ARUP

Technical Note

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cc	Dŵr Cymru Welsh Water
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Subject	Geotechnical Desk Study & Contaminated Land Preliminary Risk Assessment

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1. Project Background

Arup have been commissioned by Dŵr Cymru Welsh Water to undertake the RIBA Stage 2 design services for the re-development of the Elan Valley Visitor Centre (the site). The works to the existing building include a new reception and retail space; multimedia experience and exhibition; and café and kitchen extension. Furthermore, works to the exterior of the building include sustainable drainage, landscaping and pubic realm improvements.

Arup's Ground Engineering Team have been asked to prepare a desk study which includes a review of published information relating to ground conditions and ground risk, and the preparation of a conceptual site model and a contaminated land Preliminary Risk Assessment (PRA). A Groundsure report was obtained to help inform this desk study [1].

2. Site Layout

The existing visitors centre is centred on National Grid Reference SN 92810 64627. The site currently comprises connected one and two story buildings with adjacent hardstanding car parks, play parks and grassed areas. The site is situated downstream of Caban Coch Reservoir ~380m to the west. Within the vicinity of the proposed development, the site sits at ~215m OD. The site's topography rises sharply to the north towards the B4518 which sits at ~245m OD. This slope reflects the naturally dipping bedrock mapped in this area; however, western parts of the slope are steeper due to historically stockpiled material thought to have been placed during construction of Caban Coch Dam. The site is bounded to the south by the River Elan, flows of which are controlled by Caban Coch Dam.

Figure 1: Site layout.

3. Site History

The site's history is dominated by its role during the construction of Caban Coch Dam. The former sloped, rough riverbank (shown in Photograph 1 appears to have been reclaimed to form a plateau to facilitate buildings for the dam's construction (see Photograph 2), and subsequent redevelopment in to a visitor centre. A summary of the site's history is presented in Table 1.

Note enquiries were made to obtain historical records associated with the original dam construction and redevelopment of the visitor's centre building, but at the time of writing of this report no relevant information had been obtained.

Table 1: Summary of site history.

Date	Source	Observations
1887	County Series OS Map (1:10,000 Scale)	No clear and obvious features. Map shows site prior to construction of Caban Coch Dam. Two footpaths shown intersecting the current location of the visitor centre with a bridge over the Elan River to the south. Existing ground surface at the time interpreted as "rough pasture" from historical OS characteristic sheets.
1889	County Series OS Map (1:2,500 Scale)	No significant changes.

Date	Source	Observations
1894-1895	Historical Photographs [2]	 **Photograph 1: Photograph showing early stage of the construction of Caban Coch Dam. Historical ground profile shown in foreground [2].**
1902-1904	Historical Photographs [2]	 **Photograph 2: Auxiliary buildings at Caban Coch [2].**
1905	County Series OS Map (1:10,000 Scale, and 1:2,500 Scale)	Footpaths and bridges no longer shown. New suspension bridge annotated to the north-east. Caban Coch Dam annotated as "in course of construction". Quarry annotated to the west. Current stockpile plateau shown to the north-west. "Tanks" annotated to the north of the site along the current alignment of the B4518. Buildings from Photograph 2 not shown on OS

Date	Source	Observations
		map. Plateau appears to have been created beneath and surrounding current location of the visitor centre.
1948	County Series OS Map (1:10,000 Scale)	Two separate buildings shown within footprint of current visitor centre. Completed construction of Caban Coch Dam. "Bronze axe heads" annotated, probably relating to the Caban Coch hoard discovered 1895 (dating from ~2000-700BC) [3]. Two small buildings shown to the north-east.
1948	County Series OS Map (1:10,000 Scale)	No significant change.
1980-1981	National Grid OS Map (1:10,000 Scale)	Extension of southern building shown on 1948 map. Weir annotated adjacent to site spanning the River Elan. Additional small building shown to the north-east. Footpath from B4518 to the site annotated.
2001	National Grid OS Map (1:10,000 Scale)	"Visitor Centre" annotated for the first time. Multiple buildings within site boundary shown as one building. Access roads and roundabouts shown.
2010	National Grid OS Map (1:10,000 Scale)	Extension of visitor centre to the south and additional access roads.
2024	National Grid OS Map (1:10,000 Scale)	No significant change.

