

Geo-technical and land contamination assessment

1867 – GCRE Onllwyn Road Bridge & Embankment

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Introduction

This technical note has been created to accompany the planning application and provide a summary of the geotechnical and geo-environmental information available so far. For background of the project, existing site information and details regarding the emerging bridge/embankment design, reference should be made to the Expedition RIBA Stage 2 Report: 1867-EXP-RE-001.

Reference documents

The whole site has been subject to several surveys and ground investigations. The information is available in the following documents:

- Ground investigation, April 2022, from Quantum Geotech
- Coal Mining Risk Review, January 2023, from Atkins
- Dynamic sampling and rotary drilling exploration hole log, BH 114, December 2022, from Jackson Geo services
- Global Centre of Rail Excellence Stage 1 Ground Investigation Specifications, September 2022, from Atkins
- Mining Note, June 2022, from ARUP
- Geotechnical and Geo-environmental Desk Study, December 2019, from ARUP
- Specification for Treatment of Mine Workings and Mine Entries, March 2023, from Atkins
- Ground Treatment (Including Void Stabilisation) Design Input Statement, March 2023, from Atkins
- Ground investigation report, new version from February 2023, from Atkins
- Earthworks Specification, December 2022, from Atkins
- Zone 1A Geo-Environmental Interpretive Report, March, 2023, from Atkins
- Stage 1 Ground Investigation: Factual Report, March 2023, from Jackson Geo services (outside of project boundaries)

- Bridge Works Ground Investigation: Factual Report, July 2023, from Jackson Geo services included in Appendix B
- Phase II Geo-Environmental Assessment (Bridge & Embankment), July 2023, from A-Squared Studio (reference 2583-A2S-XX-XX-RP-Y-0001-01) included in Appendix A2
- RIBA 2 Geotechnical Review (Bridge and Embankment), July 2023, from A-Squared included in Appendix A1
- Coal Mining Risk Assessment from the Coal Authority (July 2023) in Appendix C

Ground information

The table below provides a summary of the anticipated ground conditions based on a review of publicly available information, and previous ground investigation undertaken at 'The Washery', which is part of the wider site, immediately east of the bridge area. For more detailed Information refer to Appendix A1.

Unit	Depth* [m]	Thickness [m]	Description
Made Ground	0.0	1.0	Blackish grey gravelly fine to coarse SAND with low cobble content. Gravel is angular to subangular fine to coarse of mudstone and limestone. Cobbles are angular to subangular limestone and concrete
Weathered South Wales Coal Formation	1.0	1.8	Recorded as possible residual soil. Firm to stiff light grey mottled orangish brown slightly sandy gravelly silty CLAY
South Wales Coal Formation	2.8	Unproven	Extremely weak to weak, becoming moderate at depth MUDSTONE and SILTSTONE

Table 1: Expected ground conditions [1]

It is understood that sub-artesian groundwater is present on site at around 3m below ground (at track levels on the bottom of the embankment). Sub-artesian water can exert pressure on the underlying soil and rock formations, leading to instability and potential slope failure, and saturated superficial soils or fill – reducing their bearing capacity and leading to additional settlements. It is recommended that a short- and long-term sub-artesian water level is considered in the design of the bridge and embankment. Where appropriate, early contractor engagement may be appropriate to discuss construction techniques, particularly if piled foundations are to be implemented.

- Geotechnical and geo-environmental investigation (GI)

Expedition issued GI specifications in November 2022, updated in April 2023 [2]. Jackson Geo Services undertook geotechnical investigations on the site in June 2023. The Factual Report (G23012B) is included in Appendix B.

Two boreholes were drilled by Jackson Geo Services, BR-BH02 (06.06.2023) and BR-BH02 (09.06.2023) in early June. Both reached the scheduled depth of 25m below ground level (tracks level) (bgl).

Events of hitting artesian water were recorded by Jackson Geo Services team as follows:

- BH02: water strike recorded and circa -18m bgl and water stabilised at -1.7m bgl
- BH01: water strike recorded and circa -22m bgl and water stabilised at -3.3m bgl (overnight).

The Jackson team installed packers on both boreholes.

Trial pits were also dug, and samples sent to laboratories for geotechnical and geo-environmental testing.

The full boreholes logs, and geotechnical/geoenvironmental testing data is included in the Report in Appendix B.

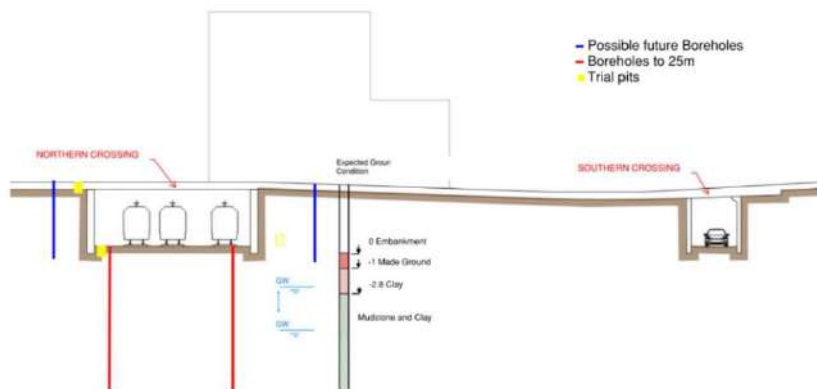
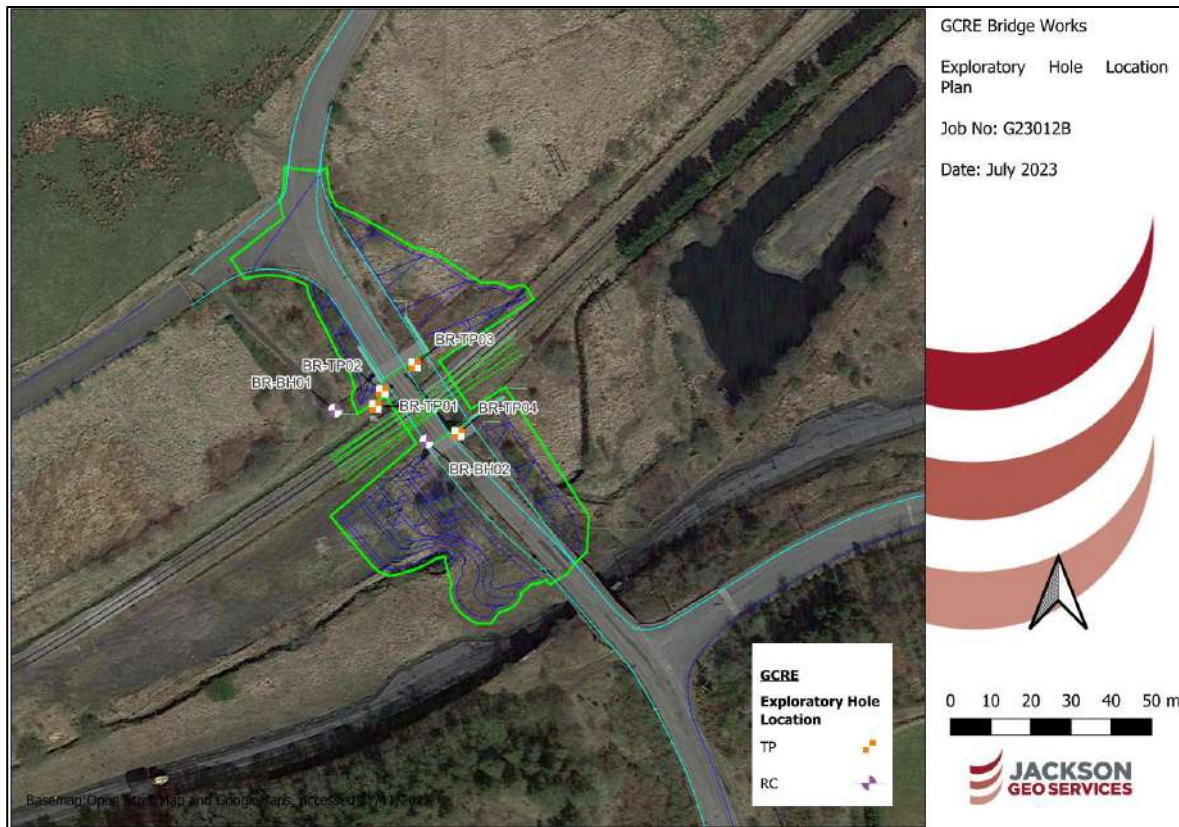


Figure 1: Location of Boreholes and Trial pits [2]

A-Squared studio have undertaken a Phase II Geo-Environmental Assessment (Appendix A2), interpreting the Jackson Geo test data, this has targeted a number of potential on-site sources of contamination including Made Ground, Rail/Tram lines, former colliary use, contaminated surface water from mineral railway, former Onllwyn Railway Station and a historic storage tank. The report identified a potential risk from contamination, which is described in the following section.

Ground risks

The following risks have been identified [1]:

- Presence of mining galleries and shallow workings in proximity of the bridge/embankment:

There is a risk of presence of mining galleries under the alignment of the bridge. They are expected to be at about -20m below ground level, assuming a cavity depth of 2m. However, this guidance is based on the cavity depth observed across the broader site, which may be overly conservative for the specific location of the bridge and embankment.

Mitigation measures:

- Site specific Coal mining risk assessment has been completed: refer to section 1.4.1
- Design to consider shallow foundations as preferred option.
- Implications of local collapse of a gallery to be assessed during RIBA Stage 3
- Probing campaign to be defined to confirm or rule out the presence of galleries

- Variability in embankment material

The embankment is likely made up of Made Ground / fill which is inherently inconsistent by nature.

Mitigation measure:

- Additional ground investigation to be specified to cover the embankment material.

- Groundwater

It is understood that groundwater has stabilised at around 3m below ground (where ground is the tracks level). The long-term water table should be considered for the design of deep and shallow foundations. For the purpose of geotechnical design, it is recommended that the long-term groundwater table is taken at ground level (i.e. track level).

Mitigation measure:

- It is recommended that a short- and long-term sub-artesian water level is considered in the design of the bridge and embankment.

- Presence of shallow compressible material

Based on the review of nearby borehole logs, it is likely that there is a shallow layer of peat / compressible material present beneath the site which could have a considerable impact on the settlement of any new structure.

Mitigation measure:

- Geotechnical investigation at the bridge location has shown that there is no peat there.

- Additional ground investigation to be done within the embankments area to confirm the presence of compressible materials or not.
- Assessment of a probable settlement to be done in RIBA3

- Below ground obstructions

Below-ground obstructions may be present which will impact piling (if needed) of retaining walls / bridge foundations.

Mitigation measure:

- A probing exercise will be undertaken prior to any proposed piling works.

- Contamination

Contamination may be present in the existing ground (and in particular the embankment which is made from site-won fill material), and from potential historic sources on/nearby the site.

Mitigation measure:

A suite of geo-environmental tests has been done, and results are included in the Phase II geo-environmental assessment included in Appendix A2. This report generally concludes that there is a low risk from contamination to receptors on the site. However, the report concludes that there is an unacceptable risk to proposed future site users by direct contact, ingestion and inhalation from untested material on site. Mitigation measures include undertaking targeted geo-environmental testing on the embankment itself, producing a detailed remediation strategy and adopting a suitable sulphate resistant design class for buried concrete structures. Additional geo-environmental testing has been specified to better qualify the embankment ground properties and conclude on the contamination risks (refer to Appendix B).

Coal Mining Risk Assessment

The site is identified as being in an area which has undergone historical coal mining and therefore an extensive mining network is expected to be present beneath the site. The site is located within a Coal Authority 'Development High Risk Area' – defined as an “area which contains one or more recorded coal mining related features which have the potential for instability or a degree of risk to the surface from the legacy of coal mining operations”.

Atkins has produced a Coal Mining Risk Review for the whole site in January 2023 [3].

A site-specific coal mining risk (refer to Appendix C) has been completed and concluded that the risk from shallow mine workings is low but there is a medium risk for deep cavities. Therefore, the Coal Authority has requested intrusive ground investigation. A first GI campaign with bore holes has been done and no cavities were found. A supplementary probing campaign will be specified before the start of the works (see mitigation measures listed below). The report also highlights the need for Gas Risk Assessment. This should be undertaken during RIBA3.

Section 5 – Conclusions

This report has identified that the proposed development site has been subject to past coal mining activity, namely the presence of recorded shallow mine workings in the Bute (Peacock) seam and possible unrecorded shallow mine workings in the Nine Feet seam. The risk to the site from legacy mining features is medium.

Nevertheless, subject to the undertaking of appropriate site investigations and any potential necessary remedial measures as outlined in Section 4a of this report, the Coal Authority considers that the site may be made safe and stable for future development and the risk to the development reduced to low. The recorded coal mining legacy issues present within the site do not pose any particular implications for the layout of the proposed development.

The Coal Authority advises the developer undertake a detailed Gas Risk Assessment where proposed development occurs over shallow coal reserves as is the case here.

Figure 2: Extract from Coal Mining Risk Assessment (full report can be found in Appendix C)

References

- [1] A-squared Studio, “ GCRE Wales: RIBA 2 Geotechnical Review (Bridge and Embankment)”, 04/07/2023
- [2] Expedition, “GCRE Bridge – Ground Investigation specification”, 21/04/2023
- [3] Atkins, “Global centre for Rail Excellence: Coal Mining Risk Review”, 16/01/2023

Appendix A – A-Squared

B1 – Geotechnical review

B2 – Phase II Geo-environmental Assessment



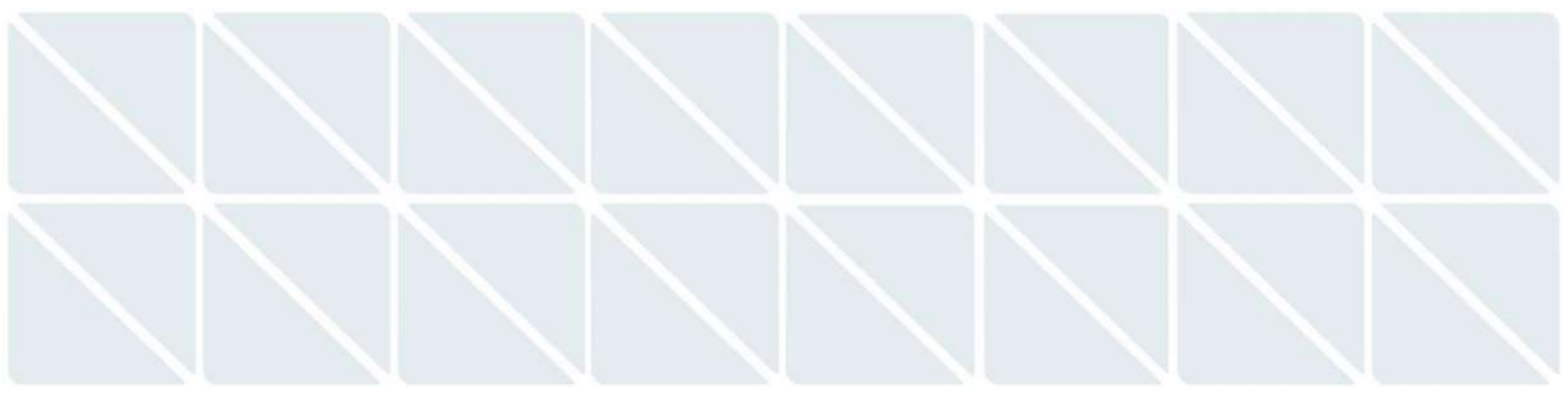
A-squared Studio

GCRE Wales

RIBA 2 Geotechnical Review (Bridge and Embankment)

July 2023

2583-A2S-XX-XX-RP-Y-0001-01





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Appendices

Appendix A: Selected Project Information

Appendix B: Site Acceptance Criteria



1. Introduction

The site is located at the head of the Dulais and Tawe valleys, north-east of Swansea, South Wales. The site lies on the edge of the Brecon Beacons National Park and spans the county borough boundary of Neath Port Talbot and Powys. The proposed development comprises the construction of the Global Centre for Rail Excellence (GCRE), which will provide state-of-the-art rolling stock and infrastructure testing, research and maintenance for the UK and international rail industry. The site has been identified as being in an area of previous coal mining activity and is highly likely to be situated atop historical workings / galleries.

The proposed scheme includes the replacement of the existing bridge structure to accommodate the required clearance of the underlying track, reprofiling of the embankment approaches to suit these enhanced track clearances and an adjoining platform connecting the embankment to the nearby proposed HQ building. At present, the reuse of some of the bridge structure is being explored. The bridge location is presented in Figure 1.1.

This document provides a review of the available information, risks and recommendations, and further actions in relation to the bridge and embankment, which form part of the proposed scheme.



Figure 1.1 Location of the proposed development

1.1. Information Sources

The following information sources have been reviewed to identify the risks and provide recommendations:

- *Land at Nant Helen and Onllwyn Coal Washery, Geotechnical and Geoenvironmental Desk Study*, produced by Arup Limited (Arup), dated December 2019.
- *Detailed Mine Workings Study*, produced by Arup, dated June 2020.
- *Global Centre of Rail Excellence (GCRE), Coal Mining Risk Review*, produced by Atkins Limited (Atkins), dated January 2023 (ref. GCRE001-AWJV-00-XX-RP-GE-00003).
- *Global Centre of Rail Excellence Ground Investigation: Factual Report*, produced by Quantum Geotechnical Limited, dated April 2022 (ref. Q0652/FR_01).



- *Global Centre of Rail Excellence (GCRE), Ground Investigation Report*, produced by Atkins, dated February 2023 (ref. GCRE001-AWJV-00-XX-RP-GE-00002).
- Borehole and trial pit logs produced by Jackson Geo Services.
- CIRIA C758D: Abandoned mine workings manual.



2. Ground Conditions

2.1. Ground Investigation

Site-specific ground investigation was undertaken by Jackson Geo Services between 02/06/2023 to 09/06/2023.

The investigation comprised:

- 2no. cable percussion boreholes to 25mbgl,
- 4no. trial pits to 1.2m,
- In-situ geotechnical testing,
- Laboratory geotechnical and geo-environmental testing.

