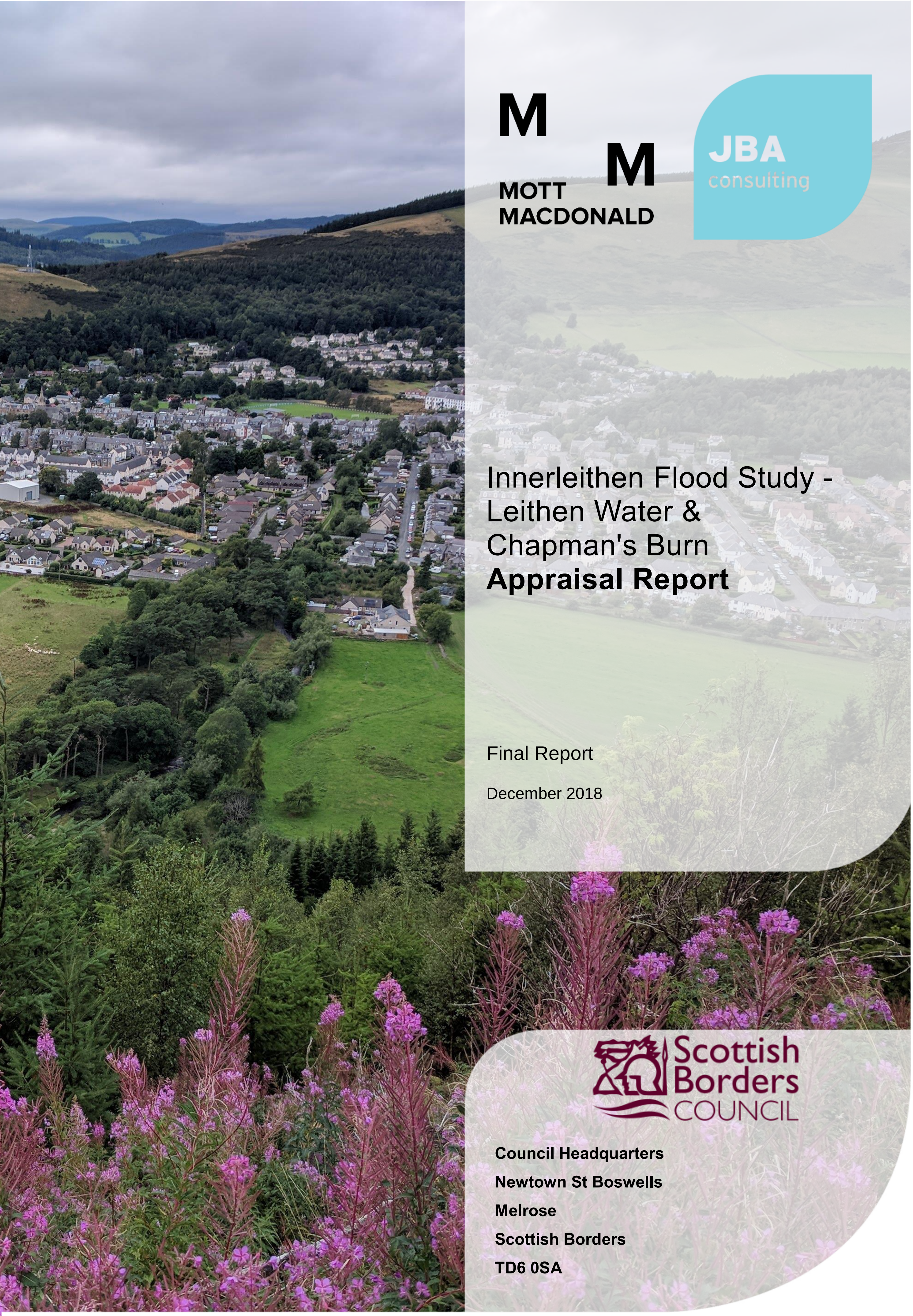

MOTT MACDONALD

JBA consulting

# Innerleithen Flood Study - Leithen Water & Chapman's Burn
# **Appraisal Report**

Final Report

December 2018

Scottish Borders COUNCIL

**Council Headquarters**
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# Revision History

| Revision Ref / Date Issued | Amendments | Issued to |
|---|---|---|
| S0-P01.01 / 2018 | - | Angus Pettit |
| S0-P01 | Minor amendments | |
| S4-P01 / October 2018 | - | Scottish Borders Council |
| S4-P02 / December 2018 | Post-council review and amendments | Scottish Borders Council |

# Contract

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

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Technical Director

# Purpose

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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 Innerleithen, 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, PVA 13/04 includes Innerleithen and the surrounding towns of Eddleston, Peebles, Selkirk, Stow and Galashiels. According to this PVA, Innerleithen has an Annual Average Damage (AAD) of £800k in total with £660k associated with residential properties and £140k for non-residential properties. A flood protection study is identified as one of the key actions to be taken as a means to reduce this risk and this report presents the findings of part of the study.

# Acknowledgements

We would like to thank Scottish Borders Council, Turner Townsend and Mott MacDonald for the data, supporting information and reviews undertaken throughout the study. We 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.

# Copyright



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# Innerleithen Flood Risk Management Business Case

## Context

Innerleithen is at risk from flooding from the Leithen Water, Chapman's Burn and the River Tweed. This appraisal report focuses on flood risk from the Leithen Water and Chapman's Burn. Flooding from the River Tweed is discussed in the River Tweed Appraisal report.

The Leithen Water is a sub-catchment of the River Tweed which covers an area of 57 $km^2$. The Leithen Water is the primary watercourse in the catchment and the main reach is 18 km in length with four smaller tributaries entering in the upper catchment. It flows south through the centre of Innerleithen. The channel is heavily urbanised in sections of its reach through the town, with stretches where the watercourse has been straightened or with vertical walled banks.

Chapman's Burn is a small burn rising in St Ronan's Wood on Caerlee Hill to the west of Innerleithen. It flows for a short distance as an open channel before being culverted under St Ronan's Terrace and St Ronan's Way, after a short length the channel is fully culverted and directed south through the town of Innerleithen until it emerges into the River Tweed. This extensive culverting formed the Innerleithen - Hall Street Flood Prevention Scheme 1988. The original path of the watercourse flowed from west to east into the Leithen Water.

JBA was commissioned in 2017 to carry out a review of past flood events, determine the likely risk to different properties and to propose a set of 'options' that may reduce the flood risk to an acceptable level. This report is the culmination of this work and aims to provide a detailed explanation of the various steps carried out in order to identify a preferred set of interventions that offer a sustainable method of flood protection whilst seeking to benefit the environment and the community of Innerleithen. A number of supporting documents and drawings have also been prepared to complement this report and provide additional detail on certain aspects.

A modelling exercise was carried out to estimate river levels on both watercourses. A range of possible flood events were modelled from events with a probability of occurring once in every 2 year period, a 50% Annual Probability (AP) or 2 year event; up to an extremely large event with a probability of occurring once in every 1000 year period, a 0.1% AP or 1000 year event. Increases due to predicted climate change were included for at the 3.3% AP (30 year) and 0.5% AP (200 year) events.

The Leithen Water and Chapman's Burn were modelled separately so that the resulting damage from flooding could be attributed to each watercourse. The Leithen Water is estimated to cause inundation to 48 properties at the 0.5% AP (200 year) event and 190 properties for the 0.5% AP (200 year) with an allowance for climate change.

For Chapman's Burn, 31 properties are at risk of flooding from the 0.5% AP (200 year) event and 44 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:

| | |
|---|---|
| Households at risk - Leithen Water | 48 at the 200 year flood (188 with climate change) |
| Households at risk - Chapman's Burn | 31 at the 200 year flood (44 with climate change) |
| Non-residential properties at risk - Leithen Water | 11 at the 200 year flood (31 with climate change) |
| Non-residential properties at risk - Chapman's Burn | 8 at the 200 year flood (10 with climate change) |
| Key receptors at risk | A72, B709, 4 electricity sub-stations |

## Flood Mitigation Options

A range of flood protection options were reviewed and short listed based on their viability. Two options for the Leithen Water and three options for the Chapman's Burn were short listed as potentially viable solutions to protect to a suitable standard of protection. The short-listed options for the Leithen Water are:

- Property Level Protection (PLP) or
- Direct defences

For Chapman's Burn the short listed options are:

- Property Level Protection
- Culvert upgrade or
- Flood attenuation with some culvert improvement

A sub-option for Chapman's Burn which involves increased channel conveyance was also considered.

## Improving public awareness and resilience

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

- Installation of a flow gauge on the Leithen Water and Chapman's Burn (Leithen Water's high flow measurements at the existing level gauge could be taken to allow a rating curve to be developed). Placing gauges on these watercourses would give greater confidence to the size of the estimated peak flow flood events, provide calibration data to increase the confidence of the hydraulic model and could be used to improve the Flood Warning system on the Leithen Water.
- The Council provides partial funding for at-risk home owners to purchase PLP. This has not been taken up by any residents in Innerleithen yet. 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 and emergency services. Community engagement should be continued to raise awareness of flood risk and potential short- and longer-term solutions.
- Innerleithen's Resilient Communities sandbag store is located at the Fire Station on Hall Street. 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. 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. They are also light weight so can be positioned without difficulty by a larger number of people. It may also save the Council time in filling, distributing and delivering sandbags to communities when sandbag stores run out.
- Scottish Planning Policy should be leveraged to provide the potential for future implementation of other options that are currently not possible or to avoid unnecessary development on the floodplain in Innerleithen.

## Expected benefits

A flood damage assessment has been undertaken for the present-day Do Nothing, Do Minimum and each of the above options. The Present Value flood damages calculated for the Do Nothing and Do Minimum scenario for the Leithen Water are estimated to be £5.8m and £0.8m respectively. The damages avoided for each option are in the range of £5.1-5.2m, protecting 37 residential and 10 to 11 non-residential properties (depending on the option assessed).

For Chapman's Burn the Present Value flood damages calculated for the Do Nothing and Do Minimum scenario are estimated to be £4.6m and £2.8m respectively. The damages avoided for each option are in the range of £2.4-4.4m, protecting 3 to 23 residential and 3-8 non-residential properties (depending on the option assessed). Total damages avoided for each option are provided in the investment appraisal summary table overleaf.

## Working with natural processes and decrease burden on sewer network

### NFM

Natural Flood Management (NFM) is a method whereby wider catchment benefits could be achieved alongside a traditional flood protection option, potentially reducing flood flows within Innerleithen. Opportunities within the upper catchment of the Leithen Water could to some extent counteract the effects of increasing river flows with climate change. 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. 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. The NFM measures which are likely to have the largest influence on reducing flood risk are:

- Along contour woodland planting in the steep headwater sections of the Glentress Water and Glentress Burn.
- Buffer strips along watercourses with limited bank and floodplain vegetation.
- Install leaky bunds along the Glentress Water in the north of the catchment.
- Debris dams and blocking of ditches.
- Wetland creation in the upper Leithen Water

No NFM options have been identified for the Chapman's Burn.

### Burden reduction on sewer network

Two of the shortlisted options to manage flood risk from the Chapman's Burn involve substantially improving the urban sewer network. The direct defence option on the Leithen Water shall help to reduce the stress on the urban sewer system by containing flood flows to the channel and preventing them entering the sewer network.

## 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 level of appraisal and is typical for schemes at an early stage of appraisal. Whole life present value costs for the Leithen Water options range from £1.1m to £1.5m. Whole life present value costs for Chapman's Burn options range from £0.08m to £4.3m. Total costs for each option are provided in the investment appraisal summary table overleaf.

## Investment appraisal

The investment appraisal is provided below. The option with the highest benefit-cost ratio (BCR) for the Leithen Water is the Direct Defences option with a BCR of 4.3 with a net present value of £4m. However, when this option is compared against the Do Minimum option then the saving in damage reduction is only £0.2 m. This highlights the importance of the Do Minimum interventions over a Do Nothing approach and the need for continued inspection and maintenance of the watercourse. It also highlights the risk posed by structure blockage upstream of key structures within the town. It suggests that much of the flood risk to the town can be minimised by good practice watercourse maintenance and may reflect the lack of flooding within the recent flood record.

For the Chapman's Burn the most cost effective option which increases the standard of protection to an acceptable level is PLP with a BCR of 3.8 with a net present value of approximately £2m. The difference between the Do Minimum and PLP option has a saving of £0.75m. The following cost-benefit ratio tables are for the Leithen Water and Chapman's Burn respectively. There is some overlapping flood risks where several properties are at flood risk from both watercourses; 5 properties with flooding over threshold have been identified.

Investment appraisal for the Leithen Water

| Option name | Do Nothing | Do Minimum | Direct Defences - Leithen Water | PLP - Leithen Water |
|---|---|---|---|---|
| **PV Costs (£k)** | - | - | 747 | 944 |
| **Optimism Bias (60%)** | - | - | 448 | 566 |
| **Total PV Costs (£k)** | 0 | 0 | 1,194 | 1,510 |
| **PV damage (£k)** | 5,814 | 831 | 642 | 712 |
| **PV damage avoided (£k)** | - | 4,983 | 5,172 | 5,102 |
| **Net present value (£k)** | - | 4,983 | 3,979 | 3,591 |
| **Benefit-cost ratio** | - | - | 4.3 | 3.4 |

Investment appraisal for Chapman's Burn

| Option name | Do Nothing | Do Minimum | PLP - Chapman's Burn | Culvert upgrade | Offline Storage | Channel Improvement |
|---|---|---|---|---|---|---|
| **PV Costs (£k)** | - | - | 347 | 2,733 | 1,631 | 48 |
| **Optimism Bias (60%)** | - | - | 208 | 2,438 | 1,271 | 32 |
| **Total PV Costs (£k)** | 0 | 0 | 555 | 4,372 | 2,610 | 77 |
| **PV damage (£k)** | 4,608 | 2,835 | 2,085 | 248 | 248 | 2,130 |
| **PV damage avoided (£k)** | - | 1,773 | 2,403 | 4,361 | 4,361 | 2,478 |
| **Net present value (£k)** | - | 1,773 | 1,968 | -2,141 | 972 | 2,401 |
| **Benefit-cost ratio** | - | - | 3.8 | 0.7 | 1.3 | 32.0 |

For each of the options assessed there are a number of constraints and opportunities that must be considered and discussed with stakeholders and the public before a preferred option is selected. A summary of these is provided in the appraisal summary table overleaf.

## Residual risks and planning for future flooding

The shortlisted options protect to the 200 year flood event. As the effects of climate change continue to be felt additional properties will require protection. For the PLP option to protect against flood risk for the Leithen Water alone the number of properties that will need PLP increases substantially from 48 to 188 with 1 property (Glentrail House, Traquair Street) flooding to a depth too great for PLP to protect against. This shows that Innerleithen is very susceptible to effects of climate change. If PLP is chosen as the preferred option, then the properties currently identified as being in the 200 year flood risk zone should be given PLP. PLP needs replacement every 25 years, at each replacement interval the PLP requirement should be reassessed, which will identify the requirement of additional properties. It is likely that an additional 140 properties will be require PLP by 2080. A flood wall could protect against flooding from the Leithen Water in the future if it is combined with bridge raising, however, to do so now would mean the installation of vastly increased wall lengths and an increase in wall heights. As the number of properties requiring PLP would need to increase so much a wall is likely to become cost effective compared to PLP, however, this will need to be balanced against the visual impact of flood walls on the community. The options on Chapman's Burn could be designed to accommodate the 200 year plus climate change flow. If one of these options is progressed then it should be designed for the 200 year plus climate change flow.

Regardless of the chosen option NFM should be integrated into the scheme. The NFM measures recommended takes place throughout the catchment but would require extensive works to gain a significant reduction in flood flows. NFM, when implemented correctly, shall have a positive effect on flood flows, helping the soil to absorb more water, slow the flow of water into the watercourse and create more open water bodies on the land and may help to mitigate against the increase in frequent flood flows from climate change. Further modelling is required to determine the most effective locations for NFM and the potential benefit that could be derived.

## Conclusions and recommendations

This report presents the results of a detailed flood risk appraisal for Innerleithen Water in relation to flooding from the Leithen Water and Chapman's Burn. Each watercourse was assessed independently, 48 properties are estimated to be at risk of flooding from the 0.5% AP (200 year) "Do Minimum" flood event from the Leithen Water and 31 from the Chapman's Burn.

Flooding from the Leithen Water inundating properties is not observed until the 50 year flood event. One significant factor in keeping this standard of protection is the ongoing maintenance programme. Modelling suggests that if maintenance were to stop there would be an increase in flood damage of approximately £5m and a reduced standard of protection. In order to keep the damages low a coarse in-river debris screen is recommended upstream of the A72 Road Bridge to prevent possible future blockage. Similarly, on the Chapman's Burn, to increase resilience from the damage that could be caused from screen blockage, approximately £1.8m, telemetry on the culvert screens is recommended. This would alert the Council immediately to a blockage which could then be removed as a priority.

Before any option on the Chapman's Burn is considered, gauging of the watercourse is recommended to provide a better estimate on flood flows. The modelling suggests that flooding should be occurring more frequently than every 2 years, however, the recorded flood history suggests otherwise. A comparison of the peak flood flows versus the ReFH2 flows showed a vast difference in the flow estimates, for example the 2 year peak flow Rainfall Runoff estimate is 0.18 $m^3/s$ compared to a 0.03$m^3/s$ for the ReFH2.

A sub option for Chapman's Burn which involves increased channel conveyance was also considered, while this does not increase the standard of protection to an acceptable level, it does remove several properties near Chapman's Burn from the 200 year flood risk extent. Improving channel conveyance on the Chapman's Burn has a very large BCR ratio, a ratio of 32, indicating that this is a very cost effective improvement to flood risk. However, in-depth analysis at the outline design stage is recommended to determine the impact of flood risk to properties downstream of the works.

PLP for both the Leithen Water and Chapman's Burn are cost effective solutions with a BCR of between 3.4 and 4.3 respectively, however, other options provide greater damage reduction. Offline storage is a feasible option to protect against Chapman's Burn flooding to the 200 year flood event. It has a positive BCR and can be adapted to cater for the 200 year plus climate change flood event. This option utilising Victoria Park playing field as a storage area during a storm event. Both the offline storage and PLP options could be designed to protect against the effects of climate change with a relatively small increase in cost.

Considering all of the above JBA recommends putting the following measures in place:

- Make the current condition more resilient. This includes installation of a coarse debris screen upstream of the A72 Road Bridge and telemetry on Chapman's Burn culvert screens.
- Carry out improvements works on the Chapman's Burn channel to increase conveyance to the FPS culvert inlet and install a gauge on the Chapman's Burn to give a better estimate of flood flows. The impact on properties downstream needs to be assessed in more detail prior to channel improvement works. Once more confidence has been developed in the flood flow estimates the options should be reassessed.
- Implement the Direct Defence option on the Leithen Water.

Public opinion is very important, as after all, it is the homes and business of the community that the FPS will endeavour to protect. For this reason, SBC and JBA presented the options at a public meeting, thereby giving the community a voice in shaping the scheme to how they would like it.

| 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 |
|---|---|---|---|---|---|---|---|
| Property Level Protection (PLP) - Leithen Water<br>(0.5% AP - 200 year) | 47 of 48 | No impact | NFM measures have been identified and could be incorporated within the scheme to provided additional environmental benefits. | Intrusive into people's homes, will require reinstallation every 25 years.<br>Some flood damages are associated with each flood event, as well as clean up cost.<br>Roads and gardens are not protected. | All properties protected with PLP will also be protected under the 200 year climate change event, additional properties will require PLP as the 200 year climate change flood extent is larger. | Option should be presented to public for comment.<br>Signage relating to flooding and sand bag stores should be erected. Ensure Innerleithen residents are aware of the Resilient Community Programme<br><br>Test reliability of flood warning system and consider improving it by installing an additional gauge further up the catchment | BCR 3.4 |
| Direct Defences – Leithen Water<br>(0.5% AP - 200 year) | 48 of 48 | Minimal direct impact | | In order to avoid excess wall lengths only properties who are anticipated to suffer flood damages above floor level have been targeted for protection. The minimum required wall length is 450 m with a wall height of between 450mm to 900mm. Gardens and low level damage to homes will still be experienced by several properties | This option will not protect properties from flood events in excess of the 200 year event. Designing to the 200 year plus climate change event is requires a wall length of approximately 800 to 1000m and would require raising of the A72 Road Bridge to avoid wall heights in excess of 2.5 m. | | BCR 4.3 |
| Property Level Protection (PLP) - Chapman's Burn<br>(0.5% AP - 200 year) | 24 of 31 | No impact | No suitable additional NFM measures | Intrusive into people's homes, will require reinstallation every 25 years.<br>Some flood damages are associated with each flood event, as well as clean-up cost.<br>Roads and gardens are not protected. | All properties protected with PLP will also be protected under the 200 year climate change event, additional properties will require PLP as the 200 year climate change flood extent is larger. | Installation of a flow gauge on the Chapman's Burn for flood warning, calibration and flow estimates. | BCR 4.3 |
| Culvert Upgrade – Chapman's Burn | 31 of 31 | | | Replacement of culverts shall be disruptive to the community for access and noise. | Channel and culvert could be made larger now to accommodate further increase in flows. | | BCR 0.7 |
| Offline Storage – Chapman's Burn<br>(0.5% AP - 200 year) | 31 of 31 | A portion of the existing culvert could be replaced with an open channel instead of a larger culvert | | Offline storage embankment peak height is approximately 1.3m at street level so should not be too much of a visual impact. The offline storage is utilising an existing playing field, the playing field is to be maintained but will require some redevelopment. | Channel, storage culvert could be made larger now to accommodate further increase in flows. | | BCR 1.3 |
| Channel Upgrade – Chapman's Burn<br>(50% AP - 2 year) | 3 of 28 | No impact | | Effect of flood water after upgrade needs to be assessed in greater detail | Channel could be made larger now to accommodate further increase in flows. | | BCR 32 |

| Negative | | | Neutral | | | Positive |
|---|---|---|---|---|---|---|

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# Abbreviations

| | |
|---|---|
| 1D | One Dimensional (modelling) |
| 2D | Two Dimensional (modelling) |
| BCR | Benefit cost ratio |
| CAD | Computer Aided Design |
| CAR | Controlled Activity Regulations (2010) |
| CCTV | Closed-Circuit Television |
| CEH | Centre for Ecology and Hydrology |
| DEFRA | Department of the Environment, Food and Rural Affairs (formerly MAFF) |
| 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 |
| FWA | Flood Warning Area |
| GIS | Geographical Information System |
| ISIS | Hydrology and hydraulic modelling software |
| MAFF | Ministry of Agriculture Food and Fisheries (now part of Defra) |
| mAOD | metres Above Ordnance Datum |
| NFM | Natural Flood Management |
| OS | Ordnance Survey |
| PLP | Property Level Protection |
| PR | Percentage Runoff |
| PV | Present Value |
| PVb | Present Value benefits |
| PVc | Present Value costs |
| QMED | Median Annual Flood (with return period 2 years) |
| RBMP | River Basin Management Plan |
| SAC | Special Area of Conservation, protected under the EU Habitats Directive |
| SEPA | Scottish Environment Protection Agency |
| SSSI | Site of Special Scientific Interest |
| SUDS | Sustainable Urban Drainage Systems |
| TUFLOW | Two-dimensional Unsteady FLOW (a hydraulic model) |
| WFD | Water Framework Directive |

# 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.

Throughout this report a flood event will primarily be written as a return period in years, i.e. 200 year 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

**Chapman Modelling Report** - AEM-JBAU-IL-00-RP-A-0008-Chapman_Modelling_Report-S3-P01.pdf

**Leithen Water Modelling Report** - AEM-JBAU-IL-00-RP-A-0006-Leithen_Water_Model_Report-S4-P02.pdf

**Flood Risk Review** - AEM-JBAU-IL-00-RP-A-0001-Flood_Risk_Review-S4-P02

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

# 1 Introduction

The conservation town of Innerleithen sits on the tributary of the Leithen Water with the River Tweed. The Leithen Water is a sub-catchment of the River Tweed being 18 km long with a drainage area of 57 $km^2$. It runs south through the centre of Innerleithen, following the B709 though the urbanised area of Innerleithen to the High Street Bridge. To the north west of the town a small burn rises on Caerlee Hill, this burn is known as Chapman's Burn. This watercourse, at one time, was a tributary of the Leithen Water. In the late 1980's a Flood Protection Scheme (FPS) was carried out on Chapman's Burn. This scheme culverted and redirected a large portion of the burn so that it now flows directly into the River Tweed via a culvert outfall. Figure 1-1 depicts the route of the two watercourses through Innerleithen. This report focuses on the flood risk to Innerleithen from these two watercourses. Each watercourse was modelled separately. Figure 1-2 and Figure 1-3 shows the area of Innerleithen covered by each watercourse and the location of model cross sections.

Figure 1-1: Watercourse overview

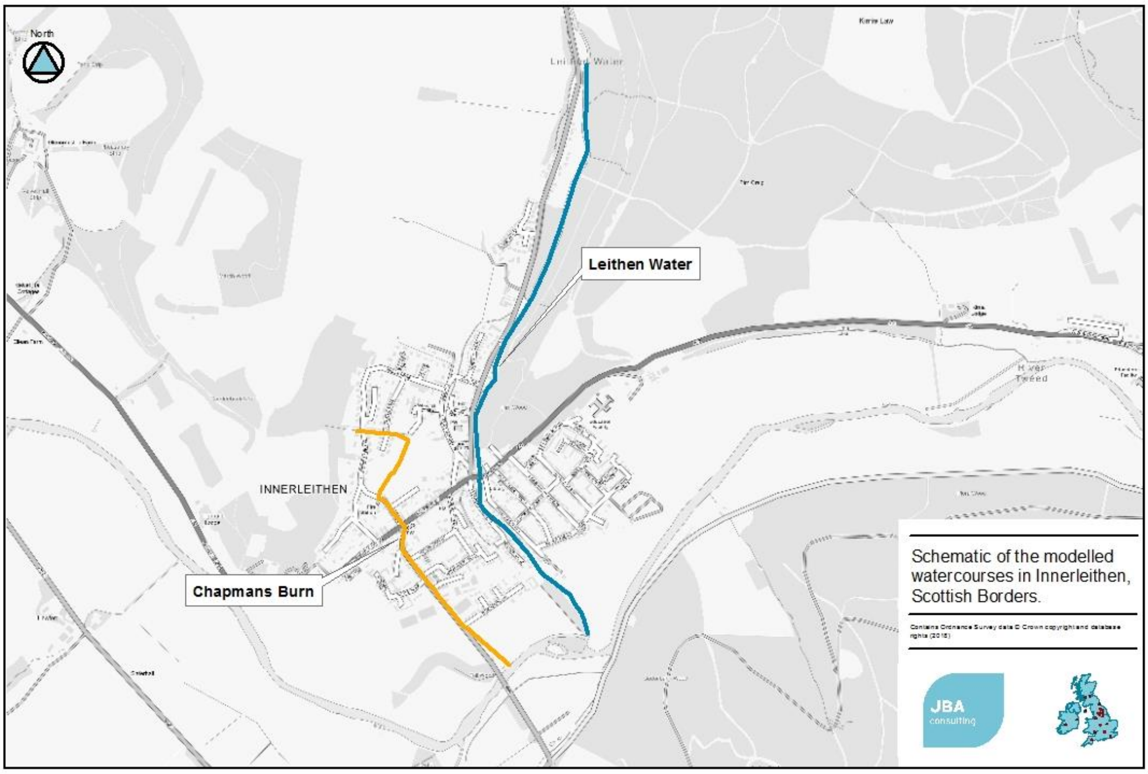


Figure 1-2: Chapman's Burn model overview

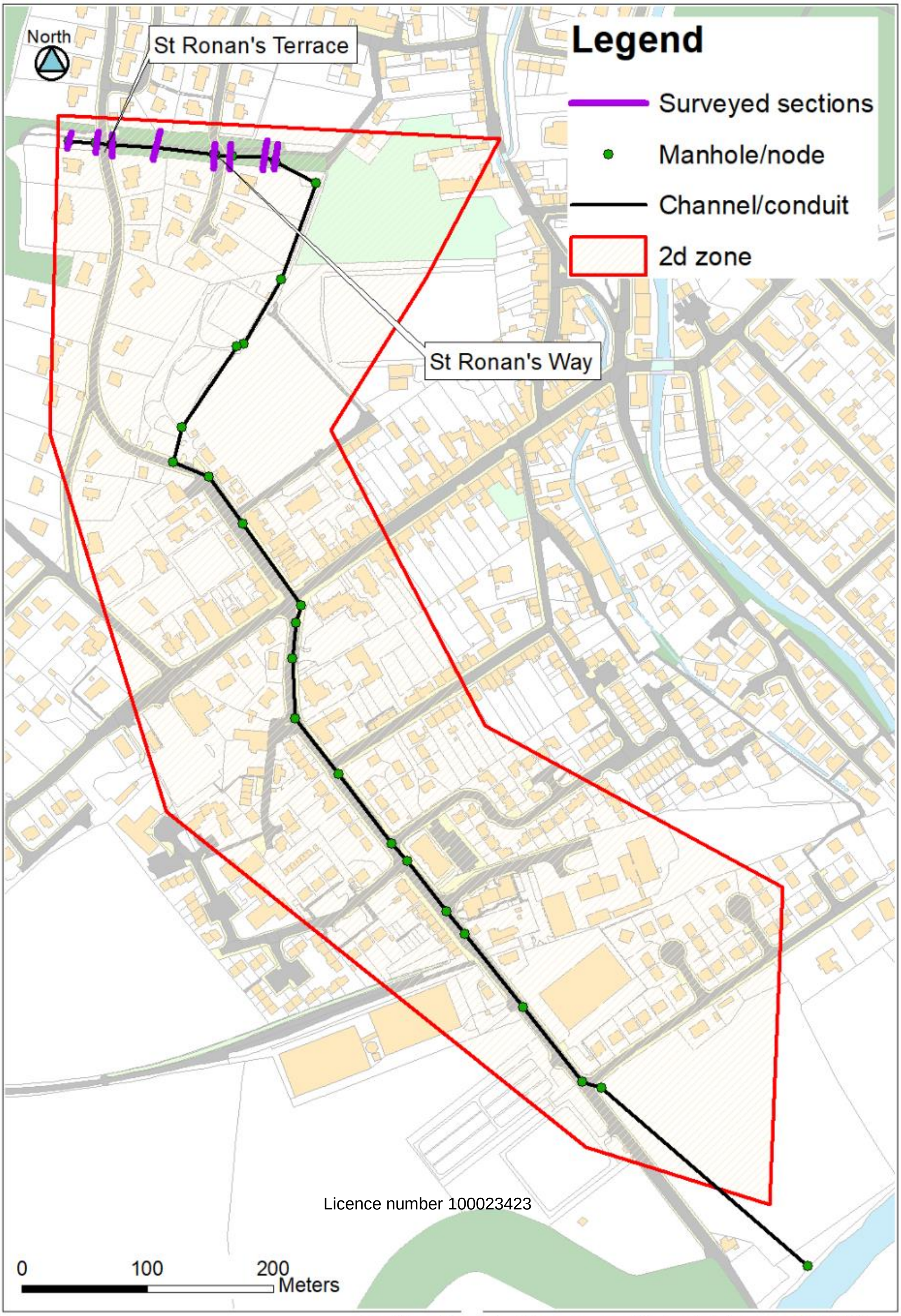
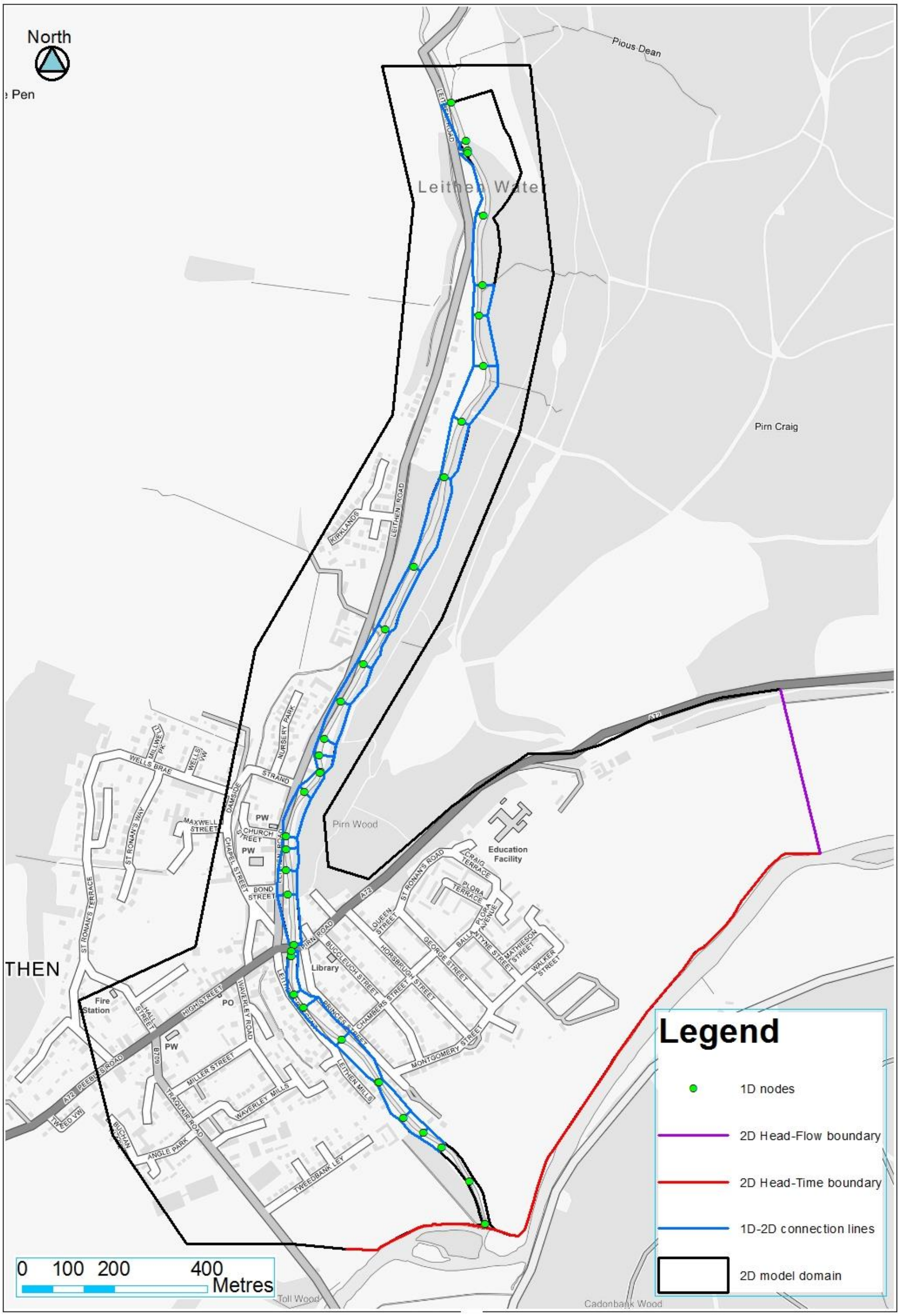


Figure 1-3: Leithen Water model overview

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## 1.1 Flooding mechanism from Chapman's Burn and Leithen Water

Chapman's Burn does not have a recent history of flooding, however the modelling suggests that the flooding is a result of undersized culverts, poor channel conveyance and surcharging of manholes. Flooding occurs at the upstream face of the culvert under St Ronan's Terrace and at the entrance to the FPS culvert. Surcharging of the culverts first occurs on Hall Street.

There are few recent recorded flood events from either the Tweed or the Leithen Water, however, there are a number of historical records from the 1800s through to the mid-1900s of Innerleithen being affected by flooding from both these rivers. The recent records show isolated flooding to Montgomery Street (1994 to 2002) and flooding of Princes Street (2002).

### 1.1.1 Previous studies

No previous flood studies have been undertaken for the Chapman's Burn or Leithen Water, however, an assessment of the lade running parallel to the Leithen Water was undertaken. This report showed that the capacity of the lade is small and additional flow should not be directed into it.

### 1.1.2 Watercourse condition and catchment opportunities

River Basin Management Plan (RBMP) and natural flood management (NFM) study was undertaken. The watercourses condition and character are described as follows:

Figure 1-4: Tributaries of the Leithen Water

**Chapman's Burn**

Chapman's Burn rural catchment is very small, steep and forested. No NFM improvements have been recommended.

**Leithen Water**

The Leithen Water flows initially in a south easterly direction, at the confluence with the Glentress Water the Leithen Water enters a wide "U" shaped valley flowing south. The upper Leithen Water catchment, including the sub catchments of the Craighope and Williamslee Burns, is densely forested with privately owned commercial plantations and a large windfarm on the northern hills. Here the valleys are steep sided with narrow areas of floodplain in the valley floors. Many small and steep tributaries enter, flowing through the dense forests.

