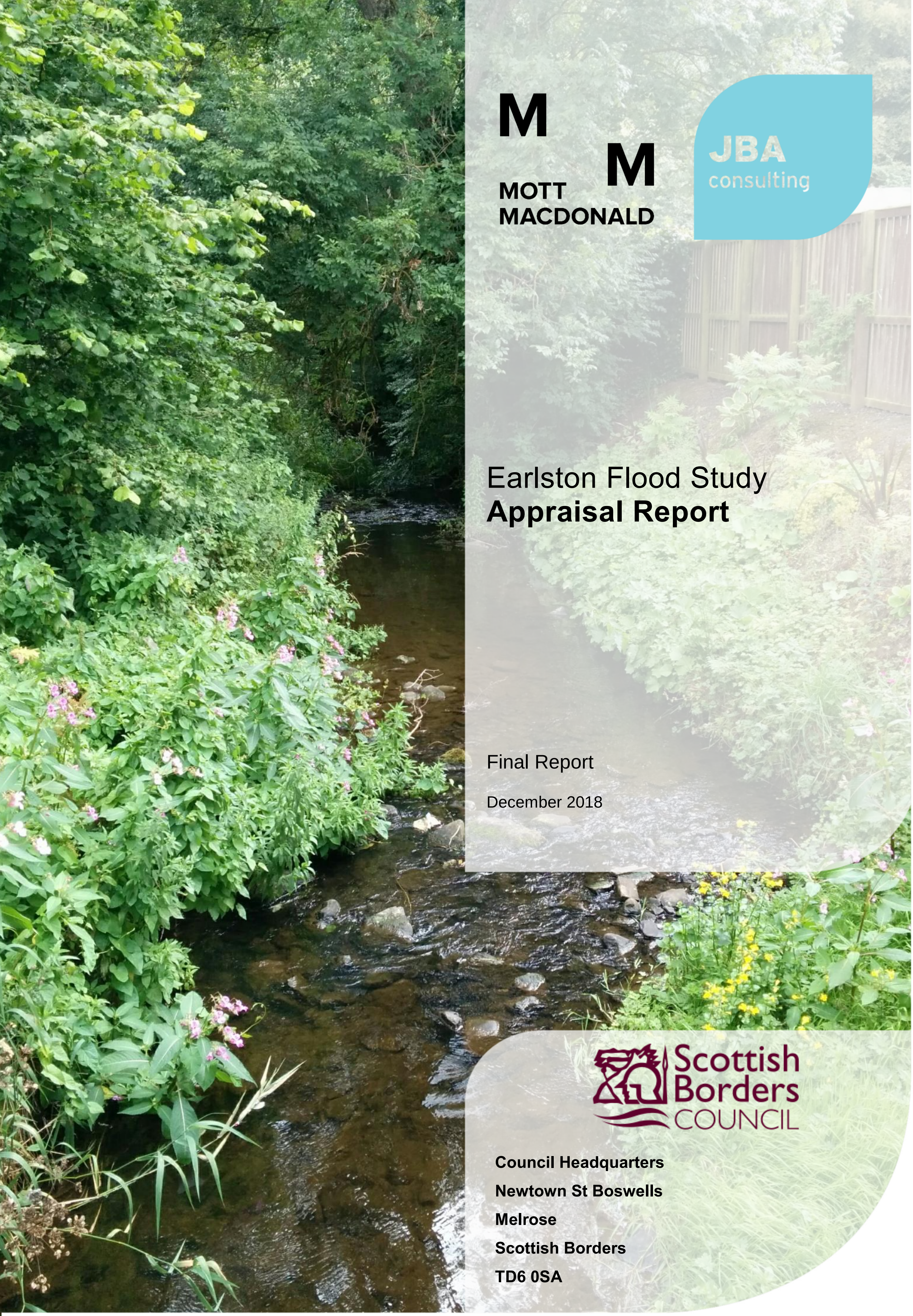


MOTT MACDONALD

JBA consulting

Earlston Flood Study
Appraisal Report

Final Report

December 2018

Scottish Borders COUNCIL

Council Headquarters
Newtown St Boswells
Melrose
Scottish Borders
TD6 0SA

JBA Project Manager

Angus Pettit
Unit 2.1 Quantum Court
Research Avenue South
Heriot Watt Research Park
Riccarton
Edinburgh
EH14 4AP
UK

Revision History

Revision Ref / Date Issued	Amendments	Issued to
S0-P01.02 / September 2018	-	Angus Pettit
S0-P01	Minor amendments	
S4-P01 / September 2018	-	Scottish Borders Council
S4-P02 / December 2018	Post council review and amendments	Scottish Borders Council

Contract

This report describes work commissioned by Duncan Morrison, on behalf of Scottish Borders Council, by a letter dated 16 January 2017. Scottish Borders Council's representative for the contract was Duncan Morrison). Barney Bedford, Christina Kampanou and Hannah Otton of JBA Consulting carried out this work.

Prepared by ....Barney Bedford BSc MSc
Analyst

Reviewed by ....Angus Pettit BSc MSc CEnv CSci MCIWEM C.WEM
Technical Director

Purpose

This document has been prepared as a Draft Report for Scottish Borders Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

JBA Consulting has no liability regarding the use of this report except to Scottish Borders Council.

Our work has followed accepted procedure in providing the services but given the residual risk associated with any prediction and the variability which can be experienced in flood conditions, we can take no liability for the consequences of flooding in relation to items outside our control or agreed scope of service.

Legislative framework

This flood study was commissioned in order to gain a greater understanding of the flood mechanisms in Earlston, improve upon SEPA's Flood Risk Management maps, and provide an appraisal of options which could reduce flood risk. In 2015, as part of the Flood Risk Management

(Scotland) Act 2009, the Scottish parts of the Tweed catchment were designated as the Tweed Local Plan District by SEPA. Flood risk must therefore be addressed by SEPA's Flood Risk Management Strategy (FRMS) and the local authorities' Local Flood Risk Management Plan (LFRMP). Of the 13 Potentially Vulnerable Areas (PVA) defined by SEPA within the Tweed catchment, the Earlston PVA (reference 13/05) includes Earlston and the small surrounding communities. According to this PVA, Earlston's main flood risk is from the Leader Water and Turfford Burn and there is the potential for approximately £640,000 Annual Average Damages (AAD). A flood protection study is identified as one of the key actions to be taken as a means to reduce this risk and this report presents the findings of part of the study.

Acknowledgements

We would like to thank Scottish Borders Council, Turner Townsend and Mott MacDonald for the data, supporting information and reviews undertaken throughout the study. We are thankful to members of SEPA for the review of the hydrological calculations and flood modelling methodologies. We would also like to thank Euro Environmental Group Ltd for providing CCTV information to support the study and APEM Ltd for providing a Digital Terrain Model for the study area.

Copyright

Carbon Footprint

A printed copy of the main text in this document will result in a carbon footprint of 322g if 100% post-consumer recycled paper is used and 409g if primary-source paper is used. These figures assume the report is printed in black and white on A4 paper and in duplex.

JBA is aiming to reduce its per capita carbon emissions.

Earlston Flood Risk Management Business Case

Context

Earlston in the Scottish Borders has a history of property flooding, mainly from the Turfford Burn. JBA was commissioned in 2017 to carry out a review of past flood events, determine the likely risk to different properties and to propose a set of 'options' that may reduce the flood risk to an acceptable level. This report is the culmination of this work and aims to provide a detailed explanation of the various steps carried out in order to identify a preferred set of interventions that offer a sustainable method of flood protection whilst seeking to benefit the environment and the community of Earlston.

This report focusses on the Leader Water, Turfford burn and Brock Burn, three watercourses within Earlston. The Leader Water, the largest of the watercourses, flows north to south and is a tributary of the River Tweed. The Turfford Burn flows from the northeast of Earlston and close to the town before discharging into the Leader Water. The Brock Burn and a small unnamed burn adjacent to it flow down agricultural land to the east of Earlston before joining the Turfford Burn.

A modelling exercise was carried out to estimate river levels on each of the watercourses, with the Leader Water being modelled from Haughhead to a point 900m downstream of the Turfford Burn confluence. The Turfford Burn was modelled from upstream of the new High School to its confluence with the Leader Water, and the Brock Burn was modelled as a surface water modelling exercise covering the whole of Earlston. A range of possible flood events were modelled from the 2 year flood to a 1000 year flood. Increases due to predicted climate change were included for the 3.3% AP (30 year) and 0.5% AP (200 year) events.

It was found that 8 properties are at risk of flooding from the 0.5% AP (200 year) event for the two main watercourses and 23 are at risk for the same event with a climate change allowance. With climate change the additional risk stems mainly from an increased number of properties at risk from the Turfford Burn.

Risk metrics

The following risk metrics are provided to aid prioritisation by SEPA:

Properties at risk	8 at the 200 year flood (23 with climate change)
Non-residential properties at risk	4 at the 200 year flood (6 with climate change)
Key receptors at risk	Four properties on the Turfford Burn centred around Georgefield Bridge including the Crossing House and flooding to the entrance to the Primary School; and four properties alongside the Leader Water at Haughhead and near to the confluence with the Turfford Burn.

Flood Mitigation Options

A range of flood protection options were then reviewed and short listed based on their viability. Options were found for both watercourses that protect against the 0.5% AP (200 year) event. The only viable option on the Leader Water capable of providing a 200 year standard of protection would be a direct defences option involving the construction of walls and embankments along the bank and set back. On the Turfford Burn a number of possible options would provide a 200 year standard of protection either through construction of new channels to allow flood waters to bypass the main channel or through construction of a flood storage embankment in agricultural land upstream of Earlston. The short-listed options are as follows:

Leader Water

- Direct defences (walls and embankments) across agricultural land and along the bank of the watercourse near Mill Road.

Turfford Burn

- Option 1 - Construction of a bypass channel through the high school playing field.

- Option 2 - Bypass of the Turfford Burn and FPS channels by means of a new channel to the southeast.
- Option 3 - Construction of a flood storage area upstream of Earlston.

Both watercourses

- Property Level Protection (PLP) to protect the 8 properties at risk.

Brock Burn

- Diversion channel across agricultural land to convey the Brock Burn and unnamed burn.

Improving public awareness and resilience

In addition to these short-listed options a number of non-structural options and good practice flood risk management measures have been investigated and recommended for implementation by Scottish Borders Council. Some of these are already in place elsewhere and could be implemented either in the short term or alongside a Flood Protection Scheme. These include the following:

- Flood warning is not currently in place on the Turfford Burn and should be implemented, particularly to assist with emergency procedures if a scheme is not promoted in short-term. Properties that could use PLP measures would also benefit from flood warning.
- Flood action groups, in partnership with the Community Council should seek to establish a network of support between members of the community, Scottish Borders Council, Tweed Forum and emergency services. Community engagement should be continued to raise awareness of flood risk and potential short- and longer-term solutions.
- A Resilient Communities sandbag store is available in Earlston containing 50-60 sandbags. This is located in Acorn Drive. The Council should consider if this is suitably located to assist residents at risk from both main watercourses. Furthermore, the use of a flood 'pod' system that can also be used by the community should be considered. Flood 'pods' are community storage boxes which contain flood sacks; purpose designed bags filled with absorbent material. The key advantage of this approach is that they can be distributed before a flood and are ideal for locations with limited warning or response times. It may also save the Council time in filling, distributing and delivering sandbags to communities when sandbag stores run out.
- Scottish Planning Policy should be leveraged to provide the potential for future implementation of other options that are currently not possible or to avoid unnecessary development on the floodplain.

Expected benefits

A flood damage assessment has been undertaken for the present-day Do Nothing, Do Minimum and each of the above options. The Present Value flood damages calculated for the Do Nothing and Do Minimum scenario are estimated to be £830k and £409k respectively. The damages avoided for each option are in the range of £443-656k (depending on the option assessed). Total damages avoided for each option are provided in the investment appraisal summary table.

Number of properties protected:

	Leader Water Direct Defences	Bypass channel	Total bypass channel	Storage area	PLP
Present value damages avoided (£k)	372	551	656	466	601
Residential properties benefitting	2	2	2	1	4
Non-residential properties benefitting	2	2	2	1	4

	Leader Water Direct Defences	Bypass channel	Total bypass channel	Storage area	PLP
Total no. properties benefitting	4	4	4	2	8

Working with natural processes

Natural Flood Management (NFM) is a method whereby wider catchment benefits could be achieved alongside potentially reducing river flows. Opportunities within the Boondreigh Water, Leader Water and Turfford Burn catchments could, to some extent, counteract the effects of increasing river flows with climate change if implemented across the catchment. Natural Flood Management opportunities should be progressed where feasible through additional catchment modelling (assuming LIDAR data can be procured) and early engagement with land owners and other stakeholders. Should NFM be progressed as part of a scheme funding should be sought through the scheme itself but in the shorter term it may be possible to secure funding through other sources if the focus can be widened from flood risk management to catchment and land management benefit.

Costs

Costs for each option have been estimated using the Environment Agency's Long Term Costing tool (2012). An optimism bias factor of 60% has been added to the total costs to allow for uncertainties in design at this stage and is typical for schemes at an early stage of appraisal. Whole life present value costs range from £0.5m to £4.9m. Total costs for each option are provided in the investment appraisal summary table.

Investment appraisal

The investment appraisal is provided below. None of the structural options have been found to be cost effective but PLP option has a benefit cost ratio of 1.3 and a net present value of £122k. As the only cost-beneficial option it should be potentially put forward for funding.

Investment appraisal summary tables:

	Do Nothing	Do Minimum	Direct Defences - Leader Water	Bypass channel - Turfford Burn	Total bypass - Turfford Burn
Total PV Costs (£k)	-	-	2.061	1,054	1,808
PV damage (£k)	830	409	388	174	174
PV damage avoided (£k)	-	422	443	656	656
Net present value (£k)	-	422	-1,618	-398	-1,152
Benefit-cost ratio	-	-	0.2	0.6	0.4

	Storage - Turfford Burn	PLP
Total PV Costs (£k)	4,857	479
PV damage (£k)	364	115
PV damage avoided (£k)	466	601
Net present value (£k)	-4,391	122
Benefit-cost ratio	0.1	1.3

Residual risks and planning for future flooding

A number of measures could be implemented to reduce the residual risk brought by above design standard flood events, particularly likely with climate change:

- Natural Flood Management (NFM) practices could aid in reducing flows in Earlston and provide some resilience to climate change. These measures would also bring wider catchment benefits such as upland habitat restoration and carbon sequestration, making this a 'no regrets' option to take forward. A detailed NFM study should be carried out to attempt to focus the placement of works within the catchment and quantify the benefits of these practices.
- Privately funded 'manual' Property Level Protection (PLP) would increase property resistance to flood waters in the short term and funding could be supplemented by the Council's subsidy scheme.
- The diversion channel proposed for the Brock Burn should be constructed alongside any development of the site.
- As recommended by SEPA during stakeholder engagement, Scottish Planning Policy should be leveraged to avoid development of land that has been shown to flood in this report. For example, the latest model and mapping produced as part of this report should be considered for any new developments and in particular the area to the south of the Turfford Burn.

Conclusions and recommendations

Flooding in Earlston affects few properties, making the PLP option the only economic means identified of reducing flood risk. A number of structural options were identified but their costs were too high compared to the benefit they brought. If the impacts of climate change occur as expected using current guidance, more properties will be affected more frequently than at present. If this is the case, the structural options presented may become more viable in the future.

Wider benefits and opportunities in the surrounding catchments could be packaged along with PLP and put forward for funding during the next FRM cycle.

Option (Standard of protection)	Properties protected	Environmental implications	Working with natural processes	Constraints/ limitations	Mitigating residual risks	Improved public awareness	Best use of public money	Wider benefits
Leader Water - Direct Defences (0.5% AP - 200 year)	4	Some implications for RBMP due to walls on riverside. Minimal in-channel working required so little impact on watercourse.	NFM measures have been identified and can be incorporated within the scheme to provide additional benefits. All structural options provide a high standard of protection so environmental benefits may be greater than those relating to flood risk. NFM may counteract the impacts of climate change to some extent.	Long defences to protect relatively few properties. No protection from Turfford Burn.	Increased defence extents and heights possible. Residual risk to properties at risk from the Turfford Burn properties so would need to be reduced through one of the other options. Possible to use NFM to manage residual risk.	Options should be presented to public for comment. Signage relating to flooding and sand bag stores should be setup. Council should continue to work with Earlston residents alongside ‘Resilient communities’ programme.	Not cost-effective so should not be progressed without considerable changes.	Maintain existing businesses and employment locally. Minimal impacts to community beyond visual impacts. Road flooding stopped.
Turfford Burn - Bypass channel (0.5% AP - 200 year)	4	Bypass would only be used in times of flood so would not impact RMBP significantly. Minimal in-channel works but some bank reinforcement likely to be required.		May mean that playing field can no longer be used. No protection from Leader Water.	The Leader Water direct defences option or PLP could be used to reduce this residual risk. Possible to use NFM to manage residual risk.	Flood Warning should be implemented on the Turfford Burn. Signage and stage board should be installed near Georgefield Bridge in the short term,		
Turfford Burn - Total bypass channel (0.5% AP - 200 year)	4	Potential for long-term RBMP improvements by replacing the heavily engineered sections of the Turfford Burn with a channel designed to mimic a natural channel.		Loss of main channel may be important to residents. No protection from Leader Water.				
Turfford Burn - Flood storage (20% AP - 50 year to 0.5% AP - 200 year)	2 (2 properties will continue to flood below the 50 year event)	Occasional storage of water may impact plant life and have negative impact on sediment/nutrient transport in the watercourse.		Temporary storage of flood waters upstream of the town introduces a new risk to the town. No protection from Leader Water.	Larger embankment to store floodwaters possible, this could either reduce the pass-forward flow from the storage area to below the			As above with lower impact within Earlston since no measures will be visible to the community.

Option (Standard of protection)	Properties protected	Environmental implications	Working with natural processes	Constraints/ limitations	Mitigating residual risks	Improved public awareness	Best use of public money	Wider benefits
					20% AP (50 year) event or increase the peak protection to the 0.5% AP (200 year) plus climate change.			
Both main watercourses - PLP (1% AP – 100 year)	8: Only 1 property with 1% AP (100 year) standard of protection; remaining 7 are protected to 0.2% AP (500 year) flood event	Little to no impact.		Flood waters will continue to flood roads, limiting access.	Property survey for the one property at risk from the 0.5% AP (200 year) event with PLP may reveal alternative options; otherwise very little residual risk.		Good benefit cost ratio (1.3) and the only cost-effective solution for Earlston that has been found.	Aside from individual property works wider community not affected. Minimal community disruption and change to the affected areas of the town.
Brock Burn – Diversion channel (0.5% AP – 200 year)	*Damage calculations not performed.*	Channel likely to be more natural than current straight channels so should improve RMBP qualities.		Works may reduce ease of site development as planned in Local Development Plan.	Works do not address flooding from other sources or general ponding on the road during heavy rainfall.	Stage board could be installed on the A6105 in the short term alongside signage.	Not appraised.	Elderly residents of affected properties able to leave their properties during heavy rain events.

Negative			Neutral			Positive

Contents

Contents

List of Figures

List of Tables

Abbreviations

1D .... One Dimensional (modelling)

2D .... Two Dimensional (modelling)

BCR .... Benefit Cost Ratio

CCTV .... Closed Circuit Television

DTM .... Digital Terrain Model

EA .... Environment Agency

FCERM .... Flood and Coastal Erosion Risk Management (R&D programme)

FEH................................. Flood Estimation Handbook

FPS .... Flood Protection Scheme

FRM .... Flood Risk Management

GIS.................................. Geographical Information System

mAOD .... metres Above Ordnance Datum

OS................................... Ordnance Survey

PLP .... Property Level Protection

PV .... Present Value

PVb .... Present Value benefits

PVc .... Present Value costs

QMED .... Median Annual Flood (with return period 2 years)

Ramsar .... The intergovernmental Convention on Wetlands, signed in Ramsar, Iran, in 1971

RBMP.............................. River Basin Management Plan

SAC................................. Special Area of Conservation, protected under the EU Habitats Directive

SEPA .... Scottish Environment Protection Agency

SPA................................. Special Protection Area for birds, protected under the EU Habitats Directive

SSSI................................ Site of Special Scientific Interest

TPO................................. Tree Preservation Order

TUFLOW......................... Two-dimensional Unsteady FLOW (a hydraulic model)

Return period and probability

For flood frequency analysis the probability of an event occurring is often expressed as a return period. A return period is the average interval (number of years) between two years containing one or more floods of a given magnitude or greater. As an example, the flood magnitude with a return period of 200 is referred to as the 200 year flood.

Another useful term closely linked to return period is a floods annual probability, AP. This is the probability of a flood greater than a given magnitude occurring in any year and calculates as the inverse of the return period. For example, there is a 1 in 200 chance of a flood exceeding the 200 year flood in any one year so the AP is calculated by 1/200 giving a 0.5% AP for the 200 year flood event.

Supporting Documents

Hydrology report - AEM-JBAU-EA-00-RP-A-0003-Earlston_Hydrology_Report-S4-P03.pdf

Asset condition assessment report - AEM-JBAU-EA-00-RP-A-0002-Asset_condition_assessment-S4-P01.pdf

RBMP & NFM report - AEM-JBAU-EA-00-RP-E-0002-Earlston_NFM_Report-S4-P03.pdf

Preliminary Ecological Appraisal - AEM-JBAU-EA-00-RP-E-0001-PEA-S4-P01.pdf

Modelling report - AEM-JBAU-EA-00-RP-A-0005-Earlston_Modelling_Report-S4-P01.pdf

Flood maps - supplied as PDF's for return periods 2-1000 years including climate change runs and for the Do Nothing and Do Minimum scenarios.

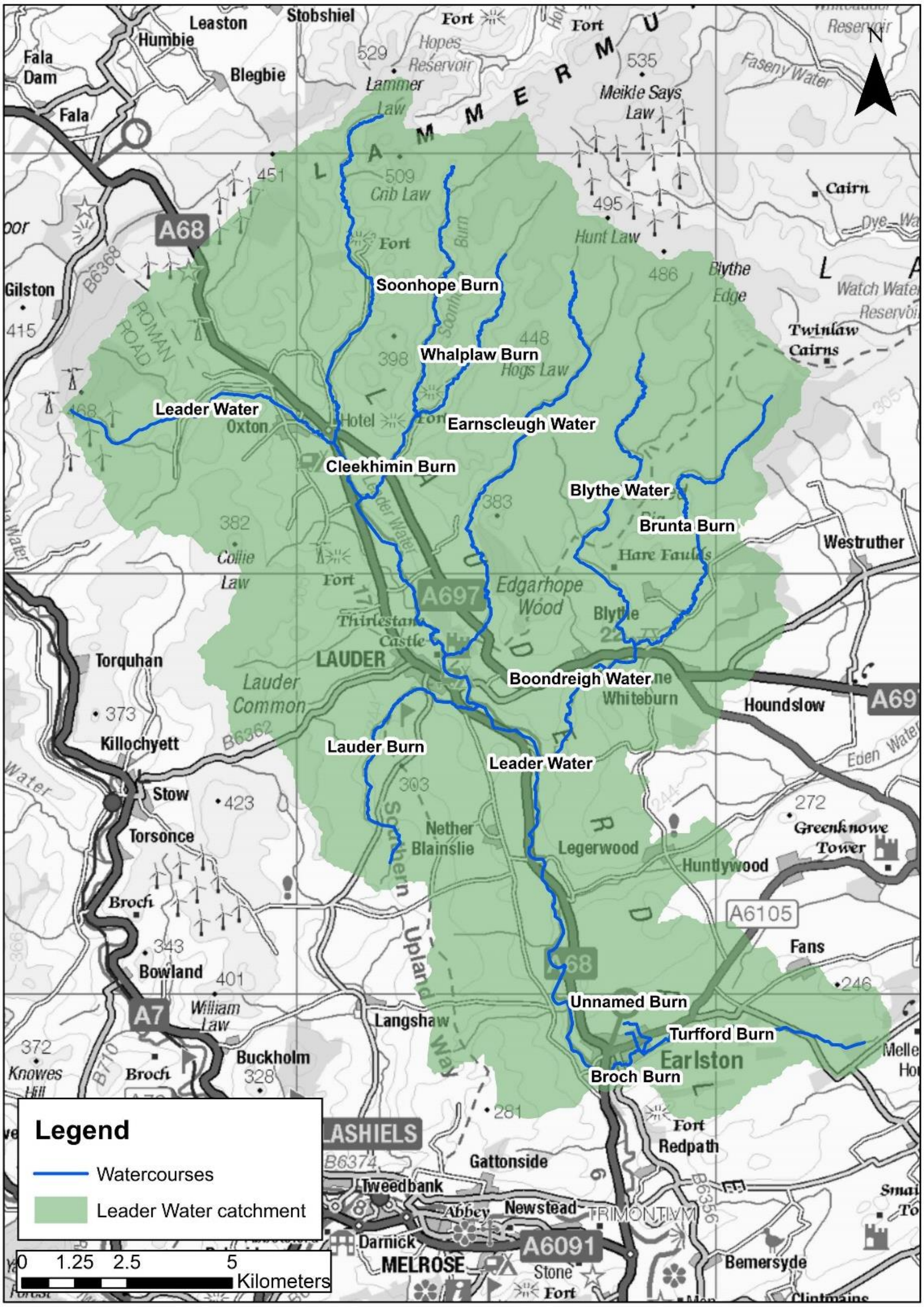
1 Introduction

Earlston is a small town to the east of Galashiels with a moderate population of under 2000 people according to the 2011 census. From the north flows the larger of two watercourses, the Leader Water and from the east flows the Turfford Burn, these are shown in Figure 1-1.

The Leader Water has its source in the Lammermuir Hills at approximately 500mAOD and features a large flat floodplain upstream of Earlston. As it flows closer to Earlston a number of properties occupy the floodplain which then becomes steeper and wooded as it flows south towards the River Tweed 4km downstream. It has a catchment area of approximately 270km^2 considerably larger than the other watercourses near Earlston.

The Turfford Burn, previously known as the Earlston Burn, is a small burn with a modified channel flowing from north east to south west, flowing close to the centre of the town before diverting again into agricultural land and a steeper sided forested area before entering the Leader Water. It has a catchment area of 23km^2, representing only 7% of the flow into the Leader Water at Earlston. With a source in the arable agricultural land to the east of Earlston it has been straightened in various parts mainly to accommodate agriculture and railways but also in an attempt to control flooding from the burn within the town itself. The burn features a flood bypass channel and culvert which was constructed as part of a Flood Protection Scheme in the 1960's but since this time further flooding has been witnessed in this area of the town, as discussed in Section 2.1.

Figure 1-1: Study area and Leader Water catchment



Contains Ordnance Survey data (C) Crown copyright and database rights (2017) Ordnance Survey (100023423)

Two ephemeral watercourses flow from agricultural land in the east of Earlston under Church Street (A6105) through culverts and ultimately into the Turfford Burn to the south.

The north of the Leader Water catchment is steep with narrow valleys carrying several small watercourses into the river. Whilst these tributaries are likely to have a flashy response to rainfall in contrast to the area south of Lauder which exhibits a slower, delayed response to rainfall thanks to the large flat floodplain, large meanders and high permeability in the superficial deposits and soils. The upper catchment is characterised by moorland and open pasture whilst the lower areas and the catchment of the Turfford Burn have a dominance of arable land interspersed with forest.

1.1 Flooding in Earlston

SEPA flood maps show that there is a high (10% AP) probability of flooding from the Leader Water and Turfford Burn in Earlston. The high likelihood flood outline shows the agricultural land on the left bank of the Leader Water being completely inundated and properties around Mill Road and Acorn Drive flooded. On the Turfford Burn the main area of properties that is predicted to flood is the area surrounding Georgefield Bridge including the primary school. The new High School car park is also known to flood.

Earlston forms part of the Tweed Local Plan District and is within Potentially Vulnerable Area (PVA) 13/05 which includes Earlston and the area within the Leader Water catchment as far north as the Boondreigh Water confluence. A total of 70 residential properties and 50 non-residential properties are expected to be at risk of flooding, causing an average of £640,000 in damages annually.

Land use is not expected to change significantly with climate change and thus the relationship between the watercourse and surrounding land is not expected to vary to a major extent. Nevertheless, the increases in flows expected from climate change make good land management practices - potentially capable of influencing river levels - particularly important in this largely rural landscape. Section 2.2.1 details how climate change has been approached within this study.

1.1.1 Previous studies

There are not known to have been any previous flood studies dealing with flooding across Earlston. Prior to construction of the FPS scheme in the 1960's it is assumed that a study was carried out but JBA have not had access to this. The scheme was designed to accommodate a 4% AP (25 year) flood event on the burn. A review of the FPS scheme by the Scottish Government in 2006 highlighted that the presence of the diversion channel did little to mitigate the flood risk in the town from the Turfford Burn due to the flood relief culvert being under capacity and having low spots on the headwall and surrounding banks that allowed flood waters to escape. It was concluded that the scheme may have a negative impact on property flooding at low return periods and no positive impact at higher return periods. The report suggested exploring other options for flood alleviation such as upstream storage.

Numerous FRA's have dealt with individual sites, such as for development of the former High School site. This study presents a comprehensive investigation into flooding across the town.

1.1.2 Watercourse condition and catchment opportunities

The catchment of the two main watercourses are dominated by rural land uses and provide scope for improvements in watercourse condition and flood risk management by means of emulation of natural processes that slow the passage of flood waters. Natural means of land and watercourse management are of particular importance here since the Turfford Burn is designated a Special Area of Conservation (SAC) as far upstream as the former curling pond, approximately 600m upstream of the new High School; as is much of the Leader Water catchment.

The Leader Water and Turfford Burn were both graded as good by SEPA under the River Basin Management Plan (RBMP) 2014 study and will therefore only require monitoring to ensure their good status is maintained.

A review of the SEPA and Scottish Borders Council NFM maps was carried out and incorporated into the recommendations made in section 4.4.6. Among wider recommendations the maps show that there is potential for tree planting, upland habitat restoration and floodplain storage.

1.2 Aims and objectives

The options appraisal seeks to provide information appropriate to Scottish Borders Council to inform their decision on the most sustainable catchment-wide strategy for flood risk management in Earlston that contributes, where possible, to achieving RBMP objectives and is acceptable to key stakeholders and the community. This report describes the information used to form conclusions on the suitability, feasibility and economic viability of different options for flood risk mitigation.

Proposals and conceptual designs have been developed to:

a. Provide protection from a 0.5% AP (200 year) magnitude flood event if feasible or a lower magnitude event in other cases.
b. Deliver multiple benefits to the wider catchments and local communities.
c. Highlight opportunities to reduce river flows through Natural Flood Management practices and quick wins.

2 Preliminary investigations

2.1 Flood history

A comprehensive review of historic flood events in Earlston has been carried out and is included in the Hydrology report referenced in the Supporting Documents section at the start of this report. A selection of the most recent flood events is included in Table 2-1 below.

The new High School playing fields in Earlston have been inundated several times including prior to school construction in October 2002 where flooding was due to a diversion culvert presenting a constriction in the channel, and in October 2012 where it was believed bank protection on the Turfford Burn collapsed and caused water to flow over the playing fields. When water passes onto the playing fields it is able to pass onto Georgefield Bridge and bypass the burn, entering the flat area between the burn and the primary school on the right bank.

Table 2-1: Recent Earlston Flood History

Date	Flood Record
October 2002	Crossing House on the left bank of Turfford Burn was inundated and the eastern school grounds flooded. Flooding believed to be due to a diversion culvert presenting a constriction resulting in the water level in the diversion channel to rise and flow across the bridge from the diversion channel and playing fields.
12 October 2012	Flooding to Georgefield Road Bridge and playground area of Earlston[1].
25 October 2012	Flooding to the playing field at the confluence between the Leader Water and the Turfford Burn, adjacent to Acorn Drive. Flooding appears to be as a result of high water levels in the Leader Water. This is confirmed by the third highest flow on record at the Leader Water gauge, peaking at 14:00 on 25th October 2012).
4 December 2015 (Storm Desmond)	Flooding to Church Street as a result of runoff from the fields to the north and backing up of culverts passing beneath the road from the Broch Burn and unnamed burn. Flood photos show ponded water on Church Street during this event.
December 2016	Flooding similar to the earlier October 2012 event. Evidence supplied to JBA by local landowner during site visit.

The Leader Water is not known to have experienced significant flooding in the recent past but there are historical reports of properties on the left bank floodplain experiencing flooding. In general the channel bed is much lower than the floodplain.

2.2 Flood estimation

The methodologies used to derive flood estimates for the watercourses in Earlston are explained in the Hydrology report referenced in the Supporting Documents section at the start of this report.

Hydrological analysis was conducted to obtain information about flow characteristics in the reach of interest. The Flood Estimation Handbook (FEH) Statistical method was used to derive peak river flows for a range of Annual Probability events. Due to the limitations of the Leader Water at Earlston gauging station, pooling group analysis was used with Earlston as the donor. The peak flow estimates for the Leader Water in Earlston (National Grid Reference: NT 57450 37150) for a range of Annual Probability (AP) events are presented in Table 2-1.

For the Turfford Burn and its smaller tributaries, comparisons were made between the Statistical Method and different rainfall based methods. Following this comparison, it was deduced that the most appropriate approach was to use ReFH2 with donor parameters and FEH13 rainfall for those catchments. Following their review of the hydrology aspect of the study SEPA recommended instead that a conservative approach be taken, favouring the higher flow estimates produced using the FEH Rainfall Runoff method. This method was therefore used in the hydraulic modelling

1 Video of October 2012 flood event available at: https://www.youtube.com/watch?v=hbog-CNKA_8

described in Section 2.7. The peak flow estimates for the Turfford Burn upstream of its confluence with the Leader Water (National Grid Reference: NT 57450 38000) for a range of Annual Probability (AP) events are presented in Table 2-1.

Table 2 1: Peak flow estimates for the Leader Water and Turfford Burn

Return Period (Years)	Annual Probability (AP) (%)	Leader Water at Earlston (m^3/s)	Turfford Burn at Earlston (m^3/s)
2	50	58.92	5.11
5	20	84.40	7.27
10	10	104.50	8.61
30	3.33	142.70	11.58
50	2	164.27	13.26
75	1.33	183.55	14.46
100	1	198.55	15.45
200	0.5	239.83	18.09
1000	0.1	371.98	26.71

The two smaller burns running through agricultural land to the north are ungauged and similarly to the Turfford Burn the FEH Rainfall Runoff method was used to estimate their peak flows. The Broch Burn is estimated to have a peak flow of 1.09m^3/s for the 0.5% AP (200 year) event and the unnamed burn a peak flow of 1.75m^3/s for the same event.

Due to the lack of gauging on the Turfford Burn there is some uncertainty in the flow estimates produced. If the ReFH2 method were used rather than Rainfall Runoff this would result in a higher standard of protection in the Do Minimum scenario than is the case with the Rainfall Runoff method. Table 2-2 below shows the equivalent return periods with the ReFH2 and Rainfall Runoff methods. Using peak flows from the ReFH2 method would increase the standard of protection substantially. For example, a flood defence designed to protect against the 100 year event with rainfall runoff would be equivalent to the 283 year event using the ReFH2 method. This highlights a critical uncertainty in the flood flow estimates for this catchment.

Whilst a precautionary approach is recommended, due to this uncertainty in design flows, the ungauged catchment and the lack of flood records for the burn, it is recommended that SEPA or the Council install a flow gauge on the burn prior to undertaking any flood mitigation works so that an improved estimate of design flows can be investigated further.

Table 2-2: Comparison of return periods with the Rainfall Runoff method versus ReFH2 method

Return period using Rainfall Runoff method (Years)	Equivalent return period with ReFH2 method (Years)
2	11
5	31
10	51
30	121
50	181
75	233
100	283
200	451

2.2.1 Climate change

SEPA's summary report on Flood Risk Management and climate change concludes that climate change impacts are likely to vary spatially across Scotland. In summarising the different increases in river flows predicted by climate models as we move towards the 2080's a number of estimates for the River Tweed were provided. The high emissions scenario, 'unlikely to be exceeded' uplift estimate of 33% has been used to enable the impacts of climate change to be integrated into the overall assessment.

This uplift was applied to the 3.33% AP (30 year) and 0.5% AP (200 year) magnitude events only.

A 33% uplift in river flows by the year 2080 would mean that larger floods will be expected to occur more regularly. For example, a flood with an annual probability of 10% (likely to occur every 10 years) in the present day would increase to having a probability of 27% (likely to occur every 4 years) by 2080. For the larger magnitude events this is likely to be more concerning, with a present-day 1% AP (100 year) event, for example, being expected to occur with an annual probability of 3% (every 33 years) by 2080. These future changes are something that must be considered when designing flood protection measures and are explored further during the options appraisal later in the report.

2.3 Survey data

Topographic survey data from a 2004 modelling exercise on the Turfford Burn was supplied by Scottish Borders Council and used to inform a section of the 1D hydraulic model. To complete the coverage of cross section data along the full study reach of the burn and the Leader Water a topographic channel survey was conducted by JBA Consulting in March 2017. Following the topographic survey some additional cross section data for the area adjacent to the new High School was extracted from the Digital Terrain Model (DTM) that is discussed below.

