Kionslieu Reservoir

Discontinuance Feasibility Assessment Report

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Executive Summary

Kionslieu Reservoir is located approximately 800m north-east of the village of Foxdale, Isle of Man. The reservoir was constructed historically to support local mining operations but has not been used for this purpose for many decades. The reservoir now provides a public amenity and is a prominent landscape feature with notable viewpoints in particular from the north and east. The reservoir is under the ownership and control of the Department of Environment, Food and Agriculture (DEFA).

An inspection carried out in 2017 identified that the reservoir is in an unsatisfactory condition and does not meet current industry standards in terms of reservoir safety. The reservoir presents a significant threat in terms of the potential for inundation flooding, in particular to the village of Foxdale a short distance west of the site. To carry out the improvement works necessary to satisfy reservoir safety standards and to help ensure the safety of people and property downstream will require significant capital investment. In view of these anticipated costs DEFA has commissioned Stillwater Associates to undertake a study into the feasibility of discontinuing Kionslieu Reservoir, the results of which are provided in this report.

The primary objective of this reservoir feasibility assessment is to inform DEFA on a feasible option to formally discontinue the reservoir in accordance with the requirements of the Isle of Man Water Act 1991, which generally reflects the requirements of the Reservoirs Act 1975 (England and Wales) and associated legislation.

The assessment also considers the measures and works required for the option to retain the reservoir and bring it up to current UK reservoir safety standards.

A systematic approach was taken for the assessment process. Visual inspections have been carried out at the site to determine the current condition of the dam and appurtenant structures, to understand the operation of the reservoir and downstream flood risk, and to become familiar with the general surrounding landscape. Subsequent to the visual inspection, a number of high-level desktop assessments have been undertaken to determine and collate the relevant high-level information needed for DEFA to be able to make an informed decision on whether or not to discontinue the reservoir. These assessments included:

- Existing access arrangements and proposed construction access;
- Future surveys / investigations required for discontinuance and retain options;
- Hydrology and hydraulics for discontinuance and retain options;
- Downstream flood risk for discontinuance and retain options;
- Opportunities for improved public access and greater amenity value;
- Land and stakeholder considerations.

High-level costs and project programmes associated with the various options are given in the main report and appendices.

The following **two** options were considered feasible for **Kionslieu Reservoir**:

Option 1: Partial removal of the western embankment by excavating a long notch to downstream stream bed level, with sufficient embankment removed to ensure no upstream impoundment in the western area of the original basin. This option will allow an approximate volume of 9,000m^3 to be stored in the eastern area of the original basin, retained by an apparent high point centrally within the reservoir basin, and

Option 2: Retaining the existing reservoir, with remedial works and improvements to bring the dam to current UK reservoir safety standards, including leakage remedial works with consideration of the following sub-options:

Option 2a: no allowance for leakage control measures, assuming the results of leakage investigations show that there is no leakage at the site;

Option 2b: leakage mitigation installed on 50% of the embankments.

In discussion with Manx Utilities, with overall jurisdiction for flood risk management, it would be necessary to develop the preferred option with reference to the wider flood risk. There is a well understood history of flooding in Foxdale, downstream of the reservoir site. Appropriate mitigation measures would need to be incorporated into the chosen scheme to help alleviate the flood risk.

A summary of the options is provided in the table below along with a comparison of the key important considerations assessed as part of the study.

Kionslieu Reservoir: important considerations related to the feasible options

Consideration	Option 1: Discontinuance	Option 2: Retain Reservoir
Summary of option	**Partial removal of the western embankment by excavating a long notch to downstream stream bed level, with sufficient embankment removed to ensure no upstream impoundment in the western area of the original basin. An approximate volume of 9,000m^3 to be stored in the eastern area of the original basin, retained by an apparent high point centrally within the reservoir basin.**	**Retain existing reservoir, with remedial works and improvements to bring dam to current UK standards.** **Option 2a - No leakage control measures required.** **Option 2b – Leakage control measures required along 50% of the embankments.**
Technical constraints **(dam structure and stability, overflow capacity and emergency drawdown requirements)**	*Removal of western embankment is technically straightforward, and addition of temporary diversion channel further simplifies the works.*	*Installation of new scour facility considered to be technically straightforward and would provide an opportunity to install a new main outlet with larger capacity. Reprofiling of downstream embankment to reduce gradients of slopes may be challenging due to access on to crest and toe areas, and will encroach on to land downstream of the existing toes;* *Implementing leakage control measures (option 2b) may be technically challenging, depending on location, nature of embankment fill material and extent of leakage.*
Silt Management	*Formal silt management works required throughout entire reservoir basin, including:* • *Downstream silt trap during discontinuance works;* • *Excavate silt to form channel through the site of the reservoir basin;* • *Contain the silt adjacent to the channel by constructing bunds from excavated embankment fill material;* • *Relocate surplus unused silt material on existing elevated areas within reservoir basin.* *Use existing stone pitching from upstream face of western embankment to form pools and riffles within channel.*	*No new permanent measures required. Localised silt removal at upstream end of proposed scour facility during improvement works. Potential for localised silt removal at upstream end of existing overflow pipe prior to CCTV survey and/or replace existing outlet/overflow with an outlet with larger capacity.*
Downstream Flood Risk	*The removal of a large section of the western embankment will largely remove the attenuation benefits of the reservoir, which will result in an increase in downstream flood risk from fluvial events, potentially increasing the frequency of shallow flooding in Foxdale, affecting residential and commercial properties.* ***Off-site works will be required to mitigate downstream flood risk. A holistic approach, working in collaboration with Manx Utilities can yield flood risk benefits to the village of Foxdale.*** *Risk of inundation flooding from reservoir failure removed.*	*The addition of an auxiliary spillway on the left (southern) end of the western embankment likely to increase downstream flows during flood events.* ***Off-site works will be required to mitigate downstream flood risk. A holistic approach, working in collaboration with Manx Utilities can yield flood risk benefits to the village of Foxdale.*** *Improvement works will reduce the risk of inundation flooding from reservoir failure to an acceptable level in line with current reservoir safety standards.*
Land ownership/interests	*Temporary impacts on adjacent landowners for access and diversions of watercourses, requiring consultations and negotiations/agreements in advance of works.*	*Permanent land take adjacent to both western and eastern boundaries to accommodate extended embankment slopes, as well as temporary impacts for construction accesses.* *Potentially difficult consultations and negotiations with affected landowners.*

Consideration	Option 1: Discontinuance	Option 2: Retain Reservoir	
Access	*Existing accesses will need to be substantially improved, either temporarily or permanently, to enable access for the necessary construction plant.* *Temporary access to be provided along the existing northern inlet channel and the area within the alignment of the proposed inflow diversion channel adjacent to the western embankment.* *To further improve the public access at the reservoir and its amenity value it is proposed that a new public car park be constructed to the north of the reservoir site and at the end of the existing public footpath as part of this option.*	*Access to the eastern embankment for construction purposes will need to be formalised in discussion with the landowner.* *Existing accesses will need to be substantially improved, either temporarily or permanently, to enable access for the necessary construction plant.* *Temporary access to be provided along the existing inlet channel and the area within the alignment of the proposed inflow diversion channel adjacent to the western embankment.* *To further improve the public access at the reservoir and its amenity value it is proposed that a new public car park be constructed to the north of the reservoir site and at the end of the existing public footpath as part of this option.*	
Amenity, Landscape and Biodiversity	*Notable change in landscape with significant reduction in reservoir footprint. although a smaller body of water will be retained on the eastern side of the site.* *A Preliminary Ecological Assessment (PEA) is required to identify likely adverse impacts with guidance o appropriate mitigation measures.* *Due to the potential for mine waste within the reservoir, lowering the reservoir water level will require monitoring of water quality to avoid polluting the downstream watercourse. Consultation with local authorities and stakeholders along with further ecological assessments and surveys may be required.*	*No significant change to reservoir footprint. Embankments will have grass surfaces with little or no retained vegetation. Minimal impact on existing landscape.* *A Preliminary Ecological Assessment (PEA) is required to identify likely adverse impacts, if any, with guidance on appropriate mitigation measures.* *Due to the potential for mine waste within the reservoir, lowering the reservoir water level to construct new scour facility will require monitoring of water quality to avoid polluting the downstream watercourse. Consultation with local authorities and stakeholders along with further ecological assessments and surveys may be required.*	
Archaeology and Heritage	*No adverse impacts anticipated in terms of archaeology and no requirement for an archaeological watching brief. Heritage impacts not anticipated although consultation should be carried out with local specialist.*		
Safety	*Additional safety signage should be installed to minimise long term public safety liability.*		
Planning and Consents	*Planning permission may be required, subject to pre-planning consultation. DEFA currently investigating the possibility of undertaking the works as emergency works.*		
Ongoing Monitoring and Maintenance	*No requirements in terms of reservoir safety legislation.* *If retained by DEFA carry out annual visits to monitor estate interests.*	*Assume DEFA will maintain the assets in accordance with the requirements of the Water Act 1991 (follows the requirements of the Reservoirs Act 1975).* *Improved regime with regular (weekly) surveillance, inspections and reporting to meet current industry standards and regulatory requirements.*	
Indicative Total Whole Life Cost [(1)(2)]	**£545,000**	**£1,025,000**[(3)]	**£1,215,000**[(3)]

(1) Estimate includes CAPEX and OPEX over 50 years (refer to **Appendices 6.1 and 6.2**).

(2) No allowance included for off-site works to mitigate increased downstream flood risk resulting from either the discontinue or retain options.

(3) No allowance included in retain options for land negotiations and land purchase required for increased footprint of extended embankments.

Contents

1 Scope

Stillwater Associates were commissioned by Department of Environment, Food and Agriculture (DEFA) to carry out a feasibility study into the possible discontinuance of Kionslieu Reservoir.

It is understood that the main reasons why DEFA are considering discontinuance of the reservoir are:

a) *The reservoir no longer serves a strategic benefit and /or the risks are disproportionally high for the benefit the reservoir provides; and*

b) *The reservoir currently presents an unacceptably high threat of inundation flooding to residential and commercial properties, and the local school downstream of the site. Significant capital investment will be required to improve the reservoir to satisfy reservoir safety standards in line with current legislation.*

This report draws together the various separate assessments that were carried out as part of the overall feasibility study for **Kionslieu Reservoir** and presents this information in such a way as to allow DEFA to decide on the most appropriate way forward. A discontinuance option along with the option of retaining the dam are presented, and high-level costs and project programmes associated with each option are included.

2 Background

A summary of key information on Kionslieu Reservoir is included in Table 2.1 below:

Table 2.1: Summary of key information on Kionslieu Reservoir

Parameter	Description / value
Location	Situated approximately 800m east of the village of Foxdale, Isle of Man. Nearest Post Code: IM4 3HL National Grid Reference: SC 289 783
Reservoir capacity	24,500m^3
Dam Construction	Earth embankment dam
Date Built	Unknown – estimated 19th century
Consequence Category (Note 1)	Category A (Note 2)
Summary of downstream consequence of failure and downstream flood risk	A review of the downstream flood risk with the existing reservoir and overflow arrangements (discussed in more detail in **Appendix 4**) indicates that there is a risk of inundation flooding to various residential and commercial properties downstream of the east and west embankments in the event of embankment failure and an uncontrolled release of water downstream. The anticipated extent of flooding downstream in the event of a breach failure of the western embankment is such that this reservoir would be designated as "High-Risk" according to the Reservoirs Act 1975, as applied in England and Wales. An uncontrolled release of water from the reservoir would pose a significant risk to life as well as causing extensive property damage. To the east, the village of Foxdale would be at risk of flooding, including the A24 road. To the west, the A24 road, Eairy Reservoir and the hamlet of Eairy are all at potential risk of flooding. This inundation flood threat would be removed by discontinuing the reservoir. Alternatively, a satisfactory retain option would involve extensive works to improve the reservoir embankments such that the risk was reduced to an acceptable level, in line with current reservoir safety legislation. Note that Foxdale, west of the site, has a history of fluvial flooding. Removal of the Kionslieu reservoir, or improved overflow arrangements if the reservoir is retained, will increase the rate of water discharging from the site during fluvial flood events. Increased flows would be expected to exacerbate the fluvial flood risk in Foxdale. This change is likely to be small but downstream watercourse improvements should be implemented to mitigate this change. There is a significant opportunity with this scheme to address the long standing flooding issues at Foxdale village.

Notes:

1. Consequence Category defined in Floods and Reservoir Safety 4th Edition (Institution of Civil Engineers, 2015)
2. The consequence category for Kionslieu Reservoir based on the last Inspection Report (April 2018)

Kionslieu Reservoir, which is owned and operated by DEFA, has an estimated stored volume of just under 25,000m^3. Under current legislation the reservoir is therefore not classified as a 'large raised' reservoir. Further, irrespective of this reservoir not meeting the relevant volume threshold, the relevant legislation would only apply to this reservoir if it was under the control of Manx Utilities. However, in accordance with Section 3(1) of the Health & Safety at Work Act (IoM), DEFA have a duty of care to ensure that Kionslieu Reservoir does not pose a risk to downstream residents or communities. Therefore, DEFA have stated their preference to operate in accordance with the reservoir safety legislation contained within Schedule 3 of the Isle of Man Water Act 1991, which follows the general requirements of the Reservoirs Act 1975, as applied in England.

3 Available Data

The following information was made available to Stillwater Associates for the purpose of this study:

Table 3.1: List of information on Kionslieu Reservoir available to Stillwater Associates

Item / Document	Details
Inspection Reports	26th April 2018
General sketches	• Overflow arrangement (2014) – included in Inspection Report (2018)
Water Quality and Silt Analysis	• Electronic PDF File (File name: 9862/17 AD - Certificate of Analysis – Heavy Metals Analysis, 24/11/2017) • Electronic PDF File (File name: 133/18 AT - Certificate of Analysis – Hardness Analysis, 5/01/2018) • Electronic PDF File (File name: 9866/17 SL - Certificate of Analysis – Heavy Metals Analysis, 24/11/2017)
Bathymetric survey	• Electronic AutoCAD File (File name: A397-LS-01; 22/12/2017) – Mullen Consulting • Electronic PDF File (File name: A397-LS-01; 22/12/2017) – Mullen Consulting • Electronic AutoCAD File (File name: A397-LS-02; 22/12/2017) – Mullen Consulting • Electronic PDF File (File name: A397-LS-02; 22/12/2017) – Mullen Consulting • Electronic AutoCAD File (File name: A397-LS-03; 22/12/2017) – Mullen Consulting • Electronic PDF File (File name: A397-LS-03; 22/12/2017) – Mullen Consulting
Topographical Survey	• Electronic AutoCAD File (File name: A397-LS-04; 31/01/2020) – Mullen Consulting • Electronic PDF File (File name: A397-LS-04; 31/01/2020) – Mullen Consulting
Ownership plan	• Electronic PDF File (File name: Land ownership plan – 2016, 19/10/2016)

4 Description of the Reservoir

Table 4.1 below shows key information and dimensions relating to the reservoir.

Table 4.1: Summary of the key features relating to Kionslieu Reservoir

Feature	Value	Source / comment
Reservoir surface area at TWL	37,000m^2	Based on information from last Inspection Report (April 2018). This has been verified by the capabilities provided by Google Earth software.
Reservoir volume at TWL	24,500m^3	Based on information from last Inspection Report (April 2018).
Maximum dam height	Western Embankment: 5m Eastern Embankment: 6m	Based on information from last Inspection Report (April 2018).
Total freeboard	2.21m	Based on information from last Inspection Report (April 2018).
Top Water Level	147.13mAOD	Topographical Survey (January 2020)
Dam Crest level	149.34mAOD	Topographical Survey (January 2020)
Flood category	A	Based on information from last Inspection Report (April 2018). Assessed category on the basis of Floods & Reservoir Safety (ICE, 2015, 4th edition).
Catchment area	0.39km^2	Based on information from last Inspection Report (April 2018).

4.1 *Location*

Kionslieu Reservoir is located approximately 800m east of the village of Foxdale, Isle of Man, as shown in Figure 4.1 below.

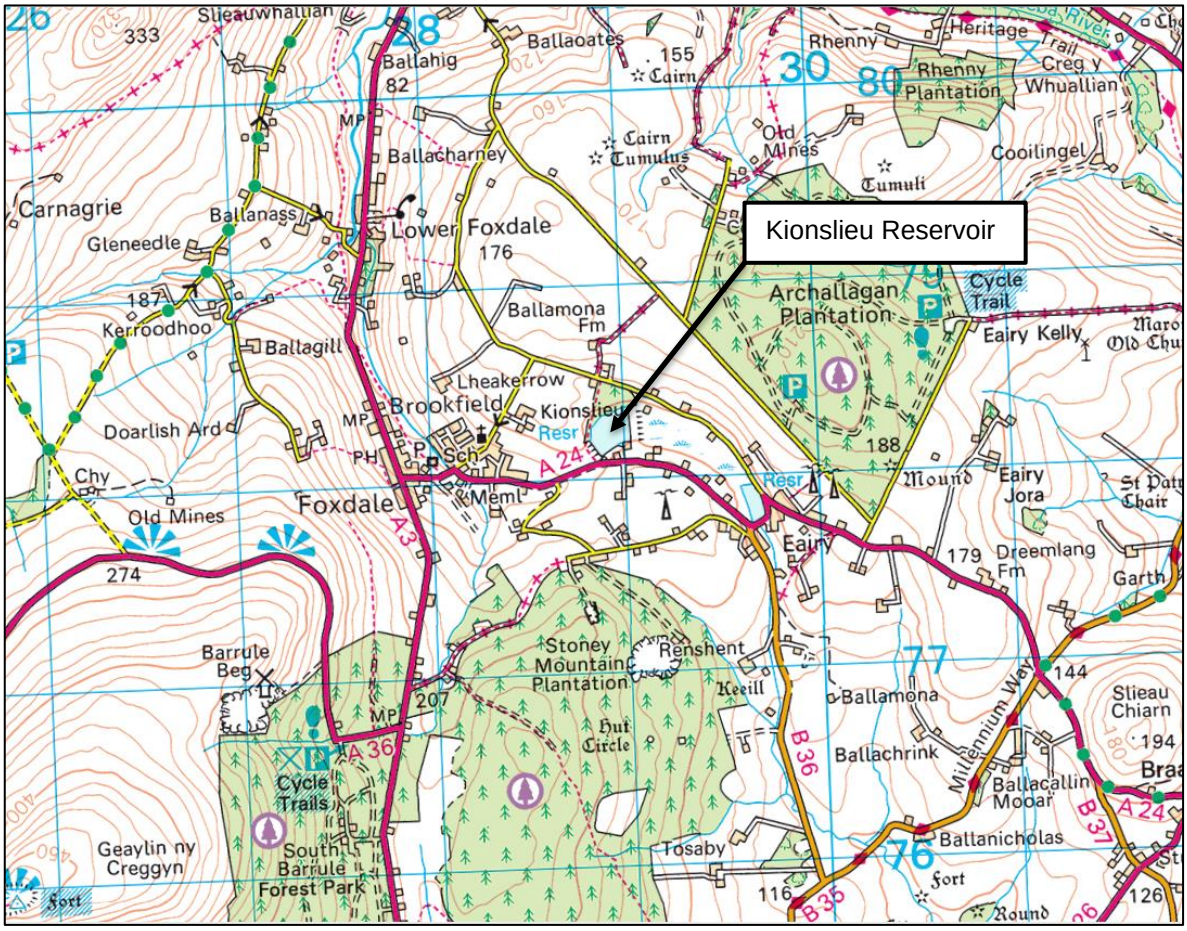


Figure 4.1: Location of Kionslieu Reservoir (courtesy of www.bing.com/maps)

4.2 *Access Arrangements*

A more detailed description of the existing access arrangements is included in **Appendix 1**.