From the point where it leaves the forest in the upper catchment, the channel meanders, mostly freely, across a relatively wide floodplain with a series of pool and riffle features and extensive gravel bar deposition structures in several locations.

Continuing downstream the floodplain narrows and the western side of the valley is largely open hillside with occasional small woodland areas. The east side, all the way down to Innerleithen, is Forestry Commission plantation.

The lower reaches of the Leithen Water are generally straight and confined within artificial banks, although the bed is natural and there is still a fair amount of riparian vegetation. The reach through the town itself is straight with several crossings and extensive bank protection on both banks before a short natural reach on the approach to the Tweed confluence.

The sub-catchments of the Glentress Water and Glentress Burn comprise mainly open hillside of moor/heathland used for rough grazing. The main watercourse displays similar characteristics for the next 2km or so. The main tributaries are typically similar in character to the Leithen Water, although narrower and steeper. Generally, the bed material is mixed, with gravel- and cobble-sized clasts within a matrix of finer material. Several minor tributaries enter along this reach, short and steep in nature with little in the way of vegetation on the banks.

## 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 Innerleithen that contribute 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 Leithen Water 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 in the Innerleithen area has been carried out and is included in the Hydrology report referenced in the Supporting Documents section at the start of this report. There have been few recorded cases from Chapman's Burn or Leithen Water, however, the presence of the FPS on the Chapmans Burn suggests that there may have been flood events from this watercourse in the past that resulted in the need for the construction of this FPS.

Generalised flooding within the Innerleithen area was reported in 2016, 2012, 2005, 2002, 1994 and 1949. Leithen Water flood events specifically include 2005, 2002 and 1949. Streets that have previously been inundated include Leithen Crescent, Montgomery Street and St Ronan's Terrace. The River Tweed is also known to flood the road bridge on Traquair Road.

Table 2-1 Selection of the most recent flood events in the area.

| Date | Flood Record |
|---|---|
| 2002 | Flooding at Montgomery Street, at least one house was inundated |
| 2002 | Flooding of Princes Street from the Leithen Water |
| 2005 | SEPA commented the general area was subject to flooding from the River Tweed. Other sources of flooding attributed to the Leithen Water |
| 2012 | SEPA reported flooding in the Innerleithen area |
| 2016 | Flooding in June from a combination of the Chapmans Burn overtopping the banks and surface water runoff. Flooding of two businesses and one residential property on St. Ronan's Way. |

## 2.2 Review of Previous flood studies

5 known Flood Risk Assessments (FRAs) have been carried out for specific sites in Innerleithen. These FRAs along with their finding are documented in a Flood Risk Review document referenced in the supporting materials section at the beginning of this report. The main findings of this report are summarised in the table below.

Table 2-1 Summary findings of previous FRAs

| Document Name | Key Findings |
|---|---|
| Proposed Residential Development, Kirklands, Innerleithen. Flood Risk Assessment, August 2005 | Risk of flooding is from:<br>• high water levels in the Leithen Water resulting in overtopping<br>• the Mill Lade. Flow in the Lade is restricted by sluices and water can be diverted back into the Leithen Water along its reach to prevent backing up at culverts<br>• hillslope runoff |
| Proposed Development at Kirklands Farm, Innerleithen. Flood Risk Assessment, September 2008 | Flow entering the Lade is dependent on water levels in the Leithen Water |
| Flood Risk Assessment for Haughead Farm, Innerleithen. October 2014 | • The 0.5% AP (200 year) event for the River Tweed was estimated to be 697 $m^3/s$<br>• At the site location the River Tweed has an estimated 0.5% AP (200 year) flood level of 139.55 mAOD |
| Church Hall, Innerleithen Flood Risk Assessment. November 2014 | • The 0.5% AP (200 year) event for the Leithen Water was estimated to be 93.3 $m^3/s$.<br>• At the site location the 0.5% AP (200 year) level was estimated to be 148.49 mAOD<br>• |

| | |
|---|---|
| Condition Assessment and Database of Flood and Coastal Defences. Innerleithen Flood Prevention Scheme 1988. Final Report. December 2005 | Unsteady state MicroDrainage WinDes model and JFlow used to model flood extents. Inundation began with a flood < 0.67m$^3$/s but properties were not affected until flows reached 1.075m$^3$/s |

## 2.3 Flood estimation

The methodology used to derive flood estimates for the Leithen Water and the Chapman's Burn 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. The Flood Estimation Handbook (FEH) was used to derive peak river flows for a range of Annual Probability events for both watercourses.

SEPA operate a level only gauge on the Leithen Water at Innerleithen. A theoretical rating exists for this site but the documentation for this rating[1] suggests that "Comparison with neighbouring gauges suggests high flows may be conservatively low". The Leithen Water was therefore effectively treated as ungauged. Pooling group analysis was therefore used for the Leithen Water just upstream of its confluence with the Tweed. A Generalised Logistic distribution was used for the growth curve and the Gala Water at Galashiels gauging station (station number 21013) was used as the donor for QMED. This resulted in an adopted QMED value of 25.9 m$^3$/s.

Estimates for the Chapmans Burn at Innerleithen were obtained by scaling FEH Rainfall Runoff estimates from the Eddleston Burn upstream of the Tweed to each location by catchment area. Initially, the approach selected was the scaled ReFH2 values with FEH13 rainfall and donor parameters. However, at an early modelling stage for the Chapmans Burn, it was identified that a scaled version of the FEH Rainfall-Runoff method, using a summer profile, was more appropriate and is also consistent with the earlier condition assessment study[2] in this area. The peak flow estimates for both watercourses for a range of Annual Probability (AP) events are presented in Table 2-1.

Table 2-1: Peak flow estimates on the Chapman's Burn and Leithen Water

| Return Period (Years) | Annual Probability (AP) (%) | Chapman's Burn FPS inlet (m$^3$/s) | Chapman's Burn At confluence (m$^3$/s) | Leithen Water at Tweed confluence (m$^3$/s) |
|---|---|---|---|---|
| 2 | 50 | 0.18 | 0.99 | 25.90 |
| 5 | 20 | 0.29 | 1.60 | 35.59 |
| 10 | 10 | 0.36 | 2.01 | 42.75 |
| 30 | 3.33 | 2.08 | 2.77 | 55.24 |
| 50 | 2 | 2.39 | 3.18 | 62.39 |
| 75 | 1.33 | 2.62 | 3.49 | 68.34 |
| 100 | 1 | 2.81 | 3.74 | 72.88 |
| 200 | 0.5 | 3.32 | 4.42 | 84.97 |
| 1000 | 0.1 | 4.15 | 7.02 | 120.91 |

Consideration was given to joint probability modelling of the three watercourses. Initial model results showed some overlap of flooding between the Leithen Water and Chapman's Burn for flood events with a return period of 100 years of more. It was decided to model these two watercourses independently so that the damage for a flood event could be attributed to each watercourse. The influence of the River Tweed was accounted for by applying the peak 30 year flood level on the

1 SEPA, Innerleithen rating rev1 RW 050810

2 Scottish Executive Condition Assessment and Database of Flood and Coastal Defences, Innerleithen Flood Prevention Scheme 1998, Final Report, JBA Consulting 2005

River Tweed to the downstream boundary of both watercourses; assessed as being a suitable joint probability flood event on the Tweed for extreme flood flows on the Leithen Water.

Since the Chapman's Burn is ungauged there is some uncertainty in the flow estimates produced. Whilst JBA was requested to use the more conservative Rainfall Runoff flood flow estimates the lack of flood history coupled with the model results suggest that the FEH Rainfall Runoff flows are over estimating. There is a significant difference between the ReFH2 flow estimates and the FEH Rainfall Runoff estimates. Table 2-2 highlights this by showing the equivalent flood estimates side by side for a given return period. The flow rates in the table below are taken downstream of St Ronan's Way at the FPS inlet.

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

Table 2-2: Chapman's Burn Peak ReFH2 flood flows to equivalent Rainfall Runoff in years

| Return Period (Years) | FEH Rainfall Run off Flow estimates (m3/s) | FEH ReFH2 Flow estimates (m3/s) |
|---|---|---|
| 2 | 0.18 | 0.03 |
| 5 | 0.29 | 0.05 |
| 10 | 0.36 | 0.06 |
| 30 | 2.08 | 0.08 |
| 50 | 2.39 | 0.09 |
| 75 | 2.62 | 0.11 |
| 100 | 2.81 | 0.12 |
| 200 | 3.32 | 0.14 |

The inflow into Chapman's culvert for the catchment was broken into 4 inputs; one at the top of the reach, another at the junction of Hall Street with High Street, and another two along Traquair Street. The total inflow at each location for each event is shown in the Table 2-3.

Table 2-3: Chapman's cumulative flood flow estimates

| Return period (years) | Top of reach Flow estimate ($m^3/s$) | Hall Street Junction Flow estimate ($m^3/s$) | Traquair Street Flow estimate ($m^3/s$) | Tweedbank Ley Flow estimate ($m^3/s$) |
|---|---|---|---|---|
| **2** | 0.18 | 0.58 | 0.87 | 0.99 |
| **5** | 0.30 | 0.94 | 1.41 | 1.60 |
| **10** | 0.38 | 1.18 | 1.77 | 2.01 |
| **25** | 0.49 | 1.54 | 2.32 | 2.64 |
| **30** | 0.52 | 1.62 | 2.44 | 2.77 |
| **50** | 0.60 | 1.86 | 2.80 | 3.18 |
| **75** | 0.65 | 2.04 | 3.07 | 3.49 |
| **100** | 0.70 | 2.19 | 3.30 | 3.74 |
| **200** | 0.83 | 2.59 | 3.90 | 4.42 |
| **500** | 1.04 | 3.24 | 4.87 | 5.52 |
| **1000** | 1.32 | 4.11 | 6.18 | 7.02 |

### 2.3.1 Climate change

SEPA's summary report on Flood Risk Management and climate change[3] concludes that climate change impacts are likely to vary spatially across Scotland. In summarising the different increases

3 Flood risk management and climate change - Sepa
https://www.sepa.org.uk/media/219494/ceh-cc-report-wp1-overview-final.pdf

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 on both watercourses would increase to having a probability of greater than 20% (likely to occur more than every 5 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 approximately 3.3% (every 30 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.

## 2.4 Survey data

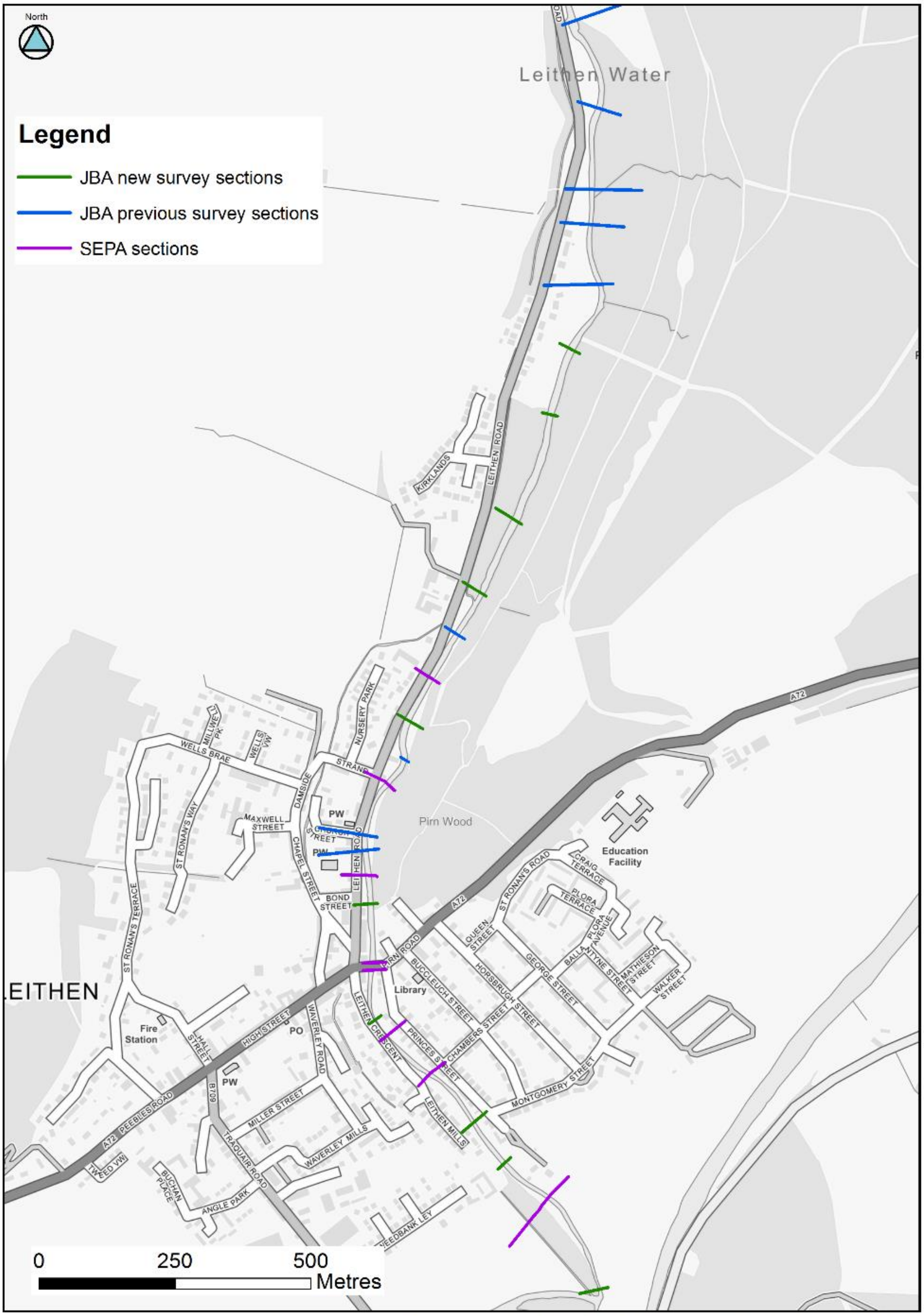
As there was no pre-existing channel survey data for the Chapman's Burn, JBA Consulting undertook a new cross section survey in March 2017. Figure 1-2 is a cross section location map which indicated the position of each of the cross sections (shown in purple). As the FPS culvert conveys the majority of the Chapman's Burn, a CCTV assessment was deemed appropriate. This was supplemented with survey levels of visible manholes and as-built drawing from the original FPS scheme. This allowed for an estimation of invert levels and the degree of blockage or damage within the culvert.

The Leithen Water survey is compiled of existing survey supplemented by new survey carried out by JBA Consulting. Figure 2-1 colour codes the existing and new survey cross sections. The survey is made up of channel cross sections and structures which cross the watercourse. During the survey photographs were taken at key locations of the watercourse and at structures such as bridges and weirs to provide an assessment of the condition of the watercourse, this is summarised in Section 4.3. A labelled cross section location map for both watercourses is shown in Appendix C.

### 2.4.1 Digital elevation model

1m and 2m LiDAR data has been collected for large parts of Scotland. Innerleithen has been included in this LiDAR data. This LiDAR data was used as the ground model for 2D element of the model, which is all ground outside of the river channel. There is a length of approximately 600m section on the left bank of the Leithen Water at the upmost extent of the model where 2m LiDAR data was not available. This was modelled with extended survey data and NextMAP data with a grid size of 5m. Further details are available in the Leithen Water Model Audit report referenced at the beginning of this report.

Figure 2-1: Survey on the Leithen Water

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### 2.4.2 Critical assets assessment

A full report into the condition of assets along the Leithen Water and the Chapman's Burn is provided in the Asset Condition Assessment report and a separate report was carried out to focus on the Mill lade(referenced in the Supporting Documents section at the beginning of this report) and summarised overleaf.  There are structures on Chapman's Burn and the Leithen Water which have an impact on flood risk.

On Chapman's Burn the initial flood risk arises from a poorly formed and undersized culvert under St Ronan's Terrace. In addition, there is a danger of partial or full screen blockage on the culverts downstream, both of which have poor channel conveyance on their approach.

The two lower bridges in Innerleithen have been identified as contributing to flood risk.

Table 2-4: Critical infrastructure

<table>
<tr><th colspan="3">Assets</th></tr>
<tr><td>FPS culvert screen</td><td>St Ronan's Way screen</td><td>St Ronan's Terrace inlet</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">Screens are well maintained and have an inspection regime. The Council has a duty to ensure the FPS screen is clear and well maintained.</td></tr>
<tr><td colspan="3">A72 Road Bridge</td></tr>
<tr><td>The A72 Road Bridge is in good condition. During flood flows its low clearance makes it susceptible to blockage by large debris. Modelling has shown flood water backing up behind this bridge which causes flooding at higher return period events.</td><td colspan="2"></td></tr>
<tr><td colspan="3">Pedestrian Bridge</td></tr>
<tr><td>This bridge, at the end of Montgomery Street has also been identified as contributing to flood risk. Constriction of the flow is seen at the 50 year event flood event. Some benefits can be gained by modifying this bridge.</td><td colspan="2"></td></tr>
</table>

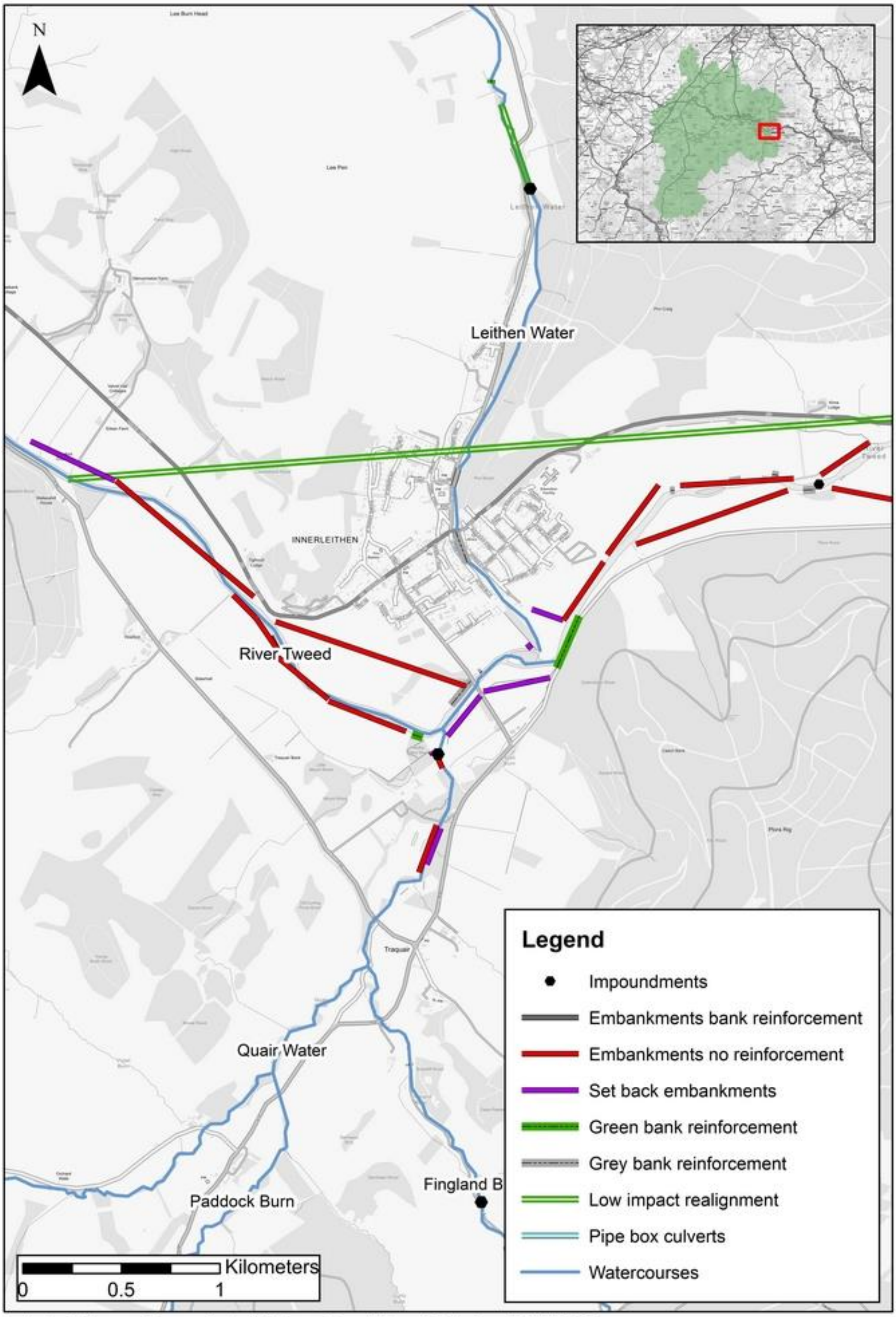
| Mill lade | |
|---|---|
| The lade has a capacity of less than the 2 year return period event at several of its culverts. Therefore water should be kept out of the lade from overland flow paths as part of the scheme if possible. |  |

## 2.5 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. The Leithen Water is characterised as being in 'Moderate' overall condition due to the presence of invasive species: North American signal crayfish. Its physical condition is 'Good' and there are limited pressures along it, as shown in Figure 2-2.

The Tweed at Innerleithen is characterised as being in 'Good' condition. There is potential for improvements on the Tweed but these are unlikely to affect the flood mechanisms from the Leithen Water.

Figure 2-2: Significant morphological pressures at Innerleithen



## 2.6 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.

Recommendations for NFM within the Leithen Water catchment are described in section 0 and are can be briefly summarised as: increasing buffer strips to 5m wide around watercourses that have limited bank vegetation, planting along contour woodland in the steep headwaters of Glentress Water and Glentress Burn. In upper catchments that are already highly forested, it is recommended that drainage and blocking furrows/ditches be investigated. Floodplain storage where the land is flat, along with livestock management to keep them away from riparian vegetation is also recommended (Figure 4-1).

## 2.7 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 and Leithen Water are characterised as a Special Area of Conservation (SAC) due to the presence of Atlantic Salmon, Otters, Lamprey and water-Crowfoot. The River Tweed is also a designated Site of Special Scientific Interest (SSSI) due to the additional presence of beetle, fly and vascular plant assemblages. The woodland habitat offers high ecological value for foraging Badger and so all workings and excavations should be covered overnight to prevent exploration by Badger, and night-time working should be avoided, which will protect the bats that are present in the area as well. In-channel works should be limited to August and September to avoid impacting on spawning and migrating seasons for fish. Depending on the design of proposed works, it may be necessary to conduct pond surveys to assess the presence of Great Crested Newts and an otter survey to assess the impact on holt sites and resting places. No non-native invasive species were found during the site visit.

## 2.8 Hydraulic modelling

A hydraulic model was developed, informed by the above-mentioned datasets, to estimate water levels during simulated floods. The following paragraphs are a summary of the model structure and the scenarios used to generate flood maps 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.

### 2.8.1 Model setup

As the Chapmans Burn is largely culverted it was decided that InfoWorks ICM (Integrated catchment management) was the most appropriate modelling software to use. While the Leithen Water was suited to FM-TUFLOW.

For the Leithen Water the modelling package used was Flood Modeller-TUFLOW, 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. 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 2m by TUFLOW for increased simulation efficiency.

A similar approach was employed the open channel section of Chapman's Burn while the culverted reaches were modelled in InfoWorks ICM. This software facilitates 1D/2D culvert modelling and allows culverts to surcharge and spill into the floodplain when there is sufficient head to demand it. The 2D model domain for each model was large enough to be outside the 1000 year flood extent. See Figure 1-2 and Figure 1-3 for a schematic model overview.

No photographic evidence or data is available with which to calibrate the Innerleithen models. In place of this information the time-varying model outputs have been interrogated to ensure that model flows follow reasonable flow paths and achieve sensible depths. Maximum flood depths appear realistic, water can leave the downstream domain with ease (i.e. no 'glass walling' or backing up), and a visual check suggests that extents and depth grids realistically align with the underlying topography. SEPA's existing flood map for this area has also been used to validate flood extents generated within this study and outputs align. Future modelling studies at this location will benefit from calibration data.

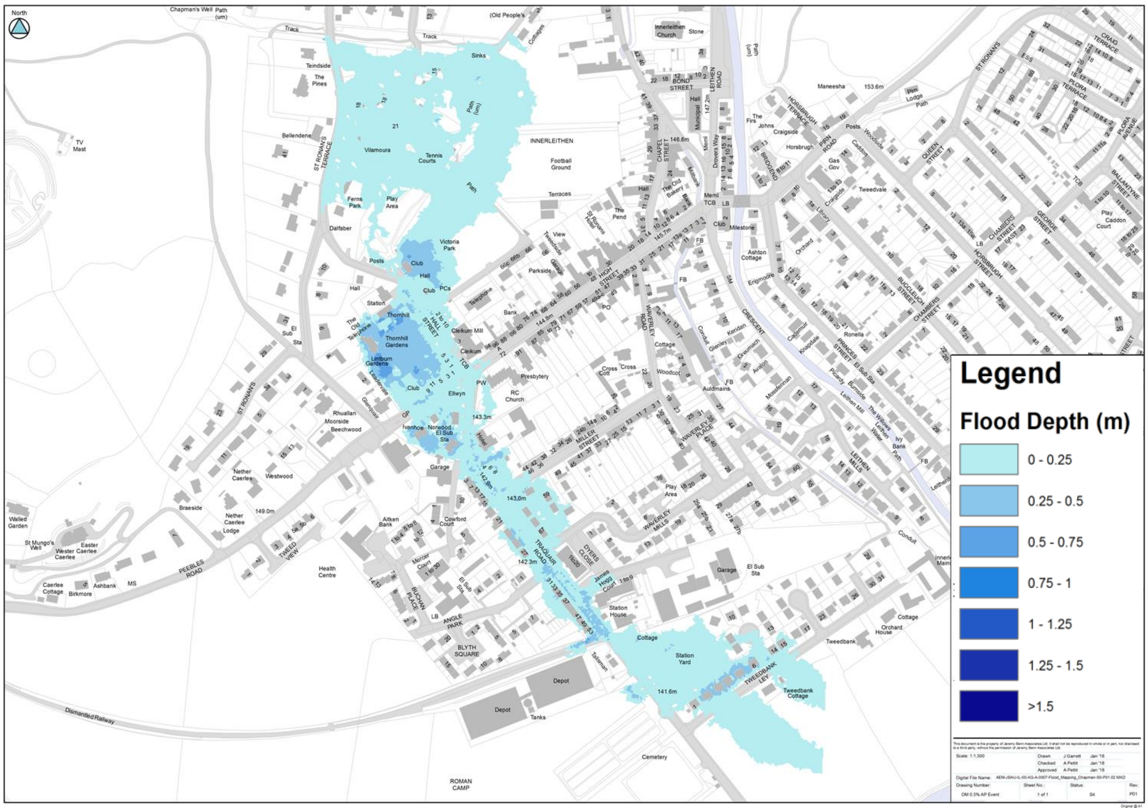
### 2.8.2 Model scenarios

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

### 2.8.3 Model results

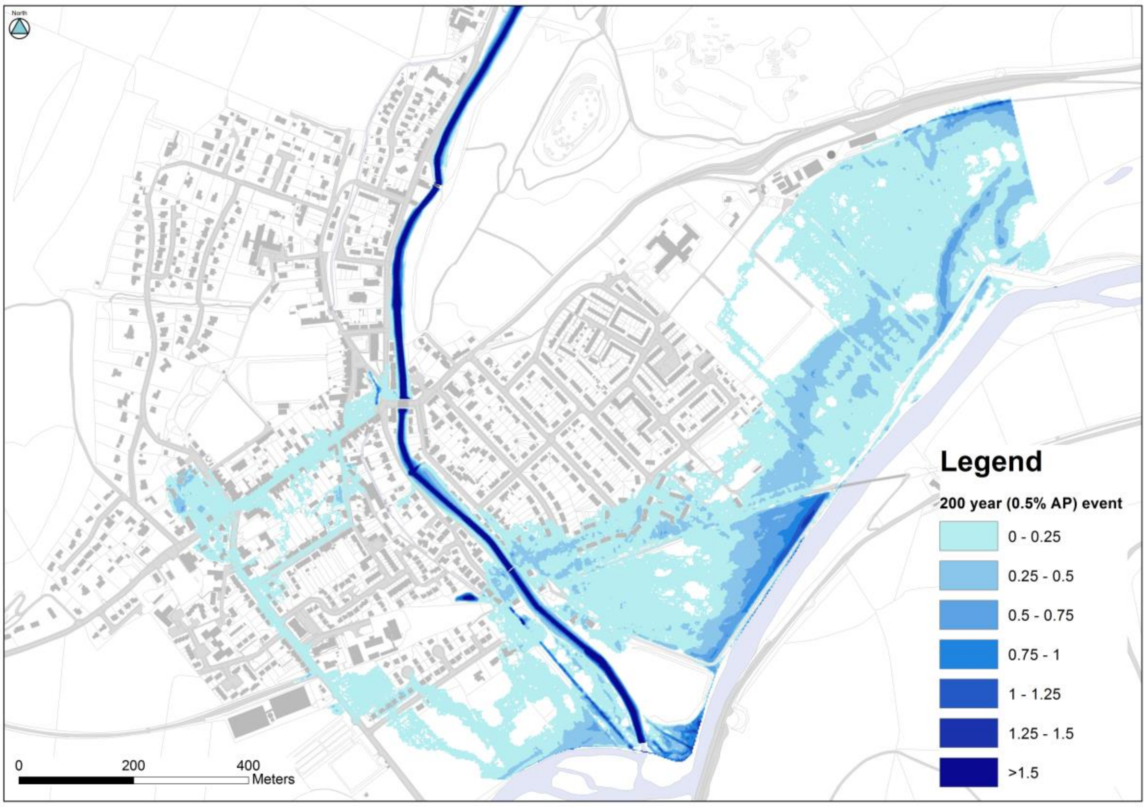
Figure 2-3 and Figure 2-4 is the 200 year flood depth map for the Do Minimum Scenario for the Chapman's Burn and Leithen Water respectively. The results show that the flooding mechanism for the Chapman's Burn is that of water overtopping the right bank, especially upstream of each of the structures. This is compounded with surcharging of manholes in numerous places along the length of the culvert. Out of bank flooding is seen from the 2 year flood event.

Figure 2-3: 200 year Do Minimum flood depth map for the Chapman's Burn




The Leithen Water has a higher standard of protection; out of bank flooding is not seen until the 25 year return period event. The flood mechanism for the Leithen water is out of bank flooding on the left bank on to Princes Street which propagates onto Montgomery Street. This is followed by out of bank flooding on the right bank with water flowing south through the end of Leithen Mills. For higher flows, 75 year return period event and above, water backs up sufficiently behind the A72 High Street bridge for water to overtop the right bank. The 100 year flood event is large enough to flow west along High Street and access Hall Street, Traquair Road and Waverley Road. The A72 Road Bridge can convey the 100 year flood event without causing enough constriction to cause a backing up behind the bridge. The footbridge downstream restricts flow at a flow rate less than the 50 year flood event.

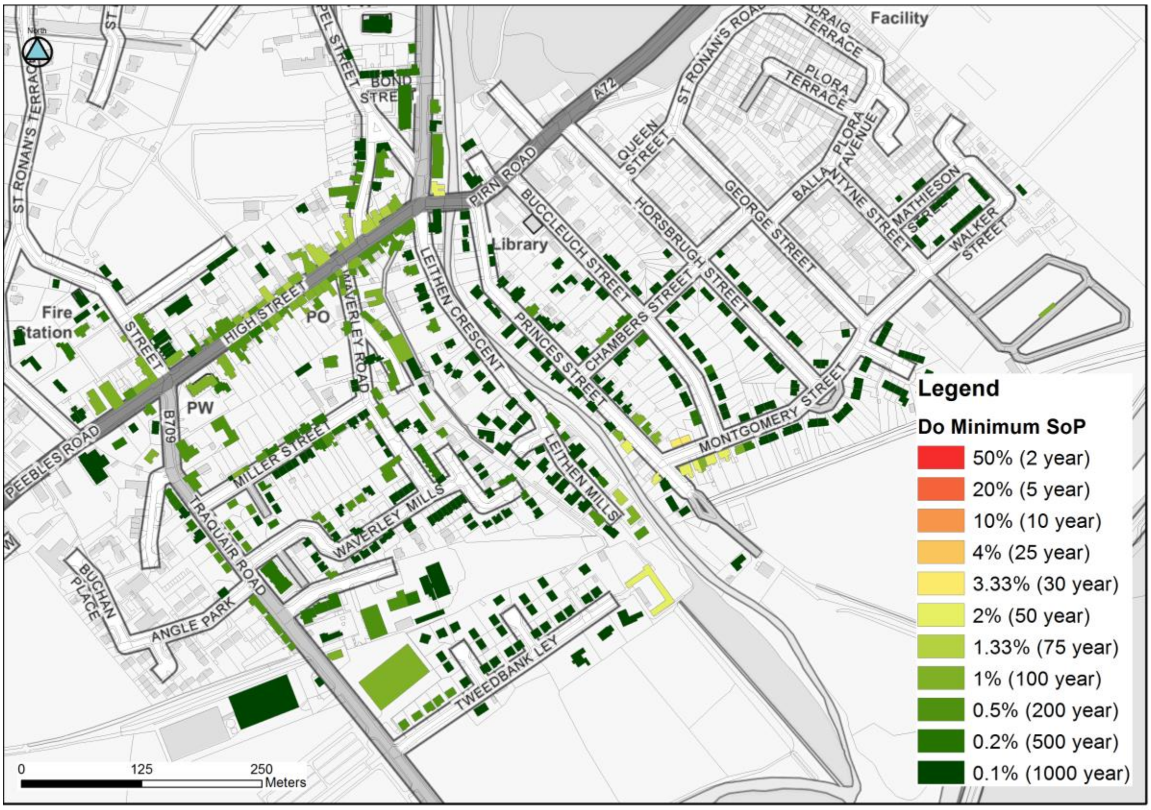
Figure 2-4: 200 year Do Minimum flood depth map for the Leithen Water




### 2.8.4 Current standard of protection

The Figure 2-5 and Figure 2-6 below shows the present-day level of protection for each property in Innerleithen from flooding from the Leithen Water and Chapman's Burn respectively. 'Standard of protection' is the largest flood event which is not expected to cause flooding to a property, larger magnitude events would be expected to cause property flooding. For example, a property with a 4% AP (25 year) standard of protection would be expected to flood at the 3.33% AP (30 year) flood.

Figure 2-5: Do Minimum Standard of Protectbion Map for the Leithen Water

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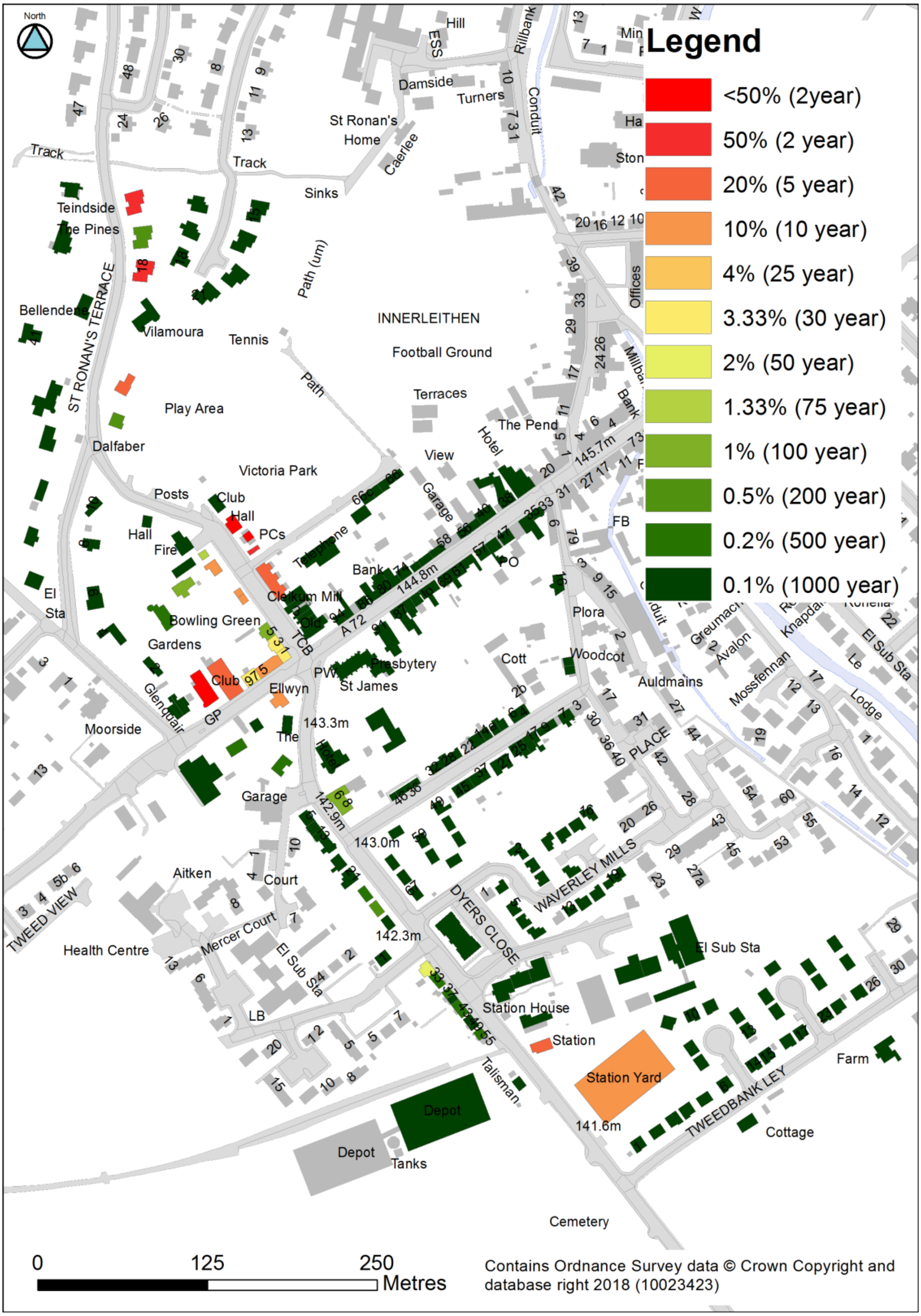
* The flood history suggests that the Vale & Leithen Social Club flooded from the June 2016 pluvial flood event. The property is shown to have a fluvial standard of protection of 1000 years, this suggests that the property is at a much greater risk from pluvial flooding than fluvial and/or the modelling does not accurately represent the geometry in this location.