LIDAR data has been collected for large parts of Scotland however Earlston, at the time of modelling, was not included in this dataset. To provide ground data for the hydraulic model a new Digital Terrain Model (DTM) was procured as part of this study. In June 2017 APEM Ltd captured aerial stereo imagery which was converted to a 0.25m Digital Surface Model and filtered to generate a bare earth DTM. Unlike LIDAR, this technique does not penetrate surface vegetation and report ground levels beneath, making post-processing reliant on ground levels surrounding the objects that are to be removed from the DSM rather than being able to use actual data beneath the objects. For Earlston, the resultant DTM contained some areas of poorly informed ground levels beneath vegetation that appear to be unreliable. One such area is on the left bank of the Leader Water at Haughhead. In the majority of locations there is enough confidence in surveyed river cross sections and ground levels in the DTM from nearby expanses of open ground to inform the modelling, but some areas feature greater uncertainty.

Several site visits were conducted to provide context to the data, to photograph key areas and to provide an assessment of the condition of the watercourse, particularly at structures such as bridges and weirs as is summarised below.

A CCTV culvert survey was carried out by Euro Environmental Group (EEG) Ltd for the culvert on the Brock Burn and the FPS culvert, full details of which are included in the Asset Review report completed as part of this study[2].

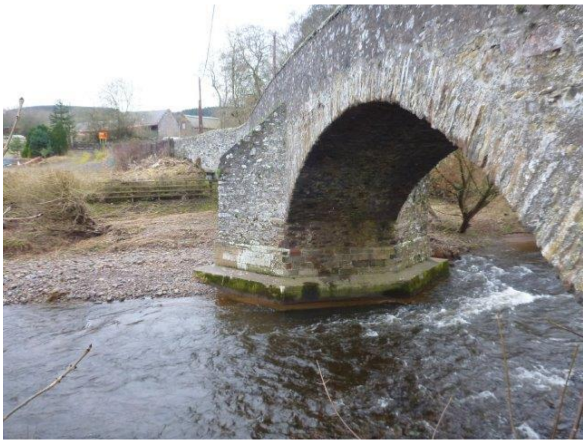
2.3.1 Asset condition assessment

A full report into the condition of assets in Earlston is provided in the Asset Condition Assessment report, referenced in the Supporting Documents section at the beginning of this report.

The following tables show the condition of some critical assets on the watercourses around Earlston.

2 Asset Review, JBA Consulting (2017) AEM-JBAU-EA-00-RP-A-0004-Asset_Review-S4-P01.pdf

Mill Road Bridge



Scour protection on central pier

Type: Double span vehicular bridge
Upstream Grid Ref: NT 57059 38241
Opening Height (m): 5.51
Opening Width (m): 29.9
Soffit Level (m): 103.76
Material: Masonry bridge
Condition: Grade 2 (Good)
Part of FPS: No
Comments:

- Scour protection on central pier
- Flow on left side only during low flows
- Low blockage risk

Debris Screen and Concrete Orifice

Debris Screen and concrete orifice

Type: Debris screen and orifice
Upstream Grid Ref: NT 58195 38649
Height (m): 2m
Width (m): 1.2m
Material: Concrete orifice with steel debris screen
Condition: Grade 2 (Good)
Part of FPS: Yes
Comments:

- Safety rails in good condition
- Screen well maintained
- Debris dumped on banks needs removed
- Gabion walls on left bank downstream of screen is slightly deformed
- Level monitor on screen to warn council of blockage

FPS Diversion Channel

Turfford Burn looking downstream of the diverted channel

Type: Channel
Upstream Grid Ref: NT 58204 38634
Width (m): 2m
Length (m): 175m
Material: Silt
Condition: Grade 3 (Fair)
Part of FPS: Yes
Comments:

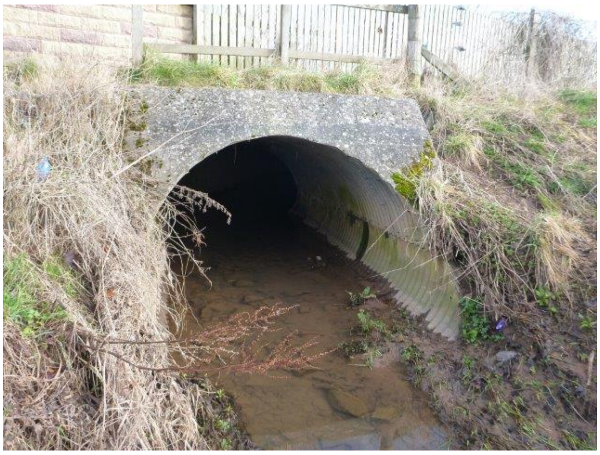
- Presence of rock armour
- Poorly maintained
- Gabion basket at inlet in poor condition, allowing bypassing
- Designed silt level unclear
- Channel generally overgrown with vegetation.

FPS Diversion Channel

Gabion basket and build-up of silt at entrance to diverted channel

FPS Diversion Channel Culvert

Upstream face of culvert inlet. Gabion walls on banks



Culvert outlet with concrete headwall

Type: Culvert
Upstream Grid Ref: NT 58073 38576
Opening Width (m): 1.6m
Opening Height (m):
Material: Steel culvert with concrete headwall.
Condition: Grade 2 (Good)
Part of FPS: Yes
Comments:

- Inlet is clear with no sediment but overgrown vegetation
- Access gate on left bank, 5m upstream of inlet
- Heavily vegetated on surrounding banks
- 2 levels of gabion walls on both banks upstream of the culvert.

Georgefield Bridge

Downstream face of bridge

Type: Vehicular arch bridge
Upstream Grid Ref: NT 579721 38572
Opening Height (m): 1.60
Opening Width (m): 7.23
Soffit Level (m): 103.12
Material: Stone
Condition: Grade 2 (Good)
Part of FPS: No
Comments:

- Masonry single span arch bridge
- Some debris in watercourse
- Sandbags dumped downstream of bridge
- Bridge in good condition with few cracks

Brock Burn culvert (under A6105)

Collapsed roof in culvert

Type: Culvert
Upstream Grid Ref: NT 58442 38935
Diameter (m): 0.375
Material: Concrete culvert.
Condition: Grade 4 (Poor)
Part of FPS: No
Comments:

- Sediment filling up to 15% of culvert area
- Collapsed roof at a point
- No screen on inlet

2.4 River Basin Management plan – Summary

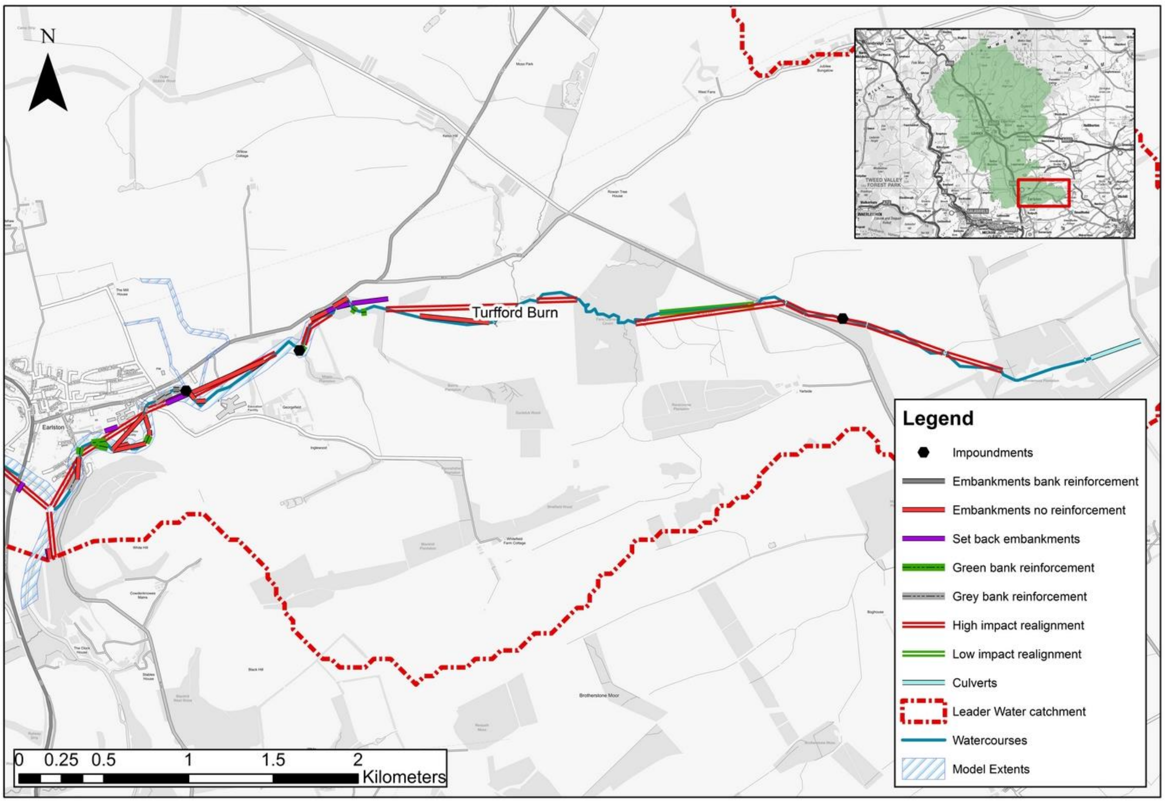
A full report into the condition of the watercourse is provided in the Natural Flood Risk Management and River Basin Management Plan report, referenced in the Supporting Documents section at the beginning of this report.

Both the Leader Water and Turfford Burn are characterised as being in 'Good' physical condition according to the RBMP however a number of morphological pressures were found along the Turfford Burn (Figure 2-1), particularly downstream of Earlston High School. Both watercourses have undergone historic realignment in various parts. Opportunities to improve the condition within the flood scheme is limited as the Turfford Burn is highly urbanised in this area. Upstream of the flood scheme extent, meandering of the burn to increase sinuosity would improve channel morphology and help with flood mitigation downstream. Removal of high impact realignment east of the A6105/B9397 road junction would release approximately 86% of the Turfford Burn channel capacity.

The Leader Water's main physical pressures are located south of Lauder where there are a number of embankments, grey bank and green bank reinforcement. At the time of the walkover the Leader Water was undergoing active erosion and establishing a sinuous morphology, as well as being well connected to the flood plain so there are limited opportunities to further improve its physical condition. The main recommendation is to set back or remove embankments where they are not providing direct protection to properties or land.

The Boondreigh Water, a tributary to the Leader Water, is generally in good physical condition, however along the straightened sections of the watercourse, in-stream woody debris dams are recommended to encourage out-of-bank flow and improve connection to the floodplain.

Figure 2-1: Physical pressures on the Turfford Burn



The Brock Burn and unnamed burn to the east of Earlston are too small to have been considered in the RBMP dataset but they are both artificially straightened field drains which could be improved by increasing sinuosity to establish a more natural morphology.

2.5 Natural Flood Management – Summary

A full report into the NFM opportunities within the Leader catchment is provided in the Natural Flood Risk Management and River Basin Management Plan report, referenced in the Supporting Documents section at the beginning of this report.

Based on a review of these two datasets and a walkover survey of the catchment, there are a number of NFM opportunities for the Leader Water and Turfford Burn catchments. The findings and recommendations for Earlston and the surrounding catchments are included in Section 4.4.6.

2.6 Preliminary ecological appraisal – Summary

A full report into the presence and importance of different habitats along the Leader Water is provided in the Preliminary Ecological Appraisal report, referenced in the Supporting Documents section at the beginning of this report.

The Leader Water is a designated Special Area of Conservation (SAC) due to its proximity to the Tweed and therefore potential for Atlantic Salmon, Lamprey, Otter and Water Crowfoot.

The woodland habitat in the area offers habitat of high ecological value for foraging Badger and there were records of Badger in the locality, as well as being of high ecological value for foraging bats, otters, red squirrels, reptiles and of moderate habitat value for water voles.

A Habitat Regulation Appraisal (HRA) Screening Assessment should be undertaken to identify significant effects/impacts on the protected species in the watercourse and an Appropriate

Assessment (AA) will need to be conducted if possible impacts are identified during the screening process.

Vegetation clearance should be restricted to as small an area as possible and further surveys for the precise location of Great Crested Newts, Water Voles and Otters may need to be carried out. Tree works should be avoided between February and September when Red Squirrel kits are born and dependent on their mother, night time working should be avoided between April-September when bats are most active, and workings and excavations should be covered at night to prevent exploration by badger.

In channel works should be completed between May and September to avoid impacting on migrating and spawning Atlantic Salmon.

2.7 Hydraulic modelling

A hydraulic model was developed, informed by the above-mentioned datasets, to estimate water levels on the Leader Water and Turfford Burn during simulated floods. Below is a summary of the model structure and the results used to generate flood maps and to calculate the cost of flood damages in the later stages of the appraisal. Further details of the modelling approach, including calibration and sensitivity analysis, is provided in the Model Audit report referenced in the Supporting Documents section at the beginning of this report.

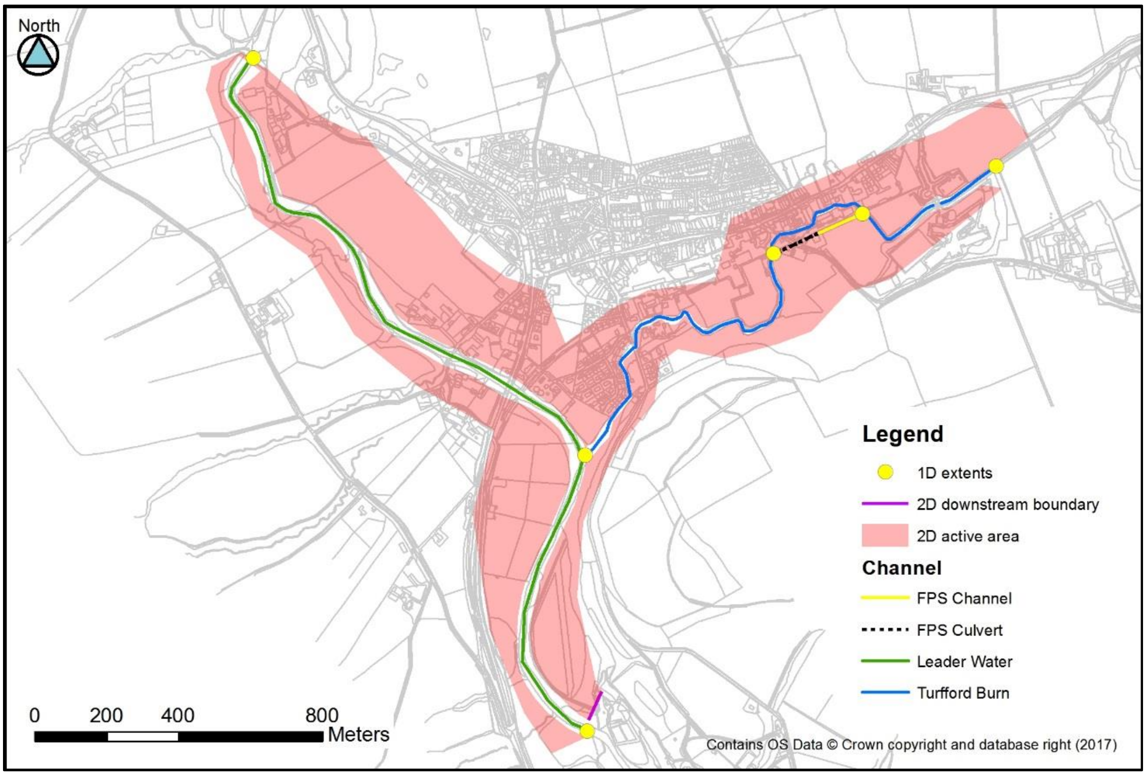
2.7.1 Model setup

The modelling package Flood Modeller-TUFLOW was used to develop the hydraulic model, offering the ability to create a 1D-2D model where the river channel is modelled in 1D and the floodplain in 2D. This approach allows for complex floodplain flow routing not possible with a simpler 1D only model. The model extends from the footbridge at Haughhead to a point 850m downstream of where the Turfford Burn discharges into the Leader Water. The Turfford Burn is modelled from upstream of the new High School to its confluence with the Leader Water.

Survey data for the 1D model was collected in 2017 by JBA Consulting. No bank-top survey was available to inform the link between 1D and 2D model domains but there was generally enough combined confidence in the DTM and surveyed channel cross sections to give a good indication of the elevations at which water should pass from the channel onto the floodplains. The 2D floodplain was formed from 25cm photogrammetry-derived DTM, resampled to 2m by TUFLOW for increased simulation efficiency. The 2D model domain extended over the full study area.

The downstream boundary of the model was a simple normal depth boundary at the downstream extent of the Leader Water channel. The backwater equation was used to estimate whether the River Tweed could have an influence on river levels through Earlston. In the absence of accurate river depths at the confluence of the Leader Water and River Tweed a number of iterations were calculated to determine the channel water depth that would be required at the Tweed confluence to have an effect on water levels at Earlston. Given a slope of 0.004 (based on the 4.4km distance to the confluence and the 20m drop in elevation) a water depth of 25m would be required to have an effect in Earlston. This is not realistic and therefore the backwater at the Tweed confluence is not expected to have an influence in Earlston.

Figure 2-2: Earlston model overview schematic



In the absence of surveyed flood levels, the model was proved against photographs and videos taken during past flood events on the Turfford Burn. The flow paths predicted by the model appear to be representative of those experienced to date and also broadly align with those predicted in the SEPA flood risk maps. There are some differences in the floodplain flood extents on the left bank of the Leader Water which stem from uncertainty in bank levels at the upstream extent of the model, upstream of the properties at Haughhead. Since no further topographical data were available for the forested ground at this location the DTM ground levels were used.

The DTM being derived from photogrammetry data means that ground levels beneath vegetation cover are not known. Whilst post-processing provided estimation of ground levels it is suspected that the resulting data is not accurate. Should LIDAR data become available the model should be re-run to improve confidence in the outputs and to reduce uncertainty in the damage and cost estimations later in the report.

2.7.1.1 Modelling flooding from the Brock Burn and Unnamed Burn

Representative flood risk from the two small burns was modelled using a 2D only model using JFlow, JBA's in-house modelling software. A range of 0.5% AP (200 year) events were simulated based on different rainfall intensities over different storm durations.

2.7.2 Model scenarios

A full range of model simulations were performed covering the full range of AP events for a worst case 'Do Nothing' and present day 'Do Minimum' scenario, with the model being modified slightly between scenarios. A description of the differences between these model scenarios is provided in section 3.2 below and in the Do Nothing Assumptions report referenced in the Supporting Documents section at the beginning of this report.

Additional model scenarios were used to test the feasibility and successes of different flood protection options that emerged during the options long-listing process described in section 4.5.

2.7.3 Model results

Figure 2-3 and Figure 2-4 below show the estimated flood depths for the 0.5% AP (200 year) flood event in Earlston. The remaining flood maps are provided alongside this report.

Figure 2-3: 0.5% AP (200 year) flood depth map for the Do Minimum scenario on the Turfford Burn

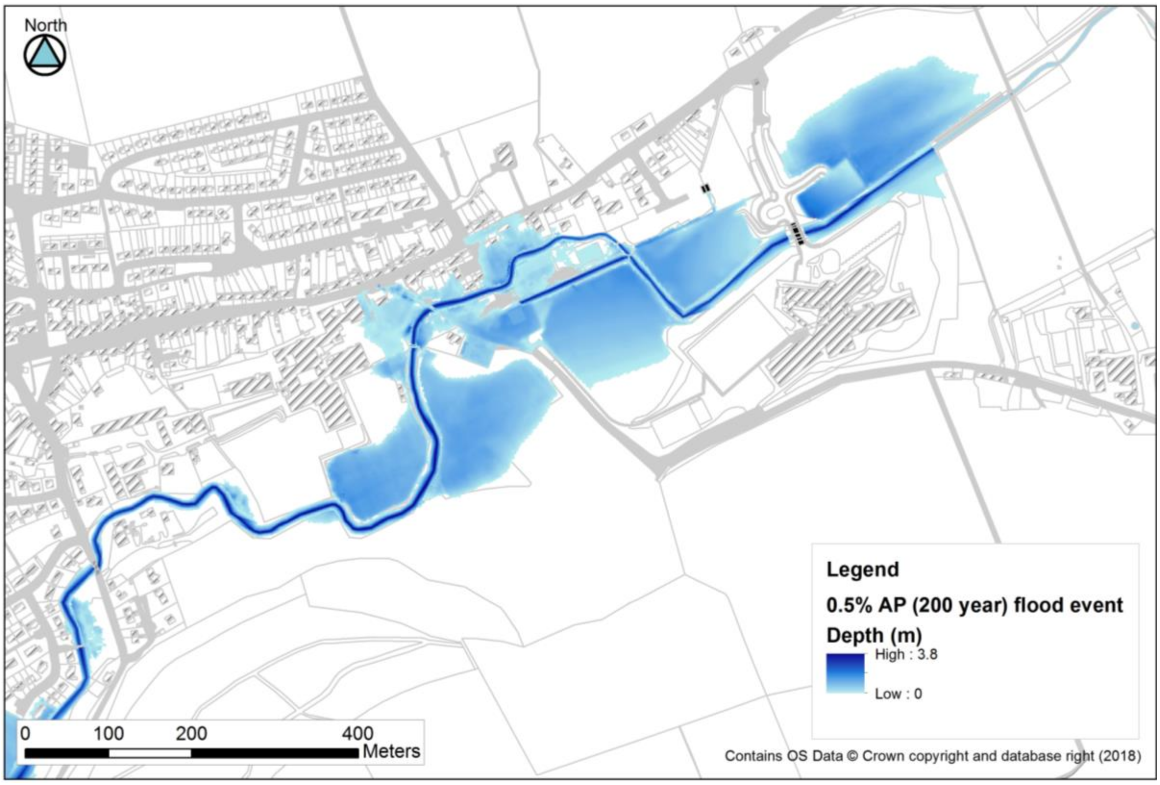
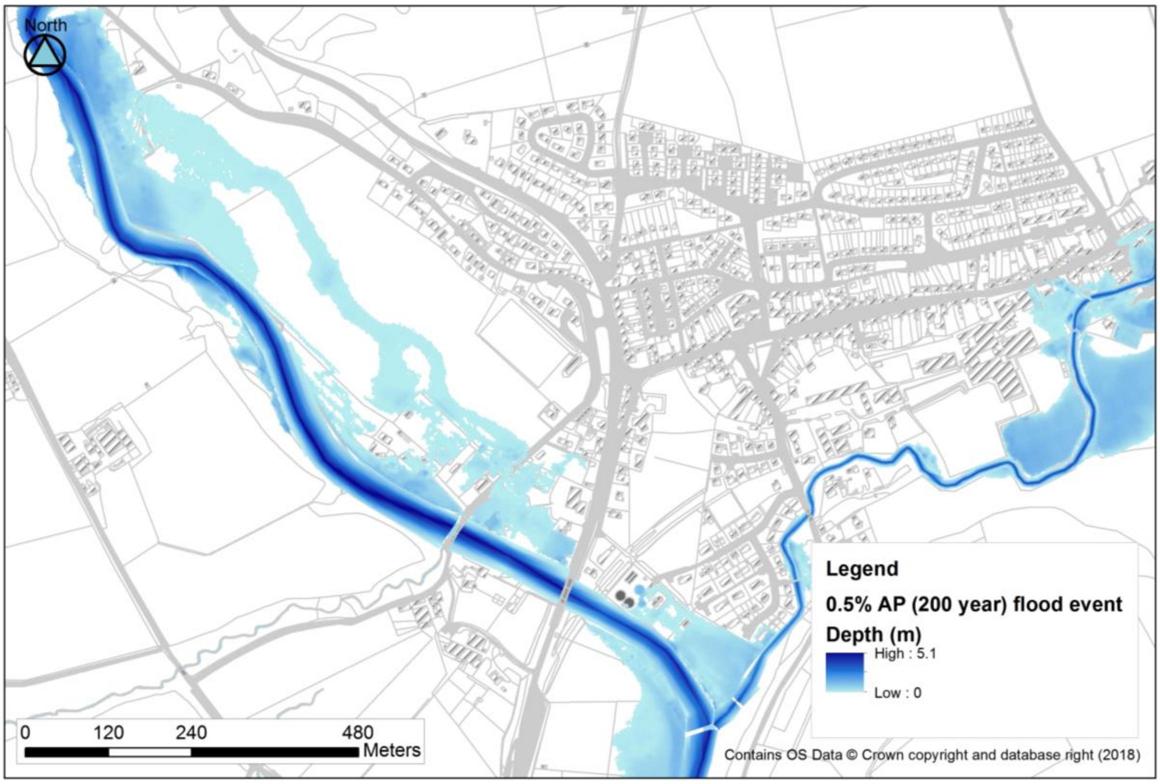


Figure 2-4: 0.5% AP (200 year) flood depth map for the Do Minimum scenario on the Leader Water



2.7.3.1 Flood risk from the Leader Water

The flood mapping has shown that properties at Haughead are likely to flood from water directly leaving the watercourse around the pedestrian suspension bridge upstream. When this water is able to pass into the agricultural land to the south it is then able to flow towards properties around Mill Road, only re-entering the river at the A68 road bridge where the carriageway is raised well above floodplain level. Downstream of the A68 water is able to leave the river again, passing onto the floodplain around Acorn Drive first and inundating the sewage works during higher magnitude events.

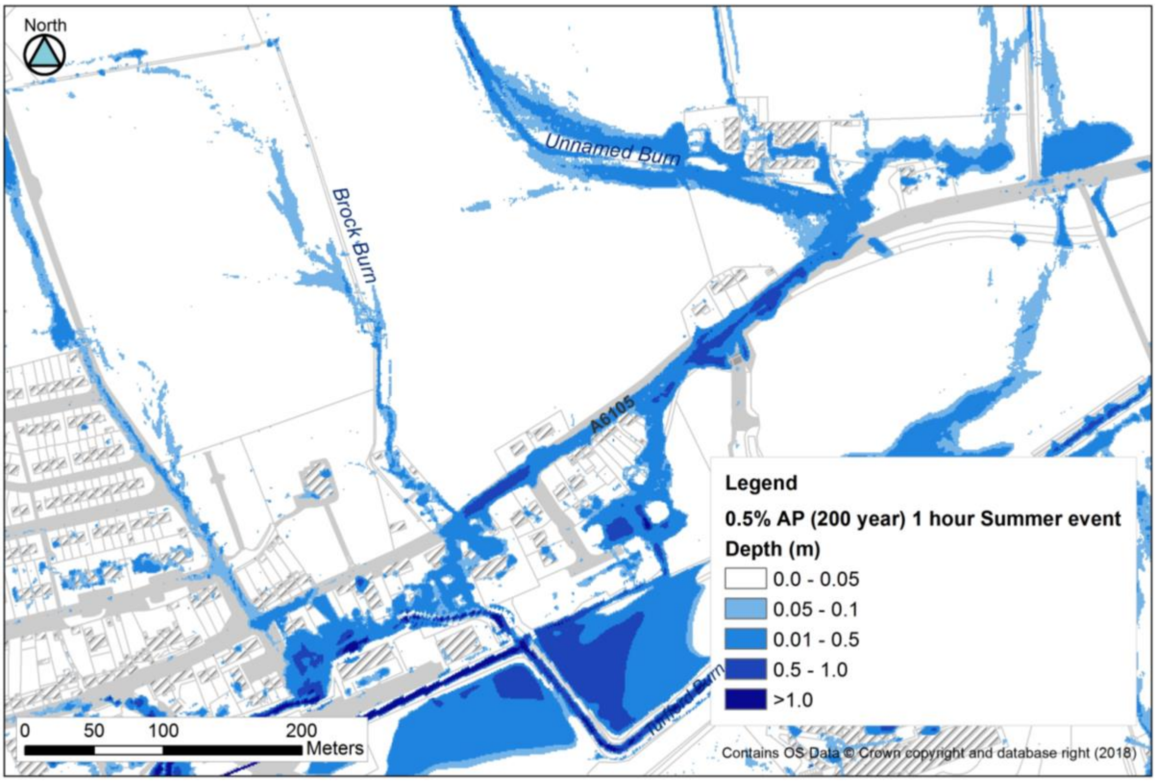
2.7.3.2 Flood risk from the Turfford Burn

The mapping shows that the new High School car park is likely to be flooded from the 20% AP (5 year) event and water is likely to leave the burn to inundate the playing fields at the 50% AP (2 year) event. At the 10% AP (10 year) event water from the playing fields reaches Georgefield Bridge and passes over it towards properties on the other side. During larger floods water passing over the bridge is supplemented by flows leaving the burn downstream of the bridge on the right bank to create a larger flooded area. Turfford Park industrial estate is predicted to flood from the 4% AP (25 year) event from water leaving the FPS channel and the main channel of the burn. Land adjacent to the former High School site is shown to flood once the embankments constructed using waste material from the FPS are overtopped.

2.7.3.3 Flood risk from the Brock Burn and Unnamed Burn

Of the different storm durations modelled the 1 hour summer and 10 hour winter events were found to cause the largest flood outlines. The flood depth map for the 1 hour duration summer event is shown in Figure 2-5. The flood maps show the potential for significant road inundation, particularly problematic for the properties to the east of the church. Beyond the road water is seen to flood to the south where it eventually meets the Turfford Burn.

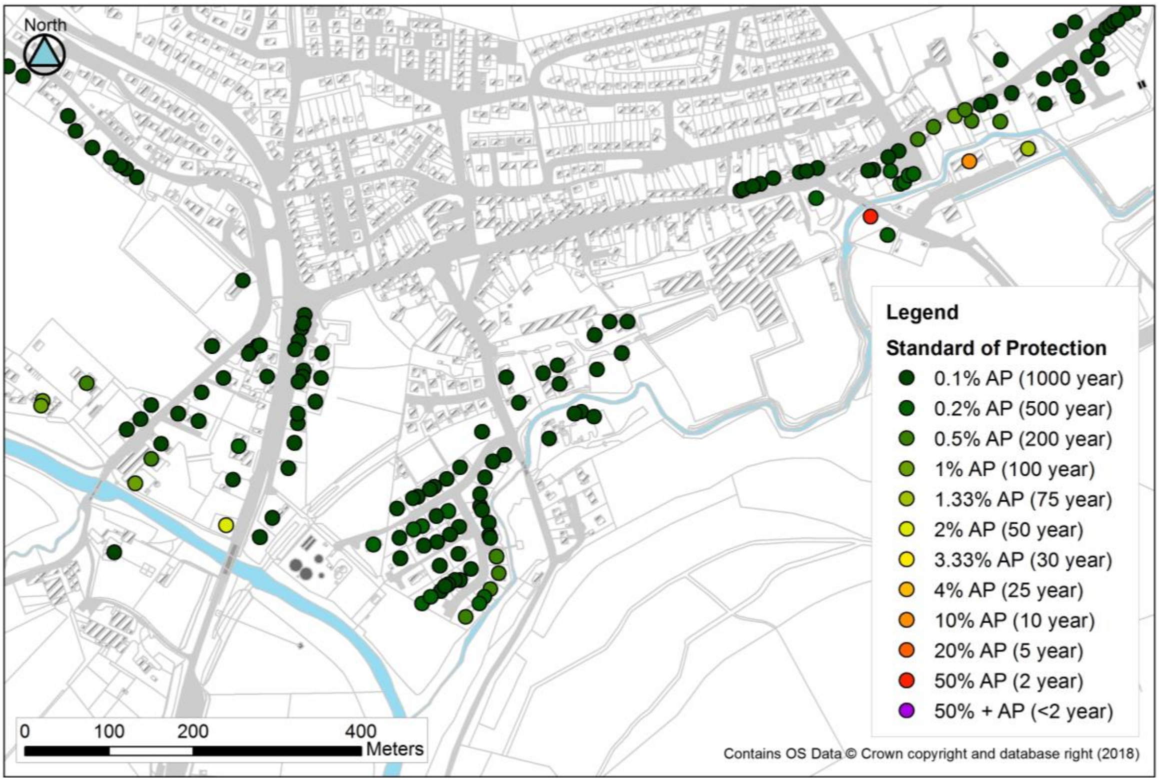
Figure 2-5: 0.5% AP (200 year) 1 hour Summer event flood depth map for the Do Minimum scenario on the Brock Burn and Unnamed Burn



2.7.4 Current standard of protection

The figure below shows each property's present-day level of protection from flooding without any flood defences or such-like in place. 'Standard of protection' is the largest flood event which is not expected to cause flooding to a property, larger magnitude events would be expected to cause property flooding. For example, a property with a 4% AP (25 year) standard of protection would be expected to flood at the 3.33% AP (30 year) flood.

Figure 2-6: Standard of protection for the properties at risk in the Do Minimum scenario



Overall properties have a high standard of protection across the town but a number of properties bordering the burn have a low standard of protection. The most likely to be affected is The Crossing Cottage which has a standard of protection of only the 50% AP (2 year) event. Beyond this most properties have a higher standard of protection with a further single property having a 10% AP (10 year) standard.

On the Leader Water the lowest standard of protection is the 2% AP (50 year) event, with most properties having at least a 1% AP (100 year) standard of protection.

2.7.5 The effects of climate change on flood extents

Climate change is expected to increase the frequency of flood events which will mean that an event statistically expected to occur every 2 years at present might be expected to occur every 1 year, for example. Similarly, this might mean a flood currently expected to occur every 200 years flood might be expected to occur nearer to every 100 years in the future.

The 0.5% AP (200 year) event with a 33% increase for climate change produces a more extensive flood outline with greater flood depths. Figure 2-7 shows the difference between the present day 0.5% AP (200 year) flood outline and the flood depth map expected as a result of climate change. The climate change simulation results in a slightly enlarged flood extent and increased flood depths by up to 1m upstream of the A68 on the Leader Water.

