Chapter 7 – Water Management - Contents

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7. Water Management

7.1 Executive Summary

7.1.1 The Proposed Development is to build and operate a new pumped storage hydro (PSH) scheme with an installed capacity of up to 600 Megawatt (MW), 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.

7.1.2 The lower reservoir, Loch Ness, is approximately 36 km long and has a surface area of approximately 56 km^2. The water level in Loch Ness is currently controlled by the weir at Dochfour, the structure is known as 'Ness Weir'. The construction of the existing PSH scheme at Foyers led to a modification of the weir to install two sluice gates to provide a minimum flow into the River Ness in dry conditions. The Caledonian Canal also has a set of lock gates at Dochgarroch which are regulated by a CAR licence dictating water consumption from Loch Ness. CAR licences are also existing for the Foyers PSH scheme and the consented PSH scheme Red John.

7.1.3 The minimum navigable Loch Ness level for the Caledonian Canal is 15.27 m AOD. The Applicant understands that SSE formed an agreement with the then British Waterways (now Scottish Canals) to maintain Loch Ness levels above 15.27m AOD. This prevents Foyers PSH from pumping water should Loch Ness levels approach this level. The average available operating range in Loch Ness is approximately 0.55 m, this assumes drawing down Loch Ness from the average water level to the minimum level for canal navigation. The maximum annual range is 1.14 m which assumes drawing down from the median annual maximum flood water level to the minimum level for canal navigation.

7.1.4 The Proposed Development would release compensation flow from the foot of Dam 1 on the Allt an t Sluichd, which is the natural outlet of Loch Kemp. The flow would be regulated to mimic the natural conditions in the burn at a volume to be agreed with SEPA as part of the CAR licence. During construction of the Proposed Development, the construction of Dam 1 would maintain the natural outflow from Loch Kemp into the Allt an t Sluichd.

7.1.5 The Proposed Development would only operate between agreed minimum and maximum levels of Loch Ness. These shall be within the operating ranges of existing and consented PSH schemes on Loch Ness to avoid additional impact to the extremes of level in Loch Ness. A stop generating level is proposed to protect against adverse impacts in terms of flooding when the Loch Ness level exceeds the estimated 1-in-10 year flood. A stop pumping level is proposed to prevent operation during extreme low loch levels in Loch Ness to safeguard operation of the Caledonian Canal and for other water users.

7.1.6 A hydrological model has been prepared to simulate Loch Ness levels according to inflows, outflows and operation of pumped storage schemes. Level duration curves were plotted of the modelled loch levels over a simulated 50 year period. The model shows that operation of all three schemes would cumulatively have a minor impact on Loch Ness levels. The level exceeded 90% of time is increased by 1 cm by adding the Proposed Development. The largest change to loch levels occurs around L70 (level exceeded 70% of the time), where the loch level is reduced by 10 cm. These changes are considered minor in the context of the annual variation of the loch of over 1 m.

7.2 Introduction

7.2.1 The Proposed Development comprises a system to transfer water between Loch Ness (lower reservoir) and an upper reservoir created by enlarging the existing Loch Kemp (upper reservoir). This Chapter presents a summary of the baseline hydrological conditions and a review of the water management strategy for the Proposed Development. Details of the Proposed Development are included in **Chapter 3: Description of Development**. An assessment of potential effects on water-based recreation is included in **Chapter 9: Land Use and Recreation** and an assessment of potential effects on the water environment (hydrology and hydrogeology) is included in **Chapter 14: Geology, Soils and Water**.

7.2.2 This Chapter has been prepared by [redacted] of Fichtner Consulting Engineers Limited and [redacted] of Mott MacDonald Limited. A table presenting relevant qualifications and experience of key staff involved in the preparation of this Chapter is included in **Volume 4, Appendix 4.1: EIA Team**, contained within Volume 4 of this EIA Report.

7.2.3 This Chapter is supported by:

- Volume 2, Figure 7.1: Loch Ness Hydrological Catchment Area;
- Volume 2, Figure 7.2: Major Water Features and Hydro Development;
- Volume 2, Figure 7.3: Historic Loch Ness Levels with Pumped Hydro Curtailment Levels;
- Volume 2, Figure 7.4: Ness Weir Overview; and
- Volume 4, Appendix 7.1: Loch Ness PSH - Hydrological Modelling Technical Note.

7.3 Scope of Assessment

Study Area

7.3.1 The Study Area for this Chapter comprises the Loch Ness Hydrological Water Catchment Area, as illustrated in **Volume 2, Figure 7.1: Loch Ness Hydrological Catchment Area.** Major water features within the Loch Ness Hydrological Water Catchment Area are illustrated in **Volume 2,Figure 7.2: Major Water Features and Hydro Development** and are referenced in this Chapter where relevant**.**

Consultation Responses

7.3.2 The scope of the assessment has been determined through a review of the Scoping Opinion and consultation with stakeholders.

