

8 GEOLOGY & GROUND CONDITIONS

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8 GEOLOGY AND GROUND CONDITIONS

8.1 Introduction

8.1.1 This Chapter presents the Geology and Ground Conditions Impact Assessment undertaken in accordance with IEMA guidelines and provides a description of the geology, ground conditions within, and also in the immediate vicinity of, the Development. The chapter provides details of the geological conditions and the presence of potentially contaminated land and hazardous materials. The effects of the Development on the ground conditions and of constraints posed by the existing ground conditions on the Development are considered for the construction, operational and decommissioning phases of the Development. Where appropriate, mitigation measures are presented to minimise the effects of actual or predicted adverse effects.

Summary of 2012 Environmental Statement Chapter

8.1.2 The chapter set out the baseline conditions including an appraisal of regional and site specific geology and ground conditions. Approximately 690,000m³ of surplus material was assumed to be generated from the re-profiling of Q1. This material would be deposited in the spoil mounds to the south west of Q1. Approximately 225,000m³ of surplus material would be generated from the proposed tunnelling and works around Q6 and Q8; this material would be utilised in the Q6 dam.

8.1.3 Whilst there was no evidence for the presence of significantly contaminated ground within the Order Limits, because of the history of the area, the potential for ground contamination, in particular the presence of munitions, could not be discounted.

8.1.4 Potential impacts on ground conditions and geology were associated principally with the construction phase of the approved scheme. Potential

impacts on the hydrogeological conditions were considered in Chapter 9 Water Resources of the 2012 ES.

- 8.1.5 Overall, it was concluded that there would be no significant effects of the approved scheme relating to ground conditions or geology.

Scope of 2015 Environmental Statement Chapter

- 8.1.6 This Chapter has been updated to include additional information relating to the changes to the Order Limits and the Development with respect to ground conditions and also to include the details of a preliminary intrusive ground investigation, designed to clarify the geological, geotechnical and hydrogeological conditions across the Development. The Chapter has been updated also to consider the findings of a UXO survey of the Development area carried out by Zetica in February 2015, and then updated in May 2015.
- 8.1.7 The original Construction Environmental Management Plan (CEMP) has been replaced by a Code of Construction Practice (CoCP) which will be implemented for the appropriate management of any contaminated ground. In addition, an Ordnance Management Strategy will be developed in consultation with the HSE for the management of potentially unexploded ordnance (UXO) discovered in and around Q6 and Q8 during construction works.
- 8.1.8 This chapter has now also been updated in line with the additional mapping and site investigation works to inform the design of the Development. This includes the movement of excess slate from Q6 to Q1 to form the excess slate mounds at Q1.
- 8.1.9 Geotechnical information from the preliminary GI works, which was completed in August 2015, will follow as part of the pre-examination period. Geo-environmental information from groundwater monitoring is provided in Chapter 9 Water Resources. An assessment of the results of the ground investigation will be provided to NRW and Gwynedd Council during the pre-examination phase of the DCO.

8.2 Scope of Assessment

8.2.1 The assessment has considered the geology and the ground conditions of the Development and surrounding area, based on published and other publicly available information and observations made during a site visit in February 2012. The data has been used to undertake a detailed assessment of the existing conditions on, and in the immediate vicinity of, the site. The existing conditions form the baseline against which the assessment of effects has been determined.

8.2.2 The principal objectives of this chapter are to identify:

- Geological factors which might affect the technical viability of the Development and any associated effects on the adjacent area;
- Effects that the Development may have on the geology and ground conditions and any interactions with contaminated land during construction, operation and decommissioning;
- Constraints that these features may place on the Development; and,
- Mitigation measures which may be required to minimise any adverse effects of or on the Development.

8.3 Sources of Information

8.3.1 The following sources of information have been used in the assessment of the geology and ground conditions and a review of the presence of contaminated land:

- British Geological Survey (BGS) 1:50,000 scale map, Sheet 106 Bangor;
- BGS 1:10,000 scale map SH56SE;
- BGS borehole logs;
- Strata Surveys Limited, Ground Investigation Report No. 14566, entitled 'Glyn Rhonwy, Llanberis' dated April 2009;
- Historical Ordnance Survey plans of the area;

- Eryri Consultancy report, entitled 'Glyn Rhonwy Pumped Storage Hydroelectric Facility: Preliminary Pollution Risk Assessment' dated July 2011;
- A report of a hydrogeological site walkover investigation by AECOM, dated February 2012;
- Zetica report, reference P3300-12-R1-B, entitled 'Sitesafe UXO desk study, Glyn Rhonwy, Llanberis, Gwynedd' dated February 2015 and updated May 2015; and
- Zetica report, reference P3300-12, entitled 'Sitesafe UXO Desk Study, Cefn Du, Llanberis, Gwynedd' dated 27th May 2015.

8.3.2 In order to confirm the geological, geotechnical and hydro-geological conditions on and around quarries Q1 and Q6, a preliminary ground investigation was designed. The preliminary ground investigation commenced in April 2015. Based on the findings of the preliminary investigation, further ground investigations will be carried out at the detailed design stage by the Principal Contractor.

8.4 Legislation and Policy Framework

National Policy Statements

8.4.1 National Policy Statements (NPS) for energy infrastructure were designated under the Planning Act 2008. For the Development, the relevant statements are the Overarching NPS for Energy (EN-1) published by The Department for Energy and Climate Change (DECC) in July 2011.

8.4.2 The section in the Overarching NPS for Energy (EN-1) relevant to the ground conditions assessment is:

- Section 4.10: Pollution control and other environmental regulatory regimes,

8.4.3 Section 2.22 of EN-4 on Water Quality and Resources will apply to the new penstock, but only where this relates to groundwater.