Access to the reservoir site is achieved from the south via approximately 150m of an existing public footpath and cycle track on to the crest of the western embankment. The track connects to the A24 (Foxdale Road) at National Grid Reference SC 289 780.

Access to the eastern embankment can only be achieved at present through the grounds of a private dwelling, through a disused gated accessed off the A24 (Foxdale Road) at National Grid Reference SC 290 780.

Vehicular access is currently not available to the embankment crests, embankment downstream toes or along the rim of the reservoir.

Pedestrians are able to gain access to the entire western and eastern embankment crests, downstream toes, abutments, reservoir surrounds and the overflow structure although public access is limited to the western embankment crest.

Formal public vehicle parking is not currently available.

4.3 *Condition Assessment*

A detailed description of the current condition of the dam and appurtenant structures is included in **Appendix 2** which is based on observations made during site visits to the reservoir on 26th November 2019 and 8th January 2020. It is concluded that the dam embankments are generally in poor condition, with over-steep slopes and clear signs of poor construction. There are indications of potential leakage in some areas, most notably associated with the eastern embankment. There

are no signs currently of major structural issues such as slope instability, large cracks or settlement.

4.4 *Hydrology and Hydraulics*

The hydrology and hydraulics associated with the existing reservoir on this site are discussed in more detail in **Appendix 4**. A high-level assessment of the hydrology and hydraulics at the reservoir has been undertaken based on the available information in the last Inspection Report.

Floods and Reservoir Safety Fourth Edition (FRS4) published by the Institution of Civil Engineers (ICE) in 2015 sets out the standards to be achieved in terms of overflow capacity. Kionslieu Reservoir, according to the 2018 Inspection Report, is currently categorised as a Category A reservoir in terms of flood risk. When considering the potential threat posed by the reservoir in the event of a breach failure of the western embankment it is anticipated that the reservoir would be designated as a '**High Risk**' reservoir. The standards state that a Category A reservoir should be designed to convey the Design Flood (1 in 10,000 year event) through the overflows whilst maintaining adequate freeboard for wave action. In addition, the reservoir should also be able to safely pass the Safety Check Flood (PMF) event accepting that some overtopping of the dam may occur under this event.

The last Inspection Report (2018) estimated the following flood inflows for the reservoir:

Table 2: Kionslieu Reservoir: summary of flood inflows

Flood Event	Peak inflow (m^3/s)
Safety Check Flood (Summer PMF)	7.35
Design Flood (10,000-year flood)	3.70
1,000-year flood	2.20
150-year flood	1.50

It is clear that the flood inflows shown in Table 4 above are significantly in excess of the estimated maximum capacity of the existing overflow/outlet pipe ($0.40m^3/s$). Therefore, it is reasonable to assume that **the current overflow capacity at Kionslieu Reservoir is not sufficient to safely pass the Design Flood and Safety Check Flood for a Category A dam in accordance with the latest reservoir safety guidance**.

As the stillwater flood levels have not been determined for the 10,000-year and PMF events, it is not possible to complete a reliable wave overtopping assessment for the reservoir. However, a sensitivity assessment has been undertaken following the methodology in FRS4 and assuming a water level at TWL of 147.41mAOD. The results show that the significant wave height (H_s) at this reservoir, based on the fetch length, wind speed and wind direction, would be expected to be approximately 0.23m.

Since publication of FRS4 in 2015, further guidance on wave overtopping flows has been published in the EurOtop II manual. The most significant aspect of this update is that grassed embankments are deemed not to be at risk from wave overtopping when the significant wave height is less than 0.3m, as is the case at Kionslieu Reservoir. Therefore, the risk of failure of the embankment due to wave overtopping alone, is considered to be negligible.

Despite the existing freeboard of 2.21m (distance between TWL and the lowest crest level), the grossly inadequate existing overflow capacity is likely to result in the dams being overtopped during the extreme flood events considered. The situation is likely to be made worse by waves.

The performance of the existing reservoir in respect of current UK standards is further discussed in **Appendix 6.2**.

5 Ecology

5.1 *Preliminary Ecological Assessment*

A Preliminary Ecological Assessment (PEA) should be carried out to help determine the potential adverse impacts resulting from the discontinuance works, and to develop an appropriate mitigation strategy. This assessment will also identify further desk top assessments and/or surveys that should be undertaken to properly inform the scheme design.

5.2 *Biodiversity: enhancement opportunities*

A PEA would identify potential enhancement opportunities that could be considered in conjunction with the discontinuance options, which may include:

- Creation of significant river corridor biodiversity.
- Erection of bird and bat boxes on semi-mature trees.
- Landscaping of the reservoir banks and planting of native marginal and aquatic vegetation of local provenance.

6 Archaeology and Heritage

It is considered unlikely that the proposed works will adversely impact archaeology in view of the limited extent of intrusive activities into a constructed embankment. However, consideration should be given to appropriate consultation with the relevant heritage stakeholder to determine the nature and age of the structures might be of heritage interest.

7 Land Issues & Stakeholders

7.1 *Land Considerations*

DEFA has provided a land ownership plan (PDF document entitled 'Boundary Overlay', dated February 2020) indicating that DEFA owns the entire reservoir generally, and the Kion Slieu Plantation north of the reservoir. DEFA does not own all of either the eastern or western embankments.

The areas surrounding the reservoir, the immediate bankside areas and the majority of the eastern and western embankments are owned by Third Parties. Permissions or agreements are therefore likely to be required, or purchase of land, to perform much of the proposed improvement works, most notably the modifications to embankments for either of the options.

The plan showing the extent of the DEFA owned land and associated privately owned land in the vicinity of the reservoir is included in **Appendix 5**.

7.2 *Stakeholders*

The following key stakeholders have been identified, with further details found in **Appendix 5**.

Stakeholder	Interest
DEFA	Owner: ownership includes the majority of the reservoir area and bankside areas, plus the Kion Slieu Plantation.
Manx Utilities	Flood risk: longstanding history of fluvial flooding in Foxdale.
Manx National Heritage (TBC)	Heritage
Manx Wildlife Trust	Existing ecology. Potential future ecology opportunities with either retained or discontinued reservoir.
Private land owners	Owners of land surrounding the reservoir and downstream of the site with riparian responsibility for watercourses and drainage.

8 Engineering Options

8.1 *Overview*

This section summarises the options that were identified as feasible for discontinuance and also includes the option of keeping the reservoir in its current form. The technical constraints, impact on downstream flood risk, and high-level costs related to each option are presented.

The detailed assessment of options for Kionslieu Reservoir is included in **Appendix 6**.

Two options were considered as follows:

Option 1: Partial removal of the western embankment by excavating a long notch to downstream stream bed level, with sufficient embankment removed to ensure no upstream impoundment in the western area of the original basin. This option will allow an approximate volume of 9,000m^3 to be stored in the eastern area of the original basin, retained by an apparent high point centrally within the reservoir basin (refer **Appendix 6.1**).

Option 2: Retaining the existing reservoir, with remedial works and improvements to bring the dam to current UK reservoir safety standards (refer **Appendix 6.2**), including leakage remedial works with consideration of the following sub-options:

Option 2a: no allowance for leakage control measures, assuming the results of leakage investigations show that there is no leakage at the site;

Option 2b: leakage mitigation installed on 50% of the embankments.

8.2 *Options Summary*

Table 8.1 below provides a summary of the options that were considered, and the works associated with each.

8.3 *Option Costs*

Table 8.2 below summarises and compares the scheme implementation costs and a 50 year 'whole life' cost for each option. The estimated total implementation cost range for each option includes an allowance for the following items:

- Studies & Investigations
- Design (including construction management costs)
- Construction
- Measures to address downstream flood risk (**the costs related to this item still need to be investigated / confirmed**)
- Environmental mitigation (**the costs related to this item still need to be investigated / confirmed**)
- Operational and maintenance costs over 50 years

The costs of off-site works, for instance to improve watercourses downstream in Foxdale, are not included in the option costings. The extent of works necessary to mitigate flood risk, and potentially to deliver improvements to the current risk, will need to be established in consultation with Manx Utilities, and likely to require a flood study for the area of interest.

Table 8.1: Kionslieu - summary of anticipated technical constraints and works required for the respective options

Consideration	Required Standard	Works Required to Achieve Standard	
		Option 1: Discontinuance	**Option 2: Retain Reservoir**
Dam Structure: Condition and Proposed Works	Ongoing satisfactory structural condition anticipated for next 50 years.	Partial removal of the western embankment by excavating a long notch to downstream stream bed level, with sufficient embankment removed to ensure no upstream impoundment in the western area of the original basin. An approximate volume of 9,000m^3 to be stored in the eastern area of the original basin, retained by an apparent high point centrally within the reservoir basin. A natural stream to be excavated along with silt in the reservoir basin to allow the natural stream to follow a path towards the downstream watercourse. Silt mitigation measures to be implemented to ensure no silt travels into the downstream watercourse.	Retain existing reservoir, with remedial works and improvements to bring dam to current UK standards. Option 2a: No leakage control measures required. Option 2b: Leakage control measures required along 50% of the embankments. Construction of a new scour facility through western embankment. CCTV survey of existing overflow pipe and clearance if required and/or construction of a larger overflow/outlet pipe. Construction of a new auxiliary spillway on the left (southern) abutment of the western embankment to increase spillway capacity.
Dam Structure: Stability	Long term stability under all foreseeable loading conditions	During detailed design, appropriate material tests should be carried out in order to determine the properties of the embankment fill and to ascertain the founding conditions. The notch side slopes should then be properly designed to ensure that they will be stable. No further investigations or stability checks are proposed for this option.	Based on condition assessment (January 2020), no evidence of immediate untoward movement or distress, raising no concerns of instability. However, due to the steep gradient of the downstream face of both embankments, slope regrading to reduce gradient is proposed to ensure future long-term stability. Based on results of leakage detection surveys, to be carried out if a retain option is adopted, leakage control measures may be required in the future as part of Option 2b.
Existing Overflow: Capacity	Category A Dam: Design standard is 1 in 10,000-yr event and must safely pass PMF event (safety check flood) without significant damage. Kionslieu reservoir could be designated as "**High Risk**".	None – Overflow structures not intended to operate following discontinuance.	Existing overflow capacity at Kionslieu Reservoir is not sufficient to safely pass the Design Flood and Safety Check Flood for a Category A dam in accordance with the latest reservoir safety guidance. See **Appendix 4** for flood assessment.

Consideration	Required Standard	Works Required to Achieve Standard	
		Option 1: Discontinuance	**Option 2: Retain Reservoir**
Existing Overflow: Downstream Flood Risk	Downstream flood risk should not be increased. Kionslieu reservoir has been designated as "**High Risk**".	The removal of a large section of the western embankment will also largely remove the attenuation benefits of the reservoir. Inevitably this will result in an increase in downstream flood risk from fluvial events, potentially increasing the frequency of shallow flooding in Foxdale, affecting residential and commercial properties. Detailed consideration will need to be given to measures to mitigate this risk, in discussion with the flood risk management team at Manx Utilities.	The addition of an auxiliary spillway on the left end of the western embankment will increase downstream flows during flood events.
		Discontinuance option **removes the threat of reservoir breach inundation flooding**.	Improvement works for the retain option will **reduce the risk of reservoir breach inundation to an acceptable level**.
		Mitigation works should be implemented in discussion with Manx Utilities to mitigate downstream fluvial flood risk at Foxdale. An appropriate scheme undertaken in conjunction with the Kionslieu discontinuance or improvements can address and potentially alleviate longstanding existing flooding issues.	
Emergency Drawdown Capacity	Under the Guidance for Reservoir Drawdown Capacity indicative drawdown with reservoir at top water level should exceed Q_{10} inflow, to allow at least gradual drawdown from top water level under this scenario. Kionslieu reservoir could be designated as "**High Risk**".	Not applicable: impoundment removed.	There are currently no existing permanent drawdown arrangements at Kionslieu Reservoir. Reservoir drawdown in an emergency would fully rely on temporary equipment brought to site. See **Appendix 4** and **Appendix 6.2** for details regarding emergency drawdown capacity.
Managing Reservoir Water Levels during Construction	As a minimum, provide capacity on site to pass the Q_{10} inflow.	A temporary diversion channel could be constructed adjacent to the western embankment to divert the main inflow stream away from the reservoir. It has been estimated that the proposed channel would be able to pass the majority of the Q_{10} inflows. Mobile pumps could be brought to site for over-pumping of additional inflows from direct rainfall and runoff into the reservoir basin. Indicative capacity requirements given in **Appendix 6.1**.	A temporary diversion channel could be constructed adjacent to the western embankment to divert the main inflow stream away from the reservoir. It has been estimated that the proposed channel would be able to pass the majority of the Q_{10} inflows. Mobile pumps could be brought to site for over-pumping during the scour facility construction. Indicative capacity requirements given in **Appendix 6.2**.

Consideration	Required Standard	Works Required to Achieve Standard	
		Option 1: Discontinuance	**Option 2: Retain Reservoir**

Managing Silt / Water Quality	Ensure that silt is not transported downstream during and after any works.	Silt management during / after construction to include:
		• Silt clearance from natural watercourse;
		• Re-vegetation of bankside areas;
		• Temporary or permanent measures to retain silt, including:
		  o sediment traps with lowered bed levels;
		  o sediment traps using small raised structures;
		  o detention basins.
		A new area of reedbed established upstream of the western embankment notch could be used to provide a level of treatment to surface water flows and to assist with the attenuation of low flows from the discontinued reservoir basin.
			Localised silt removal at upstream end of location of new proposed scour facility to allow access for works. Some localised silt removal may also be required upstream of the existing overflow to allow a CCTV survey and potential clearance. No significant permanent measures required.

Access	Access as existing – pedestrian access only for permanent solution.	Temporary and permanent access will be required for the both the discontinuance and retain options. The arrangements for access should be determined by the proposed contractor to suit their choice of accessing the site with materials and equipment. Works may include: • Trees on the route of the permanent / temporary access tracks will require felling. • Vegetation and topsoil layer to be stripped and set aside for future re-use. • Installation of suitable temporary track surface (Geotextile / granular fill, bogmats or proprietary trackway system). • Installation of a permanent stone track surface along the existing cycle track (geotextile, granular fill, hardcore and stone) on the western embankment. • Temporary access tracks will need to be completely removed on completion of the works and the area returned to its pre-scheme condition. • Permanent access tracks will need to be cleared of any construction debris and made good on completion of the works. The amenity value of the site could be enhanced with the provision of improved public access at the reservoir site, for instance with a new public car park constructed to the north of the reservoir site adjacent to the existing public footpath.	

Consideration	Required Standard	Works Required to Achieve Standard	
		Option 1: Discontinuance	**Option 2: Retain Reservoir**
Amenity, Landscape and Biodiversity	Continued amenity for walkers; Avoid/minimise adverse impact on landscape; Seek biodiversity enhancements where possible.	The existing amenity value of the impounded body of water will be partially lost under this option. However, as the reduced reservoir will still normally hold 9,000m^3 of water, some amenity value will remain following the works. It is proposed that the newly exposed reservoir basin area is rehabilitated and seeded to encourage the natural flora of the surrounding area to establish. The amenity value of the river is retained and with minor works the remaining dam structure can be allowed to vegetate to help maximise the future ecology and biodiversity value of the site. Potential for adverse impacts on ecology unless appropriate mitigation measures implemented. A PEA should be undertaken to identify potential adverse impacts in consultation with the relevant stakeholders. The elevated areas within the reservoir basin that will be exposed following discontinuance will be landscaped. It is proposed that pre-seeded coir roles be placed in the exposed area to assist with rapid establishment of vegetation and planting as part of the landscaping works.	Amenity value retained – no additional works required. No change to lake footprint or appearance of dam, and no impact on existing landscape. Due to the requirement to draw down the reservoir as well as to bring in large plant to allow the scour facility construction works, suitable ecological assessments may be required with a potential need for minor ecological mitigations.
Archaeology and Heritage	Avoid adverse impacts.	It is considered unlikely that the proposed works will adversely impact archaeology in view of the limited extent of intrusive activities into a constructed embankment. However, consideration should be given to appropriate consultation with the relevant heritage stakeholder to determine the nature and age of the structures might be of heritage interest.	
Safety	Prevent access on to crest and/or prevent falls from crest or into reservoir.	• Add signage at each abutment which contains the following wording as a minimum: **'No Public Access – Danger – Sheer Drop – Deep Water – Soft Mud – Danger of Death'** • Consideration should be given to providing safety rings on the eastern bankside areas.	• Add signage at each abutment which contains the following wording as a minimum: **'No Swimming – Danger Deep Water – Beware of Thin Ice – Danger of Death'** • Ensure sufficient life rings are in place on both embankments.
Planning and Consents	Obtain necessary planning permissions and consents.	Planning permission may be required. Material considerations include: • Landscape; • Ecology and biodiversity impacts; • Downstream flood risk. Other third party consents may also be required. **DEFA will investigate and confirm whether or not planning permission is required.**	No change of use and no changes proposed to the dam or reservoir apart from improvement works to the embankments. No off-site impacts anticipated. Need for planning and consents considered to be unlikely. **DEFA will investigate and confirm whether or not planning permission is required.**

Consideration	Required Standard	Works Required to Achieve Standard	
		Option 1: Discontinuance	**Option 2: Retain Reservoir**
Ongoing Monitoring and Maintenance	Consequence Category A Dam; with the potential to be designated "**High Risk**". Full supervision and inspection requirements of Water Act 1991 apply (as Reservoirs Act 1975 for England and Wales).	• Six monthly monitoring visits to assess vegetation regeneration until steady conditions with more detailed annual visit to check estate/boundary issues. • No future maintenance required.	• Improvement works should be overseen by Qualified Civil Engineer (QCE). • Weekly surveillance visits, with formal surveillance sheet record of findings. • Maintain Prescribed Form of Record (PFR). • Consider preparation of On-site Plan. • Following requirements of Water Act 1991, a Supervising Engineer to be appointed at all times, with annual statements submitted to Enforcement Authority. • Following the requirements of the Water Act 1991, ten yearly inspections required. • Regular planned maintenance including six monthly operation of scour valve and, as and when required, painting of handrails and mechanical equipment, vegetation management.

