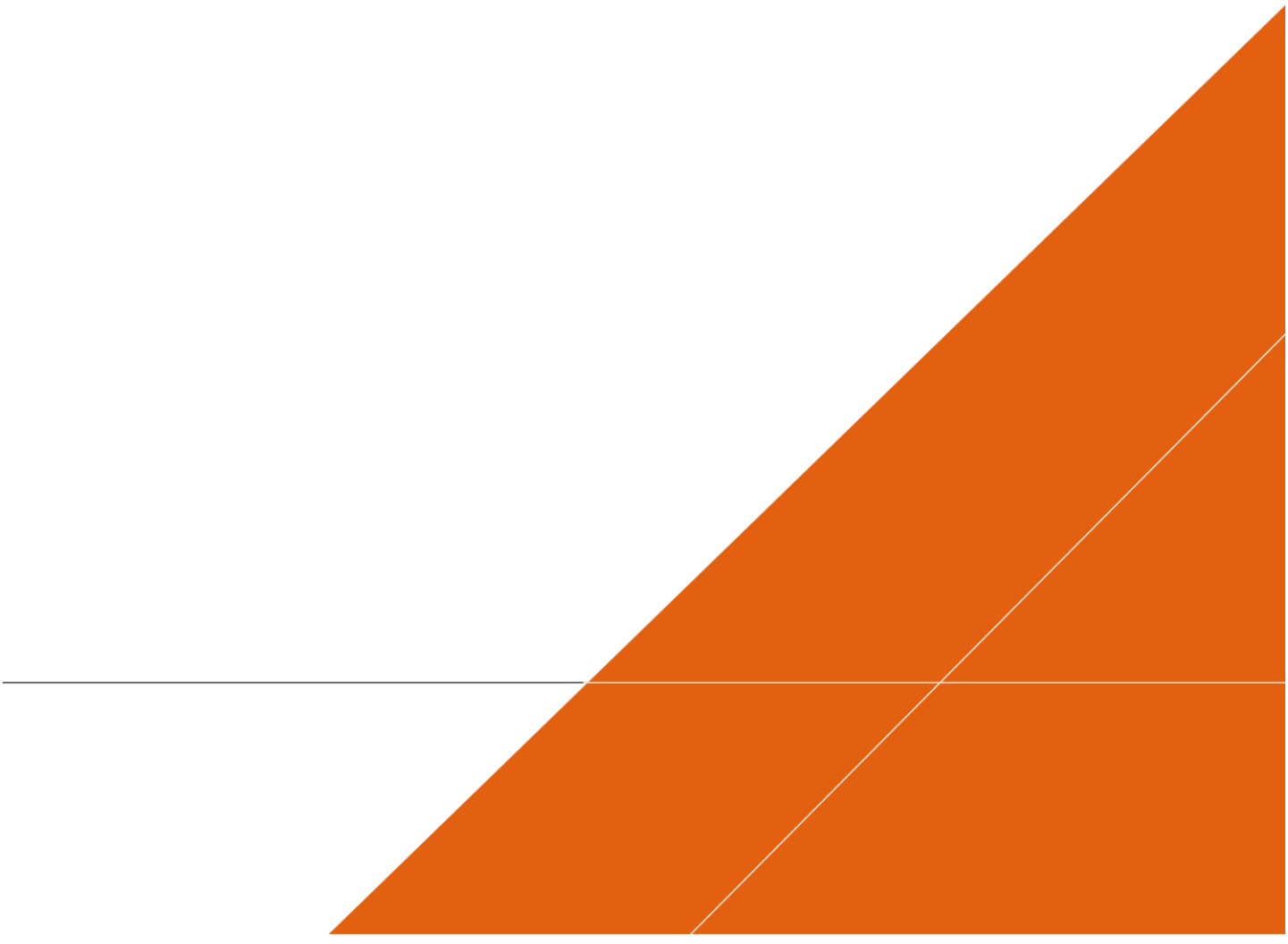
ARCADIS Design & Consultancy for natural and built assets

