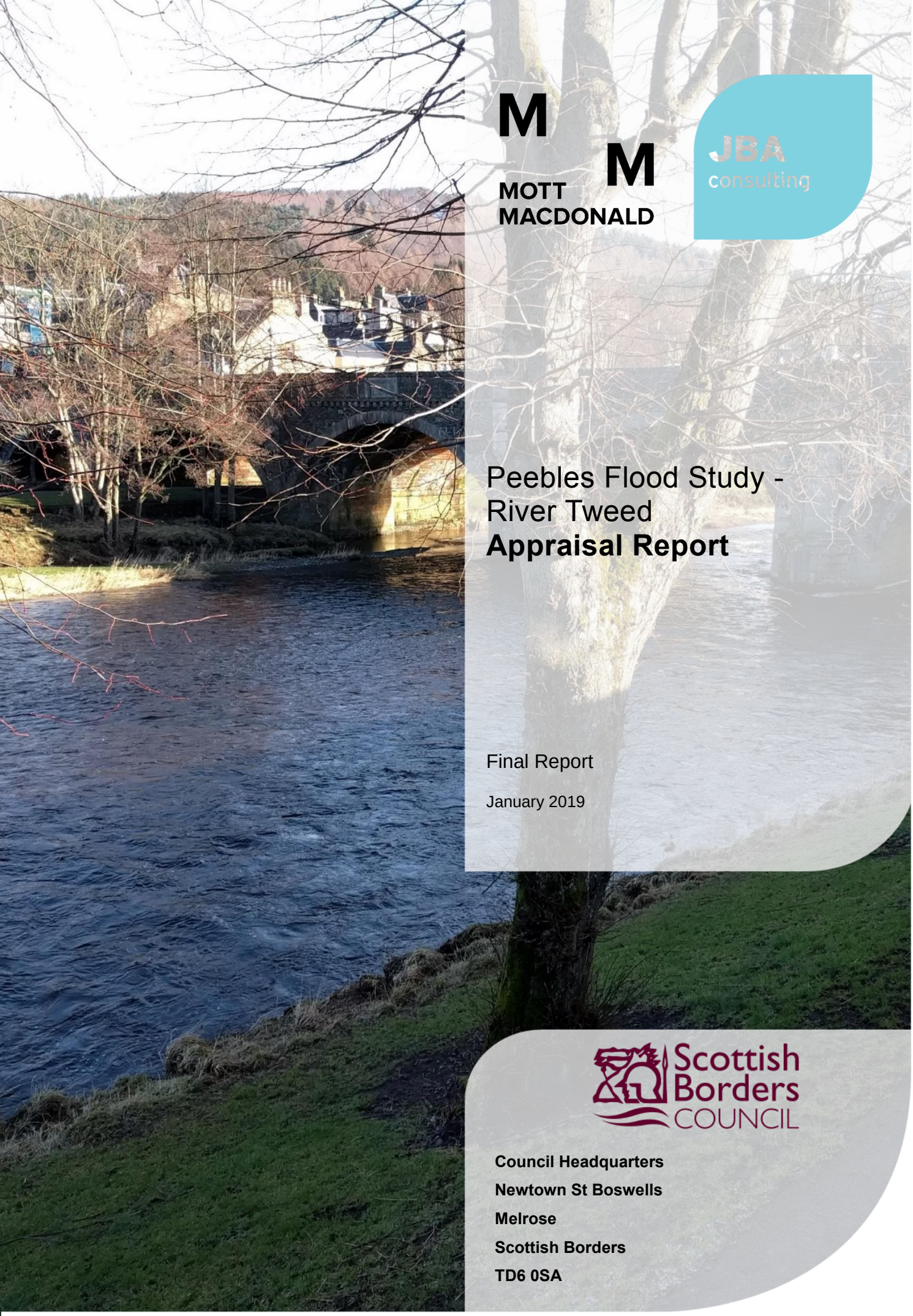

MOTT MACDONALD

JBA consulting

Peebles Flood Study - River Tweed
Appraisal Report

Final Report

January 2019

Scottish Borders COUNCIL

Council Headquarters
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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, Hannah Otton and Christina Kampanou of JBA Consulting carried out this work.

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Purpose

This document has been prepared as a Final 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 Peebles, 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 Peebles PVA (reference 13/04) includes Peebles and the surrounding communities of Eddleston, Innerleithen, Selkirk, Stow and Galashiels. According to this PVA, Peebles has a lengthy history of flooding and the potential for approximately £1,200,000 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 the Scottish Borders Council, Turner Townsend and Mott MacDonald for the data, supporting information and reviews undertaken throughout the study. We would also like to thank 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.

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JBA is aiming to reduce its per capita carbon emissions.

Peebles FRM Business Case

Context

Peebles in the Scottish Borders has a history of property flooding. 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 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 Peebles. A number of supporting documents and drawings have also been prepared to complement this report and provide additional detail on certain aspects.

The River Tweed is a large watercourse extending from a source to the west of Peebles and passing through several Borders towns with various sized tributaries contributing to its flow.

A modelling exercise was carried out to estimate river levels and map flood extents on the River Tweed from upstream of Peebles to beyond Walkerburn. A range of possible flood events were modelled from the 2 year flood to a 1000 year flood. Increases due to predicted climate changes were included (using a 33% uplift) at the 30 year and 200 year floods.

It was found that 158 properties are at risk of flooding from the 200 year event and 189 are at risk for the same event with a climate change allowance.

Risk metrics

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

Properties at risk	158 at the 200 year flood (189 with climate change)
Non-residential properties at risk	23 at the 200 year flood (24 with climate change)
Key receptors at risk	Swimming Pool, various properties on Tweed Green

Flood Mitigation Options

A range of flood protection options were then reviewed and short listed based on their viability. The only viable option in Peebles capable of providing a 200 year standard of protection would be a direct defences option involving the construction of walls and embankments alongside, and set back from, the River Tweed. However, such a high standard of protection would require extremely large flood defences (in the order of 2m in height) to be constructed throughout the centre of Peebles and alter the look and feel of the town both for residents and visitors alike. Alternative standards of protection were therefore sought, and direct defence schemes with a 50, 75 or 100 year standard of protection were found to be cost effective. The short-listed options are as follows:

- Option 1 - direct defence option with a 50 year standard of protection
- Option 2 - direct defence option with a 75 year standard of protection
- Option 3 - direct defence option with a 100 year standard of protection
- Option 4 - provision of property level protection

Improving public awareness and resilience

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

- Flood warning for Peebles is already in place but should be recalibrated in light of recent flood events. Consideration of the preferred option should be given as flood gate closure may be an implication of the preferred scheme and therefore a consideration of any future recalibration. Flood Warning should also be reviewed for Tweedside Caravan Park in Innerleithen and further downstream in Walkerburn to allow appropriate responses to forecast floods.

- Peebles is within a Flood Warning area operated by SEPA and 39 properties have property-level protection (PLP), increasing the preparedness for these frequently affected properties. The Council's PLP discount scheme could be implemented further in advance of any possible flood protection scheme.
- 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 public sandbag store at the fire station and Resilient Communities sandbag store are available in Peebles. The Council should consider the use of a flood 'pod' system. Community storage boxes, which contain flood sacks; purpose designed bags filled with absorbent material. These may 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 in Peebles.

Expected benefits

A flood damage assessment has been undertaken for the present-day Do Nothing and Do Minimum scenarios and each of the above options. The Present Value flood damages calculated for the Do Nothing and Do Minimum scenario are estimated to be £22.2m and £8.1m respectively. The damages avoided for each option are in the range of £14.2-16.7m (depending on the option assessed). Total damages avoided for each option are provided in the investment appraisal summary table.

Number of properties protected:

	50 year option	75 year option	100 year option	PLP
Damages avoided (£k)	15,611	16,107	16,733	14,182
Residential properties benefitting (% of Do Minimum)	16	23	45	59
Non-residential properties benefitting (% of Do Minimum)	12	13	14	6
Total no. properties benefitting	28	36	59	65

Working with natural processes

Natural Flood Management (NFM) is a method whereby wider catchment benefits could be achieved alongside potentially reducing flood flows within Peebles. Opportunities within the upper catchment could to some extent counteract the effects of increasing river flows with climate change but it is unlikely that they could provide complete protection against large magnitude flood events. 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.

Other opportunities for improved RBMP morphological benefits are discussed below.

- Removal of existing low embankments on the River Tweed floodplain downstream of the confluence with the Soonhope Burn could lead to RBMP benefits and minor decreases in flood levels upstream. Further investigation is required to determine if these works and possible wetland creation would help to offset any increase in flood levels as a result of the preferred options. This should be investigated further at the outline design stage.

Costs

Costs for each option have been estimated using the Environment Agency's Long Term Costing tool (2015). 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 £1.8m to £11.3m. Total costs for each option are provided in the investment appraisal summary table.

Investment appraisal

The investment appraisal is provided below. Taking into account the properties already benefitting from PLP, a PLP option has the highest benefit-cost ratio of the options tested, with a ratio of 8.0 and a net present value of £12,401k. This is compared to the benefit-cost ratio of 3.0 and net present value of £10,361k for the 50 year direct defences option. For reference, the 50 year option would provide protection to a flood similar in magnitude to that witnessed in Peebles in December 2015 as a result of Storm Frank. The incremental benefit-cost ratio shows that there is sufficient benefit from the 75 year option over and above that of the 50 year option to offset the additional costs. Despite a lower incremental benefit-cost ratio for the 100 year option this remains cost-effective and should be taken forward in preference to the other options given the greater protection it offers.

Investment appraisal summary table:

	Do Nothing	Do Minimum	50 year option	75 year option	100 year option	PLP
Total PV Costs (£k)	-	-	5,251	5,740	11,346	1,781
PV damage (£k)	22,185	8,110	6,573	6,077	5,451	5,301
PV damage avoided (£k)	-	14,075	15,611	16,107	16,733	14,182
Net present value (£k)	-	14,075	10,361	10,368	5,388	12,401
Benefit-cost ratio	-	-	3.0	2.8	1.5	8.0

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 the River Tweed and provide some resilience to climate change. A detailed NFM study should be carried out to attempt to quantify the benefits of these practices in the Tweed valley.
- The raising of Priorsford Bridge has not been recommended as part of the options as it should not impact flood levels in Tweed Green up to the 1% AP (100 year) flood event. However, blockage of this structure and the impact this might have on flood levels upstream and the risk of damage to the structure itself suggest that it would be a 'no regrets' option to raise this either as part of the scheme (making the scheme more resilient to above design flows) or opportunistically as part of a major maintenance upgrade to the structure, should this ever be required.
- The River Tweed ordinarily flows through three of its five arches with community access through the first two arches via a path and park space. Channelising the second arch to increase channel capacity during high flow events was investigated. The effects were positive, reducing flood levels but by less than 150mm. Considering the scale of the work required this option is not considered to be effective enough to carry forward, but should be reconsidered at the outline design stage once the preferred option has been confirmed.
- Direct defences could be designed to allow for demountable defences to be added to provide additional protection when large magnitude flood events are expected. The cost and infrastructure required to implement demountable defences are substantial and should be avoided if possible. Alternatively, designing defences that can be easily raised in the future would be a more preferable option. For example, installing a wall on top of a flood embankment would be a suitable option.
- Property Level Protection (PLP) would increase property resistance to flood waters and if implemented alongside a flood protection scheme could be an effective means of further reducing property flood damages.

- The large difference between Do Nothing and Do Minimum damages highlights that watercourse maintenance and particularly bridge blockage could have a large impact on flood levels within Peebles. Careful assessment of freeboard requirements upstream of Tweed Bridge is required to determine the effects of bridge blockage on defence heights under a range of scenarios.

Conclusions and recommendations

With the 2% AP (50 year), 1.33% AP (75 year) and 1% AP (100 year) direct defences options all being shown to be cost beneficial and sharing more similarities than differences any could be chosen as the preferred option for the Council to put forward for funding during the next FRM cycle. The higher standard of protection offered by the 100 year defences and the expected decline in standard of protection with climate change make this the most desirable option.

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
Direct Defences (2% AP - 50 year)	28	Implications for RBMP, set back defences selected wherever possible. Minimal in-channel works.	NFM measures have been identified and can be incorporated within the scheme to provided additional benefits. Opportunities to set back defences and retain the use of Tweed Green as an amenity area. Opportunities to remove embankment downstream of Peebles. Pumping stations behind defences considered to deal with secondary flood risk.	Defence heights likely to be most acceptable to community Large number of gates required.	Increased defence extents and heights possible but should be designed for at this stage rather than added on later. Demountable defences could be used in the future. Possible to use PLP & NFM to manage residual risk.	Option should be presented to public for comment. Signage relating to flooding and sand bag stores and work with Peebles residents alongside 'Resilient communities' programme. Flood Warning should be continued on the River Tweed and updated if necessary in light of the recommendations made and depending on the options proposed.	Highest benefit cost ratio of defended options but 75 year option provides greater long term benefit.	Maintain existing businesses and employment locally Minimal impacts to community beyond visual impacts Opportunities to set back defences and retain the use of Tweed Green as an amenity area.
Direct Defences (1.33% AP - 75 year)	36	Implications for RBMP, set back defences selected wherever possible. Minimal in-channel works.		Large number of gates required.	As above.		Incremental benefit cost ratio of 1.0 relative to 2% AP (50 year) option meaning that this option has the longest term benefits. Aligns best with council criteria to provide at least a 75 year standard.	As above with greater flood resilience.
Direct Defences (1% AP - 100 year)	59	Implications for RBMP, set back defences selected wherever possible. Minimal in-channel works.		Wall heights in some areas obstrusive and additional defences required. Large number of gates required.	As above. Priorsford Bridge raising should be considered to improve protection for above design standard events.		Highest standard of protection but lowest benefit cost ratio.	As above with greater flood resilience. Greatest resilience against climate change.
PLP (10% AP – 10 year)	69	Little to no impact.	NFM measures have been identified and can be incorporated within the scheme to provided additional benefits.	No improvement in standard of protection for some frequently flooded properties. Inconsistent standard of protection.	As above.		Highest benefit cost ratio due to low relative costs but not a long-term solution.	Minimal community disruption and change to the town.

Negative			Neutral			Positive

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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 Mapping

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-PB-00-RP-A-0003-Peebles_Hydrology_Report-S4-P03.pdf

Asset condition assessment report - AEM-JBAU-PB-00-RP-A-0002-Asset_condition_assessment-S0-P01.02.pdf

RBMP & NFM report - AEM-JBAU-PB-00-RP-E-0002-Peebles_NFM_Report-S4-P02.pdf

Preliminary Ecological Appraisal - AEM-JBAU-PB-00-RP-E-0001-PEA-S1-P01.pdf

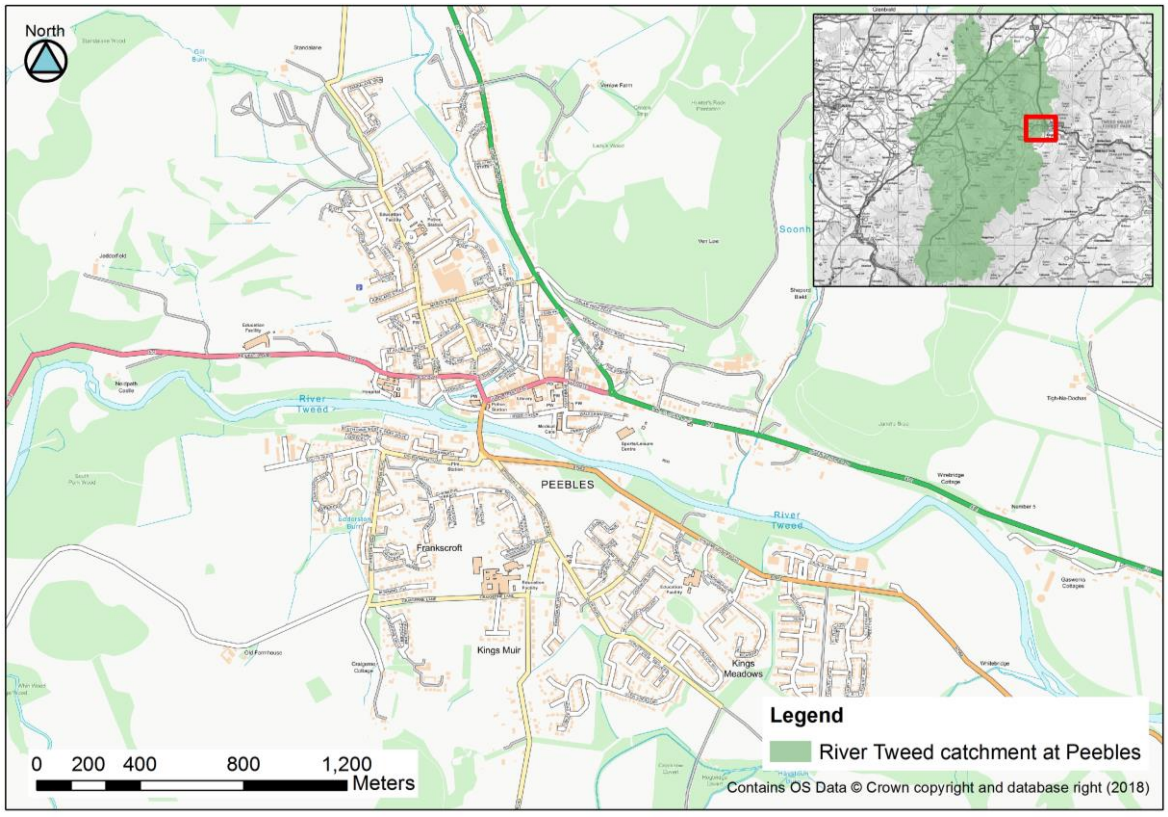
Modelling report - AEM-JBAU-PB-00-RP-A-0007-Tweed_Modelling_Report-S4-P01.pdf

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

1 Introduction

The River Tweed flows through the Borders town of Peebles as a large channel, extending from its source in the hills to the west to its mouth on the east coast of Scotland. Peebles has one of the largest populations in the Scottish Borders and is an important hub for visitors to the area. Much of the town sits on high ground away from the river but a number of properties have been built upon the floodplain and have witnessed flooding in the past.

Figure 1-1: Study area and area in relation to wider catchment



Studies relating to the tributaries of the River Tweed in Peebles, the Edderston Burn, Eddleston Water, Soonhope Burn and Haystoun Burn are reported separately since they have independent responses to rainfall and have therefore been treated in relative isolation to the River Tweed study. This study predominantly covers the risk from the River Tweed in Peebles. However, the study and hydraulic model cover the region from Peebles to Walkerburn. Flood risk to these communities is also discussed within this report.

The large catchment area, as shown in the figure above, produces a long and slow flood response with water needing to fall consistently in the upper catchment to the west to produce a sizeable flood response downstream. Much of the catchment is covered by agricultural grazing land and forestry with only small villages and hamlets upstream of Peebles. The A701 and A72 roads both pass alongside the Tweed from Peebles to its source providing important links between wider communities.

At present there are no formal flood defences within Peebles that mitigate the risk from the River Tweed. Agricultural and disused railway embankments constrain the Tweed at various points and provide some protection to riparian land, particularly Kingsmeadows embankment in central Peebles

1.1 Flooding from the River Tweed

SEPA flood maps show many properties in central Peebles to be at high to medium risk of river flooding from the River Tweed and its tributaries. The risk of surface water flooding is lower, with parkland and roads more greatly affected than properties. Peebles forms part of the Tweed Local Plan District and is within Potentially Vulnerable Area (PVA) 13/04 which also includes Eddleston, Innerleithen, Selkirk, Stow and Galashiels. Within this PVA there are estimated to be 1,900 residential properties and 1,000 non-residential properties at risk of flooding.

Flooding has affected the residents of Peebles over the past century, primarily in central areas of the town in the main corridor overlooking the River Tweed. Large historic floods such as 1948 had a huge impact and would have a significant affect today with the increase in the number of properties built within the flood extents of large magnitude floods. In recent years Tweed Green has seen the greatest frequency of flooding since the green itself is a flat and low area of land with no protection from high river flows. The properties surrounding the Green are often the first affected by flooding with properties in Tweed Avenue, Kingsknowe and the swimming pool following if water levels continue to rise. Areas along the south bank of the Tweed tend to flood less frequently with South Park, Kingsmeadows, Greenside tending to be the first affected but mainly from road flooding.

Following Storm Frank (December 2015) a number of properties in Tweed Green and Tweed Avenue received Property Level Protection products in an attempt to improve their resistance to shallow flood flows. Tweed Avenue suffers from flooding originating in Tweed Green from a number of sources: passing through a passage known as 'the vennel'; flows entering through properties on the riverside including Priorsford House; and from water flowing around a disused railway embankment from the Gytes Leisure Centre. Otherwise the flow mechanisms are straightforward.

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

The River Tweed and Peebles have been the focus of numerous flood risk studies. A great many individual assessments have been carried out, mainly for individual developments or to address individual flow pathways. A past study into the gravel island upstream of Tweed Bridge found that this has no impact on water levels in this area, with its removal estimated to reduce water levels at Tweed Bridge by under 200mm. Several sections of the River Tweed have been modelled in the past to estimate flood risk to the Tweedbridge Court site and the Gytes Leisure Centre pitches where a 3G sports pitch was proposed.

More recently a series of post-flood surveys was carried out; most recently for various communities in the Scottish Borders following the December 2015 flooding which occurred as a result of Storm Frank and brought significant flooding to Peebles. This survey collected details of the storm event including photographs and estimates of flood extents based on wrack marks which provides a useful reference for current hydraulic model calibration. The flood on 30 December 2015 was the largest on record with an estimated peak flow of 500m^3/s and an event rarity of 55-70 years.

Prior to December 2015 a post flood survey was carried out in 2009 for what was the 6th largest flood event on record. This flood had an estimated return period of 10-25 years.

The SFDAD reviewed the South Park scheme. This highlighted this secondary risk to Peebles and is discussed in its own report.

1.1.2 Watercourse condition and catchment opportunities

The Tweed catchment upstream of Peebles is dominated by rural land uses and provides scope for improvements in watercourse condition and flood risk management by means of emulation of natural processes. Natural means of land and watercourse management are of particular importance here since the River Tweed is a Special Area of Conservation (SAC) seeking to maintain the environment in a state habitable by Atlantic salmon, otter and lamprey.

From its headwaters to Peebles, the River Tweed was graded as moderate condition by SEPA under the River Basin Management Plan (RBMP) 2014 study due to the presence of Talla reservoir and its potential impact upon plant and animal communities. No action is expected until the next FRM cycle due to the minor impacts on flows and water levels that the reservoir has and its unconfirmed effects on plant and animal communities. Downstream of Peebles the River Tweed achieved a Good status and will only require monitoring to ensure its good status is maintained. The Eddleston Water, a catchment of the River Tweed has a poor status due to its physical condition, impacted by urban and rural land uses, and only a moderate condition based on water quality. A significant study is underway within this catchment to emulate natural processes through NFM's measures including remeandering, tree planting, embankment removal and introduction of flow restrictions and leaky barriers to increase floodplain storage. The Eddleston Project is being carried out and studied by a partnership led by Tweed Forum.

Elsewhere in the Tweed catchment SEPA's NFM maps show that there is Medium potential for runoff reduction across the catchment, medium potential for floodplain storage close to the Tweed and some areas of high potential, some areas of high erosion and deposition. A full review of the specific opportunities for NFM interventions within the Tweed catchment is provided in the NFM report summarised in section 2.5.

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 Peebles that contributes, where possible, to achieving RBMP objectives and are 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 River Tweed catchment 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 from the River Tweed 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 and includes some medium magnitude events such as Storm Frank, December 2015.

The most regularly flooded areas in Peebles are on the left bank downstream of Tweed Bridge including Tweed Green, Tweed Avenue and Gytes Leisure centre sports pitches which all lie directly on the River Tweed floodplain without formal means of flood protection. Other properties in Peebles have been close to being flooded from the Tweed in the recent past but are not as commonly at risk.

The Tweed Green area of Peebles has been flooded in December 2015, December 2013, November 2009, January 2005, October 1949 and 1937. During the December 2015 event, a number of residential properties were internally flooded along with the Care Home on Tweed Green. A property at Tweed Green was also flooded in January 2005 and Morelands Hospital on Tweed Green was flooded to a depth of 6-8 feet in 1949. The Whitestone Park and Kerfield Park pitches, which lie almost 200m from the banks of the river, were flooded in December 2013. Other major flooding events in Peebles include October 1977 and January 1962, where flooding occurred across a large part of the Scottish Borders, January 1951 and August 1948. The flood in 1948 is broadly compared to a 0.5% AP (200 year) flood event.

Table 2-1: Peebles recent flood history

Date	Flood Record
January 2018	High flow on the River Tweed but no reported property flooding. Gytes Leisure centre and Tweed Green inundated.
5/30 Dec 2015	The Tweed Green area of Peebles was inundated by water from the River Tweed on two occasions. Internal property flooding to a number of residential properties and the care home on Tweed Green was witnessed.
30 Dec 2013	The Tweed Green area of Peebles was inundated by water from the River Tweed. No properties were flooded, only surrounded by water. Flooding of Gytes Leisure Centre pitches recorded almost 200m from river banks.
19 Nov 2009	River Tweed flooded at Tweed Green in Peebles. Property was also flooded at Cardrona* and onthe Ettrick Water.
Oct 2005	Peebles was affected by flooding from the Eddleston Water.
8 Jan 2005	Property at Tweed Green, Peebles was flooded from the River Tweed.
*Note: Unknown location of flooding within Cardrona as not present in Council records. Possible that flooding occurred to the golf club.	

2.2 Flood estimation

The methodology used to derive flood estimates for the River Tweed catchment is 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. Due to the length of the modelled reach and significance of some of the River Tweed's tributaries separate peak flow calculations were estimated such that they could be included as individual inflows to the model which is described in section 2.7. The River Tweed gauge at Peebles (station number 21003, approximately 450m downstream of Tweed Green) was found to be the closest gauge and due to its proximity to Peebles it is likely that this dataset provides a good approximation of flow conditions.

The Flood Estimation Handbook (FEH) Statistical methods was used to derive peak river flows for a range of Annual Probability events. The single site analysis growth curve for the Tweed at Peebles was assumed to be appropriate for all locations along the Tweed to the downstream extent of the

model at Walkerburn. The Peebles gauging station was assumed to be the donor site for QMED adjustment.

A review of the Tweeds ungauged tributaries led to the calculation of each tributaries contribution to the Tweeds' flow and the inclusion of the most significant ones as separate inflows to the hydraulic model. At each inflow point along the reach of interest, QMED was calculated from adjusted catchment descriptors, the donor multiplier was applied to QMED per the Peebles gauging station and the single site growth curve from Peebles was applied. This allowed a consistent increase in flood flows from upstream to downstream. This methodology was approved for use by SEPA during their review of the hydrological inputs to models for the wider Scottish Borders modelling study. The peak flow estimates for central Peebles (National Grid Reference: NT 2492 4031) for a range of Annual Probability (AP) events are presented in Table 2-2. Full details of peak flows at other locations on the River Tweed can be found in the associated hydrology report.

Table 2-2: Peak flow estimates at Peebles

Return Period (Years)	Annual Probability (AP) (%)	Tweed at Peebles (m^3/s)
2	50	179.9
5	20	250.3
10	10	307.5
30	3.33	419.4
50	2	484.1
75	1.33	542.6
100	1	588.6
200	0.5	717.0
1000	0.1	1142.1

2.2.1 Climate change

SEPA's summary report on Flood Risk Management and climate change[1] 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 18% (likely to occur every 6 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 2% (every 52 years) by 2080. These future changes are something that must be considered when designing flood protection measures and is explored further during the options appraisal later in the report.

2.3 Survey data

Topographic survey data from several previous modelling exercises in and around Peebles were made available for this study and primarily consisted of river cross section data which was used in the 1D hydraulic model. To complete the coverage of cross section data along the full study reach a topographic channel survey was conducted by JBA Consulting in March 2017 along parts of the watercourse. This information was combined with two different LIDAR Digital Terrain Models (DTM's) to provide ground levels across the study area and much of the Tweed catchment. Where the LIDAR datasets overlap some interpolation was performed to join them together, with the more

1 Flood Risk Management and Climate Change, SEPA, https://www.sepa.org.uk/media/219494/ceh-cc-report-wp1-overview-final.pdf

recent dataset which covers the Peebles area favoured over the slightly older dataset covering the area further downstream. Combined, this data provides the physical basis for the hydraulic model.

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.

2.3.1 Asset condition assessment

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

The critical assets within Peebles are the weir upstream of Tweed Bridge, Tweed Bridge itself and Priorsford Bridge adjacent to Tweed Green. The asset condition assessment found these structures to be in Grade 2 (Good) condition when surveyed in 2017. The weir was found to be missing small sections of its crest and has vegetation encroaching on its edges but neither issue is expected to influence flood risk in Peebles. Tweed Bridge and Priorsford Bridge are the most likely structures to increase flood risk, both exerting some control on water levels upstream and being at least partly susceptible to blockage. The minor structural defects identified in the assessment are not likely to influence water levels around these structures. Kingsmeadows embankment is an integral feature within central Peebles and forms a robust flood defence that remains in good condition despite its age. Vegetation cover is uniform and well maintained and this feature has proven to be successful in reducing flood risk to properties in the Kingsmeadows area.

Weir upstream of Tweed Bridge

Concrete weir with defects highlighted in red

Type: Weir
Upstream Grid Ref: NT 24871 40326
Width (m): 73.81
Material: Concrete
Condition: Grade 2 (Good)
Part of FPS: No
Comments:

- Areas of missing/partially collapsed weir highlighted in red.
- Minor vegetation encroachment.

Tweed Bridge

Downstream face of bridge with vegetation on left bank

Type: Five span arch bridge
Upstream Grid Ref: NT 25048 40301
Opening Width (m): 75.38
Opening Height (m): 5.90
Soffit Level (mAOD): 162.78
Material: Masonry
Condition: Grade 2 (Good)
Part of FPS: No
Comments:

- Overgrown vegetation on left bank.
- Scour protection in place at piers.
- Island upstream of bridge which some members of the community would like to be removed.
- Drain outfall on left bank 20m

Tweed Bridge

Scour protection on front on pier

upstream of bridge.