Figure 2-7: 0.5% AP (200 year) flood outlines with and without an allowance for climate change - Turfford Burn

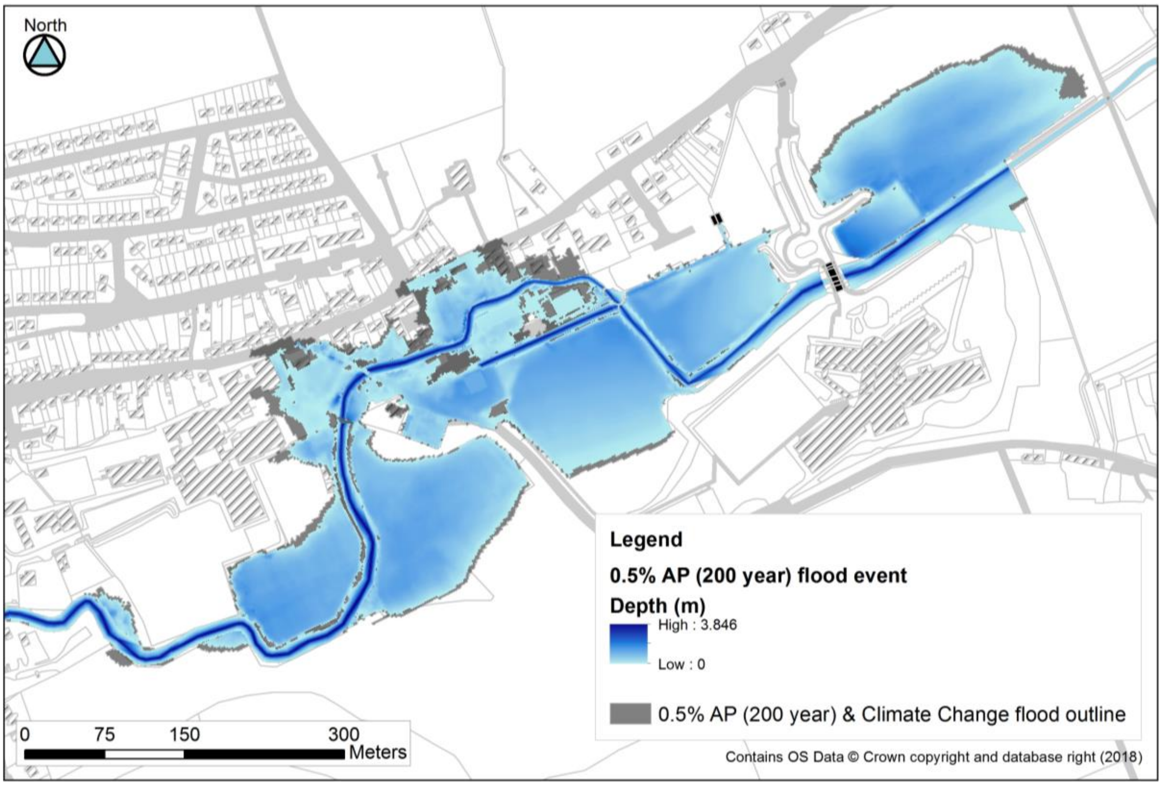
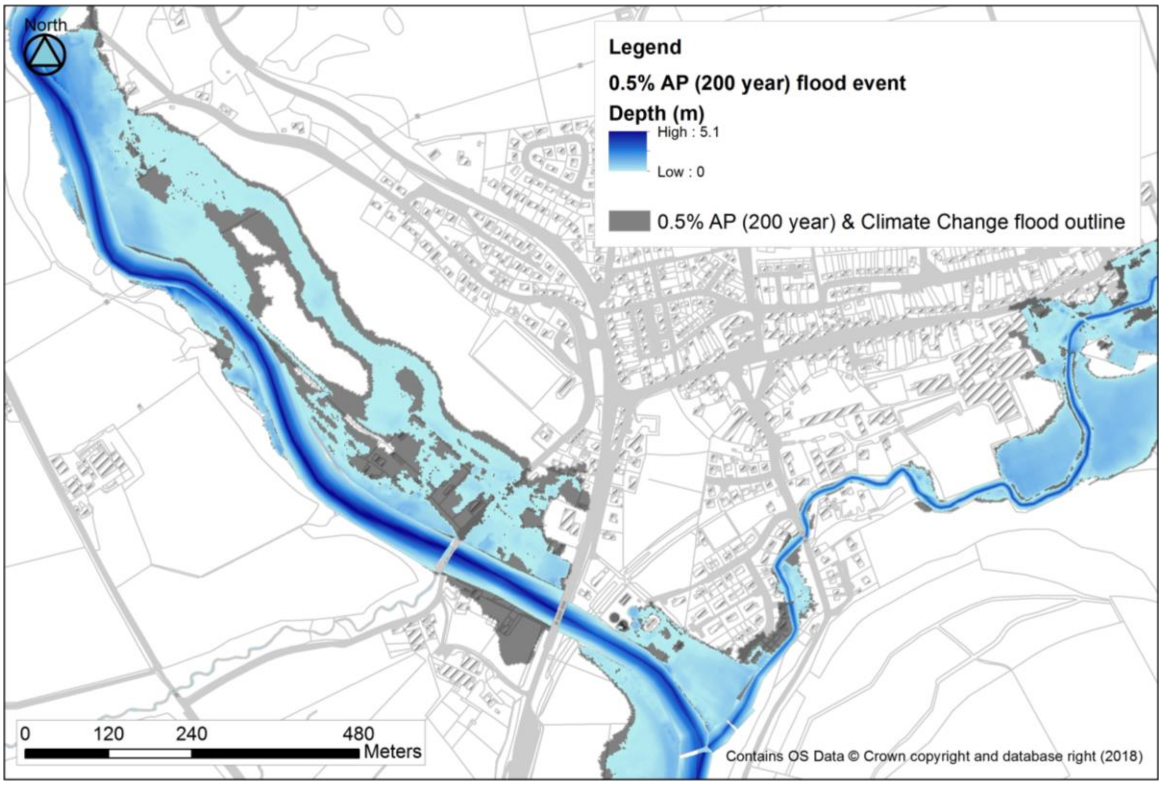


Figure 2-8: 0.5% AP (200 year) flood outlines with and without an allowance for climate change - Leader Water



3 Appraisal approach

3.1 Overview

The economic appraisal phase of the project requires analysis of the flood damages as calculated from the hydraulic modelling study and identification of problem areas. Through a long and short-listing process flood risk management options for these areas are reviewed and ultimately a short list of viable options is proposed. Comparison of the flood damages with and without the proposed flood risk mitigation options gives the flood damage 'benefit' of that option. Engineering costs are applied to each of the proposed options and this allows calculation of the benefit-cost ratio (BCR). The next sections detail this process and present the findings.

3.2 Problem definition

There are 4 properties in Earlston at risk from the Leader Water and 4 at risk from the Turfford Burn Burn at the 0.5% AP (200 year) event. Under existing conditions flooding is estimated to begin at the 1.33% AP (75 year) flood event on the Leader Water and the 20% AP (5 year) event on the Turfford Burn. There are at present no defences in place along the Leader Water but the FPS bypass channel on the Turfford Burn has potentially reduced the number of properties at risk compared to before construction. At present no properties are known to have purchased Property Level Protection (PLP) products.

3.2.1 Consequences of Doing Nothing

The starting point for a scheme appraisal is always to develop a suitable Do Nothing and Do Minimum option that can be used as a consistent baseline against which other options are compared. The Do Nothing represents the 'walk-away' option; cease all maintenance and repairs to existing defences and watercourse activities. This therefore represents a scenario with no intervention in the natural processes and serves as a baseline against which all other options are compared.

Assessing the level of risk for both the Do Nothing and Do Minimum options needs to consider how the watercourse will change and how any flow controlling assets or flood defences will react or deteriorate over the appraisal period. The following recommendations are therefore used for the Do Nothing and Do Minimum options:

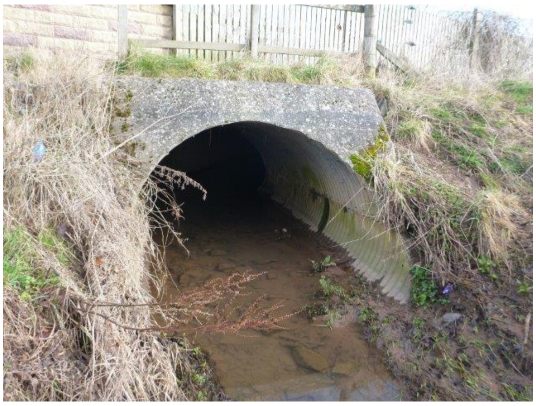
3.2.2 Do Nothing - Turfford Burn

Under the Do Nothing scenario the watercourses would not be maintained. This would lead to a gradual degradation of the banks and vegetation growth. As investigations into the condition of vegetation growth have highlighted the highly seasonal growth of in-channel vegetation, the Do Nothing scenario is represented in the model as a 10% increase in Manning's 'n' roughness from year 0 in the appraisal.

Winter channel vegetation	Summer channel vegetation
	

The flow control structure has a screen on it. As this is part of an FPS, the Council have a duty to inspect and maintain this asset. Furthermore, whilst there is not a history of significant blockage, due to the nature of the watercourse and upstream catchment a standard two-thirds blockage would not be unusual despite current maintenance. The Council has also noted an ongoing issue associated with straw/hay matting up the screen and an issue with out-of-hours access to the screen (access is via the farm supplies store).

No further structures within either watercourse has screens and there is no history of structure blockage. Bridge blockage has therefore not been included but has been assessed separately as a modelling sensitivity test. The CCTV culvert survey found that the FPS diversion channel culvert is blocked by approximately 10%. This could increase over time under a Do Nothing scenario. A value of 20% has been used.

Diversion channel flow control screen	Blockage of diversion channel culvert
	

The flood embankments on the Turfford Burn are part of the FPS and should technically be maintained. Whilst some degradation of these embankments has occurred since construction, as they only protect agricultural land any further deterioration is unlikely to increase flood risk to Earlston. Thus, maintenance of these embankments should not be a high priority for the Council. No change to these embankments has therefore been assumed as part of the Do Nothing scenario.

The inlet weir on the entrance to the diversion channel has degraded. As this is part of the FPS (and the Council has a duty to maintain it), the assumption for this asset is that it should be repaired rather than degrade further. The current condition and level of this is therefore retained for the Do Nothing and Do Minimum scenarios.

Inlet weir to diversion channel
 Note: Water flows left to right in photo

3.2.3 Do Nothing - Leader Water

There are no flood defences on the Leader Water. It is therefore assumed that only the channel manning's roughness is likely to change under a Do Nothing scenario. A 20% uplift in Manning's roughness has therefore been assumed.

3.2.4 Do Minimum

The Do Minimum scenario effectively represents the current scenario whereby the watercourse and all structures are maintained and replaced if they deteriorate to a point that is unacceptable. The following additional assumptions are made:

- Manning's represent current (winter) conditions on all watercourses.
- Blockage of the screen on the diversion channel orifice structure is blocked by 1/3rd.
- 10% blockage of the diversion channel culvert.
- Modelling of the Brock Burn assuming a culvert blockage of 15% based on the CCTV survey.

3.2.5 Accounting for climate change

Under the Climate Change (Scotland) Act (2009) local authorities have a duty to use an evidence-based approach to develop means to reduce the impact of climate change through mitigation measures (reducing emissions), planning to adapt to a changing climate and acting sustainably. This project appraisal fulfils the ‘adaptation’ and ‘acting sustainably’ duties.

4 Flood risk management options

4.1 Critical success factors (objectives)

The long list of options has been assessed against a number of critical success factors:

1. Options whether in isolation or combination must reduce flood risk providing an appropriate level of protection to people, property, business, community assets and natural environment.
2. Option must be technically appropriate and feasible.
3. Option should help to deliver sustainable flood risk management (e.g. help contribute to amenity and urban regeneration, improve the environment and biodiversity and improve or reduce existing maintenance regimes).
4. Options should not have insurmountable or legal constraints (e.g. land ownership, health and safety or environmental protection constraints).
5. Options should represent best value for money and minimise the maintenance burden and costs as much as possible.
6. Desirable BCR when measured in parallel with other success criteria.
7. Should incorporate National, Regional and Local agendas/objectives.
8. Should be deliverable by 2028 or a future agreed funding period when assessed with other success criteria.

4.2 Guideline standard of protection

The Scottish Government do not specify design standards for flood protection schemes. However, the standard of protection against flooding typically used in Scotland is the 0.5% AP flood (1 in 200 year). This standard is the level of protection required for most types of residential and commercial/industrial development as defined by Scottish Planning Policy (SPP).

Whilst design standards are a useful tool in terms of engineering goals and useful benchmarks, as well as in clear communication to stakeholders and the public, there is a general move in Scotland away from design standards to a risk based approach. Restricting options to desired standards of protection can limit consideration of factors that influence defence effectiveness and can limit future responses to external factors.

It is expected that a variety of protection levels are considered during the design process including the 0.5% and 1% annual probabilities and in some cases a lesser level. The guidance also states that options should be tested against a 1% annual probability plus allowances for climate change. Ministerial guidance[3] recommends appraising against the 1% AP (100 year) standard with an allowance for climate change but where the 0.5% AP standard is not achievable the focus has been on appraising to an appropriate lower standard rather than specifically the 1% AP standard with an allowance for climate change.

Based on the above guidance the aim of the scheme will be to assess options up to the 0.5% AP (200 year) plus climate change flood if possible, but to test lower return period events if appropriate.

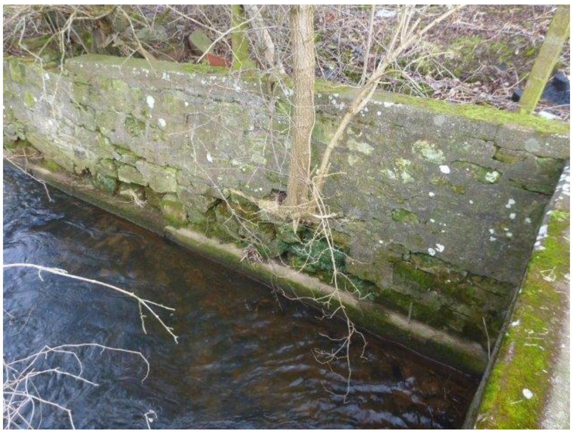
Based on the fact that other schemes within the Scottish Borders deliver a standard of protection in excess or to the 1:33% AP (75 year) plus climate change, it is not anticipated that a standard of protection less than this is deemed to be appropriate in terms of the critical success factors for this study.

4.3 Short term structural and maintenance recommendations and quick wins

Several measures or short term 'quick wins' have been identified that cover a range of aspects from maintenance to small scale works. Due to the relatively short reach of interest and the lack of structures on the burn there are relatively few of these actions recommended. These are summarised in Table 4-1.

3 Scottish Government (2011) Delivering sustainable flood risk management. Guidance document. Scottish Government, Edinburgh. http://www.gov.scot/Publications/2011/06/15150211/0

Table 4-1: Short term structural / channel maintenance recommendations and quick wins

Problem	Action	Photo
Vegetation growth alongside and within Turfford Burn - problem particularly pronounced in summer period.	General vegetation maintenance and removal.	 **Summer view of the burn adjacent to the primary school**  ***Winter view of the same section of the burn***
Structures and walls in poor condition along the Turfford Burn	Inspection of structure and maintenance to walls/mortar where required.	 ***Tree growing through wall downstream of concrete orifice***

Problem	Action	Photo
Debris dumped on banks causing potential blockage risk. Gabion walls on the left downstream bank of screen slightly deformed. Access to screen difficult.	Repair and monitoring of deformed walls. Removal of dumped debris. Consider alternative safe and open access to screen.	 ***Debris screen and concrete office***
Poorly maintained rock armour and FPS channel generally overgrown. Flow bypasses gabion basket via diverted channel.	Inspection and maintenance of rock armour and channel vegetation.	 ***FPS Diversion channel looking downstream from Turfford Burn***  ***Gabion basket and build-up of silt at entrance to diverted channel***

Problem	Action	Photo
Broken and displaced joint fractures, some debris upstream of manhole and failure in culvert roof in the Brock Burn culvert beneath the A6105. Culvert beneath new High School entrance bridge partially blocked with debris and vegetation.	Repair culvert at manhole, clear debris, consider relining culvert. Consider trash screen and or in-channel coarse debris screens	 ***Displaced joint***  ***Partial roof collapse***
Flooding to road around Georgefield Bridge from the Turfford Burn and on A6105 from the Brock Burn	Install flood stage boards and signage on road around Georgefield Bridge and on A6105 for surface water flooding from the Brock Burn.	 ***Georgefield Bridge in flood*** (Photo courtesy of YouTube upload by user Chris ja, October 2012)

4.4 Non-structural flood risk management recommendations

4.4.1 Flood warning

The Leader Water is part of the Gala and Leader Water river flood warning scheme operated by SEPA and as such it is recommended that this flood warning is maintained. There is currently no river gauge on the Turfford Burn and no system to provide advanced warning of flood events. Whilst flood warning is a challenge for a small catchment there are feasible options that could provide some warning to the community prior to flood events. A level gauge could be procured by SEPA or the Council and introduced on the burn. A gauge would also provide wider benefits by providing useable hydrometric data to improve hydrological estimates for future flood studies.

Alternatively, a third-party warning system could be procured and managed by either the Council or a local Flood Group. Such devices work by monitoring river levels and provide a text-based warning to key people within the community when levels reach a predefined point. The water level monitor on the FPS control structure may have the potential to send messages to predfined members of the community.

Installation of a gauge and recording of flood events when they occur would aid in the development of high flow ratings on the burn. Regardless of whether flood warning is implemented, flood levels should be recorded against stage boards and wrack marks should be surveyed whenever flood events occur to help build up a long-term flood record of events that can be used for future flood forecasting system calibration and general flood understanding.

4.4.2 Emergency action plans

The Council's Emergency Action Plan is the Severe Weather Plan which was updated in July 2018. This describes the Council's emergency response procedures, flood gate procedures and flood warning procedures. It has been designed to run as a standalone plan but can be run in conjunction with other emergency plans such as the Media & Communications Plan and the Care for People Plan. The emergency plan is initiated by Met Office weather warnings and SEPA flood warning information. The plan is coordinated through all Category 1 and Category 2 responders including Scottish Water, voluntary groups (community flood action groups) and public utility companies through the Joint Agency Control Centre (Bunker) at Scottish Borders Council.

This emergency plan is updated regularly as new information becomes available. It is recommended, if it has not already been done, that this is updated with the findings of this study, in particular the revised flood mapping. Regular reviews and preparation of community level emergency plans may be necessary to ensure that the following are up to date:

- Flood maps,
- Properties at risk (and any protected by PLP),
- Safe access and egress routes,
- Flood warning actions and escalation plans,
- Locations of community sandbag stores,
- Dissemination roles and responsibilities,
- Evacuation procedures,
- Onsite and/or temporary refuge locations/planning, and
- Back-up planning.

Emergency planning should encourage communication at a community level to ensure good response rates during a flood. Examples of this include flood group leaders, flood wardens and buddy schemes that encourage communities to act together and to help provide assistance to those needing additional help (e.g. vulnerable residents). To some extent this level of organisation is already in place through Earlston's Resilient Communities team who act during emergencies and have access to equipment to assist them in doing so.

The Councils emergency plans should be updated with the findings of this study including the updated flood risk maps and which properties are at risk.

4.4.3 Raising public awareness and community flood action groups

Responsible Authorities have a duty to raise public awareness of flood risk. Helping individuals understand the risks from which they are most vulnerable is the first step in this process.

Everyone is responsible for protecting themselves and their property from flooding. Property and business owners can take simple steps to reduce damage and disruption to their homes and businesses should flooding happen. This includes preparing a flood plan and flood kit, installing property level protection, signing up to the Resilient Communities Initiative, and ensuring that properties and businesses are insured against flood damage. Flood Action Groups are well known to assist with this awareness raising and resilience.

Scottish Borders Council have a well-established resilient communities programme, of which 43 of 70 community areas are signed up to in the Scottish Borders. These are resilience groups which operate during times of emergency, including flooding. A resilient community group is located in Earlston. As an ongoing action, Scottish Borders Council will continue to work closely with these resilient community groups, other local groups and members of the public to raise awareness of flood risk. It is recommended that the outputs from this study are shared with the resilience group to ensure that they are aware of the new flood maps and to assist with emergency procedures.

Council awareness raising activities are to be combined with on-going public meetings and consultation for proposed flood schemes as part of further developments associated with this study. Information from the Council is also expected to be disseminated through website, social media and other community engagement activity as appropriate.

4.4.4 Community sandbag stores

Scottish Borders Council continues to use community sandbag stores located at publicly accessible areas including fire stations and school grounds. Resilient Communities sandbag stores are also now widely distributed across the Scottish Borders in areas that have signed up to the Resilient Communities Initiative - this includes Earlston which has a resilient communities sandbag store, holding an estimated 50-60 sandbags. The Council should review the location of this and investigate if further stores are necessary.

It is recommended that the Council considers the use of the flood 'pod' system: community storage boxes, which contain flood sacks which are purpose designed bags filled with absorbent material. The key advantage of this approach is that they can be distributed before a flood and are ideal for locations with limited warning or response times. It may also save the Council time in filling, distributing and delivering sandbags to communities when sandbag stores run out. Whilst careful review of the siting and number of these pods would be required, they may offer a useful approach in Earlston. This approach would need to be combined with the existing flood advanced warning and flood awareness campaign provided by SEPA (i.e. flood alerts), but also some level of definitive flood warning system on the Turfford Burn such as a water level gauge.

4.4.5 Property level protection (PLP)

Scottish Borders Council currently offer a discounted PLP scheme to properties at risk of flooding, selling discounted PLP products to residents through a capped council-funded subsidy. The scheme makes manual PLP products more affordable than they would otherwise be and there has been some uptake to date. Manual PLP products that must be installed in advance of a flood event are in general seen as a short-term solution. Nevertheless, a full PLP scheme using passive (or 'automatic') products will be considered alongside the other options in the investment appraisal. Whether full funding would be provided through a flood protection scheme or if resident contributions would be sought is not considered at this stage.

At present no properties in Earlston are known to have taken up the Scottish Borders PLP scheme offered by the council. The lack of flood warning on the Turfford Burn is the main limiting factor for the use of manual PLP products.

4.4.6 Natural Flood Management

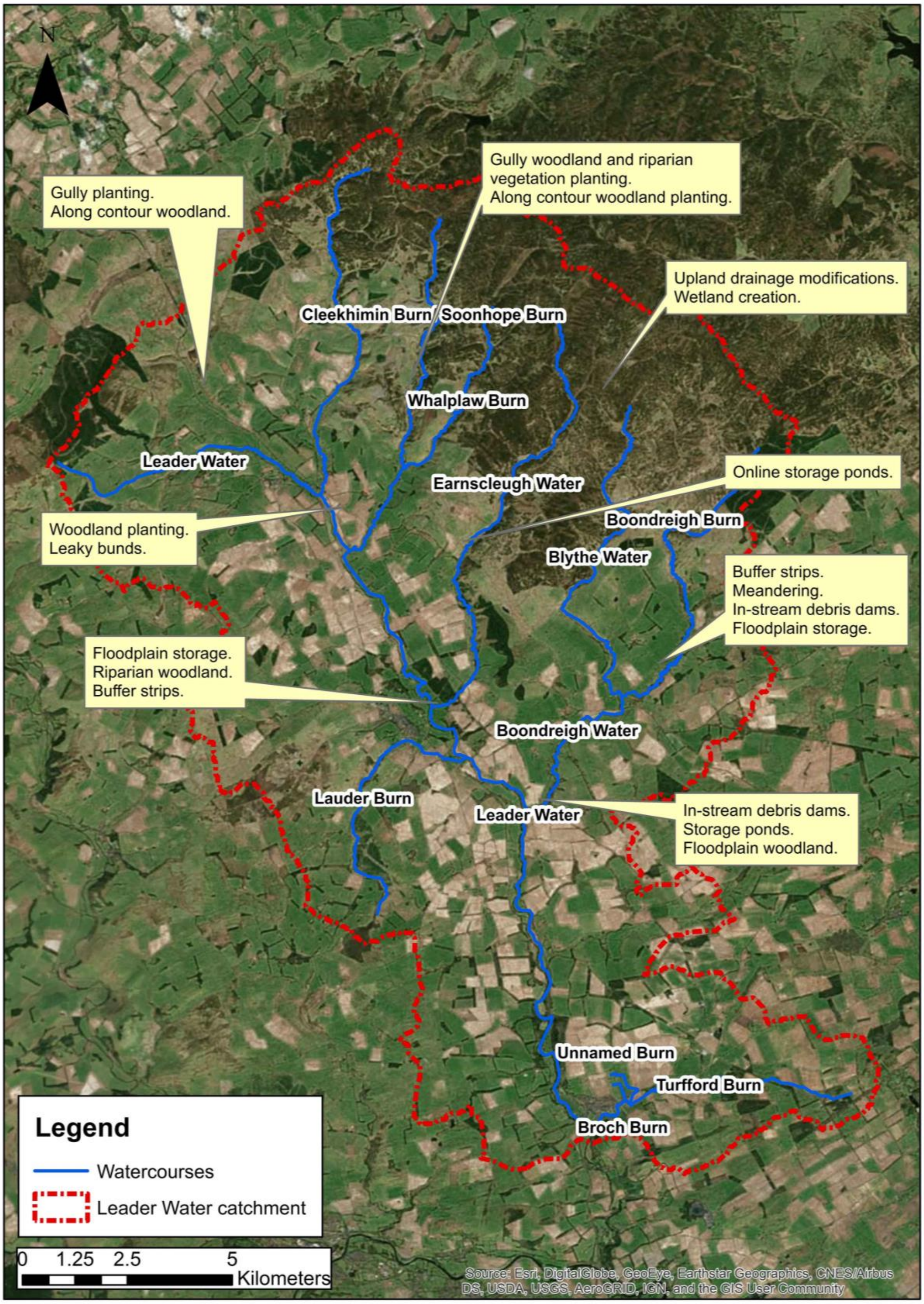
Natural Flood Management (NFM) opportunities were identified as part of this study by reviewing available datasets (opportunity maps) and undertaking a catchment walkover. The main recommendations for the Turfford Burn catchment include increasing the buffer strip to 5m along most of the watercourse, to prevent livestock grazing to the channel edge. Growth of hedgerows within the catchment to act as natural flow barriers along with tree planting to reduce runoff and create natural woody debris in the channel are also recommended.

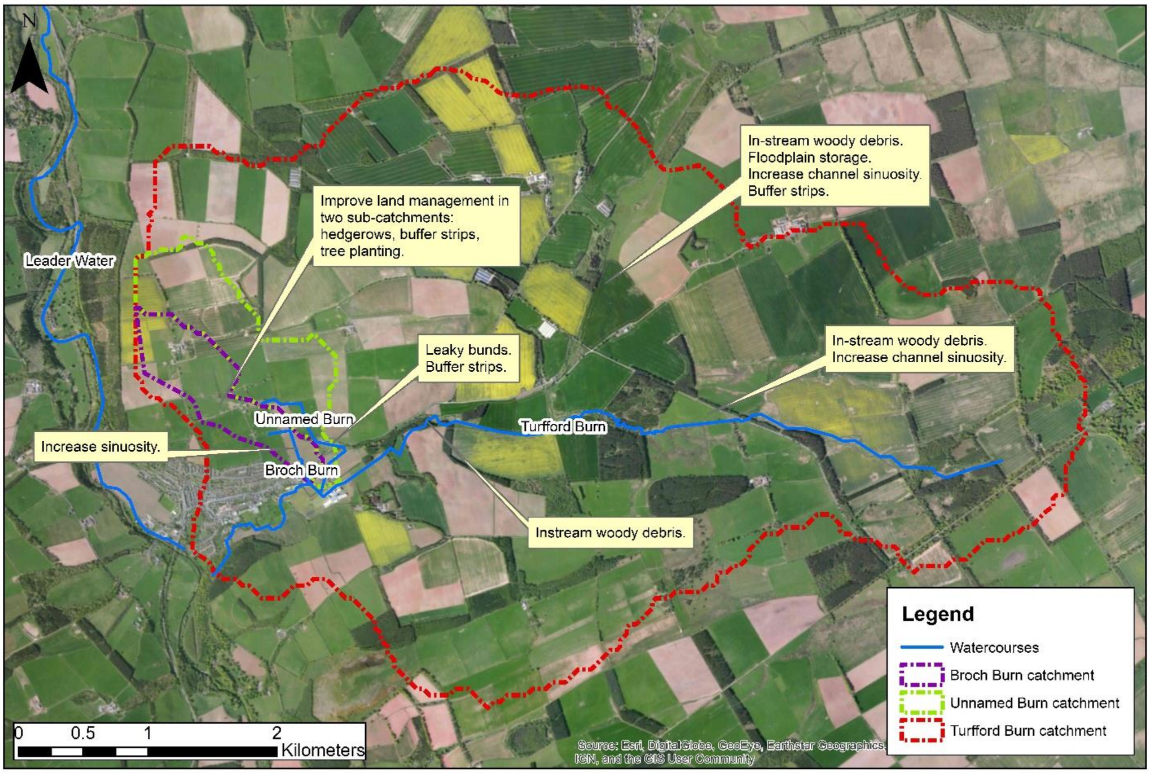
The Boondreigh Water catchment has the potential for blocking of upland drains to encourage bog formation, thus reducing runoff from the upper catchment. Along-contour tree planting and planting of floodplain woodland will both reduce runoff and increase infiltration. Leaky bunds at field boundaries will hold back and slow runoff as well.

In the upper Leader Water catchment, along-contour tree planting and gully planting is suggested. Buffer strips up to 5m in width are also suggested along the majority of watercourses, along with increasing the floodplain storage potential at Lauder through online ponds (Figure 4-1).

Figure 4-1: Suggested NFM measures for the Leader Water catchment

Figure 4-2: Suggested NFM measures for the Turfford Burn catchment





4.5 Long list of options

The following table provides an overview of potential flood alleviation options that could benefit Earlston. Those that are most viable have been assessed further in the following section.

Measure	Discussion
Relocation	**Technical**: Relocation or abandonment of properties not usually politically or socially viable. Option not cost effective as purchase costs will be same as capped damages. **Environmental**: No significant environmental or RBMP benefits or impacts. **Constraints**: Multiple objections likely if carried out via a FPS. **Decision: Option discounted**
Flood warning	**Technical**: The Gala and Leader Water river flood warning system presently covers the gauged Leader Water but not the Turfford Burn. There could be difficulties providing flood warning on the small Turfford Burn catchment but a level gauge or text-based third-party warning system could be procured or adapted from the trash screen gauge already in place. An alarm within the High School to warn against rising water levels near the car park could be procured by the school to avoid repeated costly insurance claims. **Environmental**: No significant environmental or RBMP benefits or impacts. **Constraints**: No significant constraints. **Decision: All further options assume that Flood Warning is maintained on the Leader Water and that some form of warning system should be sought for the Turfford Burn**
Resistance - means of reducing water ingress into a property to enable faster recovery	**Technical**: All Scottish Borders properties at risk of flooding are able to make use of the Flood Protection Products Discount scheme operated by the council. The depth and velocity of the Leader Water flood flows may exceed capabilities of retrofit PLP products. **Environmental**: No significant environmental or RBMP benefits or impacts. **Constraints**: 'Automatic' or 'passive' PLP products would be required for properties on the Turfford Burn given the current lack of flood warning. Flood warning on the Turfford Burn should be implemented to increase

Measure	Discussion
	preparedness. May not be accepted by the community as the only flood protection measure. **Decision: Option carried forward**
Resilience - means of reducing the impacts of flood water ingress on a property to enable faster recovery	**Technical**: Due to the small number of properties at risk from low magnitude, frequent flood events this option could be investigated further and progressed by the Council outside of a formal scheme. **Environmental**: No significant environmental or RBMP benefits or impacts. **Constraints**: May not be accepted by the community as the only flood protection measure. **Decision: Option discounted as part of this report but could be investigated for the few properties with a low standard of protection**
Watercourse maintenance	**Technical**: The Turfford Burn is overgrown, particularly in the summer months and increased maintenance is likely to offer flood risk management benefit. Access may be difficult to some areas of the burn for more substantial maintenance works. Due to the good condition of the Leader Water this option is unlikely to provide a flood protection benefit. **Environmental**: Channel maintenance may have minor negative impacts if spawning areas disrupted but these are unlikely to be significant. Sediment removal would likely harm aquatic ecosystems and increase bank erosion. **Constraints**: Possible stretching of council resources to ensure an intensified inspection and maintenance regime is carried out. **Decision: Option carried forward alongside other broader options**
Natural Flood Management (NFM)	Natural Flood Management options have been assessed in a standalone report. It is recommended that the options proposed are taken forward either as a standalone action to make the catchment more flood resilient or as part of a wider NFM study. It is recommended that further data gathering and modelling is undertaken to develop the options assessed.
Storage	**Technical:** The upper Turfford Burn catchment may be suitable for storage. An increase in online storage may also be possible in the field upstream of the former Earlston High School site if embankment removal was carried out. Identifying a suitable location for storage in the Leader catchment is difficult due to the number of roads crossing the floodplain between Earlston to Lauder. Further upstream the positive effects of storage are likely to be diminished. **Environmental**: The Tweed SAC designation covers the section of the Leader Water that would need to be used for storage but the upper reaches of the Turfford Burn are not protected. **Constraints:** Unlikely to be cost effective due to the size of structures required. **Decision: Option carried forward for further investigation**
Control structures	**Technical:** There is already a passive control structure on the burn which works effectively and amendments to it are unlikely to impact on flood risk. Large control structures would be required on the Leader Water which would not be feasible given the small scale of the flooding problem from the Leader Water in Earlston. **Environmental:** Could provide wetland habitats. **Constraints:** Unlikely to be cost effective due to the size of structures required and the lack of floodplain space for useful volumes of water to be held back. **Decision: Option discounted**
Demountable defences	**Technical:** Lead time of flooding is very short on the burn, making this option technically unviable. On the Leader Water there would be no real benefit to the use of demountable defences over fixed defences since costs would be greater and reliability lower than their fixed alternatives. Ensuring constant availability of trained personnel capable of deploying

Measure	Discussion
	defences would put excessive pressure on the council or highlight a requirement for even more costly automatic defences. **Environmental:** No significant environmental or RBMP benefits or impacts although likely to be preferred from an environmental standpoint when compared to direct defences. **Constraints:** Defence deployment likely to be unreliable compared to fixed defences. High initial and ongoing costs. **Decision:** **Option discounted due to cost relative to permanent defences**
Direct defences	**Technical:** Direct defences in certain locations along the Turfford Burn would be spatially constrained and access difficult due to the encroachment of properties onto the watercourse. An extensive suite of defences is likely to be required to protect the properties susceptible to flooding. There is likely to be sufficient space available on the Leader Water for embankments and flood walls making this a viable option. **Environmental:** Defences may cause an obstruction for some species, especially if walls are constructed rather than embankments. Reduction in RBMP status. **Constraints:** Some objections likely at public consultation. **Decision:** **Option carried forward**
Channel modification	**Technical**: Channel deepening on the Turfford Burn is not likely to provide much benefit due to the flood mechanisms witnessed historically, particularly as a result of flood flows passing towards/over Georgefield bridge. Removal of agricultural embankments, notably the one bordering the field to the east of the old High School site, could provide minor flood risk and RBMP benefits. On the Leader Water channel modification is unlikely to provide flood protection benefits as an independent option due to the scale that would be required to accommodate the large flows. Space not available for widening along the whole reach through Earlston. **Environmental**: May have negative impacts if spawning areas disrupted but these are unlikely to be significant. Sediment removal would likely harm aquatic ecosystems and increase bank erosion/steepening noted along some reaches of the burn. Embankment removal on the burn could, in the longer term, provide environmental benefit as a result of floodplain reconnection and wetland creation. **Constraints**: Land ownership constraints likely to be encountered and may be viewed negatively by residents favouring alternative options. **Decision:** **Option carried forward for testing on the Turfford Burn**
Diversion	**Technical**: This is likely to be possible between the new High School and former High School site but bypassed flows would need to be taken underneath or over Georgefield Road. There is no suitable site for channel diversion on the Leader Water through Earlston. Diversion of the Unnamed Burn and Brock Burn is likely to be the most successful option in reducing flood flows from intense rainfall events. This area falls within site BEARL002 identified in the Earlston Local Development Plan[4] as a site for Business and Industrial development which may have to be designed in conjunction with a diversion system. **Environmental**: New wetlands and community greenspace could be provided alongside a diversion channel. **Constraints**: Diversion would be constrained by roads, properties and topography. Water from the small burns would need to cross the A6105 either in a new culvert or on the road itself before passing into a drainage channel.

4 Earlston Local Development Plan (2016) Scottish Borders Council: https://www.scotborders.gov.uk/download/downloads/id/852/earlston.pdf

Measure	Discussion
	Decision: **Option considered**
Bridge removal or modification	**Technical**: Several bridges along the Turfford Burn surcharge and thus could be modified or removed to provide flood risk benefits. Combinations of options that improve bridge and general channel conveyance could be looked at but are unlikely to address the main mechanisms of flooding. The bridges on the Leader Water do not impose significant constrictions on the river during high flows so modification is unlikely to bring flood risk benefits. **Environmental**: Potential for improvements in line with Water Framework Directive (WFD) targets and improve RBMP guidelines. **Constraints**: Access across the burn could be impacted if works were progressed. **Decision:** **Option discounted**

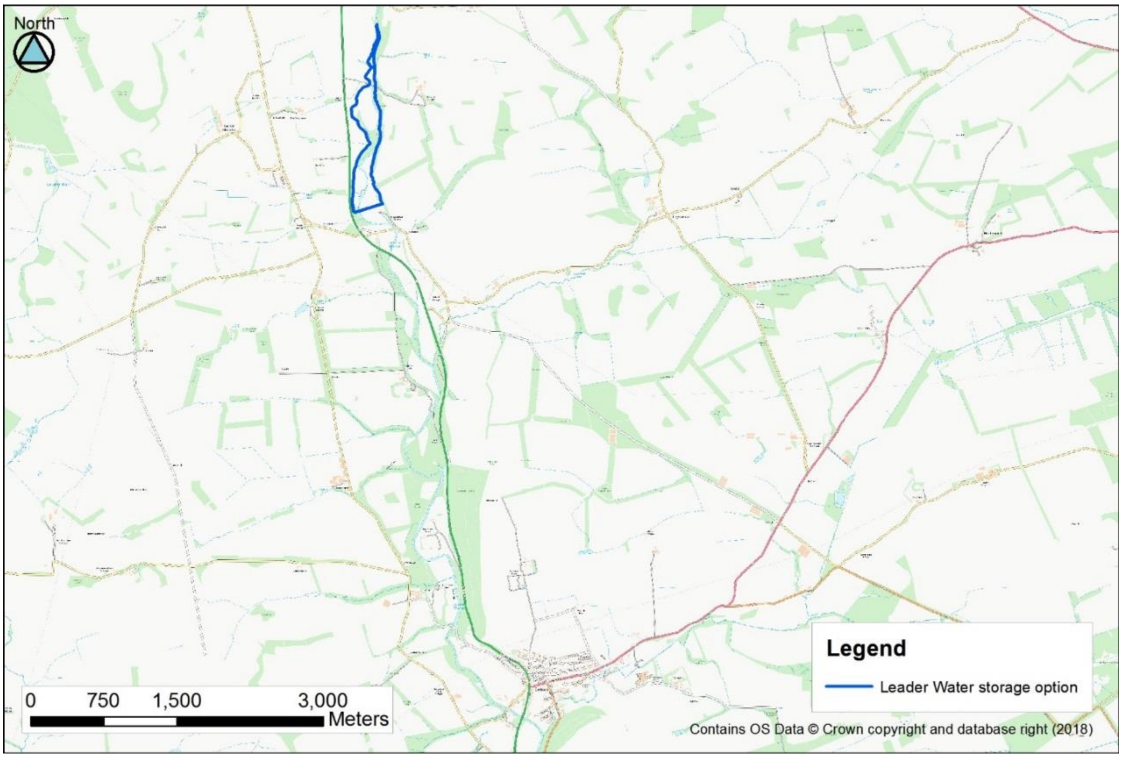
4.6 Feasibility study

A number of options were assessed further and in more detail using modelling to test the technical feasibility where applicable. These are discussed further below.

