Loch Kemp Storage - EIA Report

Appendix 3.4: Outline Spoil Management Plan

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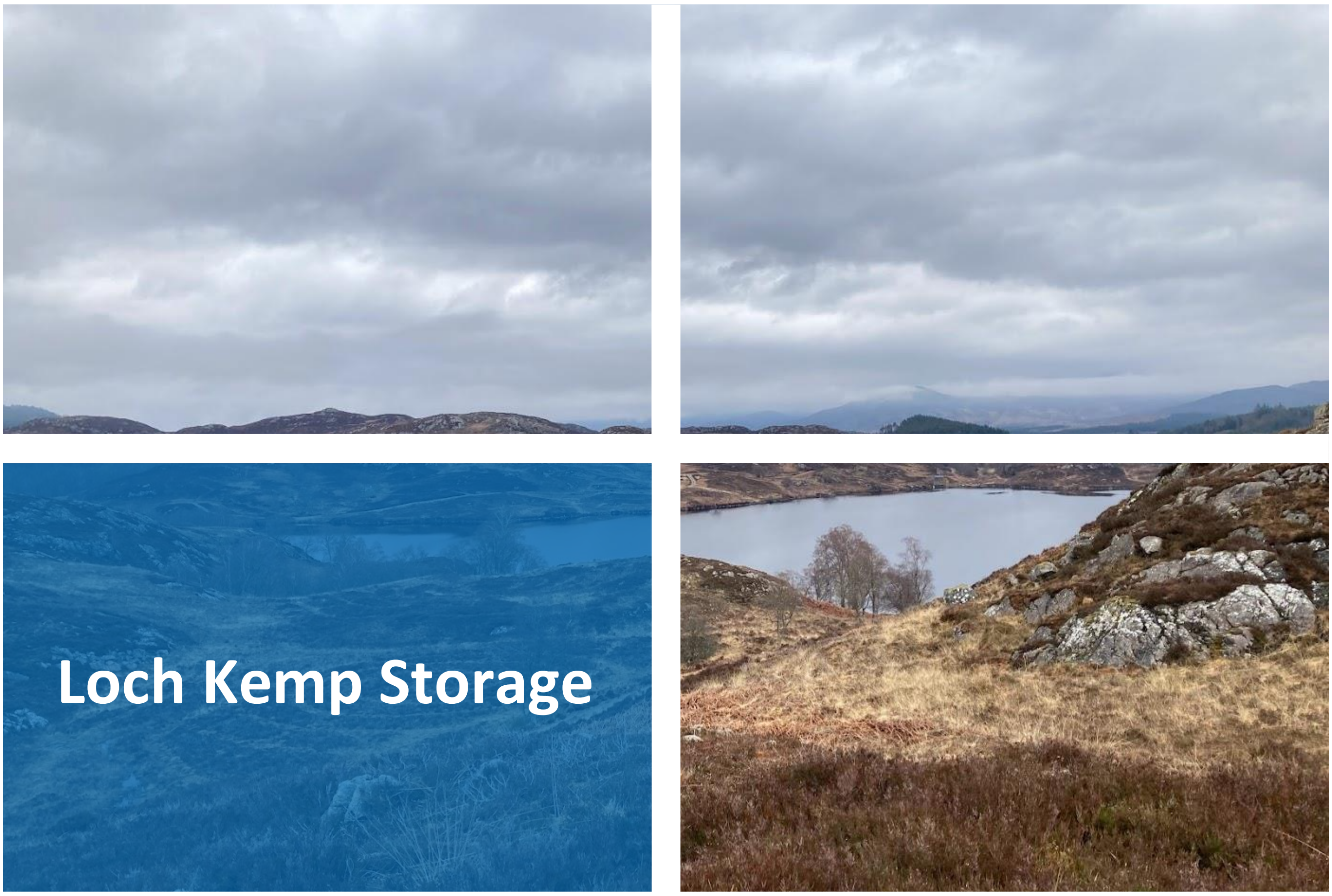

Loch Kemp Storage Ltd

Outline Spoil Management Plan

Loch Kemp Storage

A STATERA COMPANY

ENGINEERING CONSULTING

Document approval

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1	08/08/2023	Update following revised material balance	MJC	TC2
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Contents

1 Introduction

1.1 Background

Fichtner Consulting Engineers (Fichtner) has prepared this Outline Spoil Management Plan to describe how spoil would be managed during the construction of the proposed Loch Kemp Storage pumped storage hydropower scheme (the Proposed Development).