7.3.3 Scoping responses received relevant to Water Management are summarised in **Table 7.1: Consultation Responses.**

Table 7.1: Consultation Responses

Consultee	Consultation Type	Summary Response	Comment/Action Taken
THC	Scoping	THC strongly advice early consultation with SEPA to identify if a CAR license is necessary and the extent of the information required by SEPA to assess any license application	The Applicant has engaged with SEPA about obtaining a CAR licence and communication on this matter is ongoing.
		THC advise that if culverting should be proposed, either in relation to new or upgraded tracks, then it should be noted that SEPA has a general presumption against modification, diversion or culverting of watercourses.	Culverts will be required for track drainage. There are two burn crossings at Dam 1 and Dam 4. In each case, the Dam structure will provide the crossing. Details on culverts and watercourse crossing are provided in **Chapter 14: Geology, Soils and Water** and **Volume 4, Appendix 14.3: Schedule of Watercourse Crossings**.
		THC advise that schemes should be designed to avoid crossing watercourses, and to bridge watercourses where this cannot be avoided.	Noted
		THC advise that the EIA Report will be expected to identify all water crossings and include a systematic table of watercourse crossings or channelling, with detailed justification for any such elements and design to minimise impact, accompanied by photography of each watercourse affected and dimensions of the watercourse.	Details on watercourse crossings are provided in the Chapter 14: Geology, Soils and Water and Volume 4, **Appendix 14.3: Schedule of Watercourse Crossings**.
		THC recommend that it may be useful to demonstrate choice of watercourse crossing by means of a decision tree, taking into account factors including catchment size (resultant flows), natural habitat and environmental concerns.	Details on watercourse crossings are provided in the **Chapter 14: Geology, Soils and Water** and **Volume 4, Appendix 14.3: Schedule of Watercourse Crossings** but this is not considered relevant given that there are only two water crossings, both of which occur at dam structures, which are integral parts of the project.

		THC note the need for, and information on, abstractions of water supplies for concrete works or other operations should be identified. The EIA Report should identify whether a public or private source is to be utilised. If a private source is to be utilised, full details on the source and details of abstraction need to be provided.	This issue was addressed in a letter (sent via email) from to THC on the 25th May 2022. Any impact on water resources due to abstraction will be described in the CAR licence application. **Chapter 14: Geology, Soils and Water** identifies licenced water abstractions, private water supplies and potential impacts to water resources and proposes mitigation measures where appropriate.
		THC advise that the Applicant will be required to identify any private water supplies, including pipework, which may be adversely affected and submit details of the measures proposed to prevent contamination or physical disruption. An on site survey will be required.	There is one Private Water Supply within the Site classed as a surface water abstraction from Loch Paiteag, located at NGR 247402 815421. It serves six properties within Dell Estate, which are party to the Application. It has been agreed that the Dell Estate water supply will be re-routed to avoid any potential impact. Further details are provided **Chapter 14: Geology, Soils and Water**.
		THC advise that the operator of Red John PSH should be part of the discussion on water management as it is a scheme with an extant consent.	This issue was addressed in a letter (send via email) from ASH to THC on the 25th May 2022. This letter notes that the Developer will take this comment on board and will seek to engage in discussion with the operator of this scheme. The Applicant made contact with the Developer of Red John PSH (via phone and email) to request whether they could provide information on their agreement on their stop pumping level to inform the hydrological modelling for the Proposed Development. The Developer of Red John PSH responded (via email) to confirm that they are unable to share this information due to their Non-disclosure Agreement (NDA) with SSE Renewables. However, **Section 7.9** of this Chapter includes a cumulative assessment, which considers the cumulative impact of the Proposed Development

			and other pumped storage schemes on water levels in Loch Ness, including Foyers PSH and Red John PSH.
		THC's Flood Risk Management Team have set out that the application should include a Flood Risk Assessment and Drainage Impact Assessment (DIA).	This issue was addressed in a letter (send via email) from ASH (with input from SLR) to THC on the 25th May 2022. **Chapter 14: Geology, Soils and Water** presents a screening assessment of flood risk sources and principles that would be adopted to control and manage the rate and quality of runoff shed from site during the construction phase of the project. A DIA for the construction phase would be included in the CEMP, which would be prepared following granting of planning permission and it is anticipated would be secured by a planning condition. Measures to manage runoff during construction would also be agreed with SEPA following grant of planning and in accordance with a Construction Site Licence as required by the Controlled Activity Regulations (CAR). Flood risk during the operational phase of development would be controlled and managed by a separate CAR authorisation which would be agreed with SEPA.
SEPA	Scoping	If water abstraction or dewatering are proposed, a table of volumes and timings of groundwater abstraction and related mitigation measures should be provided.	Abstraction and discharge rates between the lower and upper reservoirs during operation are described in **Section 7.8** of this Chapter. Water abstraction from Loch Kemp and Loch Ness will likely be required during construction but this would be secured separately by a CAR authorisation.
		SEPA ask for consideration to be given to effects on salmon smolt movement from Loch Dochfour into the River Ness, an issue SEPA is currently considering. This can be discussed further as part of CAR pre-application discussions.	An assessment of the potential impacts of the Proposed Development on salmon smolts is discussed further in **Chapter 13: Fish.**
		Due to the steep slopes and potential for pollution, SEPA advise that there needs to be a significant buffer between the track down	The buffer between the access track down to the lower reservoir works and the All a'Chinn Mhoraich will be as large as possible but the

