Biglis Active Travel Bridge

Geotechnical Desk Study

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Contents

Tables

Figures

Appendices

1 Introduction

Arcadis has been commissioned by the Vale of Glamorgan Council to undertake a geotechnical desk study of a proposed new Active Travel Route (ATR) between Barry and Dinas Powys in South Wales, UK. The ATR is one of several ATR schemes within the Vale of Glamorgan with the combined effect of encouraging active travel and improving connections between local communities.

The scope of this geotechnical desk study report is limited to the proposed Biglis bridge in the southern area of the Barry to Dinas Powys ATR scheme, where the ATR crosses the Cadoxton river. The proposed ATR runs immediately south of and parallel to the A4055. In the site area, the route and the bridge align roughly northeast-southwest. For the purposes of this report, the 'Site' is defined as the section of scheme immediately surrounding the proposed Biglis bridge.

The purpose of this desk study report is to assess the potential geotechnical constraints of the proposed pedestrian and cycle bridge only. This report represents a review of the available information in order to develop an approach to investigate the ground model.

Review of environmental aspects including geo-environmental, utility information and ecological information for the scheme is outside the scope of this report but will be required prior to any site work.

A separate flooding assessment is being undertaken as part of the works, therefore hydrogeological and hydrological content review is not within the scope of this report.

2 Site Setting

2.1 Site Location and Description

The Site is located approximately 300m east of Palmerstown, Barry, South Wales, UK. The nearest post code is CF63 2BA and the Site is centred at Ordnance Survey grid reference ST 14896 69301. Figure 2-1 shows the Site extents defined within the scope of this report.

Figure 2-1: Site Boundaries

No site walkover has been undertaken to date due to access constraints, so the Site has been characterised using the freely available satellite imagery and mapping (Ref. 1).

The Site consists of grassy farmland on both sides of the Cadoxton river. The river is approximately 6m wide at its widest point on Site according to the site imagery (Ref 1). Several mature trees are shown next to the river in the south, and an unknown pipe is shown on the eastern riverbank with multiple pedestrian gravel tracks leading east and south away from the river.

The Site is shown by OS mapping (Ref. 2) to be relatively flat at approximately 7m Ordnance Datum (OD) on the west bank of the river and 6m OD on the east bank of the river.

The Site is adjacent to the A4055 which bounds the Site to the north, with an existing road bridge over the river Cadoxton. Immediately north of the road, Cold brook joins Cadoxton river from the north, crossing under the road and continuing as Cadoxton river in a south westerly direction. Several drainage channels are shown within 200m of the Site to the east and southeast, connecting to the Cadoxton river approximately 50m south of the Site.

The area surrounding the Site is predominantly farmland and grassy fields, with some farm barns shown approximately 100m northeast of the Site.

Approximately 100m south of the Site several stockpiles of white material are shown, with an access road back up to the A4055.

2.2 Site History

A review of the available historical Ordnance Survey maps, Welsh Tithe Maps and satellite imagery (Ref. 3, Ref. 4 and Ref. 1) has been undertaken to assess the historical development of the Site and surrounding areas. It is not the intention of this report to provide a full history. A summary of the main historical development on and off the Site is given in Table 2-1.

Table 2-1: History of the Site and Surrounding Area

Date Range	On the Site	Surrounding Area
1840 – 1879	The Welsh Tithe Map (Ref. 4) from 1840 shows the Site as arable farmland, with the Cadoxton river running through the Site. A footpath is shown to run through the Site adjacent to the river.	The surrounding area is arable farmland with Cold brook joining the Cadoxton river from the north. Multiple footbridges are shown to the north and south of the Site for the footpaths. Area to the east labelled as liable to floods. Third unnamed waterway shown joining the Cadoxton river at the same point as Cold brook.
1879 - 2001	No significant changes.	A road and bridge are shown bounding the Site to the north. Area to the north of the Site is labelled as liable to floods. A brickworks and railway are shown approximately 100m southwest of the Site. Biglis pumping station is shown approximately 500m north of the Site next to a spring. Pumping station disused by 1946.
2001 - 2013	No significant changes.	Industrial area in Palmerstown constructed replacing the brickworks and railway approximately 300m from the Site.
2013 - Present	Pipe on east riverbank exposed by 2013.	White material stockpiles appear 100m south of the Site by 2019.