- Flood protection wall along right wall upstream of bridge

Kingsmeadows disused railway embankment

Viewed from right bank

Type: Embankment
Upstream Grid Ref: NT 25189 40202
Length (m): 300
Material: Mixed ground
Condition: Grade 2 (Good)
Part of FPS: No
Comments:

- Well managed vegetation
- Crest consistent
- Few signs of degradation

Priorsford Footbridge

Upstream face of bridge

Type: Pedestrian suspension bridge
Upstream Grid Ref: NT 25364 40196
Opening Width (m): 45.93
Opening Height (m): 4.83
Soffit Level (mAOD): 160.14
Material: Steel cable, concrete and brick piers with timber deck.
Condition: Grade 2 (Good)
Part of FPS: No
Comments:

- Pedestrian ramps leading to bridge
- Minor spalling on brickwork
- Small amount of vegetation on piers
- Bridge in good condition

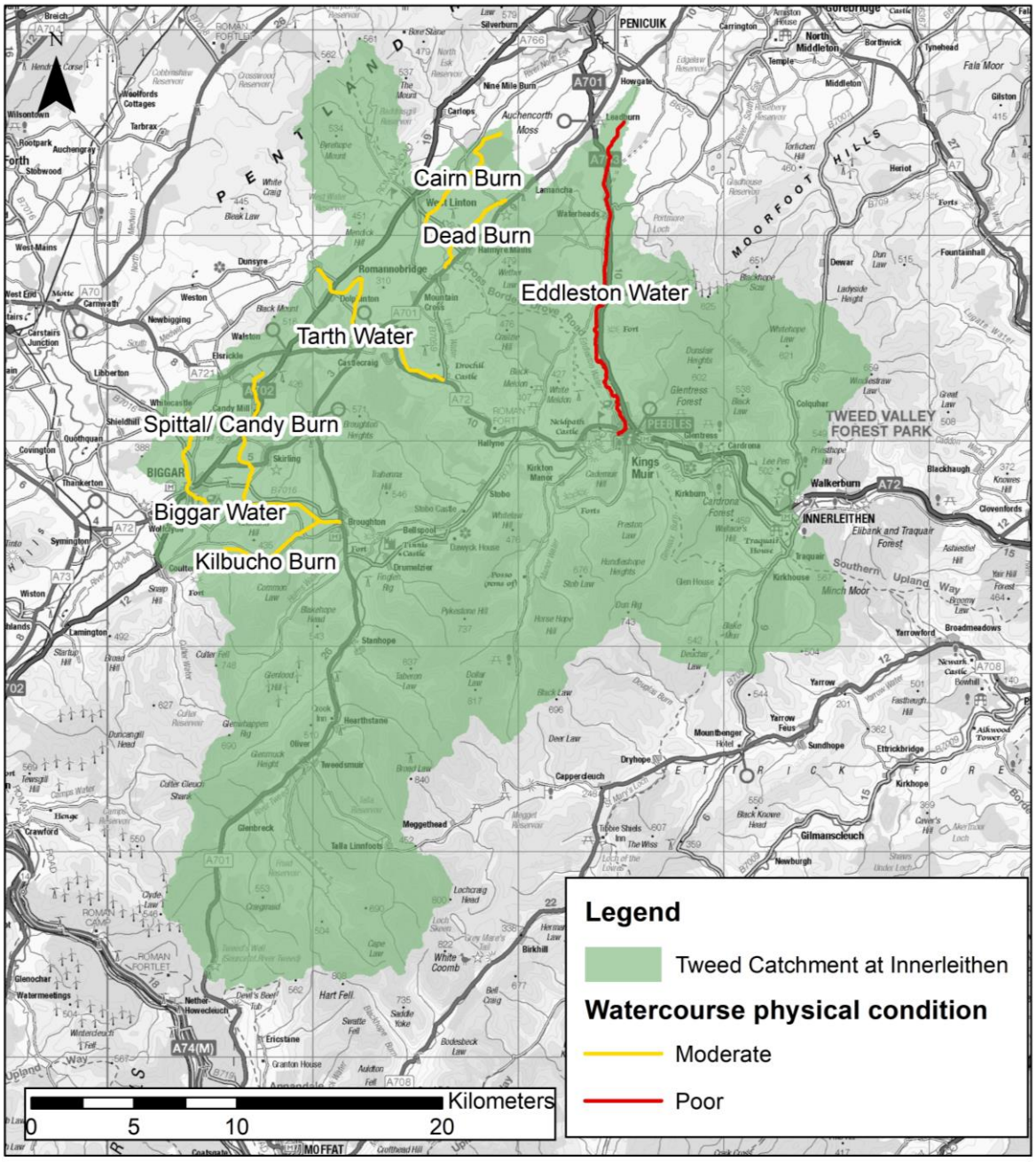
Minor spalling in brickwork and some vegetation growing through cracks in concrete

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.

The River Tweed is in 'Good' physical condition however a number of its tributaries are in 'Moderate' physical condition (Cairn Burn, Dead Burn, Tarth water, Biggar Water, Kilbucho Burn and Spittal/Candy Burn) and the Eddleston Water is in 'Poor' physical condition (Figure 2-1).

Figure 2-1: RBMP watercourse condition



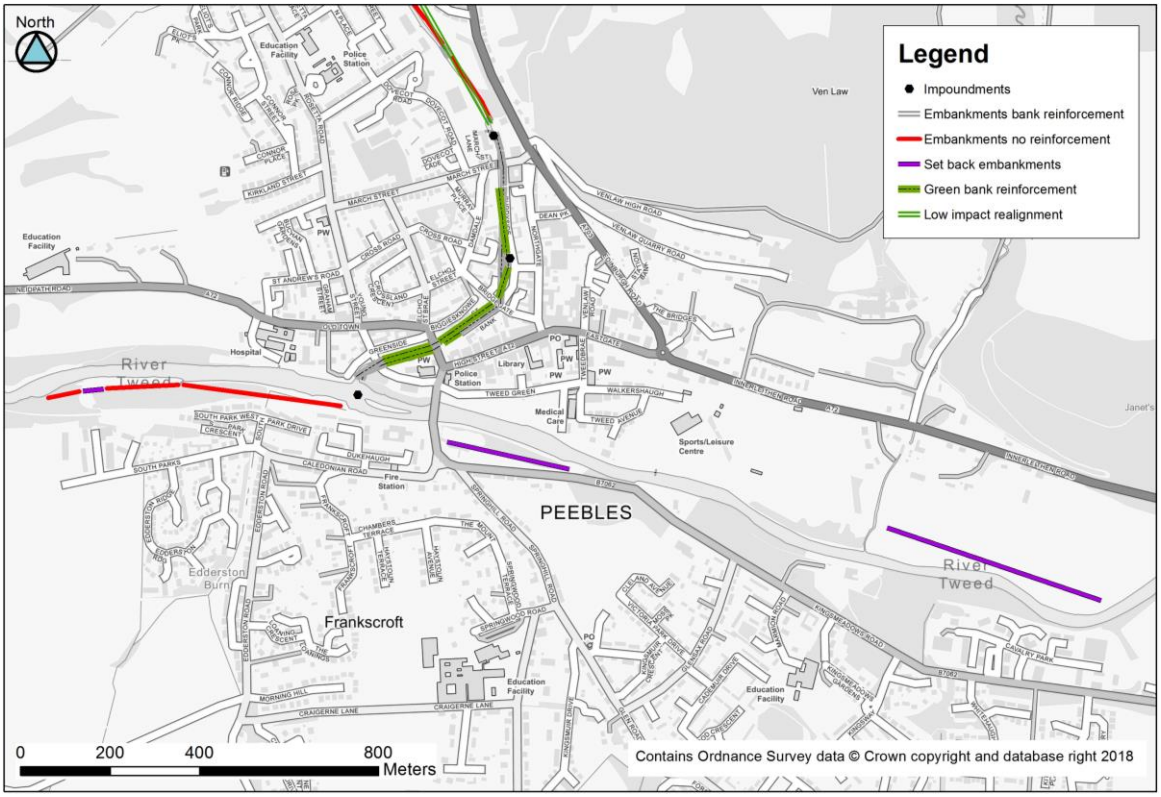
Contains Ordnance Survey data (C) Crown copyright and database rights (2017) Ordnance Survey (100023423)

Close to Peebles there are three main areas featuring embankments. Upstream of Tweed Brdige on the right bank embankments carry a fooptath but provide some opportunity to reconnect the floodplain which is slightly lower on the landward side. Within Peebles Kingsmeadows embankment forms a physical pressure but acts to protect properties from flooding and thus cannot be removed. Downstream of Peebles embankments feature within agricultural land, either remnants of dismantled railways or as agricultural embankments. These are areas that should be explored further to assess whether floodplain reconnection is likely to produce positive results. A basic assessment has been carried out in section 4.7.1 but further testing is required. There may be opportunities to also lower or remove the weir on the River Tweed and this has been investigated as part of this study in section 4.6.1.

The Cairn Burn, Dead Burn and Tarth Water are all tributaries of the Lyne Water. Along the lower section of the Cairn Burn, removal of embankments to allow re-meandering of the watercourse is suggested. Remeandering is also recommended for the upper straightened sections of the Dead Burn as well as removing an embankment in the lower section to open up a large area of floodplain storage. The Tarth Burn will also benefit from meandering as it is highly straightened along its entire

length, and this would release a large proportion of its watercourse capacity. It is recommended that these are investigated further as part of any wider NFM/RBMP studies in the upper Tweed catchment.

Figure 2-2: Physical pressures within the scheme extent



2.5 Natural Flood Management – Summary

A full report into the NFM opportunities within the Tweed 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. The report reviews the two following data sources:

- SEPA's NFM mapping highlights a number of locations where different NFM measures would be suitable and the key measures for the Tweed catchment are Runoff Reduction, Floodplain Storage and Sediment Management (Figure 2-3).
- Scottish Borders Council developed a series of land use framework maps[2] that include NFM opportunities for tree planting, increased infiltration and upland habitat restoration and wetland creation and floodplain storage. Their mapping was based on ecosystem services which are the benefits humans derive from the natural environment.

Based on a review of these two datasets and a walkover survey of the catchment, there are a number of NFM opportunities for the River Tweed catchment, as well as many recommendations within its sub-catchments that contribute a large proportion of flow to the watercourse. These are summarised in Figure 2-3 and as follows:

- The Lynewater sub-catchments have a number of opportunities for NFM including increasing riparian vegetation in the middle sections of the Cairn and Dead Burns. Upland along contour woodland planting and habitat restoration are recommended for the Tarth Water catchment to increase upland storage and infiltration. Planting of buffer strips and restriction of livestock grazing along the watercourse will reduce erosion of banks and runoff into the watercourse.
- The Edderston Burn catchment includes the opportunities for wetland creation in the upper catchment, implementation of debris dams within its tributaries to slow flow and encourage pooling, as well as increasing the overall size of the buffer strips along its length.

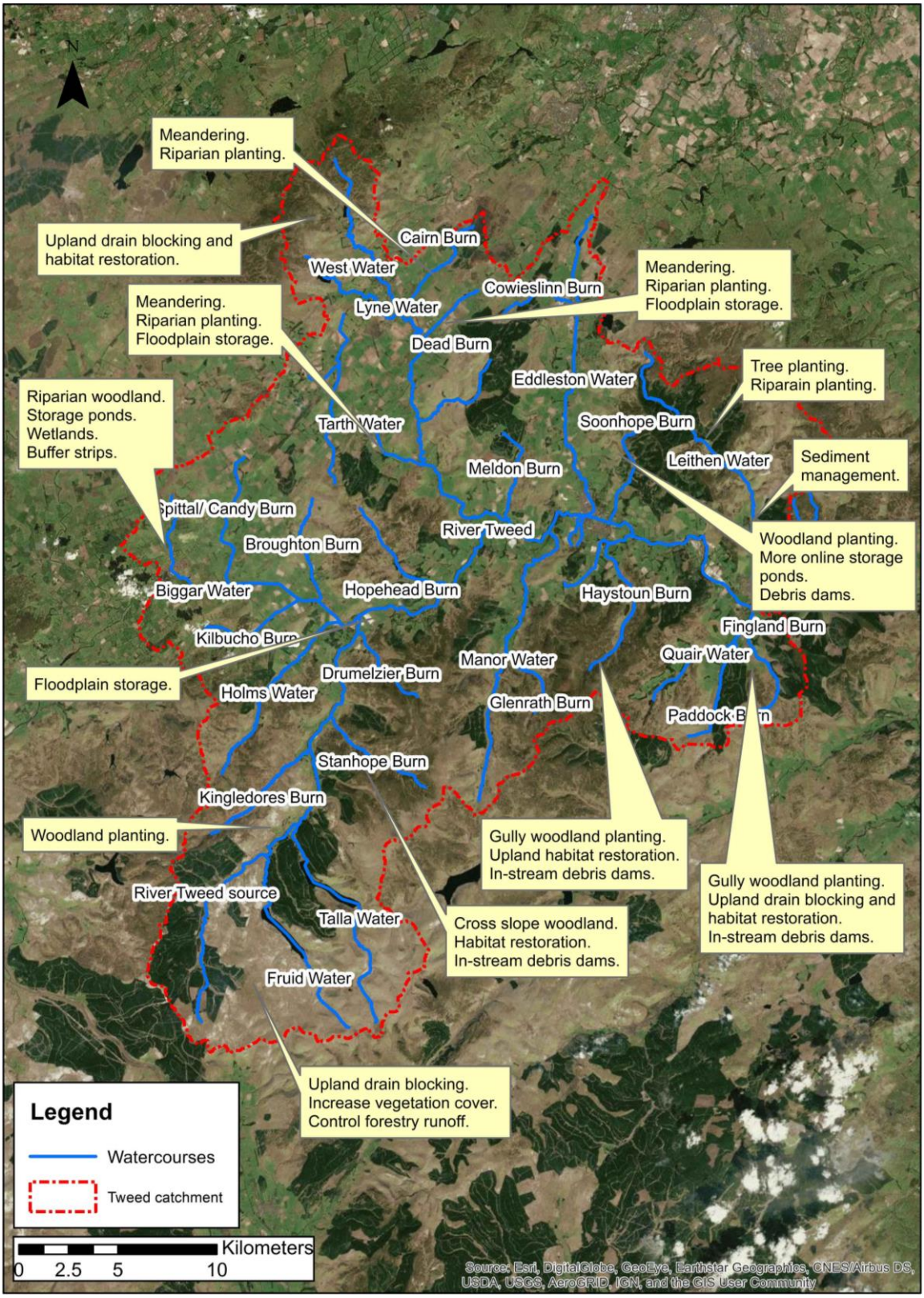
2 https://www.scotborders.gov.uk/info/20013/environment/723/biodiversity/5

- The Haystoun Burn catchment has high potential for reduction runoff through upland woodland planting, and floodplain storage can be implemented though creation of online storage ponds, floodplain planting and meandering of the watercourse.
- The Soonhope Burn NFM opportunities include riparian planting, floodplain planting where it has previously been implemented, restriction of livestock grazing by the watercourse and the creation of leaky bunds to reduce runoff.

General recommendations for the upper Tweed catchment include upland drain blocking, increased vegetation cover, habitat restoration and woodland planting.

Overall it is recommended that Scottish Borders Council implement some or all of the recommendations for progressing with NFM as a 'no regrets' option and in partnership with existing organisations that have experience of discussing NFM with landowners and delivering these types of measures. How this is done will require further consideration as to whether these are implemented as part of a Flood Protection Scheme or as part of a wider catchment management approach to NFM.

Figure 2-3: Tweed catchment NFM opportunities



2.6 Preliminary ecological appraisal – Summary

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

The River Tweed is designated as a Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC) due to the presence of Atlantic Salmon, Brook Lamprey, River Lamprey, Sea Lamprey, Otter, and floating vegetation often dominated by water-crowfoot.

The ecological importance of the survey area for protected species is considered high for nesting birds, badgers, otters, bats, great crested newts and fish, whilst it is considered moderate for red squirrels, water vole and reptiles. There is a presence of rhododendron across the survey area at Peebles and so measures must be taken to remove this plant and ensure no further spread.

A Habitat Regulation Appraisal (HRA) should be undertaken to identify any significant effects/impacts on the protected species. An Appropriate Assessment (AA) needs to be conducted if possible impacts are identified. The proposed flood alleviation works may need to be undertaken in-channel in some circumstances and the presence of Atlantic Salmon and Lamprey means that works should not be scheduled in the spawning season for these species which leaves the months of August and September as potential working windows for in-channel works. Night time working should be avoided as bats are most active at night and works on trees should be avoided between February and September when red squirrels' kits are born and dependant on their mother. A further Water Vole survey should be carried out if finalised works are likely to have an adverse impact on the banks of the tributaries, and an Otter Survey of the area may be necessary once the location of the works is known and the impact they may have on holt sites and resting places.

The invasive non-native species Rhododendron was identified where the Soonhope Burn discharges into the River Tweed. In the past, notifiable non-native species such as Japanese Knotweed and Himalayan Balsam have also been found within 1km of Peebles.

Whilst there are SAC's, SPA's and SSSI's located within the catchment (e.g. the Moorfoot Hills in the north east of the catchment, the Tweedsmuir Hills in the south east, and Westwater reservoir at the source of the Tarth Water is a Ramsar designated site) these are unlikely to be impacted by works within the communities assessed, other than as part of the wider NFM measures.

Peebles and the immediate surrounding area is a designated Conservation Area and all trees within it are designated with Tree Protection Orders (TPOs). If arboricultural works to trees cannot be avoided, it might be necessary to apply for the TPO to be lifted to allow for the works to proceed.

2.7 Hydraulic modelling

A hydraulic model was developed, informed by the above-mentioned datasets, to estimate water levels during simulated floods. Below is a summary of the models 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 upstream of Peebles to downstream of Walkerburn to allow a review of the flood risk to Cardrona, Innerleithen and Walkerburn.

As noted above, survey data for the 1D model were collated from a number of sources, dating from 2007 to 2017. No bank-top survey was available to inform the link between 1D and 2D model domains but there was enough combined confidence in the LIDAR 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 1m LIDAR, resampled to 4m by TUFLOW for increased simulation efficiency. Only the urbanised extents of Peebles were included in the 2D model domain, with the remainder of the model reach to Walkerburn being modelled using the 1D cross sections extended with LIDAR data to include the floodplains.

Figure 2-4: River Tweed model overview schematic - 2D area

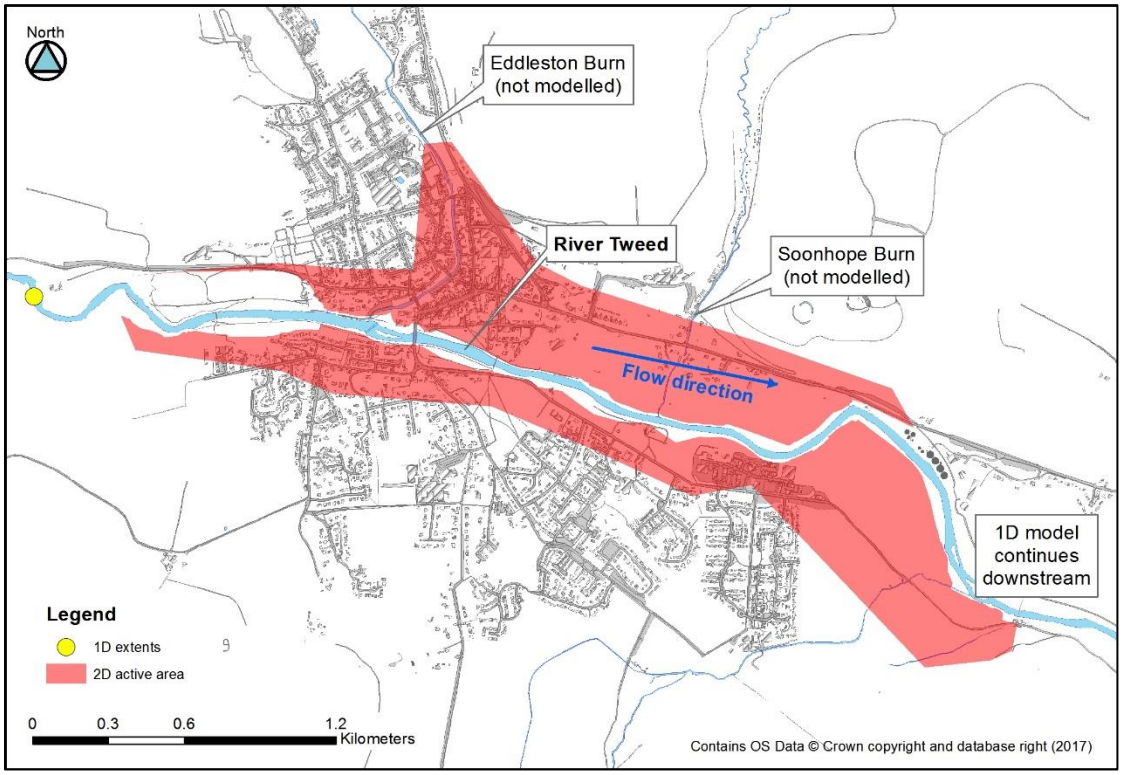


Figure 2-5: River Tweed model overview schematic - Full model extent

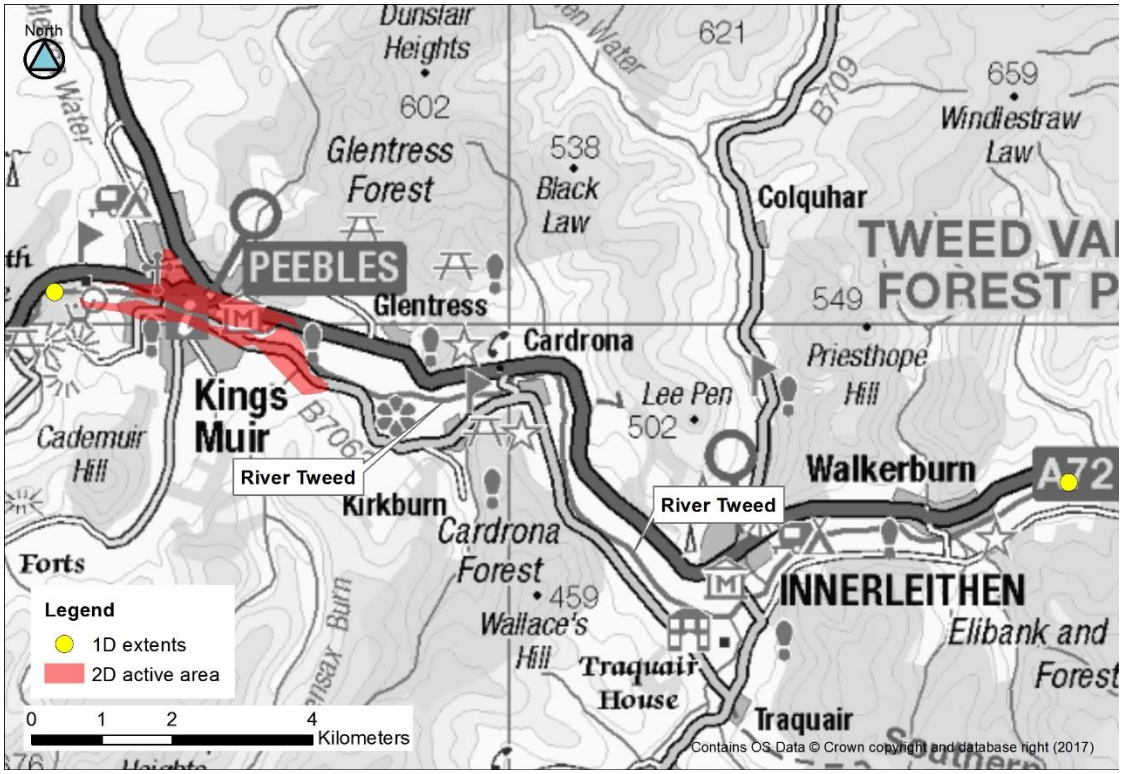
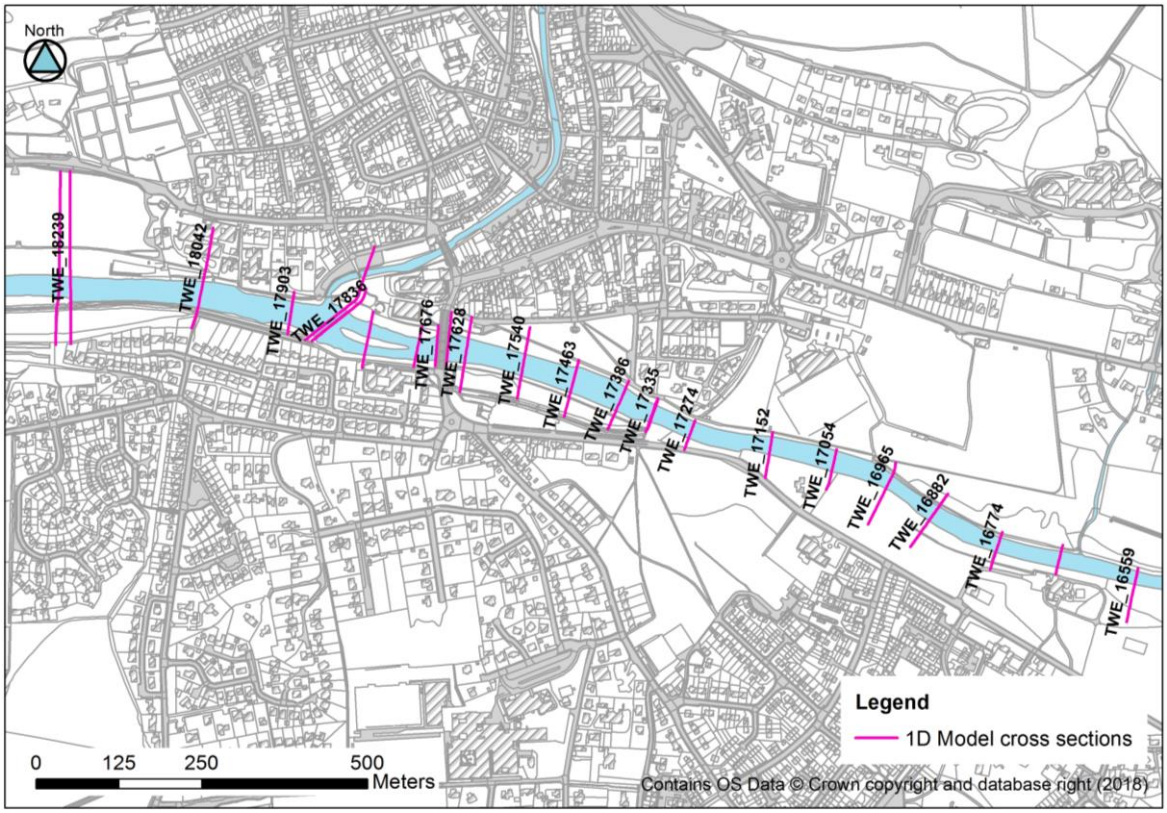


Figure 2-6: River Tweed model 1D cross sections



The model was calibrated using information collected during a post-flood survey carried out along the River Tweed following Storm Frank in late December 2015. Data collected included survey levels and photographs of wrack marks to demark flood extents and hydrometric data provided by SEPA from the Peebles river gauge. This allowed the same event to be reproduced in the model and the flood's maximum levels and extents compared with the post-flood data. This process highlighted that the weir upstream of Tweed Bridge, Tweed Bridge itself and Priorsford Bridge all likely have more of an influence on model results compared to during a real flood. Some modifications to roughness within the model were performed to attempt to bring the simulated river levels closer to those witnessed during the real event. Full details are provided in the Model Audit Report referenced in the Supporting Documents section of this report.

2.7.2 Model scenarios

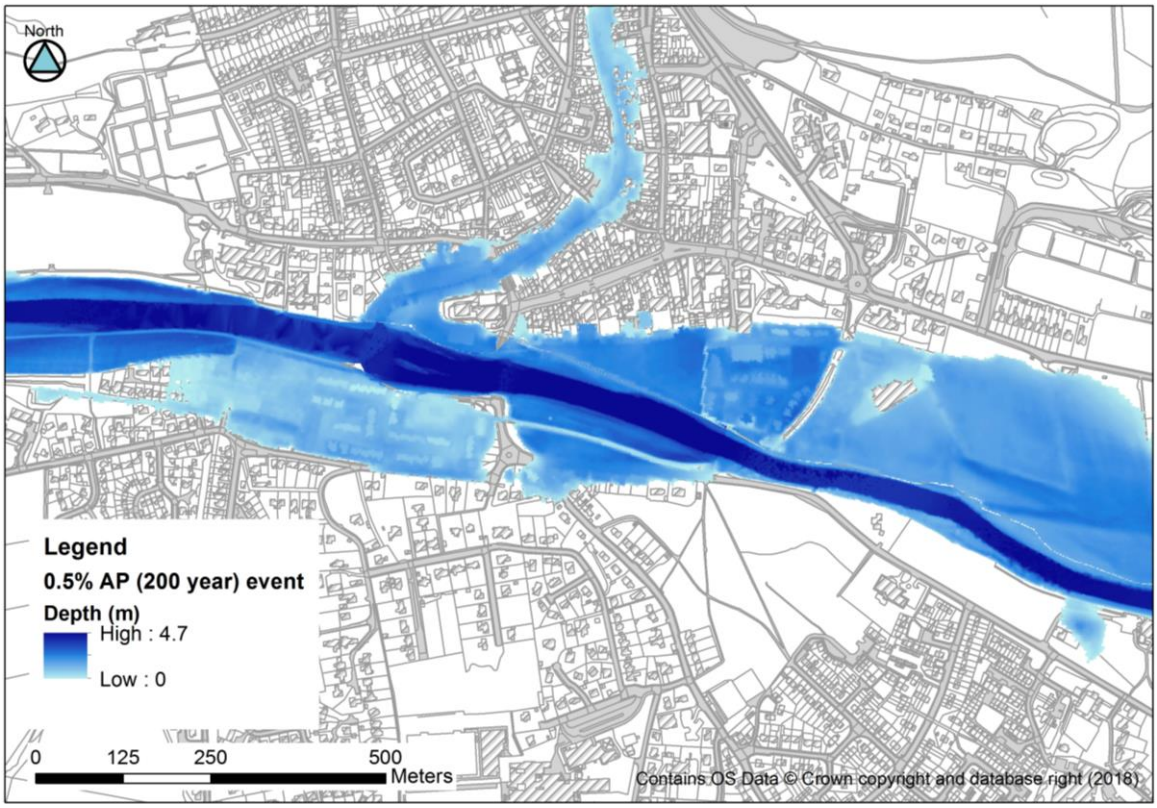
A full range of model simulations were performed covering the full range of AP events for a worst case 'Do Nothing' and present day 'Do Minimum' scenario, with the model being modified slightly between scenarios. A description of the differences between these model scenarios is provided in section 3.2 below. A full suite of sensitivity tests were also carried out to test the models response to changes in roughness, bridge blockage, inflows and downstream boundary conditions.

Additional model scenarios were used to test the feasibility and likely 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 2-7 below shows the estimated flood depths for the 0.5% AP (200 year) flood event in Peebles. The remaining flood depth maps are issued alongside this report and include the maps for Cardrona, Innerleithen and Walkerburn.

Figure 2-7: 200 year flood depth map for Peebles in the Do Minimum scenario



The flood mechanisms in Peebles are generally straightforward with water levels rising in the main channel and extending to areas lower enough to be inundated. Gytes leisure centre pitches and Tweed Green are some of the earliest places to be inundated during a flood. The swimming pool and areas of Greenside become inundated once water levels rise upstream of Tweed bridge. Properties on the south (right) bank of the river flood less regularly but modelling has shown that properties in the South Park area are likely to begin suffering from garden flooding at the 1.3% AP (75 year) and property flooding from the 0.5% AP (200 year). Flood flows have been observed to pass from Tweed Green through to Tweed Avenue via 'the vennel'. This behaviour is not captured in the Do Minimum model runs which assumes that the vennel temporary barrier and property walls along the boundary of Tweed Green resist flood waters. Priorsford Bridge is known to cause water to back up onto Tweed Green but the model suggests that substantial headloss does not occur across the structure until over the 1% AP (100 year) event.