		to the outlet and the All a'Chinn Mhoraich. Areas of existing track that cannot be used should be identified for restoration.	topography in this area is challenging for track construction so the opportunity to microsite the track is limited. Changes to the access track to the lower reservoir works to increase the buffer between the track and this watercourse are detailed in **Chapter 2: Design Evolution and Alternatives.** This issue is addressed further in **Chapter 14: Geology, Soils and Water.**
		SEPA advises that a detailed drawing of the potential pier or loading area in Loch Ness should be provided accompanied by as assessment of effects on the water body	The causeway which extends out into Loch Ness, as previously presented to SEPA as part of previous design iterations for the Proposed Development, is no longer part of the site design, as described in **Chapter 2: Design Evolution and Alternatives**). The design of the quayside and pier has been updated to a smaller footprint, which both extensions to the powerhouse platform- drawings of the quayside and pier area during construction and operation are included in **Volume 2, Figures 3.4: Indicative Layout of Lower Reservoir Works – During Construction** and **Figure 3.5: Indicative Layout of Lower Reservoir Works – During Operation** respectively.
Scottish Canals	Scoping	SC request that the assessment should consider cumulative effects, along with the existing schemes at Foyers, Glen Doe and the approved 'Red John' scheme on Water Management, including canal operational considerations, asset fatigue through increased fluctuation and effects to flows to the River Ness from the Ness Weir on Loch Dochfour or other proposed alternative, taking cognisance of seasonal variations and considerations or implications to migratory species.	**Section 7.9** of this chapter provides a cumulative assessment of the impact of the Proposed Development in combination with other operational and consented PSH schemes on Loch Ness on loch levels. An assessment, including a cumulative assessment, of the potential impacts of the Proposed Development on migratory fish species is included in **Chapter 13: Fish.**
		SC advise that the impacts of fluctuating water levels on the lock operations by both operational and non-SC staff also needs to be considered	SC has been consulted during the EIA process, as detailed in **Chapter 5: Scoping and Consultation**. Due to the loch level curtailment / stop pumping level that would be in place for all PSHs on Loch Ness, as described in **paragraphs 7.9.1** and **7.9.3** of this Chapter, Foyers PSH operation would remain the driver of any impacts on lowest loch levels

			which may impact lock operations. Potential impacts on boat moorings considered in **Chapter 9: Land Use and Recreation**.
		SC advise that sediment deposition from non-controlled river discharges create deltas within the canal. The Dochfour Burn in particular creates a hazard to navigation during normal water levels and fluctuating water levels make the requirement to dredge the outfall of Dochfour Burn more frequent and urgent. The creation of a stilling basin on the Dochfour Burn upstream of the discharge point to the canal should be assessed as a possible solution in dealing with the sediment delta deposited in the canal, at low water levels.	Controls to limit the potential for sedimentation (and therefore shallows in navigable waterbodies) in presented **in Section 14.7** of **Chapter.14: Geology, Soils and Water**.
		SC has a smolt sluice adjacent to the Dochgarroch Lock which must be fully operational between 1st April to 1 July annually. The assessment should consider the impact of fluctuating water levels on the smolt sluice and the fish pass within the Ness Weir.	Due to the loch level curtailment / stop pumping level that would be in place for all PSHs, as described in **paragraphs 7.9.1** and **7.9.3** of this Chapter, Foyers PSH operation would remain the main driver of impacts on the fish pass within the Ness Weir, as the stop pumping level of the Proposed Development is higher than this level. The smolt chute and sluice are located at slightly higher elevation and this issue is considered further in **Chapter 13: Fish**.
Stratherrick and Foyers Community Council	Scoping	The Stratherrick and Foyers Community Council are also concerned about the cumulative impacts of this and other operational / proposed schemes on Loch Ness and ask for calculations and estimates of the effects on hydrology.	**Section 7.9** of this chapter provides a cumulative assessment of the Proposed Development and other operational and consented PSH schemes on Loch Ness on the loch levels.
Ness District Salmon Fisheries Board (Ness DSFB)	Scoping	Foyers PSH abstracts and discharges, on a daily basis, more water than would flow down the River Ness during a moderate size spate. Consequently, Foyers PSH already affects water levels in Loch Ness, and River Ness, but the cumulative impact of three PSH schemes in Loch Ness on downstream river levels is significantly greater, and potentially quite destructive to other interests e.g.	The Developer has been in discussions with SC since July 2021 and is carrying out hydrological modelling to assess the range of impacts on Loch Ness, taking account of the existing Foyers PSH operation and the consented Red John PSH scheme. Due to the loch level curtailment / stop pumping level that would be in place for all PSHs on Loch Ness, as described in **Sections 7.9.1** and **7.9.3** of this Chapter, Foyers PSH

