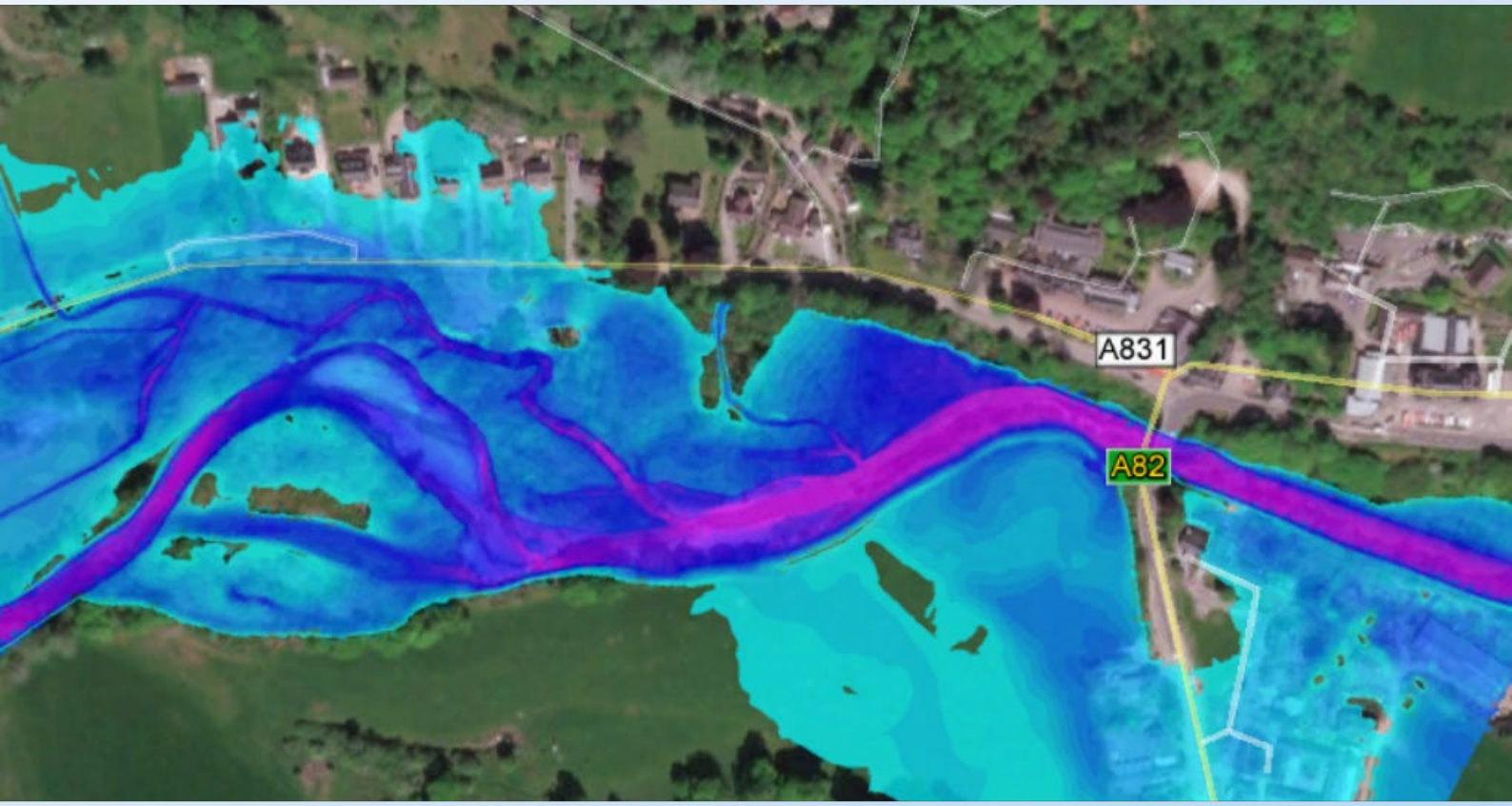
The Highland Council

DRUMNADROCHIT FLOOD PROTECTION SCHEME

Design Justification Report



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The Highland **Council**

DRUMNADROCHIT FLOOD PROTECTION SCHEME

Design Justification Report

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EXECUTIVE SUMMARY

WSP were commissioned by The Highland Council for the development of the design for the Drumnadrochit Flood Protection Scheme (FPS).

Drumnadrochit has a long history of flooding from the River Enrick, with events being recorded as far back as 1818. In addition there is frequent nuisance flooding to the A831 at Kilmichael that disrupts traffic and access to properties.

In 2016 JBA Consulting carried out a feasibility study, including hydrological modelling, that resulted in a number of recommended options. These were further refined and developed in this study, leading to the preferred solutions of:

- A reinforced concrete protection wall between the Enrick and Drumnadrochit to the east of the A82 to protect properties against a flood with a 200-year return period.
- An embankment to the west of Drumnadrochit to protect properties against a flood with a 200-year return period.
- A reinforced concrete wall to protect the A831 at Kilmichael against floods up to a 10-year return period.

A number of further surveys were carried out including topography, ecology, drainage and a detailed tree survey to inform the design. A screening opinion was obtained that confirmed an Environmental Impact Assessment was not required.

Consultations were carried out with key stakeholders and consultees, as well as a public engagement event.

This report describes this process in more detail, and concludes with a closer description of the engineering solutions and the process involved in construction.

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1. INTRODUCTION

1.1. BACKGROUND TO THE SCHEME

1.1.1. WSP and CBEC were commissioned by The Highland Council (THC) to provide guidance in the development of a Flood Protection Scheme (FPS) under the Flood Risk Management (Scotland) Act 2009.

1.1.2. The FPS will focus mainly on the protection of the village of Drumnadrochit and the A82, but will also provide some relief from flooding to the A831 road at Kilmichael village, approximately 0.5 km to the west.

1.1.3. The area was identified as being at risk during SEPA's first National Flood Risk Assessment (NFRA) in 2011, and was included in the Inverness and the Great Glen Potentially Vulnerable Area (PVA).

1.1.4. WSP undertook this work with CBEC as sub-consultants. The division of labour for this project was as follows:

WSP

- Project Management
- Geotechnical engineering
- Structural engineering
- Environmental and ecological assessment

CBEC

- Geomorphological modelling
- Hydrology
- Hydraulic modelling

WSP also sub-consulted work to Scottish Arboricultural Services (SAS) for the arboricultural survey.

1.2. STUDY AREA

1.2.1. The location of the study area is shown in Figure 1-1 overleaf, and the study boundary is also shown in Figure 1-2.