PRINCE LLEWELYN

Design Philosophy

DECEMBER 2019



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Version control

Version	Date	Author	Checker	Approver	Changes
1	16/12/2019	NT	DS	AH	First Issue
2	23/01/2020	NT	DS	AH	Minor changes addressing comments by NRW PM
3	30/01/2020	NT	DS	AH	Change to Figure 3
4	18/03/2020	NT	DS	AH	Change to meet altered designs

CONTENTS

1 Background

The purpose of this document is to outline the philosophy that will be adopted by Arcadis Consulting (UK) Ltd for the design of the works at Prince Llewelyn Reservoir on behalf of the Client, Natural Resources Wales (NRW).

Prince Llewelyn is a small reservoir owned by Natural Resource Wales (NRW). The total capacity of the reservoir is 5,477m^3. As such, it is not subject to any safety requirements under the Reservoirs Act 1975 (as amended by the Flood and Water Management Act 2010) as its volume is below the 10,000 m^3 threshold for Welsh statutory reservoirs. However, NRW consider it to be a priority asset based on both its current condition and proximity to residential properties and a major road, with the potential for loss of life in the event of a breach. Therefore, NRW has taken the decision to decommission the reservoir to significantly reduce their future liability.

The dam is an embankment of an unknown fill with masonry facing. It is 5.8m at greatest height, spanning 39m in length with a 4m crest width. There is an additional 1m shelf on the upstream face that is one meter lower than the main crest. The dam has a bottom outlet which is inoperable, as well as two lower points on the crest working as informal spillways.

Concerns about the dam safety were raised following the observation of severe leakages on the downstream face during recent flood events, when the reservoir water level was particularly high. Concerns were strengthened by the lack of a working bottom outlet, which would not allow an emergency drawdown to lower the hydrostatic pressure on the dam and reduce the leakage.

As a consequence of these concerns, NRW have decided to decommission the embankment and reduce their ongoing future liability, together with lower requirements for maintenance.

NRW provided a brief for the design (NPS-PS-0027-15 CE468-507 Mid: Prince Llewelyn) which details all of the required deliverables:

1) Detailed design of the works to decommission the reservoir.
2) Provision of contract documentation to allow NRW to tender the works:
   - Works Information (WI);
   - Site Information (SI);
   - Works Specification;
   - Design Basis Statement;
   - Pre-Construction Information;
   - Designer’s H&S Hazard Record;
   - Drawings – the first 3 drawings in the series should be
     (1) Existing works plan – indicating hazards (deep water, steep embankments, weight limits etc.
     (2) Existing conditions – photographic record of key areas of work;
     (3) Proposed Works – including proposed site compound, working boundaries and land ownership

1.2 Site Description

Prince Llewelyn Reservoir is a small reservoir located between the villages of Dolwyddelan and Pont-y-Pant, south of Betws-y-Coed (National Grid Reference SH 7428 5305) shown in Figure 1. The red line highlights the access route to the reservoir form the major trunk road (A470).

