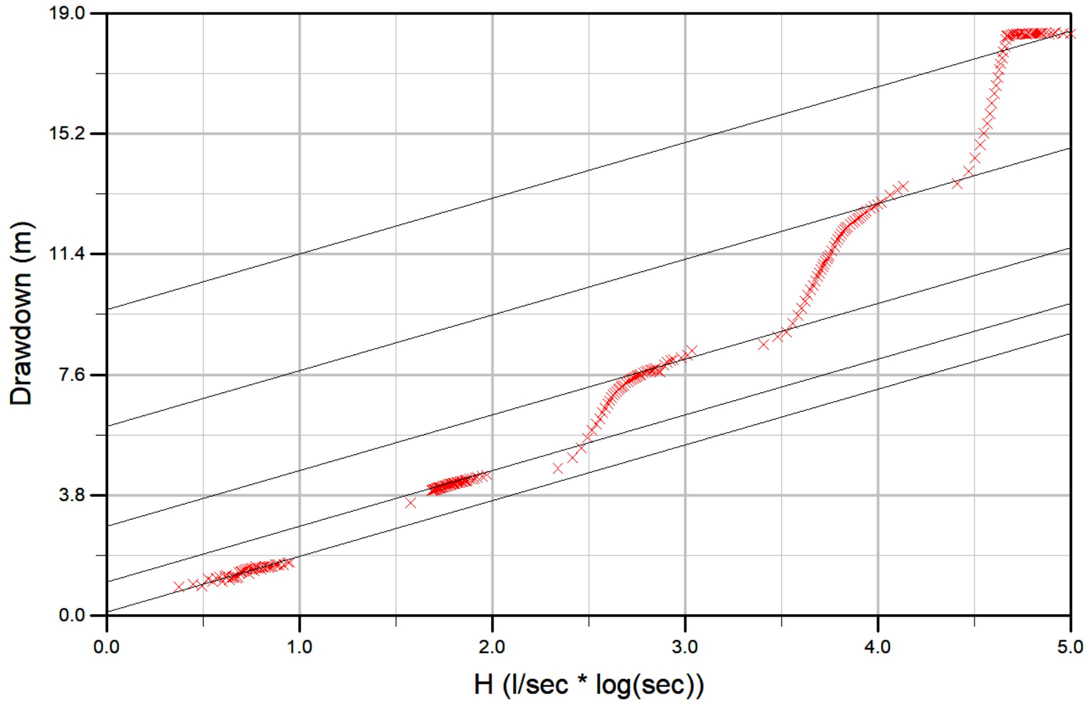


Figure M-1 - Eden and Hazel (1973) – Step 1

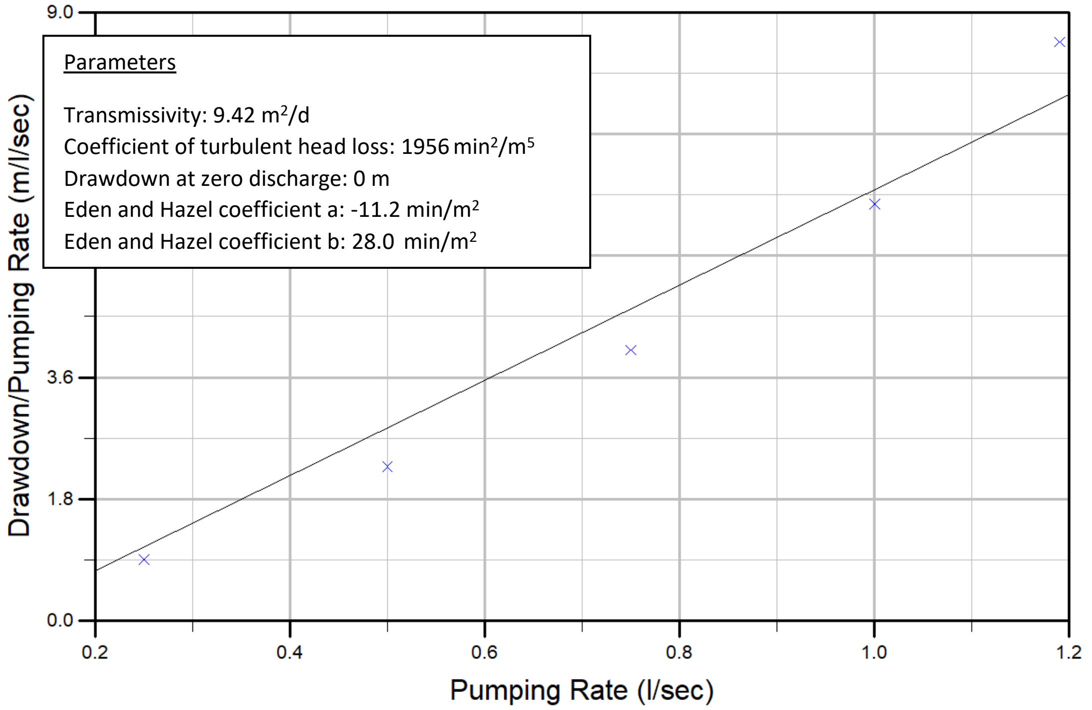


Figure M-2 - Eden and Hazel (1973) – Step 2

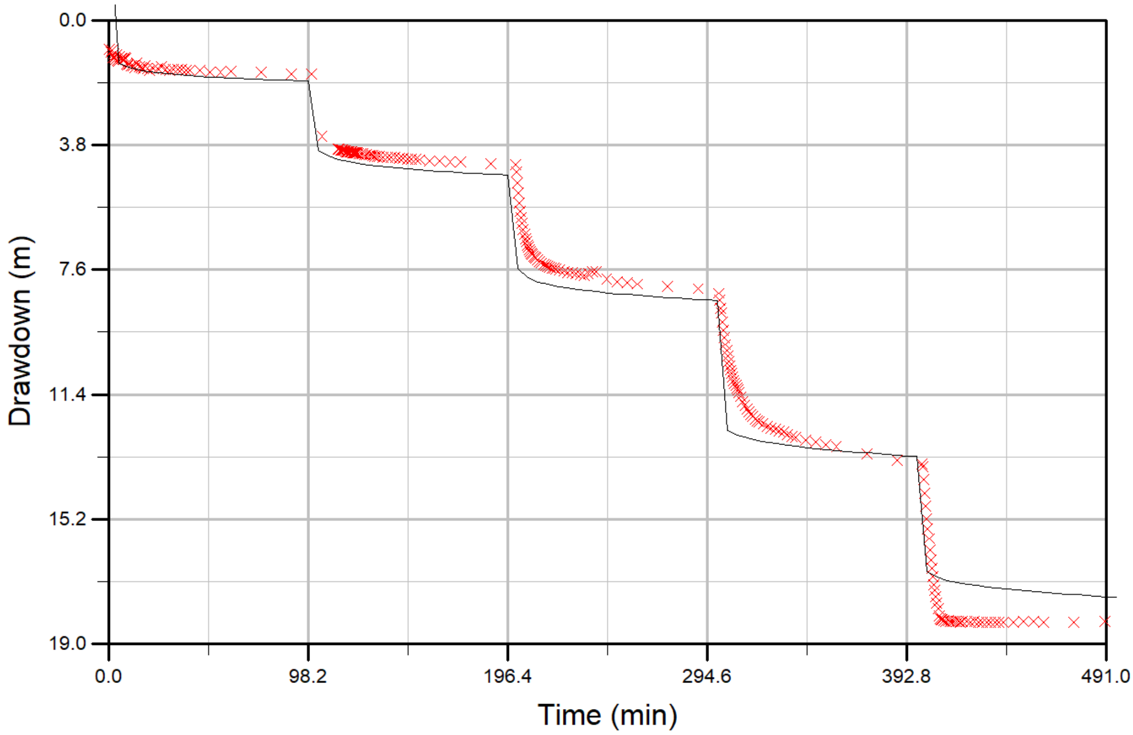


Figure M-3 - Eden and Hazel (1973) – predicted well response

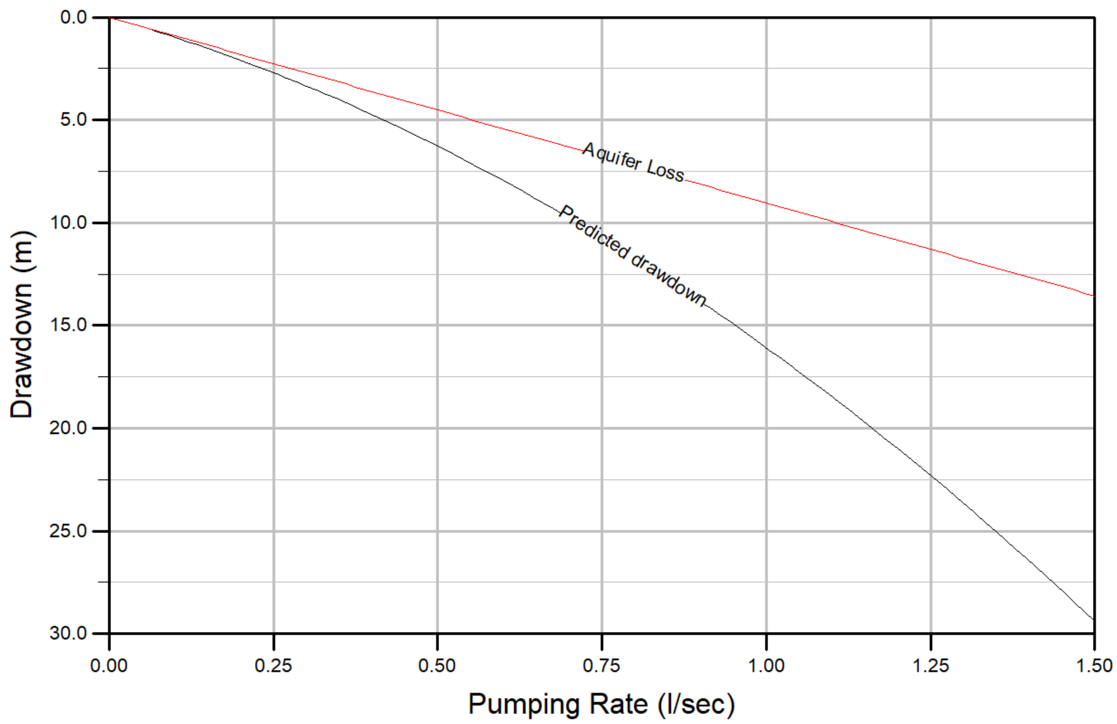
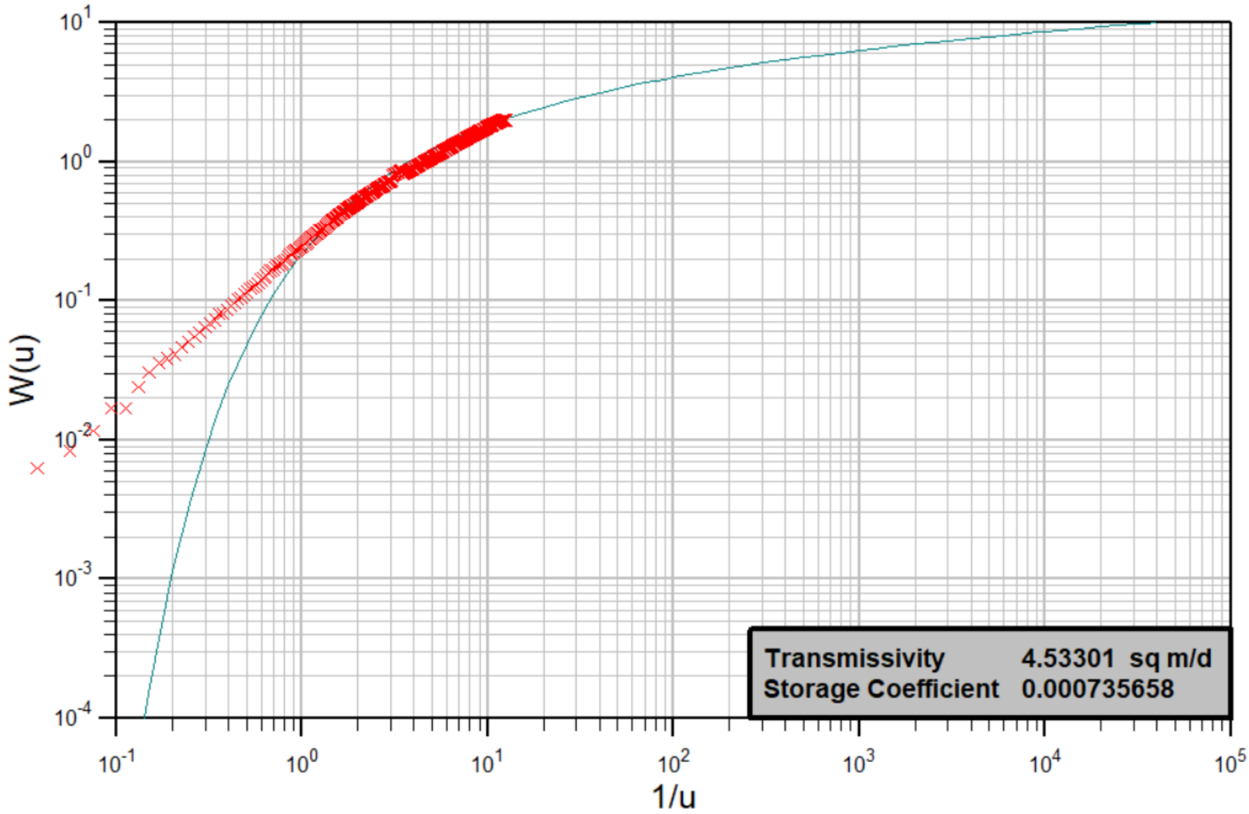


Figure M-4 - Eden and Hazel (1973) - predicted drawdown for 7 days pumping

F.3 Additional analysis of constant rate test data

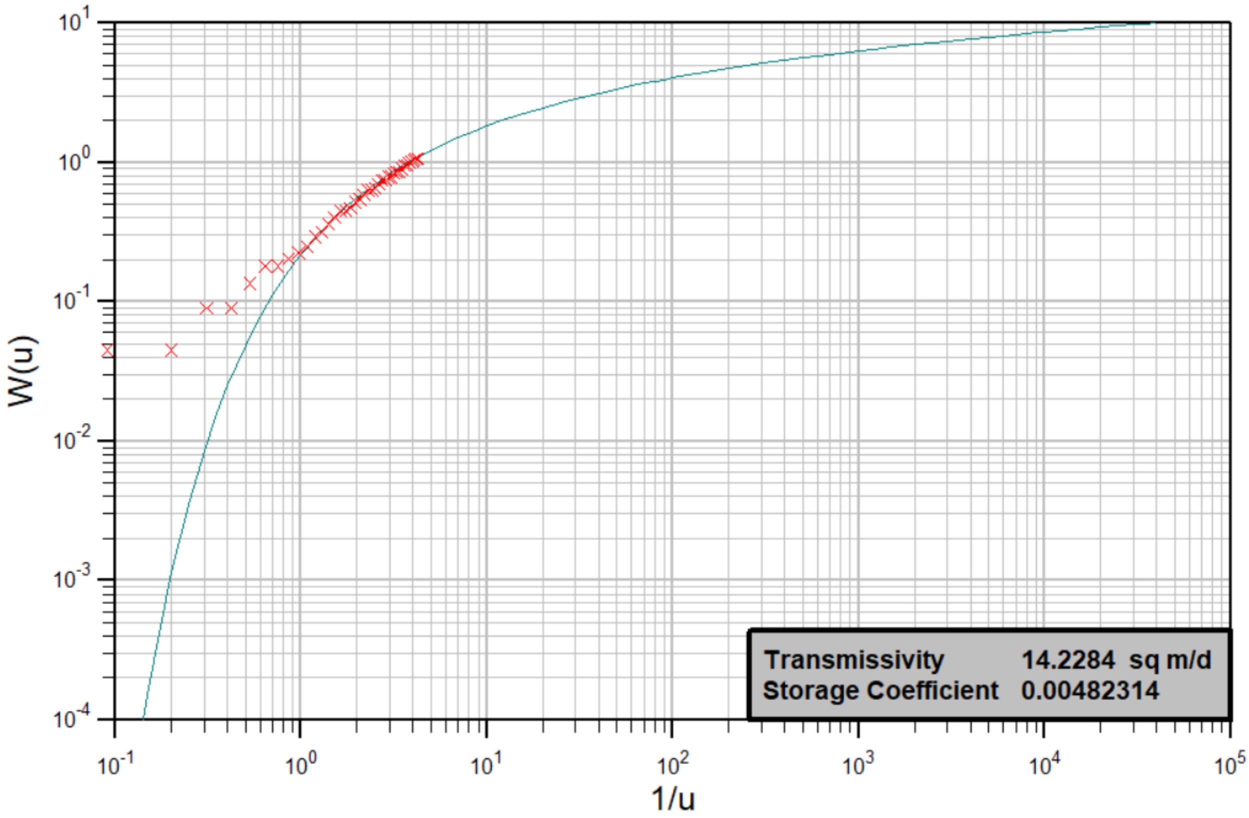
BH522

F.3.1 A significant drawdown was observed at BH522, but this monitoring well did not show typical confined behaviour. Its response was a "leaky" response and likely influenced by the significant amount of clay screened in this well. It also did not show typical recovery behaviour at the end of the test – recovery was much slower. The observed response is likely due to draining down of the screened clay units, which will recover very slowly due to their low permeability. Curve matching to the Theis curve was not appropriate and given the availability of other locations with good curve-matching, data from this well has not been included in Table 6-2.



BH525D

F.3.2 Drawdown at BH525D was relatively small for the distance from the pumped well. This is likely due to poor connectivity of the fracture network between the pumped well and this location, although it is also possible that this location is receiving recharge via the soakaway which is located upgradient from it. The curve fitting for this well is not definitively in one position so a range of values could be derived. Given the availability of other locations with good curve-matching, data from this well has not been included in Table 6-2.


W(u)
1/u
Transmissivity 14.2284 sq m/d
Storage Coefficient 0.00482314

Appendix G. Screening Sheets

Assessment Criteria : *Public Open Space (Parks) - 1% SOM Sand*

☐ Use MRL Values?