		angling, but also to the ecology of the River Ness. The flow regulating sluices installed at Dochfour Weir to try and regulate flows in the River Ness are only partially successful. A potential scenario whereby all three Ness PSH schemes abstract, simultaneously, during low loch levels, could result in record low water levels in Loch, the River Ness, as well as in the Caledonian Canal. Predicted climate-induced effects include greater duration and frequency of water scarcity in future. The cumulative impact of these schemes will have potential to exacerbate existing issues.	operation would be remain the driver of any impacts on the loch level and on the Ness Weir, as the stop pumping level of the Foyer would be lower than the stop pumping levels applied to Red John PSH (if constructed) and/or the Proposed Development, meaning Foyers would be able to draw down Loch Ness water levels lower than these schemes, either in isolation or in-combination. **Section 7.9** of this chapter provides a cumulative assessment of the impact of the Proposed Development in combination with other operational and consented PSH schemes on Loch Ness on loch levels. An assessment, including a cumulative assessment, of the potential impacts of the Proposed Development on fish species and impacts on migratory fish at Ness Weir, is included in **Chapter 13: Fish.**
		NDSFB request that the EIA completes a thorough assessment of the cumulative impact on loch and river levels, in the context of climate change, when more extremes in weather are expected.	A cumulative assessment, which will consider the cumulative impact of the Proposed Development and other PSH schemes on water levels within the Loch Ness Catchment, including Foyers and Red John is included in **Section 7.9** of this Chapter. As detailed in **paragraph 7.9.11** of this Chapter, no specific climate change investigations have been undertaken to date. Climate change projections for Scotland suggest drier summers and wetter winters meaning that the operation of PSH schemes in Loch Ness would be subject extensive curtailment. However, there should not be any fundamental change to the nature of PSH impact on loch levels. There is some potential for PSH to mitigate extreme levels by pumping during flood events and generating in dry periods.
		Ness DSFB welcome this statement “It is proposed to carry out detailed hydrological modelling to explore and assess the potential effects of the Proposed Development on water management within the Loch Ness catchment during the operational phase of the Proposed Development”, however, the cumulative impact of	A cumulative assessment, which consider the cumulative impact of the Proposed Development with other PSH schemes on water levels within the Loch Ness Catchment, including Foyers and Red John PSHs is summarised in **Section 7.9** of this Chapter. This assessment has been informed by hydrological modelling, as described in **Volume 4, Appendix 7.1: Loch Ness PSH - Hydrological Modelling Technical Note**.

		this proposed scheme and others already operational, or consented, needs to be included within the hydrological modelling.	
Scottish Water (SW)	Scoping	The EIA should include an assessment of the potential impacts on water abstraction locations within the vicinity.	It is proposed that water abstraction should be addressed as part of the CAR licence application so is not considered further as part of the EIA Report.
Nature Scot (NS)	Further Consultation	During a meeting with NS (via MS Teams) about the potential impacts of the Proposed Development on the Urquhart Bay Woods SAC, NS enquired whether the Caledonian Canal was subject to curtailment and if this had been considered as part of the hydrological modelling.	This issue is addressed in **paragraph 7.9.3** of this Chapter.

7.4 Overview of Development and Baseline Conditions

7.4.1 The nominal maximum installed generation capacity of the Proposed Development would be up to 600 MW, this corresponds to a rated flow between the reservoirs of approximately 392 m^3/s.

7.4.2 The maximum energy storage of the Proposed Development would be up to almost 9 GWh, which corresponds to a useable water storage volume of 21 Mm^3 (million cubic metres) in the upper reservoir.

7.4.3 The upper reservoir would be formed by raising the existing Loch Kemp by approximately 28 m from its existing 177 m AOD elevation to approximately 205 m AOD by constructing four new saddle dams and four minor cut-off dams. Dam 1 would incorporate a spillway, a spillway discharge channel, and reservoir drawdown and compensation water release facilities.

7.4.4 The lower reservoir is formed by Loch Ness. Loch Ness has a catchment area of approximately 1,781 km^2, is 36 km long and has a surface area of approximately 56 km^2. The catchment areas for Loch Ness is shown on **Volume 2, Figure 7.1: Loch Ness Hydrological Catchment Area.**

7.4.5 The water level in Loch Ness is currently controlled by the weir at Dochfour, the structure is known as the 'Ness Weir'. The location of the Ness Weir is illustrated on **Volume 2, Figure 7.2: Major Water Features and Hydro Development**.

7.4.6 The Ness Weir was originally constructed during the period 1815 to 1825 as part of the Caledonian Canal, which is a canal system linking the lochs of the Great Glen to provide a waterway between the east and west coasts of Scotland. The Ness Weir was constructed between Loch Ness / Loch Dochfour and the River Ness to raise the loch for the canal works and control loch levels under varying river flows.

7.4.7 The construction of the Foyers PSH scheme in the 1970s, which utilises water from Loch Ness, led to a modification of the Ness Weir with the installation of two sluice gates to provide minimum flows for fish passage in dry conditions. The sluice gates discharge a minimum flow into the River Ness during periods when Loch Ness is drawn down below the weir crest level.

7.4.8 The water that is released from Ness Weir to the River Ness then flows through Inverness to the sea at Kessock within the Beauly Firth.

7.4.9 The North of Scotland Hydro-Electric Board originally constructed the Foyers Pumped Storage Scheme. It is now owned by SSE Renewables Ltd (SSE) and SSE also operates the sluice gates at Ness weir as required.

7.4.10 The existing CAR licence for Foyers PSH (CAR/L/1010015 v2) sets out maximum allowable discharge and abstraction flows into and from Loch Ness respectively.

7.4.11 Scottish Canals hold a CAR licence for operation of the Caledonian Canal CAR/L/1010718 and this includes the Ness Weir and the canal locks. The licence for lock operation states a maximum of 37 uses of the lock per day. Based on the lock dimensions this represents a volume of about 56 Ml, or an average over the day of about 0.65 m3/s.

7.4.12 The minimum navigable Loch Ness level for the Caledonian Canal is 15.27 m AOD, as illustrated on **Volume 2, Figure 7.3: Historic Loch Ness Levels with Pumped Hydro Curtailment Levels**. The

Applicant understands that SSE formed an agreement with the then British Waterways (now Scottish Canals) to maintain Loch Ness levels above 15.27m AOD. This prevents Foyers from pumping water should Loch Ness water levels approach this level to safeguard canal operations.