This will be updated following grant of consent from the Scottish Ministers Energy Consents Unit under Section 36 of the Electricity Act (1989) and would form part of the Construction Environmental Management Plan (CEMP) for the Proposed Development. It is intended that this would be updated for approval by the planning authority (on behalf of the Scottish Ministers) prior to commencement of construction. This Outline Spoil Management Plan has been developed to support the application for consent to demonstrate that appropriate management of spoils arising as a result of the Proposed Development has been considered.

The CEMP will include the measures to manage the risks associated with the management of spoil such as dust. As such these are not contained within this Outline Spoil Management Plan.

1.2 Objective

The objectives of this Outline Spoil Management Plan are:

1. To provide an overview of the construction methods to be used with reference to the identifying areas where spoil would be extracted, minimised and provide an estimate of quantities; and
2. To outline how spoil would be managed within the Proposed Development.

1.3 Scoping and consultation

A Scoping Opinion was sought from Scottish Ministers on the environmental information to be provided in the EIA Report. Details of the scoping discussions for the Proposed Development in relation to spoil management are presented in Table 3 of Appendix A.

2 Overview of the Proposed Development

The Proposed Development is to build and operate a new up to 600 Megawatt (MW) pumped storage scheme utilising the existing Loch Kemp as the upper storage reservoir and Loch Ness as the lower reservoir. To allow drawdown for storage, Loch Kemp would be raised by approximately 28 m from its existing 177 m AOD elevation to approximately 205 m AOD. Four new saddle dams between 16 – 34 m high and four minor cut off dams would be constructed around Loch Kemp to form the upper reservoir.

The Proposed Development is situated on Dell Estate approximately 13 kilometres (km) to the north-east of Fort Augustus. The Proposed Development comprises two main areas of work: the upper reservoir works comprising the upper reservoir (Loch Kemp), eight dams and an inlet structure; and the lower reservoir works comprising a powerhouse building, (including administration facilities and visitor facilities), a quayside with a pier and an access tunnel adit on the shore of Loch Ness, linked by a series of underground tunnels (see **Volume 2,** Error! Reference source not found.**Propsoed Development** of the EIA Report). The slopes between the upper and lower reservoir, encompass a combination of woodlands, some of which forms part of the Ness Woods Special Area of Conservation (SAC) designated site whilst the upper area consists primarily of upland moorland and managed land for game shooting.

Access during the construction and operation of the Proposed Development would utilise the existing B862 public road and Dell Estate forestry tracks (to be upgraded and extended) and would involve a new access onto the B862, and the creation of other new access tracks around the site, including a new access track to the lower reservoir works on the shore of Loch Ness.

The principal components of the Proposed Development, which would provide a generating capacity of up to 600 MW with a generation energy storage capacity of up to 9 Gigawatt Hours (GWh), are set out below:

- Dams and Upper Reservoir – Four new saddle dams between 16 – 34 m high and four, minor cut-off dams would be constructed around Loch Kemp to enable the storage of water by increasing the size of the existing Loch Kemp to form the upper reservoir. Rockfill dams are intended to be used where feasible to promote reuse of excavated rock material.
- Underground Waterway System – Screened intakes would feed an underground tunnel system carrying water between the upper and lower reservoirs, through to the powerhouse. The underground waterway system may require a surge shaft for each of the two pressure tunnels located on a local high point.
- Powerhouse Building and Substation – A series of shafts with a surface building located on the shore of Loch Ness would contain reversible pump turbines and motor generators together with associated equipment such as transformers. The powerhouse building would also house administration and visitor facilities. Also located within the powerhouse building would be a 275 kV gas insulated switchgear (GIS) substation, firefighting equipment and an emergency diesel generator.
- Outlet Area - A tailrace structure would be located on the shore of Loch Ness integral with the powerhouse building.
- Quayside and Pier- A quayside would also be constructed adjacent to the powerhouse building and outlet area which would allow the delivery of larger items by boat during construction and operational access to the powerhouse from the loch (including access by members of the public to the visitor centre).
- Access Tunnels - Tunnels would be provided for accessing the underground waterway and cable system.