Figures showing the estimated flood risk to Cardrona, Innerleithen and Walkerburn are presented below. Although agricultural and park land surrounding Cardrona and Innerleithen are estimated to flood from the 50% AP (2 year) event there are no permanent properties at risk of flooding from the River Tweed at low return periods. Properties in Montgomery Square, Innerleithen are at risk from the 0.5% AP (500 year) and 0.1% AP (1000 year) events but the extremely low probability of these events occurring means that providing flood protection is not feasible. Tweedside Caravan Park in Innerleithen is at higher risk but due to the seasonal nature of the risk and portability of the caravans this area is not addressed in the flood protection measures proposed later in the report. Analysing flood risk in Walkerburn is outwith the scope of this project but the flood mapping has shown that properties are estimated to flood from around the 4% AP (25 year) flood event. A future review of flood risk to Walkerburn should be undertaken using the modelling and mapping produced as part of this study with the aim of identifying flood protection options. Since Cardrona and Innerleithen are not expected to be at high risk of flooding the focus for the remainder of the report is on Peebles.

Figure 2-8: 200 year flood depth map for Cardrona in the Do Minimum scenario

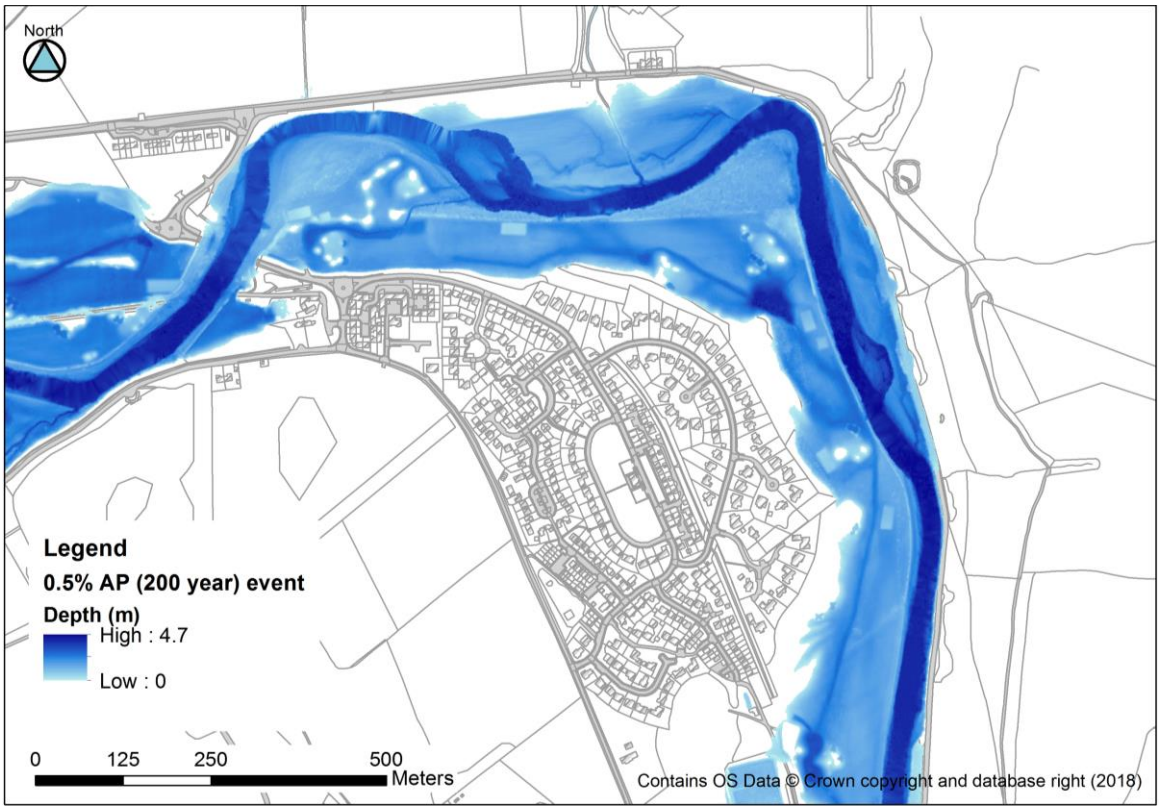


Figure 2-9: 200 year flood depth map for Innerleithen in the Do Minimum scenario

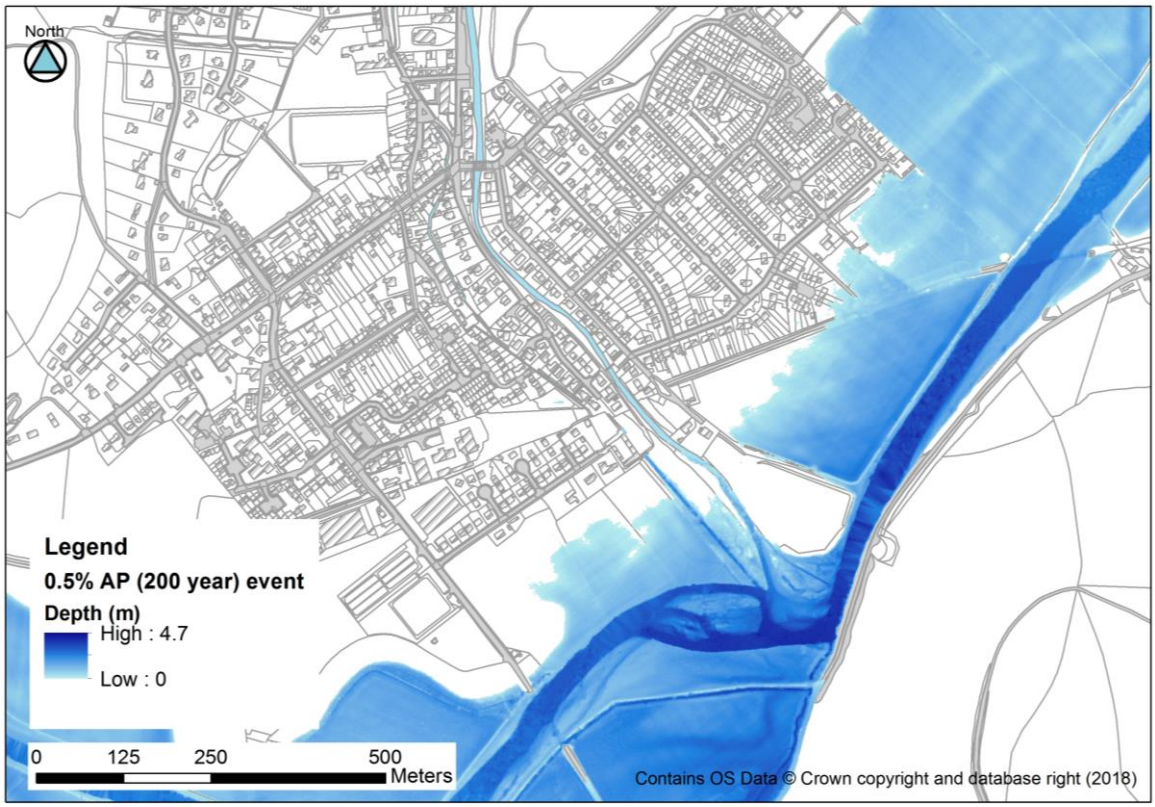
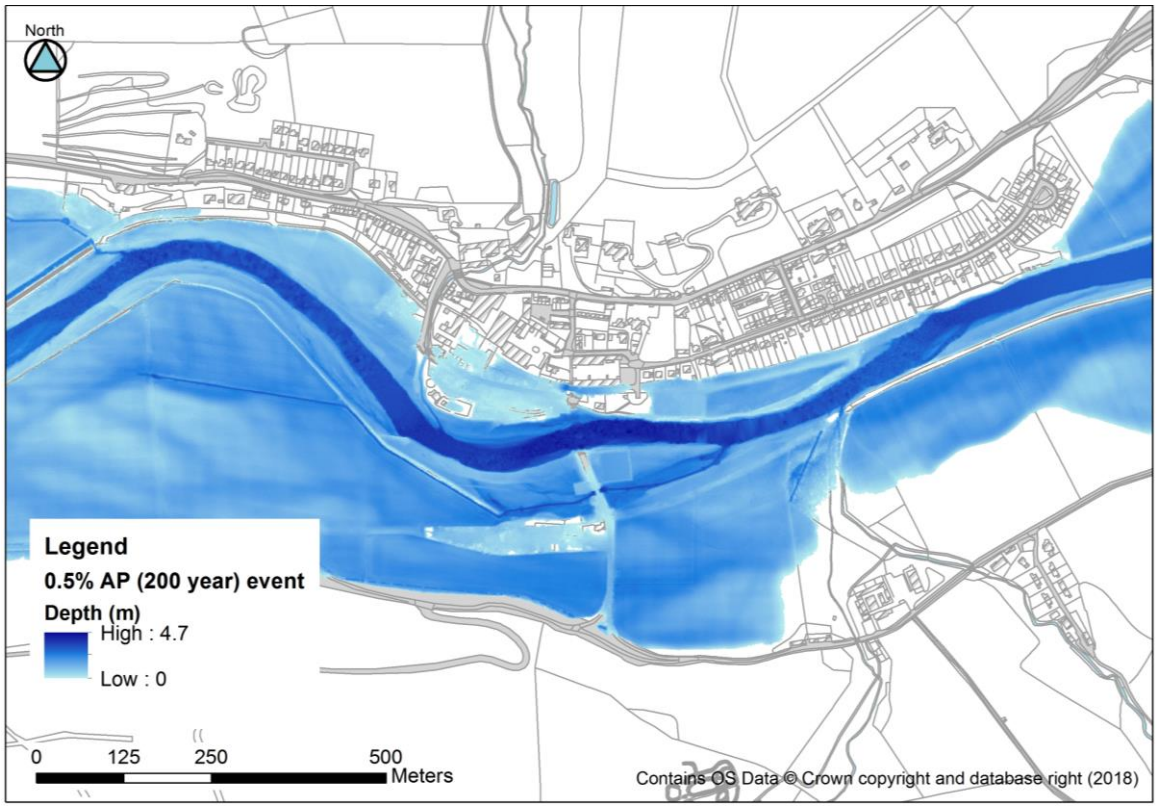


Figure 2-10: 200 year flood depth map for Walkerburn in the Do Minimum scenario



2.7.4 Current standard of protection

The figures below show the present day level of protection each property in Peebles has from flooding of the River Tweed. '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.

Much of Peebles benefits from a 100 year or greater standard of protection, further improved if taking into account the PLP products used around Tweed Green and Walkershaugh. Notable exceptions are properties along Greenside, Tweed Green (without PLP) and Tweed Avenue and the public swimming pool.

Figure 2-11: Standard of protection for the properties at risk in the Do Minimum scenario

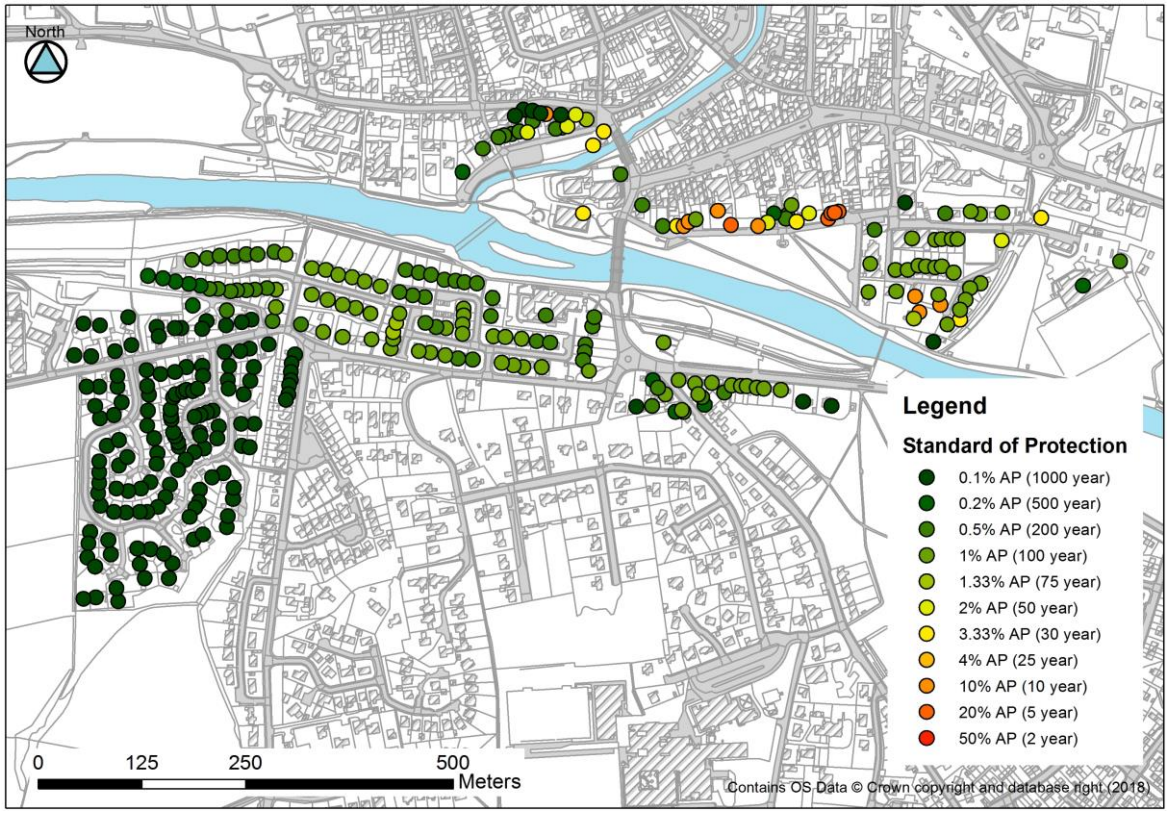
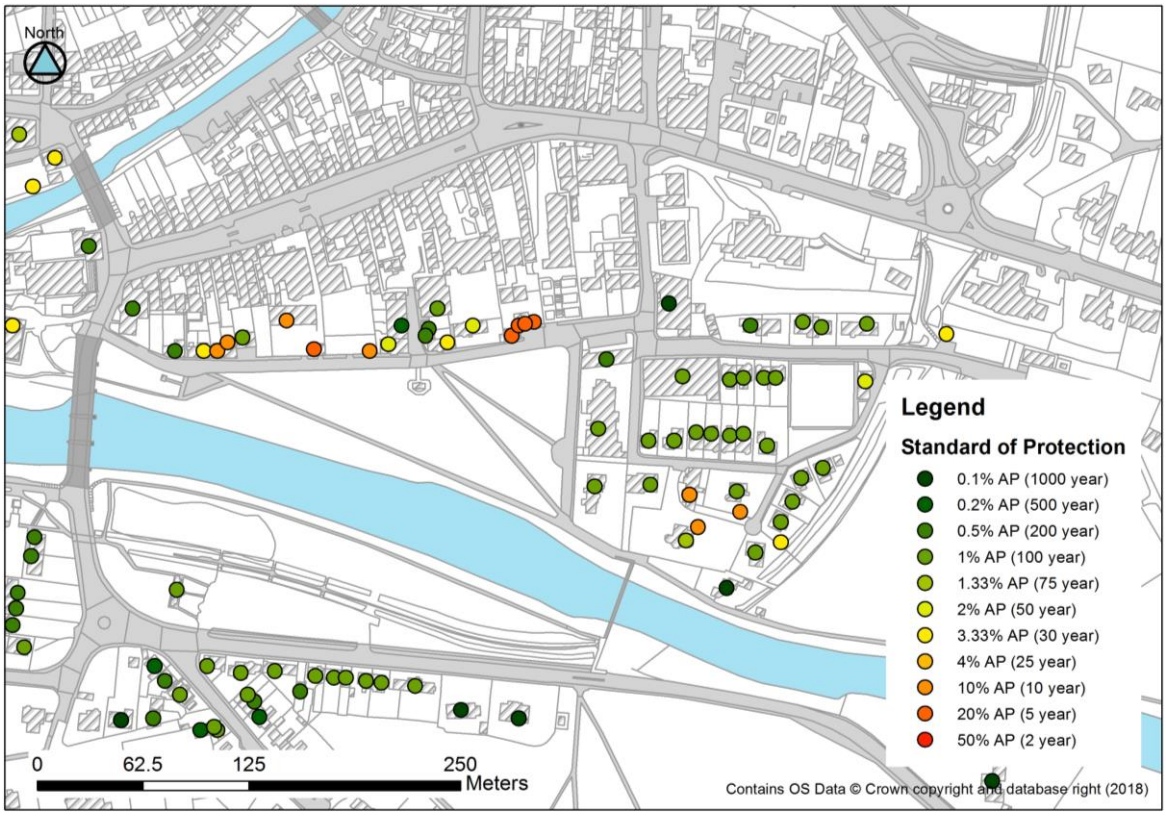


Figure 2-12: Standard of protection for the Do Minimum scenario for central Peebles



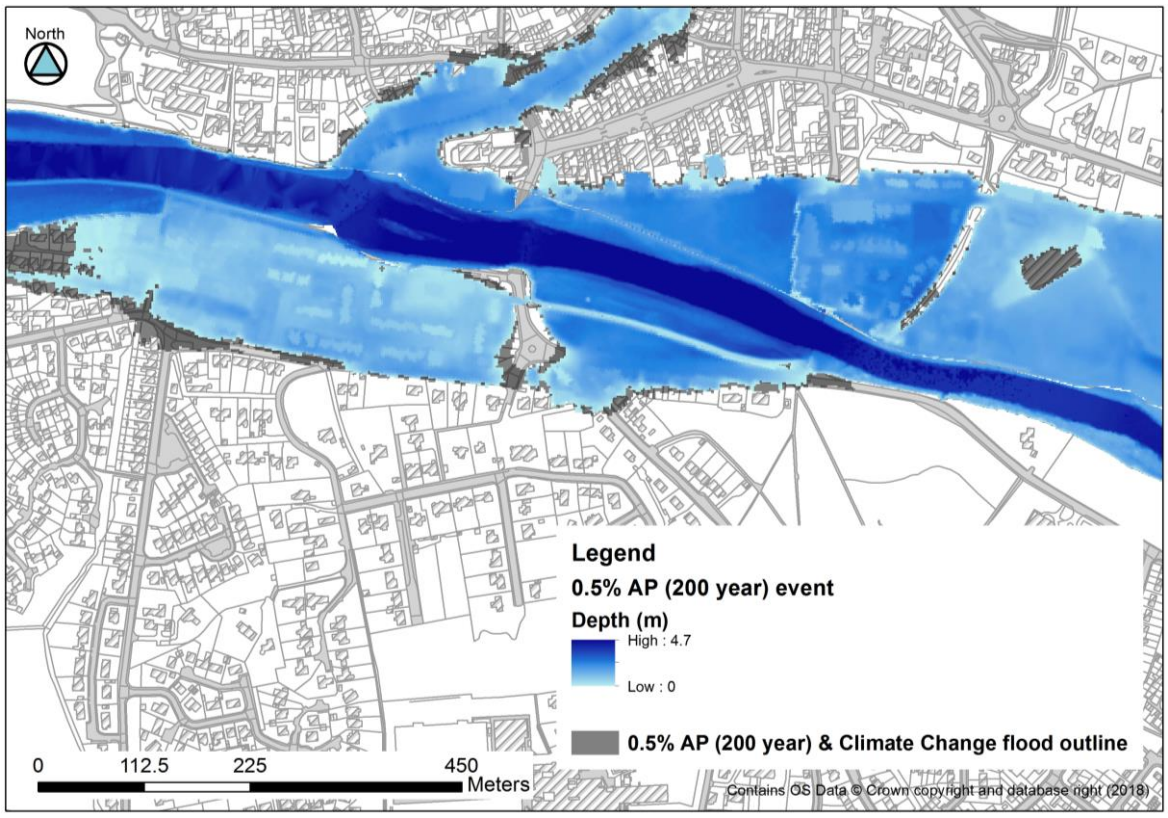
2.7.5 The effects of climate change on flood extents

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 2-13 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 but significantly increased flood depths in the order of 0.6m in the centre of Tweed Green.

Figure 2-13: 0.5% AP (200 year) flood outlines with and without an allowance for climate change



3 Appraisal approach

3.1 Overview

The 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 158 properties in Peebles at risk from the River Tweed at the 0.5% AP (200 year) event. Flooding is estimated to begin at the 10% AP (10 year) event under existing conditions and can therefore be considered a frequent and serious problem for the local community. Apart from the flood protection scheme (FPS) on the Edderston Burn (a diversion channel) and the old railway embankment between the two bridges, there are only informal defences in agricultural land around Peebles. There are no formal flood defences at present but there is a temporary barrier on the 'vennel' at Tweed Green and sand bags have historically been used to act as defences during flood flows . A number of previously affected properties have Property Level Protection (PLP) which provide some resistance to flood waters but the total number of properties at risk and frequency of flooding mean that it is necessary to explore options for more significant longer term flood protection measures.

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.

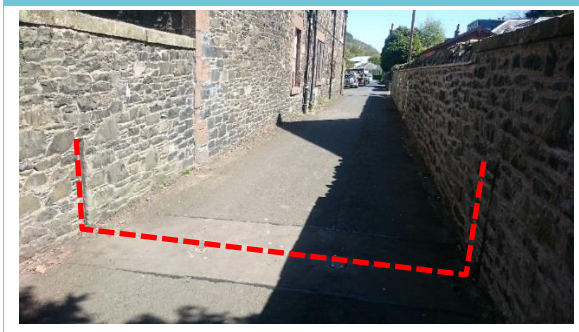
Assessing the level of risk for both the Do Nothing and Do Minimum options needs to consider how the watercourse will change and how any flow controlling assets or flood defences will react or deteriorate over the appraisal period. The following recommendations are therefore used for the Do Nothing and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

3.2.2 Do Nothing - River Tweed

Under the Do Nothing scenario the watercourses would not be maintained. This would lead to a gradual degradation of the banks and vegetation growth. However, as the floodplain is used recreationally, it is likely to remain well maintained for non-flood reasons; thus the bank and floodplain roughness is not anticipated to increase significantly. The Do Nothing scenario is represented in the model as a 10% increase in Manning's 'n' roughness within the town and a 20% increase for all other areas. This is applied throughout the appraisal period.

There is a temporary barrier along the vennel between Tweed Green and Tweed Avenue. Under the Do Nothing scenario this would not be used.

The old railway embankment on the south side of Tweed Green protects the properties along Kingsmeadows Road (but may still be at risk from surface water runoff). Whilst the embankment may deteriorate, and breach risk may increase over time, due to the good condition of the embankment and typical slow deterioration rates for set-back embankments, the risk of breaching is assumed to be minimal throughout the appraisal period.

Location of temporary barrier	Embankment on right bank
	

The weir upstream of the Tweed Bridge is assumed to remain in its current state throughout the appraisal period. The gravel island is represented in the model. Whilst the presence of the gravel island at this location has come and gone since OS mapping is available[3], the presence of the trees suggests that this feature will not readily be eroded. Site visits to Peebles since 2009 do not suggest that the feature is extending, thus no longer-term change to this feature is anticipated or predicted under the Do Nothing scenario.

There are no other structures within the River Tweed which would impact on flood risk. Bridge blockage may occur due to the presence of piers within the River Tweed channel. Blockage of the Tweed Bridge is assumed based on an increase of 1m either side of each bridge pier for the Tweed.

Blockage of the Fotheringham footbridge (upstream of Tweed Bridge) is not anticipated as the floodplain at this location is relatively wide. Blockage of Priorsford Bridge is modelled by an increase of 1m either side of each bridge pier and a reduction in the soffit level by 0.3m as peak flood levels have in the past been close to the bridge deck.

1949 flood levels at Priorsford Bridge

The Council has set up the Peebles Property Level Protection Scheme (PLP). This has resulted in 37 homes affected by Storm Frank receiving a range of flood measures including flood doors/barriers, self-closing airbricks, sump pumps and non-return values. Under a Do Nothing scenario the Scottish Government[4] recommends the following:

- Under the Do Nothing flood warning would cease;
- Activities to promote or subsidise PLP would also cease;

3 Letter from David Bassett to Brian Tait (SBC). DGHB\2009s0509-E-L001-1.doc

4 Scottish Government (2016). Options appraisal for flood risk management: Guidance to support SEPA and the responsible authorities. First Edition.

- Where PLP exists, this may still be applicable, however without flood warning, the scheme would be significantly less effective.

Based on the above no changes to the flood model or mapping will be considered to reflect the use of PLP in Peebles. The impact of PLP will be considered by the flood damage assessment using standard MCM[5] procedures.

3.2.3 Do Minimum - River Tweed

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. Manning's roughness represents current conditions and no bridge blockage is assumed. The temporary barrier at the entrance to the vennel (off Tweed Green) is assumed to be in place.

3.2.4 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.

5 FHRC (2013). Multi-Coloured Manual.

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[6] 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 0.2% AP floods (1 in 50 year) have been witnessed recently on the River Tweed and 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. These are summarised in Table 4-1.

6 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 recommendations and quick wins for the River Tweed

Problem	Actions	Photo
Sediment and vegetation build up on abutments and piers identified on a number of stone arch bridges upstream of Peebles.	Monitor and maintain vegetation and problematic sediment build. Repair missing stones to bridge and inspect structural stability.	 ***Downstream face of bridge***
Erosion to upstream left bank at Fotheringham footbridge.	Fill and monitor eroded upstream left bank.	 ***View from right bank looking at left abutment***
Partially collapsed and areas missing of the weir. Vegetation overgrowth in areas.	Replace or repair partially collapsed or missing areas of the weir. Maintain vegetation growth.	 ***Weir***

Problem	Actions	Photo
Vegetation island upstream of bridge; blocked drain outfall on left bank 20m upstream of bridge	Monitor growth of vegetation on island upstream of bridge; monitor and maintain drain outfall upstream of bridge. Consider a screen for the opening of the drain outfall.	 ***Downstream face of bridge with gravel island behind***  ***Drain outfall***
Minor spalling on brickwork and some vegetation growth on Priorsford Footbridge	Monitor spalling and vegetation growth.	 ***Minor spalling in brickwork and some vegetation growing through cracks in concrete.***
Invasive non-native species noted in ecological appraisal	Removal/control of invasive non-native species.	
Lack of public awareness	Provision of signage at key locations such as Tweed Green and Tweed Bridge with contact details for emergency response teams and details of how to access the Peebles sandbag store. Install stage boards around frequently flooded sites such as Tweed Green to assist emergency response and assist in future model calibration	

4.4 Non-structural flood risk management recommendations

4.4.1 Flood warning

A formal flood forecasting system exists for the Tweed at Peebles. This provides site specific advanced warning of flooding in Peebles based on a series of gauges along the River Tweed. Scottish Borders Council should continue to monitor the systems performance, particularly during high flow events. Ongoing actions should include:

- Review warnings given and feedback to SEPA if events are missed or come too late to enable action
- Improve and increase the uptake of flood warning in the community
- Record flood levels against stage boards and survey wrack marks for flood events to help build up a long-term record of flood events that can be used for future flood forecasting system calibration.
- Recalibrate forecasting model with new data on flooding since installation and original calibration. Recalibration should take into account the December 2015 flood.
- Consideration of a specific flood warning location for the Tweedside Caravan Park in Innerleithen should be reviewed.

4.4.2 Emergency action plans

The Council's Emergency Action Plan[7] 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 others 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).

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

7 Named as the 'Flood Risk Management Emergency Actions, Key Locations & Check List Information' document

properties and businesses are insured against flood damage. Flood Action Groups are well known to assist with this awareness raising and resilience.

The 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 Peebles. 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 associate 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

The Scottish Borders Council continues to use community sandbag stores located at publicly accessible areas including fire stations and school grounds. The store maintained at Peebles fire station holds an estimated 300 sandbags. Resilient Communities sandbag stores are now also widely distributed across the Scottish Borders in areas that have signed up to the Resilient Communities Initiative. These stores typically hold less than the community stores with an estimated 50-60 sandbags.

It is recommended that the Council considers the use of the flood 'pod' system. 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. Instead residents whose homes are at risk of flooding can access the boxes and can help themselves prior to and during a flood. Whilst careful review of the siting and number of these pods would be required, they may offer a useful approach in Peebles. This approach would need to be combined with the existing flood warning and flood awareness campaign.

4.4.5 Property level protection (PLP)

Scottish Borders Council currently offer a discounted PLP scheme to properties at risk of flooding through a contribution of cost price products discounted by 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.

Whilst properties with PLP are not taken into account in the hydraulic modelling, a total of 39 properties across Peebles were provided with PLP products after the December 2015 floods using the Scottish Government Flood Grant Scheme which was issued to Local Authorities effected by the winter floods. The majority of these properties are located around the Tweed Green and Tweed Avenue area of the town. Further uptake could significantly reduce annual average damages for some of those properties in close proximity to the River Tweed when used in tandem with flood warnings issued by SEPA.

PLP in general is seen as a short-term option for Peebles where a large number of properties are at risk of flooding and there are opportunities to implement a more substantial flood protection scheme. Nevertheless, a full PLP scheme 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.

4.4.6 Natural Flood Management

Capitalising on the opportunities for NFM in the River Tweed catchment could provide some flood attenuation but the scale of the catchment and the suite of measures that would be required across a wide area would mean that a large coordinated investment would be required to have a useful impact on flows within the Tweed. Measures introduced in the sub-catchments are most-likely to benefit communities resident in those sub-catchments rather than those on the River Tweed. If widespread NFM is put forward, care should be taken not to align flood peaks in the sub-catchments to ultimately combine them into a greater peak on the River Tweed than would occur without those NFM measures in place.

As summarised in section 2.5 a number of primary opportunities exist and may be considered by the council in the future. Increasing riparian vegetation in the middle sections of the Cairn and Dead Burns and along contour woodland planting and habitat restoration on the Tarth Water catchment to increase upland storage and infiltration. Planting of buffer strips and restriction of livestock grazing along the watercourse in general will reduce erosion of banks and runoff into the watercourse.

4.4.7 Planning policy

The Scottish Government laid out several measures to promote sustainable flood risk management in the Scottish Planning Policy[8]published in 2014. The Policy aims to ensure that the planning system promotes a precautionary approach to flood risk from all sources, taking the likely impacts of climate change into account. Further, new developments must not reduce floodplain storage or conveyance, achieved by locating new developments outside of the functional floodplain and away from medium to high flood risk areas. Opportunities are expected to be sought for reducing flood magnitude such as through river restoration, enhancing flood storage capacity and reducing the length of culverted watercourses. New developments must comply with requirements for Sustainable Drainage Systems (SuDS) to ensure that surface runoff does not increase as a result of the increase in man-made surfaces common to developments.

Specifically, this means that future developments in Peebles should not increase the number of properties at risk from flooding. The flood maps produced and in particular the climate change mapping produced should be used when reviewing planning policies by the Council.

