EARBA STORAGE

A GILKES ENERGY COMPANY

Earba Pumped Storage Hydro Scheme

EIA Report

Appendix 4.5: Gate Check 1 Report

Part 3 of 3

February 2024

Appendix 3 – Design Evolution

3. Design Evolution

Executive Summary

This Chapter describes the key design principles and design evolution of the Proposed Development between Scoping and submission of the Section 36 planning application.

The scheme design has been developed to minimise its footprint on local ecology and therefore its extent would be confined mainly to the footprint of the reservoirs, the powerhouse and local access tracks, plus a buried grid connection.

The main refinements of the design since Scoping stage have been to:

- Increase the power capacity from 900 MW to 1,800MW which would increase the powerhouse size;
- Increase the energy storage from 33GWh to 40 GWH by increasing the dam heights and hence reservoir volumes;
- Re-locate permanent infrastructure and temporary works following ecology surveys, to keep clear of sensitive peatlands and bird habitats; and
- Develop a significant local biodiversity enhancement and management programme to ensure biodiversity net gain in the local area.

The scheme design and layout has been developed to minimise its footprint on local ecology and habitats.

The scheme would utilise the majority of earthworks arisings within the dam structures and maintain a balance of materials within both the upper and lower parts of the site. This would avoid impacts on local road infrastructure and also avoid long haul routes for earthworks materials within the site, a key feature of the sustainable aims for the Proposed Development.

3.1 Introduction

3.1.1 This Chapter outlines the alternatives considered in the process of selecting the technology and the site for the Proposed Development. It also describes the key principles informing the design of the Proposed Development. Furthermore, it details the evolution of the design to account for:

- Consultees' responses in the Scoping Opinion and subsequently from the public and other consultees and interested parties;
- incorporation of the findings of site investigations and environmental surveys;
- further work on optimising the storage and generation capacity of the Proposed Development; and
- further engineering studies of the various scheme components.

3.1.2 This document has been written by Gilkes Energy Ltd (GEL).

3.2 Key Design Principles

3.2.1 The key principles on which the design of the Proposed Development is founded are as follows:

- Sizing the capacity of the scheme to maximise the opportunity of the site for the purpose of long term electricity storage;
- Design and location of the scheme components to minimise any impacts of the Proposed Development on the natural environment;
- Planning the construction and operation of the Proposed Development to minimise any negative effects on users of the site and communities local to and more distant from the site;
- Carefully designing and locating permanent above-ground features to minimise landscape and visual effect and to optimise the opportunity for mitigation measures;
- Sizing and designing the scheme components to adequately meet their functional requirements within the minimum design footprint;
- Optimising constructability and minimising the construction programme duration which would minimise local disruption;
- Designing the mass balance and spoil management of materials within the site such that wherever possible construction materials are won from within the site and materials displaced by the construction are put to beneficial use within the site;
- Prioritising sustainable construction principles; and
- The safe construction, operation and decommissioning of the Proposed Development.

3.2.2 The proposed Development scores highly against the above criteria when compared to other potential Pumped Storage Hydro (PSH) sites. The key principles being the ability to build a technically feasible large capacity store of potential electrical energy, close to the main grid network, with a relatively modest footprint on existing habitats, away from designated natural protection sites and relatively limited visual and other local impacts.

3.3 Design Development of the Scheme Layout by Component

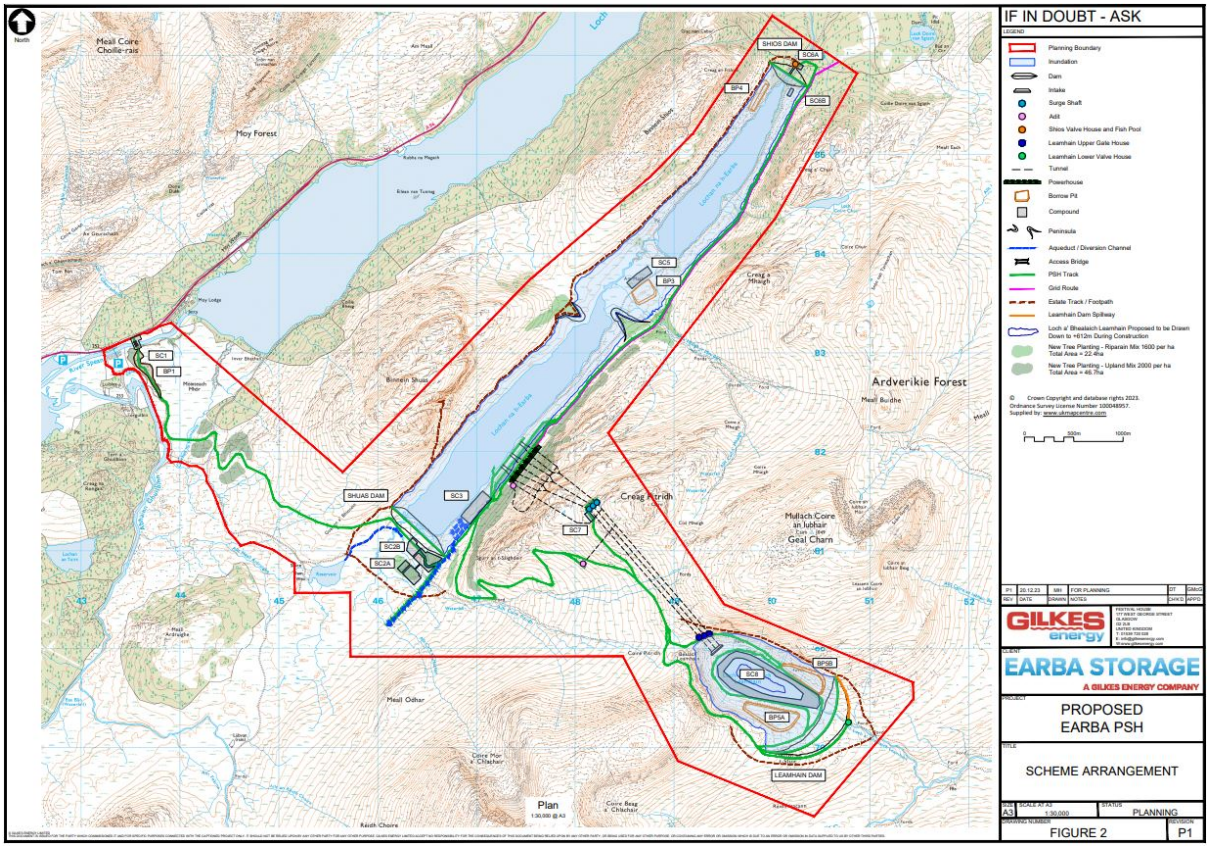

Plate 1- Scheme Layout Plan

The Leamhain and Earba Reservoirs

3.3.1 In order to create optimum economic reservoir storage for the PSH with minimum footprint, various levels were considered for raising the Earba and Leamhain lochs. The key driver was to match the top and bottom storage of the PSH, and also allow some further additional storage in the lower reservoir to allow the existing Ardverikie Hydro to continue to operate.

3.3.2 The Earba glen is a naturally very good reservoir being long and flat, with relatively narrow shoulders at each end. The existing lochans have already been dammed to create reservoir storage for the existing Ardverikie Hydro Electric scheme, which has been operating for almost 40 years.

3.3.3 The Loch Bhealaich Leamhain, which will form the upper reservoir, similarly lies in a fairly narrow coire with good reservoir potential utilising a dam located at its east end.

3.3.4 The main constraint to the overall volume of water in the system is the upper reservoir at Loch a' Bhealaich Leamhain.

3.3.5 It would be technically possible to build the Leamhain Reservoir up to the level of the saddle of the Bhealaich Leamhain, with top water level at around 740m AOD and with a storage volume of around 90Mm3. This could yield energy storage of up to approximately 70 GWh.

3.3.6 However, with the export and import capacity of the system limited at 1,800MW, The volume of water stored at 740m AOD was not considered to be the most economic or desirable option from an environmental or visual perspective:

1. At a level of 740m the Leamhain dam would become very large at approximately 100m high and over 1500m long. This is technically considered to be an upper limit as a result of the volume of rock required for a rockfill dam here.

2. The visual impact and the footprint of the 100m high dam on montane peatland and other habitats would also be significant in the upper area.

3. Economically, the additional storage which would be beyond 30 hours of full running has not yet been justified in the market or strategically.

3.3.7 If there was an opportunity to increase the capacity of the PSH to 2GW or 2.5GW, then the 70 GWh storage may become a more feasible option for relatively little extra footprint, although the visual impact of the dams and powerhouse and the footprint on the various sensitive habitats would both be slightly greater.

3.3.8 For the reasons outlined above, the top water level of the Leamhain reservoir has been selected at a lower level of 710m AOD with drawdown of 70m to 640m AOD. This will provide approximately 55Mm^3 of water stored in the upper reservoir for use in the pumped storage system.

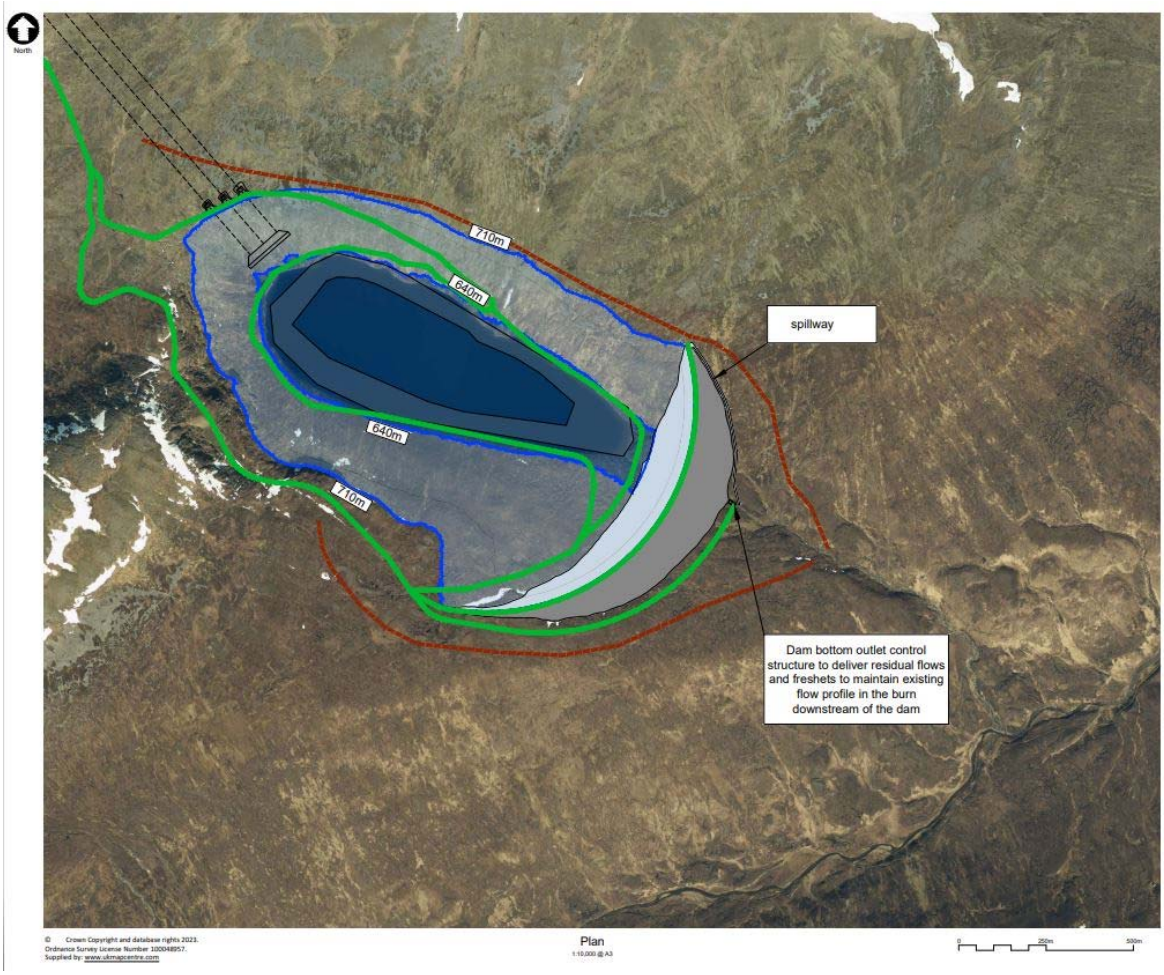

Plate 2 - Layout of Leamhain Reservoir

3.3.9 The lower Earba glen is naturally constrained by the low saddle at approximately 385 m AOD between Binnein Shuas and Binnein Shios, which is a likely upper limit and so the technically feasible reservoir storage up to 385 m AOD would be in the order of 90Mm3. Any storage above this level would require saddle dams on the west side.