- Cable Tunnel and Shaft – A short cable tunnel would extend from the access tunnel connecting to a vertical cable shaft to facilitate the grid connection from the powerhouse building. The electricity cables (the subject of a separate consenting process), would be housed within this section of tunnel and would resurface outwith the Ness Woods SAC, to connect by buried underground cable to a new switching station near Loch Kemp (which is also the subject of a separate consenting process.
- Access Roads – A series of temporary and permanent access roads would be provided for the construction of the Proposed Development and for operational and emergency access. Existing estate access and forestry tracks would be upgraded where feasible but new access tracks would also be required. Tracks used for construction would generally be 8 m in width but would be reinstated to 4 m post construction for operation and emergency access.

In addition to the above, it is anticipated that there would be a need for site establishment and laydown areas in the vicinity of the upper reservoir and lower reservoir works. Borrow pits are required to provide aggregate to construct suitable access tracks and site establishment areas, in advance of tunnel spoil being available for use. An indicative main construction compound and indicative locations for site establishment areas and borrow pits are identified on **Volume 2, Figure 3.1: Proposed Development** of the EIA Report.

3 Spoil Management

The project is committed to resource use efficiency and the following hierarchy would be adopted:

1. Reduce;
2. Re-use;
3. Recycle; and
4. Dispose of as waste and an appropriate facility.

3.1 Spoil generation

3.1.1 Spoil generating activities

As part of the Proposed Development excavation of materials would be required to construct the underground access tunnel, pressure tunnels and waterway system, cable shaft, and for the foundations for the powerhouse building.

At this stage, initial desk-based studies and field-studies have been undertaken to inform the preliminary design works included within the concept design. Detailed site investigations will be conducted to support the detailed design process. As such, the quantities presented in this Outline Spoil Management Plan are estimates and would be subject to optimisation during the detailed design process. These will include the following principal structures and features and include geophysical investigations, core drilling, testing in-situ and in laboratory:

- Dams 1 to Dam 8;
- Headrace tunnels;
- Access tunnel;
- Surge shaft;
- Cable shaft;
- Powerhouse shafts;
- Intakes within the Loch Kemp upper reservoir;
- Intakes within the Loch Ness lower reservoir; and
- Borrow pits.

As shown within the preliminary material balance in Appendix B, two construction material options are presented at the Dam 1 structure being either rockfill or roller-compacted concrete (RCC). Whilst the rockfill option presents greater potential for reuse of excavated rock material, the smaller footprint provided by an RCC dam is critical at this location in order to minimise the impact on the Ness Woods SAC ecological site. Similarly, RCC dam elements have been utilised at Dams 4 and 5 to minimise footprint in peat areas or offer greater structural security at areas of impoundment of both dam sides.

There may be the potential for fresh granitic rock excavated to be quarried for concrete aggregates for use on site. However, this is dependent upon the composition of the rock. For instance, mica-rich granites may be unsuitable for use as fine aggregates in concrete due to excessive amounts of fine, platy particles in the crushed products. The suitability for the excavated material to be used as concrete aggregate and used as a structural material within the Proposed Development would be determined following the detailed site investigation works and chemical testing.

3.1.2 Preliminary material balance determination

A preliminary material balance, determined from the concept design volumes, is provided in Appendix B. This includes estimations of material volumes generated through the rock excavation activities at the structures listed above, as well as for the construction of access tracks. The design volumes of the conceptualised project structures are also present, subject to optimisation in detailed design process.

From the geological information available at the project structures, the estimated spoil material generation and structural compacted rockfill generated as a result of excavation works are calculated, in conjunction with bulking and compaction factors (detailed in section 3.1.3).