3 Ground Conditions

3.1 Geology, Hydrogeology and Hydrology

3.1.1 Artificial Ground

The GeoIndex (Ref. 5) shows the western half of the Site is underlain by Made Ground, additionally Made Ground is also anticipated on the eastern half of the Site, relating to the historical footpath and exposed pipe running through the area. Figure 3-1 details the location and extent of the Made Ground, as shown on the Drift Geological map (Ref. 6).

3.1.2 Superficial Deposits

The GeoIndex and Geological Map of the area (Ref. 5 and 6) show that the Site is underlain by Alluvium, comprising of a mix of clay, silt, sand and gravel. Figure 3-1 details the location and extent of the Alluvium, as shown on the Drift Geological map (Ref. 6).

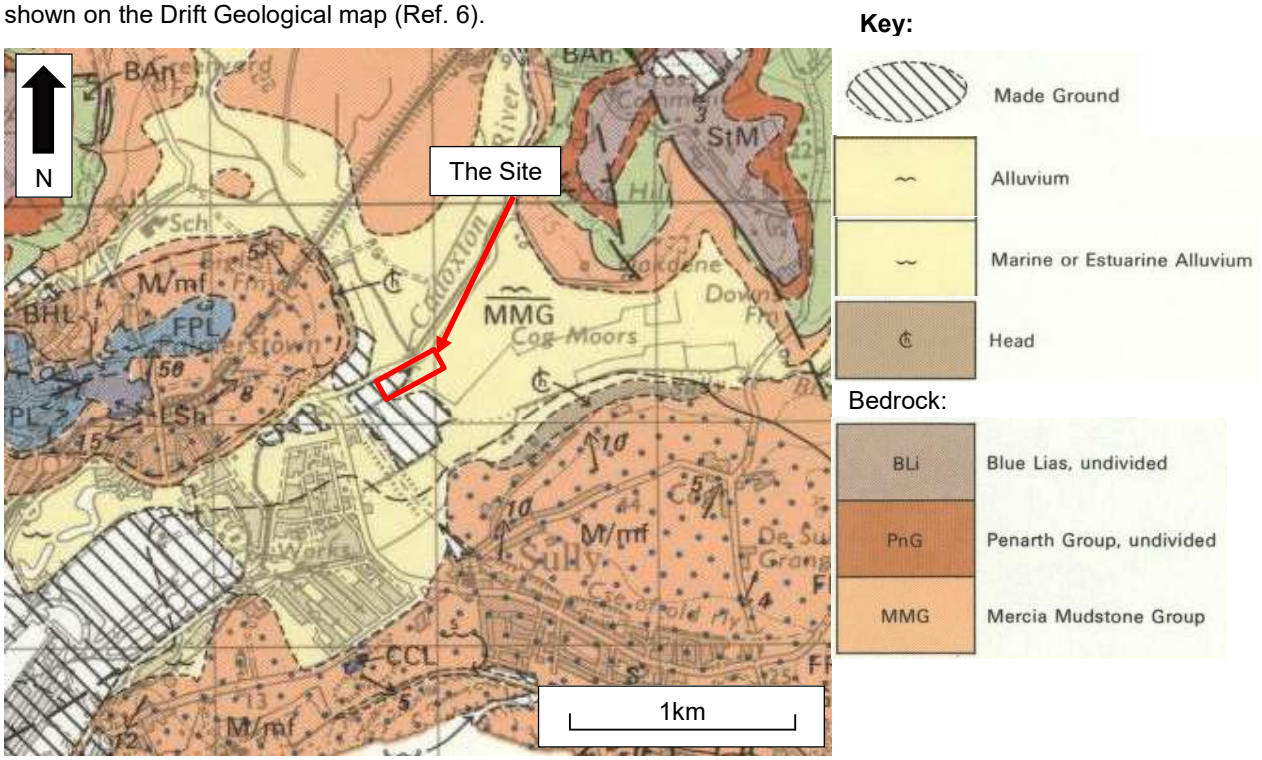

Figure 3-1: Drift Geological Map Extract (Ref. 6)

3.1.3 Bedrock Geology

The GeoIndex and Solid Geological Map of the area (Ref. 5 and 7) show that the superficial deposits are underlain by the Mercia Mudstone Group, generally comprising mudstones and siltstones with widespread thin beds of gypsum or anhydrite.