The cable percussion boreholes were undertaken from track level in order to facilitate sampling and testing of the soil underlying the existing bridge foundations. The purpose of the trial pits was to understand the geometry and extent of the existing bridge foundations and to collect data on the embankment material.

Both cable percussion boreholes encountered made ground overlying the South Wales Coal Measures Formation which appears as Clay, Gravel, Siltstone and Mudstone. Immediately beneath the Made Ground, BR-BH01 encountered weathered siltstone followed by gravel and BR-BH02 encountered firm to stiff light grey Clay. This was followed by the South Wales Coal Formation (Siltstone and Mudstone) to depth in both boreholes. This suggests that the shallow material will vary at each bridge abutment location.

The trial pits encountered various compositions of granular Made Ground (Sand, Gravels and Cobbles). The pits were proposed to be undertaken from embankment level however due to access restrictions, the contractor repositioned these to track level.

At the time of writing, only geoenvironmental laboratory test results have been returned. Jackson Geo Services have advised that geotechnical test results should be available by 03/07/2023.

2.2. Encountered Geology

The following geology was encountered at each abutment location:

Table 2.1 Abutment 1 (north) ground model

Stratum	Depth (mbgl)	Thickness (m)	Description
Made Ground	0.0	0.8	Dark grey silty gravelly fine to coarse SAND of local mudstone with low cobble content. Gravel is angular to subangular fine to coarse of mudstone and limestone. Cobbles are angular to subangular of limestone and concrete.
South Wales Coal Formation (Weathered Siltstone)	0.8	1.2	Weathered grey siltstone.
South Wales Coal Formation (Gravel)	2.0	0.5	Grey very angular to subangular medium to coarse GRAVEL of limestone.
South Wales Coal Formation (Mudstone and Siltstone)	2.5	Unproven	Extremely weak to weak, becoming moderate at depth MUDSTONE and SILTSTONE.



Table 2.2 **Abutment 2 (south) ground model**

Stratum	Depth (mbgl)	Thickness (m)	Description
Made Ground	0.0	1.0	Blackish grey gravelly fine to coarse SAND with low cobble content. Gravel is angular to subangular fine to coarse of mudstone and limestone. Cobbles are angular to subangular limestone and concrete.
South Wales Coal Formation (Clay)	1.0	1.8	Recorded as possible residual soil. Firm to stiff light grey mottled orangish brown slightly sandy gravelly silty CLAY.
South Wales Coal Formation (Mudstone and Siltstone)	2.8	Unproven	Extremely weak to weak, becoming moderate at depth MUDSTONE and SILTSTONE.

2.3. Recommended Further GI

It is recommended that further GI is undertaken – particularly to support the design and assessment of the embankment. The following is recommended at this stage:

- **Minimum of 1no. borehole or window sample from embankment level (each side).** Ideally on both abutment approach embankments, with in-situ testing (SPT testing) and sampling of the full embankment depth.

The above will aid in the characterization of the embankment fill material and assessment of its engineering performance. This is of particular importance in order to ensure the long-term serviceability performance of the embankment and any require reprofiling and carriageway level raising designs.

The GI contractor should advise on the most appropriate drilling methodology to ensure the full embankment depth can be profiled and sampled.

No further ground investigation is required to inform geo-environmental assessment of the GCRE Bridge.

It is recommended that **probing for mining galleries in the vicinity of the bridge and embankment** is undertaken to mitigate risks associated with the collapse of the mines.



3. Ground Engineering Risks

3.1. Shallow Mining Galleries Present in Close Proximity to Works

Where there are new bridge structures, an increased loading on existing structures or embankments, or sheet piling works in close proximity to shallow mining galleries with an insufficient rockhead cover (typically considered as $10t$ based on guidance from CIRIA C578D, where t represents the height of the cavity) there is a risk of instability or collapse of the void.

According to mining risk reports from Atkins and Arup, a minimum cover of 20m is recommended, assuming a cavity height of 2m. However, this guidance is based on the cavity depth observed across the broader site, which may be overly conservative for the specific location of the bridge and embankment. If targeted ground investigation (GI) reveals a reduced cavity height, it may be appropriate to suggest a shallower depth of rockhead cover.

Following a review of local existing borehole data, BH01, located west of the bridge, suggests the presence of a cavity with a depth of 1.7m and a rockhead cover of 8.2m.

At this stage it is recommended that mining cavity risk is fully mitigated through **1) a campaign of foundation probing designed to identify the presence of cavities within the zone of influence of the bridge foundations and 2) where cavities are identified, they should be infilled via a drill and grout technique.**

3.2. Variability in Embankment Material

The embankment is likely made up of Made Ground / fill which is inertly inconsistent by nature. It is recommended that investigation and geotechnical testing of the embankment is undertaken to fully understand its makeup and engineering properties for earthworks, slope stability and retaining wall design. The extent of ground investigation in the embankment is currently being discussed, however it is understood that this information will be available in RIBA stage 3.

3.3. Groundwater

It is recommended that appropriate provision for dewatering via sumps and pumps are made with regards to construction means and methods and excavation associated with the foundations of new bridge structures. Any requirements for dewatering and the subsequent ground movement should be considered as part of the design proposals, as uncontrolled dewatering be detrimental to construction proposals.

It is understood that sub-artesian groundwater is present on site, following artificial depression via pumping which ceased in 2021. The site-specific GI showed ground water to rise to approximately 3.0mbgl. The long-term water table should be considered for the design of deep and shallow foundations. For the purpose of geotechnical design, **it is recommended that the long-term groundwater table is taken at ground level (i.e. track level / toe of the existing embankment).**

Early contractor engagement may be appropriate to discuss construction techniques, particularly where pile foundations are to be implemented.

3.4. Global Stability Mechanisms of the Embankment and Retaining Structures

The design of the embankment and any proposed retaining structures should consider global stability mechanisms, taking into account the presence/proximity of any new and existing structures in the vicinity of the embankment – in particular, the HQ building.

3.5. Below Ground Obstructions

Below-ground obstructions may be present which will impact piling of retaining walls / bridge foundations. A probing exercise can be undertaken prior to any proposed piling works to mitigate the risk.



4. Foundation System

4.1. Shallow Foundations

The preferred foundation option for the bridge structure are shallow strip footings across the bridge abutment. As the ground investigation local to the bridge abutments did not identify any shallow peat or compressible material, and with a relatively thin layer of made ground, shallow foundations are considered viable without the need to excavate a substantial amount of material.

Due to the integral nature of the bridge structure, provided that relatively high flexural and axial rigidities are achieved for abutment and deck structures, it is anticipated that the strip footing foundation will not attract significant horizontal forces or overturning moments. The design of these foundations will therefore be driven by vertical bearing capacity considerations, rather than by sliding or overturning mechanisms.

Table 4.1 gives the bearing capacities of a 12m strip foundation of varying widths, founded on top of the South Wales Coal Formation **Clay** (beneath abutment 2 as this will be the critical location with the greatest thickness of superficial deposits over rockhead), assuming that negligible horizontal force components or overturning moments are applied.

Table 4.1 Eurocode 7 safe bearing capacities (kPa) for a 12.0m^[1] strip foundation

		Strip width (m)				
		1.0	1.5	2.0	2.5	3.0
Depth ^[2] (m)	0.0	80	85	90	95	100
	1.0	155	155	160	175	175
	2.0	230	235	240	240	245

1. Strip length assumed based on bridge width.
2. Depth refers to metres into the South Wales Coal Formation.
3. The angle of shearing resistance of the South Wales Coal Formation Clay conservatively taken as 24 degrees based on plasticity index testing in local boreholes.
4. Dead / Live split of 70 / 30% assumed.

Based on the shallow strip capacities presented in Table 4.1, a 3.0m strip at 2.0m depth would give sufficient capacity to support the bridge based on the most recent loading provided by Expedition.

During the proposed foundation probing campaign, any identified cavities should be grouted in order to mitigate any risk of cavity collapse. A suitable grout should be specified which is able to be injected and set within the sub-artesian water conditions, early specialist contractor engagement is advised, to understand the best techniques to adopt in these conditions.

4.2. Pile Foundations

Generally, when piling with the presence of voids due to mining, the risk of subsidence and pile buildability is mitigated through grouting of the voids. The grout general properties and viscosity can be tailored to the needs of the site, limiting the distance it will displace laterally, such that only targeted areas / cavities are infilled (i.e. the grout or other filling compounds do not flow well beyond the target area).

Should the full extent of the galleries be known through further investigation and survey, the galleries can be incorporated into the design of any bearing piles. As the South Wales Coal Formation is a relatively competent engineering material, piled foundations will generate capacities which should be sufficient to support the magnitude of envisaged scheme loading.



Should pile foundations be required to protrude through the mining galleries, grouting or permanent casing will be required, and there remains the risk that future collapse of the voids will result in additional actions on the piles. These forces imparted will require consideration in the design of the piles, both from geotechnical and structural design perspectives.



5. Integral Bridge Analysis Strategy

The following options are proposed for the process of analysis iteration between the GEO & STR bridge models. These options should be discussed and agreed between Expedition and A-squared prior to commencement of design analysis.

GEO Model

- i. Foundations, abutment walls and deck are explicitly modelled (latter two modelled in an idealised manner, as equivalent beams with appropriate flexural and axial rigidities EI and EA). Expedition to provide appropriate flexural and axial rigidity properties.
- ii. Soil is modelled as a non-linear continuum, in contact with the abutment wall and foundation.
- iii. Load cases are assessed, primarily comprising gravity and deck expansion/contraction.

STR Model

Option 1

- i. Abutments & deck explicitly modelled.
- ii. Translation and rotation springs applied at the abutment base, representing the foundation behaviour. Spring stiffness evaluated from A2 GEO model.
- iii. Earth pressure behind abutment modelled explicitly (pressure distribution from A2 GEO model).

Or

Earth pressure modelled using “prestressed” springs. Prestress representative of backfill earth pressure and spring reactions simulating earth pressure increase/reduction associated with deck expansion/contraction.

Option 2

- i. Abutments & deck modelled in separate models.
- ii. Deck model with edge spring supports representing the abutment system (including foundations) behaviour. Ideally springs would have to be able to simulate force/displacement matrix “non-diagonal” terms (i.e. displacements induced by moments and rotations induced by forces).
- iii. Abutment model with base translation and rotation springs (from GEO model) and deck forces/moments acting at the top. Earth pressure behind abutment modelled explicitly (pressure distribution from A2 GEO model) **OR** modelled using “prestressed” springs. Prestress representative of backfill earth pressure and spring reactions simulating earth pressure increase/reduction associated with deck expansion/contraction.

Or

Abutment designed based on GEO model results.



6. Embankment Strategy

The preferred option for the embankment is to re-use the existing material, where possible, to accommodate the proposals for this portion of the site, and to use excess material from the wider site, where required. This section discusses the recommended investigation and testing to understand the engineering properties of the existing material, and analysis to assess its performance as part of the proposed scheme.

6.1. Investigation and Testing

As discussed in Section 3.3, additional boreholes are recommended in order to understand the composition of the existing embankment material. As part of the additional investigation, geotechnical testing should be specified so that the embankments engineering parameters which slope stability and retaining wall design are dependent upon (generally the angle of shearing resistance and bulk unit weight) can be determined. These parameters can be assumed based on the material description, however this approach would be particularly conservative by nature. The following tests should be undertaken on the embankment material (as minimum) to derive its geotechnical parameters and to avoid unnecessarily conservative assumptions:

- In situ testing in the form of SPT or equivalent.
- Particle size distribution on granular material.
- Triaxial testing on cohesive material.
- Atterberg testing on cohesive material.

6.2. Slope Stability and Retaining Wall Analysis

An analysis of the embankment and retaining wall sections should be conducted to assess the performance of the proposed development. A detailed 2D FE analysis is recommended using geotechnical parameters and ground model derived following GI of both the embankment and underlying soil in PLAXIS 2D. A 2D FE model will capture the global stability of the retaining wall / embankment where other, more simple software analyses may fall short. Results of the analysis would include the short- and long-term SLS performance of the section, as well as bending moments and shear forces within any retaining structures.

To give an early insight into any particularly onerous sections before GI results have been returned and interpreted, a preliminary assessment can be undertaken using estimated parameters (using results from the wider site) and less detailed software (WALLAP, Slope/W or similar).

6.3. Geo-environmental Considerations

6.3.1. Human Health

The proposed development includes updates to the current bridge structure and new soft landscaping. Therefore, human health GAC have been applied to each chemical determinant based on the 'Public Open Space park' and 'commercial' generic land-use scenario. In future, should the site redevelopment plans change from those considered herein then the geo-environmental risk assessments will need to be reconsidered.

The proposed development includes soft-landscaping but only in localised areas. Therefore, potential exposure to contamination in shallow soils is viable only where soft-landscaping is proposed. There should be no regular exposure of humans to soils elsewhere at the site. Therefore, exposure of site users to contamination via direct contact / ingestion / inhalation of soils has been assessed as low risk (i.e. no unacceptable risk).



6.3.2. Removal of Soil

The available soil sample analytical results indicates that on-site Made Ground can generally be classified as non-hazardous however, Made Ground in the vicinity of BR-TP01 may be hazardous due to the localised detection of TPH greater than 1,000 mg/kg.

WAC testing was undertaken on two samples taken from BR-TP03 (0.2-0.3m bgl) and BR-TP04 (0.5-0.6m bgl). The WAC data for Made Ground at BR-TP03 and BR-TP04 indicates that acceptance of excavated Made Ground at an Inert landfill facility may not be possible due to the following:

- Total organic carbon exceeded inert landfill criteria in BR-TP03
- Total organic carbon, molybdenum and total dissolved solids exceeded inert landfill criteria in BR-TP03

If soil excavation and disposal is to take place, a full waste assessment based on *WM3* is recommended. However, this should not be needed to secure planning permission or for condition discharge.

It is important to note that non-landfill solutions are also potentially available for soils excavated from the site. Should a full waste assessment and appraisal of disposal / recycling / re-use options be required for the construction phase then A-squared can assist once specific details of the required excavation and disposal activities are known. The finalised site cut and fill model would be particularly useful for this exercise.

6.3.3. Import of Material from the Wider Site

Should cut and fill activities be taking place at the embankments, such as the import of materials from the wider site to make up levels, a Materials Management Plan (MMP) in accordance with the *CL:AIRE Definition of Waste Code of Practice* is recommended to enable compliant on-site re-use of site-won soils as non-waste materials.

It is the responsibility of the Principal Contractor to assess the suitability of any materials imported to site to achieve the proposed engineering levels. Imported materials may fall into the following three general categories:

- **Primary Aggregate** – There is no requirement to chemically validate these materials, but delivery documentation must confirm the primary nature and origin of the material.
- **Secondary Aggregate** – Documentation must be available from the supplier confirming material sources and that the materials have verifiable 'non-waste' status (suitable documentation would include evidence that the aggregate has been produced in accordance with Wrap, Quality Protocol, Aggregates from Inert Waste, End of waste criteria for the production of aggregates from inert waste and that appropriate verification testing results are available in accordance with the supplier's Factory Production Control manual or other documented QA / QC procedures);
- **Imported Soils** – Any imported soils must meet the Site Acceptance Criteria (see Appendix B) including sampling and testing at a frequency of at least 1 per 100m³ - with a minimum of 3 samples / tests undertaken for any single source of material. The laboratory certificates of analysis must be provided by the Principal Contractor. Source suitability for any soils imported from off-site should be requested by the Principal Contractor and confirmed by the project geo-environmental consultant prior to import so that the SAC in Appendix A can be confirmed as suitable.

Soil import may be necessary to construct soft-landscaped areas located above ground level (e.g. embankments). Soil imported for this purpose should be verified as per the above protocols. It is also important that the use of imported soils is not a waste operation. Once a potential source(s) of soil is identified, it is recommended that A-squared are engaged to advise on compliant import and use of the soils at the proposed development. An MMP, waste exemption or regulatory position statement may need to be adhered to for these purposes.

Any materials placed in soft-landscaping areas must also meet the relevant landscape architect specification.



It is recommended that any imported primary aggregate, secondary aggregate or soil is recorded within an Earthworks Plan including stockpile referencing and clearly identified areas of permanent placement cross-referenced with the soil sample names. The Earthworks Plan should also account for the excavation and re-use of any site-won soils if undertaken.

Site-won soils which are re-used within the earthworks do not require verification sampling / testing if they are re-used beneath external hardstanding. An exception is if a requirement is introduced in response to unexpected contamination.

6.4. Construction Sequencing

It is recommended that the following construction sequence is adopted:

- i. Excavation of embankment material to proposed level (if lower than existing) and to form abutment foundations.
- ii. Driving / construction of retaining walls / abutments.
- iii. Fill material behind walls / abutments to proposed level (if above existing).

Steps i. or iii. should be ignored depending on whether the proposed embankment level is above or below the exiting level. The above sequence assumes that the existing embankment material will be suitable from a slope stability and geoenvironmental perspective. Should it be deemed unsuitable and required to be replaced, the material should be fully excavated to ground level before commencing steps ii. and iii.