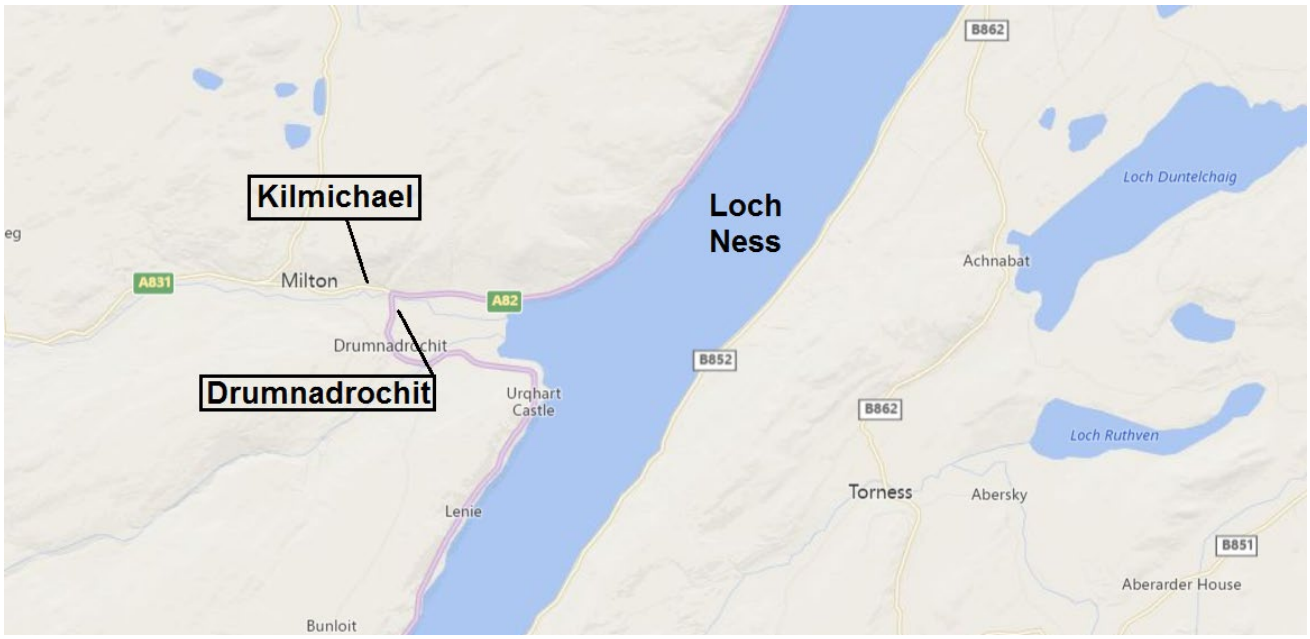


Figure 1-1 - Drumnadrochit and Kilmichael location plan

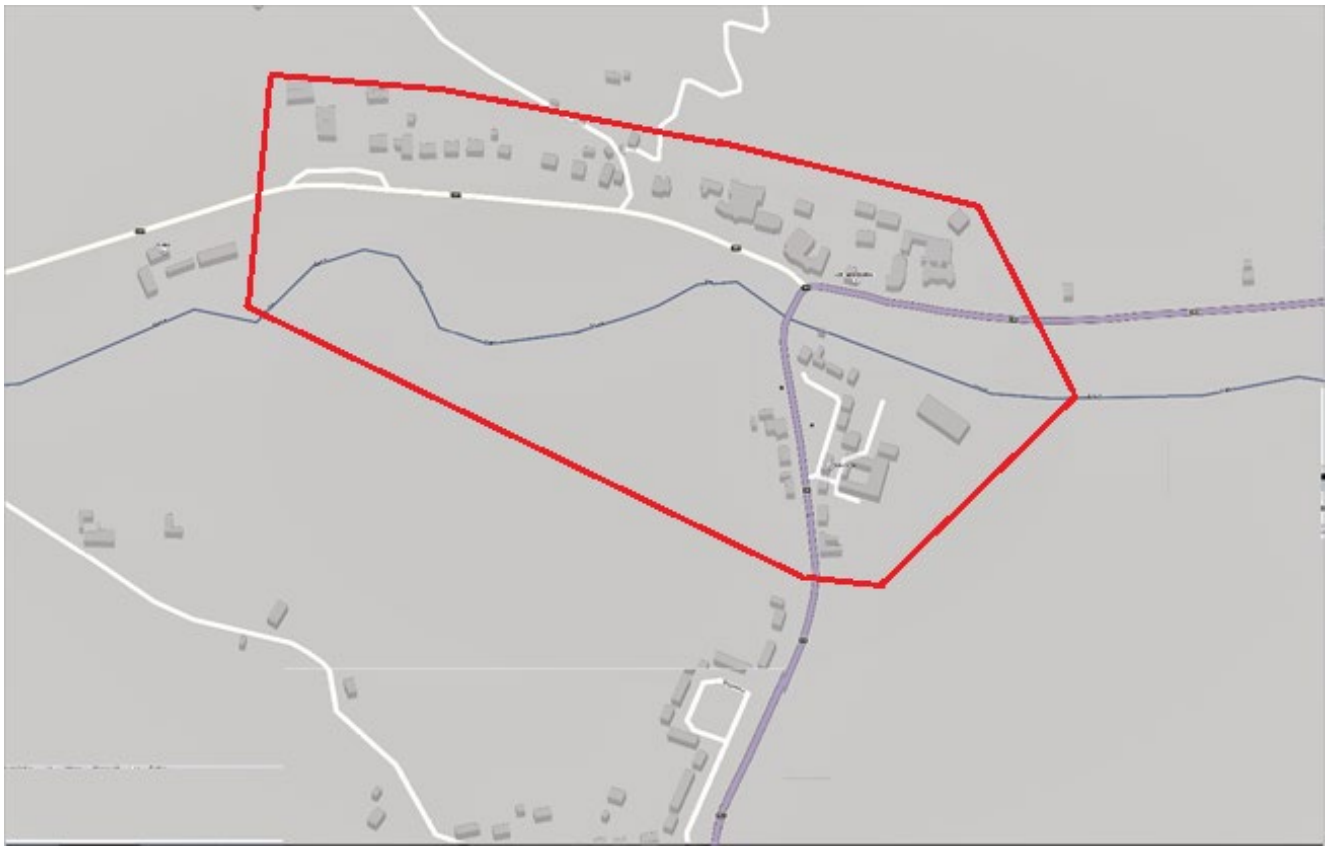


Figure 1-2 - Study area (in red)

1.3. LEGISLATIVE FRAMEWORK

1.3.1. The Flood Risk Management (Scotland) Act 2009 provides THC with general power to manage flood risk in its area and to carry out flood protection work.

1.3.2. The Drumnadrochit FPS is being promoted under Part 4 of the Act.

1.3.3. The scheme forms part of SEPA's Flood Risk Management Strategy for Potentially Vulnerable Area 01/21 (Inverness and the Great Glen).

1.4. REPORT AIMS AND OBJECTIVES

1.4.1. The aim of this report is to describe the development of the scheme origins and to provide a description of the extent and scale of the FPS. This report will also assess the impact of the scheme on the local residents and to the surrounding environment.

This report is intended to:

- Support the notification and confirmation of the FPS as per the Flood Risk Management (Scotland) Act 2009, Schedule 2
- Support the promotion of the Drumnadrochit FPS to Scottish Ministers in the event of Ministerial call-in as per Flood Risk Management (Scotland) Act 2009, Schedule 2.

1.5. PREVIOUS WORK

1.5.1. A number of previous reports exist concerning flood risk at Drumnadrochit. Reports that were considered as part of this work are listed below in Table 1-1.

Table 1-1 – Previous Studies

Title, Author and Date	Description
SAFER – Flood Risk Assessment and Survey of the River Enrick (Jacobs May 2006)	Report produced for Forestry Commission / Highland Council
Drumnadrochit Flood Appraisal Report (JBA Consulting, May 2016)	Initial flood appraisal carried out for The Highland Council that forms the basis of the options brought forward.
Drumnadrochit Flood Protection – Geomorphological Appraisal (JBA Consulting, May 2016)	Assessment of geomorphological impacts of the proposals

2. FLOODING ISSUES

2.1. FLOODING BACKGROUND

2.1.1. Drumnadrochit has a long history of flooding, with events being recorded as far back as 1818. Some of the known results are summarised in Table 2-1 below.

Table 2-1 – River Enrick Flooding History

Date of Flood	Source	Comment
1818	SEPA	River Enrick in Glen Urquhart flooded in 1818 destroying three bridges
1829	SEPA and SAFER	Similar in magnitude to 1818 flood. Torrential rain caused the River Enrick to threaten the churchyard of Glen Urquhart. Bank on north side of Drumnadrochit Bridge torn away.
1892	SEPA	A flood in 1892 destroyed five bridges on the River Enrick.
26th January 1892	SAFER	3 feet of snow fell followed 3 weeks later by heavy thaw and rain. In Strathglass 7 of 5 bridges swept away.
28th March 1908	SAFER	Highest flood for many years
17th January 1909	SAFER	Heavy rain caused a great deal of damage to roads, banks and houses in Drumnadrochit
1910, 1913, 1920	SEPA	Flood on the River Enrick
15th January 1932	Inverness Courier	Overflowed at Drumnadrochit Bridge flooded houses by the roadside - "unprecedented"
3rd November 1932	Inverness Courier	Flooding of flat land from Oakland to Drumnadrochit. Houses flooded at Drumnadrochit with long stretches of road impassable
16th February 1950	SEPA	Drumnadrochit/Lewiston - houses threatened
1950's	SEPA	Four bridges were lost in the 1950s
1956	SEPA	Flood on the River Enrick
February 1989	SAFER	Drumnadrochit/Lewiston - houses threatened
4th February 1990	SAFER	Local community noted that flooding occurred at various locations, particularly around Kilmichael and Drumnadrochit. Considerable damage to property noted, with flood banks breached and fields scoured
17th January 1993	THC	Photographs show roads flooded and impassable.
1st March 1997	THC	A member of the local community recalls water reaching alarming levels inside Glen Guest House rising to approx. 2ft. Others noted flood waters reaching to a height of 2ft at back of Post Office.
13th August 1997	THC	Flash flood following heavy overnight rain. Garden to rear of Mingulay eroded by force of water (shed lost). c 3.5 metres of garden left between house and straight vertical face of 2.1m forming river bank.
24th December 1999	SAFER	Limited details
1st June 2000	SAFER	Limited details
1st December 2006	THC	A831 Road flooded with a flood level of around 32.75 mAOD.
4th July 2007	THC	Flooding from River Enrick on road and garden of property
2010- 2016	THC	Flooding to A831 at Kilmichael 2010, 2013, 2015 & 2016

2.2. FLOOD IMPACTS

2.2.1. Flooding from the Enrick reached properties in Drumnadrochit during the 1980s and 1997, causing serious damage and risk to properties and infrastructure.

2.2.2. The March 1997 flood is estimated to have a 25-year return period. Images captured by SEPA indicate the path and extent of the flood that affected a number of properties, including the Post Office, Police Station and (anecdotally) the Fire Station.

Figure 2-1 – 1997 flood event images supplied by SEPA.

2.2.3. Kilmichael was also reported to be affected by flooding in 2010, 2013, 2015 and 2016. The reported extent of flooding did not appear to reach occupied properties, however there was hazard and disruption to the A831 which is deemed nuisance flooding.

2.2.4. Images of the 2016 event are shown in Figure 2-2 below.

Figure 2-2 - Flooding at Kilmichael, 2016[1]

2.3. CURRENT FLOOD MANAGEMENT MEASURES

2.3.1. At present flood management is restricted to intermittent dredging within the River Enrick to reduce river bed levels and remove accumulated deposits of gravel and small boulders. The Highland Council carried out dredging works in 2016, removing 1450m^3 of material to reduce flooding frequency to the A831.

2.3.2. Such dredging is known to have been undertaken historically, although the locations, dates and quantities are unknown.

2.3.3. It appears that recurrence of the nuisance flooding has reduced since the works were carried out, however they are not proposed as a sustainable solution to the problem.

[1] Glenurquhart Community Council Facebook page

Figure 2-3 - Dredging Works to River Enrick, 2016

2.4. FLOOD IMPACTS FOR DO-NOTHING SCENARIO

2.4.1. Detailed flood modelling exercises have been carried out by JBA, supplemented by WSP, with calibration against the known flood extents described in Section 2.2 above. This has allowed an assessment of the properties potentially at risk for a range of return periods, and these are summarised in Table 2-2 below.