The bedrock is shown to be shallowly dipping to the north at between 5 and 10 degrees. Two regional faults are present approximately 800m northeast and 1.5km southwest. Multiple minor faults are shown outcropping on the coast that may extend further inland to the northeast of the Site.

Figure 3-2 details the location and extent of the Mercia Mudstone Group, as shown on the Solid Geological map (Ref. 7).

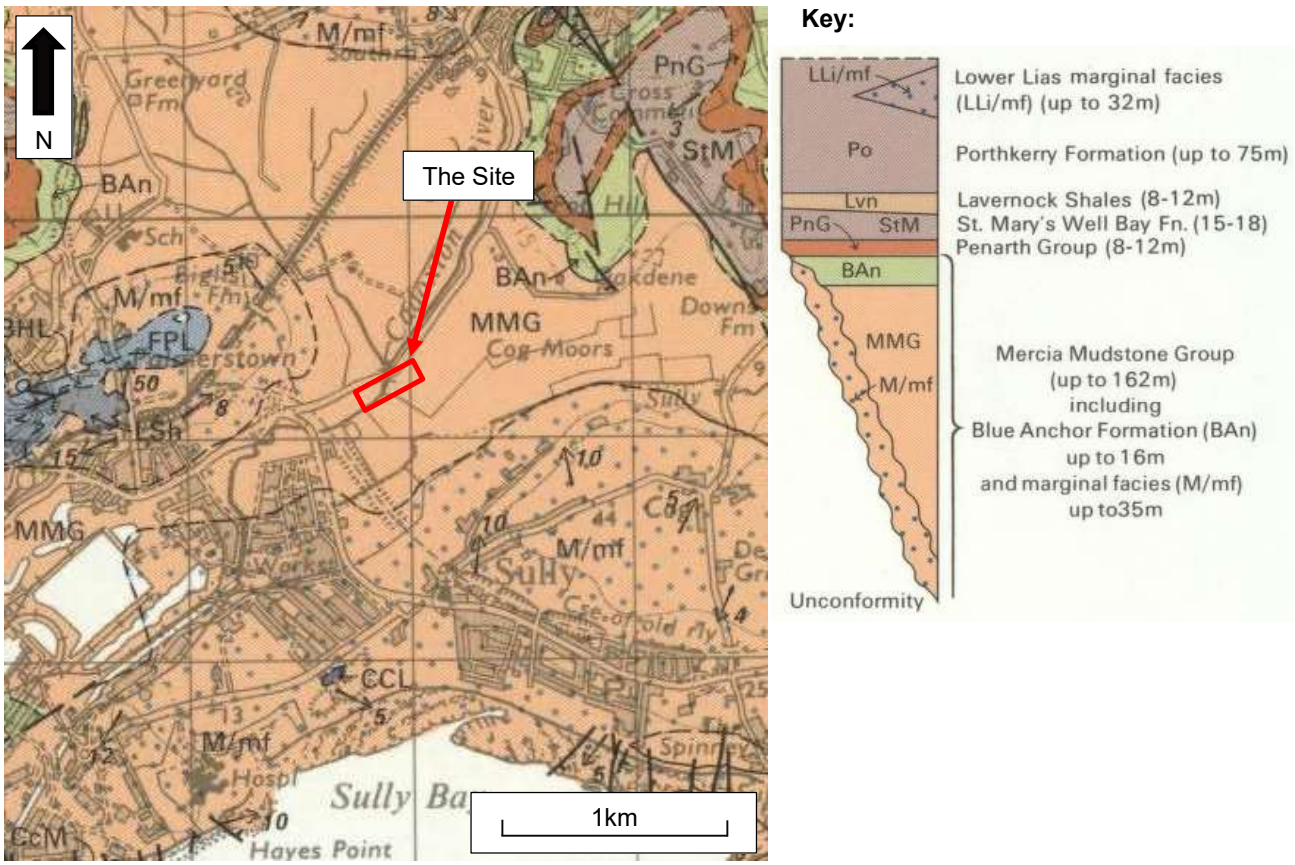

Figure 3-2: Solid Geological Map Extract (Ref. 7)

3.1.4 Groundwater

Groundwater is anticipated to be close to the local water level in the river Cadoxton and surrounding land drains. The historical maps identified the broader area to be liable to flooding, therefore the highest groundwater level is likely to be at or near ground level. The groundwater flow is likely to flow towards the river Cadoxton which flows in a general northeast to southwest direction.