3.3.10 In order to balance the storage and minimise the footprint of the reservoirs, the storage in the lower Earba reservoir has also been selected with a lower volume than technically feasible, with a range of 376m-355m AOD and with approximately 65Mm3 stored as discussed below.

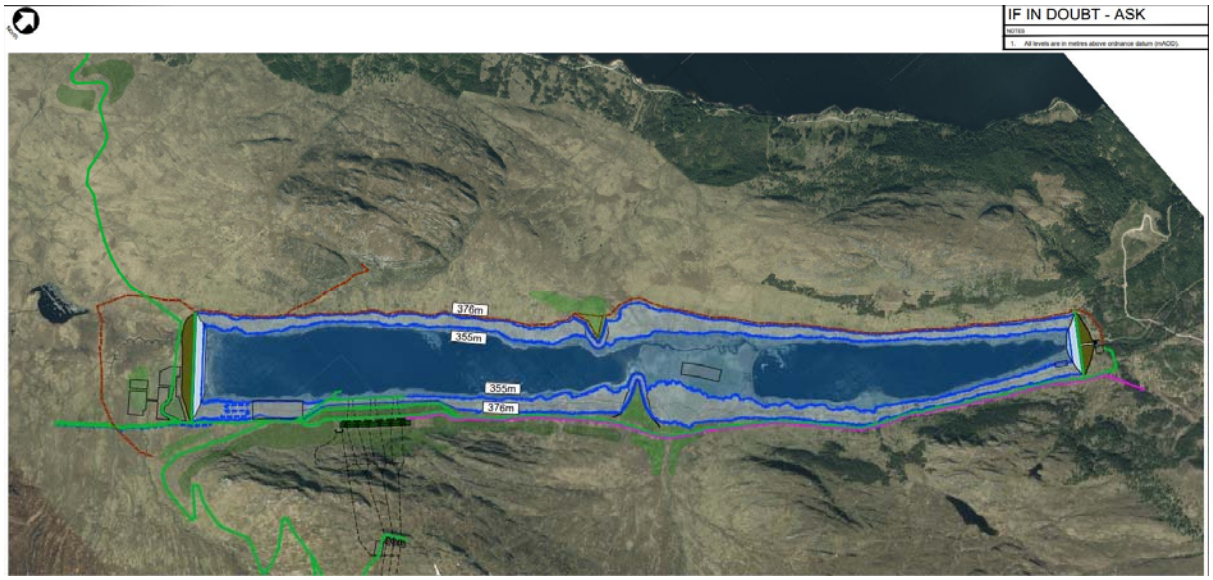

Plate 3 - Layout of Earba Reservoir

3.3.11 With the storage volume of the upper Leamhain reservoir being 55Mm3, this volume as well as a reserve volume of 10Mm^3 within the lower Earba reservoir will be required as follows:

1. to allow Ardverikie Hydro to continue to operate with some operating storage volume, together with minimum compensation flows, with some reserve storage without depleting the useable volume of water for the PSH; and

2. to further provide spare water in the system to maintain sufficient volume of water for the PSH during all seasons and allow for evaporation during dry weather, when natural rainfall may fail to top up the reservoirs.

3.3.12 The total reserve storage of 10Mm^3 to allow for these factors is added to the upper reservoir range of 55Mm^3 to give an overall 65Mm3 range in the lower reservoir, which hence sets the required lower reservoir top water level of 376m AOD.

3.3.13 It is also noted that technically, with a 70m head range in the upper reservoir and 21m in the lower reservoir, the head range between upper and lower reservoirs with 376m in Earba is close to the feasible limit for pump turbines. If the Earba loch were raised further, preliminary engineering studies indicate that this would likely reduce the minimum water pressure available for the pump turbines to below their minimum operating levels.

3.3.14 For the reasons outlined above, the planned operating ranges have been set at 710 – 640m AOD for the upper reservoir and 376 – 355m AOD for the lower reservoir.

The Leamhain Dam

3.3.15 As discussed above, it would be technically possible to raise the level of the Leamhain dam to around 740m AOD. However, this would be a huge volume of rock fill and so for economic and environmental reasons, based on the selected upper capacity of the PSH and also to reduce the visual impact and footprint of the dam, a lower dam height of 710m AOD was selected.

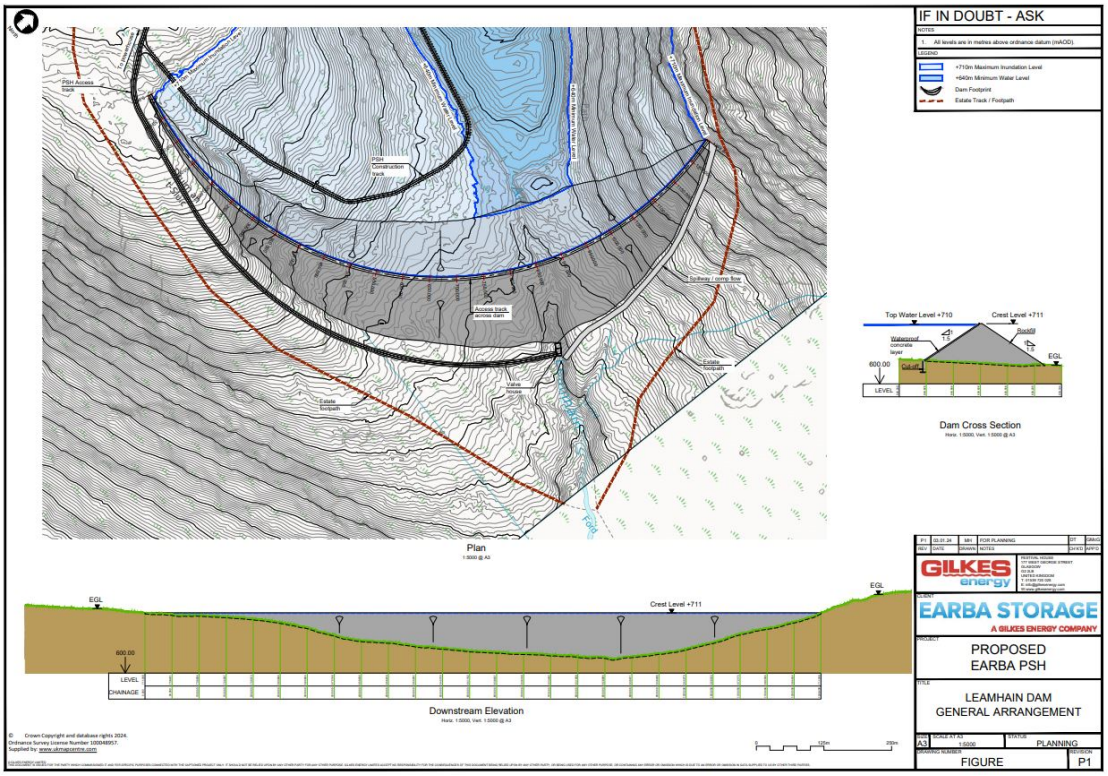

Plate 4 - Layout of Leamhain Dam

3.3.16 Several options for the position and height of the Leamhain dam were considered within the Leamhain glen. Due to the topography of the glen these were all within +/- 200m in alignment.

3.3.17 Alignments further upstream were found to constrain the ability to utilise rock borrow pits and manage the earthworks and temporary drainage of the lochan within the reservoir footprint. Options further downstream would have resulted in dams being longer and higher as the ground falls way to the east, with relatively larger footprint on the local ecology and peatland.

3.3.18 The location and height finally selected for the Leamhain Dam provided the best balance of:

1. Volume of water stored, (ie the 55Mm^3 discussed above);
2. Dam height, (75m rather than 100m as discussed above);
3. Footprint on ecological habitats;

4. Provision for rock borrow pits within the existing hill shoulders just upstream of the dam abutments; and

5. Allowance for temporary works areas while minimising the footprint of the dam and reservoir works.

3.3.19 None of the alternative dam locations or alignments other than the selected location were found to satisfy the combined factors above.

3.3.20 Subject to further ground investigation works and detailed design, the dam location may require to be microsited to suit the best possible ground conditions for the dam foundations.

3.3.21 It is therefore proposed that a micro-siting allowance of up to 150m upstream of the proposed dam alignment be allowed in finalising the dam position following further geotechnical investigations and detailed design.

3.3.22 The proposed dam would be a concrete or asphalt faced rockfill dam, with a rockfill downstream face with potential for natural greening to blend with the existing mixture of upland scree and hill moorland. This would reduce visual impact from out-with the reservoir area to the east. This type of dam is considered to be the most economic option with the smallest carbon footprint and rockfill dams are found to blend in well with the landscape.

3.3.23 It is noted that the selected dam location is well screened visually from the east by the existing shoulders of the Meallan Odhar to the northeast, the Coire Odhar shoulder of Carn Dearg to the southeast and the hills of the Ben Alder Forest to the east, including Meall Beag, Meall Dubh and Meall Cruaidh.

3.3.24 The volume of rock fill required for the Leamhain dam would be in the order of 7Mm^3, which would require to be sourced locally adjacent to the dam.

Lowering Loch Leamhain for Dam Construction

3.3.25 In order to minimise the footprint of the overall reservoir works, including the dam, the impounded reservoir and the rock borrow pits, which would be required to supply the rockfill for the dam, it is proposed that the rock borrow pits be located within the footprint of the proposed reservoir outline, but above the existing lochan shoreline.

3.3.26 Following initial geological studies, it is planned that the borrow pits would be located within the existing bedrock shoulders just upstream of the dam abutments to the north and south sides of the lochan, as shown in **Figure 2.4 – Leamhain Dam GA**.

3.3.27 Significant additional temporary works compounds and stockpiling areas would also be required in order to store and process rock taken from the borrow pits and it is proposed that these are also located within the reservoir footprint.

3.3.28 Therefore, importantly, in order to facilitate both the rock borrow pits and their associated temporary works areas within the reservoir footprint the existing Lochan would be drawn down. This would also assist with managing the temporary drainage of the relatively deep excavations required for the construction of the dam foundations. It is proposed to draw down the level of the existing lochan from 635m AOD to 612m AOD as shown below:

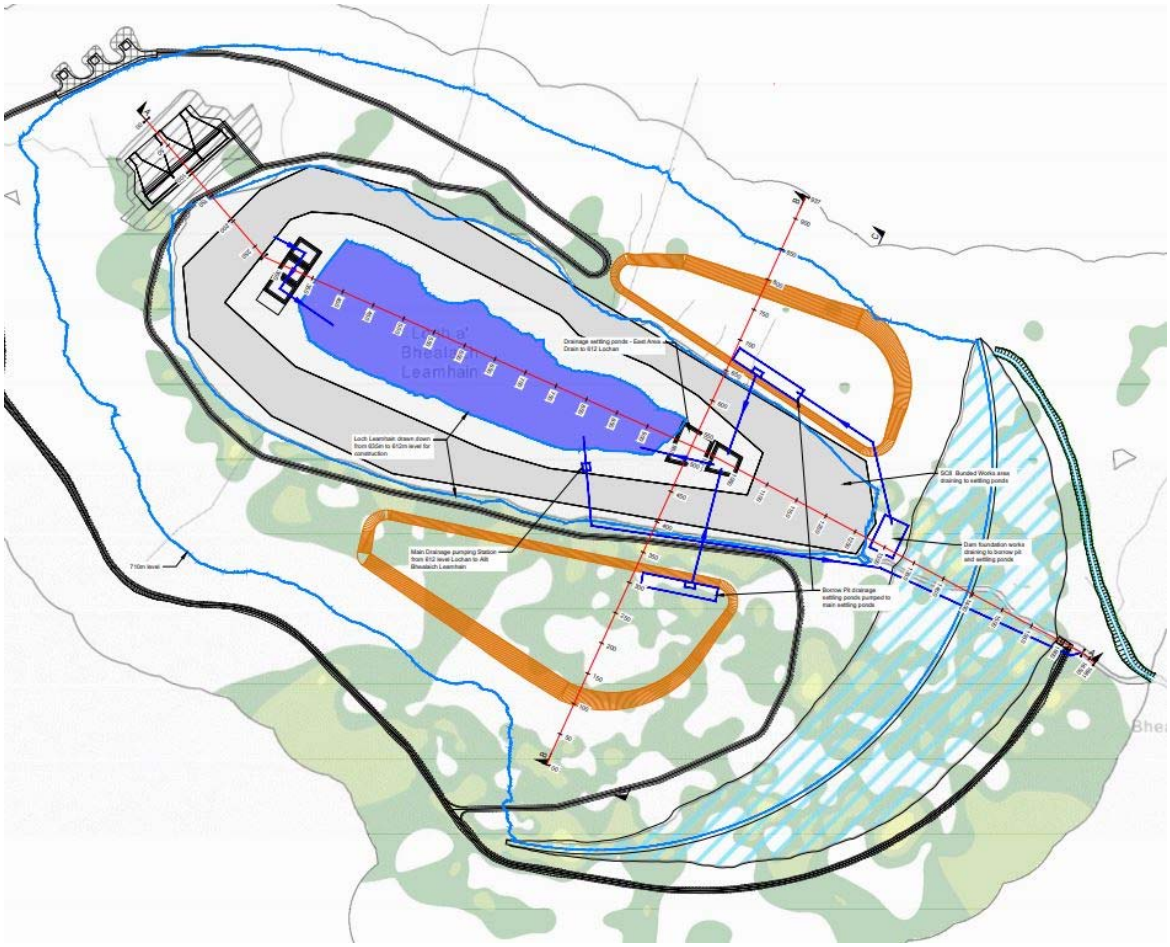

Plate 5 – Lowering and Temporary Drainage of Loch Leamhain during Dam Construction

3.3.29 This will have several beneficial effects:

- It would minimise the footprint / impact of the works on the sensitive montane habitats to the east of the dam, out-with the reservoir footprint.
- It would provide an ability to properly manage drainage and surface water run off within the reservoir works areas which would provide valuable protection to the watercourse and other habitats downstream of the dam during construction.
- It would also facilitate simpler access to the dam foundations while avoiding the need for large works areas out-with the reservoir footprint.