Discussions with SEPA provided useful insight into the areas where Local Development Plans have land allocated for development which may be at previously unidentified flood risk in the present day or that may be put at risk where the short listed options listed below plan to use undeveloped land for the storage of flood waters. For the River Tweed in particular the lower section of site SPEEB005 identified in the Local Development Plan has been identified as being at flood risk from the 4% AP (25 year) flood event and should therefore not be developed. The upper portion of this site is at risk from the Haystoun Burn and the Appraisal report for that watercourse should also be consulted.

4.5 Long list of options

The following table provides an overview of potential flood alleviation options targeting flood risk from the River Tweed in Peebles. Those with the potential to alleviate flood risk from high magnitude flood events or which offer multiple catchment-wide benefits have been assessed further in the following sections.

The following table provides an overview of potential flood alleviation options that could benefit Peebles, Cardrona and Innerleithen in terms of flooding from the River Tweed. Those that are most viable have been assessed further in the following section.

Measure	Discussion
Relocation	**Technical**: Relocation or abandonment of properties not 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**
Planning	Avoid development on land identified in this project as being at risk of flooding. This option should be actioned by the planning authorities regardless of other measures to avoid a future reduction in flood standards.
Flood warning	**Technical**: Flood Warning area already covers the full study area from Peebles to Walkerburn **Environmental**: No environmental or RBMP benefits or impacts. **Constraints**: None **Decision: Option discounted with the assumption that Flood Warning will be continued alongside the shortlisted options. Specific Flood Warning for Tweedside Caravan Park in Innerleithen should be**

8 Scottish Planning Policy, 2014, Scottish Government: https://www.gov.scot/Resource/0045/00453827.pdf

Measure	Discussion
	reviewed.
Resistance - means of reducing water ingress into a property to enable faster recovery	**Technical**: All Scottish Borders properties at risk of flooding are covered by the Flood Protection Products Discount scheme operated by the Council. Further properties moving from reliance on the council emergency sandbag store in Peebles to retrofit Property Level Protection (PLP) products is likely reduce property inundation during small floods. Many properties are likely to experience greater flood depths than the 600mm recommended as a maximum for property resistance measures but in certain localities such as Greenside in Peebles flood gates or door guards could provide a cost-effective solution to large magnitude flood events. See section 4.4.5 above. **Environmental**: No significant environmental or RBMP benefits or impacts. **Constraints**: Unlikely to be accepted by the community as the only flood protection measure. **Decision: Viable option for some properties, option taken forward**
Resilience - means of reducing the impacts of flood water ingress on a property to enable faster recovery	**Technical**: Extremely costly due to the number of properties at risk of flooding. **Environmental**: No significant environmental or RBMP benefits or impacts. **Constraints**: Multiple objections likely if carried out via a FPS. **Decision: Unlikely to be economically viable at this stage. Option not progressed further.**
Watercourse maintenance	**Technical**: Maintenance unlikely to reduce flood risk to a useful degree but maintenance schedule should be adhered to. Could play a minor role in reducing flood risk if combined with more substantial options. **Environmental**: Channel maintenance may have minor negative impacts if spawning areas disrupted but these are unlikely to be significant. **Constraints**: Possible stretching of council resources if further inspection/maintenance is proposed. **Decision: Option discounted but maintenance activities should continue to be undertaken**
Natural Flood Management (NFM)	Natural Flood Management options have been assessed as 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 on the Tweed. The option to investigate the benefits of NFM as a standalone action have not been investigated further due to the lack of evidence on the impact of mitigating significant flood risks on a catchment the size of the River Tweed.
Storage	**Technical:** Online impoundments of the River Tweed would be needed to attenuate significant flood volumes upstream of Peebles. The height of the dam needed is likely to be impractical and difficult to achieve due to the local road network which extends along valley bottoms throughout the Tweed catchment. Smaller scale storage in tandem with natural flood management options may be viable, see separate NFM report for details. **Environmental**: Impoundments to the River Tweed upstream of Peebles would significantly impact on the nature of the watercourse and the SAC classification of the River. **Constraints:** Land ownership constraints likely to be encountered. **Decision: Option discounted**
Control structures	**Technical:** There are no specific control structures on the River Tweed that, the amended regime of which would influence flood flows downstream other than Talla and Fruid Reservoirs and two smaller ones on the West Water and Baddinsgill. The existing reservoirs will help to mitigate against a flood peak, even if it is already at top water level, due to the delayed time of flow through the reservoir. Amendments to drawdown these reservoirs is unlikely due to the importance they play in providing the majority of Edinburgh's water supply and the new Glencorse Water Treatment Works. New large control structures would be required in association with the above inline storage to provide useful attenuation of flood flows.

Measure	Discussion
	Environmental: Could provide wetland habitats but likely to impede movement of flora, fauna and sediment along the watercourse thus having a net negative impact on the watercourse. **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:** Ensuring constant availability of trained personnel capable of deploying defences may put excessive pressure on council. Residents may be able to assist but reliability of defence deployment may be reduced. **Environmental:** No significant environmental or RBMP benefits or impacts although likely to be preferred from an environmental standpoint when compared to direct defences. **Constraints:** Sites for demountable defence installation would need to be identified and integrated with any other mitigation options carried forward. **Decision: Option discounted at this stage but potential for it to be used to provide climate change resilience on top of the selected option**
Direct defences	Direct defences are already in place in various locations through Peebles, mainly comprising set back embankments. **Technical:** Direct defences may be spatially constrained in certain locations within Peebles. In some places it may be possible to increase embankment heights to increase standard of protection or to adapt to future climate change. Walls are more appropriate than embankments in most locations and should be made adaptable where possible to accommodate future storm intensification due to climate change. **Environmental:** Direct defences likely to have negative RBMP impact through increased morphological pressure on the watercourse. May also disconnect river from land for some species, especially if walls are constructed rather than embankments. Walls preferred in some locations as fewer trees may need to be removed. **Constraints:** Some objections likely at public consultation but in general likely to be an acceptable option. **Decision: Option carried forward**
Channel modification	**Technical**: Floodplain reconnection feasible in some locations. Unlikely to provide sufficient flood protection benefits as an independent option due to scale that would be required to accommodate the large flows witnessed historically. If combined with NFM options then may be able to mitigate some flooding from small, frequent high flow events. Localised dredging could provide some additional channel capacity although over time sediment would again be deposited through natural processes and the dredging process would have to be repeated. This is therefore not seen as an effective long-term solution. **Environmental**: Environmental benefits from wetland creation and/or enhanced suitability of the channel for riverine organisms. Works would need to be carried out outside of Lamprey and Atlantic Salmon spawning seasons. A Habitats Regulations Appraisal would be necessary to identify whether dredging would have a negative impact to the interest features of the Special Area of Conservation (SAC) covering the River Tweed. The works would only be allowed to proceed if no negative impacts to the integrity of the SAC were identified. **Constraints**: Land ownership constraints likely to be encountered and may be viewed negatively by residents favouring alternative options. Crossing of roads and footpaths may make this option cost-prohibitive. **Decision: Option carried forward**
Diversion	**Technical**: There is no scope for channel diversion around Peebles and the River Tweed already passes alongside, rather than through, Cardrona and Innerleithen so no further bypass necessary. **Environmental**: May remove other valuable habitats in the short term but if bypass was naturalised then could provide RBMP benefits. **Constraints**: Topography and town layouts do not promote diversion.

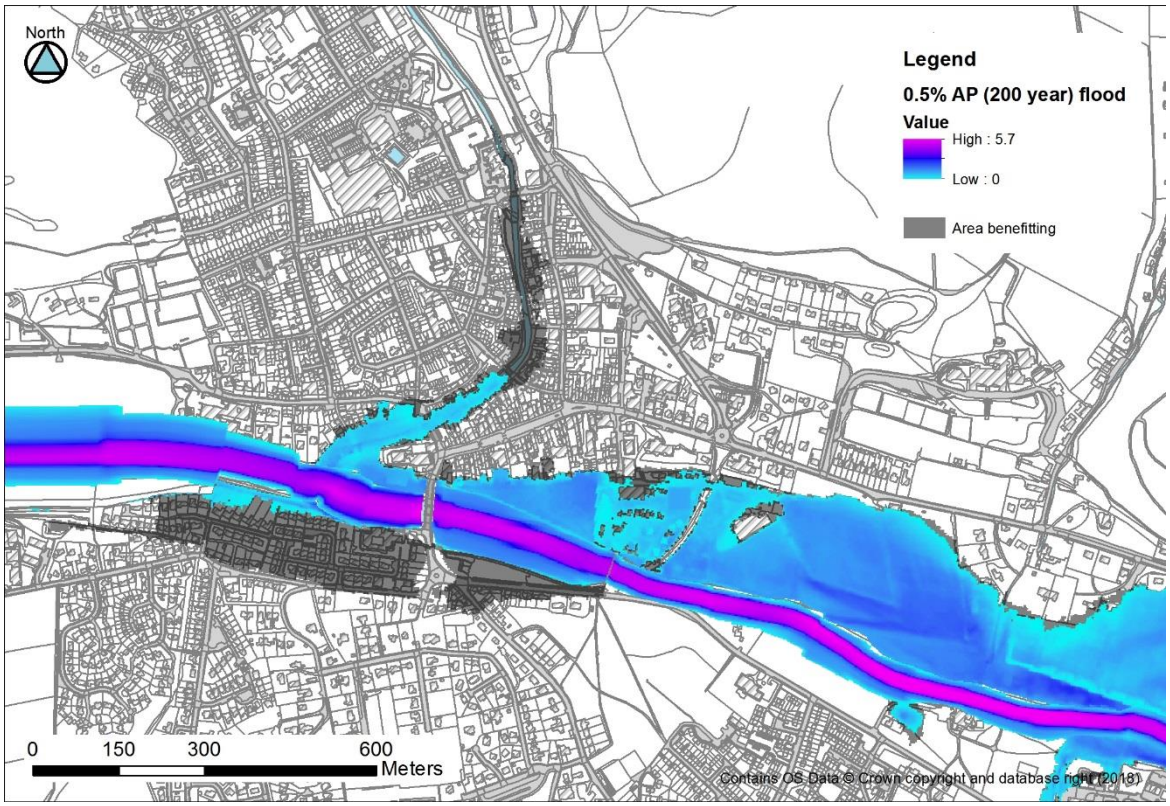
Measure	Discussion
	Decision: **Option discounted**
Bridge and Weir modification	**Technical**: Bridge conveyance is good on the whole. The interactions between the Eddleston Water confluence, weir, Tweed Bridge and Priorsford Bridge could be improved but may not be technically feasible due to the complexity of the interactions. For example, modelling has shown that if larger flows are allowed over the weir then greater flood depths are likely to occur at Tweed Green due to the constriction at Priorsford Bridge. Raising or replacement of the Grade II listed Priorsford Bridge with a larger capacity structure may provide a sufficient increase in capacity to mitigate against some flooding in the Tweed Green area. Although there may be challenges with respect to the structures statutory protection the safety benefits associated with reduced flooding should allow these to be overcome. Introducing a two-stage channel through the first arch of Tweed Bridge could improve conveyance. **Environmental**: Net improvement in RMBP impacts likely if bridges are widened, raised or the weir removed but changes are unlikely to be significant. **Constraints**: Tweed Bridge and Priorsford Bridge are both listed buildings which may constrain modifications or removal. Tweed Bridge being the only road crossing of the River Tweed in Peebles would mean that any proposed closure is likely to be objected to at public consultation and removal is not feasible. A two-stage channel within the left bank arches - reminiscent of mill lades previously passing along this course - may offer heritage value as well as improving bridge hydraulics. **Decision:** **Option carried forward**

4.6 Feasibility study

4.6.1 Channel deepening analysis with weir removal

The possibility of increasing channel capacity through deepening the channel (i.e. by removal of sediment) was considered. This option was tested along the urbanised reach through Peebles by reducing the bed level of the channel by 1m. This option was considered alongside removal of the weir in an attempt to improve channel capacity and conveyance.

Figure 4-1: Impact of channel deepening on flood extent in the 0.5% AP event



The modelling suggests that although flood extents are reduced in the bed lowering scenario, it is not sufficient to prevent flooding in the 0.5% AP event. The potential environmental impact of this scale of dredging is considered too great compared to the estimated reduction in flooding. Furthermore, the deepened channel would require regular work to maintain its depth and extensive bank stabilisation works would be required to make this a sustainable option. For these reasons this option is not seen as a long-term strategy for flood the reduction of flood risk and has not been carried forward beyond this stage of analysis.

4.6.2 Weir removal

Weir removal was tested as an independent sub-option of the bed lowering option. Results of the weir removal simulations were compared to the Do Minimum results and show that weir removal has little impact on water levels through Peebles. The differences estimated for two different flood events are shown in the table below, showing a maximum difference of 56mm upstream of the weir. Downstream of the weir at Tweed Green, an area that experiences regular flooding, the difference for both flood events is negligible.

Difference between the Do Minimum stage and following weir removal:

Location (model cross section)	3.33% AP (30 year) event	0.5% AP (200 year) event
Upstream of the weir	0.030m	0.056m
Tweed Green	0.003m	0.003m

Due to the minimal influence of the weir on water levels, particularly downstream where the main flood risk lies, this option will not be carried forward.

4.6.3 Gravel island removal

Removal of the gravel island upstream of Tweed Bridge was assessed using a hydraulic model in 2009. Using the same survey data as is used in the current model, the model estimated that vegetation removal or complete island removal had a negligible effect on water levels upstream of

Tweed Bridge. Further investigation of this as an option to mitigate flood risk is not deemed necessary, nor practical and has therefore been discounted from further analysis.

4.6.4 Raising of Priorsford Bridge

Priorsford Bridge has a high capacity for flood waters but at the 0.5% AP (200 year) event and above significant afflux occurs across the bridge, causing water levels to rise in Tweed Green and further upstream near Tweed Bridge. Raising of this Grade II listed structure onto higher abutments could alleviate this effect during those high flows. Whilst technically feasible it would be a complicated and expensive process to raise the bridge and it does not align with the flood magnitude designed against, in the short listed options below. For this reason this sub-option has not been taken forward but could be considered at later design stages or if future changes to the design standard of protection in Peebles are sought. It should also be considered if for any reason, significant maintenance works are required on this structure.

4.6.5 Floodplain lowering on the second arch of Tweed Bridge

The River Tweed ordinarily flows through three of its five arches with community access through the first two arches via a path and park space. Channelising the second arch to increase channel capacity during high flow events was investigated. The effects were positive, reducing flood levels but by less than 150mm. Considering the scale of the work required this option is not considered to be effective enough to carry forward, but should be reconsidered at the outline design stage once the preferred option has been confirmed. A mill lade is thought to have previously passed through the bridge in a similar location so this sub-option could be seen as reinstatement and provide heritage value.

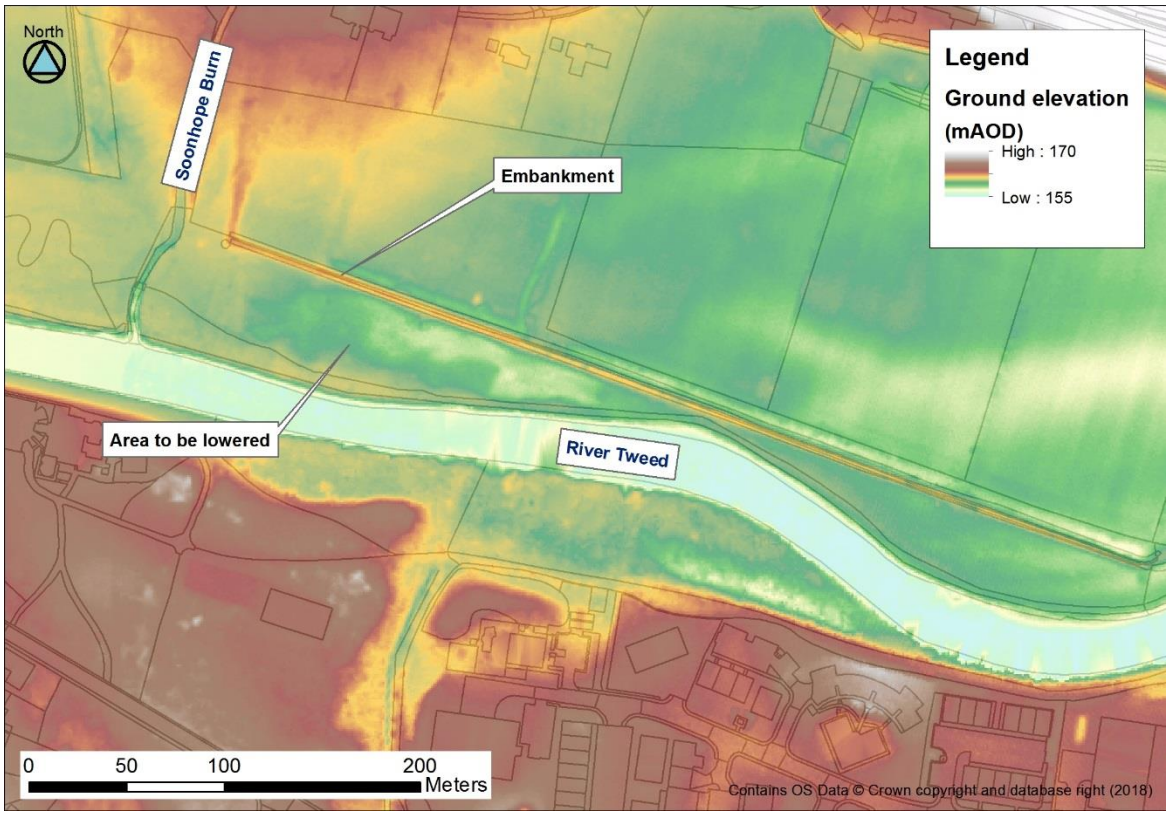
4.7 Options for delivering wider catchment benefits

4.7.1 RBMP

Removal of embankments on the shared Soonhope Burn and River Tweed floodplain could lead to minor decreases in flood levels within Peebles. When combined with floodplain lowering by 1m on the riverward side of the embankment shown in Figure 4-2, the model estimates an increase in water levels on the floodplain beyond the embankment, however no observable difference in levels was identified in Peebles itself. Further investigation is required to determine if these works would help to offset any increase in flood levels as a result of the short-listed options. This should be investigated further at the outline design stage.

This crude assessment shows that some flood risk benefit could be achieved along with providing valuable wetland habitat.

Figure 4-2: Embankment and area with potential for RBMP benefits



4.8 Short list of options

4.8.1 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 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.

In the Tweed catchment 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 communities suffering from flooding directly from smaller watercourses, mature NFM measures and improved land management in the sub-catchments of the River Tweed may reduce river flows in the main watercourse 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.

4.9 Flood Mitigation Options - Peebles

The following section details the constraints and benefits of the shortlisted options on the River Tweed. Detailed drawings for each option have also been prepared and are provided as supporting plans.

4.9.1 Options 1-3 - Construction of a suite of direct defences across Peebles

Options 1-3 - Construction of a suite of direct defences across Peebles
Description

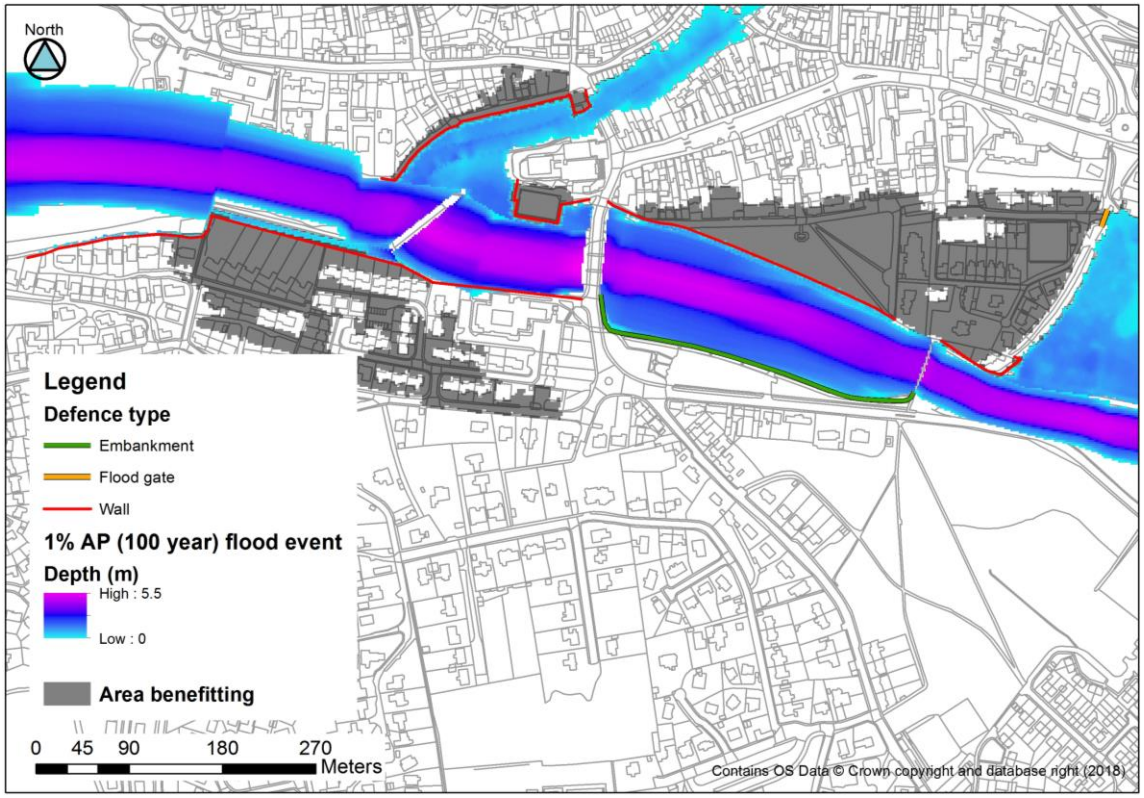
Options 1-3 - Construction of a suite of direct defences across Peebles

This option aims to provide a high standard of protection through the installation of a number of flood walls and embankments in the populated areas of Peebles. There are slight differences in the defences required to achieve different standards of protection but in general the differences come from changes in defence height.

The work includes the following: (All walls include a 300mm freeboard and embankments 600mm)

- Construct flood wall along Greenside;
- Construct flood wall around Peebles swimming pool;
- Construct embankment, wall or hybrid across Tweed Green ether along the river bank or set back;
- Reinforce the existing boundary wall around 18 Tweed Green to provide defence continuity;
- Construct wall around Priorsford Villa with flood gates for access;
- Install a flood gate across Walkershaugh to block flow return from Gytes leisure centre;
- Increase the height of the Kingsmeadows embankment on south bank (for the 75 and 100 year standards only);
- Construct wall or embankment along the footpath through Haylodge Park South on the south bank of the Tweed (100 year standard only) to Tweed Bridge; and,
- Construct wall along the northern boundary of Cavalry Park (for the 100 year standard only - recommended to build a 200 year + climate change standard defence since it is unlikely that there would be objection to a large defence in this location).

The figure below shows the defence alignments for the 1% AP (100 year) option.



Technical drawings relating to these options have been produced and are provided alongside this report, named as follows:
Option 1: 'AEM-JBAU-PB-RT-SK-C-1300-Opt3_50Yr_Direct_Defence'
Option 2: 'AEM-JBAU-PB-RT-SK-C-1200-Opt2_75Yr_Direct_Defence'
Option 3: 'AEM-JBAU-PB-RT-SK-C-1400-Opt4_100Yr_DD_1of2' and 'AEM-JBAU-PB-RT-SK-C-1401-Opt4_100Yr_DD_2of2'

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 but would not be acceptable socially due to the high defences that would be required in valuable community spaces such as Tweed Green. For example, to protect against climate change the defence on Tweed Green would need to be up to 1.1m higher than the one

Options 1-3 - Construction of a suite of direct defences across Peebles

required for the 1% AP (100 year) event giving a total height of 2.2m. Instead, this table presents defences designed to provide protection from the 2% AP (50 year), 1.33% AP (75 year) or 1% AP (100 year) event which are then compared in the benefit-cost section of the report.

Alternative quick wins / Preliminary investigations

Smaller embankments or walls would offer a lesser standard of protection but for a marginally lower cost. Similarly, protecting only those areas that experience frequent flooding, such as Tweed Green and the Swimming Pool would partially reduce the flood risk.

Geotechnical issues

- A review of available BGS borehole logs and mapping of superficial deposits indicates that most of the wall and embankments are likely to be constructed on sandy or gravelly alluvial deposits.
- A full ground investigation 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-PB-RT-SK-C-1212-Services-S0-P01.01.

- Overhead wires; electricity or phone: telecommuniciations overhead cable in close proximity to proposed Greenside Wall. Telecommunications overhead cable also present in front of swimming pool and in close proximity to proposed Kingsmeadows Embankment.
- Buried sewers, water mains, gas or electricity cables: combined sewer along Greenside Wall, Swimming Pool Wall, Tweed Green Wall and at the end of South Park Wall, electricity cables at the beginning of Greenside Wall, storm water sewer crossing the western extent of a wall within South Park opposite to Haylodge Park slightly further east, water main at the end of the wall in South Park, Scottish Gas Network main along the wall in Tweed Green, electricity cable crossing underneath the proposed Kingsmeadow Embankment extension.

Construction access

Construction access has been considered and not considered too difficult. Issues include:

- Construction would entail heavy machinery working near to the bank.
- Temporary storage of topsoil and subsoil in heaps and stockpiles.
- Groundworks and construction vehicles are likely to cause noise and vibration.
- Exclusion of public from working areas - good practice working methods such as alternative access routes and phasing of works to be considered.
- Construction access to South Park Wall: this is likely to be through the South Park West residential road. An existing retaining wall, approximately 60m long is in place, tying into B7062 bridge. No structural survey is available. Subject to further structural information of the wall, it is possible to reduce the overall length of the proposed South Park Wall.

Waste

- Expected quantity of waste material: Approximately 1,945m^3
- It is known that very limited industry was present in Peebles – soil expected to be inert.
- Proposed disposal will be according to SEPA guidance.

Further investigation required through ground investigation into level of contamination and ownership. Borders Council have identified that some of the proposed works are likely to come into contact with former gas works, woollen mills and railway lines which may be the site of contamination.

Options 1-3 - Construction of a suite of direct defences across Peebles

Proximity of defence to other structures

- Private and Public: Boundary fences close to the existing Kingsmeadows Embankment, footpath and road next to Tweed Green Wall, car park next to existing embankment at Kingsmeadows park.
- Bridges: Footbridge close to Tweed Green Wall downstream and adjacent to Kingsmeadows Embankment in the east, B7062 road (bridge) in west.
- Walls: Swimming Pool Wall next to proposed wall and property walls closed to Tween Green Wall.
- Houses: Houses close to Greenside Wall and Tweed Green Wall.

Environmental issues

- Statutory Environmental Designations (SSSI, SPA, SAC, Ramsar Sites Nature Reserves, INNS). River Tweed is a designated site of special scientific interest (SSSI). Both River Tweed and Eddleston water constitute special areas of conservation (SAC). The area within the site boundaries is also a conservation area. Habitat Regulations Appraisal will be required including an Appropriate Assessment. Relevant ecological surveys and assessment will be required including otter survey, fish surveys, habitat survey (Ranunculion fluitantis and Callitricho-Batrachion vegetation) and assessment of impacts on water quality.
- Habitat: River Tweed and Eddleston Water are Mesotrophic running waters. There is amenity grassland and bare ground around most of the defences.
- Scheduled Monuments: No scheduled monuments within the study area.
- Listed Buildings: A number of listed buildings in close proximity to the proposed defence works.
- Trees; TPO: A number of mature trees may need to be removed for the construction of the Tweed Green Wall and the Root Protection Areas of some of the mature trees around the green may mean that the defences would need to be realigned to avoid these. The option of an embankment along the riverside rather than a setback defence would have less of an environmental impact. Replanting in place of any lost trees should be incorporated into future outline and detailed designs. Consideration for mature woodland loss to make way for the Cavalry Park embankment at later design stages may make a flood wall with less land-take more favourable.

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

This option will have an aesthetic impact within Peebles regardless of which standard of protection is chosen. The presence of walls and embankments within the core amenity spaces are likely to be contested by some residents but efforts would ideally be made to ensure detailing of flood walls and embankments is in keeping with the local area and access to the green spaces in maintained.

Land take is considerable in community green areas, particularly Tweed Green where the community will also have reduced visual access to the river since a substantial length of flood wall is proposed. Defence alignments could be adjusted throughout Peebles to better accommodate community needs. For example, the Tweed Green flood wall could be set back nearer to the houses to provide a river view when walking on the green or could be designed as an embankment on the landward side and a wall on the riverside to improve aesthetics. Modelling suggests that there is no variability in flood levels between a riverside or a setback defence.

Impact on other reaches

The works increase channel flow by up to 52m^3/s for the 100 year option adjacent to Tweed Green but this effect dissipates less than 1km downstream of Cavalry Park industrial estate meaning that properties downstream of the defended area are not put at increased flood risk. The effects of the 50 year option are much lower than the 100 year option with a maximum increase in flow of 32m^3/s but the effects are reduced to zero by the downstream extent of Gytes leisure centre. Channel and floodplain levels are estimated to decrease downstream of Peebles in a defended scenario due to increased channel velocity which compensates for the

Options 1-3 - Construction of a suite of direct defences across Peebles
greater discharge.
Additional information required • A detailed topographic survey. • Detailed buried services survey, plotting their position with regards to site works. • Ground investigation.
Additional works required to account for increase flow due to climate change • Properties off Greenside and further up the Eddleston Water may flood if no defences are constructed in this area either as part of a River Tweed or Eddleston Water flood protection scheme. • Consider building adaptable walls that can be easily raised in the future. • Cavalry park industrial estate is not at risk from the 1.33% AP (75 year) flood on the River Tweed and need not be defended until the 1% AP (100 year) event. However, if any intervention is sought here, regardless of the standard chosen for the main Peebles scheme, a wall protecting to the 0.5% AP (200 year) & climate change could be most appropriate due to the lack of aesthetic or space limitations and the cost efficiency of planning for the future in this manner. This should be reviewed at outline design stage.

4.9.2 Option 4 - Property Level Protection (PLP)

Option 4 - Property Level Protection (PLP)
Description This option aims to provide an increase in standard of protection for all properties where relevant by protecting them up to a maximum depth of 0.6m. Beyond this water depth a building's integrity can be compromised. This option includes the survey, design and implementation of relevant PLP products to each property experiencing flooding. The number of properties expected to benefit from PLP: • 43 properties at the 0.5% AP (200 year) event • 24 properties at the 1% AP (100 year) event 39 properties in Peebles - in Tweed Green, Tweed Avenue and Walkershaugh - have been provided with PLP following Storm Frank (Dec. 2015) flooding and are therefore excluded from the above property counts. A full review of these measures may be needed if this option is taken forward as a more comprehensive set of measures may be required (e.g. including more expensive items such as sump pumps that may have been omitted from the original installation).
Standard of Protection (SOP) PLP will offer a variable standard of protection dependent on the property and its location on the floodplain.
Alternative quick wins / Preliminary investigations No alternative quick wins. Some properties are known to already make use of PLP measures including door guards, modified air bricks, boundary flood walls and flood gates.
Technical issues All properties would require surveying by competent parties to determine which products are appropriate. Properties with non-standard or large entrances may require bespoke options which can incur significant cost increases. The Scottish Government's Blueprint on PLP[9] should be considered when implementing this option.
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.
Environmental issues None directly.