Determinand	Unit	it of Detection	eric Assessment eria	nber of Samples	imum Value	ximum Value	nber of eedances
ACM Type		N/A	No SSV	41	-	-	0
Asbestos Identification		N/A	No SSV	0	-	-	0
pH		4	No SSV	41	5.6	8.9	0
Boron (Hot Water Soluble)	mg/kg	0.4	No SSV	41	<0.4	1.3	0
Cyanide (Complex)	mg/kg	0.5	No SSV	41	<0.01	0.27	0
Cyanide (Free)	mg/kg	0.5	34	41	<0.5	<0.5	0
Cyanide (Total)	mg/kg	0.5	No SSV	41	<0.5	3.2	0
Sulphide (Easily Liberatable)	mg/kg	0.5	No SSV	41	0.67	25	0
Sulphate (Total)	mg/kg	100	No SSV	41	<100	7400	0
Arsenic	mg/kg	1	168	41	<1	23	0
Cadmium	mg/kg	0.1	882	41	<0.1	0.65	0
Chromium	mg/kg	1	83500	41	6	35	0
Copper	mg/kg	0.5	45200	41	3.6	120	0
Mercury	mg/kg	0.1	No SSV	41	<0.1	0.35	0
Nickel	mg/kg	0.5	804	41	8.1	53	0
Lead	mg/kg	0.5	1340	41	8.1	300	0
Selenium	mg/kg	0.2	2550	41	<0.2	0.72	0
Vanadium	mg/kg	5	1550	41	<5	42	0
Zinc	mg/kg	0.5	201000	41	20	320	0
Chromium (Hexavalent)	mg/kg	0.5	251	41	<0.5	<0.5	0
Organic Matter	%	0.4	No SSV	41	0.48	24	0
Naphthalene	mg/kg	0.1	623	41	<0.1	29	0
Acenaphthylene	mg/kg	0.1	No SSV	41	<0.1	10	0
Acenaphthene	mg/kg	0.1	28600	41	<0.1	2.6	0
Fluorene	mg/kg	0.1	19600	41	<0.1	7.1	0
Phenanthrene	mg/kg	0.1	No SSV	41	<0.1	25	0
Anthracene	mg/kg	0.1	150000	41	<0.1	7.7	0
Fluoranthene	mg/kg	0.1	20200	41	<0.1	19	0
Pyrene	mg/kg	0.1	15100	41	<0.1	19	0
Benzo[a]anthracene	mg/kg	0.1	BaP Surrogate	41	<0.1	8.3	0
Chrysene	mg/kg	0.1	BaP Surrogate	41	<0.1	8.3	0
Benzo[b]fluoranthene	mg/kg	0.1	BaP Surrogate	41	<0.1	8.9	0
Benzo[k]fluoranthene	mg/kg	0.1	BaP Surrogate	41	<0.1	4.3	0
Benzo[a]pyrene	mg/kg	0.1	21.4	41	<0.1	7.3	0
Indeno(1,2,3-c,d)Pyrene	mg/kg	0.1	BaP Surrogate	41	<0.1	4.6	0
Dibenz(a,h)Anthracene	mg/kg	0.1	BaP Surrogate	41	<0.1	1.4	0
Benzo[g,h,i]perylene	mg/kg	0.1	BaP Surrogate	41	<0.1	5.2	0
Total Of 16 PAH's	mg/kg	2	No SSV	41	<2	130	0
Total Phenols	mg/kg	0.3	No SSV	41	<0.1	<0.3	0
Aliphatic TPH >C5-C6	mg/kg	1	109000	7	<0.1	<1	0
Aliphatic TPH >C6-C8	mg/kg	1	163000	7	<0.1	<1	0
Aliphatic TPH >C8-C10	mg/kg	1	9720	7	<0.1	<1	0
Aliphatic TPH >C10-C12	mg/kg	1	17700	7	<0.1	<1	0
Aliphatic TPH >C12-C16	mg/kg	1	23800	7	<1	8.1	0
Aliphatic TPH >C16-C21	mg/kg	1	864000	7	<1	14	0
Aliphatic TPH >C21-C35	mg/kg	1	864000	7	<1	47	0
Aliphatic TPH >C35-C44	mg/kg	1	No SSV	7	<1	<1	0
Total Aliphatic Hydrocarbons	mg/kg	5	No SSV	7	<5	68	0
Aromatic TPH >C5-C7	mg/kg	1	139	7	<1	<1	0
Aromatic TPH >C7-C8	mg/kg	1	69900	7	<1	<1	0
Aromatic TPH >C8-C10	mg/kg	1	5140	7	<1	<1	0
Aromatic TPH >C10-C12	mg/kg	1	8260	7	<1	<1	0
Aromatic TPH >C12-C16	mg/kg	1	10600	7	<1	10	0
Aromatic TPH >C16-C21	mg/kg	1	No SSV	7	<1	39	0
Aromatic TPH >C21-C35	mg/kg	1	7870	7	<1	240	0
Aromatic TPH >C35-C44	mg/kg	1	No SSV	7	<1	<1	0
Total Aromatic Hydrocarbons	mg/kg	5	No SSV	7	<5	290	0
Total Petroleum Hydrocarbons	mg/kg	10	No SSV	7	<10	360	0
Dichlorodifluoromethane	mg/kg	0.001	No SSV	4	<1	<1	0
Chloromethane	mg/kg	0.001	73.8	4	<0.001	<0.001	0
Vinyl Chloride	mg/kg	0.001	18	4	<0.001	<0.001	0
Bromomethane	mg/kg	0.02	No SSV	4	<0.02	<0.02	0
Chloroethane	mg/kg	0.002	82400	4	<0.002	<0.002	0
Trichlorofluoromethane	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
1,1-Dichloroethene	mg/kg	0.001	1950	4	<0.001	<0.001	0
Trans 1,2-Dichloroethene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
1,1-Dichloroethane	mg/kg	0.001	11200	4	<0.001	<0.001	0
cis 1,2-Dichloroethene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
Bromochloromethane	mg/kg	0.005	No SSV	4	<0.005	<0.005	0
Trichloromethane	mg/kg	0.001	2090	4	<0.001	<0.001	0
1,1,1-Trichloroethane	mg/kg	0.001	34900	4	<0.001	<0.001	0
Tetrachloromethane	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
1,1-Dichloropropene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
Benzene	mg/kg	0.001	139	4	<0.001	<0.001	0
1,2-Dichloroethane	mg/kg	0.002	37.9	4	<0.002	<0.002	0
Trichloroethene	mg/kg	0.001	41	4	<0.001	<0.001	0
1,2-Dichloropropane	mg/kg	0.001	79.6	4	<0.001	<0.001	0
Dibromomethane	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
Bromodichloromethane	mg/kg	0.005	33.9	4	<0.005	<0.005	0
cis-1,3-Dichloropropene	mg/kg	0.01	No SSV	4	<0.01	<0.01	0
Toluene	mg/kg	0.001	69900	4	<0.001	<0.001	0
Trans-1,3-Dichloropropene	mg/kg	0.01	No SSV	4	<0.01	<0.01	0
1,1,2-Trichloroethane	mg/kg	0.01	766	4	<0.01	<0.01	0
Tetrachloroethene	mg/kg	0.001	1400	4	<0.001	<0.001	0
1,3-Dichloropropane	mg/kg	0.002	No SSV	4	<0.002	<0.002	0
Dibromochloromethane	mg/kg	0.01	231	4	<0.01	<0.01	0
1,2-Dibromoethane	mg/kg	0.005	No SSV	4	<0.005	<0.005	0
Chlorobenzene	mg/kg	0.001	13200	4	<0.001	<0.001	0
1,1,1,2-Tetrachloroethane	mg/kg	0.002	3490	4	<0.002	<0.002	0
Ethylbenzene	mg/kg	0.001	21400	4	<0.001	<0.001	0
m & p-Xylene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
o-Xylene	mg/kg	0.001	9560	4	<0.001	<0.001	0
Styrene	mg/kg	0.001	5640	4	<0.001	<0.001	0
Tribromomethane	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
Isopropylbenzene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
Bromobenzene	mg/kg	0.001	986	4	<0.001	<0.001	0
1,2,3-Trichloropropane	mg/kg	0.05	No SSV	4	<0.05	<0.05	0
N-Propylbenzene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
2-Chlorotoluene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
1,3,5-Trimethylbenzene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
4-Chlorotoluene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
Tert-Butylbenzene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
1,2,4-Trimethylbenzene	mg/kg	0.001	225	4	<0.001	<0.001	0
Sec-Butylbenzene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
1,3-Dichlorobenzene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
4-Isopropyltoluene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
1,4-Dichlorobenzene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
N-Butylbenzene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
1,2-Dichlorobenzene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
1,2-Dibromo-3-Chloropropane	mg/kg	0.05	No SSV	4	<0.05	<0.05	0
1,2,4-Trichlorobenzene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
Hexachlorobutadiene	mg/kg	0.001	No SSV	4	<0.001	<0.001	0
1,2,3-Trichlorobenzene	mg/kg	0.002	No SSV	4	<0.002	<0.002	0
Methyl Tert-Butyl Ether	mg/kg	0.001	70800	4	<0.001	<0.001	0
N-Nitrosodimethylamine	mg/kg	0.5	No SSV	4	<0.0005	<0.0005	0
Phenol	mg/kg	0.5	685	4	<0.5	<0.5	0
2-Chlorophenol	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
Bis-(2-Chloroethyl)Ether	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
1,3-Dichlorobenzene	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
1,4-Dichlorobenzene	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
1,2-Dichlorobenzene	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
2-Methylphenol	mg/kg	0.5	47800	4	<0.5	<0.5	0
Bis(2-Chloroisopropyl)Ether	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
Hexachloroethane	mg/kg	0.5	115	4	<0.5	<0.5	0
N-Nitrosodi-n-propylamine	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
4-Methylphenol	mg/kg	0.5	47800	4	<0.5	<0.5	0
Nitrobenzene	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
Isophorone	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
2-Nitrophenol	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
2,4-Dimethylphenol	mg/kg	0.5	8740	4	<0.5	<0.5	0
Bis(2-Chloroethoxy)Methane	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
2,4-Dichlorophenol	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
1,2,4-Trichlorobenzene	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
Naphthalene	mg/kg	0.5	623	4	<0.5	1.9	0
4-Chloroaniline	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
Hexachlorobutadiene	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
4-Chloro-3-Methylphenol	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
2-Methylnaphthalene	mg/kg	0.5	No SSV	4	<0.5	1.8	0
4-Nitrophenol	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
Hexachlorocyclopentadiene	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
2,4,6-Trichlorophenol	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
2,4,5-Trichlorophenol	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
2-Chloronaphthalene	mg/kg	0.5	659	4	<0.5	<0.5	0
2-Nitroaniline	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
Acenaphthylene	mg/kg	0.5	No SSV	4	<0.5	0.6	0
Dimethylphthalate	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
2,6-Dinitrotoluene	mg/kg	0.5	489	4	<0.5	<0.5	0
Acenaphthene	mg/kg	0.5	28600	4	<0.5	7.2	0
3-Nitroaniline	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
Dibenzofuran	mg/kg	0.5	No SSV	4	<0.5	3	0
4-Chlorophenylphenylether	mg/kg	0.5	No SSV	4	<0.5	<0.5	0
2,4-Dinitrotoluene	mg/kg	0.5	973	4	<0.5	<0.5	0
Fluorene	mg/kg	0.5	19600	4	<0.5	5.7	0

Location	TP505	WS537	WS505	WS503	BH511	BH509	BH506	BH516	BH544	BH533	BH538	BH508	BH539	BH548	BH547	BH540	BH541	BH527A	BH525	BH551	BH526
Sample ID	1171927	1170652	1170653	1170656	1169560	1165553	1160678	1160495	1160497	1160498	1159980	1156602	1155224	1153162	1150778	1149434	1148737	1147492	1147493	1145433	1145435
Depth	0.5m	0.8m	0.2m	0.5m	0.2m	4m	0.50m	0.5m	0.5m	0.5m	0.5m	0.5m	0.5m	0.5m	0.4m	0.3m	0.4m	0.2m	0.15m	0.5m	4.2m
Date	31/03/2021	30/03/2021	30/03/2021	30/03/2021	25/03/2021	22/03/2021	10/03/2021	11/03/2021	10/03/2021	10/03/2021	########	05/03/2021	04/03/2021	01/03/2021	25/02/2021	24/02/2021	23/02/2021	19/02/2021	########	########	########
Strata	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
ACM Type	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected
Asbestos Identification	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pH	7.5	5.9	5.6	6.4	8.5	8.9	7.6	8.8	8	7.7	7.3	8.3	8.8	8.3	7.1	7.8	8.5	8.6	6.5	8	8.3
Boron (Hot Water Soluble)	<0.4	0.56	0.67	0.76	0.56	<0.4	<0.4	0.53	<0.4	<0.4	<0.4	<0.4	0.42	<0.4	<0.4	0.47	1.3	<0.4	0.46	<0.4	<0.4
Cyanide (Complex)	<0.01	0.09	0.021	0.013	0.014	<0.01	<0.01	0.027	<0.01	<0.01	<0.01	<0.01	0.27	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyanide (Free)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cyanide (Total)	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	0.6	0.6	<0.5	<0.5
Sulphide (Easily Liberatable)	9.2	16	16	16	14	10	2.2	3.9	2	2.7	13	1.9	1.5	0.9	2.9	1.2	2.8	3.8	3.1	6.2	2.8
Sulphate (Total)	420	7400	1300	230	950	970	200	610	<100	<100	250	230	1100	<100	500	150	230	470	370	270	1300
Arsenic	4.9	6.4	14	7.1	23	7.7	3.4	15	5.4	3.2	9.1	5.8	5.7	2.8	12	4.3	6.1	12	5.3	5.5	5.2
Cadmium	0.1	0.3	0.19	<0.1	0.65	0.14	0.11	0.33	0.12	0.38	0.16	<0.1	0.42	0.13	0.21	<0.1	<0.1	0.14	<0.1	<0.1	<0.1
Chromium	17	18	16	26	17	20	18	13	15	25	35	17	22	9.4	17	18	21	15	17	23	28
Copper	13	16	18	11	66	17	7.5	25	3.6	19	25	10	41	8.7	32	14	69	28	83	17	27
Mercury	<0.1	<0.1	0.14	<0.1	0.35	<0.1	0.13	0.26	0.15	0.14	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	16	18	12	24	24	26	13	15	16	25	53	13	24	11	19	13	17	13	13	21	38
Lead	11	20	55	17	180	13	15	75	8.5	16	69	13	49	19	46	20	17	40	27	14	14
Selenium	0.3	0.36	0.36	<0.2	0.23	<0.2	<0.2	<0.2	<0.2	0.25	<0.2	<0.2	0.34	<0.2	0.27	<0.2	0.21	0.35	0.23	0.29	0.38
Vanadium	18	20	22	26	31	18	30	20	19	26	37	25	25	12	25	23	26	24	22	24	23
Zinc	39	46	42	39	310	38	24	50	24	47	62	25	86	30	86	39	31	43	29	34	58
Chromium (Hexavalent)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Organic Matter	1	24	4.8	1	12	0.64	0.64	3.1	0.53	1.2	1.1	0.69	0.59	0.57	4	0.98	0.59	1.5	2.1	0.9	1.1
Naphthalene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	3.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	<0.1	<0.1	<0.1	<0.1	<0.1	1.8	<0.1	1.8	<0.1	<0.1	<0.1	<0.1	3.7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pyrene	<0.1	<0.1	<0.1	<0.1	<0.1	0.71	<0.1	2.2	<0.1	<0.1	<0.1	<0.1	3.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo[a]anthracene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo[b]fluoranthene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo[k]fluoranthene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.8	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo[a]pyrene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-c,d)Pyrene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenz(a,h)Anthracene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo[g,h,i]perylene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Of 16 PAH's	<2	<2	<2	<2	<2	2.5	<2	4	<2	<2	<2	<2	18	<2	<2	<2	<2	<2	<2	<2	<2
Total Phenols	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Aliphatic TPH >C5-C6					<1	<1					<1	<1					<1				
Aliphatic TPH >C6-C8					<1	<1					<1	<1					<1				
Aliphatic TPH >C8-C10					<1	<1					<1	<1					<1				
Aliphatic TPH >C10-C12					<1	<1					<1	<1					<1				
Aliphatic TPH >C12-C16					<1	<1					<1	<1					<1				
Aliphatic TPH >C16-C21					<1	<1					<1	<1					<1				
Aliphatic TPH >C21-C35					<1	<1					<1	<1					<1				
Aliphatic TPH >C35-C44					<1	<1					<1	<1					<1				
Total Aliphatic Hydrocarbons					<5	<5					<5	<5					<5				
Aromatic TPH >C5-C7					<1	<1					<1	<1					<1				
Aromatic TPH >C7-C8					<1	<1					<1	<1					<1				
Aromatic TPH >C8-C10					<1	<1					<1	<1					<1				
Aromatic TPH >C10-C12					<1	<1					<1	<1					<1				
Aromatic TPH >C12-C16					<1	<1					<1	<1					<1				
Aromatic TPH >C16-C21					<1	<1					<1	<1					<1				
Aromatic TPH >C21-C35					<1	<1					<1	<1					<1				
Aromatic TPH >C35-C44					<1	<1					<1	<1					<1				
Total Aromatic Hydrocarbons					<5	<5					<5	<5					<5				
Total Petroleum Hydrocarbons					<10	<10					<10	<10					<10				

Location	BH549	BH522	BH519	BH517	BH518	BH520	BH524	BH510	TP501	BH502	BH512	BH545	TP503	TP504	BH536	BH535	BH515	BH514A	BH505	BH513
Sample ID	1145239	1143307	1142072	1141478	1141480	1141481	1141482	1171660	1175722	1178122	1178127	1161351	1175742	1174087	1166417	1163895	1163896	1194592	1162458	1203187
Depth	0.2m	0.4m	0.5m	0.5m	0.2m	0.55m	0.5m	0.5m	0.5m	0.2m	0.2m	1m	0.9m	0.6m	0.4m	0.5m	1.2m	0.3m	0.2m	0.3m
Date	########	########	########	########	########	11/02/2021	11/02/2021	29/03/2021	07/04/2021	09/04/2021	09/04/2021	15/03/2021	06/04/2021	01/04/2021	23/03/2021	18/03/2021	18/03/2021	30/04/2021	16/03/2021	18/05/2021
Strata	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
ACM Type	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected
Asbestos Identification	-	-	-	-	-	-	-	-	-	-	-	-	-	-						-
pH	8	8.2	8.3	8.2	8.3	8	8.1	7.4	8	7.5	7.6	8	6.9	8.6	7.4	6.4	8.9	6.9	7.4	7.8
Boron (Hot Water Soluble)	0.42	<0.4	<0.4	0.6	0.69	0.96	1.3	<0.4	<0.4	0.57	0.41	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Cyanide (Complex)	<0.01	0.047	<0.01	0.01	0.022	<0.01	<0.01	<0.01	0.012	0.019	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyanide (Free)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	[B] 0.50	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cyanide (Total)	<0.5	3.2	<0.5	<0.5	<0.5	<0.5	<0.5	[B] 0.50	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sulphide (Easily Liberatable)	3.3	2.1	2	1.4	0.99	0.89	0.67	5.6	25	9.3	11	5.5	2.8	3.8	7.3	1.9	1.8	7.9	8.8	8.7
Sulphate (Total)	310	470	120	260	1100	110	250	1400	190	930	930	1500	970	180	190	180	290	1000	220	950
Arsenic	8.3	5.6	13	7.4	15	7.8	7.4	23	9.5	13	14	11	<1	5.1	9.3	2.2	<1	11	5.3	15
Cadmium	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	0.38	0.14	0.24	0.24	<0.1	0.15	<0.1	<0.1	<0.1	0.16	0.21	<0.1	0.25
Chromium	21	24	20	27	22	25	19	15	34	10	9.9	27	9.2	13	28	11	6	11	20	12
Copper	31	17	17	19	29	19	8.2	120	29	13	48	18	8	6.4	19	8.7	8.9	27	7.7	51
Mercury	<0.1	0.12	<0.1	<0.1	0.16	<0.1	<0.1	0.24	<0.1	0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	0.14	0.26	<0.1	0.23
Nickel	17	16	14	19	13	20	12	22	42	8.3	11	15	8.8	11	19	8.1	10	13	12	14
Lead	24	19	12	18	300	23	31	94	28	42	58	11	8.1	13	17	17	140	170	16	76
Selenium	0.2	<0.2	<0.2	0.32	0.52	<0.2	0.64	0.46	0.42	0.35	0.46	0.72	<0.2	0.25	<0.2	0.3	<0.2	0.43	<0.2	0.46
Vanadium	25	26	23	27	31	26	29	42	41	18	24	14	11	18	35	6.2	<5	13	26	22
Zinc	34	33	24	37	56	38	27	82	320	35	59	39	20	25	34	40	21	92	29	54
Chromium (Hexavalent)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Organic Matter	9.7	1.1	0.48	1.1	5	1.1	1	13	0.5	4.8	6	0.52	2.6	0.55	0.95	1.4	4.8	8.8	1.6	7.4
Naphthalene	<0.1	29	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.93	<0.1	<0.1	<0.1	2	<0.1	<0.1	1.6	<0.1	<0.1
Acenaphthylene	<0.1	10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.75	<0.1	<0.1	<0.1	0.69	<0.1	<0.1	0.29	<0.1	<0.1
Acenaphthene	<0.1	1.8	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.5	<0.1	<0.1	<0.1	1.9	<0.1	<0.1	2.6	<0.1	<0.1
Fluorene	<0.1	7.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.2	<0.1	<0.1	<0.1	2.2	<0.1	<0.1	2.2	<0.1	<0.1
Phenanthrene	<0.1	25	<0.1	<0.1	<0.1	<0.1	<0.1	0.73	<0.1	<0.1	16	<0.1	<0.1	<0.1	13	<0.1	1.6	14	<0.1	<0.1
Anthracene	<0.1	7.7	<0.1	<0.1	<0.1	<0.1	<0.1	0.36	<0.1	<0.1	3.8	<0.1	<0.1	<0.1	4.9	<0.1	0.51	3.7	<0.1	<0.1
Fluoranthene	0.15	13	<0.1	<0.1	<0.1	<0.1	<0.1	1.4	<0.1	0.64	19	<0.1	<0.1	<0.1	14	<0.1	3	15	0.31	0.79
Pyrene	0.14	12	<0.1	<0.1	<0.1	<0.1	<0.1	1.2	<0.1	1.7	19	<0.1	<0.1	<0.1	14	<0.1	3.3	15	0.33	1
Benzo[a]anthracene	<0.1	4.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8.3	<0.1	<0.1	<0.1	5.1	<0.1	1.7	6.9	<0.1	<0.1
Chrysene	<0.1	3.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8.3	<0.1	<0.1	<0.1	5.1	<0.1	1.6	6.9	<0.1	<0.1
Benzo[b]fluoranthene	<0.1	5.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8.9	<0.1	<0.1	<0.1	6.5	<0.1	2.6	6.4	<0.1	<0.1
Benzo[k]fluoranthene	<0.1	2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.3	<0.1	<0.1	<0.1	2.4	<0.1	1.2	3	<0.1	<0.1
Benzo[a]pyrene	<0.1	3.9	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	7.3	<0.1	<0.1	<0.1	5.1	<0.1	2.3	5.9	<0.1	<0.1
Indeno(1,2,3-c,d)Pyrene	<0.1	2.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.6	<0.1	<0.1	<0.1	3.4	<0.1	1.6	3.6	<0.1	<0.1
Dibenz(a,h)Anthracene	<0.1	1.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.4	<0.1	<0.1	<0.1	1	<0.1	0.69	1.1	<0.1	<0.1
Benzo[g,h,i]perylene	<0.1	4.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5.2	<0.1	<0.1	<0.1	3.5	<0.1	2.3	4.1	<0.1	<0.1
Total Of 16 PAH's	<2	130	<2	<2	<2	<2	<2	3.7	<2	2.4	110	<2	<2	<2	85	<2	22	92	<2	<2
Total Phenols	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Aliphatic TPH >C5-C6											<1							<0.1		
Aliphatic TPH >C6-C8											<1							<0.1		
Aliphatic TPH >C8-C10											<1							<0.1		
Aliphatic TPH >C10-C12											<1							<0.1		
Aliphatic TPH >C12-C16											<1							8.1		
Aliphatic TPH >C16-C21											<1							14		
Aliphatic TPH >C21-C35											16							47		
Aliphatic TPH >C35-C44											<1							<1		
Total Aliphatic Hydrocarbons											16							68		
Aromatic TPH >C5-C7											<1							<1		
Aromatic TPH >C7-C8											<1							<1		
Aromatic TPH >C8-C10											<1							<1		
Aromatic TPH >C10-C12											<1							<1		
Aromatic TPH >C12-C16											<1							10		
Aromatic TPH >C16-C21											<1							39		
Aromatic TPH >C21-C35											28							240		
Aromatic TPH >C35-C44											<1							<1		
Total Aromatic Hydrocarbons											28							290		
Total Petroleum Hydrocarbons											44							360		