Figure 2-6: Do Minimum Standard of Protection Map for Chapman's Burn




* The flood history suggests that property 21 on St Ronan's Way flooded from the June 2016 pluvial flood event. Survey threshold levels for properties in this area were unavailable so were estimated from LiDAR data. As the ground level slopes quite steeply in this area the floor level was difficult to estimate. This property is also within the flood extent from Chapman's Burn but has been allocated a high standard of protection. As the property has recently being affected from pluvial flooding its floor level is likely been over estimated.

### 2.8.5 The effect 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 once every 200 years at present would attain a frequency of approximately 60 years in the future. For Innerleithen the 200 year flood event with the effect of climate change is in excess of the 500 year flood event.

The 0.5% AP (200 year) event with a 33% increase for climate change produces a more extensive flood outline with greater flood depths. Figure 2-7 and Figure 2-8 show the difference between the present day and future 0.5% AP (200 year) flood outline as a result of climate change. The climate change simulation results in an enlarged flood extent and increased flood depths. The increase in flood depths is modest from the Chapmans Burn with the largest depth increase of approximately 170mm and an average of about 50mm. The increase in depth from the Leithen Water is more significant with a depth increase of about 300mm on average with some local places reaching depths of in excess of 450mm on Traquair Road and Leithen Crescent.

Figure 2-7: 200 year versus 200 year plus climate change outline from the Leithen Water

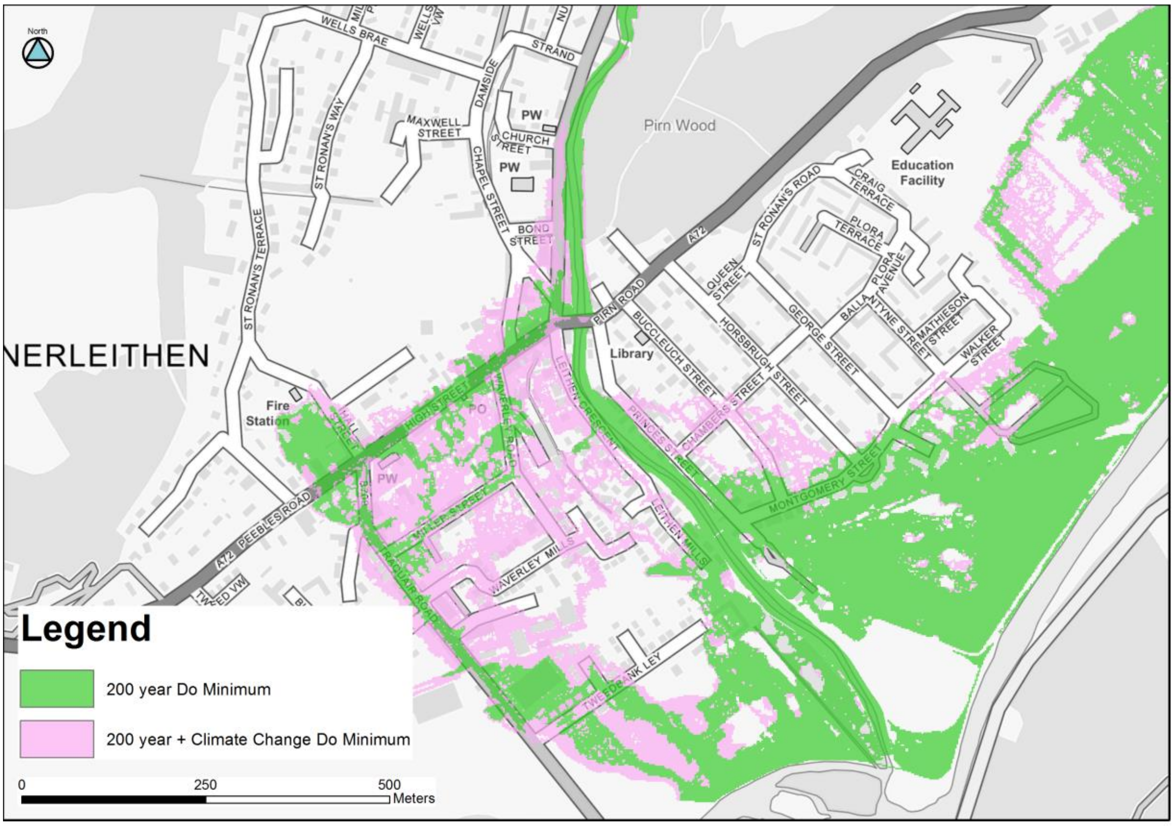
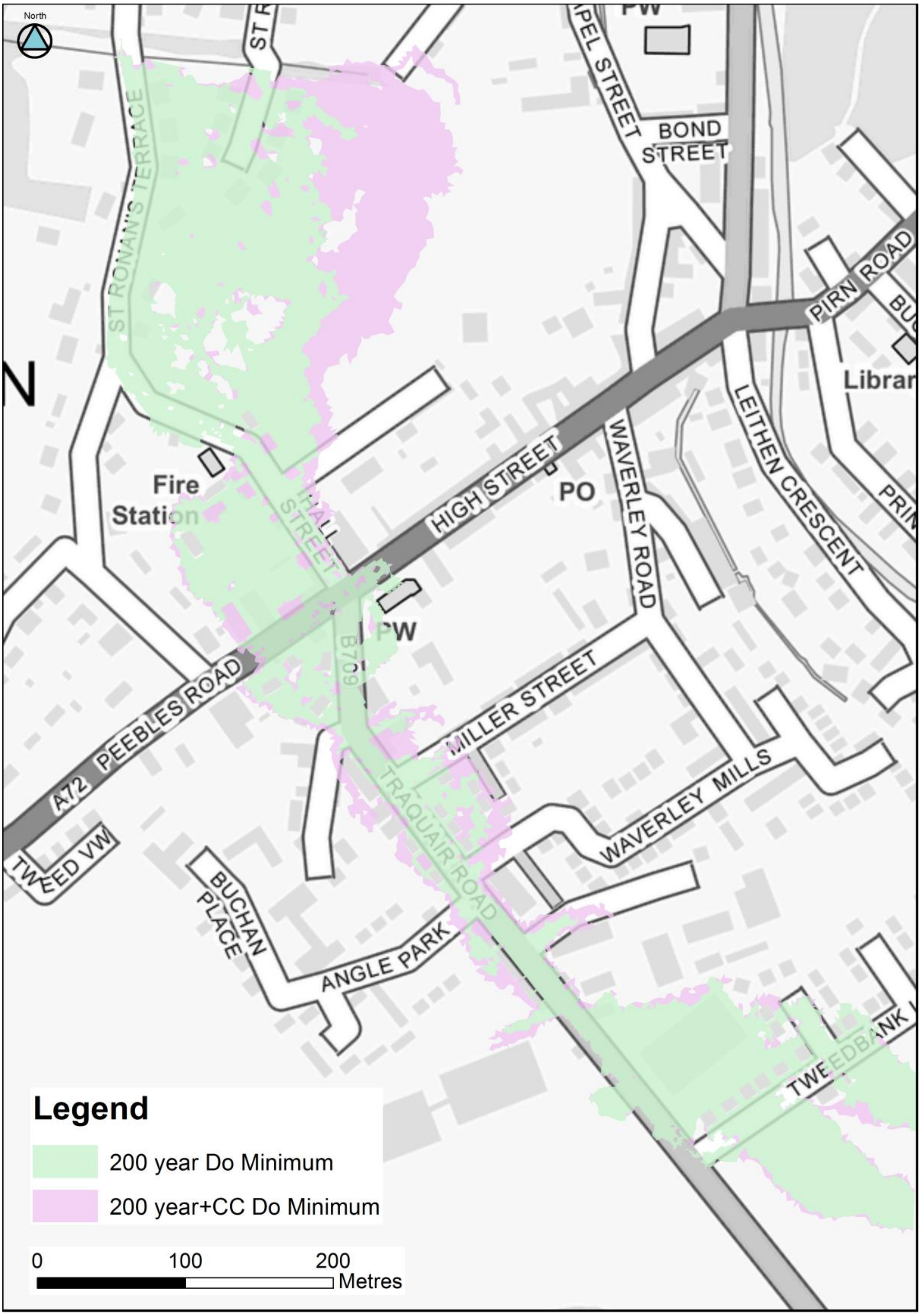


Figure 2-8: 200 year versus 200 year plus climate change comparison for the Chapman's Burn



# 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 currently 48 properties at risk from flooding from the Leithen Water and 31 properties from the Chapman's Burn for the 200 year flood event. Most of the flooding has a relatively shallow depth. The Leithen Water already has a 25 year standard of protection in place.

### 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; ceasing all maintenance and repairs to existing defences and watercourse activities. This therefore represents a scenario with no intervention in the natural processes and serves as a baseline against which all other options are compared.

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

### 3.2.2 Do Nothing

Under the Do Nothing scenario the watercourses would not be maintained. This would lead to a gradual degradation of the banks and vegetation growth. The Do Nothing scenario is represented in the model as a 20% increase in Manning's 'n' roughness from year 0 in the appraisal.

There are three key structures on the Chapmans Burn, two of which have a screen on the upstream face. The main culvert, screen and inlet structure are part of an FPS; the Council have a duty to inspect and maintain this asset. There is not a history of significant blockage, which may be in part be due to the presence of the screen on the culvert located upstream. Despite this, due to the wooded nature of the watercourse upstream a standard 2/3rds blockage would not be unusual for a maintained scenario at this structure.

The presence of the small culvert on St Ronan's Terrace and the screen on St Ronan's Way culvert, that was partially blocked by leaf litter during the site visits, illustrates that these upstream structures could block under both a Do Nothing and Do Minimum scenario. The small opening and lack of any in-stream debris collectors at the St Ronan's Terrace suggest that an appropriate blockage scenario for these culverts should be 2/3rds blockage under the Do Nothing scenario.

Table 3-1: Culvert inlets on the Chapman's Burn

| Main culvert inlet | St Ronan's Way screen | St Ronan's Terrace inlet |
|---|---|---|
|  |  |  |

On the Leithen Water bridge blockage has not been witnessed regularly, but the Council have in the past cleared a large log out of the watercourse in the reach downstream of the weir at the mill lade inlet. Due to this and the wooded nature of the upper catchment some allowance for blockage was applied. Blockage of the two main bridges is represented by lowering the soffit levels by 0.5m.

The weir at the top of the town is likely to deteriorate further, if no maintenance is undertaken on this structure. However, as any deterioration is unlikely to change flood flows downstream, no changes in the model have been made.

### 3.2.3 Do Minimum

The Do Minimum scenario effectively represents the current scenario whereby the watercourse and all structures are maintained and replaced if they deteriorate to a point that is unacceptable. The Council have a legal obligation to maintain the Chapman's Burn Culvert as it is a Flood Protection Scheme (FPS). Whilst maintenance is expected for the Chapman's Burn, due to the small catchments and rapid run-off, the ability to keep screens and culverts clear will mean that blockages could occur. A 1/3rd screen blockage scenario has therefore been assumed.

## 3.3 Aims of investment appraisal

The aim of the investment appraisal is to identify the properties that are most at risk, identify the flood mechanism, the damage that results from flooding and the cost of reducing or completing protecting against flood damage. Important infrastructure should be given special consideration as flooding to these properties could result in risk to life. In Innerleithen 4 electrical substations have been identified as being at flood risk. As well as identifying the most cost effective solution, the impact on the community, critical infrastructure and the environment are also considered.

# 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[1] 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) flood if possible, but to test lower return period events if appropriate.

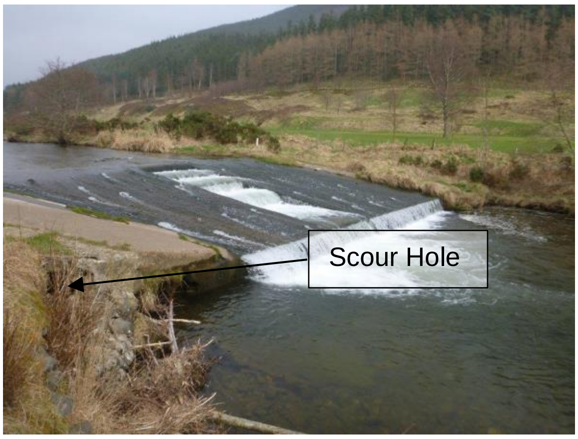
Based on the fact that 0.2% AP floods (1 in 50 year) have been witnessed recently on the River Tweed and other schemes within the Scottish Borders deliver a standard of protection in excess or to the 1:33% AP (75 year), it is not anticipated that a standard of protection less than this is deemed to be appropriate in terms of the critical success factors for this study.

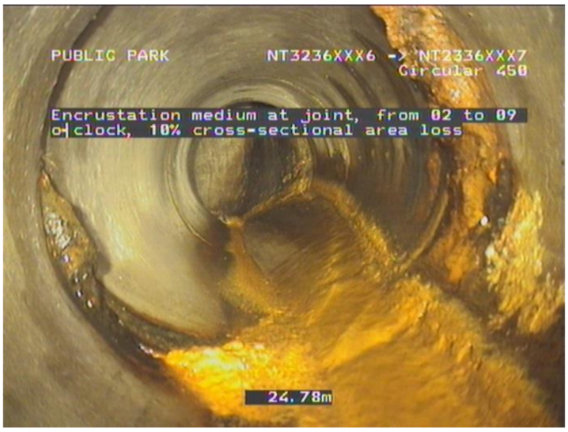
## 4.3 Short term structural and maintenance recommendations and quick wins

Several measures or short term 'quick wins' have been identified that cover a range of aspects from maintenance to small scale works. These are presented in report "AEM-JBAU-PB-00-RP-A-0002-Asset_condition_assessment-S0-P01.02" and summarised in Table 4-1.

[1] 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 Leithen Water (Ref 1-6), Chapman's Burn (Ref 7-9)

| Ref | Problem | Action | Photo |
|---|---|---|---|
| **Leithen Water** | | | |
| 1 | Minor cracks and deformity in masonry and concrete on structures | Monitor and repair if necessary | ***Downstream face of bridge***  ***Deformed stones on corner of right abutment*** |
| 2 | Scour on weir (at entrance to Mill Lade) | Repair to erosion and infill of scour hole.. | ***Scour hole next to right bank by weir.***   |
| 3 | Broken/removed weir at end of bank protection. | Remove broken weir. |  ***Gabion wall along left bank just downstream of bridge*** |

| | | | |
|---|---|---|---|
| 4 | Modelling has shown that the effects of bridge blockage can dramatically increase the number of properties at flood risk. As the Leithen Water has steep sided heavily wooded banks in its catchment placing an in channel coarse debris screen, similar to the image, is recommended upstream of the town as a "Quick Win." | |  **Coarse debris screen** |
| 5 | There are two narrow gaps between buildings on the right bank just upstream of the Main Street Road Bridge. These gaps become pathways for flood events with a 75 year or greater magnitude return period event. Placing a floodgate in each opening could help contain the flood flow to the Leithen Water at this location, preventing the flow path along the A72. (This issue is addressed as part of the Direct Defences option) | |  |
| 6 | Raising of footbridge at end of Montgomery Street and if feasible the A72 Road Bridge as a "Quick Win". See section 4.6.1 (This is incorporated into the Direct Defences option) | | |
| **Chapman's Burn** | | | |
| 7 | Joint displacement; silt and sand encrustation causing some blockage. Also some defective connections. | Keep culvert free of debris. Consider replacement in the future. |   ***Inside of culvert*** |

| | | | |
|---|---|---|---|
| 8 | Debris build-up with downstream of outlet roughly 30% blocked with silt | General vegetation maintenance and removal of built up silts. |  ***Semi blocked culvert outlet*** |
| 9 | The improvement of channel capacity in the Chapman's Burn could be considered as a FPS option or be undertaken a "Quick Win"<br>The improvement would require enlargement of the two smaller culverts and screens, lowering of the bed on approach to the existing FPS culvert and minor bank raising along the right bank<br>This is described in more detail in section 4.8.5 and is incorporated into each structural option proposed for the Chapman's Burn. | |  ***Culvert inlet*** |
| 10 | Installation of telemetry on the culvert screens on Chapman's Burn. If the culvert inlet shown in row 9 above is not upgraded, then a screen with telemetry is also recommended | | |

## 4.4 Non-structural flood risk management recommendations

### 4.4.1 Flood warning

Chapman's Burn does not have a flood forecasting system, however, even if it did it is likely to be ineffective at providing flood warning as the response time of the catchment to rainfall is very short and too short to give adequate warning to residents. A gauge on the burn would however give far greater confidence to hydrological analysis so that, in time, future flood estimates could be predicted with a smaller error range and could also be used for model calibration. To get a system set up quickly in the short term, the use of a third party river level monitor or those provided by Hydro-Logic and others could be considered.

The Leithen Water through Innerleithen has a SEPA Flood Warning system. There is a flood warning level gauge installed at the High Street Bridge. This system could be improved if the level gauge was converted to a flow gauge as it currently relies on a theoretical rating for this level gauge. Consideration should be given to installing an additional flow gauge further up the catchment which could provide additional warning time. SEPA should be consulted to discuss the system requirements to upgrade the flood warning system following a review of the flood warning performance.

### 4.4.2 Emergency action plans

The Council's Emergency Action Plan is the Severe Weather Plan which was updated in July 2018. This describes the Council's emergency response procedures, flood gate procedures and flood warning procedures. It has been designed to run as a standalone plan but can be run in conjunction with 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. The use of such warnings would need to be assisted through integration with the Council's emergency action plan[4] that would help define the process of how warnings would be disseminated to the public and the preparation of responses to such warnings. 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

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

businesses should flooding happen. This includes preparing a flood plan and flood kit, installing property level protection, signing up to the Resilient Communities Initiative, and ensuring that properties and businesses are insured against flood damage. A Flood Action Group could assist with this awareness raising and resilience.

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

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

### 4.4.4 Community sand **bag** stores

Scottish Borders Council continues to use community sandbag stores located at publicly accessible areas including fire stations and school grounds. The Innerleithen Fire Station store holds an estimated 300 sandbags. Resilient Communities sandbag stores are now widely distributed across the Scottish Borders in areas that have signed up to the Resilient Communities Initiative - this includes Innerleithen which holds an estimated 100 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 Innerleithen due to the short lead times. This approach would need to be combined with the above flood warning and flood awareness campaign

### 4.4.5 Property level protection (PLP)

The Council already have in place a flood protection products discount scheme which sells PLP products at subsided prices to assist home owners at risk purchase PLP for their property. In the past 5 years, no one in Innerleithen has availed themselves of this scheme yet. PLP could be implemented as a full FPS and be managed by the Council. PLP is discussed as an option in its own right later in the chapter.

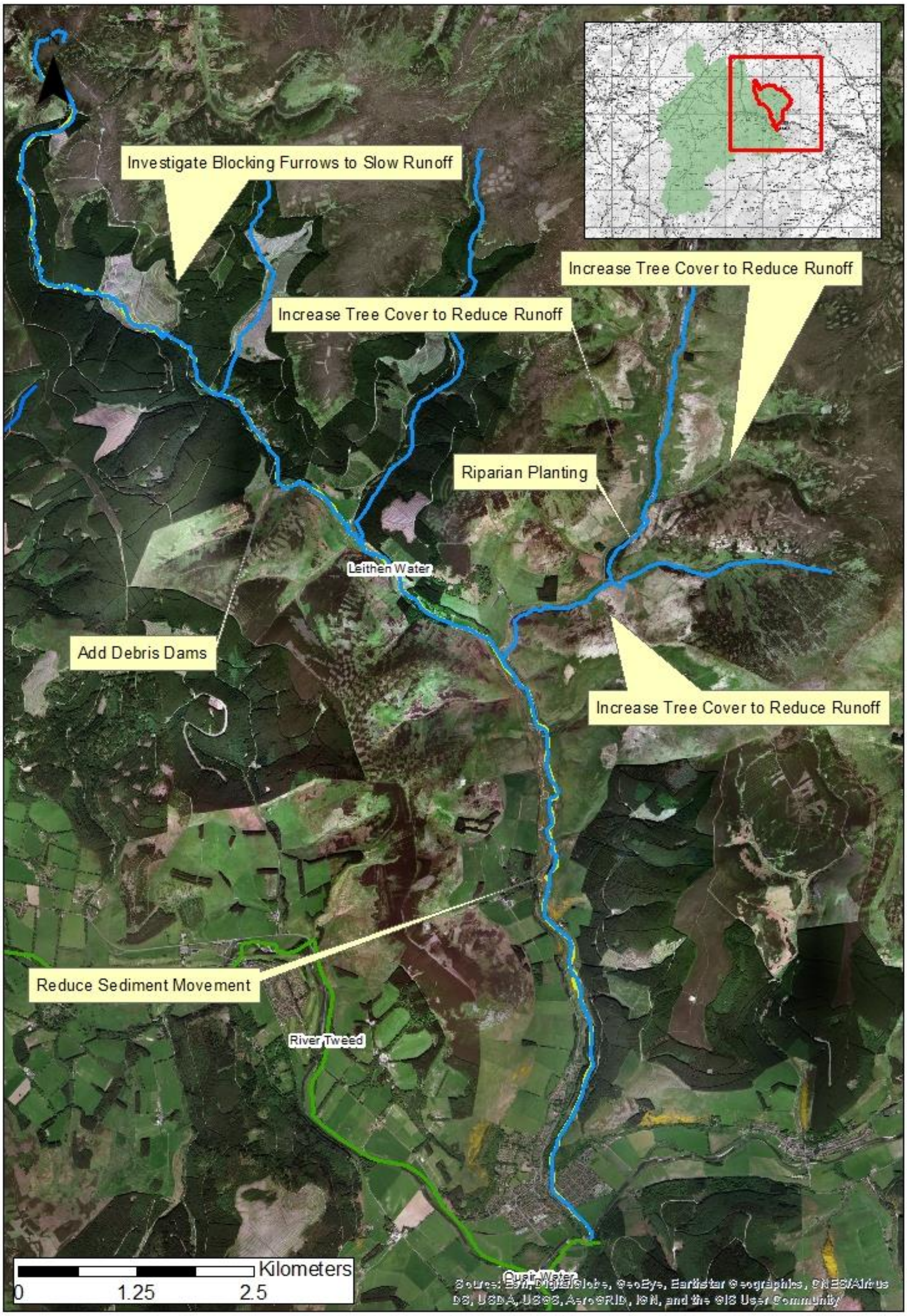
### 4.4.6 Natural Flood Management

Natural Flood Management options have been assessed as a standalone report listed in the supporting guidance section of this report, numerous NFM opportunities were identified. The Leithen Water has numerous opportunities for Natural Flood Management. A growing body of evidence suggests that careful introduction of NFM measures may allow for reduced river flows in some cases. The greatest benefits of NFM can be seen on smaller catchments. NFM measures which include woodland planting have a larger impact on flood risk reduction as they mature. Whilst the evidence for influence of NFM on flood flows is growing, the impact on larger flows at this stage appears minimal. Mature NFM measure may help to some extent to counteract climate change increases for the more frequent flows. For this reason we recommend that NFM measures be taken forward either alongside the more traditional short listed option or on their own if ultimately no other options are taken forward to outline design stage. The NFM measures which are likely to have the largest influence on reducing flood risk are listed below and displayed in Figure 4-1:

- Plant along contour woodland in the steep headwater sections of the Glentress Water and Glentress Burn.
- Provide additional buffer strips, at least 5m wide, around watercourses with limited bank and floodplain vegetation.
- Ensure livestock are kept away from riparian vegetation to prevent its loss and erosion of the banks.
- Install leaky bunds along the Glentress Water in the north of the catchment.
- Upper catchment already has extensive planting in place, with some natural woody debris dams, more debris dams could be constructed.
- In highly forested upper catchments consider investigating drainage and blocking furrows / ditches.
- Encourage floodplain storage in the upper Leithen Water where the land is flat through creation of wetlands

These measures will not interfere with any of the proposed options and could be implemented as soon as funding and consent is available. All of the above NFM measures require consultation and agreement from landowners, the purchase of LiDAR data and additional modelling. Meeting landowners to determine the level of acceptance could be carried out at the next stage.

Figure 4-1: Leithen Water NFM opportunities



### 4.4.7 Planning policy

The Scottish Government laid out several measures to promote sustainable flood risk management in the Scottish Planning Policy 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 Innerleithen 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 insights into the areas where Local Development Plans have allocated land for development which may be in a previously unidentified flood risk zone or that may be put at risk where the short-listed options listed below plan to use undeveloped land for the storage or conveyance of flood waters. An extract from the latest Innerleithen Local Development Plan[5] identifies some redevelopment, single properties, that is within the 200 year flood risk zone as well as redevelopment of Caerlee Mill which depending on the size of the redevelopment will impact of the 200 year flood outline. The Business and Industrial sites also lie within the flood risk zone but flood risk assessments are a requirement of the Local Development Plan prior to development of these sites.

## 4.5 Long List of Options

The following table provides an overview of potential flood alleviation options targeting flood risk from the Leithen Water and Chapman's Burn. 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.

Table 4-2: Long list of options

| Measure | Watercourse | Discussion |
|---|---|---|
| Relocation | **All** | **Technical**: Relocation or abandonment of properties not politically or socially viable. Option not cost effective as purchase costs will be same as capped damages.<br>**Environmental**: No significant environmental or RBMP benefits or impacts.<br>**Constraints**: Multiple objections likely if carried out via a FPS.<br>**Decision: Option discounted** |
| Flood warning | **Leithen Water** | **Technical**: FWA currently in place for Leithen Water at Innerleithen.<br>**Environmental**: No environmental or RBMP benefits or impacts.<br>**Constraints**: None<br>**Decision: Developing existing infrastructure should be considered** |
| | **Chapman's Burn** | **Technical**: No FWA currently for Chapman's Burn. Would require gauge installation or monitoring in order to inform alert stages. Additionally, the catchment response time is too short to provide a suitable warning time. Gauge installation would help with flow prediction and model calibration.<br>**Environmental**: No environmental or RBMP benefits or impacts.<br>**Constraints**: None<br>**Decision: Option discounted** |
| Resistance - means of | **All** | **Technical**: All Scottish Borders properties at risk of flooding are covered by the Flood Protection Products Discount scheme |

5 https://www.scotborders.gov.uk/downloads/file/873/innerleithen - LDP Settlement Profile Innerleithen

| Measure | Watercourse | Discussion |
|---|---|---|
| reducing water ingress into a property to enable faster recovery | | operated by the council. Further properties moving from reliance on the council emergency sandbag store in Innerleithen to retrofit Property Level Protection (PLP) products is likely to reduce property inundation during small floods. This option is particularly suited to tackle flooding from the Chapman's Burn as flood depths are shallow.<br>**Environmental**: No significant environmental or RBMP benefits or impacts.<br>**Constraints**: Unlikely to be accepted by the community as the only flood protection measure.<br>**Decision: Option taken forward** |
| Resilience - means of reducing the impacts of flood water ingress on a property to enable faster recovery | **All** | **Technical**: Extremely costly due to the number of properties at risk of flooding. Very intrusive to homes, restricting floor finishes to tiles, concrete or similar, upheaval electrical and mechanical systems in the house and large interior decoration requirements.<br>**Environmental**: No significant environmental or RBMP benefits or impacts.<br>**Constraints**: Multiple objections likely if carried out via a FPS.<br>**Decision: Unlikely to be economically viable at this stage. Option not progressed further.** |
| Watercourse maintenance | **All** | **Technical**: Maintenance of the watercourse plays a critical role in limiting flood risk. The modelling has shown there is a huge increase in flood damages if maintenance was to cease.<br>**Environmental**: Channel maintenance may have minor negative impacts if spawning areas disrupted but these are unlikely to be significant.<br>**Constraints**: Possible stretching of Council resources if further inspection/maintenance is proposed.<br>**Decision: Option taken forward** |
| Natural Flood Management (NFM) | **All** | Natural Flood Management options have been assessed as a standalone report.<br>**Option to be taken forward alongside other options** |
| Storage | **Leithen Water** | **Technical:** Limited potential on Leithen Water or main tributaries (Williamslee Burn, Craighope Burn, Glentress Water) due to presence of roads/access tracks in the valley bottom close to the watercourse. See section 4.6.2.<br>**Environmental**: Special Area of Conservation (SAC) designations along the Leithen Water. Disturbance to wildlife likely during construction. Potential benefits through new habitat creation.<br>**Constraints:** Leithen Water SAC, land ownership constraints likely to be encountered.<br>**Decision: Option reviewed further in Section 4.6.2 but ultimately discounted** |
| | **Chapman's Burn** | **Technical:** No suitable location in the upper catchment as the ground is very steep and wooded. Most of the catchment is within an urban area. Very limited space for a reservoir. However, a small storage reservoir could be incorporated into the playing fields in Victoria Park.<br>**Environmental**: Large scale destruction of woodland for little benefit if placed in the rural catchment. Could be implemented in the urban area without a negative impact on the environment.<br>**Constraints:** Lack of available space**.**<br>**Decision: Option to be taken forward alongside other options** |
| Control structures | **Leithen Water** | **Technical:** There are two narrow gaps between buildings on the right bank just upstream of the Main Street Road Bridge. These gaps become pathways for flood events with a 75 year or greater magnitude return period event. Placing a floodgate in |

| Measure | Watercourse | Discussion |
|---|---|---|
| | | each opening could help contain the flood flow to the Leithen Water at this location.<br>**Environmental:** Neutral effect<br>**Constraints:** Agreement from all landowners required.<br>**Decision: Quick Win or taken forward alongside other options** |
| | **Chapman's Burn** | **Technical**: Control structures in the form of sealed manholes and non-return valves on the incoming culverts could help to mitigate flooding from the current FPS culvert.<br>**Environmental**: No foreseeable negative environmental impact if carried out correctly<br>**Constraints**: The impact of non-return valves placed on culverts connected to the FPS Culvert and sealed manhole units have not been assessed on pipework which is not the FPS.<br>**Decision: Option to be taken forward alongside reservoir option** |
| Demountable defences | **All** | **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.<br>**Environmental:** No significant environmental or RBMP benefits or impacts although likely to be preferred from an environmental standpoint when compared to direct defences.<br>**Constraints:** Not enough lead time for deployment on Chapman's Burn with such a fast time to peak. Could be possible on the Leithen Water with advanced flood warning system but to protect against the 200 year flood event almost 1600m of demountable defences is required which would take a considerable about of time to put in place.<br>**Decision: Option discounted** |
| Direct defences | **Leithen Water** | **Technical:** Direct defences may be feasible in several locations along the watercourse in the form of a wall. Walls are more appropriate than embankments due to space availability and should be made adaptable where possible to accommodate future increase in flows due to climate change. In some locations, existing walls may be raised/improved to provide a better standard of protection.<br>**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.<br>**Constraints:** Some objections likely at public consultation, especially considering wall heights are 2m in some places, but in general likely to be an acceptable option.<br>**Decision: Option carried forward** |
| | **Chapman's Burn** | **Technical**: Direct defences could be used to help confine the flow to the open channel section.<br>**Environmental**: Direct defences likely to have negative RBMP impact through increased morphological pressure on the watercourse. However, the banks are anticipated to low. Does not help to alleviate flooding which surcharges the FPS culvert.<br>**Constraints**: the raised bank or wall will need to tie into culvert (upgraded) wingwalls, space maybe too limited to install an embankment in places.<br>**Decision: Option to be taken forward alongside other options** |
| Channel modification | **Leithen Water** | **Technical**: Channel deepening to a depth of 0.5m downstream of the old stone arch bridge by Leithen House to the confluence with the River Tweed contains the 200 year flood event on the Leithen Water. |

| Measure | Watercourse | Discussion |
|---|---|---|
| | | **Environmental**: The Leithen Water is classified as a Special Area of Conservation (SAC). Digging out the channel like this would have considerable environmental impacts including destruction of sensitive habitats e.g. fish spawning grounds. No significant environmental benefits. See section 4.6.3.<br>**Constraints**: Leithen Water is a SAC therefore unlikely to be permissible. This approach is not sustainable as the dredging would have to be repeated regularly to maintain the channel deepening and given the tight constraints of the urban environment the channel banks will likely require substantial support in the form of piling or similar.<br>**Decision: Option discounted** |
| | **Chapman's Burn** | **Technical**: Channel deepening possible in some locations to increase channel conveyance.<br>**Environmental**: Some negative environmental impacts including short term destruction of habitats.<br>**Constraints**: None<br>**Decision: Option to be taken forward alongside other options** |
| Diversion | **All** | **Technical**: Limited scope for channel diversion due to the presence of an urban area and topographic constrictions. Use of the Mill Lade to convey additional flows not possible due to low capacity and highly constrained channel and structures.<br>**Environmental**: May remove other valuable habitats in the short term but if bypass was naturalised then could provide RBMP benefits.<br>**Constraints**: Topography does not promote diversion.<br>**Decision: Option discounted** |
| Structure modification | **Leithen Water** | **Technical**: The footbridge at the end of Montgomery Street and the A72 road bridge are both significant constrictions to flow. Bridge conveyance is good as structures are in good condition and have no piers or other obstructions to flow. Therefore, there is little scope from improving conveyance on these structures without raising them.<br>**Environmental**: Net improvement in RMBP impacts likely if bridges are widened or raised but changes are unlikely to be significant.<br>**Constraints**: Cost of raising the bridges and associated tie in work.<br>**Decision: Quick Win or taken forward alongside other options** |
| | **Chapman's Burn** | **Technical**: The FPS culvert could be enlarged to convey the 200 year flood event.<br>**Environmental**: Water from the Chapman's Burn would need to be over-pumped to bypass the upgrade for the duration of the works.<br>**Constraints**: Enlarging the culvert would cause serious disruption to the town of Innerleithen as the upgrade would require digging up the street to below the invert of the pipe and replacement with a larger culvert. There is also a very large cost associated with this work.<br>**Decision: Option to be taken forward alongside other options** |

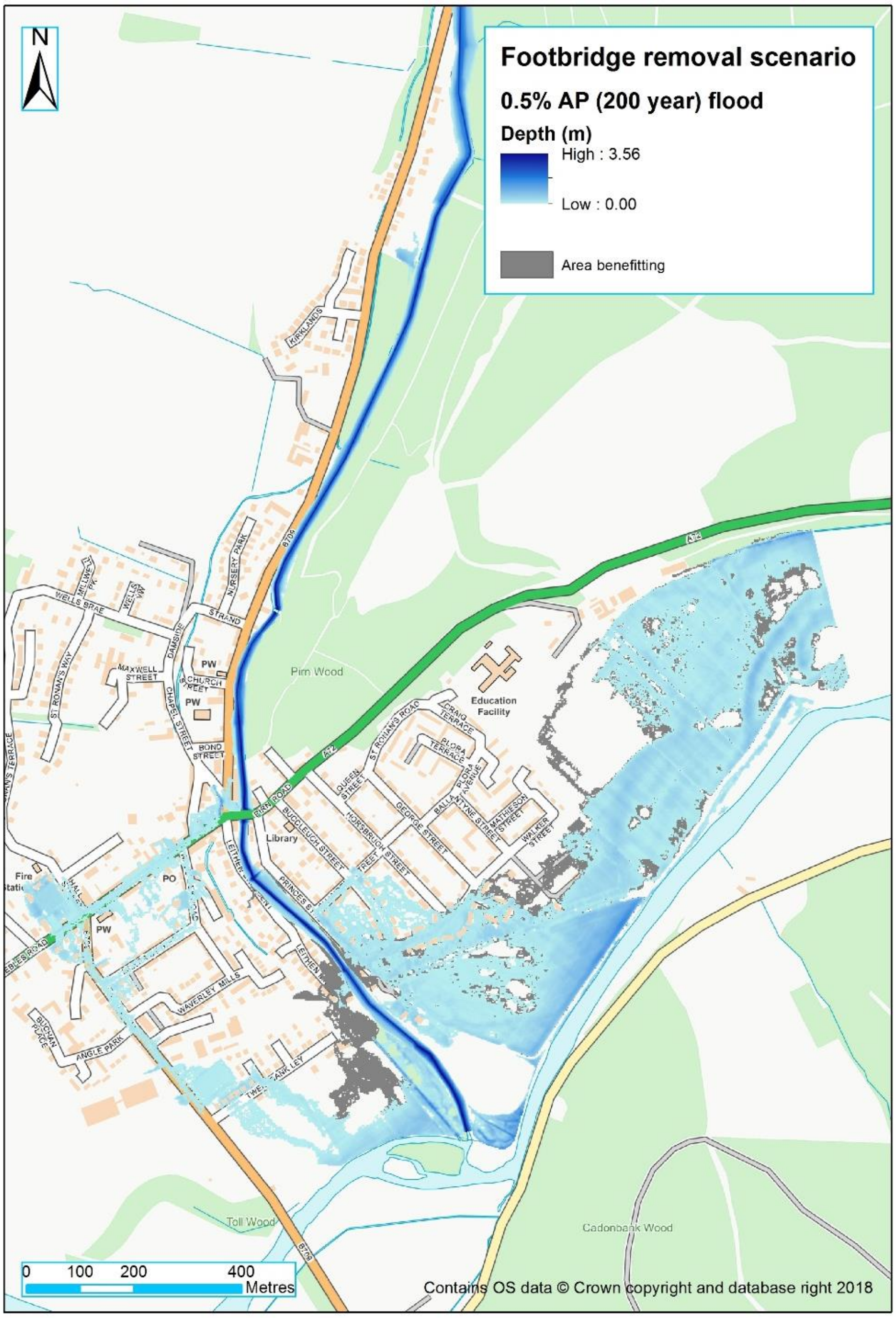
## 4.6 Feasibility study

The feasibility study worked on the basis that an option should be considered viable until proven otherwise. The justification for the elimination of those options which required modelling are described in the following section.