9 Scottish Government (2014). Assessing the Flood Risk Management Benefits of Property Level; Blueprint for Local Authorities and Scottish Water. Final Report v2.0. 13 November 2014

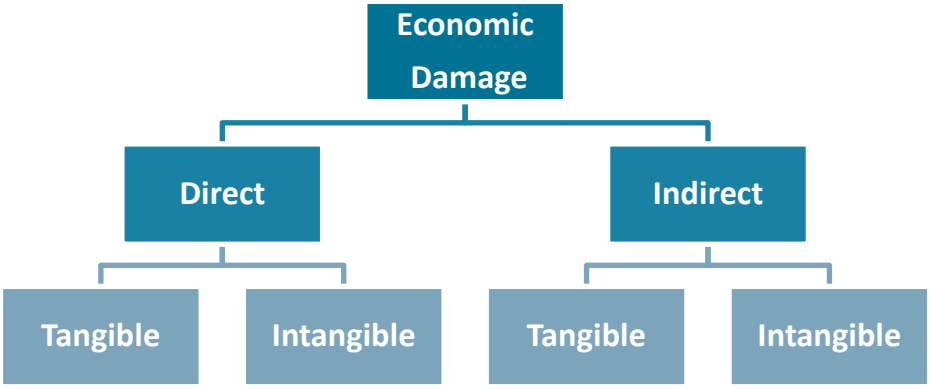
Social and community issues Due to the prevalence of flooding and highly engaged community PLP alone may not be an acceptable option. Residents are likely to expect more significant measures to be undertaken.
Impact on other reaches There will be negligible impact on other reaches due to the proportion of the River Tweed's flood volume that will be affected by reduced attenuation in properties.
Additional information required • A property threshold survey (if not already present). • Public engagement meetings. • Flood risk reviews on each property.
Additional works required to account for increase in flow due to climate change • Some properties identified as suitable for PLP may become unsuitable with increasing river flows. Additionally, some properties that are not expected to flood frequently enough to make PLP worthwhile at present may be expected to flood more frequently in the future.

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; and,
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.

Bridges assumed to block (soffits lowered by 33% and bridge piers increased in width by 1m) and the Tweed Green vennel flood barrier is not in place.

Properties at risk:

The total number of properties inundated above threshold level for the Do Nothing Scenario on the River Tweed 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	16	40	43	69	114	136	152	225	316
Non-residential	0	0	6	15	15	16	18	20	24	25	34
Total	0	1	22	55	58	85	132	156	176	250	350

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 10 properties with highest flood damages from all sources have been listed below.

Rank	Property address	Pvd (£k)	Percentage of total Pvd
1	Peebles Nursing Home, Tweed Green, EH45 8AR	646	3.8%
2	Swimming Pool, EH45 8AW	424	2.5%
3	Priorsford Cottage, Tweed Avenue, EH45 8AS	350	2.1%
4	Priorsford House, Tweed Avenue, EH45 8AS	331	2.0%
5	Detached property adjacent to Tontine Hotel car park, Tweed Green, EH45 9AT	287	1.7%
5	Peebles Community Centre, EH45 8AU	287	1.7%
5	8, Tweed Avenue, EH45 8AS	287	1.7%
5	Hawthorn Bower, Tweed Avenue, EH45 8AS	287	1.7%
5	12, Tweed Avenue, EH45 8AS	287	1.7%
10	Peebles Bowling Club, Walkershaugh, EH45 8AU	263	1.6%

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 and are presented in £k.

Return period (years)	2	5	10	25	30	50	75	100	200	500	1000
Residential	0	26	623	2,764	3,349	5,708	10,461	12,960	16,861	25,414	35,485
Non-residential	0	3	208	968	1,242	1,922	2,382	2,963	3,962	4,956	6,560
Total	0	29	831	3,732	4,591	7,630	12,843	15,923	20,823	30,371	42,045

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 loss probability curve. This figure shows that flood damages are relatively small for the lower to medium flood events but rise significantly.

Breakdown of damages:

A summary of the proportion of total damages by each damage key component is provided in the table below. Total AAD's are converted to Present Value damages assuming a 100 year appraisal period and HM Treasury standard discount rates.

Do Nothing flood damages (£k):

Property PVd	Indirect PVd	Intangible PVd	Total PVd
20,229	1,018	937	22,185

Do Minimum

Assumptions:

Represents the current state of the watercourse, maintenance continued as present, Tweed Green vennel temporary barrier is used during floods.

Properties at risk:

The total number of properties inundated above threshold level for the Do Minimum Scenario on the River Tweed 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	0	2	8	8	16	23	45	135	159	303
Non-residential	0	0	0	5	7	12	13	14	23	24	29
Total	0	0	2	13	15	28	36	59	158	183	332

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 5 ranked properties with highest flood damages from all sources have been listed below and mainly comprise buildings on Tweed Green.

Rank	Property address	Pvd (£k)	Percentage of total Pvd
1	Swimming Pool, EH45 8AW	378	5.0%
2	Detached property adjacent to Tontine Hotel car park, Tweed Green, EH45 9AT	287	3.8%
3	Old Schoolhouse, Tweed Green, EH45 8AP	220	2.9%
4	Carpet warehouse, Tweed Green, EH45 8AU	174	2.3%
5	Bank House, Tweed Green, EH45 8AP	171	2.3%
5	4 Tweed Green, EH45 8AP	171	2.3%
5	1 Tweed Green, EH45 8AP	171	2.3%
5	2 Tweed Green, EH45 8AP	171	2.3%
5	3 Tweed Green, EH45 8AP	171	2.3%
5	13 Greenside, EH45 8JF	171	2.3%

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 and are presented in £k.

Return period (years)	2	5	10	25	30	50	75	100	200	500	1000
Residential	0	0	51	465	531	958	1,784	3,167	13,154	18,582	30,375
Non-residential	0	0	2	148	206	455	765	1,003	2,864	4,152	5,239
Total	0	0	53	614	737	1,413	2,549	4,170	16,019	22,734	35,614

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 loss probability curve. This figure shows that flood damages are relatively small for the lower to medium flood events but rise significantly.

Breakdown of damages:

A summary of the proportion of total damages by each damage key component is provided in the table below. Total AAD's are converted to Present Value damages assuming a 100 year appraisal period and HM Treasury standard discount rates.

Do Minimum flood damages (£k):

Property PVd	Indirect PVd	Intangible PVd	Total PVd
7,380	374	356	8,110

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[10] 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 £14-16.7m, although the benefit gained from the Do Minimum option is nearer £0.1-2.7m. This highlights a couple of points with regard to the options:

- The importance of maintaining the channel and mitigating against bridge blockage is important. Whilst the blockage aspect cannot be managed entirely, it may have implications on the freeboard values used, particularly upstream of the Tweed Bridge. It may also be wise to raise or modify Priorsford footbridge as part of the scheme to limit the risks associated with this structure.
- The PLP option has limited gains over the Do Minimum option.
- There is still a significant residual flood risk associated with the town. This is due to the high flood damages for the above design events. Works to address this residual risk should therefore be considered.

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

	DN	DM	Option 1	Option 2	Option 3	PLP
Option name	Do Nothing	Do Minimum	Direct Defences	Direct Defences	Direct Defences	PLP
SoP	5	5	50	75	100	10
Benefits						
PV monetised flood damages	22,185	8,110	6,573	6,077	5,451	5,301
Total PV damages avoided	-	14,075	15,611	16,107	16,733	14,182*
***Note:** PLP benefits are scaled down by 16% to account for the likelihood of PLP products only being 84% effective						

10 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, therefore these costs are unlikely.

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.

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[11]. 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.

6.3.1 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.

6.4 River Tweed - Option 1 - Direct defences with a 50 year standard of protection

This option consists of the following measures:

- Greenside Wall with a vehicular gate: A concrete wall, 263m long with 0.5m average height.
- Tweed Green Embankment with two pedestrian flood gates: An embankment approximately 250m long with a total volume approximately 2,218m^3. This would rise to a height of 1.0m

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

and have a footprint of approximately 12m. This is priced according to the embankment and not the alternative option of the wall.

- Tweed Green Wall: A concrete wall, 98m long with 1.0m maximum height and two pedestrian flood gates. It is calculated using a weighted average – The height of the wall is less than 1.0m for 26m approximately, and higher than 1.0m for 68m approximately.
- Swimming Pool Wall: A concrete wall, 125m long, 1.1m high and one vehicular flood gate and one pedestrian flood gate. The cost of the wall is calculated using a weighted average – The height of the wall is less than 1.1m for 57m approximately, and higher than 1.1m for 68m approximately.
- Pumping Station at South Park West: A pumping station with 1.5m^3/s capacity.

Costs are based on achieving a 50-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)
Greenside Wall	0.5m	263m	£1,428	£368,591
Tweed Green Embankment	1.0m	2,218m^3	£120	£483,076
Tweed Green Wall	1.0m	98m	£2,876	£267,468
Swimming Pool Wall	1.1m	125m	£2,511	£311,364
Greenside Wall Vehicular Gate	0.5 x 5m	-	£20,700	£20,700
Swimming Pool Wall Vehicular Gate	1.1 x 5m	-	£13,800	£13,800
Swimming Pool Wall Pedestrian Gate	1.1 x 2m	-	£5,500	£5,500
Tweed Green Wall Gate 1	1.0 x 2m	-	£5,500	£5,500
Tweed Green Wall Gate 2	1.0 x 2m	-	£6,400	£6,400
Tweed Green Wall Gate 3	1.0 x 2m	-	£5,000	£5,000
Tweed Green Wall Gate 4	1.0 x 2m	-	£10,000	£10,000
Tweed Green Gate	1.0 x 1m	-	£10,000	£10,000
Pumping Station	-	1,500l/s	-	£607,136
Other Costs – Access path on top of Tweed Green Embankment	-	480m^2	£100	£48,000
Excavation and Tipping	-	1,729m^3	125.05	216,299
			Total Capital cost	£2,331,134

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

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	281	281
Capital cost	2,331	2,252
Maintenance cost	2,634	748
Total	**5,246**	**3,282**
Total incl. Optimism Bias	-	5,253

6.5 River Tweed - Option 2 - Direct defences with a 75 year standard of protection

This option consists of the following measures:

- Greenside Wall with a vehicular gate: A concrete wall, approximately 263m long with 0.7m average height.
- Tweed Green Embankment with two pedestrian flood gates: An embankment approximately 250m long with average height 1.2m and total volume approximately 4,767m^3. The embankment would have a 14m wide footprint. An alternative defence possibility consisting of a boundary wall is shown on the drawing but is not included for in the option costing.
- Tweed Green Wall: A concrete wall, approx.98m long, with 1.4m maximum height and two pedestrian flood gates. The cost of the wall is priced using a weighted average according to the different heights of the wall. The wall is less than 1.2m high for approximately 2m and higher than 1.2m for approximately 96m.
- Kingsmeadows Embankment: An extension of 14m to the existing embankment (to make a total length of approximately 354m and building a new footpath on top of the existing embankment with raising of crest approximately 0.2 to 0.3m.
- Swimming Pool Wall: A concrete wall, 125m long, 1.3m average height and one vehicular flood gate and one pedestrian flood gate. The wall is priced using a weighted average – the wall is lower than 1.3m high for approximately 28m and higher than 1.3m for 97m.
- Two more pedestrian flood gates at South Park.
- Pumping Station at South Park West: A pumping station with 1.5m^3/s capacity.

Costs are based on achieving a 75-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)
Kingsmeadows Embankment	+0.2m	150m^3	£239	£35,941
Greenside Wall	0.7m	263m	£1,428	£615,985
Tweed Green Embankment	1.2m	4,767m^3	£120	£570,345
Tweed Green Wall	1.1m	98m	£2,857	£299,985
Swimming Pool Wall	1.3m	125m	£2,972	£374,472
Greenside Wall Vehicular Gate	0.7 x 5m	-	£20,800	£20,800
Tweed Green Wall Gate 1	1.1 x 2m	-	£5,500	£5,500
Tweed Green Wall Gate 2	1.1 x 2m	-	£5,500	£5,500
Tweed Green Wall Gate 3	1.1 x 2m	-	£10,000	£10,000
Swimming Pool Wall Vehicular Gate	1.3 x 5m	-	£20,800	£20,800
Swimming Pool Wall Pedestrian Gate	1.3 x 2m	-	£5,500	£5,500
Tweed Green Gate	1.2 x 2m	-	£10,000	£10,000
Pumping Station	-	1,500l/s	-	£607,136
Other Costs - Access Path on top of Kingsmeadows Embankment	-	780m^2	£100	£70,800
Other Costs - Access Path on top of Tweed Green Embankment	-	498m^2	£100	£49,800
Excavation and tipping	-	1,945m^3	£125.05	£243,285
			Total Capital cost	£2,708,440

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

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	221	221

Element	Cash cost (£k)	PV Cost (£k)
Capital cost	2,708	2,360
Maintenance cost	2,639	750
Total	**5,568**	**3,587**
Total incl. Optimism Bias	-	5,742

6.6 River Tweed - Option 3 - Direct defences with a 100 year standard of protection

This option consists of the following measures:

- Greenside Wall with a vehicular gate: A concrete wall, 263m long, 0.9m average height.
- Tweed Green Embankment with two pedestrian flood gates: An embankment approximately 250m long, 1.3m average height and total volume approximately 5,199m^3. The embankment would have a footprint of 15m in width.
- Tweed Green Wall: A concrete wall, 98m long, 1.1m maximum height and two pedestrian flood gates.
- Kingsmeadows Embankment: Existing embankment to be extended by 14m. Total volume approximately 419m^3. Construction of a new footpath on top of the entire embankment. Footpath will raise crest of existing embankment by approximately 0.25 to 0.5m.
- Swimming Pool Wall: A concrete wall, 125m long, 1.4m high and one vehicular flood gate and one pedestrian flood gate.
- South Park Wall West: A concrete wall, approximately 190m long and average height of 1.9m.
- South Park Wall: A concrete wall, approximately 369m long and average height of 2m.
- Pumping Station at South Park West: A pumping station with 1.5m^3/s capacity.
- Cavalry Park embankment: An embankment approximately 244m long with maximum height 1.6m. There are some high points where the water level is below ground level, however a more conservative approach has been followed. Total volume approximately 4,725m^3.

Costs are based on achieving a 100-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)
Greenside Wall	1.2m	263m	£3,432	£885,671
Tweed Green Embankment	1.6m	5,199m^3	£81	£423,510
Tweed Green Wall	1.1m	98m	£2,281	£214,414
Swimming Pool Wall	1.2m	125m	£3,045	£377,580
Kingsmeadows Embankment	+0.5m	419m^3	£239	£100,262
South Park Wall West	1.3m	190m	£3,432	£666,398
South Park Wall	0.7m	369m	£2,807	£1,035,783
Cavalry Park Embankment	1.2m	4,725m^3	£120	£565,320
Greenside Wall Vehicular Gate	0.9 x 5m	-	£33,800	£33,800
Swimming Pool Wall Vehicular Gate	1.5 x 5m	-	£19,800	£19,800
Swimming Pool Wall Pedestrian Gate	1.5 x 2m	-	£6,000	£6,000
Tweed Green Wall Gate 1	1.1 x 2m	-	£19,500	£19,500
Tweed Green Wall Gate 2	1.1 x 2m	-	£21,000	£21,000

Location	Typical defence height	Length / Volume	Unit cost	Total Cost (Rounded)
Tweed Green Wall Gate 3	1.1 x 2m	-	£16,500	£16,500
Tweed Green Wall Gate 4	1.1 x 2m	-	£15,000	£15,000
Tweed Green Gate	1.3 x 2m	-	£15,000	£15,000
South Park Wall West Gate 1	1.3 x 2m	-	£50,400	£50,400
South Park Wall West Gate 2	1.3 x 2m	-	£38,400	£38,400
Pumping Station	-	1,500l/s	-	£607,136
Other costs – access path on Kingsmeadows Embankment	-	708m^2	£100	£70,800
Other costs – access path on Tweed Green Embankment	-	498m^2	£100	£49,800
Other costs – access path on Cavalry Park Embankment	-	488m^2	£100	£48,800
Excavation and tipping	-	3,663m^3	£125.05	£458,058
			Total Capital cost	£5,752,432

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

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	608	608
Capital cost	5,752	5,558
Maintenance cost	3,255	925
Total	**9,616**	**7,091**
Total incl. Optimism Bias	-	11,348

6.7 River Tweed - Option 4 - PLP

Table 6-7: Unit and total estimated capital costs

Property type	Count	Capital cost - mid range automatic
Detached	27	£226,341
Semi-detached	5	£39,290
Terraced	33	£148,236
Flat	8	£36,864
Shop	1	£12,117
School	0	-
Total	74	£462,848

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

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	88	88
Capital cost	1,851	768
Maintenance cost	907	258
Total	**2,846**	**1,113**
Total incl. Optimism Bias	-	1,781

6.8 Summary of whole life costs

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

Table 6-9: Summary of PV costs for all options

Option	PV Cost (£k)
1 - 50 year standard direct defences	5,253
2 - 75 year standard direct defences	5,742
3 - 100 year standard direct defences	11,348
4 - Property Level Protection	1,781

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 values. 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. All of the direct defences options are cost effective, as is the PLP option.

Table 7-1: Benefit cost ratio for options on the River Tweed (£k)

	Do Nothing	Do Minimum	50 year option	75 year option	100 year option	PLP
PV Costs (£k)	-	-	3,282	3,587	7,091	1,113
Optimism Bias (60%)	-	-	1,969	2,152	4,255	668
Total PV Costs (£k)	-	-	5,251	5,740	11,346	1,781
PV damage (£k)	22,185	8,110	6,573	6,077	5,451	5,301
PV damage avoided (£k)	-	14,075	15,611	16,107	16,733	14,182
Net present value (£k)	-	14,075	10,361	10,368	5,388	12,401
Benefit-cost ratio	-	-	3.0	2.8	1.5	8.0
Incremental benefit-cost ration	-	-	-	1.0	0.1	0.1

The incremental benefit-cost ratios for each of the defended options show that the 75 year defence standard has sufficient benefits over and above the 50 year option compared to the difference in investment required. The 75 year standard involves increasing the heights of the same defences required for the 50 year option but also requires marginal raising of the Kingsmeadows embankment. Further defence raising for the 100 year option must be combined with additional defences along the bank in the South Park area of Peebles which adds significant costs due to the defence length required but there is a large increase in the number of properties protected (23 properties in addition to the 36 protected by the 75 year option). Due to this increase in the number of properties protected and the longer term benefits in the face of climate change this option is the most preferable of the direct defences options.

To take climate change into consideration for the 75 year option a, assuming a 33% uplift in flows by 2080 as used throughout this study, the 1.33% AP (75 year) flood event would be greater in magnitude than the present-day 1% AP (100 year) flood event and therefore would require defences

in excess of those detailed for Option 3 above. Although potentially feasible due to the higher standard of protection on offer, this option would likely have a lower benefit-cost ratio than Option 3 and defence heights may be contested by the community.

The PLP option has little economic benefit over and above the Do Minimum option for what is still a substantial investment. 43 properties suitable for PLP are estimated to benefit at the 0.5% AP (200 year) flood event but 93 would remain unprotected due to flood depths being too great. Crucially, although PLP would protect some properties up to the 0.5% AP (200 year) event others would only be protected up to the 4% AP (25 year) event due to flood depths exceeding the maximum capacity for PLP. The mixed performance of this option is highlighted in Table 7-2 which shows the number of properties benefitting. The PLP option would also rely on PLP products being maintained, replaced and used as expected over the full appraisal period to provide the expected benefit. Although the direct defences options protect some properties to a lower standard of protection than the PLP option they offer an even standard of protection.

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

Return period (years)	10	25	30	50	75	100	200	500	1000
Do Minimum	2	13	15	28	36	59	158	183	332
With PLP	0	2	2	2	9	12	93	171	314
Difference	**-2**	**-11**	**-13**	**-26**	**-27**	**-47**	**-65**	**-12**	**-18**

If one of the direct defences options is taken forward by the Council it could be combined with Option 3 from the Eddleston Water study. This option is not cost-effective on its own (BCR of 0.4) but if combined with the 100 year option on the Tweed, which is actually the least cost-effective solution, it provides a cost-effective scheme protecting the most densely populated areas of Peebles with a BCR of 1.1 and a net present value of £1,799. This may be the only way that a cost-effective solution to flooding on the Eddleston Water could be developed.

The 100 year direct defences option on the River Tweed would have an influence on the Edderston Burn and therefore some works on the burn would likely be required to ensure suitable interaction between the two. Since the Edderston Burn study has produced options that are cost-effective on their own these measures could be combined with works on the River Tweed and even the Eddleston Water as noted above. An Peebles-wide benefit-cost ratio taking all watercourses into account has not been calculated at this stage but should any of these options be taken forward this would likely be a useful exercise.

7.3 Residual risks

The most cost effective option taking into account incremental benefits offers a 75 year standard of protection, leaving properties at risk to larger magnitude floods. This risk is likely to further increase with climate change. A range of additional actions are proposed which could be used to reduce this residual risk:

- Natural Flood Management (NFM) practices could aid in reducing flows in the River Tweed and provide some resilience to climate change. A detailed NFM study should be carried out to attempt to quantify the benefits of these practices in the Tweed valley.
- The raising of Priorsford Bridge has not been recommended as part of the options as it should not impact flood levels in Tweed Green up to the 1% AP (100 year) flood event. However, blockage of this structure and the impact this might have on flood levels upstream and the risk of damage to the structure itself suggest that it would be a 'no regrets' option to raise this either as part of the scheme (making the scheme more resilient to above design flows) or opportunistically as part of a major maintenance upgrade to the structure, should this ever be required.
- The River Tweed ordinarily flows through three of its five arches with community access through the first two arches via a path and park space. Channelising the second arch to increase channel capacity during high flow events was investigated. The effects were positive, reducing flood levels but by less than 150mm. Considering the scale of the work required this option is not considered to be effective enough to carry forward, but should be reconsidered at the outline design stage once the preferred option has been confirmed.
- Direct defences could be designed to allow for demountable defences to be added during times of flood either on top of or behind the permanent defences, This would increase the

standard of protection and allow the permanent defences to be constructed to lower heights and therefore be less intrusive to the community when river levels are low. In general, the cost and infrastructure required to implement demountable defences are substantial and should be avoided if possible. Alternatively, designing permanent defences that can be easily raised in the future would be a more preferable option. For example, installing a wall on top of a flood embankment.

- Property Level Protection (PLP) would increase property resistance to flood waters and if implemented alongside a flood protection scheme could be an effective means of further reducing property flood damages.
- The large difference between Do Nothing and Do Minimum damages highlights that watercourse maintenance and particularly bridge blockage could have a large impact on flood levels within Peebles. Careful assessment of freeboard requirements upstream of Tweed Bridge is required to determine the effects of bridge blockage on defence heights under a range of scenarios.

8 Public consultation

A public consultation event was held in Peebles during November 2018 to gauge opinion on the flood mitigation options proposed as part of this study. In general, the residents in attendance were in approval of the scheme as a whole but expressed strong opinion that the feel of Peebles should be maintained wherever possible through careful consideration of defence types, position and visual appearance of the structures themselves.

There was an acceptance that there is a problem in Peebles with properties being located on the floodplain of the River Tweed and due to the size of the river, topography and local infrastructure direct defences are the only real opportunity to substantially reduce flood risk. There were questions regarding the opportunities for Natural Flood Management practices in the upper catchment and better land management on the whole. The natural flood management assessments carried out as part of the Borders Flood Studies have captured some opportunities that may exist, but it was highlighted to residents that more detailed work is required to be able to establish the extent to which natural techniques could be used to reduce flood risk on the River Tweed.

Most frequently residents were concerned about a potential change in accessibility to green spaces as a result of the direct defences options proposed. Wall heights were found to be acceptable but it was the reduced access to green spaces, limited to gaps in defences where flood gates would be positioned, that was seen to be most controversial. One member of the public suggested that the 'place' of Tweed Green is actually more valuable than the buildings that surround it. As a long-term amenity Tweed Green should, in his opinion, be preserved as it has been for many years with careful consideration of flood defence positioning and appearance. Tweed Green was the main point of focus for many residents with one even suggesting that she would 'prefer' to have those properties at risk receive PLP rather than alter the green. Others were more accepting of the direct defence proposals and even if not resident on the green and at flood risk from the River Tweed could acknowledge the requirement for such defences.

There was general consensus that a set-back hybrid wall-embankment defence on the green would be preferable to an embankment on the riverside which would reduce views of the river unless standing on top of the defence. Residents expressed concern over how any final design affects the mature trees currently growing on the green. One suggestion was to incorporate flood defences into the garden walls which surround the green rather than have a separate defence but this would be complicated by the property walls which front onto the road in some places. There were several mentions of future abandonment of the properties at flood risk around Tweed Green, Tweed Avenue and Whitehaugh as a more sensible long-term option than altering the look of the green.

Some residents were of the opinion that there is not enough weight given to Natural Flood Management as a solution in this flood study. The council responded highlighting that the long-listing process ruled out any options that are not able to provide a substantial benefit. Natural Flood Management is seen as a positive measure capable of delivering multiple catchment benefits and should be taken forward separately but it is not expected that it would be sufficient to provide protection from high magnitude flood events on a large river like the River Tweed.

9 Conclusions and recommendations

9.1 Summary

This report presents the results of a detailed flood risk appraisal for Peebles in relation to flooding from the River Tweed. Peebles has a history of flooding from the River Tweed and other watercourses (the other watercourses are reported on separately). Areas around Tweed Green, Kingsmeadows and the swimming pool are most frequently affected by flooding, with the most recent out of bank flooding occurring in January 2018 and more significant flooding which affected properties occurring in December 2015. 158 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 Peebles. These investigations involved a review of Peebles' flood history, an assessment of the hydrological inputs to the River Tweed, 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 with the populated area of Peebles being covered by the 2D domain, 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 watercourse ceases, and the latter representing the present-day watercourse condition, assuming Flood Warning and temporary flood barriers are maintained and used.

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 Peebles's flood risk problem. Mapping has been produced for the reach between Peebles and Walkerburn. Cardrona and Innerleithen have minimal risk from the River Tweed. Walkerburn is at risk, but further assessment (other than mapping) is outside the scope of this assessment.

Several short-term measures were proposed which may assist in reducing flood risk to some properties. Peebles already benefits from being within a SEPA Flood Warning area and this should be maintained. Natural Flood Management (NFM) is a method whereby wider catchment benefits could be achieved whilst also potentially reducing flood flows within Peebles. Opportunities within the upper catchment could to some extent counteract the effects of increasing river flows with climate change. Property Level Protection (PLP) is already in use by 39 properties but could be used by more residents of Peebles 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.

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. Three of the short list options are based on direct defences being constructed alongside the River Tweed through Peebles but the options would be designed to protect against different magnitude flood events, the 2% AP (50 year), 1.33% AP (75 year) and 1% AP (100 year). Option 1, with a 2% AP (50 year) Standard of Protection consists of walls and embankments with a combined length of 736m throughout Peebles. These defences are focussed around the north bank of the River Tweed around the swimming pool and Tweed Green. Options 2 and 3 that protect against 1.33% AP (75 year) and 1% AP (100 year) floods require the introduction of defences on the south bank of the River Tweed with these options having combined defence lengths of 1090m and 1893m, respectively. Property Level Protection (PLP) was also included as an option, providing protection for properties experiencing flooding up to 0.6m in depth. This option is less favourable than a direct defences option since it carries greater risk of defence failure and does not protect all properties against the same magnitude flood event.

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 £8,110,000. 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.

All three direct defences options are cost beneficial in addition to the PLP option. Whilst the 2% AP (50 year) defences option has the highest benefit cost ratio (3.0) the incremental benefit cost ratios show that the benefit of defending to a 1.33% AP (75 year) standard over and above the 2% AP (50 year) standard are worth the additional investment. Whilst the incremental benefit cost ratio for the 1% AP (100 year) option is not above 1 it remains cost-effective in its own right and considering it protects 23 additional properties over and above the 75 year option it is a preferable option. With a 33% increase in river flows due to climate change a present day 100 year flood will have a return period of approximately 38 years by the year 2080. This has the effect of making the maximum flood that the defences would be able to protect against occur more frequently and therefore makes the case for defending against the largest flood feasible, in this case the 100 year flood. Under the more probable 50th percentile 'as likely as not to be exceeded' climate change uplift of 21% the 2080 standard of protection of a present-day 100 year scheme would be 49 years rather than 38 using the climate change uplifts applied throughout this study. Although 49 years suggests a higher standard of protection this is still significantly lower than the 100 year standard that the scheme would seek to achieve at inception. These examples highlight why it is important to provide as high a standard of protection as feasible now so that there remains a reasonable standard of protection following increases in flood flow frequency as a result of predicted climate change.

Public consultation highlighted concern for the aesthetics of direct flood defences and a change to the 'feel' of the town as a result. Nevertheless, there was an appreciation that flood defences are required in order to reduce the flood risk to Peebles and the height of the proposed defences was not a major concern to the members of the public in attendance. This suggests that the option offering the highest standard of protection would be the best option overall for delivering the study's critical success factors.

9.2 Recommendations

The above assessments have led to the following key recommendations for Peebles:

The 1% AP (100 year) option is cost-effective and should be taken forward by the Council. Although other options are more cost-effective this option provides the highest standard of protection of the options assessed and protects 64% more properties than the 1.33% AP (75 year) option. Crucially it will maintain an acceptable standard of protection as climate change advances, making it a more robust scheme.

In the short term PLP should be marketed to those at flood risk in the wider community, particularly since the community is so engaged in flooding. 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.

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.

Flood Warning should be continued on the River Tweed and will be required for any future direct defences option involving flood gates or for any PLP products that require temporary installation. Flood Warning should also be reviewed for Tweedside Caravan Park in Innerleithen to allow appropriate responses to forecast floods.

Wherever possible, Scottish Planning Policy should be leveraged to provide the potential for future implementation of other options that are currently not possible due to the sporadic presence of properties on the floodplain.

Finally, this study has highlighted greater flood risk to Walkerburn than was previously expected. It is therefore recommended that a flood study should be carried out for Walkerburn to quantify the risk and assess flood risk management options.