Location	TP505	BH511	BH512	BH514A
Dichlorodifluoromethane	<1	<1	<1	<1
Chloromethane	<0.001	<0.001	<0.001	<0.001
Vinyl Chloride	<0.001	<0.001	<0.001	<0.001
Bromomethane	<0.02	<0.02	<0.02	<0.02
Chloroethane	<0.002	<0.002	<0.002	<0.002
Trichlorofluoromethane	<0.001	<0.001	<0.001	<0.001
1,1-Dichloroethene	<0.001	<0.001	<0.001	<0.001
Trans 1,2-Dichloroethene	<0.001	<0.001	<0.001	<0.001
1,1-Dichloroethane	<0.001	<0.001	<0.001	<0.001
cis 1,2-Dichloroethene	<0.001	<0.001	<0.001	<0.001
Bromochloromethane	<0.005	<0.005	<0.005	<0.005
Trichloromethane	<0.001	<0.001	<0.001	<0.001
1,1,1-Trichloroethane	<0.001	<0.001	<0.001	<0.001
Tetrachloromethane	<0.001	<0.001	<0.001	<0.001
1,1-Dichloropropene	<0.001	<0.001	<0.001	<0.001
Benzene	<0.001	<0.001	<0.001	<0.001
1,2-Dichloroethane	<0.002	<0.002	<0.002	<0.002
Trichloroethene	<0.001	<0.001	<0.001	<0.001
1,2-Dichloropropane	<0.001	<0.001	<0.001	<0.001
Dibromomethane	<0.001	<0.001	<0.001	<0.001
Bromodichloromethane	<0.005	<0.005	<0.005	<0.005
cis-1,3-Dichloropropene	<0.01	<0.01	<0.01	<0.01
Toluene	<0.001	<0.001	<0.001	<0.001
Trans-1,3-Dichloropropene	<0.01	<0.01	<0.01	<0.01
1,1,2-Trichloroethane	<0.01	<0.01	<0.01	<0.01
Tetrachloroethene	<0.001	<0.001	<0.001	<0.001
1,3-Dichloropropane	<0.002	<0.002	<0.002	<0.002
Dibromochloromethane	<0.01	<0.01	<0.01	<0.01
1,2-Dibromoethane	<0.005	<0.005	<0.005	<0.005
Chlorobenzene	<0.001	<0.001	<0.001	<0.001
1,1,1,2-Tetrachloroethane	<0.002	<0.002	<0.002	<0.002
Ethylbenzene	<0.001	<0.001	<0.001	<0.001
m & p-Xylene	<0.001	<0.001	<0.001	<0.001
o-Xylene	<0.001	<0.001	<0.001	<0.001
Styrene	<0.001	<0.001	<0.001	<0.001
Tribromomethane	<0.001	<0.001	<0.001	<0.001
Isopropylbenzene	<0.001	<0.001	<0.001	<0.001
Bromobenzene	<0.001	<0.001	<0.001	<0.001
1,2,3-Trichloropropane	<0.05	<0.05	<0.05	<0.05
N-Propylbenzene	<0.001	<0.001	<0.001	<0.001
2-Chlorotoluene	<0.001	<0.001	<0.001	<0.001
1,3,5-Trimethylbenzene	<0.001	<0.001	<0.001	<0.001
4-Chlorotoluene	<0.001	<0.001	<0.001	<0.001
Tert-Butylbenzene	<0.001	<0.001	<0.001	<0.001
1,2,4-Trimethylbenzene	<0.001	<0.001	<0.001	<0.001
Sec-Butylbenzene	<0.001	<0.001	<0.001	<0.001
1,3-Dichlorobenzene	<0.001	<0.001	<0.001	<0.001
4-Isopropyltoluene	<0.001	<0.001	<0.001	<0.001
1,4-Dichlorobenzene	<0.001	<0.001	<0.001	<0.001
N-Butylbenzene	<0.001	<0.001	<0.001	<0.001
1,2-Dichlorobenzene	<0.001	<0.001	<0.001	<0.001
1,2-Dibromo-3-Chloropropane	<0.05	<0.05	<0.05	<0.05
1,2,4-Trichlorobenzene	<0.001	<0.001	<0.001	<0.001
Hexachlorobutadiene	<0.001	<0.001	<0.001	<0.001
1,2,3-Trichlorobenzene	<0.002	<0.002	<0.002	<0.002
Methyl Tert-Butyl Ether	<0.001	<0.001	<0.001	<0.001
N-Nitrosodimethylamine	<0.0005	<0.0005	<0.0005	<0.0005
Phenol	<0.5	<0.5	<0.5	<0.5
2-Chlorophenol	<0.5	<0.5	<0.5	<0.5
Bis-(2-Chloroethyl)Ether	<0.5	<0.5	<0.5	<0.5
1,3-Dichlorobenzene	<0.5	<0.5	<0.5	<0.5
1,4-Dichlorobenzene	<0.5	<0.5	<0.5	<0.5
1,2-Dichlorobenzene	<0.5	<0.5	<0.5	<0.5
2-Methylphenol	<0.5	<0.5	<0.5	<0.5
Bis(2-Chloroisopropyl)Ether	<0.5	<0.5	<0.5	<0.5
Hexachloroethane	<0.5	<0.5	<0.5	<0.5
N-Nitrosodi-n-propylamine	<0.5	<0.5	<0.5	<0.5
4-Methylphenol	<0.5	<0.5	<0.5	<0.5
Nitrobenzene	<0.5	<0.5	<0.5	<0.5
Isophorone	<0.5	<0.5	<0.5	<0.5
2-Nitrophenol	<0.5	<0.5	<0.5	<0.5
2,4-Dimethylphenol	<0.5	<0.5	<0.5	<0.5
Bis(2-Chloroethoxy)Methane	<0.5	<0.5	<0.5	<0.5
2,4-Dichlorophenol	<0.5	<0.5	<0.5	<0.5
1,2,4-Trichlorobenzene	<0.5	<0.5	<0.5	<0.5
Naphthalene	1.9	1.9	<0.5	<0.5
4-Chloroaniline	<0.5	<0.5	<0.5	<0.5
Hexachlorobutadiene	<0.5	<0.5	<0.5	<0.5
4-Chloro-3-Methylphenol	<0.5	<0.5	<0.5	<0.5
2-Methylnaphthalene	1.8	1.8	<0.5	<0.5
4-Nitrophenol	<0.5	<0.5	<0.5	<0.5
Hexachlorocyclopentadiene	<0.5	<0.5	<0.5	<0.5
2,4,6-Trichlorophenol	<0.5	<0.5	<0.5	<0.5
2,4,5-Trichlorophenol	<0.5	<0.5	<0.5	<0.5
2-Chloronaphthalene	<0.5	<0.5	<0.5	<0.5
2-Nitroaniline	<0.5	<0.5	<0.5	<0.5
Acenaphthylene	0.6	0.6	<0.5	<0.5
Dimethylphthalate	<0.5	<0.5	<0.5	<0.5
2,6-Dinitrotoluene	<0.5	<0.5	<0.5	<0.5
Acenaphthene	7.2	7.2	<0.5	<0.5
3-Nitroaniline	<0.5	<0.5	<0.5	<0.5
Dibenzofuran	3	3	<0.5	<0.5
4-Chlorophenylphenylether	<0.5	<0.5	<0.5	<0.5
2,4-Dinitrotoluene	<0.5	<0.5	<0.5	<0.5
Fluorene	5.7	5.7	<0.5	<0.5

Assessment Criteria : *Public Open Space (Parks) - 1% SOM Sand*

☐ **Use MRL Values?**

		it of Detection	eric Assessment eria	mber of Samples	imum Value	ximum Value	mber of eedances		Strata
Diethyl Phthalate	mg/kg	0.5	85800	4	<0.5	<0.5	0		
4-Nitroaniline	mg/kg	0.5	No SSV	4	<0.5	<0.5	0		
2-Methyl-4,6-Dinitrophenol	mg/kg	0.5	No SSV	4	<0.5	<0.5	0		
Azobenzene	mg/kg	0.5	No SSV	4	<0.5	<0.5	0		
4-Bromophenylphenyl Ether	mg/kg	0.5	No SSV	4	<0.5	<0.5	0		
Hexachlorobenzene	mg/kg	0.5	No SSV	4	<0.5	<0.5	0		
Pentachlorophenol	mg/kg	0.5	No SSV	4	<0.5	<0.5	0		
Phenanthrene	mg/kg	0.5	No SSV	4	2	40	0		
Anthracene	mg/kg	0.5	150000	4	<0.5	12	0		
Carbazole	mg/kg	0.5	No SSV	4	<0.5	3	0		
Di-N-Butyl Phthalate	mg/kg	0.5	2620	4	<0.5	<0.5	0		
Fluoranthene	mg/kg	0.5	20200	4	4.6	47	0		
Pyrene	mg/kg	0.5	15100	4	4	43	0		
Butylbenzyl Phthalate	mg/kg	0.5	No SSV	4	<0.5	<0.5	0		
Benzo[a]anthracene	mg/kg	0.5	BaP Surrogate	4	2.2	24	0		
Chrysene	mg/kg	0.5	BaP Surrogate	4	2.3	24	0		
Bis(2-Ethylhexyl)Phthalate	mg/kg	0.5	No SSV	4	<0.5	<0.5	0		
Di-N-Octyl Phthalate	mg/kg	0.5	20000	4	<0.5	<0.5	0		
Benzo[b]fluoranthene	mg/kg	0.5	BaP Surrogate	4	2.7	26	0		
Benzo[k]fluoranthene	mg/kg	0.5	BaP Surrogate	4	0.91	11	0		
Benzo[a]pyrene	mg/kg	0.5	21.4	4	2.1	25	2	TP505, 1171927, 0.5m; BH511, 1169560, 0.2m	SOIL
Indeno(1,2,3-c,d)Pyrene	mg/kg	0.5	BaP Surrogate	4	0.98	12	0		
Dibenz(a,h)Anthracene	mg/kg	0.5	BaP Surrogate	4	<0.5	3.6	0		
Benzo[g,h,i]perylene	mg/kg	0.5	BaP Surrogate	4	1	15	0		
PCB 28	mg/kg	0.01	No SSV	1	<0.01	<0.01	0		
PCB 52	mg/kg	0.01	No SSV	1	<0.01	<0.01	0		
PCB 90+101	mg/kg	0.01	No SSV	1	<0.01	<0.01	0		
PCB 118	mg/kg	0.01	No SSV	1	<0.01	<0.01	0		
PCB 153	mg/kg	0.01	No SSV	1	<0.01	<0.01	0		
PCB 138	mg/kg	0.01	No SSV	1	<0.01	<0.01	0		
PCB 180	mg/kg	0.01	No SSV	1	<0.01	<0.01	0		
Total PCBs (7 Congeners)	mg/kg	0.1	No SSV	1	<0.1	<0.1	0		

Location	TP505	WS537	WS505	WS503	BH511	BH509	BH506	BH516	BH544	BH533	BH538	BH508	BH539	BH548	BH547	BH540	BH541	BH527A	BH525	BH551
Sample ID	1171927	1170652	1170653	1170656	1169560	1165553	1160678	1160495	1160497	1160498	1159980	1156602	1155224	1153162	1150778	1149434	1148737	1147492	1147493	1145433
Depth	0.5m	0.8m	0.2m	0.5m	0.2m	4m	0.50m	0.5m	0.5m	0.5m	0.5m	0.5m	0.5m	0.5m	0.4m	0.3m	0.4m	0.2m	0.15m	0.5m
Date	31/03/2021	30/03/2021	30/03/2021	30/03/2021	25/03/2021	22/03/2021	10/03/2021	11/03/2021	10/03/2021	10/03/2021	########	05/03/2021	04/03/2021	01/03/2021	25/02/2021	24/02/2021	23/02/2021	19/02/2021	########	########
Strata	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Diethyl Phthalate	<0.5				<0.5															
4-Nitroaniline	<0.5				<0.5															
2-Methyl-4,6-Dinitrophenol	<0.5				<0.5															
Azobenzene	<0.5				<0.5															
4-Bromophenylphenyl Ether	<0.5				<0.5															
Hexachlorobenzene	<0.5				<0.5															
Pentachlorophenol	<0.5				<0.5															
Phenanthrene	40				40															
Anthracene	12				12															
Carbazole	3				3															
Di-N-Butyl Phthalate	<0.5				<0.5															
Fluoranthene	47				47															
Pyrene	43				43															
Butylbenzyl Phthalate	<0.5				<0.5															
Benzo[a]anthracene	24				24															
Chrysene	24				24															
Bis(2-Ethylhexyl)Phthalate	<0.5				<0.5															
Di-N-Octyl Phthalate	<0.5				<0.5															
Benzo[b]fluoranthene	26				26															
Benzo[k]fluoranthene	11				11															
Benzo[a]pyrene	25				25															
Indeno(1,2,3-c,d)Pyrene	12				12															
Dibenz(a,h)Anthracene	3.6				3.6															
Benzo[g,h,i]perylene	15				15															
PCB 28																				
PCB 52																				
PCB 90+101																				
PCB 118																				
PCB 153																				
PCB 138																				
PCB 180																				
Total PCBs (7 Congeners)																				

Location	BH526	BH549	BH522	BH519	BH517	BH518	BH520	BH524	BH510	TP501	BH502	BH512	BH545	TP503	TP504	BH536	BH535	BH515	BH514A	BH505	BH513
Sample ID	1145435	1145239	1143307	1142072	1141478	1141480	1141481	1141482	1171660	1175722	1178122	1178127	1161351	1175742	1174087	1166417	1163895	1163896	1194592	1162458	1203187
Depth	4.2m	0.2m	0.4m	0.5m	0.5m	0.2m	0.55m	0.5m	0.5m	0.5m	0.2m	0.2m	1m	0.9m	0.6m	0.4m	0.5m	1.2m	0.3m	0.2m	0.3m
Date	########	########	########	########	########	########	11/02/2021	11/02/2021	29/03/2021	07/04/2021	09/04/2021	09/04/2021	15/03/2021	06/04/2021	01/04/2021	23/03/2021	18/03/2021	18/03/2021	30/04/2021	16/03/2021	18/05/2021
Strata	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Diethyl Phthalate												<0.5							<0.5		
4-Nitroaniline												<0.5							<0.5		
2-Methyl-4,6-Dinitrophenol												<0.5							<0.5		
Azobenzene												<0.5							<0.5		
4-Bromophenylphenyl Ether												<0.5							<0.5		
Hexachlorobenzene												<0.5							<0.5		
Pentachlorophenol												<0.5							<0.5		
Phenanthrene												2							11		
Anthracene												<0.5							2.8		
Carbazole												<0.5							0.99		
Di-N-Butyl Phthalate												<0.5							<0.5		
Fluoranthene												4.6							13		
Pyrene												4							11		
Butylbenzyl Phthalate												<0.5							<0.5		
Benzo[a]anthracene												2.2							5.2		
Chrysene												2.3							5.6		
Bis(2-Ethylhexyl)Phthalate												<0.5							<0.5		
Di-N-Octyl Phthalate												<0.5							<0.5		
Benzo[b]fluoranthene												2.7							5.9		
Benzo[k]fluoranthene												0.91							2.1		
Benzo[a]pyrene												2.1							5		
Indeno(1,2,3-c,d)Pyrene												0.98							2.7		
Dibenz(a,h)Anthracene												<0.5							0.68		
Benzo[g,h,i]perylene												1							3.3		
PCB 28																			<0.01		
PCB 52																			<0.01		
PCB 90+101																			<0.01		
PCB 118																			<0.01		
PCB 153																			<0.01		
PCB 138																			<0.01		
PCB 180																			<0.01		
Total PCBs (7 Congeners)																			<0.1		

ATKINS

Assessment Criteria :	Drinking Water Standard England and Wales/WHO			
CaCO (mg/l): 0.00	pH 0.00			
Calcium (mg/l): 0.00	DOC (mg/l) 0.00	Catchment area:	Freshwater not listed	

Constituents	Unit	Limit of Detection	Generic Assessment Criteria	Number of Samples	Minimum Value	Maximum Value	Number of Exceedences	Locations of Exceedences
pH		N/A	6.5-9.5	14	7.5	9.7	1	BH547, 1150778, SOILm
Chloride	mg/l	1	250	14	1.4	8.9	0	
Ammonia (Total ammonia as N)	mg/l	0.05	0.39	14	<0.05	0.16	0	
Nitrite	mg/l	0.02	0.5	14	<0.02	0.19	0	
Nitrate	mg/l	0.5	50	14	<0.5	39	0	
Sulphate	mg/l	1	250	14	<1	71	0	
Cyanide (Total)	mg/l	0.05	0.05	14	<0.05	0.07	1	BH511, 1169560, SOILm
Arsenic (Dissolved)	mg/l	0.0002	0.01	14	<0.0002	0.028	1	BH541, 1148737, SOILm
Boron	mg/l	0.01	1	14	0.01	0.078	0	
Cadmium (Dissolved)	mg/l	0.00012	0.005	14	<<0.00008	<0.00012	0	
Chromium	mg/l	0.0005	0.05	14	<0.0005	0.042	0	
Copper (Dissolved)	mg/l	0.0005	2	14	<0.0005	0.019	0	
Nickel (Dissolved)	mg/l	0.0005	0.02	14	<0.0005	0.02	0	
Lead (Dissolved)	mg/l	0.0005	0.01	14	<0.0005	0.022	2	BH541, 1148737, SOILm; BH510, 1171660, SOILm
Selenium (Dissolved)	mg/l	0.0005	0.01	14	<0.0005	0.0029	0	
Zinc (Dissolved)	mg/l	0.003	3	14	<0.003	0.028	0	
Mercury	mg/l	0.00001	0.001	14	<0.00001	0.00059	0	
Chromium (Hexavalent)	mg/l	0.02	See Total Chromium	14	<0.02	<0.02	0	
Naphthalene	mg/l	0.00001	See BaP	14	<0.00001	<0.00001	0	
Acenaphthylene	mg/l	0.00001	See BaP	14	<0.00001	<0.00001	0	
Acenaphthene	mg/l	0.00001	See BaP	14	<0.00001	<0.00001	0	
Fluorene	mg/l	0.00001	See BaP	14	<0.00001	<0.00001	0	
Phenanthrene	mg/l	0.00001	See BaP	14	<0.00001	<0.00001	0	
Anthracene	mg/l	0.00001	See BaP	14	<0.00001	<0.00001	0	
Fluoranthene	mg/l	0.00001	See BaP	14	<0.00001	<0.00001	0	
Pyrene	mg/l	0.00001	See BaP	14	<0.00001	<0.00001	0	
Benzo[a]anthracene	mg/l	0.00001	See BaP	14	<0.00001	<0.00001	0	
Chrysene	mg/l	0.00001	See BaP	14	<0.00001	<0.00001	0	
Benzo[b]fluoranthene	mg/l	0.00001	See PAH Sum of 4	14	<0.00001	<0.00001	0	
Benzo[k]fluoranthene	mg/l	0.00001	See PAH Sum of 4	14	<0.00001	<0.00001	0	
Benzo[a]pyrene	mg/l	0.00001	0.00001	14	<0.00001	<0.00001	0	
Indeno(1,2,3-c,d)Pyrene	mg/l	0.00001	See PAH Sum of 4	14	<0.00001	<0.00001	0	
Dibenz(a,h)Anthracene	mg/l	0.00001	See BaP	14	<0.00001	<0.00001	0	
Benzo[g,h,i]perylene	mg/l	0.00001	See PAH Sum of 4	14	<0.00001	<0.00001	0	
Total Of 16 PAH's	mg/l	0.0002	No WSV	14	<0.0002	<0.0002	0	
Phenol	mg/l	0.03	0.05	14	<0.03	0.055	1	WS537, 1170652, SOILm

Location	WS537	BH511	BH516	BH533	BH538	BH508	BH547	BH541	BH527A	BH519	BH518	BH510	TP503	BH514A
Sample ID	1170652	1169560	1160495	1160498	1159980	1156602	1150778	1148737	1147492	1142072	1141480	1171660	1175742	1194592
Depth	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm
Date	30/03/2021	25/03/2021	11/03/2021	10/03/2021	12/03/2021	05/03/2021	25/02/2021	23/02/2021	19/02/2021	15/02/2021	11/02/2021	29/03/2021	06/04/2021	30/04/2021
Strata	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Zone														
pH	7.5	8	8.1	7.8	8.5	8.1	9.7	8.5	8.1	8.3	8.4	7.6	8.4	9
Chloride	3.4	5.8	8.9	2.2	2.5	1.4	6.2	2.4	6.8	4.2	3	6.8	2.5	6.4
Ammonia (Total ammonia as N)	<0.05	<0.05	0.1	<0.05	<0.05	<0.05	0.16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.13
Nitrite	0.025	<0.02	0.088	0.14	0.1	<0.02	0.056	<0.02	0.083	0.044	0.064	0.066	0.026	0.19
Nitrate	<0.5	3.5	4.5	1.4	<0.5	<0.5	1.8	<0.5	3.1	2.2	22	2.6	<0.5	39
Sulphate	71	39	27	3.4	7.1	3.2	7.9	12	5.4	<1	11	10	6.9	9.7
Cyanide (Total)	<0.05	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Arsenic (Dissolved)	0.0019	0.0029	0.0012	0.00048	<0.0002	0.00075	0.002	0.028	0.00067	<0.001	0.0021	0.0078	0.0015	0.0035
Boron	0.037	0.045	0.035	0.011	0.013	0.011	0.01	0.078	0.016	<0.02	<0.02	0.023	0.035	0.038
Cadmium (Dissolved)	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00008	<0.00008	<0.00008	<0.00012	<0.00012	<0.00011
Chromium	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0011	0.021	0.0034	<0.001	<0.001	0.0012	<0.0005	0.042
Copper (Dissolved)	0.0064	0.0038	0.0033	0.0044	<0.0005	0.0062	0.01	0.004	0.0048	0.0024	0.0065	0.019	0.0017	0.012
Nickel (Dissolved)	0.0018	0.0013	0.0012	0.0028	<0.0005	0.0011	0.0019	0.00063	0.0023	0.0024	<0.001	0.002	<0.0005	0.02
Lead (Dissolved)	<0.0005	0.00058	0.00055	<0.0005	<0.0005	<0.0005	0.0049	0.022	<0.0005	<0.001	0.0084	0.019	<0.0005	0.0083
Selenium (Dissolved)	<0.0005	0.0016	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0013	<0.0005	<0.001	0.0029	0.00056	0.0018	0.00056
Zinc (Dissolved)	0.023	0.012	<0.003	<0.003	0.0036	<0.003	0.015	0.028	0.0037	0.0093	0.0071	0.0059	<0.003	0.011
Mercury	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.000012	<0.00001	<0.00001	0.00059	<0.00001	0.000011	<0.00001
Chromium (Hexavalent)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Naphthalene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Acenaphthylene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Acenaphthene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Fluorene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Phenanthrene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Anthracene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Fluoranthene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Pyrene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[a]anthracene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Chrysene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[b]fluoranthene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[k]fluoranthene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[a]pyrene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Indeno(1,2,3-c,d)Pyrene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Dibenz(a,h)Anthracene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[g,h,i]perylene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Total Of 16 PAH's	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Phenol	0.055	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03

Assessment Criteria :	***Freshwater EQS***		
CaCO (mg/l):	**0.00**	**pH**	**0.00**
Calcium (mg/l):	**0.00**	**DOC (mg/l)**	**0.00**
Catchment area:	**Freshwater not listed**		