4. Ground Conditions

The BGS published geology of the site shows the bedrock geology underlying the site to comprise the Caban Conglomerate Formation (see Figure 2). This comprises interbedded Mudstone and Sandstone [4]. Two faults are mapped bounding the site striking north-west to south-east with the nearest recorded dip measurement recorded ~350m west of the site showing a 28° dip to the east (see Figure 3) [5].

No natural Superficial Deposits are mapped under the site, with the nearest natural deposits mapped ~180m downstream (east) comprising Alluvium (clay, silt, sand and gravel). Photograph 1 shows the natural ground profile before the riverbank was reclaimed for the construction of Caban Coch Dam. The ground surface appears to comprise large boulders likely originating from weathered Caban Conglomerate rock. The plateau of land that contains the site is there for expected to comprise predominantly Made Ground. The source of this material to form the plateau is unknown. The material is also the main potential source of contamination for the site as the material may contain waste materials associated with the dam's construction.

Groundwater is anticipated to be in continuity with the Elan River. The site sufficiently downstream for groundwater not to be affected by the reservoir.

Figure 4 shows a conceptual cross section of the site, from north to south through the visitor's centre building.

It should be noted that during construction of a new gravel car park ~100m to the east, it has been anecdotally noted that bedrock was encountered at shallow depth. This is also anticipated within the site boundary.

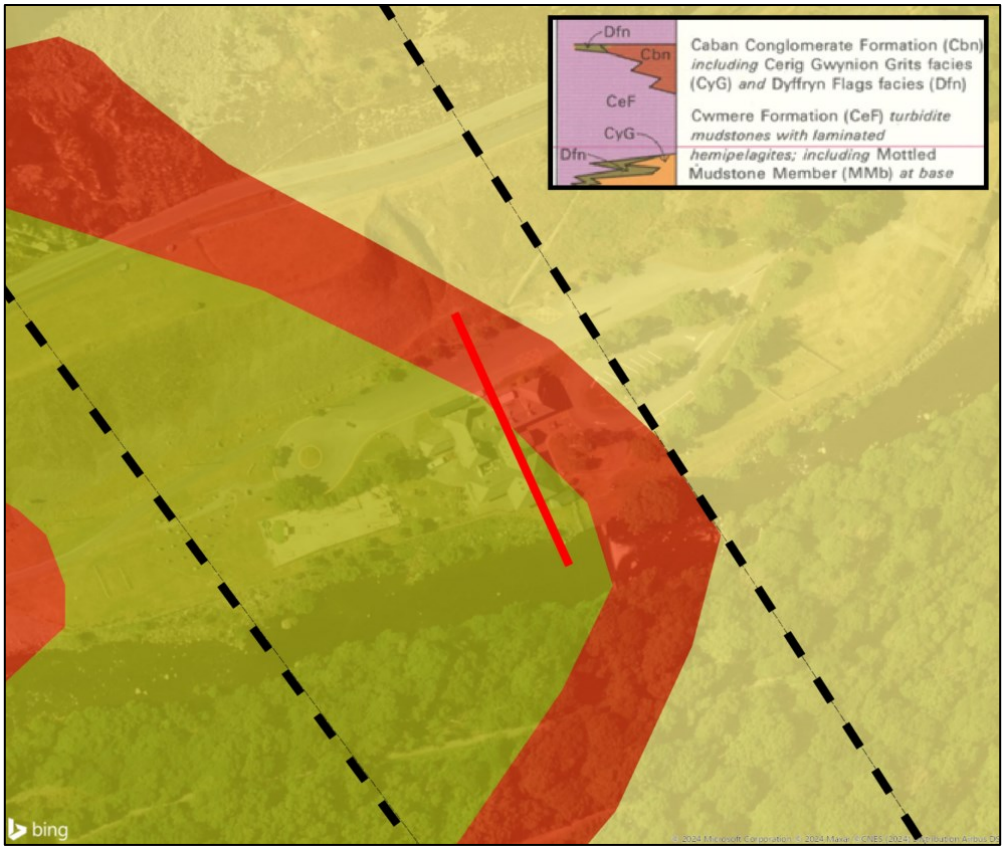

Figure 2: Extract from BGS GeoIndex [6] and 1:50,000 scale bedrock geology map [4].