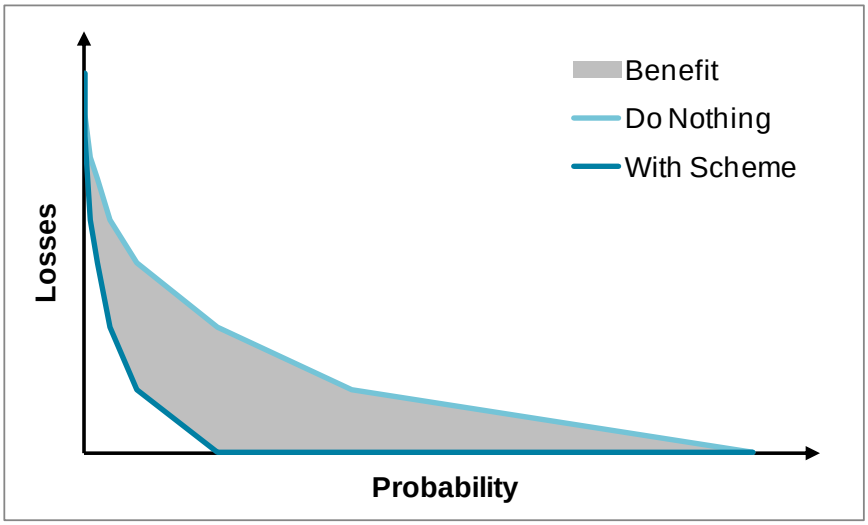
Appendices

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 B-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 then 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 B-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 B-1, were used to generate direct flood damage estimates.

Table B-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 2018 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[12]. Equivalent yield varies regionally and temporarily, but is recommended to be a value of 10-12.5 for flood defence purposes[13]. 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 are based on January 2017 values and therefore do not need to be brought up to date to compare the costs and benefits.

12 www.saa.gov.uk
13 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)[14] 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.

14 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)	August 18
Scottish Borders Council				Printed	03/12/2018
Project name				Prepared by	B.Bedford
Tweed Flood Study				Checked by	A.Pettit
Project reference				Checked date	September 18
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	**DN**	**DM**	**OP03**	**OP02**	**OP04**	
Option name	Do Nothing	Do Minimum	DD - 50yr	DD - 75yr	DD - 100yr	PLP
AEP or SoP (where relevant)	5	5	50	75	100	200
COSTS:						
PV enabling costs	0	0	281	221	608	88
PV capital costs	0	0	2,252	2,617	5,558	768
PV operation and maintenance costs	0	0	748	750	925	258
Optimism bias adjustment	0	0	1,969	2,152	4,255	668
PV negative costs (e.g. sales)	0	0				
PV contributions						
Total PV Costs £k excluding contributions	0	0	5,251	5,740	11,346	1,781
Total PV Costs £k taking contributions into account	0	0	5,251	5,740	11,346	1,781
BENEFITS:						
PV monetised flood damages	22,185	8,110	6,573	6,077	5,451	5,301
PV monetised flood damages avoided		14,075	15,611	16,107	16,733	14,182
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	22,185	8,110	6,573	6,077	5,451	5,301
Total monetised PV benefits £k		14,075	15,611	16,107	16,733	14,182
Total PV damages £k	22,185	8,110	6,573	6,077	5,451	5,301
Total PV benefits £k		14,075	15,611	16,107	16,733	14,182
DECISION-MAKING CRITERIA:						
Based on monetised PV benefits (ex cludes benefits from scoring and weighting and ecosystem services)						
Net Present Value **NPV**		14,075	10,361	10,368	5,388	12,401
Average benefit/cost ratio **BCR**			3.0	2.8	1.5	8.0
Incremental benefit/cost ratio **IBCR**			0.3	1.0	0.1	0.1
			Highest bcr	IBCR>1		
Best practicable environmental option (WFD)						

Brief description of options:

DN	Do Nothing
DM	Do Minimum
OP03	DD - 50yr
OP02	DD - 75yr
OP04	DD - 100yr
PLP	PLP

Comments and assumptions:

Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council

Project name
Tweed Flood Study

Option:
Do nothing

Project reference -

Base date for estimates (year 0)	43101	First year of damage:	0	Prepared (date)	August 18
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	03/12/2018
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	September 18

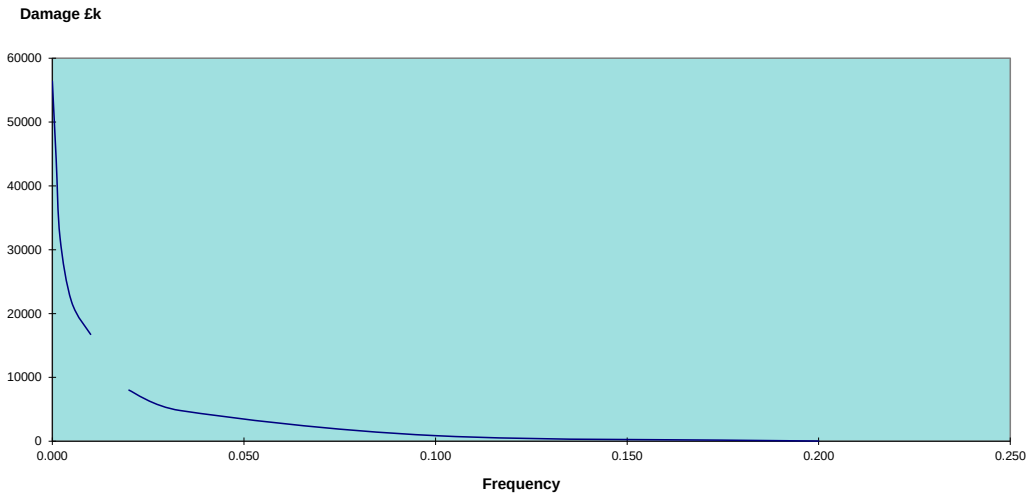
	Average waiting time (yrs) between events/frequency per year										Total PV
	5	10	30	50	75	100	200	500	1000	Infinity	£k
	0.200	0.100	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k										
Residential property	26	623	3,349	5,708	10,461	12,960	16,861	25,414	35,485	45,555	15,832
Ind/commercial (direct)	3	208	1,242	1,922	2,382	2,963	3,962	4,956	6,560	8,058	4,397
Ind/comm (indirect)	0	6	37	58	71	89	119	149	197	242	132
Traffic related										-	-
Emergency services	1	35	188	320	586	726	944	1,423	1,987	2,551	887
Other	-	-	-	-	-	-	-	-	-	-	-
Intangible damages										-	937
										-	-
Total damage £k	31	872	4,816	8,008	13,500	16,737	21,886	31,943	44,229	56,406	
Area (damagexfrequency)	4.64	45.17	190	85	72	50	96.56	80.74	38.09	50.32	

Total area, as above	713
PV Factor, as above	29.813
Present value (assuming no change in damage or event frequency)	21,248

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: Tweed Flood Study **Option: Do nothing**



Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council

Project name
Tweed Flood Study

Option:

Project reference -

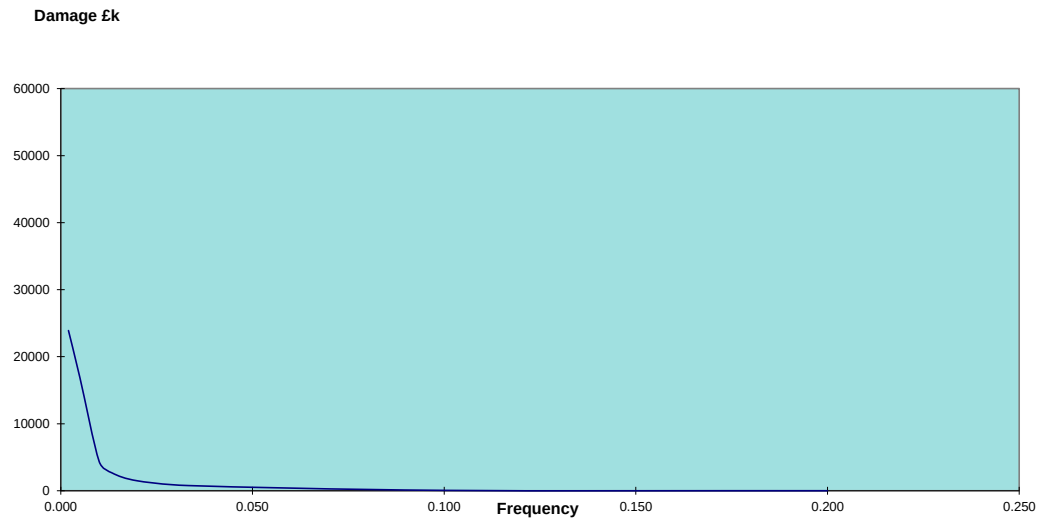
Base date for estimates (year 0)	43101	First year of damage:	0	Prepared (date)	August 18
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	03/12/2018
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by	B.Bedford
				Checked by	A.Pettit
Applicable year (if time varying)				Checked date	September 18

	Average waiting time (yrs) between events/frequency per year										Total PV
	5	10	30	50	75	100	200	500	1000	Infinity	£k
	0.200	0.100	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k										
Residential property	-	51	531	958	1,784	3,167	13,154	18,582	30,375	42,169	5,915
Ind/commercial (direct)	-	2	206	455	765	1,003	2,864	4,152	5,239	6,325	1,465
Ind/comm (indirect)	-	0	6	14	23	30	86	125	157	150	43
Traffic related										-	-
Emergency services	-	3	30	54	100	177	737	1,041	1,701	2,361	331
Other	-	-	-	-	-	-	-	-	-	-	-
Intangible damages										-	356
										-	-
Total damage £k	-	56	773	1,480	2,672	4,377	16,841	23,899	37,472	51,005	
Area (damagexfrequency)		3	28	15	14	12	53	61	31	44	

Total area, as above	260	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	7,755	8,110

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: Tweed Flood Study **Option:**



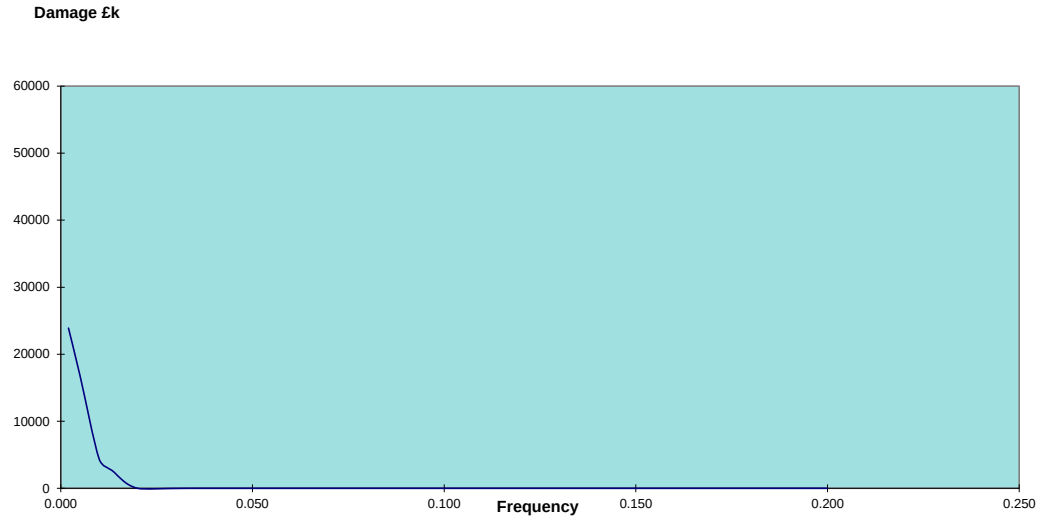
Client/Authority					
Scottish Borders Council					
Project name		**Option:**			
Tweed Flood Study					
Project reference	-				
Base date for estimates (year 0)	43101	First year of damage:	0	Prepared (date)	August 18
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	03/12/2018
Discount 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	September 18

	Average waiting time (yrs) between events/frequency per year										Total PV
	5	10	30	50	75	100	200	500	1000	Infinity	£k
	0.200	0.100	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k										
Residential property	-	-	-	-	1,784	3,167	13,154	18,582	30,375	42,169	4,870
Ind/commercial (direct)	-	-	-	-	765	1,003	2,864	4,152	5,239	6,325	1,078
Ind/comm (indirect)	-	-	-	-	23	30	86	125	157	150	31
Traffic related										-	-
Emergency services	-	-	-	-	100	177	737	1,041	1,701	2,361	273
Other	-	-	-	-	-	-	-	-	-	-	-
Intangible damages										-	321
										-	-
Total damage £k	-	-	-	-	2,672	4,377	16,841	23,899	37,472	51,005	
Area (damagexfrequency)		-	-	-	9	12	53	61	31	44	

Total area, as above	210	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	6,253	6,573

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: Tweed Flood Study **Option:**



Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council

Project name
Tweed Flood Study

Option:

Project reference -

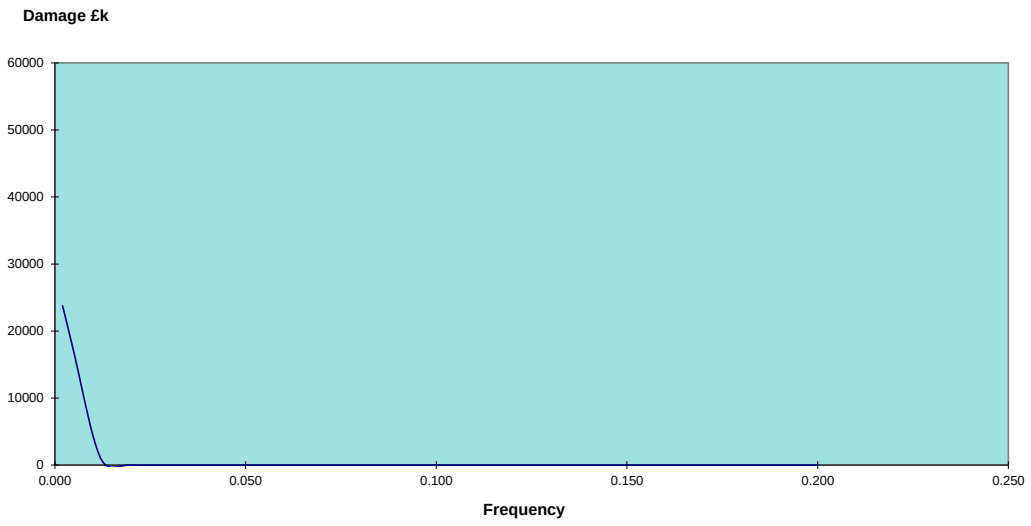
Base date for estimates (year 0)	43101	First year of damage:	0	Prepared (date)	August 18
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	03/12/2018
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by	B.Bedford
				Checked by	A.Pettit
Applicable year (if time varying)				Checked date	September 18

	Average waiting time (yrs) between events/frequency per year										Total PV
	5	10	30	50	75	100	200	500	1000	Infinity	£k
	0.200	0.100	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k										
Residential property	-	-	-	-	-	3,167	13,154	18,582	30,375	42,169	4,604
Ind/commercial (direct)	-	-	-	-	-	1,003	2,864	4,152	5,239	6,325	964
Ind/comm (indirect)										-	-
Traffic related										-	-
Emergency services	-	-	-	-	-	177	737	1,041	1,701	2,361	258
Other	-	-	-	-	-	-	-	-	-	-	-
Intangible damages										-	251
										-	-
Total damage £k	-	-	-	-	-	4,347	16,755	23,775	37,315	50,855	
Area (damagexfrequency)		-	-	-	-	7	53	61	31	44	

Total area, as above	195	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	5,826	6,077

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: Tweed Flood Study **Option:**



Summary Annual Average Damage

Sheet Nr.

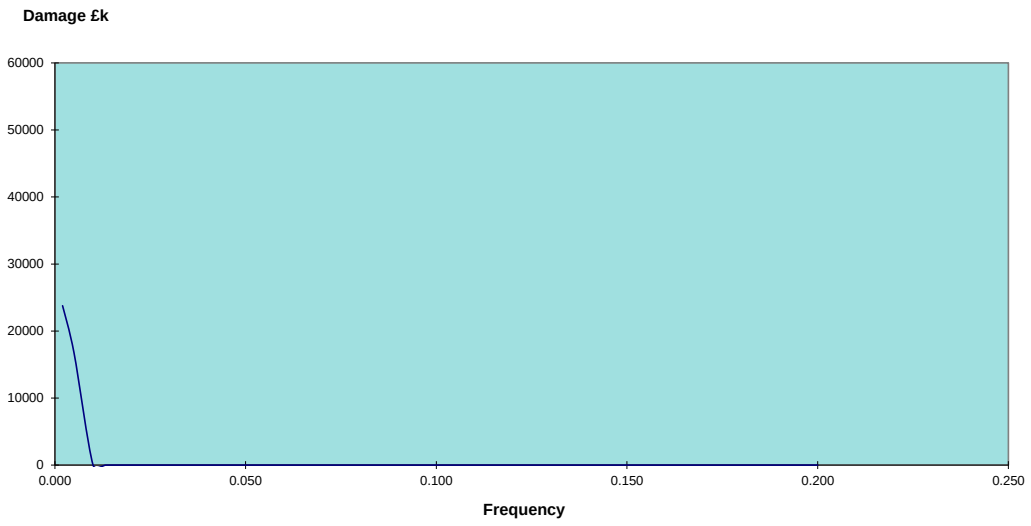
Client/Authority					
Scottish Borders Council					
Project name		**Option:**			
Tweed Flood Study					
Project reference	-				
Base date for estimates (year 0)	43101	First year of damage:	0	Prepared (date)	August 18
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed	03/12/2018
Discount 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	September 18

	Average waiting time (yrs) between events/frequency per year										Total PV
	5	10	30	50	75	100	200	500	1000	Infinity	£k
	0.200	0.100	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k										
Residential property	-	-	-	-	-	-	13,154	18,582	30,375	42,169	4,211
Ind/commercial (direct)	-	-	-	-	-	-	2,864	4,152	5,239	6,325	840
Ind/comm (indirect)										-	-
Traffic related										-	-
Emergency services	-	-	-	-	-	-	737	1,041	1,701	2,361	236
Other	-	-	-	-	-	-	-	-	-	-	-
Intangible damages										-	165
										-	-
Total damage £k	-	-	-	-	-	-	16,755	23,775	37,315	50,855	
Area (damagexfrequency)		-	-	-	-	-	42	61	31	44	

Total area, as above	177	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	5,286	5,451

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: Tweed Flood Study **Option:**



Summary Annual Average Damage

Sheet Nr.

Client/Authority
Scottish Borders Council

Project name
Tweed Flood Study

Option:

Project reference -

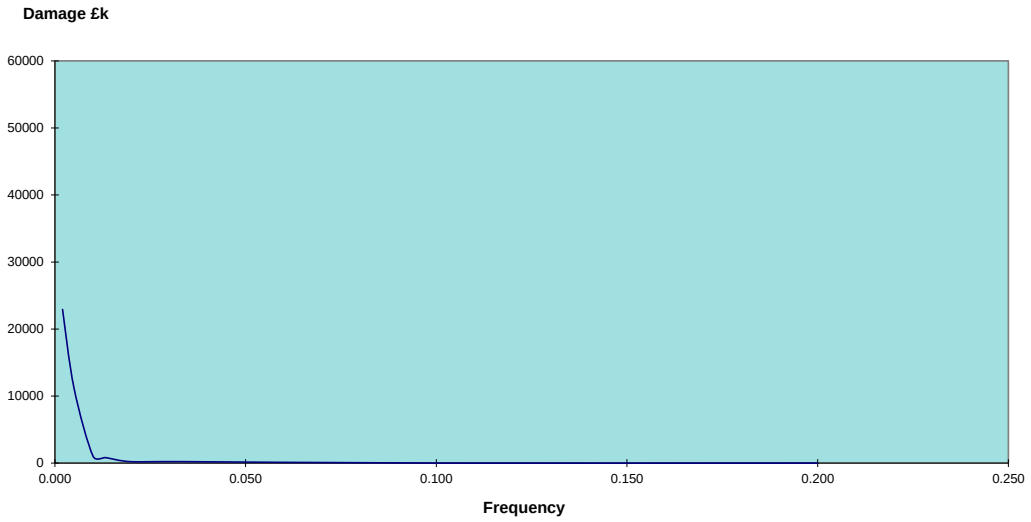
Base date for estimates (year 0)	43101	First year of damage:	0	Prepared (date)		August 18
Scaling factor (e.g. £m, £k, £)	£k	Last year of period:	99	Printed		03/12/2018
Discount rate	3.5%	PV factor for mid-year 0:	29.813	Prepared by		B.Bedford
				Checked by		A.Pettit
Applicable year (if time varying)				Checked date		September 18

	Average waiting time (yrs) between events/frequency per year										Total PV
	5	10	30	50	75	100	200	500	1000	Infinity	£k
	0.200	0.100	0.033	0.020	0.013	0.010	0.005	0.002	0.001	0	
Damage category	Damage £k										
Residential property	-	-	175	182	537	687	8,058	18,018	29,807	41,595	3,973
Ind/commercial (direct)	-	2	33	14	245	302	2,690	3,892	5,103	6,314	922
Ind/comm (indirect)										-	-
Traffic related										-	-
Emergency services	-	-	10	10	30	38	451	1,009	1,669	2,329	222
Other	-	-	-	-	-	-	-	-	-	-	-
Intangible damages										-	184
										-	-
Total damage £k	-	2	219	206	812	1,028	11,199	22,919	36,579	50,239	
Area (damagexfrequency)		0	7	3	3	3	31	51	30	43	

Total area, as above	172	
PV Factor, as above	29.813	
Present value (assuming no change in damage or event frequency)	5,117	5,301

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: Tweed Flood Study **Option:**



River Tweed - 50 year direct defences

Summary of costs

Client/Authority		Prepared (date)	
Scottish Borders Council		Printed	07/12/2018
Project/Option name		Prepared by	C.Kampanou
River Tweed FPS / 50 year defences		Checked by	S.Cooney
Project reference	2017s5526	Checked date	
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	£280.95
Capital Costs	£2,331.13
O & M Costs	£2,633.67
Other Costs	£0.00
Total Real Cost	£5,245.76
Total Cost PV	£3,282.89
Total Cost PV + OB	**£5,252.62**

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.

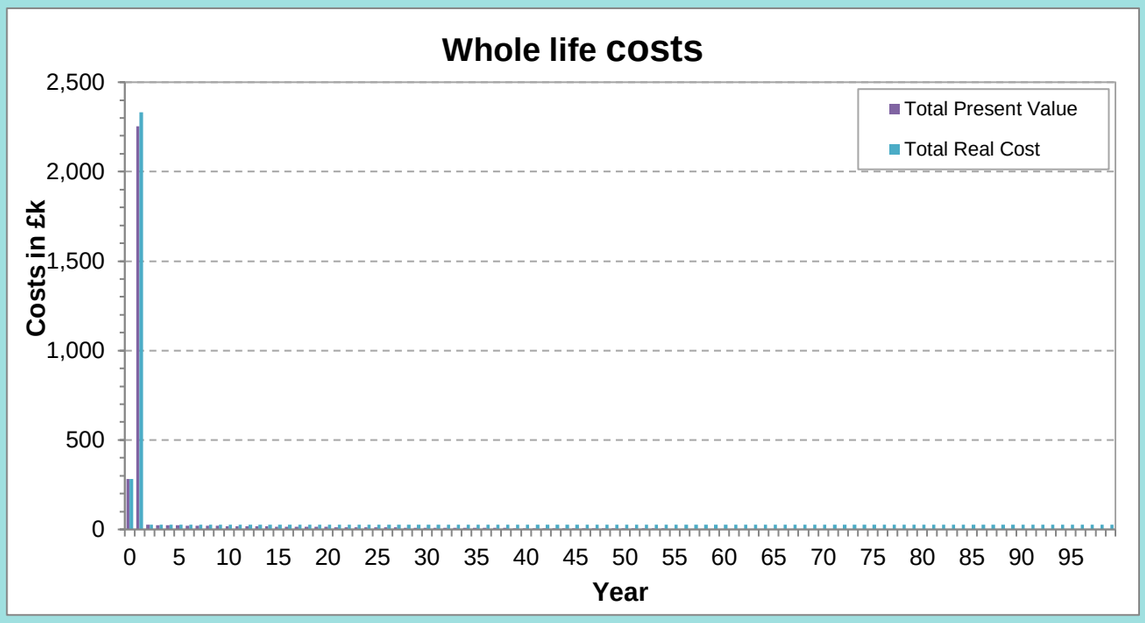
FRM Measure	Asset	Open / Go to Costing Sheet	Delete Sheet	Enabling Costs	Capital Costs	O & M Costs	Other Costs	Total Cost Cash	Total Cost PV
Fluvial raised defence	Embankment			£125.60	£483.08	£82.42	£0.00	£691.10	£615.76
	Wall			£85.27	£947.42	£15.29	£0.00	£1,047.98	£1,005.00
	Sheet Piling								
Channel management	N/A								
Culvert & screen	N/A								
Control assets	Weir								
	Pumping station			£54.64	£607.14	£1,272.30	£0.00	£1,934.08	£1,004.05
	Flood gate			£15.44	£77.20	£1,263.66	£0.00	£1,356.30	£449.09
	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	£216.30	£0.00	£0.00	£216.30	£208.98
User Defined 2	Various								
User Defined 3	Various								