3.3.30 The significant working areas provided would eventually lie within the permanent reservoir footprint and would be located below minimum final water levels. This would minimise the impacts in both temporary conditions and reduce long term impacts of the temporary works footprint by containing it within the reservoir low water inundation zone.

3.3.31 The level of the lochan would be reduced by around 20m leaving approximately 5 Ha of the lochan area remaining, at a surface level of approximately 612m AOD, with depth up to 8m.

3.3.32 To maintain the drawn down level, the lochan would be over-pumped into the burn discharging downstream of the loch, the Allt Loch a' Bhealaich Leamhain. Some

allowance would be made in the management of the lochan levels, in the order of 3m of allowable local loch level rise, to allow build up due to run off in wet weather.

3.3.33 The detailed proposals for the borrow pits and works areas and drainage measures would be contained in the Construction Environmental Management Document (CEMD) and associated Pollution Prevention Plan. Preliminary proposals for all of the works associated with the Leamhain dam include measures for the drainage and silt management required to ensure clean water discharges into the downstream watercourse. All of the site compounds and works areas and borrow pits would be drained to settling lagoons which would then pass clean water by gravity to the lowered lochan prior to being pumped to the downstream Allt Loch a' Bhealach Leamhain watercourse.

The Shios Dam

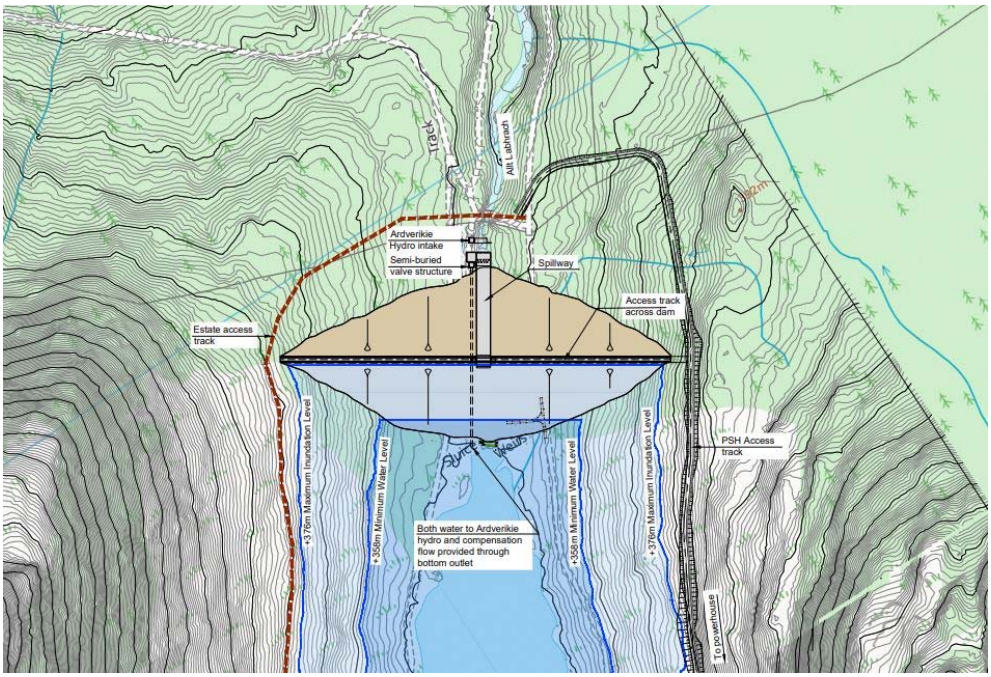

Plate 6 - Shios Dam on Plan

3.3.34 The Shios dam site is the only natural practical site for a dam at this end of the Earba Lochans. It is well screened and at a natural neck in the valley just beyond the existing loch end, best suited for a dam site. No alternative sites were considered to be realistic or suitable.

3.3.35 In order to maintain an overall balance of earthworks on the project and for sustainability, the Shios dam has been designed as a concrete or asphalt faced embankment dam with gentle slopes of around 1 in 3 gradient, which will be tolerant of a range of fill materials from local surface excavations or from the underground works. With grass on the downstream face, the dam will blend in with the local grassy hillsides on each side of the valley.

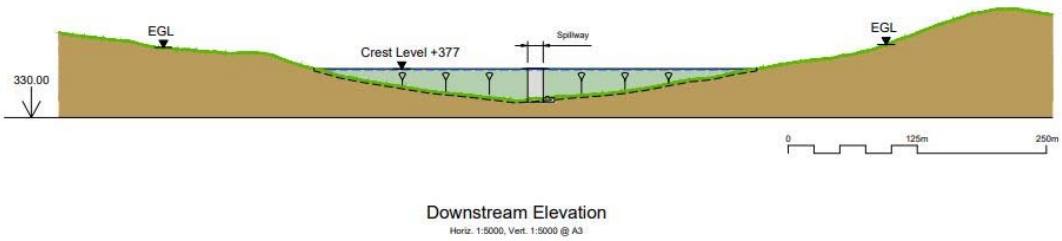

Plate 7 – Shios Dam Elevation

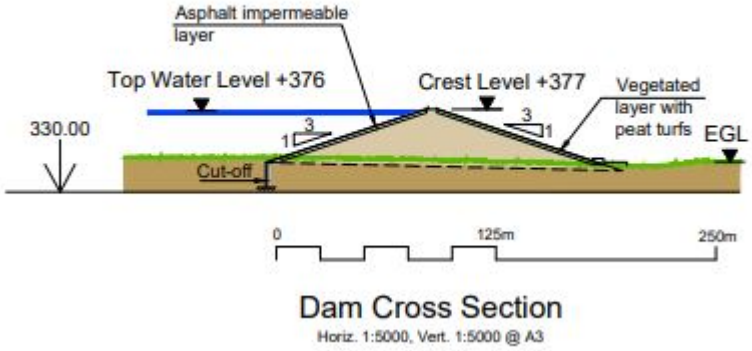

Plate 8 – Shios Dam Section

3.3.36 Together with the blending in of the downstream dam face with the natural grass on the abutments, native woodland tree planting in front of the dam will add to the existing tree cover and the dam will be well screened from immediate view from the north.

The Shuas Dam, Pitridh Aqueduct, Shuas Aqueduct and Local Area

3.3.37 Several options for the Shuas dam location were considered.

3.3.38 The best natural alignment for the dam would be running north south on the watershed just east of the small reservoir, around 800m southwest of the selected location. However, this would have a significant impact on:

1. the local peatland and riparian habitats in the area between Lochan na h Earba and up to the natural watershed just short of the Allt Meall Ardruighe reservoir to the southwest; and

2. It would bring major dam construction works very close to the Allt Meall Ardruighe reservoir, which has an ornithological constraint with a diver nest on the lochan.

3.3.39 In order to keep the footprint of the Shuas dam and the reservoir clear of the blanket bog and ornithological constraint, the dam was moved northeast and as close to the existing beach of the Lochan Na H-Earba as is considered practical.

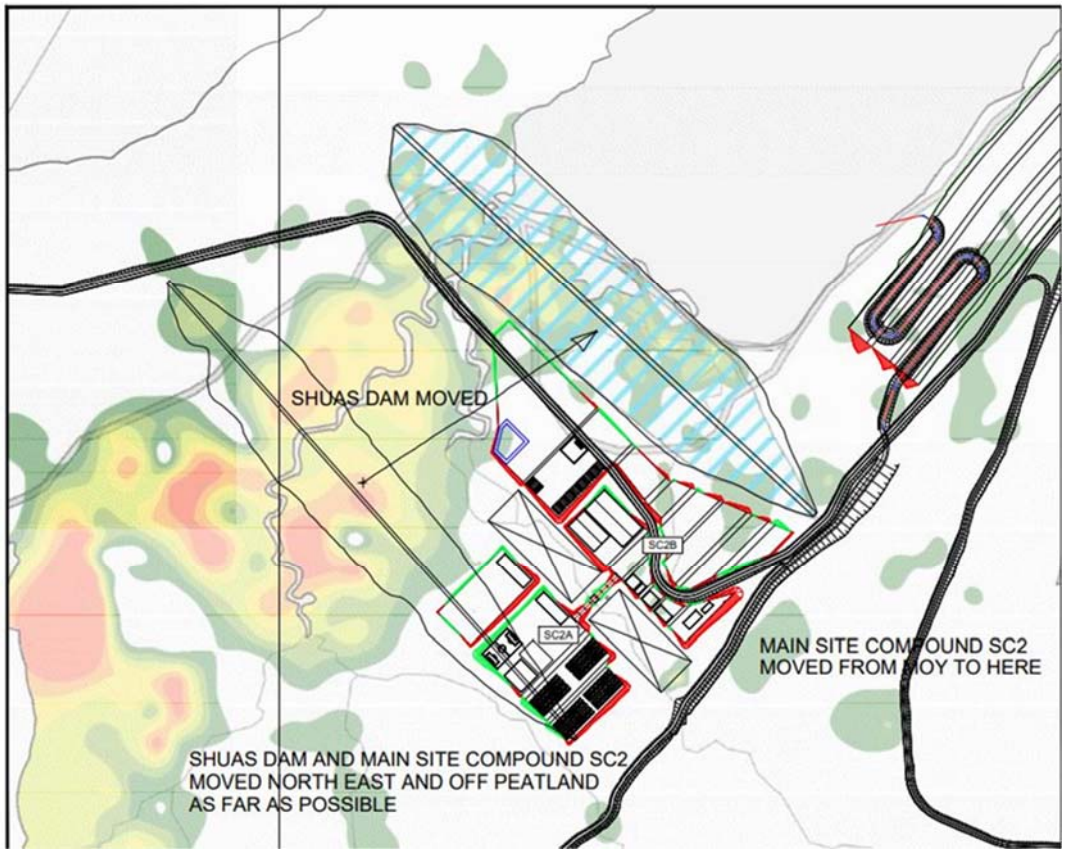

Plate 9 – Shuas Dam Location

3.3.40 The low spot created southwest of this dam location would then collect the natural inflow from the burns streaming west off the Coire Pitridh area into the Upper Lochan na h Earba.

3.3.41 In order to reduce the flow of water collecting in the natural bowl west of Shuas Dam, it is proposed that the burns falling from Coire Pitridh be diverted to the northeast and into the Earba Reservoir. The Pitridh Aqueduct diversion works are described in more detail below.

3.3.42 The alignment of the Pitridh aqueduct is effectively constrained by two key factors:

1)the need to run it as low as possible to maximise the catchment area, and

2) the need for the channel to fall at a suitable gradient to divert and carry significant spate flows from the four Pitridh burns,

Small compensation flows would be passed into the lower burns below the diversion if required. The alignment and sizing of the diversion needs to be sufficiently steep and wide such that the diversion will carry fairly high return period spate flows without spilling into the old watercourses.

3.3.43 Initial sizing of this diversion suggests a channel of similar size to the existing main burns, albeit slightly wider and flatter, on the traverse across the hill to the Earba reservoir. The layout of this diversion aqueduct is shown below.