Table 2-2 – Properties at risk in "do nothing" scenario.

Return Period (years)	2	10	25	50	100	200CC
Residential properties	0	0	3	7	9	12
Non-residential properties	0	5	12	19	23	25
Total	0	5	15	26	32	37

2.4.2. An image of the most extreme flood event analysed, for the 200-year return period event with climate change allowance, is shown in Figure 2-4 overleaf.

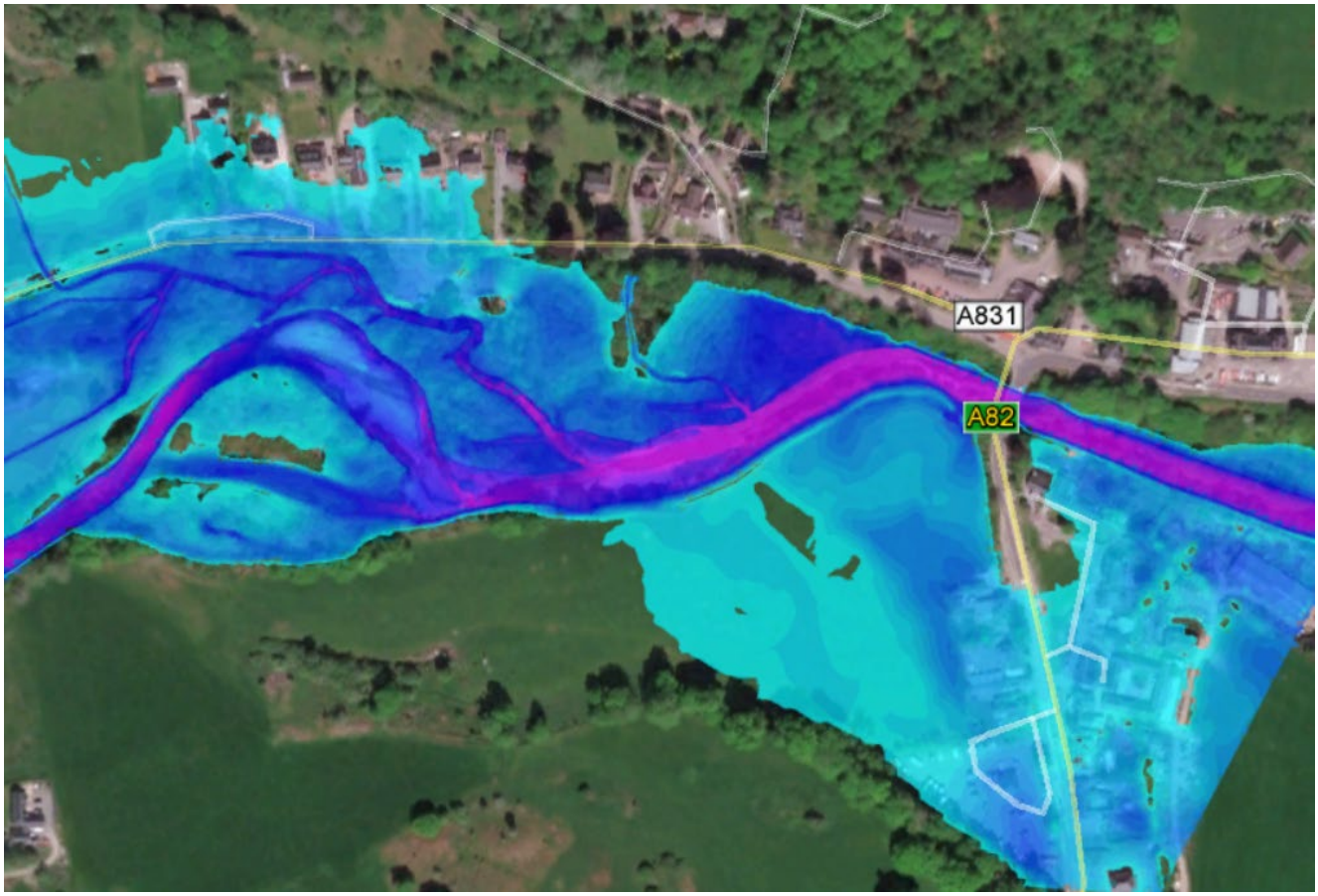


Figure 2-4 - Predicted flood extents for 200-year return period "do nothing" scenario

2.5. FLOOD SOURCES AND MECHANISMS

2.5.1. Fluvial

The main source of fluvial flooding to Drumnadrochit is from the River Enrick, and this forms the bulk of the hydrological modelling works.

Frequent flooding also occurs at Kilmichael over the A831 that is contributed to by nearby small watercourses and these are included in the extended model.

2.5.2. Groundwater

The soils and geology at Drumnadrochit are such that shallow groundwater flooding may occur in the low-lying fields to the west of the A82. There is a minor risk that this may occur behind a new flood embankment during an extreme event, due to the increase in head at the protected face of the embankment. This shall be taken into account in the design, and geotechnical studies and the production of a geotechnical report will simulate the effects of the embankment on groundwater flow in the area. This report also describes any other groundwater flood mitigation steps that are to be taken.

2.5.3. Drainage systems

There is considered to be a potential risk of flooding to properties due to back flow of drains during high river events that coincide with high rainfall on the site. The study shall consider installing flap-valves at surface water drainage outfalls to the River Enrick. This means that no flow would be allowed through the pipes during such times, therefore surface water flow paths are to be determined. This analysis shall be undertaken by WSP using InfoWorks Integrated Catchment Modelling (ICM) software, which is an accepted tool for modelling the integration of drainage systems with river systems.

2.6. GEOMORPHOLOGICAL CONSIDERATIONS

2.6.1. The River Enrick is geomorphologically active in this area, mostly because of the nature of the geology and soils in the area, and also due to high velocities during peak storm events. This has led to transportation of gravels and boulders downstream that deposit in the lower meanders of the river within the study area.

2.6.2. Natural Flood Management (NFM) techniques involve holding back water in upper catchments in natural floodplains to control flows in the downstream event. These have been the subject of several studies.

2.6.3. The act of channelling the river through floodwalls may lead to an increase in velocities during peak events. These shall be assessed, particularly around the A82 road bridge, to determine if additional erosion protection is required.

2.7. CLIMATE CHANGE

There are many potential impacts of the climate changes underway as identified by the Intergovernmental Panel on Climate Change (IPCC) which include:

- Rising temperatures.
- Rising sea levels.
- An increase in storm severity as rainfall events are more concentrated.
- An increase in flooding risk due to alterations to catchment characteristics.

In order to allow for such changes at this location, an additional 20% flow has been added to peak runoffs in accordance with current guidance.

2.8. POST-SCHEME FLOOD RISK

Following assessment of the flood risk, a number of measures were examined to reduce flood risk to properties and infrastructure. These included:

- An earthworks flood embankment along the southern bank of the Enrick upstream of the A82 to protect properties to the west of the A82.

- An alternative earthworks flood embankment set back from the southern bank of the Enrick upstream of the A82.
- A solid protection wall downstream of the A82 on the southern bank of the Enrick to protect properties to the east of the A82.
- A solid/earthwork wall on the north bank of the Enrick to reduce carriageway flooding on the A831.
- Natural Flood Management mitigation measures consisting of excavation/dredging of historical channels in the upstream meanders of the Enrick.
- Installation of valves to drainage to prevent back flooding through pipework.

The selected scheme is further described in Section 4. Following installation of the scheme the aims of the project shall be achieved, namely:

- Protection of residential properties for events up to a 200-year return period (with climate change allowance)
- Reduction of nuisance flooding to the A831 for events up to a 10-year return period.

3. HYDROLOGICAL/HYDRAULIC MODELLING AND ANALYSIS

The following chapter describes the hydraulic modelling method adopted by CBEC as part of this study, and how information from these models was derived and interpreted.

3.1. DESIGN FLOOD ESTIMATION

3.1.1. Statistical Method for the River Enrick

Flood Estimation Handbook version 13 (FEH13) parameters were used in the analysis, in accordance with national guidelines. The method of flood estimation used was also based upon national guidelines, with the Statistical Method of flow estimation being used for the main component of flow, i.e. the River Enrick, and the Revitalised Flood Hydrograph 2 (ReFH2) method used for the smaller catchments that contributed to flooding on the A82 by Kilmichael.

JBA Consulting's 2016 report was consulted during this analysis. This study used the single-site analysis method to predict extreme flows in the River Enrick, whereas the CBEC analysis looked at the pooling-group method. Other deviations from JBA's approach related to the FEH parameters used – JBA used 1999 FEH parameters, whereas this approach used FEH 2013 parameters. AMAX series were also updated to 2013 as part of CBEC's approach.

Design flows using the Statistical Method are shown in Table 3-1 below, and a hydrograph showing the variation in flow over time for the 200-year event is shown in Figure 3-1 overleaf.