Table 8.2: Kionslieu summary of option scheme costs and future operation and maintenance costs

Cost Elements	Option 1: Discontinuance	Option 2a: Retain	Option 2b: Retain (including leakage mitigation works)
CAPEX			
Studies & Investigations	£50,000	£30,000	£30,000
Design (including construction management)	£90,000	£80,000	£110,000
Construction	£390,000	£350,000	(3) £510,000
Measures to address downstream flood risk	TBC	TBC	TBC
Environmental mitigation	TBC	TBC	TBC
Sub-total	£530,000	£460,000	£650,000
OPEX			
OPEX over 50 years	(1) £15,000	(2) £565,000	(2) £565,000
Total Whole Life Cost over 50 years	**£545,000**	**£1,025,000**	**£1,215,000**

Notes:

(1) OPEX costs for discontinuance option assumes one visit per year by DEFA.

(2) OPEX costs for retain option assumes the following:

a. Weekly visits by DEFA to the site, an annual visit and report by the Supervising Engineer, and an allowance for grass cutting throughout the year;

b. £20,000 every ten years (£5,000 for S10 inspection and report, and £15,000 for potential improvement works recommended in the report);

c. £7,500 every 25 years to drain down reservoir and service draw-off pipes and valves.

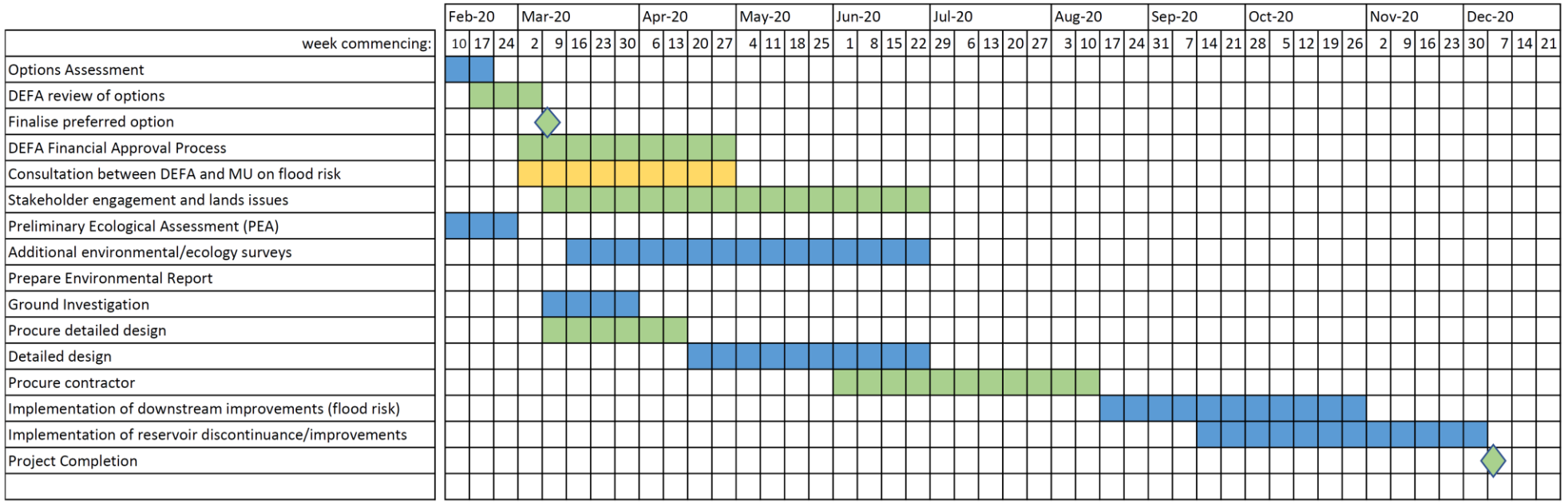
(3) Additional leakage mitigation measures assumed including sheet piles driven to foundation depth along the approximately 50% of the length of each embankment.

9 Project Programme

An indicative programme has been prepared showing the high level activities anticipated for the project. Timeframes for internal approval processes will need to be reviewed and updated as appropriate, as the project progresses. The programme below indicates the shortest perceived overall delivery period for the project.

Consideration will need to be given to the likely earliest start date for works on site. To minimise risk of construction delays it would be normal to avoid the winter period for carrying out earthworks and it may be prudent to plan the discontinuance works for spring 2021.

Konslieu Reservoir - Reservoir Safety Works
Project Delivery Programme



Appendix 1 Access Arrangements

1. Description of Existing Access

Access to the reservoir site is achieved from the south via approximately 150m of an existing public cycle track on to the crest of the western embankment. The track connects to the A24 (Foxdale Road) at National Grid Reference SC 289 780 (see Drawing P10477-001).

Access to the eastern embankment can only be achieved at present through the grounds of a private dwelling, through a disused gated access off the A24 (Foxdale Road) at National Grid Reference SC 290 780.

Vehicular access is currently not available to the embankment crests, embankment downstream toes or along the rim of the reservoir.

Pedestrians are able to gain access to the entire western and eastern embankment crests, downstream toes, abutments, reservoir surrounds and the overflow structure although public access is limited to the western embankment crest.

Formal public vehicle parking is not currently available.

2. Condition of Existing Access Track (Western Embankment)

The existing cycle track to the reservoir western embankment crest was observed to be narrow with an uneven profile, but overall good condition. The track is not adequate for Private / Light Goods Vehicles (P/LGVs), Heavy Goods Vehicles (HGVs) or any specialist 4x4 vehicles and can currently only be used for pedestrian/cycle access.

3. Construction Access

The current access arrangements are not suitable for any vehicle access, including the majority of normal construction plant.

The existing access track to the western embankment crest is currently the shortest route to gain access for construction purposes.

Access to the eastern embankment for construction purposes will need to be formalised in discussion with the landowner.

Accesses will need to be substantially improved, either temporarily or permanently, to enable access for the necessary construction plant.

No access is currently available to the existing inlet channel and the area within the alignment of the proposed inflow diversion channel along the western embankment during construction. Suitable temporary access will need to be provided to allow construction and reinstatement of the diversion channel, most likely across farmland from the north.

4. Works Required for Discontinuance Construction Access

The works required to form the permanent / temporary construction access tracks will be highly dependent on the following aspects:

- The extent and type of works required to discontinue the reservoir.
- The volume of material to be relocated around the site, or to completely removed from site, to achieve the discontinuance.
- The mechanical plant selected by the Contractor to undertake the required works.
- The time of year the works are undertaken.
- Any environmental constraints identified in the ecology assessments.

As a minimum the following works are envisaged:

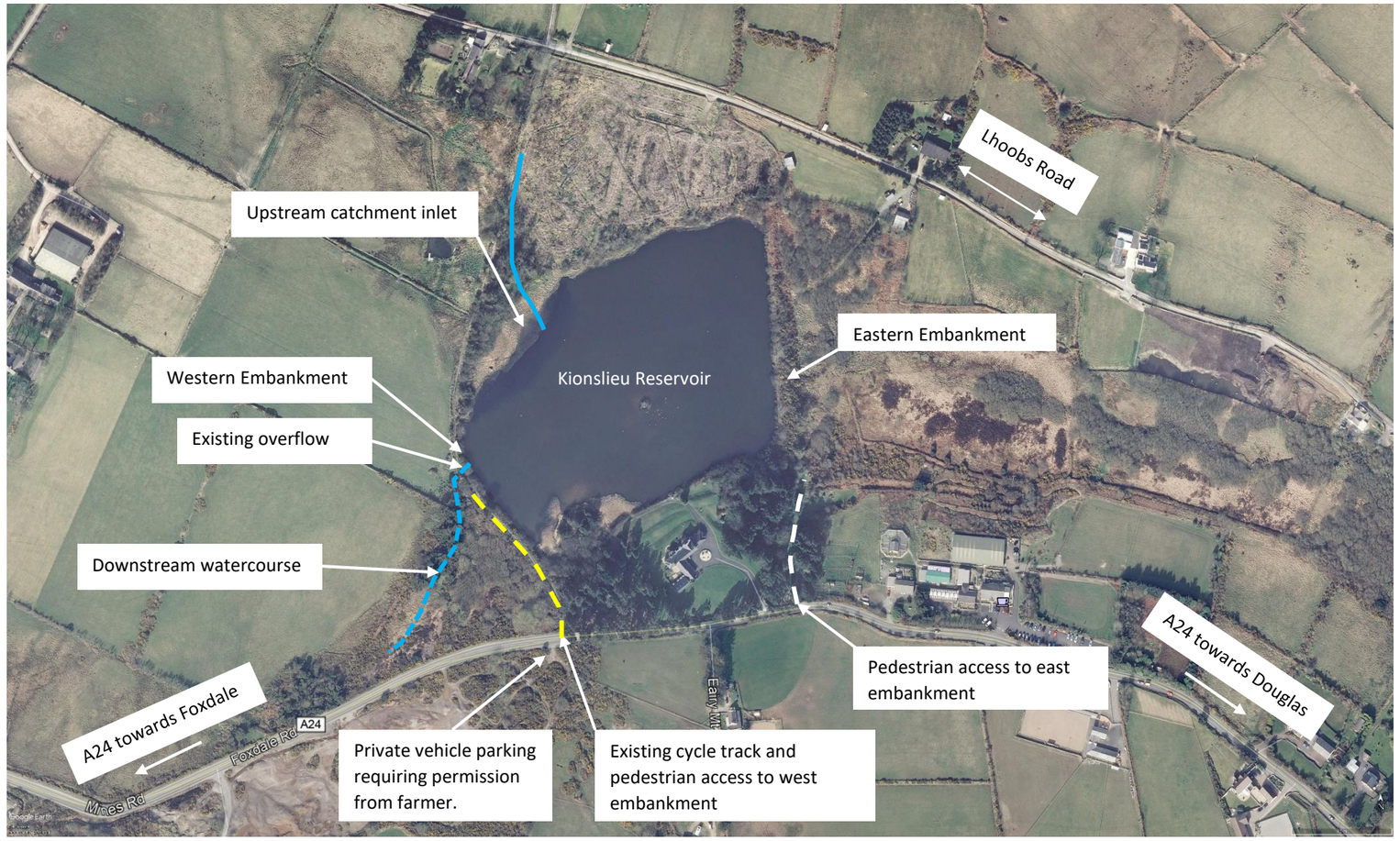
- Trees on the route of the permanent / temporary access tracks will require felling.
- Vegetation and topsoil layer to be stripped and set aside for future re-use.
- Installation of suitable temporary track surface (Geotextile / granular fill, bogmats or proprietary trackway system).

- Installation of a permanent stone track surface along the existing cycle track (geotextile, granular fill, hardcore and stone) on the western embankment.
- Temporary access tracks will need to be completely removed on completion of the works and the area returned to its pre-scheme condition.
- Permanent access tracks will need to be cleared of any construction debris and made good on completion of the works.

Where possible any trees felled as part of creating the construction accesses should be sectioned and retained on site for habitat creation.

5. Ownership / Permissions Issues

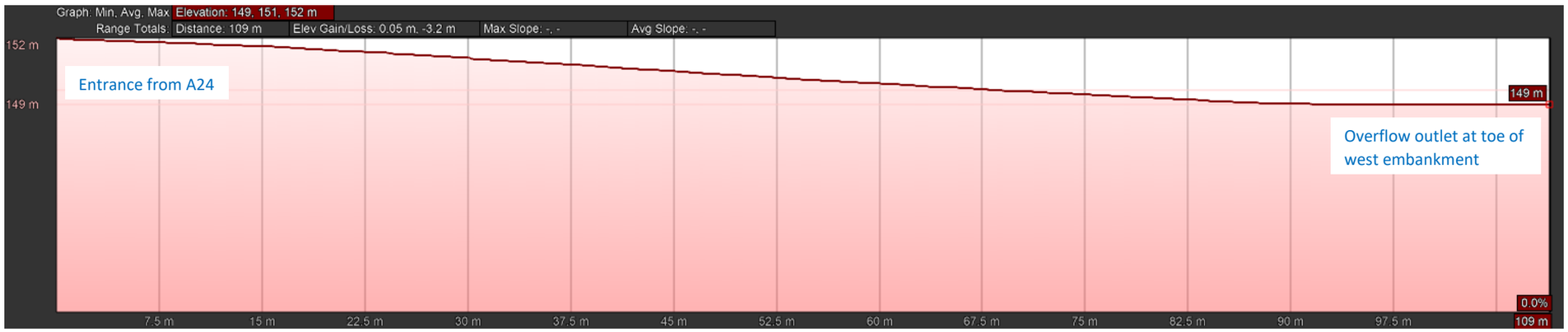
Ownership and right of access issues associated with the access tracks are discussed in **Appendix 5 – Land Issues & Stakeholders**



Access plan for Kionslieu Reservoir

Entrance to existing cycle track leading to west embankment (looking East)

Entrance to pedestrian access track towards east embankment (looking West)



Existing cycle track elevation profile leading to West Embankment

Notes:
Refer to accompanying text description of access route.

Stillwater Associates
Reservoir Safety & Water Consultancy

Client:	The Department of Environment, Food and Agriculture (DEFA), Isle of Man Government
Project:	Kionslieu Reservoir Discontinuance Feasibility Assessment
Drawing title:	Kionslieu Reservoir Site Access
Drawing number:	P1077-001
Date:	March 2020

Appendix 2 Condition Assessment

1. Description and Key Features

The layout of the site is shown in Figure 1 below.

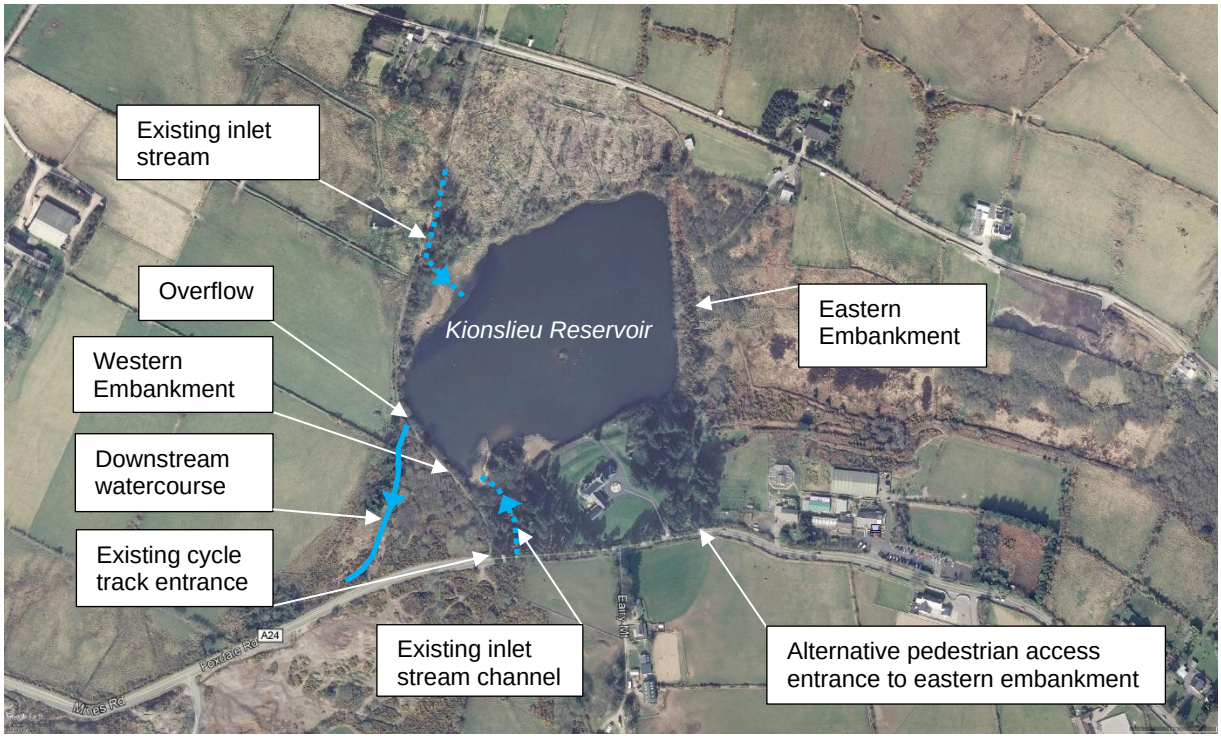


Figure 1: Layout of the site (courtesy of Google Earth)

The last Inspection Report dated April 2018 gave the following summary about Kionslieu Reservoir:

'Kionslieu Reservoir was built in connection with mining operations in the Foxdale area and was formed around the end of the 18th century or early 19th century. The reservoir has a surface area of 37,000 m^2 at its normal top water level (147.41 m OD). The maximum reservoir depth is about 1.5 m and it holds back about 24,500 m^3 of water at that level, plus an unknown quantity of mine tailings.

'The general arrangement of the reservoir is shown in [Figure 1 above]. There are embankments at both the eastern and western ends of the reservoir. The overflow is located at the centre of the west embankment. There are no facilities for drawing water from the lake or for emptying it.

'No records relating to the construction of the dam have survived, however it would be reasonable to assume that the embankments are of homogeneous type and built largely by end tipping mine waste.

'The west embankment is curved on plan and up to 5 m high. The gradient of the downstream face varies but is generally between 1 on 1½ to 1 on 2. The dam crest is 110 m long and about 4 m wide and carries a public footpath around the western side of the reservoir. The upstream face is very steep, possibly about 1 on 1, and is said to be protected by stone pitching.

'The east embankment is straight on plan and up to about 6 m high. The crest is about 170 m long and narrows from about 5 m at the south to less than 3 m at the north. The slope gradients are similar to the western embankment. The outer face is vegetated while the inner face is stone pitched.

The overflow is located towards the north end of the west embankment. It comprises a concrete blockwork channel about 0.75 m wide that leads to a headwall just upstream of the dam crest. The maximum retention level is defined by stop logs in a slot at the head of the channel. A 350 mm pipeline runs through beneath the embankment crest and emerges close to the outer toe. The original pipeline failed in 2013 or before and the lower part was washed away. The arrangement was repaired in 2014. The floor of the channel below the discharge point is lined with cobbles down to the watercourse below the dam.'

There are no other inlet / outlet structures, pipelines or ancillary structures located at the reservoir. Historical maps from 1883 indicate a sluice on the eastern embankment, although this facility is no longer visible and presumably has been abandoned.

There may once have been a scour outlet at the western embankment but it is no longer operational. The only way of lowering the water level would be to bring temporary pumps to the site.

The key features of Kionslieu Reservoir are summarised in Table 1 below.