Constituents	Unit	Limit of Detection	Generic Assessment Criteria	Number of Samples	Minimum Value	Maximum Value	Number of Exceedences	Locations of Exceedences
pH		N/A	6-9	14	7.5	9.7	1	BH547, 1150778, SOILm
Chloride	mg/l	1	250	14	1.4	8.9	0	
Ammonia (Total ammonia as N)	mg/l	0.05	0.2	14	<0.05	0.16	0	
Nitrite	mg/l	0.02	0.01	14	<0.02	0.19	11	WS537, 1170652, SOILm; BH516, 1160495, SOILm; BH533, 1160498, SOILm; BH538, 1159980, SOILm; BH547, 1150778, SOILm; BH527A, 1147492, SOILm; BH519, 1142072, SOILm; BH518, 1141480, SOILm; BH510, 1171660, SOILm; TP503, 1175742, SOILm; BH514A, 1194592, SOILm
Nitrate	mg/l	0.5	N/A	14	<0.5	39	0	
Sulphate	mg/l	1	400	14	<1	71	0	
Cyanide (Total)	mg/l	0.05	N/A	14	<0.05	0.07	0	
Arsenic (Dissolved)	mg/l	0.0002	0.05	14	<0.0002	0.028	0	
Boron	mg/l	0.01	2	14	0.01	0.078	0	
Cadmium (Dissolved)	mg/l	0.00012	0.00008	14	<<0.00008	<0.00012	0	
Chromium	mg/l	0.0005	See Cr VI as first pass	14	<0.0005	0.042	0	
Copper (Dissolved)	mg/l	0.0005	0.001	14	<0.0005	0.019	13	WS537, 1170652, SOILm; BH511, 1169560, SOILm; BH516, 1160495, SOILm; BH533, 1160498, SOILm; BH508, 1156602, SOILm; BH547, 1150778, SOILm; BH541, 1148737, SOILm; BH527A, 1147492, SOILm; BH519, 1142072, SOILm; BH518, 1141480, SOILm; BH510, 1171660, SOILm; TP503, 1175742, SOILm; BH514A, 1194592, SOILm
Nickel (Dissolved)	mg/l	0.0005	0.004	14	<0.0005	0.02	1	BH514A, 1194592, SOILm
Lead (Dissolved)	mg/l	0.0005	0.0012	14	<0.0005	0.022	5	BH547, 1150778, SOILm; BH541, 1148737, SOILm; BH518, 1141480, SOILm; BH510, 1171660, SOILm; BH514A, 1194592, SOILm
Selenium (Dissolved)	mg/l	0.0005	N/A	14	<0.0005	0.0029	0	
Zinc (Dissolved)	mg/l	0.003	0.0123	14	<0.003	0.028	3	WS537, 1170652, SOILm; BH547, 1150778, SOILm; BH541, 1148737, SOILm
Mercury	mg/l	0.00001	0.00007	14	<0.00001	0.00059	1	BH518, 1141480, SOILm
Chromium (Hexavalent)	mg/l	0.02	0.0034	14	<0.02	<0.02	0	
Naphthalene	mg/l	0.00001	0.002	14	<0.00001	<0.00001	0	
Acenaphthylene	mg/l	0.00001	Screen BaP only	14	<0.00001	<0.00001	0	
Acenaphthene	mg/l	0.00001	Screen BaP only	14	<0.00001	<0.00001	0	
Fluorene	mg/l	0.00001	N/A	14	<0.00001	<0.00001	0	
Phenanthrene	mg/l	0.00001	Screen BaP only	14	<0.00001	<0.00001	0	
Anthracene	mg/l	0.00001	0.0001	14	<0.00001	<0.00001	0	
Fluoranthene	mg/l	0.00001	0.0000063	14	<0.00001	<0.00001	0	
Pyrene	mg/l	0.00001	N/A	14	<0.00001	<0.00001	0	
Benzo[a]anthracene	mg/l	0.00001	Screen BaP only	14	<0.00001	<0.00001	0	
Chrysene	mg/l	0.00001	Screen BaP only	14	<0.00001	<0.00001	0	
Benzo[b]fluoranthene	mg/l	0.00001	Screen BaP only	14	<0.00001	<0.00001	0	
Benzo[k]fluoranthene	mg/l	0.00001	Screen BaP only	14	<0.00001	<0.00001	0	
Benzo[a]pyrene	mg/l	0.00001	0.00000017	14	<0.00001	<0.00001	0	
Indeno(1,2,3-c,d)Pyrene	mg/l	0.00001	Screen BaP only	14	<0.00001	<0.00001	0	
Dibenz(a,h)Anthracene	mg/l	0.00001	N/A	14	<0.00001	<0.00001	0	
Benzo[g,h,i]perylene	mg/l	0.00001	Screen BaP only	14	<0.00001	<0.00001	0	
Total Of 16 PAH's	mg/l	0.0002	No WSV	14	<0.0002	<0.0002	0	
Phenol	mg/l	0.03	0.0077	14	<0.03	0.055	1	WS537, 1170652, SOILm

Location	WS537	BH511	BH516	BH533	BH538	BH508	BH547	BH541	BH527A	BH519	BH518	BH510	TP503	BH514A
Sample ID	1170652	1169560	1160495	1160498	1159980	1156602	1150778	1148737	1147492	1142072	1141480	1171660	1175742	1194592
Depth	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm	SOILm
Date	30/03/2021	25/03/2021	11/03/2021	10/03/2021	12/03/2021	05/03/2021	25/02/2021	23/02/2021	19/02/2021	15/02/2021	11/02/2021	29/03/2021	06/04/2021	30/04/2021
Strata	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Zone														
pH	7.5	8	8.1	7.8	8.5	8.1	9.7	8.5	8.1	8.3	8.4	7.6	8.4	9
Chloride	3.4	5.8	8.9	2.2	2.5	1.4	6.2	2.4	6.8	4.2	3	6.8	2.5	6.4
Ammonia (Total ammonia as N)	<0.05	<0.05	0.1	<0.05	<0.05	<0.05	0.16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.13
Nitrite	0.025	<0.02	0.088	0.14	0.1	<0.02	0.056	<0.02	0.083	0.044	0.064	0.066	0.026	0.19
Nitrate	<0.5	3.5	4.5	1.4	<0.5	<0.5	1.8	<0.5	3.1	2.2	22	2.6	<0.5	39
Sulphate	71	39	27	3.4	7.1	3.2	7.9	12	5.4	<1	11	10	6.9	9.7
Cyanide (Total)	<0.05	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Arsenic (Dissolved)	0.0019	0.0029	0.0012	0.00048	<0.0002	0.00075	0.002	0.028	0.00067	<0.001	0.0021	0.0078	0.0015	0.0035
Boron	0.037	0.045	0.035	0.011	0.013	0.011	0.01	0.078	0.016	<0.02	<0.02	0.023	0.035	0.038
Cadmium (Dissolved)	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00008	<0.00008	<0.00008	<0.00012	<0.00012	<0.00011
Chromium	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0011	0.021	0.0034	<0.001	<0.001	0.0012	<0.0005	0.042
Copper (Dissolved)	0.0064	0.0038	0.0033	0.0044	<0.0005	0.0062	0.01	0.004	0.0048	0.0024	0.0065	0.019	0.0017	0.012
Nickel (Dissolved)	0.0018	0.0013	0.0012	0.0028	<0.0005	0.0011	0.0019	0.00063	0.0023	0.0024	<0.001	0.002	<0.0005	0.02
Lead (Dissolved)	<0.0005	0.00058	0.00055	<0.0005	<0.0005	<0.0005	0.0049	0.022	<0.0005	<0.001	0.0084	0.019	<0.0005	0.0083
Selenium (Dissolved)	<0.0005	0.0016	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0013	<0.0005	<0.001	0.0029	0.00056	0.0018	0.00056
Zinc (Dissolved)	0.023	0.012	<0.003	<0.003	0.0036	<0.003	0.015	0.028	0.0037	0.0093	0.0071	0.0059	<0.003	0.011
Mercury	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.000012	<0.00001	<0.00001	0.00059	<0.00001	0.000011	<0.00001
Chromium (Hexavalent)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Naphthalene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Acenaphthylene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Acenaphthene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Fluorene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Phenanthrene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Anthracene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Fluoranthene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Pyrene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[a]anthracene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Chrysene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[b]fluoranthene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[k]fluoranthene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[a]pyrene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Indeno(1,2,3-c,d)Pyrene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Dibenz(a,h)Anthracene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[g,h,i]perylene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Total Of 16 PAH's	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Phenol	0.055	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03

ATKINS CatWasteSoil

Classification Assessment Tool of Soil Wastes - Hazard Summary Sheet

Site Name	A57
Location	Mottram
Site ID	
Job Number	5201114
Date	6/29/2021
User Name	lucy.rutland@atkinsglobal.com
Company Name	Atkins

Hole ID	Sample Depth	Hazardous Waste Y/N	HP1	HP2	HP3	HP4	HP5	HP6	HP7	HP8	HP9	HP10	HP11	HP12	HP13	HP14	HP15	HP16
TP505	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
WS537	0.8m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
WS505	0.2m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
WS503	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH511	0.2m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH509	4m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH506	0.50m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH516	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH544	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH533	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH538	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH508	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH539	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH548	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH547	0.4m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH540	0.3m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH541	0.4m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH527A	0.2m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH525	0.15m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH551	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH526	4.2m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH549	0.2m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH522	0.4m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH519	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH517	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH518	0.2m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH520	0.55m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH524	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH510	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
TP501	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH502	0.2m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH512	0.2m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH545	1m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
TP503	0.9m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
TP504	0.6m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH536	0.4m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
TP505	0.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
WS537	1.2m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
WS505	0.3m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
WS503	0.2m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
BH511	0.3m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No

Assessment Criteria :	Drinking Water Standard England and Wales/WHO		
CaCO (mg/l)	0.00	pH	8.40
Calcium (mg/l)	28.00	DOC (mg/l)	0.00
Catchment area:	Freshwater not listed		

Constituents	Unit	Limit of Detection	Generic Assessment Criteria	Number of Samples	Minimum Value	Maximum Value	Number of Exceedences	Locations of Exceedences
pH		N/A	6.5-9.5	81	6.4	9.4	1	BH509, 13.0m
Electrical Conductivity	µS/cm	1	No WSV	81	60	26000	0	
Biochemical Oxygen Demand	mg O2/l	4	No WSV	81	4	41	0	
Chemical Oxygen Demand	mg O2/l	10	No WSV	81	10	160	0	
Redox Potential	mV	N/A	No WSV	81	0	100	0	
Alkalinity (Bicarbonate)	mg CaCO3/l	10	No WSV	81	33	660	0	
Chloride	mg/l	1	250	81	1.9	12000	5	BH513, 22m; BH509, 13.0m; BH506(S), 3.9m; BH509, 12.00m; BH506A(S), 4.00m
Ammonia (Total ammonia as N)	mg/l	0.05	0.39	81	<0.05	0.59	2	BH514A(D), 16.00m; BH519A, 23.55m
Ammonium	mg/l	0.05	0.5	81	<0.05	4.1	41	BH536 (D), 7.5m; BH503, 15m; BH519A, 23.55m; BH520, 7m; BH547A, 5.0m; BH545(D), 10.5m; BH509, 13.0m; BH506(S), 3.9m; BH514A, 18.0m; BH515(S), .5m; BH515(d), 14.5m; BH536, 7m; BH501, 14.5m; BH503, 15.5m; bh513, 24m; bh515, 8m; bh511, 9m; BH514A, 18m; BH515, 9.5m; BH515, 14.5m; BH518, 22m; BH535, 6.5m; BH535, 10.5m; BH519A, 23.55m; BH539, 8.5m; 547A, 4.00m; 503, 16.00m; 502, 3.00m; 501, 23.55m; 535(S), 5.50m; 535(D), 11.00m; 536(S), 5.00m; 536(D), 7.00m; BH515 (D), 15.00m; BH515 (S), 10.00m; BH516, 22.00m; BH509, 12.00m; BH506A(S), 4.00m; BH511, 9.50m; BH514A(D), 16.00m; BH519A, 23.55m
Ammoniacal Nitrogen	mg/l	0.05	0.39	81	<0.05	3.2	43	BH536 (D), 7.5m; BH503, 15m; BH519A, 23.55m; BH520, 7m; BH547A, 5.0m; BH545(D), 10.5m; BH509, 13.0m; BH506(S), 3.9m; BH514A, 18.0m; BH515(S), .5m; BH515(d), 14.5m; BH516, 23.0m; BH536, 7m; BH501, 14.5m; BH503, 15.5m; bh513, 24m; bh515, 8m; bh511, 9m; BH514A, 18m; BH515, 9.5m; BH515, 14.5m; BH518, 22m; BH549, 8.5m; BH535, 6.5m; BH535, 10.5m; BH519A, 23.55m; BH539, 8.5m; 547A, 4.00m; 503, 16.00m; 502, 3.00m; 501, 23.55m; 535(S), 5.50m; 535(D), 11.00m; 536(S), 5.00m; 536(D), 7.00m; BH515 (D), 15.00m; BH515 (S), 10.00m; BH516, 22.00m; BH509, 12.00m; BH506A(S), 4.00m; BH511, 9.50m; BH514A(D), 16.00m; BH519A, 23.55m
Nitrite	mg/l	0.02	0.5	81	0.02	4.4	8	BH516, 23.0m; BH518, 22m; BH520, 24m; BH550A, 8m; BH547, 4m; BH545, 22m; BH541, 4m; BH540, 8m
Nitrate	mg/l	0.5	50	81	<0.5	15	0	
Sulphate	mg/l	1	250	81	<1	410	2	BH535, 10.5m; 535(D), 11.00m
Cyanide (Total)	mg/l	0.05	0.05	81	<0.05	0.1	1	BH535, 10.5m
Cyanide (Free)	mg/l	0.05	See Cyanide (total)	81	<0.05	0.09	0	
Cyanide (Complex)	mg/l	0.05	0.05	81	<0.05	<0.05	0	
Sulphide	mg/l	0.05	No WSV	81	<0.05	<0.05	0	
Nitrogen (Total Dissolved)	mg/l	1	No WSV	81	<1	17	0	
Calcium	mg/l	2	N/A	81	4.8	2500	0	
Potassium	mg/l	0.5	N/A	81	1.2	23	0	
Magnesium	mg/l	0.2	N/A	81	0.85	160	0	
Sodium	mg/l	1.5	200	81	1.9	5200	5	BH509, 13.0m; BH506(S), 3.9m; BH535, 10.5m; BH539, 8.5m; BH509, 12.00m
Arsenic (Dissolved)	mg/l	0.0002	0.01	81	<0.0002	0.03	2	BH539, 8.5m; 502, 3.00m
Boron (Dissolved)	mg/l	0.01	No WSV	81	<0.01	0.9	0	
Cadmium (Dissolved)	mg/l	0.00011	0.005	81	0.00011	0.0019	0	
Copper (Dissolved)	mg/l	0.0005	2	81	<0.0005	0.17	0	
Iron (Dissolved)	mg/l	0.005	0.2	81	0.005	53	9	BH509, 13.0m; BH506(S), 3.9m; BH501, 14.5m; BH535, 6.5m; BH536, 4m; BH539, 8.5m; BH544 (S), 4.5m; BH509, 12.00m; BH506A(S), 4.00m
Manganese	mg/l	0.0005	0.05	81	0.0033	2.8	1	BH519A , 8m
Nickel (Dissolved)	mg/l	0.0005	0.02	81	<0.0005	0.095	3	BH509, 13.0m; BH539, 8.5m; BH509, 12.00m
Lead (Dissolved)	mg/l	0.0005	0.01	81	<0.0005	0.13	2	BH539, 8.5m; BH544 (S), 4.5m
Selenium (Dissolved)	mg/l	0.0005	0.01	81	<0.0005	0.017	2	BH506(S), 3.9m; BH539, 8.5m
Vanadium (Dissolved)	mg/l	0.0005	No WSV	81	<0.0005	0.043	0	
Zinc (Dissolved)	mg/l	0.0025	3	81	<0.0025	0.23	0	
Chromium (Total)	mg/l	0.0005	0.05	81	<0.0005	0.023	0	
Mercury	mg/l	0.00001	0.001	81	<0.00001	<0.00001	0	
Chromium (Hexavalent)	mg/l	0.02	See Total Chromium	81	<0.02	<0.02	0	
Total Organic Carbon	mg/l	2	No WSV	81	2	200	0	
Aliphatic TPH >C5-C6	mg/l	0.0001	15	81	<0.0001	<0.0001	0	
Aliphatic TPH >C6-C8	mg/l	0.0001	15	81	<0.0001	<0.0001	0	
Aliphatic TPH >C8-C10	mg/l	0.0001	0.3	81	<0.0001	<0.0001	0	
Aliphatic TPH >C10-C12	mg/l	0.0001	0.3	81	<0.0001	<0.0001	0	
Aliphatic TPH >C12-C16	mg/l	0.0001	0.3	81	<0.0001	<0.0001	0	
Aliphatic TPH >C16-C21	mg/l	0.0001	N/A	81	<0.0001	<0.0001	0	
Aliphatic TPH >C21-C35	mg/l	0.0001	N/A	81	<0.0001	<0.0001	0	
Aliphatic TPH >C35-C44	mg/l	0.0001	N/A	81	<0.0001	<0.0001	0	
Total Aliphatic Hydrocarbons	mg/l	0.005	No WSV	81	<0.005	<0.005	0	
Aromatic TPH >C5-C7	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Aromatic TPH >C7-C8	mg/l	0.0001	0.7	81	<0.0001	<0.0001	0	
Aromatic TPH >C8-C10	mg/l	0.0001	0.3	81	<0.0001	<0.0001	0	
Aromatic TPH >C10-C12	mg/l	0.0001	0.09	81	<0.0001	<0.0001	0	
Aromatic TPH >C12-C16	mg/l	0.0001	0.09	81	<0.0001	<0.0001	0	
Aromatic TPH >C16-C21	mg/l	0.0001	0.09	81	<0.0001	<0.0001	0	
Aromatic TPH >C21-C35	mg/l	0.0001	0.09	81	<0.0001	<0.0001	0	
Aromatic TPH >C35-C44	mg/l	0.0001	N/A	81	<0.0001	<0.0001	0	
Total Aromatic Hydrocarbons	mg/l	0.005	No WSV	81	<0.005	<0.005	0	
Total Petroleum Hydrocarbons	mg/l	0.01	No WSV	81	<0.01	<0.01	0	
Dichlorodifluoromethane	mg/l	0.001	No WSV	81	<0.00001	0.0039	0	
Chloromethane	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0	
Vinyl Chloride	mg/l	0.001	0.0005	81	<<0.00001	<0.001	0	
Bromomethane	mg/l	0.005	No WSV	81	<<0.00001	<0.005	0	
Chloroethane	mg/l	0.002	No WSV	81	<<0.00001	<0.002	0	
Trichlorofluoromethane	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0	
1,1-Dichloroethene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0	
Trans 1,2-Dichloroethene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0	
1,1-Dichloroethane	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0	
cis 1,2-Dichloroethene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0	
Bromochloromethane	mg/l	0.005	No WSV	81	<<0.00001	<0.005	0	
Trichloromethane	mg/l	0.001	See Trihalomethanes	81	<<0.00001	<0.001	0	
1,1,1-Trichloroethane	mg/l	0.001	N/A	81	<<0.00001	<0.001	0	
Tetrachloromethane	mg/l	0.001	0.004	81	<<0.00001	<0.001	0	
1,1-Dichloropropene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0	
Benzene	mg/l	0.001	0.001	81	<<0.00001	<0.001	0	
1,2-Dichloroethane	mg/l	0.002	0.003	81	<0.0002	0.0039	1	BH541, 4m
Trichloroethene	mg/l	0.001	0.01 (sum of TCE & PCE)	81	<0.001	<0.001	0	
1,2-Dichloropropane	mg/l	0.001	0.04	81	<0.001	<0.001	0	
Dibromomethane	mg/l	0.01	No WSV	81	<<0.001	<0.01	0	
Bromodichloromethane	mg/l	0.005	See Trihalomethanes	81	<0.005	<0.005	0	
cis-1,3-Dichloropropene	mg/l	0.01	No WSV	81	<<0.002	<0.01	0	
Toluene	mg/l	0.001	0.7	81	<0.001	<0.001	0	
Trans-1,3-Dichloropropene	mg/l	0.01	No WSV	81	<<0.001	<0.01	0	
1,1,2-Trichloroethane	mg/l	0.01	N/A	81	<<0.001	<0.01	0	
Tetrachloroethene	mg/l	0.001	0.01 (sum of TCE & PCE)	81	<0.001	<0.001	0	
1,3-Dichloropropane	mg/l	0.002	No WSV	81	<<0.001	<0.002	0	
Dibromochloromethane	mg/l	0.01	See Trihalomethanes	81	<<0.005	<0.01	0	
1,2-Dibromoethane	mg/l	0.005	0.0004	81	<0.001	0.017	3	BH520, 7m; BH525(S), 5m; BH549, 8m
Chlorobenzene	mg/l	0.001	N/A	81	<0.001	<0.001	0	
1,1,1,2-Tetrachloroethane	mg/l	0.002	No WSV	81	<<0.001	<0.002	0	
Ethylbenzene	mg/l	0.001	0.3	81	<0.001	<0.001	0	
m & p-Xylene	mg/l	0.001	See Xylenes (total)	81	<0.001	<0.001	0	
o-Xylene	mg/l	0.001	See Xylenes (total)	81	<0.001	<0.002	0	
Styrene	mg/l	0.001	0.02	81	<0.001	<0.001	0	
Tribromomethane	mg/l	0.001	No WSV	81	<0.001	<0.001	0	
Isopropylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.01	0	
Bromobenzene	mg/l	0.001	No WSV	81	<0.001	<0.005	0	
1,2,3-Trichloropropane	mg/l	0.05	No WSV	81	<<0.01	<0.05	0	
N-Propylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0	
2-Chlorotoluene	mg/l	0.001	No WSV	81	<0.001	<0.01	0	
1,3,5-Trimethylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.01	0	
4-Chlorotoluene	mg/l	0.001	No WSV	81	<0.001	<0.001	0	
Tert-Butylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.002	0	
1,2,4-Trimethylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.01	0	
Sec-Butylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.005	0	
1,3-Dichlorobenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0	
4-Isopropyltoluene	mg/l	0.001	No WSV	81	<0.001	<0.002	0	
1,4-Dichlorobenzene	mg/l	0.001	0.3	81	<0.001	<0.001	0	
N-Butylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0	
1,2-Dichlorobenzene	mg/l	0.001	1	81	<0.001	<0.001	0	
1,2-Dibromo-3-Chloropropane	mg/l	0.05	0.001	81	<<0.001	<0.05	0	
1,2,4-Trichlorobenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0	
Hexachlorobutadiene	mg/l	0.001	0.0006	81	<0.001	<0.001	0	
1,2,3-Trichlorobenzene	mg/l	0.002	No WSV	81	<<0.001	<0.002	0	
Methyl Tert-Butyl Ether	mg/l	0.001	No WSV	81	<0.001	<0.05	0	
Naphthalene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0	
Acenaphthylene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0	
Acenaphthene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0	
Fluorene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0	
Phenanthrene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0	
Anthracene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0	
Fluoranthene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0	
Pyrene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0	
Benzo[a]anthracene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0	
Chrysene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0	
Benzo[b]fluoranthene	mg/l	0.00001	See PAH Sum of 4	81	<0.00001	<0.001	0	
Benzo[k]fluoranthene	mg/l	0.00001	See PAH Sum of 4	81	<0.00001	<0.001	0	
Benzo[a]pyrene	mg/l	0.00001	0.00001	81	<0.00001	<0.05	0	
Indeno(1,2,3-c,d)Pyrene	mg/l	0.00001	See PAH Sum of 4	81	<0.00001	<0.001	0	
Dibenz(a,h)Anthracene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0	
Benzo[g,h,i]perylene	mg/l	0.00001	See PAH Sum of 4	81	<0.00001	<0.002	0	
Total Of 16 PAH's	mg/l	0.0002	No WSV	81	<0.0002	<0.001	0	
Phenol	mg/l	0.03	0.05	81	<0.03	<0.03	0	
Suspended Solids at 105	mg/l	5	No WSV	81	9	13000	0	

Assessment Criteria :	Drinking Water Standard England and Wales/WHO							
CaCO (mg/l): 0.00		pH 8.40						
Calcium (mg/l): 29.00		DOC (mg/l) 0.00				Catchment area:	Freshwater not listed	