Table 3-1 - River Enrick Design flows used in the analysis

Return Period (years)	Flows (m^3/s)
2	63.03
5	84.44
10	99.57
30	125.55
50	139.02
100	159.13
200	181.69
200+ cc	218.03
1000	245.61

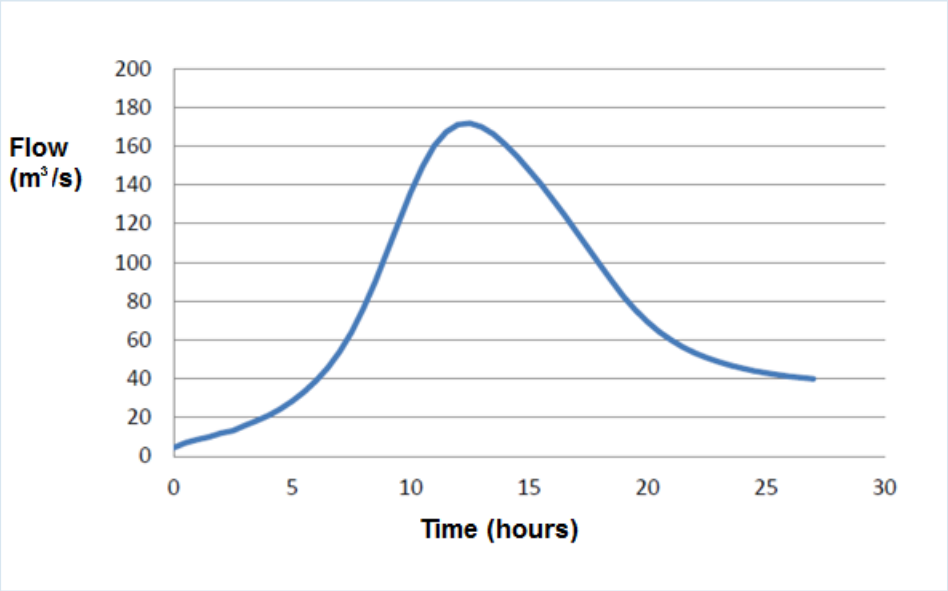


Figure 3-1 - Hydrograph for 200-year event for River Enrick

3.1.2. ReFH2 Method for Kilmichael area

The ReFH2 method was used to estimate design flows for the watercourses in the Kilmichael area, i.e. the Culnakirk and Balchraggan Burns. These are summarised in Table 3-2 below.

Table 3-2 - Derived flows for the Culnakirk and Balchraggan Burns

Return Period (years)	Flows (m^3/s)	
	Culnakirk Burn	Balchraggan Burn
2	0.85	0.94
5	1.35	1.50
10	1.73	1.92
30	2.36	2.62
50	2.67	2.97
100	3.11	3.46
200	3.57	3.97
200+ cc	4.29	4.76
1000	4.73	5.25

3.2. HYDRAULIC MODELLING

3.2.1. General

The hydraulic modelling component of the work was carried out by CBEC using SRH software. This complements and adds to the work carried out by JBA previously that forms the basis of the scheme, and also is more suited to assessment of Natural Flood Management techniques. It was, however, necessary to make some updates to the JBA methodology based on the time elapsed since the last study and changes to practice and available data sets. The changes are described below.

3.2.2. Topographical Survey

A topographic survey was conducted to collect cross-sectional and detailed grid data at specified locations of the River Enrick within the design area. The survey extended to 1.3 km of the River Enrick (upstream extent: NH 49833 30113, downstream extent: NH 50997 30040).

Surveying was undertaken with Leica RTK GPS (Leica GS14 and GS08) and Leica GS14 base-station equipment to survey the required reach. A Trimble S6 'robotic' optical ('total station') instrument was used to collect data where GPS signal was unavailable. The Trimble S6 was also used to collect reflector-less points where additional information around the A82 road bridge was obtained. All points were surveyed in the OSGB36 datum coordinate system.

The survey was conducted in such a way that allowed characterization of the physical form/ hydraulic function of all bedforms, while avoiding superfluous detail that would add to cost. All channel structures (e.g. bridges, culverts and embankments, etc.) were captured in sufficient detail as required.

The surveys representatively characterised variation in the horizontal (i.e. channel planform) and vertical (i.e. relative topographic highs, bars, riffle crests/ hydraulic controls, and lows, pool centres).

Cross sections were extended to a maximum of 30 m from 'top of bank' to allow for tie in with existing LiDAR data. Within the middle section of the reach (~NH 50409 30188) a complex bar feature and several small channels exist. Data was collected from this area in a non-uniform gridded format (i.e. not cross-section based), allowing for greater point density around areas of highest elevation variability. Such a 'point scatter' approach is essential to capture the salient aspects of morphology in more complex topographic areas (e.g. at complex alluvial bar features and other hydraulic structures).

The topographic survey was carried out by CBEC survey staff in January and February 2016. Data processing was then conducted using AutoCAD Civil 3D 2016, in which a detailed 3D triangulated and break lined digital elevation surface was built. The floodplains in the surface were further extended by LiDAR data. The surface was meshed for hydraulic computations using Aquavaeo SMS 11.1.

3.2.3. Structures

The A82 bridge is a large structure spanning the Enrick in Drumnadrochit village itself. Flows do not reach the bridge soffit, and so, to model this bridge and the transfer of momentum through it

accurately, the bridge was modelled fully in 2D. This required that the bridge deck be 'daylighted' using Computer Aided Design (CAD). The bridge was therefore represented by the surveyed channel bed through the bridge and the bridge abutments on each bank. The bridge is shown in Figure 2.4. The model results were carefully compared with the JBA model, where this bridge was represented by a 1D unit, and no significant differences were found in water levels upstream of the bridge.

Figure 3-2 - A82 Bridge

Two minor tributaries, the Culnakirk Burn and the Allt Tarbh/Balchraggan burn enter the Enrick through culverts through the A831. There is also a culvert/drain through the embankment at Aldergrove. Each of these culverts were surveyed and opened in the 2D model. The Culnakirk Burn and the Allt Tarbh only account for 2% and 2.2% of the total Enrick flow respectively at the 200-year flow peak and so the functional floodplain is not significantly affected by the choice to model these by daylighted flow routes. The daylighted culvert through the embankment at Aldergrove carries around 2.4% the total Enrick and floodplain flow at the 10-year flow peak and so while the culvert is necessary for an accurate representation of floodplain flow routes (see the Calibration section), it accounts for only a small amount of the total flow and so representing the culvert by a daylighted notch does not compromise overall model accuracy.

In addition to these topographic adjustments, the entire LiDAR surface was adjusted in AutoCAD Civil 3D to accurately represent properties by their surveyed finished floor level.

This approach was considered acceptable by SEPA.

3.3. MODEL BOUNDARIES

3.3.1. The model was set up so that it contained the entire functional floodplain for the 200-year +20% climate change allowance event. Therefore, there were no 'glass walls' in the model and water could run off both the floodplain and channel at the downstream end.

3.3.2. The water surface elevation (either as a function of time, or of discharge) must be supplied at the downstream end of any 1D or 2D hydraulic model. Typically, when the downstream water elevation is not known a normal depth assumption is used, where water elevation is computed as a function of discharge using bed slope, bed friction, bed cross sectional area and hydraulic radius. If there is any downstream backwater effect, then the actual water surface elevation may be higher than normal depth. To take account of downstream backwater effects, and to be conservative in terms of flood risk, CBEC used a different, more accurate, approach.

3.3.3. Two other larger models were available for the study that contained estimates of water surface elevation at the downstream end of the 2D model. These two models were the SEPA commissioned flood model, which extended approximately 2km downstream of CBEC model boundary, and the recent JBA 1D/2D flood model, which extended 680m beyond the CBEC model boundary. The SEPA model has the advantage that its downstream boundary is Loch Ness, with a relatively constant, well known elevation. The JBA downstream boundary was itself normal depth, but this model is relatively detailed and calibrated against flood photos.

Figure 3-3 shows each model domain. The CBEC 2D model is a black polygon, with the downstream boundary at the right. The JBA normal depth boundary is at the right of the red 200yr flood outline, and is 680m downstream of the CBEC model boundary. The SEPA flood model boundary is 2km downstream. The water elevation and discharge through CBEC model boundary line was extracted from both of these larger models, and a best-fit rating curve extracted, which was supplied as the downstream rating for the 2D model. This rating is included in the figure.