7.4.13 The Applicant understands that there is a requirement to ensure a compensation flow is provided to the River Ness downstream of Ness Weir. The Scottish Canals Water Control Manual V12 for the Caledonian Canal states that the minimum compensation flow is 28.3m3/s. In drought conditions when Loch Ness levels are at their lowest this is delivered by sluice gates built into Ness Weir which are operated by SSE.

7.4.14 A SEPA level gauge is installed at Foyers. The dataset available extends back to April 2014. Analysis of the record to date shows Loch Ness's mean water level is 15.82 m AOD. The level exceeded 99% of the year is 15.45 m AOD and the level exceeded 1% of the year is 16.38 m AOD, as illustrated in **Volume 2, Figure 7.3: Historic Loch Ness Levels with Pumped Hydro Curtailment Levels**.

7.4.15 The average available operating range in Loch Ness is approximately 0.55 m, this assumes drawing down Loch Ness from the mean water level to the minimum level for canal navigation. The maximum annual range is 1.14 m, which assumes drawing down from the median annual maximum flood water level to the minimum level for canal navigation. For the Proposed Development to store a full 9 GWh in its upper reservoir, it would reduce the level in Loch Ness by 0.37 m, including Foyers PSH and Red John PSH this would reduce the level in Loch Ness by 0.73 m. This would be an extreme case and it is unlikely that all three PSH schemes would pump a full reservoir cycle simultaneously. A more typical scenario would be a four hour dispatch of each station which would result in a total reduction in Loch Ness level of 0.15 m, which is well within the typical range of Loch Ness.

7.5 Water Management and Proposed Operation of the Proposed Development

7.5.1 The aim of the water management strategy for the Proposed Development is to ensure that the plant is able to operate in any mode at any time for as long as possible. From a water transfer perspective, this can be one of three principal conditions:

- Pumping mode - Transferring water from the lower reservoir to the upper reservoir;
- Generating Mode - Transferring water from the upper reservoir to the lower reservoir; and
- Standing By - i.e. no water transfer taking place.

Hydrological Modelling

Loch Ness (Lower Reservoir)

7.5.2 It is not intended to manage Loch Ness water levels beyond their existing level range, although variation in water levels within these limits is expected to be more frequent within likely daily and weekly cycles. The likely changes to the loch level regime are discussed in **Section 7.9**. The Proposed Development will require a CAR licence issued by SEPA, which will dictate a minimum and maximum level of Loch Ness which the Proposed Development may operate between. The minimum level for pumping operation would not be below the operating level of existing and consented pumped storage in Loch Ness, as illustrated by the Kemp 'Hands Off' (or stop pumping) level in **Volume 2, Figure 7.3: Historic Loch Ness Levels with Pumped Hydro Curtailment Levels**, meaning the Proposed Development would have a minimal impact on the minimum level of Loch Ness. The maximum level of generating operation would be set at the 1 in 10 year flood return period to prevent worsening flood conditions downstream, as illustrated by the Kemp proposed 'Stop

Generating' level in **Volume 2, Figure 7.3: Historic Loch Ness Levels with Pumped Hydro Curtailment Levels.**

7.5.3 It is not possible to fully predict future Loch Ness level duration cycles at this stage of the project as the operation of the Proposed Development would be in response to future electricity markets. However, modelling of the predicted range of operation in wet and dry weather has been undertaken using an operating profile developed by energy analysts Lane Clark & Peacock (LCP), as discussed below.

Loch Kemp (Upper Reservoir)

7.5.4 Similarly, it is not possible to predict the future level duration characteristics for the upper reservoir behind the new dam, which would vary by up to 28 m between approximately 177 m AOD and 205 m AOD. It is also worth noting that unlike Loch Ness, the surface area of the upper reservoir reduces as the water level is drawn down. This means that the rate of drawdown increases as the level in the upper reservoir drops.

7.5.5 Assuming a 4 hour dispatch of the Proposed Development and assuming Loch Kemp is half full then this would mean a rate of drop of approximately 9.4 m over 4 hours. Assuming the same starting position of half full, pumping for 4 hours would increase the level of Loch Kemp by approximately 4.2 m.

7.6 Compensation Flow in the Allt an t Sluichd below Dam 1

7.6.1 Compensation flow would be released at the foot of Dam 1 on the Allt an t Sluichd outlet of Loch Kemp. This is proposed at a flow to mimic the natural conditions in the burn at a volume to be confirmed and agreed with SEPA as part of the CAR licence application.

7.6.2 To record the natural conditions in the burn a level gauge was installed to take a reading at intervals of 15 minutes over a period of 12 months. Manual flow readings were also taken on 16 instances over the 12 month period. This information allowed a continuous flow series to be calculated for the period. This was correlated against analogue stations operated by SEPA with much longer flow records. The selected analogue stations were Balnafoich, Mill of Tore and Whitebridge. This method provides a long-term characteristic for flow in the river.

7.7 Residual Flow in the Allt an t Sluichd below Dam 1

7.7.1 In addition to the compensation release described in **Section 7.6**, the flow below Dam 1 would also be maintained during the construction period. To achieve this, it is anticipated that a cofferdam would initially be installed across approximately half of the burn to allow construction of the first section of the dam. Natural flow would be able to pass downstream via the remaining half of the channel following the natural regime according to precipitation as the first section of the dam is constructed. The first section of the dam would incorporate the release for compensation flow via a bottom outlet structure, which would ensure the natural flow downstream would be maintained whilst the remainder of the dam is constructed. Once the construction of Dam 1 is complete, the bottom outlet would continue to be used in the operating phase for compensation flow release, as described in **Section 7.6**. The final design of Dam 1, including the bottom outlet structure, would be subject to detailed design.