Figure 3: Extract from 1:10,000 scale geology map [5]. Narest recorded dip measurement circled in red.

5. Existing Structure and Foundations

Given the size of existing buildings and the anticipated ground conditions beneath the site, the existing structure is anticipated to sit on shallow pad/strip foundations ~1m BGL. The depth and formation of hard standing across the site is also anticipated to be ~1m thick. No drawings of the existing structure have been provided for review at this stage.

6. Land Designations and Protected Zones

A Groundsure Enviro+Geo Insight report [1] was purchased as part of this study which collates information relating to potential ground engineering related risk to the site.

The bedrock underlying the site is designated as a Secondary B aquifer with medium vulnerability. The designation of the superficial aquifer underlying the site is unknown.

Natural Resources Wales maps the site to encroach on an area of high risk to flooding from the River Elan. However, given the sites location a short distance downstream of Caban Coch Dam, the control of flows from the reservoir are likely to significantly affect the flood risk at the site. Data from Ambiental Risk Analytics shows a localised area to the north-east corner of the site that is at risk to surface water ponding and flooding.

The site is surrounded to the north and south by Sites of Specific Scientific Interest (SSSI's) and Special Protection areas. The south of the site and Elan River is bounded by Ancient Semi Natural Woodland.

7. Preliminary Geo-Environmental Assessment

In line with the Environment Agency's (also adopted by Natural Resources Wales) Land Contamination Risk Management (LCRM) Stage 1 Risk Assessment [7], the first stage of risk

assessment must always start with a Preliminary Risk Assessment (PRA). LCRM details the steps that are necessary in order to complete a PRA, which include defining the overall site objectives (i.e. the site development proposals) and development of an initial Conceptual Site Model (CSM).

This section of the report follows the necessary steps required in line with Stage 1 of LCRM, to establish whether there are any potentially unacceptable risks posed by land contamination as part of this development.

7.1 Conceptual Site Model (CSM)

A Conceptual Site Model (CSM) describes the scenario in which the risks to human health and the environment posed by contaminated land are assessed. It describes the ground and surface conditions and considers the proposed development. In particular, the model identifies and describes the sources of the potential contamination, the behaviour of the contamination in environmental media such as soil and groundwater, surface water and air. It also identifies and characterises potential human health and environmental receptors, and plausible pathways.

The potential risks to human health and the environment have been considered in the context of a conceptual source-pathway-receptor model of the site, identifying:

- The principal pollutant hazards associated with the site (the sources);
- The principal receptors at risk from the identified hazards; and
- The existence, or absence, of plausible pathways which may exist between the identified hazards and receptor.

For risks to be present at the site, all three elements (source-pathway-receptor) of a potential contaminant linkage (PCL) must be present. PCLs are described below.

The development proposals, as described in the Project Background section will comprise of a commercial development (Visitor Centre) with some potential for landscaped areas. The site's history and land use is dominated by the formation of a land plateau and construction of the building to facilitate the construction of the dam at the turn of the 19th century, and subsequent redevelopment in to a visitors centre in the 1980's.

The proposed development is likely to lie within the current footprint of the visitor centre. It is not anticipated that any deep foundation solution will be required. Only shallow foundation scenarios are covered as part of this Stage 1 Risk Assessment exercise. There is also potential for the development to utilise sustainable drainage (i.e., SUDS) which may permit infiltration into the ground.

7.1.1 Sources

The following potential sources of contamination have been identified as part of this desk study review.

- (S1) Made Ground: The material immediately underlying the site comprises Made Ground. The site is situated on an anthropogenic plateau constructed to facilitate the construction of Caban

Coch Dam. The source and nature of this material is unknown. Made Ground may contain contaminants such as asbestos, metals, general inorganic contaminants, and hydrocarbons.

7.1.2 Pathways

The potential pathways by which the identified receptors may be exposed to contamination because of the development proposals are likely to include:

- (P1) Ingestion and inhalation of soils or dust;
- (P2) Inhalation of vapour, and possible ground gas;
- (P3) Dermal contact with soils or groundwater;
- (P4) Leaching of contaminants from Made Ground and vertical migration into groundwater;
- (P5) Migration of contaminants in groundwater to surface water through horizontal migration;
- (P6) Preferential pathways created because of construction, for example, any service trenches;
- (P7) Direct contact between construction materials and services and contaminated soil/water.