Table 1: A summary of the key features relating to Kionslieu Reservoir

Feature	Value	Source / comment
Location: National Grid Reference	SC 289 783	Last Inspection Report (April 2018)
Location: nearest postcode	IM4 3HL	Grid Reference Finder - https://gridreferencefinder.com/
Reservoir surface area at TWL	37,000m^2	Last Inspection Report (April 2018)
Reservoir volume at TWL	24,500m^3	Last Inspection Report (April 2018)
Reservoir Silt Volume	Unknown	
TWL	147.13mAOD	Topographical Survey (January 2020)
Minimum Crest Level	149.34mAOD	Topographical Survey (January 2020)
Total freeboard	2.21m	Topographical Survey (January 2020)
Maximum dam height	Western Embankment – 5m Eastern Embankment – 6m	Last Inspection Report (April 2018)
Flood category	Category A	Last Inspection Report (April 2018)
Catchment area	0.39km^2	Last Inspection Report (April 2018)
Date Built	Unknown – estimated at 18th century or early 19th century	Last Inspection Report (April 2018)

2. Site Visit

Site visits were made on 26th November 2019 and the 8th January 2020 by Stillwater Associates. The first of these visits was accompanied by DEFA. The weather on the day of the November 2019 visit was overcast with heavy rain showers. On the day of the second visit the weather was sunny and dry. The reservoir water level on both occasions was just above the invert of the outlet pipe in the western embankment with the overflow/outlet pipe flowing approximately half full (Photograph 1).

Significant vegetation clearance of the embankments was undertaken prior to and was ongoing at the time of the January 2020 visit. This allowed much improved access and visibility to inspect the areas of the embankments which had been hidden by vegetation.

The purpose of the site visits was to assess the overall condition of the structures, to become familiar with the typical surrounding site conditions and to investigate access options for future construction (discontinuance) or improvement (retain reservoir) works.

3. Condition Assessment

The condition of the different features relating to Kionslieu Reservoir are summarised in Table 2 below. This assessment is based on site visits and a review of reports provided by DEFA. Section 4 below contains further photographs of the site visits.

Table 2: Condition assessment

Feature/consideration	Condition/observations
Western Embankment - Upstream face	*Heavily overgrown prior to the January 2020 visit. Where face visible, above water level, slope is steep, say 1V:1.5H. On lower sections upstream face is closer to 1V:1H. No signs of movement or slipping. Stone pitching is present generally. Some minor erosion evident from wave action.* *See Photograph 1 and 2.*
Western Embankment - Crest	*Wide crest with fence along downstream side. Heavily overgrown constraining the footpath/cycleway which has become excessively worn and rutted prior to January 2020. Soft and extremely muddy in places at the time of both visits. No indications at any location of movement or settlement.* *See Photograph 3.*
Western Embankment - Downstream face	*Not accessible and heavily overgrown at the time of the November 2019 visit. With access available in January 2020 the downstream face generally could be assessed, seen to be steep, say 1V:1.5H typically, and extremely uneven suggesting random placing of fill when constructed. No indications of seepage in the downstream face or toe areas where accessible. Further and closer inspections needed if a retain option is to be adopted.* *See Photograph 4.*
Eastern Embankment - Upstream face	*Significant clearing carried out in January 2020 with much of the slope visible, above water level, slope is steep, say 1V:1.5H. No signs of movement or slipping. Stone pitching is present generally.* *See Photograph 6.*
Eastern Embankment - Crest	*Largely cleared in January 2020. Dense vegetation has prevented access, keeping crest in a generally satisfactory condition. No signs of movement or settlement.* *A central section of the embankment, at the outlet/overflow structure, appears to be lower than the main embankment either side, and would thus tend to operate as an auxiliary spillway. Levels would need to be confirmed with a topographical survey.* *See Photograph 7.*
Eastern Embankment - Downstream face	*Sufficiently cleared in January 2020 to allow access. Oversteep, say 1V:1.5H. No signs of movement or slipping. No indications of seepage through the embankment. However, toe area waterlogged and boggy which could possibly indicate seepage at a low level or through the foundations. Further investigations would be needed if a retain option is adopted.* *See Photographs 5 and 8.*
Main Overflow/Outlet	*Inlet and outlet clear and operating freely. Upstream end of outlet pipe flowing approximately half full at the time of both visits. Outlet structure headwall constructed of masonry, appears to be stable with no signs of movement.* *See Photographs 9 and 10.*
Outlet Works	*No outlet works other than the main overflow.*
Other Pipes	*None.*
Access	*Access on to the western embankment crest available using existing public footpath/cycleway off A24 Foxdale Road. Footpath in poor condition, heavily rutted, soft and muddy on day of visit.* *Access to eastern embankment only through private land (residential property), through old gateway off A24 Foxdale Road. No access on to embankment due to dense vegetation.* *See Photographs 11, 12, 13..*
Site safety	*There are no specific safety measures in place on site. There is free access to the western embankment with a public footpath/cycleway.*
Surrounding slopes	*Bankside areas are gently sloping into the reservoir basin. No stability issues are anticipated and no signs of movement or slips in surrounding land.* *See Photographs 14 and 15.*

4. Photographs

Photograph 1: Upstream face of the western embankment.

Photograph 2: Upstream face of the western embankment.

Photograph 3: Crest of western embankment. Fence and downstream slope on left of photo.

Photograph 4: Downstream face of western embankment.

Photograph 5: Upstream face of eastern embankment.

Photograph 6: Upstream face of eastern embankment.

Photograph 7: Crest of eastern embankment.

Photograph 8: Downstream face of eastern embankment.

Photograph 9: Upstream headwall and overflow/outlet structure.

Photograph 10: View of downstream overflow outlet.

Photograph 11: Footpath/cycleway access to western embankment from A24 Foxdale Road.

Photograph 12: Gateway into private land for access to eastern embankment.

Photograph 13: Boardwalk/cycle track around north-western area of reservoir.

Photograph 14: Bankside area – north-western side of reservoir.

Photograph 15: Bankside area – south-eastern side of reservoir.

Appendix 3 Surveys [Lidar, Bathymetric]

1. Availability of Data

The following survey / investigation data is currently available for Kionslieu Reservoir:

Type	Format	Date	Reference(s)	Provided by:
Bathymetric survey	PDF drawings / AutoCAD drawings	18/12/2017	A397-LS-01 A397-LS-02 A397-LS-03	Mullen Consulting
Topographical survey	PDF drawings / AutoCAD drawings	31/01/2020	A397-LS-04	Mullen Consulting
Water Quality and Silt Analysis	PDF report	06/12/2017	9862/17AD, 133/18 AT, 9866/17 SL	DEFA
Land Ownership	PDF plan (draft)	19/10/2016	-	DEFA
Unexploded Ordnance (UXO) Risk Assessment	PDF summary table	12/01/2020	-	Zetica UXO

2. Required

The following surveys or investigations may be required for the discontinuance and/or retain options considered as part of this assessment:

Key:
Green – Survey / investigation required
Amber – Survey / investigation may be required
Red – Survey / investigation not required

***Note: surveys with an asterisk will require the embankments to be completely cleared of vegetation. Vegetation clearance should be carried out and completed by end of February 2020.**

Survey / Investigation	Option 1: (Discontinue)	Option 2: (Retain)
Ground Investigation (GI)*	Option 1 (Discontinue): Minor GI required to determine the composition of the existing embankments, material required to regularise the crest and slacken the downstream slopes, as well as determine the strength of the material to be excavated for the extended stream channel and auxiliary spillway	Option 2 (Retain): Major GI required to determine the composition of the western embankment and the silt / mine waste material within the reservoir basin. Additional investigations may also be required to inform any potential leakage control works.
Soil / silt contamination investigation	Option 1 (Discontinue): Detailed soil / silt contamination tests would have to be carried out on the samples taken from the reservoir basin to determine whether the material can be disposed of on-site or whether it needs to be treated and / or taken to a licensed disposal facility.	Option 2 (Retain): No investigation required as the silt within the basin will remain in place.
Heritage Assessment	Options 1 & 2: A heritage assessment may be required for both options to determine whether the proposed works will impact any existing heritage structures or monuments.	

Ecology Survey*	Options 1 & 2: An ecology survey would be required for both options to determine the likely impacts of the works to the surrounding ecology, to identify species specific surveys and mitigation measures to address potential adverse impacts.	
Archaeology Survey	Options 1 & 2: Archaeology assessment is not anticipated as being required for either option.	
Leakage Investigation*	Option 1 (Discontinue): Although there will be shallow impounding behind the eastern embankment it is thought unlikely that there would be a risk of significant seepage	Option 2 (Retain): The retain option will require a careful examination of the embankments with the reservoir full to check for leakage
Unexploded Ordnance (UXO) Risk Assessment	Options 1 & 2: A Pre-Desk Study Risk Assessment was obtained from Zetica UXO on the 21st January 2020. The assessment concludes that no official statistics for bombing in the Isle of Man is currently available and no records have been found that indicate the reservoir site has been bombed in the past, however the assessment identifies the reservoir site as lying within a low risk zone. The assessment further concludes that a more detailed desk study is not essential in this instance (refer to Section 3)	

3. Unexploded Ordnance (UXO) Risk Assessments

zeticauxo

Pre-Desk Study Assessment

Site:	Kionslieu Reservoir, Isle of Man
Client:	Stillwater Associates
Contact:	
Date:	21st January 2020
Pre-WWI Military Activity on or Affecting the Site	None identified.
WWI Military Activity on or Affecting the Site	None identified.
WWI Strategic Targets (within 5km of Site)	The following strategic targets were located in the vicinity of the Site: ■ Transport infrastructure.
WWI Bombing	None identified on the Site.

Interwar Military Activity on or Affecting the Site	None identified.
WWII Military Activity on or Affecting the Site	None identified.
WWII Strategic Targets (within 5km of Site)	The following strategic targets were located in the vicinity of the Site: ■ Transport infrastructure. ■ Light industry, including quarrying.
WWII Bombing Decoys (within 5km of Site)	None.
WWII Bombing	No official statistics for bombing in the Isle of Man have been found, the bombing density is believed to be very low. No readily available records have been found to indicate that the Site was bombed.
Post-WWII Military Activity on or Affecting the Site	None identified.
Recommendation	A detailed desk study, whilst always prudent, is not considered essential in this instance.
This summary is based on a cursory review of readily available records. Caution is advised if you plan to action work based on this summary. It should be noted that where a potentially significant source of UXO hazard has been identified on the Site, the requirement for a detailed desk study and risk assessment has been confirmed and no further research will be undertaken at this stage. It is possible that further in-depth research as part of a detailed UXO desk study and risk assessment may identify other potential sources of UXO hazard on the Site.	

Appendix 4 Hydrology & Hydraulics

1. Existing Overflow Capacity

Flood Assessment

The last Inspection Report (26th April 2018) carried out under Paragraph 3 of Schedule 3 of the Water Act 1991 reported that a high-level "rapid" flood assessment was completed by the previous Inspecting Engineer. The report states that the assessment was undertaken to determine "*a rough estimate as to the likely behaviour of the reservoir during severe and/or extreme flood events*".
A summary of the main considerations and assumptions is shown in Table 1 below:

Table 1: Kionslieu Reservoir flood assessment: key considerations and assumptions

Consideration	Value / Assumption	Source / Comment
Flood Risk Category	A	Inspection Report (April 2018)
Catchment area (km^2)	0.39	Inspection Report (April 2018)
Reservoir capacity (m^3) at TWL	24,500	Inspection Report (April 2018)
Reservoir surface area (m^2) at TWL	37,000	Inspection Report (April 2018)
SAAR (mm)	1,329	FEH / Inspection Report (April 2018)
Overflow invert level (m AOD) / TWL	147.13	Topographical Survey (January 2020)
Lowest dam crest level (m AOD) – between eastern and western embankments	149.34	Topographical Survey (January 2020)
Static freeboard (m)	2.21	Difference in level between existing overflow invert level and lowest crest level.
Overflow type	Pipe / orifice	Inspection Report (April 2018)
Effective overflow diameter (m)	0.30	Topographical Survey (January 2020)
Estimated maximum flow capacity (m^3/s)	0.40	Inspection Report (April 2018)

A summary of the flood inflows estimated from the rapid assessment is shown in Table 2 below.

Table 2: Kionslieu Reservoir: summary of flood inflows

Flood Event	Peak inflow (m^3/s)
Safety Check Flood (Summer PMF)	7.35
Design Flood (10,000-year flood)	3.70
1,000-year flood	2.20
150-year flood	1.50

Floods and Reservoir Safety Fourth Edition (FRS4) published by the Institution of Civil Engineers (ICE) in 2015 sets out the standards to be achieved in terms of overflow capacity. Kionslieu Reservoir is currently categorised as a Category A reservoir in terms of flood risk. The anticipated extent of flooding downstream in the event of a breach failure of the western embankment is such that this reservoir would be designated as "High-Risk". The requirements for a Category A dam according to FRS4 are shown in Table 3 below:

Table 3: Design standards for flood safety at Category A dam (ICE, 2015)

Feature	Design Flood (see Note 1)	Safety Check Flood (see Note 1)
Requirements	*No damage (safety margin provided by freeboard)*	*Safety of dam cannot be assured for floods greater than this*
Annual chance of flood	*1 in 10,000*	*Probable Maximum Flood (PMF)*
Wave freeboard	*Accept some wave overtopping as small waves but causing no damage.*	*Quantity of wave freeboard does not exceed that for "marginally safe performance" – interpreted as 1 litre/sec/m wave overtopping rate for embankment dams.*
Notes: *1. Standards defined in process diagram in Appendix 3 of FRS4.*		

All the estimated flood inflows shown in Table 2 above are significantly in excess of the suggested maximum capacity of the existing overflow pipe (0.40m^3/s). Therefore, it is reasonable to assume that the current capacity at Kionslieu Reservoir is not sufficient to safely pass the Design Flood and Safety Check Flood for a Category A dam in accordance with the latest reservoir safety guidance, and that the reservoir embankments would be expected to overtop during the PMF event or even the 10,000-year event.

The combination of the existing indicative freeboard of 2.21m, the reservoir surface area and the low discharge capacity of the existing overflow would suggest that the reservoir could provide some useful flood attenuation during smaller (higher probability) events. However, during extreme flood events the attenuation would be very small / negligible and the inevitable overtopping would pose the significant risk of breach failure, resulting in an uncontrolled release of the stored water. It is noted that the actual freeboard has yet to be confirmed, requiring a detailed topographic survey to be undertaken.

The last Inspection Report, dated April 2018, stated the following:

'The capacity of the system is controlled by the hydraulics of the 350 mm pipeline that passes through the embankment. In the first instance, the small opening will be vulnerable to blockage by floating debris at times of flood. Even if the pipeline should remain clear, then it seems highly unlikely that it would be able to cope with flows in excess of 0.4 m^3/s. As such, it is anticipated that the system will surcharge and choke even under very minor flood events, with the prospect of the water level building up until it eventually overtops the crest or some other low spot. The current arrangement is clearly inadequate and is incapable of passing any significant flood safely. The safety of the reservoir would be threatened if a PMF was to occur.'

Wave Assessment

In terms of dam safety, current practice requires consideration of the potential for wave overtopping, to help make an assessment of the possible impacts on the dam structure. The wave overtopping calculation depends on the following factors:

- the geometry of the upstream face;
- freeboard above wave-free water levels;
- wind speed at the site;
- the fetch across the reservoir to the dam over which waves would be developed.

The upstream face of the main embankment structure consists of a steeply sloped section (estimated at 1V:1H) which is protected by stone pitching. The most significant fetch (length of water surface over which waves can develop) is estimated at 240m by taking a line from the location of the western embankment to the northern part of the eastern embankment.

As the stillwater flood levels have not been determined for the 10,000-year and PMF events, it is not possible to complete a reliable wave overtopping assessment for the reservoir. However, a sensitivity assessment has been undertaken following the methodology in FRS4 and assuming a water level at TWL of 147.41mAOD. The results show that the significant wave height (H_s) at this reservoir, based on the fetch length, wind speed and wind direction, would be expected to be approximately 0.23m.

Since publication of FRS4 in 2015, further guidance on wave overtopping flows has been published in the EurOtop II manual. The most significant aspect of this update is that grassed embankments are deemed not to be at risk from wave overtopping when the significant wave height is less than 0.3m, as is the case at Kionslieu Reservoir. Therefore, the risk of failure of the embankment due to wave overtopping alone, is considered to be negligible.

Despite the existing freeboard of 2.21m (distance between TWL and the lowest crest level), the grossly inadequate existing overflow capacity is likely to result in the dams being overtopped during the extreme flood events considered. The situation is likely to be made worse by waves.

The implications of the flood assessment on the reservoir retained, and discontinuance options, and the resultant downstream flood risk are considered in detail in **Appendix 6, Engineering Options**.

Existing Downstream Flood Risk: Fluvial Flooding

A study of the topography and local stream flows shows that the land drainage flowing to the reservoir basin then passes in a western direction only towards Foxdale. There are two main inflows to the reservoir. A drainage ditch from the north appears to collect the majority of land drainage and surface run-off from the north. There is a second inlet from the south which is a historic man-made diversion of part of the Struan Barrule catchment, bringing in water from Stoney Mountain Plantation and an element of surface run-off along its route to Kionslieu.

A flood risk scoping study was carried out in 2013 which highlights the key areas at risk of flooding in the Foxdale area, and the causes.

Houses at Springfield Terrace on Mines Road are understood to flood on a regular basis. This appears to be as a result of local constrictions, primarily undersized or possibly partially collapsed culverts along the southern side of the road, although overland flooding from the agricultural land to the east and north has also been reported.

Historically there has been severe flooding through the main low lying part of the village, with damage to commercial and residential properties. The local primary school is also low lying and immediately adjacent to the river. It is apparent that the flooding in this area can result from the overland flows from the east, including out of bank flows from the watercourse following the A24. More extreme flooding in the area results from a combination of flood flows in the Struan Barrule, from the south, and from the local watercourses from the east.

Existing Downstream Flood Risk: Dam Breach Inundation Flooding

The reservoir lies on a saddle with two valleys leading away in easterly and south-westerly directions.

The south-westerly valley follows the route of the A24 (Foxdale Road) into the village of Foxdale approximately 800m to the south-west. The nearest properties at risk from reservoir failure are located on the eastern side of Foxdale. At the centre of the village the primary school and commercial properties are low-lying are directly within the flood envelope. The valley turns north in Foxdale and continues along the route of the Struan Barrule before reaching the sea at Peel. If the western embankment was to breach, then the flood wave would flow westward and pass through Foxdale village, which would threaten the safety of the residents, the school and commercial properties.

The easterly valley consists mainly of marsh/heathland and agricultural land with a small number of residential properties on rising ground, before reaching Eairy Reservoir, some 1,000m to the east of Kionslieu Reservoir. The hamlet of Eairy is located immediately downstream of the Eairy Reservoir which contains various residential and commercial properties. The valley then follows a south-eastern path toward the sea near Ballasalla. If the eastern embankment was to breach, then the flood wave would flow eastward and pass through Eairy Reservoir. The flood wave would be expected to overtop Eairy dam with the significant potential that Eairy Reservoir also would fail. A number of residential properties would be at risk.