### 4.6.1 Removal of footbridge at end of Montgomery Street

The impact of removing the footbridge at the end of Montgomery Street, which presents a constriction to flow in events greater than the 10% AP event, was tested. There is also the potential to modify the bridge, so that the soffit is sufficiently high to not be a constriction to flow in high magnitude events. This was carried out by removing the bridge section from the 1D model and the corresponding node connections in the 2D domain. The impact of the removal of the footbridge is shown in Figure 4-2. Water levels in the 0.5% AP event immediately upstream of the bridge location are reduced by 0.45m in the bridge removal scenario, and out of bank flow is significantly reduced on the right bank. However, the flood extent on the left bank is still considerable enough to flood many properties. Therefore, this is unlikely to be an acceptable option to take forward as a standalone option for appraisal, however, could be considered as a "Quick Win" or be carried out in conjunction with another option.

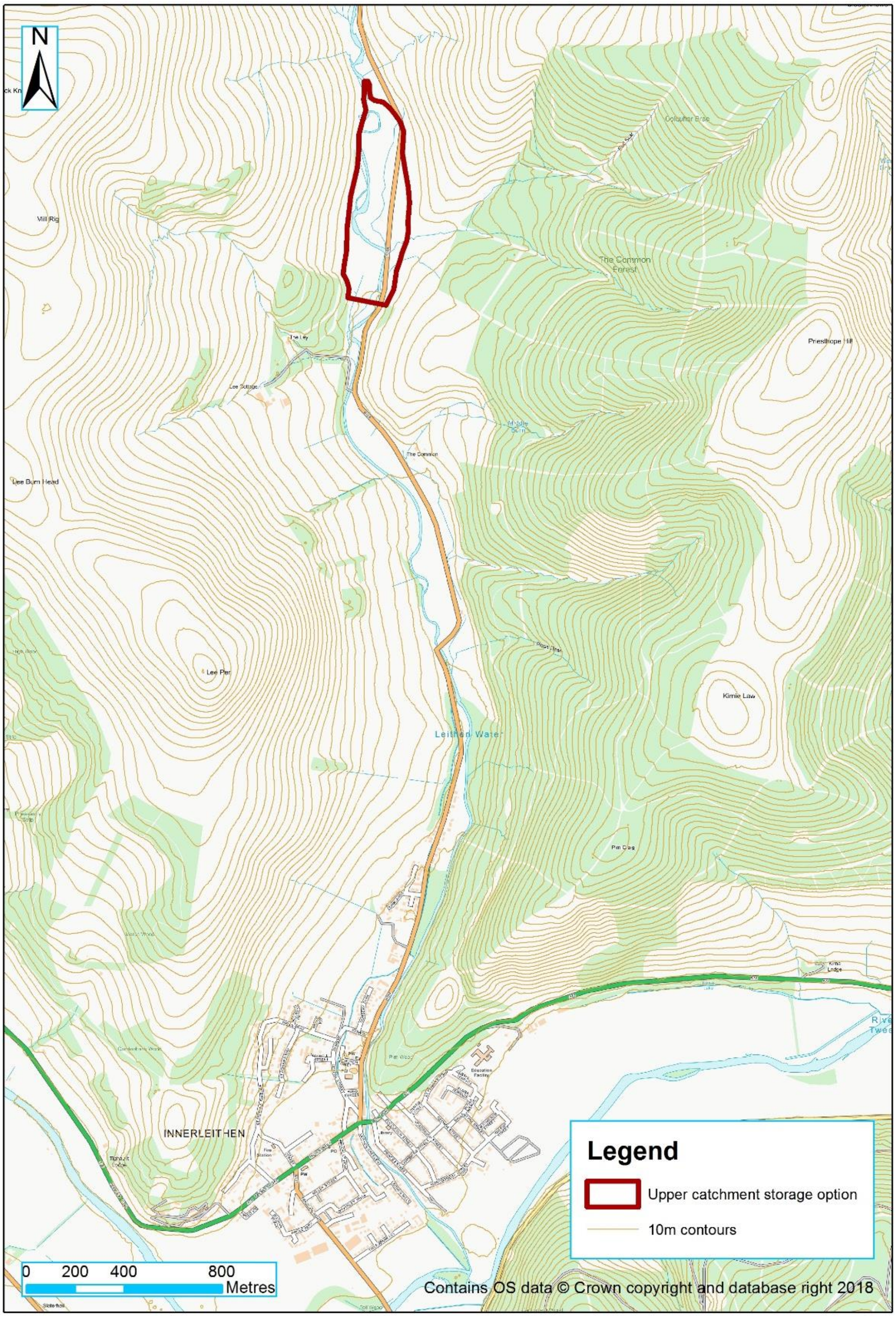
Figure 4-2: Impact of removal of the footbridge at the end of Montgomery Street on flood extent in the 0.5% AP event



### 4.6.2 Storage analysis on the Leithen Water

For a storage option to have any meaningfull effect on flood risk reduction from the Leithen Water it would have to be able to store a very large volume of water. The natural topography through which the Leithen Water flows was examined to identify the most suitable place to form a storage area with minimal amount of excavation or construction. The most suitable location identified is shown in Figure 4-3 and was tested for suitability using a reservoir unit in Flood Modeller.

Figure 4-3: Location of storage option on the Leithen Water



A basic Flood Modeller model was built to test the attenuation of flows by creating an orifice opening and the storage behind a theoretical dam structure. The storage behind the dam was based on an area/elevation relationship extracted from 5m resolution NextMap data.

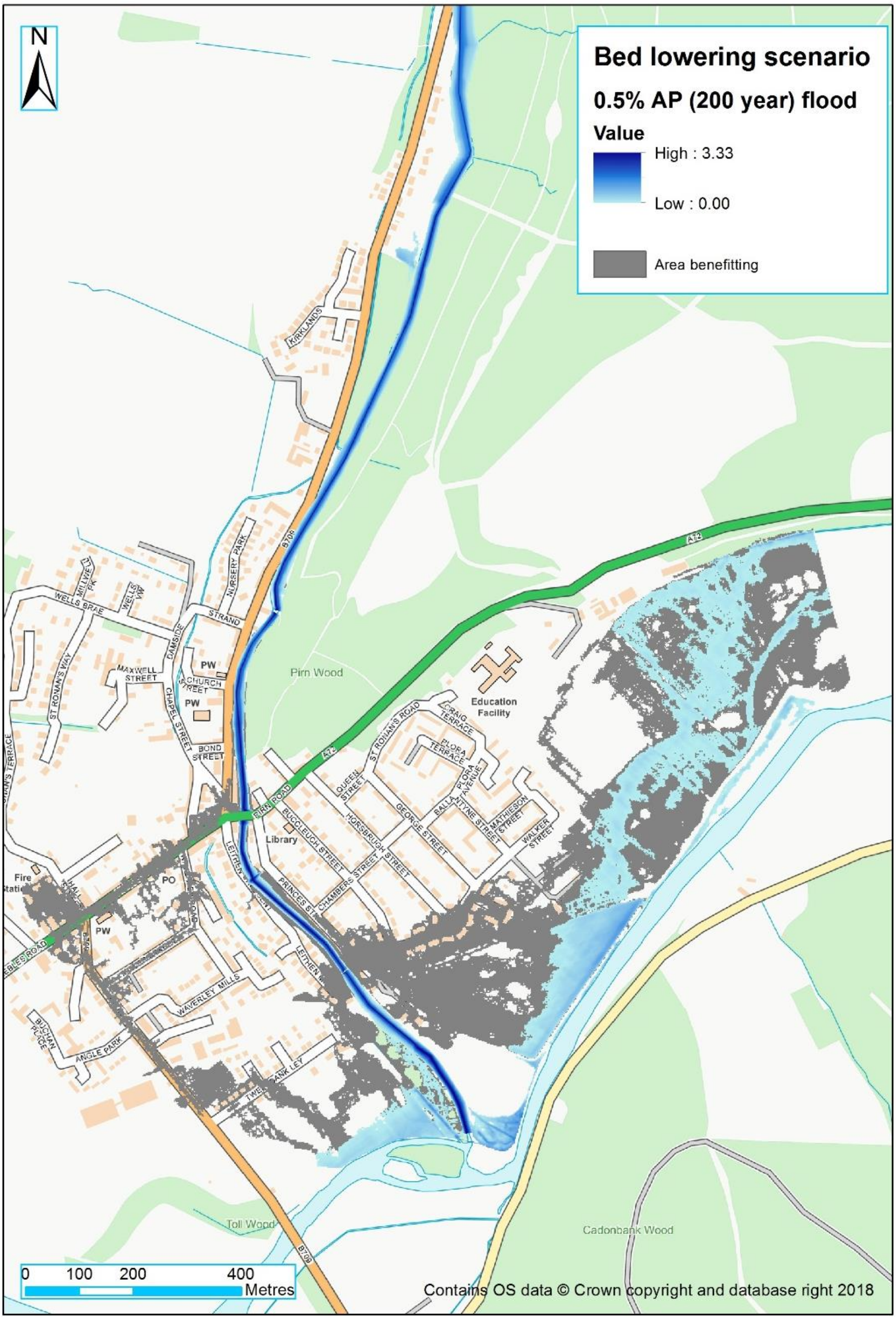
The model was tested with an orifice area that limits flow to 55.53$m^3$/s in the downstream urban reach (the flow that the current watercourse can convey before property flooding occurs). An orifice area of 5.6$m^2$ was required, resulting in a maximum water level in the storage area of 198.96mAOD (9.54m above bed level).

The results suggest that a significant structure would be required to store and attenuate flood flows in the upper catchment, which would have significant aesthetic implications and would require the rerouting of a section of road. The construction of the embankment, rerouting of the road and compensation costs for the loss of land are likely to be very high, therefore outweighing any benefits in terms of flood risk. The occasional storage of large volumes of water directly upstream of an urbanised area would represent a new risk and a critical maintenance burden for the Council, due to upkeep of the embankment and regular removal of sediment build up behind the structure. Environmental constraints include the SAC along the Leithen Water. For these reasons, the option for storage on the Leithen Water has been discounted and is not appraised further in the short listed options.

### 4.6.3 Channel deepening analysis on the Leithen Water

The possibility of increasing channel capacity through deepening the channel (i.e. by removal of sediment) was considered. This option was tested between downstream of the arch bridge (by Leithen House) and the confluence with the River Tweed by reducing the bed level of the 1D channel by 0.5m. This option was considered in an attempt to improve channel capacity and conveyance. The results of the analysis when compared to the Do Minimum 0.5% AP flood extent are shown in Figure 4-4. The modelling suggests that flood extents are sufficiently reduced in the bed lowering scenario to prevent property flooding in the 0.5% AP event. However, technical and environmental constraints are considered too great compared to the estimated reduction in flooding. The deepened channel would require regular work to maintain its depth and extensive bank stabilisation and scour protection works would be required to make this a sustainable option. Furthermore, it is likely that the bed level would gradually revert to the historic natural level and grade, requiring additional and intermittent in-channel works, making the solution unsustainable geomorphologically. For these reasons this option is not seen as a long-term strategy for the reduction of flood risk and has not been carried forward beyond this stage of analysis.

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



## 4.7 Short list of options

Watercourse maintenance and NFM shall be implemented to some extent with all short listed options. The following options have been short listed:

For the Leithen Water

- PLP
- Direct defences

For the Chapman's Burn

- PLP
- Channel improvement, reservoir and sealing of manholes
- Channel improvement and culvert upgrade

### 4.7.1 Designing for climate change

In line with Scottish Planning Policy, the goal for the chosen scheme was a 0.5% AP (200 year) standard of protection. 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.

## 4.8 Flood Mitigation Options - Innerleithen

The following section details the constraints and benefits of the shortlisted options for the Leithen Water and Chapman's Burn. A plan is included which shows the location, extents and the area benefiting for the various interventions.

### 4.8.1 Option 1 - Property Level Protection (PLP) - Applicable to Leithen Water and Chapman's Burn

| Option 1 - Property Level Protection (PLP) |
| --- |
| **Description**<br>This option aims to provide an increase in standard of protection for all properties where required by protecting properties 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 against flooding from the Chapman's Burn is 24 and from the Leithen Water is 47. There is, however, an overlap of properties between the watercourses so the overall number of properties requiring PLP will be less than the combined number. |

Figure 4-5: PLP option for 200 year Chapman's Burn flood event

Figure 4-6: PLP option for 200 year Leithen Water flood event


## Standard of Protection (SOP)

Modelling suggests that PLP will protect all residential properties and all bar 5 non-residential properties in Innerleithen up to the 200 year flood event.

## Alternative quick wins / Preliminary investigations

Continue with Council subsided PLP scheme for properties which opt for it in the short term.

| 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 significant increase costs. |
| **Additional works required to account for increase in 200 year flow due to climate change** |
| If climate change is to be accounted for then additional measures will be needed, flooding from the Leithen Water will make 2 properties unsuitable for PLP and an additional 140 properties will require PLP to protect against flooding from the Leithen Water. 7 additional properties will no longer be protected by PLP from the Chapman's Burn and 6 additional properties will require PLP from increased depth of flooding from Chapman's Burn. |

#### 4.8.2 Option 2 - Construction of a flood wall along the Leithen Water

**Option 2 - Construction of a suite of direct defences across Peebles**

**Description**

This option aims to provide a 200 year standard of protection through the installation of flood walls. At first the flood walls protected all properties within the flood extent, however, this option proved too costly and invasive into people's properties. The option was revised to the absolute minimum length required. This means that several properties will be affected by flooding but to a level below the property threshold level. The affected properties are largely located along the left bank of the Leithen Water between the High Street Bridge and the footbridge downstream. These properties will likely suffer a small amount of damage in large flood events.

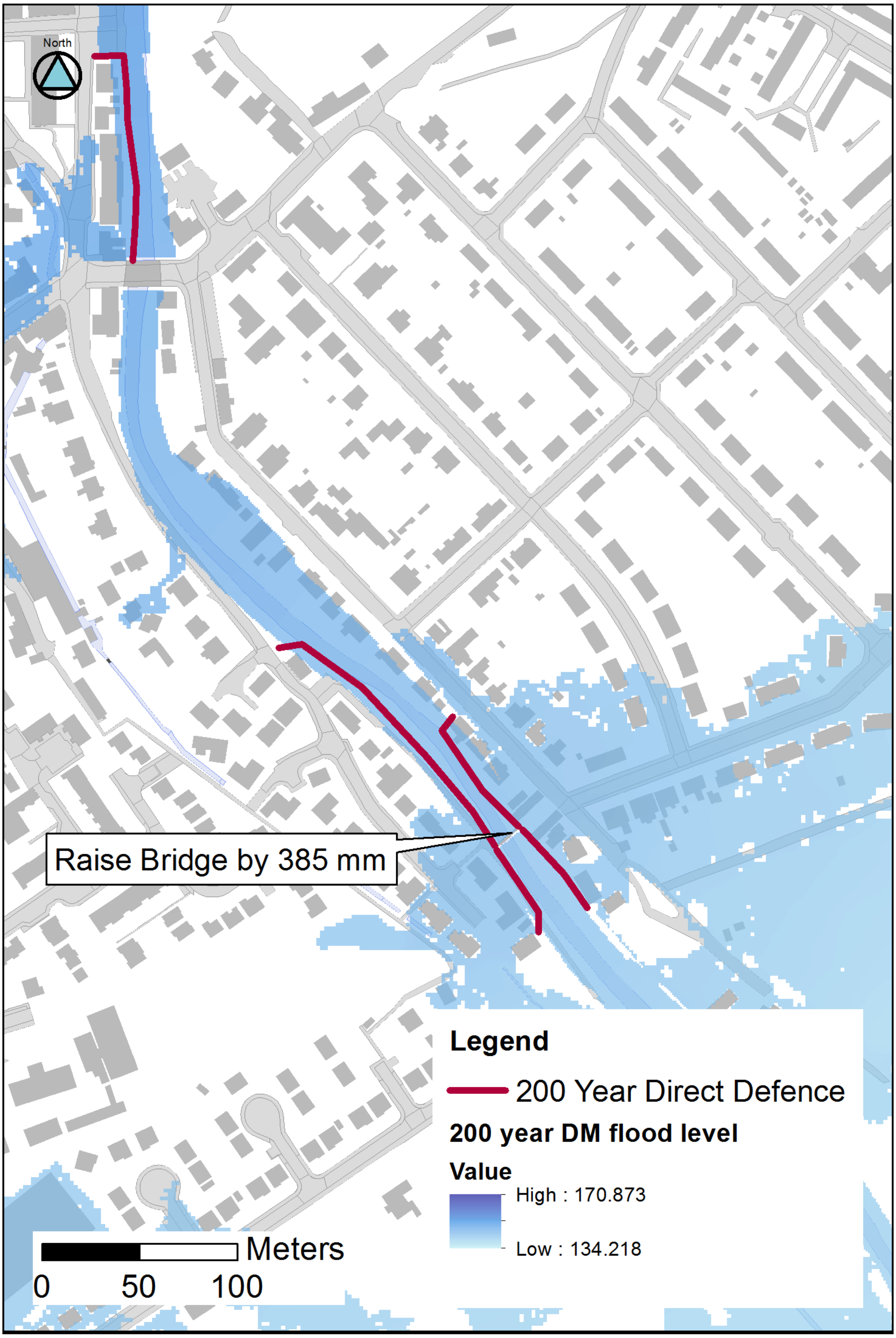
The flood wall placement is shown in Figure 4-7. 5 lengths of wall are required as shown in Table 4-3 :

Table 4-3: Direct defences wall heights and lengths

| Location | Length (m) | Average height with freeboard (mm) |
|---|---|---|
| **Right bank upstream of A72 Road Bridge** | 120 | 650 |
| **Right bank upstream of footbridge** | 155 | 750 |
| **Left bank upstream of footbridge** | 75 | 900 |
| **Right bank downstream of footbridge** | 50 | 450 |
| **Left bank downstream of footbridge** | 50 | 450 |

See drawing "AEM-JBAU-IL-LW-SK-C-1300-Opt1_200Yr _Direct_Def-S3-P01.pdf" for further details

Figure 4-7: 200 year Direct Defences Option



**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 for all properties. This equates to a flow of approximately 73$m^3$/s.

**Alternative quick wins / Preliminary investigations**

Shorter wall lengths and wall raising could offer a lower standard of protection but for a lower cost.

**Geotechnical issues**

Available readily available ground information is provided in the BGS Data Reference drawing; AEM-JBAU-IL-00-SK-C-1002-BGS_Existing_Ground_Data.

- A review of available BGS borehole logs and mapping of superficial deposits indicates that most of the walls are likely to be constructed on clay, sandy or silty deposits.
- It is assumed that a full GI will be required at a later stage in the project.

**Services**

- Overhead and underground services have been identified and their location is shown on drawing AEM-JBAU-IL-00-SK-C-1003-Services_Plan
- A communication overhead cable has been identified close to the wall on right bank downstream.
- Water main and SGN gas main close to flood wall on right bank upstream. A Scottish Water main is located directly upstream of the A72 bridge, on the left bank. A water main and a combined sewer cross the Leithen Water, approximately 350m and 370m downstream of the A72 bridge, respectively.

**Construction access**

- Construction access to right bank: Easy access from Leithen Road to right bank – temporary closure of road.
- Construction access to left bank will be mainly through private gardens.

**Waste**

According to SEPA regulations, before excavation the soil will be assessed for suitability to be classified as greenfield soil and the end-use of the soil will be identified. Soil must be of undeveloped, uncontaminated land, agricultural and forestry land or uncontaminated overburden from mining and quarries and can include vegetation i.e. grass, turf, mulch and leaf debris, but not tree stumps. The soil could be used to another development for engineering works as per the planning permission, in development on brownfield land to meet site-specific capping requirements for remediation, in SUDS and in the construction of roads and verges. A planning permission specifying the volumes of greenfield soil excavated is required.

- Expected quantity of waste material: Approximately 863$m^3$.
- Nature (inert, non-hazardous, hazardous): Cognisance of historical industry in the vicinity of the watercourse including gasworks (Leithen Crescent), woollen mills, sawmills and slaughter houses - residual risk to be considered at detailed design.
- Proposed disposal will be according to SEPA guidance.

**Environmental issues**

- Statutory Environmental Designations (SSSI, SPA, SAC, Ramsar Sites Nature Reserves, INNS). Leithen Water has been identified as a special area of conservation (SAC). Most of the area within the boundaries is also a Special Conservation Area (SAC), including Leithen Road, High Street and Leithen Crescent.
- Landscape designation - Innerleithen Conservation Area - consideration required at detailed design for wall materials and specification along Leithen Crescent and along the 100m within the Conservation Area along Leithen Road.
- Habitat: The area upstream of A72 bridge is a National Forest Inventory with mixed, mainly broadleaved trees and windthrow. Habitat Regulations Appraisal (HRA) and Appropriate Assessment required for Natura (SAC and SPA) site. Additional surveys / assessments required for the impacts of proposed works on bats, breeding birds, otter, fish and water quality are required.
- Scheduled Monuments: Pirn Wood Fort approximately 400m north of A72.
- Listed Buildings: A number of listed buildings within the site boundaries.
- Trees; TPO: A few trees may need to be removed - loss of visual amenity and habitat.

Replanting proposals to be considered at detailed design.

- Hydromorphology - further assessments of flow, channel substrate may be required
- Consultation with SNH and SEPA required

**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.
- Flooding of construction works.

**Social and community issues**

- Some aesthetic issues are anticipated as this option has been designed to mitigate flood risk to extreme flood events, in some locations the wall will be above eye level. In particular, this option limits physical and visual access to the river along the west bank.

**Impact on other reaches**

The Leithen Water discharges directly into the River Tweed after passing through Innerleithen. As the water is contained by the walls, causing more water to reach the River Tweed in a shorter period of time, it is anticipated that there will be an increase in flow on the River Tweed. Given the relative size of the River Tweed to the Leithen Water the increase is anticipated to be small.

**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 in 200 year flow due to climate change**

- The 200 year with climate change option was assessed, initial modelling showed that wall lengths need to be increased to approximately 800m and wall heights increase significantly, it is likely that the A72 Road bridge would also require raising. The wall heights upstream of the road bridge would need to be raised by 1.35m on top of the 200 year flood defence level if the bridge was not raised.

### 4.8.3 Option 3 - Chapman's Burn channel improvement with culvert upgrade

**Option 3 - Channel improvements with culvert upgrade**

**Description**

This option aims to provide a 200 year standard of protection through increased conveyance through the open channel of Chapman's Burn with a greatly increased culvert diameter of the existing FPS culvert and is graphically represented in Figure 4-7.

The following improvements are proposed for the channel upgrade:

- Low section, approximately 3m length on right bank upstream of culvert on St Ronan's Terrace to be raised to 170.77 mAOD. A maximum increase in height of 0.9m.
- Culvert at St Ronan's Terrace to be replaced with an 850mm diameter culvert and head wall raised to top of bank level, 170.77 mAOD. Invert of soffit to be lowered by 0.87m to accommodate new culvert.
- Raise a 10m length of the right bank upstream of the FPS culvert by a height of 0.45m.
- Lower 10m length of channel on approach to FPS culvert. Maximum bed lowering at culvert face to be 0.59m, gradually tie into existing channel bed upstream.
- Oversize the replacement thrash screen on FPS culvert to reduce head loss across the culvert and design in a manner that allows for safe removal of debris.

The existing FPS culvert is to be enlarged along its entire length of 1,140m. The increase in culvert diameter is displayed in the Table 4-2. See drawing "AEM-JBAU-IL-CB-SK-C-1100-

Opt2_200Yr_Chan_Up_New_Cul-S3-P01" for further details and a map showing the location of each culvert.

Table 4-4: Option 3 culvert upgrade dimensions

| Culvert start | Existing Culvert diameter (mm) | Proposed Culvert diameter (mm) |
|---|---|---|
| **NT32368901** | 280 | 900 |
| **Inlet_0000** | 300 | 1200 |
| **XXX1** | 300 | 900 |
| **XXX3** | 450 | 900 |
| **XXX4** | 450 | 900 |
| **XXX5** | 450 | 900 |
| **XXX6** | 450 | 900 |
| **XXX7** | 600 | 900 |
| **XXX8** | 600 | 900 |
| **XXX9 UTR** | 600 | 1200 |
| **XX10** | 600 | 1350 |
| **XX11 UTR** | 600 | 1350 |
| **XX12 UTR** | 600 | 1350 |
| **XX13 UTR** | 600 | 1350 |
| **XX14 UTR** | 600 | 1350 |
| **XX15** | 600 | 1350 |
| **XX16** | 600 | 1500 |
| **XX17** | 600 | 1500 |
| **XX18** | 600 | 1500 |
| **XX19 UTR** | 675 | 1500 |
| **XX20** | 675 | 1500 |
| **XX21** | 675 | 1500 |
| **XXX7** | 600 | 900 |

Figure 4-8: Option 3 Chapman's Burn channel and culvert upgrade




**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 for all properties from the Chapman's Burn.

**Alternative quick wins / Preliminary investigations**

Installing smaller culverts to accommodate a lower standard would only achieve a small saving.

### Geotechnical issues

Available readily available ground information is provided in the BGS Data Reference drawing: BGS Data drawing data reference 'AEM-JBAU-IL-00-SK-C-1002-BGS_Existing_Ground_Data'.

- A review of available BGS borehole logs and mapping of superficial deposits indicates that most of the walls are likely to be constructed on clay, sandy or silty deposits.
- It is assumed that a full GI will be required at a later stage in the project.

### Services

- Overhead and underground services have been identified and their location is shown on drawing AEM-JBAU-IL-00-SK-C-1003-Services_Plan.
- Buried sewers, water mains, gas or electricity cables: A combined sewer and water main are crossing underneath the proposed Embankment A and upgraded culvert A. A storm water sewer and a foul sewer are close to proposed Embankment B. There are combined sewers, water mains and SGN gas cables between manhole XXX7 and XX21.
- Buried comms or Fibre Optics: A BT underground cable is close to proposed Embankment A, Culvert A and Embankment B. A BTU cable is also present along the proposed culverts, starting approximately upstream of XXX6.

### Construction access

- Construction access to Embankment A: Access off St. Ronan's Terrace.
- Construction Access to Culvert A: Via St. Ronan's Terrace.
- Construction Access to Embankment B: Via Maxwell Street
- Construction Access to Inlet_0000: Off Maxwell Street.
- Construction Access to Culverts between XXX1 and XXX7 manholes: Through Victoria Park.
- Construction Access to Culverts between XXX7 and XXX10 manholes: Via Hall Street.
- Construction Access to Culverts between XXX10 and Leithen Water: Via Traquair Road.

### Waste

According to SEPA regulations, before excavation the soil will be assessed for suitability to be classified as greenfield soil and the end-use of the soil will be identified. Soil must be of undeveloped, uncontaminated land, agricultural and forestry land or uncontaminated overburden from mining and quarries and can include vegetation i.e. grass, turf, mulch and leaf debris, but not tree stumps. The soil could be used to another development for engineering works as per the planning permission, in development on brownfield land to meet site-specific capping requirements for remediation, in SUDS and in the construction of roads and verges. A planning permission specifying the volumes of greenfield soil excavated is required.

- Expected quantity of waste material: Approximately 30m$^3$.
- Nature (inert, non-hazardous, hazardous): It is understood that no industry was present in Innerleithen – soil expected to be inert. Soil will need to be disposed as per SEPA's guidance. Consideration required of historical curling and skating ponds at Victoria Park because, whilst the proposed design does not intersect them, these ponds have historically been used for refuse disposal.

### Environmental issues

- Statutory Environmental Designations (SSSI, SPA, SAC, Ramsar Sites Nature Reserves, INNS). Leithen Water has been identified as a special area of conservation (SAC). Most of the area within the boundaries is also a Special Conservation Area (SAC), including Maxwell Street, Hall Street and a small part of Traquair Road.
- Habitat: The area of the proposed Embankment A is a National Forest Inventory. Habitat Regulations Appraisal (HRA) and Appropriate Assessment required for Natura (SAC and SPA) site. Additional surveys / assessments required for the impacts of proposed works on bats, breeding birds, otter, fish and water quality are required.
- Landscape designation - Innerleithen Conservation Area - consideration required at detailed design for wall materials and specification Listed Buildings: A number of listed buildings are located close to the proposed works.
- Trees; TPO: A few trees may need to be removed.
- Hydromorphology - further assessments of flow, channel substrate may be required
- Consultation with SNH and SEPA required

| 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.<br>• Flooding of construction works |
| **Social and community issues** |
| There will be road disruption for a number of weeks as culverts are replaced. |
| **Impact on other reaches** |
| The Chapman discharges directly into the River Tweed after passing through Innerleithen. As the water shall now be contained within the culvert, causing more water to reach the River Tweed in a shorter period of time, it is anticipated that there will be an increase in flow on the River Tweed, however, given the relative size of the River Tweed to the Chapman's Burn increase is anticipated to be negligible. |
| **Additional information required** |
| • A detailed topographic survey to capture top of bank levels.<br>• Detailed buried services survey, plotting their position with regards to site works.<br>• Ground investigation. |
| **Additional works required to account for increase in 200 year flow due to climate change** |
| • The 200 year plus climate change event could be easily incorporated into this scheme option. The channel conveyance of the Chapman's Burn could be increased via channel widening or bank raising, the increase in channel widening or bank raising is anticipated to be minimal. An increase in cost installing larger culverts would also be a small increase to the cost of the project. |

### 4.8.4 Option 4 - Chapman's Burn channel improvement with offline storage

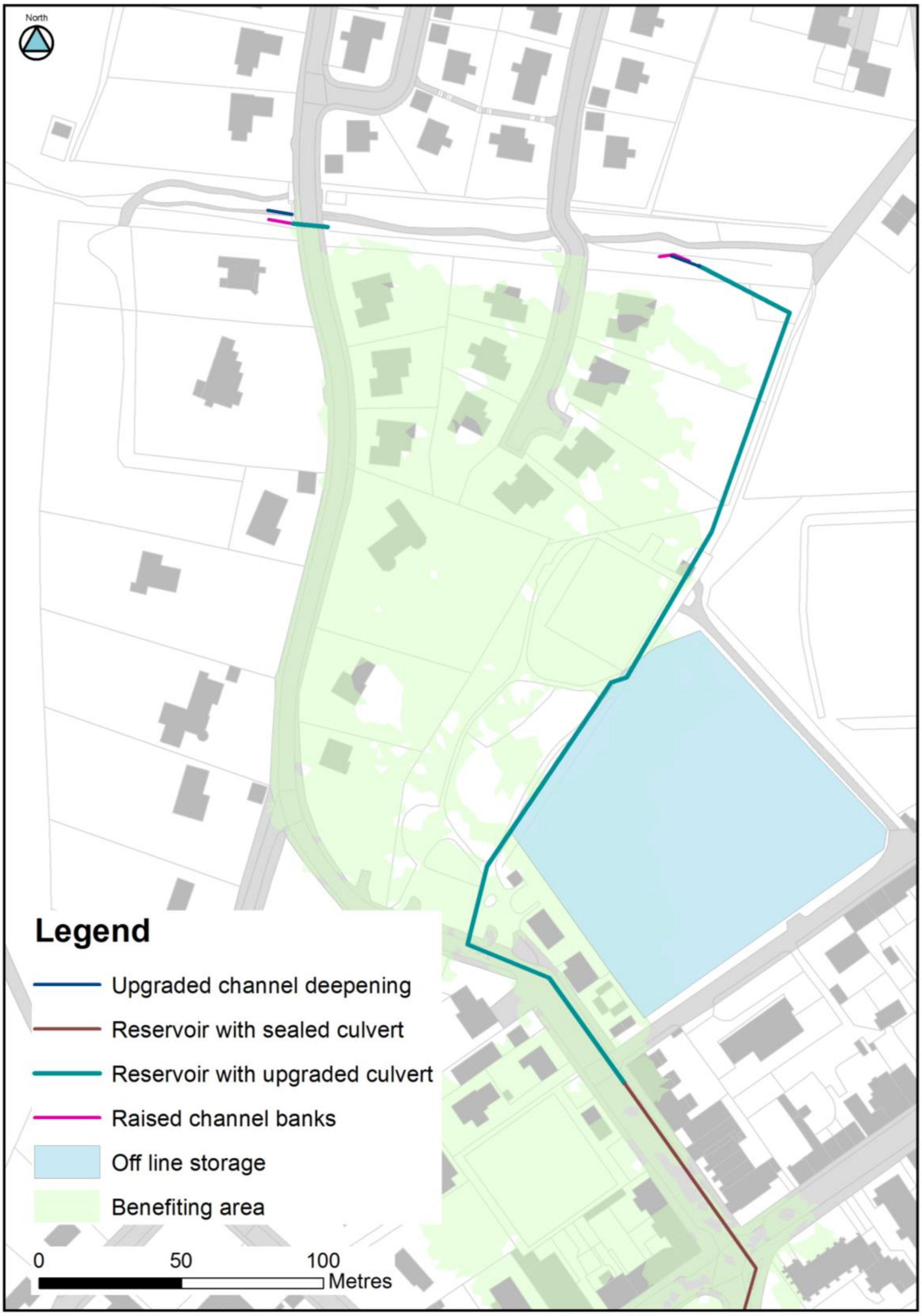
| Option 4 - Chapman's Burn channel improvement with offline storage |
|---|
| **Description** |
| This option aims to provide a 200 year standard of protection through increased conveyance through the open channel of Chapman's Burn with a short section of culvert upgrade, offline storage and non-return valve installation on existing culvert. The offline storage is proposed for Victoria Park and will be created with earth embankments, the highest embankment side will be facing Hall Street. The embankments will enclose the park on four sides but will tie into the existing ground level so will decrease from their maximum height of 1.3m. The storage area will hold approximately 3,500 $m^3$ when full.  Figure 4-7 focuses on the storage and associated works. From manhole xxx5 at the start of the offline storage the existing FPS culvert requires non-return valves to be fitted along its length to the discharge point to each incoming pipe and each manhole is to be sealed up to the River Tweed.<br>The following improvements are proposed for the channel upgrade:<br>• Low section, approximately 3m length on right bank upstream of culvert on St Ronan's Terrace to be raised to 170.77 mAOD. A maximum increase in height of 0.9m.<br>• Culvert at St Ronan's Terrace to be replaced with an 850mm diameter culvert and head wall raised to top of bank level, 170.77 mAOD. Invert of soffit to be lowered by 0.87m to accommodate new culvert.<br>• Raise a 10m length of the right bank upstream of the FPS culvert by a height of 0.45m.<br>• Lower 10m length of channel on approach to FPS culvert. Maximum bed lowering at culvert face to be 0.59m, gradually tie into existing channel bed upstream.<br>• Oversize the replacement thrash screen on FPS culvert to reduce head loss across the culvert and design in a manner that allows for safe removal of debris.<br>The existing FPS culvert is to be enlarged up to the new offline storage. The increase in culvert diameter is displayed in the Table 4-5. A new length of culvert is required to connect to the new storage area. The non-return valves on the culvert and manholes will allow pressure to build within the culvert as larger flows enter at the FPS inlet. This build of pressure will be released as water flows into the offline storage.<br>See drawing "AEM-JBAU-IL-CB-SK-C-1200-Opt3_200Yr_Chl_ReP_Strg_MH-S3-P01" for |

further details and a map showing the location of each element.