3.3.44 With the Pitridh Aqueduct in place, there would still be some limited accumulation of runoff in the approximately 1km2 low area between the dam, the aqueduct and the watersheds to the south and west.

3.3.45 In order to mitigate this, the proposed Shuas Culvert would be constructed alongside the existing estate track, to collect residual run off water from blanket bog the bottom of the existing burns and divert it away from the toe of the Shuas Dam and into the adjacent Allt Meall Ardruighe reservoir to the west.

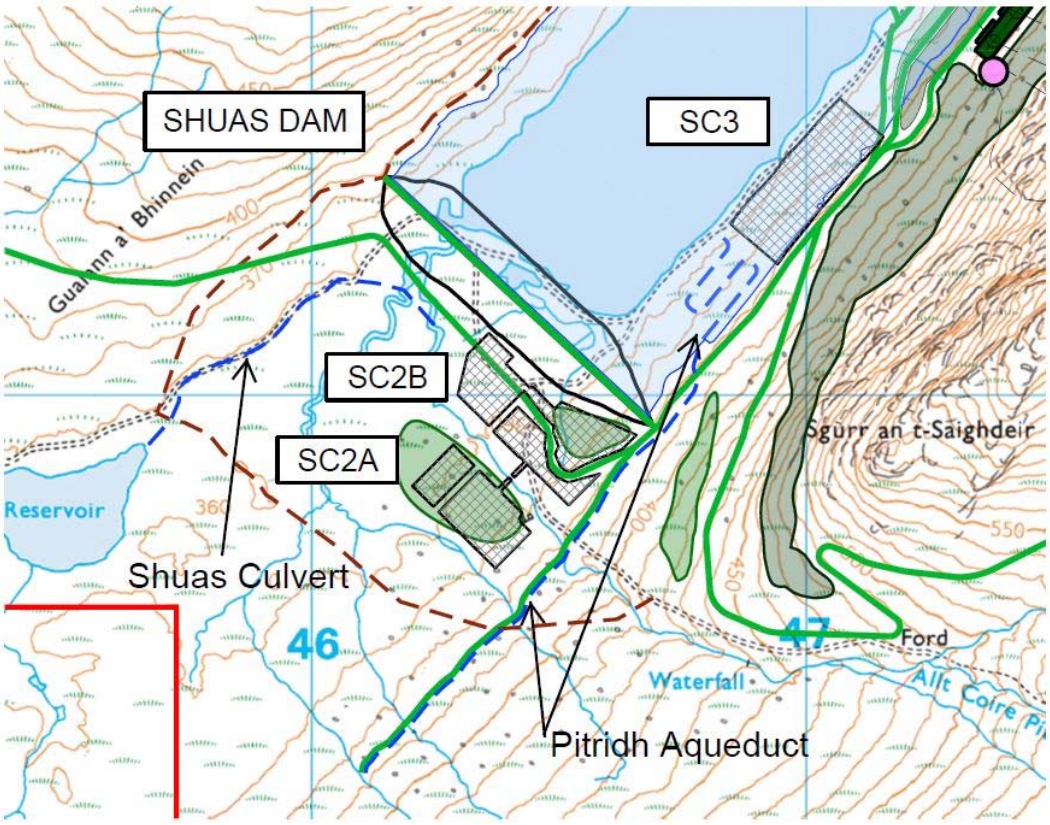

Plate 10 - Plan Showing Pitridh Aqueduct and Shuas Culvert

3.3.46 It is proposed that this drainage measure will maintain the existing ground water regime in the bog area southwest of Shuas dam and improve it where required to maintain the water levels in the blanket bog habitats maintaining them in the best possible condition.

3.3.47 This drainage measure, together with local peatland restoration using some of the peat extracted from the Shuas Dam footprint, should improve the habitats in the local area and the wider peatland area southwest of Shuas Dam and around the small reservoir.

3.3.48 By moving the dam to the northeast, close to the shore of the existing lochan, the majority of the 30 ha or so of peatland directly in the Shuas dam area has been avoided, however there is a small area of blanket bog beneath part of the dam foundation, generally between 1 and 1.5m deep, with localised pockets between 1.5 and 2m deep. It is not practicable to move the dam clear of this area and so it is proposed that the peat removed from the dam foundation here is used locally to reinstate damaged peatland in the remaining Shuas area immediately to the southwest. It can also be used to reinstate eroded peatland areas on the Coire Pitridh reserve to the immediate east of this area and reinstate bare track edges and forest areas locally.

3.3.49 Similar to the Shios Dam, the sustainable option for the Shuas dam would be to utilise rock and other arisings from the underground works and achieve an overall balance of earthworks on the project site. The Shuas dam has been selected as a concrete or asphalt faced embankment dam with gentle slopes of around 1 in 3 gradient, which will be tolerant of a range of fill materials from local surface workings or from the underground works. With grass on the downstream face, the dam will blend in with the local grassy hillsides on each side of the valley.

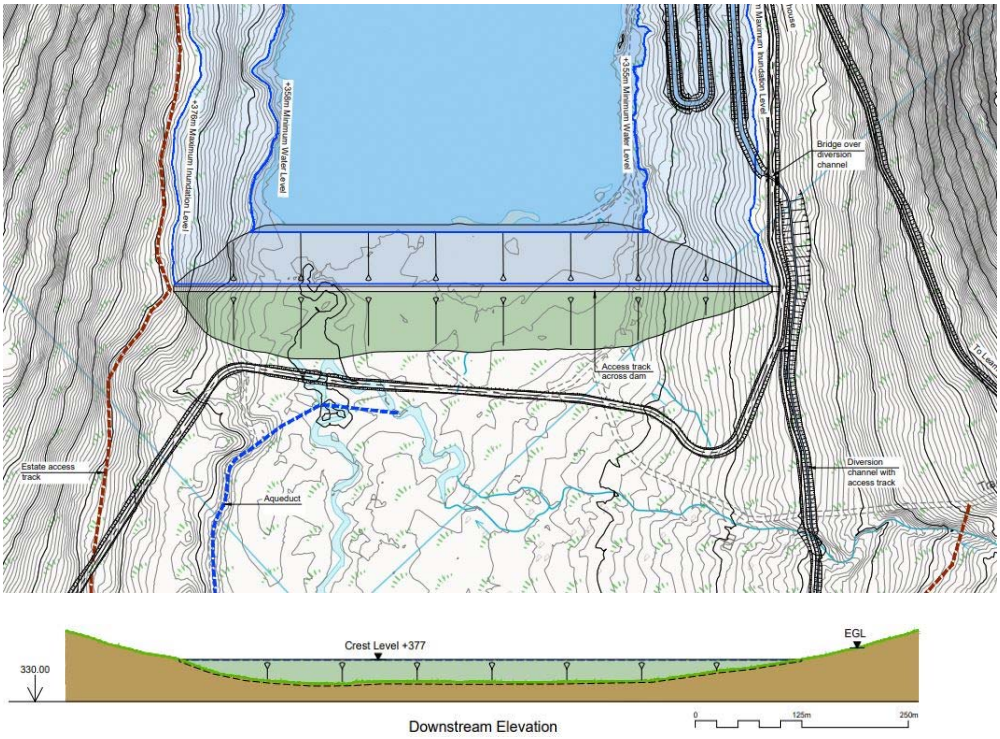

Plate 11 - Shuas Dam Plan and Elevation

3.3.50 Together with the blending in of the downstream dam face with the natural grass on the abutments, native woodland tree planting in front of and around the abutments of the dam will break up the slightly linear crest of the dam from various viewpoints, as well as enhancing the habitats of the area.

3.3.51 Rock level is expected to be at some depth in the Shuas dam area and so deep cut offs formed by grout curtains or other piling methods will likely be employed to assist in sealing the toe of the dam.

The Powerhouse

3.3.52 The proposed 1800MW capacity pumped storage scheme would be served by up to six pump / turbines, each of nominal 300MW generating capacity. Different options have been considered for the powerhouse configuration which would house both the pump turbines and associated electro-mechanical equipment.

Cavern vs Shafts

3.3.53 The pump / turbines for pumped hydro storage schemes need to be set well below the level of the lower reservoir in order that they can perform correctly. They also need to be balanced in terms of the hydraulics such that there is not a long pressurised water column on either side of the pump / turbine, which could lead to significant transient loads, (ie water hammer).

3.3.54 The requirement to set the plant low – below the level of the lower reservoir water level - means that it needs to be located either in a shaft from ground level or in a cavern.

3.3.55 In the case of Earba, the waterways are relatively short and the ability to include surge shafts in the hill above the powerhouse allows the option for the positioning of the pump / turbine plant and powerhouse in a shaft relatively close to the lower reservoir.

3.3.56 This has a significant advantage for the technical and economic feasibility of the scheme. It would allow many elements of the works to be constructed concurrently which greatly reduces programme time and hence the cost, rendering the scheme more feasible to develop and build.

3.3.57 The shaft option would best be located close to the lower reservoir to keep the shafts as shallow as possible if the hydraulic transients can be dealt with using surge shafts.

3.3.58 A cavern option can sometimes be more flexible in location but can lead to a longer and more expensive construction programme, with greater volume of underground works needing to be dealt with.

3.3.59 Analysis of likely construction programmes has shown that the shaft option would likely cost significantly less than a cavern option in civil works plus time related costs. This is because the various elements of the civil construction works can more easily be carried out concurrently and are accessible earlier in the construction sequence. This would also require less disposal of spoil materials from underground works.

3.3.60 For Earba the shaft option has hence been selected, since the access to the shaft powerhouse is relatively straightforward and, as above, will be more economically feasible in terms of programme time and the amount of underground works to carry out and the associated arisings to dispose of.