The description in Table 4 and

Table ***5*** below is based on the published 1:50,000 scale Ordnance Survey maps (available on the internet) and Google Earth. Figure 1 below shows the features that are described in Table 4 and

Table ***5***.

There are no long-term flood risk maps available for this reservoir to assist in the determination of downstream risk to communities and properties. The extent of flood risk has been estimated from contours on the Ordnance Survey mapping.

Table 4: Features downstream of western embankment

Estimated distance downstream (m)	Feature	Comments
5	Cycle track	The existing cycle track would be completely destroyed if the western embankment were to breach.
150	A24 (Foxdale Road)	Details of a conveyance structure underneath this road are unknown. It may be likely that this road will be flooded during major fluvial events and / or the uncontrolled release of water from Kionslieu Reservoir in the event of a dam breach.
800	Residential properties on eastern extent of Foxdale village	Due to the low elevation of this village in relation to the stream bed level it is likely that it will be flooded during major fluvial events and / or the uncontrolled release of water from Kionslieu Reservoir in the event of a dam breach.
1,000	Primary school, residential and commercial properties.	Properties are low-lying in the centre of the village.

Table 5: Features downstream of eastern embankment

Estimated distance downstream (m)	Feature	Comments
190	Manx Society for the Prevention of Cruelty to Animals & a Cafe	On rising ground – may be at risk of flooding from reservoir failure.
310	1 no. Residential property & A24 (Foxdale Road)	On rising ground – may be at risk of flooding from reservoir failure.
1,000	Eairy Reservoir	If the eastern embankment was to breach, then the flood wave would flow eastward and pass through Eairy Reservoir, which could threaten the safety of that reservoir, and may lead to the breach of the reservoir and subsequent uncontrolled release of water downstream into the Eairy hamlet.
1,100	Eairy Hamlet	The hamlet of Eairy may be at risk of flooding during extreme major fluvial events and / or the uncontrolled release of water from Kionslieu Reservoir in the event of a dam breach and potential subsequent uncontrolled release of water from Eairy Reservoir.

The downstream flood risk associated with the reservoir retained and discontinuance options is considered in detail in **Appendix 6, Engineering Options**.

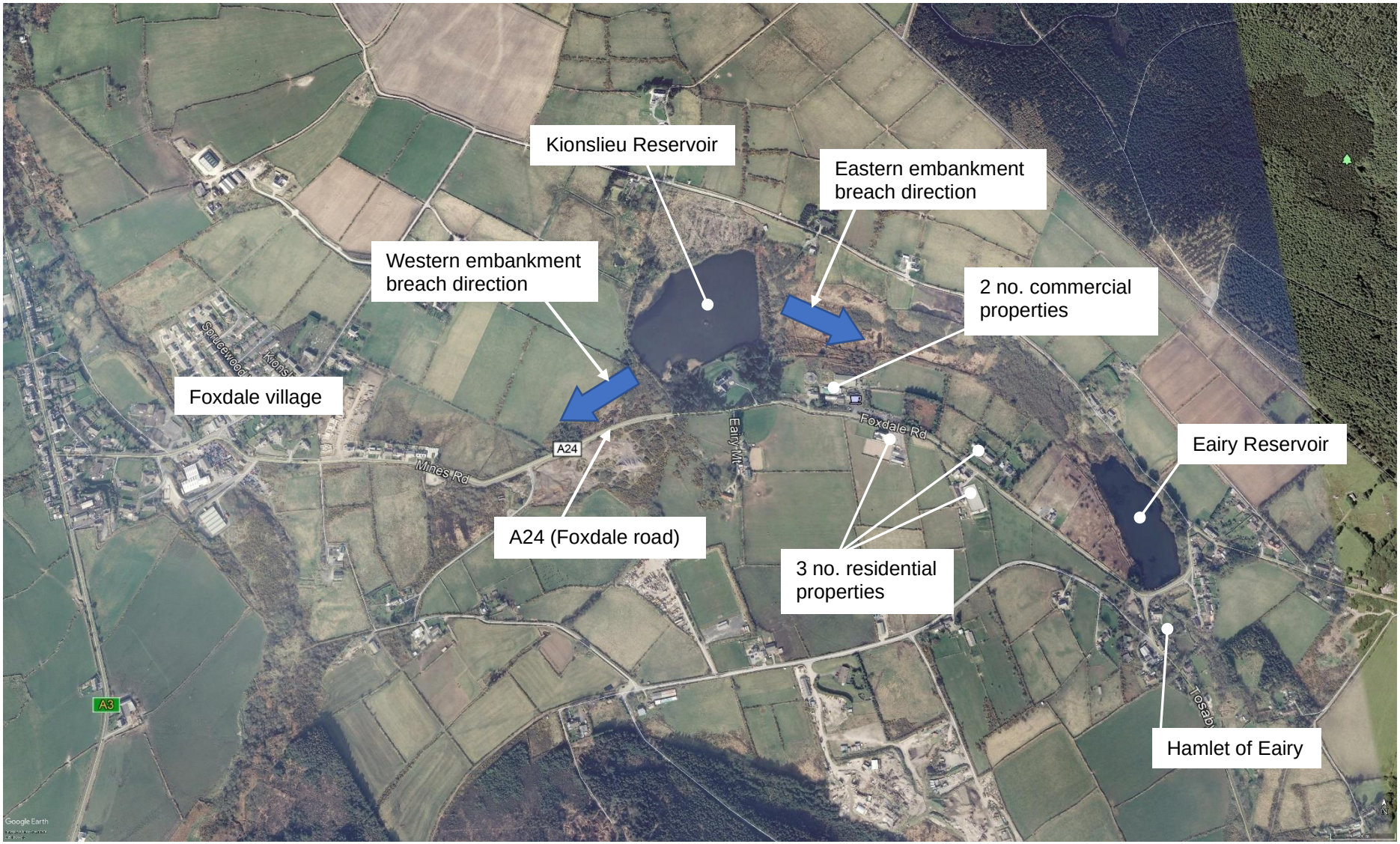


Figure 1: Features downstream of the dam (courtesy of Google Earth)

2. Existing Drawdown Capacity

Guidance

Guidance on the drawdown capacity required for an embankment dam such as Kionslieu Reservoir is given in the "Guide to Drawdown Capacity for Reservoir Safety and Emergency Planning (Environment Agency, 2017), and also in CIRIA Report 148 (CIRIA, 1996).

In accordance with the guidance it is suggested that sufficient drawdown capacity is provided to satisfy the following criteria:

- initial drawdown rate of 5% of water depth in one day;
- 33% of water depth in three days.

These rates would need to be achieved with a Q_{50} inflow, that being the inflow to the reservoir that is exceeded on 50% of the days in a typical year.

The second of these criteria, 33% of water depth drawn down in three days is based on the Canal & River Trust approach (refer to Section 6.6.3 and Table 6.4 in the Guide).

Reservoir inflows

The inflows to the reservoir are not currently controlled and therefore need to be considered during the drawdown assessment. Generally, if gauged flow data from similar catchments is available, the daily inflows can be estimated by adjusting the gauged data according to the catchment area of the gauging station relative to the catchment area of the reservoir. Care must be taken to ensure that the catchment characteristics of the chosen gauging station(s) are similar to that of the catchment containing the reservoir. The Guide to Drawdown Capacity for Reservoir Safety and Emergency Planning (EA, 2017) regards this approach as sufficient for use during calculation of drawdown capacity.

For this assessment data from gauging station number LF2000 for West Baldwin Reservoir on the Isle of Man was used as the associated catchment is considered to have similar characteristics to that of Kionslieu Reservoir. The flow gauging data has been adjusted according to the ratio of the squares of the areas between the two catchments.

Recent flow data is also available for the nearby Cringle Reservoir, from recent similar studies. This data has been used as a comparator for the West Baldwin assessed data.

Table 6: Results of the inflow assessment for Kionslieu Reservoir using adjusted inflows for West Baldwin Reservoir [This data used in Appendix 6, Engineering Options].

Exceedance Flow Q_x[1]	**West Baldwin Reservoir Inflows (LF2000) – (m^3/s)** **A_1 = 7.01km^2**	**Cringle Reservoir Inflows – (m^3/s)[2]** **A_2 = 5.1km^2**	**Kionslieu Reservoir (adjusted) Inflows – (m^3/s)** **A_3 = 0.39km^2**	
			West Baldwin	*Cringle[2]*
Q_{90}	*0.039*	*0.04*	*0.009*	*0.011*
Q_{70}	*0.078*	*-*	*0.018*	*-*
Q_{50}	***0.139***	***0.15***	***0.033***	***0.041***
Q_{10}	***0.546***	***0.60***	***0.128***	***0.165***
Q_5	*0.745*	*-*	*0.175*	*-*

Notes:

[1]This is the flow rate exceeded on x% of days in a typical year

[2]From previous recent assessment, used as a comparator.

Existing Drawdown Arrangements

No permanent operable drawdown facilities exist at the reservoir site. The last Inspection Report (2018) stated that there may have been a scour facility within the western embankment in the past. However, there is no evidence of this facility which is believed to have been abandoned.

It is concluded that there are currently no permanently installed facilities that are able to draw down the reservoir water level. The drawdown capacity at Kionslieu Reservoir would fully rely on temporary equipment brought to site.

Existing Drawdown Capacity

There is currently no existing permanent drawdown capacity at Kionslieu Reservoir.

The implications of the existing installed drawdown capacity at Kionslieu Reservoir in relation to the reservoirs retained and discontinuance options are considered in detail in **Appendix 6, Engineering Options**.

Appendix 5 Land Issues & Stakeholder Engagement

1. Stakeholders

Table 1 below provides the list of anticipated stakeholders who may have an interest in this project.

Table 1: Kionslieu Reservoir – list of stakeholders

Ref.	Stakeholder	Interest	Contact
1	DEFA	Owner: ownership includes entire reservoir area and bankside areas.	
		Planning & Building Control Directorate	
2	Manx Utilities	Flood risk	
3	Manx National Heritage (TBC)	Heritage	
4	Manx Wildlife Trust	Existing ecology. Potential future ecology opportunities with either retained or discontinued reservoir.	
5	Private land owners	Owners of land surrounding the reservoir	Unknown
Notes:			

Appendix 6 Engineering Options

1. Introduction

Kionslieu Reservoir, which is owned and operated by DEFA, has an estimated stored volume of just under 25,000m^3. Under current legislation the reservoir is therefore not classified as a 'large raised' reservoir. Further, irrespective of this reservoir not meeting the relevant volume threshold, the relevant legislation would only apply to this reservoir if it was under the control of Manx Utilities. However, in accordance with Section 3(1) of the Health & Safety at Work Act (IoM), DEFA have a duty of care to ensure that Kionslieu Reservoir does not pose a risk to downstream residents or communities. Therefore, DEFA have stated their preference to operate in accordance with the reservoir safety legislation contained within Schedule 3 of the Isle of Man Water Act 1991, which follows the general requirements of the Reservoirs Act 1975, as applied in England.

The 'discontinuance' of a reservoir, under Section 13 of the Reservoirs Act 1975, as applied in England, requires an owner to reduce a reservoir's impounded capacity to a volume that is less than 25,000m^3. The corresponding threshold in Wales and Scotland is 10,000m^3. The change in threshold applicable in Wales and Scotland results from the amendments made to the legislation by the Flood and Water Management Act 2010. In some cases, owners choose to reduce the capacity to, say 24,000m^3 (in England) or 9,000m^3 (in Wales) to avoid being subject to the requirements of the Reservoirs Act 1975 whilst some owners will choose to remove, or 'notch', the dam completely with no water then being impounded (effectively zero storage). Due to the potential change in the threshold from 25,000m^3 to 10,000m^3 in England it is considered prudent to ensure the long term discontinuance is achieved by a reduction in storage to less than 10,000m^3.

Under a discontinuance option the long-term operation and maintenance costs of the asset would be significantly lower compared to a scenario where the reservoir is retained and remains within the ambit of the Reservoirs Act 1975.

DEFA has stated its preference to retain some storage volume within the reservoir following the discontinuance works, to maintain a level of visual, landscape and amenity value of the reservoir.

The following discontinuance option has been considered for this assessment:

Option 1 - *Partial removal of the western embankment by excavating a long notch to downstream stream bed level, with sufficient embankment removed to ensure no upstream impoundment in the western area of the original basin. This option will allow an approximate volume of 9,000m^3 to be stored in the eastern area of the original basin, retained by an apparent high point centrally within the reservoir basin.*

This document provides a high-level assessment of the actions necessary to discontinue the reservoir to achieve this option. The assessment includes a high-level estimate of the cost associated with the proposed works along with future costs associated with ongoing monitoring and maintenance activities. The activities discussed in this document are all considered from a dam safety point of view, i.e. to ensure a satisfactory and safe discontinuance, to the extent that the future threat of inundation flooding to properties is removed, and also from the perspective of residual long-term downstream flood risk, i.e. the flood risk associated with fluvial events.

2. Dam Structure: Proposed Works to Discontinue

Under the discontinuance option it is proposed that a full-height notch is excavated in the embankment. It is proposed that the notch width at ground level is no less than 10m wide to allow for large debris, such as fallen trees to pass through during a flood event. The notch will be partially lined with stone material sourced from the upstream face of the removed section of embankment to protect against erosion. The cutting to create the notch would have side slopes of 1:3 (V:H) to ensure long-term stability. The excavated embankment material can be relocated or re-used within the reservoir basin to form a defined channel within the footprint to allow water to safely pass through the discontinued structure. The aim would be to restore the newly exposed area of reservoir basin to its pre-reservoir state as far as possible. The re-use of the excavated material on site will help to minimise the need for transporting material off site and reduce the scheme out-turn cost.

A natural low area exists in the western area of the existing reservoir basin. This area will be excavated along with silt in the reservoir basin to create an engineered stream for flood inflows to discharge through the notch and toward the existing downstream watercourse. The location of the excavated notch will be in line with the lowest point on the new engineered stream to ensure minimal

excavation. The excavation of the embankment notch will require the demolition of the existing overflow masonry structure.

Within the main notch opening a concrete low flow notch channel would be created, a bottom width of approximately 3m, side slopes of 1V:2.5H and an approximate depth of 0.5m, to control low flows from the site up to the 1 in 100 year flood.

For this option it is proposed that all the existing pipework, if found, be removed as part of the discontinuance works.

See Figure 1 for a sketch of the proposed Option 1.

3. Residual Dam Structure: Stability

During detailed design, geotechnical tests should be carried out to determine the properties of the embankment fill and to determine the embankment foundation conditions. The notch side slopes should then be properly designed to ensure that they will be stable.

The foreseeable loading scenarios on the western embankment, with greatly reduced upstream water depths, would be expected to be considerably less onerous on the retained sections of embankment compared to the existing loadings with the reservoir fully impounding.

The foreseeable loading scenarios on the eastern embankment are also expected to be significantly reduced, corresponding to the reduced normal top water level within the reduced reservoir.

With no impounded water against the western embankment, and a significant reduction in water levels against the eastern embankment there should be no future leakage issues associated with the discontinued reservoir.

No further investigations or stability checks are proposed for this option.

4. Proposed New Overflow: Capacity

The works proposed for this option will ensure that the majority of inflows from the catchment will flow unimpeded through the discontinued reservoir site and into the existing downstream watercourse. Inflows from the north east area of the site will enter the reduced reservoir area before flowing west through the discontinued area. A second structure will be constructed at the outlet from the eastern area of the reservoir to control flows into the new engineered stream within the western area of the basin, which will convey the flows toward the downstream engineered notch and into the downstream watercourse.

It is important to note that with this new arrangement the existing flood attenuation benefits of the reservoir, by virtue of the available storage above top water level, will be greatly reduced.

5. Proposed New Overflow: Downstream Flood Risk

A review of the downstream flood risk with the existing reservoir and overflow arrangements indicates that the existing overflow capacity would be unable to safely pass the Design Flood (10,000-year) and Safety Check Flood (PMF) events without overtopping of the embankment crests. However, the significant freeboard above normal top water level does yield significant flood storage benefits, in particular for the higher probability, less extreme floods.

The removal of a large section of the western embankment will also largely remove the attenuation benefits of the reservoir, although the current attenuation effect is likely to be small. Inevitably there will be an increase in downstream flood risk from fluvial events, potentially increasing the frequency of shallow flooding in Foxdale, in particular at Springfield Terrace, affecting residential and commercial properties.

Detailed consideration will need to be given to measures to mitigate this risk, in discussion with the flood risk management team at Manx Utilities. Such measures could, for instance, include:

- Improvement works to the watercourse immediately downstream of the reservoir site, and upstream of Foxdale, including reconstructing culverts or restoring open channels where possible to remove constrictions;

- Modify the man-made channel drawing water from the Stoney Mountain Plantation, to limit inflows to the reservoir;
- Enlarging the existing restriction imposed by the river culvert conveying the river beneath Foxdale village (Clocktower Industrial Estate and A24 Mines Road).

There is a significant opportunity with this scheme for a collaborative approach with Manx Utilities to address the long standing flooding issues at Foxdale village.

6. Emergency Drawdown Capacity

As the discontinued reservoir would store less than 10,000m^3 of water the requirements of the Reservoirs Act 1975 will no longer apply. Further, the proposed discontinuance is intended to ensure there is negligible residual risk from the reservoir. There will be requirement, therefore for emergency drawdown facilities.

7. Managing Reservoir Water Levels During Construction

Use of Existing Facilities

No permanent operable drawdown facility is available at the reservoir to drain the reservoir prior to implementing the discontinuance works or to control inflows during the works.

Use of Mobile Equipment

In the absence of any permanently installed drawdown facilities on site, other means of drawdown will need to be considered. The equipment required to draw down the reservoir depends on:

- The inflows coming into the reservoir(s) at the upstream end (pass through flows);
- The amount it is wished to lower the reservoir(s) by (lowering rate).

a) Pumps

Pumps will provide a good solution for reservoir drawdown although these will need to be diesel powered, requiring deliveries of fuel to site. Consideration will need to be given to how the pumps are supervised when the site staff are not otherwise present, overnight and at weekends. The pumps will need to be carefully installed and managed to ensure they do not present a risk of pollution to the water environment.

Table 2 below provides an indication of the sizes and numbers of pumps that would be required to handle normal flows through the reservoir and to draw down the reservoir.

b) Siphons

The use of siphon pipes provides a valuable option to assist the drawdown, requiring no power once the pipes are primed and operating. Suggested details of the sizes and numbers of pipes that might be needed are given in Table 2 below. Due to the nature of the siphon operation this approach would not be reliable for drawing down more than the top 1m or so of the reservoir below top water level, or for the continued conveyance of water once the reservoir level has been lowered. Pumps will need to be employed to remove water from the lower areas of the reservoir basin prior to the commencement of works.