8.4.4 There are no sections relevant to the ground conditions assessment in EN-5.

National Legislation and Guidance

8.4.5 Key national policies in respect of geology and contaminated land considered in this assessment include:

- Environmental Damage (Prevention and Remediation) Regulations, 2009;
- Environmental Protection Act 1990; and
- Environment Agency CLR11: Model Procedures for the Management of Land Contamination, 2004.

Regional Policy

8.4.6 Planning Policy Wales (PPW) contains the following policies which are considered in this assessment:

- 12.5 – Planning to reduce and manage waste;
- 12.6 – Development plans and waste planning;
- 12.7 – Development control and waste planning;
- 13.5 – Dealing with unstable and contaminated land;
- 13.6 – Development plans and contaminated land;
- 13.7 – Development control and contaminated land;
- 13.8 – Development plans and unstable land; and
- 13.9 – Development control and unstable land.

Local Policy

8.4.7 The only local policy of direct relevance to this chapter is contained within the Gwynedd Unitary Development Plan 2001-2016. Policy B30 of the Plan refers to Contaminated Land, stating that:

“Proposals to develop or reclaim contaminated or potentially contaminated land or buildings in a manner that takes land or buildings from a negative value to a positive value to the environment will be refused unless all the following criteria can be met:

- *A detailed report on research into the site (including a risk assessment) is submitted with the planning application in order to establish the nature and extent of any contamination;*
- *(where there is evidence of contamination) a strategy, consistent with good practice, for removing, reducing or treating the contamination is included with the planning application; and*
- *that the threat of contamination will not continue following treatment of the site. When a development is approved planning conditions or agreements will be used to ensure that the necessary reclamation and monitoring measures are implemented, in accordance with details submitted as part of the planning application.”*

8.5 Consultation

- 8.5.1 For the approved scheme, a Scoping Report was submitted to Gwynedd Council in November 2011, which included the proposed methodology for assessing potential effects on geology and ground conditions including contaminated land. Responses to the Scoping Report were obtained from both Gwynedd Council and from the Environment Agency Wales (EAW) (now NRW) and can be found in Volume 3, Appendix 2.1.
- 8.5.2 The response from EAW included a comment that “*contamination during construction and operation phase should be included in the EIA*”. The response from Gwynedd Council did not include any comments in respect of geology or contaminated land issues.
- 8.5.3 Subsequent meetings were held with EAW and Gwynedd Council to discuss their responses to the Scoping Report for the 2012 ES in more detail and to agree an approach for the assessment of the ground conditions in the EIA.
- 8.5.4 In response to the Scoping letter submitted on the 12th November 2014, NRW provided no comment to the scope of the Ground Conditions chapter in their response dated the 16th December 2014.
- 8.5.5 The Secretary of State’s Scoping Opinion identified several issues in respect of ground conditions which needed to be addressed in the final ES.

These included an assessment of the suitability of the slate waste for use in the dam construction; clarification of the possible presence of hazardous materials on the site and, if present, how these will be managed; and the need for further information on the ground and groundwater conditions.

- 8.5.6 NRW were provided with a preliminary GI works specific Construction Environmental Management Plan with details of the proposed works on the 26th February 2015. Their comments, which were received on the 6th March 2015, required clarification on the use of bentonite and requested details of the Environmental Clerk of Works and site contractor. This was subsequently amended and approved.
- 8.5.7 The UXO report (February 2015) was submitted to NRW for comment on the 26th March 2015, in advance of a meeting held on the 30th March. In their email response dated 23rd April 2015, NRW welcomed the report but advised that commenting upon the adequacy or appropriateness of the search of UXO was not within their remit, but that it was within the remit of the Health and Safety Executive (HSE). NRW advised that any material to be reused as part of the Development, once screened for ordnance, should be tested for suitability and managed within the framework of an approved Materials Management Plan (MMP).
- 8.5.8 Gwynedd Council responded on the 29th June 2015 who confirmed that as long as the recommendations in Sections 9.1 and 9.2 of the UXO report (February 2015) were followed in regard to future ground investigations and works, then there would be no objection. In addition any further investigations would have to assess the contamination risk of the chemical residues left behind from the past disposal of the activities of ordnance at the site.
- 8.5.9 The HSE was consulted as part of the Section 42 consultation period, but provided no response on the issue of UXO.
- 8.5.10 Throughout the meetings with NRW, advice has been provided on the scope of the monitoring undertaken for the preliminary GI works. It is proposed to provide the full results during the pre-examination period.

8.6 Methodology

Desk Study

8.6.1 A desk study of the geology and contaminated land aspects of the site and surrounding area has been carried out using a combination of published and other publicly available information; discussions with NRW; and site observations. The following sections of this chapter have been divided to consider separately the geological conditions and the presence of contaminated land.

Site Walkover

8.6.2 A site walkover was carried out on 2nd February 2012 to observe the geological, hydrogeological and surface water features on and in the vicinity of the approved scheme boundary. A copy of the report of the walkover investigation is provided in Volume 3, Appendix 8.1.

Impact Assessment Methodology

8.6.3 The methodology adopted to assess the potential effects of the Development on geology and contaminated land was based on the current best practice of using the source-pathway-receptor model. For there to be an identifiable risk, not only must there be contaminants present on the site (source - i.e. contaminated ground, leachate or landfill gas) but also there must be a receptor (people, habitats and species or water bodies) and a pathway which allows the source to reach the receptor (examples of pathways include direct contact, flow through air, or water via fractures, adits, and permeable sediments and rocks). All three elements must be present to form a potential contaminant linkage before an impact can occur. The potential effects of the construction, operation and decommissioning of the Development on soils and geology have been determined by a qualitative assessment of this form.

8.6.4 The significance of potential effects associated with contaminated land has been assessed based broadly on guidelines in CIRIA document 552 'Contaminated Land Risk Assessment, A Guide to Good Practice' (2001).

