

Llyn Tegid Reservoir Safety Improvements

Flood Consequence Assessment



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1. Summary

A reservoir safety scheme is proposed at Llyn Tegid in order to comply with Natural Resources Wales' statutory duty under the Reservoirs Act 1975. This is subject to a major planning application and involves strengthening of the existing embankments.

A Flood Consequences Assessment (FCA) has been undertaken in line with current national planning policy and in particular, Welsh Government's Technical Advice Note 15: Development and Flood Risk (TAN15). This demonstrates how the proposed works will not result in an increase in downstream fluvial flood risk and therefore a full FCA is not required.

2. Introduction

A reservoir safety scheme is proposed at Llyn Tegid which is subject to a major planning application. The proposed development sits within an area shown to be at risk of flooding (see appendix 6.1) and the defences themselves form the line between the 'C1' defended floodplain of Bala town and 'C2' undefended floodplain of Llyn Tegid and the River Dee as defined by TAN15. This report looks at the impact the works may have on flood risk and consequences, in line with current national planning policy and in particular Welsh Government's Technical Advice Note 15: Development and Flood Risk (TAN15).

Llyn Tegid is a natural lake with approximately 2,950m of embankments at its northern end (including the embankments along the River Dee and Afon Tryweryn, which contribute to the lake's function as a reservoir). The outflow is controlled by Bala Sluices, which is a gated water control structure that controls the combined outflow from Llyn Tegid and the Afon Tryweryn. This allows Llyn Tegid to be used for flood control (as a reservoir) and to regulate the River Dee downstream.

Llyn Tegid is registered as a Category A Large Raised Reservoir under the Reservoirs Act 1975 (RA75). As such there are additional legal duties on Natural Resources Wales (NRW) which include formal inspections by an All Reservoirs Panel Engineer (ARPE - registered with DEFRA (Department for Environment, Food & Rural Affairs)) and compliance with recommendations made by the ARPE within their report (known as a Section 10 report).

Following a Section 10 report in November 2014, modifications to impounding structures at Llyn Tegid are required to satisfy Measures in the Interest of Safety (MIOS). The outstanding MIOS related to this project are as follows:

(iii) works are carried out to safely accommodate the design storm and the associated still water flood surcharge and wave surcharge.

(iv) a seepage/ stability analysis be carried out on the embankments to try to predict how the embankments will behave in the design flood.

The preferred option following an appraisal study in 2018 consists primarily of protection to the Llyn Tegid northern lake embankment, and left bank of the River Dee to allow safe overtopping during the design storm event. This will include reinforcement of landward embankment faces with a stability berm and buried 3D geotextile mat ('Enkamat' or similar) and replacement of the existing lakeshore rip-rap stone wave protection on the lake embankment. Embankment levels are not being

raised as part of the proposed safety works and there are no changes proposed to the operation of the Bala sluices or the wider Dee Regulation.

3. Background

3.1 Bala Lake Scheme and Dee Regulation

The Bala Lake Scheme, constructed between 1953-1956, involved lowering the lake outlet by 2m, constructing new raised embankments, engineered river channels and new sluice gates downstream of the confluence of the Dee and the Tryweryn. This was to achieve two main purposes; reducing flooding and providing additional water for river support during low flow periods, thereby increasing the amount of water available for abstraction by the various water undertakers. The sluices and raised embankments provided around 21,000,000m³ of controllable, stored water in Llyn Tegid. The management of water resources on the River Dee represents a major example of advanced river basin management. It combines the supply of water, flood alleviation, fishery management, recreation and hydro-power generation. Three reservoirs, Llyn Tegid, Llyn Celyn and Llyn Brenig assist in managing flows in the River Dee. A fourth, Alwen Reservoir, supplies water directly by pipeline.

The level of water impounded behind the sluices as part of its water regulation function does not in normal conditions encroach on the *embankments* that protect the town of Bala (between 1.1 and 1.5m above sluice cill level of 159.2 mAOD). This is comparable to the volume of water impounded behind Thomas Telford's original sluices (1805) that the Bala Lake Scheme replaced. During flood events however, the operational management of the sluices impounds water against these defences to provide short term storage and mitigate flood risk to the Dee valley downstream. Therefore the primary function of the *embankments*, whose presence bring Llyn Tegid under RA75, is for flood defence purposes.