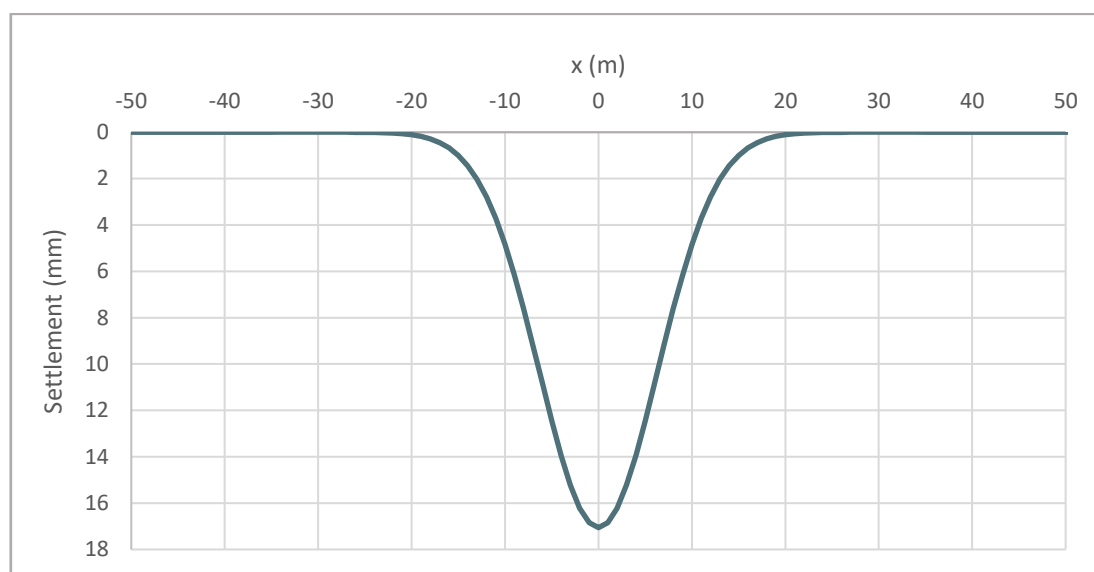
Compacted granular engineering fill will be required behind bridge abutment and retaining walls. This will also likely extend locally below the shallow abutment foundations. The specification and exact geometry of this fill placement should be developed as the design progresses.



7. Mining Gallery Collapse Impact

An assessment has been undertaken to quantify the degree of settlement that may occur due to the collapse of a mining gallery was undertaken and presented in *Mining Risks and Recommendations* technical note produced by A-squared in March 2023 (ref. 2583-A2S-XX-XX-TN-Y-0002-00). This assessment gives the settlement should a circa 0.7m diameter circular void collapse at 15.75mbgl (representative of nearby known gallery depths and diameters). A settlement of 17mm $\pm 20\%$ has been approximated for the collapse of a single gallery based on the information available at the time of writing. This settlement will occur with a Gaussian distribution, as presented in Figure 7.1.

The true depth and diameter of the potential galleries beneath the bridge are unknown at this stage, and the expected magnitude of settlement and subsequent differential settlement may be larger or smaller than given in this technical note.



Assumes $k=0.4$ and 70% volume loss.

Figure 7.1 Estimated settlement distribution from the collapse of a single mining gallery

When assessing the impact of gallery collapse on the bridge structure or embankment, the differential settlement that will occur between the abutments of the bridge, or structures atop of the embankment should be considered, and should be limited in order to avoid structural damage. A general rotation limit that is often adopted (and is stated in Eurocode 7: Geotechnical design – Part 1: General rules, Annex H) is $1/500h$.

A preliminary assessment of the worst-case differential settlement across the bridge structure has been undertaken, assuming the collapse of a single gallery (with geometry and depth assumptions outlined above) beneath one of the bridge abutments which would induce a maximum differential settlement across the structure. The worst-case differential settlement was found to be approximately $1/850h$, assuming a bridge deck length of 18.0m, and ignoring any settlement due to loading of the bridge. This comfortably falls within the limit of $1/500h$.

It should be noted that the above assessment makes assumptions on the thickness of, and depth to the mining gallery. This has been assumed based on the known thickness of and depth to a nearby gallery, which may be different (and induce a higher magnitude of settlement) beneath the bridge structure. In addition to this, settlement due to loading has been ignored as part of the preliminary assessment. A detailed assessment should take place considering both the settlement due to loading and the actual thickness and depth of the gallery once known.

The risk of gallery collapse should be mitigated through grouting of the cavities as and when they are discovered during probing.



8. RIBA 3 Design - Next Steps

Shallow foundations are the preferred option for the scheme. Following the review of site-specific GI, this foundation option is deemed to be viable with a sufficient bearing capacity based on the current loading information supplied by Expedition, and when considering the ground conditions present at the site. It is recommended that regardless of the chosen foundation option, the risk of cavity collapse is mitigated through probing and grouting of the cavities.

The next steps and requirements for RIBA 3 are as follows:

- Specification of further GI.
- Interpretation of GI data and production of a Geotechnical Design Report & Phase II quantitative geo-environmental assessment. This can be produced based on the existing GI data with a later addendum covering additional GI works, if required.
- Specification of probing campaign (across bridge abutment / foundation element locations).
- Detailed slope stability and retaining wall analysis (initial preliminary assessment if required).
- Agreement of integral bridge design analysis strategy with the bridge design team.
- GEO integral bridge analysis to feed in to STR model.
- Following GQRA, it is considered that there is no unacceptable risk (ref. *LCRM*) so no geo-environmental remediation is required to enable the proposed development to be suitable for use.
- Production of a geotechnical and ground engineering risk matrix, to be populated throughout RIBA3.



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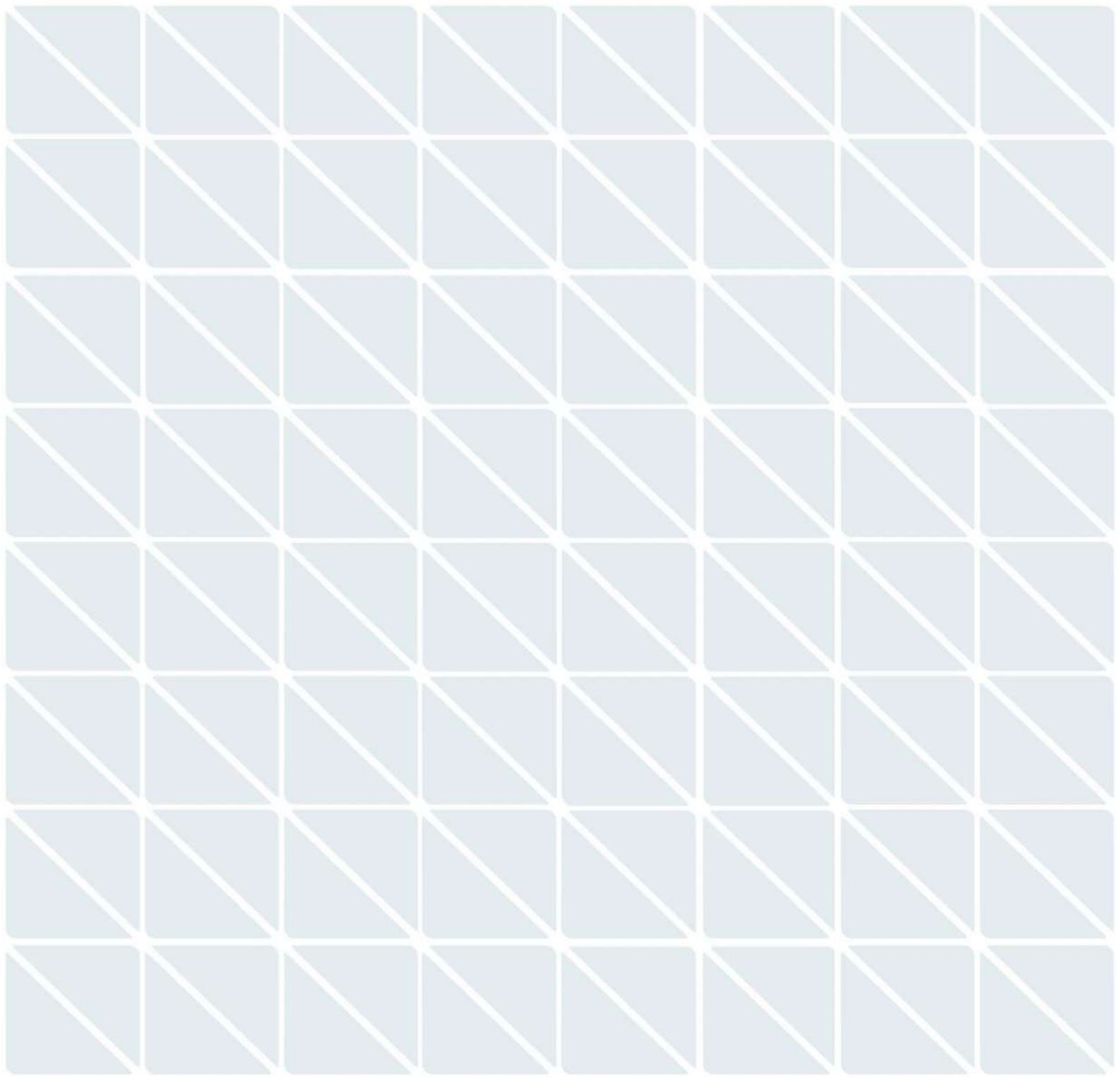
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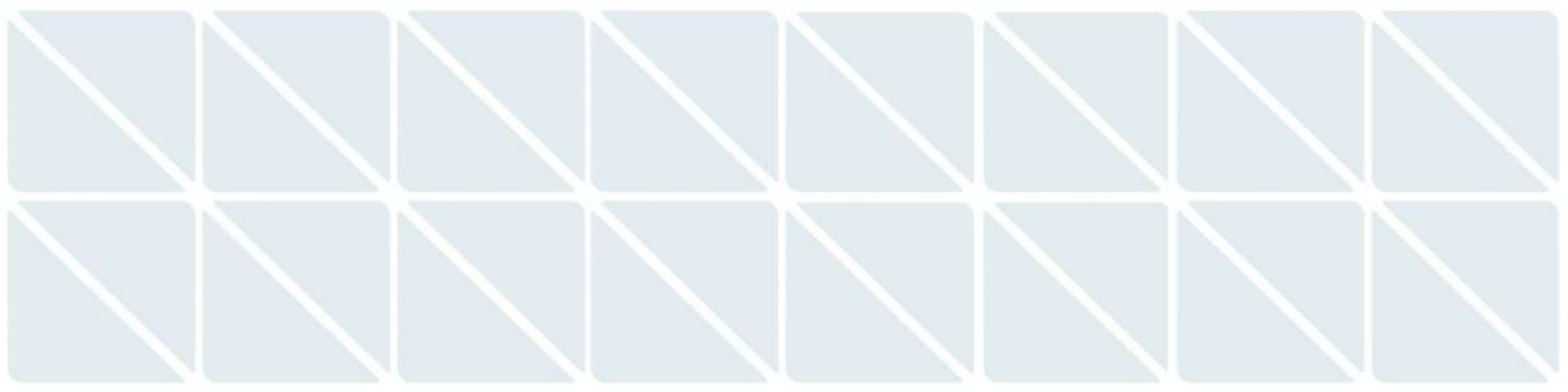
A-squared Studio

GCRE Wales

Phase II Geo-environmental Assessment (Bridge & Embankment)

July 2023

2583-A2S-XX-XX-RP-Y-0001-01





Project Name	GCRE Wales
Project Number	2583
Client	Expedition Ltd
Document Name	Phase II Geo-environmental Assessment (Bridge & Embankment)

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Appendices

Appendix A: Factual Report

Appendix B: Qualitative Risk Assessment Matrix

Appendix C: GQRA Screening Tables



1. Introduction

A-squared Studio Engineers Ltd (A-squared) has been engaged by Expedition Ltd (Expedition) to prepare a Phase II Geo-environmental Assessment for the proposed bridge redevelopment works on Onllwyn Road, located at the head of the Dulais and Tawe valleys, north-east of Swansea, South Wales (herein called the 'site').

1.1. Study Aims and Objectives

The aim of this report is to interpret the results of recent ground investigation and present a generic quantitative risk assessment (GQRA) based on the ground investigation results, proposed development plans, and the following reports:

- Ove Arup & Partners Ltd (ARUP), Land at Nant Helen and Onllwyn Coal Washery, *Geotechnical and Geoenvironmental Desk Study* (ref. 264904-00), dated December 2019.
- ATKINS Member of the SNC-Lavalin Group (Atkins), Global Centre of Rail Excellence Zone 1A, *Geo-environmental Interpretive Report* (ref. GCRE001-AWJV-00-XX-RP-GE-00002), dated March 2023.
- Global Centre of Rail Excellence, Bridge Works Ground Investigation, Factual Report prepared by Jacksons Geo Service (Jacksons), dated July 2023 (ref: G23012B).

The GQRA has been undertaken for the proposed development in general accordance with *Land Contamination Risk Management* (LCRM) guidance, published by the Environmental Agency of the UK Government website, and in the context of *National Planning Policy Framework* (NPPF) requirements and *The Building Regulations 2010, Approved Document C – Site preparation and resistance to contaminants and moisture (2004 Edition incorporating 2010 and 2013 amendments)*. The GQRA assessment present in Section 6 of this report has been undertaken to determine whether there is any unacceptable risk (ref. LCRM) which needs to be further addressed and recommend further works considered necessary.

The ground investigation has been undertaken in general accordance with *BS10175:2011 Investigation of Potentially Contaminated Sites – Code of Practice*.

Geotechnical assessment is not included in this report.

1.2. Information Sources

- Global Centre of Rail Excellence, Bridge Works Ground Investigation, Factual Report prepared by Jacksons, dated July 2023 (ref: G23012B).
- Ove Arup & Partners Ltd (ARUP), Land at Nant Helen and Onllwyn Coal Washery, *Geotechnical and Geoenvironmental Desk Study* (ref. 264904-00), dated December 2019.
- ATKINS Member of the SNC-Lavalin Group (Atkins), Global Centre of Rail Excellence Zone 1A *Geo-environmental Interpretive Report* (ref GCRE001-AWJV-00-XX-RP-GE-00002), dated March 2023.
- 5th Studio and Expedition, Pont Y Offeriad, Onllwyn Road, RIBA Stage 0/1: Feasibility Report, Draft dated October 2022.



2. The Site and Proposed Development

2.1. Development Site and Current Site Use

The site is a bridged area that crosses over an active railway line. The site is part of the wider Global Centre for Rail Excellence (GCRE) boundary which lies on the edge of the Brecon Beacons National Park and spans the county borough boundary of Neath Port Talbot and Powys, as is shown in Figure 2.1.

The site is located on Onllwyn Road, located at the head of the Dulais and Tawe valleys, northeast of Swansea, South Wales. The approximate National Grid reference is 284128, 210513 with a footprint that covers approximately 0.08 hectares (ha). The approximate ground surface elevation at the site is 233m above Ordnance Datum (OD) on top of the bridge and 230m OD on the underlying railway line.

The proposed GCRE development will provide state-of-the-art rolling stock and infrastructure testing, research and maintenance for the UK and international rail industry. The site has been identified as being in an area of previous coal mining activity and is highly likely to be situated atop historical workings / galleries.

The current land uses within a 250m radius surrounding the site is summarised in Table 2.1.

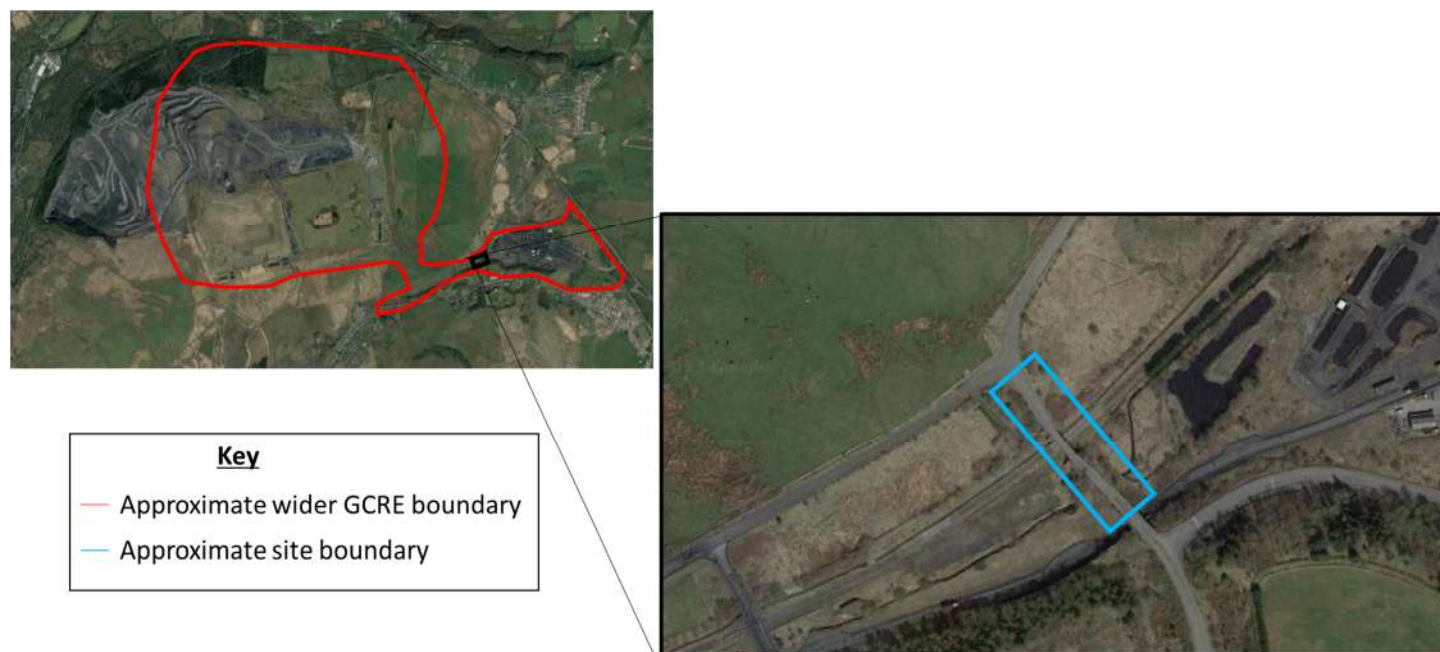


Figure 2.1 Location of the proposed development

Table 2.1 Surrounding land uses summary

Bearing from Site	Features directly adjacent to the site boundary	Other identified land uses and key structures
North	Onllwyn road – A single carriage tarmacked road running in a north to south direction (which passes through the site).	Up to and beyond 250m north of the site is undeveloped land associated with the wider GCRE site.
South	Onllwyn road – A single carriage tarmacked road running in a north to south direction (which passes through the site).	Undeveloped fields are present up to 200m south of the site. A tarmacked road associated with the Onllwyn Colliery washery and distribution centre is present approximately 50m south of the site. Onllwyn Road and Wembley Avenue (single carriage way roads) are present 200m south of the site.