In assessing the significance of the potential effects of the Development, three key factors were considered:

- The probability of an effect being realised;
- The sensitivity and/or importance of the receiving environment; and
- The potential magnitude of any effect.

Significance Criteria

8.6.5 The general methodology for assessing effects using sensitivity and magnitude, which is outlined in Section 2.4 of Chapter 2 Approach to EIA, is being followed in relation to this impact assessment; no topic specific criteria are considered necessary.

8.7 Baseline Conditions

Regional Geology

8.7.1 The Development is located in an area of largely Cambrian rocks of the Comley Series. The quarries are located principally within the Llanberis Slates Formation, predominantly consisting of purple and green mudstones and siltstones with sandstone bands. The Llanberis Slates are underlain by siltstone, sandstone and conglomerate of the Fachwen Formation. The Llanberis Slates are overlain by turbiditic sandstones of the Bronllwyd Grit Formation. Table 8-1 provides a summary of the regional geology.

Table 8-1 Regional Geology			
Age	Formation	Thickness (m)	Lithology
Recent	Head	Variable, often absent	Poorly-sorted, gravelly clay
Tertiary	Dolerite dykes	N/A	Fine to medium grained igneous intrusive rocks.
Cambrian	Bronllwyd Grit Formation	400	Medium to coarse turbiditic sandstone
	Llanberis Slates Formation	860	Purple, green and grey siltstone and mudstone with sandstone bands
	Fachwen Formation	480	Sandstone and conglomerate with

Table 8-1 Regional Geology			
Age	Formation	Thickness (m)	Lithology
			interbedded siltstone, tuffs and sandstone.
	Padarn Tuff Formation	More than 460	Acidic ash-flow tuff

- 8.7.2 The Llanberis Slates form a narrow outcrop, between approximately 750m and 900m wide, running roughly south west to north east through the Development and is the rock formerly worked in the quarries. The older Fachwen and the Padarn Tuff Formations are located to the north west. The younger Bronllwyd Grit is located to the south east.
- 8.7.3 The bedrock is extensively folded and faulted. Faulting is shown within the site and in the immediate vicinity, particularly to the north west. The faults generally trend north east to south west. The BGS 1:50,000 map shows that the strata dip at an angle of approximately 40° to the south east. A copy of the BGS 1:50,000 scale geology map is provided in Volume 4, Figure 8.1.
- 8.7.4 The Cambrian strata locally are cut by a series of dolerite dykes, which are interpreted as Tertiary age. These comprise fine to medium grained, green dolerite. The dykes run in a general north west to south east direction.
- 8.7.5 It is concluded that the geological conditions in the area and in the Development are of **low** sensitivity.
- 8.7.6 Superficial deposits are largely absent and there are extensive outcrops of the bedrock across the area. Head deposits are mapped to the north west on the Padarn Tuff Formation. The head deposits consist mainly of poorly sorted deposits of gravelly clay with sand and gravel and lenses of peat and silt formed by solifluction and soil creep processes.

Site Specific Geology and Ground Conditions

- 8.7.7 A review of the BGS borehole archive has identified four boreholes and one trial pit within the Glyn Rhonwy quarry complex, together with a number of

trial pits in the area excavated for Gwynedd Council and the Welsh Development Agency (WDA) in the vicinity of Q6 and Q8.

- 8.7.8 Copies of the borehole and trial pit logs within the quarries are provided in Volume 3, Appendix 8.2. The boreholes vary in depth between 10m and 11.5m and typically show a sequence of quarry waste (slate) over purple slate.
- 8.7.9 Information on the ground conditions in the area developed by Gwynedd Council adjacent to Q6 and Q8 is contained in the Strata Surveys report of April 2009. A total of 20 trial pits were excavated on the development platform to depths between 0.5m and 2.5m. All the trial pits proved a surface layer of made ground or fill, consisting mainly of purple slate, up to very large boulder size. Demolition rubble was present in trial pit TP2-2 to 2.5m depth. In trial pit TP4-2, a concrete slab at 1.2m depth prevented further progress. Water was struck in only one trial pit (TP5-4) at a depth of 0.7m.
- 8.7.10 Limited geochemical testing of nine samples of the made ground or fill showed no evidence of significant contamination.
- 8.7.11 The UXO reports (May 2015) provide detailed information on the use of the quarries on the site for the storage and decommissioning of ordnance and munitions. The reports indicate that munitions were stored and decommissioned in Q4, Q5, Q6, Q7 and Q8. There is no evidence that Q1, Q2 and Q3 or Q3a were used for the storage and decommissioning of munitions. Figures 8.2 and 8.3, adapted from the UXO report, show the ordnance disposal pits at the site. Details of the ordnance disposal activities carried out in the area are provided in Section 8.8.
- 8.7.12 Further information on the ground conditions, including the potential for the presence of contaminated ground and residual ordnance, is being gathered from a preliminary GI works, which commenced in April 2015 and was completed onsite in August 2015. The GI targeted the two quarries (Q1 and Q6) which form the principal elements of the Development, together with the route of the penstock and the route of the spillway from Q6 to Llyn Padarn. A plan showing the locations of the boreholes and trial pits is

provided in Figure 8.4. The findings of the ground investigation will be provided to NRW and to Gwynedd Council during the pre-examination phase.

8.7.13 An initial observation from the ground investigation is the identification of a small quantity of inert munitions scrap was found in the slate waste in Q6, namely anti-material rounds, practice bombs and marker mortars.

8.7.14 Across much of the Development, the bedrock is covered by extensive spoil heaps of slate, which mask the bedrock.

Q1 (Chwarel Fawr)

8.7.15 Q1 is bisected almost in half by a fault dipping at approximately 60-70° to the south east. The fault brings sandstone (quartzite) in the north west of the quarry against slate in the south east. The sandstone is highly fractured and has been benched to allow the quarry to be deepened to access the slate in the south eastern part of the quarry. The sandstone is present as areas of fractured and poor quality rock on the north western face of the quarry.