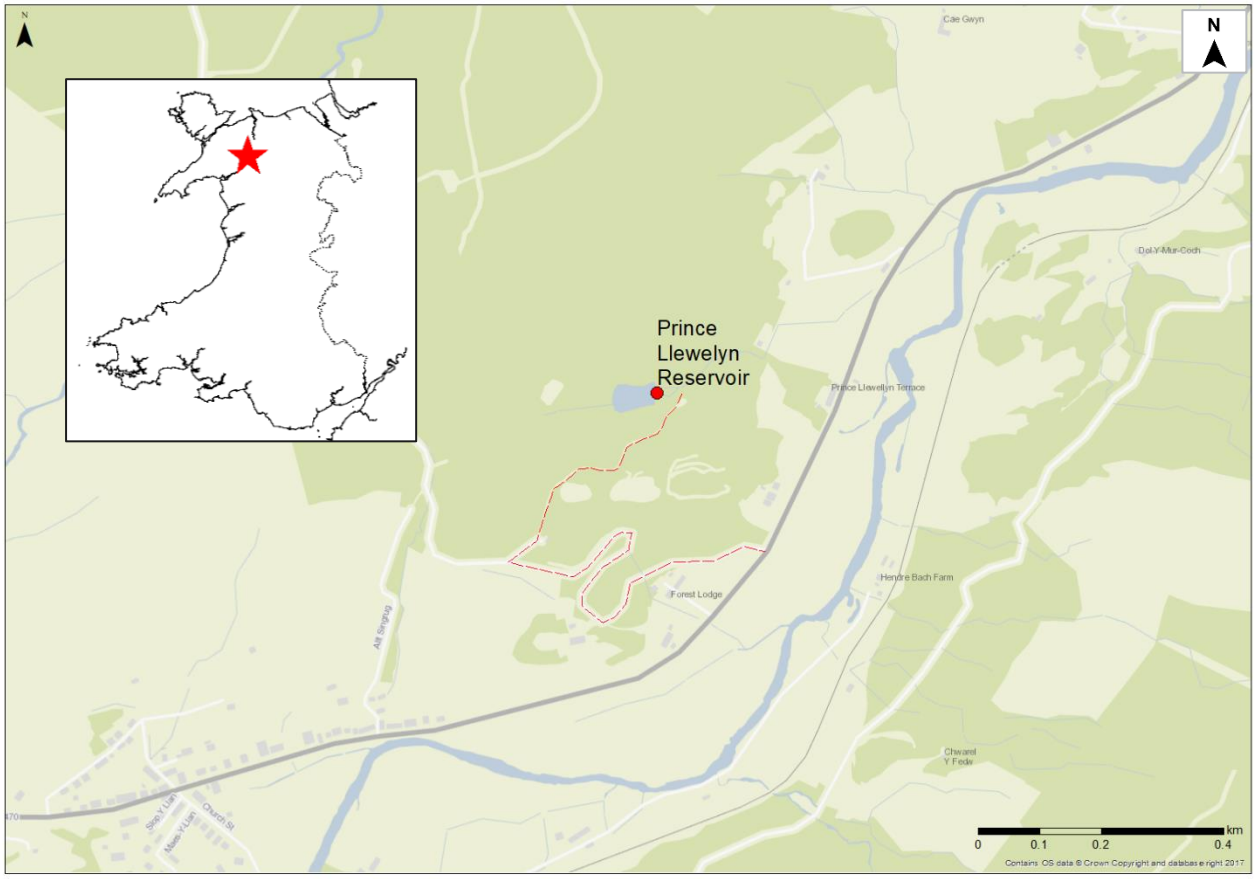

Figure 1 - Locale of Prince Llewelyn Reservoir (© OS Maps, All Rights Reserved)

2 Design Methodology

The design methodology is based on the overall philosophy to reduce the future maintenance and liability of the Prince Llewelyn Reservoir to NRW without modifying the flood risk for the downstream receptors. Thus, the design should provide similar flood flow attenuation, whilst reducing the reservoir volume. As an additional design criterion, the new reservoir configuration should not allow any mobilisation of the silt currently stored in the reservoir, due to the potential presence of contaminated sediments from previous mining activities in the area.

To achieve this, we have outlined a methodology that covers the following aspects:

- Site access;
- Works on the embankment;
- Addition of a formal spillway;
- Works on the downstream channel.

2.1 Site access

The embankment is currently accessible to within 30m of the downstream face via a forestry track (see Figure 2). To ensure the safe decommissioning of the embankment, access will be required to the downstream toe, as well as to the righthand-side crest and rim of the reservoir during construction.

As the dam is located at a higher elevation than the existing track, the new track shall have gradient appropriate for the transit of the construction plant.

A compound for the Contractor will also be required to be set up on the laydown area adjacent to the forest track.