The superficial deposits are a Secondary A, designated aquifer of 'Medium' vulnerability. The Mercia Mudstone group is designated as a Secondary B aquifer of 'Medium' vulnerability, as detailed by the National Resources Wales viewer (Ref. 8).

The Site is categorised as being within a Flood Zone 3 area for rivers, with 1% or greater chance of flooding per year as detailed by the Flood map for planning (Ref. 8). The area to the north of the Site is also covered by Flood Zones 2 and 3 for surface water and small watercourses, equating to 0.1% to 1% and greater than 1% chance of flooding per year.

A separate flood risk assessment is being undertaken as part of the works which does not form part of this report.

3.2 Mining and Natural Voids

3.2.1 Mineral and Construction Extraction

The GeoIndex (Ref. 5) shows that brick Clay is present beneath overburden by less than 5m across the Site. The Globe Brick Works is shown on the Mines and quarries database 280m southwest of the Site and may have extracted brick Clay on the western half of the Site.

The Site lies in a mineral resource area for superficial sand and gravel, with a sub-alluvial source.

It is likely that part or all of the Site has had extractions for mineral and construction purposes.

3.2.2 Coal Mining

The Site is not in a coal mining risk area, as shown by the Coal Authority's interactive map viewer (Ref. 9).

3.2.3 Evaporite Dissolution

The BGS Lexicon (Ref. 10) states that the Mercia Mudstone Group has beds of evaporites, notably halite, gypsum and anhydrite. These minerals are dissolvable into the groundwater, causing a potential for natural voids under the Site area.

3.3 Unexploded Ordnance (UXO)

As seen in Figure 2-1 according to Zetica online UXO Risk Maps (Appendix A), the Site is within an area of low risk with a zone of medium risk starting from 300m to the west of the Site.

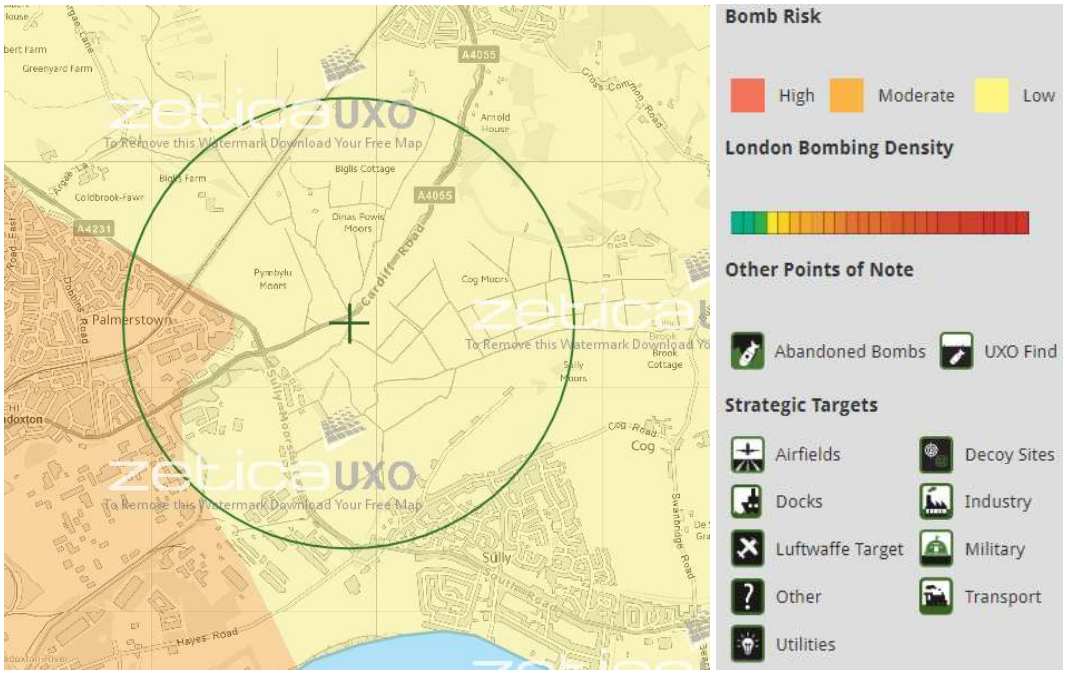

Figure 3-3: UXO Risk Map

Based on this information, there is no greater probability of encountering UXO here than anywhere else in the UK. A detailed risk assessment for the area is not requested.