Inflow channel diversions

Managing water levels and flood flows during construction of the discontinuance works will be greatly simplified by diverting the main inflow stream from the north away from the reservoir. This can be done by constructing a temporary channel along the northern boundary of the site on the adjacent agricultural land, connecting into the watercourse downstream of the western embankment. For the purpose of this assessment the dimensions of the inflow channel have been assumed to be 1m bottom width, 1m depth and 1 in 1 side slopes with a 1 in 100 channel gradient. The maximum capacity of this diversion channel has been estimated as approximately 4.32 m^3/s. The existing inflow channel is to be temporarily blocked with a low cofferdam to ensure all inflows pass around the reservoir in the diversion channel. The channel will be infilled and land reinstated upon completion of the discontinuance works.

There is a secondary inflow on the southern side of the reservoir, a historic diversion of flows from Stoney Mountains Plantation. A local option for diverting this watercourse would be to excavate a

notch in the western embankment towards its southern end and create a permanent diversion to the west. Alternatively, it may be possible to stop the flow of water into the watercourse at source, in the Stoney Mountain Plantation. The latter approach would also be of benefit in terms of downstream flood risk in Foxdale, but there may be ecology implications in terms of the loss of a significant length of watercourse.

Indicative Capacity Requirements

The calculations in Table 1 below provide a high-level indication of the anticipated abstraction rate that might be required to draw down the reservoir in advance of implementing the works. Both pumps and siphons have been considered, although the siphons may only be able to practically remove the top 1m or so of the reservoir depth and pumps will need to be employed to draw from the lower parts of the basin.

A target rate of 300mm reduction in reservoir level per day has been assumed, based on general good practice for ensuring embankment stability while lowering reservoir water levels. Consideration will also need to be given to possible environmental / ecological and or downstream flooding constraints.

Table 1: Temporary measures for managing reservoir water levels – initial drawdown

Item	Units	Value	Source / Comment
Q_{50} inflow[1]	m^3 / s	n/a	**Diversion channel will be able to divert the entire Q_{50} inflow.**
	m^3 / day	n/a	
Area of reservoir, a	ha	3.7	Flood Assessment (**Appendix 4**)
Suggested target rate, D_i	mm /day	300	This can be changed depending on the requirements of the scheme
Volume to be evacuated based on target rate, V	m^3 / day (litres/sec)	11,100 (128)	10 x a x D_i
Pumps			
Recommended number of 80mm diesel pumps (Assuming 30 l/sec delivery per pump at 6m head).	nr	5 [12,960m^3/day]	GP80M from Sykes Pumps
Recommended number of 100mm diesel pumps (Assuming 40 l/sec delivery per pump at 6m head).	nr	4 [13,824m^3/day]	GP100 from Sykes Pumps
Siphon Pipes			
Estimated nr. of 150mm dia. siphon pipes, assuming 40m pipe length.	nr	5 [12,290m^3/day]	High-level estimate for siphon discharge

Notes:

1. *Appropriate inflow pass-through allowance – refer to Section 5.2 of the "Guide to Drawdown Capacity for Reservoir Safety and Emergency Planning" (Environment Agency, 2017).*

Once the reservoir level has been sufficiently drawn down to safely carry out discontinuance works, any additional inflows into the reservoir basin that are not diverted by the temporary diversion channel, such as inflows due to direct rainfall, would have to be rerouted to keep the working area dry, most likely by temporary pumps. For the purpose of this assessment, it has been assumed that 80% of the Q_{10} inflow will be diverted by the temporary diversion channel for the duration of the works, and that temporary pumps will be required to keep the working area dry from the remaining 20% of inflows. The actual rate of pumping and associated temporary pump arrangements would need to be determined at construction stage.

An indicative capacity calculation has been provided below in Table 2 to demonstrate the typical arrangement of pumps that would be required to pass the Q_{10} inflow with the reservoir already draw down to the desired level. It should be noted that there are two separate inlets to the reservoir and any pipes or pumps should be located at each of these inlets to divert incoming flows.

Table 2: Indicative flow diversion (over-pumping) requirements during discontinuance works

Item	Units	Value	Source / Comment
Catchment Area (A)	km^2	0.39	Inspection Report (2017)
Q_{10} inflow (20% of 0.165m^3/s))	m^3 / s	0.033	**Assume the diversion channel will be able to divert the 80% of the Q_{10} inflow.**
	m^3 / day	2,851	
Volume to be evacuated based on inflows, V	m^3 / day	2,851	As above
Pumps			
Recommended number of 80mm diesel pumps (Assuming 30 l/sec delivery per pump at 6m head).	nr	2 [5,184m^3/day]	GP80M from Sykes Pumps
Recommended number of 100mm diesel pumps (Assuming 40 l/sec delivery per pump at 6m head).	nr	1 [3,456 m^3/day]	GP100 from Sykes Pumps

8. Managing Silt / Water Quality

A bathymetric survey of soft bed levels within the reservoir basin was undertaken by Mullen Consulting on 22nd December 2017 (see **Appendix 3**). Hard bed levels were not measured during this survey and therefore the amount and depth of silt present in the reservoir is currently not known. For the purpose of this assessment, it has been assumed that there is a general scatter of relatively shallow (about 200mm deep) silt over the reservoir. In reality the amount of silt in the reservoir may be significantly more.

Based on the assumption of 200mm silt depth throughout the reservoir basin, it has been estimated that approximately 1,000m^3 of silt would need to be excavated from the western side of the basin to create a channel that would convey inflows towards the new engineered notch at the western embankment and into the downstream watercourse.

It is anticipated that the excavated silt would be dredged and placed in the following two locations:

a) Within silt tubes to form the side walls / berms of the new engineered channel and to retain any silt material adjacent to the new stream behind the silt tubes. Gravel and geotextile lined low-level drainage notches would be constructed at regular intervals through the berms to aid de-watering and consolidation of the silt.

b) Unused excavated silt will be placed in an area of elevated ground in the reservoir basin immediately adjacent to and south of the proposed new channel. The relocated material is to be retained behind a new bund / silt tube constructed of excavated silt or fill material. This area will be landscaped as part of the works.

This approach should minimise the effort involved in relocating the silt within the reservoir basin, avoiding the need to take any silt off site.

The following measures may need to be considered as part of the design of silt management measures for the discontinuance option, some of which have been considered in the cost estimation for this option:

- Silt clearance from natural watercourse;
- Re-vegetation of bankside areas;
- Temporary or permanent measures to retain silt, including:

- Sediment traps with lowered bed levels;
- Sediment traps using small raised structures;
- Detention basins.

It is proposed that a new reedbed is established upstream of the western embankment notch to provide a level of treatment to surface water flows and to assist with the attenuation of low flows.

9. Access

Refer to **Appendix 1** for existing access conditions and anticipated construction access arrangements. For the discontinuance option, apart from the need to clear the eastern embankment at the design stage to allow access for surveys, there will be no requirement for a construction access to this location.

In addition to the temporary construction accesses that will be required to enable the works to be implemented at the western end of the site it is proposed to include an element of permanent vehicle access to the new control structure at the section of removed embankment. It is anticipated that the permanent access would be an engineered stone track that would also be used in the future as part of the public footpath and cycle way. Works will also be carried out to widen and improve the apron at Foxdale Road to create a safer junction with the public highway. The arrangements for temporary access tracks should be determined by the proposed contractor to suit their choice of accessing the site with materials and equipment, but as a minimum, the following works are envisaged:

- Trees along the route of the permanent / temporary accesses will require felling, and the timber can be used on site for habitat creation.
- Vegetation and topsoil layer to be stripped and set aside for future re-use.
- Installation of suitable temporary track surface (Geotextile / granular fill, bogmats or proprietary trackway system).
- Installation of a permanent stone track surface along the existing cycle track (geotextile, granular fill, hardcore and stone) from Foxdale Road to the new control structure.
- The temporary access tracks will need to be completely removed on completion of the works and the areas returned to its pre-scheme condition.
- The permanent access tracks will need to be cleared of construction debris and made good on completion of the works.

Furthermore, to further improve the public access at the reservoir, it is proposed that a new public car park be constructed to the north of the reservoir site and at the end of the existing public footpath (see Figure 1).

10. Amenity, Landscape and Biodiversity

Amenity

The existing amenity value of the impounded body of water will be partially lost under this option. However, as the reduced reservoir will still normally hold 9,000m^3 of water, some amenity value will remain following the works. It is proposed that the newly exposed reservoir basin area is rehabilitated and seeded to encourage the natural flora of the surrounding area to establish. The amenity value of the river is retained and with minor works the remaining dam structure can be allowed to vegetate to help maximise the future ecology and biodiversity value of the site.

Minor improvements will be needed to ensure that the remaining dam structure and water body are made sufficiently safe for public use: see Section 12 below.

Landscape

The removal of a full-height notch which is at least 10m wide at the bottom with 1:3 (V:H) sloping sides cut into the existing embankment section of the dam will leave approximately 70m length of the western embankment dam either side of the notch. The maximum height of the retained sections of the western embankment would be approximately 5m either side of the notch. The full height of retained embankment would become visible from the upstream, as well as from downstream.

The eastern embankment will be retained and will require no works other than appropriate planting. With a significantly reduced water level a notably greater height of embankment will be permanently

exposed on the upstream side, whilst the visible height of the downstream side will be the same as at present.

The elevated areas within the reservoir basin that will be exposed following discontinuance will be landscaped. It is proposed that pre-seeded coir roles be placed in the exposed area to assist with rapid establishment of vegetation and planting as part of the landscaping works.

Overall the most notable landscape change will be the loss of a significant portion of the reservoir footprint, the large notch in the western embankment. The visual impact of this is expected to be most notable when viewed from the Archallagan Road, north east of the site.

The newly created river channel can incorporate appropriate features, and made sinuous, to establish a valuable new river corridor with landscape as well as biodiversity benefits.

Biodiversity: potential impacts and mitigation

A Preliminary Ecological Assessment should be carried out to help determine the potential adverse impacts resulting from the discontinuance works, and to develop an appropriate mitigation strategy. This assessment will also identify further desk top assessments and/or surveys that should be undertaken to properly inform the scheme design.

Biodiversity: enhancement opportunities

Potential enhancement work opportunities can be considered in conjunction with the discontinuance option. Examples of such works may include:

- Creation of significant river corridor biodiversity.
- Erection of bird and bat boxes on semi-mature trees.
- Landscaping of the reservoir banks and planting of native marginal and aquatic vegetation of local provenance.

Water depth changes affecting water quality

11. Archaeology and Heritage

It is considered unlikely that the proposed works will adversely impact archaeology in view of the limited extent of intrusive activities into a constructed embankment. However, consideration should be given to appropriate consultation with the relevant heritage stakeholder to determine the nature and age of the structures might be of heritage interest.

12. Safety

The following improvements are suggested in terms of public health and safety:

- Add signage at appropriate bankside areas:

  'No Public Access – Danger – Sheer Drop – Deep Water – Danger of Death – Soft Mud'

Consideration should be given to providing safety rings on the eastern bankside areas.

13. Planning and Consents

The works required to discontinue the reservoir are considered to be significant and would have a major visual and landscape impact on the site. It is considered that, under normal circumstances planning permission would be required.

The planning authority is likely to consider the following matters:

- Change to landscape by removing the footprint of the reservoir;
- Ecology and biodiversity impacts;
- Confirmation of negligible change in downstream flood risk.

Other third party consents may also be required.

It is noted that, in this instance, DEFA is investigating the option of undertaking the works as 'emergency works' in view of the very real threat posed by the reservoir in its existing condition. DEFA will investigate and confirm whether or not planning permission is required.

14. Monitoring and Maintenance Requirements

Once discontinued Kionslieu Reservoir will no longer require any formal supervision or inspections to satisfy the normal requirements of the Water Act 1991. However, under the proposed discontinuance option there will be a retained eastern embankment which will still impound up to 9,000m^3 of water. Limited but formalised monitoring and maintenance will still be necessary to ensure the long-term integrity of the embankment.

Appropriate monitoring and maintenance regimes are summarised in Table 3 and Table 4 respectively.

Table 3: Summary of suggested monitoring/ surveillance for Kionslieu Reservoir under discontinuance Option 1

Element	Observations	Frequency
Reservoir Level	Not required.	
Drainage and leakage flows	Not required.	
Western embankment	No requirement to inspect the retained sections of embankment, but visual check/assessment of condition of the access track and cycleway should be carried out.	Annually
Eastern embankment	Walk-over consisting of a visual check of the all areas of the retained embankment (movement, cracks, settlement), including the abutment and toe areas.	Annually
Overflow	Not required.	
Valves/ Pipework	Not required.	
Fence, Handrailing and Signage	Visual check observing for any damage to fences, handrails and signs.	At every visit
Topographic Survey	Not required.	

Table 4: Summary of routine maintenance for Kionslieu Reservoir under discontinuance Option 1

Maintenance Task	Frequency
Carry out general maintenance as advised by the Supervising Engineer.	Not applicable
Maintain the condition of pipe work/ metal work and valves, including appropriate preparation (rust removal) and painting/coating.	
Control or eliminate burrowing animals.	As and when required on the eastern embankment only, following annual inspections.
Grass cutting and clearance/ cutting back of vegetation on downstream side of dam, maintaining an approximate 2m distance from the toe of the dam and mitres.	
Remove vegetation, including pulling of saplings and woody vegetation, from all areas of the eastern embankment and new notch in western embankment.	As and when required to maintain integrity of retained structure and ensure that the notch is kept clear of any obstruction to flow.
Repair and maintain signage, handrails (including appropriate preparation and painting/coating) and fences.	As and when required

Maintenance Task	Frequency
Repair or filling in of any sheep scrapes or rodent/ burrowing animal holes.	As and when required on the eastern embankment only,
Operational valve testing, alternating between partial and full tests.	Not applicable

15. High-level Cost Estimation

A high-level costing exercise has been undertaken for this option based on the currently available information and the perceived activities required to deliver the option. The costings have been prepared using data from previously delivered schemes involving equivalent activities as well as industry standard rates for civil engineering projects, with an overall range of the anticipated project cost presented.

Engineering Works

Where appropriate specialist engineering contractors have been approached for advice and budget cost estimates to provide confidence in the overall costings.

Environmental Works

Indicative costs associated with an initial ecology assessment of the reservoir site have been included in this assessment. However indicative costs for implementing mitigation measures have not been included.

It is likely that a Preliminary Ecological Assessment will be required to identify any ecological impacts in relation to this option and the associated ecology mitigation works and / or potential opportunities for enhancement works. Enhancement works would be in addition to ecology mitigation and are not required to fulfil the objective of the discontinuance option.

For the discontinuance option an allowance has been made for managing silt within the permanent works based on the outputs of the bathymetric survey undertaken in 2017. It should be noted that this survey was a soft bed survey only giving no information on the depth of silt in the reservoir, and therefore no indication of the volume of silt that will need to be managed. An assumed depth has been applied, based on knowledge from similar schemes elsewhere.

Future Operation and Maintenance

Future operational costs have been estimated to provide a 'whole-life' project cost over a 50-year timeframe. The future operational costs for this option are expected to be for a single annual visit to the site by DEFA staff to inspect the condition of the engineered notch in the western embankment and the eastern embankment. An allowance has also been made of maintenance, primarily vegetation management.

An estimated range of the overall project cost along with the estimated 50-year 'whole life' scheme cost is given in Table 5 overleaf.

Table 5: Cost Estimate for Option 1: Discontinuance

Cost Elements	Option 1: Discontinuance
CAPEX	
Studies & Investigations	£50,000
Design (including construction management)	£90,000
Construction	£390,000
Measures to address downstream flood risk	*TBC*
Environmental mitigation	*TBC*
Sub-total	£530,000
OPEX	
OPEX over 50 years	(1) £15,000
Total Whole Life Cost over 50 years	**£545,000**

Notes:

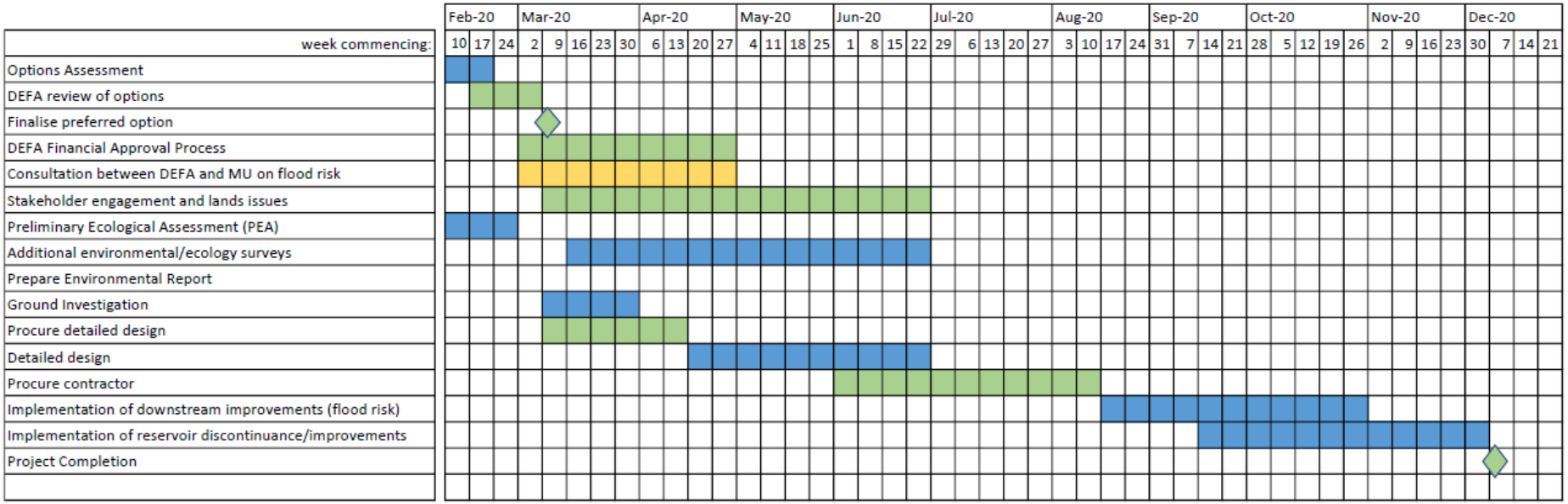
(1) OPEX costs for discontinuance option assumes one visit per year by DEFA

16. Project Programme

An indicative programme has been prepared showing the high level activities anticipated for the project. Timeframes for internal approval processes will need to be reviewed and updated as appropriate, as the project progresses. The programme below indicates the shortest perceived overall delivery period for the project.

Consideration will need to be given to the likely earliest start date for works on site. To minimise risk of construction delays it would be normal to avoid the winter period for carrying out earthworks and it may be prudent to plan the discontinuance works for spring 2021.