Constituents	Unit	Limit of Detection	Generic Assessment Criteria	Number of Samples	Minimum Value	Maximum Value	Number of Exceedences	Locations of Exceedences	525(D)	547A	BH545(D)	503	502	501	535(S)	535(D)	536(S)	536(D)	BH515 (D)	BH515 (S)	BH516	BH509	BH506A(S)	BH511	BH514A(D)	BH519A	BH524A
									11.00m	4.00m	22.00m	16.00m	3.00m	23.55m	5.50m	11.00m	5.00m	7.00m	15.00m	10.00m	22.00m	12.00m	4.00m	9.50m	16.00m	23.55m	13.00m
									13/07/2021	13/07/2021	13/07/2021	13/07/2021	13/07/2021	13/07/2021	13/07/2021	13/07/2021	13/07/2021	13/07/2021	12/07/2021	12/07/2021	12/07/2021	12/07/2021	12/07/2021	12/07/2021	12/07/2021	12/07/2021	
pH		N/A	6.5-9.5	81	6.4	9.4	1	BH509, 13.0m	8.8	8.6	8.6	8.8	8.7	8.6	8.6	8.5	8.5	8.4	8.6	8.7	8.7	7.4	8.2	8.6	8.8	8.8	8.5
Electrical Conductivity	µS/cm	1	No WSV	81	60	26000	0		270	400	540	470	560	450	460	1200	670	660	440	470	310	26000	4300	1200	60	490	570
Biochemical Oxygen Demand	mg O2/l	4	No WSV	81	4	41	0		<4	<4	<4	<4	34	9	<4	8	<4	<4	<4	<4	4	32	<4	<4	<4	<4	<4
Chemical Oxygen Demand	mg O2/l	10	No WSV	81	10	160	0		17	20	19	15	140	43	17	33	22	22	14	14	23	130	28	15	<10	10	<10
Redox Potential	mV	N/A	No WSV	81	0	100	0		43	46	35	42	56	65	68	70	63	71	65	68	62	0	7.8	3.8	6.7	40	70
Alkalinity (Bicarbonate)	mg CaCO3/l	10	No WSV	81	33	660	0		83	320	320	240	430	350	270	410	250	400	180	200	210	110	320	210	180	230	290
Chloride	mg/l	1	250	81	1.9	12000	5	BH513, 22m; BH509, 13.0m; BH506(S), 3.9m; BH509, 12.00m; BH506A(S), 4.00m	13	30	10	220	23	14	15	22	62	12	22	22	17	11000	380	180	25	15	22
Ammonia (Total ammonia as N)	mg/l	0.05	0.39	81	<0.05	0.59	2	BH514A(D), 16.00m; BH519A, 23.55m	<0.05	0.087	0.058	0.15	0.22	0.25	0.28	0.18	0.24	0.19	0.3	0.3	0.3	<0.05	0.1	0.26	0.59	0.44	<0.05
Ammonium	mg/l	0.05	0.5	81	<0.05	4.1	41	BH536 (D), 7.5m; BH503, 15m; BH519A, 23.55m; BH520, 7m; BH547A, 5.0m; BH545(D), 10.5m; BH509, 13.0m; BH506(S), 3.9m; BH514A, 18.0m; BH515(S), .5m; BH515(d), 14.5m; BH536, 7m; BH501, 14.5m; BH503, 15.5m; bh513, 24m; bh515, 8m; bh511, 9m; BH514A, 18m; BH515, 9.5m; BH515, 14.5m; BH518, 22m; BH535, 6.5m; BH535, 10.5m; BH519A, 23.55m; BH539, 8.5m; 547A, 4.00m; 503, 16.00m; 502, 3.00m; 501, 23.55m; 535(S), 5.50m; 535(D), 11.00m; 536(S), 5.00m; 536(D), 7.00m; BH515 (D), 15.00m; BH515 (S), 10.00m; BH516, 22.00m; BH509, 12.00m; BH506A(S), 4.00m; BH511, 9.50m; BH514A(D), 16.00m; BH519A, 23.55m	0.19	0.55	0.24	0.61	1.1	1.5	1.6	1.4	1.6	1.7	1.6	1.3	1.3	2.3	1.6	1.6	2	1.5	0.27
Ammoniacal Nitrogen	mg/l	0.05	0.39	81	<0.05	3.2	43	BH536 (D), 7.5m; BH503, 15m; BH519A, 23.55m; BH520, 7m; BH547A, 5.0m; BH545(D), 10.5m; BH509, 13.0m; BH506(S), 3.9m; BH514A, 18.0m; BH515(S), .5m; BH515(d), 14.5m; BH516, 23.0m; BH536, 7m; BH501, 14.5m; BH503, 15.5m; bh513, 24m; bh515, 8m; bh511, 9m; BH514A, 18m; BH515, 9.5m; BH515, 14.5m; BH518, 22m; BH549, 8.5m; BH535, 6.5m; BH535, 10.5m; BH519A, 23.55m; BH539, 8.5m; 547A, 4.00m; 503, 16.00m; 502, 3.00m; 501, 23.55m; 535(S), 5.50m; 535(D), 11.00m; 536(S), 5.00m; 536(D), 7.00m; BH515 (D), 15.00m; BH515 (S), 10.00m; BH516, 22.00m; BH509, 12.00m; BH506A(S), 4.00m; BH511, 9.50m; BH514A(D), 16.00m; BH519A, 23.55m	0.19	0.51	0.24	0.63	1.1	1.4	1.5	1.2	1.5	1.5	1.6	1.3	1.3	1.8	1.3	1.6	2.2	1.8	0.25
Nitrite	mg/l	0.02	0.5	81	0.02	4.4	8	BH516, 23.0m; BH518, 22m; BH520, 24m; BH550A, 8m; BH547, 4m; BH545, 22m; BH541, 4m; BH540, 8m	0.03	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	0.024	0.02	0.044	0.068	0.048	0.022	<0.02	0.024	0.029	<0.02	0.15
Nitrate	mg/l	0.5	50	81	<0.5	15	0		1.3	<0.5	0.96	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sulphate	mg/l	1	250	81	<1	410	2	BH535, 10.5m; 535(D), 11.00m	28	19	43	28	120	11	40	330	45	12	5.5	14	19	110	170	42	30	25	24
Cyanide (Total)	mg/l	0.05	0.05	81	<0.05	0.1	1	BH535, 10.5m	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cyanide (Free)	mg/l	0.05	See Cyanide (total)	81	<0.05	0.09	0		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cyanide (Complex)	mg/l	0.05	0.05	81	<0.05	<0.05	0		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sulphide	mg/l	0.05	No WSV	81	<0.05	<0.05	0		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrogen (Total Dissolved)	mg/l	1	No WSV	81	<1	17	0		3.5	2	2.9	3.9	9.4	4.6	3.5	4	4.4	2.5	5.6	5.3	16	10	12	3.4	2.5	1.3	<1
Calcium	mg/l	2	N/A	81	4.6	2500	0		16	69	20	37	110	75	84	89	83	98	34	35	35	2500	140	83	26	46	50
Potassium	mg/l	0.5	N/A	81	1.2	23	0		1.7	2.4	2.9	2.1	1.2	1.2	1.7	4.1	2.3	2.4	8	7.9	13	11	3.5	2.5	7.7	2.8	3.8
Magnesium	mg/l	0.2	N/A	81	0.85	160	0		7.5	15	14	15	26	23	23	27	26	37	19	20	11	160	37	16	13	26	26
Sodium	mg/l	1.5	200	81	1.9	5200	5	BH509, 13.0m; BH506(S), 3.9m; BH535, 10.5m; BH539, 8.5m; BH509, 12.00m	14	25	72	33	140	48	15	200	33	31	17	24	34	5200	170	77	45	13	15
Arsenic (Dissolved)	mg/l	0.0002	0.01	81	<0.0002	0.03	2	BH539, 8.5m; 502, 3.00m	0.00044	0.0025	0.0028	0.0028	0.013	0.0027	0.0038	0.008	0.0018	0.0049	0.00056	0.0015	0.001	0.00069	0.0025	0.0013	0.00099	0.00029	<0.0002
Boron (Dissolved)	mg/l	0.01	No WSV	81	<0.01	0.9	0		0.057	0.092	0.2	0.06	0.056	0.026	0.028	0.044	0.06	0.58	0.67	0.67	0.9	0.85	0.66	0.51	0.69	0.54	0.064
Cadmium (Dissolved)	mg/l	0.00011	0.005	81	0.00011	0.0019	0		<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011
Copper (Dissolved)	mg/l	0.0005	2	81	<0.0005	0.17	0		0.0032	0.00089	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0012	<0.0005	<0.0005	0.0013	0.0033	<0.0005	<0.0005	0.00061	0.0012	0.0011	0.0017
Iron (Dissolved)	mg/l	0.005	0.2	81	0.005	53	8	BH509, 13.0m; BH506(S), 3.9m; BH501, 14.5m; BH535, 6.5m; BH536, 4m; BH545, 8.5m; BH544 (S), 4.5m; BH509, 12.00m; BH506A(S), 4.00m	<0.005	<0.005	<0.005	<0.005	0.013	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.015	53	0.63	<0.005	<0.005	<0.005	<0.005
Manganese	mg/l	0.0005	0.05	81	0.0033	2.8	1	BH515A, 8m																			
Nickel (Dissolved)	mg/l	0.0005	0.02	81	<0.0005	0.098	3	BH509, 13.0m; BH539, 8.5m; BH509, 12.00m	0.0017	0.0016	0.00085	0.00073	0.003	0.0019	0.0024	0.0061	0.0027	0.0029	0.0011	0.0022	0.002	0.09	0.006	0.0024	0.0013	0.00094	0.0011
Lead (Dissolved)	mg/l	0.0005	0.01	81	<0.0005	0.13	2	BH539, 8.5m; BH544 (S), 4.5m	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Selenium (Dissolved)	mg/l	0.0005	0.01	81	<0.0005	0.017	2	BH506(S), 3.9m; BH539, 8.5m	<0.0005	<0.0005	<0.0005	0.00094	<0.0005	<0.0005	0.0011	0.00067	<0.0005	<0.0005	<0.0005	0.00073	0.0006	<0.0005	0.0024	<0.0005	<0.0005	<0.0005	<0.0005
Vanadium (Dissolved)	mg/l	0.0005	No WSV	81	<0.0005	0.043	0		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Zinc (Dissolved)	mg/l	0.0025	5	81	<0.0025	0.25	0		0.035	0.0042	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	0.011	<0.0025	<0.0025	0.0089	<0.0025	0.062	0.018	<0.0025	<0.0025	<0.0025	0.0086
Chromium (Total)	mg/l	0.0005	0.05	81	<0.0005	0.023	0		0.0065	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0011
Mercury	mg/l	0.00001	0.001	81	<0.00001	<0.00001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Chromium (Hexavalent)	mg/l	0.02	See Total Chromium	81	<0.02	<0.02	0		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Organic Carbon	mg/l	2	No WSV	81	3	200	0		16	47	98	45	150	78	55	86	58	64	38	44	42	48	78	40	34	46	<2
Aliphatic TPH >C5-C6	mg/l	0.0001	15	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aliphatic TPH >C6-C8	mg/l	0.0001	15	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aliphatic TPH >C8-C10	mg/l	0.0001	0.3	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aliphatic TPH >C10-C12	mg/l	0.0001	0.3	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aliphatic TPH >C12-C16	mg/l	0.0001	0.3	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aliphatic TPH >C16-C21	mg/l	0.0001	N/A	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aliphatic TPH >C21-C35	mg/l	0.0001	N/A	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aliphatic TPH >C35-C44	mg/l	0.0001	N/A	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Total Aliphatic Hydrocarbons	mg/l	0.005	No WSV	81	<0.005	<0.005	0		<0.005		<0.005	<0.005							<0.005		<0.005				<0.005		<0.005
Aromatic TPH >C5-C7	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aromatic TPH >C7-C8	mg/l	0.0001	0.7	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aromatic TPH >C8-C10	mg/l	0.0001	0.3	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aromatic TPH >C10-C12	mg/l	0.0001	0.09	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aromatic TPH >C12-C16	mg/l	0.0001	0.09	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aromatic TPH >C16-C21	mg/l	0.0001	0.09	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aromatic TPH >C21-C35	mg/l	0.0001	0.09	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aromatic TPH >C35-C44	mg/l	0.0001	N/A	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Total Aromatic Hydrocarbons	mg/l	0.005	No WSV	81	<0.005	<0.005	0		<0.005		<0.005	<0.005							<0.005		<0.005				<0.005		<0.005
Total Petroleum Hydrocarbons	mg/l	0.01	No WSV	81	<0.01	<0.01	0		<0.01		<0.01	<0.01							<0.01		<0.01				<0.01		<0.01
Dichlorodifluoromethane	mg/l	0.001	No WSV	81	<0.00001	0.0039	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Chloromethane	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Vinyl Chloride	mg/l	0.001	0.0005	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Bromomethane	mg/l	0.005	No WSV	81	<<0.00001	<0.005	0		<0.005		<0.005	<0.005							<0.005		<0.005				<0.005		<0.005
Chloroethane	mg/l	0.002	No WSV	81	<<0.00001	<0.002	0		<0.002		<0.002	<0.002							<0.002		<0.002				<0.002		<0.002
Trichlorofluoromethane	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,1-Dichloroethene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Trans 1,2-Dichloroethene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,1-Dichloroethane	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
cis 1,2-Dichloroethene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Bromochloromethane	mg/l	0.005	No WSV	81	<<0.00001	<0.005	0		<0.005		<0.005	<0.005							<0.005		<0.005				<0.005		<0.005
Trichloromethane	mg/l	0.001	See Trihalomethanes	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,1,1-Trichloroethane	mg/l	0.001	N/A	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Tetrachloromethane	mg/l	0.001	0.004	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,1-Dichloropropene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Benzene	mg/l	0.001	0.001	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,2-Dichloroethane	mg/l	0.002	0.003	81	<0.0002	0.0039	1	BH541, 4m	<0.002		<0.002	<0.002							<0.002		<0.002				<0.002		<0.002
Trichloroethene	mg/l	0.001	0.01 (sum of TCE & PCE)	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,2-Dichloropropane	mg/l	0.001	0.04	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Dibromomethane	mg/l	0.01	No WSV	81	<<0.001	<0.01	0		<0.01		<0.01	<0.01							<0.01		<0.01				<0.01		<0.01
Bromodichloromethane	mg/l	0.005	See Trihalomethanes	81	<0.005	<0.005	0		<0.005		<0.005	<0.005							<0.005		<0.005				<0.005		<0.005
cis-1,3-Dichloropropene	mg/l	0.01	No WSV	81	<<0.002	<0.01	0		<0.01		<0.01	<0.01							<0.01		<0.01				<0.01		<0.01
Toluene	mg/l	0.001	0.7	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Trans-1,3-Dichloropropene	mg/l	0.01	No WSV	81	<<0.001	<0.01	0		<0.01		<0.01	<0.01							<0.01		<0.01				<0.01		<0.01
1,1,2-Trichloroethane	mg/l	0.01	N/A	81	<<0.001	<0.01	0		<0.01		<0.01	<0.01							<0.01		<0.01				<0.01		<0.01
Tetrachloroethene	mg/l	0.001	0.01 (sum of TCE & PCE)	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,3-Dichloropropane	mg/l	0.002	No WSV	81	<<0.001	<0.002	0		<0.002		<0.002	<0.002							<0.002		<0.002				<0.002		<0.002
Dibromochloromethane	mg/l	0.01	See Trihalomethanes	81	<<0.005	<0.01	0		<0.01		<0.01	<0.01							<0.01		<0.01				<0.01		<0.01
1,2-Dibromoethane	mg/l	0.005	0.0004	81	<0.001	0.017	3	BH520, 7m; BH525(S), 5m; BH549, 8m	<0.005		<0.005	<0.005							<0.005		<0.005				<0.005		<0.005
Chlorobenzene	mg/l	0.001	N/A	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,1,1,2-Tetrachloroethane	mg/l	0.002	No WSV	81	<<0.001	<0.002	0		<0.002		<0.002	<0.002							<0.002		<0.002				<0.002		<0.002
Ethylbenzene	mg/l	0.001	0.3	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
m & p-Xylene	mg/l	0.001	See Xylenes (total)	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
o-Xylene	mg/l	0.001	See Xylenes (total)	81	<0.001	<0.002	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Styrene	mg/l	0.001	0.02	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Tribromomethane	mg/l	0.001	No WSV	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Isopropylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.01	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Bromobenzene	mg/l	0.001	No WSV	81	<0.001	<0.005	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,2,3-Trichloropropane	mg/l	0.05	No WSV	81	<<0.01	<0.05	0		<0.05		<0.05	<0.05							<0.05		<0.05				<0.05		<0.05
N-Propylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
2-Chlorotoluene	mg/l	0.001	No WSV	81	<0.001	<0.01	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,3,5-Trimethylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.01	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
4-Chlorotoluene	mg/l	0.001	No WSV	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Tert-Butylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.002	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,2,4-Trimethylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.01	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Sec-Butylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.005	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,3-Dichlorobenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
4-Isopropyltoluene	mg/l	0.001	No WSV	81	<0.001	<0.002	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,4-Dichlorobenzene	mg/l	0.001	0.3	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
N-Butylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,2-Dichlorobenzene	mg/l	0.001	1	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,2-Dibromo-3-Chloropropane	mg/l	0.05	0.001	81	<<0.001	<0.05	0		<0.05		<0.05	<0.05							<0.05		<0.05				<0.05		<0.05
1,2,4-Trichlorobenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Hexachlorobutadiene	mg/l	0.001	0.0006	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,2,3-Trichlorobenzene	mg/l	0.002	No WSV	81	<<0.001	<0.002	0		<0.002		<0.002	<0.002							<0.002		<0.002				<0.002		<0.002
Methyl Tert-Butyl Ether	mg/l	0.001	No WSV	81	<0.001	<0.05	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Naphthalene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Acenaphthylene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Acenaphthene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Fluorene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Phenanthrene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Anthracene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Fluoranthene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Pyrene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[a]anthracene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Chrysene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[b]fluoranthene	mg/l	0.00001	See PAH Sum of 4	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[k]fluoranthene	mg/l	0.00001	See PAH Sum of 4	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[a]pyrene	mg/l	0.00001	0.00001	81	<0.00001	<0.05	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Indeno(1,2,3-c,d)Pyrene	mg/l	0.00001	See PAH Sum of 4	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Dibenz(a,h)Anthracene	mg/l	0.00001	See BaP	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[g,h,i]perylene	mg/l	0.00001	See PAH Sum of 4	81	<0.00001	<0.002	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Total Of 16 PAH's	mg/l	0.0002	No WSV	81	<0.0002	<0.001	0		<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Phenol	mg/l	0.03	0.05	81	<0.03	<0.03	0		<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Suspended Solids at 105	mg/l	5	No WSV	81	9	13000	0		30	400	1500	8800	2000	6100	7200	2300	340	950									170

Assessment Criteria :	Freshwater EQS		
CaCO (mg/l)	0.00	pH	8.40
Calcium (mg/l)	28.00	DOC (mg/l)	0.00
Catchment area:	Freshwater not listed		