3.4 Historical Boreholes

No previous site-specific ground investigations are available, however there are 9No. BGS exploratory holes available for review on the GeoIndex (Ref. 5) within 500m of the Site. The exploratory holes have been reviewed and the key findings are presented below:

Table 3-1: Historical Borehole Summary

Exploratory Hole *(hole type)*	Distance from Site	Depth range (m BGL)	Description
ST16NW30 *(Mineral Bore)*	280m northwest	GL – 0.3	Topsoil
		0.3 – 1.68	Brown Clay
		1.68 – 2.62	Weathered Mercia Mudstone Group bedrock, described as red Marl.
		2.62 – 3.0	Bedrock, described as Sandstone.
ST16NW31 *(Mineral Bore)*	320m west	GL – 0.3	Topsoil
		0.3 – 1.24	Brown Clay
		1.24 – 2.4	Weathered Mercia Mudstone Group bedrock, described as a red Marl.
ST16NW32 *(Mineral Bore)*	360m west	GL – 0.33	Fill
		0.33 – 4.0	Brown and grey mottled Clay
ST16NW33 *(Mineral Bore)*	360m west	GL – 3.0	Soft brown and grey Clay. Traces of peat were noted between 2.8m BGL and the base of the hole. Bedrock was not encountered.
ST16NW29 *(Mineral Bore)*	370m northwest	GL – 0.15	Topsoil
		0.15 – 1.7	Soft brown, red and grey Clay
		1.7 – 2.7	Mercia Mudstone Group bedrock, described as a hard and soft bands of red and grey Marl.
ST16NW34 *(Mineral Bore)*	410m west	GL – 0.46	Topsoil
		0.46 – 2.7	Brown mottled Clay. Bedrock was not encountered.

ST16NW362 *(Percussion Borehole)*	430m west	GL – 1.7	Made Ground: stony Clay
		1.7 – 5.5	Firm grey broad silty Clay with occasional laminations.
		5.5 – 5.54	Mercia Mudstone Group bedrock, identified as moderately weathered light grey silty calcareous Mudstone.
ST16NW35 *(Mineral Bore)*	430m west	GL – 0.6	Disturbed ground
		0.6 – 3.4	Soft brown and blue-grey Clay
		3.4 – 4.0	Weathered Mercia Mudstone Group bedrock was likely encountered, described as a soft red and grey marly Clay.
ST16NW361 *(Percussion Borehole)*	440m west	GL – 1.5	Stiff brown, red sandy fine gravelly Clay
		1.5 – 1.51	Bedrock, identified as grey Limestone
Additional general notes: Groundwater information was not recorded on the majority of the logs available, however boreholes ST16NW361 and ST16NW362 noted that the holes were dry.			

4 Preliminary Geotechnical Constraints

4.1 Proposed Development

A pedestrian / cycle bridge is proposed for the Site area. The exact dimensions of the bridge and preferred foundation type are not currently known. The bridge is currently anticipated to be of reinforced concrete construction with a bridge span of approximately 10m between two abutments, one on each bank of Cadoxton river.

4.2 Ground and Groundwater Conditions

The ground conditions identified for the Site are Made Ground (western riverbank) or topsoil (eastern riverbank) overlying Alluvium, overlying a bedrock of the Mercia Mudstone Group. The bedrock is anticipated to be variably weathered and likely to be encountered at a shallow depth of circa 1.5m BGL. The closest available exploratory hole is 280m northwest of the Site, therefore a site-specific ground investigation is recommended.

Information on the groundwater level(s) under the Site is extremely limited, but as the Site is within a flood risk area, the highest groundwater is assumed to be at ground level. The separate flood risk assessment should ascertain a flood level.

To keep settlements of the approach embankments low, any earthworks design should consider the settlement and strength characteristics of the alluvium and weathered Mercia Mudstone rockhead. Additionally, any peat encountered under the bridge structure or approach embankments is recommended to be excavated out and replaced with compacted backfill. It is recommended that once geo-environmental aspects of the landfill are identified, the preliminary geotechnical constraints are also assessed.

The foundations of the proposed bridge should be assessed once the ground conditions of the Site are better clarified by a site-specific ground investigation. The ground conditions as shown by historical boreholes suggest feasibility for shallow bridge foundations to rest on the Mercia Mudstone Group at the bridge abutment locations. If alluvium or poor ground is present at the bridge foundation locations to significant (say >2m) depths, piled foundations may become more economical.