Bearing from Site	Features directly adjacent to the site boundary	Other identified land uses and key structures
		Residential homes with gardens are present 250m southeast of the site
West	Railway line running in an east to west direction (which passes through the site)	Up to and beyond 250m of the site are undeveloped fields associated with the wider GCRE site. Tarmacked road associated with the Onllwyn Colliery washery and distribution centre is present approximately 200m west of the site.
East	Railway line running in an east to west direction (which passes through the site)	Undeveloped fields with surface water bodies (Lagoons) present 50m east of the site associated with the washery and distribution area. Hard standing road associated with the Onllwyn Colliery washery and distribution centre is present approximately 150m east of the site which leads into the main washery and distribution area located approximately 190m east.

2.2. Site History

Historically, the bridge has been a place where a variety of activities associated with a colliery occurred: including the freight and passenger (temporarily) station of Onllwyn on the Neath and Brecon Railway Line, and the colliery operations and associated buildings, tracks, sheds, wagons and the Halfway Inn (public house).

Halfway Inn and Onllwyn Station are prominent on all historic photos and maps. The passenger service of Onllwyn Station was withdrawn in 1962 and its use was constrained to mineral business, from Onllwyn to Neath. Some ground features and minimal remnants, including the railway track and most of the signalling house structure, are indications of the once busy station.

Remnants of past operations can be found at the ground level of the bridge (by the tracks and access road) – such as the wagon retaining wall and retaining walls of the winding house.



Figure 2.2 Historical site plans (ref. 5th Studio and Expedition Feasibility Report)

2.3. Proposed Development

The scheme for the proposed development comprises the updating of the current bridge structure and layout to allow for vehicle, cycling and pedestrian access to the wider GCRE site. There are currently six design options with the final yet to be confirmed at the time of writing. The six options can be observed in Figure 2.3 and Figure 2.4. Generally, the main change is the alignment of the road and railway. All the options include proposed soft landscaped areas to the west of the new road layout.



SUMMARY
OPTIONS APPRAISAL

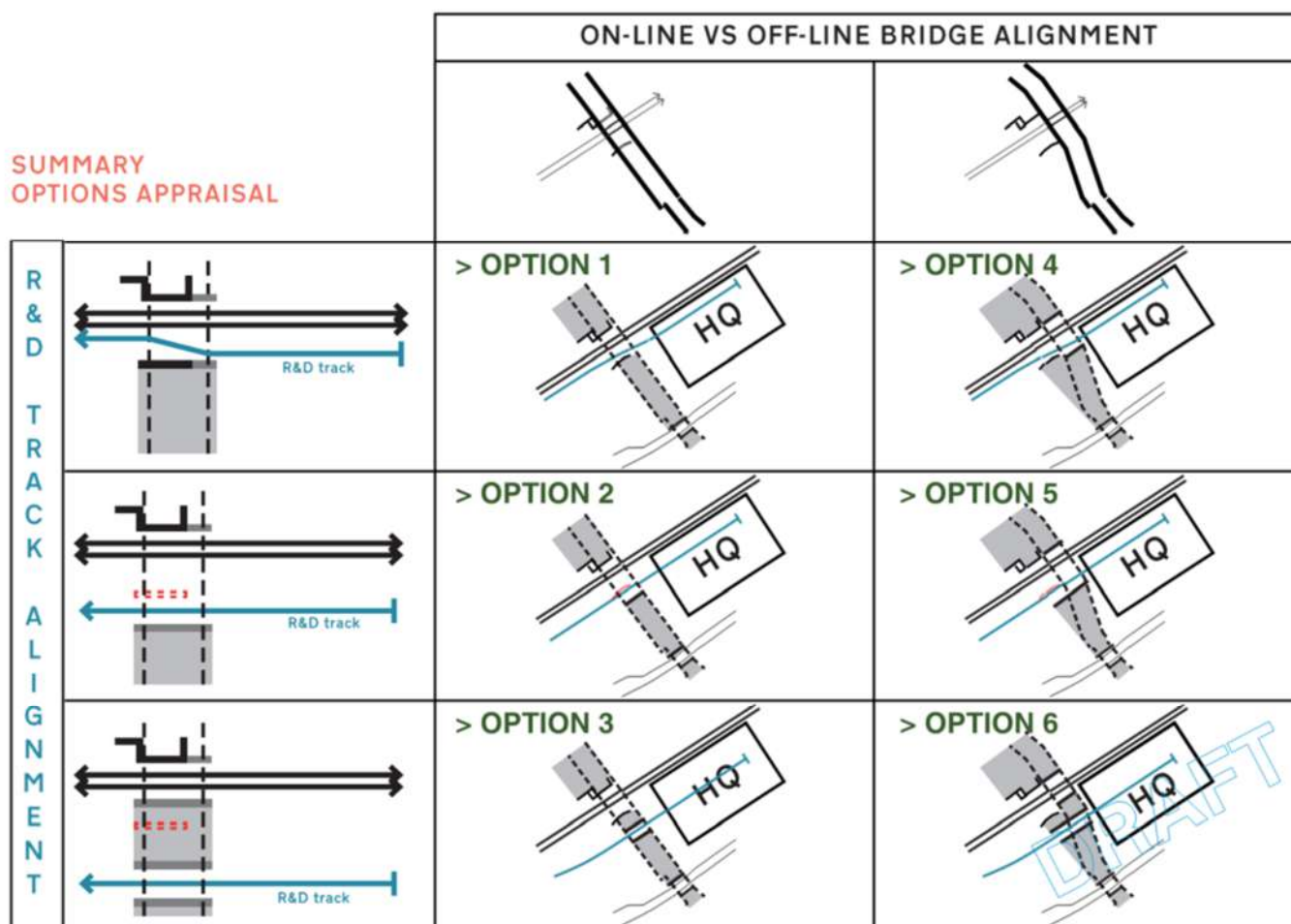


Figure 2.3 Summary option plans for the new proposed road layout.



Figure 2.4 Summary proposed development plans.



2.4. Initial Conceptual Site Model (CSM) and Preliminary Risk Assessment (PRA)

This site is in the northwest corner of the washery which itself is in the southern portion of the wider GCRE site. A desk study for the wider GCRE has been prepared by ARUP and includes a PRA. This desk study reference is *ARUP, Land at Nant Helen and Onllwyn Coal Washery, Geotechnical and Geoenvironmental Desk Study (ref. 264904-00), dated December 2019*.

The ARUP PRA identifies the following potentially significant sources of contamination at the GCRE site:

- Made Ground anticipated to comprise of material used for infilling of former open cast sites.
- Four large cylindrical fuel tanks.
- Former and current rail/tram lines.
- Four former pollution incidents with pollutants identified as 'coal', 'construction and demolition materials and wastes' and two incidents occurring with sewage material'.

In addition, a geo-environmental interpretive report has been undertaken by Atkins within the washery area, referred to by Atkins as Zone 1A (see Figure 2.5 below). The Atkins report is referenced in Section 1. The Atkins report also includes a PRA which identifies the following potentially significant sources of contamination for Zone 1A:

- Made Ground associated with historic and current industrial activities (coal washery, former colliery, railway land, spoil heaps).
- Potentially contaminated surface water/road run off from current mineral railway and coal washery.
- Localised spillages of hydrocarbons/fuels from current mineral railway activities.
- Historic industrial activities.
- Ground gas generated from natural peat deposits.

The Atkins PRA also identified the following potential off-site sources of contamination for Zone 1A:

- Made Ground associated with historical and current mining and quarrying activities.
- Historical landfill within 80m of Zone 1A.
- Fuel storage and fuelling activities within Zone 2A.
- Vehicle repair areas in Zone 2A.
- Machine graveyards areas in Zone 2A.
- Machine repair shops in Zone 2A.
- Electrical substations in Zone 2A.
- Potentially contaminated surface water/road run off from historical and current mining activities in Nant Helen and wider Washery areas. Mineral Railway and Coal washery.

(Note – Zone 2A is part of the GCRE site, located adjacent south to Zone 1A).

A site investigation has also been undertaken at the wider Zone 1A area, based on the Atkins PRA. However, no intrusive locations were advanced within the site boundary under assessment herein.

A-squared has undertaken a review of the existing PRAs and prepared an initial CSM and PRA relevant to the specific site boundary under assessment herein (proposed bridge redevelopment works), see Section 2.4.1 to 2.4.3.

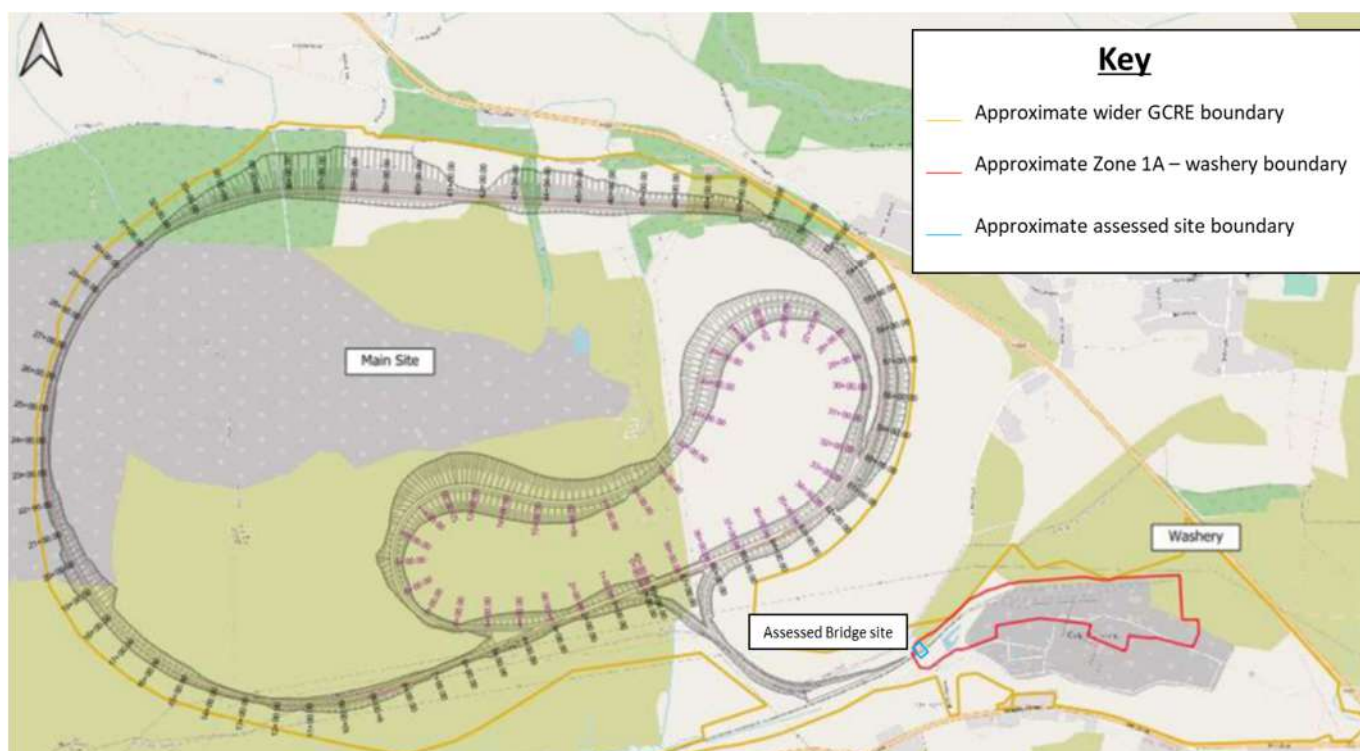


Figure 2.5 Plan displaying the area of Zone 1A (ref. Atkins report).

2.4.1. Potential Sources

2.4.1.1. On-Site Sources

- Made Ground
- Rail/tram lines
- Former Onllwyn Station (railway)
- General former colliery use
- Potentially contaminated surface water/road run off from current mineral railway
- Storage tank

Typical contaminants associated with these potential sources include heavy metals and metalloids, cyanide, acids / alkalis, PAHs, TPHs, VOCs, SVOC, PCBs, asbestos, herbicides, sulphates, ground gases and MTBE.

The fuel tanks and pollutant incidents listed in the ARUP desk study are not relevant for the exact site boundary assessed in this report, because the potential sources are over 250m away. In addition, geological maps indicate that peat does not underlie the site, so potential natural sources of ground gas have not been considered further.

2.4.1.2. Off-Site Sources

- Historic industrial activities (including quarrying and mining) in the surrounding area
- Rail/tram lines
- Scrapyard 190m east (in Zone 1A)
- Garage 220m east (in Zone 1A)
- Historical landfill / refuse tip 150m southwest



Typical contaminants associated with these potential sources include heavy metals and metalloids, acids / alkalis, PAHs, TPHs, VOC, PCBs, sulphates, cyanide, ammoniacal nitrogen, ground gases and MTBE. Asbestos has not been indicated for the potential off-site sources as there is no relevant pathway for asbestos to migrate through the ground towards the site.

The features identified in the Atkins report associated with Zone 2A (vehicle repair, machine graveyard, machine repair shops, electrical substations, fuel storage, surface water/road run off) are not relevant off-site sources for this assessment due to their distance (>250m) from the proposed bridge.

Notes –

TPH – total petroleum hydrocarbons (inc. BTEX)

PAH – polycyclic aromatic hydrocarbons

VOC – volatile organic compounds

SVOC – Semi – volatile organic compounds

BTEX – benzene, toluene, ethylbenzene, xylenes

PCBs – polychlorinated biphenyls

MTBE – methyl tert-butyl ether

Asbestos – potential free fibres, debris and / or fragments of asbestos containing material (ACM).

Ground gas – methane, carbon dioxide, carbon monoxide and / or hydrogen sulphide (excludes soil vapour)

2.4.2. Potential Receptors

- Human health of proposed site users (road and pedestrian traffic, and users of the proposed soft-landscaping to the west of the bridge).
- Human health of off-site commercial (180m east) and residential (closest 210m southwest) users.
- Property including proposed on-site bridge foundations and off-site buildings and below ground structures (buried concrete and underground services).
- Controlled waters (shallow groundwater) – Secondary A Aquifer (South Wales Middle Coal Measure Formation) associated with the bedrock anticipated beneath the site.
- Controlled waters (surface waters) – Site drains and lagoons (50m east) which feed into River Dulais (approximately 750m southwest).
- Flora and fauna in proposed soft-landscaped areas and off-site.

The River Camnat and Onllwyn Gorsllwyn are located 500m east and 150m northeast of Zone 1A, respectively, as identified by Atkins. However, the site boundary under assessment herein is in the western extremity of Zone 1A. The distances from the site to these two features is approximately 1km to the River Camnat and 750m to Onllwyn Gorsllwyn. Therefore, these features are not considered further as potential receptors in the site-specific PRA. In addition, grazing cattle are unlikely on the land immediately surrounding the site, so have not been considered further herein.

2.4.3. Site-specific CSM and PRA

The information presented in Section 2 has been compiled to produce a summary of the identified potential contaminant linkages, based on the initial CSM presented in Section 2.4.1 and Section 2.4.2. Table 2.2 presents a PRA for the proposed redevelopment based on the identified potential contaminant linkages. This assessment has been performed considering the details of the proposed development presented in this report. Qualitative risk classifications are provided in accordance with CIRIA C552: Contaminated Land Risk Assessment, A Guide to Good Practice (Rudland et al., 2001) (see summary in Appendix B). Where no potentially complete contaminant linkage is identified then no risk classification is provided. Risks classed as 'low to moderate' or greater have been classified as unacceptable risk (ref. LCRM guidance) and therefore further assessment is required.



Table 2.2 summarises the relevant contaminant linkages and presents a PRA for the proposed development. The PRA provides a baseline summary of site understanding prior to undertaking the site investigation and GQRA presented later.