Table 4-5: Culvert upgrade dimensions to reservoir

| Culvert start | Existing Culvert diameter (mm) | Proposed Culvert diameter (mm) |
|---|---|---|
| **NT32368901** | 280 | 900 |
| **Inlet_0000** | 300 | 1200 |
| **XXX1** | 300 | 900 |
| **XXX3** | 450 | 900 |
| **XXX4** | 450 | 600 |
| **XXX5** | 450 | 600 |
| **XXX6** | 450 | 600 |

Figure 4-9: Option 4 Chapman's Burn channel and offline storage






**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 for all properties from the Chapman's Burn.

## Alternative quick wins / Preliminary investigations

Instead of upgrading the length of the FPS culvert from the FPS culvert inlet to the offline storage approximately half of this culvert could be converted to open channel.

## Geotechnical issues

Available readily available ground information is provided in the BGS Data Reference drawing: 'AEM-JBAU-IL-00-SK-C-1002-BGS_Existing_Ground_Data'.

- A review of available BGS borehole logs and mapping of superficial deposits indicates that most of the walls are likely to be constructed on clay, sandy or silty deposits.
- It is assumed that a full GI will be required at a later stage in the project.
- Embankments. A 1.25m deep x 0.5m wide cut-off trench backfilled with imported clay is included under embankments for costing purposes.
- Walls. A 1.25m deep x 0.5m wide mass concrete filled trench cut-off is included under walls for costing purposes.

## Services

Overhead and underground services have been identified and their location is shown on drawing AEM-JBAU-IL-00-SK-C-1003-Services_Plan.

- Buried sewers, water mains, gas or electricity cables: A combined sewer and water main are crossing underneath the proposed Embankment A and upgraded culvert A. A storm water sewer and a foul sewer are close to proposed Embankment B. There are combined sewers, water mains and SGN gas cables between manhole XXX7 and XX21.
- Buried comms or Fibre Optics: A BT underground cable is close to proposed Embankment A, Culvert A and Embankment B. A BTU cable is also present along the proposed culverts, starting approximately upstream of XXX6.

## Construction access

- Construction Access to Embankment A: Access off St. Ronan's Terrace.
- Construction Access to Culvert A: Via St. Ronan's Terrace.
- Construction Access to Embankment B: Via Maxwell Street
- Construction Access to Inlet_0000: Off Maxwell Street.
- Construction Access to Culverts between XXX1 and XXX7 manholes and the reservoir: Through Victoria Park.

## Waste

According to SEPA regulations, before excavation the soil will be assessed for suitability to be classified as greenfield soil and the end-use of the soil will be identified. Soil must be of undeveloped, uncontaminated land, agricultural and forestry land or uncontaminated overburden from mining and quarries and can include vegetation i.e. grass, turf, mulch and leaf debris, but not tree stumps. The soil could be used to another development for engineering works as per the planning permission, in development on brownfield land to meet site-specific capping requirements for remediation, in SUDS and in the construction of roads and verges. A planning permission specifying the volumes of greenfield soil excavated is required.

- Expected quantity of waste material: Approximately 30m$^3$.
- Nature (inert, non-hazardous, hazardous): It is understood that no industry was present in Innerleithen – soil expected to be inert. Soil will need to be disposed as per SEPA's guidance.
- Cognisance required of historical curling pond and skating pond at Victoria Park (adjacent to manhole points XXX5 and XXX6) as whilst the proposed design does not intersect them, such ponds have historically been used for refuse disposal.

## Environmental issues

- Statutory Environmental Designations (SSSI, SPA, SAC, Ramsar Sites Nature Reserves, INNS). Leithen Water has been identified as a special area of conservation (SAC). Most of the area within the boundaries is also a Special Conservation Area (SAC), including Maxwell Street, Hall Street and a small part of Traquair Road.
- Habitat: The area of the proposed Embankment A is in a National Forest Inventory. Habitat Regulations Appraisal (HRA) and Appropriate Assessment required for Natura (SAC and SPA) site. Additional surveys / assessments required for the impacts of proposed works on bats, breeding birds, otter, fish and water quality are required.
- Landscape designation - Innerleithen Conservation Area - consideration required at detailed

design for wall materials and specification

- Listed Buildings: A number of listed buildings are located close to the proposed works.
- Trees; TPO: the embankment around the pitch in Victoria Park would require the removal of mature trees
- Hydromorphology - further assessments of flow, channel substrate may be required
- Consultation with SNH and SEPA required

**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.
- Flooding of construction works

**Social and community issues**

There will be road disruption for a number of weeks as culverts are replaced. Victoria Park which is a playing field will have to be fitted in around the storage, may result in a smaller pitch, occasionally the pitch will not be usable for a short period (small portion will be flooded for a couple of hours) potentially every 2 years.

**Impact on other reaches**

The Chapman discharges directly into the River Tweed after passing through Innerleithen. As the water shall now be contained within the culvert, causing more water to reach the River Tweed in a shorter period of time, it is anticipated that there will be an increase in flow on the River Tweed, however, given the relative size of the River Tweed to the Chapman's Burn increase is anticipated to be negligible.

**Additional information required**

- A detailed topographic survey to capture top of bank levels.
- Detailed buried services survey, plotting their position with regards to site works.
- Ground investigation.

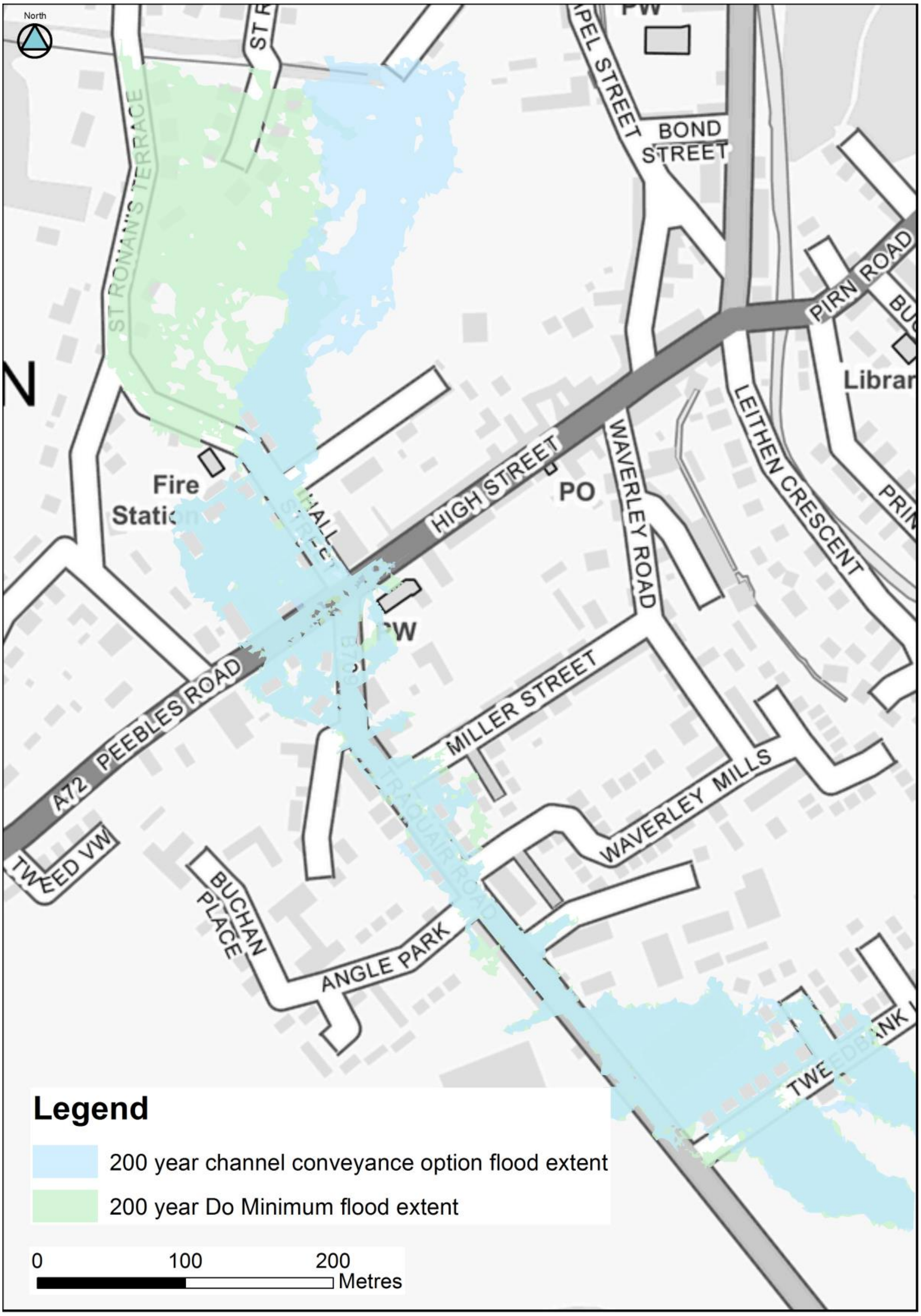
**Additional works required to account for increase in 200 year flow due to climate change**

- The 200 year plus climate change event could be easily incorporated into this scheme option. The channel conveyance of the Chapman's Burn could be increased via channel widening or bank raising, the increase in channel widening or bank raising is anticipated to be minimal. An increase in cost installing larger culverts would also be a small increase to the cost of the project. The peak depth of water in the offline storage is 1m so there is capacity to increase this depth if it is required to accommodate climate change flow.

### 4.8.5 Option 5- Chapman's Burn channel improvement

An alternative option which reduces flood risk to several properties up to the 200 year flood event is to carry out just the channel improvements described in Option 3 and 4 on the Chapman's Burn to carry the full 200 year flow up to the existing FPS culvert. From this location the majority of flood water flows over undeveloped or open green space. When it emerges onto Hall Street it re-joins its original path, which it would have taken had it overtopped the channel by St Ronan's Terrace culvert and flowed south down St Ronan's Terrace. A map for the 200 year flood event with and without channel improvement is shown in Figure 4-10. This option may slightly change the flood risk to a number of properties downstream but this is thought to be minimal, more detail analysis should be carried out at outline design stage if this option is taken forward.

Figure 4-10: Chapman's Burn channel improvement option

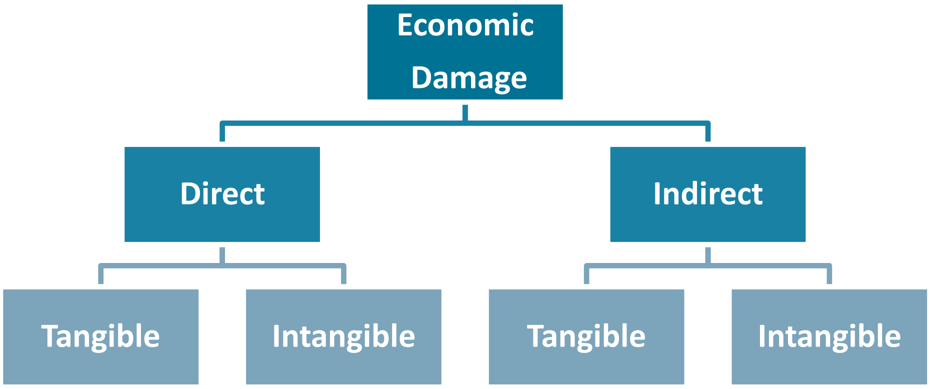


# 5 Investment appraisal

## 5.1 Damage methodology

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

Figure 5-1: Aspects of flood damage




Flood damage estimates have been derived for the following items:

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

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

## 5.2 Flood damage results

Flood damage results for the Do Nothing and Do Minimum options for flooding from the Leithen Water are shown overleaf followed by flooding from the Chapman's Burn.

## Do Nothing - Leithen Water

**Assumptions:**

20% increase in Manning's 'n' roughness to the channel and 0.5m blockage applied across the length of the 2 main bridges by lowering the bridge soffit by 0.5m in the model.

**Properties at risk**:

The total number of properties inundated above threshold level for the "Do Nothing" Scenario in South Parks 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 | 1 | 8 | 9 | 36 | 54 | 77 | 121 | 177 | 234 |
| Non-residential | 0 | 0 | 0 | 0 | 0 | 9 | 14 | 19 | 19 | 27 | 33 |
| Total | 0 | 0 | 1 | 8 | 9 | 45 | 68 | 96 | 140 | 204 | 267 |

**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 over the 100 year appraisal period are listed below.

| Rank | Property address | Pvd (£k) | Percentage of total Pvd |
|---|---|---|---|
| 1 | TRAQUAIR ARMS HOTEL, EH44 6PD | 286 | 6% |
| 2 | DARL SERVICES, STATION YARD, EH44 6PD | 254 | 5% |
| 3 | ST. RONANS HOTEL, EH44 6HF | 132 | 3% |
| 4 | PIRN HAUGH, PRINCES STREET, EH44 6JX | 110 | 2% |
| 5 | LOTHIAN BORDERS & ANGUS CO-OP SOCIETY LTD, PEEBLES ROAD, EH44 6QZ | 99 | 2% |
| 6 | 46, MILLER STREET, EH44 6QS | 72 | 1% |
| 7 | SCOTTS MOTORS, MORNINGSIDE, EH44 6QP | 72 | 1% |
| 8 | 1, HALL STREET, EH44 6PE | 65 | 1% |
| 9 | INNERLEITHEN UNION CLUB CO LTD, EH44 6QX | 60 | 1% |
| 10 | ORCHARD HOUSE, EH44 6PF | 57 | 1% |

**Event property damages:**

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

| Return period (years) | 5 | 10 | 25 | 30 | 50 | 75 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|---|---|---|---|
| Residential | 0 | 3 | 208 | 231 | 994 | 1,531 | 2,133 | 3,481 | 5,736 | 7,973 |
| Non-residential | 0 | 0 | 0 | 0 | 1,077 | 1,348 | 5,931 | 6,151 | 7,825 | 8,609 |
| Total | 0 | 3 | 208 | 231 | 2,071 | 2,879 | 8,065 | 9,632 | 13,561 | 16,582 |

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. The table above shows that flood damages are relatively small for the lower events but rise significantly once the flood defences are exceeded.

**Breakdown of damages**:

A summary of the proportion of total damages by each damage 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 discount rates.

Do Nothing flood damages (£k):

| Property AAD | Property PVd | Indirect PVd | Intangible PVd | Total PVd |
|---|---|---|---|---|
| 177 | 5,074 | 210 | 530 | 5,814 |

## Do Minimum - Leithen Water

**Assumptions:**

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.

**Properties at risk**:

The total number of properties inundated above threshold level for the "Do Minimum" Scenario in South Parks 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 | 0 | 0 | 0 | 1 | 10 | 11 | 37 | 126 | 180 |
| Non-residential | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 11 | 29 | 38 |
| Total | 0 | 0 | 0 | 0 | 0 | 1 | 10 | 12 | 48 | 155 | 218 |

**Key beneficiaries:**

The flood damages derived have been ranked (top 10) 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. Under the Do Minimum scenario the Xmod in Station Yard on Traquair Road accounts for 17% of the total damage. It should be noted that the Xmod only receives damage from the 200 year flood event and above.

| Rank | Property address | Pvd (£k) | Percentage of total Pvd |
|---|---|---|---|
| 1 | THE XMOD, STATION YARD, TRAQUAIR ROAD, EH44 6PD | 132 | 17% |
| 2 | INNERLEITHEN MAINS, EH44 6PF | 43 | 5% |
| 3 | ST. RONANS HOTEL, EH44 6HF | 21 | 3% |
| 4 | 38, HIGH STREET, EH44 6HF | 18 | 2% |
| 5 | BANK HOUSE, 2 HIGH STREET, EH44 6HA | 15 | 2% |
| 6 | 30, PRINCESS STREET, EH44 6JP | 14 | 2% |
| 7 | 2, MILLBANK, EH44 6HA | 13 | 2% |
| 8 | 2, MONTGOMERY STREET, EH44 6JP | 12 | 2% |
| 9 | GLENTRAIL, TRAQUAIR ROAD, EH44 6PD | 12 | 2% |
| 10 | THE BARBER SHOP,10 HIGH STREET, EH44 6HN | 12 | 1% |

**Event property damages:**

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

| Return period (years) | 5 | 10 | 25 | 30 | 50 | 75 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|---|---|---|---|
| Residential | 0 | 0 | 0 | 0 | 8 | 119 | 185 | 660 | 2,773 | 4,560 |
| Non-residential | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 549 | 1,696 | 2,218 |
| Total | 0 | 0 | 0 | 0 | 8 | 119 | 227 | 1,209 | 4,469 | 6,778 |

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. The table above shows flood damages are not seen till the 50 year flood event and then quickly increases.

**Breakdown of damages**:

A summary of the proportion of total damages by each damage 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 discount rates.

Do Nothing flood damages (£k):

| Property AAD | Property PVd | Indirect PVd | Intangible PVd | Total PVd |
|---|---|---|---|---|
| 28 | 790 | 37 | 4 | 831 |

## Do Nothing - Chapman's Burn

**Assumptions:**

20% increase in Manning's 'n' roughness to the channel and a 2/3 blockage on culvert screens.

**Properties at risk**:

The total number of properties inundated above threshold level for the "Do Nothing" Scenario in South Parks 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 | 3 | 4 | 6 | 11 | 10 | 14 | 17 | 21 | 24 | 26 | 35 |
| Non-residential | 1 | 2 | 3 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Total | 4 | 6 | 9 | 19 | 18 | 22 | 25 | 29 | 32 | 34 | 43 |

**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 are listed below.

| Rank | Property address | Pvd (£k) | Percentage of total Pvd |
|---|---|---|---|
| 1 | XMOD Station Yard, TRAQUAIR ROAD | 371 | 17% |
| 2 | FERNS PARK, ST RONAN'S TERRACE, EH44 6RB | 300 | 14% |
| 2 | 15, ST RONAN'S WAY, EH44 6RG | 300 | 14% |
| 2 | 22 ST RONAN'S TERRACE, EH44 6RB | 300 | 14% |
| 5 | INNERLEITHEN UNION CLUB CO LTD, EH44 6QX | 193 | 9% |
| 6 | 18 ST RONAN'S TERRACE, EH44 6RB | 183 | 9% |
| 7 | ALPINE BIKES, PEEBLES ROAD, EH44 6QX | 123 | 6% |
| 8 | 17 ST RONAN'S WAY, EH44 6RG | 96 | 4% |
| 9 | VICTORIA PARK HALL, , HALL STREET, EH44 6QT | 53 | 2% |
| 10 | CLUB HOUSE VICTORIA GREEN, HALL STREET | 28 | 1% |

**Event property damages:**

JBA's damage calculation method provides event damages based on MCM depth damage curves. Full results are provided in Appendix A. 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 | 72 | 195 | 190 | 287 | 204 | 229 | 248 | 289 | 340 | 416 | 546 |
| Non-residential | 47 | 58 | 137 | 292 | 310 | 417 | 531 | 594 | 717 | 872 | 1,032 |
| Total | 118 | 253 | 327 | 579 | 514 | 646 | 779 | 883 | 1,057 | 1,288 | 1,578 |

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. The table above shows that flood damages are small for the lower events but rises steadily with higher flood events.

**Breakdown of damages**:

A summary of the proportion of total damages by each damage 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 discount rates.

Do Nothing flood damages (£k):

| Property AAD | Property PVd | Indirect PVd | Intangible PVd | Total PVd |
|---|---|---|---|---|
| 155 | 5,190 | 236 | 166 | 5,592 |

## Do Minimum - Chapman's Burn

**Assumptions:**

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. A 1/3 blockage on culvert screens is assumed.

**Properties at risk**:

The total number of properties inundated above threshold level for the "Do Minimum" Scenario in South Parks 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 | 2 | 5 | 9 | 9 | 13 | 17 | 19 | 23 | 26 | 35 |
| Non-residential | 1 | 2 | 3 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Total | 1 | 4 | 8 | 17 | 17 | 21 | 25 | 27 | 31 | 34 | 43 |

**Key beneficiaries:**

The flood damages derived have been ranked (top 10) and assessed in terms of the proportion of flood damages per property. This highlights key beneficiaries of the scheme and is an useful auditing tool. Under the Do Minimum scenario the Xmod in Station Yard on Traquair Road and a property on St Roan's Terrace accounts for 46% of the total damage. In the short term consideration should be given to PLP for the residential property and investigation into diverting flood flows away from XMOD.

| Rank | Property address | Pvd (£k) | Percentage of total Pvd |
|---|---|---|---|
| 1 | XMOD Station Yard TRAQUAIR ROAD | 378 | 26% |
| 2 | 22 ST RONANS TERRACE, EH44 6RB | 300 | 20% |
| 3 | INNERLEITHEN UNION CLUB CO LTD, HIGH STREET, EH44 6QX | 193 | 13% |
| 4 | FERNS PARK, ST RONAN'S TERRACE, EH44 6RB | 128 | 9% |
| 5 | ALPINE BIKES, PEEBLES ROAD, EH44 6QX | 126 | 9% |
| 6 | 18 ST RONAN'S TERRACE, EH44 6RB | 86 | 6% |
| 7 | VICTORIA PARK HALL, HALL STREET, EH44 6QT | 53 | 4% |
| 8 | 3, HIGH STREET, EH44 6QX | 28 | 2% |
| 9 | CLUB HOUSE VICTORIA GREEN, HALL STREET | 28 | 2% |
| 10 | STATION COTTAGE, TRAQUAIR STREET, EH44 6PD | 23 | 2% |

**Event property damages:**

JBA's damage calculation method provides event damages based on MCM depth damage curves. Full results are provided in Appendix A. 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 | 2 | 5 | 9 | 9 | 14 | 18 | 20 | 24 | 27 | 36 |
| Non-residential | 3 | 4 | 5 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Total | 3 | 6 | 10 | 17 | 17 | 22 | 26 | 28 | 32 | 35 | 44 |

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. The table above shows that flood damages are small for the lower events but rises steadily with higher flood events.

**Breakdown of damages**:

A summary of the proportion of total damages by each damage 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 discount rates.

Do Nothing flood damages (£k):

| Property AAD | Property PVd | Indirect PVd | Intangible PVd | Total PVd |
|---|---|---|---|---|
| 95 | 2,985 | 112 | 149 | 3,246 |

### 5.2.1 Options

The flood damages for each option were calculated for each return period event up to the 1000 year flood 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 level of damages avoided as a result of the option, also known as the benefit of the option.

In line with current guidance[6] 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

## 5.3 Damage benefit summary - Leithen Water

The tables below summarise the damages avoided for each option from each watercourse. The Leithen Water results show that each of the options assessed significantly reduce flood damages in the order of £5.1 -5.2m, the benefit gained from the Do Minimum option is approximately £5.0m. This highlights a couple of points with regard to the options:

- The difference in the damages between the Do Nothing and Do Minimum shows the positive impact that the proactive ongoing maintenance carried out by the Council is contributing to flood damage reduction. The additional benefits from implementation of a scheme is small in the region of £0.19 to £0.12 m.
- With the proposed scheme in place there will still be a residual damage of approximately £0.64m to £0.69m. This is due to the flood damages associated with the 500 year and 1000 year flood event.

Table 5-1: Leithen Water option benefit table (£k)

| Option name | Do Nothing | Do Minimum | Direct defences | PLP |
|---|---|---|---|---|
| **SoP** | 5 | 50 | 200 | 200 |
| **BENEFITS:** | | | | |
| **PV flood damages** | 5,814 | 831 | 642 | 690 |
| **PV flood benefits** | | 4,983 | 5,172 | 5,124 |
| **Total PV damages benefits adjusted** | | 4,983 | 5,172 | 5,102 |

## 5.4 Damage benefit summary - Chapman's Burn

The Chapman's Burn results show that each of the proposed options assessed significantly reduce flood damages in the order of £2.4 -4.4m, the benefit gained from the Do Minimum option is approximately £1.8m. This highlights a couple of points with regard to the options:

- The difference in the damages between the Do Nothing and Do Minimum shows the positive impact that the proactive ongoing maintenance carried out by the Council is contributing to flood damage reduction. The additional benefits from implementation of a scheme is in the region of £0.6 to 2.6m.
- With the proposed scheme in place there will still be a residual damage of approximately £0.2m to 2.1m. For options protecting to the 200 year event this flood damage is associated with the 500 year and 1000 year flood event and is the lower estimate (0.9m).

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

Table 5-2: Chapman's Burn option benefit table (£k)

| Option name | Do Nothing | Do Minimum | PLP | Enlarged Culvert | Reservoir with Sealed Culverts | Improved Channel Conveyance |
|---|---|---|---|---|---|---|
| **SoP** | <2 | <2 | 200 | 200 | 200 | 2 |
| **BENEFITS:** | | | | | | |
| **PV flood damages** | 4,608 | 2,835 | 2,085 | 248 | 248 | 2,130 |
| **PV flood benefits** | | 1,773 | 2,523 | 4,361 | 4,361 | 2,478 |
| **Total PV damages benefits adjusted** | | 1,773 | 2,403 | 4,361 | 4,361 | 2,478 |

# 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. Costs have been updated from 2012 values to present day (2018) values using CPI (Consumer Price Index) to account for inflation.

## 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 used to derive the whole life costs for each assessed scheme option. This is an interactive excel spreadsheet which determines capital costs based primarily on defence dimensions but also considers other factors influence costs. Enabling and operation and maintenance costs are also estimated using this spreadsheet. The whole life costs of PLP was costed separately using Scottish Government Guidance "Assessing the Flood Risk Management Benefits of Property Level Protection Technical and Economic Appraisal Report Final Report v2.0 November 2014 ".

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

SEPA's 'Costing of Flood Risk Management Measures' 2013 project report was used to determine maintenance costs for the proposed assets. 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[7]. 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.

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

## 6.4 Leithen Water and Chapman's Burn - Option 1 - PLP

The PLP will take the form of automatic PLP that will seal the property against water ingress without any input from the inhabitants. Examples of what this will be include door guards, airbrick sealers, non-return valves on plumbing and sump pumps. Costs are based on the Scottish Government Guidance "Assessing the Flood Risk Management Benefits of Property Level Protection Technical and Economic Appraisal Report Final Report v2.0 November 2014 ". The cost of PLP is based on standard dwellings, it is not applicable to large buildings or ones with numerous or large opening, for this reason non-residential properties are usually excluded from PLP analysis. Both watercourses have been assessed and costed independently of each other. PLP has been applied to 47 properties to protect from flooding from the Leithen Water and 24 properties to protect against flooding from the Chapman's Burn. The Xmod has not been included in the PLP option as this stage as more bespoke measures may be required for this property. Table 6-1 describes the capital cost to install PLP at the required properties. Table 6-2 outlines the whole life cost for a PLP scheme for a 100 year appraisal period. Maintenance costs are significant as PLP is assumed to be replaced every 25 years. Table 6-3 and Table 6-4 are the corresponding tables for PLP protection from the Chapman's Burn.

Table 6-1: Unit and total estimated capital costs for initial installation for Leithen Water PLP

| Property type | Count | Capital cost - mid range automatic |
|---|---|---|
| Detached | 12 | £100,596 |
| Semi-detached | 4 | £31,432 |
| Terraced | 8 | £35,936 |
| Flat | 12 | £55,296 |
| Shop | 11 | £133,287 |
| Total | 47 | £356,547 |

Table 6-2: Total cash and Present Value (PV) option costs for Leithen Water PLP

| Element | Cash cost (£k) | PV Cost (£k) |
|---|---|---|
| Enabling cost | 56 | 56 |
| Capital cost | 1,783 | 689 |
| Maintenance cost | 699 | 199 |
| **Total** | 2,537 | 943 |
| ***Total incl. Optimism Bias*** | - | 1,509 |

For Chapman's Burn the following properties would benefit from PLP but have not been deemed applicable to standard PLP costs because of their construction type or scale and so have been excluded from the costing.

- Victoria Park Hall, HALL STREET, EH44 6QT
- INNERLEITHEN UNION CLUB CO LTD, HIGH STREET, EH44 6QX
- XMOD Station Yard TRAQUAIR ROAD
- Public convenience by Victoria Park
- Bowling Green club House A
- Bowling Green club House B
- Club house Victoria Green

Table 6-3: Unit and total estimated capital costs for initial installation for Chapman's Burn PLP

| Property type | Count | Capital cost - mid range automatic |
|---|---|---|
| Detached | 7 | £58,681 |
| Semi-detached | 0 | £0 |
| Terraced | 7 | £31,444 |

| Property type | Count | Capital cost - mid range automatic |
|---|---|---|
| Flat | 9 | £41,472 |
| Shop | 1 | £12,117 |
| Office | 0 | £0 |
| Total | 24 | £143,714 |

Table 6-4: Total cash and Present Value (PV) option costs for Chapman's Burn PLP

| Element | Cash cost (£k) | PV Cost (£k) |
|---|---|---|
| Enabling cost | 28 | 28 |
| Capital cost | 575 | 238 |
| Maintenance cost | 282 | 80 |
| **Total** | 885 | 347 |
| ***Total incl. Optimism Bias*** | - | 555 |

Total costs for this option from both flood sources are provided in the tables above. Tables 6-5 and 6-6 total the combined costs for PLP to protect against both sources. This takes into account any properties that are at risk from both sources (to avoid double counting).

Table 6-5: Unit and total estimated capital costs for combined PLP option

| Property type | Count | Capital cost - mid range automatic |
|---|---|---|
| Detached | 18 | £150,894 |
| Semi-detached | 4 | £31,432 |
| Terraced | 14 | £62,888 |
| Flat | 18 | £82,944 |
| Shop | 12 | £145,404 |
| Office | 0 | £0 |
| Total | 66 | £473,562 |

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

| Element | Cash cost (£k) | PV Cost (£k) |
|---|---|---|
| Enabling cost | 78 | 78 |
| Capital cost | 1,894 | 785 |
| Maintenance cost | 928 | 264 |
| **Total** | 2,901 | 1,127 |
| ***Total incl. Optimism Bias*** | - | 1,804 |

## 6.5 Leithen Water - Option 2 - Direct defences with 200-year standard of protection

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

Table 6-7: Unit and total estimated costs

| Location | Typical defence height (m) | Length (m) | Unit cost | Total Cost (Rounded) |
|---|---|---|---|---|
| Right bank upstream of A72 Road Bridge | 0.65 | 120 | £1,428 | £171,371 |
| Wall upstream of footbridge | 0.75 | 193 | £1,428 | £275,622 |
| Wall downstream of footbridge | 0.45 | 100 | £1,428 | £142,810 |
| Excavation and tipping | - | 863m$^3$ | £125 | £107,918 |
| | | | **Total Capital cost** | £697,721 |

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

| Element | Cash cost (£k) | PV Cost (£k) |
|---|---|---|
| Enabling cost | 53 | 53 |
| Capital cost | 714 | 690 |
| Maintenance cost | 13 | 4 |
| **Total** | **780** | **747** |
| ***Total incl. Optimism Bias*** | - | 1,195 |

## 6.6 Chapmans Burn - Option 3 - Control measures with improved channel conveyance with 200-year standard of protection

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

Table 6-9: Unit and total estimated costs

| Location | Typical defence height | Length / Volume | Unit cost | Total Cost (Rounded) |
|---|---|---|---|---|
| Embankment A | 0.45m | 61m$^3$ | £239 | £14,611 |
| Embankment B | 0.45m | 26 | £239 | £6,269 |
| Upgraded culvert | 900mm dia. | 12m | £1,216 | £17,517 |
| Inlet_0000- XXX1 | 1200mm dia. | 36m | £1,946 | £70,068 |
| XXX1-XXX9UTR | 900mm dia. | 330m | £1,095 | £361,288 |
| XXX9-XX10 | 1200mm dia. | 80m | £1,946 | £155,707 |
| XXX10 - XX16 | 1500mm dia. | 236m | £2,068 | £488,048 |
| XXX16 - Leithen Water | 1500mm dia. | 456m | £2,190 | £998,469 |
| Drop channel | - | 6m$^3$ | £200 | £1,120 |
| | | | **Total Capital cost** | £2,123,096 |

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

| Element | Cash cost (£k) | PV Cost (£k) |
|---|---|---|
| Enabling cost | 188 | 188 |
| Capital cost | 2,123 | 2,051 |
| Maintenance cost | 1,734 | 493 |
| **Total** | **4,046** | **2,733** |
| ***Total incl. Optimism Bias*** | - | 4,372 |

## 6.7 Chapmans Burn - Option 4 - Control measures, direct defences and storage area with 200-year standard of protection

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

Table 6-11: Unit and total estimated costs

| Location | Typical defence height | Length / Volume | Unit cost | Total Cost (Rounded) |
|---|---|---|---|---|
| Embankment A | 0.45m | 61.1m3 | £239 | £14,611 |
| Embankment B | 0.45m | 26 m³ | £239 | £6,269 |
| Reservoir Embankment | 1m | 3,906m³ | £120 | £467,331 |
| Upgraded culvert | 900mm dia. | 12m | £1,216 | £17,517 |
| Inlet_0000- XXX1 | 1200mm dia. | 36m | £1,946 | £70,068 |
| XXX1-XXX3 | 900mm dia. | 82m | £1,216 | £99,750 |
| XXX3-XXX6 | 600mm dia. | 143m | £547 | £78,279 |
| XXX7 - Reservoir | 600mm dia. | 35m | £608 | £72,380 |
| Sealed manholes | - | 14No. | £5,750 | £80,500 |
| Reservoir | - | 9,887m³ | £44.5 | £440,183 |
| Dropped channel | 1m | 5.6m³ | £200 | £1,120 |
| | | | **Total Capital cost** | £1,348,007 |

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

| Element | Cash cost (£k) | PV Cost (£k) |
|---|---|---|
| Enabling cost | 156 | 156 |
| Capital cost | 1,348 | 1,302 |
| Maintenance cost | 608 | 173 |
| **Total** | **2,112** | **1,631** |
| ***Total incl. Optimism Bias*** | - | 2,610 |

## 6.8 Chapmans Burn - Option 5 - Control measures, direct defences and channel modification with 200-year standard of protection

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

Table 6-13: Unit and total estimated costs

| Location | Typical defence height | Length / Volume | Unit cost | Total Cost (Rounded) |
|---|---|---|---|---|
| Embankment A | 0.45m | 61m$^3$ | £239 | £14,611 |
| Embankment B | 0.45m | 26 m$^3$ | £239 | £6,269 |
| Upgraded culvert | 900mm dia. | 12m | £1,216 | £17,517 |
| Dropped channel | 1m | 5.6m$^3$ | £200 | £1,120 |
| Excavation and tipping | - | 30m$^3$ | £125.05 | £3,752 |
| | | | **Total Capital cost** | £43,268 |

Table 6-14: Total cash and Present Value (PV) option costs

| Element | Cash cost (£k) | PV Cost (£k) |
|---|---|---|
| Enabling cost | 3.5 | 3.5 |
| Capital cost | 43 | 42 |
| Maintenance cost | 11 | 3 |
| **Total** | **58** | **48** |
| ***Total incl. Optimism Bias*** | - | 77 |

## 6.9 Summary of whole life costs

Table 6-15: Summary of total present value option costs

| Option number | Option name | Total PV Cost with 60% optimism bias (£k) |
|---|---|---|
| | Do Nothing | 0 |
| | Do Minimum | 0 |
| Option 1 | PLP - Leithen Water | 1,509 |
| Option 1 | PLP - Chapman's Burn | 555 |
| Option 1 | PLP - combined | 1,804 |
| Option 2 | Direct Defences - Leithen Water | 1,195 |
| Option 3 | Culvert upgrade - Chapman's Burn | 4,372 |
| Option 4 | Offline Storage - Chapman's Burn | 2,610 |
| Option 5 | Channel improvement - Chapman's Burn | 77 |

# 7 Benefit-cost analysis

## 7.1 Introduction

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

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

## 7.2 Benefit-cost results - Innerleithen

The benefit cost results for the shortlisted options are provided in the table below. A scheme with a benefit cost ratio greater than 1 means that the benefits outweigh the costs therefore the scheme is cost effective. Table 7-1 shows that the Direct Defence option is the most cost effective option for protecting properties from flooding from the Leithen Water. The Direct Defence option also has a high Benefit Cost Ratio of 4.3 making the option economically viable. Table 7-2 shows that PLP is the most cost effective and viable solution to provide a 200 year standard of defence from flooding from the Chapman's Burn. However the sub option of channel improvement has a present value benefit of approximately £700k at a cost of approximately £77k.