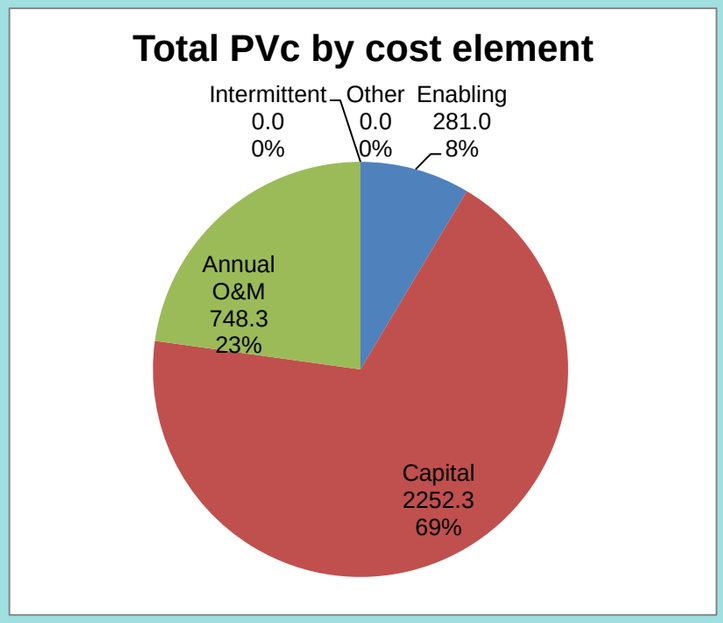
River Tweed - 50 year direct defences

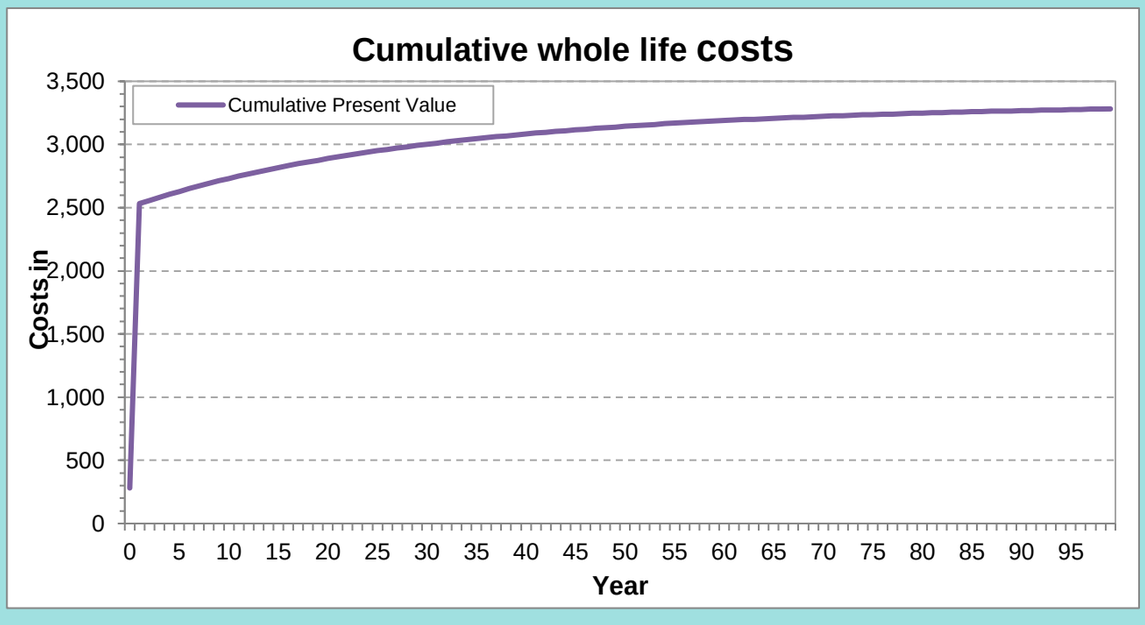
Whole Life and Present Value Cost Analysis		PV factor	29.813				Total PVc (£k):	3281.6	
		Enabling £k	Capital £k	Annual O&M £k	Intermittent O&M £k	Other £k	TOTALS: Current price	PV (£k)	
	Total real cost	281.0	2331.1	2633.7	0.0	0.0	5245.76	3281.6	
	Total PV cost	281.0	2252.3	748.3	0.0	0.0		3281.6	Cumulative
year	Discount Factor								PV Costs (£k)
0	1.000	281.0	0.0	0.0	0.0	0.0	281.0	281.0	281.0
1	0.966	0.0	2331.1	0.0	0.0	0.0	2331.1	2252.3	2533.3
2	0.934	0.0	0.0	26.9	0.0	0.0	26.9	25.1	2558.3
3	0.902	0.0	0.0	26.9	0.0	0.0	26.9	24.2	2582.6
4	0.871	0.0	0.0	26.9	0.0	0.0	26.9	23.4	2606.0
5	0.842	0.0	0.0	26.9	0.0	0.0	26.9	22.6	2628.6
6	0.814	0.0	0.0	26.9	0.0	0.0	26.9	21.9	2650.5
7	0.786	0.0	0.0	26.9	0.0	0.0	26.9	21.1	2671.6
8	0.759	0.0	0.0	26.9	0.0	0.0	26.9	20.4	2692.0
9	0.734	0.0	0.0	26.9	0.0	0.0	26.9	19.7	2711.7
10	0.709	0.0	0.0	26.9	0.0	0.0	26.9	19.1	2730.8
11	0.685	0.0	0.0	26.9	0.0	0.0	26.9	18.4	2749.2
12	0.662	0.0	0.0	26.9	0.0	0.0	26.9	17.8	2767.0
13	0.639	0.0	0.0	26.9	0.0	0.0	26.9	17.2	2784.2
14	0.618	0.0	0.0	26.9	0.0	0.0	26.9	16.6	2800.8
15	0.597	0.0	0.0	26.9	0.0	0.0	26.9	16.0	2816.8
16	0.577	0.0	0.0	26.9	0.0	0.0	26.9	15.5	2832.3
17	0.557	0.0	0.0	26.9	0.0	0.0	26.9	15.0	2847.3
18	0.538	0.0	0.0	26.9	0.0	0.0	26.9	14.5	2861.8
19	0.520	0.0	0.0	26.9	0.0	0.0	26.9	14.0	2875.7
20	0.503	0.0	0.0	26.9	0.0	0.0	26.9	13.5	2889.2
21	0.486	0.0	0.0	26.9	0.0	0.0	26.9	13.0	2902.3
22	0.469	0.0	0.0	26.9	0.0	0.0	26.9	12.6	2914.9
23	0.453	0.0	0.0	26.9	0.0	0.0	26.9	12.2	2927.1
24	0.438	0.0	0.0	26.9	0.0	0.0	26.9	11.8	2938.8
25	0.423	0.0	0.0	26.9	0.0	0.0	26.9	11.4	2950.2
26	0.409	0.0	0.0	26.9	0.0	0.0	26.9	11.0	2961.2
27	0.395	0.0	0.0	26.9	0.0	0.0	26.9	10.6	2971.8
28	0.382	0.0	0.0	26.9	0.0	0.0	26.9	10.3	2982.1
29	0.369	0.0	0.0	26.9	0.0	0.0	26.9	9.9	2992.0
30	0.356	0.0	0.0	26.9	0.0	0.0	26.9	9.6	3001.6
31	0.346	0.0	0.0	26.9	0.0	0.0	26.9	9.3	3010.9
32	0.336	0.0	0.0	26.9	0.0	0.0	26.9	9.0	3019.9
33	0.326	0.0	0.0	26.9	0.0	0.0	26.9	8.8	3028.6
34	0.317	0.0	0.0	26.9	0.0	0.0	26.9	8.5	3037.2
35	0.307	0.0	0.0	26.9	0.0	0.0	26.9	8.3	3045.4
36	0.298	0.0	0.0	26.9	0.0	0.0	26.9	8.0	3053.4
37	0.290	0.0	0.0	26.9	0.0	0.0	26.9	7.8	3061.2
38	0.281	0.0	0.0	26.9	0.0	0.0	26.9	7.6	3068.8
39	0.273	0.0	0.0	26.9	0.0	0.0	26.9	7.3	3076.1
40	0.265	0.0	0.0	26.9	0.0	0.0	26.9	7.1	3083.2
41	0.257	0.0	0.0	26.9	0.0	0.0	26.9	6.9	3090.2
42	0.250	0.0	0.0	26.9	0.0	0.0	26.9	6.7	3096.9
43	0.243	0.0	0.0	26.9	0.0	0.0	26.9	6.5	3103.4
44	0.236	0.0	0.0	26.9	0.0	0.0	26.9	6.3	3109.7
45	0.229	0.0	0.0	26.9	0.0	0.0	26.9	6.1	3115.9
46	0.222	0.0	0.0	26.9	0.0	0.0	26.9	6.0	3121.8
47	0.216	0.0	0.0	26.9	0.0	0.0	26.9	5.8	3127.6
48	0.209	0.0	0.0	26.9	0.0	0.0	26.9	5.6	3133.2
49	0.203	0.0	0.0	26.9	0.0	0.0	26.9	5.5	3138.7
50	0.197	0.0	0.0	26.9	0.0	0.0	26.9	5.3	3144.0
51	0.192	0.0	0.0	26.9	0.0	0.0	26.9	5.1	3149.2
52	0.186	0.0	0.0	26.9	0.0	0.0	26.9	5.0	3154.2
53	0.181	0.0	0.0	26.9	0.0	0.0	26.9	4.9	3159.0
54	0.175	0.0	0.0	26.9	0.0	0.0	26.9	4.7	3163.7
55	0.170	0.0	0.0	26.9	0.0	0.0	26.9	4.6	3168.3
56	0.165	0.0	0.0	26.9	0.0	0.0	26.9	4.4	3172.7
57	0.160	0.0	0.0	26.9	0.0	0.0	26.9	4.3	3177.0
58	0.156	0.0	0.0	26.9	0.0	0.0	26.9	4.2	3181.2
59	0.151	0.0	0.0	26.9	0.0	0.0	26.9	4.1	3185.3
60	0.147	0.0	0.0	26.9	0.0	0.0	26.9	3.9	3189.2
61	0.143	0.0	0.0	26.9	0.0	0.0	26.9	3.8	3193.1
62	0.138	0.0	0.0	26.9	0.0	0.0	26.9	3.7	3196.8
63	0.134	0.0	0.0	26.9	0.0	0.0	26.9	3.6	3200.4
64	0.130	0.0	0.0	26.9	0.0	0.0	26.9	3.5	3203.9
65	0.127	0.0	0.0	26.9	0.0	0.0	26.9	3.4	3207.3
66	0.123	0.0	0.0	26.9	0.0	0.0	26.9	3.3	3210.6
67	0.119	0.0	0.0	26.9	0.0	0.0	26.9	3.2	3213.8
68	0.116	0.0	0.0	26.9	0.0	0.0	26.9	3.1	3216.9
69	0.112	0.0	0.0	26.9	0.0	0.0	26.9	3.0	3219.9
70	0.109	0.0	0.0	26.9	0.0	0.0	26.9	2.9	3222.9
71	0.106	0.0	0.0	26.9	0.0	0.0	26.9	2.8	3225.7
72	0.103	0.0	0.0	26.9	0.0	0.0	26.9	2.8	3228.5
73	0.100	0.0	0.0	26.9	0.0	0.0	26.9	2.7	3231.2
74	0.097	0.0	0.0	26.9	0.0	0.0	26.9	2.6	3233.8
75	0.094	0.0	0.0	26.9	0.0	0.0	26.9	2.5	3236.3
76	0.092	0.0	0.0	26.9	0.0	0.0	26.9	2.5	3238.8
77	0.090	0.0	0.0	26.9	0.0	0.0	26.9	2.4	3241.2
78	0.087	0.0	0.0	26.9	0.0	0.0	26.9	2.4	3243.6
79	0.085	0.0	0.0	26.9	0.0	0.0	26.9	2.3	3245.8
80	0.083	0.0	0.0	26.9	0.0	0.0	26.9	2.2	3248.1
81	0.081	0.0	0.0	26.9	0.0	0.0	26.9	2.2	3250.3
82	0.079	0.0	0.0	26.9	0.0	0.0	26.9	2.1	3252.4
83	0.077	0.0	0.0	26.9	0.0	0.0	26.9	2.1	3254.5
84	0.075	0.0	0.0	26.9	0.0	0.0	26.9	2.0	3256.5
85	0.074	0.0	0.0	26.9	0.0	0.0	26.9	2.0	3258.5
86	0.072	0.0	0.0	26.9	0.0	0.0	26.9	1.9	3260.4
87	0.070	0.0	0.0	26.9	0.0	0.0	26.9	1.9	3262.3
88	0.068	0.0	0.0	26.9	0.0	0.0	26.9	1.8	3264.1
89	0.067	0.0	0.0	26.9	0.0	0.0	26.9	1.8	3265.9
90	0.065	0.0	0.0	26.9	0.0	0.0	26.9	1.7	3267.7
91	0.063	0.0	0.0	26.9	0.0	0.0	26.9	1.7	3269.4
92	0.062	0.0	0.0	26.9	0.0	0.0	26.9	1.7	3271.0
93	0.060	0.0	0.0	26.9	0.0	0.0	26.9	1.6	3272.7
94	0.059	0.0	0.0	26.9	0.0	0.0	26.9	1.6	3274.2
95	0.057	0.0	0.0	26.9	0.0	0.0	26.9	1.5	3275.8
96	0.056	0.0	0.0	26.9	0.0	0.0	26.9	1.5	3277.3
97	0.055	0.0	0.0	26.9	0.0	0.0	26.9	1.5	3278.8
98	0.053	0.0	0.0	26.9	0.0	0.0	26.9	1.4	3280.2
99	0.052	0.0	0.0	26.9	0.0	0.0	26.9	1.4	3281.6

River Tweed - 50 year direct defences

Whole life cost charts







River Tweed - 50 year direct defences

Summary of costs

Client/Authority		Prepared (date)	
Scottish Borders Council		Printed	07/12/2018
Project/Option name		Prepared by	C.Kampanou
River Tweed FPS / 75 year defences		Checked by	S.Cooney
Project reference	2017s5526	Checked date	
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	£220.70
Capital Costs	£2,708.44
O & M Costs	£2,638.55
Other Costs	£0.00
Total Real Cost	£5,567.69
Total Cost PV	£3,588.57
Total Cost PV + OB	**£5,741.71**

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			£54.57	£726.89	£86.85	£0.00	£868.30	£781.55
	Wall			£93.87	£1,043.05	£15.74	£0.00	£1,152.67	£1,106.12
	Sheet Piling								
Channel management	N/A								
Culvert & screen	N/A								
Control assets	Weir								
	Pumping station			£54.64	£607.14	£1,272.30	£0.00	£1,934.08	£1,004.05
	Flood gate			£17.62	£88.09	£1,263.66	£0.00	£1,369.36	£461.79
	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	£243.28	£0.00	£0.00	£243.28	£235.06
User Defined 2	Various								
User Defined 3	Various								

River Tweed - 50 year direct defences

Whole Life and Present Value Cost Analysis		PV factor	29.813				Total PVc (£k):	3587.3	
		Enabling £k	Capital £k	Annual O&M £k	Intermittent O&M £k	Other £k	TOTALS: Current price	PV (£k)	
	Total real cost	220.7	2708.4	2638.6	0.0	0.0	5567.69	3587.3	
	Total PV cost	220.7	2616.9	749.7	0.0	0.0		3587.3	Cumulative
year	Discount Factor								PV Costs (£k)
0	1.000	220.7	0.0	0.0	0.0	0.0	220.7	220.7	220.7
1	0.966	0.0	2708.4	0.0	0.0	0.0	2708.4	2616.9	2837.5
2	0.934	0.0	0.0	26.9	0.0	0.0	26.9	25.1	2862.7
3	0.902	0.0	0.0	26.9	0.0	0.0	26.9	24.3	2887.0
4	0.871	0.0	0.0	26.9	0.0	0.0	26.9	23.5	2910.4
5	0.842	0.0	0.0	26.9	0.0	0.0	26.9	22.7	2933.1
6	0.814	0.0	0.0	26.9	0.0	0.0	26.9	21.9	2955.0
7	0.786	0.0	0.0	26.9	0.0	0.0	26.9	21.2	2976.2
8	0.759	0.0	0.0	26.9	0.0	0.0	26.9	20.4	2996.6
9	0.734	0.0	0.0	26.9	0.0	0.0	26.9	19.8	3016.4
10	0.709	0.0	0.0	26.9	0.0	0.0	26.9	19.1	3035.5
11	0.685	0.0	0.0	26.9	0.0	0.0	26.9	18.4	3053.9
12	0.662	0.0	0.0	26.9	0.0	0.0	26.9	17.8	3071.7
13	0.639	0.0	0.0	26.9	0.0	0.0	26.9	17.2	3088.9
14	0.618	0.0	0.0	26.9	0.0	0.0	26.9	16.6	3105.6
15	0.597	0.0	0.0	26.9	0.0	0.0	26.9	16.1	3121.6
16	0.577	0.0	0.0	26.9	0.0	0.0	26.9	15.5	3137.2
17	0.557	0.0	0.0	26.9	0.0	0.0	26.9	15.0	3152.2
18	0.538	0.0	0.0	26.9	0.0	0.0	26.9	14.5	3166.7
19	0.520	0.0	0.0	26.9	0.0	0.0	26.9	14.0	3180.7
20	0.503	0.0	0.0	26.9	0.0	0.0	26.9	13.5	3194.2
21	0.486	0.0	0.0	26.9	0.0	0.0	26.9	13.1	3207.3
22	0.469	0.0	0.0	26.9	0.0	0.0	26.9	12.6	3219.9
23	0.453	0.0	0.0	26.9	0.0	0.0	26.9	12.2	3232.1
24	0.438	0.0	0.0	26.9	0.0	0.0	26.9	11.8	3243.9
25	0.423	0.0	0.0	26.9	0.0	0.0	26.9	11.4	3255.3
26	0.409	0.0	0.0	26.9	0.0	0.0	26.9	11.0	3266.3
27	0.395	0.0	0.0	26.9	0.0	0.0	26.9	10.6	3276.9
28	0.382	0.0	0.0	26.9	0.0	0.0	26.9	10.3	3287.2
29	0.369	0.0	0.0	26.9	0.0	0.0	26.9	9.9	3297.1
30	0.356	0.0	0.0	26.9	0.0	0.0	26.9	9.6	3306.7
31	0.346	0.0	0.0	26.9	0.0	0.0	26.9	9.3	3316.0
32	0.336	0.0	0.0	26.9	0.0	0.0	26.9	9.0	3325.1
33	0.326	0.0	0.0	26.9	0.0	0.0	26.9	8.8	3333.9
34	0.317	0.0	0.0	26.9	0.0	0.0	26.9	8.5	3342.4
35	0.307	0.0	0.0	26.9	0.0	0.0	26.9	8.3	3350.7
36	0.298	0.0	0.0	26.9	0.0	0.0	26.9	8.0	3358.7
37	0.290	0.0	0.0	26.9	0.0	0.0	26.9	7.8	3366.5
38	0.281	0.0	0.0	26.9	0.0	0.0	26.9	7.6	3374.1
39	0.273	0.0	0.0	26.9	0.0	0.0	26.9	7.4	3381.4
40	0.265	0.0	0.0	26.9	0.0	0.0	26.9	7.1	3388.5
41	0.257	0.0	0.0	26.9	0.0	0.0	26.9	6.9	3395.5
42	0.250	0.0	0.0	26.9	0.0	0.0	26.9	6.7	3402.2
43	0.243	0.0	0.0	26.9	0.0	0.0	26.9	6.5	3408.7
44	0.236	0.0	0.0	26.9	0.0	0.0	26.9	6.3	3415.1
45	0.229	0.0	0.0	26.9	0.0	0.0	26.9	6.2	3421.2
46	0.222	0.0	0.0	26.9	0.0	0.0	26.9	6.0	3427.2
47	0.216	0.0	0.0	26.9	0.0	0.0	26.9	5.8	3433.0
48	0.209	0.0	0.0	26.9	0.0	0.0	26.9	5.6	3438.7
49	0.203	0.0	0.0	26.9	0.0	0.0	26.9	5.5	3444.1
50	0.197	0.0	0.0	26.9	0.0	0.0	26.9	5.3	3449.4
51	0.192	0.0	0.0	26.9	0.0	0.0	26.9	5.2	3454.6
52	0.186	0.0	0.0	26.9	0.0	0.0	26.9	5.0	3459.6
53	0.181	0.0	0.0	26.9	0.0	0.0	26.9	4.9	3464.5
54	0.175	0.0	0.0	26.9	0.0	0.0	26.9	4.7	3469.2
55	0.170	0.0	0.0	26.9	0.0	0.0	26.9	4.6	3473.8
56	0.165	0.0	0.0	26.9	0.0	0.0	26.9	4.4	3478.2
57	0.160	0.0	0.0	26.9	0.0	0.0	26.9	4.3	3482.5
58	0.156	0.0	0.0	26.9	0.0	0.0	26.9	4.2	3486.7
59	0.151	0.0	0.0	26.9	0.0	0.0	26.9	4.1	3490.8
60	0.147	0.0	0.0	26.9	0.0	0.0	26.9	4.0	3494.7
61	0.143	0.0	0.0	26.9	0.0	0.0	26.9	3.8	3498.6
62	0.138	0.0	0.0	26.9	0.0	0.0	26.9	3.7	3502.3
63	0.134	0.0	0.0	26.9	0.0	0.0	26.9	3.6	3505.9
64	0.130	0.0	0.0	26.9	0.0	0.0	26.9	3.5	3509.4
65	0.127	0.0	0.0	26.9	0.0	0.0	26.9	3.4	3512.8
66	0.123	0.0	0.0	26.9	0.0	0.0	26.9	3.3	3516.1
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69	0.112	0.0	0.0	26.9	0.0	0.0	26.9	3.0	3525.5
70	0.109	0.0	0.0	26.9	0.0	0.0	26.9	2.9	3528.5
71	0.106	0.0	0.0	26.9	0.0	0.0	26.9	2.9	3531.3
72	0.103	0.0	0.0	26.9	0.0	0.0	26.9	2.8	3534.1
73	0.100	0.0	0.0	26.9	0.0	0.0	26.9	2.7	3536.8
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75	0.094	0.0	0.0	26.9	0.0	0.0	26.9	2.5	3541.9
76	0.092	0.0	0.0	26.9	0.0	0.0	26.9	2.5	3544.4
77	0.090	0.0	0.0	26.9	0.0	0.0	26.9	2.4	3546.8
78	0.087	0.0	0.0	26.9	0.0	0.0	26.9	2.4	3549.2
79	0.085	0.0	0.0	26.9	0.0	0.0	26.9	2.3	3551.5
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85	0.074	0.0	0.0	26.9	0.0	0.0	26.9	2.0	3564.1
86	0.072	0.0	0.0	26.9	0.0	0.0	26.9	1.9	3566.1
87	0.070	0.0	0.0	26.9	0.0	0.0	26.9	1.9	3567.9
88	0.068	0.0	0.0	26.9	0.0	0.0	26.9	1.8	3569.8
89	0.067	0.0	0.0	26.9	0.0	0.0	26.9	1.8	3571.6
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94	0.059	0.0	0.0	26.9	0.0	0.0	26.9	1.6	3579.9
95	0.057	0.0	0.0	26.9	0.0	0.0	26.9	1.5	3581.5
96	0.056	0.0	0.0	26.9	0.0	0.0	26.9	1.5	3583.0
97	0.055	0.0	0.0	26.9	0.0	0.0	26.9	1.5	3584.4
98	0.053	0.0	0.0	26.9	0.0	0.0	26.9	1.4	3585.9
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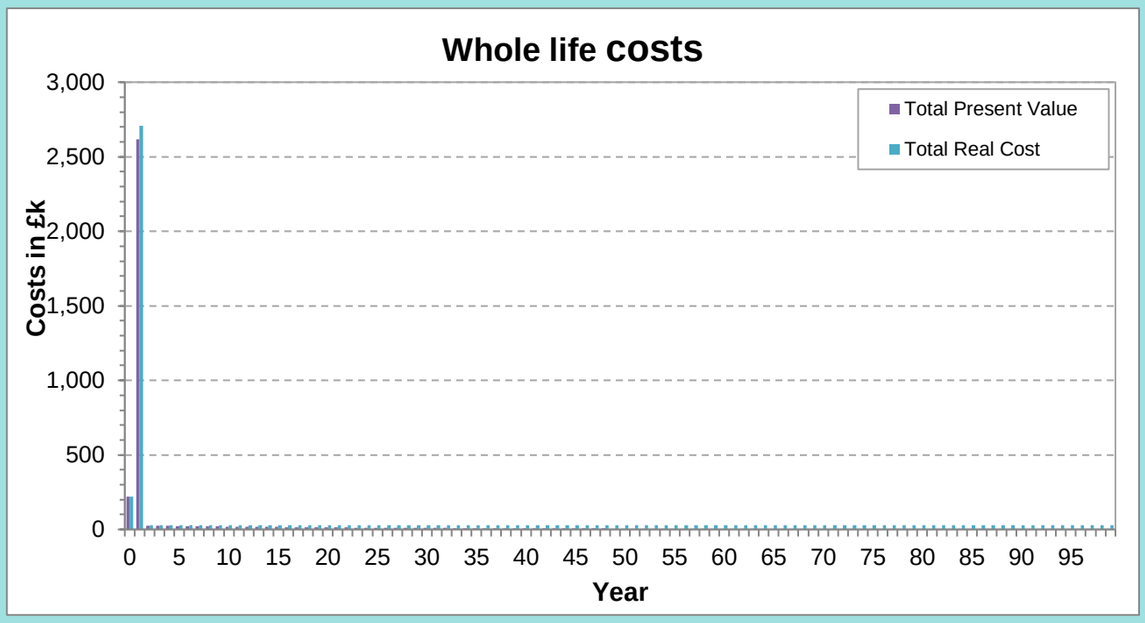
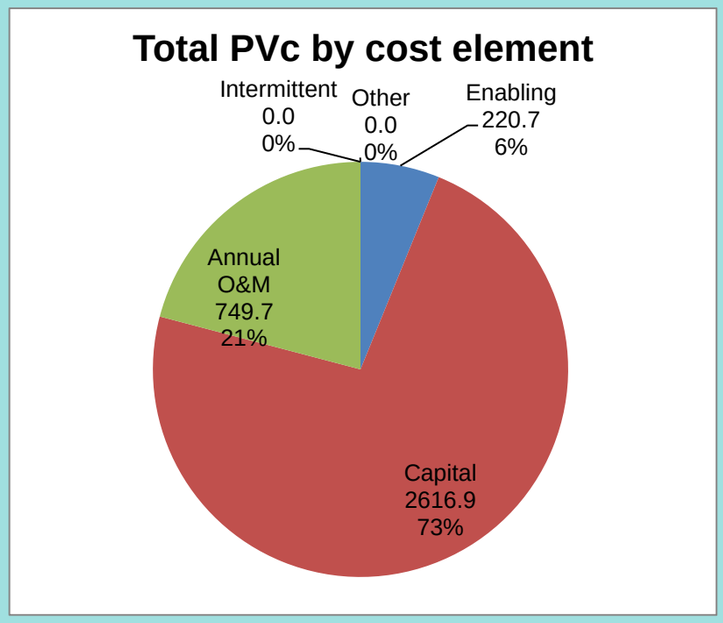
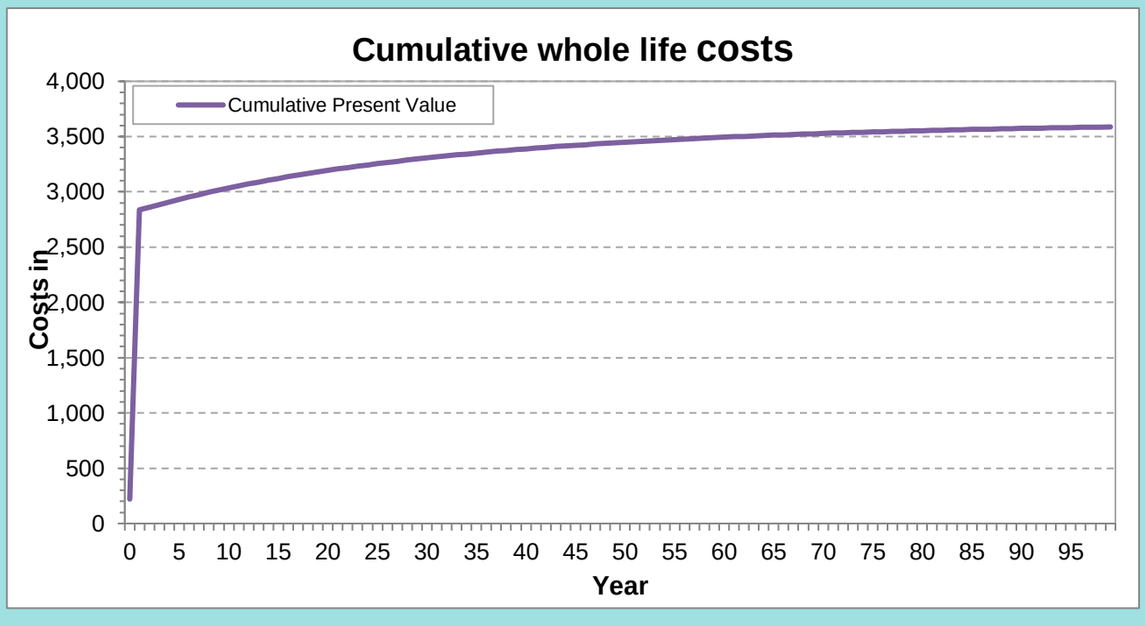
River Tweed - 50 year direct defences

Whole life cost charts







River Tweed - 100 year direct defences

Summary of costs

Client/Authority		Prepared (date)	
Scottish Borders Council		Printed	07/12/2018
Project/Option name		Prepared by	C.Kampanou
River Tweed FPS / 100 year defences		Checked by	S.Cooney
Project reference	2017s5526	Checked date	
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	£608.43
Capital Costs	£5,752.43
O & M Costs	£3,254.86
Other Costs	£0.00
Total Real Cost	£9,615.72
Total Cost PV	£7,092.47
Total Cost PV + OB	**£11,347.95**

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.

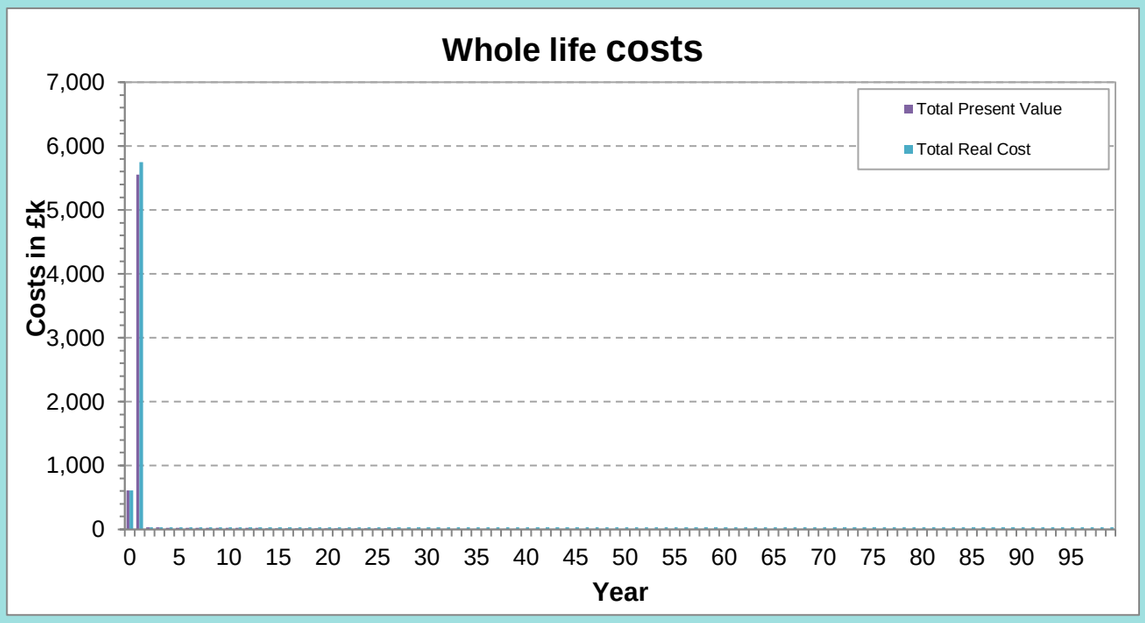
FRM Measure	Asset	Open / Go to Costing Sheet	Delete Sheet	Enabling Costs	Capital Costs	O & M Costs	Other Costs	Total Cost Cash	Total Cost PV
Fluvial raised defence	Embankment			£217.82	£1,258.49	£167.36	£0.00	£1,643.67	£1,481.31
	Wall			£286.19	£3,179.85	£33.45	£0.00	£3,499.48	£3,368.01
	Sheet Piling								
Channel management	N/A								
Culvert & screen	N/A								
Control assets	Weir								
	Pumping station			£54.64	£607.14	£1,272.30	£0.00	£1,934.08	£1,004.05
	Flood gate			£49.78	£248.90	£1,781.75	£0.00	£2,080.43	£796.54
	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	£458.06	£0.00	£0.00	£458.06	£442.57
User Defined 2	Various								
User Defined 3	Various								