Table 2.2 PRA Table

Potential Contaminant Source	Potential Pathway	Potential Receptor	Potential Contaminant Linkage	Risk Level Classification
On-site (See Section 2.4.1.1)	Direct contact with soil	Human health of proposed site end users	Yes	Low to moderate †
	Inhalation of windblown soil		(Proposed works include areas of soft landscaping where exposure is possible)	Low to moderate †
	Ingestion of soil			Low to moderate †
	Impact to water supply pipes followed by ingestion of contaminated water supply	Human health of proposed site end users	No (New pipes assumed not to be laid as part of proposed development works)	No classification
	Ground gas generation and inhalation		No (Proposed plans indicate no indoor areas where ground gas could possibly accumulate)	No classification
	Soil vapour generation and inhalation		No (Proposed plans indicate no indoor areas where vapour could possibly accumulate)	No classification
	Inhalation of windblown soil from the site	Off-site human health	Yes (Site unlikely to be a source of a substantial volume of wind blow dust)	Very low
	Off-site migration and direct contact with impacted soil		Yes (No potentially sensitive human health receptors have been identified in proximity where these pathways are relevant)	Very low
	Off-site migration and ingestion of impacted soil			Very low
	Impact to water supply pipes followed by ingestion of contaminated water supply		Yes (Nearest off-site developments are 190m east. On-site contamination (if present) is unlikely to migrate this distance and impact water supply pipes)	Low



Potential Contaminant Source	Potential Pathway	Potential Receptor	Potential Contaminant Linkage	Risk Level Classification
	Ground gas generation, off-site migration and inhalation		Yes (Potential sources of ground gas identified on site, however, areas surrounding the site are not built up and therefore no viable receptors are located nearby).	Low
	Soil vapour generation, off-site migration and inhalation		Yes (Potential sources of vapour identified on site, however, areas surrounding the site are not built up and therefore no viable receptors are located nearby).	Low
	Direct contact		Yes (New structures may be subjected to sulphate "attack")	Low to moderate †
	Migration followed by ignition of ground gas	On-site buildings / structures (proposed)	No (Proposed plans indicate no indoor areas where ground gas could possibly accumulate)	No classification
	Migration followed by ignition of soil vapour		No (Proposed plans indicate no indoor areas where vapour could possibly accumulate)	No classification
	Off-site migration followed by direct contact		Yes (Gross contamination with the potential to migrate off-site and damage structures by direct contact is not anticipated)	Very low
	Off-site migration followed by ignition of ground gas	Off-site buildings / structures	Yes (Potential sources of ground gas identified on site, however, areas surrounding the site are not built up and therefore no viable receptors are located nearby).	Very low
	Off-site migration followed by ignition of soil vapour		Yes (Potential sources of vapour identified on site,	Very low



Potential Contaminant Source	Potential Pathway	Potential Receptor	Potential Contaminant Linkage	Risk Level Classification
			however, areas surrounding the site are not built up and therefore no viable receptors are located nearby).	
	Leaching and migration to groundwater via the unsaturated zone; Perched water percolation or lateral migration; Migration via advection and diffusion in the saturated zone; and Vertical and lateral migration of free-phase product in the unsaturated and saturated zones.	Controlled waters – Underlying Secondary A Aquifer (South Wales Middle Coal Measure Formation) Controlled waters – Surface water features (on site drains which feed into the River Dulais)	Yes (Shallow groundwater may be present associated with natural deposits beneath the site)	Low to moderate † Low to moderate †
	On-site ingestion / dermal contact / inhalation / root uptake	Flora and fauna in proposed soft-landscaped areas	Yes (The proposed soft-landscaping is of low ecological sensitivity)	Low
	Off-site migration at shallow depth followed by ingestion / dermal contact / inhalation / root uptake	Off-site flora and fauna in soft-landscaped areas nearby	Yes (Land immediately surrounding the site if of low ecological sensitivity)	Low
Off-site (See Section 2.4.1.2)	On-site migration followed by direct contact or ingestion of soil	Human health of proposed site end users	Yes (Proposed works include areas of soft landscaping)	Low to moderate †
	Inhalation of windblown soil from off-site		Yes (The surrounding site is unlikely to produce substantial amounts of windblown dust)	Low
	On-site migration followed by impact to water supply pipes and ingestion of the water supply		No (New pipes assumed not part of the proposed bridge development works)	No classification
	Ground gas generation, on-site migration and inhalation		No (Proposed plans indicate no indoor areas where ground gas could possibly accumulate)	No classification



Potential Contaminant Source	Potential Pathway	Potential Receptor	Potential Contaminant Linkage	Risk Level Classification
	Soil vapour generation, on-site migration and inhalation		No (Proposed plans indicate no indoor areas where vapour could possibly accumulate)	No classification
	On-site migration followed by direct contact		Yes (It is unlikely that gross contamination with potential to damage structures is migrating onto site)	Very low
	On-site migration followed by ignition of ground gas	On-site buildings / structures (proposed)	No (Proposed plans indicate no indoor areas where ground gas could possibly accumulate)	No classification
	On-site migration followed by ignition of soil vapour		No (Proposed plans indicate no indoor areas where vapour could possibly accumulate)	No classification
	On-site ingestion / dermal contact / inhalation / root uptake	Flora and fauna in proposed soft-landscaped areas	Yes (Soft-landscaping proposed is of low ecological sensitivity)	Very low

† - unacceptable risk (ref. *LCRM* guidance)

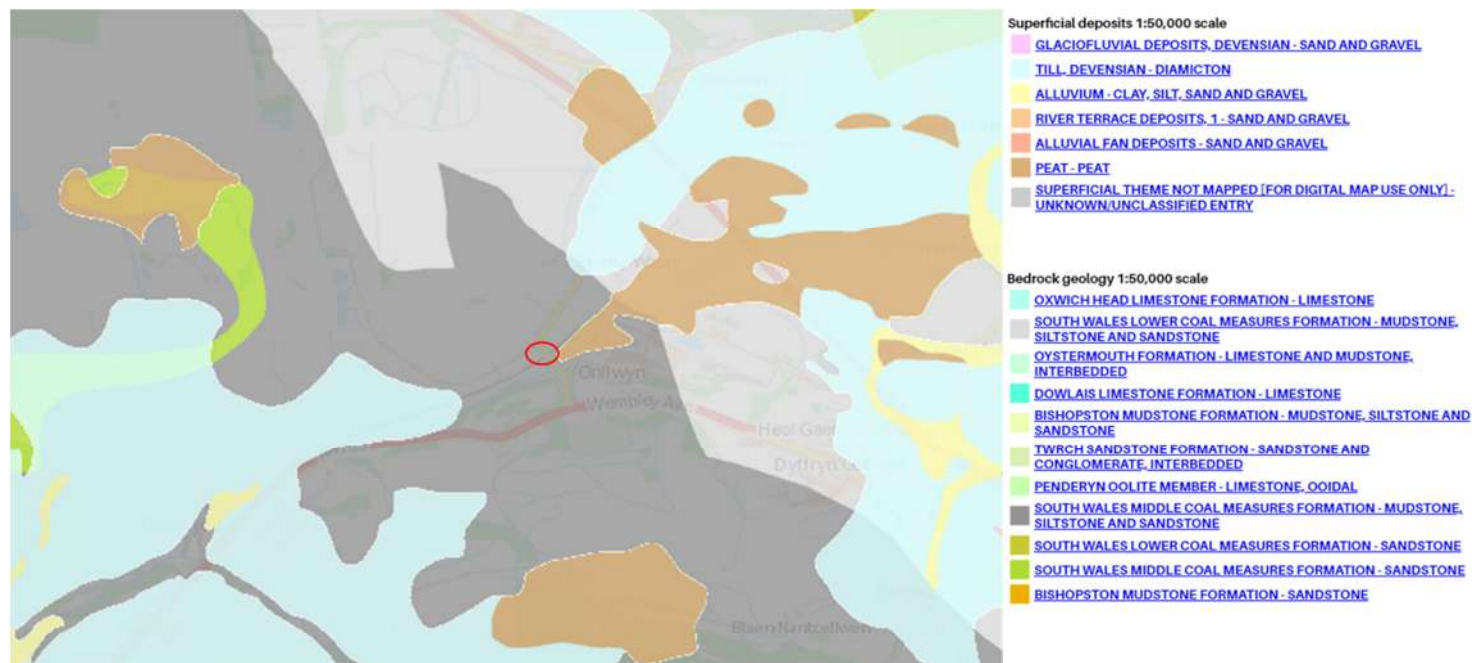


3. Geological Setting

3.1. Site Geology and Anticipated Ground Conditions

Figure 3.1 illustrates the location of the development within the context of a regional geological map. The map illustrates the spatial distribution of superficial (drift) deposits and bedrock outcrops at the ground surface. Made Ground is generally not shown but is assumed to be present on site due to historical demolition and construction works.

The geology map indicates that superficial deposits are not present on site and the site is directly underlain by the South Wales Middle Coal Measure Formation. Superficial Peat deposits have not been mapped at the site.



Approximate site location marked by red circle.

Figure 3.1 Geological context of the site



4. Ground Investigation

4.1. Overview

A site-specific ground investigation was undertaken in June 2023 by Jacksons. Details of the ground investigation findings are presented in the Factual Report (as referenced in Section 1), which is included as Appendix A.

The purpose of the ground investigation was to inform the management and mitigation of geotechnical and geo-environmental risks associated with the proposed redevelopment. In order to ensure that all geo-technical and geo-environmental risks have been managed two stages of site investigation works are proposed. The first of these phases involves investigation at the base of the embankment adjacent to the railway line and the second phase will investigate the embankment. This Phase II geo-environmental report assesses the findings of the first stage of intrusive works and should be fully updated after the second stage of works has been completed. This report is specifically to address geo-environmental risks and not geo-technical risks, so the relevant geo-environmental aims of the investigation were as follows:

- To collect chemical laboratory data to inform the GQRA.
- To log the ground conditions to inform CSM development.

The scope for the geo-environmental aspects of the investigation included:

- 1 No. dynamic sampling with rotary follow on (BR-BH02) to a maximum depth of 25.50m bgl with hand dug inspection pits.
- 1 No. rotary cored borehole (BR-BH01) to a maximum depth of 25.00m bgl with hand dug inspection pits.
- 4 No. hand dug trial pits to a maximum depth of 1.1m bgl.
- Soil logging to engineering standards.
- Soil sampling.
- Geo-environmental in-situ testing and laboratory testing.

An exploratory hole plan is presented in Figure 4.1. Packers were installed in all the boreholes during the site investigation due to the sub-artesian water properties of the underlying geology. These packers were installed to help seal the hole and guard against any water reaching the surface at a later date. Due to this methodology, monitoring installations within the boreholes were not possible.

4.2. Testing

Geo-environmental In-Situ Testing:

- Soil sample VOC head-space testing using a PID.

Geo-environmental Soils Laboratory Testing:

- 5no. Water Soluble Sulphate
- 5no Cyanide (free and total)
- 5no. Soil Organic Matter (SOM)
- 6no. Total Organic Carbon (TOC)
- 5no. pH
- 5no. Heavy Metals and Metalloids Suite
- 5no. TPH CWG
- 5no. Speciated PAH (EPA 16)
- 5no. Total Phenols
- 2no Waste Acceptance Criteria (WAC)
- 4no. VOC Suite



- 4no. (SVOC) Suite
- 4no.(PCB) (WHO 12 Congeners)
- 2no Herbicide Suites
- 5no. Asbestos Identification

Geo-environmental Leachate Laboratory Testing:

- 3no. Water Soluble Sulphate
- 3no Cyanide (free and total)
- 3no. pH
- 3no. Heavy Metals and Metalloids Suite
- 3no. Total Phenols

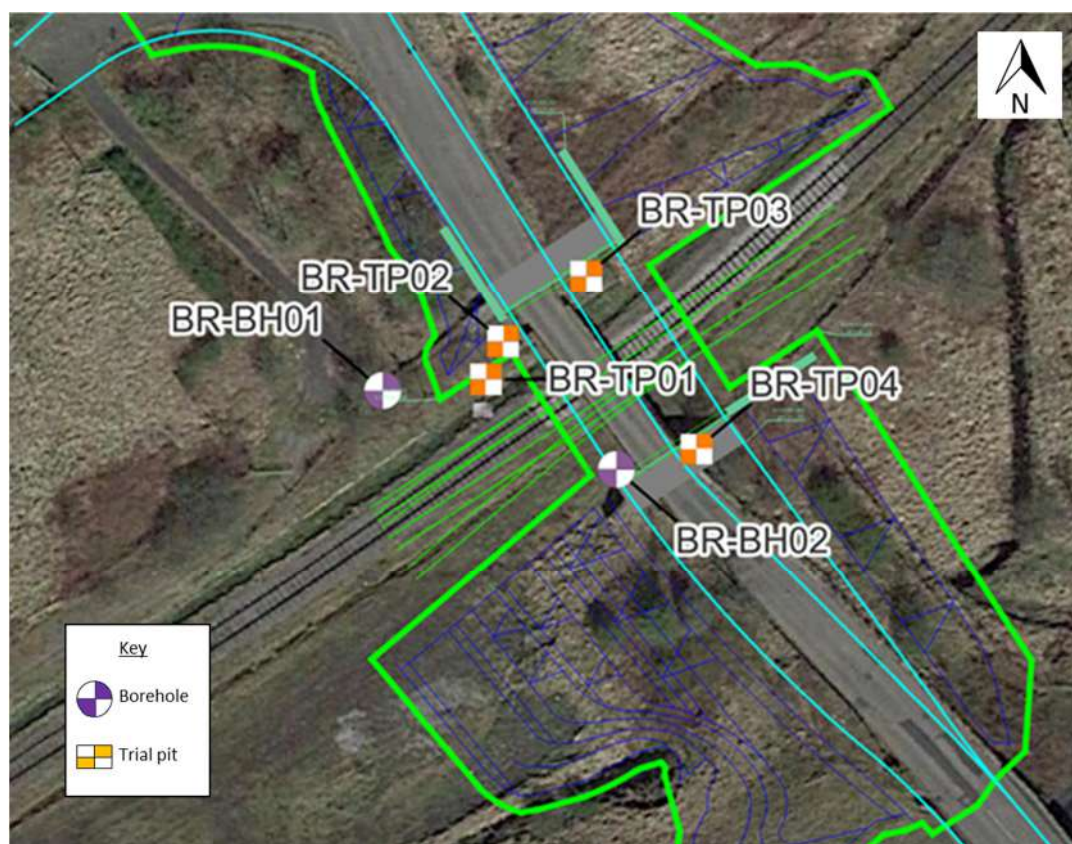


Figure 4.1 Exploratory hole location plan



5. Ground Conditions

5.1. Ground Model

A summary of the ground conditions encountered during the intrusive investigation is presented in Table 5.1.

Table 5.1 Summary of the encountered geological profile

Unit	Maximum Elevation (m OD)	Minimum Elevation (mOD)	Maximum Depth (m bgl)	Minimum Depth (m bgl)	Thickness (m)	Description
Made Ground	232.03	227.13	1.10	0.00	0.8 to 1.10*	Blackish grey gravelly fine to coarse SAND with low cobble content and frequent rootlets (up to 15mm). Gravel is angular to subangular fine to coarse of mudstone and limestone. Cobbles are angular to subangular limestone and concrete (BR-BH01).
						Black ash and bricks (BR-BH01).
						Dark grey silty gravelly fine to coarse SAND of local mudstone with low cobble content. Gravel is angular to subangular fine to coarse of mudstone and limestone. Cobbles are angular to subangular of limestone and concrete (BR-BH02).
						Greyish brown, gravelly fine to coarse SAND with medium cobble content. Gravel is angular to subrounded of siltstone and concrete (BR-TP01, BR-TP03 and BR-TP04).
						Greyish brown, sandy angular to subangular GRAVEL of mudstone. Sand is fine to coarse (BR-TP04).
South Wales Middle Coal Measure Formation (Weathered Siltstone)	228.28	227.08	2.00	0.80	1.20	Slightly sandy angular to subangular COBBLES of frequent concrete and brick with occasional mudstone (up to 100mm). Sand is fine to medium (BR-TP02).
						Weathered grey siltstone. (BH-BR01)
						Grey very angular to subangular medium to coarse GRAVEL of limestone (BR-BH01)
South Wales Middle Coal Measure Formation (interbedded Mudstone and Siltstone)	226.58	202.63*	25.50*	1.00	22.50 to 24.50*	Extremely weak to weak, becoming moderate at depth MUDSTONE and SILTSTONE. Beds of coal were encountered ranging from 6.56m bgl to 12.7m bgl

* Base of strata not encountered

5.1.1. Made Ground

The Made Ground is a heterogeneous mixture of natural soils and deleterious materials of anthropogenic origin. Made Ground was encountered in the boreholes to depths of up to 0.8m and 1.1m within the trial pits. The base of the Made Ground was not encountered within the trial pits.

Within the trial pits, Made Ground was predominantly greyish brown, gravelly fine to coarse SAND other than BR-TP02 where it was cobbles. Within the boreholes, Made Ground was predominantly a dark coloured (grey or black) gravelly SAND.



5.1.2. South Wales Middle Coal Measure Formation – Weather Siltstone

Weathered SILTSTONE of the South Wales Middle Coal Measure Formation was only observed in BR-BH01 underlaying the Made Ground and overlying gravels at a depth ranging from 0.8m bgl to 2.0m. This unit can be described as grey weathered SILTSTONE.

5.1.3. South Wales Middle Coal Measure Formation – Gravel

A granular unit of the South Wales Middle Coal Measure Formation were only observed in BR-BH01 underlaying the weathered siltstone and overlying Mudstone at a depth ranging from 2.0m bgl to 2.5m. These gravels consisted of grey very angular to subangular medium to coarse GRAVEL of limestone.

5.1.4. South Wales Middle Coal Measure Formation –Siltstone and Mudstone

Due to the over depths of the intrusive investigation locations, interbedded MUDSTONE and SILTSTONE were only encountered within BR-BH01 and BR-BH02. In BR-BH02 these units directly underlay Made Ground at a depth of 1.0m bgl and in BR-BH01 underlay South Wales Middle Coal Measure Formation gravels at a depth of 2.5m bgl. This unit can be described as interbedded, extremely weak to weak, becoming moderate at depth MUDSTONE and SILTSTONE with beds of coal present from 6.56m bgl to 12.7m bgl

5.2. Groundwater

Water strikes recorded during the drilling process were as follows:

- Water strike in BR-BH01 on the 7th June (16:00) at 6.20m bgl. On its completion, BR-BH01 was recorded as being dry (9th June at 16:00).
- Water ingress in BR-BH02 at 0.7m bgl. Assumed to be perched water within the Made Ground.
- Water strike in BR-BH02 on the 2nd June (16:50) at 2.10m bgl. On its completion, BR-BH02 groundwater was recorded as resting at 2.20m bgl.

5.3. Visual / Olfactory Evidence of Contamination

Visual / olfactory evidence of contamination was encountered in BR-BH01 (ash at 0.6 to 0.8m bgl) and in BR-BH02 (colliery spoil at 0.7-1.0m bgl). Soil sample head-space readings were recorded in both the boreholes. Neither borehole has PID readings above equipment detection limit.



6. Generic Quantitative Risk Assessment (GQRA)

6.1. Introduction

The following section provides a GQRA using the available information including data gathered from the recent ground investigation. Based on the results, the CSM and geo-environmental risk assessment for the proposed development is updated from PRA stage. GQRA screening tables are included as Appendix C.

The assessment presented in this section has been undertaken to determine whether there is any unacceptable risk (ref. *LCRM*) which needs to be further addressed. Recommendations for further work are provided where necessary.

GQRA has been undertaken for the unacceptable risks identified in the PRA, as follows:

- Further assessment of on-site human health risks (see Section 6.3).
- Further assessment of controlled waters risks (see Section 6.4).

Assessing the risks from sulphate attack of foundations is a geotechnical assessment. Geotechnical assessment falls outside the scope of this report. Geotechnical findings and assessments are included within a separate Geotechnical Design Report (GDR). A piling works risk assessment is also not included in this report.

Risks to site workers and the environment during the construction phase of the proposed redevelopment can be appropriately managed by successful implementation of construction phase risk assessments and method statements (RAMS). Therefore, the associated construction phase land contamination risks are not considered further in this document but should be appropriately considered and mitigated by the Principal Contractor in their preparation and implementation of construction phase RAMS and Construction Phase Plan (CPP).