4.6.1 Storage on the Leader Water

Two locations were tested for storage upstream of Earlston, with only one found to be capable of storing sufficient volumes of flood water. This area is shown in Figure 4-1 overleaf.

Figure 4-3: Storage area tested on the Leader Water



A basic Flood Modeller model was built to test the attenuation of flows by creating an orifice opening and dam structure behind which water is stored. The storage behind the dam was based on an area/elevation relationship extracted from the NEXTMap 5m DTM data.

The model was tested with a range of orifice flow areas that would attenuate different proportions of the 200 year flow. Ideally the orifice would be limited to 6m^2 to limit the outflow from the storage area to a flow of approximately 115m^3/s and therefore mitigate the majority of flood risk to properties bordering the Leader Water.

The results of the storage modelling suggest that insufficient volume is available to be able to limit the outflow to 115m^3/s without inundating major transport links such as the A68. In order to avoid flooding roads the maximum allowable water level in the storage reservoir would need to be 137mAOD yet given the size of the area available for storage this would require an outflow of approximately 220m^3/s, a flow rate between the 1% and 0.5% AP flood events which would therefore allow a similar level of property flooding to the unattenuated 0.5% AP event.

In the absence of a more appropriate location for storage - with a greater drop in bed level or making use of a much longer stretch of the watercourse without concern for road inundation - storage on the Leader Water is not a feasible option.

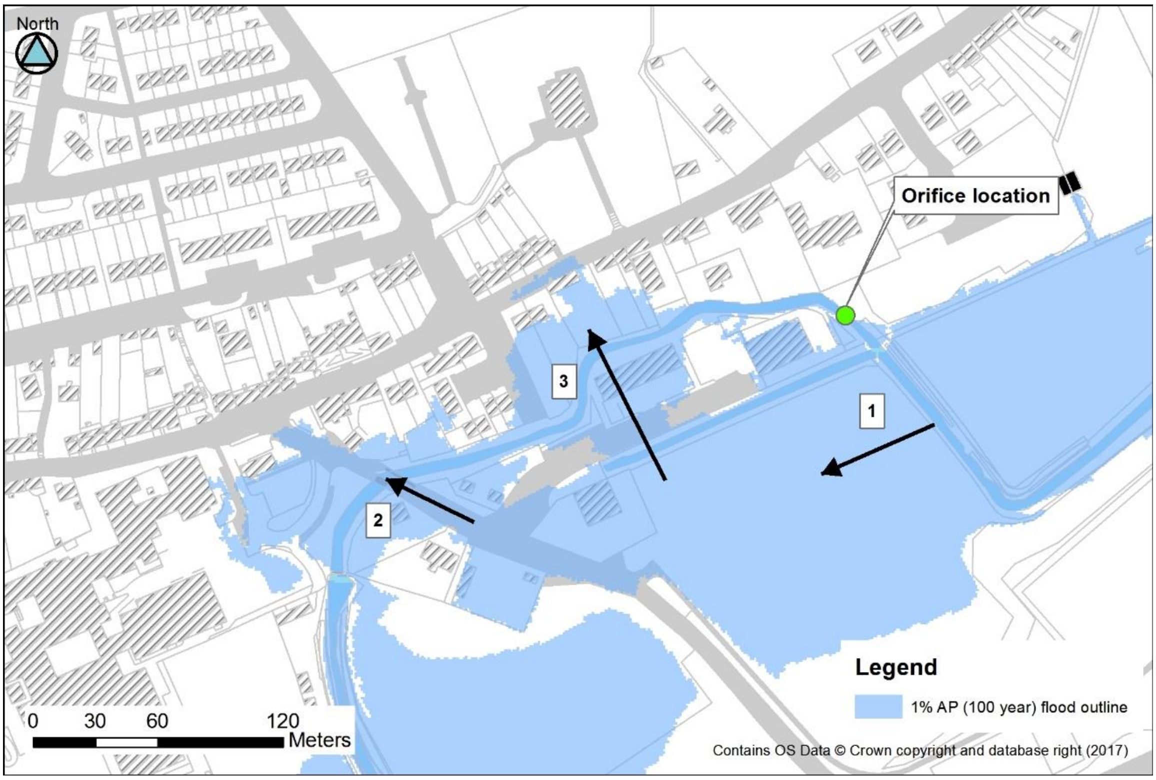
4.6.2 Channel deepening analysis on Turfford Burn

The possibility of increasing channel capacity through deepening of the channel (i.e. by removal of sediment) was considered. The area with the greatest potential for sediment removal is the section of channel between the orifice structure on the main burn and Georgefield Bridge, a section that does not experience high flows due to the controlling effects of the orifice structure.

Analysis of the flow routes at work during the largest floods shows that lowering of the bed through the main reach would not effectively reduce flood risk to Earlston. The reasons are based on the two primary sources of out of bank flows originating from sections of the burn upstream of the orifice rather than downstream. Experience in watercourses elsewhere has consistently shown a minor impact of channel deepening on reducing simulated flooding, and one which is only temporary. The natural sedimentation process would restock the channel with sediment and bring the channel back to the present-day condition, reducing any increase in channel capacity.

Lowering of the bed through the main reach would not effectively reduce flood risk through Earlston. The section where silt has historically built up is a reach heavily controlled by the orifice structure, making downstream changes to the channel likely to be unsuccessful. Figure 4-4 below shows the flow mechanisms at work in the area surrounding Georgefield Bridge, where regular property flooding is estimated to occur under the 'Do Minimum' scenario which reflects the current status of the burn. The inundation shown at different times during model simulations has been analysed and is simplified in the figure.

Figure 4-4: Flow pathways around Georgefield Bridge



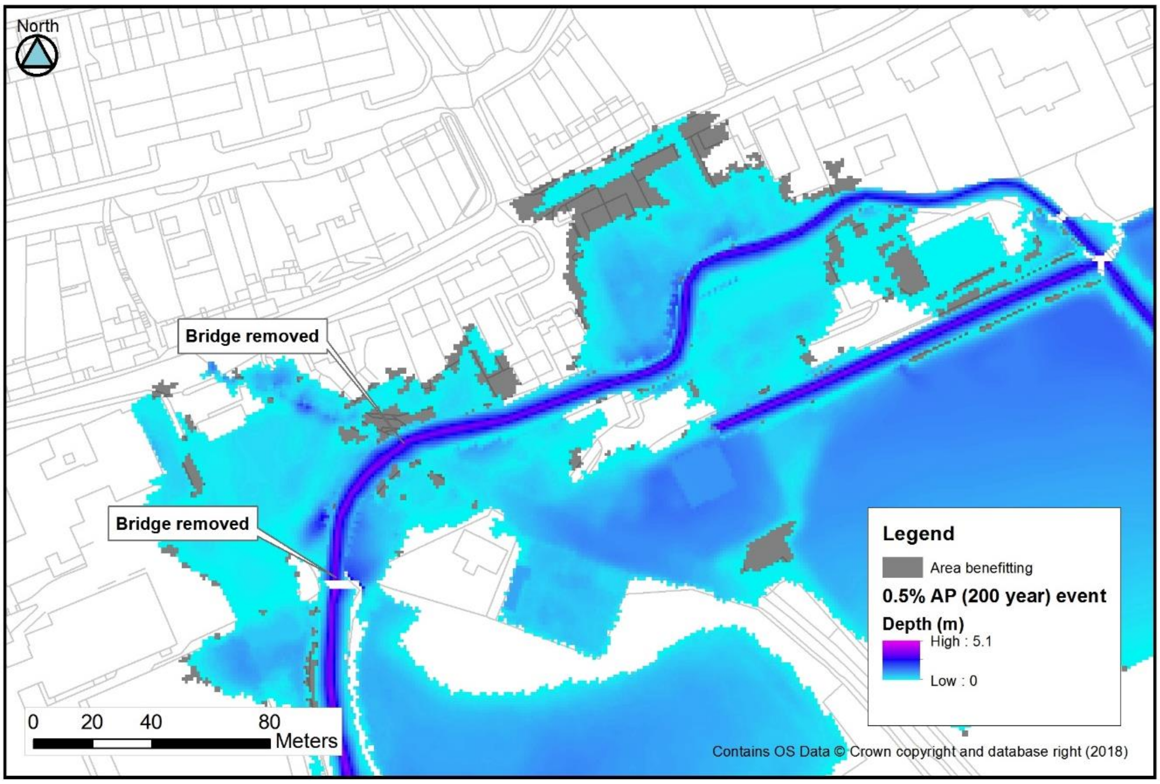
The figure shows the order in which flooding occurs. Initially, water leaves the burn at site 1, flowing across the High School athletics pitch and onto Georgefield Road, ultimately flowing over Georgefield Bridge and beyond at site 2. Whilst some water leaves the right side of the diversion channel at site 3 earlier in the model simulation, the main flooding occurs when water from the athletics pitch flows across the FPS channel and across the Turfford Burn at site 3. Some minor attenuation is possible through bed lowering between the orifice and the downstream extent of the map but this is unlikely to reduce flooding from the flow routes predicted to occur under present watercourse conditions.

Analysis of the Turfford Burn long section shows changes in bed level at a number of points which may suggest sediment accumulations as a result of obstructions or slowing water velocities. Two such changes are evident around the entry to the orifice and FPS channel, as well as upstream of the FPS culvert outlet, where flow from the culvert may cause slowing of water in the main channel upstream. Despite possible sediment accumulations neither of these areas plays a critical role in causing property flooding. Furthermore, any removal of sediment would not be a long-term solution as the channel would seek to re-equilibrate to the present-day conditions. This option is not carried forward to the short list.

4.6.3 Bridge removal or raising

Bridge removal was tested to assess the impact of head losses across a number of bridges on the Turfford Burn. Georgefield Bridge, Old High School footbridge, and the B6356 Road bridge were removed from the model but only minimal reductions in flooding are estimated for the 0.5% AP (200 year) flood event. Figure 4-5 below shows the area benefitting surrounding Georgefield Bridge. Flood levels were only reduced by up to 0.05m and by an average of less than 0.001m. For the scale of intervention required this minor change in estimated flooding is not acceptable and this option is therefore not carried forward to the short list.

Figure 4-5: Area benefitting from the removal of Turfford Burn bridges



4.7 Short list of options

4.7.1 Designing for climate change

In line with Scottish Planning Policy a 0.5% AP (200 year) standard of protection for any scheme was the goal throughout the short listing process. Wherever possible, options have been short-listed that at least aim to mitigate flooding to this standard and strive to meet the design standard for this event with an allowance for climate change, a 33% increase in the peak river flow.

Where a 0.5% AP (200 year) standard is not feasible interventions have been designed to allow for the greatest flood risk benefit possible after consideration of technical, environmental and social limitations and opportunities. River flood flows are expected to rise with climate change and where possible this has been accounted for in the design, for example by allowing for adaptable defences or by targeting a slightly higher standard of protection than may be favoured at the current time.

Upstream of Earlston the opportunities for Natural Flood Management are many. A growing body of evidence suggests that careful introduction of NFM measures may allow for reduced river flows in some cases. Although the greatest benefits would likely be seen for the properties suffering from flooding from small watercourses like the Turfford Burn, well-established NFM measures and improved land management in the sub-catchments of the Leader Water may also reduce river flows and to some extent counteract climate change increases. For this reason we recommend that NFM measures be taken forward either alongside the more traditional options listed below or on their own if ultimately no other options are taken forward to outline design stage.

4.8 Flood Mitigation Options - Leader Water

The following section details the constraints and benefits of the shortlisted options on the Leader Water.

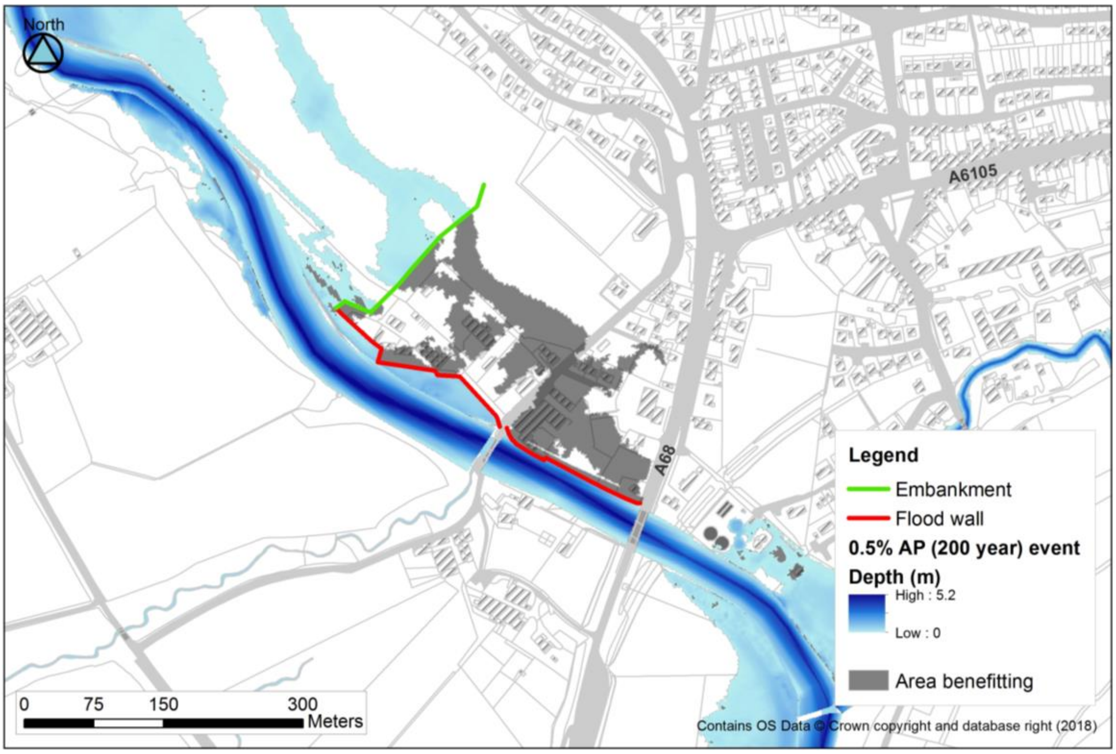
4.8.1 Option 1 - Construction of direct defences along the Leader Water

Option 1 - Construction of direct defences along the Leader Water

Description

This option aims to provide a high standard of protection to properties bordering the Leader Water through the installation of direct flood defences. The option entails the following:

- Install embankment across agricultural land to the northwest of Mill Road for a distance of up to 230m, and a maximum height of 0.7m (includes a 600mm freeboard).
- Install a flood wall at the top of the Leader Water bank for a distance of 240m ending at Mill Road, to a maximum height of 0.85m (includes a 300mm freeboard).
- Construct a wall from Mill road to the southeast over a length of 175m and a height of 0.3m.



Note: There is some uncertainty in the DTM used in the modelling along the left bank of the Leader Water, especially close to Haughhead. This may mean that the flow path across the agricultural land is inaccurate and that Haughhead properties could be at greater or lesser flood risk than expected.

Technical drawings relating to this option have been produced and are provided alongside this report, named as follows:

AEM-JBAU-EA-LW-SK-C-1100-Opt1_200Yr_Direct_Def_1of2-S3-P01.pdf

AEM-JBAU-EA-LW-SK-C-1100-Opt1_200Yr_Direct_Def_2of2-S3-P01.pdf

Standard of Protection (SOP)

Modelling of the above option suggests that a standard of protection of a 0.5% AP (200 year) flood is achievable. This equates to a flow of 240m³/s.

Alternative quick wins / Preliminary investigations

Smaller embankments or wall raising would offer a lesser standard of protection but for a lower cost.

Geotechnical issues

- A full GI will be required at a later stage in the project.
- A cut-off is likely to be needed. Piling may be difficult in this material and other forms of cut-off may need to be considered.

Services

Overhead and underground services have been identified and their location is shown on drawing AEM-JBAU-EA-LW-SK-C-1002-LW_Services.

- High and low voltage cables, several storm water sewers and a gas main were identified in the plans close to some of the defences. This should be further reviewed and a full buried services investigation carried out at a later stage.

Construction access

Construction access has been considered and is generally good, through agricultural land or along roads. Some areas along the river bank from Mill Road and the water treatment works are likely to be more challenging.

Waste

- Expected quantity of waste material: Approximately 2,271m³.
- Nature (inert, non-hazardous, hazardous): Soil may be contaminated in areas along the river bank where former mills, sawmills and general 'works' have been identified.
- Proposed disposal: All waste produced during construction should be contained and prevented from entering the watercourse. Stock piles of soil and non-toxic spoil and construction waste should be located away from the river (at least c.10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works.

Environmental issues

- Statutory Environmental Designations: Leader Water and the Turfford Burn are part of the River Tweed SAC. Habitats Regulations Appraisal (HRA) and Appropriate Assessment are required.
- Additional surveys and assessments may be required for otter, water vole, fish (with particular reference to Atlantic salmon, brook lamprey and river lamprey, habitat (with reference to Ranunculion fluitantis and Callitricho-Batrachion vegetation), bats (works affecting trees, walls, built structures and bridges), breeding birds, water quality, flow and hydromorphology
- Consultation required with SNH and SEPA.
- Habitat: The area around both banks of Leader Water upstream (approximately 300m upstream of Mill Road), the right bank down to Mill Road is a National Forest Inventory. The area within the site boundaries is mainly amenity grassland and broadleaved semi-natural woodland.
- Listed Buildings: There are a number of listed buildings within the site boundaries but works are not expected to immediately affect them.
- Trees - Tree Protection Orders (TPO's): A few trees may need to be removed for the construction of the flood walls along the river bank. Replanting proposals to be considered at detailed design stage.

Health and safety hazards noted

- Geotechnical and excavation works - In channel works, falling into excavations, collapse of the sides of excavation, damage to underground services, undermining of nearby structures.

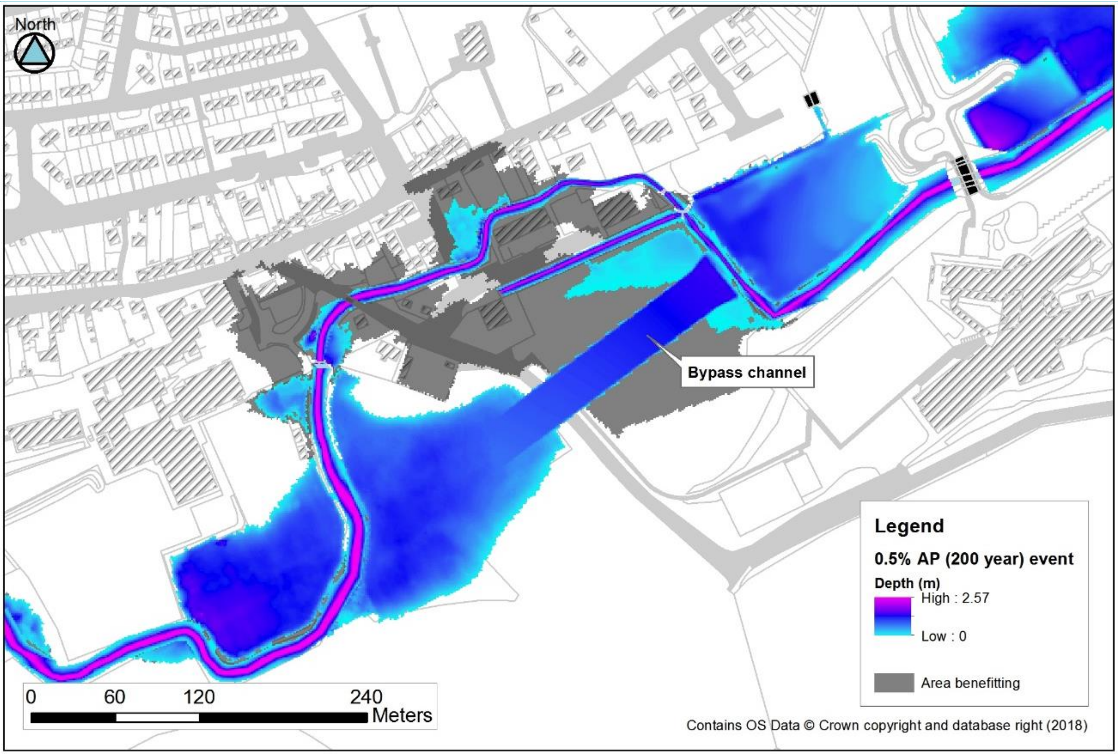
• Construction – flooding of works.
Social and community issues Some aesthetic issues as this option has been designed to mitigate flood risk to extreme flood events which requires a significant physical intervention. Land take is minimal but a substantial length of flood embankment/wall is proposed. The protection of Mill Road aligns with the Earlston Local Development Plan[4] aim to ensure Business and Industrial Safeguarding in this area under site code zEL57.
Impact on other reaches Modelling suggests that the flow and level in the Leader Water downstream of the confluence with the Turfford Burn may be slightly lower with the defences in place than in the present day Do Minimum scenario. Increased velocities in the region of 0.03m/s are likely to cause a reduction in flow of approximately $0.6m^3/s$. The increase in velocity makes the flood peak slightly earlier than with no defences in place. Ultimately, it is not expected that any areas downstream will be at increased flood risk. Scottish Water should be consulted relating to the water treatment works which is expected to continue flooding with this option.
Additional information required • A detailed topographic survey. • Detailed buried services survey, plotting their position with regards to site works. • Ground investigation. • LIDAR data required to increase confidence in hydraulic model before outline design.
Additional works required to account for increase in 200 year flow due to climate change • Consider building adaptable walls that can easily be raised in the future. • To account for climate change a number of additional walls and embankments would be required including an embankment at Haughhead in the region of 2.5m in height and walls around the football pitch near Acorn Drive and alongside the Turfford Burn channel to a height of approximately 0.85m.

4.9 Flood Mitigation Options - Turfford Burn

The following section details the constraints and benefits of the shortlisted options on the Turfford Burn.

4.9.1 Option 1 - Construction of bypass channel across High School athletics pitch

Option 1 - Construction of bypass channel across High School athletics pitch
Description This option aims to provide a high standard of protection through the creation of an approximately 340m long flood relief channel to allow a portion of the burns' flows to bypass the main channel and the FPS channel. The work includes the following: • Excavate a 340m long channel to a maximum depth of 1.2m and a maximum bottom width of 30m. The channel was modelled with a side slope of 1 in 3, a channel slope of 0.0023 and a Manning's *n* roughness value of 0.035. • Lower the left bank of the Turfford Burn at the entrance to the bypass channel to a level of approximately 103.5m, a reduction of 0.5m. *Continued on next page.*



A technical drawing relating to this option has been produced and is provided alongside this report, named as follows:

AEM-JBAU-EA-TB-SK-C-1100-Opt1_200Yr_Part_By_Chan-S3-P01.pdf

Standard of Protection (SOP)

Modelling of the above option suggests that a standard of protection of the 0.5% AP (200 year) event is achievable, with out of bank flows on the remainder of the burn flooding gardens but not affecting them during a 200 year event. This equates to a flow of 18.1m^3/s.

Alternative quick wins

A smaller, less intrusive bypass channel would offer a lesser standard of protection, for a lower cost and may be more acceptable to the community and High School but this would be unlikely to reduce the number of properties at risk by a substantial amount.

The complete bypass channel option below proposes an alternative bypass option in which the current channel is blocked and completely bypassed by a new channel which borders the High School playing field rather than cutting through it.

Geotechnical issues

Bank and bed stabilisation at the entrance to the bypass channel may be required.

A full GI will be required at a later stage in the project.

Services

Overhead and underground services have been identified and their location is shown on drawing AEM-JBAU-EA-TB-SK-C-1002-TB_Services.

There are no buried services shown on the provided drawings close to the proposed works but this should be reviewed should the works be carried forward to later design stages.

Construction access

Construction access has been considered and will be possible off Georgefield Road.

- Construction would entail heavy machinery working along the bank with possible in-channel working and bank repair works.

Waste

- Expected quantity of waste material: Approximately 9,538m^3.
- Nature (inert, non-hazardous, hazardous): It is understood that no industry was present in Earlston – soil expected to be inert.
- Temporary storage of topsoil and subsoil in heaps and stockpiles.
- Production of waste including silt, dust and construction waste. Further investigation required

through GI into level of contamination and ownership. Stock piles of soil and non-toxic spoil and construction waste should be located away from the river (at least c.10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works.

Environmental issues

- Statutory Environmental Designations: Leader Water and the Turfford Burn are part of the River Tweed SAC. Habitats Regulations Appraisal (HRA) and Appropriate Assessment are required.
- Additional surveys and assessments may be required for otter, water vole, fish (with particular reference to Atlantic salmon, brook lamprey and river lamprey, habitat (with reference to Ranunculion fluitantis and Callitricho-Batrachion vegetation), bats (works affecting trees, walls, built structures and bridges), breeding birds, water quality, flow and hydromorphology
- Consultation required with SNH and SEPA.
- Habitat: The area of the proposed bypass channel is a National Forest Inventory with broadleaved trees, low density vegetation and young trees.
- Trees; TPO: A few trees may need to be removed and should be replaced as necessary.
- No potential land contamination constraints identified.

Health and safety hazards noted

- Geotechnical and excavation works - In channel works, falling into excavations, collapse of the sides of excavation.
- Construction – flooding of works.

Social and community issues

The option may make the high schools' sports field unusable for its current purpose. With careful design it may be possible to use sections of this field still or through lowering of the whole field it may be possible to maintain its use. An alternative space may be available in the surrounding agricultural land.

Impact on other reaches

The increased flooding to the right bank floodplain identified in the modelling of this option could impact site (AEARL002) identified in the Local Development Plan[4] for Earlston and is highlighted as a site for future housing, currently an open space for community use. Allowing this site to flood would have RBMP benefits and would aid the flood mitigation abilities of the proposed option. This site is estimated to flood and should therefore not be developed.

Additional information required

- A detailed topographic survey to inform detailed design of the channel which may differ from that used in the hydraulic model.
- Detailed buried services survey, plotting their position with regards to site works.
- Ground investigation.
- LIDAR data required to increase confidence in hydraulic model before outline design.

Additional works required to account for increase in 200 year flow due to climate change

Remove embankment surrounding agricultural land upstream of former Earlston High School site (right bank). This land is included in the Local Development Plan for Earlston as a site for future housing but the modelling conducted for the present study suggests that it may flood from the 20% AP (5 year) event and upwards. It is therefore not advisable to develop this land and instead maintaining it as a flood storage area would be more sustainable. Modelling has shown that the rapid passing of water down the bypass channel and back into the main channel may partially constrict flows in the bypassed section of the main channel and fail to significantly reduce water levels as might be expected from the bypassing of flood flows. Removal of this agricultural embankment has been found to greatly increase conveyance in this area of the channel where the FPS channel and proposed bypass channel re-enter the main channel. There is estimated to be a reduction in water levels of 0.79m compared to the Do Minimum scenario, and 0.25m when compared with the bypass channel alone. This is sufficient to reduce the risk of flooding to the gardens of properties backing on to the burn from High Street and Church Place.

The standard of protection could be further improved through the use of NFM measures in the upper catchment, as described in section 4.4.6.

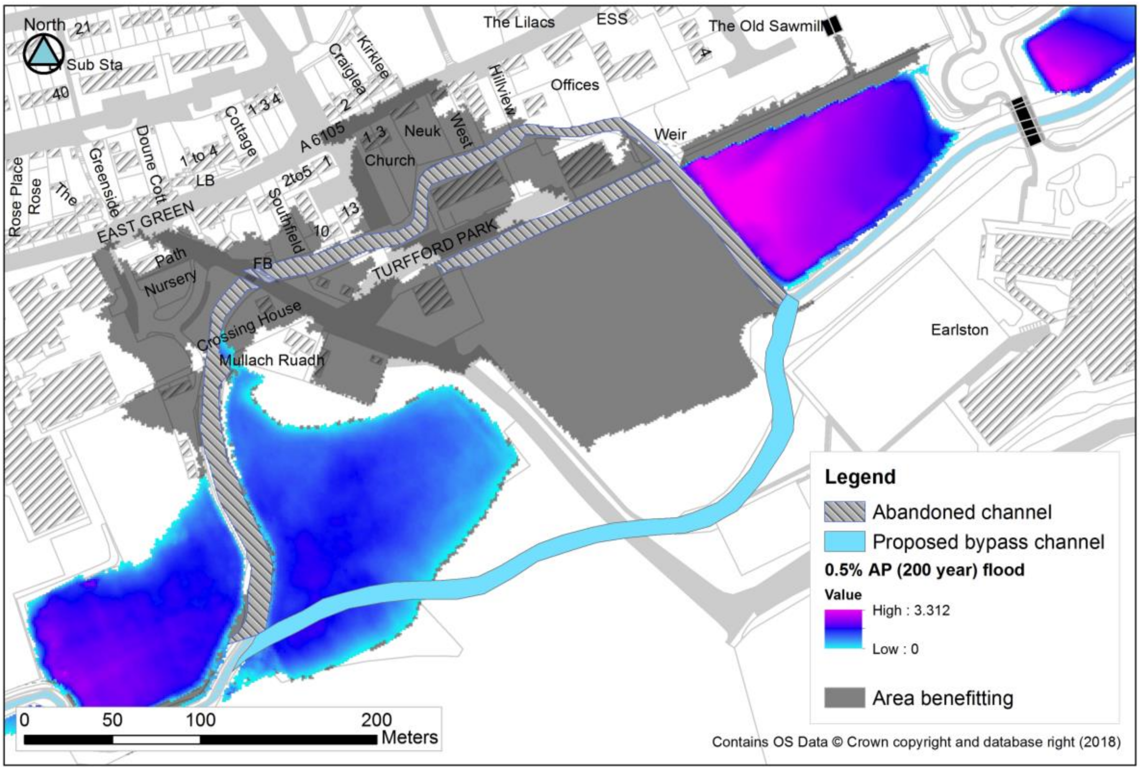
4.9.2 Option 2 - Construction of channel to completely bypass a section of the Turfford Burn

Option 2 - Construction of channel to completely bypass a section of the Turfford Burn

Description

This option aims to provide a high standard of protection through the installation of an approximately 430m long replacement channel positioned around the High School athletics pitch to allow all of the burns' flow to bypass the main channel and the current FPS channel. The work includes the following:

- Excavate a 430m long channel to a maximum depth of 2.3m, bottom width of 3m, side slope of 1 in 3, channel slope of 0.005 and a Manning's n roughness value of 0.035. The channel would be cut into the embankment which leads up to the artificial pitch and tennis courts.
- Lower the left bank of the Turfford Burn at the entrance to the new channel by approximately 1.8m.
- Block the current Turfford Burn and FPS channels at the entrance to the new channel.



A technical drawing relating to this option has been produced and is provided alongside this report, named as follows:

AEM-JBAU-EA-TB-SK-C-1200-Opt2_200Yr_Full_By_Chan-S3-P01.pdf

Standard of Protection (SOP)

Modelling of the above option suggests that a standard of protection of a 0.5% AP (200 year) flood is achievable. This equates to a flow of 18.09m^3/s.

Alternative quick wins

A smaller bypass channel capable of conveying smaller flows could be constructed for a marginally lower cost, with a calculated spill allowed into the playing field and agricultural land to the northwest to alleviate flooding from the largest magnitude events.

Geotechnical issues

Bank and bed stabilisation at the entrance to the bypass channel may be required.

Consideration of the existing embankment to artificial pitch and path/tennis courts

A full GI will be required at a later stage in the project.

Services

Overhead and underground services have been identified and their location is shown on drawing AEM-JBAU-EA-TB-SK-C-1002-TB_Services.

Whilst the available data shows no buried services in the vicinity of the proposed bypass channel it is possible that not all data for this area of Earlston has been provided for the current study. This should be reviewed at outline design stage and accompanied by a later full buried services investigation where ground works are required.

Construction access

Construction access has been considered and will be possible off Georgefield Road for the channel. Infilling of the current channel may need to be done in stages working from the playing fields down, accessing along the burn as it is filled in.

- Construction would entail heavy machinery working along the bank with possible in-channel working and bank repair works.

Waste

- Expected quantity of waste material: Approximately 9,159m^3.
- Nature (inert, non-hazardous, hazardous): It is understood that no industry was present in Earlston – soil expected to be inert.
- Temporary storage of topsoil and subsoil in heaps and stockpiles.
- Production of waste including silt, dust and construction waste. Further investigation required through GI into level of contamination and ownership. Stock piles of soil and non-toxic spoil and construction waste should be located away from the river (at least c.10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works.

Environmental issues

- Statutory Environmental Designations: Leader Water and the Turfford Burn are part of the River Tweed SAC. Habitats Regulations Appraisal (HRA) and Appropriate Assessment are required.
- Additional surveys and assessments may be required for otter, water vole, fish (with particular reference to Atlantic salmon, brook lamprey and river lamprey, habitat (with reference to Ranunculion fluitantis and Callitricho-Batrachion vegetation), bats (works affecting trees, walls, built structures and bridges), breeding birds, water quality, flow and hydromorphology
- Consultation required with SNH and SEPA.
- Habitat: The area of the proposed bypass channel is a National Forest Inventory with broadleaved trees, low density vegetation and young trees.
- Trees; TPO: A few trees may need to be removed. Mitigation planting to be considered at detailed design.
- No land contamination constraints identified.

Health and safety hazards noted

- Geotechnical and excavation works - In channel works, falling into excavations, collapse of the sides of excavation.
- Construction – flooding of works.

Social and community issues

The abandoned channel may be best accepted by the community if it is engineered to become a new community walkway or landscaped to provide an attractive appearance . This should be a minor problem since few properties near the Turfford Burn overlook the watercourse.

A footbridge over the new channel will be required as a minimum to retain access over the new channel onto the school playing fields.

Impact on other reaches

There is proposed to be increased flooding to the agricultural land either side of the main Turfford Burn channel at the end of the bypass channel. This relies upon embankment removal along the right bank of the site identified in the Local Development Plan4 as AEAR002 which is allocated for future housing. The flooding of this area of land is crucial to the functioning of the bypass channel in its modelled configuration as it attenuates some flow before passing to the lower reaches of the burn.

Additional information required

- A detailed topographic survey to inform detailed design of the channel which may differ from that used in the hydraulic model.

- Detailed buried services survey, plotting their position with regards to site works.
- Ground investigation.
- LIDAR data required to increase confidence in hydraulic model before outline design.

Additional works required to account for increase in 200 year flow due to climate change

- A larger single channel or two-stage channel could be constructed to accommodate a larger flow but this may begin to have too great a land-take to be acceptable to the school and community. Other areas of the burn such as upstream of the bypass channel inlet are likely to require direct defences to avoid flood waters overtopping the burn and flowing towards properties.

4.9.3 Option 3 - Flood storage in the upper catchment

Option 3 - Flood storage in the upper catchment

Description

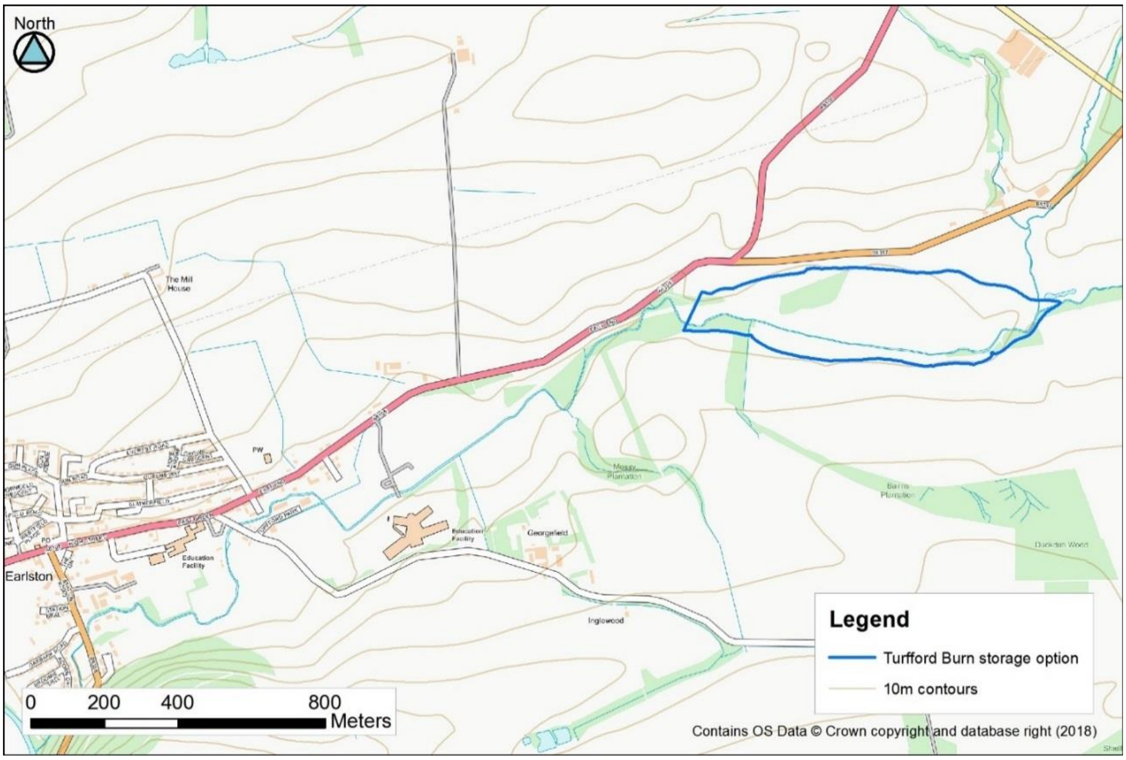
This option aims to provide flood attenuation in the upper catchment through construction of an embankment approximately 1km upstream of Earlston High School on the Turfford Burn. The work includes the following:

- Construction of an embankment on the Turfford Burn to retain the majority of floodwater in the upper catchment
- Construction of an orifice control unit to release stored water into the burn downstream at a rate which avoids flooding within Earlston.