Konslieu Reservoir - Reservoir Safety Works
Project Delivery Programme



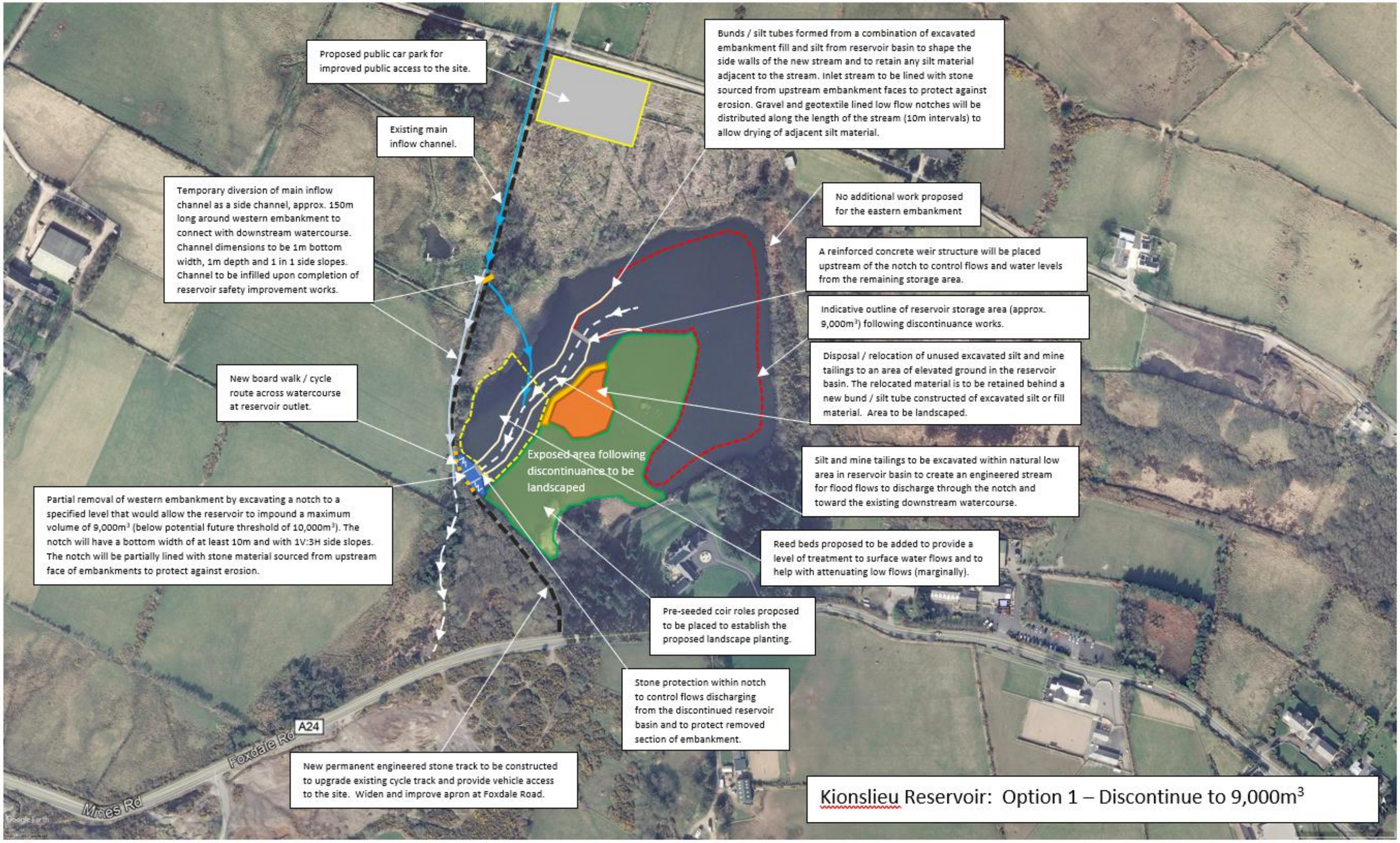


Figure 1: Option 1 - Kionslieu Reservoir discontinuance

1. Introduction

This document provides a high-level assessment of the actions necessary to retain Kionslieu Reservoir rather than discontinue it. The assessment includes high-level estimates of the costs associated with the improvement works that would be necessary to ensure the condition of the reservoir meets current reservoir safety standards. Accordingly, the assessment also considers the ongoing monitoring and maintenance requirements.

2. Dam Structure: Condition and Proposed Works to Retain

A condition assessment of the embankment dams and appurtenant structures was carried out and is discussed in more detail in **Appendix 2**. The assessment concludes that the eastern and western embankments, which impound the reservoir, are poorly constructed and are in a poor condition.

For the retain option a number of significant improvement works will be necessary, including:

- regularising the full length of the western and eastern embankment crests;
- regrading of the downstream slopes of the western and eastern embankment to 1V:3H to improve stability;
- construction of a new reinforced grass auxiliary spillway on the left (southern) abutment of the western embankment;
- construction of a new permanent engineered stone access track along the toe area of the western embankment to replace the existing cycle track;
- installation of a new low-level scour outlet pipe and upstream control valve;
- leakage mitigation works (subject to the findings of investigations).

The existing main overflow will be retained, but the overflow pipe will need to be inspected using CCTV and cleared if required. In addition, an allowance has been made to remove the abandoned scour arrangement, if this still exists within the western embankment.

All of the above elements of work would need to be implemented to satisfy current reservoir safety standards. It is considered likely that the proposed works would have been recommended in a statutory Section 10 Inspection Report by an All Reservoirs Panel Engineer under the Reservoirs Act 1975 if the reservoir was located within England or Wales.

3. Dam Structure: Stability

The foreseeable loading scenarios would not be expected to change as a result of the proposed improvement works. The retain option would maintain the existing reservoir level, and the proposed additional spillway would reduce the frequency of raised water levels within the reservoir.

There is insufficient data available at this stage to carry out a stability analysis of the dam. Topographic surveys and ground investigations will be needed to provide the necessary data. However, a close inspection of the both embankment dam indicates no evidence of immediate untoward movement or distress, raising no immediate concerns of instability of the western or eastern embankments.

The existing downstream face slope gradients of both the western and eastern embankments have been reported as 1V:2H, although a closer inspection carried out in January 2020 has shown the slopes to be steeper in places, possibly as steep as 1V:1.5H. This is considered to be too steep for an embankment with a height of 5 to 6m, with the risk of slips occurring. The retain option will include works to reduce the slope gradients to at least 1V:3H to ensure the long-term stability of the embankments. The actual final gradient would need to be chosen during detailed design based on the results of appropriate ground investigations within the embankments and the embankment foundations.

In the past leakage has been observed along the existing overflow pipe through the western embankment where signs of soil erosion were also identified. It has been reported that these leakages have ceased following remedial and improvement works to the outlet structure. A close inspection carried out in January 2020 did not identify leakage, although access was limited and there

was still significant vegetation on the downstream slopes and toe areas. It was noted that the toe area of the eastern embankment has standing water which could be an indication of leakage through the embankment fill or foundation material. It will be necessary to carry out a more detailed inspection to determine whether or not there is a leakage issue. If the results of this investigation identify signs of leakage, and it is decided that the reservoir should be retained, it is likely that leakage control measures will need to be undertaken. Options for addressing leakage include grouting, sheet piling or a cement-bentonite cut-off wall within the embankment and/or foundations.

As the presence of leakage at the reservoir is currently unknown, the retain option has been grouped into two possible sub-options a & b:

Option 2a: Retaining the existing reservoir, with remedial works and improvements to bring the dam to current UK reservoir safety standards, and with no allowance for leakage control measures, assuming the leakage investigation results show that there is no leakage at the site.

Option 2b: Retaining the existing reservoir, with remedial works and improvements to bring the dam to current UK reservoir safety standards, and with an allowance for leakage control measures along 50% of the embankments, assuming the leakage investigation results show there is leakage at the site.

The general improvement works suggested for the reservoir are unlikely to change the loading scenarios at the dam, however if leakage control measures need to be implemented, it should be recognised that the loading scenarios on the dam may change during construction. The effect of any changes in loading scenarios would need to be investigated and mitigation measures implemented if necessary. These investigations would form part of the detailed design of improvement works and would require additional information gathered from ground investigations to understand the material composition of the embankment and the foundation conditions.

4. Overflow Arrangements

The hydrology and hydraulics associated with the existing reservoir on this site are discussed in more detail in **Appendix 4**.

Flood Inflows

The last Inspection Report (26th April 2018) carried out under Paragraph 3 of Schedule 3 of the Water Act 1991 reported that a high-level "rapid" flood assessment was completed by the previous Inspecting Engineer. A summary of the inflows estimated from the rapid assessment is shown in Table 1 below:

Table 1: Kionslieu Reservoir: summary of flood inflows (Rapid Method)

Flood Event	Peak inflow (m^3/s)
Safety Check Flood (Summer PMF)	7.35
Design Flood (10,000-year flood)	3.70
1,000-year flood	2.20
150-year flood	1.50

It is not clear whether the flood estimates in the Inspection Report take account of the inflow from the Stoney Mountain watercourse. The flood inflows will need to be revisited, and may increase, as part of any more detailed options assessment or detailed design.

Floods and Reservoir Safety Fourth Edition (FRS4) published by the Institution of Civil Engineers (ICE) in 2015 sets out the required standards in terms of overflow capacity. Kionslieu Reservoir is currently categorised as flood risk consequence Category A and would notionally be assumed to have a "High" risk designation in line with the terms of the Flood & Water Management Act 2010 (England and Wales). The requirements for a Category A dam according to FRS4 are shown in Table 2 below:

Table 2: Design standards for flood safety at Category A dam (ICE, 2015)

Feature	Design Flood (see Note 1)	Safety Check Flood (see Note 1)
Requirements	*No damage (safety margin provided by freeboard)*	*Safety of dam cannot be assured for floods greater than this*
Annual chance of flood	*1 in 10,000*	*Probable Maximum Flood (PMF)*
Wave freeboard	*Accept some wave overtopping as small waves but causing no damage.*	*Quantity of wave freeboard does not exceed that for "marginally safe performance" – interpreted as 1 litre/sec/m wave overtopping rate for embankment dams.*
Notes: *1. Standards defined in process diagram in Appendix 3 of FRS4*		

Wave Assessment and Freeboard Requirement

As the stillwater flood levels have not been determined for the 10,000-year and PMF events, it is not possible to complete a reliable wave overtopping assessment for the reservoir. However, a sensitivity assessment has been undertaken following the methodology in FRS4 and assuming a water level at TWL of 147.41mAOD. The results show that the significant wave height (H_s) at this reservoir, based on the fetch length, wind speed and wind direction, would be expected to be approximately 0.23m.

Since publication of FRS4 in 2015, further guidance on wave overtopping flows has been published in the EurOtop II manual. The most significant aspect of this update is that grassed embankments are deemed not to be at risk from wave overtopping when the significant wave height is less than 0.3m, as is the case at Kionslieu Reservoir. Therefore, the risk of failure of the embankment due to wave overtopping alone, is considered to be negligible.

Despite the existing freeboard of 2.49m (distance between TWL and the lowest crest level), the grossly inadequate existing overflow capacity is likely to result in the dams being overtopped during the extreme flood events considered. The situation is likely to be made worse by waves.

5. Existing Overflow: Downstream Flood Risk

A review of the downstream flood risk with the existing reservoir and overflow arrangements (discussed in more detail in **Appendix 4**) indicates that the existing overflow capacity would be unable to safely pass the Design Flood (10,000-year) and Safety Check Flood (PMF) events without overtopping of the embankment crests. However, the significant freeboard above normal top water level does yield significant flood storage benefits, in particular for the higher probability, less extreme floods.

If the western embankment was to breach, then the flood wave would flow westward and pass through Foxdale village, which would threaten the safety of the residents, the school and commercial properties.

If the eastern embankment was to breach, then the flood wave would flow eastward and pass through Eairy Reservoir. The flood wave would be expected to overtop Eairy dam with the significant potential that Eairy Reservoir also would fail. A number of residential properties would be at risk.

Houses at Springfield Terrace on Mines Road are understood to flood on a regular basis. This appears to be as a result of local constrictions, primarily undersized or possibly partially collapsed culverts along the southern side of the road, although overland flooding from the agricultural land to the east and north has also been reported.

Historically there has been severe flooding through the main low lying part of the village, with damage to commercial and residential properties. The local primary school is also low lying and immediately adjacent to the river. It is apparent that the flooding in this area can result from the overland flows from the east, including out of bank flows from the watercourse following the A24. More extreme flooding in the area results from a combination of flood flows in the Struan Barrule, from the south, and from the local watercourses from the east.

There is a significant opportunity with this scheme for a collaborative approach with Manx Utilities to address the long standing flooding issues at Foxdale village.

6. Proposed New Overflow: Capacity

To satisfy reservoir safety standards with the retain option it will be necessary to provide significantly increased spillway capacity. A cost-effective approach might be to construct an auxiliary spillway at the left (southern) abutment. As this might be expected to operate relatively frequently, to some extent, possibly on average once per year, it is suggested that a tied concrete block spillway is constructed. An indication of the suggested location and scale of this spillway is shown on the option sketch.

7. Proposed New Overflow: Downstream Flood Risk

Inevitably, with a new spillway constructed, the reservoir will spill more frequently, with increased flows downstream. This will result in more frequent higher flows in the downstream watercourses and some form of appropriate mitigation will need to be implemented off-site. The extent and scale of this mitigation could be less than that required for the discontinuance option, but in reality the nature of the off-site improvements is likely to be such that substantial works would be carried out to alleviate the already existing flooding issues in Foxdale.

8. Emergency Drawdown Capacity

A drawdown assessment was carried out for the existing arrangement and the results are discussed in more detail in **Appendix 4**. It was concluded that no permanent operable facilities currently exist at the dam that could facilitate drawdown of the reservoir. The inflows to Kionslieu Reservoir have been estimated by adjusting inflow data from other catchments with similar catchment characteristics. The estimated inflow data for Kionslieu Reservoir is shown in Table 4 below:

Table 3: Estimated reservoir inflows

Exceedance Flow Q_x[1]	**Estimated Reservoir Inflow (m^3/s)**
Q_{90}	*0.011*
Q_{70}	-
Q_{50}	*0.041*
Q_{10}	*0.165*
Q_5	-
Notes: [1]This is the flow rate exceeded on x% of days in a typical year	

In accordance with the guidance it is suggested that sufficient drawdown capacity is provided to allow the reservoir to be drawn down at an initial rate of 5% of water depth in one day and 33% of water depth in 3 days under a Q_{50} inflow (the inflow to the reservoir that is exceeded on 50% of the days in a typical year). The second requirement of 33% of water depth drawn down in 3 days assumes the Canal & River Trust approach (refer to Section 6.6.3 and Table 6.4 in the Guide).

Following a high-level drawdown capacity calculation, it has been estimated that installing a 250mm diameter low-level scour pipe would be able to fulfil the above requirements in terms of drawdown capacity, and it would then be unlikely that additional temporary equipment is needed to drawdown the reservoir in the required period.

The “Guide to Drawdown Capacity for Reservoir Safety and Emergency Planning” (Environment Agency, 2017) provides specific guidance on when it might be considered acceptable to rely only on temporary equipment to draw down a reservoir. Of particular importance are:

a) Activation time (how long it would take to transport the equipment to site and set it up);

b) The existence of an emergency plan (which should be able to demonstrate that the required drawdown capacity can be achieved within the necessary timeframe);

c) For dams where there is a potential risk to life, it is recommended that temporary drawdown capacity does not make up more than 50% of the total capacity required for drawdown.

The "Guide to Drawdown Capacity for Reservoir Safety and Emergency Planning" (Environment Agency, 2017) further lists that under the following circumstances, reliance on only temporary drawdown equipment may be appropriate:

a) Small capacity reservoirs where the required drawdown rates are easily achieved by temporary facilities and where such facilities can be set up reliably and quickly;

b) Where the consequences of a dam failure are low (such as Category C & D dams);

c) Where the cost of installing permanent facilities is disproportionate to the reduction in risk.

Ultimately it will be for the relevant All Reservoirs Panel Engineer, appointed by DEFA, to assess the site-specific factors at Kionslieu Reservoir, define the target drawdown rate and flow diversion rate, and agree the measures proposed to achieve those rates.

Considering all of the above, and for the purpose of this study, it is believed that if the reservoir is retained, the drawdown capabilities at the reservoir would not be acceptable, and a new scour / drawdown facility would need to be installed to fulfil the relevant emergency drawdown requirements discussed above.

For costing purposes, it has been assumed that a new low level scour outlet pipe with an upstream control valve would be constructed, which will discharge into the downstream watercourse. These works will require the reservoir to be emptied and a section of the western embankment excavated. Consideration should be given during design stage to construct the new scour facility in the location of the existing overflow pipe. This would have the added benefit of allowing the installation of a new larger overflow pipe along with the new low-level scour pipe.

9. Managing Reservoir Water Levels During Construction

Use of Existing Facilities

No permanent operable drawdown facility is available at the reservoir to drain the reservoir prior to implementing the discontinuance works or to control inflows during the works.

Use of Mobile Equipment

In the absence of any permanently installed drawdown facilities on site, other means of drawdown will need to be considered. The equipment required to draw down the reservoir depends on:

- The inflows coming into the reservoir(s) at the upstream end (pass through flows);
- The amount it is wished to lower the reservoir(s) by (lowering rate).

a) Pumps

Pumps will provide a good solution for reservoir drawdown although these will need to be diesel powered, requiring deliveries of fuel to site. Consideration will need to be given to how the pumps are supervised when the site staff are not otherwise present, overnight and at weekends. The pumps will need to be carefully installed and managed to ensure they do not present a risk of pollution to the water environment.

Error! Reference source not found. below provides an indication of the sizes and numbers of pumps that would be required to handle normal flows through the reservoir and to draw down the reservoir.

b) Siphons

The use of siphon pipes provides a valuable option to assist the drawdown, requiring no power once the pipes are primed and operating. Suggested details of the sizes and numbers of pipes that might be needed are given in **Error! Reference source not found.** below. Due to the nature of the siphon operation this approach would not be reliable for drawing down more than the top 1m or so of the reservoir below top water level, or for the continued conveyance of water once the reservoir level has been lowered. Pumps will need to be employed to remove water from the lower areas of the reservoir basin prior to the commencement of works.

Inflow channel diversions

Managing water levels and flood flows during construction of the discontinuance works will be greatly simplified by diverting the main inflow stream from the north away from the reservoir. This can be done by constructing a temporary channel along the northern boundary of the site on the adjacent agricultural land, connecting into the watercourse downstream of the western embankment. For the

purpose of this assessment the dimensions of the inflow channel have been assumed to be 1m bottom width, 1m depth and 1 in 1 side slopes with a 1 in 100 channel gradient. The maximum capacity of this diversion channel has been estimated as approximately 4.32 m^3/s. The existing inflow channel is to be temporarily blocked with a low cofferdam to ensure all inflows pass around the reservoir in the diversion channel. The channel will be infilled and land reinstated upon completion of the discontinuance works.

There is a secondary inflow on the southern side of the reservoir, a historic diversion of flows from Stoney Mountains Plantation. A local option may be available for diverting this watercourse through pipes over the southern end of the western embankment, possibly in conjunction with limiting inflows at the abstraction point on the upper reaches of the Struan Barrule. Alternatively, it may be possible to stop the flow of water into the watercourse at the abstraction point on the Struan Barrule. The latter approach would be of benefit in terms of reducing the scale of the new spillway, and in terms of downstream flood risk in Foxdale, but there may be ecology implications in terms of the loss of a significant length of watercourse.