6.2. Targeted Potential Sources of Contamination

GQRA should be based on adequate site investigation which appropriately targets potential sources of contamination and / or exposure pathways. The targeting of potential on-site sources of contamination identified in the PRA is summarised in Table 6.1 and Figure 6.1. All identified potential on-site sources of contamination have been targeted.

Table 6.1 Targeting of Potential On-site Sources of Contamination

Potential Source	Targeted Exploratory Locations
Made Ground	All intrusive locations
Rail/tram lines	All intrusive locations
Former general colliery use	All intrusive locations
Potentially contaminated surface water/road run off from current mineral Railway	All intrusive locations
Former Onllwyn Station (railway)	BR-BH01, BR-TP01 and BR-TP02
Storage Tank	BR-TP03



Figure 6.1 Exploratory locations compared to the identified potential sources

6.3. Human Health Risk Assessment (Dermal Contact, Ingestion and Soil Inhalation)

The soil sample laboratory analytical results have been compared to human health generic assessment criteria (GAC) appropriate for assessing risks for the specifically proposed development. The selected human health GAC include the LQM/CIEH 'Suitable 4 Use Levels' (S4ULs). The S4ULs are based on Health Criteria Values that represent minimal or tolerable levels of risks to health as described in the Environment Agency's SR2 guidance, ensuring that the resulting assessment criteria are 'suitable for use' under Planning.

For each chemical substance, S4ULs include individual GAC for 6 no. generic land-uses (residential with home grown produce, residential without home grown produce, allotments, commercial and 2 no. public open space land uses) and a range of Soil Organic Matter (SOM) contents. All toxicological and physical-chemical parameters used in the derivation of the S4ULs are presented and discussed in the source publication.

In some instances, selected human health GAC used in this report have been applied from the DEFRA 'Category 4 Screening Levels' (C4SLs), CL:AIRE GAC, Environment Agency (EA) Soil Guideline Values (SGVs) and Atkins AtRisk Soil Screening Values (SSVs). The human health GAC source reference used for each chemical determinant is presented in the GQRA screening tables included as Appendix C. C4SLs have been used preferentially where available.

The proposed development includes updates to the current bridge structure and new soft landscaping. Therefore, human health GAC have been applied to each chemical determinant based on the 'public open space (park)' and 'commercial' generic land-use scenario. In future, should the site redevelopment plans change from those considered herein then the geo-environmental risk assessments presented in this report will need to be reconsidered.



The human health GAC for mercury assumes the presence of elemental mercury as a conservative worst-case assumption.

There is no published human health GAC with respect to asbestos or asbestos containing materials (ACMs) in soil. Industry best practice document 'Asbestos in soil and made ground: a guide to understanding and managing risks', CIRIA C733, 2014, indicates that soils containing asbestos concentrations of 0.001 % w/w may be able to liberate airborne fibre concentrations that exceed contemporary occupational exposure limits for nuisance dust. However, as detailed in other research, including publications such as the CAR-SOIL Industry Guidance (2016), in circumstances where very low concentrations of asbestos are identified in soils, the associated risks are considered low. In this study an initial asbestos human health GAC of 'no asbestos detected above laboratory detection limit' is adopted i.e. mitigation or further assessment is required if asbestos in soil is detected at or above <0.001 % w/w.

All soil samples which underwent laboratory analysis for geo-environmental purposes were collected from Made Ground. If the laboratory method detection limit is greater than the human health GAC then this is not recorded as an exceedance of the GAC.

The identified exceedances of the selected human health GAC are summarised in Table 6.2 and spatially orientated on Figure 6.2 and Figure 6.3.

Table 6.2 Human Health GAC Exceedances Summary

Exploratory Location	Depth (m bgl)	Stratum	Determinant	Detected Concentration (mg/kg)	Human Health GAC for commercial scenario (mg/kg)	Human Health GAC for public open space (park) scenario (mg/kg)
BR-TP01	0.2-0.3	Made Ground	Benzo(a)anthracene	130	170	49
			Chrysene	170	350	93
			Benzo(b)fluoranthene	220	44	13
			Benzo(a)pyrene	140	77	21
			Dibenzo(a,h)anthracene	26	3.5	1.1
BR-TP03	0.2	Made Ground	Benzo(b)fluoranthene	24	44	13
			Dibenzo(a,h)anthracene	1.6	3.5	1.1

The detected exceedances for benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene and dibenzo(a,h)anthracene at BR-TP01 and benzo(b)fluoranthene and dibenzo(a,h)anthracene at BR-TP03 are coincident with elevated TPH concentrations (2,700 mg/kg total TPH in BR-TP01 and 240 mg/kg in BR-TP03), indicating a possible localised hydrocarbon source. Alternatively, the detected concentrations may be chemical signatures of locally higher concentrations of ash / coal. BR-TP01 targets Made Ground, former rail/tram lines, former general colliery use and current mineral railway use and BR-TP03 targets the same potential sources of contamination in addition to the former storage tank area. Similarly elevated PAH concentrations have not been detected in the other soil samples.

The proposed development includes soft-landscaping but only in localised areas. Therefore, potential exposure to contamination in shallow soils is viable only where soft-landscaping is proposed. There should be no regular exposure of humans to soils elsewhere at the site. BR-TP01 and BR-TP03 were not advanced where soft-landscaping is proposed as can be observed in Figure 6.2 and Figure 6.3. However, the intrusive locations in the vicinity of the proposed soft landscaped area (BR-BH02 and BR-TP04) were completed at the base and not the top of the current embankment. Therefore, the Made Ground in the proposed soft landscaped areas has not fully been investigated and it is recommended that further site investigation along with laboratory testing is undertaken at the top of



the embankment to further assess this material. Until the material in the proposed soft landscaped area is fully investigated, exposure of site users to contamination via direct contact / ingestion / inhalation of soils remains assessed as low to moderate risk (i.e. unacceptable risk).

If further investigation is not undertaken then the unacceptable risks can be addressed by removing the exposure pathways. Where Made Ground remains near to the ground surface following completion of the proposed development a suitable clean capping layer can be installed in areas of soft landscaping to appropriately mitigate the risk. It is recommended that a detailed specification and verification regime for a clean capping layer is provided within a Remediation Strategy for the proposed development.

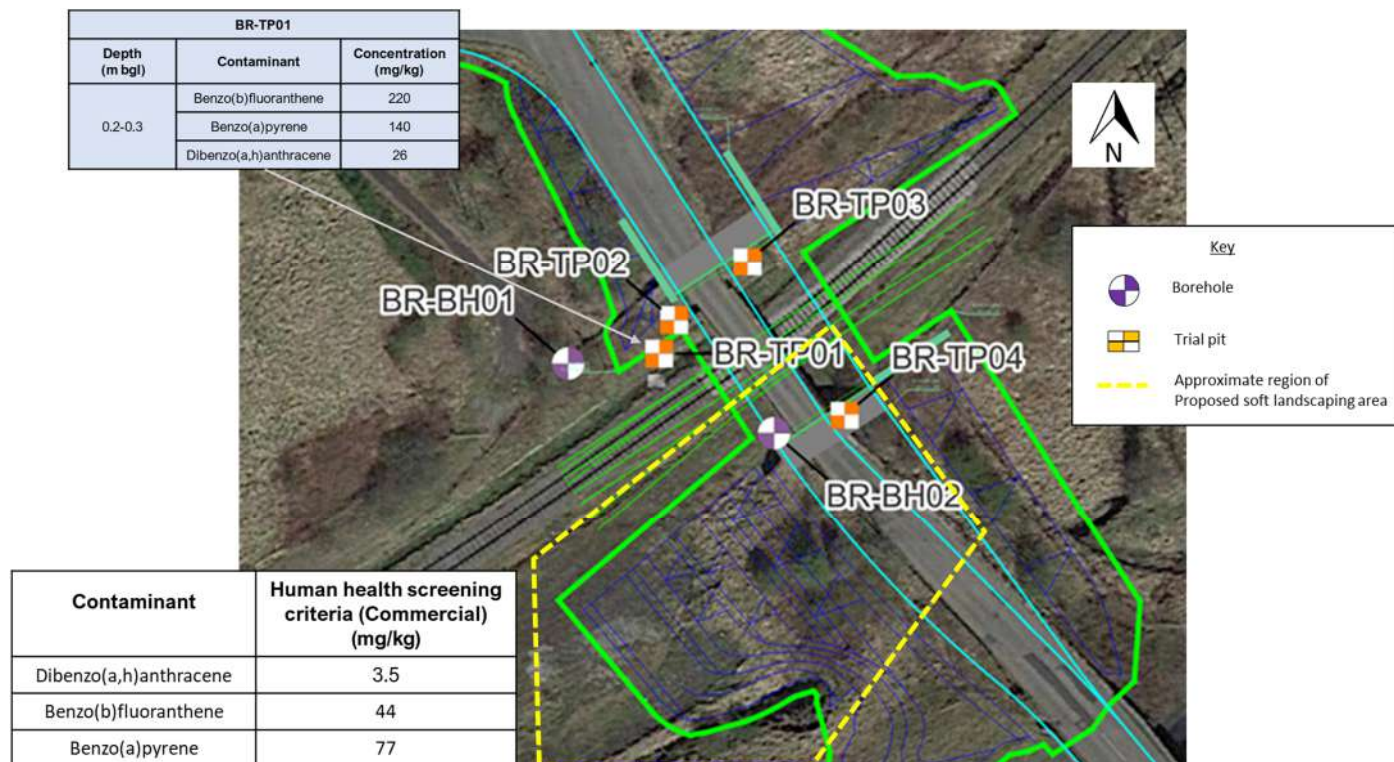


Figure 6.2 Human health GAC exceedances plan (commercial)

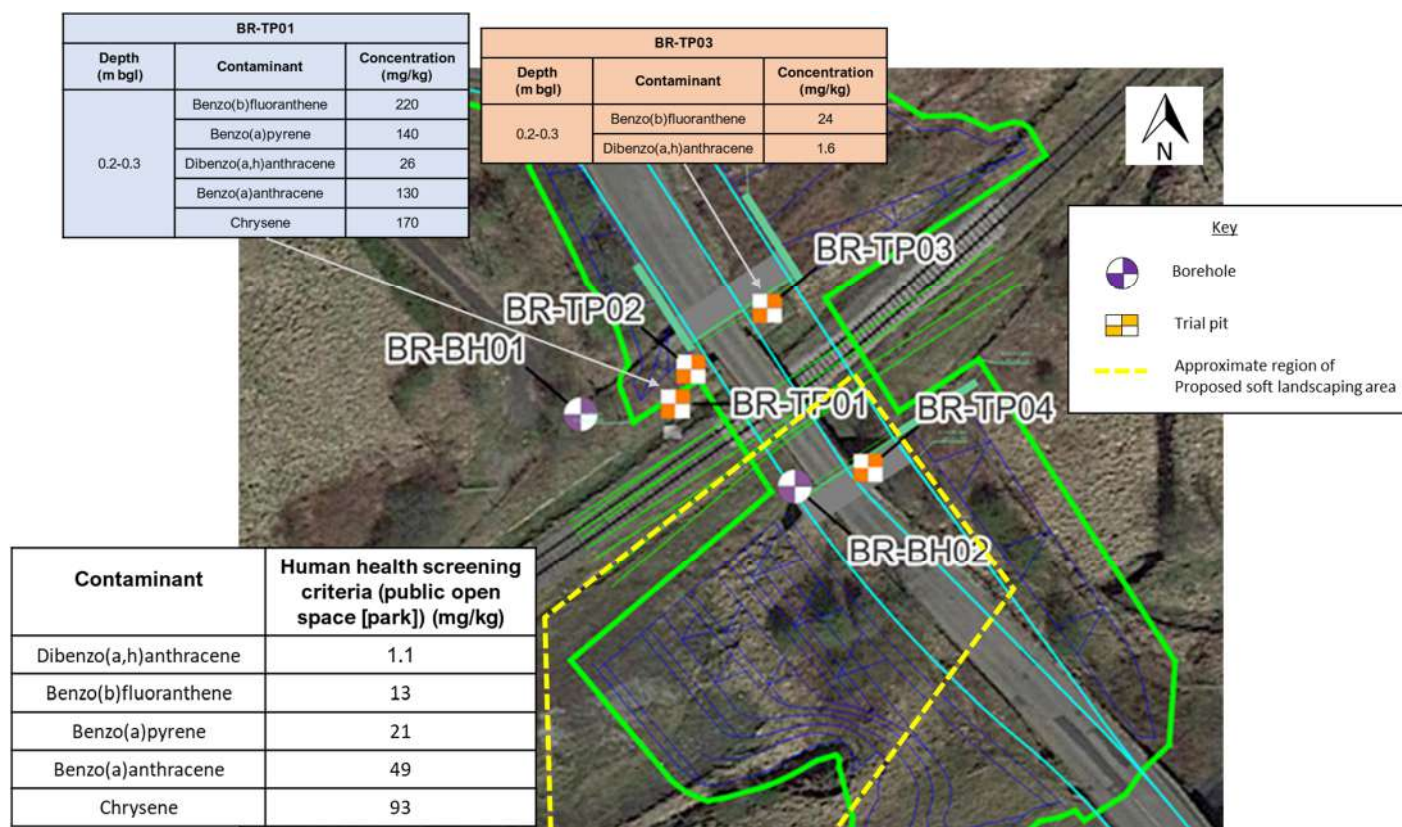


Figure 6.3 Human health GAC exceedances plan (public open space [park])

6.4. Controlled Waters Risk Assessment

Made Ground samples underwent soil leachate testing. Soil leachate laboratory analytical results for heavy metals, metalloids and inorganics in Made Ground have been compared to generic assessment criteria (GAC) considered appropriate for the assessing controlled waters risks. Controlled waters GAC have been selected to assess risks to drinking water quality and the aquatic environment in surface waters.

The selected drinking water GAC are based on Drinking Water Standards (DWS) published by the UK and EU, as well as Guidance Values (GVs) published by the World Health Organisation (WHO). The DWS and GV are used as values indicative of low risk to drinking water quality and have been selected given the aquifer status of the South Wales Middle Coal Measure Formation beneath the site (Secondary A Aquifer).

The selected environmental quality GAC are based on freshwater Environmental Quality Standards (EQS) published by the UK and EU, and also operational targets published by the Environment Agency (EA). The EQS and operational targets are used as values indicative of low risk to the aquatic environment and have been selected given surface drains on site and lagoons 50m east which feed into the River Dulais.

Surrogate assessment criteria have also been used for some determinants if there are not appropriate published GAC included in the source references listed above.

The environmental quality GAC and drinking water GAC used in this assessment are generally considered to be highly conservative for the manner used in this report, but technically robust for a GQRA.

The leachate laboratory analytical results are presented in a screening table comparing the detected chemical concentrations to the selected GAC in Appendix C. Where laboratory method detection limits are greater than the GAC this is not recorded as an exceedance. The results generally indicate low risk to controlled waters with concentrations not exceeding the selected drinking



water GAC. Where exceedance of the environmental quality GAC have been identified they are summarised in Table 6.3 and spatially orientated on Figure 6.5.

Table 6.3 Exceedances of the environmental quality GAC

Exploratory location	Tested strata	Determinant	Detected Concentration (ug/l)	Environmental quality GAC (ug/l)
BR-TP01	Made Ground	Copper	2.1	1.0
		Lead	1.9	1.2
BR-TP04	Made Ground	Chromium	8.8	4.7
		Copper	33	1.0
		Nickle	4.6	4.0
BR-BH01	Made Ground	Cadmium	0.13	0.08
		Copper	8.4	1.0
		Lead	3.0	1.2
		Zinc	22	10.9

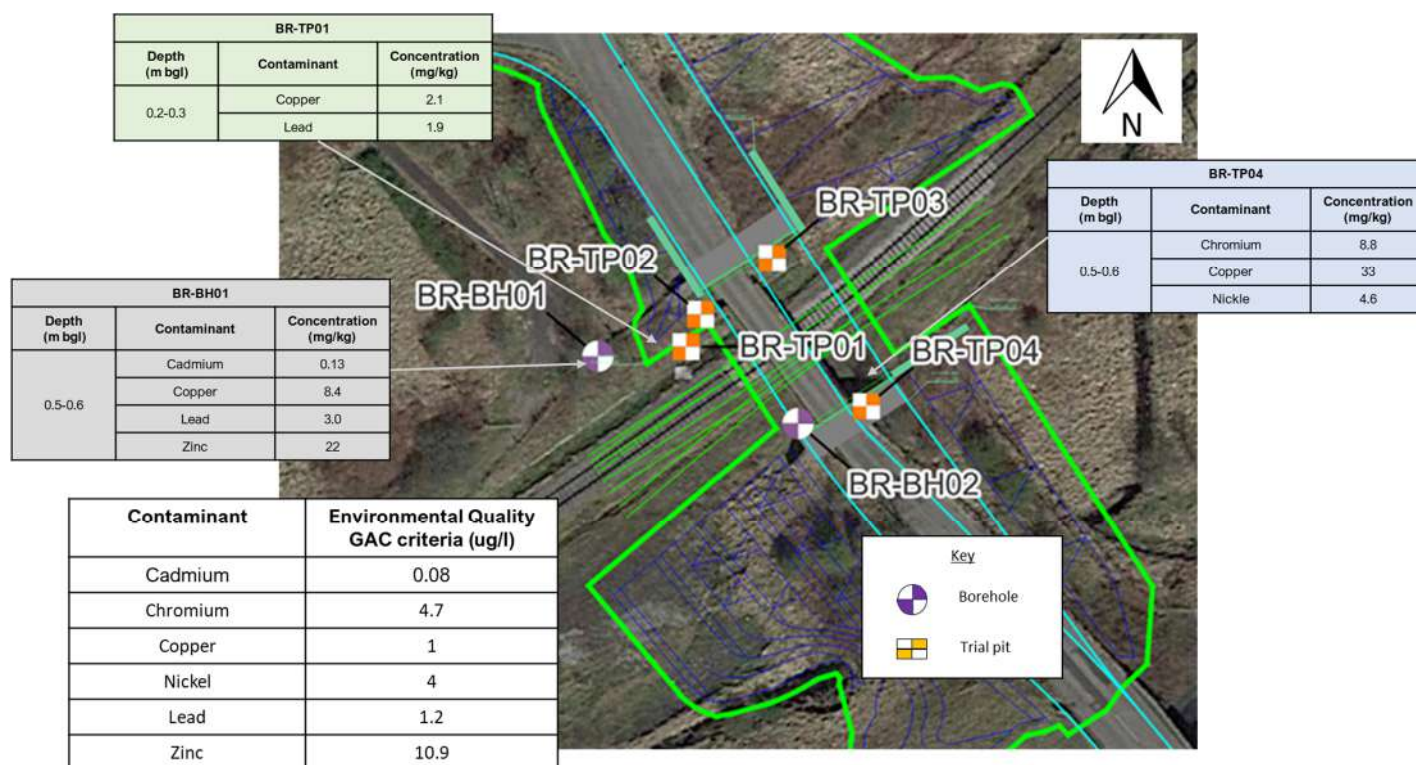


Figure 6.5 Environmental quality GAC exceedances plan

The exceedances of the environmental quality GAC in Made Ground soil leachate samples are relatively marginal. In view that the laboratory leachate test is more aggressive than natural leaching processes, that the natural deposits underlying the Made Ground (South Wales Middle Coal Measure Formation) have been found to be predominantly cohesive, and that no surface water receptors



are located within 50m, the marginal exceedances represent low risk to surface waters. Since no exceedances of the drinking water GAC have been identified, the leachate results also represent low risk to aquifer quality beneath the site.