Section 9 of the Dee and Clwyd River Authority Act 1973 specifies the present statutory framework for regulation of the River Dee using Llyn Tegid, Llyn Celyn and Llyn Brenig by the Dee and Clwyd River Authority. Following a number of legislative changes, culminating in the Natural Resources Body for Wales (Functions) Order 2013, the role of the Dee and Clwyd River Authority is now fulfilled by NRW and Environment Agency (EA) acting jointly. NRW and the EA have agreed the framework for this joint operation. NRW provide day to day operational management services on behalf of the two organisations.

The management regime of the Bala sluices is controlled by the Dee Regulation Scheme. NRW sit on the Dee Regulation Statutory Consultative Committee (DCC - also including United Utilities, Dwr Cymru Welsh Water (DCWW), Hafren Dyfrdwy and the Canals and Rivers Trust). Any alterations to flow regulation require approval from the DCC which could take a considerable length of time and have impacts on its flood prevention and flow regulation function.

The proposed safety scheme aligns with the current well established Dee Regulations, ensuring that Llyn Tegid can continue to function effectively into the future. No changes to the embankment levels, water levels or control philosophy of the Bala sluice gates is proposed.

3.2 Previous Studies

NRW is the registered Undertaker for Llyn Tegid in accordance with RA75. RA75 exists to protect public safety by reducing the risk of an uncontrolled release of water from large raised reservoirs (capable of holding 10,000 cubic metres, or more, above the natural level of any part of the

surrounding land) and the potentially catastrophic flooding this can cause. Llyn Tegid can hold over 21 million cubic metres of water when full to its top water level. It is a Category A reservoir (having the highest required standards of protection according to industry guidance).

In the event of a breach, approximately 850 properties would be directly impacted in Bala, with further inundation to properties and businesses downstream. The approximate (localised) inundated area is shown below, with the full extent shown in appendix 6.2:



Figure 3.1: Bala Inundation Area from Reservoir Breach (from NRW Flood Risk Website)

A number of investigative studies have been carried out at Llyn Tegid related to the MIOS including hydraulic modelling, ground investigations & interpretive studies, groundwater modelling and structural assessment of control gates.

The latter led to the major refurbishment project of the Bala Sluices which was completed in September 2015. Any subsequent improvement work to the impounding structures will be in compliance with local policy of the River Dee Catchment Flood Management Plan (CFMP).

The River Dee at Llyn Tegid and the contributing River Tryweryn from Llyn Celyn have been modelled previously by JBA Consulting in 2011. Atkins were commissioned to further develop the existing model and construct a linked 1D-2D model to assess flood routing from both Llyn Tegid (River Dee) and the River Tryweryn. Hydrological inflows were calculated for the 1 in 100, 150, 1000, 10,000 year and the Probable Maximum Flood (PMF). As Llyn Tegid is currently a Category A reservoir the model outputs are focussed on the 10,000 year (design flood) and PMF (safety check flood) events (in-line with industry guidance - Floods & Reservoir Safety 4th Edition). Black & Veatch undertook the project appraisal and further reined the model outputs which are summarised in table 3.1 and figure 3.2.

Table 3.1: Summary of peak water levels

	Peak water level 'design flood' 1 in 10,000yr (mAOD)	Peak water level 'safety check flood' PMF (mAOD)	Min. existing embankment crest level (mAOD)
Llyn Tegid lake shore embankments	164.25	165.18	163.95
River Dee left bank embankments	164.17	165.05	163.61
River Tryweryn right bank embankments	164.80	165.41	165.37