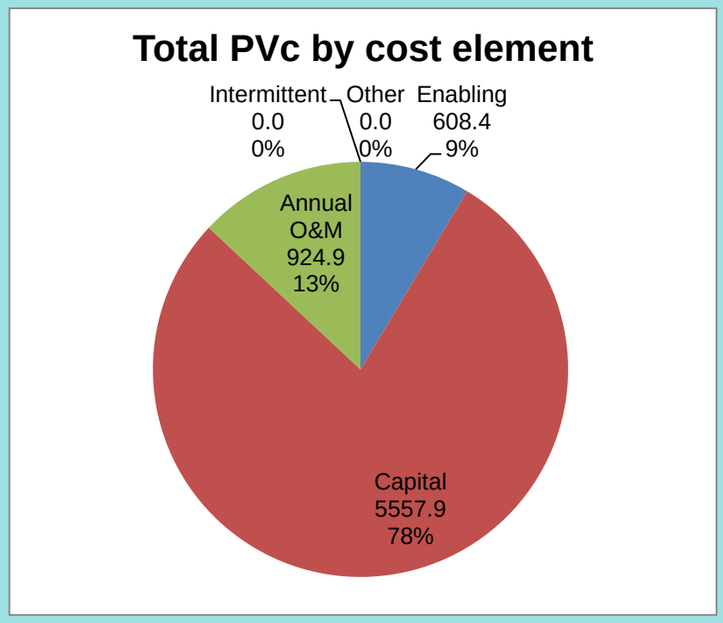
River Tweed - 100 year direct defences

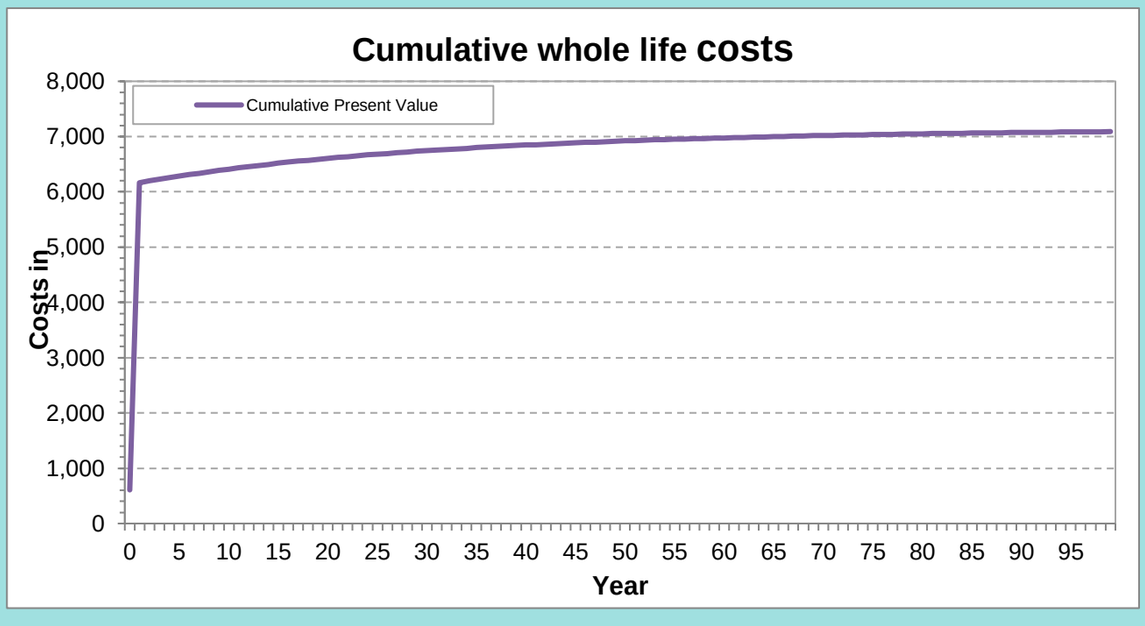
Whole Life and Present Value Cost Analysis		PV factor	29.813				Total PVc (£k):	7091.2	
		Enabling £k	Capital £k	Annual O&M £k	Intermittent O&M £k	Other £k	TOTALS: Current price	PV (£k)	
	Total real cost	608.4	5752.4	3254.9	0.0	0.0	9615.72	7091.2	
	Total PV cost	608.4	5557.9	924.9	0.0	0.0		7091.2	Cumulative
year	Discount Factor								PV Costs (£k)
0	1.000	608.4	0.0	0.0	0.0	0.0	608.4	608.4	608.4
1	0.966	0.0	5752.4	0.0	0.0	0.0	5752.4	5557.9	6166.3
2	0.934	0.0	0.0	33.2	0.0	0.0	33.2	31.0	6197.3
3	0.902	0.0	0.0	33.2	0.0	0.0	33.2	30.0	6227.3
4	0.871	0.0	0.0	33.2	0.0	0.0	33.2	28.9	6256.2
5	0.842	0.0	0.0	33.2	0.0	0.0	33.2	28.0	6284.2
6	0.814	0.0	0.0	33.2	0.0	0.0	33.2	27.0	6311.2
7	0.786	0.0	0.0	33.2	0.0	0.0	33.2	26.1	6337.3
8	0.759	0.0	0.0	33.2	0.0	0.0	33.2	25.2	6362.5
9	0.734	0.0	0.0	33.2	0.0	0.0	33.2	24.4	6386.9
10	0.709	0.0	0.0	33.2	0.0	0.0	33.2	23.5	6410.5
11	0.685	0.0	0.0	33.2	0.0	0.0	33.2	22.7	6433.2
12	0.662	0.0	0.0	33.2	0.0	0.0	33.2	22.0	6455.2
13	0.639	0.0	0.0	33.2	0.0	0.0	33.2	21.2	6476.4
14	0.618	0.0	0.0	33.2	0.0	0.0	33.2	20.5	6496.9
15	0.597	0.0	0.0	33.2	0.0	0.0	33.2	19.8	6516.8
16	0.577	0.0	0.0	33.2	0.0	0.0	33.2	19.2	6535.9
17	0.557	0.0	0.0	33.2	0.0	0.0	33.2	18.5	6554.4
18	0.538	0.0	0.0	33.2	0.0	0.0	33.2	17.9	6572.3
19	0.520	0.0	0.0	33.2	0.0	0.0	33.2	17.3	6589.6
20	0.503	0.0	0.0	33.2	0.0	0.0	33.2	16.7	6606.3
21	0.486	0.0	0.0	33.2	0.0	0.0	33.2	16.1	6622.4
22	0.469	0.0	0.0	33.2	0.0	0.0	33.2	15.6	6638.0
23	0.453	0.0	0.0	33.2	0.0	0.0	33.2	15.1	6653.0
24	0.438	0.0	0.0	33.2	0.0	0.0	33.2	14.5	6667.6
25	0.423	0.0	0.0	33.2	0.0	0.0	33.2	14.1	6681.6
26	0.409	0.0	0.0	33.2	0.0	0.0	33.2	13.6	6695.2
27	0.395	0.0	0.0	33.2	0.0	0.0	33.2	13.1	6708.3
28	0.382	0.0	0.0	33.2	0.0	0.0	33.2	12.7	6721.0
29	0.369	0.0	0.0	33.2	0.0	0.0	33.2	12.2	6733.3
30	0.356	0.0	0.0	33.2	0.0	0.0	33.2	11.8	6745.1
31	0.346	0.0	0.0	33.2	0.0	0.0	33.2	11.5	6756.6
32	0.336	0.0	0.0	33.2	0.0	0.0	33.2	11.2	6767.7
33	0.326	0.0	0.0	33.2	0.0	0.0	33.2	10.8	6778.6
34	0.317	0.0	0.0	33.2	0.0	0.0	33.2	10.5	6789.1
35	0.307	0.0	0.0	33.2	0.0	0.0	33.2	10.2	6799.3
36	0.298	0.0	0.0	33.2	0.0	0.0	33.2	9.9	6809.2
37	0.290	0.0	0.0	33.2	0.0	0.0	33.2	9.6	6818.8
38	0.281	0.0	0.0	33.2	0.0	0.0	33.2	9.3	6828.2
39	0.273	0.0	0.0	33.2	0.0	0.0	33.2	9.1	6837.2
40	0.265	0.0	0.0	33.2	0.0	0.0	33.2	8.8	6846.0
41	0.257	0.0	0.0	33.2	0.0	0.0	33.2	8.5	6854.6
42	0.250	0.0	0.0	33.2	0.0	0.0	33.2	8.3	6862.9
43	0.243	0.0	0.0	33.2	0.0	0.0	33.2	8.1	6870.9
44	0.236	0.0	0.0	33.2	0.0	0.0	33.2	7.8	6878.8
45	0.229	0.0	0.0	33.2	0.0	0.0	33.2	7.6	6886.4
46	0.222	0.0	0.0	33.2	0.0	0.0	33.2	7.4	6893.7
47	0.216	0.0	0.0	33.2	0.0	0.0	33.2	7.2	6900.9
48	0.209	0.0	0.0	33.2	0.0	0.0	33.2	7.0	6907.8
49	0.203	0.0	0.0	33.2	0.0	0.0	33.2	6.7	6914.6
50	0.197	0.0	0.0	33.2	0.0	0.0	33.2	6.6	6921.1
51	0.192	0.0	0.0	33.2	0.0	0.0	33.2	6.4	6927.5
52	0.186	0.0	0.0	33.2	0.0	0.0	33.2	6.2	6933.7
53	0.181	0.0	0.0	33.2	0.0	0.0	33.2	6.0	6939.7
54	0.175	0.0	0.0	33.2	0.0	0.0	33.2	5.8	6945.5
55	0.170	0.0	0.0	33.2	0.0	0.0	33.2	5.7	6951.1
56	0.165	0.0	0.0	33.2	0.0	0.0	33.2	5.5	6956.6
57	0.160	0.0	0.0	33.2	0.0	0.0	33.2	5.3	6962.0
58	0.156	0.0	0.0	33.2	0.0	0.0	33.2	5.2	6967.1
59	0.151	0.0	0.0	33.2	0.0	0.0	33.2	5.0	6972.2
60	0.147	0.0	0.0	33.2	0.0	0.0	33.2	4.9	6977.0
61	0.143	0.0	0.0	33.2	0.0	0.0	33.2	4.7	6981.8
62	0.138	0.0	0.0	33.2	0.0	0.0	33.2	4.6	6986.4
63	0.134	0.0	0.0	33.2	0.0	0.0	33.2	4.5	6990.8
64	0.130	0.0	0.0	33.2	0.0	0.0	33.2	4.3	6995.1
65	0.127	0.0	0.0	33.2	0.0	0.0	33.2	4.2	6999.4
66	0.123	0.0	0.0	33.2	0.0	0.0	33.2	4.1	7003.4
67	0.119	0.0	0.0	33.2	0.0	0.0	33.2	4.0	7007.4
68	0.116	0.0	0.0	33.2	0.0	0.0	33.2	3.8	7011.2
69	0.112	0.0	0.0	33.2	0.0	0.0	33.2	3.7	7015.0
70	0.109	0.0	0.0	33.2	0.0	0.0	33.2	3.6	7018.6
71	0.106	0.0	0.0	33.2	0.0	0.0	33.2	3.5	7022.1
72	0.103	0.0	0.0	33.2	0.0	0.0	33.2	3.4	7025.6
73	0.100	0.0	0.0	33.2	0.0	0.0	33.2	3.3	7028.9
74	0.097	0.0	0.0	33.2	0.0	0.0	33.2	3.2	7032.1
75	0.094	0.0	0.0	33.2	0.0	0.0	33.2	3.1	7035.2
76	0.092	0.0	0.0	33.2	0.0	0.0	33.2	3.1	7038.3
77	0.090	0.0	0.0	33.2	0.0	0.0	33.2	3.0	7041.3
78	0.087	0.0	0.0	33.2	0.0	0.0	33.2	2.9	7044.2
79	0.085	0.0	0.0	33.2	0.0	0.0	33.2	2.8	7047.0
80	0.083	0.0	0.0	33.2	0.0	0.0	33.2	2.8	7049.8
81	0.081	0.0	0.0	33.2	0.0	0.0	33.2	2.7	7052.5
82	0.079	0.0	0.0	33.2	0.0	0.0	33.2	2.6	7055.1
83	0.077	0.0	0.0	33.2	0.0	0.0	33.2	2.6	7057.7
84	0.075	0.0	0.0	33.2	0.0	0.0	33.2	2.5	7060.2
85	0.074	0.0	0.0	33.2	0.0	0.0	33.2	2.4	7062.6
86	0.072	0.0	0.0	33.2	0.0	0.0	33.2	2.4	7065.0
87	0.070	0.0	0.0	33.2	0.0	0.0	33.2	2.3	7067.3
88	0.068	0.0	0.0	33.2	0.0	0.0	33.2	2.3	7069.6
89	0.067	0.0	0.0	33.2	0.0	0.0	33.2	2.2	7071.8
90	0.065	0.0	0.0	33.2	0.0	0.0	33.2	2.2	7074.0
91	0.063	0.0	0.0	33.2	0.0	0.0	33.2	2.1	7076.1
92	0.062	0.0	0.0	33.2	0.0	0.0	33.2	2.1	7078.1
93	0.060	0.0	0.0	33.2	0.0	0.0	33.2	2.0	7080.1
94	0.059	0.0	0.0	33.2	0.0	0.0	33.2	2.0	7082.1
95	0.057	0.0	0.0	33.2	0.0	0.0	33.2	1.9	7084.0
96	0.056	0.0	0.0	33.2	0.0	0.0	33.2	1.9	7085.9
97	0.055	0.0	0.0	33.2	0.0	0.0	33.2	1.8	7087.7
98	0.053	0.0	0.0	33.2	0.0	0.0	33.2	1.8	7089.5
99	0.052	0.0	0.0	33.2	0.0	0.0	33.2	1.7	7091.2

River Tweed - 100 year direct defences

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)	£87.6
Year of capital works (year)	1
Capital cost (£k)	£462.8
Annual maintenance cost (£k)	£9.3
Other cost (£k)	£0.0
Other works frequency (years)	1
Other cost (£k)	£0.0
Other works frequency (years)	1
Replacement (£)	462.848
Replacement frequency (years)	25
Optimism Bias	60%

Key	
	Information
	Calculation
	Cost input
	Default

Total PVc (£k) with Optimism Bias:		**1781**
Total PVc (£k):		**1113**

Initial discount rate	**3.5%**	**29.813**

		Cost Elements				PvD			TOTALS:	
		Enabling	Capital	Maint.	Interm.	Enabling	Capital	Maint.	Cash	PV
	Cash sum	88	1851	907	0	88	768	258	2846	**1113**
year	Discount Factor									
0	1.000	87.6			0	87.616			87.6	87.6
1	0.966		463		0		447.1961		462.8	447.2
2	0.934			9	0			8.641471	9.3	8.6
3	0.902			9	0			8.349248	9.3	8.3
4	0.871			9	0			8.066906	9.3	8.1
5	0.842			9	0			7.794112	9.3	7.8
6	0.814			9	0			7.530543	9.3	7.5
7	0.786			9	0			7.275887	9.3	7.3
8	0.759			9	0			7.029842	9.3	7.0
9	0.734			9	0			6.792118	9.3	6.8
10	0.709			9	0			6.562433	9.3	6.6
11	0.685			9	0			6.340515	9.3	6.3
12	0.662			9	0			6.126102	9.3	6.1
13	0.639			9	0			5.918939	9.3	5.9
14	0.618			9	0			5.718781	9.3	5.7
15	0.597			9	0			5.525393	9.3	5.5
16	0.577			9	0			5.338544	9.3	5.3
17	0.557			9	0			5.158013	9.3	5.2
18	0.538			9	0			4.983588	9.3	5.0
19	0.520			9	0			4.81506	9.3	4.8
20	0.503			9	0			4.652232	9.3	4.7
21	0.486			9	0			4.49491	9.3	4.5
22	0.469			9	0			4.342909	9.3	4.3
23	0.453			9	0			4.196047	9.3	4.2
24	0.438			9	0			4.054152	9.3	4.1
25	0.423			9	0			3.917055	9.3	3.9
26	0.409		463	9	0	189.2297		3.784594	472.1	193.0
27	0.395			9	0			3.656613	9.3	3.7
28	0.382			9	0			3.532959	9.3	3.5
29	0.369			9	0			3.413487	9.3	3.4
30	0.356			9	0			3.298055	9.3	3.3
31	0.346			9	0			3.201995	9.3	3.2
32	0.336			9	0			3.108733	9.3	3.1
33	0.326			9	0			3.018188	9.3	3.0
34	0.317			9	0			2.930279	9.3	2.9
35	0.307			9	0			2.844931	9.3	2.8
36	0.298			9	0			2.762069	9.3	2.8
37	0.290			9	0			2.681621	9.3	2.7
38	0.281			9	0			2.603515	9.3	2.6
39	0.273			9	0			2.527685	9.3	2.5
40	0.265			9	0			2.454063	9.3	2.5
41	0.257			9	0			2.382585	9.3	2.4
42	0.250			9	0			2.313189	9.3	2.3
43	0.243			9	0			2.245815	9.3	2.2
44	0.236			9	0			2.180403	9.3	2.2
45	0.229			9	0			2.116896	9.3	2.1

	46	0.222			9	0	2.055239	9.3	2.1
	47	0.216			9	0	1.995378	9.3	2.0
	48	0.209			9	0	1.93726	9.3	1.9
	49	0.203			9	0	1.880835	9.3	1.9
	50	0.197			9	0	1.826053	9.3	1.8
	51	0.192		463	9	0	88.64335 1.772867	472.1	90.4
	52	0.186			9	0	1.72123	9.3	1.7
	53	0.181			9	0	1.671097	9.3	1.7
	54	0.175			9	0	1.622425	9.3	1.6
	55	0.170			9	0	1.575169	9.3	1.6
	56	0.165			9	0	1.529291	9.3	1.5
	57	0.160			9	0	1.484748	9.3	1.5
	58	0.156			9	0	1.441503	9.3	1.4
	59	0.151			9	0	1.399518	9.3	1.4
	60	0.147			9	0	1.358755	9.3	1.4
	61	0.143			9	0	1.31918	9.3	1.3
	62	0.138			9	0	1.280757	9.3	1.3
	63	0.134			9	0	1.243453	9.3	1.2
	64	0.130			9	0	1.207236	9.3	1.2
	65	0.127			9	0	1.172074	9.3	1.2
	66	0.123			9	0	1.137936	9.3	1.1
	67	0.119			9	0	1.104792	9.3	1.1
	68	0.116			9	0	1.072614	9.3	1.1
	69	0.112			9	0	1.041373	9.3	1.0
	70	0.109			9	0	1.011041	9.3	1.0
	71	0.106			9	0	0.981594	9.3	1.0
	72	0.103			9	0	0.953003	9.3	1.0
	73	0.100			9	0	0.925246	9.3	0.9
	74	0.097			9	0	0.898297	9.3	0.9
	75	0.094			9	0	0.872133	9.3	0.9
	76	0.092		463	9	0	42.54308 0.850862	472.1	43.4
	77	0.090			9	0	0.830109	9.3	0.8
	78	0.087			9	0	0.809862	9.3	0.8
	79	0.085			9	0	0.79011	9.3	0.8
	80	0.083			9	0	0.770839	9.3	0.8
	81	0.081			9	0	0.752038	9.3	0.8
	82	0.079			9	0	0.733695	9.3	0.7
	83	0.077			9	0	0.7158	9.3	0.7
	84	0.075			9	0	0.698342	9.3	0.7
	85	0.074			9	0	0.681309	9.3	0.7
	86	0.072			9	0	0.664692	9.3	0.7
	87	0.070			9	0	0.64848	9.3	0.6
	88	0.068			9	0	0.632663	9.3	0.6
	89	0.067			9	0	0.617232	9.3	0.6
	90	0.065			9	0	0.602178	9.3	0.6
	91	0.063			9	0	0.587491	9.3	0.6
	92	0.062			9	0	0.573162	9.3	0.6
	93	0.060			9	0	0.559182	9.3	0.6
	94	0.059			9	0	0.545543	9.3	0.5
	95	0.057			9	0	0.532238	9.3	0.5
	96	0.056			9	0	0.519256	9.3	0.5
	97	0.055			9	0	0.506591	9.3	0.5
	98	0.053			9	0	0.494235	9.3	0.5
	99	0.052			9	0	0.482181	9.3	0.5

C Appendix C - Public Consultation Questionnaire

Peebles 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 Peebles Flood Study Exhibition on 6th November 2018. Local knowledge and feedback is key to influencing decisions on flood protection schemes and out of 56 people who attended the exhibition, 17 questionnaire responses were received (30%).

Questionnaire Format

The anonymous questionnaires that were available to the local public of Peebles consisted of 10 questions which could be circled 'yes' or 'no' and also 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 sheet:

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

****Council responses within red*

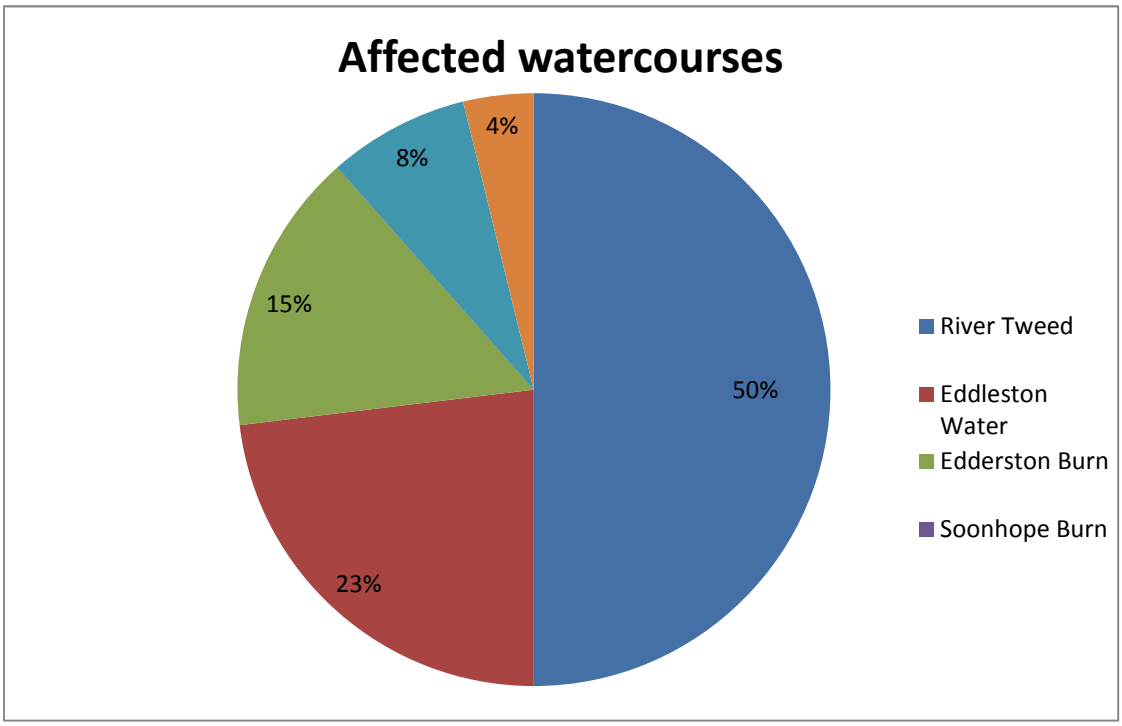
Question 1

Please circle the watercourse/s which impact upon you?

In Peebles there are five main water courses which are of concern and may impact upon different people depending on where they live in the town. The watercourses that were available to circle on the questionnaire were **the River Tweed, Eddleston Water, Edderston Burn, Soonhope Burn and Haystoun Burn**. There was also an 'N/A' option to circle if you were not affected by any of these or would rather not say. Some residents who may have been affected by a few different watercourses circled multiple answers which are reflected in the table below.

Affected watercourse	Number of people affected
River Tweed	13
Eddleston Water	6
Edderston Burn	4
Soonhope Burn	0
Haystoun Burn	2
N/A or unspecified	1

As shown from the data collected, the members of the public who took part in the questionnaire were mostly affected by the River Tweed & Eddleston Water watercourses.



Question 2

Have you previously experienced flooding?

Out of the 17 participants, 11 answered yes to this question and the remaining 6 answered 'No'. Of those who answered 'Yes' there were a variety of comments, mostly explaining what date they experienced the flooding. The majority of comments related to the devastating floods of December 2015, one resident noted "major impact" describing the effect of the flooding in their home in Peebles. A few participants noted that they were evacuated and some had witnessed flooding but not in their homes.

Question 3

Do you want to see a flood protection scheme in the site of interest?

15 people answered yes to this question, indicating that there is a strong desire to have a flood protection scheme in Peebles. 1 person answered no but stated "I realise it is required". The 1 participant who did not circle an answer stated that they were "undecided". Most made comments regarding wanting a protection scheme in order to protect their homes after previously being flooded, examples of which are below;

- *"The exhibition suggested that a proposed scheme was very cost effective. Flooding is devastating for those involved. We all pay a price (e.g. through insurance)".*
- *"To prevent further flooding of our residence."*
- *"Most definitely. Need to reduce risk of this happening again."*
- *"To prevent flooding of properties."*
- *I don't want our house/street to be flooded again - we were affected for 2 years afterward.*

One participant expressed their opinion on what type of scheme they would like making it clear that they would not like a wall to be built and that they would like Natural flood Management (NFM) to be used instead.

- *"It depends, Natural flood management yes, walls etc. no."*

Question 4

Do you approve of the approach that we are taking in developing a Flood Protection Scheme in your community?

14 out of the 17 Participants answered yes to this question and 3 left it unanswered but provided additional details which support why they chose not to answer. Those who answered yes supported their answers with positive comments welcoming the approach that is being taken towards the development of a flood scheme:

- *"Great consultation information and friendly staff to explain info at the event."*
- *"Tweed Green, Tweed Avenue and Walkershaugh were badly affected by the flood in 2015 and the scheme is very much addressing this."*
- *"To protect my home. Any flood reduction would be appreciated. Older folk find it hard to use normal property protection measures. Not everyone can afford them."*
- *"Seems to be very comprehensive."*

The participants who left the question unanswered were concerned about the visual effect of the proposed flood schemes and some believed the flooding is caused by poor land management:

- *"Too much emphasis on structural 'solutions' in town, the main problem is the catchments are terribly managed by landowners / farmers. Tax payers are basically subsiding poor land management. We are paying to create more floods."*
  - *A long list of solutions was drawn up and non-feasible options were withdrawn from the process, allowing us to create a short list of options, with a preferred option. In this instance, there is no feasible alternative to structural solutions within Peebles but we will look at areas where NFM measures can be incorporated. With regards to land management upstream, policy changes etc. would be required out with the remit of flood risk management.*
- *"Partially. I think the council is listening more than before. I still think [there is] too much emphasis on hard solutions and not enough on soft (NFM)."*
  - *Answer as above.*

Question 5

Are there any flood related issues that you feel we have missed?

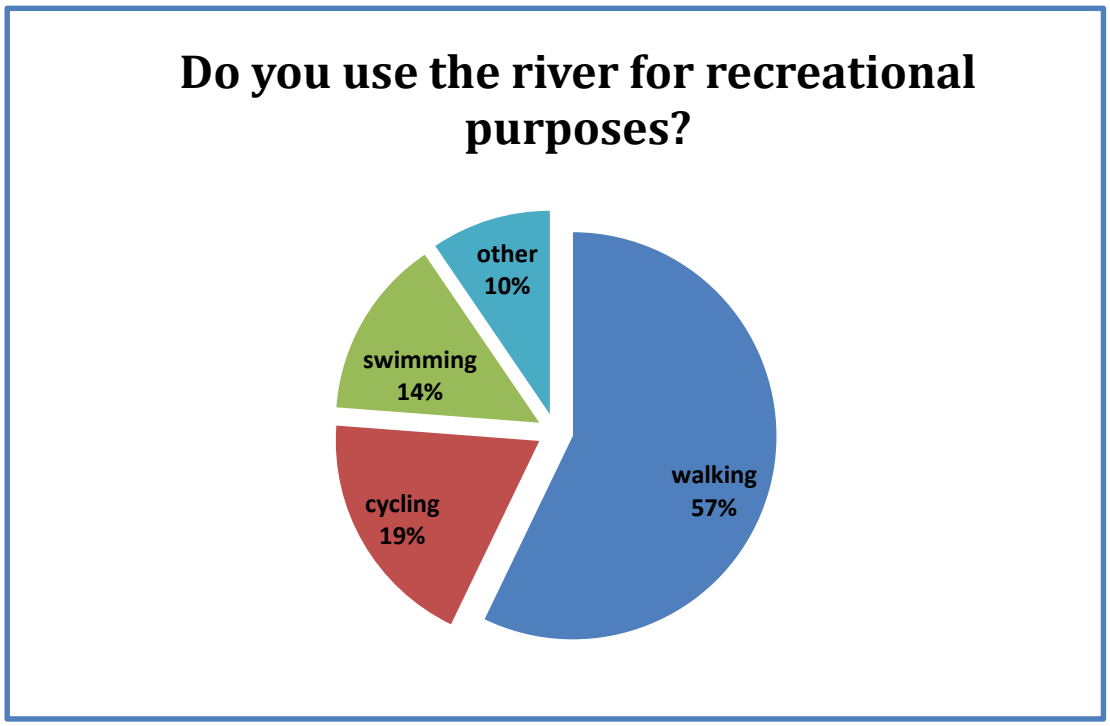
There was a divided response to this question. 8 People answered 'no' showing they are happy that the majority of flood issues in Peebles have been discussed. 3 people answered 'yes' and 6 left it unanswered however included comments regarding some issues that may have been missed. The comments from those that answered yes and where a comment has been left but the question was left unanswered are shown in the table below:

Response no.	Watercourse area	Comments
1	Eddleston Water	*"Timeline of Eddleston water incorrect. Not stating water levels in 2000 (my home was flooded twice)" – Can be incorporated.*
2	Eddleston Water Edderston Burn River Tweed	*"Yes flooding from Eddleston Water at Manor Swore Bridge not included. Advised member of team." – Can be incorporated.*
3	River Tweed Eddleston Water	*"More on NFM. It is more proven than you give credit for. The challenges are also social and political - engaging with and/or regulating land use in the catchment." – NFM potential will be looked at as a long-term strategy?*
4	River Tweed	*"The plan shows how lateral water would be kept out. One of the biggest unknowns is what the water table would do in event of significant flooding." – Protection against groundwater would be incorporated into the design, for example sheet piling for the wall or a waterproof core of an embankment taken down x metres.*
5	River Tweed	*"Natural flood defences upstream of Peebles were mentioned, but largely ignored. Scottish Water and the Forestry Commission could help but do not seem minded too. (They are public bodies in Scotland, and should therefore be accountable to us all, but they don't seem to be in reality)" – Stakeholder engagement with Scottish Water and Forestry will take place / has taken place. NFM potential will be considered.*
6	River Tweed Edderston Burn	*"Despite the poster explaining why sediment removal is not suitable I can see the huge island forming in the Tweed is affecting the river banks (erosion) and will soon impact the Tweed bridge." – Study undertaken on effect on removing the island – very limited effect and will likely re-fill very quickly – we will not be removing (or undertaking any other dredging)*
7	Eddleston Water	*"Yes flooding from Eddleston water at Manor Swore Bridge not included. Advised member of the team." – Can be incorporated.*
8	Eddleston Water	*"The whole grant system which incentivises poor land management, over grazing by sheep etc. is ridiculous. After exiting the CAP, build grants from bottom up to incentivise good land management." – Policy that is out with flood risk management.*

Question 6

Do you use the river for recreational purposes?

Collated data from the questionnaire makes it apparent that walking is the most common recreational activity that people use the riverside for. Other recreational uses include cycling and swimming, as shown in the chart below.



Question 7

Do you have any concerns about how the flood mitigation options proposed may affect recreation activities at the river?

Out of the 17 participants 12 were not concerned about the flood defences affecting any of their recreational activities that they take part in at the river. 1 left the question unanswered and the remaining 4 circled 'yes' indicating that they were concerned. Issues raised by participants who circled 'yes' included concerns about access to the river and the existing walkway and the aesthetics of the proposed flood defence options.

"Too many structures affecting how the river looks and works."

"Yes. It is essential we are not cut off from walking along the river. The "Three Bridges walk" is a very popular and regular walk for many."

"Mitigation for other areas needs to blend in as much as possible, both on the ground & for events."

A mitigation option that blends in suitably with the current area is essential and we will look to reduce the aesthetic losses and mitigate these with alternatives such as raised footpaths. The riverside walkway will exist post-scheme.

Question 8

Currently are there any access issues to the existing river infrastructure including issues which effect individuals with a disability?

9 people responded 'yes' – there were issues accessing the river infrastructure, 3 responded 'no' and 5 left the question unanswered. Below are a couple of comments from participants who responded with 'yes'.

"The hump and the path below riverside house which is not fit for purpose - muddy and eroded."

"Behind Haylodge hospital, pathway not possible in a wheelchair. Both Priorsford & Haylodge footbridge have been successfully dealt with."

The answers to this question are useful as if there are any issues of accessibility, we can work to address these and consider them in the design of flood defences.

Question 9

Are you particularly concerned with any of the proposed options?

11 people respondents were not concerned with the proposed options, representing around 65 percent of the total consultees. Concerns and issues that were raised on the questionnaires by those answering yes are shown in the table below.

Response no.	Watercourse area	Comments
1	River Tweed	*"Somewhat [concerned] about building a wall in Tweed Green"*
2	Eddleston Water	*"Structural protection measures focus on good land management upstream and flood individual houses. Stop grants for land management that increases flood risk."*
3	River Tweed	*"If a wall or embankment is sited at Tweed Green then access to existing footpaths could be an issue."*

Question 10

Do you have any other issues that you would like to raise?

The final question on the questionnaire gave participants the opportunity to voice any issues they had, which may not have applied to the other questions. 3 people raised their concerns, 8 had no issues to raise and 6 left the question unanswered. The concerns highlighted by residents are detailed below;

Response no.	Watercourse area	Comments
1	River Tweed	*"Water level data from the early stages of the Tweed, at Glenbreck and Kingledores, is critical to understanding the potential of flooding in Peebles. The monitoring needs to be well protected."*
2	Eddleston Water	*"Look at link between CAP, land ownership / reform, length / security of tenancy for farmers and floods! Identify and treat the causes not only the symptoms"*
3	Eddleston Water River Tweed	*"Take NFM seriously"*

A participant who raised an issue included a comment displaying their positive thoughts about a flood defence to protect property:

"Fully in support of proposal to protect property affected by the River Tweed with the construction of a flood retaining wall. Seems to be excellent cost/benefit"

Outcome / Conclusion

As shown from the data collected in the questionnaires, there has been a generally positive response to flood defence options presented in Peebles. However, the questionnaire has highlighted issues that will be considered at the next stages of the process, including negative comments about flood walls and the lack of natural flood management.

The mainly positive view is likely to be because many people have unfortunately been affected by flooding in the recent past, understand how devastating flooding can be and appreciate the benefit of having their properties protected by a formal flood protection scheme.

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