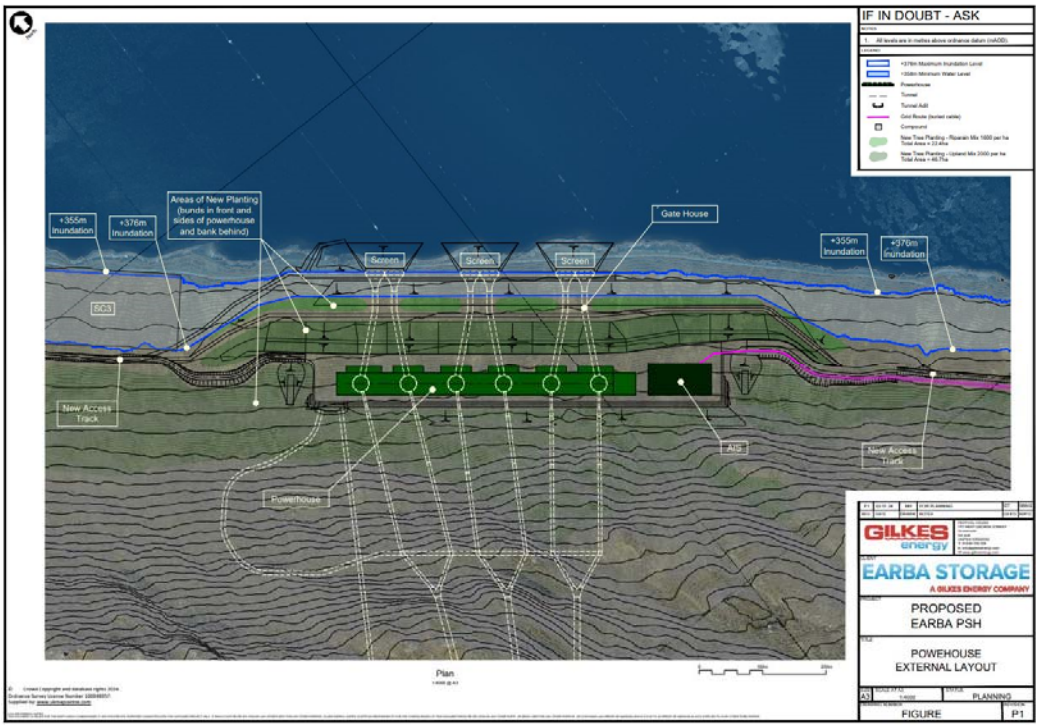

Plate 12 – Powerhouse Layout Plan

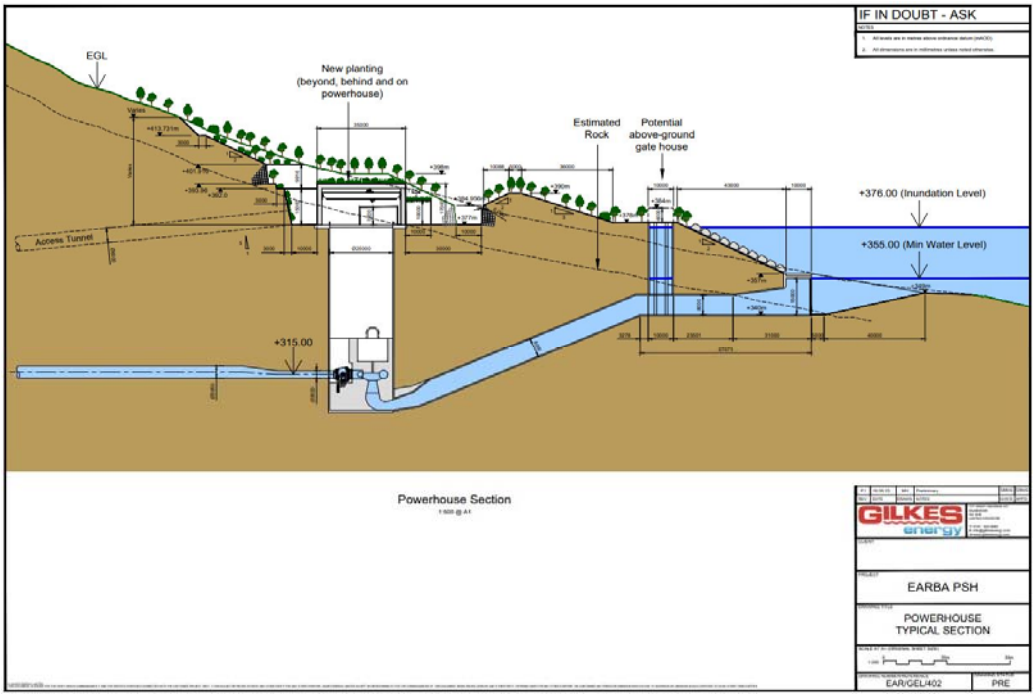

Plate 13 – Powerhouse Typical Cross-section

3.3.61 The materials balance calculations suggest that the rock spoil from the tunnels and shafts can be put to use in building the Earba dams plus local landscaping of promontaries within the Earba reservoir, with no balance of spoil remaining to be disposed of. This is a key factor in favour of the selection of the shaft option.

Powerhouse Location for Shortest Tunnels and Best Geology

3.3.62 The tunnel alignments generally follow the shortest straightest route, assuming that no particular topography and geology dictates that some form of skewed alignment

would be required. Early geological desk studies and site mapping have not found any reason to deviate from the straight route at this stage.

3.3.63 Further geotechnical investigations may indicate that the powerhouse and tunnel alignments would be better located by adjusting the alignment slightly to either side of the current tunnel alignment.

3.3.64 In such a case the powerhouse location may be moved slightly southwest or northeast along Lochan Na H-Earba. It is proposed that a micro-siting allowance for the be made within the planning conditions. The surge shaft positions would be unlikely to require micro-siting.

3.3.65 That said, the proposed arrangement of reservoirs, tunnels and powerhouse which have been selected, combine to form the most compact option, with shortest tunnel alignments between the nearest points of the upper and lower reservoirs where the upper and lower control works are located.

Powerhouse Landscaping Options Considered

3.3.66 It would be possible to locate the powerhouse on a prominent, higher terrace with longer shafts and less earthworks for the platform. However, the powerhouse has been located within a cutting to lower the envelope of the building such that the roofline is below the general profile of the Earba valley minimising visual intrusion within the glen.

3.3.67 A design statement will discuss the evolution of the architectural design of the powerhouse.

3.3.68 There will also be targeted landscaping and native woodland planting around the powerhouse to reflect the existing Scots pine woodlands at the north end of Lochan na h Earba.

3.3.69 Native woodland planting is also planned on new promontories located in the middle of the Earba reservoir, to reflect the existing woodland copses along the northern lochan. The intention is that these promontories will provide an important landscape function to break up the views along the valley, in the same way that the isthmus between the upper and lower lochans and the existing small promontory with its copse of native woodland does currently.

The Lower Inlet / Outlet Works

3.3.70 Above ground structures were considered for the lower gate control works but this option was not selected, in order to avoid the impact of potentially industrial looking lifting gantries and motor houses adjacent to the Lower Earba reservoir. The planned structure of the lower gate house chambers would be sunk into the ground to minimise visual impact. The chambers will have access covers for maintenance flush with ground level and landscaped with local native woodland planting around them to screen the areas. These are shown on the typical powerhouse cross section above.

3.3.71 The lower inlet/ outlet works will consist of screens up to 200m long which would act as inlets during pumping and outlets during generation. These structures and screens would be almost fully below low water levels but with an access platform at the top of the screens which will be exposed just above minimum water level to allow access and maintenance of the screens when the reservoir is fully drawn down. This design has been selected to minimize the visual impact of the lower outlet works on the shore of Loch Earba.

The Underground Waterway System

3.3.72 Several options were considered for the number and sizing of the underground waterway tunnels and shafts.

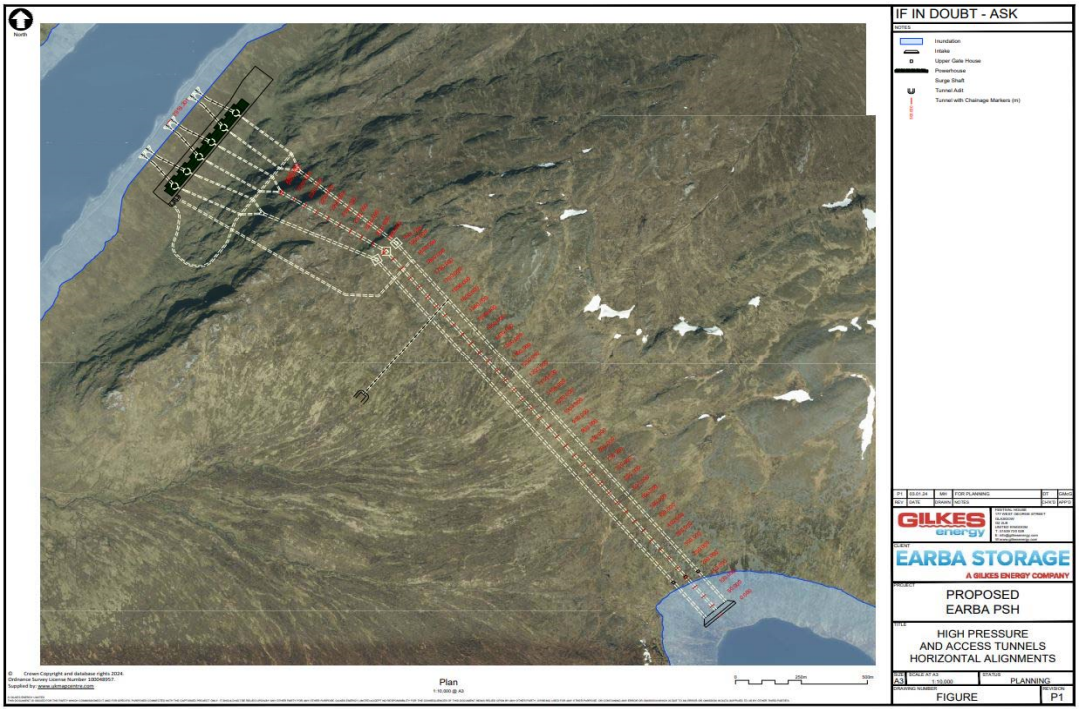

Plate 14 - Tunnel Layout Plan

3.3.73 The selected arrangement has been found to best suit the technical and constructability requirements of large diameter lined headrace (upstream) tunnels with capacity of up to 1,800MW. The buildability considerations for the tunnels means that any tunnel would likely have an upper diameter limit in the order of 10m. The proposed 1800MW capacity pumped storage scheme would require to be served by up to three such headrace tunnels -up to 10m in diameter. These would each divide into two smaller tunnels close to the powerhouse with steel lined elements to suit geological conditions, such that there would be one individual headrace tunnel serving each of up to six pump turbines. There would also be up to six tailrace tunnels, each serving one turbine shaft and running out to the lower control works.

Surge Shafts and Intermediate Adit

3.3.74 As discussed, the surge shafts need to be located close to the powerhouse, but with sufficient freeboard to contain the free water surface within the shaft during the maximum transient event. With surge shafts of up to 15m in diameter, the maximum free water surface is calculated to rise approximately 40 to 50m above maximum top reservoir level and so the top of the surge shaft needs to be above 770m AOD to give sufficient freeboard above maximum transient water level. The surge shafts would also be as close to the powerhouse as possible. The location of the shafts has been selected on the criteria above , and to fit the tunnel layout.

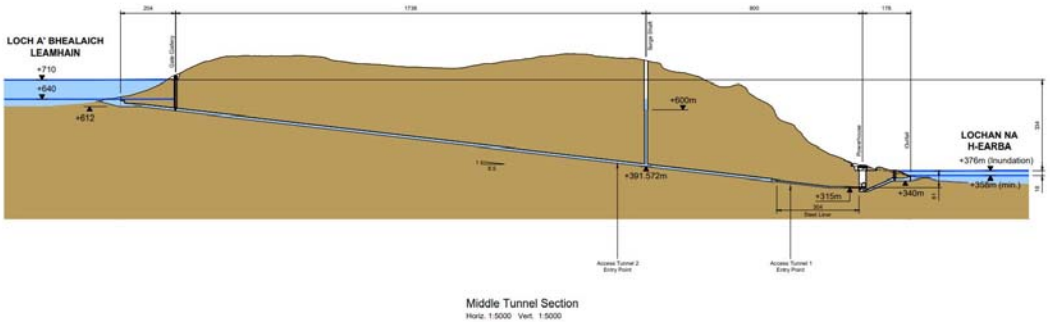

Plate 15 - Tunnel Longitudinal Section

3.3.75 There are several options for the vertical alignment of the upper headrace tunnel. It could be at a fairly flat gradient between 610m AOD at the upper intake - 590m AOD at the surge shaft. In the selected option for planning, an intermediate access tunnel adit is proposed at around 600m elevation in order to facilitate access to the upper tunnelling works as well as for operational maintenance. The tunnel portal would be adjacent to the main track up from the powerhouse to Bhealaich Leamhain, approximately half way along the track.

The Upper Inlet / Outlet Works

3.3.76 The inlet structures at the Leamhain reservoir would be located at the west end of the reservoir and would be set several metres below lowest operational water level to reduce visibility and for hydraulic efficiency. The submerged intakes would be fitted with smolt screens and there would be a low-level access to the top of the screens which is only visible and accessible when the reservoir is fully drawn down to below 635m AOD level for maintenance. This is approximately 5m below the 640m AOD minimum proposed operating level and so the structures would be submerged under the full range of normal operating conditions.

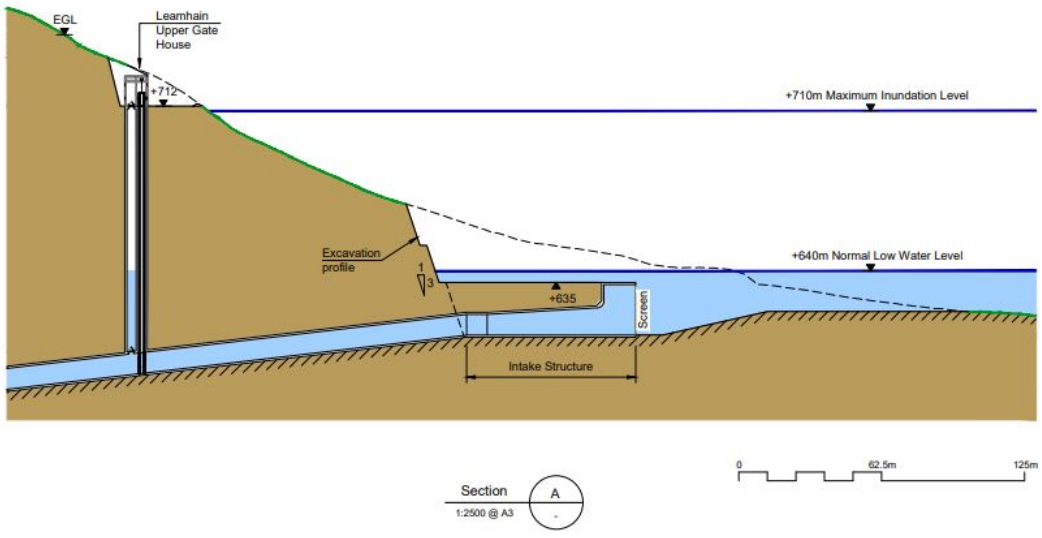

Plate 16 - Upper Inlet and Control Works Section

3.3.77 There were several possible options for the isolation gates which would be required to close off and isolate the headrace tunnels from the upper Leamhain reservoir. In order to maintain the natural appearance of the upper reservoir as far as possible,

rather than having three 75m high gate towers within the reservoir, the proposed gate shafts would be set into the hillside to the west of the Leamhain reservoir.