Constituents	Unit	Limit of Detection	Generic Assessment Criteria	Number of Samples	Minimum Value	Maximum Value	Number of Exceedences	Locations of Exceedences
pH		N/A	6-9	81	6.4	9.4	1	BH516, 23.0m
Electrical Conductivity	µS/cm	1	No WSV	81	60	26000	0	
Biochemical Oxygen Demand	mg O2/l	4	No WSV	81	4	41	0	
Chemical Oxygen Demand	mg O2/l	10	No WSV	81	10	160	0	
Redox Potential	mV	N/A	No WSV	81	0	100	0	
Alkalinity (Bicarbonate)	mg CaCO3/l	10	No WSV	81	33	660	0	
Chloride	mg/l	1	250	81	1.9	12000	5	BH513, 22m; BH509, 13.0m; BH506(S), 3.9m; BH509, 12.00m; BH506A(S), 4.00m
Ammonia (Total ammonia as N)	mg/l	0.05	0.2	81	<0.05	0.59	11	BH516, 23.0m; 502, 3.00m; 501, 23.55m; 535(S), 5.50m; 536(S), 5.00m; BH515 (D), 15.00m; BH515 (S), 10.00m; BH516, 22.00m; BH511, 9.50m; BH514A(D), 16.00m; BH519A, 23.55m
Ammonium	mg/l	0.05	0.26	81	<0.05	4.1	61	BH536 (D), 7.5m; BH541, 4m; BH513, 22m; BH513, 9m; BH502, 3m; BH503, 15m; BH519A, 23.55m; BH520, 7m; BH525(S), 5m; BH547A, 5.0m; BH545(D), 10.5m; BH509, 13.0m; BH506(S), 3.9m; BH514A, 18.0m; BH511, 9.0m; BH515(S), .5m; BH515(d), 14.5m; BH536, 7m; BH501, 14.5m; BH502, 3m; BH503, 15.5m; bh513, 24m; bh515, 8m; bh511, 9m; BH514A, 18m; BH516, 23m; BH517, 9.5m; BH525, 11.5m; BH515, 9.5m; BH515, 14.5m; BH518, 22m; BH520, 24m; BH524A, 13m; BH551, 8m; BH549, 8.5m; BH547, 4m; BH545, 22m; BH535, 6.5m; BH535, 10.5m; BH536, 4m; BH519A, 23.55m; BH540, 8m; BH539, 8.5m; BH525(S), 4.50m; 547A, 4.00m; 503, 16.00m; 502, 3.00m; 501, 23.55m; 535(S), 5.50m; 535(D), 11.00m; 536(S), 5.00m; 536(D), 7.00m; BH515 (D), 15.00m; BH515 (S), 10.00m; BH516, 22.00m; BH509, 12.00m; BH506A(S), 4.00m; BH511, 9.50m; BH514A(D), 16.00m; BH519A, 23.55m; BH524A, 13.00m
Ammoniacal Nitrogen	mg/l	0.05	0.2	81	<0.05	3.2	63	BH536 (D), 7.5m; BH541, 4m; BH513, 22m; BH513, 9m; BH502, 3m; BH503, 15m; BH519A, 23.55m; BH520, 7m; BH525(S), 5m; BH547A, 5.0m; BH545(D), 10.5m; BH509, 13.0m; BH506(S), 3.9m; BH514A, 18.0m; BH511, 9.0m; BH515(S), .5m; BH515(d), 14.5m; BH516, 23.0m; BH536, 7m; BH501, 14.5m; BH502, 3m; BH503, 15.5m; bh513, 24m; bh515, 8m; bh511, 9m; BH514A, 18m; BH516, 23m; BH517, 9.5m; BH525, 11.5m; BH515, 9.5m; BH515, 14.5m; BH518, 22m; BH520, 24m; BH524A, 13m; BH551, 8m; BH549, 8.5m; BH547, 4m; BH545, 22m; BH535, 6.5m; BH535, 10.5m; BH536, 4m; BH519A, 23.55m; BH540, 8m; BH539, 8.5m; BH525(S), 4.50m; 547A, 4.00m; BH545(D), 22.00m; 503, 16.00m; 502, 3.00m; 501, 23.55m; 535(S), 5.50m; 535(D), 11.00m; 536(S), 5.00m; 536(D), 7.00m; BH515 (D), 15.00m; BH515 (S), 10.00m; BH516, 22.00m; BH509, 12.00m; BH506A(S), 4.00m; BH511, 9.50m; BH514A(D), 16.00m; BH519A, 23.55m; BH524A, 13.00m
Nitrite	mg/l	0.02	0.01	81	0.02	4.4	49	BH536 (D), 7.5m; BH541, 4m; BH513, 22m; BH513, 9m; BH502, 3m; BH503, 15m; BH519A, 23.55m; BH520, 7m; BH524A, 8m; BH525(S), 5m; BH547A, 5.0m; BH545(D), 10.5m; BH509, 13.0m; BH506(S), 3.9m; BH514A, 18.0m; BH511, 9.0m; BH515(d), 14.5m; BH516, 23.0m; bh513, 24m; BH514A, 18m; BH516, 23m; BH515, 9.5m; BH515, 14.5m; BH518, 22m; BH520, 24m; BH524A, 13m; BH550A, 8m; BH551, 8m; BH549, 8.5m; BH547, 4m; BH545, 22m; BH535, 10.5m; BH538, 15.5m; BH519A, 23.55m; BH541, 4m; BH540, 8m; Upstream, 0m; Downstream, 0m; 525(D), 11.00m; 502, 3.00m; 536(S), 5.00m; 536(D), 7.00m; BH515 (D), 15.00m; BH515 (S), 10.00m; BH516, 22.00m; BH509, 12.00m; BH511, 9.50m; BH514A(D), 16.00m; BH524A, 13.00m
Nitrate	mg/l	0.5	N/A	81	<0.5	15	0	
Sulphate	mg/l	1	400	81	<1	410	1	BH535, 10.5m
Cyanide (Total)	mg/l	0.05	N/A	81	<0.05	0.1	0	
Cyanide (Free)	mg/l	0.05	0.001	81	<0.05	0.09	1	BH535, 10.5m
Cyanide (Complex)	mg/l	0.05	N/A	81	<0.05	<0.05	0	
Sulphide	mg/l	0.05	No WSV	81	<0.05	<0.05	0	
Nitrogen (Total Dissolved)	mg/l	1	No WSV	81	<1	17	0	
Calcium	mg/l	2	N/A	81	4.8	2500	0	
Potassium	mg/l	0.5	N/A	81	1.2	23	0	
Magnesium	mg/l	0.2	N/A	81	0.85	160	0	
Sodium	mg/l	1.5	N/A	81	1.9	5200	0	
Arsenic (Dissolved)	mg/l	0.0002	0.05	81	<0.0002	0.03	0	
Boron (Dissolved)	mg/l	0.01	No WSV	81	<0.01	0.9	0	
Cadmium (Dissolved)	mg/l	0.00011	0.00008	81	0.00011	0.0019	13	BH513, 22m; BH525(D), 10m; BH549, 8m; BH509, 13.0m; bh513, 24m; BH517, 9.5m; BH525, 4.5m; BH551, 8m; BH549, 8.5m; BH541, 4m; BH539, 8.5m; BH544 (D), 14m; BH544 (S), 4.5m
Copper (Dissolved)	mg/l	0.0005	0.001	81	<0.0005	0.17	35	BH536 (D), 7.5m; BH541, 4m; BH520, 7m; BH524A, 8m; BH525(S), 5m; BH547A, 5.0m; BH509, 13.0m; BH506(S), 3.9m; BH516, 23.0m; BH538, 15.5m; bh513, 24m; bh515, 8m; BH514A, 18m; BH516, 23m; BH525, 11.5m; BH515, 9.5m; BH518, 22m; BH535, 10.5m; BH538, 15.5m; BH541, 4m; BH540, 8m; BH539, 8.5m; BH544 (D), 14m; BH544 (S), 4.5m; Upstream, 0m; BH519A , 8m; Downstream, 0m; BH525(S), 4.50m; 525(D), 11.00m; 536(S), 5.00m; BH515 (S), 10.00m; BH516, 22.00m; BH514A(D), 16.00m; BH519A, 23.55m; BH524A, 13.00m
Iron (Dissolved)	mg/l	0.005	1	81	0.005	53	5	BH509, 13.0m; BH501, 14.5m; BH539, 8.5m; BH544 (S), 4.5m; BH509, 12.00m
Manganese	mg/l	0.0005	0.123	81	0.0033	2.8	1	BH519A , 8m
Nickel (Dissolved)	mg/l	0.0005	0.004	81	<0.0005	0.095	11	BH509, 13.0m; BH506(S), 3.9m; BH516, 23.0m; BH502, 3m; BH541, 4m; BH540, 8m; BH539, 8.5m; BH544 (S), 4.5m; 535(D), 11.00m; BH509, 12.00m; BH506A(S), 4.00m
Lead (Dissolved)	mg/l	0.0005	0.0012	81	<0.0005	0.13	2	BH539, 8.5m; BH544 (S), 4.5m
Selenium (Dissolved)	mg/l	0.0005	N/A	81	<0.0005	0.017	0	
Vanadium (Dissolved)	mg/l	0.0005	No WSV	81	<0.0005	0.043	0	
Zinc (Dissolved)	mg/l	0.0025	0.0123	81	<0.0025	0.23	24	BH513, 22m; BH519A, 23.55m; BH520, 7m; BH525(D), 10m; BH509, 13.0m; BH506(S), 3.9m; bh513, 24m; BH517, 9.5m; BH525, 11.5m; BH551, 8m; BH549, 8.5m; BH519A, 23.55m; BH519A, 23.55m; BH541, 4m; BH540, 8m; BH539, 8.5m; BH544 (D), 14m; BH544 (S), 4.5m; BH519A , 8m; Downstream, 0m; BH525(S), 4.50m; 525(D), 11.00m; BH509, 12.00m; BH506A(S), 4.00m
Chromium (Total)	mg/l	0.0005	See Cr VI as first pass	81	<0.0005	0.023	0	
Mercury	mg/l	0.00001	0.00007	81	<0.00001	<0.00001	0	
Chromium (Hexavalent)	mg/l	0.02	0.0034	81	<0.02	<0.02	0	
Total Organic Carbon	mg/l	2	No WSV	81	2	200	0	
Aliphatic TPH >C5-C6	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Aliphatic TPH >C6-C8	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Aliphatic TPH >C8-C10	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Aliphatic TPH >C10-C12	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Aliphatic TPH >C12-C16	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Aliphatic TPH >C16-C21	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Aliphatic TPH >C21-C35	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Aliphatic TPH >C35-C44	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Total Aliphatic Hydrocarbons	mg/l	0.005	No WSV	81	<0.005	<0.005	0	
Aromatic TPH >C5-C7	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Aromatic TPH >C7-C8	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Aromatic TPH >C8-C10	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Aromatic TPH >C10-C12	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Aromatic TPH >C12-C16	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Aromatic TPH >C16-C21	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Aromatic TPH >C21-C35	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Aromatic TPH >C35-C44	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0	
Total Aromatic Hydrocarbons	mg/l	0.005	No WSV	81	<0.005	<0.005	0	
Total Petroleum Hydrocarbons	mg/l	0.01	No WSV	81	<0.01	<0.01	0	
Dichlorodifluoromethane	mg/l	0.001	No WSV	81	<0.00001	0.0039	0	
Chloromethane	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0	
Vinyl Chloride	mg/l	0.001	N/A	81	<<0.00001	<0.001	0	
Bromomethane	mg/l	0.005	No WSV	81	<<0.00001	<0.005	0	
Chloroethane	mg/l	0.002	No WSV	81	<<0.00001	<0.002	0	
Trichlorofluoromethane	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0	
1,1-Dichloroethene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0	
Trans 1,2-Dichloroethene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0	
1,1-Dichloroethane	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0	
cis 1,2-Dichloroethene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0	
Bromochloromethane	mg/l	0.005	No WSV	81	<<0.00001	<0.005	0	
Trichloromethane	mg/l	0.001	0.0025	81	<<0.00001	<0.001	0	
1,1,1-Trichloroethane	mg/l	0.001	0.1	81	<<0.00001	<0.001	0	
Tetrachloromethane	mg/l	0.001	0.012	81	<<0.00001	<0.001	0	
1,1-Dichloropropene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0	
Benzene	mg/l	0.001	0.01	81	<<0.00001	<0.001	0	
1,2-Dichloroethane	mg/l	0.002	0.01	81	<0.0002	0.0039	0	
Trichloroethene	mg/l	0.001	0.01	81	<0.001	<0.001	0	
1,2-Dichloropropane	mg/l	0.001	N/A	81	<0.001	<0.001	0	
Dibromomethane	mg/l	0.01	No WSV	81	<<0.001	<0.01	0	
Bromodichloromethane	mg/l	0.005	N/A	81	<0.005	<0.005	0	
cis-1,3-Dichloropropene	mg/l	0.01	No WSV	81	<<0.002	<0.01	0	
Toluene	mg/l	0.001	0.074	81	<0.001	<0.001	0	
Trans-1,3-Dichloropropene	mg/l	0.01	No WSV	81	<<0.001	<0.01	0	
1,1,2-Trichloroethane	mg/l	0.01	0.4	81	<<0.001	<0.01	0	
Tetrachloroethene	mg/l	0.001	0.01	81	<0.001	<0.001	0	
1,3-Dichloropropane	mg/l	0.002	No WSV	81	<<0.001	<0.002	0	
Dibromochloromethane	mg/l	0.01	N/A	81	<<0.005	<0.01	0	
1,2-Dibromoethane	mg/l	0.005	N/A	81	<0.001	0.017	0	
Chlorobenzene	mg/l	0.001	N/A	81	<0.001	<0.001	0	
1,1,1,2-Tetrachloroethane	mg/l	0.002	No WSV	81	<<0.001	<0.002	0	
Ethylbenzene	mg/l	0.001	0.02	81	<0.001	<0.001	0	
m & p-Xylene	mg/l	0.001	See Xylenes (total)	81	<0.001	<0.001	0	
o-Xylene	mg/l	0.001	See Xylenes (total)	81	<0.001	<0.002	0	
Styrene	mg/l	0.001	0.05	81	<0.001	<0.001	0	
Tribromomethane	mg/l	0.001	No WSV	81	<0.001	<0.001	0	
Isopropylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.01	0	
Bromobenzene	mg/l	0.001	No WSV	81	<0.001	<0.005	0	
1,2,3-Trichloropropane	mg/l	0.05	No WSV	81	<<0.01	<0.05	0	
N-Propylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0	
2-Chlorotoluene	mg/l	0.001	No WSV	81	<0.001	<0.01	0	
1,3,5-Trimethylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.01	0	
4-Chlorotoluene	mg/l	0.001	No WSV	81	<0.001	<0.001	0	
Tert-Butylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.002	0	
1,2,4-Trimethylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.01	0	
Sec-Butylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.005	0	
1,3-Dichlorobenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0	
4-Isopropyltoluene	mg/l	0.001	No WSV	81	<0.001	<0.002	0	
1,4-Dichlorobenzene	mg/l	0.001	0.02	81	<0.001	<0.001	0	
N-Butylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0	
1,2-Dichlorobenzene	mg/l	0.001	0.02	81	<0.001	<0.001	0	
1,2-Dibromo-3-Chloropropane	mg/l	0.05	N/A	81	<<0.001	<0.05	0	
1,2,4-Trichlorobenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0	
Hexachlorobutadiene	mg/l	0.001	0.0006	81	<0.001	<0.001	0	
1,2,3-Trichlorobenzene	mg/l	0.002	No WSV	81	<<0.001	<0.002	0	
Methyl Tert-Butyl Ether	mg/l	0.001	No WSV	81	<0.001	<0.05	0	
Naphthalene	mg/l	0.00001	0.002	81	<0.00001	<0.001	0	
Acenaphthylene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0	
Acenaphthene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0	
Fluorene	mg/l	0.00001	N/A	81	<0.00001	<0.001	0	
Phenanthrene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0	
Anthracene	mg/l	0.00001	0.0001	81	<0.00001	<0.001	0	
Fluoranthene	mg/l	0.00001	0.0000063	81	<0.00001	<0.001	0	
Pyrene	mg/l	0.00001	N/A	81	<0.00001	<0.001	0	
Benzo[a]anthracene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0	
Chrysene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0	
Benzo[b]fluoranthene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0	
Benzo[k]fluoranthene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0	
Benzo[a]pyrene	mg/l	0.00001	0.00000017	81	<0.00001	<0.05	0	
Indeno(1,2,3-c,d)Pyrene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0	
Dibenz(a,h)Anthracene	mg/l	0.00001	N/A	81	<0.00001	<0.001	0	
Benzo[g,h,i]perylene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.002	0	
Total Of 16 PAH's	mg/l	0.0002	No WSV	81	<0.0002	<0.001	0	
Phenol	mg/l	0.03	0.0077	81	<0.03	<0.03	0	
Suspended Solids at 105	mg/l	5	No WSV	81	9	13000	0	

Assessment Criteria :	Freshwater EQS				
CaCO (mg/l):	0.00	pH	8.40		
Calcium (mg/l):	29.00	DOC (mg/l)	0.00	Catchment area:	Freshwater not listed