4.3 Geotechnical Hazards and Constraints

The following constraints have been identified that pose risk to the Site which are tabulated in Table 4-1.

Table 4-1: Geotechnical Hazards and Constraints

Hazard	Constraint
Uncertain Ground Conditions	There is currently limited information regarding the site-specific ground conditions beneath the Site area. There is potential for ground conditions to be present that were not identified in the existing information. Furthermore, there is potential for extensive low strength / density and/or highly compressible materials within the Made Ground and Alluvium. Information on groundwater depths / levels is also very limited.
Made Ground (composition and variability)	The presence of Made Ground on the Site could present a number of geotechnical challenges as detailed below: Material Composition: Made Ground is commonly heterogeneous in its nature being a non-geological and or non-engineered material. Made Ground commonly contains man-made materials or waste which, in the case of organic type materials, can deteriorate with time. Furthermore, given that primarily fine- and coarse-grained materials behave differently under loading, the variable and unknown nature of Made Ground can lead to a wide range of bearing capacities and settlements (both total and differential). Fine gained soils can also present a long-term settlement hazard. Strength/ Density/Compressibility: In addition to heterogenous material composition (above), the variable strength of fine-grained materials and/or variable density of coarse-grained materials, and in turn variable compressibility, can also lead to a wide range of bearing capacities and settlements (both total and differential). The inclusion of a variety of man-made materials, material grain sizes and a lack of control or compaction during historical material placement can also lead to voids forming within Made Ground and potential localised collapse upon loading. The characteristics above can affect the engineering performance of the materials to support proposed foundations, earthworks, and associated infrastructure.
Landfill	The made ground on the western half of site has been identified as a historic landfill site. Landfill is generally known for its variability in properties and thickness and as a contamination source. The variability can cause problems related to bearing capacity or excess settlement (total and differential) for structures and infrastructure. The contamination can cause ground conditions aggressive to concrete. Further advice from a geo-environmental engineer should be sought.
Variable Rockhead depth and weathering	The historical maps identified that the Mercia Mudstone rockhead has likely been mined for brick clay on the western half of the Site, which will result in variable

	rockhead levels. Additionally, the available BGS exploratory holes showed a range of rockhead levels and variable rockhead weathering conditions.
Natural Voids	The bedrock geology is shown to contain evaporite deposits by the published geological information. These deposits are water soluble and could in the future or may have already dissolved, leaving voids in the bedrock.
High Groundwater / Flooding	The available information indicates that the Site is at risk of flooding. The separate flood risk assessment should indicate potential flood levels.
Peat	Peat was encountered in exploratory hole ST16NW33 as a minor constituent; however, more could be present within the site area. Peat is classed as a 'Problematic soil'. It is of low strength, often laterally discontinuous and has potential for high-volume change with water and induced pressure. These characteristics can cause problems related to bearing capacity or excess settlement (total and differential) for shallow founded structures and infrastructure. Peat can also be pyritic, causing conditions that are aggressive to concrete. Excavations in peat are also likely to be problematic due to its low shear strength and high-water content, potentially leading to sidewall instability.
Soft Soil	Alluvium is mapped to be present on site and all exploratory holes indicate that it may be predominantly cohesive in nature. Alluvial soft soils (silt and clay) are deposited in terrestrial braided rivers or shallow marine environments and commonly contain buried channels and lenses or layers of fine- or coarse-grained material materials within the larger material mass. These soils are commonly of low strength or density which can cause problems related to bearing capacity or excess settlement (total and differential) for structures and infrastructure. The materials can also present constraints for trafficability of plant during investigation and construction, especially during winter or prolonged wet periods.

5 Environmental Conditions

A review of the environmental conditions is not within the scope of this report.

However, as Made Ground has been identified on site, a review of the DataMap Wales (Ref. 11) has been undertaken to see if it is a landfill site. The viewer shows that a historical landfill is present on the western half of site, known as 'Biglis Tip No. 1'. No operational dates are shown. A geo-environmental assessment is recommended to assess the impact of the landfill and associated contaminants on the proposed development.

At the time of drafting, it is understood that a feasibility study is currently being undertaken. This has not been reviewed.