As a precautionary measure within this assessment, it is assumed that only 50% of excavated material at the project structures will be of a quality sufficient for reuse in structural applications (before the application of any bulking/compaction factors). Whilst the remaining 50% of unsuitable material would be instead only suitable for reuse in backfill applications. Where geological mapping and geotechnical assessments have indicated rock mass of high quality for construction, a higher two-thirds (67%) yield of structural reuse rock mass and a lower generation of spoil for backfill of one-third (33%) are assumed. From the concept design, this is assumed to be the case at the majority of the underground structures (waterway pressure tunnels, main access tunnel, cable tunnel, intake excavation) where the surrounding rock mass quality is of critical importance. The factor used for each structure within the Proposed Development is listed within the preliminary material balance in Appendix B.

The assumptions set out within this Outline Spoil Management Plan, and their respective impacts upon the material balance, should be reassessed following the completion of detailed ground investigation works and within the detailed design process to minimise the impact and generation of spoil material from the Proposed Development.

3.1.3 Material volume compaction/bulking factors

The factors presented in Table 1 have been used within the preliminary material balance to represent the physical characteristics of in-situ rock mass after excavation, compaction and bulking processes.

Table 1: Material volume factors

Material type	Material volume factor of solid rock excavation volume	Justification
Uncompacted excavated material	1.50	Uncompacted excavated material is assumed to occupy 150% of the volume of in-situ rock mass due to being uncompacted with high quantity of void space within material.
Compacted spoil material	1.30	Compacted spoil material is assumed to occupy 130% of the volume of in-situ rock mass due to processing on site and prior to reinstatement within backfill locations and borrow pits where used.
Compacted structural material	1.20	Compacted structural material is assumed to occupy 120% of the volume of in-situ rock mass due to further compaction during processing than is typically conducted for spoil. This is to reduce

Material type	Material volume factor of solid rock excavation volume	Justification
		void space and enhance the structural properties of the material. Typically a bulking agent is added to the matrix to fill any remaining void space to further enhance the structural properties of the overall material.

The determination of preliminary material balance estimates presented in section 3.1.4 are a result of the assumptions from section 3.1.2 and the factors set out in Table 1 of section 3.1.3.

3.1.4 Material balance totals

As shown within the preliminary material balance in Appendix B, a total estimated c.1,125,000 m^3 of material that would be excavated as a result of the structures within the Proposed Development.

From the total excavation, an estimated c.680,000 m^3 of structurally suitable compacted rock mass would be generated (based on the factors set out in sections 3.1.2 and 3.1.3).

Meanwhile, an estimated c. 838,000 m^3 of spoil material would be generated which would not be suitable for reuse in structural applications but would be suitable for backfilling applications.

The design volume estimated from the concept design requires a total of c.608,000 m^3 of rock suitable for structural applications. As such, it is anticipated that almost all of the design volume rockfill requirements of the Proposed Development can be met from material yielded as a result of excavation of the project structures. At the early stages of construction and prior to excavation of the project structures, an import of material would be required for the establishment of the initial access routes from the B862 site access to site excavation areas. It would be necessary for this to be externally sourced quarried material. The volumes of materials required for this are to be confirmed during the detailed design and opportunities to utilise borrow pit sources will be utilised as much as possible.

The surplus structural rockfill (c.72,000 m^3) generated as a result of the excavation of project structures which cannot be accommodated within the design volume is anticipated to be mostly reused as aggregates for structural concrete on site or within backfill applications on site. After compaction of both the spoil material and surplus rockfill to compacted spoil material (factor set out in Table 1 of section 3.1.3), a total compacted spoil volume of c.674,000 m^3 is anticipated.

When considering the precautionary factors assumed within sections 3.1.2 and 3.1.3, it is hoped that a greater percentage of rock excavated at the Proposed Development would be suitable for reuse within structural applications. This is particularly the case for material yielded from underground works or at the intake structures where favourable rock quality is expected from available geological and geotechnical information. It is expected that the results of detailed ground investigation works would inform the effect of this upon the preliminary material balance. As a result of potentially higher percentage yields of structurally suitable rock material in some of the major excavation works, the corresponding spoil generation percentages from these activities would be lower, in turn reducing the overall spoil generation volume of the Proposed Development.