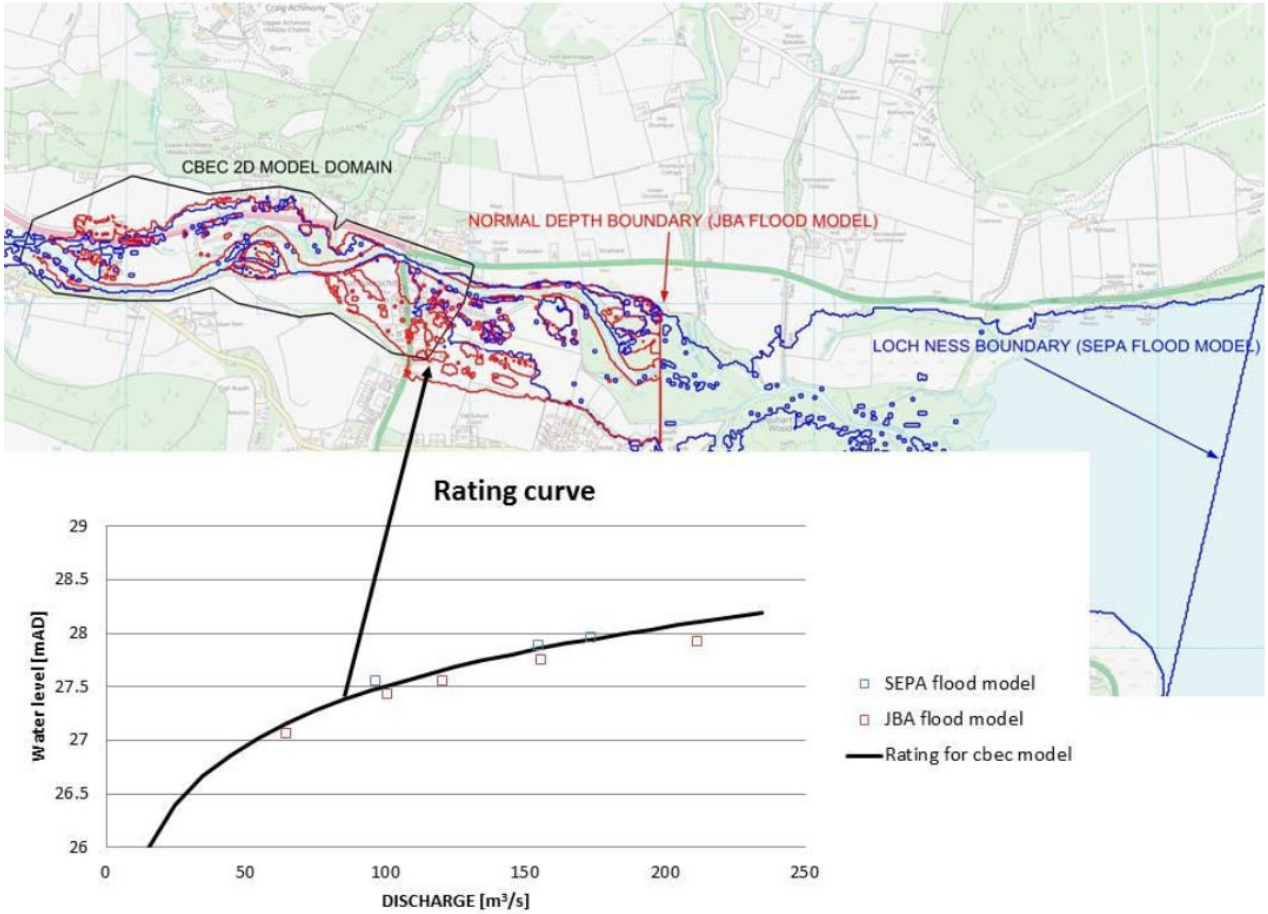


Figure 3-3 - Model boundaries and rating curve

4. DEVELOPMENT OF THE SCHEME

4.1. STANDARD OF FLOOD PROTECTION OBJECTIVE

4.1.1. The FPS is designed to protect existing properties to a 0.5% Annual Exceedance Probability (200-year return period) with climate change allowance.

4.1.2. The FPS is also designed to reduce the frequency of flooding on the A831 to events exceeding a 10% AEP (10-year return period).

4.2. KEY SCHEME OBJECTIVES

4.2.1. The first element of the flood protection scheme is intended to protect properties within the village of Drumnadrochit. The area at risk of flooding from the River Enrick has been identified by flood modelling. A direct defence is proposed to provide a 200-year level of protection including climate change. Two options for the line of the defence have been identified in the Flood Appraisal Report by JBA. The proposals will also have to address local drainage issues.

4.2.2. The second element of the flood protection scheme is intended to protect the A831 Drumnadrochit to Cannich road in the locality of Kilmichael. The road is currently susceptible to regular flooding, primarily from the adjacent River Enrick. This element of the scheme comprises up to two lengths of new roadside defence in order to provide a 10-year level of protection from the River Enrick. The proposals will also have to address local drainage issues, and in particular the possibility that flooding may arise due to runoff from land to the north of the road. An initial line and crest level of the defence has already been proposed following a Flood Appraisal Report by JBA.

4.2.3. A Natural Flood Management Study is proposed to look at the Natural Flood Management options for the full catchment of the River Enrick. The need for the study has been identified in SEPA's national flood risk management strategy and the study will be undertaken under the framework of the Flood Risk Management Act. The study is intended to coordinate and complement the proposed flood scheme and has the objective of reducing flood risk in Drumnadrochit. The study shall take into account, and build upon, the previous studies.

4.3. GEOTECHNICAL REVIEW

GROUND CONDITIONS

4.3.1. Geotechnical investigation was required to determine the engineering properties of the ground around the various structures, and the hydraulic performance of the materials in and beneath eth structures. The intrusive ground investigation works were undertaken between 18 April and 12 May 2017, and included ten Cable Percussion Boreholes, three hand held window sample holes and three dynamic window sample holes.

4.3.2. The site is underlain by alluvial and glacial deposits comprising interbedded silt, sand and gravel, with inclusions of metamorphic and igneous rock from the surrounding solid geology. These deposits are therefore considered likely to be similar and, as such, the boundary between the two strata difficult to distinguish. In situ permeability tests (falling head and rising head) were attempted in cable percussive boreholes. The results of the tests suggest that the hydraulic conductivity of the alluvium varies quite significantly, based on the proportion of fines present. Rockhead may be shallow, and bedrock is anticipated to comprise psammite and semipelite in the west of the site and sandstone in the east.

4.3.3. No information is available regarding the flow of groundwater beneath the Site. However, it is considered likely that shallow groundwater within the Alluvium will be in hydraulic connectivity with the River Enrick.

4.3.4. Environmental samples were taken from selected cable percussive and window sample boreholes and trial pits. Six samples were submitted for geo-chemical analysis. Chemical contaminants at site have not been found in excess of adopted human health criteria. From the testing carried out, no substantial contamination has been identified either site wide or localised.

4.3.5. Groundwater levels encountered in the boreholes and trial pits during drilling and excavation and monitoring are typically at or close to the nearest river bed levels recorded in the CBEC topographic survey. Groundwater is therefore considered likely to primarily flow from west is east and have hydraulic connectivity with the River Enrick.

FLOOD WALL

4.3.6. Based on the flood levels provided by CBEC, a flood wall anticipated to be approximately 1.70m in height with allowance of 600mm freeboard is proposed to protect properties on the south bank of the River Enrick, to the east of the A82.

4.3.7. Groundwater is indicated to be shallow in this area at approximately 2.0m below ground level, and is thought to be in hydraulic connectivity with the River Enrick. The alluvium is thought to be highly permeable and it may be necessary to use a cut-off wall beneath the flood wall, such as a bentonite/ concrete key, to increase the seepage path below the flood wall foundation.

4.3.8. A sheet piled wall is not considered to be a viable option for the given ground conditions. Dense gravel with occasional cobbles and boulders were encountered at shallow depth in this area, and it is considered unlikely that a sheet piled wall solution would be able to penetrate this material to the required depth without imposing significant stresses on the proposed wall. Most of the exploratory holes encountered obstructions at shallow depth. The window samples and trial pits made limited progress into the alluvium, with the window samples typically terminated on obstructions at shallow depth, and the collapse of the trial pit walls during excavation which should be considered during foundation excavation.

4.3.9. A conventional concrete retaining wall is therefore proposed, and geotechnical parameters for bearing and overturning have been determined to inform the design.

DRUMNADROCHIT EMBANKMENT

4.3.10. The embankments are anticipated to bear directly onto the alluvium, comprising dense sand and gravel at shallow depth. The alluvium is thought to be highly permeable and it may be necessary to

use a cut-off wall beneath the embankment, such as a bentonite/ concrete key, to increase the seepage path below the embankment foundation, or a horizontal clay/bentonite layer to extend seepage paths.

4.3.11. The topsoil should be stripped before construction to help key the embankment and reduce settlement. The stripped soil could be used to cover the embankment and establish suitable grass cover.

4.3.12. The embankment is recommended be constructed using imported Class 2 Cohesive Fill in accordance to Design Manual for Roads and Bridges Volume 1 Specification for Highway Works series 600 (SHW). The materials should be placed in layers and compacted with mechanical plant to improve embankment strength and reduce permeability.

4.3.13. If the proposed embankments are constructed using imported or site-won compacted sand and gravel, in addition to the cut-off below the embankment formation a cut off in the embankment centre is likely to be required to reduce seepage through the embankment. This can be achieved using a clay core for a shallow cut-off, or a concrete key for a deeper cut-off.

4.3.14. Given the rural site setting, the embankment formation should be checked for the presence of buried agricultural land drains prior to construction. Land drains may lead to excessive seepage and embankment failure if not removed.

4.4. EROSION

The Enrick is already subject to bank erosion along its length, however the installation of flood walling can risk increasing the velocity of the river at high flows from water that would otherwise have flowed into the protected area.