Table 7-1: Benefit cost ratio for the short-listed option for Leithen Water (£k)

| Option name | Do Nothing | Do Minimum | Direct Defences - Leithen Water | Direct Defences - PLP |
|---|---|---|---|---|
| **PV Costs (£k)** | - | - | 747 | 944 |
| **Optimism Bias (60%)** | - | - | 448 | 566 |
| **Total PV Costs (£k)** | 0 | 0 | 1,194 | 1,510 |
| **PV damage (£k)** | 5,814 | 831 | 642 | 712 |
| **PV damage avoided (£k)** | - | 4,983 | 5,172 | 5,102 |
| **Net present value (£k)** | - | 4,983 | 3,979 | 3,591 |
| **Benefit-cost ratio** | - | - | 4.3 | 3.4 |

Table 7-2: Benefit cost ratio for the short-listed option for Chapman's Burn (£k)

| Option name | Do Nothing | Do Minimum | PLP - Chapman's Burn | Culvert upgrade | Offline Storage | Channel Improvement |
|---|---|---|---|---|---|---|
| **PV Costs (£k)** | - | - | 347 | 4,063 | 1,348 | 48 |
| **Optimism Bias (60%)** | - | - | 208 | 2,438 | 1,271 | 32 |
| **Total PV Costs (£k)** | 0 | 0 | 555 | 6,501 | 3,389 | 77 |
| **PV damage (£k)** | 4,608 | 2,835 | 2,085 | 248 | 248 | 2,130 |
| **PV damage avoided (£k)** | - | 1,773 | 2,403 | 4,361 | 4,361 | 2,478 |
| **Net present value (£k)** | - | 1,773 | 1,968 | -2,141 | 972 | 2,401 |
| **Benefit-cost ratio** | - | - | 3.8 | 0.7 | 1.3 | 32.0 |

## 7.3 Benefit-cost results with climate change

The shallow depths experienced in Innerleithen mean that PLP will protect to a greater return periods than the 200 year plus climate change, however, more properties will fall within the 200 year plus climate change flood extent and so additional properties will require PLP as the effects of climate change are felt. It is estimated that approximately 140 additional properties will require PLP to protect against flooding from the Leithen Water by the 2080's. The timing of the provision of these is clearly uncertain; however the use of PLP is in effect a very reactive and climate adaptable option in that new properties can be added if and when these are needed.

The cost of protecting properties using the direct defence option on the Leithen Water to the 200 year plus climate change event is anticipated to very costly and intrusive, with additional wall lengths in the region of 800m to 1000m in length required, in addition to bridge raising of the A74 Road Bridge and wall heights in excess of 2m high. Adaptation to climate change for this option is likely to be technically difficult and costly in this location.

Chapman's Burn channel and offline storage could be made larger to accommodate larger flows expected with climate change. The requirements and cost to accommodate climate change should be looked at outlined designed stage but are not thought to substantially increase the cost of the scheme.

# 8 Public Consultation

A public consultation event was held in Innerleithen on the 4th October 2018 to gauge opinion on the flood mitigation options proposed as part of this study. The public consultation was attended by 28 people. The majority of residents in attendance were in favour of a flood protection scheme for Innerleithen. There was very little interest or concern related to flood risk from Chapman's Burn, however, the option to reduce flood risk from the Leithen water via flood walls was well received. The residents provided a lot of useful feedback both verbally on the day and by filing in the provided questionnaire. 9 residents filled in a questionnaire. The results of the questionnaire are presented in Appendix B and summarised below:

**Summary of questionnaire**

The response in the questionnaire mirrored what was expressed on the day. Flood walls along the Leithen Water to reduce flood risk is desirable as long as the position of the walls do not block access to properties or completely block off access to the watercourse. The pathways along the Leithen Water are enjoyed by the community so efforts should be made to maintain access and views along these. The approach taken by Scottish Borders Council to this flood risk appraisal was applauded by the community.

Other views expressed on the day were as follows:

- The Mill Lade, especially at the upper end, is of concern to many residents. There is a steep culvert with a screen which has a tendency to block. This caused flooding out onto the main road (B709) in 2012 or 2013.
- The wall option for Leithen, while desirable, needs to be modified to maintain access to the watercourse from back gardens.
- There is an ongoing surface water issue effecting Kirklands housing estate
- Access road to Traquair floods from the River Tweed.
- The gravel islands at the estuary of the Leithen Water with the River Tweed have grown over the years and the course of the Leithen Water at the estuary has changed over the years
- The River Tweed was diverted away from Traquair House circa 1850. Its course once ran by Traquair house over the footprint of the remaining pond. It was diverted for approximately 1.5 miles from Tweed Bridge upstream.
- Chapman's Burn was unknown to many residents.
- The housing estate to the north of Chapman's Burn was known to have numerous seasonal springs in it. Several springs were formalised. One resident spoke of three springs, a fresh water, sulphur and saline spring. Horses were washed down using water from the sulphur spring. These springs have now mostly been lost and the remaining sulphur one has become very diluted, potentially indicating that the clay pipes have cracked or become disjointed.

# 9 Conclusions and recommendations

This report presents the results of a detailed flood risk appraisal for Innerleithen Water in relation to flooding from the Leithen Water and Chapman's Burn. Each watercourse was assessed independently, 48 properties are estimated to be at risk of flooding from the 0.5% AP (200 year) "Do Minimum" flood event from the Leithen Water and 31 from the Chapman's Burn.

A detailed set of preliminary investigations was carried out prior to this appraisal such that it was possible to inform discussion of flood protection options for Innerleithen. These investigations involved a review of Innerleithen's flood history; an assessment of the hydrological inputs to the Leithen Water and Chapman's Burn; 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 watercourses.

The Leithen Water hydraulic model consists of a 1D-2D Flood Modeller Pro - TUFLOW model. The river channel was represented in 1D while the town was represented by the 2D portion of the model. This 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.

The same approach was taken for the Chapman's Burn except a modelling software known as InfoWorks ICM was used, the key advantage of using this modelling software package is it ability to model surcharging culverts. This was important for the Chapman's Burn as the watercourse has a greater culverted length than open channel.

Once these flood 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 Innerleithen's flood risk problem. Flood protection options have been assessed based on the anticipated damages avoided from the implementation of the scheme and compared against the cost of building and maintaining the flood mitigation works. An optimism bias factor of 60% has been added to the total costs to allow for uncertainties in design at this level of appraisal and is typical for schemes at an early stage of appraisal.

There is some overlap of flood damages from the Leithen Water and Chapman's Burn, as the watercourses were assessed independently of one another there will be some double counting of flood damages.

Flooding from the Leithen Water inundating properties is not observed until the 50 year flood event. One significant factor in keeping this standard of protection is the ongoing maintenance programme. Modelling suggests that if maintenance were to stop there would be an increase in flood damage of approximately £5m and a greatly reduced standard of protection. In order to keep the damages low, a coarse in river debris screen is recommended upstream of the A72 Road Bridge to prevent possible future blockage. Similarly, on the Chapman's Burn, to increase resilience from the damage that could be caused from screen blockage, currently a difference of approximately £1.8m, telemetry on the culvert screens is recommended. This would alert the Council immediately to a blockage which could then be removed as a priority.

Before any option on the Chapman's Burn is considered, gauging of the watercourse is recommended to provide a better estimate on flood flows. The modelling suggests that flooding should be occurring more frequently than every 2 years, however, the recorded flood history suggests otherwise. A comparison of the peak flood flows versus the ReFH2 flows showed a vast difference in the flow estimates, for example the 2 year peak flow estimate corresponds to close to the ReFH2 400 year peak flow.

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. The following options for each watercourse each protecting to the 200 year (0.5% AP) event were considered:

- Leithen Water:
    - PLP

- Direct defences
- Chapman's Burn:
  - PLP
  - Culvert upgrade
  - Off-line storage

A sub option for Chapman's Burn which involves increased channel conveyance was also considered, while this does not increase the standard of protection for Innerleithen, it does remove several properties near Chapman's Burn from flood risk. Improving channel conveyance on the Chapman's Burn has a very large BCR ratio, a ratio of 32, indicating that this is a very cost effective improvement to flood risk. However, in-depth analysis at the outline design stage is recommended to determine the impact of flood risk to properties downstream of the works.

PLP for both the Leithen Water and Chapman's Burn is the most cost effective solution with a BCR of between 3.4 and 4.3. There is an overlap of five properties in the PLP option.

Offline storage is a feasible option to protect against Chapman's Burn flooding to the 200 year flood event, it has a positive BCR and can be adapted to cater for the 200 year plus climate change flood event. This option utilises Victoria Park playing field as a storage area during a storm event.

Considering all of the above JBA recommends putting the following measures in place:

- Improve the resilience of culverts and screens. This includes installation of a coarse debris screen upstream of the A72 Road Bridge and telemetry on Chapman's Burn culvert screens.
- Carry out improvements works on the Chapman's Burn channel to increase conveyance to the FPS culvert inlet and install a gauge on the Chapman's Burn to give a better estimate of flood flows. The impact on properties downstream needs to be assessed in more detail prior to channel improvement works. Once more confidence has been developed in the flood flow estimates the options should be reassessed.
- Implement the Direct Defence option on the Leithen Water.

Public opinion is very important, as after all, it is the homes and business of the community that the FPS will endeavour to protect. For this reason, SBC and JBA presented the options at a public meeting, thereby giving the community a voice in shaping the scheme to how they would like it.

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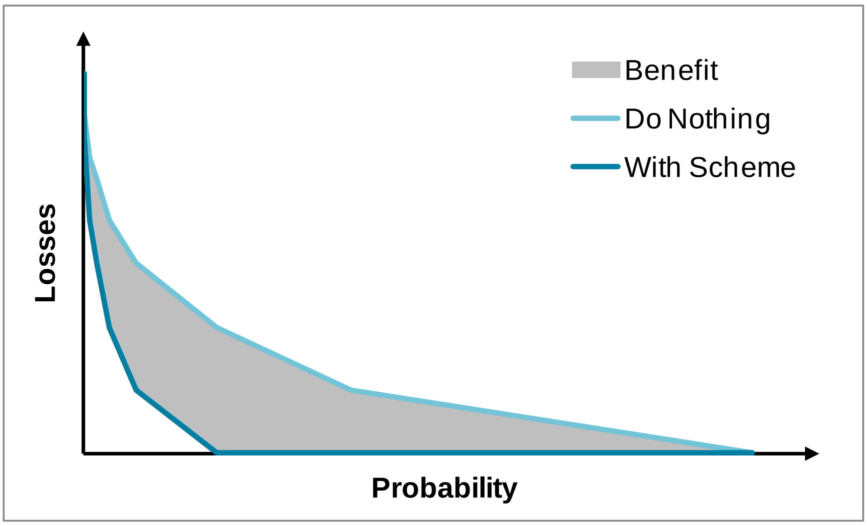
# Appendices

# A Economic Appraisal

## 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 together 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 **Error! Reference source not found.**-1: Loss Probability Curve




To derive these two curves, straight lines are drawn between the floods for which there is 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/estimated threshold levels.

A flood damage estimate was generated using JBA's in-house flood damage tools, FRISM. These estimated 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 building floor's area) flood damage estimates have been used to cost the flood damage generated from a single flood event.

The following assumptions, presented in 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 property type | MCM codes broken down by type and age. | Appropriate for this level of analysis. |
| Non-residential property type | Standard 2017 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 2017 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 Broughton were obtained from the Scottish Assessors Association website[8]. Equivalent yield varies regionally and temporarily, but is recommended to be a value of 10-12.5 for flood defence purposes[9]. A value of 12.5 was used.

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

JBA consulting

### A.1.4 Updating of Damage Values

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

## A.2 Intangible damages

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

## A.3 Indirect damages

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

### A.3.5 Indirect commercial damages

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

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

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

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

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

# Project Summary Sheet

| | | | | | |
|---|---|---|---|---|---|
| **Client/Authority** | | | Prepared (date) | | 12/07/2018 |
| Scottish Borders Council | | | Printed | | 07/12/2018 |
| **Project name** | | | Prepared by | | JG |
| Leithen Water FPS | | | Checked by | | |
| **Project reference** | | | Checked date | | |
| Base date for estimates (year 0) | Jan-2018 | | | | |
| Scaling factor (e.g. £m, £k, £) | £k | | | | |
| Year | 0 | 75 | | | |
| Discount Rate | 3.5% | 2.50% | | | |
| Optimism bias adjustment factor | 60% | | | | |

**Costs and benefits of options**

| | Costs and benefits £k | | | | | |
|---|---|---|---|---|---|---|
| Option number | **Do Nothing** | **Do Minimum** | **PLP** | **OP05** | | **-** |
| Option name | Do Nothing | Do Minimum | PLP | Direct Defences | | |
| AEP or SoP (where relevant) | 2 | 50 | 200 | 200 | | |
| **COSTS:** | | | | | | |
| PV capital costs | 0 | 0 | 689 | 690 | | |
| PV operation and maintenance costs | 0 | 0 | 199 | 4 | | |
| PV enabling costs | 0 | 0 | 56 | 53 | | |
| Optimism bias adjustment | 0 | 0 | 566 | 448 | | |
| **Total PV Costs £k excluding contributions** | 0 | 0 | 1,510 | 1,194 | | |
| **Total PV Costs £k taking contributions into account** | 0 | 0 | 1,510 | 1,194 | | |
| **BENEFITS:** | | | | | | |
| PV monetised flood damages | 5,814 | 831 | 690 | 642 | | |
| PV monetised flood damages avoided | | 4,983 | 5,102 | 5,172 | | |
| PV monetised erosion damages | 0 | 0 | 0 | 0 | | |
| PV monetised erosion damages avoided (protected) | | 0 | 0 | 0 | | |
| **Total monetised PV damages £k** | 5,814 | 831 | 712 | 642 | | |
| **Total monetised PV benefits £k** | | 4,983 | 5,102 | 5,172 | | |
| **Total PV damages £k** | 5,814 | 831 | 712 | 642 | | |
| **Total PV benefits £k** | | 4,983 | 5,102 | 5,172 | | |
| **DECISION-MAKING CRITERIA:** | | | | | | |
| ***Based on monetised PV benefits (excludes benefits from scoring and weighting and ecosystem services)*** | | | | | | |
| Net Present Value **NPV** | | 4,983 | 3,591 | 3,979 | | |
| Average benefit/cost ratio **BCR** | | | 3.4 | 4.3 | | |

**Brief description of options:**

| | |
|---|---|
| Do Nothing | Do Nothing |
| Do Minimum | Do Minimum |
| OP05 | Direct Defences |
| PLP | PLP |
| - | |
| - | |
| - | |

**Comments and assumptions:**

## Summary Annual Average Damage

**Sheet Nr.**

**Client/Authority**
Scottish Borders Council
**Project name**
Leithen Water FPS
**Project reference** -

**Option:**
Do Nothing

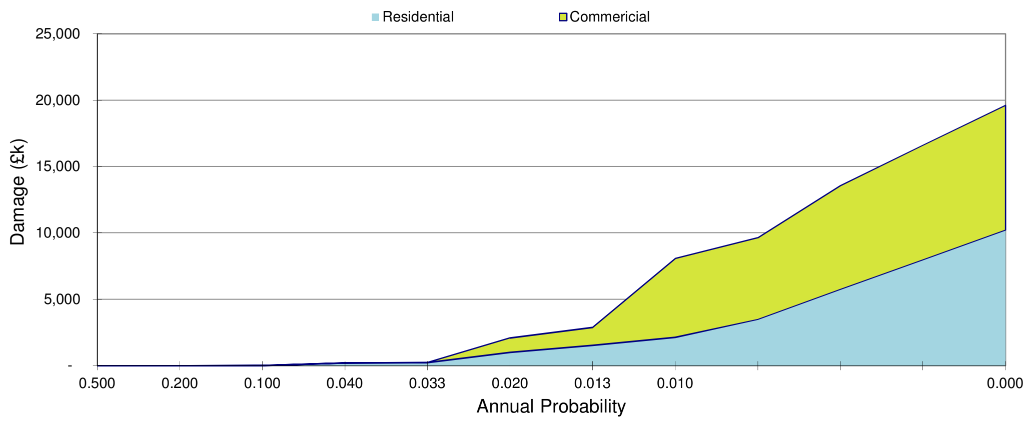
| | | | | | |
|---|---|---|---|---|---|
| Base date for estimates (year 0) | 43101 | First year of damage: | 0 | Prepared (date) | 12/07/2018 |
| Scaling factor (e.g. £m, £k, £) | £k | Last year of period: | 99 | Printed | 07/12/2018 |
| Discount rate | 3.5% | PV factor for mid-year 0: | 29.813 | Prepared by | JG |
| | | | | Checked by | 0 |
| Applicable year (if time varying) | | | | Checked date | 0 |

| | Average waiting time (yrs) between events/frequency per year | | | | | | | | | | | | Total PV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2<br>0.500 | 5<br>0.200 | 10<br>0.100 | 25<br>0.040 | 30<br>0.033 | 50<br>0.020 | 75<br>0.013 | 100<br>0.010 | 200<br>0.005 | 500<br>0.002 | 1000<br>0.001 | Infinity<br>0 | £k |
| Damage category | Damage £k | | | | | | | | | | | | |
| Residential property | - | - | 3 | 208 | 231 | 994 | 1,531 | 2,133 | 3,481 | 5,736 | 7,973 | 10,211 | 2,219 |
| Ind/commercial (direct) | - | - | - | - | - | 1,077 | 1,348 | 5,931 | 6,151 | 7,825 | 8,609 | 9,393 | 2,856 |
| Ind/comm (indirect) | - | - | - | - | - | 32 | 40 | 178 | 185 | 235 | 258 | 282 | 86 |
| Traffic related | | | | | | | | | | | | - | - |
| Emergency services | - | - | 0 | 12 | 13 | 56 | 86 | 119 | 195 | 321 | 447 | 572 | 124 |
| Other | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Intangible damages | | | | | | | | | | | | - | 530 |
| | | | | | | | | | | | | - | - |
| Total damage £k | - | - | 3 | 220 | 244 | 2,159 | 3,005 | 8,362 | 10,011 | 14,117 | 17,287 | 20,458 | |
| Area (damagexfrequency) | | - | 0 | 7 | 2 | 16 | 17 | 19 | 46 | 36 | 16 | 19 | |

| | | |
|---|---|---|
| Total area, as above | 177 | |
| PV Factor, as above | 29.813 | |
| Present value (assuming no change in damage or event frequency) | 5,284 | 5,814 |

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: Leithen Water FPS** **Option: Do Nothing**



## Summary Annual Average Damage

**Sheet Nr.**

**Client/Authority**
Scottish Borders Council
**Project name**
Leithen Water FPS
**Project reference** -

| | | | | | | |
|---|---|---|---|---|---|---|
| Base date for estimates (year 0) | 43101 | First year of damage: | 0 | Prepared (date) | 12/07/2018 |
| Scaling factor (e.g. £m, £k, £) | £k | Last year of period: | 99 | Printed | 07/12/2018 |
| Discount rate | 3.5% | PV factor for mid-year 0: | 29.813 | Prepared by | JG |
| | | | | Checked by | 0 |
| Applicable year (if time varying) | | | | Checked date | 0 |

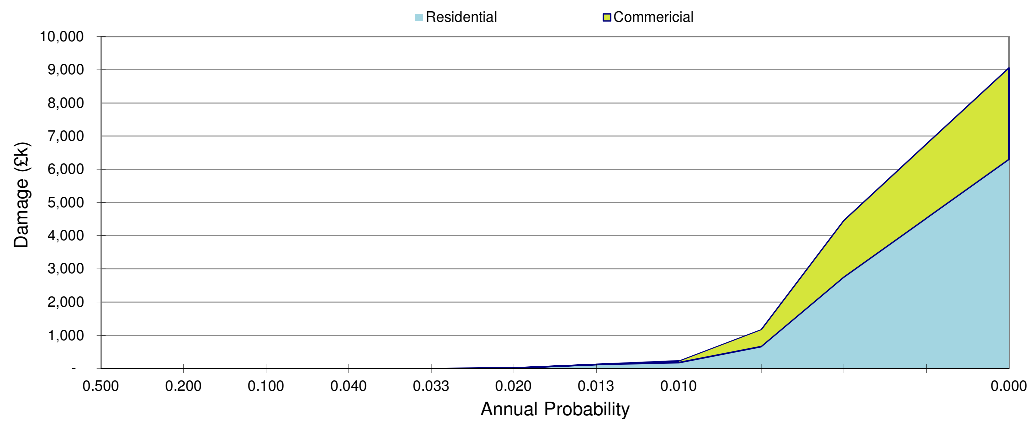
**Option:**
Do Minimum

| | Average waiting time (yrs) between events/frequency per year | | | | | | | | | | | | Total PV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 5 | 10 | 25 | 30 | 50 | 75 | 100 | 200 | 500 | 1000 | Infinity | £k |
| | 0.500 | 0.200 | 0.100 | 0.040 | 0.033 | 0.020 | 0.013 | 0.010 | 0.005 | 0.002 | 0.001 | 0 | |
| Damage category | Damage £k | | | | | | | | | | | | |
| Residential property | - | - | - | - | - | 8 | 119 | 180 | 654 | 2,750 | 4,527 | 6,303 | 513 |
| Ind/commercial (direct) | - | - | - | - | - | - | - | 43 | 519 | 1,712 | 2,233 | 2,755 | 277 |
| Ind/comm (indirect) | - | - | - | - | - | - | - | 1 | 16 | 51 | 67 | 83 | 8 |
| Traffic related | | | | | | | | | | | | - | - |
| Emergency services | - | - | - | - | - | 0 | 7 | 10 | 37 | 154 | 253 | 353 | 29 |
| Other | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Intangible damages | | | | | | | | | | | | - | 4 |
| | | | | | | | | | | | | - | - |
| Total damage £k | - | - | - | - | - | 8 | 126 | 234 | 1,225 | 4,668 | 7,081 | 9,494 | |
| Area (damagexfrequency) | | - | - | - | - | 0 | 0 | 1 | 4 | 9 | 6 | 8 | |

| | | |
|---|---|---|
| Total area, as above | 28 | |
| PV Factor, as above | 29.813 | |
| Present value (assuming no change in damage or event frequency) | 827 | 831 |

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: Leithen Water FPS** **Option: Do Minimum**



## Summary Annual Average Damage

**Sheet Nr.**

**Client/Authority**
Scottish Borders Council
**Project name**
Leithen Water FPS
**Project reference** -

**Option:** PLP

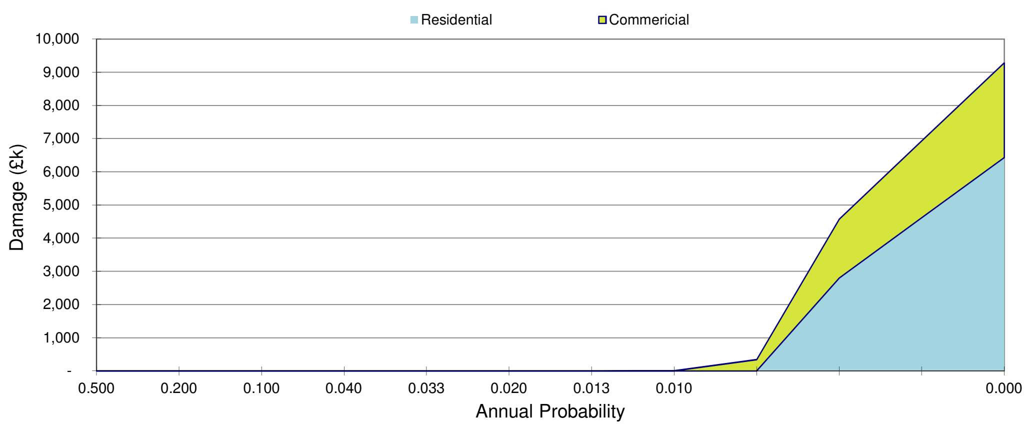
| | | | | | |
|---|---|---|---|---|---|
| Base date for estimates (year 0) | 43101 | First year of damage: | 0 | Prepared (date) | 12/07/2018 |
| Scaling factor (e.g. £m, £k, £) | £k | Last year of period: | 99 | Printed | 07/12/2018 |
| Discount rate | 3.5% | PV factor for mid-year 0: | 29.813 | Prepared by | JG |
| | | | | Checked by | 0 |
| Applicable year (if time varying) | | | | Checked date | 0 |

| | Average waiting time (yrs) between events/frequency per year | | | | | | | | | | | | Total PV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 5 | 10 | 25 | 30 | 50 | 75 | 100 | 200 | 500 | 1000 | Infinity | £k |
| | 0.500 | 0.200 | 0.100 | 0.040 | 0.033 | 0.020 | 0.013 | 0.010 | 0.005 | 0.002 | 0.001 | 0 | |
| Damage category | Damage £k | | | | | | | | | | | | |
| Residential property | - | - | - | - | - | - | - | - | - | 2,796 | 4,611 | 6,427 | 400 |
| Ind/commercial (direct) | - | - | - | - | - | - | - | 2 | 344 | 1,777 | 2,313 | 2,849 | 259 |
| Ind/comm (indirect) | - | - | - | - | - | - | - | 0 | 10 | 53 | 69 | 85 | 8 |
| Traffic related | | | | | | | | | | | | - | - |
| Emergency services | - | - | - | - | - | - | - | - | - | 157 | 258 | 360 | 22 |
| Other | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Intangible damages | | | | | | | | | | | | - | 1 |
| | | | | | | | | | | | | - | - |
| Total damage £k | - | - | - | - | - | - | - | 2 | 354 | 4,782 | 7,252 | 9,722 | |
| Area (damagexfrequency) | | - | - | - | - | - | - | 0 | 1 | 8 | 6 | 8 | |

| | | |
|---|---|---|
| Total area, as above | 23 | |
| PV Factor, as above | 29.813 | |
| Present value (assuming no change in damage or event frequency) | 689 | 690 |

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: Leithen Water FPS** **Option: PLP**



## Summary Annual Average Damage

Sheet Nr.

| | | | |
|---|---|---|---|
| **Client/Authority** | | | |
| Scottish Borders Council | | | |
| **Project name** | | **Option:** | |
| Leithen Water FPS | | Direct Defences | |
| **Project reference** | - | | |
| Base date for estimates (year 0) | 43101 | First year of damage: 0 | Prepared (date) 12/07/2018 |
| Scaling factor (e.g. £m, £k, £) | £k | Last year of period: 99 | Printed 07/12/2018 |
| Discount rate | 3.5% | PV factor for mid-year 0: 29.813 | Prepared by JG |
| | | | Checked by 0 |
| Applicable year (if time varying) | | | Checked date 0 |

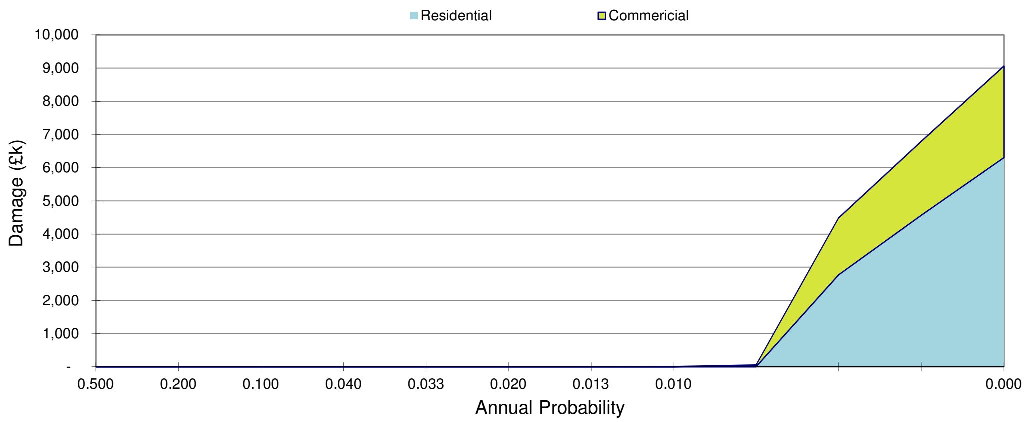
Average waiting time (yrs) between events/frequency per year

| | 2 | 5 | 10 | 25 | 30 | 50 | 75 | 100 | 200 | 500 | 1000 | Infinity | Total PV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.500 | 0.200 | 0.100 | 0.040 | 0.033 | 0.020 | 0.013 | 0.010 | 0.005 | 0.002 | 0.001 | 0 | £k |
| Damage category | Damage £k | | | | | | | | | | | | |
| Residential property | - | - | - | - | - | - | - | - | 0 | 2,773 | 4,560 | 6,303 | 395 |
| Ind/commercial (direct) | - | - | - | - | - | - | - | 2 | 47 | 1,712 | 2,233 | 2,755 | 216 |
| Ind/comm (indirect) | - | - | - | - | - | - | - | 0 | 1 | 51 | 67 | 83 | 6 |
| Traffic related | | | | | | | | | | | | - | - |
| Emergency services | - | - | - | - | - | - | - | - | 0 | 155 | 255 | 353 | 22 |
| Other | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Intangible damages | | | | | | | | | | | | - | 2 |
| | | | | | | | | | | | | - | - |
| Total damage £k | - | - | - | - | - | - | - | 2 | 49 | 4,692 | 7,115 | 9,494 | |
| Area (damagexfrequency) | | - | - | - | - | - | - | 0 | 0 | 7 | 6 | 8 | |

| | | |
|---|---|---|
| Total area, as above | 21 | |
| PV Factor, as above | 29.813 | |
| Present value (assuming no change in damage or event frequency) | 639 | 642 |

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: Leithen Water FPS** **Option: Direct Defences**



### 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) | £55.6 |
| Year of capital works (year) | 1 |
| Capital cost (£k) | £356.5 |
| Annual maintenance cost (£k) | £7.1 |
| Other cost (£k) | £0.0 |
| Other works frequency (years) | 1 |
| Other cost (£k) | £0.0 |
| Other works frequency (years) | 1 |
| Replacement (£) | 356.5 |
| Replacement frequency (years) | 20 |
| Optimism Bias | 60% |

**Key**

| | |
|---|---|
| | Information |
| | Calculation |
| | Cost input |
| | Default |

| Element | Cash cost (£k) | PV Cost (£k) |
|---|---|---|
| Enabling cost | 56 | 56 |
| Capital cost | 1,783 | 689 |
| Maintenance cost | 699 | 199 |
| **Total** | 2,537 | 943 |
| ***Total incl. Optimism Bias*** | - | 1,509 |

| | | | | | | | | | **Total PVc (£k) with Optimism Bias:** | **1,509** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Initial discount rate** | **3.5%** | **29.813** | | | | | | | **Total PVc (£k):** | **943** |
| | | **Cost Elements** | | | | **PV** | | | **TOTALS:** | |
| | | **Enabling** | **Capital** | **Maint.** | **Interm.** | **Enabling** | **Capital** | **Maint.** | **Cash** | **PV** |
| | **Cash sum** | 56 | 1783 | 699 | 0 | 56 | 689 | 199 | 2537 | **943** |
| **year** | **Discount Factor** | | | | | | | | | |
| 0 | 1.000 | 55.6 | | | 0 | 55.6 | | | 55.6 | 55.6 |
| 1 | 0.966 | | 357 | | 0 | | 344.5 | | 356.5 | 344.5 |
| 2 | 0.934 | | | 7 | 0 | | | 6.7 | 7.1 | 6.7 |
| 3 | 0.902 | | | 7 | 0 | | | 6.4 | 7.1 | 6.4 |
| 4 | 0.871 | | | 7 | 0 | | | 6.2 | 7.1 | 6.2 |
| 5 | 0.842 | | | 7 | 0 | | | 6.0 | 7.1 | 6.0 |
| 6 | 0.814 | | | 7 | 0 | | | 5.8 | 7.1 | 5.8 |
| 7 | 0.786 | | | 7 | 0 | | | 5.6 | 7.1 | 5.6 |
| 8 | 0.759 | | | 7 | 0 | | | 5.4 | 7.1 | 5.4 |
| 9 | 0.734 | | | 7 | 0 | | | 5.2 | 7.1 | 5.2 |
| 10 | 0.709 | | | 7 | 0 | | | 5.1 | 7.1 | 5.1 |
| 11 | 0.685 | | | 7 | 0 | | | 4.9 | 7.1 | 4.9 |
| 12 | 0.662 | | | 7 | 0 | | | 4.7 | 7.1 | 4.7 |
| 13 | 0.639 | | | 7 | 0 | | | 4.6 | 7.1 | 4.6 |
| 14 | 0.618 | | | 7 | 0 | | | 4.4 | 7.1 | 4.4 |
| 15 | 0.597 | | | 7 | 0 | | | 4.3 | 7.1 | 4.3 |
| 16 | 0.577 | | | 7 | 0 | | | 4.1 | 7.1 | 4.1 |
| 17 | 0.557 | | | 7 | 0 | | | 4.0 | 7.1 | 4.0 |
| 18 | 0.538 | | | 7 | 0 | | | 3.8 | 7.1 | 3.8 |
| 19 | 0.520 | | | 7 | 0 | | | 3.7 | 7.1 | 3.7 |
| 20 | 0.503 | | | 7 | 0 | | | 3.6 | 7.1 | 3.6 |
| 21 | 0.486 | | 357 | 7 | 0 | | 173.1 | 3.5 | 363.7 | 176.6 |
| 22 | 0.469 | | | 7 | 0 | | | 3.3 | 7.1 | 3.3 |
| 23 | 0.453 | | | 7 | 0 | | | 3.2 | 7.1 | 3.2 |
| 24 | 0.438 | | | 7 | 0 | | | 3.1 | 7.1 | 3.1 |
| 25 | 0.423 | | | 7 | 0 | | | 3.0 | 7.1 | 3.0 |
| 26 | 0.409 | | | 7 | 0 | | | 2.9 | 7.1 | 2.9 |
| 27 | 0.395 | | | 7 | 0 | | | 2.8 | 7.1 | 2.8 |
| 28 | 0.382 | | | 7 | 0 | | | 2.7 | 7.1 | 2.7 |
| 29 | 0.369 | | | 7 | 0 | | | 2.6 | 7.1 | 2.6 |
| 30 | 0.356 | | | 7 | 0 | | | 2.5 | 7.1 | 2.5 |
| 31 | 0.346 | | | 7 | 0 | | | 2.5 | 7.1 | 2.5 |
| 32 | 0.336 | | | 7 | 0 | | | 2.4 | 7.1 | 2.4 |
| 33 | 0.326 | | | 7 | 0 | | | 2.3 | 7.1 | 2.3 |
| 34 | 0.317 | | | 7 | 0 | | | 2.3 | 7.1 | 2.3 |
| 35 | 0.307 | | | 7 | 0 | | | 2.2 | 7.1 | 2.2 |
| 36 | 0.298 | | | 7 | 0 | | | 2.1 | 7.1 | 2.1 |
| 37 | 0.290 | | | 7 | 0 | | | 2.1 | 7.1 | 2.1 |
| 38 | 0.281 | | | 7 | 0 | | | 2.0 | 7.1 | 2.0 |
| 39 | 0.273 | | | 7 | 0 | | | 1.9 | 7.1 | 1.9 |
| 40 | 0.265 | | | 7 | 0 | | | 1.9 | 7.1 | 1.9 |
| 41 | 0.257 | | 357 | 7 | 0 | | 91.8 | 1.8 | 363.7 | 93.6 |
| 42 | 0.250 | | | 7 | 0 | | | 1.8 | 7.1 | 1.8 |
| 43 | 0.243 | | | 7 | 0 | | | 1.7 | 7.1 | 1.7 |
| 44 | 0.236 | | | 7 | 0 | | | 1.7 | 7.1 | 1.7 |
| 45 | 0.229 | | | 7 | 0 | | | 1.6 | 7.1 | 1.6 |
| 46 | 0.222 | | | 7 | 0 | | | 1.6 | 7.1 | 1.6 |
| 47 | 0.216 | | | 7 | 0 | | | 1.5 | 7.1 | 1.5 |
| 48 | 0.209 | | | 7 | 0 | | | 1.5 | 7.1 | 1.5 |
| 49 | 0.203 | | | 7 | 0 | | | 1.4 | 7.1 | 1.4 |
| 50 | 0.197 | | | 7 | 0 | | | 1.4 | 7.1 | 1.4 |
| 51 | 0.192 | | | 7 | 0 | | | 1.4 | 7.1 | 1.4 |
| 52 | 0.186 | | | 7 | 0 | | | 1.3 | 7.1 | 1.3 |
| 53 | 0.181 | | | 7 | 0 | | | 1.3 | 7.1 | 1.3 |
| 54 | 0.175 | | | 7 | 0 | | | 1.2 | 7.1 | 1.2 |
| 55 | 0.170 | | | 7 | 0 | | | 1.2 | 7.1 | 1.2 |
| 56 | 0.165 | | | 7 | 0 | | | 1.2 | 7.1 | 1.2 |
| 57 | 0.160 | | | 7 | 0 | | | 1.1 | 7.1 | 1.1 |
| 58 | 0.156 | | | 7 | 0 | | | 1.1 | 7.1 | 1.1 |
| 59 | 0.151 | | | 7 | 0 | | | 1.1 | 7.1 | 1.1 |
| 60 | 0.147 | | | 7 | 0 | | | 1.0 | 7.1 | 1.0 |
| 61 | 0.143 | | 357 | 7 | 0 | | 50.8 | 1.0 | 363.7 | 51.8 |
| 62 | 0.138 | | | 7 | 0 | | | 1.0 | 7.1 | 1.0 |
| 63 | 0.134 | | | 7 | 0 | | | 1.0 | 7.1 | 1.0 |
| 64 | 0.130 | | | 7 | 0 | | | 0.9 | 7.1 | 0.9 |
| 65 | 0.127 | | | 7 | 0 | | | 0.9 | 7.1 | 0.9 |
| 66 | 0.123 | | | 7 | 0 | | | 0.9 | 7.1 | 0.9 |
| 67 | 0.119 | | | 7 | 0 | | | 0.9 | 7.1 | 0.9 |
| 68 | 0.116 | | | 7 | 0 | | | 0.8 | 7.1 | 0.8 |
| 69 | 0.112 | | | 7 | 0 | | | 0.8 | 7.1 | 0.8 |
| 70 | 0.109 | | | 7 | 0 | | | 0.8 | 7.1 | 0.8 |
| 71 | 0.106 | | | 7 | 0 | | | 0.8 | 7.1 | 0.8 |
| 72 | 0.103 | | | 7 | 0 | | | 0.7 | 7.1 | 0.7 |
| 73 | 0.100 | | | 7 | 0 | | | 0.7 | 7.1 | 0.7 |
| 74 | 0.097 | | | 7 | 0 | | | 0.7 | 7.1 | 0.7 |
| 75 | 0.094 | | | 7 | 0 | | | 0.7 | 7.1 | 0.7 |
| 76 | 0.092 | | | 7 | 0 | | | 0.7 | 7.1 | 0.7 |
| 77 | 0.090 | | | 7 | 0 | | | 0.6 | 7.1 | 0.6 |
| 78 | 0.087 | | | 7 | 0 | | | 0.6 | 7.1 | 0.6 |
| 79 | 0.085 | | | 7 | 0 | | | 0.6 | 7.1 | 0.6 |
| 80 | 0.083 | | | 7 | 0 | | | 0.6 | 7.1 | 0.6 |
| 81 | 0.081 | | 357 | 7 | 0 | | 29.0 | 0.6 | 363.7 | 29.5 |
| 82 | 0.079 | | | 7 | 0 | | | 0.6 | 7.1 | 0.6 |
| 83 | 0.077 | | | 7 | 0 | | | 0.6 | 7.1 | 0.6 |
| 84 | 0.075 | | | 7 | 0 | | | 0.5 | 7.1 | 0.5 |
| 85 | 0.074 | | | 7 | 0 | | | 0.5 | 7.1 | 0.5 |
| 86 | 0.072 | | | 7 | 0 | | | 0.5 | 7.1 | 0.5 |
| 87 | 0.070 | | | 7 | 0 | | | 0.5 | 7.1 | 0.5 |
| 88 | 0.068 | | | 7 | 0 | | | 0.5 | 7.1 | 0.5 |
| 89 | 0.067 | | | 7 | 0 | | | 0.5 | 7.1 | 0.5 |
| 90 | 0.065 | | | 7 | 0 | | | 0.5 | 7.1 | 0.5 |
| 91 | 0.063 | | | 7 | 0 | | | 0.5 | 7.1 | 0.5 |
| 92 | 0.062 | | | 7 | 0 | | | 0.4 | 7.1 | 0.4 |
| 93 | 0.060 | | | 7 | 0 | | | 0.4 | 7.1 | 0.4 |
| 94 | 0.059 | | | 7 | 0 | | | 0.4 | 7.1 | 0.4 |
| 95 | 0.057 | | | 7 | 0 | | | 0.4 | 7.1 | 0.4 |
| 96 | 0.056 | | | 7 | 0 | | | 0.4 | 7.1 | 0.4 |
| 97 | 0.055 | | | 7 | 0 | | | 0.4 | 7.1 | 0.4 |
| 98 | 0.053 | | | 7 | 0 | | | 0.4 | 7.1 | 0.4 |
| 99 | 0.052 | | | 7 | 0 | | | 0.4 | 7.1 | 0.4 |