3.3.78 This would allow the gate operation and access shafts to be buried, with only the gatehouses at the top being above ground level. These gatehouses would be set with floor levels just above the Leamhain reservoir spill level at approximately 712m AOD. The roof of the gatehouse along with the rear and side walls would be buried such that the building appears built into the sloping hillside and could only be viewed from one elevation, from the south east. The backfilled roof levels would be around 725m AOD, which is well below the existing ground level of the saddle at the Bhealaich Leamhain and so the small, buried gatehouses would be visually below the ridgeline when viewed from the reservoir to the east and would be fully screened from views from the Coire Pitridh in the west.

Access to the Site

3.3.79 Initial studies suggest that heavy loads would most likely be delivered via the port at Corpach, which has fewer sensitive bridge structures than the A9 route. Tunnel steel linings would most likely be delivered from the Inverness area via the A9. This is covered in **Chapter 17 – Transport and Access**.

Access from the A86

3.3.80 The site lies approximately 3km from the A86 trunk road and is currently served by estate tracks via the Moy bridge and junction, which is close to the proposed main works compound.

3.3.81 Access to the north and east side of the development area from the A86 is also possible at Gallovie Farm but this is not proposed for the main access.

3.3.82 The Scoping report proposed access using the existing Moy Bridge junction, but following further assessment, the existing junction was found not to be compliant for construction traffic. Furthermore, the existing bridge is single track and likely too narrow for construction traffic and large hydro-electric components. This S36 application therefore proposes to use a new junction and bridge compliant with Transport Scotland requirements and directly accessing the site entrance compound.

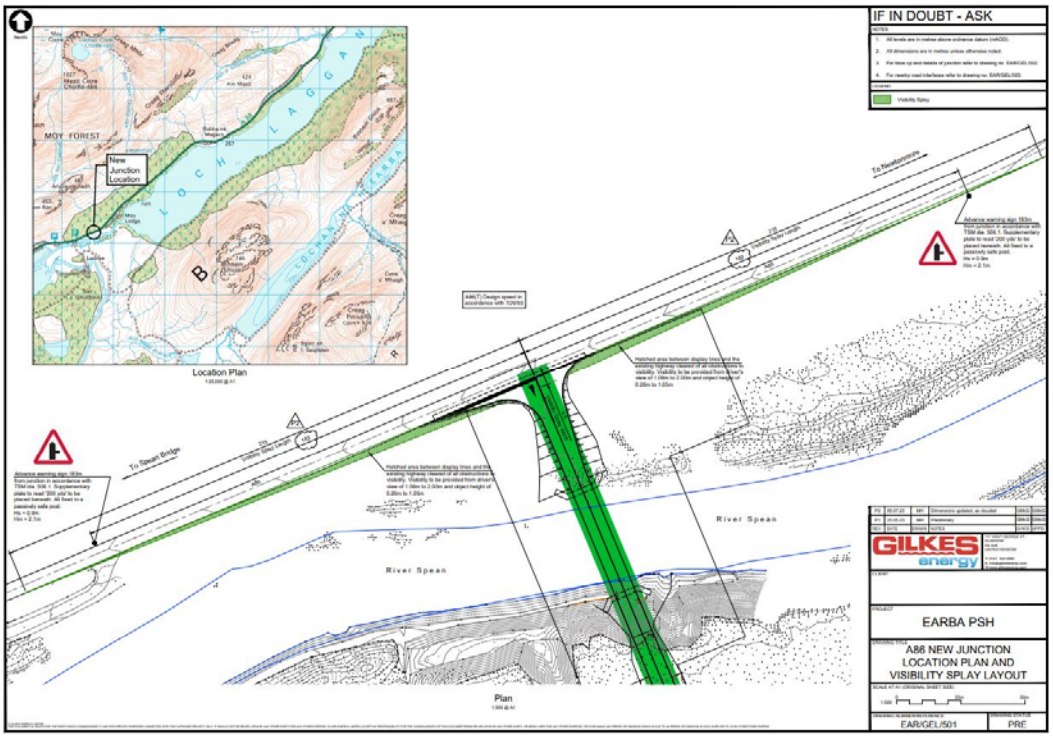

Plate 17 - New A86 Junction Layout Plan

Construction Compounds

3.3.83 The development of options for the site construction compounds is discussed below.

3.3.84 The original intention was to have the main 8 Ha construction works compound next to the A86 site entrance at Moy, however the area to the east of the entrance compound was found to be mainly sensitive blanket bog. Following ecological habitat and peat depth surveys, the compound here has been reduced in size and tailored to avoid the sensitive peatland habitats as shown in plate 18 below. The smaller compound here has become the site entrance compound, SC1, and the main construction camp, SC2, has been moved to a new location close to the Shuas dam and the powerhouse, which is discussed below.

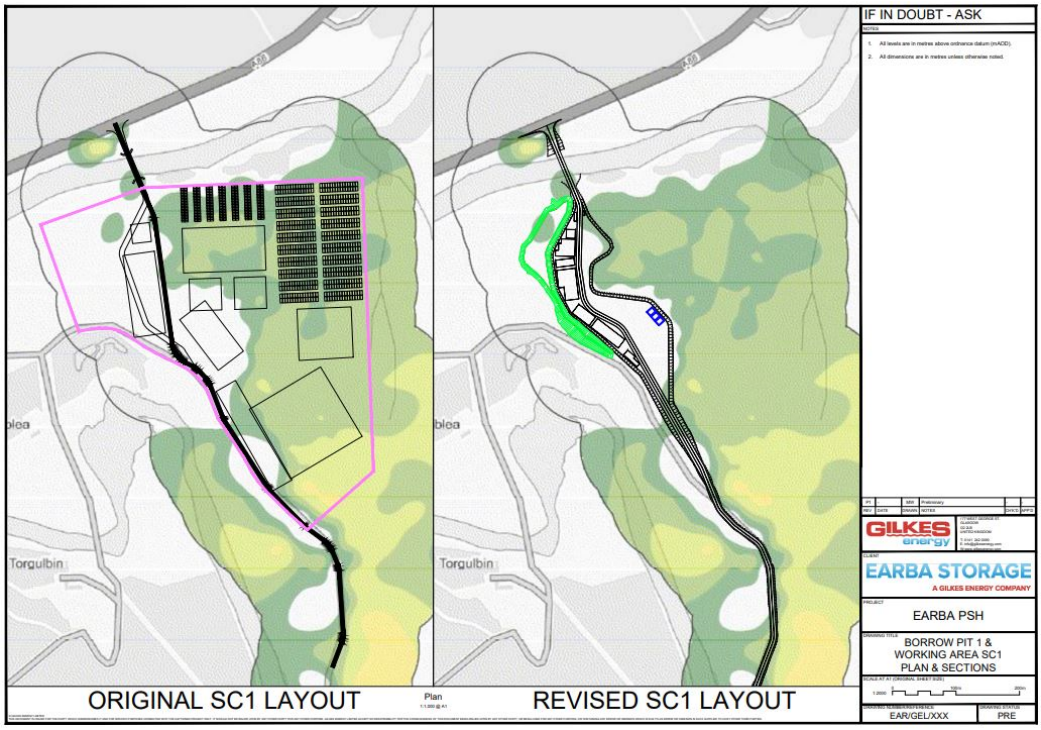

Plate 18 - Development of Site Compound SC1 at Moy to reduce peatland footprint

3.3.85 The options for the remaining site compounds have been developed so that the location and shape work with the land by terracing where required to avoid large cut and fill operations. The compounds have been configured to minimise the footprint of the works and avoid areas of sensitive ecological habitats.

3.3.86 In order to further reduce the permanent impact of the site compounds, the site compounds SC3, 5 and 6B at Earba reservoir and SC8 at Leamhain reservoir, which would be sufficiently large to contain stone processing as part of the earthworks programme, have been located within the reservoir inundation areas where topography allows and avoiding sensitive peatland habitats.

3.3.87 There was an opportunity to explore the use of the terraced site compound areas within the reservoir footprints to enhance aquatic habitats within the reservoirs and limit / offset the possible impacts of reservoir drawdown on shoreline habitats. Therefore, as an initial measure, what was originally site compound SC4 has been removed and the area would be utilised by the Pitridh diversion channel to allow the gradient of the proposed channel to fall sufficiently gently to allow spawning fish to navigate out of the reservoir under any water level condition and find suitable spawning beds along this watercourse.

3.3.88 Further possible habitat creation is envisaged in both the upper and lower reservoirs using a variety of possible floating media as possible spawning bed and littoral habitats for plants and invertebrates, which would sustain the ecology of the reservoirs in future.

3.3.89 In the upper Leamhain area, the originally proposed locations for the site compounds were found to be located on peatland and so the arrangements were re-developed to minimise footprint on peatland. SC8 is now the main works Site compound at Loch Leamhain and it is located within the shore line of the drawn down lochan and encompasses the lochan in order to provide sufficient working space and manage the drainage of the working areas in order to maintain clean discharges following rainfall and storm water runoff conditions. The details of

options for SC8 and the proposals for de-watering Loch Leamhain are discussed below.

The Site Entrance Compound (SC1)

3.3.90 The Site Entrance Compound (approximately 3 ha) would contain some offices, parking and holding areas for all vehicles accessing the site, to avoid any vehicles stopping on the local laybys on the A86 near the proposed junction. The compound would be continuously manned to manage vehicles arriving at the site and would ensure wheel washing facilities are used prior to construction traffic leaving site and returning on to the A86 highway. Some laydown areas would be provided for material deliveries to the site.

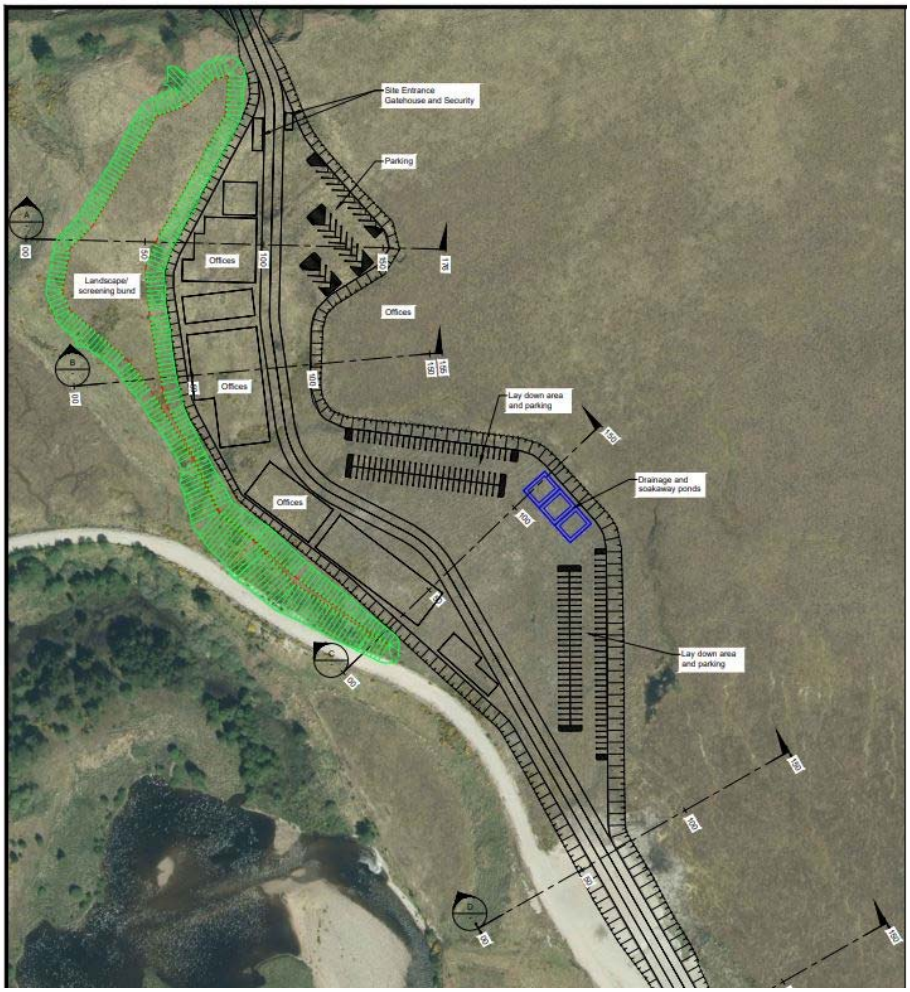

Plate 19 – Site Entrance Compound (SC1)

3.3.91 This compound SC1 would be formed by extracting stone over part of its area to a depth of 3 to 4m, as part of Borrow Pit - BP1 works, with spoil used to form a 3m high noise barrier and bund along the west edge of the track and laydown areas. The design has been developed such that the lowered platform in this area would be used for parking and laydown areas and the sunken profile together with the bund would mitigate and assist in noise abatement to minimise the impact of site traffic movements on nearby properties.