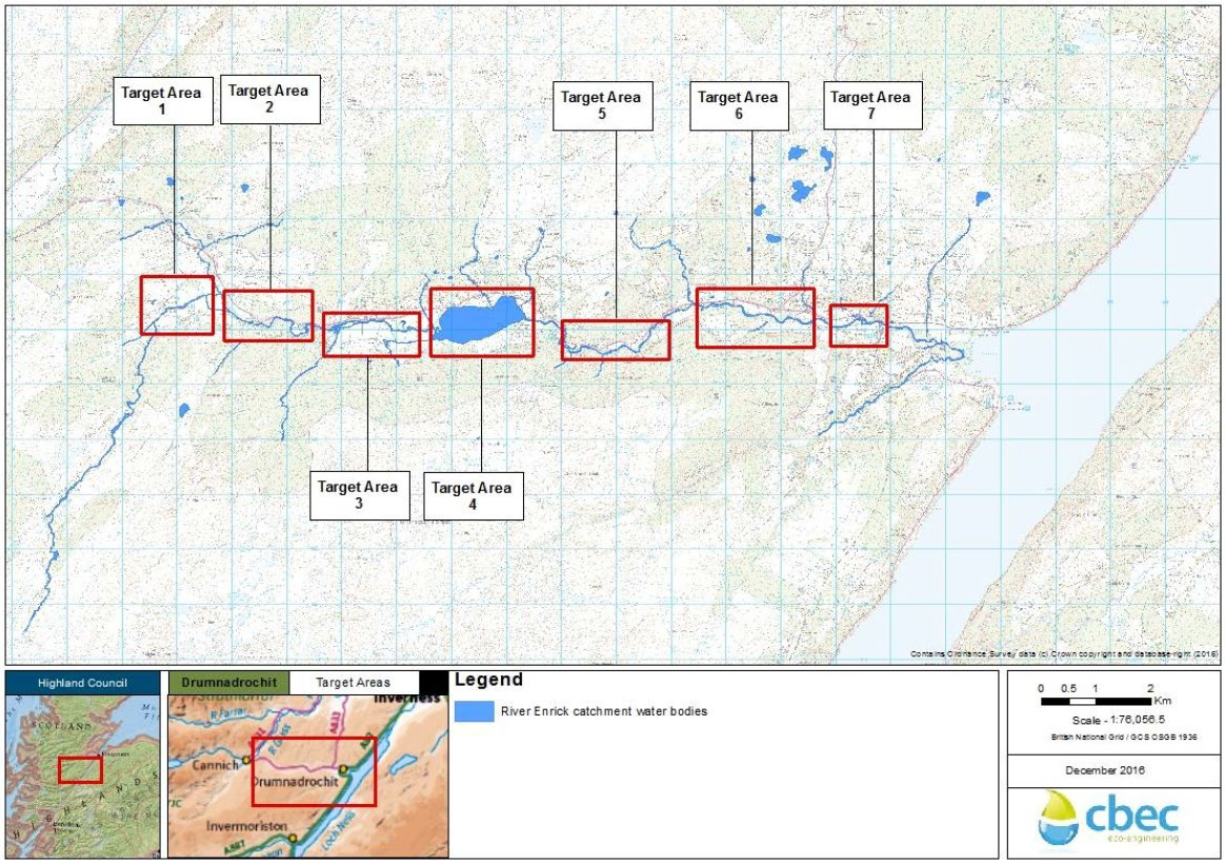
The impact of velocities and shear stresses before and after the installation of the scheme has been modelled, and there are increases in velocities in front of the Drumnadrochit flood wall. As there is also the potential for undermining the new protection wall it has been determined that erosion protection is required at this location. Of several options considered, which included gabion baskets, and engineered concrete structures, it has been determined that natural rock armour is the preferred solution. This rock shall also have topsoil brushed into exposed faces to encourage growth of vegetation.

4.5. NATURAL FLOOD MANAGEMENT

4.5.1. Natural Flood Management (NFM) is a process of managing flood events by amending catchment characteristics, and improving the retention of flood waters in existing natural storage basins along eth length of the river. It has the benefit of avoiding hard flood defences where possible, and attempts to replicate the normal behaviour of the river.

CBEC investigated seven target areas for Natural Flood Management options on the River Enrick in December 2016 (shown in Figure 4-1 below).

Figure 4-1 - Natural Flood Management Target areas



4.5.2. The options included techniques such as:

- Creation of marshlands/wetlands.
- Restriction of flows downstream of flood plains.
- Block/ remove field drainage and convert land-use to rough grazing and forest.
- Installation of In-channel measures to reduce conveyance/ promote sediment deposition.
- Localised adjustment of cross-sectional profile.
- Remove embankments and bank protection to improve channel-floodplain connectivity.
- Measures to control sediment input from erosion of valley sides.
- Introduce hydraulic control to increase storage capacity in Loch Meiklie.
- Re-open sedimented channels at high flow events to increase area of sediment deposition and reduce water level.

4.5.3. The studies options, of which most were outside the study area, all showed benefits in reducing flood levels and improving bio- diversity. One option lay within the study area. It was, however, concluded that the NFM options did not provide sufficient protection to achieve the overall aims of the project, namely the protection of properties at the 200-year event, and the protection of the A831 at the 10-year event. They remain potential future projects and a viable study, however they have not been included in the Drumnadrochit FPS for the reason stated above.

5. SOCIAL AND ENVIRONMENTAL IMPACT

5.1. ENVIRONMENTAL IMPACT ASSESSMENT

SCREENING OPINIONS

5.1.1. As part of the planning process and to ensure adequate opportunity for consideration, regulators were approached regarding their opinion on the need for an environmental impact assessment (EIA) for the Drumnadrochit Flood Protection Scheme (FPS). This screening process is a recognised and required procedure under The Flood Risk Management (Flood Protection Schemes, Potentially Vulnerable Areas and Local Plan Districts) (Scotland) Regulations 2010. Screening secures regulators' answers as to whether an EIA would be necessary for the FPS.

5.1.2. Regulators and other statutory authorities in the area were approached as follows;

- Scottish Environment Protection Agency (SEPA)
- Scottish Water
- Royal Society for the Protection of Birds (RSPB)
- Scottish Natural Heritage (SNH)
- Ness District Salmon Fishery Board (NDSFB)

5.1.3. The Ness and Beauly Fisheries Trust was also considered, but as they are not a statutory organisation and are already represented within the NDSFB it was decided that the fishery board response would suffice.

5.1.4. Only SEPA gave a definitive response regarding the need for an EIA and stated that they do not consider an EIA necessary. The remaining responses gave no undue concerns about the FPS. Taking care, carrying out best practice and complying with the relevant standards and procedures is necessary and expected by the respondees and all in the design team. It was therefore concluded that an EIA is not necessary. More detail on responses is given in Section 5.3 below.

ECOLOGICAL SURVEY

5.1.5. A Phase 1 habitat survey was carried out by an experienced ecologist in WSP in November 2016, and a number of potential ecological constraints were identified.

- **Bats:** All the flood protection locations that require the felling of trees will also require dedicated tree assessments in search of potential roosting opportunities for bats. Some items are already identified to be retained if possible. The bat habitat suitability assessment of trees can be undertaken at any time of year and involves a ground-based inspection in search of features with the potential to support roosting bats.
- **Nesting Birds:** It is recommended that any vegetation removal/tree felling works are undertaken outwith the nesting bird season (recognised as March to August inclusive
- **Badgers:** It will be necessary to undertake a dedicated badger survey, as the presence of active badger setts, west of the main embankment, indicates that a clan is active in the area.

- **Otters:** The River Enrick provides good habitat to support otter and evidence of otter was recorded along the southern bank of the river during the survey effort comprising a holt, sprainting activity and further potential resting spots identified. Given the presence of otter activity/evidence upstream, this has implications for the Drumnadrochit defence wall, given the potentially disruptive method of works proposed (rock armour) to the southern bank. It is recommended that a dedicated otter survey along the river be undertaken to ascertain the extent of otter activity along the water channel.

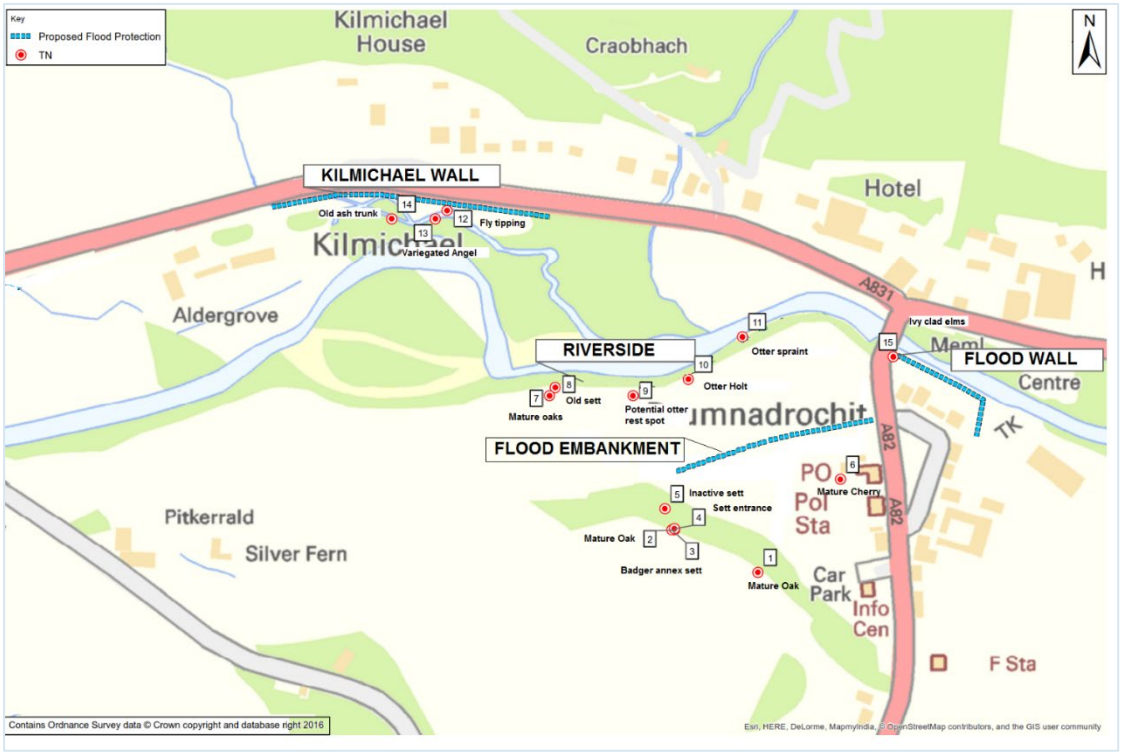


Figure 5-1 - 2016 Ecological Survey noted items

5.1.6. An updated ecological survey shall be carried out prior to construction to assess any changes since the last survey.