8.7.16 It is unclear whether the sandstone is the underlying Fachwen Formation or one of the sandstone bands within the Llanberis Slate Formation.

Q2 (Chwarel Cefn Du)

8.7.17 Q2 does not form part of the Development but is described here to provide geological context as it is partly within the Order Limits.

8.7.18 The major fault in Q1 appears to extend into Q2 and cuts the north western edge of the quarry. Consistent with the exposures in Q1, the fault brings sandstone to the northwest against slate in the southeast. The sandstone again appears to be poor quality being heavily fractured and blocky. Access to the quarry was not possible without rope access but it appears that the sandstone is intercepted by a dyke approximately half way along the quarry. The dyke trends north north west to south south east. The slate present in the majority of the quarry generally is competent, although there are parts of the quarry where the slate is more jointed producing a blocky appearance and areas of instability.

Q3, Q3a and Q4 (Cook and Ddol)

8.7.19 These quarries do not form part of the Development. Both quarries have been excavated for slate.

Q5 (known locally as Gideon / Filmset Quarry)

8.7.20 Q5 is included within the Order Limits as a precautionary measure but is not a direct part of the Development.

8.7.21 Q5 has been excavated entirely into the slate apart from a prominent greenish dolerite dyke which crosses the quarry in a north west to south east direction and largely has been retained in-situ during working of the quarry. There is evidence of failure of the dolerite dyke and also of the slate on the quarry walls.

Q6 (Glyn Rhonwy)

8.7.22 This is the only quarry within the Order Limits accessible by foot. The access from the north eastern wall of the quarry consists of slate spoil. The quarry is divided by a large buttress of unworked slate trending northwest to south east and which extends approximately 70% across the width of the quarry.

8.7.23 The quarry is excavated principally into slate. However, borehole SH56SE 18, located immediately east of the quarry, proved a 2.5m thick band of sandstone/quartzite at a depth of 8.0m overlying greyish-green and purple slate. There is evidence of numerous small scale faults on the south eastern face of the quarry. There also is evidence of major slope failure on the buttress and of general instability of the quarry faces.

Q8 (Former Munitions Store)

8.7.24 The former World War II munitions store is in quarry Q8 (Pit 1A) located to the north east of Q6. Q8 was used initially for the storage of munitions and subsequently for the burning and decommissioning of ordnance and munitions. There are no proposals to use the former munitions store for any element of the Development, although the proposed spillway from Q6 to Llyn Padarn would pass around the western and south eastern sides of the quarry.

Pit 1B/2B

8.7.25 The UXO report also refers to another quarry that was infilled as part of the MOD clearance works. This quarry is known as Pit 1B/2B and is located to the east of the north eastern corner of Q6. It is reported that this quarry contains only non-explosive scrap and was used as the disposal area for inert material from other quarries on the site. It is understood that clearance of the quarry was completed in 1975, following which the quarry was used for the disposal of domestic refuse and then backfilled with slate waste, covered and restored to ground level. There is a possibility that the footprint of the proposed dam around Q6 may include part of this former quarry. If the footprint of the proposed dam covers Pit 1B/2B, a ground investigation of the former quarry will be undertaken to confirm the ground conditions.

Slate waste

8.7.26 The Development area contains numerous stockpiles and slate spoil heaps. The largest of these are located on the north western side of the quarries, particularly between Q2 and Q4, although some are also present south west and west of Q1.

8.7.27 The spoil heaps are attributed to historical tipping of 'reject' slate. The faces of the spoil heaps and stockpiles are generally free of any major vegetation but have been colonised by scrub and lichens, and show previous evidence of instability through circular failures and slumping. No activities are proposed as part of the Development around the Q2 or Q4 slate waste stockpiles. The slate mounds to the south west of Q1 are likely to be incorporated in to the excess slate mounds shown in Figure 4.1.

Afon Gwyrfai a Llyn Cwellyn SSSI

8.7.28 The Afon Gwyrfai a Llyn Cwellyn SSSI covers the whole length of the Afon Gwyrfai to the west of the Development. Q1 is located in the catchment of the Afon Gwyrfai. The SSSI is designated partly on geological grounds. This is related to the presence on the shore of Llyn Cwellyn, of a small trial mineral working which proved fluorite mineralisation. As the location of the mineral working is upstream of the sub-catchment from Q1, it is concluded that the Development would have no potential to affect this geological

feature. A copy of the SSSI designation is presented in Volume 3, Appendix 7.1. The SSSI is considered to have a **high** sensitivity or value.

8.8 Historical Land Use

8.8.1 An assessment of the contaminated land issues associated with the Development has been based on a review of the following information:-

- historical Ordnance Survey (OS) plans of the area for the period 1889 to 2011;
- a Landmark Envirocheck report of the development;
- Eryri Consultancy report, entitled '*Glyn Rhonwy Pumped Storage Hydroelectric Facility: Preliminary Pollution Risk Assessment*' dated July 2011;
- Zetica report, reference P3300-12-R1-B, entitled 'Sitesafe UXO desk study, Glyn Rhonwy, Llanberis, Gwynedd' dated February and updated May 2015; and,
- Zetica report, reference P3300-12, entitled 'Sitesafe UXO Desk Study, Cefn Du, Llanberis, Gwynedd' dated 27th May 2015.

8.8.2 The land within the Order Limits was originally open agricultural land. The first OS maps, dated 1889, show that quarrying was already extensive in the area. It is understood that quarrying commenced around 1802 with more extensive workings from about 1840. In 1889 a railway link was constructed which connected the quarries to the Llanberis to Caernarfon railway line. It is understood that at this time there was a rapid expansion of the quarries, with slate being exported by both rail and sea. There is evidence of an extensive tunnel system, which appears to connect many of the quarries. It is considered likely that the tunnels were used for access, drainage and for the removal of slate to the lake and railhead. Copies of the historical OS plans are provided in Volume 3, Appendix 8.3. The quarry locations are shown in Volume 4, Figure 1.2. A timeline for the quarry system is included as Plate 4-1 in Chapter 4 Project Description.