7.1.3 Receptors

Potential receptors at the site include:

- (R1) Future site users (post development). This would include future users of the Visitor Centre;
- (R2) Future intrusive maintenance workers (post development);
- (R3) Construction workers;
- (R4) Site neighbours during construction (residential land use ~500m downstream, unlikely to be impacted);
- (R5) River Elan (adjacent to site);
- (R6) Secondary B bedrock aquifer (Caban Conglomerate Formation);
- (R7) Construction materials and building services.

7.1.4 Preliminary Risk Assessment (PRA)

A summary of the potential contaminant linkages (PCL), and qualitative assessment of risk in line with CIRIA C552 [8], is presented in Table 2.

Table 2: Summary of PCL and qualitative assessment of risk.

Potential Source	Potential Receptor	Possible Pathway	Probability	Consequence	Pre-Mitigation Risk	Proposed Mitigation / Comment
S1: Made Ground	R1: Future site users	P1: Ingestion and inhalation of soils or dust	Likely	Mild	**Moderate/Low**	S1 may contain asbestos. Soils may become exposed if landscaping cover is minimal (subject to erosion over time)/poorly maintained. In this case, the probability of P1 and P3 is likely in relation to R1, with a mild consequence. In areas of the site covered by building/hardstanding P1 and P3 would not be plausible. Risk driven by landscaped areas. S1 is unlikely to have a significant gas generation potential, therefore very low risk (same consequence assumed). It is recommended that intrusive investigation is undertaken to provide further clarity on the nature of the Made Ground, which should include: - Soils testing to confirm the contaminative properties (or lack of) of S1; - Assess the suitability of soils for use in potential landscaping (which is the risk-driver for 'Moderate/Low' risk designation in relation to P1 and P3).
		P2: Inhalation of vapour, and possible ground gas	Unlikely	Mild	**Very low**	
		P3: Dermal contact with soils or groundwater	Likely	Mild	**Moderate/Low**	
	R2: Future intrusive maintenance workers	P1: Ingestion and inhalation of soils or dust	Low likelihood	Mild	**Low**	The frequency of in-ground maintenance works post completion of the scheme is low, and therefore the probability associated with the identified pathways is of a low likelihood. Mild consequence assumed. There will be a requirement to undertake intrusive investigation (as described above), for the purpose of chemical testing and additional risk assessment for end use receptors. The findings of those risk assessments will determine whether there is the requirement for any remediation/control measures to be implemented at the site. Under the Construction Design Management (CDM) regulations, there is a requirement to document any issues relating to land contamination in the site Health & Safety File. It is then the responsibility of the organisation undertaking site maintenance works to provide adequate provisions (e.g. Personal Protective Equipment) to those undertaking these works, to ensure that any risks from land contamination are managed appropriately.
		P2: Inhalation of vapour, and possible ground gas	Low likelihood	Mild	**Low**	
		P3: Dermal contact with soils or groundwater	Low likelihood	Mild	**Low**	
	R3: Construction workers	P1: Ingestion and inhalation of soils or dust	Likely	Mild	**Moderate/Low**	Construction workers will be in direct contact (P1 and P3) with S1 during construction works, for example, excavations required to achieve the appropriate formation levels. S1 may contain contaminants such as asbestos, metals, general inorganics, and hydrocarbons. Intrusive investigation is required to be undertaken including soils testing to confirm levels of contamination present in Made Ground, and to advise on any mitigation measures required to reduce risks posed by P1 and P3. In relation to P2, construction workers will not manually enter confined trench spaces, and most works will be undertaken via mechanical means, meaning that there are few scenarios where gases (originating from the ground) can accumulate and present a risk. Gas generation and vapour potential from soil is low.
		P2: Inhalation of vapour, and possible ground gas	Low likelihood	Mild	**Low**	
		P3: Dermal contact with soils or groundwater	Likely	Mild	**Moderate/Low**	
	R4: Site neighbours (residential land use ~500m downstream)	P1: Ingestion and inhalation of soils or dust	Unlikely	Mild	**Very low**	Given the proximity of this receptor and the small-scale nature of the works, very low risk assumed.
	R5: River Elan	P5: Migration of contaminants in groundwater to surface water through horizontal migration	Low likelihood	Medium	**Moderate/Low**	Potential for leaching of contaminants into groundwater through disturbing Made Ground, flow of groundwater to the River Elan is not anticipated to be significant based on Secondary B status. Leachate testing of the source to be undertaken (i.e. S1) to understand risks.
	R6: Secondary B bedrock aquifer	P4: Leaching of contaminants from Made Ground and vertical migration into groundwater	Low likelihood	Mild	**Low**	The majority of the site is currently occupied by hardstanding at surface, with limited opportunity for infiltration. Our understanding of groundwater levels at the site is largely unknown, although the current evidence indicates that it may be relatively shallow (ground investigation to confirm this). For the proposed development, it is likely that excavations for earthworks/foundations will remove some quantities of Made Ground (S1), and hardstanding/building cover will be reinstated. Low risk if S1 is re-used at surface in landscaping and therefore it is recommended that soil leachate sampling and testing is undertaken.
		P6: Preferential pathways	Low likelihood	Mild	**Low**	Preferential pathways may be created between Made Ground (S1) and the underlying Secondary B aquifers (R6). Testing of the source (S1) required to assess general contamination risks.
	R7: Building services	P7: Direct contact between construction materials and	Likely	Medium	**Moderate**	BRE Special Digest 1 (2005) testing of soils will be required, and subsequent assessment, to ensure that an appropriate grade and specification of concrete is used as part of the design.