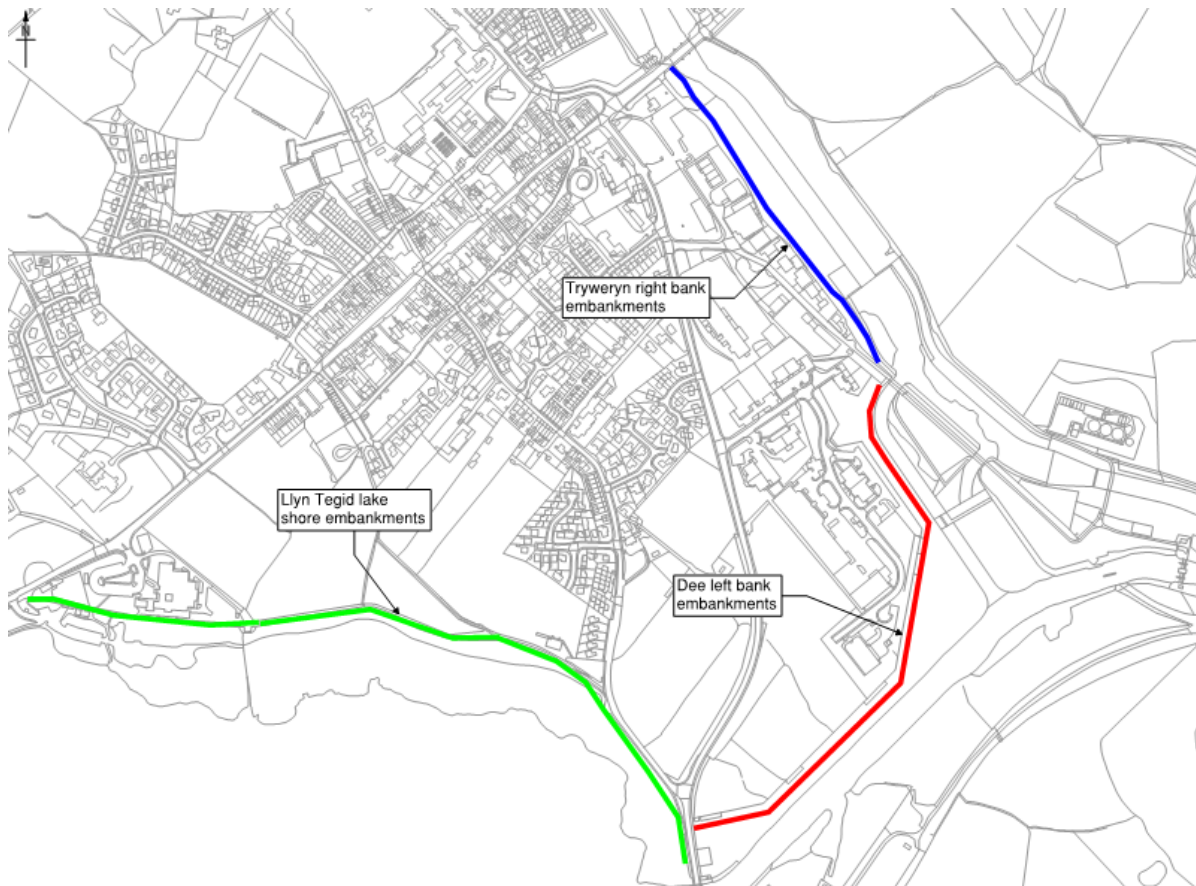


Figure 3.2 – Tegid Embankments

The baseline model results indicate that peak water levels in Llyn Tegid are higher than the existing embankment crest for both the design and safety check flood events.

If this volume of overtopping was to occur then significant damage is likely to be caused to the embankment and there could be either a partial or catastrophic failure of the reservoir embankments, hence the works will reduce the flood risk from this source. This modelling work helped inform the appraisal study in 2018 and the subsequent strengthening recommendations.

4. Flood Consequence Assessment

It is not considered appropriate or necessary to undertake a full FCA for the proposed strengthening works. The proposals are for strengthening only and existing embankments are not being raised and their footprint remains substantially the same. This will improve their long term safety and ensure compliance with statutory obligations under RA75. Additionally, the control philosophy of the outlet from Bala (via the sluices) is not being altered and so there is no impact on the flood risk profile locally or downstream. The section below however sets out the importance of the Llyn Tegid in its role in mitigating flood risk (also see appendix 6.3) and how other approaches of Business As Usual (BAU) and Walkaway have been considered and discounted.