## Summary of costs

| | | | |
|---|---|---|---|
| **Client/Authority** | | Prepared (date) | |
| Scottish Borders Council | | Printed | 07/12/2018 |
| **Project/Option name** | | Prepared by | C.Kampanou |
| Leithen Water | | 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 | £53.08 |
| Capital Costs | £713.72 |
| O & M Costs | £13.29 |
| Other Costs | £0.00 |
| Total Real Cost | £780.10 |
| Total Cost PV | £746.78 |
| Total Cost PV + OB | **£1,194.85** |

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

**Additional user notes:**

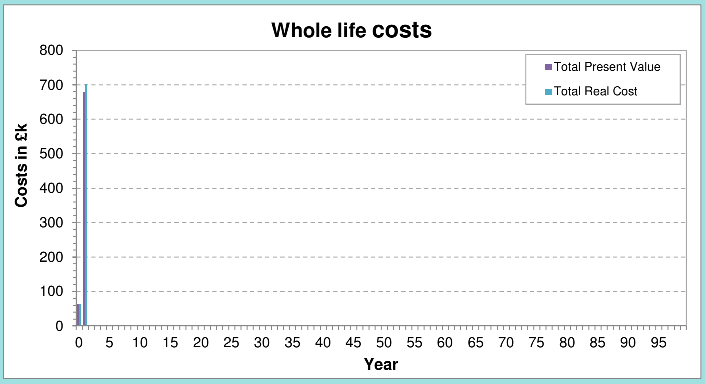
Add additional user notes here.

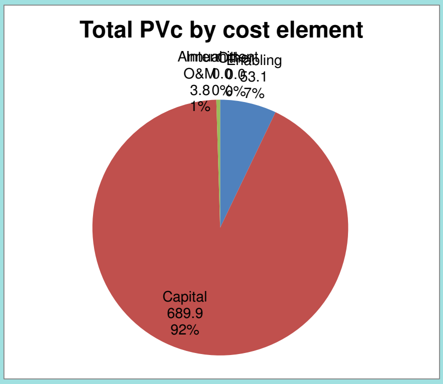
| FRM Measure | Asset | Open / Go to Costing Sheet | Delete Sheet | Enabling Costs | Capital Costs | O & M Costs | Other Costs | Total Cost Cash | Total Cost PV |
|---|---|---|---|---|---|---|---|---|---|
| Fluvial raised defence | Embankment | | | | | | | | |
| | Wall | | | £53.08 | £595.80 | £13.29 | £0.00 | £662.18 | £632.52 |
| | Sheet Piling | | | | | | | | |
| Channel management | N/A | | | | | | | | |
| Culvert & screen | N/A | | | | | | | | |
| Control assets | Weir | | | | | | | | |
| | Pumping station | | | | | | | | |
| | Flood gate | | | | | | | | |
| | Outfall | | | | | | | | |
| | Flow barrier | | | | | | | | |
| Coastal protection | Wall | | | | | | | | |
| | Revetment | | | | | | | | |
| | Groyne | | | | | | | | |
| | Recharge | | | | | | | | |
| Flood storage | N/A | | | | | | | | |
| Flood warning and forecasting | Various | | | | | | | | |
| Temporary & demountable barriers | Various | | | | | | | | |
| Household resistance | Various | | | | | | | | |
| Household resilience | Various | | | | | | | | |
| SUDS and urban drainage | Various | | | | | | | | |
| Managed realignment | Various | | | | | | | | |
| Habitat creation | Various | | | | | | | | |
| Landuse & runoff management | Various | | | | | | | | |
| River Restoration | Various | | | | | | | | |
| User Defined 1 | Various | | | £0.00 | £107.92 | £0.00 | £0.00 | £107.92 | £104.27 |
| User Defined 2 | Various | | | £0.00 | £10.00 | £0.00 | £0.00 | £10.00 | £10.00 |
| User Defined 3 | Various | | | | | | | | |

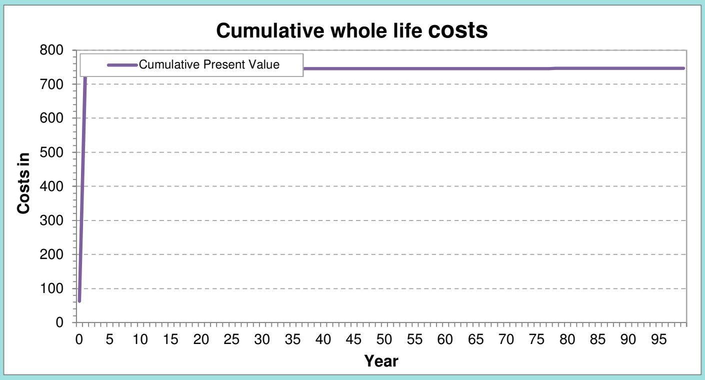
**Whole Life and Present Value Cost Analysis**

| | | PV factor | 29.813 | | | | Total PVc (£k): | 746.8 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Enabling £k | Capital £k | Annual O&M £k | Intermittent O&M £k | Other £k | TOTALS: Current price | PV (£k) | |
| | Total real cost | 53.1 | 713.7 | 13.3 | 0.0 | 0.0 | 780.10 | 746.8 | |
| | Total PV cost | 53.1 | 689.9 | 3.8 | 0.0 | 0.0 | | 746.8 | Cumulative |
| year | Discount Factor | | | | | | | | PV Costs (£k) |
| 0 | 1.000 | 53.1 | 10.0 | 0.0 | 0.0 | 0.0 | 63.1 | 63.1 | 63.1 |
| 1 | 0.966 | 0.0 | 703.7 | 0.0 | 0.0 | 0.0 | 703.7 | 679.9 | 743.0 |
| 2 | 0.934 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 743.1 |
| 3 | 0.902 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 743.3 |
| 4 | 0.871 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 743.4 |
| 5 | 0.842 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 743.5 |
| 6 | 0.814 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 743.6 |
| 7 | 0.786 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 743.7 |
| 8 | 0.759 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 743.8 |
| 9 | 0.734 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 743.9 |
| 10 | 0.709 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 744.0 |
| 11 | 0.685 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 744.1 |
| 12 | 0.662 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 744.2 |
| 13 | 0.639 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 744.3 |
| 14 | 0.618 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 744.4 |
| 15 | 0.597 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 744.4 |
| 16 | 0.577 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 744.5 |
| 17 | 0.557 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 744.6 |
| 18 | 0.538 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 744.7 |
| 19 | 0.520 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 744.7 |
| 20 | 0.503 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 744.8 |
| 21 | 0.486 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 744.9 |
| 22 | 0.469 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 744.9 |
| 23 | 0.453 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 745.0 |
| 24 | 0.438 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 745.1 |
| 25 | 0.423 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 745.1 |
| 26 | 0.409 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 745.2 |
| 27 | 0.395 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 745.2 |
| 28 | 0.382 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 745.3 |
| 29 | 0.369 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 745.3 |
| 30 | 0.356 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.4 |
| 31 | 0.346 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.4 |
| 32 | 0.336 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.5 |
| 33 | 0.326 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.5 |
| 34 | 0.317 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.5 |
| 35 | 0.307 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.6 |
| 36 | 0.298 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.6 |
| 37 | 0.290 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.7 |
| 38 | 0.281 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.7 |
| 39 | 0.273 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.7 |
| 40 | 0.265 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.8 |
| 41 | 0.257 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.8 |
| 42 | 0.250 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.9 |
| 43 | 0.243 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.9 |
| 44 | 0.236 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.9 |
| 45 | 0.229 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 745.9 |
| 46 | 0.222 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.0 |
| 47 | 0.216 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.0 |
| 48 | 0.209 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.0 |
| 49 | 0.203 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.1 |
| 50 | 0.197 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.1 |
| 51 | 0.192 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.1 |
| 52 | 0.186 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.1 |
| 53 | 0.181 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.2 |
| 54 | 0.175 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.2 |
| 55 | 0.170 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.2 |
| 56 | 0.165 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.2 |
| 57 | 0.160 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.3 |
| 58 | 0.156 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.3 |
| 59 | 0.151 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.3 |
| 60 | 0.147 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.3 |
| 61 | 0.143 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.3 |
| 62 | 0.138 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.4 |
| 63 | 0.134 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.4 |
| 64 | 0.130 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.4 |
| 65 | 0.127 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.4 |
| 66 | 0.123 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.4 |
| 67 | 0.119 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.4 |
| 68 | 0.116 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.5 |
| 69 | 0.112 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.5 |
| 70 | 0.109 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.5 |
| 71 | 0.106 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.5 |
| 72 | 0.103 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.5 |
| 73 | 0.100 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.5 |
| 74 | 0.097 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.5 |
| 75 | 0.094 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.6 |
| 76 | 0.092 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.6 |
| 77 | 0.090 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.6 |
| 78 | 0.087 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.6 |
| 79 | 0.085 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.6 |
| 80 | 0.083 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.6 |
| 81 | 0.081 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.6 |
| 82 | 0.079 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.6 |
| 83 | 0.077 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.6 |
| 84 | 0.075 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.7 |
| 85 | 0.074 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.7 |
| 86 | 0.072 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.7 |
| 87 | 0.070 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.7 |
| 88 | 0.068 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.7 |
| 89 | 0.067 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.7 |
| 90 | 0.065 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.7 |
| 91 | 0.063 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.7 |
| 92 | 0.062 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.7 |
| 93 | 0.060 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.7 |
| 94 | 0.059 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.7 |
| 95 | 0.057 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.8 |
| 96 | 0.056 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.8 |
| 97 | 0.055 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.8 |
| 98 | 0.053 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.8 |
| 99 | 0.052 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 746.8 |

**Whole life cost charts**



## Project Summary Sheet

| | | | | |
|---|---|---|---|---|
| **Client/Authority** | | | Prepared (date) | |
| Scottish Borders Council | | | Printed | 07/12/2018 |
| **Project name** | | | Prepared by | JG |
| Chapman FPS | | | Checked by | |
| **Project reference** | | | Checked date | |
| 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 | Option 1 | Option 2 | Option 3 | Option 4 | Option 5 | Option 6 | |
| Option name | Do Nothing | Do Minimum | PLP | Enlarged Culvert | Reservoir With Sealed Culverts | Improved Channel Conveyance | |
| AEP or SoP (where relevant) | 2 | 5.00 | 200.00 | 200.00 | 200.00 | 200.00 | |
| **COSTS:** | | | | | | | |
| PV capital costs | 0 | 0 | 238 | 2,123 | 1,348 | 42 | |
| PV operation and maintenance costs | 0 | 0 | 80 | 1,752 | 614 | 3 | |
| PV enabling costs | 0 | 0 | 28 | 188 | 156 | 4 | |
| Optimism bias adjustment | 0 | 0 | 208 | 2,438 | 1,271 | 29 | |
| PV negative costs (e.g. sales) | 0 | 0 | 0 | 0 | 0 | 0 | |
| **Total PV Costs £k excluding contributions** | 0 | 0 | 555 | 6,501 | 3,389 | 77 | |
| **Total PV Costs £k taking contributions into account** | 0 | 0 | 555 | 6,501 | 3,389 | 77 | |
| **BENEFITS:** | | | | | | | |
| PV monetised flood damages | 4,608 | 2,835 | 2,085 | 248 | 248 | 2,130 | |
| PV monetised flood damages avoided | | 1,773 | 2,403 | 4,361 | 4,361 | 2,478 | |
| 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** | 4,608 | 2,835 | 2,085 | 248 | 248 | 2,130 | |
| **Total monetised PV benefits £k** | | 1,773 | 2,523 | 4,361 | 4,361 | 2,478 | |
| **Total PV damages £k** | 4,608 | 2,835 | 2,085 | 248 | 248 | 2,130 | |
| **Total PV benefits £k** | | 1,773 | 2,403 | 4,361 | 4,361 | 2,478 | |
| **DECISION-MAKING CRITERIA:** | | | | | | | |
| ***Based on monetised PV benefits ( ex cludes benefits from scoring and weighting and ecosystem services)*** | | | | | | | |
| Net Present Value **NPV** | | 1,773 | 1,968 | -2,141 | 972 | 2,401 | |
| Average benefit/cost ratio **BCR** | | | 4.3 | 0.7 | 1.3 | 32.0 | |
| Best practicable environmental option (WFD) | | | | | | | |

**Brief description of options:**

| | |
|---|---|
| Option 1 | Do Nothing |
| Option 2 | Do Minimum |
| Option 3 | PLP |
| Option 4 | Enlarged Culvert |
| Option 5 | Reservoir With Sealed Culverts |
| Option 6 | Improved Channel Conveyance |

**Comments and assumptions:**

## Summary Annual Average Damage

**Sheet Nr.**

**Client/Authority**
Scottish Borders Council

**Project name**
Chapman FPS

**Option:**
Do Nothing

**Project reference** -

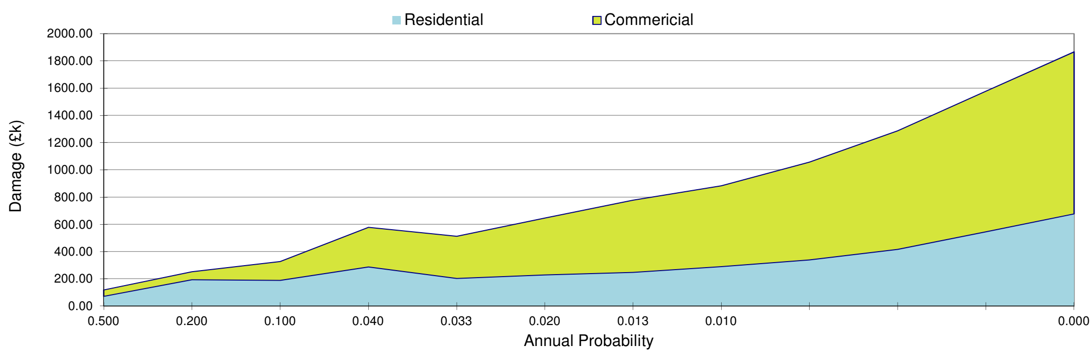
| | | | | | |
|---|---|---|---|---|---|
| Base date for estimates (year 0) | 43101 | First year of damage: | 0 | Prepared (date) | 00/01/1900 |
| Scaling factor (e.g. £m, £k, £) | £k | Last year of period: | 99 | Printed | 07/12/2018 |
| Discount rate | 3.5% | PV factor for mid-year 0: | 29.813 | Prepared by | JG |
| | | | | Checked by | 0 |
| Applicable year (if time varying) | | | | Checked date | 0 |

| | Average waiting time (yrs) between events/frequency per year | | | | | | | | | | | | Total PV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 5 | 10 | 25 | 30 | 50 | 75 | 100 | 200 | 500 | 1000 | Infinity | £k |
| | 0.500 | 0.200 | 0.100 | 0.040 | 0.033 | 0.020 | 0.013 | 0.010 | 0.005 | 0.002 | 0.001 | 0 | |
| Damage category | Damage £k | | | | | | | | | | | | |
| Residential property | 71.62 | 194.94 | 189.62 | 286.92 | 203.69 | 228.72 | 248.20 | 289.08 | 340.31 | 415.99 | 546.21 | 676.42 | 3,077.91 |
| Ind/commercial (direct) | 46.66 | 58.25 | 137.04 | 292.19 | 310.38 | 416.94 | 530.89 | 594.32 | 717.12 | 872.21 | 1031.52 | 1190.83 | 2,112.53 |
| Ind/comm (indirect) | 1.399843509 | 1.75 | 4.11 | 8.77 | 9.31 | 12.51 | 15.93 | 17.83 | 21.51 | 26.17 | 30.95 | 35.72 | 63.38 |
| Traffic related | | | | | | | | | | | | - | - |
| Emergency services | 4.010513878 | 10.92 | 10.62 | 16.07 | 11.41 | 12.81 | 13.90 | 16.19 | 19.06 | 23.30 | 30.59 | 37.88 | 172.36 |
| Other | 0 | - | - | - | - | - | - | - | - | - | - | - | - |
| Intangible damages | | | | | | | | | | | | - | 165.90 |
| | | | | | | | | | | | | - | - |
| Total damage £k | 123.6881269 | 265.85 | 341.38 | 603.94 | 534.78 | 670.97 | 808.92 | 917.42 | 1,098.01 | 1,337.66 | 1,639.26 | 1,940.85 | |
| Area (damagexfrequency) | | 58.43 | 30.36 | 28.36 | 3.80 | 8.04 | 4.93 | 2.88 | 5.04 | 3.65 | 1.49 | 7.60 | |

| | | |
|---|---|---|
| Total area, as above | 154.57 | |
| PV Factor, as above | 29.813 | |
| Present value (assuming no change in damage or event frequency) | 4608 | 5,592.08 |

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: Chapman FPS** **Option: Do Nothing**



## Summary Annual Average Damage

**Sheet Nr.**

**Client/Authority**
Scottish Borders Council
**Project name**
Chapman FPS
**Project reference** -

**Option:**
Do Minimum

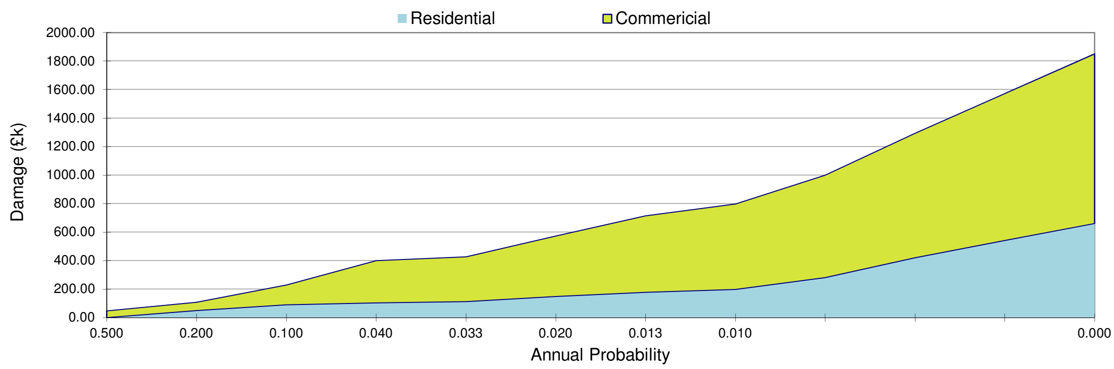
| | | | | | |
|---|---|---|---|---|---|
| Base date for estimates (year 0) | 43101 | First year of damage: | 0 | Prepared (date) | 00/01/1900 |
| Scaling factor (e.g. £m, £k, £) | £k | Last year of period: | 99 | Printed | 07/12/2018 |
| Discount rate | 3.5% | PV factor for mid-year 0: | 29.813 | Prepared by | JG |
| | | | | Checked by | 0 |
| Applicable year (if time varying) | | | | Checked date | 0 |

| | Average waiting time (yrs) between events/frequency per year | | | | | | | | | | | | Total PV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 5 | 10 | 25 | 30 | 50 | 75 | 100 | 200 | 500 | 1000 | Infinity | £k |
| | 0.500 | 0.200 | 0.100 | 0.040 | 0.033 | 0.020 | 0.013 | 0.010 | 0.005 | 0.002 | 0.001 | 0 | |
| Damage category | Damage £k | | | | | | | | | | | | |
| Residential property | 0.00 | 48.83 | 90.91 | 103.38 | 112.29 | 147.24 | 177.09 | 197.58 | 279.81 | 420.25 | 540.43 | 660.61 | 852.25 |
| Ind/commercial (direct) | 47.16 | 58.39 | 138.72 | 296.38 | 314.96 | 425.43 | 536.19 | 598.52 | 718.38 | 872.40 | 1031.11 | 1189.83 | 2,132.89 |
| Ind/comm (indirect) | 1.414824888 | 1.75 | 4.16 | 8.89 | 9.45 | 12.76 | 16.09 | 17.96 | 21.55 | 26.17 | 30.93 | 35.69 | 63.99 |
| Traffic related | | | | | | | | | | | | - | - |
| Emergency services | 0 | 2.73 | 5.09 | 5.79 | 6.29 | 8.25 | 9.92 | 11.06 | 15.67 | 23.53 | 30.26 | 36.99 | 47.73 |
| Other | 0 | - | - | - | - | - | - | - | - | - | - | - | - |
| Intangible damages | | | | | | | | | | | | - | 148.82 |
| | | | | | | | | | | | | - | - |
| Total damage £k | 48.57565447 | 111.71 | 238.89 | 414.44 | 442.98 | 593.68 | 739.29 | 825.11 | 1,035.41 | 1,342.35 | 1,632.74 | 1,923.13 | |
| Area (damagexfrequency) | | 24.04 | 17.53 | 19.60 | 2.86 | 6.91 | 4.44 | 2.61 | 4.65 | 3.57 | 1.49 | 7.40 | |

| | | |
|---|---|---|
| Total area, as above | 95.09 | |
| PV Factor, as above | 29.813 | |
| Present value (assuming no change in damage or event frequency) | 2835 | 3,245.68 |

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: Chapman FPS** **Option: Do Minimum**



## Summary Annual Average Damage

**Sheet Nr.**

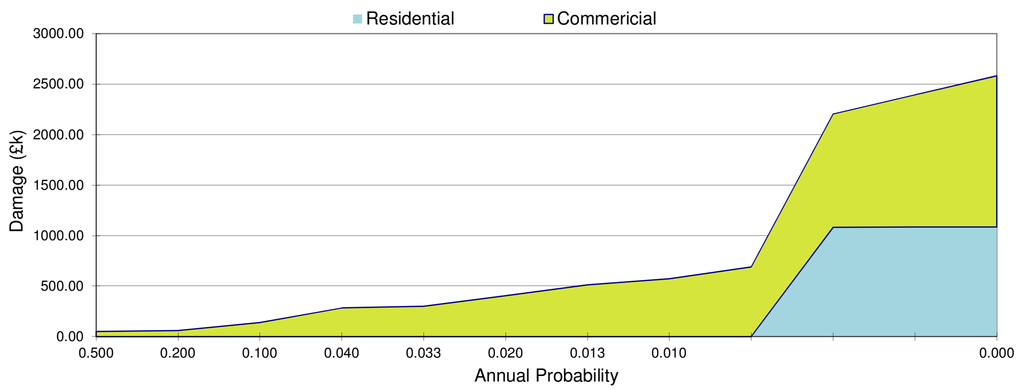
| | | | | | |
|---|---|---|---|---|---|
| **Client/Authority** | | | | | |
| Scottish Borders Council | | | | | |
| **Project name** | | **Option:** | | | |
| Chapman FPS | | PLP | | | |
| **Project reference** | - | | | | |
| Base date for estimates (year 0) | 43101 | First year of damage: | 0 | Prepared (date) | 00/01/1900 |
| Scaling factor (e.g. £m, £k, £) | £k | Last year of period: | 99 | Printed | 07/12/2018 |
| Discount rate | 3.5% | PV factor for mid-year 0: | 29.813 | Prepared by | JG |
| | | | | Checked by | 0 |
| Applicable year (if time varying) | | | | Checked date | 0 |

| | Average waiting time (yrs) between events/frequency per year | | | | | | | | | | | | Total PV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 5 | 10 | 25 | 30 | 50 | 75 | 100 | 200 | 500 | 1000 | Infinity | £k |
| | 0.500 | 0.200 | 0.100 | 0.040 | 0.033 | 0.020 | 0.013 | 0.010 | 0.005 | 0.002 | 0.001 | 0 | |
| Damage category | Damage £k | | | | | | | | | | | | |
| Residential property | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1081.58 | 1082.73 | 1083.89 | 162 |
| Ind/commercial (direct) | 47.16 | 58.39 | 138.72 | 282.16 | 299.03 | 404.31 | 512.17 | 572.36 | 687.45 | 1123.94 | 1311.93 | 1499.93 | 2145 |
| Ind/comm (indirect) | 1 | 2 | 4 | 8 | 9 | 12 | 15 | 17 | 21 | 34 | 39 | 45 | 64 |
| Traffic related | | | | | | | | | | | | 0 | 0 |
| Emergency services | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 61 | 61 | 61 | 9 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Intangible damages | | | | | | | | | | | | 0 | 19 |
| | | | | | | | | | | | | 0 | 0 |
| Total damage £k | 49 | 60 | 143 | 291 | 308 | 416 | 528 | 590 | 708 | 2300 | 2495 | 2690 | |
| Area (damagexfrequency) | | 16 | 10 | 13 | 2 | 5 | 3 | 2 | 3 | 5 | 2 | 8 | |

| | | |
|---|---|---|
| Total area, as above | 69.94 | |
| PV Factor, as above | 29.813 | |
| Present value (assuming no change in damage or event frequency) | 2085 | 2,399 |

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: Chapman FPS** **Option: PLP**



## Summary Annual Average Damage

**Sheet Nr.**

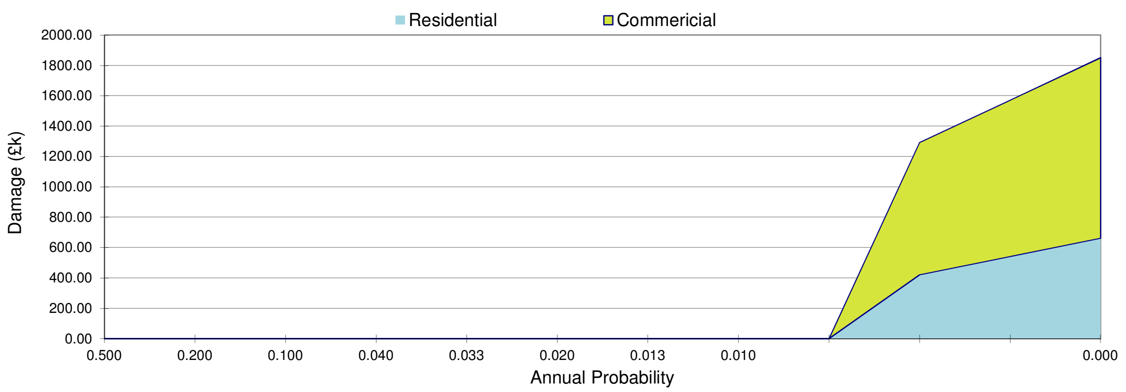
| | | | | | |
|---|---|---|---|---|---|
| **Client/Authority** | | | | | |
| Scottish Borders Council | | | | | |
| **Project name** | | **Option:** | | | |
| Chapman FPS | | Enlarged Culvert | | | |
| **Project reference** | - | | | | |
| Base date for estimates (year 0) | 43101 | First year of damage: | 0 | Prepared (date) | 00/01/1900 |
| Scaling factor (e.g. £m, £k, £) | £k | Last year of period: | 99 | Printed | 07/12/2018 |
| Discount rate | 3.5% | PV factor for mid-year 0: | 29.813 | Prepared by | JG |
| | | | | Checked by | 0 |
| Applicable year (if time varying) | | | | Checked date | 0 |

| | Average waiting time (yrs) between events/frequency per year | | | | | | | | | | | | Total PV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 5 | 10 | 25 | 30 | 50 | 75 | 100 | 200 | 500 | 1000 | Infinity | £k |
| | 0.500 | 0.200 | 0.100 | 0.040 | 0.033 | 0.020 | 0.013 | 0.010 | 0.005 | 0.002 | 0.001 | 0 | |
| Damage category | Damage £k | | | | | | | | | | | | |
| Residential property | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 420.25 | 540.43 | 660.61 | 98.47 |
| Ind/commercial (direct) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 872.40 | 1031.11 | 1189.83 | 177.36 |
| Ind/comm (indirect) | 0 | - | - | - | - | - | - | - | - | 26.17 | 30.93 | 35.69 | 5.32 |
| Traffic related | | | | | | | | | | | | - | - |
| Emergency services | 0 | - | - | - | - | - | - | - | - | 23.53 | 30.26 | 36.99 | 5.51 |
| Other | 0 | - | - | - | - | - | - | - | - | - | - | - | - |
| Intangible damages | | | | | | | | | | | | - | 8.26 |
| | | | | | | | | | | | | - | - |
| Total damage £k | 0 | - | - | - | - | - | - | - | - | 1,342.35 | 1,632.74 | 1,923.13 | |
| Area (damagexfrequency) | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.01 | 1.49 | 4.81 | |

| | | |
|---|---|---|
| Total area, as above | 8.31 | |
| PV Factor, as above | 29.813 | |
| Present value (assuming no change in damage or event frequency) | 248 | 294.92 |

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: Chapman FPS** **Option: Enlarged Culvert**



## Summary Annual Average Damage

Sheet Nr.