7.7.2 Although the dam would be fitted with a spillway for reservoir safety reasons, the small catchment and the large water abstraction capability make it extremely unlikely that the upper reservoir would reach spillway level. The residual flow regime downstream of the dam would therefore ordinarily be unaffected by spill events from the dam.

7.7.3 The Proposed Development would be designed with control systems which would prevent pumping once the upper reservoir is full. The spillway would therefore be designed to pass the naturally occurring extreme flood event (which would have occurred with or without the Proposed Development being present) required for reservoir safety reasons to ensure the safety of the dam structure.

7.8 Proposed Abstraction and Discharge Rates and Volumes

7.8.1 The Proposed Development would both abstract and discharge water between the upper and lower reservoirs dependent upon operating mode and the difference in level between the two reservoirs. The maximum flow rates are shown in **Table 7.2: Proposed Abstraction and Discharge Flows** which are the extreme situation at minimum and maximum water level in Loch Kemp. For the purposes of modelling, the discharge at duty point is taken which is approximately the average flow across the reservoir operating range.

Table 7.2: Proposed Abstraction and Discharge Flows

Location	OS NGR	Maximum Discharge to (m3/s)	Maximum Abstraction from (m3/s)
Lower Reservoir	NH 453 165	455	360
Upper Reservoir	NH 465 164	360	455

7.8.2 The maximum volume of water that could be transferred between the upper and lower reservoirs by the operation of the Proposed Development is approximately 21 Mm^3. Based upon an installed generation capacity of up to 600 MW this would take approximately 15 hours continuous operation at maximum output. This represents the maximum single transfer of water which the Proposed Development could physically perform.

7.8.3 This case results in a rate of change of level in Loch Ness due to the Proposed Development of around 0.02 – 0.025 m/hour within the parameters discussed above.

7.8.4 The maximum operational drawdown within the lower reservoir (Loch Ness) during a pumping cycle (i.e. when water is pumped up to and stored in the upper reservoir) would be approximately 0.37 m if the Proposed Development was operating in isolation. However, this represents an absolute worst-case scenario, where the upper reservoir would be filled from the minimum to maximum level. Current trends in other operational PSH schemes indicate an average dispatch time of 4 hours. If this scenario is assumed as the reasonable worst-case scenario, water levels in Loch Ness would reduce by 0.08 m during four hours of pumping operation. During generation cycle (when water is released from the upper reservoirs) within the same scenario, water levels in Loch Ness would increase on average by 0.10 m during four hours of generation.

7.8.5 The maximum operational drawdown within the upper reservoir would be approximately 28 m. For the purposes of assessment within this EIA Report, the assumed maximum water level within the upper reservoir would be 205 m AOD and the assumed minimum water level would be 177 m AOD. The upper reservoir rate of change of level would be between around 1–5 m/hour. These levels would be subject to detailed design.

7.8.6 The Proposed Development would be operated as a closed system, which means no water would be transferred outside the catchment. Any water pumped up from Loch Ness would either return to Loch Ness via the generation cycle or be passed into the Allt an t Sluichd as compensation flow which in turn flows to Loch Ness.

7.9 Cumulative Impact on Loch Ness

7.9.1 There is one operating PSH on Loch Ness called Foyers and one consented PSH called Red John (Planning Ref: 18/05427/S36). Foyers PSH is located at the village of Foyers on the eastern shore of Loch Ness, approximately 7 km northeast of the Proposed Development. Red John PSH would be constructed on the eastern shore of Loch Ness, near the village of Dores and would be located approximately 20 km northeast of the Proposed Development, as shown on **Volume 2, Figure 7.2: Major Water Features and Hydro Development** (also refer to **Volume 2, Figure 3.2: Site Context)**. It is the Applicant's understanding that the 'stop pumping' level of Foyers PSH is dictated by the agreement between British Waterways (BWB) and North of Scotland Hydro-Electric Board (NoSHEB, now SSEN Renewables) (1970). The Applicant has based its analysis on the levels and flows in the agreements or licences shown in **Table 7.3: Stop Pumping Levels, Abstraction and Discharge Flows for Loch Ness PSHs**. Notwithstanding this, the stop pumping level that would be allocated to the Proposed Development through the CAR Licence process and would not be below the stop pumping level of Foyers PSH. In the modelling the level for Red John was set higher (15.38 m AOD) to provide additional protection for the existing Foyers PSH scheme against potential adverse impacts from Red John PSH's operation. For the Proposed Development a further increase to 15.42 m AOD has been adopted.

7.9.2 Stop generation levels (to protect against adverse impacts in terms of flooding) have not yet been agreed under the CAR licence application. For the purposes of modelling, it has been assumed that there would be no generation at any scheme when the Loch Ness level exceeds the estimated 1-in-10 year flood level of 17.44 m AOD. This is referred to as the 'Stop Generating' Level (as illustrated on **Volume 2, Figure 7.3: Historic Loch Ness Levels with Pumped Hydro Curtailment Levels**).