Earba Reservoir Area – Site Compound 2 (Main Site Compound)

3.3.92 As discussed above, due to extensive blanket bog in the Moy area adjacent to the site entrance, the main construction site compound, SC2 (approximately 9 ha) was moved into an area with minimal impact on existing ecology, a flat area of dry grassland adjacent to and just south of Shuas Dam as shown below, This has significantly reduced the impact and footprint of the temporary works on more sensitive peatland habitats.

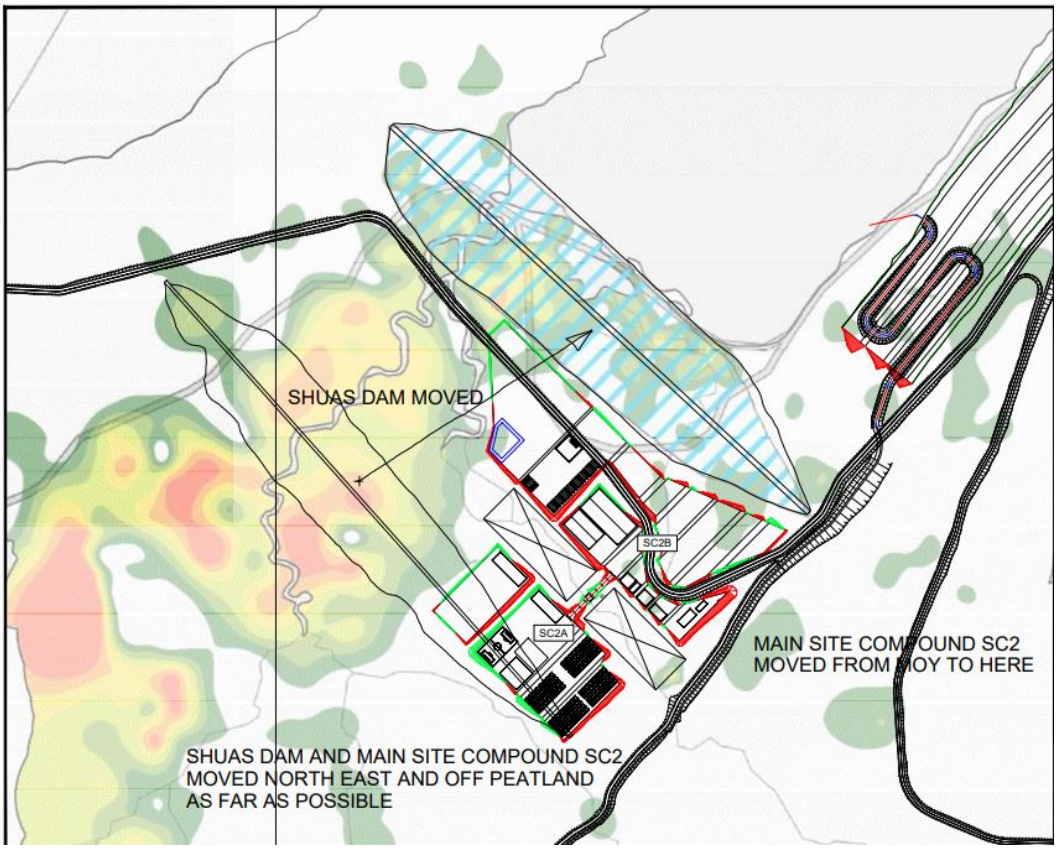

Plate 20 – Main Site Compound (SC2)

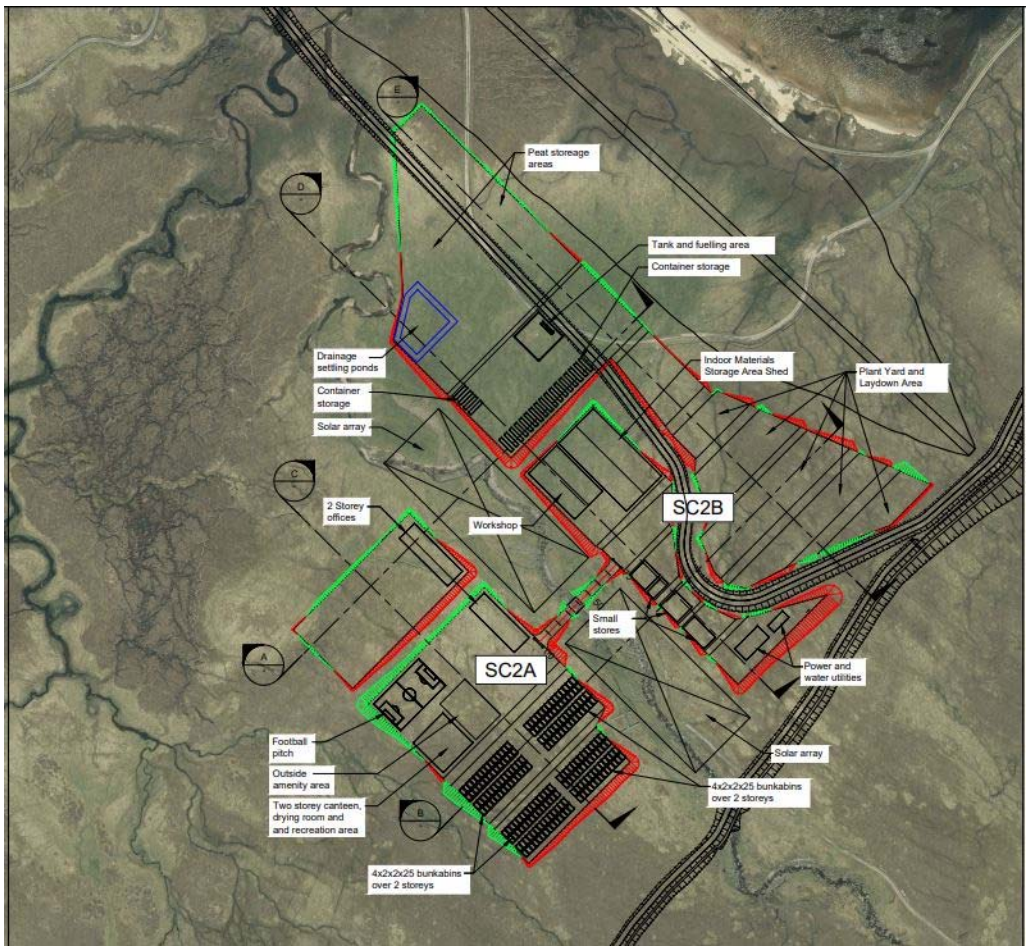

Plate 21 – Proposed Layout of Main Site Compound (SC2)

3.3.93 SC2A – (300mx120m) would contain offices and accommodation units, which would be stacked in two or three storey levels to minimise the footprint on the ground, plus a recreational area for workers.

3.3.94 SC2B – (300mx150m) part of the main compound in front of Shuas Dam, would include parking and laydown areas for plant and equipment as well as water, sanitary and electrical services and provision for a small concrete batching plant for the later phases of the project. It would also contain a bunded holding area for any deeper catotelm peat or amorphous peat some volumes of which may be extracted from the Shuas dam foundations.

3.3.95 The powerhouse site compound SC3 (600m by 150m, approximately 9 ha) would be formed by two or three terraced level areas running above the existing Locha na h Earba shoreline but within the proposed upper inundation zone of the lower reservoir. This compound would contain a bulk earthworks / materials handling area and a concrete batching plant for the main civil works stages of the project, as well as additional temporary laydown for plant and materials.

3.3.96 The site compound SC5 (250mx100m approximately 2.5 ha) would be located adjacent to borrow pit BP3, between the existing Locha na h Earba lochs but within the proposed upper inundation zone of the lower reservoir. This compound would be used for earthworks material processing for the Shios and Shuas dams and

powerhouse. Alternative locations were considered for SC5 but the proposed location being within the reservoir footprint and being a known gravel area away from peatland and wet heath areas presented the best location in terms of habitats and works footprint.

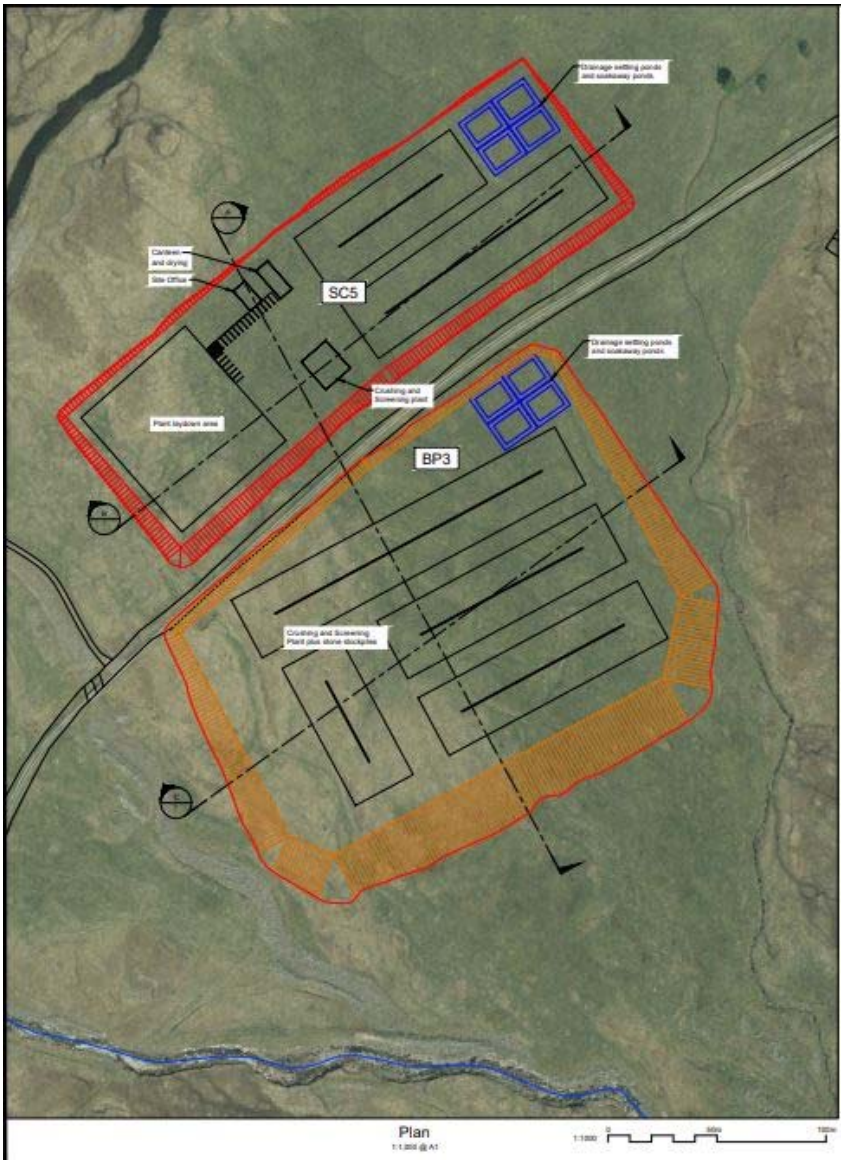

Plate 22 - Proposed Layout of Site Compound SC3 and Borrow Pit BP5

3.3.97 The site compound SC6 (2x50mx50m approximately 0.5 ha) would consist of two small approximately 50m square satellite compounds located in clearings between the existing trees at Shios Dam, to serve the Shios Dam construction. Alternative locations were considered but the proposed location of these satellite compounds fits best with local topography, between existing trees and clear of peatland. They have been split into two parts to best fit the available terrain, being located way from peatland and wet heath areas and being the best locations in terms of habitats and works footprint. The south compound SC6A would be used for construction related activities and would be de-commissioned and reinstated prior to reservoir filling The north compound location SC6B would enable it to serve the works following the reservoir inundation, being out-with the reservoir footprint and so would be utilised for site offices and welfare during filling of the reservoir and commissioning.

3.3.98 The small site compound SC7 (100mx50m approximately 0.5 ha) would serve the shaft works for the three surge shafts at 750m to 780m elevation on the west flank of Creag Pitridh. It has been adjusted to fit locally on the relatively flat ground beside the access track adjacent to the shafts in this craggy area.