3.2 Spoil re-use

3.2.1 Re-use on-site

Within the concept design of the Proposed Development, six additional areas were initially identified for being potentially suitable areas for the reuse or deposition of spoil generated during construction. The potential design volume of the areas identified are displayed in Table 2.

Table 2: Potential spoil re-use areas

Area description	Potential backfill volume (m^3)
Dam 3 downstream fill up to elevation 201.5 m AOD (planted dam tail)	400,100
Reservoir fill SW of Dam 3	424,100
Dam 5 downstream fill up to elevation 201.5 m AOD (planted dam tail)	195,600
Valley fill to north of Proposed Development	146,800
North of Dam 2, fill up to elevation 205 m AOD	215,100
Reduced excavation at Kemp inlet	133,000

Assessment of the areas listed in Table 2 suggested that the latter four areas were deemed unsuitable for reuse due to a combination of environmental, topographical, and engineering feasibility constraints. Therefore, the suitable areas identified within the Proposed Development are the area downstream of the Dam 3 structure and the reservoir fill SW of Dam 3 with a cumulative spoil reuse capacity of 824,200 m^3. With the total compacted spoil volume of c.674,000 m^3 listed in section 3.1.4, it is anticipated that that all spoil generated by the Proposed Development would be able to be reused on site, with a surplus potential backfill volume of c. 150,000 m^3 (an additional 22.3% of the total compacted spoil volume).

Furthermore, the backfilling of these two areas would allow planting of native tree species in a tiered natural barrier to reduce the landscape visual impact of Dam 3, the largest above ground structure within the Proposed Development.

3.2.2 Use of spoil off-site

It is the intention that all spoil would be re-used on site, based on the precautionary measures set out within section 3.1.2. However, should the results of the ground investigation works alter the detailed design to the point where an excess of spoil material would be generated that could not be managed on site, off-site transportation would be required. Due to the initial estimates within the preliminary material balance, the exact use of this material is not known, however it is expected that this would be used as aggregate in the construction industry.

Any spoil removed from the site would be tracked and recorded. This would be transported from site using an appropriate licenced contractor. Contractors would be required to provide tracking receipts to confirm appropriate disposal of spoil from the Proposed Development.

Haulage routes associated with the movement of spoil which cannot be re-used on site should be described in the Construction Traffic Management Plan. It is thought that for significant volumes of material being transported off-site, the use of barges from Loch Ness to Inverness Port would be most appropriate to minimise the road and traffic impacts on the surrounding communities.

4 Management and Monitoring

This Outline Spoil Management Plan has been produced to support the application for consent for the Proposed Development under Section 36 of the Electricity Act (1989). This will be reviewed prior to commencement of construction works once the detailed site investigations and detailed design works have taken place, with the intention of optimising reuse of excavated material on site. Thereafter, the approved Spoil Management Plan would be a live document and reviewed annually during the construction period as a minimum. The development and management of the Spoil Management Plan would be the responsibility of the Principal Contractor.

Once the ground conditions are assessed through detailed ground investigation works, the usability of the excavated spoil material would be better understood. As such, an updated material balance would be produced which would, in turn, determine an updated additional structural rock material requirement from borrow pits, as detailed in the Volume 4, Appendix 3.5: Draft Borrow Pit Screening Report of the EIA Report.

Spoil would be managed on-site within the Proposed Development boundary by transferring the material internally from the excavation sites to the processing, laydown and final reuse areas. Physical and chemical testing would be conducted on material samples before transfer to reuse areas. The excavated material would be processed on-site to meet the required grain sizes and structural properties. In order to yield the required grain sizes, the blasting pattern would be managed to ensure that the resulting particle size adheres to the requirements of the structural reuse specifications, particularly in the case of dam structures for safety reasons.