The construction works will be subject to a Flood Risk Activity permit (FRAP). The FRAP process will ensure that flood risk impacts will be mitigated and controlled appropriately such that Bala and downstream communities are not vulnerable during the construction period. For example the regulation of the Dee and the operation of the sluices will continue as normal. Rip-rap will also be replaced in sections to limit exposure of the embankments during its replacement with suitable contingency plans in place to respond to any adverse weather event forecasts.

An Outline Business Case (OBC) was prepared at the end of the appraisal project stage for funding approval from Welsh Government (WG). This did not undertake a detailed assessment of damages avoided since the strategic driver for the project is not improvement of the standard of protection per se, but a legal requirement to prevent a sudden and catastrophic collapse of the structure which could lead to significant and dangerous flooding. A Cost Effectiveness Analysis (CEA) approach was adopted, in-line with WG appraisal guidance where there is a legal imperative to complete a project (as in this case) and is therefore a proportionate approach.

Given the number of properties at risk in Bala (800+) and a conservative estimate of £40k per property (typical UK insurance claim for domestic flooding) we would expect damages avoided to be in the region of £32M. This is before consideration of infrastructure damage or risk to life, so we are confident that if the work necessary to meet our legal obligations is within this sum it is also a sound economic investment.

This business case appraises three approaches:

- **Business As Usual (BAU)** – the baseline scenario of present-day conditions with no intervention measures.
- **Walkaway (reservoir discontinuance)** – take Llyn Tegid out of RA75 by removing significant sections of the embankment such that it cannot impound >10,000m³ above natural ground level.
- **Do-something** – a range of options to meet MIOS

Table 4.1 provides a high-level summary of an assessment of each of these approaches.