A technical drawing relating to this option has been produced and is provided alongside this report, named as follows:
AEM-JBAU-EA-TB-SK-C-1300-Opt3_200Yr_Stor_&_Attenu-S3-P01.pdf

Analysis

Two locations were analysed for storage in the upper catchment with only one found to be suitable, as shown in the figure below.



A basic Flood Modeller model was built to test the attenuation of flows by creating an orifice opening and dam structure behind which water is stored. The storage behind the dam was based on an area/elevation relationship extracted from NEXTMap 5m DTM data.
The model was tested with an orifice area that attenuates flow to 4m^3/s in the downstream

reach (1m^3/s less than the flow that the current watercourse can convey before property flooding occurs). This flow equates to less than the 2% AP (50 year) event, allowing for minor flow contributions from small drains between the storage area and Earlston itself. The 2% AP event is estimated to result in the flooding of only two properties but significantly reduces flood risk from larger events. The residual risk to the two buildings (The Crossing House and the building comprising Turfford Park industrial units 1-3) could be mitigated through the retrofit of automatic PLP products or potentially through the raising of kerbs or small walls.

An orifice area of 2.9m^2 was required, resulting in a maximum water level in the storage area of 117.45mAOD, 3.45m above bed level. The results suggest that a 5m+ high structure would be required to store and attenuate flood flows in the upper catchment and that this could alleviate the majority of flooding occurring from the Turfford Burn.

An alternative site closer to the new Earlston High School was tested in the same manner but was found to have insufficient storage capacity to avoid flooding the A6105 road.

The structure itself would have aesthetic implications, and the occasional storage of large volumes of water directly upstream of an urbanised area would represent a new risk and a critical maintenance burden for the Council yet the reduction in property flooding would likely far outweigh the negative implications.

Standard of Protection (SOP)

The modelling suggests that this option would begin to take effect at flood events larger than the 20% AP (50 year) event and attenuate flows between the 50 year flow and the 0.5% AP (200 year) flow. At larger flows only the proportion of the flow equating to the 200 year flow would be attenuated, with any additional volume spilling over the embankment. Two properties would continue to flood at the 50 year event, meaning that PLP or other measures would need to be introduced to increase their resilience.

Alternative quick wins

There are no quick win alternatives for this option. Providing storage for smaller magnitude flood events only would not protect a large number of properties.

Geotechnical issues

Buried services in the proposed area of defence have not been investigated due to the sites location outside the main town. A full buried services investigation should be undertaken at the time of detailed design.

Design to take cognisance of historical railway cutting, mill pond and gravel fill which all may have been subject to infilling with materials of unknown provenance.

Services

Overhead and underground services have been identified and their location is shown on drawing AEM-JBAU-EA-TB-SK-C-1002-TB_Services.

No services information was provided for the current study for the area upstream of Earlston where the storage area would be located thus this information should be reviewed at outline design stage.

Construction access

Construction access likely to be possible through agricultural land to the north.

- Construction would entail heavy machinery working along the bank with possible in-channel working and bank repair works.

Waste

- Waste material: Assumed to be 50% of the embankment volume to allow for foundation and cut-off requirements. Expected quantity of waste: 3,250m^3.
- Nature (inert, non-hazardous, hazardous): It is understood that no industry was present in Earlston – soil expected to be inert.
- Temporary storage of topsoil and subsoil in heaps and stockpiles.
- Production of waste including silt, dust and construction waste. Further investigation required through GI into level of contamination and ownership. All waste produced during construction should be contained and prevented from entering the watercourse. Stock piles of soil and non-toxic spoil and construction waste should be located away from the river (at least c.10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works.

Environmental issues

- Habitat: The area of the proposed defences is a National Forest Inventory with broadleaved trees and conifer. Opportunities for biodiversity enhancements such as creation of wet woodland or wetland for waders and wildfowl.
- Trees; TPO: A few trees may need to be removed. Compensatory planting to be considered at detailed design stage - one potential area for planting is the area between the storage area and the A6105/B6397
- Statutory Environmental Designations: Leader Water and the Turfford Burn are part of the River Tweed SAC. Habitats Regulations Appraisal (HRA) and Appropriate Assessment are required
- Additional surveys and assessments may be required for otter, water vole, fish (with particular reference to Atlantic salmon, brook lamprey and river lamprey, habitat (with reference to Ranunculion fluitantis and Callitricho-Batrachion vegetation), bats (works affecting trees, walls, built structures and bridges), breeding birds, water quality, flow and hydromorphology
- Consultation required with SNH and SEPA.
- The Council have advised that a mill pond, gravel pit and sheepwash are known to have existed in the area proposed for flood water storage so an assessment of their implications on water quality may be required.

Health and safety hazards noted

- Geotechnical and excavation works - In channel works, falling into excavations, collapse of the sides of excavation.
- Construction – flooding of works.
- Periodic storage of large volumes of flood water upstream of the town presents a new risk to properties.

Social and community issues

Whilst these measures have little visible impact within Earlston there are likely to be some objections.

Flooding on the scale that has been seen in recent years would still occur since the storage area would contain flows up to the 20% AP (50 year) event.

Impact on other reaches

The storage area will attenuate large flood flows and have a beneficial impact downstream. At low return periods no attenuation will occur, giving a neutral impact.

Additional information required

- A detailed topographic survey to inform detailed design of the channel which may differ from that used in the hydraulic model.
- Detailed buried services survey, plotting their position with regards to site works.
- Ground investigation.
- LIDAR data required to increase confidence in hydraulic model before outline design.

Additional works required to account for increase in 200 year flow due to climate change

Additional storage could be utilised by constructing a larger embankment to hold back water for potential climate change increases in river flows. The 0.5% AP (200 year) event plus climate change event would equate to a flow of 24m^3/s and would require an additional 0.8m of height on the embankment to accommodate a maximum water level of 118.2mAOD.

4.9.4 Option 4 - Property Level Protection (PLP)

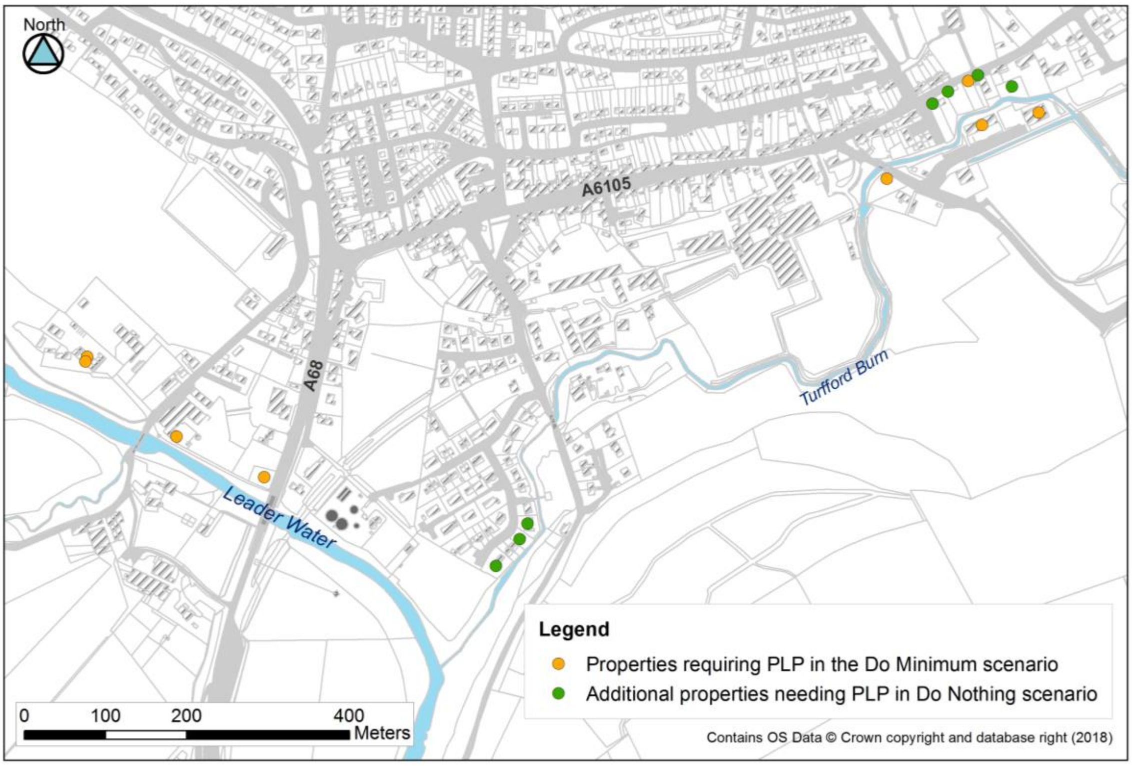
Option 1 - Property Level Protection (PLP)

Description

PLP could be offered as a standalone option to the few properties in Earlston at flood risk which all appear to be suitable for PLP products. In the absence of Flood Warning on the Turfford Burn and in the interest of reliability these properties would need to be fitted with passive PLP products that do not require manual operation and therefore advanced warning of a flood. Similarly, those properties at risk from flooding of the Leader Water are recommended to be fitted with passive products to ensure that properties remain protected when the owners are absent.

Analysis

Property suitability for PLP was determined by identifying the properties that are predicted to flood to a depth of between 0 and 0.6m. Of this subset only those properties that benefit from PLP products during floods with an annual probability of up to 0.5% AP (200 year) are included but this does not exclude properties that show an additional benefit during larger magnitude flood events.



In total 8 properties (4 on each watercourse) were found to be able to benefit from PLP products up to the 0.5% AP (200 year) flood event but their individual suitability would need to be assessed by site survey. Units 1-3 in Turfford Park industrial estate have been grouped as one property for the property damage assessment but have been costed for separately below. More bespoke or costly measures may be required for these units and Border Farm Supplies due to the construction of the buildings - further investigation into the possible measures is required.

The figure above shows the additional properties that may be suitable for PLP in the Do Nothing scenario. Whilst it is not expected that the Do Nothing scenario will be realised, uncertainty in the DTM used in the modelling and hydrological estimates on the Turfford Burn potentially make protecting these additional seven properties a sensible option to further improve resilience.

No technical drawing has been produced for this option.

Standard of Protection (SOP)

All properties identified are expected to be able to achieve at least a 1% AP (100 year) standard of protection through the use of PLP products, assuming passive PLP is used rather than manually operated products. 7 of the 8 properties also achieve a 0.2% AP (500 year) standard of protection.

Alternative quick wins / Preliminary investigations

Those properties identified could make use of the councils PLP discount scheme in order to fast-track the potential benefits of this option, but suitable surveyors/suppliers would need sought by individual property owners and passive products are likely to have significant additional cost implications.

In some cases, minor modifications to the grounds of the property, i.e. a raised lip on the driveway may be enough to deflect flows away from the property.

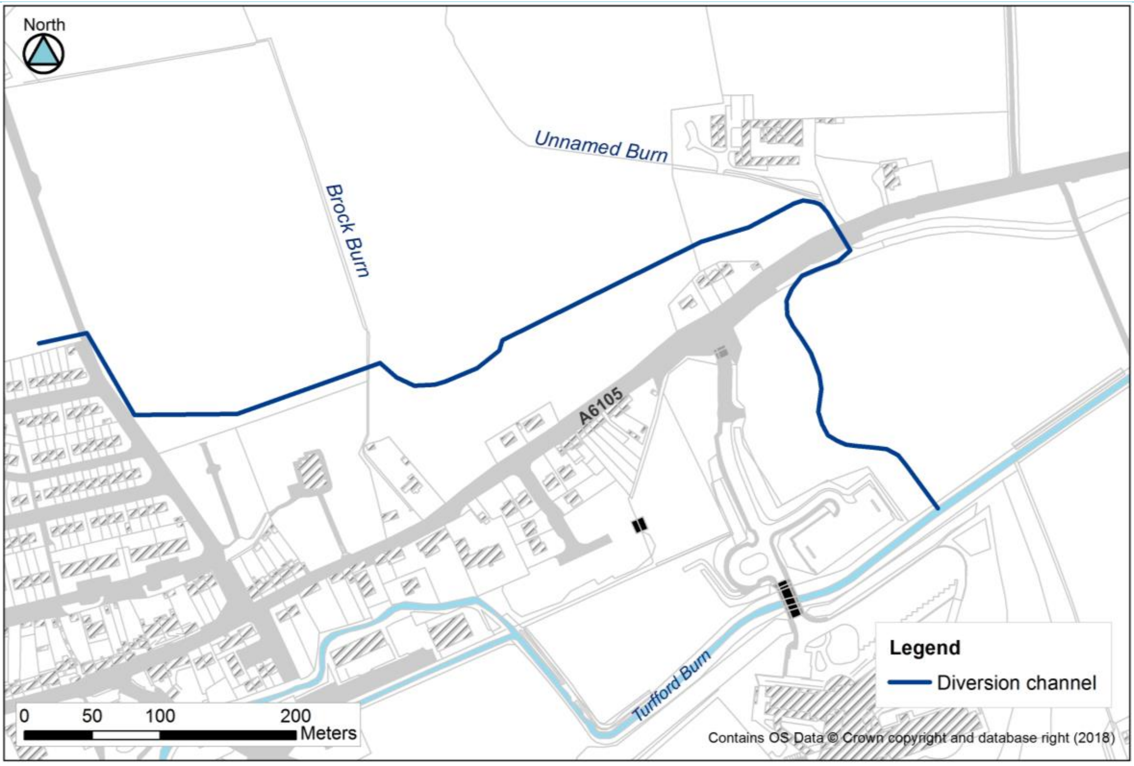
Technical issues Each properties' suitability for PLP products would need to be individually assessed by competent surveyors and PLP solutions would need to be selected or designed and fitted by competent contractors.
Construction issues Some, particularly non-residential properties, may require bespoke PLP products and building remedial works may be required to allow the products to work effectively. This will increase the estimated costs.
Social and community issues This option may not be accepted by the community as the only means of addressing flood risk in Earlston
Additional works required to account for increase in 200 year flow due to climate change Standard PLP products tend to be limited to an effective height of 0.6m to preserve the integrity of property walls. Since 0.6m has been used as an upper limit for flood depths in the analysis for this option a higher standard of protection, such as to account for climate change, could only be achieved by incorporating this option with more significant measures such as those options discussed above. PLP will provide 4 of the properties with a high enough standard of protection to alleviate flooding to the 0.1% AP (1000 year) flood event and 3 of the remaining 4 would benefit from protection to the 0.2% AP (500 year) event which is estimated to be slightly smaller than the 0.5% AP (200 year) plus climate change event.

4.10 Flood Mitigation Options - Brock Burn

The following section details the constraints and benefits of the shortlisted options on the Brock Burn. A plan, included in the Figures section at the end of the report, shows the location and extents of the various interventions.

4.10.1 Option 1 - Surface water diversion bund

Option 1 - Surface water diversion bund
Description This option aims to redirect surface water that typically flows into the Brock Burn into a new channel that is culverted under the A6105 road and ultimately flows into the Turfford Burn. The work includes the following: • Construction of a new channel across the agricultural land oblique to the flow of the unnamed burn and Brock Burn. • Construct culvert beneath A6105.



A technical drawing relating to this option has been produced and is provided alongside this report, named as follows:

AEM-JBAU-EA-BB-SK-C-1100-Opt1_200Yr_Open_Channel-S3-P01

Standard of Protection (SOP)

This option protects against the 0.5% AP (200 year) 10 hour winter rainfall event which was found to have the largest flood extent of the scenarios tested.

Alternative quick wins / Preliminary investigations

NFM could be investigated further as it may be possible to hold more water within the agricultural land than at present.

The land through which the diversion channel flows is allocated for Business and Industrial use in the Earlston Local Development Plan[4] and it is therefore possible that these works could be incorporated into the development and be carried out by the developer rather than the Council.

Geotechnical issues

- A full GI will be required at a later stage in the project.

Services

Overhead and underground services have been identified and their location is shown on drawing AEM-JBAU-EA-TB-SK-C-1002-TB_Services.

There are no buried services identified on the plans close to the proposed works but an overhead telecommunications line is shown close to the edge of the diversion channel between the A6105 and the Turfford Burn. This should be reviewed at outline design stage.

Construction access

Access likely to be possible off the A6105 into agricultural land to the north and south.

Waste

- Waste quantity of waste material: Approximately 3,487m^3.
- Nature (inert, non-hazardous, hazardous): It is understood that no industry was present in Earlston – soil expected to be inert.
- All waste produced during construction should be contained and prevented from entering the watercourse. Stock piles of soil and non-toxic spoil and construction waste should be located away from the river (at least c.10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works.

JBA consulting

Environmental issues

- Habitat: The area of the site downstream of the A6105 channel is within the National Forest Inventory for its broadleaved trees, low density vegetation and young trees.
- Listed Buildings: Earlston Cemetery west of Brock Burn is listed.
- Statutory Environmental Designations: Leader Water and the Turfford Burn are part of the River Tweed SAC. Habitats Regulations Appraisal (HRA) and Appropriate Assessment are required.
- Additional surveys and assessments may be required for otter, water vole, fish (with particular reference to Atlantic salmon, brook lamprey and river lamprey, habitat (with reference to Ranunculion fluitantis and Callitricho-Batrachion vegetation), bats (works affecting trees, walls, built structures and bridges), breeding birds, water quality, flow and hydromorphology.
- Course of the diverted channel south of the A6105 should be adjusted as necessary to minimise loss of mature trees bordering the road which screen the school from the road.
- Consultation required with SNH and SEPA.

Social and community issues

Very few community impacts other than the minor visual impact. The agricultural land is primarily grazing land so should not be impacted by a gradual 0.8m deep channel. The works to take the new channel underneath the A6105 may cause temporary traffic disruption.

Impact on other reaches

The works may increase the flow in the Turfford Burn since the water courses will be better connected than at present. Currently water is ponding on the A6105 and this option does not attenuate the flows in the same way, thus increasing the runoff rate into the Turfford Burn. At outline design stage some small attenuation ponds could be added to the design for the diversion channel.

The land is allocated for Business and Industrial use under the Earlston Local Development Plan[4] (site BEARL002) and as such it may be possible to attenuate some of this flow with sustainable urban drainage design in any proposed development on this site or to use NFM to store additional water within the land if it is not developed.

Additional information required

- A detailed topographic survey to inform detailed design of the channel which may differ from that used in the hydraulic model.
- Detailed buried services survey, plotting their position with regards to site works.
- Ground investigation.
- LIDAR data required to increase confidence in hydraulic model before outline design.

Additional works required to account for increase in 200 year flow due to climate change

Climate change simulations were not performed for the surface water mapping and thus it has not been possible to estimate the size of the channel required to accommodate the 200 year plus climate change flow. The flow in the channel is expected to be small so a 33% increase could likely be accommodated through a slight increase in the depth or width of the channel.

4.11 Residual risk

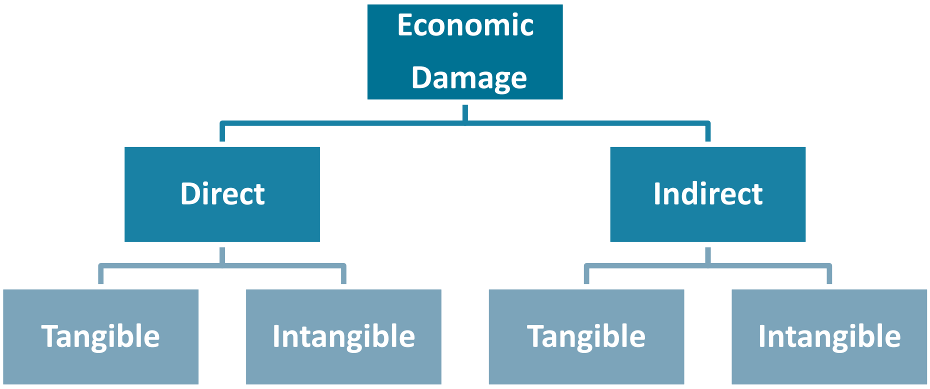
With the exception of the PLP option the options presented above treat the flood risk from the Leader Water and Turfford Burn separately. If protection from both watercourses is sought, then options will need to be combined into an Earlston-wide option.

5 Investment appraisal

5.1 Damage methodology

Flood damage assessment can include direct, indirect, tangible and intangible aspects of flooding, as shown in the Figure 5-1. Direct damages are the most significant in monetary terms, although the MCM and additional research provide additional methodologies, recommendations and estimates to account for the indirect and intangible aspects of flood damage.

Figure 5-1: Aspects of flood damage



Flood damage estimates have been derived for the following items:

1. Direct damages to residential properties;
2. Direct damages to commercial and industrial properties;
3. Indirect damages (emergency services);
4. Intangible damages associated with the impact of flooding;
5. Damage to vehicles;
6. Emergency evacuation and temporary accommodation costs.

The assumptions and additional data used to calculate the flood damages is provided in Appendix A.

5.2 Baseline Damages

Baseline damage results are presented for the Do Nothing and Do Minimum options overleaf.

Do Nothing

Assumptions:

Maintenance ceased, increasing hydraulic roughness due to vegetation growth and degradation of banks for both watercoures. The FPS control screen has a history of blockage, despite regular maintenance so this is assumed to block by two-thirds (60%) and the FPS culvert is at present blocked by 10% due to sediment so this is assumed to increase to 20% in the Do Nothing scenario. No history of bridge blockage on the burn so no blockage assumed on any of these structures. On the Leader Water no bridge blockage is assumed since bridges are all large.

Properties at risk:

The total number of properties inundated above threshold level for the Do Nothing Scenario in Earlston has been assessed and is provided in the table below.

Return period (years)	2	5	10	25	30	50	75	100	200	500	1000
Residential	1	1	1	2	2	2	4	5	11	27	38
Non-residential	0	0	1	1	1	2	2	2	4	7	8
Total	1	1	2	3	3	4	6	7	15	34	46

Key beneficiaries:

The flood damages derived have been ranked and assessed in terms of the proportion of flood damages per property. This highlights key beneficiaries of the scheme and is a useful auditing tool. The top ten properties are listed in the table below. The top two properties contribute a large percentage of the overall damages, making any future scheme dependent on the accuracy of the damage estimates for these properties. They should therefore be surveyed in detail at outline design stage to ensure their estimated damages are appropriate.

Rank	Property address	PVd (£k)	Percentage of total PVd
1	The Crossing House, TD4 6BH	223	28.7%
2	Units 1-3, Turfford Park Industrial Estate, TD4 6GZ	210	27.0%
3	Austin Coach Travel, TD4 6DG	73	9.4%
4	Leader Cottage, Melrose Road, TD4 6DL	64	8.3%
5	Border Farm Supplies Ltd, Turfford Park, TD4 6GZ	33	4.2%
6	CM Welsh Building Services (1), Rhymers Mill, Mill Road, TD4 6DG	21	2.7%
7	CM Welsh Building Services (2), Rhymers Mill, Mill Road, TD4 6DG	20	2.6%
8	Rhymers Mill Cottage, Mill Road, TD4 6DG	16	2.1%
9	27 Acorn Drive, TD4 6BW	10	1.2%
10	13 Acorn Drive, TD4 6BW	9	1.2%

Event property damages:

JBA's damage calculation method provides event damages based on MCM depth damage curves. Full results are provided in Appendix B. These represent the total potential flood damages based on the modelled flood level. Damages include all direct and indirect property flood damages.

Return period (years)	2	5	10	25	30	50	75	100	200	500	1000
Residential (£k)	6	16	20	49	52	56	74	103	244	690	1,275
Non-residential (£k)	0	0	34	51	54	92	110	133	284	847	1,450
Total (£k)	6	16	54	100	106	148	184	236	528	1,537	2,725

The above damages are used to calculate Annual Average Damages (AAD). Plotting the damages against the frequency of flooding (annual probabilities) allows us to determine the AAD as the area beneath the curve. This figure shows that flood damages are relatively small for the lower to medium flood events but rise significantly once the flood defences are exceeded.

Intangible & intangible damages:

A summary of the proportion of total damages by each damage component is provided in the table below.

Do Nothing flood damages (£k):

Total AAD	Property PVd	Indirect PVd	Intangible PVd	Total PVd
27	781	34	15	815

Do Minimum

Assumptions:

Maintenance carried out as scheduled, present-day hydraulic roughness representative of a winter scenario with no bridge blockage. The diversion channel culvert is expected to remain partially blocked with sediment at 10% blockage and the screen on the diversion channel orifice is assumed to be 1/3rd blocked.

Properties at risk:

The total number of properties inundated above threshold level for the Do Minimum Scenario in Earlston has been assessed and is provided in the table below.

Return period (years)	2	5	10	25	30	50	75	100	200	500	1000
Residential	0	1	1	1	1	1	2	2	4	11	26
Non-residential	0	0	0	1	1	1	1	2	4	6	7
Total	0	1	1	2	2	2	3	4	8	17	33

Key beneficiaries:

The flood damages derived have been ranked and assessed in terms of the proportion of flood damages per property. This highlights key beneficiaries of the scheme and is a useful auditing tool. The top ten properties are listed in the table below. The top three properties contribute a large percentage of the overall damages, making any future scheme dependent on the accuracy of the damage estimates for these properties. They should therefore be surveyed in detail at outline design stage to ensure their estimated damages are appropriate.

Rank	Property address	PVd (£k)	Percentage of total PVd
1	The Crossing House, TD4 6BH	127	33.5%
2	Units 1-3, Turfford Park Industrial Estate ,TD4 6GZ	93	24.5%
3	Austin Coach Travel, TD4 6DG	47	12.2%
4	Leader Cottage, Melrose Road, TD4 6DL	18	4.8%
5	Border Farm Supplies Ltd, Turfford Park, TD4 6GZ	16	4.2%
6	CM Welsh Building Services (1), Rhymers Mill, Mill Road, TD4 6DG	14	3.6%
7	CM Welsh Building Services (2), Rhymers Mill, Mill Road, TD4 6DG	13	3.3%
8	Rhymers Mill Cottage, Mill Road, TD4 6DG	9	2.3%
9	Mullach Ruadh, TD4 6BH	5	1.3%
10	27 Acorn Drive, TD4 6BW	4	1.1%

Event property damages:

JBA's damage calculation method provides event damages based on MCM depth damage curves. Full results are provided in Appendix B. These represent the total potential flood damages based on the modelled flood level. Damages include all direct and indirect property flood damages.

Return period (years)	2	5	10	25	30	50	75	100	200	500	1000
Residential (£k)	0	9	13	20	21	23	53	56	92	291	673
Non-residential (£k)	0	0	0	33	38	48	54	87	156	436	1,202
Total (£k)	0	9	13	52	59	71	108	143	248	727	1,875

The above damages are used to calculate Annual Average Damages (AAD). Plotting the damages against the frequency of flooding (annual probabilities) allows us to determine the AAD as the area beneath the curve. This figure shows that flood damages are relatively small for the lower to medium flood events but rise significantly once the flood defences are exceeded.

Intangible & intangible damages:

A summary of the proportion of total damages by each damage component is provided in the table below.

Do Minimum flood damages (£k):

Total AAD	Property PVd	Indirect PVd	Intangible PVd	Total PVd
13	380	16	12	409

5.3 Options

The flood damages for each option were calculated for each return period up to the 1% AP (1000 year) event. Average annual flood damages were converted to present value damages using the discount factor and the residual damages for each option were compared against the flood damages estimated for the Do Nothing scenario. This comparison shows the damages avoided as a result of the options' interventions, also known as the benefit.

In line with current guidance[5] the PLP option was factored to account for the effectiveness and performance of measures and availability of homeowners to install and operate the measures. PLP was assumed to be 84% effective.

5.4 Damage benefit summary

The table below summarises the damages avoided for each option. The results show that each of the options assessed significantly reduce flood damages in the order of £443-656k, leaving low residual present value damages in the range £115-656k. The Do Minimum option has a substantial benefit over the Do Nothing option.

Table 5-1: Damage benefit summary (£k)

	Both	Both	Leader Water	Turfford Burn	Turfford Burn	Turfford Burn	Both
Option name	Do Nothing	Do Minimum	Direct defences	Bypass channel	Total bypass	Storage	PLP
Standard of Protection	<2	2	200	200	200	2*	100+
BENEFITS:							
PV monetised flood damages (£k)	830	409	388	174	174	364	115
Total PV damages avoided/ benefits (£k)	-	422	443	656	656	466	601**

Notes:
* Does provide a high standard of protection for some properties however others are still at risk so this option would need to be combined with PLP.
** PLP benefits are scaled down by 16% to account for the likelihood of PLP products only being 84% effective.

5 Post-Installation Effectiveness of Property Level Flood Protection, Final Report FD2668, 2014, DEFRA

6 Cost estimates

6.1 Price Base Date

The price base date is January 2018. The costs and benefits have been discounted over the 100 year life of the scheme to determine present values.

6.2 Whole life cost estimates

Whole life costs are typically compiled from the following four key cost categories:

1. Enabling costs. These costs relate to the next stage of appraisal, design, site investigation, consultation, planning and procurement of contractors.
2. Capital costs. These costs relate to the construction of the flood mitigation measures and include all relevant costs such as project management, construction and materials, licences, administration, supervision and land purchase costs (if relevant).
3. Operation and maintenance costs. Maintenance of assets is essential to ensure that the assets remain fit for purpose and to limit asset deterioration. Costs may include inspections, maintenance and intermittent asset repairs/replacement.
4. End of life replacement or decommissioning costs. These costs are only required when the design life of assets is less than the appraisal period. Most assets are likely to have a design life in excess of the 100 year financial period but PLP is expected to have a 25 year design life so repeat costs have been included in the cost estimate for PLP.

The Environment Agency's 'Long Term Costing' tool (2012) was the basis of all costs for this assessment to provide a uniform approach to costing across the flood studies. The design specifics of the different flood risk management measures are based on the hydraulic modelling outputs and as such have the same limitations as the model. This relates specifically to the low confidence in bank levels in some areas of the model domain, as detailed in section 2.7.1.

Whole life (present value) costs have been estimated based on the above enabling, capital and maintenance costs. The following assumptions have been made:

1. The life span of the scheme and appraisal period is 100 years.
2. Discounting of costs are based on the standard Treasury discount rates as recommended by the 2003 revision to the HM Green Book (3.5% for years 0-30, 3.0% for years 31-75 and 2.5% for years 76-99).
3. Capital costs are assumed to occur in year 1 (equivalent to 2019).
4. Enabling costs occur in year 0.
5. An optimism bias of 60% has been applied and is representative of a scheme at the appraisal design stage of development. This provides a significant safety factor for cost implications and risks.

6.3 Maintenance costs

The EA Long Term Costing tool was used to calculate maintenance costs. These maintenance costs account for a default set of maintenance regimes for associated annual or frequent operation and maintenance activities.

The costs used assume efforts are made to maintain assets at condition grade 2 (Good) using the grading system described in the Environment Agency's asset condition assessment manual[6]. Average costs were used - between lower and upper bounds reproduced in the report - given the absence of detailed maintenance plans at this early design stage of development.

6.4 Optimism bias

An optimism bias of 60% has been applied and is representative of a scheme at the appraisal design stage of development. This provides a significant safety factor for cost implications and risks. This uplift is applied to present value capital and present value maintenance costs after their calculation.

6 Condition Assessment Manual (CAM) (Environment Agency, 2012)

6.5 Leader Water - Option 1 - Direct defences with 200-year standard of protection

This option consists of the following measures:

- Approximately 230m long embankment 0.7m high near Mill Road.
- A concrete wall, approximately 415m long along the river bank either side of Mill Road, up to 0.85m high.

Costs are based on achieving a 200-year standard of protection and on near immediate initiation of works.

Table 6-1: Unit and total estimated costs

Location	Typical defence height	Length / Volume	Unit cost	Total Cost (Rounded)
Embankment in agricultural land	0.7	2868m^3	£120	£343,140
Wall north of Mill Road	0.85	240m	£1.428	£342,743
Wall south of Mill Road	0.3	175m	£1,428	£249,917
Excavation and tipping	-	2,271m^3	£125	£283,989
			Total Capital cost	£1,219,788

Table 6-2: Total cash and Present Value (PV) option costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	84	84
Capital cost	1,220	1,179
Maintenance cost	89	25
Total	**1,393**	**1,288**
Total incl. Optimism Bias	-	2,061

6.6 Turfford Burn - Option 1 - Bypass channel with 200-year standard of protection

This option consists of the following measures:

- Construction of 340m long shallow bypass channel across the High School athletics pitch
- Lower the left bank of the burn at the channel inlet.

Costs are based on achieving a 200-year standard of protection and on near immediate initiation of works.

Table 6-3: Unit and total estimated costs

Location	Typical defence height	Length / Volume	Unit cost	Total Cost (Rounded)
New Bypass channel	-	340m	£1,310	£495,364
Road Lowering	-	100m	£1,175	£117,500
Embankment Reprofiling	-	400m	£75	£30,000
Other costs – land purchase	-	2.13acre	£2,500	£5,321
			Total Capital cost	£648,185
Note: A 10% contingency cost has been applied to the capital cost of new channel construction due to the high enabling costs likely as part of this option. Whilst costs of the different elements of the scheme would be relatively low the consultation and licensing fees associated with implementing these elements are likely to be high.				

Table 6-4: Total cash and Present Value (PV) option costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	28	28
Capital cost	643	621
Maintenance cost	34	10
Total	**705**	**659**
Total incl. Optimism Bias	-	1054

6.7 Turfford Burn - Option 2 - Total bypass of the burn with 200-year standard of protection

This option consists of the following measures:

- Bypass Channel: Approximately 415m long and 14m average width.
- New Culvert: Approximately 30m long, culvert units 3m wide and 1.5m high.
- Embankment Removal: Left embankment approximately 1,500m^2 and right embankment approximately 740m^2. The height of the embankments is assumed to be 1m.

Costs are based on achieving a 200-year standard of protection and on near immediate initiation of works.

Table 6-5: Unit and total estimated costs

Location	Typical defence height	Length / Volume	Unit cost	Total Cost (Rounded)
New Bypass channel	-	415m	£1,800	£747,000
Culvert	-	30m	£8,394	£251,807
Embankment Reprofiling	1m	1615m^3	£211	£30,000
Other costs – land purchase	-	1.44acre	£2,500	£3,589
			Total Capital cost	£1,032,396

Table 6-6: Total cash and Present Value (PV) option costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	118	118
Capital cost	1,032	997
Maintenance cost	53	15
Total	**1,203**	**1,130**
Total incl. Optimism Bias	-	1,808

6.8 Turfford Burn - Option 3 - Upstream Storage with a 50-200-year standard of protection

This option consists of the following measures:

- Embankment: 80m long embankment, max height 4.7m.
- Outlet structure: A 2.9m^2 precast concrete culvert with 1.4x2.1 penstock fitted to the upstream headwall.
- Storage: Approximately 190,500m^2 of storage area.

Costs are based on achieving a 200-year standard of protection and on near immediate initiation of works.

Table 6-7: Unit and total estimated costs

Location	Typical defence height	Length / Volume	Unit cost	Total Cost (Rounded)
Embankment	4.7m max	6,448m³	£81	£541,221
Storage	3m	270,933m³	£5.5	£1,803,576
Outfall	2.9m²	30m	£7,299	£224,962
Excavation and tipping (embankment only)	-	50m³	£125	£6,253
			Total Capital cost	£2,576,013

Table 6-8: Total cash and Present Value (PV) option costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	253	253
Capital cost	2,576	2,489
Maintenance cost	1,033	294
Total	**3,863**	**3,036**
Total incl. Optimism Bias	-	4,857

6.9 Earlston - PLP

The costs for this option are derived from an estimate of the number of properties of different types that are likely to require PLP. These different property types are shown in Table 6-9. The base cost data is taken from the Scottish Government guidance document on PLP (2014)[7]. Whilst 8 properties were found to be suitable for PLP, one of these properties is the building comprising Units 1-3 in Turfford Park Industrial Estate. These units have therefore been included as three separate buildings for costing purposes to account for the number of doors in the property. Whilst the middle estimate of costs has been used for the residential properties the upper estimate has been used for these non-residential properties due to the likelihood that more bespoke and thus costly PLP measures are likely to be required due to the buildings steel fabrication and large entrances.