Material would be transported using suitable HGVs, typically a 20-40 tonne tipper truck. An emphasis should be made by the Principal Contractor on minimising distance between extraction testing, and reuse areas to reduce the construction traffic volume required for spoil management and therefore, the respective environmental, social and health impacts.

It is the intention that all spoil would be re-used on site however, should the detailed design change to the point where an excess of spoil material would be generated that could not be managed on site, off-site transportation would be required. At this stage, the exact use is not known but it is expected that this will be used as aggregate in the construction industry.

5 Summary and Conclusions

This Outline Spoil Management Plan has been prepared to demonstrate that appropriate management of spoils arising as a result of the Proposed Development has been considered.

This will be reviewed prior to commencement of construction works once the detailed ground investigations and detailed design works have been conducted, with the intention to reuse as much of the excavated material on site. The development and management of the Spoil Management Plan will be the responsibility of the Principal Contractor.

Excavation of material would be required to construct the underground waterway system, cable tunnels and shaft, access tunnels, and the foundations for the powerhouse building and substations. The suitability of the excavated material to be used as concrete aggregate and used as a building material within the site and exported off-site will be determined following the detailed site investigation works and chemical testing. However, based on the preliminary studies, it is anticipated that all excavated material will be suitable for either structural reuse or as backfill material within the Proposed Development. Therefore, at this stage, it is not anticipated that disposal of spoil material offsite is required.

The excavated spoil will be managed on-site by transferring the material internally from the excavation sites to the re-use areas in project structures and temporary laydown areas using suitable HGVs. It is the intention that all spoil would be re-used on site however, should the detailed design change to the point where an excess of spoil material would be generated that could not be managed on site, off-site transportation would be required. At this stage, the exact use is not known, but it is expected that this will be used as aggregate in the construction industry.

Appendices

A Scoping Consultation Discussions

Table 3: Scoping discussions

Consultee	Consultee response	Responding comment
Scottish Ministers ECU – 07	Ministers note and welcome the proposal to including a spoil management plan and would encourage use of spoil on site (e.g. in dam construction) and details should be provided where possible on other developments where otherwise spoil may be used rather than sent to waste. As stated by the planning authority a specific chapter on forestry should be included setting out where the Control of Woodland Removal policy applies and how compliance has been demonstrated.	*This spoil management plan details the locations, estimated volumes and nature of spoil/material that will be translocated throughout the construction phase of the Proposed Development.* *Proposals on forestry, felling, translocation and compensatory planting (in line with the Control of Woodland Removal policy) are detailed in* ***Volume 1, Chapter 19: Forestry*** *of the EIA Report.*
Scottish Environmental Protection Agency (SEPA) – 8	In relation to section 8 of the attached appendix (borrow pits) and rock and overburden excavation generally as outlined in section 13 and elsewhere in scoping report: • SEPA welcome the proposal to include a spoil management plan. This should include information in relation to the type and volumes of material that will be excavated on site accompanied by clear information on temporary storage (which is likely to require an extensive area), reuse on site and use or disposal elsewhere. Any material that cannot be appropriately used within the site works will be considered waste and waste management legislation would apply. • In view of the extensive volume of excavated material being produced we do not expect the development to include additional borrow pits. • The information requirements outlined in section 8.2 of the appendix should be provided insofar as they are relevant to the excavation works proposed. • Storage locations should be as close to the excavated area as possible and avoid local sensitivities such as watercourses.	*This Spoil Management Plan has been developed in line with SEPA's advice and has been included as an Appendix to the main EIA Report. Section 3.2.1 includes information on Spoil Locations. Potential traffic associated with the removal and transportation of spoil materials will is outlined in* ***Volume 1, Chapter 16: Traffic, Access and Transport*** *of the EIA Report (and* ***Volume 4 Appendix 14.1: Transport Assessment****) but at this stage it is anticipated that the spoil material will all be used on-site and will therefore not be transported off-site, as detailed in Section 3.2.2 of this Report.* *At least one borrow pit have will be required to construct the new access track from the B862 and other enabling works. Although the intention is to limit the use of additional borrow pits, a number of potential borrow pits have been identified and included in the application for the Proposed Development in case they are required. Where possible, these potential borrow pits have been located within the area that will be 'lost' to the inundation area once the Proposed Development is operational. Further details are provided in* ***Volume 4, Appendix 3.5: Draft Borrow Pit Screening Report*** *of the EIA Report. "*