- 8.8.3 By 1928 Chwarel Cefn Du (Q2) and Chwarel Fawr (Q1) had ceased operations. By 1930, the Glyn Rhonwy quarry (Q6) had also ceased to be worked.
- 8.8.4 In the early 1940s, the Royal Air Force utilised Q6 and Q8 for the storage of munitions. In 1943, works commenced to destroy the current store of munitions and additional munitions were continually brought to the site for disposal until approximately 1956. It is understood that subsequently munitions of various types have been handled, stored and destroyed at the site, including the German nerve agent Tabun. Tabun was only stored in the quarries before being transferred to RAF Llandwrog between August 1946 and July 1947 and subsequently dumped in the Irish Sea in 1955/1956. An independent Board of Inquiry in 1969 found that ‘...all German chemical weapons appeared to have been successfully removed from RAF Llanberis to RAF Llandwrog before being sea dumped.
- 8.8.5 In 1969, works commenced to remove all ordnance from the two quarries. These operations continued until approximately 1974, when it is confirmed by the Ministry of Defence (MOD) that the operation was complete, that the quarries were cleared and rendered safe (MOD letter of 3 December 1976; Volume 3, Appendix 8.4). It is understood that during the removal operations, water was pumped from Q6 to facilitate access to all parts of the quarry. Q6 was then allowed to refill naturally.
- 8.8.6 The UXO report (contained in Volume 3, Appendix 8.5) concluded that Q4, known as Pit 3C, was used for the storage and disposal of ordnance, including incendiary materials; magnesium slag and unburnt magnesium powder; live detonators and other explosives. It is reported that the quarry was cleared of ordnance between October 1971 and April 1972.
- 8.8.7 Q5, known as Pits 3A and 3B (Figure 8.3), was used for the storage and decommissioning of munitions. In the UXO report, it is stated that work to clear the quarry of ordnance commenced in January 1971 and the work was declared complete in November 1972. It is reported that the floor of the quarry was subsequently covered with approximately 1 m of slate waste and compacted.

- 8.8.8 Q6 was the main area used for the decommissioning of ordnance. The MOD records show that the quarry was divided into two areas. The first area is referred to as Pit 2A, and is the north eastern part of the quarry to the east of the rock buttress. There is no record of this area having contained any explosives. However, it is reported that there was a large crevice in the floor of Pit 2A, which could have been used for the burial of ordnance scrap, which potentially could contain explosives. There is also a risk of ordnance being buried within the slate waste in this area. An initial observation from the ground investigation is the identification of a small quantity of munitions (spent shells) in the slate waste in Q6.
- 8.8.9 The second area is referred to as Pit 2C and it is the currently-flooded part of Q6 to the south-west of the rock buttress. This area has been given a high UXO hazard rating, due principally to the likely presence of residual ordnance associated with a former 'bomb pile' on the south eastern side of the quarry floor. It is reported that this area was not completely cleared and that any untreated ordnance was buried under approximately 2m of slate waste on the floor of the quarry. It is understood that scrap 'inert' material was pushed into crevices in the floor of the quarry. There is a possibility that these 'inert' materials contain explosives.
- 8.8.10 The UXO report shows that at least three former quarries located to the south and outside of the DCO Order Limits also were used for ordnance decommissioning.
- 8.8.11 During the ground investigation works in 2015, a mortar tail fin was discovered in Q1. The UXO report on Cefn Du (Q1) (contained in Volume 3, Appendix 8.6) concluded there was no evidence that any prolonged military training activities took place in Q1. The presence of the mortar fin was attributed to an isolated incident or to subsequent importation from other parts of the site. It was concluded that while similar discoveries in Q1 cannot be totally discounted, the quarry does not present a significant UXO hazard.
- 8.8.12 In addition to the quarries used for the storage and decommissioning of munitions, there is a record of two former landfills within 1km of the

Development. Precise details of the landfills are uncertain and it is possible that the two sites are the same. One site is referred to as Ffridd y Glyn Quarry and is located approximately 300m south of the Development at NGR SH 56500 60300. This is a former slate quarry, which is reported to have been used for the disposal of industrial waste arising from the Bernard Wardle factory in Caernarfon.

8.8.13 The second landfill also was located in a former slate quarry at the site of the current Siemens factory (NGR SH 57000 60400), approximately 500m to the south east of the development. It is reported that this site also accepted waste from the Bernard Wardle factory together with municipal waste deposited in the 1950s. There is a record that in the early 1990s, the waste materials were to be removed from this site. However, no details have been provided to confirm whether and how the materials were managed and disposed. Both sites are located outside of the DCO Order Limits on the south eastern side of the Afon Glyn; and, on the opposite side of the valley to the Development.

Summary

8.8.14 Based on a review of the available information, it is concluded that there is no evidence of existing sources of significantly contaminated land within the Development.

8.8.15 Whilst there is correspondence to suggest that Q6 and the Former Munitions Store at Q8 were rendered safe, it is considered that there remains a significant risk of the presence of residual ordnance in both quarries. This has been confirmed from a preliminary review of the nature of the slate waste in Q6.

8.8.16 There is no evidence for extensive military operations in Q1 and it is considered that the quarry does not present a significant UXO hazard.