Constituents	Unit	Limit of Detection	Generic Assessment Criteria	Number of Samples	Minimum Value	Maximum Value	Number of Exceedences	Locations of Exceedences	525(D) 11.00m 13/07/2021	547A 4.00m 13/07/2021	BH545(D) 22.00m 13/07/2021	503 16.00m 13/07/2021	502 3.00m 13/07/2021	501 23.55m 13/07/2021	535(S) 5.50m 13/07/2021	535(D) 11.00m 13/07/2021	536(S) 5.00m 13/07/2021	536(D) 7.00m 13/07/2021	BH515 (D) 15.00m 12/07/2021	BH515 (S) 10.00m 12/07/2021	BH516 22.00m 12/07/2021	BH509 12.00m 12/07/2021	BH506A(S) 4.00m 12/07/2021	BH511 9.50m 12/07/2021	BH514A(D) 16.00m 12/07/2021	BH519A 23.55m 12/07/2021	BH524A 13.00m
pH		N/A	6-9	81	6.4	9.4	1	BH516, 23.0m	8.8	8.6	8.8	8.8	8.7	8.6	8.6	8.5	8.5	8.4	8.6	8.7	8.7	7.4	8.2	8.6	8.8	8.8	8.5
Electrical Conductivity	µS/cm	1	No WSV	81	60	26000	0		270	450	540	470	560	450	460	1200	670	660	440	470	510	26000	4300	1200	60	490	570
Biochemical Oxygen Demand	mg O2/l	4	No WSV	81	4	41	0		<4	<4	<4	<4	34	9	<4	8	<4	<4	<4	<4	4	32	<4	<4	<4	<4	<4
Chemical Oxygen Demand	mg O2/l	10	No WSV	81	10	160	0		17	20	19	15	140	43	17	33	22	22	14	14	23	130	28	16	<10	10	<10
Redox Potential	mV	N/A	No WSV	81	0	100	0		43	46	26	42	66	65	68	75	63	71	65	68	62	0	7.9	3.8	4.7	49	70
Alkalinity (Bicarbonate)	mg CaCO3/l	10	No WSV	81	33	660	0		83	320	320	240	430	350	270	410	250	400	180	200	210	110	320	210	180	230	290
Chloride	mg/l	1	250	81	1.9	12000	5	BH513, 22m; BH509, 13.0m; BH506(S), 3.9m; BH509, 12.00m; BH506A(S), 4.00m	13	30	10	220	23	14	15	22	62	12	22	22	17	11000	380	180	25	15	22
Ammonia (Total ammonia as N)	mg/l	0.05	0.2	81	<0.05	0.59	11	BH516, 23.0m; 502, 3.00m; 501, 23.55m; 535(S), 5.50m; 536(S), 5.00m; BH515 (D), 15.00m; BH515 (S), 10.00m; BH516, 22.00m; BH511, 9.50m; BH514A(D), 16.00m; BH519A, 23.55m	<0.05	0.087	0.058	0.15	0.22	0.25	0.26	0.18	0.24	0.19	0.3	0.3	0.3	<0.05	0.1	0.28	0.59	0.44	<0.05
Ammonium	mg/l	0.05	0.26	81	<0.05	4.1	61	BH536 (D), 7.5m; BH541, 4m; BH513, 22m; BH513, 9m; BH502, 3m; BH503, 15m; BH519A, 23.55m; BH520, 7m; BH525(S), 5m; BH547A, 5.0m; BH545(D), 10.5m; BH509, 13.0m; BH506(S), 3.9m; BH514A, 18.0m; BH511, 9.0m; BH515(S), .5m; BH515(d), 14.5m; BH536, 7m; BH501, 14.5m; BH502, 3m; BH503, 15.5m; bh513, 24m; bh515, 8m; bh511, 9m; BH514A, 18m; BH516, 23m; BH517, 9.5m; BH525, 11.5m; BH515, 9.5m; BH515, 14.5m; BH518, 22m; BH520, 24m; BH524A, 13m; BH551, 8m; BH549, 8.5m; BH547, 4m; BH545, 22m; BH535, 6.5m; BH535, 10.5m; BH536, 4m; BH519A, 23.55m; BH540, 8m; BH539, 8.5m; BH525(S), 4.50m; 547A, 4.00m; 503, 16.00m; 502, 3.00m; 501, 23.55m; 535(S), 5.50m; 535(D), 11.00m; 536(S), 5.00m; 536(D), 7.00m; BH515 (D), 15.00m; BH515 (S), 10.00m; BH516, 22.00m; BH509, 12.00m; BH506A(S), 4.00m; BH511, 9.50m; BH514A(D), 16.00m; BH519A, 23.55m; BH524A, 13.00m	0.19	0.55	0.24	0.61	1.1	1.5	1.6	1.4	1.6	1.7	1.6	1.3	1.3	2.3	1.6	1.6	2	1.5	0.27
Ammoniacal Nitrogen	mg/l	0.05	0.2	81	<0.05	3.2	63	BH536 (D), 7.5m; BH541, 4m; BH513, 22m; BH513, 9m; BH502, 3m; BH503, 15m; BH519A, 23.55m; BH520, 7m; BH525(S), 5m; BH547A, 5.0m; BH545(D), 10.5m; BH509, 13.0m; BH506(S), 3.9m; BH514A, 18.0m; BH511, 9.0m; BH515(S), .5m; BH515(d), 14.5m; BH516, 23.0m; BH536, 7m; BH501, 14.5m; BH502, 3m; BH503, 15.5m; bh513, 24m; bh515, 8m; bh511, 9m; BH514A, 18m; BH516, 23m; BH517, 9.5m; BH525, 11.5m; BH515, 9.5m; BH515, 14.5m; BH518, 22m; BH520, 24m; BH524A, 13m; BH551, 8m; BH549, 8.5m; BH547, 4m; BH545, 22m; BH535, 6.5m; BH535, 10.5m; BH536, 4m; BH519A, 23.55m; BH540, 8m; BH539, 8.5m; BH525(S), 4.50m; 547A, 4.00m; BH545(D), 22.00m; 503, 16.00m; 502, 3.00m; 501, 23.55m; 535(S), 5.50m; 535(D), 11.00m; 536(S), 5.00m; 536(D), 7.00m; BH515 (D), 15.00m; BH515 (S), 10.00m; BH516, 22.00m; BH509, 12.00m; BH506A(S), 4.00m; BH511, 9.50m; BH514A(D), 16.00m; BH519A, 23.55m; BH524A, 13.00m	0.19	0.51	0.24	0.63	1.1	1.4	1.5	1.2	1.5	1.5	1.6	1.3	1.3	1.8	1.3	1.6	2.2	1.6	0.25
Nitrite	mg/l	0.02	0.01	81	0.02	4.4	49	BH536 (D), 7.5m; BH541, 4m; BH513, 22m; BH513, 9m; BH502, 3m; BH503, 15m; BH519A, 23.55m; BH520, 7m; BH524A, 8m; BH525(S), 5m; BH547A, 5.0m; BH545(D), 10.5m; BH509, 13.0m; BH506(S), 3.9m; [illegible] BH514A(D), 16.00m; BH519A, 23.55m; BH524A, 13.00m	0.03	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	0.024	0.02	0.044	0.068	0.048	0.022	<0.02	0.024	0.029	<0.02	0.15
Nitrate	mg/l	0.5	N/A	81	<0.5	16	0		1.3	<0.5	0.98	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sulphate	mg/l	1	400	81	<1	410	1	BH535, 10.5m	26	10	<1	38	120	11	40	330	43	<1	5.3	14	16	110	170	42	30	25	24
Cyanide (Total)	mg/l	0.05	N/A	81	<0.05	0.1	1	BH535, 10.5m	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cyanide (Free)	mg/l	0.05	0.001	81	<0.05	0.09	1		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cyanide (Complex)	mg/l	0.05	N/A	81	<0.05	<0.05	0		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sulphide	mg/l	0.05	No WSV	81	<0.05	<0.05	0		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrogen (Total Dissolved)	mg/l	2	No WSV	81	<1	17	0		3.5	2	2.5	3.9	8.4	4.6	3.5	4	4.4	2.5	5.6	5.3	16	10	13	3.4	2.5	1.5	<1
Calcium	mg/l	2	N/A	81	4.6	2500	0		110	69	37	110	73	84	89	93	98	34	35	35	2500	140	83	26	48	55	[illegible]
Potassium	mg/l	0.5	N/A	81	1.2	22	0		1.7	2.4	3.8	2.9	2.1	1.2	1.7	4.1	2.3	2.4	8	7.9	13	11	3.5	2.5	7.7	2.8	3.8
Magnesium	mg/l	0.2	N/A	81	0.65	160	0		7.5	15	14	15	26	23	23	27	26	37	19	20	11	160	27	16	13	26	26
Sodium	mg/l	0.2	N/A	81	1.8	5200	0		14	13	11	33	140	48	15	200	23	31	17	24	34	5200	170	77	40	13	15
Arsenic (Dissolved)	mg/l	0.0002	0.05	81	<0.0002	0.03	0		0.00044	0.0025	0.0028	0.0035	0.013	0.0027	0.0038	0.008	0.0019	0.0045	0.00056	0.0015	0.001	0.00069	0.0025	0.0013	0.00099	0.00029	<0.0002
Boron (Dissolved)	mg/l	0.01	No WSV	81	<0.01	0.9	0		0.057	0.092	0.2	0.36	0.058	0.026	0.028	0.044	0.56	0.58	0.67	0.67	0.9	0.66	0.66	0.51	0.55	0.54	0.064
Cadmium (Dissolved)	mg/l	0.00011	0.00008	81	0.00011	0.0019	13	BH513, 22m; BH525(S), 10m; BH549, 8m; BH509, 13.0m; bh513, 24m; BH517, 9.5m; BH525, 4.5m; BH551, 8m; BH549, 8.5m; BH541, 4m; BH539, 8.5m; BH544 (D), 14m; BH544 (S), 4.5m	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011	<0.00011
Copper (Dissolved)	mg/l	0.0005	0.001	81	<0.0005	0.17	35	BH536 (D), 7.5m; BH541, 4m; BH520, 7m; BH524A, 8m; BH525(S), 5m; BH547A, 5.0m; BH509, 13.0m; BH506(S), 3.9m; BH516, 23.0m; BH538, 15.5m; bh513, 24m; bh515, 8m; BH514A, 18m; BH516, 23m; BH525, 11.5m; BH515, 9.5m; BH516, 22m; BH520, 24m; BH535, 10.5m; BH538, 15.5m; BH541, 4m; BH540, 8m; BH539, 8.5m; BH544 (D), 14m; BH544 (S), 4.5m; Upstream, 0m; BH519A, 8m; Downstream, 0m; BH525(S), 4.50m; 525(D), 11.00m; 536(S), 5.00m; BH515 (S), 10.00m; BH516, 22.00m; BH514A(D), 16.00m; BH519A, 23.55m; BH524A, 13.00m	0.0032	0.00089	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0012	<0.0005	<0.0005	0.0013	0.0033	<0.0005	<0.0005	0.00061	0.0012	0.0011	0.0017
Iron (Dissolved)	mg/l	0.005	1	81	0.005	53	5	BH509, 13.0m; BH521, 14.5m; BH539, 8.5m; BH544 (S), 4.5m; BH509, 12.00m	<0.005	<0.005	<0.005	<0.005	0.013	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.019	53	0.63	<0.005	<0.005	<0.005	<0.005
Manganese	mg/l	0.0005	0.123	81	0.0033	2.8	1	BH519A, 8m																			
Nickel (Dissolved)	mg/l	0.0005	0.004	81	<0.0005	0.095	11	BH509, 13.0m; BH506(S), 3.9m; BH516, 23.0m; BH502, 3m; BH541, 4m; BH540, 8m; BH539, 8.5m; BH544 (S), 4.5m; 535(D), 11.00m; BH509, 12.00m; BH506A(S), 4.00m	0.0017	0.0016	0.00085	0.00073	0.003	0.0019	0.0024	0.0081	0.0027	0.0029	0.0011	0.0022	0.002	0.05	0.008	0.0024	0.0013	0.00094	0.0011
Lead (Dissolved)	mg/l	0.0005	0.0012	81	<0.0005	0.13	2	BH509, 13.0m; BH506(S), 3.9m	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Selenium (Dissolved)	mg/l	0.0005	N/A	81	<0.0005	0.017	0		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.00067	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0024	<0.0005	<0.0005	<0.0005	<0.0005
Vanadium (Dissolved)	mg/l	0.0005	No WSV	81	<0.0005	0.043	0		<0.0005	<0.0005	0.00094	<0.0005	<0.0005	<0.0005	0.0011	<0.0005	<0.0005	<0.0005	<0.0005	0.00073	0.00095	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Zinc (Dissolved)	mg/l	0.0025	0.0123	81	<0.0025	0.23	24	BH513, 22m; BH519A, 23.55m; BH520, 7m; BH525(D), 10m; BH509, 13.0m; BH506(S), 3.9m; bh513, 24m; BH517, 9.5m; BH525, 11.5m; BH551, 8m; BH549, 8.5m; BH519A, 23.55m; BH541, 4m; BH540, 8m; BH539, 8.5m; BH525(S), 4.50m; 525(D), 11.00m; BH509, 12.00m; BH506A(S), 4.00m	0.035	0.0042	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	0.011	<0.0025	<0.0025	0.0069	<0.0025	0.062	0.016	<0.0025	<0.0025	<0.0025	0.0085
Chromium (Total)	mg/l	0.0005	See Cr VI as first pass	81	<0.0005	0.023	0		0.0063	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0011
Mercury	mg/l	0.00001	0.00007	81	<0.00001	<0.00001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Chromium (Hexavalent)	mg/l	0.02	0.0034	81	<0.02	<0.02	0		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Organic Carbon	mg/l	2	No WSV	81	3	200	0		16	47	56	40	150	78	55	89	56	84	36	44	42	48	78	40	34	46	<2
Aliphatic TPH >C5-C6	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aliphatic TPH >C6-C8	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aliphatic TPH >C8-C10	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aliphatic TPH >C10-C12	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aliphatic TPH >C12-C16	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aliphatic TPH >C16-C21	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aliphatic TPH >C21-C35	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aliphatic TPH >C35-C44	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Total Aliphatic Hydrocarbons	mg/l	0.005	No WSV	81	<0.005	<0.005	0		<0.005		<0.005	<0.005							<0.005		<0.005				<0.005		<0.005
Aromatic TPH >C5-C7	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aromatic TPH >C7-C8	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aromatic TPH >C8-C10	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aromatic TPH >C10-C12	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aromatic TPH >C12-C16	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aromatic TPH >C16-C21	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aromatic TPH >C21-C35	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Aromatic TPH >C35-C44	mg/l	0.0001	0.01	81	<0.0001	<0.0001	0		<0.0001		<0.0001	<0.0001							<0.0001		<0.0001				<0.0001		<0.0001
Total Aromatic Hydrocarbons	mg/l	0.005	No WSV	81	<0.005	<0.005	0		<0.005		<0.005	<0.005							<0.005		<0.005				<0.005		<0.005
Total Petroleum Hydrocarbons	mg/l	0.01	No WSV	81	<0.01	<0.01	0		<0.01		<0.01	<0.01							<0.01		<0.01				<0.01		<0.01
Dichlorodifluoromethane	mg/l	0.001	No WSV	81	<0.00001	0.0039	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Chloromethane	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Vinyl Chloride	mg/l	0.001	N/A	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Bromomethane	mg/l	0.005	No WSV	81	<<0.00001	<0.005	0		<0.005		<0.005	<0.005							<0.005		<0.005				<0.005		<0.005
Chloroethane	mg/l	0.002	No WSV	81	<<0.00001	<0.002	0		<0.002		<0.002	<0.002							<0.002		<0.002				<0.002		<0.002
Trichlorofluoromethane	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,1-Dichloroethene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Trans 1,2-Dichloroethene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,1-Dichloroethane	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
cis 1,2-Dichloroethene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Bromochloromethane	mg/l	0.005	No WSV	81	<<0.00001	<0.005	0		<0.005		<0.005	<0.005							<0.005		<0.005				<0.005		<0.005
Trichloromethane	mg/l	0.001	0.0025	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,1,1-Trichloroethane	mg/l	0.001	0.1	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Tetrachloromethane	mg/l	0.001	0.012	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,1-Dichloropropene	mg/l	0.001	No WSV	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Benzene	mg/l	0.001	0.01	81	<<0.00001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,2-Dichloroethane	mg/l	0.002	0.01	81	<0.0002	0.0039	0		<0.002		<0.002	<0.002							<0.002		<0.002				<0.002		<0.002
Trichloroethene	mg/l	0.001	0.01	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,2-Dichloropropane	mg/l	0.001	N/A	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Dibromomethane	mg/l	0.01	No WSV	81	<<0.001	<0.01	0		<0.01		<0.01	<0.01							<0.01		<0.01				<0.01		<0.01
Bromodichloromethane	mg/l	0.005	N/A	81	<0.005	<0.005	0		<0.005		<0.005	<0.005							<0.005		<0.005				<0.005		<0.005
cis-1,3-Dichloropropene	mg/l	0.01	No WSV	81	<<0.002	<0.01	0		<0.01		<0.01	<0.01							<0.01		<0.01				<0.01		<0.01
Toluene	mg/l	0.001	0.074	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Trans-1,3-Dichloropropene	mg/l	0.01	No WSV	81	<<0.001	<0.01	0		<0.01		<0.01	<0.01							<0.01		<0.01				<0.01		<0.01
1,1,2-Trichloroethane	mg/l	0.01	0.4	81	<<0.001	<0.01	0		<0.01		<0.01	<0.01							<0.01		<0.01				<0.01		<0.01
Tetrachloroethene	mg/l	0.001	0.01	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,3-Dichloropropane	mg/l	0.002	No WSV	81	<<0.001	<0.002	0		<0.002		<0.002	<0.002							<0.002		<0.002				<0.002		<0.002
Dibromochloromethane	mg/l	0.01	N/A	81	<<0.005	<0.01	0		<0.01		<0.01	<0.01							<0.01		<0.01				<0.01		<0.01
1,2-Dibromoethane	mg/l	0.005	N/A	81	<0.001	0.017	0		<0.005		<0.005	<0.005							<0.005		<0.005				<0.005		<0.005
Chlorobenzene	mg/l	0.001	N/A	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,1,1,2-Tetrachloroethane	mg/l	0.002	No WSV	81	<<0.001	<0.002	0		<0.002		<0.002	<0.002							<0.002		<0.002				<0.002		<0.002
Ethylbenzene	mg/l	0.001	0.02	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
m & p-Xylene	mg/l	0.001	See Xylenes (total)	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
o-Xylene	mg/l	0.001	See Xylenes (total)	81	<0.001	<0.002	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Styrene	mg/l	0.001	0.05	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Tribromomethane	mg/l	0.001	No WSV	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Isopropylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.01	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Bromobenzene	mg/l	0.001	No WSV	81	<0.001	<0.005	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,2,3-Trichloropropane	mg/l	0.05	No WSV	81	<<0.01	<0.05	0		<0.05		<0.05	<0.05							<0.05		<0.05				<0.05		<0.05
N-Propylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
2-Chlorotoluene	mg/l	0.001	No WSV	81	<0.001	<0.01	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,3,5-Trimethylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.01	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
4-Chlorotoluene	mg/l	0.001	No WSV	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Tert-Butylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.002	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,2,4-Trimethylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.01	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Sec-Butylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.005	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,3-Dichlorobenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
4-Isopropyltoluene	mg/l	0.001	No WSV	81	<0.001	<0.002	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,4-Dichlorobenzene	mg/l	0.001	0.02	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
N-Butylbenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,2-Dichlorobenzene	mg/l	0.001	0.02	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,2-Dibromo-3-Chloropropane	mg/l	0.05	N/A	81	<<0.001	<0.05	0		<0.05		<0.05	<0.05							<0.05		<0.05				<0.05		<0.05
1,2,4-Trichlorobenzene	mg/l	0.001	No WSV	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Hexachlorobutadiene	mg/l	0.001	0.0006	81	<0.001	<0.001	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
1,2,3-Trichlorobenzene	mg/l	0.002	No WSV	81	<<0.001	<0.002	0		<0.002		<0.002	<0.002							<0.002		<0.002				<0.002		<0.002
Methyl Tert-Butyl Ether	mg/l	0.001	No WSV	81	<0.001	<0.05	0		<0.001		<0.001	<0.001							<0.001		<0.001				<0.001		<0.001
Naphthalene	mg/l	0.00001	0.002	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Acenaphthylene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Acenaphthene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Fluorene	mg/l	0.00001	N/A	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Phenanthrene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Anthracene	mg/l	0.00001	0.0001	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Fluoranthene	mg/l	0.00001	0.0000063	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Pyrene	mg/l	0.00001	N/A	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[a]anthracene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Chrysene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[b]fluoranthene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[k]fluoranthene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[a]pyrene	mg/l	0.00001	0.00000017	81	<0.00001	<0.05	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Indeno(1,2,3-c,d)Pyrene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Dibenz(a,h)Anthracene	mg/l	0.00001	N/A	81	<0.00001	<0.001	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo[g,h,i]perylene	mg/l	0.00001	Screen BaP only	81	<0.00001	<0.002	0		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Total Of 16 PAH's	mg/l	0.0002	No WSV	81	<0.0002	<0.001	0		<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Phenol	mg/l	0.03	0.0077	81	<0.03	<0.03	0		<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Suspended Solids at 105	mg/l	5	No WSV	81	9	13000	0		30	400	1500	8800	2000	6100	7200	2300	340	950									170

A57 Transpennine Upgrade

National Highways

Ground Gas Risk Assessment Summary

Project:	A57 Link Road
Project Number:	5201114
Client:	Highways England

Borehole	Oxygen %v/v		Methane %v/v		Carbon Dioxide %v/v		Flow l/hr		H_2S ppm	CO ppm	Hazardous Gas Values (calculated using max conc. and max steady state flow)	
	Min Min	Min Steady	Max Max	Max Steady	Max Max	Max Steady	Max Max	Max Steady	Max	Max	CH_4	CO_2
BH541	14.40	15.90	0.10	<0.1	0.90	0.50	2.5	2.5	1	91	0.0025	0.0225
BH517	21.30	21.40	<0.1	<0.1	0.10	0.10	0.1	0.1		2	0.0001	0.0001
BH549	20.90	20.90	<0.1	<0.1	0.10	0.10	0	0	4	4	0.0001	0.0001
BH551	21.40	21.50	<0.1	<0.1	0.10	0.10	0	0		2	0.0001	0.0001
BH550A	21.10	21.20	<0.1	<0.1	0.10	0.10	0	0		1	0.0001	0.0001
BH524A	18.20	20.00	<0.1	<0.1	1.70	0.30	0	0	1	2	0.0001	0.0017
BH520	21.50	21.60	<0.1	<0.1	0.10	0.10	0	0		6	0.0001	0.0001
BH525	20.90	21.00	<0.1	<0.1	0.10	0.10	0	0	1	1	0.0001	0.0001
BH522	21.70	21.70	<0.1	<0.1	0.10	0.10	0.1	0.1		1	0.0001	0.0001
BH516	20.70	20.90	<0.1	<0.1	0.10	<0.1	0.2	0.2	0	3	0.0002	0.0002
BH514A	19.20	19.20	<0.1	<0.1	0.20	0.20	21	12	3	4	0.012	0.024
BH513	20.50	20.70	<0.1	<0.1	0.10	0.10	0.1	0.1	6	455	0.0001	0.0001
BH510	20.80	21.00	<0.1	<0.1	0.10	<0.1	0.1	0.1	1	7	0.0001	0.0001
BH506A	20.50	20.50	<0.1	<0.1	0.30	0.20	0.1	0.1	2	1	0.0001	0.0003
BH508	21.10	21.10	<0.1	<0.1	0.10	0.10	0	0	2	1	0.0001	0.0001
BH540	16.40	20.20	<0.1	<0.1	0.80	0.20	0.1	0.1		20	0.0001	0.0008
BH544 (D)	17.90	20.40	<0.1	<0.1	0.20	0.10	0	0	1	44	0.0001	0.0002

Data Input and Screening

Determinand	Screening Value	Laboratory Results Unit	Method	Accreditation	Method Detection Limit	BH536 (D)
					Exploratory Hole	BH536 (D)
					Material Description	WATER
					Depth (m)	7.5
					Date Samples	30/06/2021
pH	#VALUE!		1010	U	N/A	7.9
Electrical Conductivity	#N/A	µS/cm	1020	U	1	700
Biochemical Oxygen Demand	#N/A	mg O2/l	1090	N	4	2
Chemical Oxygen Demand	#N/A	mg O2/l	1100	U	10	5
Redox Potential	#N/A	mV	1170	N	N/A	46
Alkalinity (Bicarbonate)	#N/A	mg CaCO3/l	1220	U	10	310
Chloride	#VALUE!	mg/l	1220	U	1	60
Ammonia (Free)	#VALUE!	mg/l	1220	N	0.05	0.025
Ammonium	#N/A	mg/l	1220	U	0.05	1.4
Ammoniacal Nitrogen	#N/A	mg/l	1220	U	0.05	1.2
Nitrite	#N/A	mg/l	1220	U	0.02	0.23
Nitrate	#N/A	mg/l	1220	U	0.5	0.69
Sulphate	#N/A	mg/l	1220	U	1	42
Cyanide (Total)	#VALUE!	mg/l	1300	U	0.05	0.025
Cyanide (Free)	#VALUE!	mg/l	1300	U	0.05	0.025
Cyanide (Complex)	#N/A	mg/l	1300	U	0.05	0.025
Sulphide	#N/A	mg/l	1325	U	0.05	0.025
Nitrogen (Total Dissolved)	#N/A	mg/l	1340	N	1	1.6
Calcium	#N/A	mg/l	1455	U	2	97
Potassium	#N/A	mg/l	1455	U	0.5	4
Magnesium	#N/A	mg/l	1455	U	0.2	25
Sodium	#N/A	mg/l	1455	U	1.5	35
Arsenic (Dissolved)	#N/A	µg/l	1455	U	0.2	1.5
Boron (Dissolved)	#N/A	µg/l	1455	U	10	41
Cadmium (Dissolved)	#N/A	µg/l	1455	U	0.11	0.055
Copper (Dissolved)	#N/A	µg/l	1455	U	0.5	5.4
Iron (Dissolved)	#N/A	µg/l	1455	N	5	2.5
Manganese	#N/A	µg/l	1455	U	0.5	
Nickel (Dissolved)	#N/A	µg/l	1455	U	0.5	2.5
Lead (Dissolved)	#N/A	µg/l	1455	U	0.5	1.2
Selenium (Dissolved)	#N/A	µg/l	1455	U	0.5	0.25
Vanadium (Dissolved)	#N/A	µg/l	1455	U	0.5	0.25
Zinc (Dissolved)	#N/A	µg/l	1455	U	2.5	1.25
Chromium (Total)	#N/A	µg/l	1455	N	0.5	0.25
Mercury Low Level	#N/A	µg/l	1460	U	0.01	0.005
Chromium (Hexavalent)	#VALUE!	µg/l	1490	U	20	10
Total Organic Carbon	#N/A	mg/l	1610	U	2	69
TPH Aliphatic >C5-C6	1930	µg/l	1675	N	0.1	
TPH Aliphatic >C6-C8	1400	µg/l	1675	N	0.1	
TPH Aliphatic >C8-C10	29.6	µg/l	1675	N	0.1	
TPH Aliphatic >C10-C12	22.8	µg/l	1675	N	0.1	
TPH Aliphatic >C12-C16	5.47	µg/l	1675	N	0.1	
TPH Aliphatic >C16-C21	#VALUE!	µg/l	1675	N	0.1	
TPH Aliphatic >C21-C35	#VALUE!	µg/l	1675	N	0.1	
TPH Aliphatic >C35-C44	#VALUE!	µg/l	1675	N	0.1	
Total Aliphatic Hydrocarbons	#VALUE!	µg/l	1675	N	5	
TPH Aromatic >C5-C7	88.8	µg/l	1675	N	0.1	
TPH Aromatic >C7-C8	96400	µg/l	1675	N	0.1	
TPH Aromatic >C8-C10	985	µg/l	1675	N	0.1	
TPH Aromatic >C10-C12	3870	µg/l	1675	N	0.1	
TPH Aromatic >C12-C16	10500	µg/l	1675	N	0.1	
TPH Aromatic >C16-C21	#VALUE!	µg/l	1675	N	0.1	
TPH Aromatic >C21-C35	#VALUE!	µg/l	1675	N	0.1	
TPH Aromatic >C35-C44	#VALUE!	µg/l	1675	N	0.1	
Total Aromatic Hydrocarbons	#VALUE!	µg/l	1675	N	5	
Total Petroleum Hydrocarbons	#VALUE!	µg/l	1675	N	10	
Dichlorodifluoromethane	#VALUE!	µg/l	1760	U	1	
Chloromethane	53.1	µg/l	1760	U	1	
Vinyl Chloride	2.48	µg/l	1760	N	1	
Bromomethane	#VALUE!	µg/l	1760	U	5	
Chloroethane	41500	µg/l	1760	U	2	
Trichlorofluoromethane	#VALUE!	µg/l	1760	U	1	
1,1-Dichloroethene	683	µg/l	1760	U	1	
Trans 1,2-Dichloroethene	#N/A	µg/l	1760	U	1	
1,1-Dichloroethane	#VALUE!	µg/l	1760	U	1	
cis 1,2-Dichloroethene	#N/A	µg/l	1760	U	1	
Bromochloromethane	#VALUE!	µg/l	1760	U	5	
Trichloromethane	#VALUE!	µg/l	1760	U	1	
1,1,1-Trichloroethane	13100	µg/l	1760	U	1	
Tetrachloromethane	#VALUE!	µg/l	1760	U	1	
1,1-Dichloropropene	#VALUE!	µg/l	1760	U	1	
Benzene	88.8	µg/l	1760	U	1	
1,2-Dichloroethane	37.3	µg/l	1760	U	2	
Trichloroethene	222	µg/l	1760	N	1	
1,2-Dichloropropane	96.9	µg/l	1760	U	1	
Dibromomethane	#VALUE!	µg/l	1760	U	10	
Bromodichloromethane	72.5	µg/l	1760	U	5	
cis-1,3-Dichloropropene	#VALUE!	µg/l	1760	N	10	
Toluene	96400	µg/l	1760	U	1	
Trans-1,3-Dichloropropene	#VALUE!	µg/l	1760	N	10	
1,1,2-Trichloroethane	2230	µg/l	1760	U	10	
Tetrachloroethene	1660	µg/l	1760	U	1	
1,3-Dichloropropane	#VALUE!	µg/l	1760	U	2	
Dibromochloromethane	394	µg/l	1760	U	10	
1,2-Dibromoethane	#VALUE!	µg/l	1760	U	5	
Chlorobenzene	13700	µg/l	1760	N	1	
1,1,1,2-Tetrachloroethane	1050	µg/l	1760	U	2	
Ethylbenzene	13400	µg/l	1760	U	1	
m & p-Xylene	#N/A	µg/l	1760	U	1	
o-Xylene	5000	µg/l	1760	U	1	
Styrene	38600	µg/l	1760	U	1	
Tribromomethane	#VALUE!	µg/l	1760	U	1	
Isopropylbenzene	3890	µg/l	1760	U	1	
Bromobenzene	941	µg/l	1760	U	1	
1,2,3-Trichloropropane	#VALUE!	µg/l	1760	N	50	
N-Propylbenzene	12300	µg/l	1760	U	1	
2-Chlorotoluene	#VALUE!	µg/l	1760	U	1	
1,3,5-Trimethylbenzene	#VALUE!	µg/l	1760	U	1	
4-Chlorotoluene	#VALUE!	µg/l	1760	U	1	
Tert-Butylbenzene	#VALUE!	µg/l	1760	U	1	
1,2,4-Trimethylbenzene	110	µg/l	1760	U	1	
Sec-Butylbenzene	#VALUE!	µg/l	1760	U	1	
1,3-Dichlorobenzene	#VALUE!	µg/l	1760	N	1	
4-Isopropyltoluene	#VALUE!	µg/l	1760	U	1	
1,4-Dichlorobenzene	#VALUE!	µg/l	1760	U	1	
N-Butylbenzene	#VALUE!	µg/l	1760	U	1	
1,2-Dichlorobenzene	#VALUE!	µg/l	1760	U	1	
1,2-Dibromo-3-Chloropropane	#VALUE!	µg/l	1760	U	50	
1,2,4-Trichlorobenzene	#VALUE!	µg/l	1760	U	1	
Hexachlorobutadiene	#VALUE!	µg/l	1760	U	1	
1,2,3-Trichlorobenzene	#VALUE!	µg/l	1760	U	2	
Methyl Tert-Butyl Ether	#N/A	µg/l	1760	N	1	
Naphthalene	952	µg/l	1800	N	0.01	0.005
Acenaphthylene	#VALUE!	µg/l	1800	N	0.01	0.005
Acenaphthene	375000	µg/l	1800	N	0.01	0.005
Fluorene	#VALUE!	µg/l	1800	N	0.01	0.005
Phenanthrene	#VALUE!	µg/l	1800	N	0.01	0.005
Anthracene	#VALUE!	µg/l	1800	N	0.01	0.005
Fluoranthene	#VALUE!	µg/l	1800	N	0.01	0.005
Pyrene	#VALUE!	µg/l	1800	N	0.01	0.005
Benzo[a]anthracene	53.6	µg/l	1800	N	0.01	0.005
Chrysene	#VALUE!	µg/l	1800	N	0.01	0.005
Benzo[b]fluoranthene	#VALUE!	µg/l	1800	N	0.01	0.005
Benzo[k]fluoranthene	#VALUE!	µg/l	1800	N	0.01	0.005
Benzo[a]pyrene	63.8	µg/l	1800	N	0.01	0.005
Indeno(1,2,3-c,d)Pyrene	#N/A	µg/l	1800	N	0.01	0.005
Dibenz(a,h)Anthracene	#N/A	µg/l	1800	N	0.01	0.005
Benzo[g,h,i]perylene	#VALUE!	µg/l	1800	N	0.01	0.005
Total Of 16 PAH's	#N/A	µg/l	1800	N	0.2	0.1
Total Phenols	#N/A	mg/l	1920	U	0.03	0.015
Suspended Solids at 105	#N/A	mg/l	1030	U	5	