Table 6-9: Unit and total estimated capital costs

Property type	Count	Capital cost - mid range automatic
Detached	3	£25,149
Semi-detached	2	£15,716
Terraced	1	£4,492
Office (Turfford Park properties)	4	£73,932
Total	10	£119,289

Table 6-10: Total cash and Present Value (PV) option costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	12	12
Capital cost	596	231
Maintenance cost	200	57

7 Assessing the Flood Risk Management Benefits of Property Level Protection, Scottish Government (2014)

Element	Cash cost (£k)	PV Cost (£k)
Total	**808**	**299**
Total incl. Optimism Bias	-	479

6.10 Brock Burn - Option 1 - Diversion channel with 200-year standard of protection

This option consists of the following measures:

- Diversion Channel: Approximately 980m long and 5.4m wide.
- New culvert: A concrete precast culvert, approximately 20m long and 1.75m wide by 1m high, to be constructed under the A6105 road.

Costs are based on achieving a 200-year standard of protection and on near immediate initiation of works.

Table 6-11: Unit and total estimated costs

Location	Typical defence height	Length / Volume	Unit cost	Total Cost (Rounded)
Diversion Channel	0.8m	980m	£288	£430,170
New culvert under A6105 road	1.75 x 1m	20m	£5,717	£114,347
Other costs – Land purchase	-	1.31acre	£2,500	£3,269
			Total Capital cost	£544,786

Table 6-12: Total cash and Present Value (PV) option costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	75	75
Capital cost	545	530
Maintenance cost	105	30
Total	**725**	**635**
Total incl. Optimism Bias	-	1,016

6.11 Summary of whole life costs

The table below summarises all Present Value costs for all of the short-listed options:

Table 6-13: Summary of PV costs for all options

Option	PV Cost (£k)
1 - Leader Water - Direct defences	2,061
2 - Turfford Burn - Bypass channel	1,054
3 - Turfford Burn - Total bypass of the burn	1,808
4 - Turfford Burn - Storage	4,857
5 - Main watercourses - PLP	479
6 - Brock Burn - Diversion channel	1,016

7 Benefit-cost analysis

7.1 Introduction

This section discusses the economic appraisal carried out during this study. The methods of calculating the benefits and costs are outlined together with an assessment of the benefit-cost ratios for the range of options assessed. Benefit cost analysis looks at a flood risk management strategy or practice and compares all the benefits that will be gained by its implementation to all the costs that will be incurred during the lifetime of the project. In accordance with the FCERM appraisal guidance, benefits are taken as annual average damages avoided, expressed as their present value using Treasury discount rates. These are compared with the whole life cost of the capital and maintenance costs of selected options, expressed as present value. If the benefits exceed the costs for the option, the scheme is deemed to be cost effective and worthwhile for promotion.

Benefits are assessed as the flood damages that will be avoided by the implementation of a project. To calculate the benefits it is necessary to assess the damages that are likely to occur under both the Do Nothing and Do Something scenarios. The benefits of any particular Do Something option can then be calculated by deducting the Do Something damages from the Do Nothing damages.

7.2 Benefit-cost results

The benefit cost results for the shortlisted options are provided in the table below. None of the 'Do Something' options have been found to be cost effective aside from the Property Level Protection option.

Table 7-1: Benefit cost ratio for options in Earlston(£k)

	Do Nothing	Do Minimum	Direct Defences - Leader Water	Bypass channel - Turfford Burn	Total bypass - Turfford Burn
PV Costs (£k)	-	-	1,288	659	1,130
Optimism Bias (60%)	-	-	773	395	678
Total PV Costs (£k)	-	-	2,061	1,054	1,808
PV damage (£k)	830	409	388	174	174
PV damage avoided (£k)	-	422	443	656	656
Net present value (£k)	-	422	-1,618	-398	-1,152
Benefit-cost ratio	-	-	0.2	0.6	0.4

Table 7-1 continued:

	Storage - Turfford Burn	PLP
PV Costs (£k)	3,036	299
Optimism Bias (60%)	1,822	180
Total PV Costs (£k)	4,857	479
PV damage (£k)	364	115
PV damage avoided (£k)	466	601
Net present value (£k)	-4,391	122
Benefit-cost ratio	0.1	1.3

The PLP option is the only option that is economical due to the high cost of the other options and the low overall flood damages for Earlston. The Net Present value for the Do Minimum option is higher than that for PLP but this is not a proactive means of flood risk alleviation so the PLP option should be progressed alongside the quick win measures identified in Section 4.3. A 1% AP (100 year) standard of protection can be achieved by installing PLP on the 8 properties at risk. The table below shows how many of these 8 properties benefit at different flood magnitudes.

Table 7-2: Number of properties at risk in the Do Minimum and PLP options

Return period (years)	2	5	10	25	30	50	75	100	200	500	1000
Do Minimum	0	1	1	2	2	2	3	4	8	17	33
With PLP	0	0	0	0	0	0	0	0	1	10	29
Difference	0	-1	-1	-2	-2	-2	-3	-4	-7	-7	-4

7.2.1 Brock Burn

Damage estimation for the Brock Burn has not been carried out so no benefit-cost calculation can be performed. The costs for the proposed bypass channel are listed in Table 6-11 and Table 6-12 and are high for the qualitative benefits that would be achieved. This option seeks to alleviate the nuisance surface water flood risk to the East End. How this is funded outwith a scheme requires discussion, although there remains a possibility that these works could be undertaken or funded as part of any future development on the site as earmarked in the Local Development Plan. This should be considered further by the Council when in discussion with potential developers for this site.

7.3 Residual risks

The PLP option offers a minimum of 100 year standard of protection but 7 of the 8 properties are estimated to be protected against the 0.2% AP (500 year) reducing property flood damages and leaving comparatively little risk. Nevertheless, a range of additional actions are proposed which could be used either in the interim prior to scheme agreement or to further reduce this residual risk:

- Natural Flood Management (NFM) practices could aid in reducing flows on both main watercourses in Earlston and provide some resilience to climate change. A detailed NFM modelling study should be carried out to inform the placement of NFM measures and attempt to quantify the benefits of these practices here. LIDAR data, if available, should be purchased to allow this modelling to the undertaken.
- The quick win measures identified in Section 4.3 - which focus almost wholly on channel maintenance on the Turfford Burn - should be carried out and checked on a regular basis to reduce unnecessary flood risk.
- Flood warning should be maintained on the Leader Water and some level of warning introduced on the burn in the form of a level gauge or third-party warning system.

8 Public Consultation

A public consultation event was held in Earlston in October 2018 to gauge opinion on the flood mitigation options proposed as part of this study. Few residents attended the event, with the attendee list being dominated by members of Earlston Community Council, of which few are at flood risk.

As expected, there was an understanding that there is a flood problem in Earlston given the past flooding that has occurred on the Turfford Burn and to agricultural land next to the Leader Water. However, it was accepted that the number of properties at risk is low, making the design of cost-effective solution to this flood risk difficult. The only cost-effective option identified being the PLP option was not surprising to residents.

With regard to options on the Leader Water there were no immediate comments relating to acceptability to the community. On the Turfford Burn the preferred option was seen to be the diversion channel passing to the east of the High School playing fields due to its lesser impact on residents and school users when compared with the other options.

The owner of 27 Acorn Drive, notably at risk from both the Turfford Burn and Leader Water has purchased PLP products and is happy with the peace of mind that they provide. The owner suggested that Flood Warning on the Turfford Burn would be beneficial to allow timely placement of the products to protect the property. At present the Flood Warning on the Leader Water is used but mainly the owner monitors river levels on the SEPA website rather than relying on the warning. The owner also noted bank erosion which is directly undermining the garden of this property and those neighbouring. This issue has been reviewed by the Council separately and is not considered as part of this study.

One resident noted recent flooding of the parkland next to the Leader Water that sits northwest of Rhymers Mill. In the residents' 7 years living in Earlston this land has flooded twice, although no properties were flooded on either occasion. Similarly, there is knowledge within the community of flood waters having surrounded the waste water treatment works on the bank of the Leader Water in the recent past. The flood mapping carried out as part of this study agrees with these aspects of the flood history.

The resident of Rose Cottage on High Street has noticed that the properties parking space, located on the south side of High Street, opposite the property, has flooded to shallow depths approximately twice per year in recent years. This is thought to be from surface water from the hill to the north flowing past properties on High Street and onto the road and also ponding on the road due to a lack of drainage. Mitigation of this flooding is not considered in this study but is shown in the surface water flood maps.

The owner of Craigsford House on the right bank of the Leader Water has experienced garden flooding in the past and expressed concerns over proposed Leader Water flood defences constructed on the left bank impacting water levels and velocities on the right bank and affecting the garden. Water levels would be expected to rise as a result of construction of Leader Water defences but an assessment carried out for this project did not highlight any increase in property flood risk as a result. Garden flooding has not been considered.

9 Conclusions and recommendations

9.1 Summary

This report presents the results of a detailed flood risk appraisal for Earlston in relation to flooding from the Leader Water and Turfford Burn. Earlston has in the recent past suffered from some flooding from the Turfford Burn but there is little evidence of flooding from the Leader Water. 8 properties are estimated to be at risk of flooding from the 0.5% AP (200 year) flood event.

A detailed set of preliminary investigations was carried out ahead of this appraisal such that it was possible to inform discussion of flood protection options for Earlston. These investigations involved a review of Earlston's flood history, an assessment of the hydrological inputs to the watercourses, collection and review of survey data, a River Basin Management Plan review, an assessment of Natural Flood Management opportunities in the catchment, a Preliminary Ecological Appraisal, asset condition assessment and hydraulic modelling of the river.

The hydraulic model, consisting of a 1D-2D Flood Modeller Pro-TUFLOW model allowed generation of flood inundation maps for a range of Annual Probability (AP) flood events ranging from 50% AP (2 year) to 0.1% AP (1000 year). A number of scenarios were modelled to provide sufficient information on which to base the economic appraisal at a later stage in the study. These included the Do Nothing and Do Minimum scenarios with the former representing a 'walkaway' scenario where maintenance of the watercourses is ceased, and the latter representing present-day watercourse condition, assuming flood warning is maintained on the Leader Water.

Once these maps were produced it was possible to review flood flow pathways and progress from a wide-ranging long-list of potential flood protection options to a short-list of feasible solutions tailored to Earlston's flood risk problem. Mapping has been produced for the reach from the pedestrian suspension bridge at Haughhead on the Leader Water and new High School on the Turfford Burn down to a point several hundred metres downstream of the confluence of the two watercourses. The Brock Burn was modelled using a 2D model to simulate different rainfall events and produce surface water flood maps.

Several short-term measures were proposed which may assist in reducing flood risk to some properties. These include:

- Properties on the Leader Water already benefit from being within a SEPA Flood Warning area and this should be maintained. Warning should be setup on the Turfford Burn to provide some advanced warning and to increase the availability of hydrometric data.
- Natural Flood Management opportunities should be progressed where feasible through engagement with land owners and other stakeholders. Should NFM be progressed as part of a scheme funding should be sought through the scheme itself but in the shorter term it may be possible to secure funding through other sources if the focus can be widened from flood risk management to catchment and land management benefit. Further data (including LIDAR) and modelling should be considered to develop these opportunities further.
- Property Level Protection (PLP) could be purchased by the 8 properties at risk from the 200 year event with the aid of the Scottish Borders Council PLP discount scheme in advance of any possible flood protection scheme that might be implemented in the next flood risk management funding cycle or beyond. In addition, property owners should be made aware of the resilient communities sandbag store within Earlston as a temporary measure.
- Flood warning should be continued on the Leader Water and introduced on the Turfford Burn either through installation of a level gauge by SEPA or using a third-party system.
- The Council should work with potential developers to limit development in areas at risk or in areas identified in the options proposed. The Council should also ensure that the Brock Burn diversion channel is incorporated into any future development on the site.
- LIDAR for the town should be procured and incorporated into the model and the simulations re-run to improve confidence in the outputs.
- The details of this study should be incorporated into the councils Severe Weather Plan including the updated flood maps and location of the properties at risk.

A shortlist of flood protection options was produced and reviewed by comparing the expected benefit of the scheme (property damages avoided) with the estimated costs for scheme implementation and maintenance. There is only one shortlisted option on the Leader Water, consisting of direct defences with a 0.5% AP (200 year) standard of protection. On the Turfford Burn three options are proposed, all offering a 0.5% AP (200 year) standard of protection. Two of the options involve construction of new bypass channels to take flood flows away from the Georgefield Bridge area of the burn. The other option would require construction of an embankment upstream of the town to store flood waters, passing forward the 20% AP (50 year) flood event.

Property Level Protection (PLP) was included as an Earlston-wide option, providing protection for the 8 properties experiencing flooding up to 0.6m in depth. 'Automatic' or 'passive' PLP has been specified to reduce the likelihood of failure. The option provides 7 of the 8 properties with a 0.2% AP (500 year) standard of protection and the remaining property a 1% AP (100 year) standard.

A benefit-cost analysis has been undertaken for the present-day (Do Minimum) scenario and each of the above options. The Present Value flood damages calculated for the Do Minimum scenario are estimated to be £409,000. Costs for each option have been estimated using the Environment Agency's Long Term Costing tool (2012). An optimism bias factor of 60% has been added to the total capital costs to allow for uncertainties in design at this level of appraisal and is typical for schemes at an early stage of appraisal.

None of the structural options for either of the main watercourses have been found to be cost effective but the PLP option is, with a benefit cost ratio of 1.3. Whilst the PLP option is usually considered a short-term option the use of passive PLP measures should provide sufficient protection against the shallow flood depths expected. Furthermore, the small number of properties at risk of flooding means that a large structural option is disproportionate to the risk whilst PLP is less invasive for the wider community.

9.2 Recommendations

Based on the current analysis, the level of flood risk in Earlston is not widespread or severe when compared to other Border towns as part of the wider Borders Flood Studies. Whilst there is a flood risk, the number of properties anticipated to be inundated is relatively few at lower return periods. The provision of the diversion channel as part of the previous FPS has done little to mitigate the frequent flooding to properties most at risk (at Georgefield Bridge), nor the nuisance flooding to the area and parking on the right bank in the region of the primary school.

As a result of the above, flood damages are not particularly high and thus the options for mitigation are not cost effective. As a result only the PLP option is cost effective. With this in mind, it is recommended that this option is progressed further in the short term. Passive measures are required and there may be merit in combining a property survey with detailed modelling to see if simple minor modifications to the grounds of the property or road modifications, i.e. a raised lip on the driveway or lowered curbs may be enough to deflect flows away from these properties. As some of the properties are non-residential, site specific surveys will be required by specialists as bespoke protection measures may be needed for these properties. Funding avenues for these works should be explored by the council in advance of the next flood risk management cycle.

Appendices

A Appendix A - Damage Methodology

A.1 Direct damages - methodology

The process to estimate the benefits of an intervention option is to plot the two loss-probability curves: that for the situation now, and that with the proposed option as shown in Figure A-1. The scale on the y axis is the event loss (£); the scale on the x axis is the probability of the flood events being considered. When the two curves are plotted the difference in the areas beneath the curve is the annual reduction in flood losses to be expected from the scheme or mitigation approach.

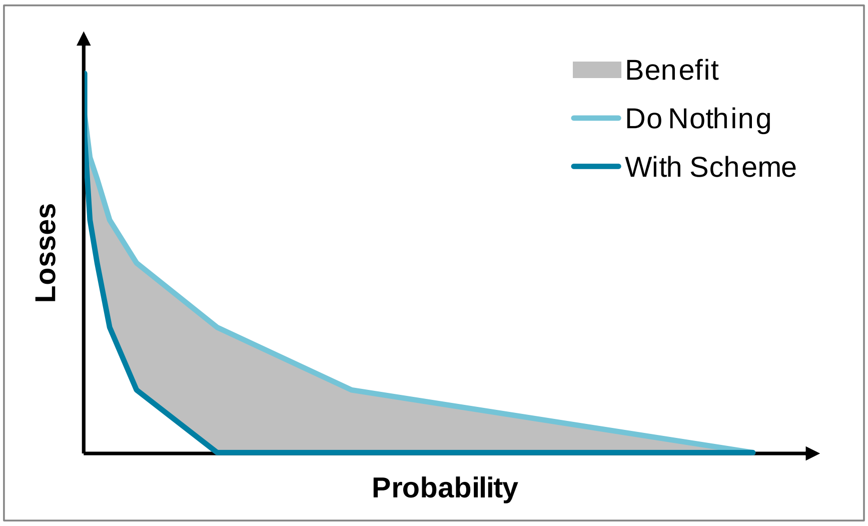


Figure A-1: Loss Probability Curve

To derive these two curves, straight lines are drawn between the floods for which there are data from the threshold event (the most extreme flood which does not cause any damage) to an extreme flood above the intended standard of protection. The greater the number of flood event probabilities, the more accurately the curves can be plotted.

A.1.1 Flood damage calculation and data

The FHRC Multi Coloured Manual (MCM) provides standard flood depth/direct damage datasets for a range of property types, both residential and commercial. This standard depth/damage data for direct and indirect damages has been utilised in this study to assess the potential damages that could occur under each of the options. Flood depths within each property have been calculated from the hydraulic modelling by comparing predicted water levels at each property to the surveyed threshold levels.

A flood damage estimate was generated using JBA's in-house flood damage tools. These estimate flood damages using FHRC data and the modelled flood level data. Each property data point was mapped on to its building's footprint. A mean, minimum and maximum flood level within each property is derived using GIS tools based on the range of flood levels around the building footprint. The inundation depth is calculated by comparing water levels with the surveyed threshold level. The mean (based on mean flood water level across the buildings floor area) flood damage estimates have been calculated and are presented in section 5.2.

The following assumptions, presented in the Table A-1, were used to generate direct flood damage estimates.

Table A-1: Damage considerations and method

Aspect	Values used	Justification
Flood duration	<12hrs	Flood water is not anticipated to inundate properties for prolonged periods.
Residential	MCM codes broken down by type	Appropriate for this level of

Aspect	Values used	Justification
property type	and age.	analysis.
Non-residential property type	Standard 2016 MCM codes applied.	Best available data used.
Upper floor flats	Upper floor flats have been removed from the flood damage estimates.	Whilst homeowners may be affected it is assumed that no direct flood damages are applicable.
MCM damage type	MCM 2016 data with no basements.	Most up to date economic analysis data used. Basements are not appropriate for the type of properties within the study area.
MCM flood type	MCM 2016 fluvial depth damages for combined fluvial-tidal scenario.	Best available data used.
Threshold level	Thresholds surveyed by surveyor for the majority of properties in area of interest.	Best available data used.
Property areas	OS Mastermap used to define property areas.	Best available data used.
Capping value	Residential properties based on house prices from Zoopla. Commercial properties valued from rateable values for individual properties (supplied by SAA).	Best available data used.

A.1.2 Property data set

The property dataset was compiled for all residential and commercial properties. The majority of these properties were visited by a JBA Surveyor during the threshold survey.

A.1.3 Capping

The FHRC and appraisal guidance suggests that care should be exercised for properties with high total (Present Value) damages which might exceed the market value of the property. In most cases it is prudent to assume that the long-term economic losses cannot exceed the capital value of the property. The present value flood damages for each property were capped at the market value using average property values obtained from internet sources (e.g. Zoopla).

Market values for non-residential properties were initially estimated from a properties rateable value based on the following equation:

Capital Valuation = (100/Equivalent Yield) x Rateable Value

Rateable values for all available properties in Peebles were obtained from the Scottish Assessors Association website[8]. Equivalent yield varies regionally and temporarily, but is recommended to be a value of 10-12.5 for flood defence purposes[9]. A value of 12.5 was used.

However, the resulting property valuations were judged as being undervalued. An alternative approach was used whereby the estimated value is 3 times the max depth damage MCM curve damage value for the commercial property type multiplied by the properties ground floor area.

A.1.4 Updating of Damage Values

The MCM data used is based on January 2017 values and therefore does not need to be brought up to date to compare the costs and benefits.

8 www.saa.gov.uk
9 Environment Agency (2009). Flood and Coastal Erosion Risk Management - Appraisal Guidance.

A.2 Intangible damages

Current guidance indicates that the value of avoiding health impacts of fluvial flooding is of the order of £286 per year per household. This value is equivalent to the reduction in damages associated with moving from a do-nothing option to an option with an annual flood probability of 1:100 year standard. A risk reduction matrix has been used to calculate the value of benefits for different pre-scheme standards and designed scheme protection standards.

A.3 Indirect damages

The multi coloured manual provides guidance on the assessment of indirect damages. It recommends that a value equal to 10.7% of the direct property damages is used to represent emergency costs. These include the response and recovery costs incurred by organisations such as the emergency services, the local authority and SEPA.

A.3.5 Indirect commercial damages

Obtaining accurate data on indirect flood losses is difficult. Indirect losses are of two kinds:

- losses of business to overseas competitors, and
- the additional costs of seeking to respond to the threat of disruption or to disruption itself which fall upon firms when flooded.

The first of these losses is unusual and is limited to highly specialised companies which are unable to transfer their productive activities to a branch site in this country, and which therefore lose to overseas competitors. The second type of loss is likely to be incurred by most Non-Residential Properties (NRPs) which are flooded. They exclude post-flood clean-up costs but include the cost of additional work and other costs associated with inevitable efforts to minimise or avoid disruption. These costs include costs of moving inventories, hiring vehicles and costs of overtime working. These costs also include the costs of moving operations to an alternative site or branch and may include additional transport costs.

Chapter 5, Section 5.7 of the MCM (2013)[10] recommends estimating and including potential indirect costs where these are the additional costs associated with trying to minimise indirect losses. This is by calculating total indirect losses as an uplift factor of 3% of estimated total direct NRP losses at each return period included within the damage estimation process.

10 Penning-Rowsell et al., 2013. Flood and Coastal Erosion Risk Management - A Manual for Economic Appraisal

B Appendix B - Economic Appraisal

Project Summary Sheet

Client/Authority			Prepared (date)	25/09/2018
Scottish Borders Council			Printed	10/01/2019
Project name			Prepared by	B.Bedford
Borders Flood Studies: Earlston - Leader Water			Checked by	A.Pettit
Project reference	2017s5526		Checked date	Sept 2018
Base date for estimates (year 0)	Jan-2018			
Scaling factor (e.g. £m, £k, £)	£k	(used for all costs, losses and benefits)		
Year	0	30	75	
Discount Rate	3.5%	3.0%	2.5%	
Optimism bias adjustment factor	60%			

Costs and benefits of options

	Costs and benefits £k				
Option number	**DN**	**DM**	**OP02**	**PLP**	**Combined**
Option name	Do Nothing	Do Minimum	Direct Defences	PLP	Combined Turfford / Leader option
AEP or SoP (where relevant)	0	2	200	200	200
COSTS:					0
PV enabling costs	0	0	84	12	113
PV capital costs	0	0	1,179	197	1,800
PV operation and maintenance costs	0	0	25	57	35
Optimism bias adjustment	0	0	773	159	1,168
PV contributions					
Total PV Costs £k excluding contributions	0	0	2,061	425	3,115
Total PV Costs £k taking contributions into account	0	0	2,061	425	3,115
BENEFITS:					
PV monetised flood damages	830	409	388	115	162
PV monetised flood damages avoided		422	443	601	668
PV monetised erosion damages	0	0	0	0	0
PV monetised erosion damages avoided (protected)		0	0	0	0
Total monetised PV damages £k	830	409	388	115	162
Total monetised PV benefits £k		422	443	601	668
Total PV damages £k	830	409	388	115	162
Total PV benefits £k		422	443	601	668
DECISION-MAKING CRITERIA:					
Based on monetised PV benefits (** *ex* ***cludes benefits from scoring and weighting and ecosystem services)					
Net Present Value **NPV**		422	-1,618	175	-2,447
Average benefit/cost ratio **BCR**			0.2	1.4	0.2
Incremental benefit/cost ratio **IBCR**			0.0	-0.1	0.0
				Highest bcr	
Best practicable environmental option (WFD)					

Brief description of options:

DN	Do Nothing
DM	Do Minimum
OP02	Direct Defences
PLP	PLP
Combined	Combined Turfford / Leader option

Comments and assumptions:

Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council
Project name
Borders Flood Studies: Earlston - Leader Water
Option: Do Nothing

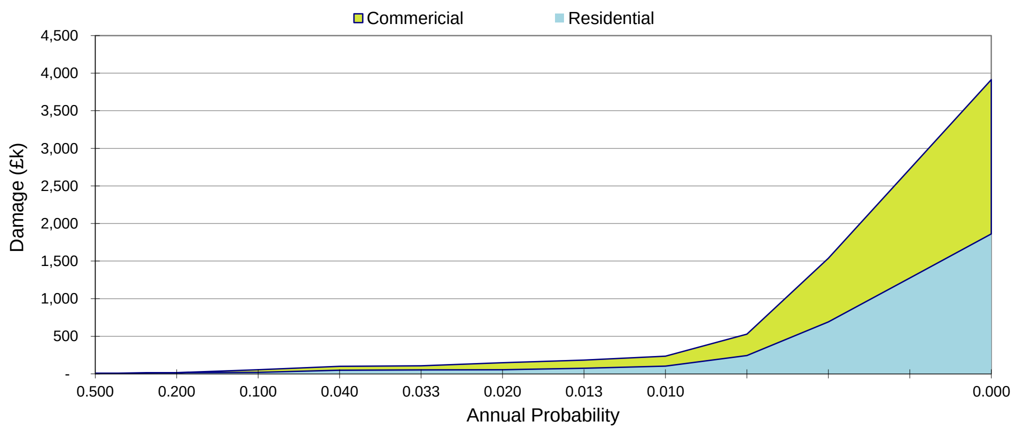
Project reference	2017s5526				
Base date for estimates (year 0)	01/01/2018	First year of damage:	0	Prepared (date)	25/09/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	10/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by	B.Bedford
				Checked by	A.Pettit
Applicable year (if time varying)				Checked date	Sept 2018

	Average waiting time (yrs) between events/frequency per year												Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k												
Residential property	6	16	20	49	52	56	74	103	244	690	1,275	1,861	414
Ind/commercial (direct)	-	-	34	51	54	92	110	133	284	847	1,450	2,053	368
Ind/comm (indirect)	-	-	1	2	2	3	3	4	9	25	43	62	11
Traffic related												-	-
Emergency services	0	1	1	3	3	3	4	6	14	39	71	104	23
Other	-	-	-	-	-	-	-	-	-	-	-	-	-
Intangible damages												-	15
												-	-
Total damage £k	7	17	56	105	111	154	191	246	550	1,601	2,840	4,079	
Area (damagexfrequency)		4	4	5	1	2	1	1	2	3	2	3	

Total area, as above	27	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	815	830

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Borders Flood Studies: Earlston - Leader Water Option: Do Nothing



Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council
Project name
Borders Flood Studies: Earlston - Leader Water
Project reference 2017s5526
Base date for estimates (year 0) 43101
Scaling factor (e.g. £m, £k, £) £k
Discount rate 3.5%
Applicable year (if time varying)

Option:
Do Minimum

First year of damage: 0
Last year of period: 99
PV factor for mid-year 0: 29.813

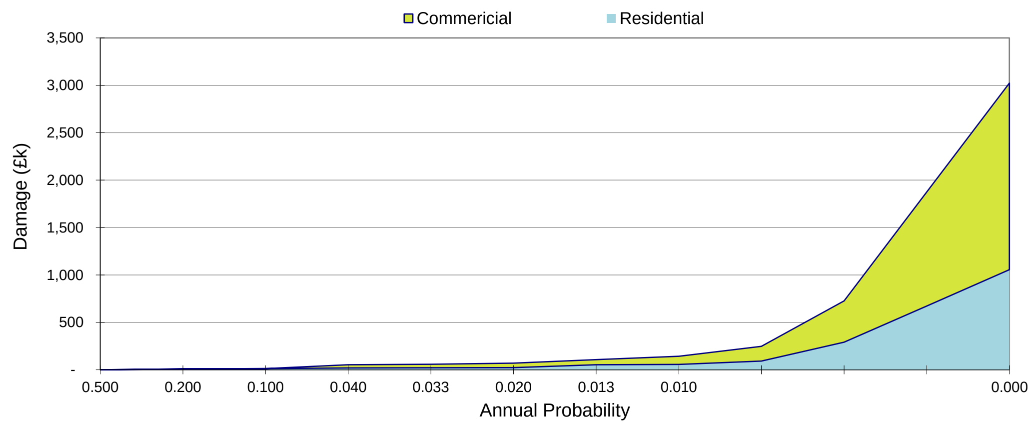
Prepared (date) 25/09/2018
Printed 10/01/2019
Prepared by B.Bedford
Checked by A.Pettit
Checked date Sept 2018

	Average waiting time (yrs) between events/frequency per year												Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k												
Residential property	-	9	13	20	21	23	53	56	92	291	673	1,055	194
Ind/commercial (direct)	-	-	-	33	38	48	54	87	156	436	1,202	1,968	187
Ind/comm (indirect)	-	-	-	1	1	1	2	3	5	13	36	59	6
Traffic related												-	-
Emergency services	-	0	1	1	1	1	3	3	5	16	38	59	11
Other	-	-	-	-	-	-	-	-	-	-	-	-	-
Intangible damages												-	12
												-	-
Total damage £k	-	9	13	54	61	73	112	148	258	757	1,949	3,141	
Area (damagexfrequency)		1	1	2	0	1	1	0	1	2	1	2.55	

Total area, as above	13	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	397	409

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Borders Flood Studies: Earlston - Leader Water Option: Do Minimum



Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council
Project name
Borders Flood Studies: Earlston - Leader Water
Project reference 2017s5526
Base date for estimates (year 0): 43101
Scaling factor (e.g. £m, £k, £): £k
Discount rate: 3.5%
Applicable year (if time varying):

Option: PLP

First year of damage: 0
Last year of period: 99
PV factor for mid-year 0: 29.813

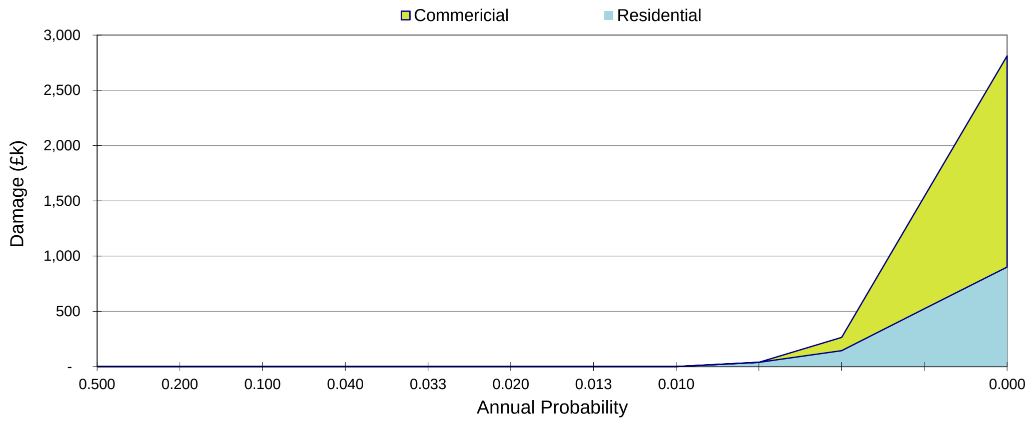
Prepared (date): 25/09/2018
Printed: 10/01/2019
Prepared by: B.Bedford
Checked by: A.Pettit
Checked date: Sept 2018

	Average waiting time (yrs) between events/frequency per year												Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k												
Residential property	-	-	-	-	-	-	-	-	38	144	522	900	42
Ind/commercial (direct)	-	-	-	-	-	-	-	-	-	120	1,016	1,911	66
Ind/comm (indirect)	-	-	-	-	-	-	-	-	-	4	30	57	2
Traffic related												-	-
Emergency services	-	-	-	-	-	-	-	-	2	8	29	50	2
Other	-	-	-	-	-	-	-	-	-	-	-	-	-
Intangible damages												-	3
												-	-
Total damage £k	-	-	-	-	-	-	-	-	41	276	1,598	2,919	
Area (damagexfrequency)		-	-	-	-	-	-	-	0	0	1	2.26	

Total area, as above	4	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	112	115

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Borders Flood Studies: Earlston - Leader Water Option: PLP



Summary Annual Average Damage

Sheet Nr.