Indicative Capacity Requirements

The calculations in Table 4 below provide a high-level indication of the anticipated abstraction rate that might be required to draw down the reservoir in advance of implementing the works. Both pumps and siphons have been considered, although the siphons may only be able to practically remove the top 1m or so of the reservoir depth and pumps will need to be employed to draw from the lower parts of the basin.

A target rate of 300mm reduction in reservoir level per day has been assumed, based on general good practice for ensuring embankment stability while lowering reservoir water levels. Consideration will also need to be given to possible environmental / ecological and or downstream flooding constraints.

Table 4: Temporary measures for managing reservoir water levels – initial drawdown

Item	Units	Value	Source / Comment
Q_{50} inflow[1]	m^3 / s	n/a	**Diversion channel will be able to divert the entire Q_{50} inflow.**
	m^3 / day	n/a	
Area of reservoir, a	ha	3.7	Flood Assessment (**Appendix 4**)
Suggested target rate, D_i	mm /day	300	This can be changed depending on the requirements of the scheme
Volume to be evacuated based on target rate, V	m^3 / day (litres/sec)	11,100 (128)	10 x a x D_i
Pumps			
Recommended number of 80mm diesel pumps (Assuming 30 l/sec delivery per pump at 6m head).	nr	5 [12,960m^3/day]	GP80M from Sykes Pumps
Recommended number of 100mm diesel pumps (Assuming 40 l/sec delivery per pump at 6m head).	nr	4 [13,824m^3/day]	GP100 from Sykes Pumps
Siphon Pipes			
Estimated nr. of 150mm dia. siphon pipes, assuming 40m pipe length.	nr	5 [12,290m^3/day]	High-level estimate for siphon discharge

Notes:

1. *Appropriate inflow pass-through allowance – refer to Section 5.2 of the "Guide to Drawdown Capacity for Reservoir Safety and Emergency Planning" (Environment Agency, 2017).*

Once the reservoir level has been sufficiently drawn down to safely carry out discontinuance works, any additional inflows into the reservoir basin that are not diverted by the temporary diversion channel, such as inflows due to direct rainfall, would have to be rerouted to keep the working area dry, most likely by temporary pumps. For the purpose of this assessment, it has been assumed that 80% of the Q_{10} inflow will be diverted by the temporary diversion channel for the duration of the works, and that temporary pumps will be required to keep the working area dry from the remaining 20% of inflows. The actual rate of pumping and associated temporary pump arrangements would need to be determined at construction stage.

An indicative capacity calculation has been provided below in **Error! Reference source not found.** to demonstrate the typical arrangement of pumps that would be required to pass the Q_{10} inflow with the reservoir already draw down to the desired level. It should be noted that there are two separate inlets to the reservoir and any pipes or pumps should be located at each of these inlets to divert incoming flows.

Table 5: Indicative flow diversion (over-pumping) requirements during discontinuance works

Item	Units	Value	Source / Comment
Catchment Area (A)	km^2	0.39	Inspection Report (2017)
Q_{10} inflow (20% of 0.165m^3/s))	m^3 / s	0.033	**Assume the diversion channel will be able to divert the 80% of the Q_{10} inflow.**
	m^3 / day	2,851	
Volume to be evacuated based on inflows, V	m^3 / day	2,851	As above
Pumps			
Recommended number of 80mm diesel pumps (Assuming 30 l/sec delivery per pump at 6m head).	nr	2 [5,184m^3/day]	GP80M from Sykes Pumps
Recommended number of 100mm diesel pumps (Assuming 40 l/sec delivery per pump at 6m head).	nr	1 [3,456 m^3/day]	GP100 from Sykes Pumps

10. Managing Silt

The retain option for Kionslieu Reservoir will keep the reservoir in operation in its current form and no significant new permanent measures in terms of silt management are envisaged.

It may be necessary to remove silt from the upstream end of the scour outlet as part of replacing the valve and refurbishing pipework or as part of installing new low level outlet arrangements.

11. Access

Refer to **Appendix 1** for existing access conditions and anticipated construction access arrangements. For the retain it will be necessary to form robust construction access tracks to both the western and eastern embankment crests and toe areas.

In addition to the temporary construction accesses that will be required to enable the works to be implemented at the western end of the site it is proposed to include an element of permanent vehicle access to the new spillway and the improved control structure centrally to the embankment.

It is anticipated that the permanent access would be an engineered stone track that would also be used in the future as part of the public footpath and cycle way. Works will also be carried out to widen and improve the apron at Foxdale Road to create a safer junction with the public highway, and a temporary apron at the junction of the eastern embankment construction access on to the Foxdale Road. The arrangements for temporary access tracks should be determined by the proposed contractor to suit their choice of accessing the site with materials and equipment, but as a minimum, the following works are envisaged:

- Trees along the route of the permanent / temporary accesses will require felling, and the timber can be used on site for habitat creation.
- Vegetation and topsoil layer to be stripped and set aside for future re-use.
- Installation of suitable temporary track surface (Geotextile / granular fill, bogmats or proprietary trackway system).
- Installation of a permanent stone track surface along the existing cycle track (geotextile, granular fill, hardcore and stone) from Foxdale Road to the new control structure.
- The temporary access tracks will need to be completely removed on completion of the works and the areas returned to its pre-scheme condition.
- The permanent access tracks will need to be cleared of construction debris and made good on completion of the works.

12. Amenity, Landscape and Biodiversity

Retaining the reservoir in its current form will retain the amenity value for the general public, with improved access on the western embankment.

Whilst the two embankments will be modified to improve stability, their appearance will remain much as now. The completed embankments should be grassed, with no dense vegetation or trees allowed to establish.

The landscape appearance will, more generally, be unaffected by this option, with the water body itself unchanged.

There may be short-term adverse impacts, during construction, in terms of ecology and biodiversity that should be checked once the scheme details have been determined.

13. Archaeology and Heritage

Since the retain option involves no significant changes to the embankments, and no change to the body of water, is seems unlikely that there will be any archaeological or heritage affects.

14. Safety

The following safety improvements are suggested:

- Add signage at each abutment which contains the following wording as a minimum:

  'No Swimming – Danger Deep Water – Beware of Thin Ice – Danger of Death'.

- Ensure sufficient life rings are in place on both embankments.

15. Planning and Consents

The works required to retain the reservoir are considered to be of sufficient significance to normally require planning consent.

The planning authority is likely to consider the following matters:

- Ecology and biodiversity impacts;
- Appearance of the new spillway on the western embankment/left abutment.
- Confirmation of negligible change in downstream flood risk.

Other third party consents may also be required.

It is noted that, in this instance, DEFA is investigating the option of undertaking the works as 'emergency works' in view of the very real threat posed by the reservoir in its existing condition. DEFA will investigate and confirm whether or not planning permission is required.

16. Monitoring and Maintenance Requirements

On the basis of retaining the reservoir at its current size, assuming DEFA intend to operate the site in accordance with current industry practice for large raised reservoirs it is suggested that the full requirements of the Reservoirs Act 1975 (England and Wales) are implemented. In terms of surveillance, monitoring and maintenance, the following requirements would need to be observed:

- A Supervising Engineer must be appointed at all times, with a recommended frequency of visiting the site no less than twice each year;
- The Supervising Engineer is required to produce an annual statement no less frequently than every 12 months;
- Regular monitoring, with weekly visits, should be undertaken by DCWW, with a formal monitoring log/surveillance sheet;
- Ten yearly inspection under schedule 3 of the Water Act 1991 and the production of a report by the Inspecting Engineer;
- Production of an On-site Plan for Kionslieu Reservoir with details of the actions to be taken in the event of a structural problem with the dam being discovered.

Suggested monitoring/ surveillance regime and anticipated routine maintenance requirements are summarised in Table 6 and Table 7 respectively.

Table 6: Summary of suggested monitoring/ surveillance for Kionslieu Reservoir retained in current form [surveillance visits by DEFA personnel]

Element	Observations	Frequency
Reservoir Level	Record of the reservoir level should be made using gauge board.	Weekly
Drainage and leakage flows	Visual inspection to check for large changes in flows and inspect the main dam for any signs of new leakage (reed growth, soft and boggy places).	Weekly
Dam wall	Walk-over consisting of a visual check of the all areas of the dam (movement, cracks, damage to concrete), including the mitres and toe areas.	Weekly
Overflow	Visual check of the visible parts of the overflow, observing the overflow walls, weir and downstream structure.	Weekly
Valves/ Pipe work	Check valve spindle for signs of malicious damage.	Weekly
Fence, Handrailing and Signage	Visual check observing for any damage to fences, handrails and signs.	Weekly
Topographic Survey	Conduct/ produce a topographic survey of the dam	As advised by the Inspecting Engineer
Notes: *Requirements based on industry good practice for surveillance and monitoring of embankment dams.*		

Table 7: Summary of routine maintenance for Kionslieu Reservoir retained in current form

Maintenance Task	Frequency
Carry out general maintenance as advised by the Supervising Engineer.	As and when required
Maintain the condition of pipe work/ metal work and valves, including appropriate preparation (rust removal) and painting/coating.	As and when required
Control or eliminate burrowing animals.	As and when required
Grass cutting and clearance/ cutting back of vegetation on downstream side of dam, maintaining an approximate 2m distance from the toe of the dam and mitres.	No less frequently than twice each year.
Remove vegetation, including pulling of saplings and woody vegetation, from all areas of the dam and overflow structure.	At least annually.
Repair and maintain signage, gates, handrails (including appropriate preparation and painting/coating) and fences.	As and when required

Maintenance Task	Frequency
Repair or filling in of any sheep scrapes or rodent/ burrowing animal holes.	As and when required
Operational valve testing, alternating between partial and full tests.	Every 6 months
Note: *Requirements based on industry typical good practice.*	

17. High-level Cost Estimation

A high-level costing exercise has been undertaken for this option based on the currently available information and the perceived activities required to deliver the option. The costings have been prepared using data from previously delivered schemes involving equivalent activities as well as industry standard rates for civil engineering projects, with an overall range of the anticipated project cost presented.

Engineering Works

Where appropriate specialist engineering contractors have been approached for advice and budget cost estimates to provide confidence in the overall costings.

Environmental Works

Indicative costs associated with an initial ecology assessment of the reservoir site have been included in this assessment. However indicative costs for implementing mitigation measures have not been included.

It is likely that a Preliminary Ecological Assessment will be required to identify any ecological impacts in relation to this option and the associated ecology mitigation works and / or potential opportunities for enhancement works. Enhancement works would be in addition to ecology mitigation and are not required to fulfil the objective of the retain option.

Future Operation and Maintenance

Future operational costs have been estimated to provide a 'whole-life' project cost over a 50-year timeframe. The future operational costs include:

- Regulatory costs (reservoir supervision and inspections);
- Maintenance and replacements costs;
- Estate costs (maintaining safety and boundaries).

An estimated range of the overall project cost along with the estimated 40-year 'whole life' scheme cost is given in Table 8 below.

Table 8: Cost Estimate for Option 2: Retain

Cost Elements	Option 2a: Retain	Option 2b: Retain (including leakage mitigation works)
CAPEX		
Studies & Investigations	£30,000	£30,000
Design (including construction management)	£80,000	£110,000
Construction	£350,000	[(3)] £510,000
Measures to address downstream flood risk	*TBC*	*TBC*
Environmental mitigation	*TBC*	*TBC*
Sub-total	£460,000	£650,000

OPEX		
OPEX over 50 years	(2) £565,000	(2) £565,000
Total Whole Life Cost over 50 years	**£1,025,000**	**£1,215,000**

Notes:

(2) OPEX costs for retain option assumes the following:
- a. Weekly visits by DEFA to the site, an annual visit and report by the Supervising Engineer, and an allowance for grass cutting throughout the year;
- b. £20,000 every ten years (£5,000 for S10 inspection and report, and £15,000 for potential improvement works recommended in the report);
- c. £7,500 every 25 years to drain down reservoir and service draw-off pipes and valves.

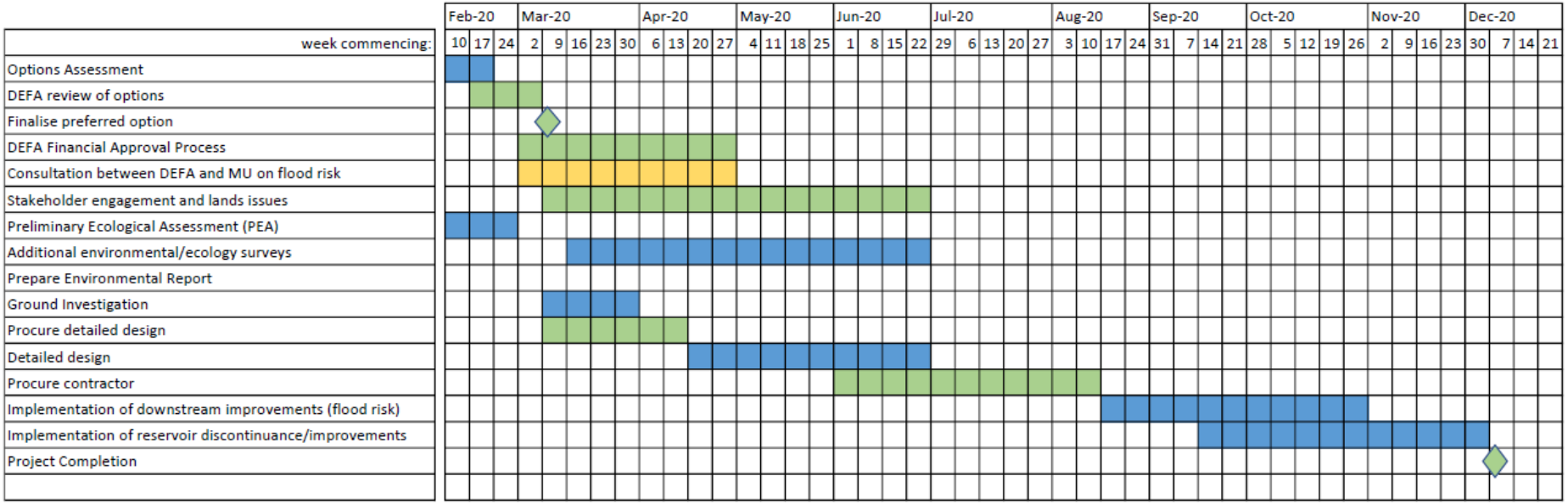
(3) Additional leakage mitigation measures assumed including sheet piles driven to foundation depth along the approximately 50% of the length of each embankment.

18. Project Programme

An indicative programme has been prepared showing the high level activities anticipated for the project. Timeframes for internal approval processes will need to be reviewed and updated as appropriate, as the project progresses. The programme below indicates the shortest perceived overall delivery period for the project.

Consideration will need to be given to the likely earliest start date for works on site. To minimise risk of construction delays it would be normal to avoid the winter period for carrying out earthworks and it may be prudent to plan the reservoir improvement works for spring 2021.

Konslieu Reservoir - Reservoir Safety Works
Project Delivery Programme



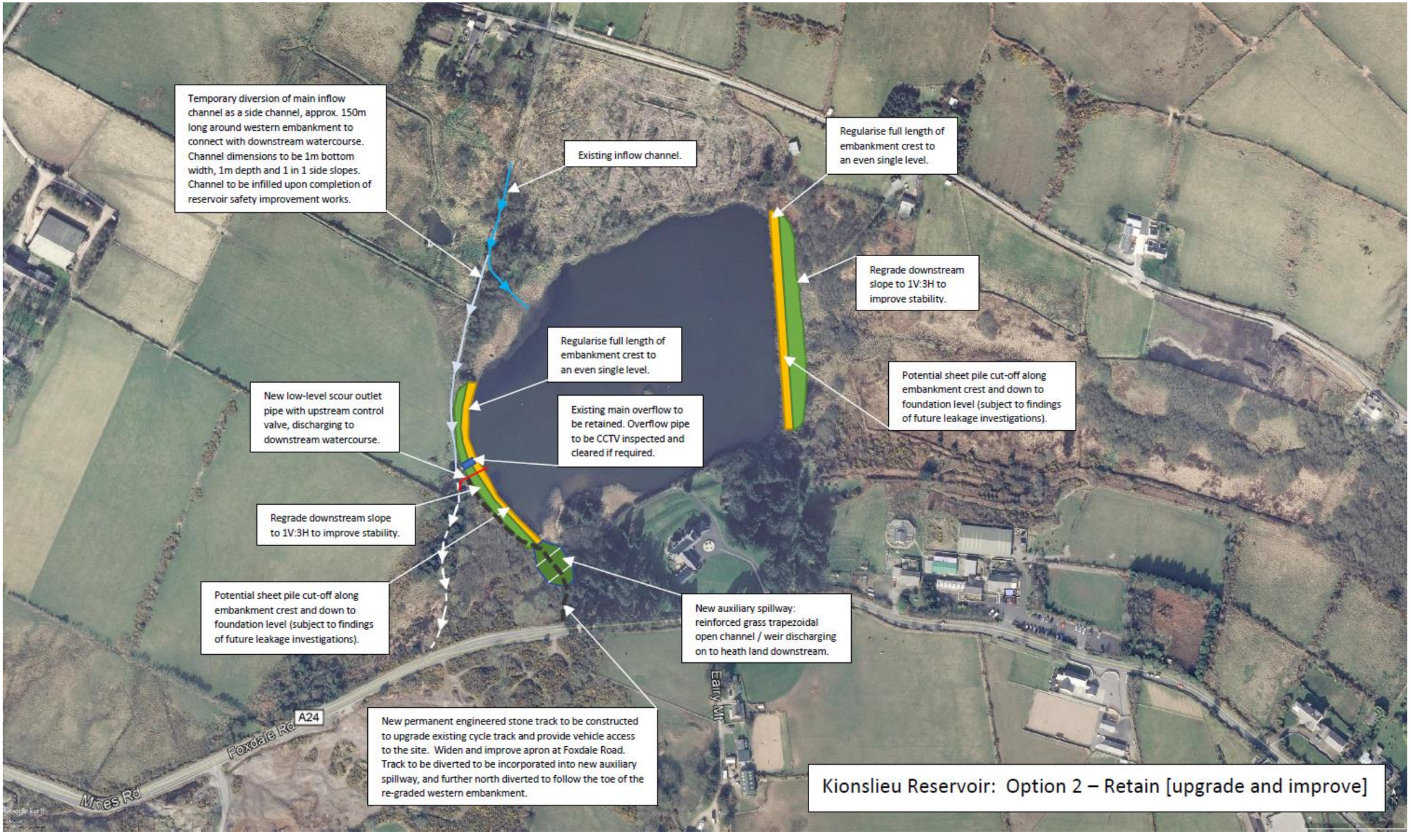


Figure 1: Option 2 – Retain Kionslieu Reservoir