Consultee	Consultee response	Responding comment
	• There may be significant transportation issues with removal of any of the material from the site so, although not an issue directly within our remit, we recommend that the assessment includes information on transport implications.	
Scottish Environmental Protection Agency (SEPA) – 10	In relation to section 9 (pollution) we can confirm that from our perspective an outline CEMP need not be provided with the application. This is on the understanding that: (1) the proposed Spoil Management Plan will address all aspects of spoil management (minimisation, handling, processing, reuse on site, reuse off site and if required disposal) and any related waste management, (2) Peat management is covered by a Peat Management Plan (3) detailed site plans are submitted which demonstrate how impacts on the environment have been minimised through design and (4) all mitigation is detailed within a suitably robust schedule of mitigation. This approach will hopefully help streamline the overall information and assessment requirements.	*An outline CEMP listing the topics that would be included in the CEMP developed by the Principal Contractor is included as* ***Volume 4, Appendix 3.3*** *of the EIA Report, however this Spoil Management Plan, a Peat Management Plan and a Schedule of Mitigation have also been included as Appendices to the EIA Report (see* ***Volume 4, Appendices 3.4, 14.1*** *and* ***3.2*** *respectively).* ***Volume 1, Chapter 2: Design Evolution and Alternatives*** *of the EIA Report provides details on how impacts on the environment have been minimised through design and is supported by site plans.*

B Preliminary Material Balance

Loch Kemp - Preliminary Material Balance

Description	*Spoil Generation Factor*	*Usable Rockfill Factor*	*Solid Volume (Excavation) (m³)*	*Spoil Material Generated (m³)*	*Compacted Rockfill Generated (m³)*	*Design Volume (m³)*	*Concrete Required incl. Shotcrete (m³)*
Loch Kemp - Upper Reservoir							
Dam 1							
Option 1 - Rockfill Dam							
- Tip/Overburden Excavation if required for Dam Seat (Rockfill Dam) (Assumed Rock Surface estimated 2m average)	50%*1.5	50%*1.2	19,400	14,550	11,640		
- Material to be used in Rockfill Dam				120,200		240,400	
Option 2 - RCC Dam							
- Tip/Overburden Excavation if required for Dam Seat (RCC Dam) (Assumed Rock Surface estimated 2m average)	50%*1.5	50%*1.2	10,000	7,500	6,000		
- Material to be used in RCC Dam						61,350	1,740
Dam 2							
- Tip/Overburden Excavation if required for Dam Seat (Assumed Rock Surface estimated 2m average)	50%*1.5	50%*1.2	1,400	1,050	840		
- Material to be used in Rockfill Dam						3,000	966
- Material to be used in RCC Dam							
Dam 3							
- Peat (Assumed Depth 2m average)	100%*1.5		57,000	85,500			
- Tip/Overburden Excavation if required for Dam Seat (Assumed Rock Surface estimated 2m average)	50%*1.5	50%*1.2	28,500	21,375	17,100		
- Material to be used in Rockfill Dam						378,700	2,142
Dam 4							
- Tip/Overburden Excavation if required for Dam Seat (Assumed Rock Surface estimated 2m average)	50%*1.5	50%*1.2	2,320	1,740	1,392		
- Material to be used in RCC Dam						17,300	260
Dam 5							
- CFRD							
- Tip/Overburden Excavation if required for Dam Seat (Assumed Rock Surface estimated 2m average)	50%*1.5	50%*1.2	8,820	6,615	5,292		
- Material to be used in Rockfill Dam						59,900	1,743
- RCC Dam							
- Tip/Overburden Excavation if required for Dam Seat (Assumed Rock Surface estimated 2m average)	50%*1.5	50%*1.2	1,190	893	714		
- Material to be used in RCC Dam						7,800	
Dam 6							
- Tip/Overburden Excavation if required for Dam Seat (Assumed Rock Surface estimated 2m average)	50%*1.5	50%*1.2	990	743	594		
- Material to be used in Rockfill Dam						4,300	378
Dam 7							
- Tip/Overburden Excavation if required for Dam Seat (Assumed Rock Surface estimated 2m average)	50%*1.5	50%*1.2	720	540	432		
- Material to be used in Rockfill Dam						1,900	378
Dam 8							
- Tip/Overburden Excavation if required for Dam Seat (Assumed Rock Surface estimated 2m average)	50%*1.5	50%*1.2	730	548	438		
- Material to be used in Rockfill Dam						800	420
Waterway							
Intake + Gate Shaft							
Surface Excavation	50%*1.5	50%*1.2	267,200	200,400	160,320		
Underground Excavation	1/3*1.5	2/3*1.2	22,400	11,200	17,920		
Access Road	50%*1.5	50%*1.2	30	23	18	15,400	
Concrete							16,800
Shotcrete							10,600
Surge Shaft							
Excavation							
Concrete							
Headrace Tunnel / Shaft							
Pressure Shaft	1/3*1.5	2/3*1.2	9,600	4,800	7,680		2,400
Concrete Lined Tunnel	1/3*1.5	2/3*1.2	97,100	48,550	77,680		26,300
Steel Lined Tunnel	1/3*1.5	2/3*1.2	28,400	14,200	22,720		11,500
Bifurcation Tunnel	1/3*1.5	2/3*1.2	2,600	1,300	2,080		1,100
Shotcrete							10,900
Powerhouse Area							
Powerhouse (underground)							
Excavation Shaft	50%*1.5	50%*1.2	95,500	71,625	57,300		
Excavation Access Gallery (between both Shafts)	50%*1.5	50%*1.2	450	338	270		