TREE SURVEY

5.1.7. A tree survey was carried out by Scottish Arboricultural Services in September 2017 in accordance with BS:5837(2012) in order to provide a Tree Constraints Plan and Tree Protection Plan.

5.1.8. Tree retention is a priority where identified, however for the engineering and rock armour works to the Drumnadrochit Wall, and the excavation for the Kilmichael Wall, it is accepted that tree removal is unavoidable.

5.1.9. The tree survey and plan are shown on drawings 2745-XS-001 and 2745-XS-002.

5.2. PUBLIC CONSULTATION

5.2.1. A public consultation meeting was held at Glen Urquhart High School, Drumnadrochit, on Wednesday 16th December 2015 attended by THC that presented the work carried by JBA at that stage. The meeting was advertised by posters. No specific feedback was received that altered the direction of the study.

5.2.2. Prior to carrying out the second public consultation, a short presentation was made to the Glen Urquhart Community Council Meeting on 23rd October 2017.

5.2.3. Once the scheme was further advanced a further Public Meeting was held 8th November 2017 at the same venue. Three members of the public submitted comment forms, all of which were supportive of the proposals.

5.3. STATUTORY CONSULTATION

5.3.1. A number of consultations have been carried out, including for EIA screening, with public bodies. Responses from the consultees are summarised below.

SEPA

5.3.2. SEPA gave detailed comments on the Screening Opinion Plan (29th January 2017), that covered the form and extent of additional information that may be required to close consultations. Key highlights are as follows:

- Further details to be provided on site layout, flood risk, (including freeboard allowances, residual risk, and wider impacts), structural design, (including overtopping considerations)
- Impacts on the water environment – a stated preference for setback embankments where possible, or assessment of impact where not possible due to land availability.
- Mitigations for pollution prevention and environmental management
- Details of borrow pits if required

5.3.3. There was concern expressed about the possible downgrading of the River Enrick from High to Good due to grey bank protection which may be exacerbated by the FPS. The setback Option 2 embankment and upstream A831 embankment would both however be distant enough (>50m) from the Enrick not to qualify and therefore SEPA noted their preference for the Option 2 embankment to the south of the river.

SCOTTISH WATER

5.3.4. Scottish Water gave no comment on whether an EIA is necessary. The Scottish Water response only considered the risk to Scottish Water assets noting that Option 2 setback embankment was close to the Scottish Water 90mm supply pipe and related pressure relief valve and listed precautions to take if construction proceeds. They also noted that Loch Ness is a drinking water supply for the Invermoriston Water Treatment works some 17km distant and that precaution needs to be ensured to protect the water supply.

ROYAL SOCIETY FOR PROTECTION OF BIRDS (RSPB)

5.3.5. The RSPB gave the following general comments on the Screening Opinion Plan (30th January 2017)

- Preference for set back earthwork embankment option rather than river edge
- Possible provision of shallow scrapes to create suitable feeding areas for young wading birds.
- sharp faced earth banks would also provide nesting sites for sand martin and kingfisher.
- any trees felled along the river bank with natural cavities in them could be left to provide nesting habitat for tree nesting ducks, alternatively provision of nest boxes is provided.
- If extensive tree removal is undertaken then artificial otter Holts should be considered
- cold searching to be carried out before clear felling or thinning operations to avoid any nest sites of protected species are avoided, with felling operations outside of the main bird breeding season.
- Consideration of other protected species including red squirrel, salmon, sea trout, freshwater mussels, and black grouse.

SCOTTISH NATURAL HERITAGE (SNH)

5.3.6. SNH gave a response from their Dingwall office. SNH are an "advisory" body and as such do not determine whether an EIA is required. They noted the presence of the Urquhart Bay Woods with SAC and SSSI designations, for the presence of "Alder wood on flood plain" and stated that the scheme should consider the conservation objectives for the site that essentially require that the habitat, and therefore distribution and viability of species, is maintained in the long term. SNH also noted a catchment-wide initiative to tackle invasive species and informed of pine martens and red squirrels in the vicinity.

NESS DISTRICT SALMON FISHERY BOARD (NDSFB)

5.3.7. NDSFB gave a short email response as the statutory body for the protection and enhancement of migratory salmon. They have asked for clarity on whether piling would be used and if so that a fisheries impact assessment would be necessary. Otherwise, NDSFB "would have no significant concerns" and seemed satisfied assuming no river bed or bank measures would be affected. They added that if this was to change then fish surveys and construction timing would need to be considered.

TRANSPORT SCOTLAND

5.3.8. The A82 is a trunk road owned by Transport Scotland. WSP met with BEAR Scotland, the network operators of the A82 on behalf of Transport Scotland. They raised no major objection to the scheme, and requested additional information on the following points:

- Clarification of velocities to the upstream face of the A82 embankment
- Assessment of impacts on the drainage from the A82, as this was perceived a s potential source of historical flooding
- Noted that HGV access points may lie in the 30mph zone of the A82.
- Noted that there is increased traffic in the holiday period which time should be avoided if possible.

5.4. STATUTORY CONSENT

CAR LICENSE

5.4.1. Proposed engineering works within the water environment will require authorisation under The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended). Management of surplus peat or soils may require an exemption under The Waste Management Licensing (Scotland) Regulations 2011. Proposed crushing or screening will require a permit under The Pollution Prevention and Control (Scotland) Regulations 2012.

WASTE MANAGEMENT LICENCE

5.4.2. A waste management licence is normally required for movement and disposal of waste material including excess soils from construction sites under the Waste Management Licencing (Scotland)

5.4.3. Regulations 2011. SEPA has adopted a regulatory position where it will not require a licence or exemption for the reuse of greenfield soils within the site boundary under their guidance 'Promoting the sustainable reuse of Greenfield soils in construction'.

5.4.4. In this instance it shall be necessary to import fill materials to form embankments, and it is expected that all stripped topsoil shall be replaced on completion of the filling works. There may, however, be a surplus of materials from the excavation for the rock armour works.

SOCIAL BENEFITS

5.4.5. On completion of the scheme the following benefits shall be experienced:

- Reduced risk of flooding of property in Drumnadrochit
- Reduced risk of flooding to public services including the Police and Fire Station, car parks and telephone exchange.
- A more secure access route along the A82.
- Greater security of access along the A831.

6. SELECTED SCHEME DESCRIPTION

6.1. DRUMNADROCHIT FLOOD DEFENCE EMBANKMENT

PURPOSE

6.1.1. The purpose of this set of works is to form a primary defence to the properties at risk of flooding.

DESCRIPTION

6.1.2. OP-01 Construction of an earth embankment approximately 200m long, from the A82 adjacent to the existing bus stop across the field to the west. The embankment shall have side slopes no steeper than 1:2.5, a 1m crest width at a level of 31.82m AOD that includes a freeboard of 600mm. The embankment shall be constructed at ground level at the western end to a maximum height of c2.6m above the existing ground level at the eastern end. Two reinforced grass ramps of 4m width will provide landowner access across the embankment.

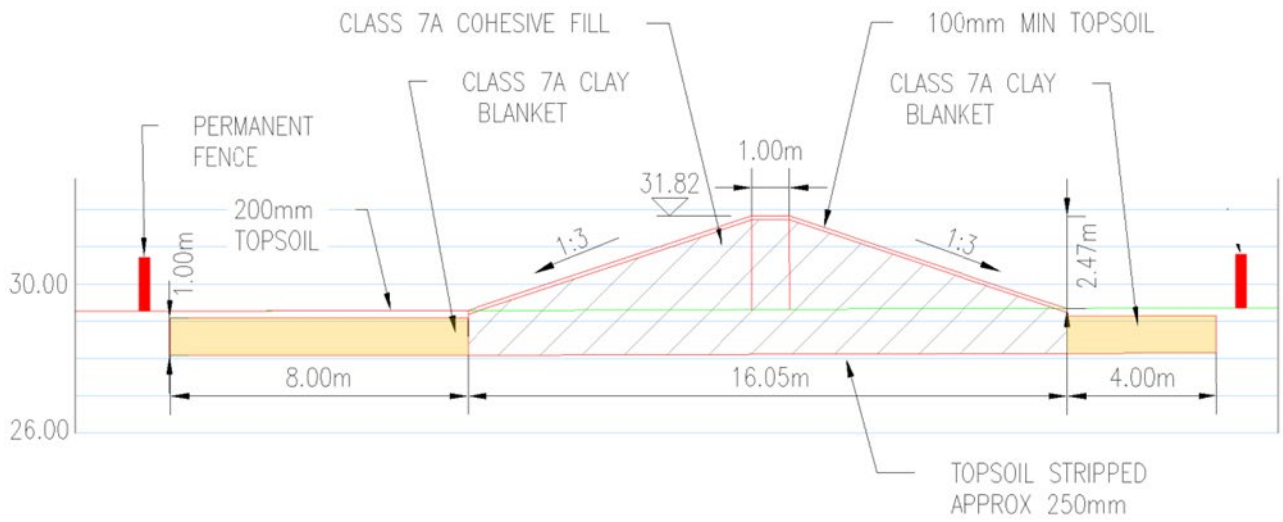


Figure 6-1 - Section through higher part of flood embankment

CONSTRUCTION PROCESS

6.1.3. A possible construction sequence is outlined below. This sequence is illustrative only and does not pre-empt how a contractor might set-up and carry out the works.