Potential Source	Potential Receptor	Possible Pathway	Probability	Consequence	Pre-Mitigation Risk	Proposed Mitigation / Comment
		services and contaminated soil/water				

8. Key Ground Risks and Preliminary Engineering Advice

8.1 Building foundations

Give the proposed works maintain the building as a one or two storey structure, foundations will be lightly loaded and therefore shallow concrete pad and strip foundations are anticipated to be suitable. Investigation is recommended to confirm the shallow ground conditions and formation parameters to inform foundation design.

The key challenge with the foundation design is likely to be at the interfaces with the historic structure, as the existing substructure arrangement is unknown. Investigation is recommended to confirm the geometry of the existing substructure, so new foundations can be sited accordingly, and consideration given to any eccentric loading depending on the location of the superstructure load paths.

There is a risk of obstructions at shallow depth and difficult digging conditions at the site. This is as a result of the potential for encountering underlying boulders (see Figure 4), shallow bedrock or inclusions within the Made Ground. Due to the two faults crossing the site (see Figure 2), there may also be step changes in rock head level and fracture-induced variations in rock structure, resulting in variation in ground conditions across the site. Ground investigation is recommended to better understand this risk.

8.2 Drainage and civils works

Sustainable drainage systems will be delivered as part of the scheme. The potential for infiltration will be dependent on the nature of the Made Ground soils and fracturing / weathering of the bedrock, both of which are unknown at this stage. Site infiltration / soakaway testing will be undertaken to inform the drainage system design, however, given discharge to the River Elan is likely to be the primarily method to discharge of water from the site the results of the infiltration testing are unlikely to significantly affect the drainage design.

Minor exterior resurfacing works are likely to be required as part of the scheme design, where pavement design will be dependent on the strength and stiffness properties of the subgrade. The subgrade will be within the Made Ground or bedrock. For areas of resurfacing works within the Made Ground, the properties have the potential to be variable across the site. Site CBR (California Bearing Ratio) testing is recommended for areas of resurfacing with subgrade in Made Ground to inform pavement design.

8.3 Land contamination

Made Ground is anticipated to underly most of the site and is a potential source of contamination. However, given the age of the original site development (turn of the 19th century) and the desk study has identified limited potential for subsequent contamination of the site soils, the risk associated with land contamination is considered to be low.

Geo-environmental testing of the Made Ground is recommended to inform the correct disposal/reuse of any arisings. Geo-environmental testing will also be undertaken to ensure any infiltration doe not result in the leaching of any contamination.

8.4 Ground investigation recommendations

A small-scale ground investigation is recommended to inform the scheme proposals and investigate potential ground risks. The ground investigation is anticipated to comprise a spread of machine and hand dug trial pits across the site which will also include the following:

- Soakaway testing within some of the trial pits to inform sustainable drainage design;
- Measurement of the geometry and form of existing building foundations;
- Obtaining soil samples for geotechnical classification to inform foundation design, pavement design and drainage infiltration;
- Obtaining soil samples for geo-environmental testing;
- In-situ CBR testing for pavement design;
- Investigate material excitability and variation in rockhead level across the site.