Excavation Tailrace Outlet	50%*1.5	50%*1.2	26,300	19,725	15,780		
Concrete							76,600
Shotcrete							3,600
Main Access Tunnel							
Excavation	1/3*1.5	2/3*1.2	25,500	12,750	20,400		
Shotcrete							2,300
Access Tunnel to Cable Shaft; Cable Shaft; Top Building Excavation							
Excavation	1/3*1.5	2/3*1.2	8,000	4,000	6,400		
Shotcrete							900
Concrete							240
Access Track							
Access Track within SAC							
Excavation incl. Powerhouse Surface Excavation	50%*1.5	50%*1.2	270,160	202,620	162,096		
Backfill						3,923	
Access Track outside SAC (excl. Dam Crest Road)							
Excavation	50%*1.5	50%*1.2	160,000	120,000	96,000		
Backfill						53,296	
Total material balance:			**1,124,910**	**838,033**	**679,466**	**607,669**	**171,267**

Balance	***Spoil Compaction Factor***	***Usable Rockfill Factor***	***Solid Volume (Excavation) (m³)***	***Spoil Material Generated (m³)***	***Compacted Rockfill Generated (m³)***	***Design Volume (m³)***	***Concrete Required incl. Shotcrete (m³)***
Uncompacted Spoil Volume				838,033			
Compacted Spoil Volume (incl. surplus structural rockfill)	**1.3**			673,621			
Additional fill areas volume							
Dam 3 Downstream Backfill						400,100	
Reservoir fill SW of Dam 3						424,100	
Dam 5 downstream fill up to elevation 201.5 m AOD (planted dam tail)						*195,600*	
Valley fill to north of Proposed Development						*146,800*	
North of Dam 2, fill up to elevation 205 m AOD						*215,100*	
Reduced excavation at Kemp inlet						*133,000*	
Total additional fill area available						**824,200**	
Surplus potential backfill volume in additional fill areas						**150,579**	
Surplus potential backfill volume as percentage of total excavation (%)						22.35%	
Estimated outstanding spoil material (m³)						**0**	
Percentage of total excavated material anticipated to be reused within Proposed Development (%)						**100.00%**	

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