2,700 mg/kg total TPH has been detected in shallow Made Ground at BR-TP01. This may reflect a localised hydrocarbon source, or alternatively the chemical signature of locally higher concentrations of ash / coal. Regardless, given the history of the site and surrounding area, that the South Wales Middle Coal Measure Formation is realistically of low resource potential, and that the detected TPH concentrations are for 'heavy-end' bands (i.e. low mobility), the localised detected TPH concentration in soil at BR-TP01 represents low risk to controlled waters.

In summary, the proposed development represents no unacceptable risk to controlled waters.



7. Updated Conceptual Site Model and Risk Assessment Summary

The results of the GQRA presented in Section 6 are summarised in Table 7.1. Table 7.1 presents an update of Table 2.2 following ground investigation. No ground conditions were encountered which required an update to the PRA prior to undertaking the quantitative risk assessments. The risk assessment matrix used in preparing Table 7.1 is provided as Appendix B.

It is considered that risks to site workers and the environment during the construction phase of the proposed redevelopment can be appropriately managed by successful implementation of construction phase RAMS. The associated construction phase risks from potential contamination should be appropriately considered and mitigated by the Principal Contractor in their preparation and implementation of construction phase RAMS and CPP.

Table 7.1 Updated Risk Assessment Summary following GQRA

Potential Contaminant Source	Potential Pathway	Potential Receptor	Potential Contaminant Linkage	Risk Level Classification
On-site (See Section 2.4.1.1)	Direct contact with soil	Human health of proposed site end users	Yes	Low to moderate †
	Inhalation of windblown soil		(See Section 6.3 – Further investigation in the region of proposed soft landscaping is recommended)	Low to moderate †
	Ingestion of soil			Low to moderate †
	Impact to water supply pipes followed by ingestion of contaminated water supply		No	No classification
	Ground gas generation and inhalation		No	No classification
	Soil vapour generation and inhalation		No	No classification
	Inhalation of windblown soil from the site	Off-site human health	Yes	Very low
	Off-site migration and direct contact with impacted soil		Yes	Very low
	Off-site migration and ingestion of impacted soil		(No change from A-squared original CSM)	Very low



Potential Contaminant Source	Potential Pathway	Potential Receptor	Potential Contaminant Linkage	Risk Level Classification
	Impact to water supply pipes followed by ingestion of contaminated water supply		Yes (No change from A-squared CSM)	Low
	Ground gas generation, off-site migration and inhalation		Yes (No change from A-squared CSM)	Low
	Soil vapour generation, off-site migration and inhalation		Yes (No change from A-squared CSM)	Low
	Direct contact	On-site buildings / structures (proposed)	Yes (Risk will be low should an appropriate sulphate design class be implemented following geotechnical assessment)	Low
	Migration followed by ignition of ground gas		No (No change from A-squared original CSM)	No classification
	Migration followed by ignition of soil vapour		No (No change from A-squared original CSM)	No classification
	Off-site migration followed by direct contact	Off-site buildings / structures	Yes (No change from A-squared original CSM)	Very low
	Off-site migration followed by ignition of ground gas		Yes (No change from A-squared CSM)	Low
	Off-site migration followed by ignition of soil vapour		Yes (No change from A-squared CSM)	Low
	Leaching and migration to groundwater via the unsaturated zone;	Controlled waters - Underlying Secondary A Aquifer (South Wales Middle Coal Measure Formation)	Yes (See Section 6.4 – No unacceptable risk identified following GQRA)	Low



Potential Contaminant Source	Potential Pathway	Potential Receptor	Potential Contaminant Linkage	Risk Level Classification
Off-site (See Section 2.4.1.2)	Perched water percolation or lateral migration; Migration via advection and diffusion in the saturated zone; and Vertical and lateral migration of free-phase product in the unsaturated and saturated zones.	Controlled waters – Surface water features (on site drains which feed into the River Dulais)		Low
	On-site ingestion / dermal contact / inhalation / root uptake	Flora and fauna in proposed soft-landscaped areas at the site	Yes (No change from A-squared CSM)	Low
	Off-site migration at shallow depth followed by ingestion / dermal contact / inhalation / root uptake	Off-site flora and fauna in soft-landscaped areas nearby	Yes (No change from A-squared CSM)	Low
	On-site migration followed by direct contact or ingestion of soil	Human health of proposed site end users	Yes (See Section 6.3 - No unacceptable risk identified following GQRA)	Low
	Inhalation of windblown soil from off-site		Yes (No change from A-squared CSM)	Low
	On-site migration followed by impact to water supply pipes and ingestion of the water supply		No (No change from A-squared original CSM)	No classification
	Ground gas generation, on-site migration and inhalation		No (No change from A-squared original CSM)	No classification



Potential Contaminant Source	Potential Pathway	Potential Receptor	Potential Contaminant Linkage	Risk Level Classification
	Soil vapour generation, on-site migration and inhalation		No (No change from A-squared original CSM)	No classification
	On-site migration followed by direct contact		Yes (No change from A-squared original CSM)	Very low
	On-site migration followed by ignition of ground gas	On-site buildings / structures (proposed)	No (No change from A-squared original CSM)	No classification
	On-site migration followed by ignition of soil vapour		No (No change from A-squared original CSM)	No classification
	On-site ingestion / dermal contact / inhalation / root uptake	Flora and fauna in proposed soft-landscaped areas at the site	Yes (No change from A-squared original CSM)	Very low

† - unacceptable risk (ref. *LCRM*)

Following GQRA, it is considered that there is an unacceptable risk (ref. *LCRM*) to proposed site users via direct contact, inhalation and ingestion with on-site sources identified in Section 2.4.1.1 and therefore further investigation and laboratory sampling within the area of the proposed soft landscaping should be undertaken.

If additional sampling is not undertaken the Made Ground should be fully removed from the areas of proposed soft landscaping or a suitable clean capping layer can be installed in areas of soft landscaping to appropriately mitigate the risk. It is recommended that a detailed specification and verification regime for a clean capping layer is provided within a Remediation Strategy for the proposed development.

Presentation of a detailed Remediation Strategy is outside the scope of this document.

A suitable sulphate design class should be specified following geotechnical assessment.



8. Preliminary Waste Assessment

The results of the geo-environmental soil analysis have been considered in view of potential soil waste classification. The waste assessment presented below is preliminary and based on the soil chemical laboratory results only. Any excavation and subsequent disposal of soils from the site should be informed by a full waste assessment for the specific excavation and disposal activities being undertaken in accordance with *Technical Guidance WM3 - Waste Classification: Guidance on the classification and assessment of waste (1st Edition v1.2.GB)*.

The available soil sample analytical results indicates that on-site Made Ground can generally be classified as Non-hazardous however, Made Ground in the vicinity of BR-TP01 may be hazardous due to the localised detection of TPH greater than 1,000 mg/kg.

WAC testing was undertaken on two samples taken from BR-TP03 (0.2-0.3m bgl) and BR-TP04 (0.5-0.6m bgl). The WAC data for Made Ground at BR-TP03 and BR-TP04 indicates that acceptance of excavated Made Ground at an Inert landfill facility may not be possible due to the following:

- Total organic carbon exceeded inert landfill criteria in BR-TP03
- Total organic carbon, molybdenum and total dissolved solids exceeded inert landfill criteria in BR-TP04

A full waste assessment based on *WM3* is recommended is soil excavation and disposal is to take place. However, this should not be needed to secure planning permission or for condition discharge.

Please be aware that non-landfill solutions are also potentially available for soils excavated from the site. Should a full waste assessment and appraisal of disposal / recycling / re-use options be required for the construction phase then we can assist once specific details of the required excavation and disposal activities are known. The finalised site cut and fill model would be particularly useful for this exercise.



9. Closing Remarks

A-squared was instructed by Expedition Ltd to prepare a Phase II Geo-environmental Assessment for the proposed bridge redevelopment. The scheme for the proposed development comprises updating the current bridge structure and layout to allow for vehicle, cycling and pedestrian access to the wider GCRE site. A localised area of soft-landscaping is also to be developed.

The geo-environmental assessment includes GQRA, has been undertaken in general accordance with *LCRM* guidance, and in the context of the requirements of the *NPPF* and *The Building Regulations 2010, Approved Document C - Site preparation and resistance to contaminants and moisture (2004 Edition incorporating 2010 and 2013 amendments)*.

Following GQRA, it is considered that there is an unacceptable risk (ref. *LCRM*) to proposed future site users by direct contact, ingestion and inhalation as the material forming the embankment has not yet been fully investigated. Therefore, further investigation and laboratory sampling in the areas of the embankment where soft landscaping is proposed should be undertaken.

A suitable sulphate design class should be specified following geotechnical assessment.

Should any changes be made to the proposed development compared to the details presented herein, or should any new information become available, then the assessments included in this report must be updated.



A-squared Studio

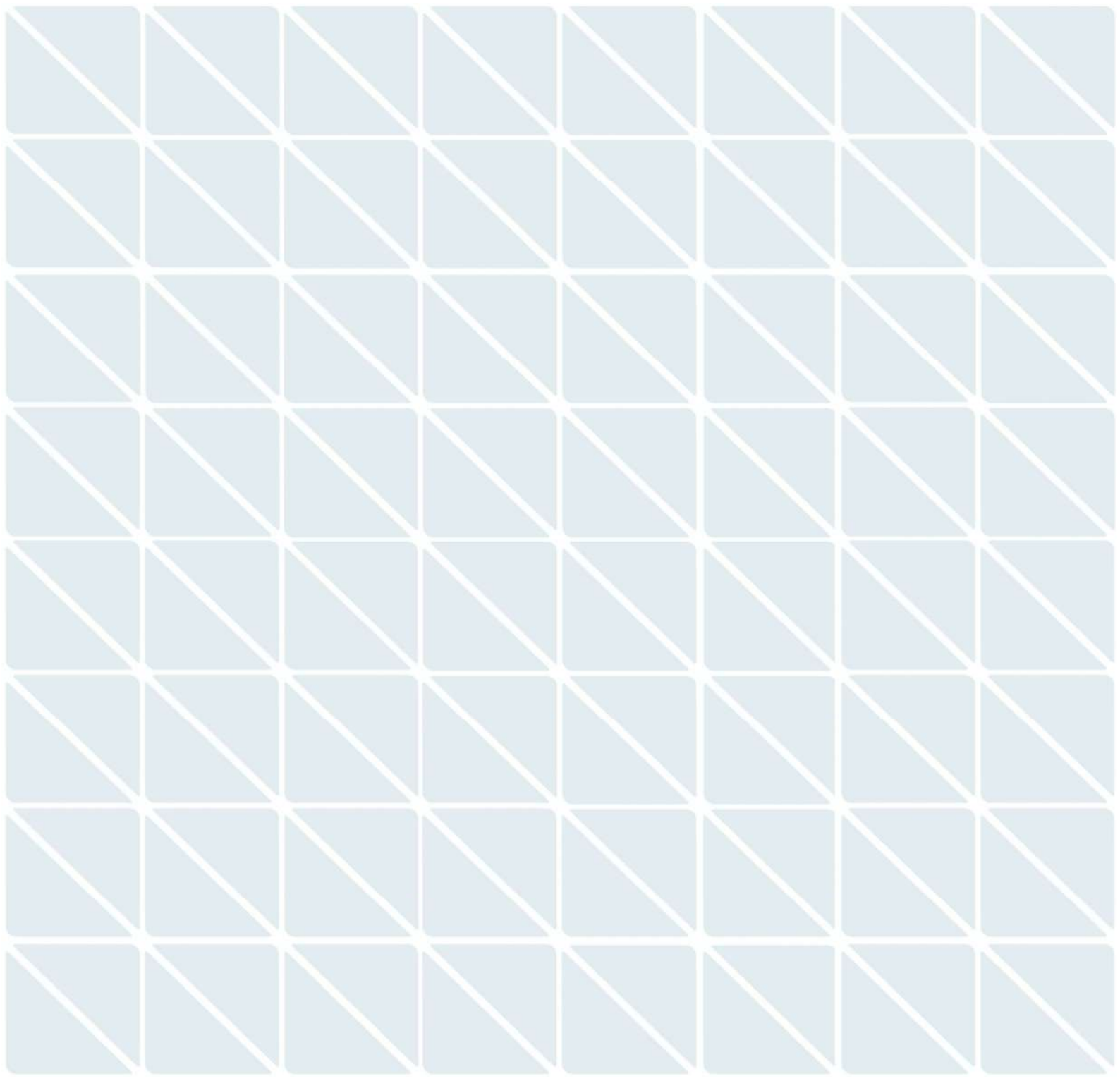
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Appendix B – Jackson Geo Services

Global Centre of Rail Excellence (GCRE)

Bridge Works Ground Investigation

Factual Report

G23012B

July 2023

GCRE Limited

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Report Control Sheet**Report Number**

G23012B

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Jackson Geo Services is a trading name of Jackson Drilling Holdings Limited – registered company number 06919550.

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1 Introduction

1.1 General

GCRE entered into a contract with Jackson Geo Services (JGS) to complete a ground investigation at the Global Centre of Rail Excellence (GCRE) site (hereafter referred to as The Site). The contract was agreed during April 2023. As per the Construction Design and Management (CDM) Regulations (2015), parties were attributed the following responsibilities:

Table 1: Responsibility Under CDM

Client	GCRE Limited
Designer	Expedition
Principal Contractor	Walters UK Limited
Sub-Contractor	Jackson Geo Services

Expedition employed A-squared Studio as their specialist designer to interpret the gathered geotechnical and geoenvironmental data.

1.2 Proposed Development

The site is proposed to be developed with a new bridge structure.

1.3 Scope of Works

The scope of investigation was defined by Expedition and is detailed within 1867 – GCRE Bridge – Ground Investigation Specification Issue 3 (dated 27 March 2023) (hereafter referred to as The Specification). In summary, the scope of investigation comprised:

- ☑ Dynamic Sampled boreholes with Rotary Follow-on Coring
- ☑ Rotary Core boreholes
- ☑ Machine Excavated Trial Pitting
- ☑ In-situ Testing
- ☑ Geotechnical Testing
- ☑ Geoenvironmental Testing
- ☑ Factual Reporting
- ☑ Production of Digital Data in AGS 4 format

1.4 Limitations

The project has been undertaken in accordance with The Specification and current standards and guidance as applicable (see References).

This report presents the observations made during desk based studies and the fieldwork period on a factual basis. Any observations within the report are limited to those which can be made based upon the information available at the time.

JGS consider the contents of the report have been produced accurately and the data presented is representative of the site conditions at the time. JGS assumes any third party

data included in the report is accurate and correct. No responsibility is accepted by JGS for inaccuracies within third party data.

This report has been written to The Specification and is for use only in this context by the named Client and their advisers and is confidential to the named Client.

This report presents information on ground conditions, including groundwater, gas and contamination concentrations and soil properties, which are based upon the available dataset for the investigation. This dataset is considered representative of the site as whole, however is limited by the locations of investigation. Ground conditions, in particular Made Ground, can vary substantially and JGS do not accept responsibility for local unforeseen changes. Furthermore, groundwater, gas concentrations and chemical concentrations can vary with time, atmospheric conditions and spatially dependent upon a variety of confining factors.