6 Conclusion

This desk study report has reviewed the freely available information for geotechnical effects on the proposed development and the key points are:

- The proposed development is a pedestrian / cycle bridge as part of a wider active travel route.
- Made ground is likely to be present on the western half of the Site, with alluvium across the Site, which overlies bedrock of the Mercia Mudstone Group, with an anticipated weathered horizon.
- The eastern Site area has been largely undeveloped since 1840, with a footpath and an exposed pipe on the eastern riverbank. The western half of site has historically been mined for brick clay and filled with landfill.
- The Site is at risk of flooding and has potentially high groundwater levels.
- There is a risk of evaporites and evaporite dissolution in the Mercia Mudstone Group on the Site.
- The Site is not in a coal mining area.
- The western half of the Site may have had brick clay extraction. It is now a historic landfill site.
- The Site has a low risk of UXO.
- Several BGS exploratory holes are available and indicate shallow rockhead. However, the closest exploratory hole is 280m northwest of the Site.
- A selection of hazards and constraints have been identified in Table 4-1 and have been included in the Geotechnical Risk Register (Appendix B).
- The current proposals described in Section 4.1 are feasible for the Site area, however, a site walkover and site-specific ground investigation is required to ascertain the on-site ground conditions.

7 Recommendations

To ascertain the ground conditions below the Site, a site walkover is recommended, followed by a site-specific ground investigation. The investigation should determine the following:

- Thickness and characteristics (including strength and stiffness parameters) of made ground and superficial deposits on the Site, particularly of the landfill area of the western half of the site.
- Depth of competent rockhead across the Site
- Intact rock strength, spacing, orientation and nature of discontinuities.
- Depth/nature of weathered zone of bedrock
- Possibility of natural voids under the bridge foundations
- How aggressive are the ground and groundwater to concrete (and corrosiveness to metal should a steel bridge be proposed)
- Groundwater level under the Site and any seasonal fluctuations.

It is recommended that a Geo-environmental assessment be carried out on the site area, to cover the risk of contaminants from the landfill under the western half of the Site. Geo-environmental testing should be added to a combined geotechnical and geoenvironmental ground investigation.

In addition, an ecological and utilities surveys are needed to be undertaken prior to any ground investigation or site works.

The following preliminary geotechnical ground investigation scope should be considered as a minimum. Further investigation could also be required for geo-environmental purposes.

- For bridge foundation design, two boreholes to be located at the proposed bridge foundations and drilled to at least 10m into the Mercia Mudstone Group.
- For earthworks design as well as for soil contamination assessment, one day’s trial pitting should also be scheduled.
- A more detailed ground investigation scope and specification should be prepared once the bridge layout has been determined and a geo-environmental assessment has been carried out.

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Appendix A

Zetica UXO Risk Map

UNEXPLODED BOMB RISK MAP

SITE LOCATION

Map Centre: 314876,169282

This map principally indicates a hazard from Unexploded Bombs (UXB) due to WWII bombardment. Other sources of Unexploded Ordnance (UXO) may be present. It should be noted that this map does not represent UXO risk and should not be reported as such when reproduced.

LEGEND

- **High:** Areas indicated as having a bombing density of 50 bombs per 1000acre or higher.
- **Moderate:** Areas indicated as having a bombing density of 15 to 49 bombs per 1000acre.
- **Low:** Areas indicated as having 15 bombs per 1000acre or less.

Miltary | **Industry** | **UXO find** | **Other**
Transport | **Docks** | **Luftwaffe targets**
Utilities | **Bombing decoy** | **Airfields**

How to use your Unexploded Bomb (UXB) risk map?

This map indicates the potential for UXBs to be present because of World War Two (WWII) bombing. It can be incorporated into a technical report, such as a Phase 1 Desk Study, or similar document as an indication of the potential for UXO encounter on a Site. Other sources of UXO may also be indicated, although note that these are not comprehensive and more detailed research is required to confirm their presence.

What if my Site is in a moderate or high density area?

We typically recommend that a detailed UXO desk study and risk assessment is undertaken for sites in an area with a moderate or high bombing density.
Additionally, if your site is in close proximity to a strategic target, military establishment, airfield or bombing decoy, then additional detailed research is recommended.

If my site is in a low risk area, do I need to do anything?

If both the map and other research confirm that there is a low potential for UXO to be present on your site, then, subject to your own comfort and risk tolerance, works can proceed with no special precautions.