Figure 2 - Access Track (Site Visit 05/02/20)

2.2 Works on the dam

The Top Water Level of the reservoir is to be permanently reduced by approximately 2.6m. To achieve this there is to be a spillway at 193.3mAOD that is 2m in width with a minimum channel depth of 600mm. To reduce the quantity of removal as well as reduce the construction access requirements, the reservoir is to be decommissioned with a v shaped notch as is shown in Figure 3.

The nature of the structure requires particular care while undertaking the construction works. The fill material and masonry facing is to be taken down gradually. The masonry is to be stored separately on site for re-use where feasible. Embankment fill to be tested for contaminants (i.e. heavy metals) to ensure appropriate disposal.

Due to the unknown properties of the embankment fill and resistance of the existing outlet crossing the dam, it is recommended that machinery does not pass over the embankment in order to avoid dam instability and collapse of the outlet.

During the decommissioning works, continual pumping (or syphoning) to discharge natural inflows will be required, in order to keep the reservoir at a level compatible with the construction works.
It is proposed to create a masonry coping to the downstream extent of the new exposed surface to ensure the structural integrity of the new notch. The rest of the exposed dam surface is to be stepped. These steps

will be formed with the masonry recovered from the dam removal. This will act as erosion protection as well as reduce the creation of material waste.

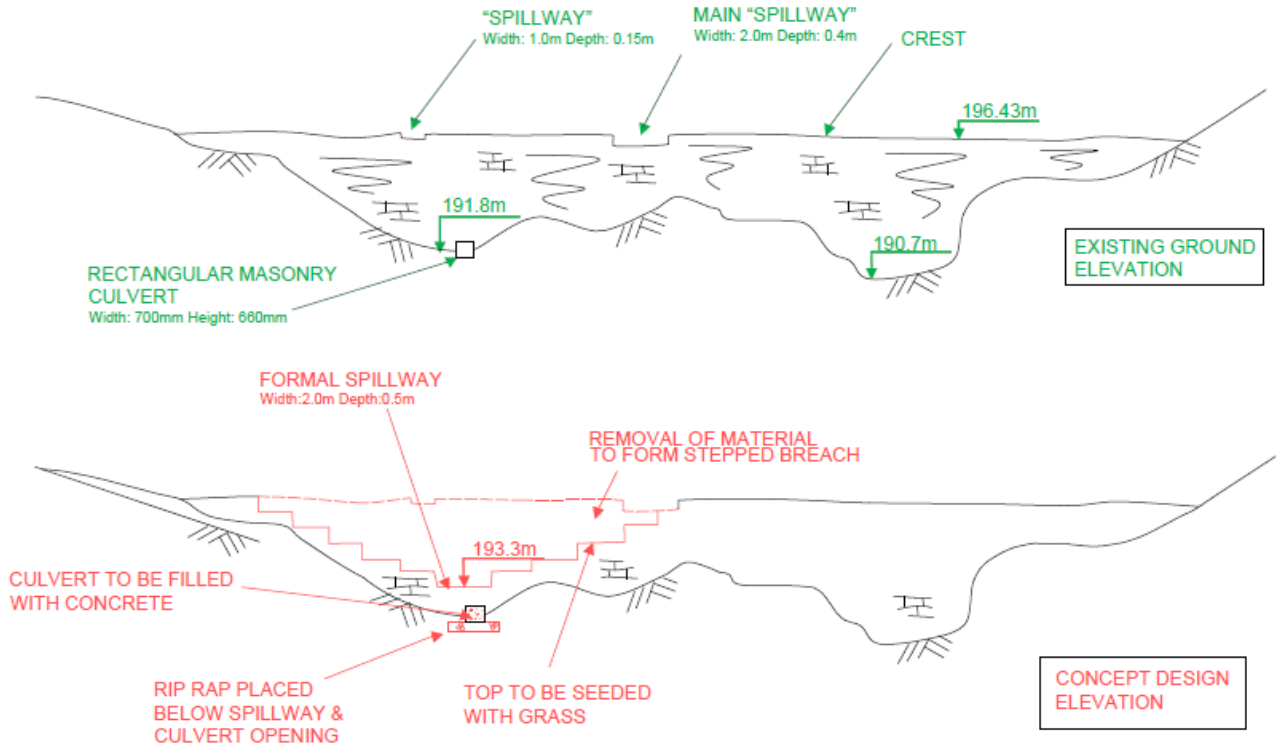

Figure 3 - Existing arrangement for Prince Llewelyn dam (above) and the proposed concept design (Adapted from (Arcadis, 2018))