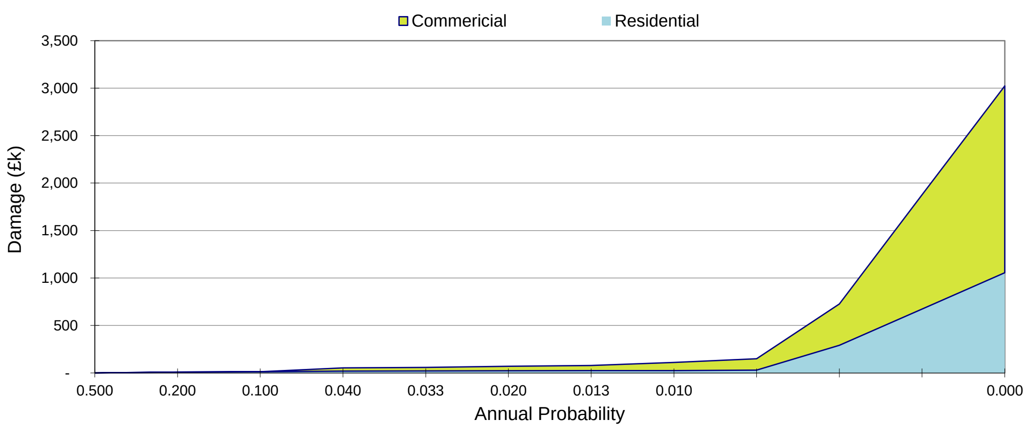
Client/Authority				
Scottish Borders Council				
Project name		**Option:**		
Borders Flood Studies: Earlston - Leader Water		Direct Defences		
Project reference	2017s5526			
Base date for estimates (year 0)	43101	First year of damage:	0	Prepared (date) 25/09/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed 10/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by B.Bedford
				Checked by A.Pettit
Applicable year (if time varying)				Checked date Sept 2018

	Average waiting time (yrs) between events/frequency per year												Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k												
Residential property	-	9	13	20	21	23	24	24	30	291	673	1,055	178
Ind/commercial (direct)	-	-	-	33	38	48	54	87	118	436	1,202	1,968	182
Ind/comm (indirect)	-	-	-	1	1	1	2	3	4	13	36	59	5
Traffic related												-	-
Emergency services	-	0	1	1	1	1	1	1	2	16	38	59	10
Other	-	-	-	-	-	-	-	-	-	-	-	-	-
Intangible damages												-	12
												-	-
Total damage £k	-	9	13	54	61	73	81	115	154	757	1,949	3,141	
Area (damagexfrequency)		1	1	2	0	1	1	0	1	1	1	2.55	

Total area, as above	13	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	376	388

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Borders Flood Studies: Earlston - Leader Water Option: Direct Defences



Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council

Project name
Borders Flood Studies: Earlston - Leader Water

Option: Combined Turfford / Leader option

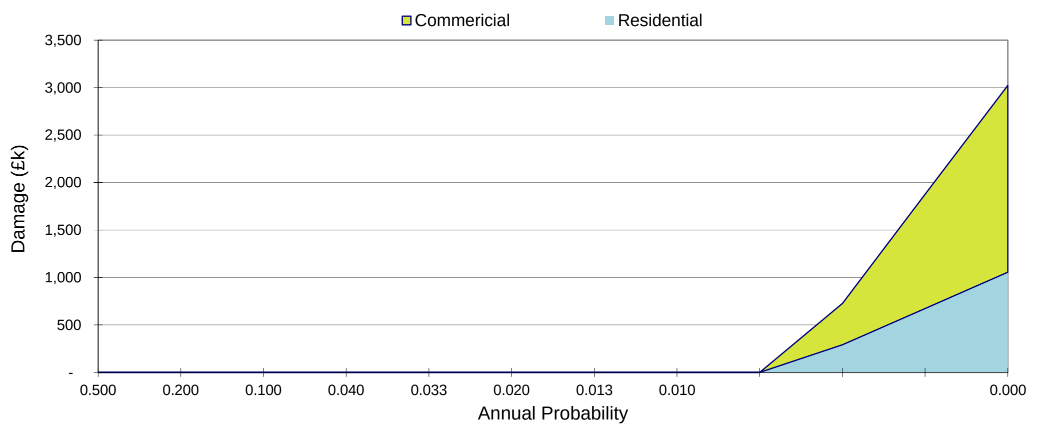
Project reference	2017s5526				
Base date for estimates (year 0)	43101	First year of damage:	0	Prepared (date)	25/09/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	10/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by	B.Bedford
				Checked by	A.Pettit
Applicable year (if time varying)				Checked date	Sept 2018

	Average waiting time (yrs) between events/frequency per year												Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k												
Residential property	-	-	-	-	-	-	-	-	-	291	673	1,055	53
Ind/commercial (direct)	-	-	-	-	-	-	-	-	-	436	1,202	1,968	91
Ind/comm (indirect)	-	-	-	-	-	-	-	-	-	13	36	59	3
Traffic related												-	-
Emergency services	-	-	-	-	-	-	-	-	-	16	38	59	3
Other	-	-	-	-	-	-	-	-	-	-	-	-	-
Intangible damages												-	12
												-	-
Total damage £k	-	-	-	-	-	-	-	-	-	757	1,949	3,141	
Area (damagexfrequency)		-	-	-	-	-	-	-	-	1	1	2.55	

Total area, as above	5	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	150	162

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Borders Flood Studies: Earlston - Leader Water Option: Combined Turfford / Leader option



Project Summary Sheet

Client/Authority			Prepared (date)	11/07/2018
Scottish Borders Council			Printed	10/01/2019
Project name			Prepared by	B.Bedford
Earlston - Turfford Burn			Checked by	A.Pettit
Project reference			Checked date	Sept 2018
Base date for estimates (year 0)	Jan-2018			
Scaling factor (e.g. £m, £k, £)	£k	(used for all costs, losses and benefits)		
Year	0	30	75	
Discount Rate	3.5%	3.00%	2.50%	
Optimism bias adjustment factor	60%			

Costs and benefits of options

	Costs and benefits £k						
Option number	**Do Nothing**	**Do Minimum**	**OP01**	**OP07**	**OP08**	**PLP**	**Combined**
Option name	Do Nothing	Do Minimum	Bypass channel	Total bypass	Storage	PLP	Combined Turfford / Leader option
AEP or SoP (where relevant)	<2	2	200	200	2	100	200
COSTS:							
PV enabling costs	0	0	28	118	253	12	113
PV capital costs	0	0	621	1,787	2,489	197	1,800
PV operation and maintenance costs	0	0	10	15	294	57	35
Optimism bias adjustment	0	0	395	1,152	1,822	159	1,168
PV contributions							
Total PV Costs £k excluding contributions	0	0	1,054	3,071	4,857	425	3,115
Total PV Costs £k taking contributions into account	0	0	1,054	3,071	4,857	425	3,115
BENEFITS:							
PV monetised flood damages	830	409	174	174	364	115	162
PV monetised flood damages avoided		422	656	656	466	601	668
PV monetised erosion damages	0	0	0	0	0		0
PV monetised erosion damages avoided (protected)		0	0	0	0		0
Total monetised PV damages £k	830	409	174	174	364	115	162
Total monetised PV benefits £k		422	656	656	466	601	668
Total PV damages £k	830	409	174	174	364	115	162
Total PV benefits £k		422	656	656	466	601	668
DECISION-MAKING CRITERIA:							
Based on monetised PV benefits (** ex **cludes benefits from scoring and weighting and ecosystem services)							
Net Present Value **NPV**		422	-398	-2,415	-4,391	175	-2,649
Average benefit/cost ratio **BCR**			0.6	0.2	0.1	1.4	0.1
Incremental benefit/cost ratio **IBCR**			0.2	-	-0.1	0.0	-4.3
Best practicable environmental option (WFD)							

Brief description of options:

Do Nothing	Do Nothing
Do Minimum	Do Minimum
OP01	Bypass channel
OP07	Total bypass
OP08	Storage
PLP	PLP
Combined	Combined Turfford / Leader option

Comments and assumptions:

Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council

Project name
Earlston - Turfford Burn

Option:
Do Nothing

Project reference -

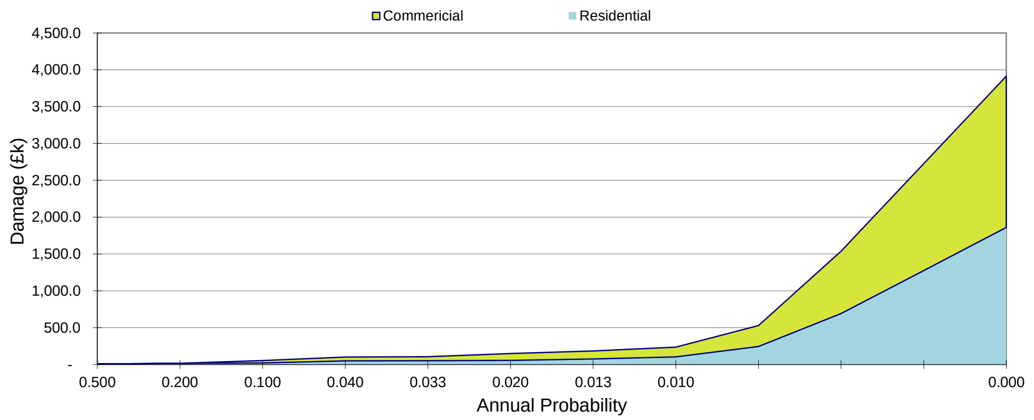
Base date for estimates (year 0)	01/01/2018	First year of damage:	0	Prepared (date)	11/07/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	10/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by	B.Bedford
				Checked by	A.Pettit
Applicable year (if time varying)				Checked date	Sept 2018

	Average waiting time (yrs) between events/frequency per year												Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k												
Residential property	6.2	16	20	49	52	56	74	103	244	690	1,275	1,861	414
Ind/commercial (direct)	-	-	34	51	54	92	110	133	284	847	1,450	2,053	368
Ind/comm (indirect)	-	-	1	2	2	3	3	4	9	25	43	62	11
Traffic related												-	-
Emergency services	0.3	1	1	3	3	3	4	6	14	39	71	104	23
Other	-	-	-	-	-	-	-	-	-	-	-	-	-
Intangible damages												-	15
												-	-
Total damage £k	7	17	56	105	111	154	191	246	550	1,601	2,840	4,079	
Area (damagexfrequency)		3.59	4	5	1	2	1	1	2	3	2	3.46	

Total area, as above	27	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	815	830

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Earlston - Turfford Burn **Option: Do Nothing**



Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council
Project name
Earlston - Turfford Burn
Project reference -

Option:
Do Minimum

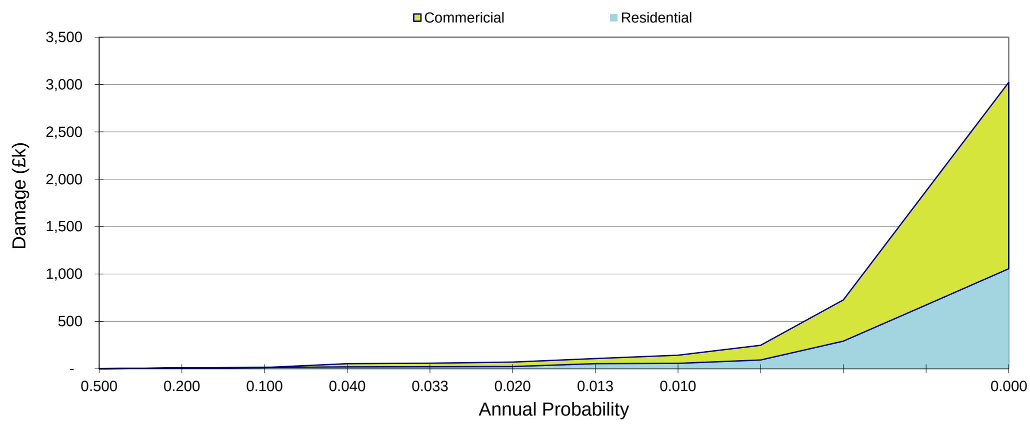
Base date for estimates (year 0)	01/01/2018	First year of damage:	0	Prepared (date) 11/07/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed 10/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by B.Bedford
				Checked by A.Pettit
Applicable year (if time varying)				Checked date Sept 2018

	Average waiting time (yrs) between events/frequency per year											Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k												
Residential property	-	9	13	20	21	23	53	56	92	291	673	1,055	194
Ind/commercial (direct)	-	-	-	33	38	48	54	87	156	436	1,202	1,968	187
Ind/comm (indirect)	-	-	-	1	1	1	2	3	5	13	36	59	6
Traffic related												-	-
Emergency services	-	0	1	1	1	1	3	3	5	16	38	59	11
Other	-	-	-	-	-	-	-	-	-	-	-	-	-
Intangible damages												-	12
												-	-
Total damage £k	-	9	13	54	61	73	112	148	258	757	1,949	3,141	
Area (damagexfrequency)		1	1	2	0	1	1	0	1	2	1	2.55	

Total area, as above	13	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	397	409

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Earlston - Turfford Burn **Option: Do Minimum**



Summary Annual Average Damage

Sheet Nr.

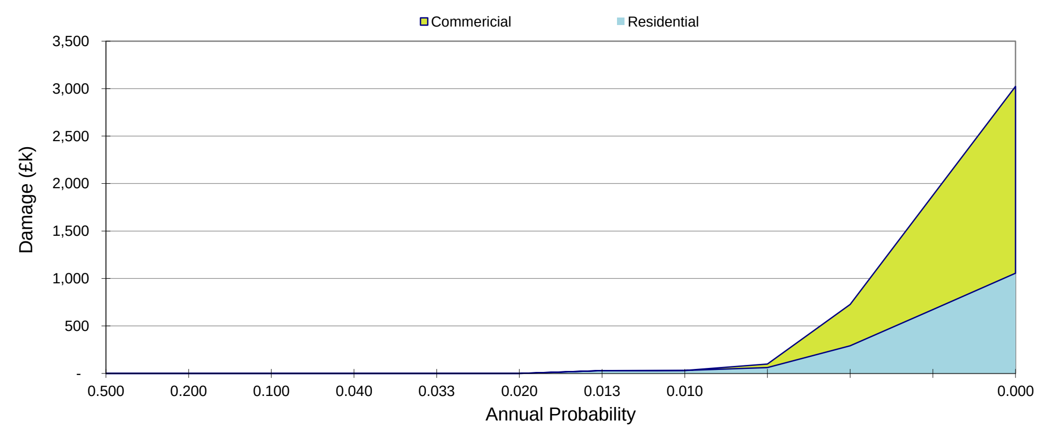
Client/Authority					
Scottish Borders Council					
Project name		**Option:**			
Earlston - Turfford Burn		Bypass channel			
Project reference	-				
Base date for estimates (year 0)	01/01/2018	First year of damage:	0	Prepared (date)	11/07/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	10/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by	B.Bedford
				Checked by	A.Pettit
Applicable year (if time varying)				Checked date	Sept 2018

	Average waiting time (yrs) between events/frequency per year												Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k												
Residential property	-	-	-	-	-	-	30	32	62	291	673	1,055	69
Ind/commercial (direct)	-	-	-	-	-	-	-	-	37	436	1,202	1,968	96
Ind/comm (indirect)	-	-	-	-	-	-	-	-	1	13	36	59	3
Traffic related												-	-
Emergency services	-	-	-	-	-	-	2	2	3	16	38	59	4
Other	-	-	-	-	-	-	-	-	-	-	-	-	-
Intangible damages												-	3
												-	-
Total damage £k	-	-	-	-	-	-	31	33	104	757	1,949	3,141	
Area (damagexfrequency)		-	-	-	-	-	0	0	0	1	1	2.55	

Total area, as above	6	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	171	174

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Earlston - Turfford Burn **Option: Bypass channel**



Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council

Project name
Earlston - Turfford Burn

Option:
Total bypass

Project reference -

Base date for estimates (year 0)	01/01/2018	First year of damage:	0	Prepared (date)	11/07/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	10/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by	B.Bedford
				Checked by	A.Pettit
Applicable year (if time varying)				Checked date	Sept 2018

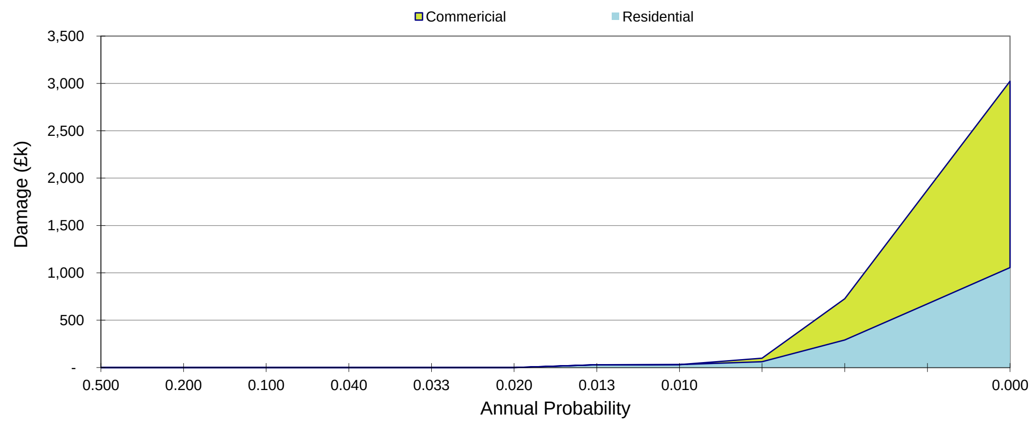
Average waiting time (yrs) between events/frequency per year

Damage category	2 0.500	5 0.200	10 0.100	25 0.040	30 0.033	50 0.020	75 0.013	100 0.010	200 0.005	500 0.002	1000 0.001	Infinity 0	Total PV £k
	Damage £k												
Residential property	-	-	-	-	-	-	30	32	62	291	673	1,055	69
Ind/commercial (direct)	-	-	-	-	-	-	-	-	37	436	1,202	1,968	96
Ind/comm (indirect)	-	-	-	-	-	-	-	-	1	13	36	59	3
Traffic related												-	-
Emergency services	-	-	-	-	-	-	2	2	3	16	38	59	4
Other	-	-	-	-	-	-	-	-	-	-	-	-	-
Intangible damages												-	3
												-	-
Total damage £k	-	-	-	-	-	-	31	33	104	757	1,949	3,141	
Area (damagexfrequency)		-	-	-	-	-	0	0	0	1	1	2.55	

Total area, as above	6	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	171	174

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Earlston - Turfford Burn **Option: Total bypass**



Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council

Project name
Earlston - Turfford Burn

Option:
Storage

Project reference -

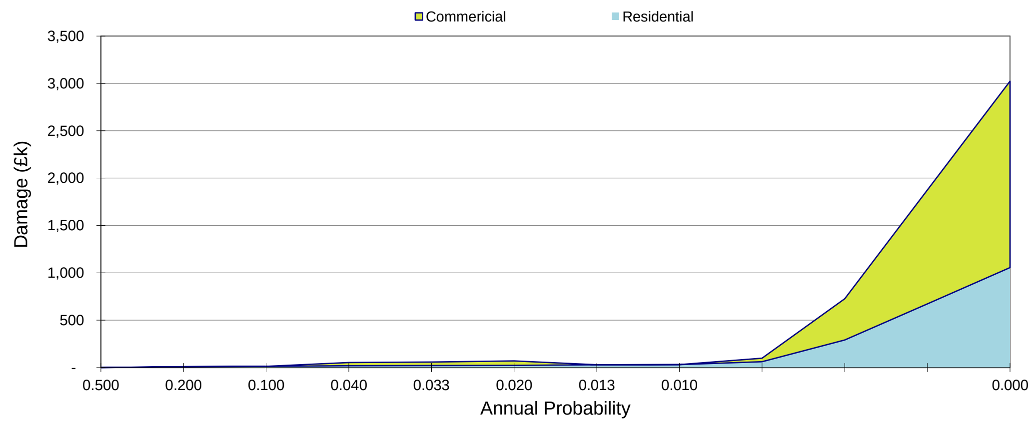
Base date for estimates (year 0)	01/01/2018	First year of damage:	0	Prepared (date)	11/07/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	10/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by	B.Bedford
				Checked by	A.Pettit
Applicable year (if time varying)				Checked date	Sept 2018

	Average waiting time (yrs) between events/frequency per year												Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k												
Residential property	-	9	13	20	21	23	30	32	62	291	673	1,055	184
Ind/commercial (direct)	-	-	-	33	38	48	-	-	37	436	1,202	1,968	154
Ind/comm (indirect)	-	-	-	1	1	1	-	-	1	13	36	59	5
Traffic related												-	-
Emergency services	-	0	1	1	1	1	2	2	3	16	38	59	10
Other	-	-	-	-	-	-	-	-	-	-	-	-	-
Intangible damages												-	12
												-	-
Total damage £k	-	9	13	54	61	73	31	33	104	757	1,949	3,141	
Area (damagexfrequency)		1	1	2	0	1	0	0	0	1	1	2.55	

Total area, as above	12	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	352	364

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Earlston - Turfford Burn **Option: Storage**



Summary Annual Average Damage

Sheet Nr.

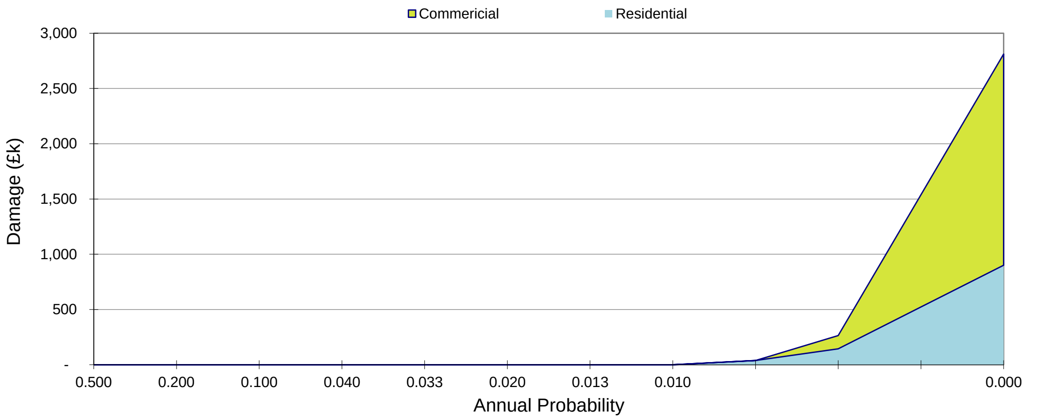
Client/Authority				
Scottish Borders Council				
Project name		**Option:**		
Earlston - Turfford Burn		PLP		
Project reference	-			
Base date for estimates (year 0)	01/01/2018	First year of damage:	0	Prepared (date) 11/07/2018
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed 10/01/2019
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by B.Bedford
				Checked by A.Pettit
Applicable year (if time varying)				Checked date Sept 2018

	Average waiting time (yrs) between events/frequency per year												Total PV
	2	5	10	25	30	50	75	100	200	500	1000	Infinity	£k
	0.500	0.200	0.100	0.040	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k												
Residential property	-	-	-	-	-	-	-	-	38	144	522	900	42
Ind/commercial (direct)	-	-	-	-	-	-	-	-	-	120	1,016	1,911	66
Ind/comm (indirect)	-	-	-	-	-	-	-	-	-	4	30	57	2
Traffic related												-	-
Emergency services	-	-	-	-	-	-	-	-	2	8	29	50	2
Other	-	-	-	-	-	-	-	-	-	-	-	-	-
Intangible damages												-	3
												-	-
Total damage £k	-	-	-	-	-	-	-	-	41	276	1,598	2,919	
Area (damagexfrequency)		-	-	-	-	-	-	-	0	0	1	2.26	

Total area, as above	4	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	112	115

Notes
Area calculations assume drop to zero at maximum frequency.
Default value for the highest possible damage assumes continuation of gradient for last two points, an alternative value can be entered, if appropriate.
One form should be completed for each option, including 'without project', and for each representative year if profile changes during scheme life (e.g. sea-level rise)
Residential property, Industrial / commercial (direct), and Other damages are itemised in Asset AAD sheet and automatically linked to this sheet

Project: Earlston - Turfford Burn **Option: PLP**



Summary of costs

Client/Authority		Prepared (date)	Sept. 2018
Scottish Borders Council		Printed	10/01/2019
Project/Option name		Prepared by	C. Kampanou
Earlston Flood Study - Leader Water Direct Defence		Checked by	S. Cooney
Project reference		Checked date	October 2018
Base date for estimates (year 0)	Jan-2018		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary

	Costs in £k
Enabling Costs	£84.22
Capital Costs	£1,219.79
O & M Costs	£89.31
Other Costs	£0.00
Total Real Cost	£1,393.32
Total Cost PV	£1,288.14
Total Cost PV + OB	**£2,061.02**

Note: Macros are required to open individual cost modules and the user should ensure they are enabled in the Excel Security Settings.

Note: Cost modules are opened from blank templates by clicking on the pentagons below. If a template exists, the user is sent the module. Only one module per worksheet is permitted.

Note: Costs are automatically summed from all individual cost module sheets every time the user returns to this summary sheet. This process takes into account the above scaling factor.

Note: If multiple measures are used, the optimism bias value used in each module is overridden by that selected above (Cell D10).

Additional user notes:

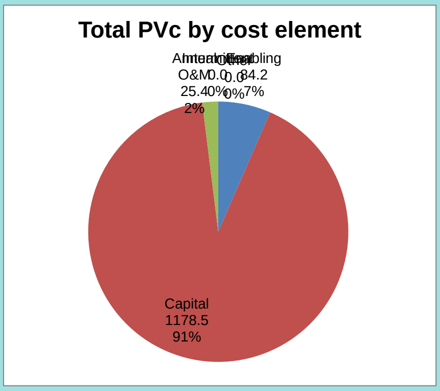
Add additional user notes here.

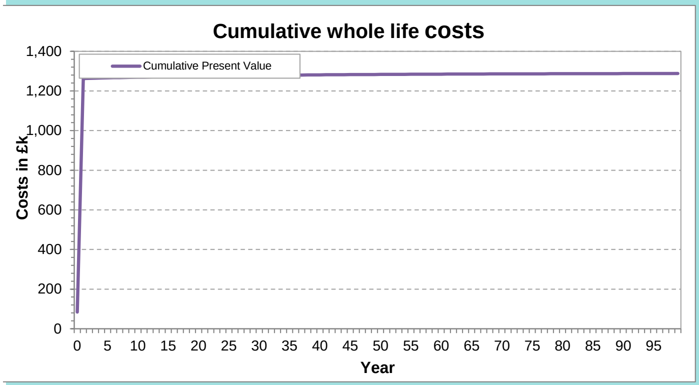
FRM Measure	Asset	Open / Go to Costing Sheet	Delete Sheet	Enabling Costs	Capital Costs	O & M Costs	Other Costs	Total Cost Cash	Total Cost PV
Fluvial raised defence	Embankment			£30.88	£343.14	£75.95	£0.00	£449.97	£384.00
	Wall			£53.34	£592.66	£13.36	£0.00	£659.36	£629.75
	Sheet Piling								
Channel management	N/A								
Culvert & screen	N/A								
Control assets	Weir								
	Pumping station								
	Flood gate								
	Outfall								
	Flow barrier								
Coastal protection	Wall								
	Revetment								
	Groyne								
	Recharge								
Flood storage	N/A								
Flood warning and forecasting	Various								
Temporary & demountable barriers	Various								
Household resistance	Various								
Household resilience	Various								
SUDS and urban drainage	Various								
Managed realignment	Various								
Habitat creation	Various								
Landuse & runoff management	Various								
River Restoration	Various								
User Defined 1	Various			£0.00	£283.99	£0.00	£0.00	£283.99	£274.39
User Defined 2	Various								
User Defined 3	Various								

Whole Life and Present Value Cost Analysis

		PV factor	29.813				Total PVc (£k):	1288.1	
		Enabling £k	Capital £k	Annual O&M £k	Intermittent O&M £k	Other £k	TOTALS: Current price	PV (£k)	
	Total real cost	84.2	1219.8	89.3	0.0	0.0	1393.32	1288.1	
	Total PV cost	84.2	1178.5	25.4	0.0	0.0		1288.1	Cumulative
year	Discount Factor								PV Costs (£k)
0	1.000	84.2	0.0	0.0	0.0	0.0	84.2	84.2	84.2
1	0.966	0.0	1219.8	0.0	0.0	0.0	1219.8	1178.5	1262.8
2	0.934	0.0	0.0	0.9	0.0	0.0	0.9	0.9	1263.6
3	0.902	0.0	0.0	0.9	0.0	0.0	0.9	0.8	1264.4
4	0.871	0.0	0.0	0.9	0.0	0.0	0.9	0.8	1265.2
5	0.842	0.0	0.0	0.9	0.0	0.0	0.9	0.8	1266.0
6	0.814	0.0	0.0	0.9	0.0	0.0	0.9	0.7	1266.7
7	0.786	0.0	0.0	0.9	0.0	0.0	0.9	0.7	1267.5
8	0.759	0.0	0.0	0.9	0.0	0.0	0.9	0.7	1268.1
9	0.734	0.0	0.0	0.9	0.0	0.0	0.9	0.7	1268.8
10	0.709	0.0	0.0	0.9	0.0	0.0	0.9	0.6	1269.5
11	0.685	0.0	0.0	0.9	0.0	0.0	0.9	0.6	1270.1
12	0.662	0.0	0.0	0.9	0.0	0.0	0.9	0.6	1270.7
13	0.639	0.0	0.0	0.9	0.0	0.0	0.9	0.6	1271.3
14	0.618	0.0	0.0	0.9	0.0	0.0	0.9	0.6	1271.8
15	0.597	0.0	0.0	0.9	0.0	0.0	0.9	0.5	1272.4
16	0.577	0.0	0.0	0.9	0.0	0.0	0.9	0.5	1272.9
17	0.557	0.0	0.0	0.9	0.0	0.0	0.9	0.5	1273.4
18	0.538	0.0	0.0	0.9	0.0	0.0	0.9	0.5	1273.9
19	0.520	0.0	0.0	0.9	0.0	0.0	0.9	0.5	1274.4
20	0.503	0.0	0.0	0.9	0.0	0.0	0.9	0.5	1274.8
21	0.486	0.0	0.0	0.9	0.0	0.0	0.9	0.4	1275.3
22	0.469	0.0	0.0	0.9	0.0	0.0	0.9	0.4	1275.7
23	0.453	0.0	0.0	0.9	0.0	0.0	0.9	0.4	1276.1
24	0.438	0.0	0.0	0.9	0.0	0.0	0.9	0.4	1276.5
25	0.423	0.0	0.0	0.9	0.0	0.0	0.9	0.4	1276.9
26	0.409	0.0	0.0	0.9	0.0	0.0	0.9	0.4	1277.3
27	0.395	0.0	0.0	0.9	0.0	0.0	0.9	0.4	1277.6
28	0.382	0.0	0.0	0.9	0.0	0.0	0.9	0.3	1278.0
29	0.369	0.0	0.0	0.9	0.0	0.0	0.9	0.3	1278.3
30	0.356	0.0	0.0	0.9	0.0	0.0	0.9	0.3	1278.6
31	0.346	0.0	0.0	0.9	0.0	0.0	0.9	0.3	1279.0
32	0.336	0.0	0.0	0.9	0.0	0.0	0.9	0.3	1279.3
33	0.326	0.0	0.0	0.9	0.0	0.0	0.9	0.3	1279.6
34	0.317	0.0	0.0	0.9	0.0	0.0	0.9	0.3	1279.8
35	0.307	0.0	0.0	0.9	0.0	0.0	0.9	0.3	1280.1
36	0.298	0.0	0.0	0.9	0.0	0.0	0.9	0.3	1280.4
37	0.290	0.0	0.0	0.9	0.0	0.0	0.9	0.3	1280.7
38	0.281	0.0	0.0	0.9	0.0	0.0	0.9	0.3	1280.9
39	0.273	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1281.2
40	0.265	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1281.4
41	0.257	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1281.6
42	0.250	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1281.9
43	0.243	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1282.1
44	0.236	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1282.3
45	0.229	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1282.5
46	0.222	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1282.7
47	0.216	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1282.9
48	0.209	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1283.1
49	0.203	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1283.3
50	0.197	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1283.5
51	0.192	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1283.6
52	0.186	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1283.8
53	0.181	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1284.0
54	0.175	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1284.1
55	0.170	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1284.3
56	0.165	0.0	0.0	0.9	0.0	0.0	0.9	0.2	1284.4
57	0.160	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1284.6
58	0.156	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1284.7
59	0.151	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1284.9
60	0.147	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1285.0
61	0.143	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1285.1
62	0.138	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1285.3
63	0.134	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1285.4
64	0.130	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1285.5
65	0.127	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1285.6
66	0.123	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1285.7
67	0.119	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1285.8
68	0.116	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1285.9
69	0.112	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1286.0
70	0.109	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1286.1
71	0.106	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1286.2
72	0.103	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1286.3
73	0.100	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1286.4
74	0.097	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1286.5
75	0.094	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1286.6
76	0.092	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1286.7
77	0.090	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1286.8
78	0.087	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1286.8
79	0.085	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1286.9
80	0.083	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.0
81	0.081	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.1
82	0.079	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.1
83	0.077	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.2
84	0.075	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.3
85	0.074	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.4
86	0.072	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.4
87	0.070	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.5
88	0.068	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.5
89	0.067	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.6
90	0.065	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.7
91	0.063	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.7
92	0.062	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.8
93	0.060	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.8
94	0.059	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.9
95	0.057	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1287.9
96	0.056	0.0	0.0	0.9	0.0	0.0	0.9	0.1	1288.0
97	0.055	0.0	0.0	0.9	0.0	0.0	0.9	0.0	1288.0
98	0.053	0.0	0.0	0.9	0.0	0.0	0.9	0.0	1288.1
99	0.052	0.0	0.0	0.9	0.0	0.0	0.9	0.0	1288.1

Whole life cost charts





Summary of costs

Client/Authority		Prepared (date)	Sept. 2018	
Scottish Borders Council		Printed	10/01/2019	
Project/Option name		Prepared by	C. Kampanou	
Earlston Flood Study - Turfford Burn Bypass		Checked by	S. Cooney	
Project reference		Checked date	October 2018	
Base date for estimates (year 0)	Jan-2018			
Scaling factor (e.g. £m, £k, £)	£k			
Optimism bias adjustment factor	60%			

PV Cost Summary

	Costs in £k
Enabling Costs	£49.00
Capital Costs	£642.86
O & M Costs	£33.64
Other Costs	£0.00
Total Real Cost	£725.51
Total Cost PV	£679.69
Total Cost PV + OB	**£1,087.50**

Note: Macros are required to open individual cost modules and the user should ensure they are enabled in the Excel Security Settings.

Note: Cost modules are opened from blank templates by clicking on the pentagons below. If a template exists, the user is sent the module. Only one module per worksheet is permitted.

Note: Costs are automatically summed from all individual cost module sheets every time the user returns to this summary sheet. This process takes into account the above scaling factor.

Note: If multiple measures are used, the optimism bias value used in each module is overridden by that selected above (Cell D10).

Additional user notes:

Add additional user notes here.

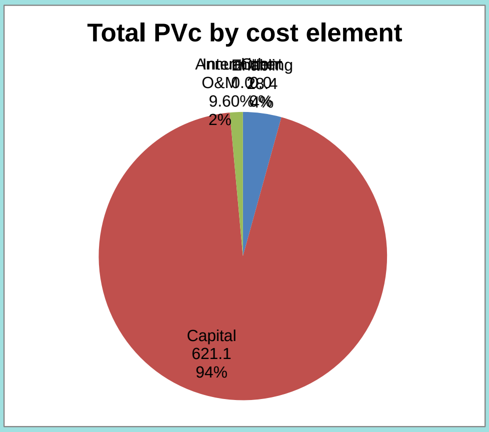
FRM Measure	Asset	Open / Go to Costing Sheet	Delete Sheet	Enabling Costs	Capital Costs	O & M Costs	Other Costs	Total Cost Cash	Total Cost PV
Fluvial raised defence	Embankment								
	Wall								
	Sheet Piling								
Channel management	N/A			£49.00	£495.364	£33.64	£0.00	£578.01	£537.18
Culvert & screen	N/A								
Control assets	Weir								
	Pumping station								
	Flood gate								
	Outfall								
	Flow barrier								
Coastal protection	Wall								
	Revetment								
	Groyne								
	Recharge								
Flood storage	N/A								
Flood warning and forecasting	Various								
Temporary & demountable barriers	Various								
Household resistance	Various								
Household resilience	Various								
SUDS and urban drainage	Various								
Managed realignment	Various								
Habitat creation	Various								
Landuse & runoff management	Various								
River Restoration	Various								
User Defined 1	Various			£0.00	£117.500	£0.00	£0.00	£117.50	£113.53
User Defined 2	Various			£0.00	£30.000	£0.00	£0.00	£30.00	£28.99
User Defined 3	Various								

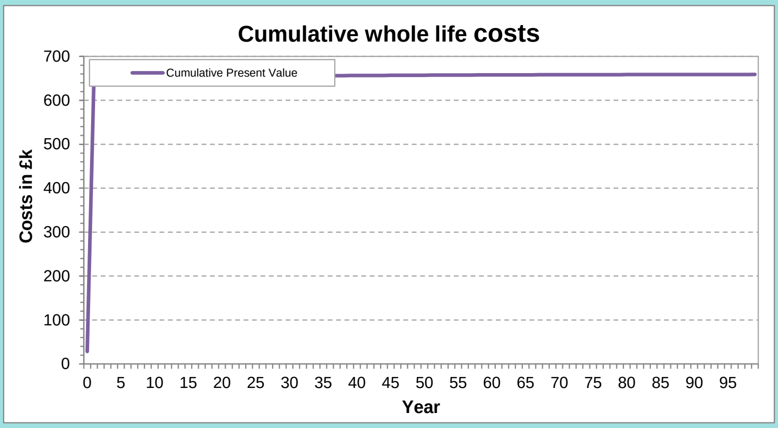
Whole Life and Present Value Cost Analysis

		PV factor	29.813				Total PVc (£k):	659.0	
		Enabling £k	Capital £k	Annual O&M £k	Intermittent O&M £k	Other £k	TOTALS: Current price	PV (£k)	
	Total real cost	28.4	642.9	33.6	0.0	0.0	704.86	659.0	
	Total PV cost	28.4	621.1	9.6	0.0	0.0		659.0	Cumulative
year	Discount Factor								PV Costs (£k)
0	1.000	28.4	0.0	0.0	0.0	0.0	28.4	28.4	28.4
1	0.966	0.0	642.9	0.0	0.0	0.0	642.9	621.1	649.5
2	0.934	0.0	0.0	0.3	0.0	0.0	0.3	0.3	649.8
3	0.902	0.0	0.0	0.3	0.0	0.0	0.3	0.3	650.1
4	0.871	0.0	0.0	0.3	0.0	0.0	0.3	0.3	650.4
5	0.842	0.0	0.0	0.3	0.0	0.0	0.3	0.3	650.7
6	0.814	0.0	0.0	0.3	0.0	0.0	0.3	0.3	651.0
7	0.786	0.0	0.0	0.3	0.0	0.0	0.3	0.3	651.2
8	0.759	0.0	0.0	0.3	0.0	0.0	0.3	0.3	651.5
9	0.734	0.0	0.0	0.3	0.0	0.0	0.3	0.3	651.8
10	0.709	0.0	0.0	0.3	0.0	0.0	0.3	0.2	652.0
11	0.685	0.0	0.0	0.3	0.0	0.0	0.3	0.2	652.2
12	0.662	0.0	0.0	0.3	0.0	0.0	0.3	0.2	652.5
13	0.639	0.0	0.0	0.3	0.0	0.0	0.3	0.2	652.7
14	0.618	0.0	0.0	0.3	0.0	0.0	0.3	0.2	652.9
15	0.597	0.0	0.0	0.3	0.0	0.0	0.3	0.2	653.1
16	0.577	0.0	0.0	0.3	0.0	0.0	0.3	0.2	653.3
17	0.557	0.0	0.0	0.3	0.0	0.0	0.3	0.2	653.5
18	0.538	0.0	0.0	0.3	0.0	0.0	0.3	0.2	653.7
19	0.520	0.0	0.0	0.3	0.0	0.0	0.3	0.2	653.9
20	0.503	0.0	0.0	0.3	0.0	0.0	0.3	0.2	654.0
21	0.486	0.0	0.0	0.3	0.0	0.0	0.3	0.2	654.2
22	0.469	0.0	0.0	0.3	0.0	0.0	0.3	0.2	654.4
23	0.453	0.0	0.0	0.3	0.0	0.0	0.3	0.2	654.5
24	0.438	0.0	0.0	0.3	0.0	0.0	0.3	0.2	654.7
25	0.423	0.0	0.0	0.3	0.0	0.0	0.3	0.1	654.8
26	0.409	0.0	0.0	0.3	0.0	0.0	0.3	0.1	654.9
27	0.395	0.0	0.0	0.3	0.0	0.0	0.3	0.1	655.1
28	0.382	0.0	0.0	0.3	0.0	0.0	0.3	0.1	655.2
29	0.369	0.0	0.0	0.3	0.0	0.0	0.3	0.1	655.3
30	0.356	0.0	0.0	0.3	0.0	0.0	0.3	0.1	655.5
31	0.346	0.0	0.0	0.3	0.0	0.0	0.3	0.1	655.6
32	0.336	0.0	0.0	0.3	0.0	0.0	0.3	0.1	655.7
33	0.326	0.0	0.0	0.3	0.0	0.0	0.3	0.1	655.8
34	0.317	0.0	0.0	0.3	0.0	0.0	0.3	0.1	655.9
35	0.307	0.0	0.0	0.3	0.0	0.0	0.3	0.1	656.0
36	0.298	0.0	0.0	0.3	0.0	0.0	0.3	0.1	656.1
37	0.290	0.0	0.0	0.3	0.0	0.0	0.3	0.1	656.2
38	0.281	0.0	0.0	0.3	0.0	0.0	0.3	0.1	656.3
39	0.273	0.0	0.0	0.3	0.0	0.0	0.3	0.1	656.4
40	0.265	0.0	0.0	0.3	0.0	0.0	0.3	0.1	656.5
41	0.257	0.0	0.0	0.3	0.0	0.0	0.3	0.1	656.6
42	0.250	0.0	0.0	0.3	0.0	0.0	0.3	0.1	656.7
43	0.243	0.0	0.0	0.3	0.0	0.0	0.3	0.1	656.8
44	0.236	0.0	0.0	0.3	0.0	0.0	0.3	0.1	656.8
45	0.229	0.0	0.0	0.3	0.0	0.0	0.3	0.1	656.9
46	0.222	0.0	0.0	0.3	0.0	0.0	0.3	0.1	657.0
47	0.216	0.0	0.0	0.3	0.0	0.0	0.3	0.1	657.1
48	0.209	0.0	0.0	0.3	0.0	0.0	0.3	0.1	657.1
49	0.203	0.0	0.0	0.3	0.0	0.0	0.3	0.1	657.2
50	0.197	0.0	0.0	0.3	0.0	0.0	0.3	0.1	657.3
51	0.192	0.0	0.0	0.3	0.0	0.0	0.3	0.1	657.3
52	0.186	0.0	0.0	0.3	0.0	0.0	0.3	0.1	657.4
53	0.181	0.0	0.0	0.3	0.0	0.0	0.3	0.1	657.5
54	0.175	0.0	0.0	0.3	0.0	0.0	0.3	0.1	657.5
55	0.170	0.0	0.0	0.3	0.0	0.0	0.3	0.1	657.6
56	0.165	0.0	0.0	0.3	0.0	0.0	0.3	0.1	657.6
57	0.160	0.0	0.0	0.3	0.0	0.0	0.3	0.1	657.7
58	0.156	0.0	0.0	0.3	0.0	0.0	0.3	0.1	657.8
59	0.151	0.0	0.0	0.3	0.0	0.0	0.3	0.1	657.8
60	0.147	0.0	0.0	0.3	0.0	0.0	0.3	0.1	657.9
61	0.143	0.0	0.0	0.3	0.0	0.0	0.3	0.0	657.9
62	0.138	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.0
63	0.134	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.0
64	0.130	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.0
65	0.127	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.1
66	0.123	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.1
67	0.119	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.2
68	0.116	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.2
69	0.112	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.2
70	0.109	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.3
71	0.106	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.3
72	0.103	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.4
73	0.100	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.4
74	0.097	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.4
75	0.094	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.5
76	0.092	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.5
77	0.090	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.5
78	0.087	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.5
79	0.085	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.6
80	0.083	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.6
81	0.081	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.6
82	0.079	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.7
83	0.077	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.7
84	0.075	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.7
85	0.074	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.7
86	0.072	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.8
87	0.070	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.8
88	0.068	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.8
89	0.067	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.8
90	0.065	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.9

91	0.063	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.9
92	0.062	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.9
93	0.060	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.9
94	0.059	0.0	0.0	0.3	0.0	0.0	0.3	0.0	658.9
95	0.057	0.0	0.0	0.3	0.0	0.0	0.3	0.0	659.0
96	0.056	0.0	0.0	0.3	0.0	0.0	0.3	0.0	659.0
97	0.055	0.0	0.0	0.3	0.0	0.0	0.3	0.0	659.0
98	0.053	0.0	0.0	0.3	0.0	0.0	0.3	0.0	659.0
99	0.052	0.0	0.0	0.3	0.0	0.0	0.3	0.0	659.0

Whole life cost charts





Summary of costs

Client/Authority		Prepared (date)	Sept. 2018	
Scottish Borders Council		Printed	10/01/2019	
Project/Option name		Prepared by	C. Kampanou	
Earlston Flood Study - Turfford Burn Total bypass		Checked by	S. Cooney	
Project reference		Checked date	October 2018	
Base date for estimates (year 0)	Jan-2018			
Scaling factor (e.g. £m, £k, £)	£k			
Optimism bias adjustment factor	60%			

PV Cost Summary

	Costs in £k
Enabling Costs	£117.59
Capital Costs	£1,032.40
O & M Costs	£53.13
Other Costs	£0.00
Total Real Cost	£1,203.12
Total Cost PV	£1,130.17
Total Cost PV + OB	**£1,808.28**

Note: Macros are required to open individual cost modules and the user should ensure they are enabled in the Excel Security Settings.
Note: Cost modules are opened from blank templates by clicking on the pentagons below. If a template exists, the user is sent the module. Only one module per worksheet is permitted.
Note: Costs are automatically summed from all individual cost module sheets every time the user returns to this summary sheet. This process takes into account the above scaling factor.
Note: If multiple measures are used, the optimism bias value used in each module is overridden by that selected above (Cell D10).