If you are unsure whether other sources of UXO may be present, you can request one of our pre-desk study assessments (PDSA) by emailing a site boundary and location to pdsa@zetica.com.

You should never plan site work or undertake a risk assessment using these maps alone. More detail is required, to include an assessment of the likelihood of a source of UXO hazard from other military activity not reflected on these maps.

If I have any questions, who do I contact?

tel: +44 (0) 1993 886682 **email:** uxo@zetica.com **web:** www.zeticauxo.com

The information in this UXB risk map is derived from a range of sources and should be used with the accompanying notes on our website.

Appendix B

Geotechnical Risk Register

Risk Matrix

Likelihood		Severity				
		1	2	3	4	5
		Minor	Moderate	Serious	Major	Catastrophic
1	Extremely unlikely	1	2	3	4	5
2	Unlikely	2	4	6	8	10
3	Likely	3	6	9	12	15
4	Extremely likely	4	8	12	16	20
5	Almost certain	5	10	15	20	25

Risk Classification and Required Actions

Risk Classification	
Low (1-8)	Ensure assumed control measures are maintained and reviewed as necessary.
Medium (9-19)	Additional control measures needed to reduce risk rating to a level that is equivalent to a test of “reasonably required” for
High (20-25)	Activity not permitted. Hazard to be avoided or risk to be reduced to tolerable level.

Geotechnical Risk Register

Risk No.	Hazard Description	Potential Consequences	Risk Before Control			Design Mitigation Measures to Manage the Risk	Risk After Control			Risk Owner
			S	L	R		S	L	R	
1	Uncertainty on ground conditions and properties - variable ground conditions.	Unexpected variation in ground conditions (e.g., soft spots leading to inadequate design or design change during construction). Total or differential settlements of foundation solutions in excess of structural limits.	5	4	20	Site specific GI is required for detailed design of the proposed development solution to determine the ground conditions on site.	5	1	5	Designer/ Principal Contractor
2	Variable rockhead depth and weathering	Unexpected variations in founding material resulting in variable settlement and potential structure instability.	5	3	15	Site specific GI is required for detailed design of the proposed development solution to determine the ground conditions on site.	5	1	5	Designer/ Principal Contractor
3	Natural voids within the rockhead	Reduction in bearing capacity of the underlying rock and sudden settlement in the event of void collapse.	5	3	15	Site specific GI is required for detailed design of the proposed development solution to determine the ground conditions on site.	5	1	5	Designer/ Principal Contractor
4	High groundwater / Flooding	May adversely affect the formation's bearing capacity, potentially resulting in structure failure. Temporary excavations may be flooded.	4	4	16	Site specific GI is required for detailed design of the proposed development solution to determine the groundwater level on site. A flood risk assessment which is part of the project should ascertain a flood level.	4	2	8	Designer/ Principal Contractor
5	Peat	Presence would adversely affect the formation's bearing capacity, potentially resulting in structure failure. Total or differential settlements of foundation solutions in excess of structural limits.	4	3	12	Site specific GI is required for detailed design of the proposed development solution to determine the extent of peat on site. Excavating out and replacing with compacted backfill is recommended.	4	1	4	Designer/ Principal Contractor

Risk No.	Hazard Description	Potential Consequences	Risk Before Control			Design Mitigation Measures to Manage the Risk	Risk After Control			Risk Owner
			S	L	R		S	L	R	
6	Soft Ground	Would adversely affect the formation's bearing capacity, potentially resulting in structure failure. Total or differential settlements of foundation solutions in excess of structural limits. Issues with trafficability of plant across the site area.	4	4	16	Site specific GI is required for detailed design of the proposed development solution to determine the properties of the alluvium on site. Site walkover to help determine ground surface conditions.	4	1	4	Designer/ Principal Contractor
7	Landfill	May adversely affect the formation's bearing capacity, potentially resulting in structure failure. Total or differential settlements of foundation solutions in excess of structural limits. Contamination risk to the environment and construction workers if disturbed or removed.	5	4	20	Geo-environmental team should be consulted on this. Site specific GI is required for detailed design of the proposed development solution to determine the extent, properties and contamination risk of the landfill on site. Ground investigation team to have adequate protection from contamination during site work.	5	2	10	Designer/ Principal Contractor

Note: S – Severity, L – Likelihood, R - Risk

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