3.3.99 Different alternative locations were considered for SC8, the necessary large working area adjacent to the borrow pits and the dam works at Loch Leamhain.

3.3.100 There are areas of flat ground around the Loch Leamhain and out-with the reservoir inundated area. However, much of this area around the reservoir is valuable montane peatland habitats.

3.3.101 Therefore, it was considered necessary to minimise the overall works footprint and keep the overall reservoir construction works within the outline of the reservoir inundation as far as possible.

3.3.102 The proposed SC8 site compounds and borrow pit locations are designed to be within the loch inundation area and away from surrounding peatland and wet heath areas. Hence the planned arrangement was considered to present the best location in terms of habitats, practicality and works footprint.

3.3.103 The site compound SC8 would be located adjacent to both borrow pit BP5A and BP5B as well as the upper control works and intake, within the proposed upper inundation zone of the upper Leamhain reservoir. This compound would encircle the drawn down Loch Leamhain and be used for offices and site establishment local to the Leamhain Dam Works as well as stockpiling and processing of rock fill for the dam during its construction.

3.3.104 This large compound would be used for earthworks processing for material from BP5A and BP5B and the intake excavations for use in the Leamhain dam. It will also be used for drainage management and settling ponds for cleaning rainwater run off from whole of the reservoir construction area before discharge to the lowered loch and Leamhain burn. This compound would only be formed after the appropriate drainage and construction environmental measures had been installed at the lochan and the lochan would then be drawn down to around 612m AOD level. SC 8 would then be formed as a raised platform at approximately 630m AOD level using sands and gravels taken from the overburden of BP5A, 5B and the dam foundation.

Permanent and Temporary Access Tracks and Paths

3.3.105 The proposed access to the site for construction and subsequent operation opted to use upgraded existing estate tracks wherever possible, but in several locations it is not suitable due to ecological constraints and location within the proposed inundations. The access tracks will also require upgrading to suit construction plant and heavy equipment deliveries.

3.3.106 Options considered were:

1. Using the existing junction, or re-routing of the access from the A86 to make a safe site entrance junction and new bridge. A new site entrance junction has been chosen to comply with traffic regulations.

2. Using / widening the existing track from Moy to Shuas Dam, or re-routeing the track to avoid local ornithology habitats along the trackside. It was decided to re-route the track over a length of 2.5km to avoid these habitats.

This option would also allow existing walkers and cyclists to use the track keeping clear of construction traffic.

3. Use the existing hill walker's footpath / track up the Allt Coire Pitridh burn for access to Leamhain Reservoir, or re-route around the north side of Coire Pitridh and away from sensitive peatland and montane habitats and well as avoiding several water crossings. It was decided to re-route the new track around the north of the Coire Pitridh for several reasons:

   (i)the gradient of the existing track is too steep for construction access;

   (ii)the existing path crosses sensitive montane habitats and many small watercourses;

   (iii)access is required to the surge shaft and high level tunnel adit in any case therefore the overall track length is reduced by intercepting these high tracks further north and west of the existing track;

   (iv)It is further envisaged that the Coire Pitridh area is in need of peatland or other montane habitat restoration and keeping the construction tracks clear of this area is considered an ecological benefit;

   (v) the visual impact of this construction track will be significantly reduced with it being routed up the south face of Sgurr an t-Saighdeir and hidden in large part from view across the open vistas from A86 area to the west; and

   (vi)This option would also allow existing walkers to use the existing Allt Coire Pitridh track keeping clear of construction traffic.

4. The existing stalkers tracks around Loch Bhealaich Leamhain will be utilised after upgrading for construction and operational access as these are the best natural routes to the loch there is no alternative. Access tracks to the low level areas within the Leamhain reservoir will generally be inundated during operation and so are mitigate visually as far as possible. Walkers would be routed around the construction access tracks as far as possible.

5. Options for the Earba tracks included upgrading existing rough tracks to the west of the lochs between Shuas and Shios to improve lochside access along Earba for walkers and cyclists and keep open recreational routes away from the works during construction. This also included adding a new footpath to Binnein Shuas for climbers.

3.3.107 The access track to the powerhouse will require to be suitable for the transport of abnormal and heavy loads including transformers and turbine generator components. The maximum proposed gradient of this track would be 1 in 12 (approximately 8%)

3.3.108 The reasons for the different track widths in different parts of the site is as follows:

1. The main access track between the A86 and the powerhouse would need to be suitable for two way traffic during construction and would be in the order of 8m wide. This would be brought in to 6m wide on completion of the construction.

2. The access between the powerhouse and Leamhain dam and the upper control works would need to be suitable for vehicles to pass during construction and would be in the order of 6m wide. This would be brought in

to 4m wide on completion of the construction, with occasional passing places.

3. The construction access tracks between the powerhouse and the Shios and Shuas dams would be in the order of 8m wide but would lie along the existing track route and within the inundation area of the reservoir. Permanent operational access tracks along the reservoir at 380m elevation would be in the order of 4m wide with occasional passing places.

3.3.109 As a general rule, following completion of construction, all of the main access tracks would be reduced in width; from the A86 to the powerhouse and between the powerhouse and Leamhain dam would be reduced to 6m wide and all other tracks would be reduced to 4m wide with earth bunding and topsoil plus peat turves added on the downhill edge of the tracks to improve the screening of the tracks visually.

3.3.110 No new permanent tracks are proposed East of Leamhain, although existing hill paths and Argo routes may be used to allow emergency access by all-terrain vehicle to the Leamhain Dam in extreme winter conditions, when the main Bhealaich Leamhain track may be snowed in.

3.3.111 Peatland Restoration and other improvements to the local biodiversity along the River Pattack and in other parts of the Ardverikie Estate are planned as mitigation / compensation measures. Any access works required for the peatland and wild habitat restoration will be considered separately from the main PSH construction and operational access.

3.4 Mass Balance and Spoil Management

3.4.1 The planning of the project has focused on ensuring that as far as possible all earthworks materials arising from the civil engineering works are put to good use in construction within the local footprint of the reservoirs.

3.4.2 An important aspect of the mass balance will be that the upper and lower areas of the project aim to achieve mass balance independently, which would avoid significant haul of earthworks materials across the site.

3.4.3 Rock fill and aggregates would be required for the access roads and temporary hardstanding areas as well as for the upper and lower dams.

3.4.4 In the lower Earba area, materials such as aggregates and engineered fill would be sourced from the rock arisings from the underground works, supplemented by selected material from the powerhouse cutting as well as local borrow pits within the reservoirs, as required.

3.4.5 Lower grade rock, sand and gravels being used for the relatively simple embankment dams and local landscaping features within the lower Earba reservoir footprint.

3.4.6 In the upper Leamhain Reservoir area, the Leamhain dam would be formed using rockfill materials sourced from rock borrow pits adjacent to the dam, with unsuitable engineering spoil materials being used to backfill the borrow pits.

3.4.7 The Preliminary Mass Balance calculations for earthworks on the project have been carried out and indicate that, in summary:

1. In the lower Earba area:

   a. The powerhouse and tailrace area cuttings and the whole of the underground tunnelling and shaft works would yield around approximately 3.5Mm3 of rock, soil and gravel arisings.

   b. The lower dams, roads and powerhouse plus tailrace area backfill and rock aggregates for concrete would utilise approximately 3.0Mm3 of rock, sand and gravel. The remaining slight surplus would be used for the loch-side landscaping in the area between the existing Earba lochans, to create planted promontories / peninsulas which will maintain to a degree, the existing views along the Earba glen with the new reservoir in place.

   c. Any additional rock and gravel required would be sourced from Borrow pits BP3 and 4 which all lie within the Earba reservoir footprint.

2. In the upper Leamhain reservoir area, the upper dam would require in the order of approximately 7.0Mm3 of rockfill. This would be sourced locally from borrow pits 5A and 5B upstream of the dam abutments on either side of the dam, as well as from the Intake excavations.

3. The mass balance of earthworks in each of the separate lower and upper areas means that there will not be a requirement to haul bulk materials between the Earba and Leamhain reservoir areas.

4. Furthermore, the project as a whole will maintain an on-site mass balance of earthworks materials, with no requirement for off-site disposal, or indeed any disposal of materials out-with the footprint of the proposed reservoirs.

5. Finally, all surplus peat excavated from the footprints of infrastructure will be put to beneficial use in landscaping, peat restoration and reinstatement works within the site of the Proposed Development or the wider Ardverikie Estate.

6. These are key aspects of the planned sustainability of the civil engineering works for the project.

7. The development of the design of the Borrow Pits are discussed in more detail in the section “Borrow Pits” below.

Construction Borrow Pits (Descriptions and Evolution of their Selection)

3.4.8 Options were considered for all borrow pits, driven by availability of suitable materials and minimising environmental impacts. A key requirement was to find borrow pits within the reservoir inundation footprint to avoid sensitive habitats out-with the reservoir areas - i.e. to locate in reservoir areas where existing habitats would already be disturbed.

3.4.9 Borrow Pit BP1 at Site compound SC1 is a small gravel borrow pit approximately 300m x 50m x 4m deep (excavated to 258 level) which would extend the existing gravel pit towards the Moy Channel and will also form the works access and site entrance compound SC1 at Moy.

3.4.10 A larger borrow pit and works area was initially considered here, but this has been scaled down in size from initial plans in order to fit the smaller works footprint required to avoid the sensitive peatland habitats in the Moy area.

3.4.11 The excavation of the borrow pit will create a low level flat area for the SC1 site entrance operations and laydown areas approximately 4m below the EGL and being in a local depression will provide natural noise barriers around these laydown and works areas.

3.4.12 The stone from BP1 would be used for local hardstandings and for track upgrades between Moy and the Shuas Area.

3.4.13 Borrow Pit 2 BP2 was originally planned to the north of the Powerhouse area, however it was located in an area with some peatland footprint and following further assessment of the required quantities of rock fill, BP2 will not be included in the planning proposals.

3.4.14 Borrow Pit BP3 is a sand and gravel borrow pit located between the existing Earba lochans within the Earba reservoir footprint, approximately 200m x 150m x 5m deep. This would yield up to 150,000m^3 of mixed sand and gravel. The stone and sand would be used for concrete aggregates as well as tracks and the Shios Dam.

3.4.15 Borrow Pit BP4 is a sand and gravel borrow pit to the southwest of Shios Dam within the Earba reservoir footprint, approximately 300m x 50m x 6m deep, which would yield up to 120,000m^3 of mixed sand, gravel and rock. This would be used for fill for the Shios Dam.

3.4.16 A further borrow pit BP 4B was considered on the east side of the lower Earba lochan adjacent to the Shios Dam area but this is closer to a sensitive ornithological site and has therefore not been taken forward for planning.

3.4.17 Borrow pit 5A in the south Leamhain dam abutment would be in the order of 250m x 300m x 40-50m deep on average. This would yield approximately 4.0Mm^3 of rock before bulking applied and approximately 5.5Mm^3 with bulking, of which around approximately 0.6Mm3 would be unsuitable, which would be returned to the borrow pit for backfill.

3.4.18 Borrow Pit 5 B in the north Leamhain dam abutment would be in the order of 300m x 150m x 40-50m deep on average. This would yield approximately 2.5Mm^3 of rock before bulking applied and approximately 3.5Mm^3 with bulking of which approximately 0.30Mm3 would be unsuitable.

3.5 Sustainability Considerations

3.5.1 The iterative design process has sought to reduce the Proposed Development footprint without compromising safety and the long-term security of the infrastructure. This will result in a reduction of raw materials required to construct the Proposed Development, reducing GHG emissions associated with the raw extraction and processing of materials, as well as transport emissions associated with material import. Additionally, there is a reduced area requiring excavation and less waste generated, reducing GHG emissions associated with these activities and waste transportation. These principles will be adopted during the detailed design of the Proposed Development as the individual elements are further refined.

3.5.2 During the design process, due regard has been given to Hydropower Sustainability Guidelines (IHA, 2020). This document sets out international good practice throughout the lifecycle stages of a hydropower project and includes a section on Climate Change Mitigation and Resilience. It includes a series of

design and construction measures to reduce GHG emissions and improve the climate resilience.

3.6 Conclusion

3.6.1 The scheme design and layout has been developed to minimise its footprint on local ecology and habitats.

3.6.2 The scheme would utilise the majority of earthworks arisings within the dam structures and maintain a balance of materials within both the upper and lower parts of the site. This would avoid impacts on local road infrastructure and also avoid long haul routes for earthworks materials within the site, a key feature of the sustainable aims for the Proposed Development.