7.9.3 The Caledonian Canal has a set of lock gates at Dochfour. The CAR licence for lock operation states a maximum of 37 uses of the lock per day. Based on the lock dimensions this represents a volume of about 56 million litres (Ml), or an average over the day of about 0.65 m^3/s. If the lock is not operated the permitted maximum number of times the impact would be even smaller. Lockage data provided by Scottish Canals for 2022 shows a maximum daily usage of 21 and a summer average of around 15, equivalent to 0.37 m^3/s and 0.26 m^3/s respectively. These average flows are extremely low compared to pumped storage operation and so are not considered further in the analysis and scoped out of further assessment.

Table 7.3: Stop Pumping Levels, Abstraction and Discharge Flows for Loch Ness PSHs

PSH	Document	Stop Pumping level (m AOD)	Maximum Discharge (m^3/s)	Maximum Abstraction (m^3/s)
Foyers	CAR Licence 1011470 v2		204.9	152.9
Foyers,	Minute of Agreement (MoA) between BWB & NoSHEB (1970)	15.27		
As Red John	CAR Licence 1176082	15.33	250	170

7.9.4 The rate of change of level in Loch Ness due to the cumulative operation of the existing Foyers PSH and the two proposed PSHs (the Proposed Development and the consented Red John PSH) would be around 0.04 – 0.05 m/hour. This would only apply if all three schemes were operating at the same time, which given the difference in storage volumes and direct catchment would not always be the case.

7.9.5 If all three PSHs were to undergo a pumping cycle (i.e. when water is pumped up to and stored Fin the upper reservoirs) simultaneously, the maximum operational drawdown within the lower reservoir (Loch Ness) would be approximately 0.73 m. However, this represents an absolute worst-case scenario, where the upper reservoirs would all be filled from the minimum to maximum level simultaneously. Current trends in other operational PSH schemes indicate an average dispatch time of 4 hours. If this scenario is assumed as the reasonable worst-case scenario, water levels in Loch Ness would reduce by 0.15 m over a four-hour period of pumping. During generation cycle (when water is released from the upper reservoirs) within the same scenario, water levels in Loch Ness would increase on average by 0.21 m during four hours of generation.

7.9.6 Energy analysts LCP have derived an operating profile for the Proposed Development, comprising rates of release or pumping for each hour of a 365-day year. As a reasonable worst case this profile has been assumed to apply to all three schemes, except that operation of Red John (which has a smaller storage capacity) would at times be constrained, either by the upper reservoir being empty when the profile indicates generation or by it being full when the profile shows pumping.

7.9.7 A 50-year series of estimated Loch Ness daily inflows was derived from the recorded data for the SEPA gauge at Ness-side which is just downstream of the outlet from Loch Ness and provides a reasonable representation of loch outflows. The outflow series was transformed to estimated inflows by means of comparing the estimated flow duration curves for inflow and outflow. Whilst this transformation is approximate it is considered satisfactory for comparative studies of current and potential future conditions.

7.9.8 A water balance model was set up on an hourly time step. The model incorporates the inflow series (assumed constant during each day), PSH operation and outflow at Ness Weir. The outflow was based on a rating curve developed through hydraulic modelling of the weir, with a minimum outflow of 28.3 m^3/s. In the first scenario only Foyers PSH is operating (considered the baseline condition), secondly for Foyers PSH plus Red John PSH and finally for all three schemes. The key output in relation to water management is the daily average water level series from which a level duration curve can be derived.

7.9.9 The level duration curves for the three scenarios are shown in **Plate 7.1: Loch Ness Level Duration Curves for Various Scenarios**, with values for selected points tabulated in **Table 7.4: Estimated levels (m AOD) for selected points on the LDC for various PSH scenarios**. The impact of the schemes is cumulative, with the Proposed Development leading to the larger change because its capacity is much larger than Red John PSH. It should also be noted that the results shown for the "Foyers only" case are an estimate of what has already happened (i.e., the baseline conditions) compared to an assumed "natural" condition, based on the LCP profile; this will differ from actual historic operation. The potential future changes due to the development of Red John and the Proposed Development are shown in the penultimate column of **Table 7.4: Estimated levels (m AOD) for selected points on the LDC for various PSH scenarios**. The potential changes due to the Proposed Development are represented by the change between "Foyers + Red John" and "+Loch Kemp", shown in the last column of **Table 7.4: Estimated levels (m AOD) for selected points on the LDC for various PSH scenarios.**

7.9.10 For the lowest levels (below the Foyers stop-pumping threshold) there is very little difference between the curves because the schemes would not be operating at such levels. There is then a reduction in levels over about half of the curve (L85 to L30), followed by smaller increases at higher levels. Table 7.4 illustrates there would be up to a 5 cm reduction in Loch Level at L50 (level exceeded 50% of the time), a 5 cm increase in Loch Level at L10 (level exceeded 10% of the time) and a 1 cm increase at L90 (level exceeded 90% of the time) if all three schemes were to operate at the same time. The largest change to loch levels, as illustrated by **Plate 7.1: Loch Ness Level Duration Curves for Various Scenarios**, would occur at approximately L70 (level exceeded 70% of the time), where the loch level would be reduced by 10 cm. Overall, there would be a slight (3 cm) reduction in the mean loch level. These changes are considered minor in the context of the annual variation of the level of Loch Ness, which varies by over 1 m.