- Advance diversion of SSE 11kV power poles, transformer, and buried cables for safety reasons.
- Temporary fencing to the perimeter of the site

- Construction of a temporary access track c4m wide from the car park to the south
- Stripping of topsoil and storage at an appropriate location,
- Placement of clay and clay liner to form the embankment.
- Replacement and seeding of topsoil.
- Installation of fencing and gates to allow landowners access and maintenance access.

6.1.4. Maintenance and operation

- The embankment sides are set at a gradient to allow grass cutting or grazing by sheep.
- Gates/fences may require replacement approximately every 20 years

6.2. DRUMNADROCHIT FLOOD DEFENCE WALL

PURPOSE

6.2.1. The purpose of this set of works is to form a primary defence to the properties at risk of flooding.

DESCRIPTION

6.2.2. **OP-02** Construction of a concrete wall between the A82 bridge over the River Enrick and Morlea. The flood wall will be 173m long, and shall be faced with a natural stone façade and concrete coping stones. The defence level shall be 30.04m above ordnance datum (mAOD) that includes a 600mm freeboard, and shall be constructed an average of 1.7m above the existing ground level. A rock armour erosion protection layer shall be placed on the southern bank of the river of 105m length or thereby, with a maximum rock size of 600mm. Existing surface water drains will pass under the flood defence wall, and these shall be closed with a non-return valve at the water's edge. Two outbuildings shall be removed and rebuilt after construction of the flood defence wall.

6.2.3.

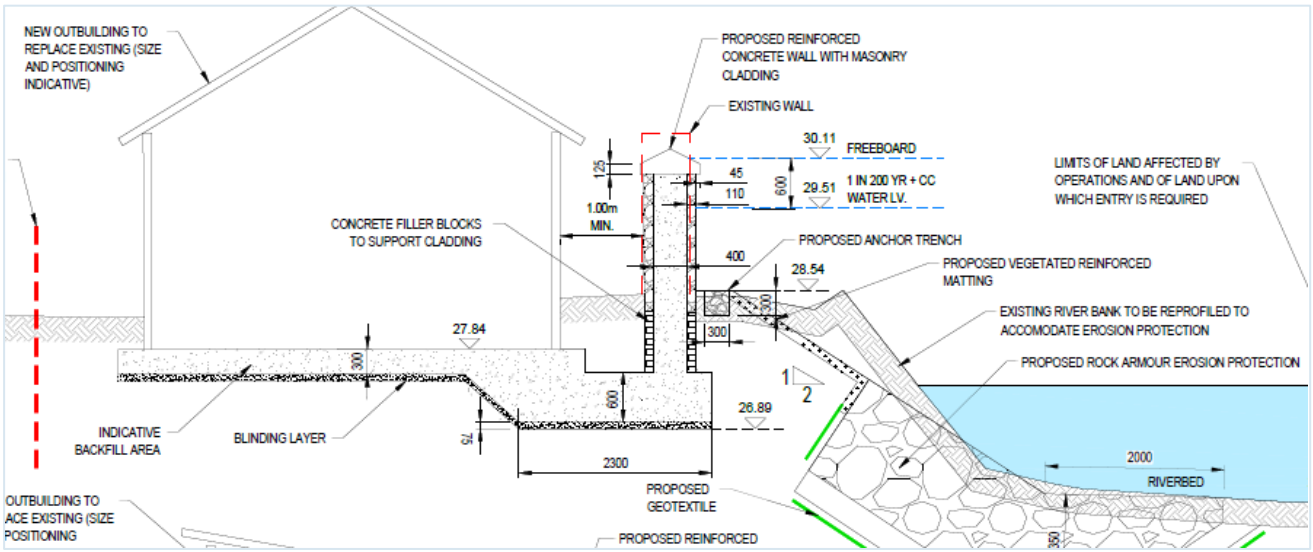


Figure 6-2 - Section through flood defence wall at outbuilding

CONSTRUCTION SEQUENCE

6.2.4. A possible construction sequence is outlined below. This sequence is illustrative only and does not pre-empt how a contractor might set-up and carry out the works.

- Construct temporary access route to the site
- Erect temporary fencing around the perimeter of the site.
- Site clearance of trees on the southern bank of the Enrick, grubbing up roots, and removal of two outbuildings and upper layers of bankside.
- Excavation to a firm bearing level and removal of unsuitable material.
- Placement of blinding concrete and erection of formwork.
- Installation of reinforcement steel cages and placement of concrete.
- Stripping of formwork.
- Backfilling of the wall with suitable material.
- Place facing stonework and coping stones.
- Place erosion protection stone and soil/seed.
- Re-erect boundary fencing.
- Remove temporary fencing and reinstate gardens.
- Install flap valves where required to prevent back flow of flood waters.
- Build two new outbuildings to the agreed specification.

6.2.5. Maintenance and operation

- The wall is constructed of reinforced concrete and stone façade that requires minimal maintenance.
- Inspection and occasional replacement of joint seals and pointing of stonework may be required every 10 years.
- Maintenance of outbuildings shall be the responsibility of the landowners.

6.3. KILMICHAEL WALL

PURPOSE

6.3.1. The purpose of this set of works is reduce the frequency of flooding to the A831 to a 10-year return period.

DESCRIPTION

6.3.2. **OP-03** Construction of a concrete flood wall approximately 158m long between the Enrick and the southern verge of the A831. The wall will be on average 0.5m above the existing ground and will have a defence level of 33.00mAOD at its western extent running to 32.70mAOD at its eastern extent, that includes a freeboard of 300mm. The existing surface water outfalls shall have non-return valves fitted to reduce the risk of flooding during high river levels.

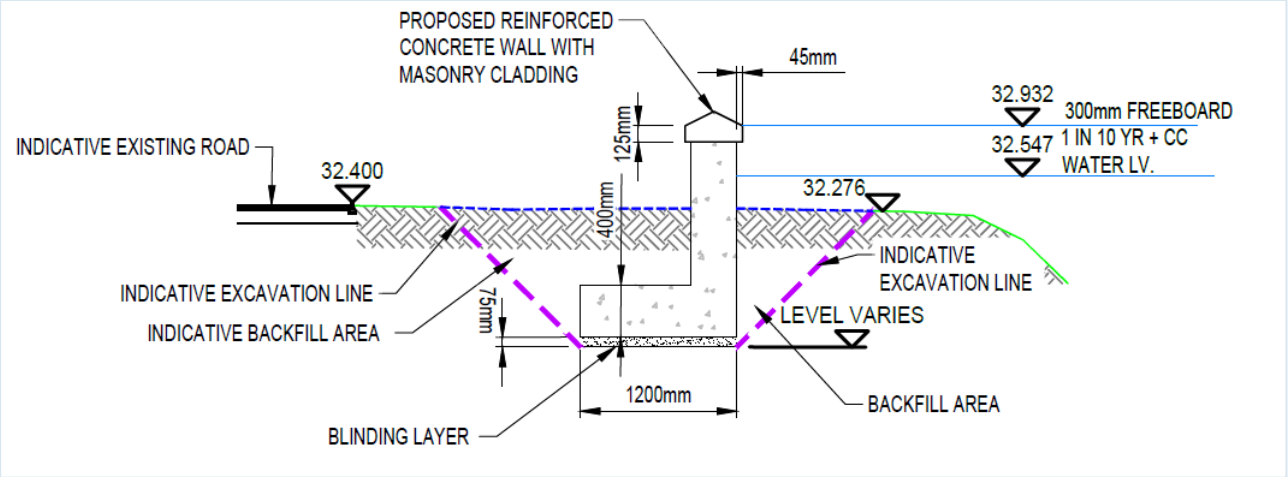


Figure 6-3 - Typical section through Kilmichael wall

CONSTRUCTION PROCESS

6.3.3. A possible construction sequence is outlined below. This sequence is illustrative only and does not pre-empt how a contractor might set-up and carry out the works.

- Erect temporary fencing around the southern perimeter of the site.
- Traffic management works as appropriate to each operation.
- Site clearance of trees on the southern side of the A831 and grubbing up roots
- Removal of topsoil from the wall base and the ditch to the south.
- Excavation to a firm bearing level and removal of unsuitable material.
- Infill of the ditch with suitable engineering fill.
- Placement of blinding concrete and erection of formwork, or placement of precast elements.

- Installation of reinforcement steel cages and placement of concrete if not precast.
- Backfilling of the wall with suitable material.
- Install flap valves where required to prevent back flow of flood waters.
- Remove temporary fencing, traffic management, and reinstate soil.

6.3.4. Maintenance and operation

- The wall is constructed of reinforced concrete requiring minimal maintenance.
- Occasional inspection of pipework shall be carried out by Scottish Water or the Highland Council as appropriate in line with normal duties.

Appendix A

LIST OF SCHEME DRAWINGS

APPENDIX A

List of Drawings Published for Drumnadrochit Flood Protection Scheme

Drawing Number	Title	Revision
Scheme Plans		
2745-GA-001	Scheme Operations Plan	G
2745-GA-002	Drumnadrochit Flood Wall General Arrangement Sheet 1 of 2	P07
2745-GA-003	Drumnadrochit Flood Wall General Arrangement Sheet 2 of 2	P07
2745-GA-004	Main Embankment Plan	G
2745-GA-005	Kilmichael Wall Sections	F
2745-XS-001	Tree clearance plan (Sheet 1 of 2)	D
2745-XS-002	Tree clearance plan (Sheet 2 of 2)	C

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