8.8.17 There currently is limited information on the detailed ground conditions across much of the Development. To clarify the geological, geotechnical and hydrogeological conditions across the Development and, in particular, in the vicinity of Q1 and Q6 and along the route of the penstock and tailraces, a preliminary ground investigation is being undertaken. The

ground investigation consists of the drilling of up to 19 inclined and vertical boreholes; 13 trial pits; 17 sampling pits; and, associated geotechnical testing and groundwater monitoring. Figure 8.4 shows the proposed locations of the boreholes and pits.

8.9 Potential Effects

Construction Phase

- 8.9.1 The main potential effects of the Development on geology and contaminated land would be associated with the construction phase, in which substantial re-profiling of Q1 and Q6 would be required and the turbine access shaft and the penstock between the two quarries would be formed through a combination of excavation and tunnelling.
- 8.9.2 In addition, a spillway would be constructed between Q6 and Llyn Padarn to provide a controlled overflow from Q6 and an abstraction point for water from Llyn Padarn. The spillway would run around the edge of Q8. A spillway also will run underground from Q1 to the nearby watercourse of Nant-y-Betws.
- 8.9.3 In Q1 it will be necessary to reprofile the sides of the quarry, in particular the northern, western and southern walls. Suitable material excavated from the quarry will be used to form the dam on the southern side of the quarry. There is no evidence that the material which would be excavated from Q1 is anything other than previously-excavated or in-situ natural materials with no potential for contamination.
- 8.9.4 The proposed design of the dam and the reprofiling of Q1 will result in the generation of approximately 160,000m³ of excess material although this may be less, dependent on ground conditions and the bulking factor. However the excess material is unlikely to be contaminated and therefore there is a **negligible** effect in relation to contaminated land at the Q1 site.
- 8.9.5 The potential reprofiling of Q6 northern wall could mean that the existing slate tip to the north would also have to be reprofiled and stabilised. This slate tip has been in existence for several decades and therefore could be expected to have reached its maximum stable condition, including its angle

of repose. The GI works to be undertaken by the PC will confirm the potential for Q6 wall profiling, if stabilisation works will be needed for the slate tip, and what method is appropriate for the scale of works. The proposed footprint of the Q6 dam may include part of the backfilled quarry Pit 1B/2B. An investigation will be carried out to assess whether any remedial measures are required to stabilise the backfilled quarry and allow placement of the Q6 dam.

- 8.9.6 The proposed tunnelling for the penstock, the construction of the spillway and the construction of the power house shafts, would result in the generation of approximately 650,000m³ of material at Q6. Mainly virgin material will be deposited in the Q6 dam and also form part of the quarry reprofiling. Other than at the north eastern end of the tunnel and at the surface entry points to the shafts, it is envisaged that the works would be formed within the undisturbed Llanberis Slates Formation. Accordingly, it is unlikely that any of the tunnel arisings would be contaminated and therefore redistribution of the excess material poses **negligible** effects.
- 8.9.7 Excess materials from Q6 of approximately 650,000m³ will be transferred by a conveyor within the penstock to Q1 for disposal. There is potential for this material to contain munitions and all the material will be screened before it is transferred to the conveyor.
- 8.9.8 It is concluded that the construction of the Q1 and Q6 reservoirs; their associated dams and spillways; the penstock; and, the construction of the power house would have **negligible** potential for environmental impacts from a geological and ground contamination viewpoint.
- 8.9.9 The historical use of Q6 and Q8 for ordnance storage and/or decommissioning has the potential to adversely affect the Development. There are no proposals to disturb Q8 other than through the construction of the spillway from Q6, which passes around the outside of Q8. The water in Q6 was drained to allow access for the removal of all munitions. Whilst it is recorded that the munitions were removed and decommissioned, there is a likelihood that some munitions remain in both quarries and that these may be disturbed by the works required to form the lower reservoir.

- 8.9.10 Once the quarry has been dewatered, a visual inspection of the quarry floor will be carried out. This will inform whether the floor will need grading to form a flat base for any lining which may or may not be required. Sediment testing has been undertaken in Q6 which yielded minimal sediment samples and therefore it is unlikely that any potential munitions are contained within the limited sediment on the quarry floor, but more likely in crevices. Any munitions discovered will be managed in accordance with an Ordnance Management Strategy developed in consultation with the HSE.
- 8.9.11 It is not feasible at this stage to carry out a detailed survey for the presence of munitions in Q6, as much of the quarry is currently flooded. There is evidence in the UXO report that munitions may be uncovered during the works in Q6 and around Q8. Therefore there is the potential for **moderate adverse** effects, principally on construction workers.
- 8.9.12 The only nationally important geological feature in the area is part of the Afon Gwyrfai a Llyn Cwellyn SSSI, located to the west of the development area. This is a small exposure of a trial fluorite mineral working. As the location is upstream of the Development, it is considered that the Development has no potential to affect the exposure.
- 8.9.13 Other than the possible presence of munitions in Q6 and Q8, the only other area of potentially contaminated ground in the vicinity of the Development is the closed landfill site at Ffridd y Glyn Quarry, which may have been remediated in the early 1990s. As the landfill is located on the opposite side of the Afon Glyn valley and as the DCO application area does not include any land on the south eastern side of the valley, it is concluded that the presence of possible contaminated ground at Ffridd y Glyn Quarry does not present a risk to the Development and therefore is considered to have a **negligible** effect on the Development.
- 8.9.14 Table 8-2 presents a summary of the impact assessment for the geological and contaminated land aspects during the construction phase of the Development.

Operational Phase

8.9.15 The construction phase of the Development will include appropriate measures to manage any long-term risks associated with any contaminated land identified during the installation of the Development, albeit the only real source of possible contamination is the dumped munitions potentially present in Q6. During the construction phase, all necessary monitoring and remediation will be approved by NRW and Gwynedd Council through DCO Requirement. As any contaminated land and hazardous materials (ordnance) will be treated and managed as part of the construction phase, they will therefore not pose any risk during operation and the potential for effects from existing contaminated land is therefore **negligible**.