Plate 7.1: Loch Ness Level Duration Curves for Various Scenarios

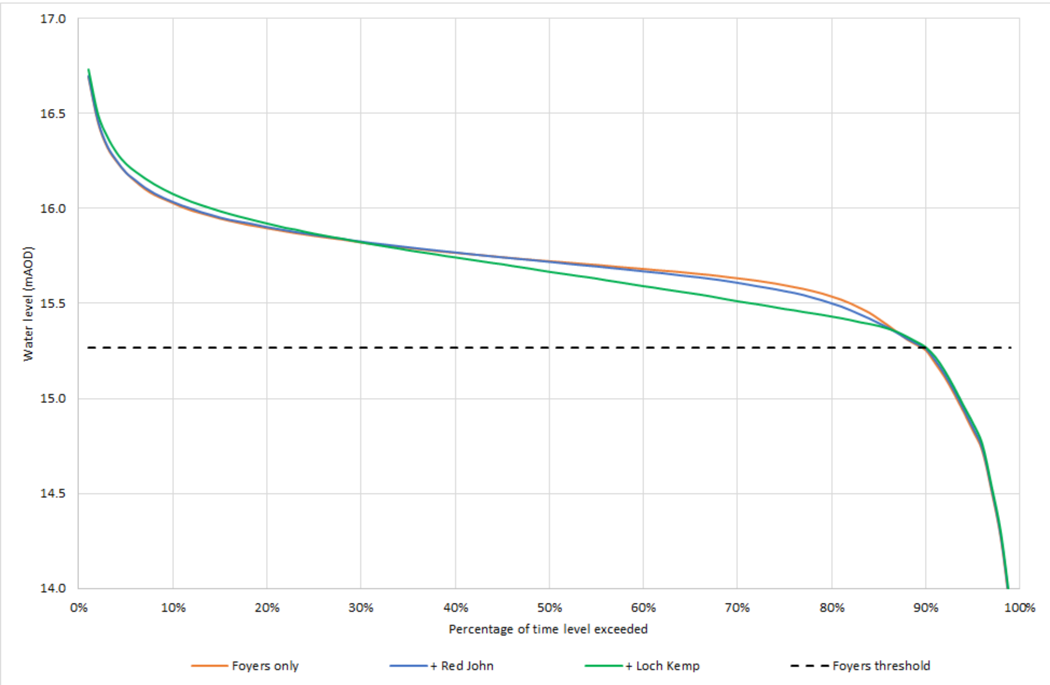

Table 7.4: Estimated levels (m AOD) for selected points on the LDC for various PSH scenarios

	exceedance	Foyers only	+ Red John	+ Loch Kemp	Change from current	Change due to Loch Kemp
L1	1%	16.69	16.70	16.73	0.04	0.03
L10	10%	16.03	16.03	16.08	0.05	0.05
L30	30%	15.82	15.83	15.82	0.00	-0.01
L50	50%	15.72	15.72	15.67	-0.05	-0.05
L70	70%	15.63	15.61	15.51	-0.12	-0.10
L90	90%	15.25	15.26	15.27	0.02	0.01
L99	99%	13.87	13.88	13.90	0.03	0.02
Overall mean		15.67	15.66	15.63	-0.04	-0.03

7.9.11 No specific climate change investigations have been undertaken to date. Climate change projections for Scotland broadly show drier summers and wetter winters. The summers may contain more frequent/longer periods of low loch levels. This would mean that the operation of PSH schemes would be subject to more extensive curtailment. However, there should not be any fundamental change to the nature of PSH impact on loch level, i.e. an increase in diurnal variation, slightly increased high loch levels and slightly lower average levels. There is some potential for PSH to mitigate extreme levels by pumping during flood events and generating in dry periods.

7.10 Conclusions

7.10.1 The Proposed Development is to build and operate a new PSH with an installed capacity of up to 600 Megawatt (MW) utilising the existing Loch Kemp as the upper storage reservoir and Loch Ness as the lower reservoir.

7.10.2 The maximum energy storage of the Proposed Development would be up to almost 9 GWh, which corresponds to a useable water storage volume of 21 Mm^3 (million cubic metres) in the upper reservoir.

7.10.3 The Proposed Development would release compensation flow from the foot of Dam 1 on the Allt an t Sluichd which is the natural outlet of Loch Kemp. The flow would be regulated to mimic the natural flows in the burn at a volume to be agreed as part of the CAR licence. During construction of the Proposed Development, the construction of Dam 1 would maintain the natural outflow Loch Kemp into the Allt an t Sluichd.

7.10.4 The Proposed Development would only operate between agreed minimum and maximum levels of Loch Ness. These shall be within the operating ranges of existing and consented PSH schemes on Loch Ness to avoid additional impact to the extremes of level in Loch Ness.

7.10.5 A hydrological model has been prepared to simulate Loch Ness levels according to inflows, outflows and operation of pumped storage schemes. Level duration curves were plotted of the modelled loch levels over a simulated 50 year period.

7.10.6 The model shows that operation of Foyers PSH, Red John PSH and the Proposed Development cumulatively would have only a minor impact on Loch Ness levels. The level exceeded 90% of time is increased by 1 cm by adding the Proposed Development. The largest change to loch levels occurs at L70 (level exceeded 70% of the time), where the loch level is reduced by 10 cm. These changes are considered minor in the context of the annual variation of the loch of over 1 m. No specific climate change investigations have been undertaken to date however, there should not be any fundamental change to the nature of PSH impact on loch levels as a result of climate change. It is noted there is potential for PSH to mitigate extreme levels by pumping during flood events and generating in dry periods.