2.3 Addition of a Formal Spillway

A formal spillway is proposed. This is designed to ensure that there is no significant increase in the flood levels to downstream property. A Flood Study was produced by Arcadis in November 2019 and provided by NRW proposed a spillway with a central 0.25m wide and 0.45m deep slot in order to ensure flood attenuation for the 1 in 10,000year event, However, further considerations about the design and buildability of the proposed spillway, together with the change of the Design Flood to 1 in 1,000year event requested by NRW, led to substantial changes to the proposed configuration. It features a spillway 2m wide at base with walls at 20° to the vertical at 600mm in height. Each of the remaining steps are 1.5m wide and 0.6m in height.

At the time of this report, an updated flood study is under production to appraise the flood attenuation provided by the new spillway. Verbally confirmed preliminary results for the 1 in 1,000 year flood event show that the peak flow of the new configuration is about 3.7% higher than the one in the current configuration. This increase can be considered negligible, as less than 5% initially confirmed by NRW as the upper limit, and therefore the proposed design can be considered acceptable. However, final results need to be confirmed by NRW through the provision of the final updated Flood Study and the assessment of the consequences downstream, from which the proposed geometry will be confirmed.

It is proposed that since the dam is approximately 10m in width at 193.3mAOD, that the spillway have a slope of 1 in 100 to aid in passing of low flows.

To ensure structural integrity and prevent the loss of material within the dam, it is proposed to make the spillway out of mortared masonry. The masonry is to be sourced from smaller pieces of the recovered masonry so that a relatively uniform surface can be achieved.

The walls of the spillway are to be set back 20° to the vertical in order to ease construction. This will be constructed with the same smaller masonry pieces as the spillway base.

To reduce the reliance on the mortar for protecting the substructure, it is proposed to lay a geotextile beneath the mortared masonry to reduce the potential for loss of fines.

This is a design variation compared to the accepted option within the Options Study due to further scoping to meet NRW's design criteria to not modify substantially the current flood attenuation capacity as well as containing the potentially contaminated silt (Arcadis, 2018) (Arcadis, 2020).

The new spillway will be positioned in line with the channel downstream of the bottom outlet as shown in Figure 3

2.4 Bottom Outlet

Prince Llewelyn Dam has a bottom outlet as shown in Figure 3. A CCTV analysis (DRAINTECH, 2016) of the existing culvert identified that there were no clear structural defects to either the masonry culvert or adjoining cast iron pipe. However, it further states that there is minor collapse and cracking with potential for further deterioration.

Therefore, it is proposed that the culvert be filled with concrete to prevent collapse. This should be carried out prior to the potential loading of the structure as a result of removing the top portions as well as from the construction plant itself.

To ensure that this is sympathetic to the structure. It is proposed to face this with masonry recovered from the dam removal process.

2.5 Works on the downstream channel

At present flows are discharged from the reservoir through several leaks, and through the informal spillways during floods. With the creation of a formal spillway, any flow will be discharged through a single waterway. As such, there will be a greater requirement to prevent scour to the downstream toe.

The channel downstream of the bottom outlet and the new spillway will be reprofiled and a channel formed with rip rap scour protection. This will be formed using masonry arising from the partial dismantling of the dam, and supplemented with imported stone where required.

References

Arcadis. (2018). *Prince Llewelyn Future Options Study.* London: Arcadis UK.

Arcadis. (2019). *Prince Llewelyn Flood Study DRAFT.* Cardiff: Arcadis UK.

DRAINTECH. (2016). *6904 PRINCE LLEWELYN NRW.* Bridgend: DRAINTECH.

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