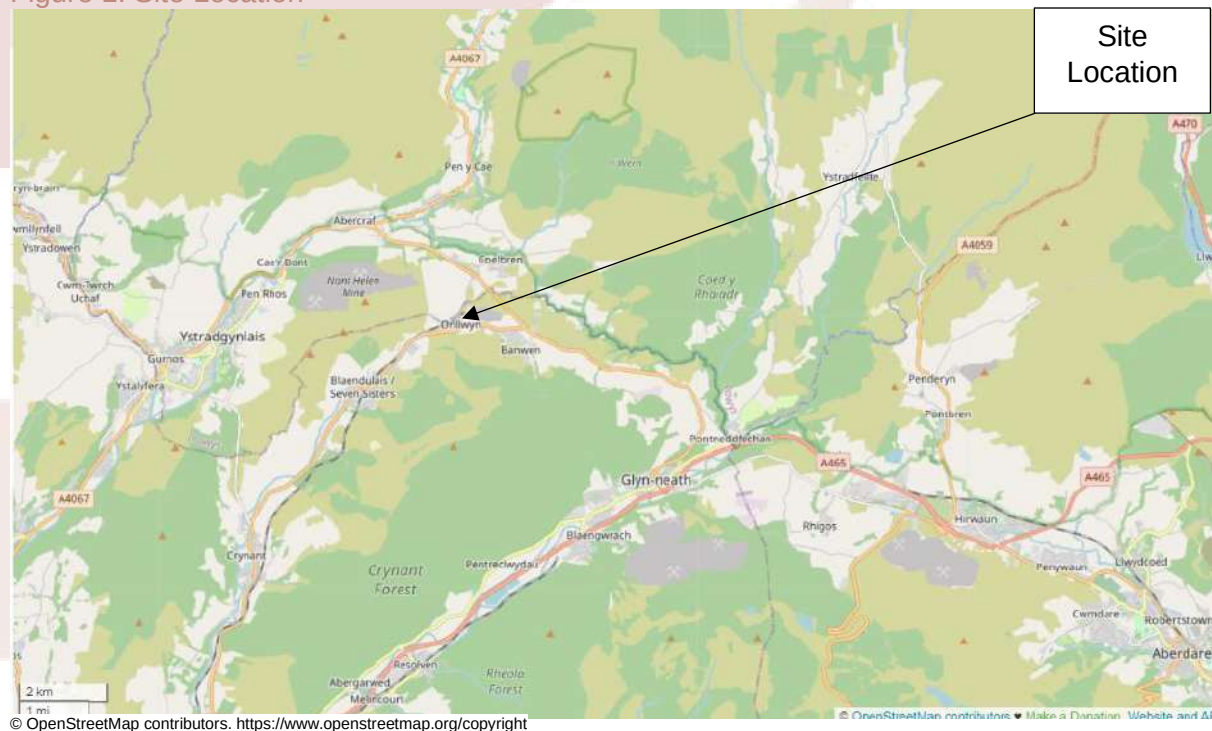
Consideration should be made as to the relevance of the information if the dataset is to be utilised after a significant period of time has elapsed from the date of investigation.

2 The Site

2.1 Site Location

The Site is situated at National Grid Reference (NGR) SN 841 105 and is approximately 200 m northwest of Onllwyn Welfare Hall. The location of The Site is shown in Figure 1:

Figure 1: Site Location



2.2 Current Use

The Site is located on the northernmost of two bridges on Onllwyn Road that form the western boundary of the former Onllwyn Washery. The bridge runs southeast to northwest and spans a now disused rail track that was used to service the washery and remove coal. It is rectangular in shape and measures 26 m by 21 m.

The Site can be split in to three levels consisting of track level below the bridge deck which is flat with a single rail track that runs in to the washery from the southwest to northeast. There are two drainages ditches (one either side) which run parallel to the track. The second level is located in the vicinity of the northwest bridge abutment. The ground rises moderately to the northeast and infills the two wings of the abutment wall which is constructed of a combination of brick and concrete. The third level is the top of the northeast abutment which is at the same height as the road. It is approximately 5 m² with a mix of brick and concrete that suggests there may have been a previous structure above ground level. The nearest waterway is 25 m to the south and is fed via settlement ponds from the washery in the east and eventually forms the Avon Dularis.

To the north The Site is bounded by previously restored opencast and Common Land which is laid to grass and used for the grazing of livestock. To the east The Site is bounded by the former Onllwyn Washery. To the south The Site is bounded by the small settlement of Onllwyn beyond which is open grassland again used for grazing livestock. To the west there is the rail track that follows the Dulais Valley, generally trending southwest to south. Also to the west there are also areas of former opencast and land associated with the former Onllwyn Colliery, the areas which have previously been worked have been restored to provide Common Land that is again used for grazing.

2.3 Anticipated Ground Conditions

The anticipated ground conditions have been assessed using the data available on the British Geological Survey (BGS) GeoIndex (onshore) Map Viewer (2023) and the published BGS map (map no. 231, 1979), these are summarised within Table 2:

Table 2: Anticipated Ground Conditions

Artificial Ground	Made Ground	Artificial Deposit
Superficial Deposits	None recorded	
Solid Geology	South Wales Middle Coal Measures Formation	Mudstone, Siltstone and Sandstone.

Areas of artificial ground are considered to be associated with the former washery, and specifically the construction of the bridge and railway onsite.

Whilst no superficial deposits are indicated on the published geological mapping information, BGS borehole data indicates that 'Boulder Clay' (now Glaciofluvial Deposits) may be located at The Site.

There is an inferred fault of unknown displacement shown on the GeoIndex (onshore) Viewer to the east of the site. It trends south south-east to north north-west and demarcates the geological boundary between the middle and lower South Wales Coal Measures.

There is potential that that mine workings associated with the South Wales Coal Measures are located beneath the site.

The Department for Environment, Food & Rural Affairs (DEFRA) MAGIC mapping system (2023) indicates The Site is located within an area where the bedrock is classified as a secondary A aquifer.

3 Fieldwork

3.1 General Information

The fieldwork was completed between 1 and 9 June 2023.

The ground investigation was undertaken in accordance with BS5930:2015+A1:2020. The works were supervised by a trained and competent JGS engineer.

The layout of the investigation locations and their unique identifiers were determined by A-squared Studio and are listed within The Specification. This information was provided to JGS prior to works commencing onsite. Walters UK Limited set out the locations onsite using co-ordinates provided.

Service drawings were provided to JGS by Walters UK Limited prior to works commencing on site and the location of the proposed investigation locations was checked against the service drawings prior to excavation.

Prior to excavation, each exploratory hole location was scanned using a Cable Avoidance Tool (CAT) to confirm the absence of services beneath the proposed excavation.

All exploratory hole locations, with the exception of machine excavated trial pits, were excavated to a depth of 1.20 m by hand prior to using mechanical plant. As hand excavation progressed, the excavations were scanned using a Cable Avoidance Tool (CAT) to continue to confirm the absence of services.

Where exploratory holes were extended into the Coal Measures, 5 in 1 gas monitors measuring carbon monoxide (CO), methane (CH₄), Carbon dioxide (CO₂), Oxygen (O₂) and Hydrogen Sulphide (H₂S) were placed at the well head during drilling in order to confirm gas concentrations, and 4 in 1 personal gas monitors were used within the drilling operatives breathing zones.

Photographs of the materials encountered were taken in accordance with The Specification and are presented in Appendix II.

Following completion of the fieldwork, all investigation locations been surveyed to National Grid and Ordnance Datum using GPS survey equipment. The location of the exploratory holes is shown on the drawings within Appendix I. The survey was completed by Walters UK Limited.

3.2 Exploratory Holes

The proposed numbers of exploratory holes, their unique identifiers, termination depths and installation requirements were provided to JGS within The Specification. The details of the as built exploratory holes, including the location ID, construction method, actual termination depth and installation detail, are listed within Table 3.

Table 3: Exploratory Hole Details

Exploratory Hole ID	Construction Method	Termination Depth (m)	Installation Details		
			Type	Diameter (mm)	Response Zone (m bgl)
BR-BH01	Rotary Cored Borehole	25.00	Backfilled with bentonite		
BR-BH02	Dynamic Sampling with Rotary Follow-on Coring	25.50			
BR-TP01	Insulated hand tools	0.80	Backfilled with arisings		
BR-TP02	Insulated hand tools	0.80	Backfilled with arisings		
BR-TP03	Insulated hand tools	0.70	Backfilled with arisings		
BR-TP04	Insulated hand tools	1.10	Backfilled with arisings		

Notes: SP – Standpipe piezometer; P – Piezometer

During the construction of exploratory holes BR-BH01 and BR-BH01 sub-artesian water strikes were encountered. In order to mitigate the potential for water egress at the surface in the future during periods where the groundwater table becomes artesian, a sacrificial packer was installed within each borehole at depth and the borehole was grouted back up to ground level to prevent water migrating to the surface.

Fair copy logs, which record the method, samples obtained, in-situ testing completed within the exploratory holes, backfill and descriptions of the material encountered, are presented within Appendix II.

3.3 Logging and Sampling

Samples of the materials encountered were obtained in accordance with The Specification for descriptive and geotechnical and geoenvironmental testing purposes.

The description of the materials encountered was completed in accordance with BS5930:2015+A1:2020, BS EN ISO 14688-1 (2018) and BS EN ISO 14689 (2018).

Geotechnical samples were stored onsite at ambient temperature and protected from extremes of weather until lab testing commenced. Once scheduled for testing, the samples were transported to Geo Site and Testing Services (GSTL).

Geotechnical samples were stored at ambient temperature and protected from extremes of weather until lab testing commenced at the onsite sample storage facility. Once scheduled for testing, the samples were transported to Geo Site and Testing Services (GSTL).

Geoenvironmental samples were packaged appropriately and dispatched directly from site to Eurofins Chemtest ensuring compliance with the deviant sampling policy. The samples were subsequently stored under laboratory conditions until testing commenced.

3.4 In-situ Testing

In-situ testing was completed in accordance with The Specification and relevant associated technical standards. In summary, the in-situ testing comprised the following:

- ☑ Standard Penetration testing
- ☑ Headspace testing using a Photo Ionisation Detector

The lateral and vertical spacing of the in-situ testing was determined by Expedition.

The in-situ testing results are presented on the exploratory hole logs within Appendix II.

4 Laboratory Testing

4.1 Geotechnical Testing

Laboratory testing for geotechnical purposes was completed at Geo Site and Testing Services Limited, UKAS registration number 2788. The testing requirements were specified by A-squared Studio and the testing has been completed in accordance with the requirements of The Specification and relevant technical standards. The geotechnical testing was completed on 3 July 2023. The testing is summarised in Table 4 and the results are presented within Appendix IV.

Table 4: Geotechnical Testing Summary

Test Type	Number of Tests
Moisture Content	3
Atterberg Limits	2
Particle Size Distribution	1
Point Load Index	6

4.2 Geoenvironmental and Geochemical Testing

Laboratory testing for geoenvironmental and geochemical purposes was completed at Eurofins Chemtest, UKAS registration number 2183. The testing requirements were specified by A-squared Studio and the testing has been completed in accordance with The Specification and relevant technical standards. The geoenvironmental testing was completed on 28 June 2023. The testing is summarised within Table 5 and the results are presented within Appendix V.

Table 5: Geoenvironmental Testing Summary

Test Type	Number of Tests
Suite D – BRE Brownfield Pyrite Present	5
Suite E – Soil	5
Suite E additional – asbestos screen, ammonium, VOCs, SVOCs	4
Asbestos screen	5
Total Organic Carbon	6
Suite F – Leachate	4
Waste Acceptance Criteria Suite	2
Polychlorinated Bi-Phenols	3
Herbicides	2

5 References

- AGS. Electronic Transfer of Geotechnical and Geoenvironmental Data (Edition 4.1.1). Association of Geotechnical and Geoenvironmental Specialists. (2022)
- BGS England and Wales Sheet 231, Merthyr Tydfil, 1:50000 geological map (solid and drift). British Geological Survey. (1979)
- BGS GeoIndex (onshore) Map Viewer. www.bgs.ac.uk. British Geological Survey. (2023)
- BRE Special Digest 1. Concrete in aggressive ground. Building Research Establishment. (2005)
- BS 1377. Methods of test for soils for civil engineering purposes. British Standards Institution. (1990)
- BS 5930:2015+A1. Code of practice for ground investigations. British Standards Institution. (2020)
- BS 10175:2011+A2. Investigation of potentially contaminated sites. Code of practice. (2017)
- BS EN 1997-2. Eurocode 7. Geotechnical design. Part 2 Ground investigation and testing. British Standards Institution. (2007, incorporating corrigendum June 2010)
- BS EN ISO 14688-1. Geotechnical investigation and testing. Identification and classification of soil. Part 1 Identification and description (2018)
- BS EN ISO 14688-2. Geotechnical investigation and testing. Identification and classification of soil. Part 2 Principles for a classification (2018)
- BS EN ISO 14689. Geotechnical investigation and testing. Identification, description and classification of rock (2018)
- BS EN ISO 22282-1:2012. Geotechnical investigation and testing. Geohydraulic testing. Part 1 General rules (2012)
- BS EN ISO 22475-1. Geotechnical investigation and testing. Sampling methods and groundwater measurements. Part 1 Technical principles for the sampling of soil, rock and groundwater. British Standards Institution. (2021)
- BS EN ISO 22476-1. Geotechnical investigation and testing. Field testing. Part 1 Electrical cone and piezocone penetration test. British Standards Institution. (2012, incorporating corrigendum January 2013)
- BS EN ISO 22476-2:2005+A. Geotechnical investigation and testing. Field testing. Part 2 Dynamic probing. British Standards Institution. (2011)
- BS EN ISO 22476-3:2005+A1. Geotechnical investigation and testing. Field testing. Part 3 Standard penetration test. British Standards Institution. (2011)
- Department for Environment, Food and Rural Affairs (DEFRA) MAGIC maps online application. DEFRA (2023)
- ISRM. The Complete ISRM Suggested Methods for Rock Characterisation, Testing and Monitoring (1974-2006). Commission on Testing Methods, International Society for Rock Mechanics (Editors Ulusay R & Hudson JA). (2007)
- Open Street Map (2023)

Appendix I

Drawings

Exploratory Hole Plan

Drawing Number:

G230012B



Basemap: Open Street Map and Google Maps, accessed 17/11/2022

GCRE
Exploratory Hole Location

TP	
RC	

GCRE Bridge Works

Exploratory Hole Location
Plan

Job No: G23012B

Date: July 2023



0 10 20 30 40 50 m



Appendix II

Exploratory Hole Logs and In-situ Testing

SPT Hammer Calibration Certificate

Certificate Number: TECAV1

Dynamic Sampling and Rotary

BR-BH01 and BR-BH02

Borehole Logs

Trial Pits Logs

BR-TP01 to BR-TP04

Dynamic Sampling Uk Ltd
Units 5-8 Victory Park
Victory Road
Derby
DE24 8ZF

SPT Hammer Energy Test Report

in accordance with BSEN ISO 22476-3:2005

SPT Hammer Ref: TECAV1
Test Date: 29/11/2022
Report Date: 29/11/2022
File Name: TECAV1.spt
Test Operator: B.HUNTER

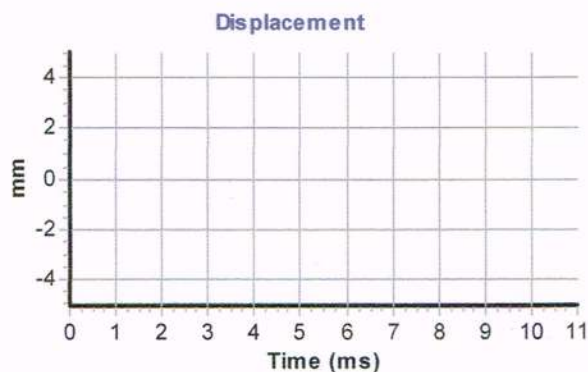
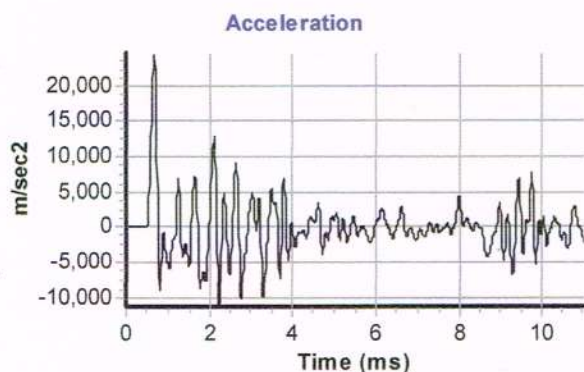
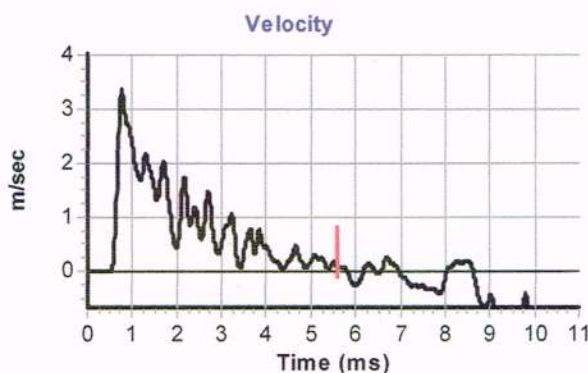
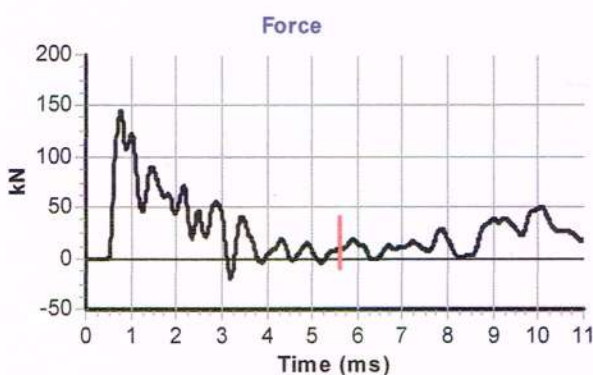
Instrumented Rod Data

Diameter d_r (mm): 54
Wall Thickness t_r (mm): 6.5
Assumed Modulus E_a (GPa): 208
Accelerometer No.1: 62901
Accelerometer No.2: 62902

SPT Hammer Information

Hammer Mass m (kg): 63.5
Falling Height h (mm): 760
SPT String Length L (m): 10.0

Comments / Location



Calculations

Area of Rod A (mm^2): 970
Theoretical Energy E_{theor} (J): 473
Measured Energy E_{meas} (J): 303

Energy Ratio E_r (%): **64**

Signed: B.Hunter
Title: Operations Manager

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Exploratory Hole Progress by Time				Exploratory Hole	
Date and Time	Depth	Casing Depth	Water Depth	BR-BH01	
				Sheet 4 of 5	
				Scale	1:25
				Drilled	KO/WH
				Logged	RF/WH
				Checked	AP

Drilling Flush					Hole Diameter		Casing Diameter		Water Added		Water Strikes						
Depth Top	Depth Base	Type	Colour	Returns	Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Date and Time	Casing	Strike	Sealed	Rising to	Time	Remarks
0.60	25.00	Air/Mist	Grey	100%	1.50	150mm	1.50	150mm			07/06/2023 08:00 08/06/2023 10:01	1.50 1.50	7.10 22.00		6.20 5.40	20mins 20mins	
Drill Bit Type		PCD			Drill Bit Condition		Good		Core Barrel Type		Conventional Triple Tube		Core Barrel Length			1.50	

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