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DOCUMENT CHECKING

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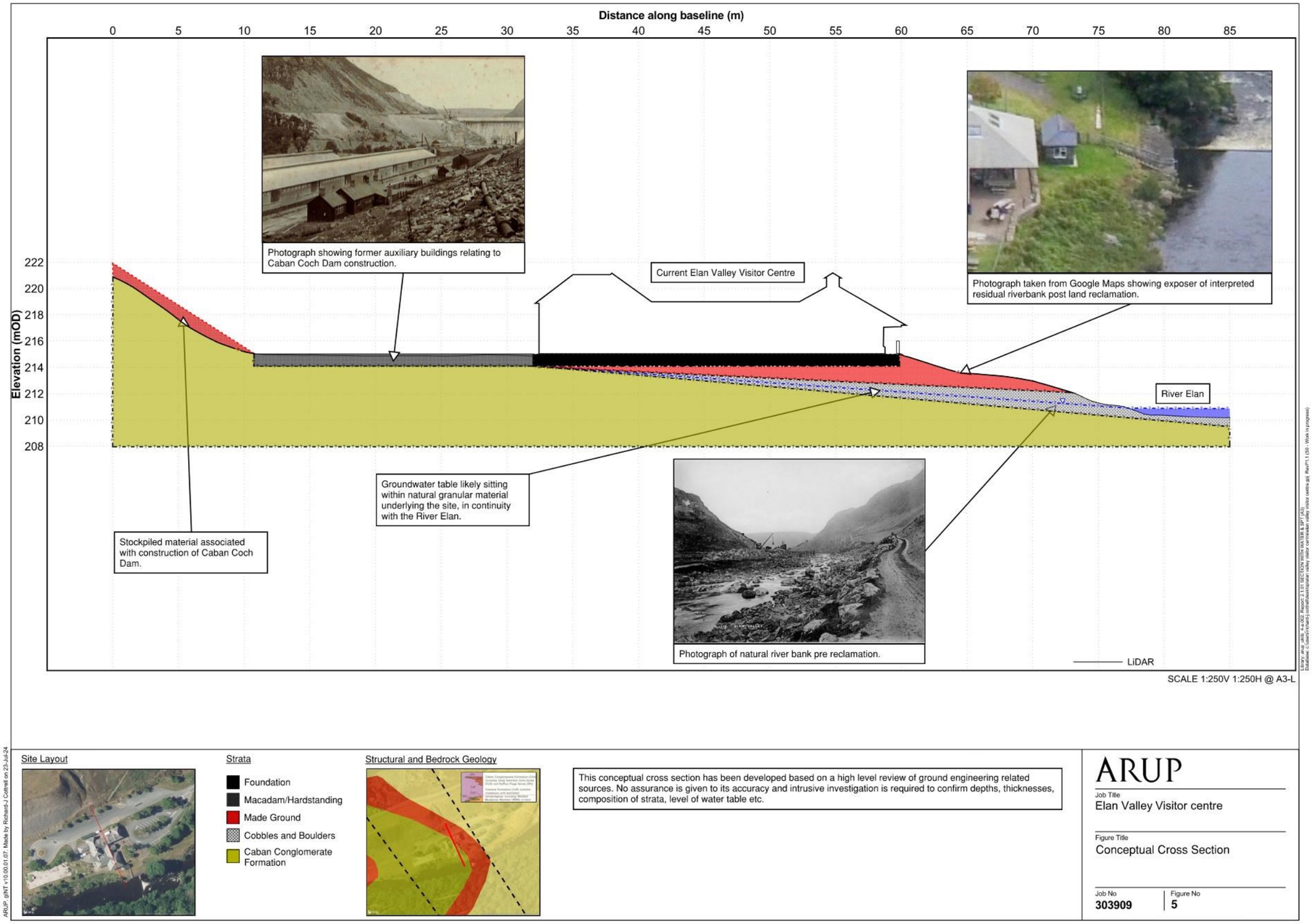

Figure 4: Conceptual Cross Section.