Table 4.1: Summary Table of Long List Options

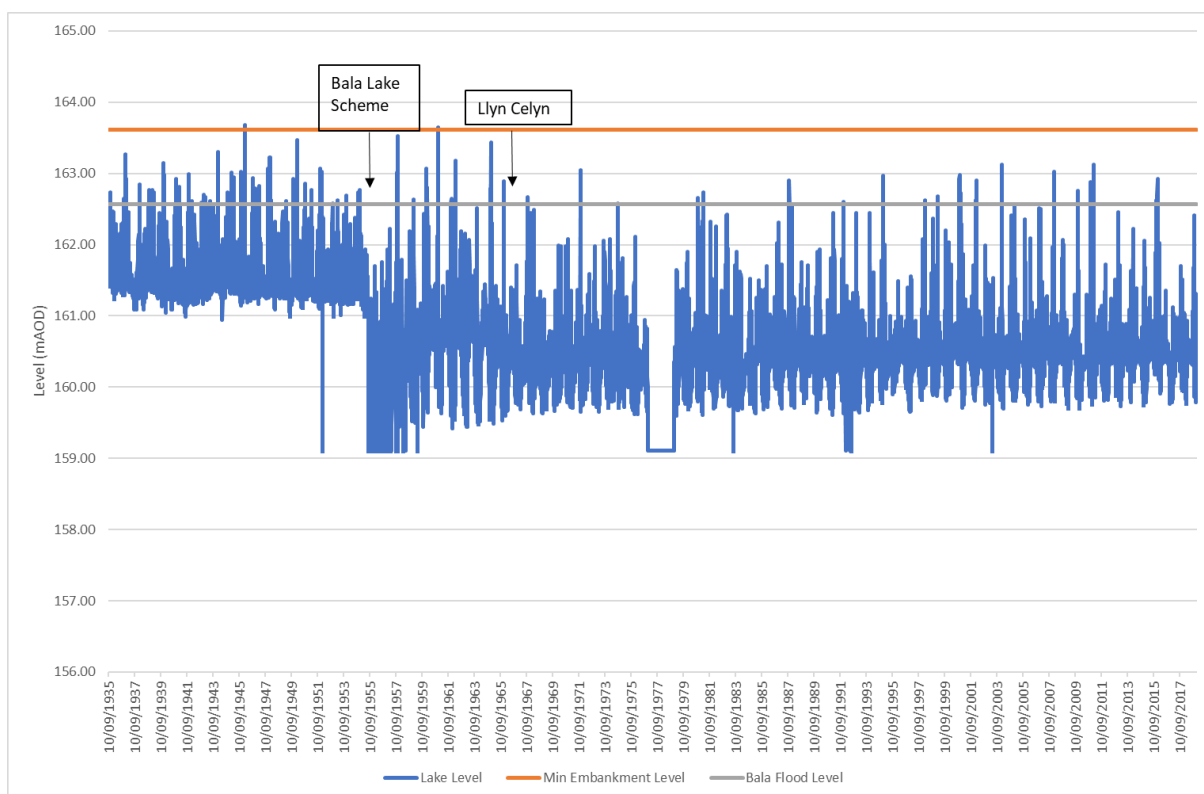
Option	Capital Cost (£M)	Damages Avoided (£M)	Comment	Recommend?
Do Something (OBC options)	6.33-9.9	32	Complies with RA75, minimises impact on environment and communities and maintains current level of flood protection to Bala and to downstream communities.	Yes
Business As Usual (BAU)	0	0 (in case of a dam failure)	In breach of RA75. The MIOS implies that the current arrangement as being an unacceptably high level of risk in the long term with many lives at risk in the event of an uncontrolled failure. The only possible options are: <ul style="list-style-type: none"> • Strengthen/ raise embankments • Discontinue (Walkaway) There are no downstream options that can affect the ability of Llyn Tegid’s embankments to withstand the design and safety check floods as required under industry Reservoir Safety Guidance.	No
Walkaway (remove reservoir storage capacity and take out of RA75 - discontinue)	Unknown (estimate £millions)	0 (at risk from regular flooding)	<ul style="list-style-type: none"> • Flood risk increased significantly in Bala and further downstream. • Undermines the original Bala Lake Scheme in the 1950’s. • NRW will no longer be able to comply with the Dee and Clwyd River Authority Act 1973. • Substantial cost to implement option with significant environmental impact. • Long time to implement (ARPE approval, Dee Regulations need to be re-drafted, significant additional modelling work required). 	No

As discussed above, BAU is not a viable option due to non-compliance with RA75. It does not address the known risks associated with the reservoir and puts people’s lives at a higher than acceptable risk for an extended length of time.

The Walkaway option is also not a viable solution for the reasons outlined in the table. The loss of the flood protection offered by the embankments to the town of Bala and to downstream communities would undermine the original 1950’s Bala Lake Scheme and be extremely controversial. NRW would no longer be able to comply with their legal obligations under the Dee and Clwyd River Authority Act 1973. The current Dee Regulations would need to be re-drafted and agreed by the Dee Consultative Committee, taking a significant length of time. Added to that the additional modelling work and environmental impact assessments plus agreement with the ARPE on an acceptable solution, it is likely to delay improving the safety of these embankments by more than a year over a ‘do something’ option.

The graph of lake levels shown in the figure 4.1 below, provides a useful example of the importance of the embankments and their integral role as part of the Dee Regulations in reducing flood risk locally to Bala. It shows the impact of the Bala Lake Scheme and the introduction of Llyn Celyn and the additional flood attenuation it provides under the Dee Regulations, whilst clearly demonstrating that lake levels still regularly exceed known flood levels in Bala town during storm events.