A57 Transpennin Upgrade
Human Health Screening
Atkins Dervied Residential 1% SOM Soil Screening Values

547A	BH545(D)	503	502	501	535(S)	535(D)	536(S)	536(D)	BH515 (D)	BH515 (S)	BH516	BH509	BH506A(S)	BH511	BH514A(D)	BH519A	BH524A
WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
4.00	22.00	16.00	3.00	23.55	5.50	11.00	5.00	7.00	15.00	10.00	22.00	12.00	4.00	9.50	16.00	23.55	13.00
13/07/2021	13/07/2021	13/07/2021	13/07/2021	13/07/2021	13/07/2021	13/07/2021	13/07/2021	13/07/2021	12/07/2021	12/07/2021	12/07/2021	12/07/2021	12/07/2021	12/07/2021	12/07/2021	12/07/2021	
8.6	8.8	8.8	8.7	8.6	8.6	8.5	8.5	8.4	8.6	8.7	8.7	7.4	8.2	8.6	8.8	8.8	8.5
450	540	470	560	450	460	1200	670	660	440	470	510	26000	4300	1200	60	490	570
2	2	2	34	9	2	8	2	2	2	2	4	32	2	2	2	2	2
20	19	15	140	43	17	33	22	22	14	14	23	130	28	16	5	10	=0.5* 10
46	26	42	66	65	68	75	63	71	65	68	62	0	7.9	3.8	4.7	49	70
320	320	240	430	350	270	410	250	400	180	200	210	110	320	210	180	230	290
30	10	220	23	14	15	22	62	12	22	22	17	11000	380	180	25	15	22
0.087	0.058	0.15	0.22	0.25	0.26	0.18	0.24	0.19	0.3	0.3	0.3	0.025	0.1	0.28	0.59	0.44	=0.5* 0.050
0.55	0.24	0.61	1.1	1.5	1.6	1.4	1.6	1.7	1.6	1.3	1.3	2.3	1.6	1.6	2	1.5	0.27
0.51	0.24	0.63	1.1	1.4	1.5	1.2	1.5	1.5	1.6	1.3	1.3	1.8	1.3	1.6	2.2	1.6	0.25
0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.024	0.02	0.044	0.068	0.048	0.022	0.01	0.024	0.029	0.01	0.15
0.25	0.98	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	=0.5* 0.50
19	43	28	120	11	40	330	45	12	5.5	14	19	110	170	42	30	23	24
0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	=0.5* 0.050
0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
2	2.9	3.9	9.4	4.6	3.5	4	4.4	2.5	5.6	5.3	16	10	12	3.4	2.5	1.3	0.5
69	29	57	110	75	84	89	93	98	34	35	35	2500	140	83	26	48	55
2.4	3.8	2.9	2.1	1.2	1.7	4.1	2.3	2.4	8	7.9	13	11	3.5	2.5	7.7	2.8	3.8
15	14	15	26	23	23	27	26	37	19	20	11	160	37	16	13	26	26
25	72	33	140	48	15	200	33	31	17	24	34	5200	170	77	45	13	15
2.5	2.8	2.6	13	2.7	3.8	8	1.8	4.5	0.56	1.5	1	0.69	2.5	1.3	0.99	0.29	0.1
92	200	60	56	26	26	44	560	580	670	670	900	660	660	510	690	540	64
0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
0.89	0.25	0.25	0.25	0.25	0.25	0.25	1.2	0.25	0.25	1.3	3.3	0.25	0.25	0.61	1.2	1.1	1.7
2.5	2.5	2.5	13	2.5	2.5	2.5	2.5	2.5	2.5	2.5	15	53000	630	2.5	2.5	2.5	2.5
1.6	0.85	0.73	3	1.9	2.4	6.1	2.7	2.9	1.1	2.2	2	90	8	2.4	1.3	0.94	1.1
0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25	0.25	0.67	0.25	0.25	0.25	0.25	0.25	0.25	2.4	0.25	0.25	0.25	0.25
0.25	0.94	0.25	0.25	0.25	1.1	0.25	0.25	0.25	0.25	0.73	0.95	0.25	0.25	0.25	0.25	0.25	0.25
4.2	1.25	1.25	1.25	1.25	1.25	1.25	11	1.25	1.25	8.9	1.25	62	16	1.25	1.25	1.25	8.5
0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.1
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
47	56	45	150	78	55	89	58	84	36	44	42	48	78	40	34	46	1
	0.05	0.05							0.05		0.05				0.05		0.05
	0.05	0.05							0.05		0.05				0.05		0.05
	0.05	0.05							0.05		0.05				0.05		0.05
	0.05	0.05							0.05		0.05				0.05		0.05
	0.05	0.05							0.05		0.05				0.05		0.05
	0.05	0.05							0.05		0.05				0.05		0.05
	0.05	0.05							0.05		0.05				0.05		0.05
	0.05	0.05							0.05		0.05				0.05		0.05
	2.5	2.5							2.5		2.5				2.5		2.5
	0.05	0.05							0.05		0.05				0.05		0.05
	0.05	0.05							0.05		0.05				0.05		0.05
	0.05	0.05							0.05		0.05				0.05		0.05
	0.05	0.05							0.05		0.05				0.05		0.05
	0.05	0.05							0.05		0.05				0.05		0.05
	0.05	0.05							0.05		0.05				0.05		0.05
	0.05	0.05							0.05		0.05				0.05		0.05
	0.05	0.05							0.05		0.05				0.05		0.05
	2.5	2.5							2.5		2.5				2.5		2.5
	5	5							5		5				5		5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	2.5	2.5							2.5		2.5				2.5		2.5
	1	1							1		1				1		1
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	2.5	2.5							2.5		2.5				2.5		2.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	1	1							1		1				1		1
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	5	5							5		5				5		5
	2.5	2.5							2.5		2.5				2.5		2.5
	5	5							5		5				5		5
	0.5	0.5							0.5		0.5				0.5		0.5
	5	5							5		5				5		5
	5	5							5		5				5		5
	0.5	0.5							0.5		0.5				0.5		0.5
	1	1							1		1				1		1
	5	5							5		5				5		5
	2.5	2.5							2.5		2.5				2.5		2.5
	0.5	0.5							0.5		0.5				0.5		0.5
	1	1							1		1				1		1
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	25	25							25		25				25		25
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	25	25							25		25				25		25
	0.5	0.5							0.5		0.5				0.5		0.5
	0.5	0.5							0.5		0.5				0.5		0.5
	1	1							1		1				1		1
	0.5	0.5							0.5		0.5				0.5		0.5
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
400	1500	8800	2000	6100	7200	2300	340	950									170

Appendix H. Geotechnical Risk Register

H.1.1 Geotechnical risks and potential hazards for the A57 project were identified and have been evaluated along with measures proposed to mitigate against the risk of these hazards occurring. This risk register has been adapted from the original Arcadis GIR. Structure and location specific registers will be considered during detailed design and outstanding risks recorded and communicated through drawings and the Operation Manual.

H.1.2 The risk assessment matrix shown in Table H-1 has been used to assess the specific geotechnical hazards associated with the design of the scheme. Each hazard is assessed for the likelihood of occurring and then multiplied by the impact the hazard will have. The combined risk assessment rating categories are presented within Table H-2.

Table H-1 – Risk Assessment Matrix

Rating	1 Very Low	2 Low	3 Medium	4 High	5 Very High
Likelihood	<5%	5% - 20%	21% - 50%	51% - 75%	>75%
Impact					
Time (Weeks)	0 -1w	1-4w	4-8w	8-12w	>12 weeks
Reputation	Public criticism of less than one day requiring minimal additional press office involvement.	Public criticism of over one day to one week and/or requiring a project team response.	Public criticism of over one to two weeks and/or requiring a significant project team response.	Public criticism of over one to two weeks and/or requiring a Chief Executive response.	Public criticism over three to four weeks and/or requiring a Secretary of State response.
Health & Safety (Effect on project employees or any other parties).	Minor injuries (non reportable); minor health or welfare issue (non reportable)	Reportable < 3 day incident; health or welfare issue affecting < 100 people for < 3 days; significant near miss	Reportable: major injury or dangerous occurrence; health or welfare issue affecting >100 people < 3 days or <100 people > 3 days.	Single fatality; health or welfare issue affecting >100 people > 3 days.	Multiple fatalities or single fatality and multiple injuries. health or welfare issue affecting > 1000 people > 3 days.
Environmental	Minor pollution event contained within site. Failure to achieve local sustainability measures.	Contamination off site - no lasting damage; failure to achieve Highways England sustainability targets < 1 week.	Contamination off site - damage < 1 month); failure to achieve Highways England sustainability targets < 1 month.	Contamination off site - damage < 1 year; failure to achieve Highways England sustainability targets < 1 year.	Contamination off site - damage > 1 year; failure to achieve Highways England sustainability targets > 1 year.

Table H-2 – Risk Assessment Rating Categories

1	1	1-5
2	2	6-10
3	3	11-15
4	4	16-20
5	5	21-25

Geotechnical Risk Register – A57/A628 Trans-Pennine Upgrade										
Risk No.	Hazard Description	Potential Consequences	Location	Risk Before Control			Design Mitigation Measures to Manage the Risk	Risk After Control		
				Impact	Likelihood	Rating		Impact	Likelihood	Rating
1	Unknown ground conditions. Limited ground investigation allows for areas of unknown material e.g. soft spots	Localised subsidence or slope instability leading to injury during construction and/or damage to infrastructure.	Route wide	4	2	8	Ground Investigation Report (GIR) to highlight any known areas of potential weak material e.g. soft spots. During construction, Contractor is required to record and inform the detailed design of anyareas of unexpected material.	4	1	4
2	High voltage overhead cables located next to the proposed development.	Possibility of injury or death during construction/operation of highway. Limitations to plant movement during construction.	Route wide	5	2	10	Detailed design of earthworks should take into consideration the vertical alignment and height of the overhead cable. Geological Long Section drawings highlight the hazard. Contractor to have suitable RAMs in place for working near overhead cables.	5	1	5
3	Construction of proposed development on or near surface depressions (Kettle Holes). Possibility of working near water.	Localised subsidence or slope instability leading to injury during construction and/or damage to infrastructure. Possible injury or death from falling into water.	Route wide	3	2	6	One feature was investigated near Eastern Cutting (BH523) during 2021 investigation - without significant risk identified. Additional area within Section 1 inaccessible during 2021 investigation, to be assessed at start of construction works. If unsuitable material encountered to be excavated and replaced. Arcadis Geological Long Section drawings highlight the hazard (Drawings HE551473-ARC-HGT- SZ_ZZ000-DR-CE-3044 to 3051).	2	2	4
4	Encountering granular lenses during construction of cuttings and excavation of the underpass	Groundwater ingress within cut slopes causing localised instability of slopes, fine wash out and surface erosion.	Route wide	3	3	9	Granular lenses should be identified during construction of cuttings. Temporary works drainage design to take account of water ingress from perched water tables. Contractor to identify suite of mitigation measures for dealing with inflow of material and water within granular lenses.	3	1	3
5	Construction of proposed development on or near laminated or occassionally high plasticity glacial till.	Localised slope instability leading to damage to infrastructure.	Route wide	3	2	6	Laminations and areas of soft ground to be considered during detailed design of slope stability, and if required mitigation proposed - such as locally slackening slope angle or excavate and replace. During construction, Contractor is required to record and inform the detailed designer of any areas of unexpected material.	3	1	3

6	Impact of earthworks affecting adjacent land, infrastructure and services	Localised subsidence or slope instability causing damage to existing/proposed infrastructure.	Route wide	3	2	6	Detailed design to take account of possible effects outside boundary. Slope design to consider risk of instability affecting third party land.	3	1	3
7	Impact of proposed development on Longdendale Aqueduct Air Shaft.	Damage to airshaft - collapse, impact on water supply. Potential damage to surrounding infrastructure.	M67 to Mottram Village	4	1	4	Hazard must be recorded on construction drawings prepared during detailed design. Detailed design of embankments to consider position and location of the airshafts and aqueduct. Construction to impose exclusion zone around shafts. Effects from embankment on feature to be analysed if necessary to demonstrate safety of shaft.	2	1	2
8	Deep excavations for the Mottram underpass and associated wingwalls.	Falling from height leading to injury or death.	Mainline CH810 - 1100	5	2	10	Contractor to have suitable RAMs in place for working at height.	4	2	8
9	Construction and lifecycle use of the Mottram Underpass and associated wingwalls in areas of artesian groundwater.	Inundation, by water or soil inflow, or collapse of excavations leading to Injury due to ground movements or drowning due to water inundation.	Mainline CH810 - 1100	5	3	15	Further design to identify the likelihood of the risk of water inundation deemed risk to be low due to low surrounding rock permeability, therefore low flows. Localised low volume water ingress to excavation is likely. Hazard must be recorded on construction drawings prepared during detailed design. Temporary works designer to develop safe construction methodology for artesian groundwater.	5	1	5
10	Construction of Mottram underpass and associated wingwalls in a faulted zone. Possibility of unforeseen ground conditions during construction.	Instability and/or rapid groundwater or soil inflow. Injury due to ground movements, or drowning due to water inundation	Mainline CH810 - 1100	5	3	15	The extent of the fault zone has been further clarified following the recent 2021 ground investigation. Proven ground conditions are to be considered for detailed design with awareness of the probability of variations in the ground and their likely effect. Hazard must be recorded on construction drawings prepared during detailed design. Temporary works designer to develop safe construction methodology.	4	2	8

11	Movement of faults in Mottram Village.	Damage to properties in Mottram village and underpass and associated wingwalls due to stress changes from underpass construction	Mainline CH810 - 1100	2	1	2	Underpass to be designed for a predicted movement. However, likelihood and impact considered very low.	2	1	2
12	Construction of the eastern cutting in an area of faulting.	Instability of cutting during excavation and uneven profile of cutting due to dip in bedrock level.	Mainline CH1100 - 1510	4	2	8	Further ground investigation was undertaken to inform design and better understand the properties of the fault i.e. size and quality. Detailed design and construction methodology to take account of probable non-homogeneity of ground and groundwater conditions over short distances. Underpass location and eastern cutting amended from previous route iterations to reduce open cut in material most affected by faulting.	2	1	2
13	Construction of the eastern cutting in an area of artesian groundwater.	Localised instability in the rock and glacial till. Possible rockfalls during construction. Weak ground in fault zone may be impacted by reducing groundwater pressures	Mainline CH1100 - 1510	4	3	8	Detailed design of the cuttings to consider the effects of the cutting on the groundwater regime and the impact on weak ground in the faulted zone of the reduction in groundwater pressures. Drainage features to collect any water ingress through the slope face. Detailed design and construction methodology to take account of probable non-homogeneity of ground and groundwater conditions over short distances. Contractor's RAMS to address mitigations against the possibility of rockfalls.	4	1	4
14	Longdendale Aqueduct, exact location, ground conditions and construction method unknown.	Damage to Aqueduct - collapse, impact on water supply. Potential damage to surrounding infrastructure.	Mainline CH1510-1710	5	3	15	For the Longdendale Aqueduct Protection Structure refer to Structures Option Report. United Utilities are completing detailed surveys (as of March 2022 incomplete) to inform detailed design. Depending on the final chosen option, further surveys would be required to confirm the material surrounding the Aqueduct, as well as its construction and location.	5	2	10

15	Construction of Mottram Moor junction on top of features suspected to be pre-existing land slips (identified in main GIR)	Localised slope instability leading causing damage to the embankment and existing/proposed infrastructure.	Mainline CH1710-1820	4	2	8	GI in this area that was planned in 2021 investigation had difficult access and inconclusive results. Therefore, a slope stability assessment to be carried out at detailed design using the latest GI information available. Use appropriate design and construction to stabilise the landslips to the extent that there is no threat to the proposed works. Mitigation may involve excavate and replace with granular material.	4	1	4
16	Construction of embankments on top of suspected slipped Head deposits.	Localised slope instability caused by possibly solifluction surfaces.	Mainline CH2250 to CH2450	3	2	6	No head deposits were logged in the 2021 GI but may be present (see Atkins GIR addendum Section 4.5.4). Due to inconsistency in description and logging of superficial material in this area, deposits have been grouped purely by granular or cohesive materials. Design process should consider possible slip surfaces and poor material. Ensure rigorous stabilising techniques or if economical, dig out and replace slipped material.	3	1	3
17	River Etherow Bridge, Construction of bridge near a water course.	Inundation of foundation during construction phase due to river flooding, as well as working near or over a water body during foundation construction.	River Etherow	4	3	12	one feature was investigated near Eastern Cutting (BH523) during 2021 investigation - without significant risk identified. Additional area within Section 1 inaccessible during 2021 investigation, to be assessed at start of construction works. If unsuitabl	3	2	6
18	Construction of Mottram Underpass, cuttings and dewatering.	Settlement of infrastructure and properties in and around Mottram village due to underpass construction – including live carriageways over proposed route	In and around Mottram Village	4	3	12	Detailed design to analyse the effects of the underpass for before, during and after construction to estimate settlement associated with temporary dewatering and permanent changes to groundwater levels from the eastern cutting. This is to feed in to permit assessment and implementation of mitigation measures	4	2	8

19	Excavability of underlying rock.	Delays to construction programme and high construction costs.	Mottram Village and East Cutting	3	3	9	An excavability assessment of the bedrock should be carried out at detailed design. Contractor to choose appropriate excavation techniques for the bedrock.	3	1	3
20	Aggressive ground on buried concrete	Degradation of concrete strength causing failure of a structure.	Route wide	3	1	3	Assessment undertaken within GIR addendum. Detailed design to use appropriate concrete mix and cover to reduce risk of attack from aggressive ground conditions.	2	1	2
21	Boulders or obstructions encountered within the superficial material during construction of piles.	Delays to construction programme and high construction costs.	Route wide	4	2	8	Unable to avoid - possible redesign of pile foundations during construction to allow for a different arrangement within the pile group.	4	2	8
22	Encountering existing services during construction	Damage to existing services, proposed infrastructure or injury or death of construction workers	Route wide	4	3	12	Latest statutory services to be used during construction. However, this does not fully mitigate against unrecorded services. Contractor to observe ground surface after stripping to identify made ground which could be in service trenches.	4	2	8
23	Site won material not suitable for re-use. Material may be found to be contaminated or unsuitable for engineering features i.e. low strength material	More material to be imported from off site. Unsuitable material may need to go to landfill or need remediation. Overall higher construction costs.	Route wide	3	2	6	A detailed earth works specification is to be carried out at detailed design (managed by the Principal Contractor) to determine volume of material to be reused including an assessment of the suitability of the soil for lime or cement stabilisation. Contractor to develop material plan that protects re-useable material from degradation e.g. from wetting.	3	1	3
24	Limited information regarding the rock quality at the River Etherow	Overly conservative design of pile foundations, wrong piling technique chosen for construction.	River Etherow	2	3	6	Further GI has been completed in this area during 2021 GI, to provide adequate information for detailed design	2	1	2
25	Localised minor voiding recorded within possible faulted Breccia encountered within the Mottram Underpass	Unfavourable pile end bearing and skin resistance capacity. Pile Limit equilibrium and Serviceability State Failure	Site wide	3	4	12	2021 GI did not record voiding in this area, therefore risk likelihood deemed to be low. Detailed design parameter selection to account for risk	2	2	4

26	Sporadic reduction of bedrock strength and rock quality with depth – localised reductions in ground bearing capacity	Excessive settlement, unfavourable impact on earth pressure co-efficients for retaining wall design	Site wide	3	4	12	Reported lower range rock strength and rock quality values to be considered during detailed design and selection of piling techniques. Possibility to make allowance for additional meterage in case of poor quality material encountered at pile base.	2	4	8
27	Unrecorded steeper joint sets within rock mass	Cutting slope rock failure	Eastern Cutting	3	4	12	Inspection of exposed rock mass to be undertaken during construction of the cutting. Bedrock samples to be obtained from exposed cutting and direct shear testing to be undertaken on joint sets for cutting slope design. Allowance to be made in construction sequencing to account for rock testing.	2	3	6
28	Mine shafts near to alignment around Mottram Moor Junction. And unrecorded mine shafts across the area.	Local ground instability and risk during construction to groundworkers	Mottram Moor Junction	3	2	6	Attempt to identify shaft during construction and avoid. Toolbox talks/site induction to identify risk of unrecorded shafts. Stop work in case of unexpected ground conditions.	3	1	3
29	Inconsistency of strata descriptions in Section 4 superficial materials between different GI phases	Confusion and mis-assignment of parameters during detailed design. Could lead to poor performance (ie settlement) of proposed infrastructure	Section 4 - River Etherow	3	2	6	This GIR has combined superficial materials. Engineering behaviour of materials rather than assigned geological description should be considered when completing detaield design.	3	1	3

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Registered office Bridge House, 1 Walnut Tree Close, Guildford GU1 4LZ
National Highways Limited registered in England and Wales number 09346363