Additional user notes:
Add additional user notes here.

FRM Measure	Asset	Open / Go to Costing Sheet	Delete Sheet	Enabling Costs	Capital Costs	O & M Costs	Other Costs	Total Cost Cash	Total Cost PV
Fluvial raised defence	**Embankment**								
	Wall								
	Sheet Piling								
Channel management	**N/A**			£67.23	£750.589	£39.58	£0.00	£857.40	£803.68
Culvert & screen	**N/A**			£50.36	£251.807	£13.55	£0.00	£315.72	£297.50
Control assets	**Weir**								
	Pumping station								
	Flood gate								
	Outfall								
	Flow barrier								
Coastal protection	**Wall**								
	Revetment								
	Groyne								
	Recharge								
Flood storage	**N/A**								
Flood warning and forecasting	**Various**								
Temporary & demountable barriers	**Various**								
Household resistance	**Various**								
Household resilience	**Various**								
SUDS and urban drainage	**Various**								
Managed realignment	**Various**								
Habitat creation	**Various**								
Landuse & runoff management	**Various**								
River Restoration	**Various**								
User Defined 1	**Various**			£0.00	£30.000	£0.00	£0.00	£30.00	£28.99
User Defined 2	**Various**								
User Defined 3	**Various**								

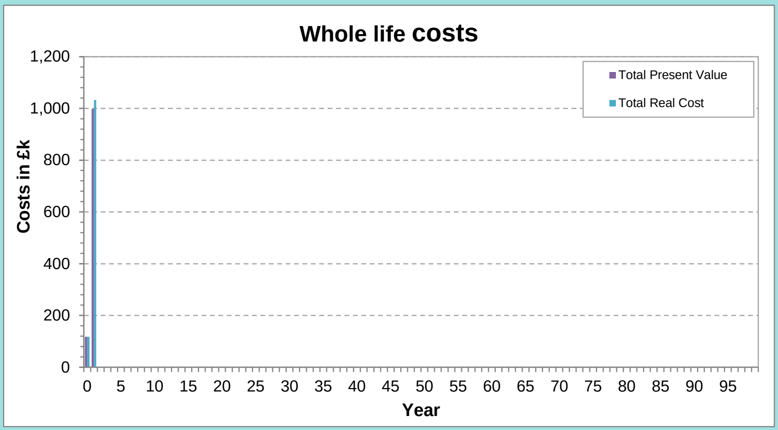
Whole Life and Present Value Cost Analysis

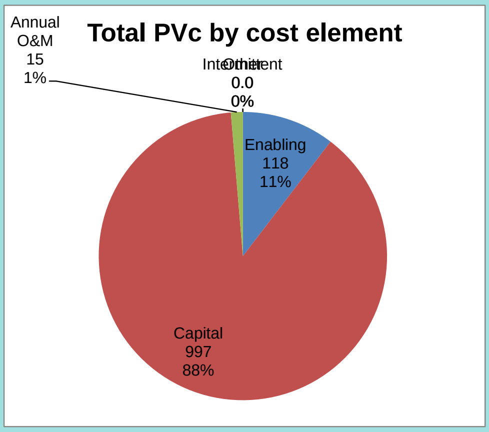
PV factor	29.813	Total PVc (£k):	1130

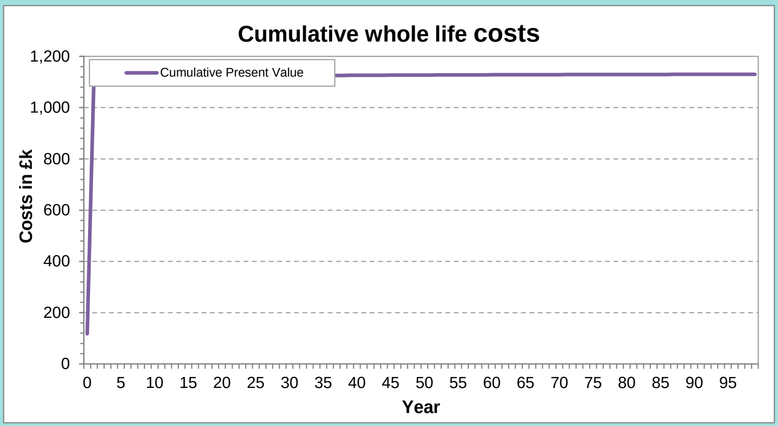
year		Enabling £k	Capital £k	Annual O&M £k	Intermittent O&M £k	Other £k	TOTALS: Current price	PV (£k)	Cumulative PV Costs (£k)
	Total real cost	118	1032	53	0.0	0.0	1203	1130	
	Total PV cost	118	997	15	0.0	0.0		1130	
year	Discount Factor								
0	1.000	117.6	0.0	0.0	0.0	0.0	117.6	117.6	117.6
1	0.966	0.0	1032.4	0.0	0.0	0.0	1032.4	997.5	1115.1
2	0.934	0.0	0.0	0.5	0.0	0.0	0.5	0.5	1115.6
3	0.902	0.0	0.0	0.5	0.0	0.0	0.5	0.5	1116.1
4	0.871	0.0	0.0	0.5	0.0	0.0	0.5	0.5	1116.5
5	0.842	0.0	0.0	0.5	0.0	0.0	0.5	0.5	1117.0
6	0.814	0.0	0.0	0.5	0.0	0.0	0.5	0.4	1117.4
7	0.786	0.0	0.0	0.5	0.0	0.0	0.5	0.4	1117.9
8	0.759	0.0	0.0	0.5	0.0	0.0	0.5	0.4	1118.3
9	0.734	0.0	0.0	0.5	0.0	0.0	0.5	0.4	1118.7
10	0.709	0.0	0.0	0.5	0.0	0.0	0.5	0.4	1119.1
11	0.685	0.0	0.0	0.5	0.0	0.0	0.5	0.4	1119.4
12	0.662	0.0	0.0	0.5	0.0	0.0	0.5	0.4	1119.8
13	0.639	0.0	0.0	0.5	0.0	0.0	0.5	0.3	1120.1
14	0.618	0.0	0.0	0.5	0.0	0.0	0.5	0.3	1120.5
15	0.597	0.0	0.0	0.5	0.0	0.0	0.5	0.3	1120.8
16	0.577	0.0	0.0	0.5	0.0	0.0	0.5	0.3	1121.1
17	0.557	0.0	0.0	0.5	0.0	0.0	0.5	0.3	1121.4
18	0.538	0.0	0.0	0.5	0.0	0.0	0.5	0.3	1121.7
19	0.520	0.0	0.0	0.5	0.0	0.0	0.5	0.3	1122.0
20	0.503	0.0	0.0	0.5	0.0	0.0	0.5	0.3	1122.3
21	0.486	0.0	0.0	0.5	0.0	0.0	0.5	0.3	1122.5
22	0.469	0.0	0.0	0.5	0.0	0.0	0.5	0.3	1122.8
23	0.453	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1123.0
24	0.438	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1123.3
25	0.423	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1123.5
26	0.409	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1123.7
27	0.395	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1123.9
28	0.382	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1124.1
29	0.369	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1124.3
30	0.356	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1124.5
31	0.346	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1124.7
32	0.336	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1124.9
33	0.326	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1125.1
34	0.317	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1125.2
35	0.307	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1125.4
36	0.298	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1125.6
37	0.290	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1125.7
38	0.281	0.0	0.0	0.5	0.0	0.0	0.5	0.2	1125.9
39	0.273	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1126.0
40	0.265	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1126.2
41	0.257	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1126.3
42	0.250	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1126.4
43	0.243	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1126.6
44	0.236	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1126.7
45	0.229	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1126.8
46	0.222	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1126.9
47	0.216	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1127.1
48	0.209	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1127.2
49	0.203	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1127.3
50	0.197	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1127.4
51	0.192	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1127.5
52	0.186	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1127.6
53	0.181	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1127.7
54	0.175	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1127.8
55	0.170	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1127.9
56	0.165	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1128.0
57	0.160	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1128.1
58	0.156	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1128.1
59	0.151	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1128.2
60	0.147	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1128.3
61	0.143	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1128.4
62	0.138	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1128.5
63	0.134	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1128.5
64	0.130	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1128.6
65	0.127	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1128.7
66	0.123	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1128.7
67	0.119	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1128.8
68	0.116	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1128.9
69	0.112	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1128.9
70	0.109	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1129.0
71	0.106	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1129.0
72	0.103	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1129.1
73	0.100	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1129.2
74	0.097	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1129.2
75	0.094	0.0	0.0	0.5	0.0	0.0	0.5	0.1	1129.3
76	0.092	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.3
77	0.090	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.4
78	0.087	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.4
79	0.085	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.5
80	0.083	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.5
81	0.081	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.5
82	0.079	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.6
83	0.077	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.6
84	0.075	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.7
85	0.074	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.7
86	0.072	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.7
87	0.070	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.8
88	0.068	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.8
89	0.067	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.9
90	0.065	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.9

91	0.063	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1129.9
92	0.062	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1130.0
93	0.060	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1130.0
94	0.059	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1130.0
95	0.057	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1130.1
96	0.056	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1130.1
97	0.055	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1130.1
98	0.053	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1130.1
99	0.052	0.0	0.0	0.5	0.0	0.0	0.5	0.0	1130.2

Whole life cost charts







Summary of costs

Client/Authority		Prepared (date)	Sept. 2018
Scottish Borders Council		Printed	10/01/2019
Project/Option name		Prepared by	C. Kampanou
Earlston Flood Study - Turfford Burn Storage		Checked by	S. Cooney
Project reference		Checked date	October 2018
Base date for estimates (year 0)	Jan-2018		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary	Costs in £k
Enabling Costs	£253.38
Capital Costs	£2,576.01
O & M Costs	£1,033.44
Other Costs	£0.00
Total Real Cost	£3,862.84
Total Cost PV	£3,035.93
Total Cost PV + OB	**£4,857.49**

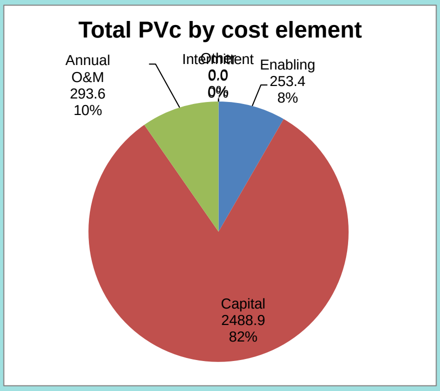
Note: Macros are required to open individual cost modules and the user should ensure they are enabled in the Excel Security Settings.
Note: Cost modules are opened from blank templates by clicking on the pentagons below. If a template exists, the user is sent the module. Only one module per worksheet is permitted.
Note: Costs are automatically summed from all individual cost module sheets every time the user returns to this summary sheet. This process takes into account the above scaling factor.
Note: If multiple measures are used, the optimism bias value used in each module is overridden by that selected above (Cell D10).
Additional user notes:
Add additional user notes here.

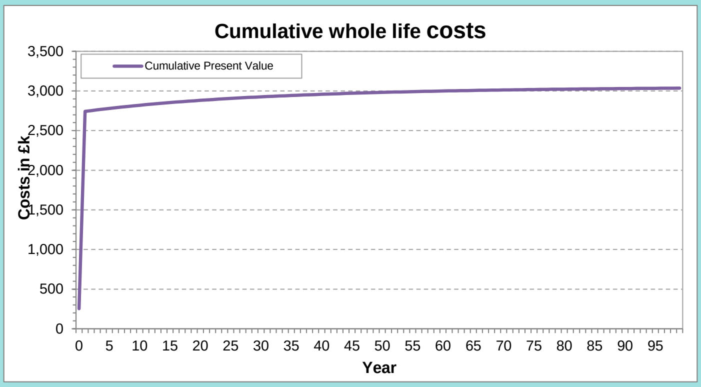
FRM Measure	Asset	Open / Go to Costing Sheet	Delete Sheet	Enabling Costs	Capital Costs	O & M Costs	Other Costs	Total Cost Cash	Total Cost PV
Fluvial raised defence	Embankment			£47.27	£541.22	£26.42	£0.00	£614.91	£577.70
	Wall								
	Sheet Piling								
Channel management	N/A								
Culvert & screen	N/A			£43.79	£224.96	£123.27	£0.00	£392.02	£296.17
Control assets	Weir								
	Pumping station								
	Flood gate								
	Outfall								
	Flow barrier								
Coastal protection	Wall								
	Revetment								
	Groyne								
	Recharge								
Flood storage	N/A			£162.32	£1,803.58	£883.75	£0.00	£2,849.65	£2,156.02
Flood warning and forecasting	Various								
Temporary & demountable barriers	Various								
Household resistance	Various								
Household resilience	Various								
SUDS and urban drainage	Various								
Managed realignment	Various								
Habitat creation	Various								
Landuse & runoff management	Various								
River Restoration	Various								
User Defined 1	Various			£0.00	£6.25	£0.00	£0.00	£6.25	£6.04
User Defined 2	Various								
User Defined 3	Various								

Whole Life and Present Value Cost Analysis

		PV factor	29.813				Total PVc (£k):	3035.9	
		Enabling £k	Capital £k	Annual O&M £k	Intermittent O&M £k	Other £k	TOTALS: Current price	PV (£k)	
	Total real cost	253.4	2576.0	1033.4	0.0	0.0	3862.84	3035.9	
	Total PV cost	253.4	2488.9	293.6	0.0	0.0		3035.9	Cumulative
year	Discount Factor								PV Costs (£k)
0	1.000	253.4	0.0	0.0	0.0	0.0	253.4	253.4	253.4
1	0.966	0.0	2576.0	0.0	0.0	0.0	2576.0	2488.9	2742.3
2	0.934	0.0	0.0	10.5	0.0	0.0	10.5	9.8	2752.1
3	0.902	0.0	0.0	10.5	0.0	0.0	10.5	9.5	2761.6
4	0.871	0.0	0.0	10.5	0.0	0.0	10.5	9.2	2770.8
5	0.842	0.0	0.0	10.5	0.0	0.0	10.5	8.9	2779.7
6	0.814	0.0	0.0	10.5	0.0	0.0	10.5	8.6	2788.3
7	0.786	0.0	0.0	10.5	0.0	0.0	10.5	8.3	2796.6
8	0.759	0.0	0.0	10.5	0.0	0.0	10.5	8.0	2804.6
9	0.734	0.0	0.0	10.5	0.0	0.0	10.5	7.7	2812.3
10	0.709	0.0	0.0	10.5	0.0	0.0	10.5	7.5	2819.8
11	0.685	0.0	0.0	10.5	0.0	0.0	10.5	7.2	2827.0
12	0.662	0.0	0.0	10.5	0.0	0.0	10.5	7.0	2834.0
13	0.639	0.0	0.0	10.5	0.0	0.0	10.5	6.7	2840.7
14	0.618	0.0	0.0	10.5	0.0	0.0	10.5	6.5	2847.3
15	0.597	0.0	0.0	10.5	0.0	0.0	10.5	6.3	2853.6
16	0.577	0.0	0.0	10.5	0.0	0.0	10.5	6.1	2859.6
17	0.557	0.0	0.0	10.5	0.0	0.0	10.5	5.9	2865.5
18	0.538	0.0	0.0	10.5	0.0	0.0	10.5	5.7	2871.2
19	0.520	0.0	0.0	10.5	0.0	0.0	10.5	5.5	2876.7
20	0.503	0.0	0.0	10.5	0.0	0.0	10.5	5.3	2882.0
21	0.486	0.0	0.0	10.5	0.0	0.0	10.5	5.1	2887.1
22	0.469	0.0	0.0	10.5	0.0	0.0	10.5	4.9	2892.0
23	0.453	0.0	0.0	10.5	0.0	0.0	10.5	4.8	2896.8
24	0.438	0.0	0.0	10.5	0.0	0.0	10.5	4.6	2901.4
25	0.423	0.0	0.0	10.5	0.0	0.0	10.5	4.5	2905.9
26	0.409	0.0	0.0	10.5	0.0	0.0	10.5	4.3	2910.2
27	0.395	0.0	0.0	10.5	0.0	0.0	10.5	4.2	2914.4
28	0.382	0.0	0.0	10.5	0.0	0.0	10.5	4.0	2918.4
29	0.369	0.0	0.0	10.5	0.0	0.0	10.5	3.9	2922.3
30	0.356	0.0	0.0	10.5	0.0	0.0	10.5	3.8	2926.0
31	0.346	0.0	0.0	10.5	0.0	0.0	10.5	3.6	2929.7
32	0.336	0.0	0.0	10.5	0.0	0.0	10.5	3.5	2933.2
33	0.326	0.0	0.0	10.5	0.0	0.0	10.5	3.4	2936.7
34	0.317	0.0	0.0	10.5	0.0	0.0	10.5	3.3	2940.0
35	0.307	0.0	0.0	10.5	0.0	0.0	10.5	3.2	2943.3
36	0.298	0.0	0.0	10.5	0.0	0.0	10.5	3.1	2946.4
37	0.290	0.0	0.0	10.5	0.0	0.0	10.5	3.1	2949.5
38	0.281	0.0	0.0	10.5	0.0	0.0	10.5	3.0	2952.4
39	0.273	0.0	0.0	10.5	0.0	0.0	10.5	2.9	2955.3
40	0.265	0.0	0.0	10.5	0.0	0.0	10.5	2.8	2958.1
41	0.257	0.0	0.0	10.5	0.0	0.0	10.5	2.7	2960.8
42	0.250	0.0	0.0	10.5	0.0	0.0	10.5	2.6	2963.4
43	0.243	0.0	0.0	10.5	0.0	0.0	10.5	2.6	2966.0
44	0.236	0.0	0.0	10.5	0.0	0.0	10.5	2.5	2968.5
45	0.229	0.0	0.0	10.5	0.0	0.0	10.5	2.4	2970.9
46	0.222	0.0	0.0	10.5	0.0	0.0	10.5	2.3	2973.2
47	0.216	0.0	0.0	10.5	0.0	0.0	10.5	2.3	2975.5
48	0.209	0.0	0.0	10.5	0.0	0.0	10.5	2.2	2977.7
49	0.203	0.0	0.0	10.5	0.0	0.0	10.5	2.1	2979.9
50	0.197	0.0	0.0	10.5	0.0	0.0	10.5	2.1	2981.9
51	0.192	0.0	0.0	10.5	0.0	0.0	10.5	2.0	2984.0
52	0.186	0.0	0.0	10.5	0.0	0.0	10.5	2.0	2985.9
53	0.181	0.0	0.0	10.5	0.0	0.0	10.5	1.9	2987.8
54	0.175	0.0	0.0	10.5	0.0	0.0	10.5	1.8	2989.7
55	0.170	0.0	0.0	10.5	0.0	0.0	10.5	1.8	2991.5
56	0.165	0.0	0.0	10.5	0.0	0.0	10.5	1.7	2993.2
57	0.160	0.0	0.0	10.5	0.0	0.0	10.5	1.7	2994.9
58	0.156	0.0	0.0	10.5	0.0	0.0	10.5	1.6	2996.5
59	0.151	0.0	0.0	10.5	0.0	0.0	10.5	1.6	2998.1
60	0.147	0.0	0.0	10.5	0.0	0.0	10.5	1.5	2999.7
61	0.143	0.0	0.0	10.5	0.0	0.0	10.5	1.5	3001.2
62	0.138	0.0	0.0	10.5	0.0	0.0	10.5	1.5	3002.6
63	0.134	0.0	0.0	10.5	0.0	0.0	10.5	1.4	3004.1
64	0.130	0.0	0.0	10.5	0.0	0.0	10.5	1.4	3005.4
65	0.127	0.0	0.0	10.5	0.0	0.0	10.5	1.3	3006.8
66	0.123	0.0	0.0	10.5	0.0	0.0	10.5	1.3	3008.1
67	0.119	0.0	0.0	10.5	0.0	0.0	10.5	1.3	3009.3
68	0.116	0.0	0.0	10.5	0.0	0.0	10.5	1.2	3010.6
69	0.112	0.0	0.0	10.5	0.0	0.0	10.5	1.2	3011.7
70	0.109	0.0	0.0	10.5	0.0	0.0	10.5	1.2	3012.9
71	0.106	0.0	0.0	10.5	0.0	0.0	10.5	1.1	3014.0
72	0.103	0.0	0.0	10.5	0.0	0.0	10.5	1.1	3015.1
73	0.100	0.0	0.0	10.5	0.0	0.0	10.5	1.1	3016.1
74	0.097	0.0	0.0	10.5	0.0	0.0	10.5	1.0	3017.2
75	0.094	0.0	0.0	10.5	0.0	0.0	10.5	1.0	3018.2
76	0.092	0.0	0.0	10.5	0.0	0.0	10.5	1.0	3019.1
77	0.090	0.0	0.0	10.5	0.0	0.0	10.5	0.9	3020.1
78	0.087	0.0	0.0	10.5	0.0	0.0	10.5	0.9	3021.0
79	0.085	0.0	0.0	10.5	0.0	0.0	10.5	0.9	3021.9
80	0.083	0.0	0.0	10.5	0.0	0.0	10.5	0.9	3022.8
81	0.081	0.0	0.0	10.5	0.0	0.0	10.5	0.9	3023.6
82	0.079	0.0	0.0	10.5	0.0	0.0	10.5	0.8	3024.5
83	0.077	0.0	0.0	10.5	0.0	0.0	10.5	0.8	3025.3
84	0.075	0.0	0.0	10.5	0.0	0.0	10.5	0.8	3026.1
85	0.074	0.0	0.0	10.5	0.0	0.0	10.5	0.8	3026.9
86	0.072	0.0	0.0	10.5	0.0	0.0	10.5	0.8	3027.6
87	0.070	0.0	0.0	10.5	0.0	0.0	10.5	0.7	3028.4
88	0.068	0.0	0.0	10.5	0.0	0.0	10.5	0.7	3029.1
89	0.067	0.0	0.0	10.5	0.0	0.0	10.5	0.7	3029.8
90	0.065	0.0	0.0	10.5	0.0	0.0	10.5	0.7	3030.5
91	0.063	0.0	0.0	10.5	0.0	0.0	10.5	0.7	3031.1
92	0.062	0.0	0.0	10.5	0.0	0.0	10.5	0.7	3031.8
93	0.060	0.0	0.0	10.5	0.0	0.0	10.5	0.6	3032.4
94	0.059	0.0	0.0	10.5	0.0	0.0	10.5	0.6	3033.0
95	0.057	0.0	0.0	10.5	0.0	0.0	10.5	0.6	3033.7
96	0.056	0.0	0.0	10.5	0.0	0.0	10.5	0.6	3034.2
97	0.055	0.0	0.0	10.5	0.0	0.0	10.5	0.6	3034.8
98	0.053	0.0	0.0	10.5	0.0	0.0	10.5	0.6	3035.4
99	0.052	0.0	0.0	10.5	0.0	0.0	10.5	0.5	3035.9

Whole life cost charts





Whole life cost and PVc analysis example - with replacement costs

Enter enabling, capital, annual O&M and other costs in table below
Enter frequency of other (or replacement) works in table below

Enabling cost (£k)	£11.8
Year of capital works (year)	1
Capital cost (£k)	£102.0
Annual maintenance cost (£k)	£2.0
Other cost (£k)	£0.0
Other works frequency (years)	1
Other cost (£k)	£0.0
Other works frequency (years)	1
Replacement (£)	101.989
Replacement frequency (years)	20
Optimism Bias	60%

Key

Light blue	Information
Yellow	Calculation
White	Cost input
Purple	Default

Initial discount rate	**3.5%**	**29.813**
Total PVc (£k) with Optimism Bias:		**425**
Total PVc (£k):		**266**

		Cost Elements				PV			TOTALS:	
		Enabling	**Capital**	**Maint.**	**Interm.**	**Enabling**	**Capital**	**Maint.**	**Cash**	**PV**
	Cash sum	12	510	200	0	12	197	57	722	**266**
year	**Discount Factor**									
0	1.000	11.8			0	11.84			11.8	11.8
1	0.966		102		0		98.5401		102.0	98.5
2	0.934			2	0			1.904156	2.0	1.9
3	0.902			2	0			1.839765	2.0	1.8
4	0.871			2	0			1.77755	2.0	1.8
5	0.842			2	0			1.71744	2.0	1.7
6	0.814			2	0			1.659362	2.0	1.7
7	0.786			2	0			1.603249	2.0	1.6
8	0.759			2	0			1.549033	2.0	1.5
9	0.734			2	0			1.49665	2.0	1.5
10	0.709			2	0			1.446038	2.0	1.4
11	0.685			2	0			1.397139	2.0	1.4
12	0.662			2	0			1.349892	2.0	1.3
13	0.639			2	0			1.304244	2.0	1.3
14	0.618			2	0			1.260139	2.0	1.3
15	0.597			2	0			1.217526	2.0	1.2
16	0.577			2	0			1.176353	2.0	1.2
17	0.557			2	0			1.136573	2.0	1.1
18	0.538			2	0			1.098138	2.0	1.1
19	0.520			2	0			1.061003	2.0	1.1
20	0.503			2	0			1.025124	2.0	1.0
21	0.486		102	2	0		49.52289	0.990458	104.0	50.5
22	0.469			2	0			0.956964	2.0	1.0
23	0.453			2	0			0.924603	2.0	0.9
24	0.438			2	0			0.893336	2.0	0.9
25	0.423			2	0			0.863127	2.0	0.9
26	0.409			2	0			0.833939	2.0	0.8
27	0.395			2	0			0.805738	2.0	0.8
28	0.382			2	0			0.778491	2.0	0.8
29	0.369			2	0			0.752165	2.0	0.8
30	0.356			2	0			0.72673	2.0	0.7
31	0.346			2	0			0.705563	2.0	0.7
32	0.336			2	0			0.685012	2.0	0.7
33	0.326			2	0			0.665061	2.0	0.7
34	0.317			2	0			0.64569	2.0	0.6
35	0.307			2	0			0.626883	2.0	0.6
36	0.298			2	0			0.608625	2.0	0.6
37	0.290			2	0			0.590898	2.0	0.6
38	0.281			2	0			0.573687	2.0	0.6
39	0.273			2	0			0.556978	2.0	0.6
40	0.265			2	0			0.540755	2.0	0.5
41	0.257		102	2	0		26.25025	0.525005	104.0	26.8
42	0.250			2	0			0.509714	2.0	0.5
43	0.243			2	0			0.494867	2.0	0.5

44	0.236			2	0		0.480454	2.0	0.5
45	0.229			2	0		0.46646	2.0	0.5
46	0.222			2	0		0.452874	2.0	0.5
47	0.216			2	0		0.439683	2.0	0.4
48	0.209			2	0		0.426877	2.0	0.4
49	0.203			2	0		0.414444	2.0	0.4
50	0.197			2	0		0.402373	2.0	0.4
51	0.192			2	0		0.390653	2.0	0.4
52	0.186			2	0		0.379275	2.0	0.4
53	0.181			2	0		0.368228	2.0	0.4
54	0.175			2	0		0.357503	2.0	0.4
55	0.170			2	0		0.34709	2.0	0.3
56	0.165			2	0		0.336981	2.0	0.3
57	0.160			2	0		0.327166	2.0	0.3
58	0.156			2	0		0.317637	2.0	0.3
59	0.151			2	0		0.308385	2.0	0.3
60	0.147			2	0		0.299403	2.0	0.3
61	0.143		102	2	0	14.53412	0.290682	104.0	14.8
62	0.138			2	0		0.282216	2.0	0.3
63	0.134			2	0		0.273996	2.0	0.3
64	0.130			2	0		0.266016	2.0	0.3
65	0.127			2	0		0.258268	2.0	0.3
66	0.123			2	0		0.250745	2.0	0.3
67	0.119			2	0		0.243442	2.0	0.2
68	0.116			2	0		0.236351	2.0	0.2
69	0.112			2	0		0.229467	2.0	0.2
70	0.109			2	0		0.222784	2.0	0.2
71	0.106			2	0		0.216295	2.0	0.2
72	0.103			2	0		0.209995	2.0	0.2
73	0.100			2	0		0.203879	2.0	0.2
74	0.097			2	0		0.197941	2.0	0.2
75	0.094			2	0		0.192175	2.0	0.2
76	0.092			2	0		0.187488	2.0	0.2
77	0.090			2	0		0.182915	2.0	0.2
78	0.087			2	0		0.178454	2.0	0.2
79	0.085			2	0		0.174101	2.0	0.2
80	0.083			2	0		0.169855	2.0	0.2
81	0.081		102	2	0	8.285611	0.165712	104.0	8.5
82	0.079			2	0		0.16167	2.0	0.2
83	0.077			2	0		0.157727	2.0	0.2
84	0.075			2	0		0.15388	2.0	0.2
85	0.074			2	0		0.150127	2.0	0.2
86	0.072			2	0		0.146465	2.0	0.1
87	0.070			2	0		0.142893	2.0	0.1
88	0.068			2	0		0.139408	2.0	0.1
89	0.067			2	0		0.136008	2.0	0.1
90	0.065			2	0		0.13269	2.0	0.1
91	0.063			2	0		0.129454	2.0	0.1
92	0.062			2	0		0.126297	2.0	0.1
93	0.060			2	0		0.123216	2.0	0.1
94	0.059			2	0		0.120211	2.0	0.1
95	0.057			2	0		0.117279	2.0	0.1
96	0.056			2	0		0.114419	2.0	0.1
97	0.055			2	0		0.111628	2.0	0.1
98	0.053			2	0		0.108905	2.0	0.1
99	0.052			2	0		0.106249	2.0	0.1

C Appendix C - Public Consultation Questionnaire

Earlston Flood Questionnaire Report

Purpose

In order to gain an insight into the reaction of the public to proposed flood protection schemes, a questionnaire was available to be filled in at the Earlston Flood Study Exhibition on 18th October 2018. Local knowledge and feedback is key to influencing decisions on flood protection schemes but out of the 15 exhibition attendees, only 1 questionnaire response was received (7%).

Questionnaire Format

The anonymous questionnaires that were available to attendees consisted of 10 questions which could be circled 'yes' or 'no' and included a comments box to elaborate on each answer. This simple layout allowed the questionnaires to be filled in quickly while still giving the option to voice opinions and feedback in greater detail. Below are all the questions which were on the questionnaire:

1. Please name the watercourse(s) which impacts upon you?
2. Have you previously experiences flooding?
3. Do you want to see a flood protection scheme in the site of interest?
4. Do you approve of the approach that we are taking in developing a Flood Protection Scheme in your community?
5. Are there any flood related issues that you feel that we have missed?
6. Do you use the river for recreational purposes?
7. Do you have any concerns about how the flood mitigation options proposed may affect recreation activities at the river?
8. Currently are there any access issues to the existing river infrastructure, including issues which effect individuals with a disability?
9. Are you particularly concerned with any of the proposed options?
10. Do you have any other issues that you would like to raise?

Questionnaire Analysis

Questionnaire uptake was particularly low in Earlston, with only one respondent.

Their flood risk is primarily from the Turfford Burn but can be affected by the backing up of the Leader Water – the resident was supportive of a flood protection scheme for the Turfford Burn and the Leader Water and was also supportive of the approach taken by the Council.

In general, their concerns were localised and centred on erosion issues along the Turfford Burn, the requirement for shoring these banks up and the silt deposition along the end stretch of the burn.

Their suggestions for improvement were implementing a gauge on the Turfford Burn, a vegetation clearance on the Turfford Burn, strengthening the banks of the Turfford Burn and assessing/mitigating the flood risk from the footbridge over the burn next to the football pitch; this bridge is low and commonly matts up with rubbish and debris.

Outcome / Conclusion

Conclusions as to the public view on the proposed schemes were uncertain due to the low questionnaire response rates.

However, discussions at the public event were generally positive. Members of the public were on the whole supportive of the process and largely appreciated that the flood risk was relatively low in Earlston – this lower flood risk potentially contributed to the lower turnout.

JBA consulting

Offices at
Coleshill
Doncaster
Dublin
Edinburgh
Exeter
Glasgow
Haywards Heath
Isle of Man
Limerick
Newcastle upon Tyne
Newport
Peterborough
Saltaire
Skipton
Tadcaster
Thirsk
Wallingford
Warrington

Registered Office
South Barn
Broughton Hall
SKIPTON
North Yorkshire
BD23 3AE
United Kingdom

t:+44(0)1756 799919
e:info@jbaconsulting.com

Jeremy Benn Associates Ltd
Registered in England
3246693