Figure 4.1: Historic Bala Lake Levels Showing Flood Risk Benefit of Embankments

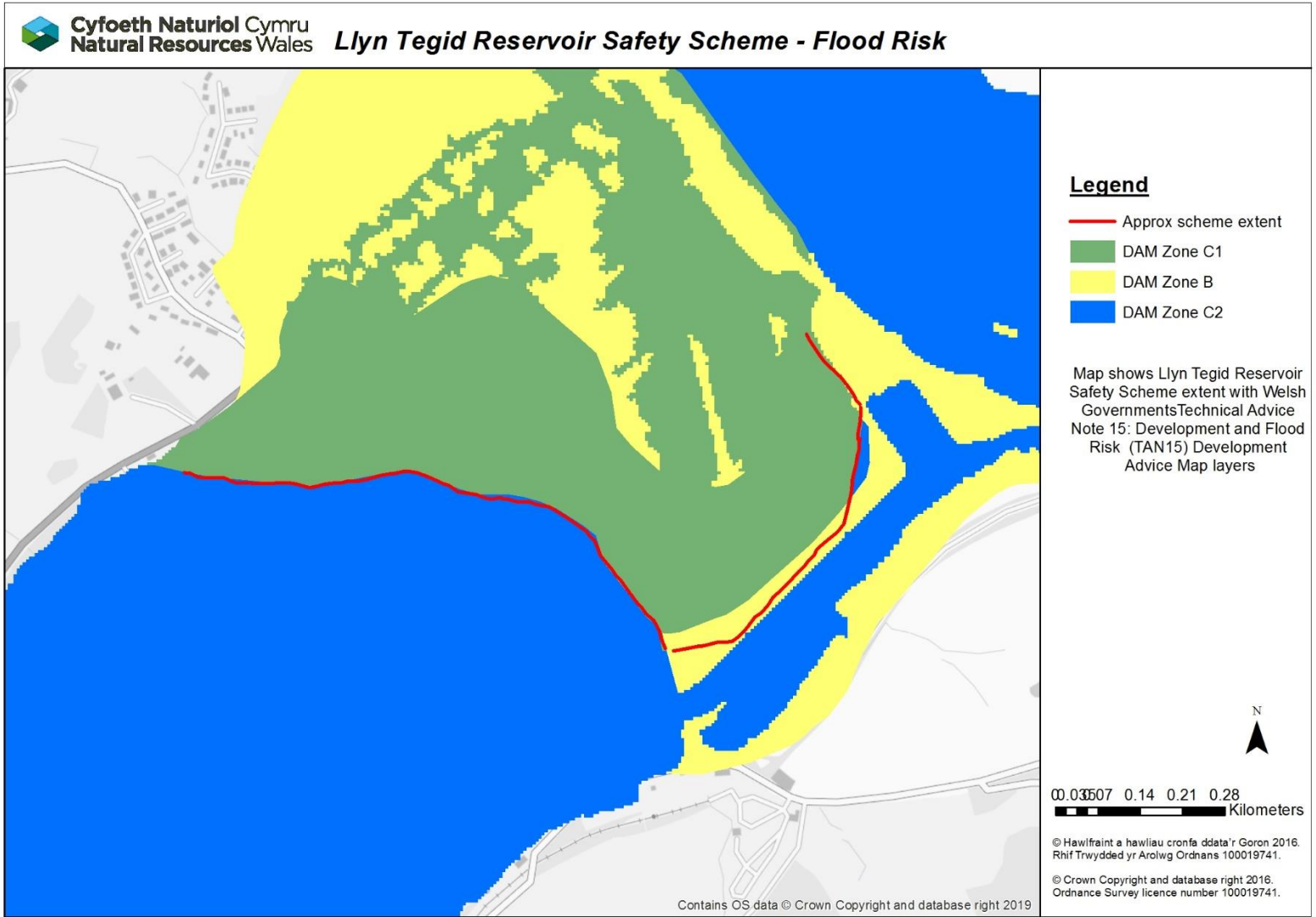


5. Conclusion

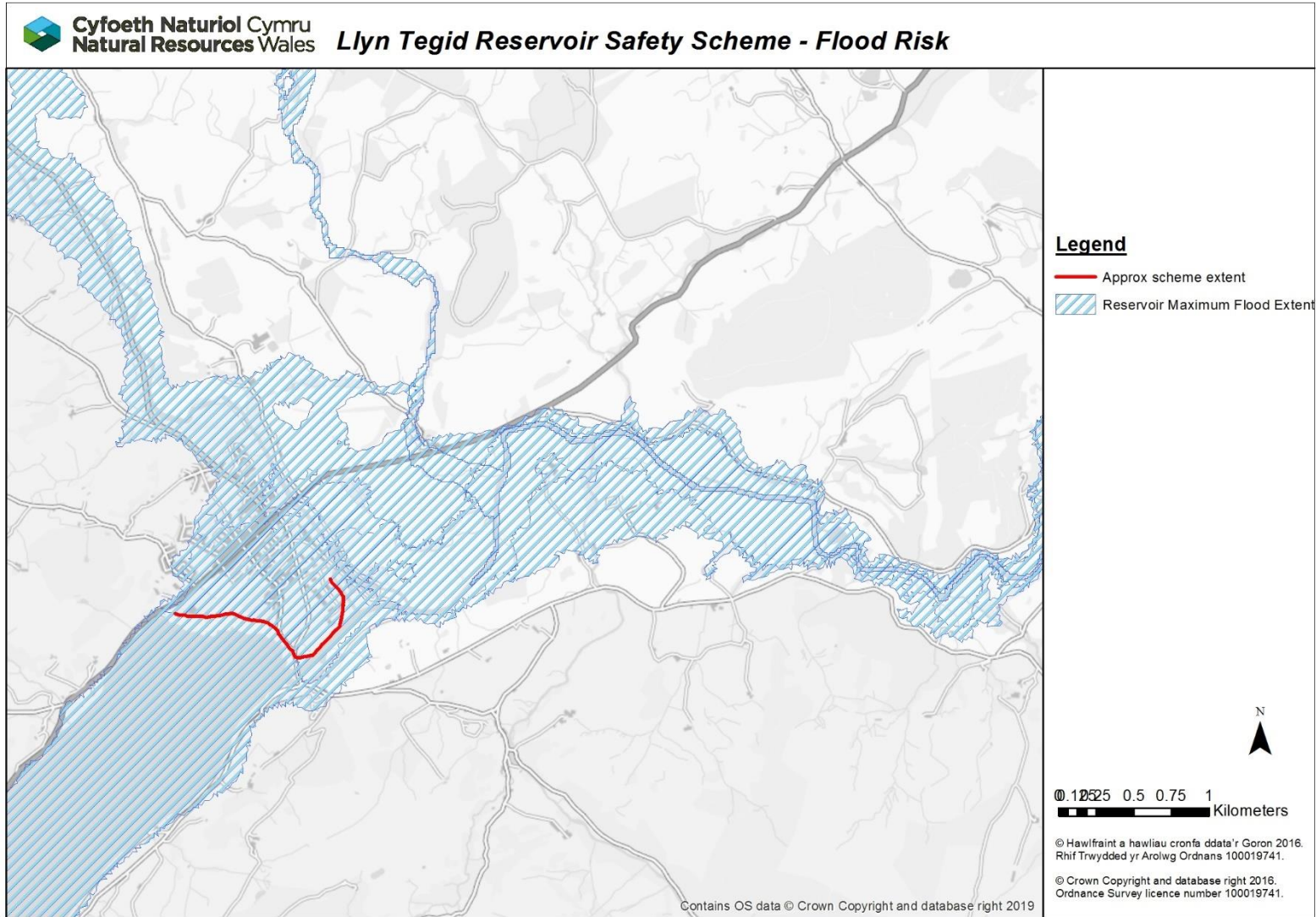
A FCA has been undertaken for Llyn Tegid reservoir safety scheme. This demonstrates how Llyn Tegid provides a vital role in protecting Bala from flooding and mitigating flood risk downstream. It also shows that the embankment strengthening works are necessary to ensure legal compliance with RA75 to ensure their long term safety. The proposed works do not result in any increase in flood storage volumes, or the way in which the Dee is regulated. Thus there is no increase in downstream fluvial flood risk and consequences as a result of the Llyn Tegid reservoir safety scheme.

6. Appendices

6.1 Llyn Tegid Development – TAN15 Development Layers



6.2 Llyn Tegid Reservoir Flood Risk Extent



6.3 Llyn Tegid Fluvial Flood Risk Extent