8.9.16 It is considered that the operation of the Development would pose no unacceptable risk to the geological and ground conditions and that there is negligible potential for any ground contamination to result from the operational phase of the Development. In accordance with the Scoping Report, it is therefore concluded that geological and contaminated land issues can be excluded from the assessment of the effects of the operational phase of the Development.

Decommissioning Phase

8.9.17 Similarly, it is considered that there would be no potential for effects on geology or contaminated land as a result of decommissioning of the Development. It is considered that geological and contaminated land issues can be excluded from the assessment of the effects of decommissioning of the Development.

8.10 Mitigation, Compensation and Enhancement Measures

8.10.1 To manage any environmental effects, the Development would be constructed in accordance with the CoCP (Appendix 16.1), which would include measures identified as necessary to minimise potential environmental impacts of the Development. It is considered that the measures, which will be included within the CoCP, will be standard measures typically employed in major construction activities.

8.10.2 Up to total of 810,000m³ of excess material will be generated from the construction of the Development. Therefore to mitigate the impacts

associated with the management of this material, the excess material will be incorporated into existing spoil mounds to the south and south west of Q1 and landscaped appropriately. Approximately 650,000m³ will be transported via a conveyor in the underground penstock.

8.10.3 The potential reprofiling of the Q6 northern wall and the potential stabilisation works of the existing slate tip to the north will be confirmed following completion of the preliminary site investigation. The scale of the stabilisation works will depend on the amount of reprofiling needed to the northern wall of Q6. The stabilisation solution for the slate mound could involve a retaining wall and reprofiling of the slate mound. If stabilisation works are needed at the slate mound, the mitigation will be designed as required, minimising any potential adverse effects on safety of properties below the mounds to **negligible**.

8.10.4 There is no evidence of contaminated ground in Q1, and therefore works in this quarry could proceed without the need for mitigation measures. Impacts of these works on and the need for mitigation measures for water quality are considered in Chapter 9 Water Resources.

8.10.5 The historical use of Q6 and Q8 for the storage and decommissioning of munitions presents the potential for historical ground contamination. The UXO report provides information about the previous removal and remediation of the quarries within the Order Limits. There is evidence that isolated munitions remain, particularly in Q6. To provide adequate control from a health and safety viewpoint, should any munitions be discovered, an Ordnance Management Strategy will be developed in consultation with HSE. The strategy will be designed to safely manage any munitions and ordnance discovered during the preparation of Q6 and during the construction of the spillway around the edge of Q8 and may also contain, but not be limited to, the following:

- Mapped areas for the potential presence of UXO;
- Programme for removal;
- Storage areas for inert and live UXO;

- Disposal methods including those for removal or disposal of live UXO and the communication procedures to be follows, and chain of custody for inert / scrap finds;
 - Details of site presence by a qualified Ordnance specialist; and
 - Methodology for the sorting of any excess material to be excavated from Q6 and transported to Q1 via conveyor such as the use of magnetic screens and spotters to identify and mitigate any effects from the presence of munitions.
- 8.10.6 Other than in and around Q6 and Q8, there is no evidence for the presence of contaminated ground within the Order Limits. Analyses of water samples taken from Q6 and Q8 showed no evidence of significant contamination (please refer to Chapter 9 Water Resources for further details).
- 8.10.7 It is considered that the potential for contaminated ground within the Order Limits is limited, other than the potential for residual munitions. However, it is proposed that a Requirement will be included in the DCO designed to appropriately manage any areas of unexpected contaminated ground, should any be discovered during the construction of the Development, and therefore mitigate any significant effects.
- 8.10.8 All potential effects on ground conditions and geology would be addressed during the construction phase of the Development. The operation and decommissioning phases of the Development would have no effect on the ground conditions. Accordingly, it is considered that no mitigation measures would be required during the operational or decommissioning phases.
- 8.10.9 The comments from NRW suggest that occupation of the Development should not occur until it can be demonstrated that the site remediation criteria have been met. It is considered that this is not practical, as remedial measures, where required, will be carried out as part of the construction works. It is expected that the Development will be subject to relevant DCO Requirements to monitor and remediate any potential effects from contaminated land to controlled waters and human health.

8.10.10 Any other material, such as the slate excavated from reprofiling of the quarry walls, will be managed in line with an MMP (to be agreed by NRW and GC as part of the approval of the CoCP, within which it will be contained) and if necessary the Ordnance Management Strategy. If it proves necessary to remove or reprofiled material from the base of either Q1 or Q6, this will be carried out in Q6 in accordance with the Ordnance Management Strategy.

8.11 Residual Effects

Construction Phase

8.11.1 Table 8-2 demonstrates how the mitigation measures identified in Section 8.10 and secured in the CoCP will manage any potentially significant effects which have been identified for the construction works phase of the Development (presence of dumped munitions), and also identifies the likely significance of any residual effects following mitigation.

8.11.2 In addition, measures are included in the CoCP to manage any unexpected ground contamination should it be identified during the construction works.

8.11.3 It is considered that with the implementation of the mitigation measures outlined, impacts from the construction phase of the Development on geology and ground conditions as a result of existing or potential contamination will be **negligible** or **of minor significance**.

Operational Phase

8.11.4 The operation of the Development would have no effects in respect of ground conditions and geology.

Decommissioning

8.11.5 The decommissioning of the Development would have no effects in respect of geology and ground conditions as the reservoirs will be left in situ and the Development drained. The penstock and underground pipework will also remain in situ.

Table 8-2 Summary of the Impact Assessment										
Effect	Description of Receptor		Description of Potential Effect				Description of Residual Effect			Change from 2012 Chapter
	Receptor	Value / Sensitivity	Nature of Effect	Duration	Magnitude	Potential Significance	Summary of Mitigation	Residual Effect	Residual Significance	
Unexpected contamination and management of excess material around Q1	Construction workers and site users	High	Adverse	Temporary	Low	Negligible	Preparation of agreed remedial procedures within CoCP	There is a low risk of ground contamination in this area. Implementation of agreed procedures to manage unexpected contamination	Negligible	No change to significance
Disposal of excess material			Adverse	Permanent	Low	Negligible	None	Material is anticipated to be inert. Incorporation into the existing spoil mounds to the south and south west of Q1 and landscaping appropriately	Negligible	No change to significance
Unexpected contamination and management of excess material at Q6	Construction workers and site users	High	Adverse	Temporary	Low	Negligible	Preparation of agreed remedial procedures within CoCP	Implementation of agreed procedures to manage unexpected contamination	Negligible	No change to significance
Disposal of excess material			Adverse	Permanent	Low	Negligible	None	Incorporation into the Q6 dam and reservoir works and controls through the CoCP.	Negligible	No change to significance
Transfer of excess material to Q1			Adverse	Permanent	Low	Negligible	Ordnance Management Strategy	Implementation of Ordnance Management Strategy will minimise risks/impacts on construction workers	Negligible	New effect
Reprofiling of Q6 and stabilisation of slate mound			Adverse	Permanent	Medium	Minor	Confirmation from site investigation works if stabilisation is needed.	Engineering solution to be designed appropriately	Negligible	New effect
Damage to exposures from construction activities	Local geology	Low	Adverse	Permanent	Negligible	Negligible	None	n/a	Negligible	No change to significance
Damage to exposure of fluorite mineralisation	Afon Gwyrfai a Llyn Cwellyn SSSI	High	Adverse	Permanent	Negligible	Negligible	None – as exposure is isolated from the Development	n/a	Negligible	Reduction in significance
Unexploded ordnance and munitions in Q1, Q6 and Q8	Construction staff (human health)	High	Adverse	Temporary	Low	Moderate	Potential for presence of UXO in Q6 and along spillway route around Q8. No evidence for UXO hazard in Q1. Preparation and implementation of Ordnance Management Strategy in conjunction with HSE to deal with any remaining munitions	Implementation of Ordnance Management Strategy will minimise risks/impacts on construction workers	Minor	No change to significance

Table 8-2 Summary of the Impact Assessment										
Effect	Description of Receptor		Description of Potential Effect				Description of Residual Effect			Change from 2012 Chapter
	Receptor	Value / Sensitivity	Nature of Effect	Duration	Magnitude	Potential Significance	Summary of Mitigation	Residual Effect	Residual Significance	
Ffridd y Glyn Quarry Landfill	Construction staff (human health)	High	Adverse	Temporary	Low	Moderate	None - Former landfill is outside the Order Limits minimising risk of impact. Deposited materials previously may have been removed.	n/a	Negligible	No change to significance

8.12 Summary and Conclusions

- 8.12.1 The only nationally important geological feature in the area is part of the Afon Gwyfrai a Llyn Cwellyn SSSI, located to the west of the development area. This includes a small exposure of a fluorite mineral working. As the location is upstream of the Development, this would not be affected by the Development.
- 8.12.2 Approximately 810,000m³ of surplus material would be generated from the Development. It is considered that this would consist of uncontaminated natural materials, with no potential as a source of contamination. This would be deposited in the spoil mounds to the south and south west of Q1.
- 8.12.3 There would be an engineering solution to the potential stabilisation works required for the slate mound to the north of Q1. The results from the preliminary site investigation will help to confirm whether reprofiling of the slate mound is actually needed.
- 8.12.4 Areas of the Development have been used for potentially contaminative uses. Both Q6 and Q8 were used for the storage and decommissioning of munitions. Although there is evidence that the two areas have been remediated, there remains a potential for residual contamination. It is considered likely that there are hazardous materials (ordnance) beneath the slate fill on the floor of Q6. An Ordnance Management Strategy will be prepared detailing procedures for the safe management of any ordnance and munitions discovered during the construction works in Q6 and the excavations around Q8.
- 8.12.5 There is no evidence for extensive military operations in Q1 and it is considered that the quarry does not present a significant UXO hazard.
- 8.12.6 Although no evidence has been identified at present, the potential for the presence of localised ground contamination cannot be discounted, due to the industrial history of the area. If any such materials are discovered, these would be appropriately managed through appropriate remedial strategies developed with NRW and Gwynedd Council secured through a DCO Requirement.

8.12.7 Overall, it is concluded that the Development would have **no significant** effects on or as a result of the ground conditions and geology.

8.13 References

Environmental Protection Act 1990

Environment Agency CLR11: Model Procedures for the Management of Land Contamination 2004

Environmental Damage (Prevention and Remediation) Regulations SI 153 2009

Gwynedd Unitary Development Plan 2001-2016

British Geological Survey 1:50,000 scale plan, Sheet 106 Bangor 1985

British Geological Survey 1:10,000 scale plan SH56SE

Strata Surveys Limited, Ground Investigation Report No. 14566 'Glyn Rhonwy, Llanberis' April 2009

Historical Ordnance Survey Plans

Eryri Consultancy Report 'Glyn Rhonwy Pumped Storage Hydroelectric Facility: Preliminary Pollution Risk Assessment' July 2011

AECOM Report 'Glyn Rhonwy Quarry Works, Llanberis, North Wales' February 2012

Landmark Envirocheck report

CIRIA Report No. 552 'Contaminated Land Risk Assessment, A Guide to Good Practice' 2001 Zetica report, reference P3300-12-R1-B, entitled 'Sitesafe UXO desk study, Glyn Rhonwy, Llanberis, Gwynedd' dated February 2015 and May 2015

Zetica report, reference P3300-12, entitled 'Sitesafe UXO Desk Study, Cefn Du, Llanberis, Gwynedd' dated 27th May 2015.