**Client/Authority**
Scottish Borders Council

**Project name**
Chapman FPS

**Option:**
Channel Conveyance

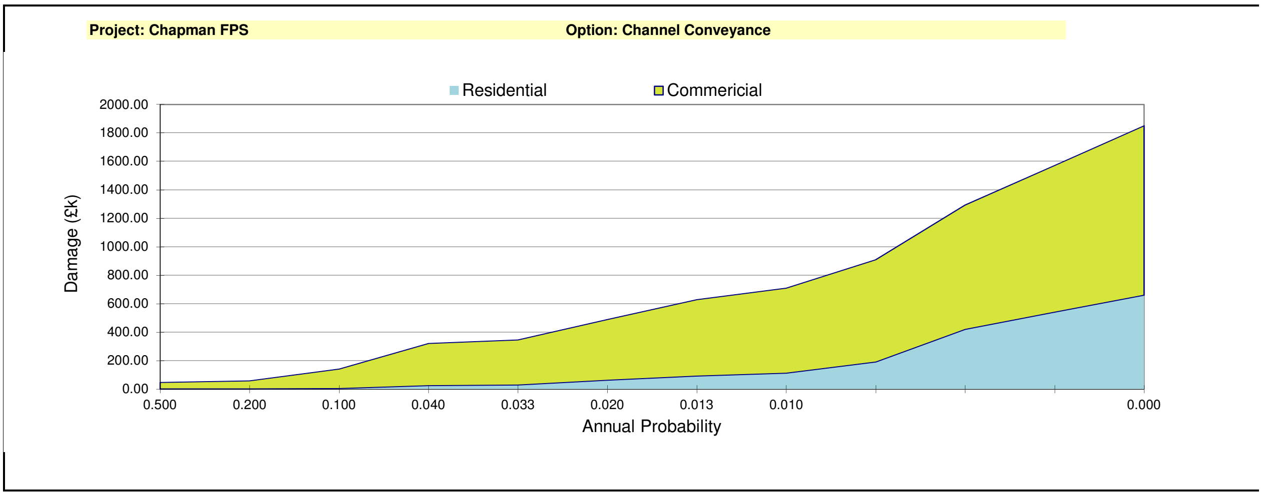
**Project reference** -

| | | | | | |
|---|---|---|---|---|---|
| Base date for estimates (year 0) | 43101 | First year of damage: | 0 | Prepared (date) | 00/01/1900 |
| Scaling factor (e.g. £m, £k, £) | £k | Last year of period: | 99 | Printed | 07/12/2018 |
| Discount rate | 3.5% | PV factor for mid-year 0: | 29.813 | Prepared by | JG |
| | | | | Checked by | 0 |
| Applicable year (if time varying) | | | | Checked date | 0 |

| | Average waiting time (yrs) between events/frequency per year | | | | | | | | | | | | Total PV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 5 | 10 | 25 | 30 | 50 | 75 | 100 | 200 | 500 | 1000 | Infinity | £k |
| | 0.500 | 0.200 | 0.100 | 0.040 | 0.033 | 0.020 | 0.013 | 0.010 | 0.005 | 0.002 | 0.001 | 0 | |
| Damage category | Damage £k | | | | | | | | | | | | |
| Residential property | 0.00 | 0.00 | 3.63 | 24.61 | 30.20 | 63.34 | 91.99 | 111.49 | 191.21 | 420.25 | 540.43 | 660.61 | 195.33 |
| Ind/commercial (direct) | 47.16 | 58.39 | 138.72 | 296.38 | 314.96 | 425.43 | 536.19 | 598.52 | 718.38 | 872.40 | 1031.11 | 1189.83 | 2,132.89 |
| Ind/comm (indirect) | 1.414824888 | 1.75 | 4.16 | 8.89 | 9.45 | 12.76 | 16.09 | 17.96 | 21.55 | 26.17 | 30.93 | 35.69 | 63.99 |
| Traffic related | | | | | | | | | | | | - | - |
| Emergency services | 0 | - | 0.20 | 1.38 | 1.69 | 3.55 | 5.15 | 6.24 | 10.71 | 23.53 | 30.26 | 36.99 | 10.94 |
| Other | 0 | - | - | - | - | - | - | - | - | - | - | - | - |
| Intangible damages | | | | | | | | | | | | - | 8.95 |
| | | | | | | | | | | | | - | - |
| Total damage £k | 48.57565447 | 60.14 | 146.71 | 331.26 | 356.30 | 505.08 | 649.42 | 734.20 | 941.85 | 1,342.35 | 1,632.74 | 1,923.13 | |
| Area (damagexfrequency) | | 16.31 | 10.34 | 14.34 | 2.29 | 5.74 | 3.85 | 2.31 | 4.19 | 3.43 | 1.49 | 7.16 | |

| | | |
|---|---|---|
| Total area, as above | 71.44 | |
| PV Factor, as above | 29.813 | |
| Present value (assuming no change in damage or event frequency) | 2130 | 2,412.11 |

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



## 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) | £78.1 |
| Year of capital works (year) | 1 |
| Capital cost (£k) | £473.6 |
| Annual maintenance cost (£k) | £9.5 |
| Other cost (£k) | £0.0 |
| Other works frequency (years) | 1 |
| Other cost (£k) | £0.0 |
| Other works frequency (years) | 1 |
| Replacement (£) | 473.6 |
| Replacement frequency (years) | 25 |
| Optimism Bias | 60% |

**Key**

| | |
|---|---|
| | Information |
| | Calculation |
| | Cost input |
| | Default |

| Element | ash cost (£ | PV Cost (£k) |
|---|---|---|
| Enabling cost | 78 | 78 |
| Capital cost | 1,894 | 785 |
| Maintenance cost | 928 | 264 |
| **Total** | 2,901 | 1,127 |
| ***Total incl. Optimism Bias*** | - | 1,804 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | **Total PVc (£k) with Optimism Bias:** | | **1804** |
| **Initial discount rate** | **3.5%** | **29.813** | | | | | | **Total PVc (£k):** | | **1127** |
| | | **Cost Elements** | | | | **PV** | | | **TOTALS:** | |
| | | **Enabling** | **Capital** | **Maint.** | **Interm.** | **Enabling** | **Capital** | **Maint.** | **Cash** | **PV** |
| | **Cash sum** | 78 | 1894 | 928 | 0 | 78 | 785 | 264 | 2901 | **1127** |
| **year** | **Discount Factor** | | | | | | | | | |
| 0 | 1.000 | 78.1 | | | 0 | 78.1 | | | 78.1 | 78.1 |
| 1 | 0.966 | | 474 | | 0 | | 457.5 | | 473.6 | 457.5 |
| 2 | 0.934 | | | 9 | 0 | | | 8.8 | 9.5 | 8.8 |
| 3 | 0.902 | | | 9 | 0 | | | 8.5 | 9.5 | 8.5 |
| 4 | 0.871 | | | 9 | 0 | | | 8.3 | 9.5 | 8.3 |
| 5 | 0.842 | | | 9 | 0 | | | 8.0 | 9.5 | 8.0 |
| 6 | 0.814 | | | 9 | 0 | | | 7.7 | 9.5 | 7.7 |
| 7 | 0.786 | | | 9 | 0 | | | 7.4 | 9.5 | 7.4 |
| 8 | 0.759 | | | 9 | 0 | | | 7.2 | 9.5 | 7.2 |
| 9 | 0.734 | | | 9 | 0 | | | 6.9 | 9.5 | 6.9 |
| 10 | 0.709 | | | 9 | 0 | | | 6.7 | 9.5 | 6.7 |
| 11 | 0.685 | | | 9 | 0 | | | 6.5 | 9.5 | 6.5 |
| 12 | 0.662 | | | 9 | 0 | | | 6.3 | 9.5 | 6.3 |
| 13 | 0.639 | | | 9 | 0 | | | 6.1 | 9.5 | 6.1 |
| 14 | 0.618 | | | 9 | 0 | | | 5.9 | 9.5 | 5.9 |
| 15 | 0.597 | | | 9 | 0 | | | 5.7 | 9.5 | 5.7 |
| 16 | 0.577 | | | 9 | 0 | | | 5.5 | 9.5 | 5.5 |
| 17 | 0.557 | | | 9 | 0 | | | 5.3 | 9.5 | 5.3 |
| 18 | 0.538 | | | 9 | 0 | | | 5.1 | 9.5 | 5.1 |
| 19 | 0.520 | | | 9 | 0 | | | 4.9 | 9.5 | 4.9 |
| 20 | 0.503 | | | 9 | 0 | | | 4.8 | 9.5 | 4.8 |
| 21 | 0.486 | | | 9 | 0 | | | 4.6 | 9.5 | 4.6 |
| 22 | 0.469 | | | 9 | 0 | | | 4.4 | 9.5 | 4.4 |
| 23 | 0.453 | | | 9 | 0 | | | 4.3 | 9.5 | 4.3 |
| 24 | 0.438 | | | 9 | 0 | | | 4.1 | 9.5 | 4.1 |
| 25 | 0.423 | | | 9 | 0 | | | 4.0 | 9.5 | 4.0 |
| 26 | 0.409 | | 474 | 9 | 0 | | 193.6 | 3.9 | 483.0 | 197.5 |
| 27 | 0.395 | | | 9 | 0 | | | 3.7 | 9.5 | 3.7 |
| 28 | 0.382 | | | 9 | 0 | | | 3.6 | 9.5 | 3.6 |
| 29 | 0.369 | | | 9 | 0 | | | 3.5 | 9.5 | 3.5 |
| 30 | 0.356 | | | 9 | 0 | | | 3.4 | 9.5 | 3.4 |
| 31 | 0.346 | | | 9 | 0 | | | 3.3 | 9.5 | 3.3 |
| 32 | 0.336 | | | 9 | 0 | | | 3.2 | 9.5 | 3.2 |
| 33 | 0.326 | | | 9 | 0 | | | 3.1 | 9.5 | 3.1 |
| 34 | 0.317 | | | 9 | 0 | | | 3.0 | 9.5 | 3.0 |
| 35 | 0.307 | | | 9 | 0 | | | 2.9 | 9.5 | 2.9 |
| 36 | 0.298 | | | 9 | 0 | | | 2.8 | 9.5 | 2.8 |
| 37 | 0.290 | | | 9 | 0 | | | 2.7 | 9.5 | 2.7 |
| 38 | 0.281 | | | 9 | 0 | | | 2.7 | 9.5 | 2.7 |
| 39 | 0.273 | | | 9 | 0 | | | 2.6 | 9.5 | 2.6 |
| 40 | 0.265 | | | 9 | 0 | | | 2.5 | 9.5 | 2.5 |
| 41 | 0.257 | | | 9 | 0 | | | 2.4 | 9.5 | 2.4 |
| 42 | 0.250 | | | 9 | 0 | | | 2.4 | 9.5 | 2.4 |
| 43 | 0.243 | | | 9 | 0 | | | 2.3 | 9.5 | 2.3 |
| 44 | 0.236 | | | 9 | 0 | | | 2.2 | 9.5 | 2.2 |
| 45 | 0.229 | | | 9 | 0 | | | 2.2 | 9.5 | 2.2 |
| 46 | 0.222 | | | 9 | 0 | | | 2.1 | 9.5 | 2.1 |
| 47 | 0.216 | | | 9 | 0 | | | 2.0 | 9.5 | 2.0 |
| 48 | 0.209 | | | 9 | 0 | | | 2.0 | 9.5 | 2.0 |
| 49 | 0.203 | | | 9 | 0 | | | 1.9 | 9.5 | 1.9 |
| 50 | 0.197 | | | 9 | 0 | | | 1.9 | 9.5 | 1.9 |
| 51 | 0.192 | | 474 | 9 | 0 | | 90.7 | 1.8 | 483.0 | 92.5 |
| 52 | 0.186 | | | 9 | 0 | | | 1.8 | 9.5 | 1.8 |
| 53 | 0.181 | | | 9 | 0 | | | 1.7 | 9.5 | 1.7 |
| 54 | 0.175 | | | 9 | 0 | | | 1.7 | 9.5 | 1.7 |
| 55 | 0.170 | | | 9 | 0 | | | 1.6 | 9.5 | 1.6 |
| 56 | 0.165 | | | 9 | 0 | | | 1.6 | 9.5 | 1.6 |
| 57 | 0.160 | | | 9 | 0 | | | 1.5 | 9.5 | 1.5 |
| 58 | 0.156 | | | 9 | 0 | | | 1.5 | 9.5 | 1.5 |
| 59 | 0.151 | | | 9 | 0 | | | 1.4 | 9.5 | 1.4 |
| 60 | 0.147 | | | 9 | 0 | | | 1.4 | 9.5 | 1.4 |
| 61 | 0.143 | | | 9 | 0 | | | 1.3 | 9.5 | 1.3 |
| 62 | 0.138 | | | 9 | 0 | | | 1.3 | 9.5 | 1.3 |
| 63 | 0.134 | | | 9 | 0 | | | 1.3 | 9.5 | 1.3 |
| 64 | 0.130 | | | 9 | 0 | | | 1.2 | 9.5 | 1.2 |
| 65 | 0.127 | | | 9 | 0 | | | 1.2 | 9.5 | 1.2 |
| 66 | 0.123 | | | 9 | 0 | | | 1.2 | 9.5 | 1.2 |
| 67 | 0.119 | | | 9 | 0 | | | 1.1 | 9.5 | 1.1 |
| 68 | 0.116 | | | 9 | 0 | | | 1.1 | 9.5 | 1.1 |
| 69 | 0.112 | | | 9 | 0 | | | 1.1 | 9.5 | 1.1 |
| 70 | 0.109 | | | 9 | 0 | | | 1.0 | 9.5 | 1.0 |
| 71 | 0.106 | | | 9 | 0 | | | 1.0 | 9.5 | 1.0 |
| 72 | 0.103 | | | 9 | 0 | | | 1.0 | 9.5 | 1.0 |
| 73 | 0.100 | | | 9 | 0 | | | 0.9 | 9.5 | 0.9 |
| 74 | 0.097 | | | 9 | 0 | | | 0.9 | 9.5 | 0.9 |
| 75 | 0.094 | | | 9 | 0 | | | 0.9 | 9.5 | 0.9 |
| 76 | 0.092 | | 474 | 9 | 0 | | 43.5 | 0.9 | 483.0 | 44.4 |
| 77 | 0.090 | | | 9 | 0 | | | 0.8 | 9.5 | 0.8 |
| 78 | 0.087 | | | 9 | 0 | | | 0.8 | 9.5 | 0.8 |
| 79 | 0.085 | | | 9 | 0 | | | 0.8 | 9.5 | 0.8 |
| 80 | 0.083 | | | 9 | 0 | | | 0.8 | 9.5 | 0.8 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 81 | 0.081 | | | 9 | 0 | 0.8 | 9.5 | 0.8 |
| 82 | 0.079 | | | 9 | 0 | 0.8 | 9.5 | 0.8 |
| 83 | 0.077 | | | 9 | 0 | 0.7 | 9.5 | 0.7 |
| 84 | 0.075 | | | 9 | 0 | 0.7 | 9.5 | 0.7 |
| 85 | 0.074 | | | 9 | 0 | 0.7 | 9.5 | 0.7 |
| 86 | 0.072 | | | 9 | 0 | 0.7 | 9.5 | 0.7 |
| 87 | 0.070 | | | 9 | 0 | 0.7 | 9.5 | 0.7 |
| 88 | 0.068 | | | 9 | 0 | 0.6 | 9.5 | 0.6 |
| 89 | 0.067 | | | 9 | 0 | 0.6 | 9.5 | 0.6 |
| 90 | 0.065 | | | 9 | 0 | 0.6 | 9.5 | 0.6 |
| 91 | 0.063 | | | 9 | 0 | 0.6 | 9.5 | 0.6 |
| 92 | 0.062 | | | 9 | 0 | 0.6 | 9.5 | 0.6 |
| 93 | 0.060 | | | 9 | 0 | 0.6 | 9.5 | 0.6 |
| 94 | 0.059 | | | 9 | 0 | 0.6 | 9.5 | 0.6 |
| 95 | 0.057 | | | 9 | 0 | 0.5 | 9.5 | 0.5 |
| 96 | 0.056 | | | 9 | 0 | 0.5 | 9.5 | 0.5 |
| 97 | 0.055 | | | 9 | 0 | 0.5 | 9.5 | 0.5 |
| 98 | 0.053 | | | 9 | 0 | 0.5 | 9.5 | 0.5 |
| 99 | 0.052 | | | 9 | 0 | 0.5 | 9.5 | 0.5 |

## Summary of costs

| | | | |
|---|---|---|---|
| **Client/Authority** | | Prepared (date) | |
| Scottish Borders Council | | Printed | 07/12/2018 |
| **Project/Option name** | | Prepared by | C.Kampanou |
| Chapman's Burn | | 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 | £188.42 |
| Capital Costs | £2,123.10 |
| O & M Costs | £1,734.39 |
| Other Costs | £0.00 |
| Total Real Cost | £4,045.91 |
| Total Cost PV | £2,732.55 |
| Total Cost PV + OB | **£4,372.07** |

**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).

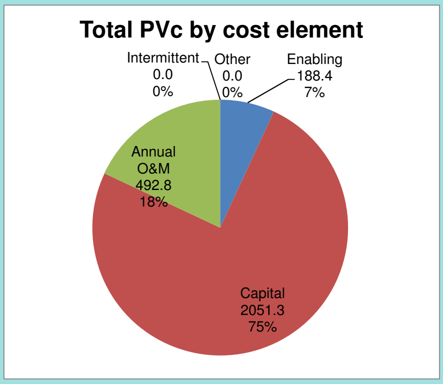
**Additional user notes:**
Add additional user notes here.

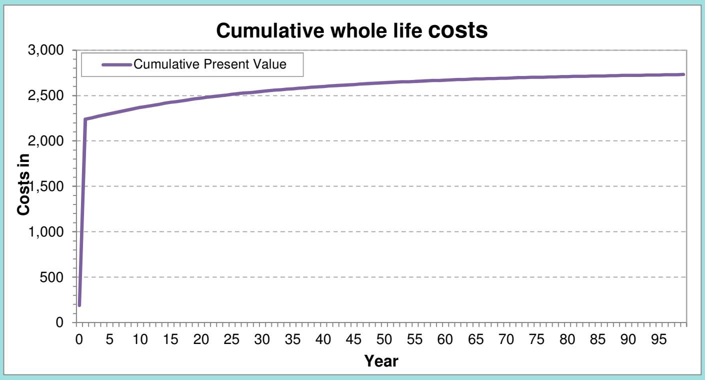
| FRM Measure | Asset | Open / Go to Costing Sheet | Delete Sheet | Enabling Costs | Capital Costs | O & M Costs | Other Costs | Total Cost Cash | Total Cost PV |
|---|---|---|---|---|---|---|---|---|---|
| **Fluvial raised defence** | **Embankment** | | | £0.00 | £20.88 | £9.91 | £0.00 | £30.79 | £22.99 |
| | **Wall** | | | | | | | | |
| | **Sheet Piling** | | | | | | | | |
| **Channel management** | **N/A** | | | | | | | | |
| **Culvert & screen** | **N/A** | | | £188.20 | £2,101.10 | £1,724.49 | £0.00 | £4,013.78 | £2,708.25 |
| **Control assets** | **Weir** | | | | | | | | |
| | **Pumping station** | | | | | | | | |
| | **Flood gate** | | | | | | | | |
| | **Outfall** | | | | | | | | |
| | **Flow barrier** | | | | | | | | |
| **Coastal protection** | **Wall** | | | | | | | | |
| | **Revetment** | | | | | | | | |
| | **Groyne** | | | | | | | | |
| | **Recharge** | | | | | | | | |
| **Flood storage** | **N/A** | | | | | | | | |
| **Flood warning and forecasting** | **Various** | | | | | | | | |
| **Temporary & demountable barriers** | **Various** | | | | | | | | |
| **Household resistance** | **Various** | | | | | | | | |
| **Household resilience** | **Various** | | | | | | | | |
| **SUDS and urban drainage** | **Various** | | | | | | | | |
| **Managed realignment** | **Various** | | | | | | | | |
| **Habitat creation** | **Various** | | | | | | | | |
| **Landuse & runoff management** | **Various** | | | | | | | | |
| **River Restoration** | **Various** | | | | | | | | |
| **User Defined 1** | **Various** | | | £0.22 | £1.12 | £0.00 | £0.00 | £1.34 | £1.31 |
| **User Defined 2** | **Various** | | | | | | | | |
| **User Defined 3** | **Various** | | | | | | | | |

**Whole Life and Present Value Cost Analysis**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | PV factor | 29.813 | | | | | Total PVc (£k): | 2732.5 | |
| | | Enabling £k | Capital £k | Annual O&M £k | Intermittent O&M £k | Other £k | TOTALS: Current price | PV (£k) | |
| | Total real cost | 188.4 | 2123.1 | 1734.4 | 0.0 | 0.0 | 4045.91 | 2732.5 | |
| | Total PV cost | 188.4 | 2051.3 | 492.8 | 0.0 | 0.0 | | 2732.5 | Cumulative |
| year | Discount Factor | | | | | | | | PV Costs (£k) |
| 0 | 1.000 | 188.4 | 0.0 | 0.0 | 0.0 | 0.0 | 188.4 | 188.4 | 188.4 |
| 1 | 0.966 | 0.0 | 2123.1 | 0.0 | 0.0 | 0.0 | 2123.1 | 2051.3 | 2239.7 |
| 2 | 0.934 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 16.5 | 2256.2 |
| 3 | 0.902 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 16.0 | 2272.2 |
| 4 | 0.871 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 15.4 | 2287.6 |
| 5 | 0.842 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 14.9 | 2302.5 |
| 6 | 0.814 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 14.4 | 2316.9 |
| 7 | 0.786 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 13.9 | 2330.8 |
| 8 | 0.759 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 13.4 | 2344.3 |
| 9 | 0.734 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 13.0 | 2357.3 |
| 10 | 0.709 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 12.5 | 2369.8 |
| 11 | 0.685 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 12.1 | 2381.9 |
| 12 | 0.662 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 11.7 | 2393.6 |
| 13 | 0.639 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 11.3 | 2405.0 |
| 14 | 0.618 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 10.9 | 2415.9 |
| 15 | 0.597 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 10.6 | 2426.5 |
| 16 | 0.577 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 10.2 | 2436.7 |
| 17 | 0.557 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 9.9 | 2446.5 |
| 18 | 0.538 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 9.5 | 2456.1 |
| 19 | 0.520 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 9.2 | 2465.3 |
| 20 | 0.503 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 8.9 | 2474.2 |
| 21 | 0.486 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 8.6 | 2482.7 |
| 22 | 0.469 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 8.3 | 2491.1 |
| 23 | 0.453 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 8.0 | 2499.1 |
| 24 | 0.438 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 7.8 | 2506.8 |
| 25 | 0.423 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 7.5 | 2514.3 |
| 26 | 0.409 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 7.2 | 2521.5 |
| 27 | 0.395 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 7.0 | 2528.5 |
| 28 | 0.382 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 6.8 | 2535.3 |
| 29 | 0.369 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 6.5 | 2541.8 |
| 30 | 0.356 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 6.3 | 2548.1 |
| 31 | 0.346 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 6.1 | 2554.2 |
| 32 | 0.336 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 5.9 | 2560.2 |
| 33 | 0.326 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 5.8 | 2566.0 |
| 34 | 0.317 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 5.6 | 2571.6 |
| 35 | 0.307 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 5.4 | 2577.0 |
| 36 | 0.298 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 5.3 | 2582.3 |
| 37 | 0.290 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 5.1 | 2587.4 |
| 38 | 0.281 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 5.0 | 2592.4 |
| 39 | 0.273 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 4.8 | 2597.2 |
| 40 | 0.265 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 4.7 | 2601.9 |
| 41 | 0.257 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 4.6 | 2606.5 |
| 42 | 0.250 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 4.4 | 2610.9 |
| 43 | 0.243 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 4.3 | 2615.2 |
| 44 | 0.236 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 4.2 | 2619.4 |
| 45 | 0.229 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 4.0 | 2623.4 |
| 46 | 0.222 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 3.9 | 2627.3 |
| 47 | 0.216 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 3.8 | 2631.1 |
| 48 | 0.209 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 3.7 | 2634.8 |
| 49 | 0.203 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 3.6 | 2638.4 |
| 50 | 0.197 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 3.5 | 2641.9 |
| 51 | 0.192 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 3.4 | 2645.3 |
| 52 | 0.186 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 3.3 | 2648.6 |
| 53 | 0.181 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 3.2 | 2651.8 |
| 54 | 0.175 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 3.1 | 2654.9 |
| 55 | 0.170 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 3.0 | 2657.9 |
| 56 | 0.165 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 2.9 | 2660.8 |
| 57 | 0.160 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 2.8 | 2663.7 |
| 58 | 0.156 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 2.8 | 2666.4 |
| 59 | 0.151 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 2.7 | 2669.1 |
| 60 | 0.147 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 2.6 | 2671.7 |
| 61 | 0.143 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 2.5 | 2674.2 |
| 62 | 0.138 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 2.4 | 2676.7 |
| 63 | 0.134 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 2.4 | 2679.1 |
| 64 | 0.130 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 2.3 | 2681.4 |
| 65 | 0.127 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 2.2 | 2683.6 |
| 66 | 0.123 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 2.2 | 2685.8 |
| 67 | 0.119 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 2.1 | 2687.9 |
| 68 | 0.116 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 2.1 | 2689.9 |
| 69 | 0.112 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 2.0 | 2691.9 |
| 70 | 0.109 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.9 | 2693.9 |
| 71 | 0.106 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.9 | 2695.7 |
| 72 | 0.103 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.8 | 2697.6 |
| 73 | 0.100 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.8 | 2699.3 |
| 74 | 0.097 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.7 | 2701.1 |
| 75 | 0.094 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.7 | 2702.7 |
| 76 | 0.092 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.6 | 2704.4 |
| 77 | 0.090 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.6 | 2705.9 |
| 78 | 0.087 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.5 | 2707.5 |
| 79 | 0.085 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.5 | 2709.0 |
| 80 | 0.083 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.5 | 2710.5 |
| 81 | 0.081 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.4 | 2711.9 |
| 82 | 0.079 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.4 | 2713.3 |
| 83 | 0.077 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.4 | 2714.7 |
| 84 | 0.075 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.3 | 2716.0 |
| 85 | 0.074 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.3 | 2717.3 |
| 86 | 0.072 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.3 | 2718.6 |
| 87 | 0.070 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.2 | 2719.8 |
| 88 | 0.068 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.2 | 2721.0 |
| 89 | 0.067 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.2 | 2722.2 |
| 90 | 0.065 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.2 | 2723.4 |
| 91 | 0.063 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.1 | 2724.5 |
| 92 | 0.062 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.1 | 2725.6 |
| 93 | 0.060 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.1 | 2726.7 |
| 94 | 0.059 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.0 | 2727.7 |
| 95 | 0.057 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.0 | 2728.7 |
| 96 | 0.056 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.0 | 2729.7 |
| 97 | 0.055 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 1.0 | 2730.7 |
| 98 | 0.053 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 0.9 | 2731.6 |
| 99 | 0.052 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 | 17.7 | 0.9 | 2732.5 |

**Whole life cost charts**

## Summary of costs

| | | | |
|---|---|---|---|
| **Client/Authority** | | Prepared (date) | |
| Scottish Borders Council | | Printed | 07/12/2018 |
| **Project/Option name** | | Prepared by | C.Kampanou |
| Chapman's Burn | | 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 | £155.86 |
| Capital Costs | £1,348.01 |
| O & M Costs | £608.13 |
| Other Costs | £0.00 |
| Total Real Cost | £2,112.00 |
| Total Cost PV | £1,631.08 |
| Total Cost PV + OB | **£2,609.73** |

**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:**

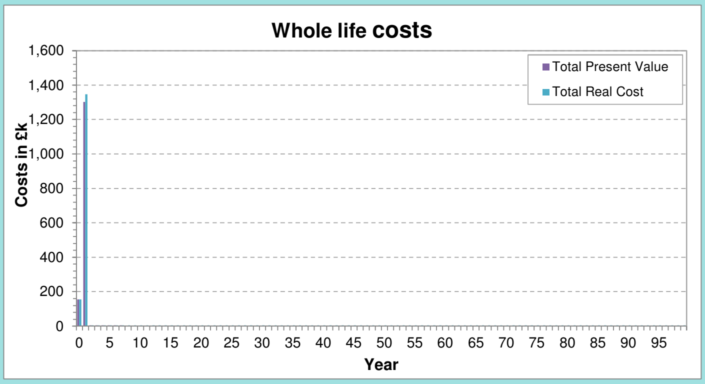
Add additional user notes here.

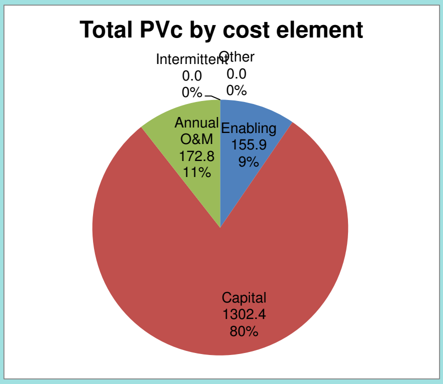
| FRM Measure | Asset | Open / Go to Costing Sheet | Delete Sheet | Enabling Costs | Capital Costs | O & M Costs | Other Costs | Total Cost Cash | Total Cost PV |
|---|---|---|---|---|---|---|---|---|---|
| Fluvial raised defence | Embankment | | | £0.00 | £488.21 | £132.75 | £0.00 | £620.96 | £509.42 |
| | Wall | | | | | | | | |
| | Sheet Piling | | | | | | | | |
| Channel management | N/A | | | | | | | | |
| Culvert & screen | N/A | | | £67.60 | £337.99 | £44.00 | £0.00 | £449.59 | £406.67 |
| Control assets | Weir | | | | | | | | |
| | Pumping station | | | | | | | | |
| | Flood gate | | | | | | | | |
| | Outfall | | | | | | | | |
| | Flow barrier | | | | | | | | |
| Coastal protection | Wall | | | | | | | | |
| | Revetment | | | | | | | | |
| | Groyne | | | | | | | | |
| | Recharge | | | | | | | | |
| Flood storage | N/A | | | £88.04 | £440.18 | £431.38 | £0.00 | £959.60 | £635.91 |
| 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 | £80.50 | £0.00 | £0.00 | £80.50 | £77.78 |
| User Defined 2 | Various | | | £0.22 | £1.12 | £0.00 | £0.00 | £1.34 | £1.31 |
| User Defined 3 | Various | | | | | | | | |

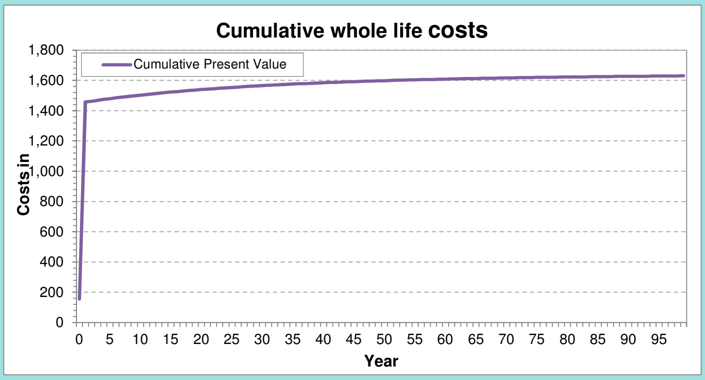
**Whole Life and Present Value Cost Analysis**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | PV factor | 29.813 | | | | | Total PVc (£k): | 1631.1 | |
| | | Enabling £k | Capital £k | Annual O&M £k | Intermittent O&M £k | Other £k | TOTALS: Current price | PV (£k) | |
| | Total real cost | 155.9 | 1348.0 | 608.1 | 0.0 | 0.0 | 2112.00 | 1631.1 | |
| | Total PV cost | 155.9 | 1302.4 | 172.8 | 0.0 | 0.0 | | 1631.1 | Cumulative |
| year | Discount Factor | | | | | | | | PV Costs (£k) |
| 0 | 1.000 | 155.9 | 0.0 | 0.0 | 0.0 | 0.0 | 155.9 | 155.9 | 155.9 |
| 1 | 0.966 | 0.0 | 1348.0 | 0.0 | 0.0 | 0.0 | 1348.0 | 1302.4 | 1458.3 |
| 2 | 0.934 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 5.8 | 1464.1 |
| 3 | 0.902 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 5.6 | 1469.7 |
| 4 | 0.871 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 5.4 | 1475.1 |
| 5 | 0.842 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 5.2 | 1480.3 |
| 6 | 0.814 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 5.0 | 1485.4 |
| 7 | 0.786 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 4.9 | 1490.2 |
| 8 | 0.759 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 4.7 | 1494.9 |
| 9 | 0.734 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 4.6 | 1499.5 |
| 10 | 0.709 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 4.4 | 1503.9 |
| 11 | 0.685 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 4.3 | 1508.1 |
| 12 | 0.662 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 4.1 | 1512.3 |
| 13 | 0.639 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 4.0 | 1516.2 |
| 14 | 0.618 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 3.8 | 1520.1 |
| 15 | 0.597 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 3.7 | 1523.8 |
| 16 | 0.577 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 3.6 | 1527.3 |
| 17 | 0.557 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 3.5 | 1530.8 |
| 18 | 0.538 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 3.3 | 1534.1 |
| 19 | 0.520 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 3.2 | 1537.4 |
| 20 | 0.503 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 3.1 | 1540.5 |
| 21 | 0.486 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 3.0 | 1543.5 |
| 22 | 0.469 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 2.9 | 1546.4 |
| 23 | 0.453 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 2.8 | 1549.2 |
| 24 | 0.438 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 2.7 | 1551.9 |
| 25 | 0.423 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 2.6 | 1554.6 |
| 26 | 0.409 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 2.5 | 1557.1 |
| 27 | 0.395 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 2.5 | 1559.5 |
| 28 | 0.382 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 2.4 | 1561.9 |
| 29 | 0.369 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 2.3 | 1564.2 |
| 30 | 0.356 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 2.2 | 1566.4 |
| 31 | 0.346 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 2.1 | 1568.6 |
| 32 | 0.336 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 2.1 | 1570.6 |
| 33 | 0.326 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 2.0 | 1572.7 |
| 34 | 0.317 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 2.0 | 1574.6 |
| 35 | 0.307 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.9 | 1576.5 |
| 36 | 0.298 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.9 | 1578.4 |
| 37 | 0.290 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.8 | 1580.2 |
| 38 | 0.281 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.7 | 1581.9 |
| 39 | 0.273 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.7 | 1583.6 |
| 40 | 0.265 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.6 | 1585.3 |
| 41 | 0.257 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.6 | 1586.9 |
| 42 | 0.250 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.6 | 1588.4 |
| 43 | 0.243 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.5 | 1589.9 |
| 44 | 0.236 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.5 | 1591.4 |
| 45 | 0.229 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.4 | 1592.8 |
| 46 | 0.222 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.4 | 1594.2 |
| 47 | 0.216 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.3 | 1595.5 |
| 48 | 0.209 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.3 | 1596.8 |
| 49 | 0.203 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.3 | 1598.1 |
| 50 | 0.197 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.2 | 1599.3 |
| 51 | 0.192 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.2 | 1600.5 |
| 52 | 0.186 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.2 | 1601.7 |
| 53 | 0.181 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.1 | 1602.8 |
| 54 | 0.175 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.1 | 1603.9 |
| 55 | 0.170 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.1 | 1604.9 |
| 56 | 0.165 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.0 | 1605.9 |
| 57 | 0.160 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.0 | 1606.9 |
| 58 | 0.156 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 1.0 | 1607.9 |
| 59 | 0.151 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.9 | 1608.8 |
| 60 | 0.147 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.9 | 1609.7 |
| 61 | 0.143 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.9 | 1610.6 |
| 62 | 0.138 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.9 | 1611.5 |
| 63 | 0.134 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.8 | 1612.3 |
| 64 | 0.130 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.8 | 1613.1 |
| 65 | 0.127 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.8 | 1613.9 |
| 66 | 0.123 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.8 | 1614.7 |
| 67 | 0.119 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.7 | 1615.4 |
| 68 | 0.116 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.7 | 1616.1 |
| 69 | 0.112 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.7 | 1616.8 |
| 70 | 0.109 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.7 | 1617.5 |
| 71 | 0.106 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.7 | 1618.2 |
| 72 | 0.103 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.6 | 1618.8 |
| 73 | 0.100 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.6 | 1619.4 |
| 74 | 0.097 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.6 | 1620.0 |
| 75 | 0.094 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.6 | 1620.6 |
| 76 | 0.092 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.6 | 1621.2 |
| 77 | 0.090 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.6 | 1621.8 |
| 78 | 0.087 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.5 | 1622.3 |
| 79 | 0.085 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.5 | 1622.8 |
| 80 | 0.083 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.5 | 1623.3 |
| 81 | 0.081 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.5 | 1623.8 |
| 82 | 0.079 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.5 | 1624.3 |
| 83 | 0.077 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.5 | 1624.8 |
| 84 | 0.075 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.5 | 1625.3 |
| 85 | 0.074 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.5 | 1625.7 |
| 86 | 0.072 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.4 | 1626.2 |
| 87 | 0.070 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.4 | 1626.6 |
| 88 | 0.068 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.4 | 1627.0 |
| 89 | 0.067 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.4 | 1627.5 |
| 90 | 0.065 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.4 | 1627.9 |
| 91 | 0.063 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.4 | 1628.3 |
| 92 | 0.062 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.4 | 1628.6 |
| 93 | 0.060 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.4 | 1629.0 |
| 94 | 0.059 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.4 | 1629.4 |
| 95 | 0.057 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.4 | 1629.7 |
| 96 | 0.056 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.3 | 1630.1 |
| 97 | 0.055 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.3 | 1630.4 |
| 98 | 0.053 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.3 | 1630.8 |
| 99 | 0.052 | 0.0 | 0.0 | 6.2 | 0.0 | 0.0 | 6.2 | 0.3 | 1631.1 |

**Whole life cost charts**



## Summary of costs

| | | | | | |
|---|---|---|---|---|---|
| **Client/Authority** | | Prepared (date) | | **PV Cost Summary** | |
| Scottish Borders Council | | Printed | 07/12/2018 | | **Costs in £k** |
| **Project/Option name** | | Prepared by | C.Kampanou | Enabling Costs | £3.50 |
| Chapman's Burn | | Checked by | S.Cooney | Capital Costs | £43.27 |
| **Project reference** | 2017s5526 | Checked date | | O & M Costs | £10.95 |
| Base date for estimates (year 0) | Jan-2018 | | | Other Costs | £0.00 |
| Scaling factor (e.g. £m, £k, £) | £k | | | Total Real Cost | £57.72 |
| Optimism bias adjustment factor | 60% | | | Total Cost PV | £48.42 |
| | | | | Total Cost PV + OB | **£77.47** |

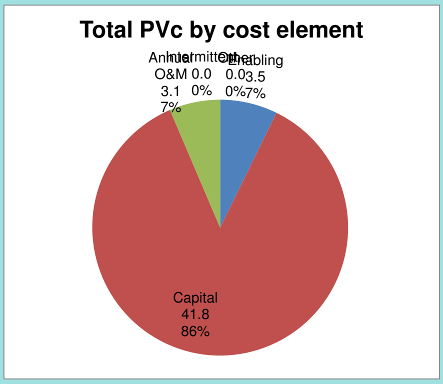
**Note:** Macros are required to open individual cost modules and the user should ensure they are enabled in the Excel Security Settings.
**Note:** Cost modules are opened from blank templates by clicking on the pentagons below. If a template exists, the user is sent the module. Only one module per worksheet 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.

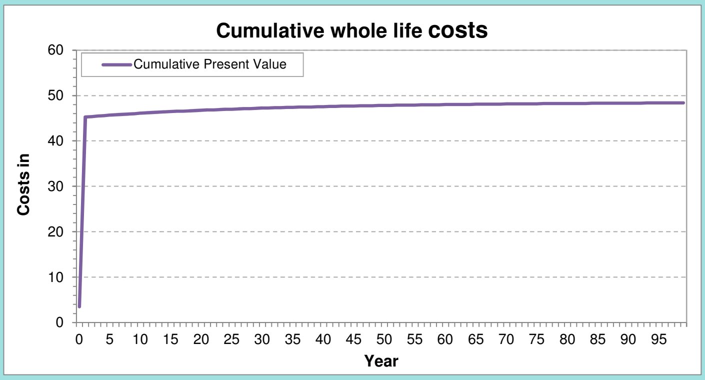
| FRM Measure | Asset | Open / Go to Costing Sheet | Delete Sheet | Enabling Costs | Capital Costs | O & M Costs | Other Costs | Total Cost Cash | Total Cost PV |
|---|---|---|---|---|---|---|---|---|---|
| Fluvial raised defence | Embankment | | | £0.00 | £20.88 | £9.91 | £0.00 | £30.79 | £22.99 |
| | Wall | | | | | | | | |
| | Sheet Piling | | | | | | | | |
| Channel management | N/A | | | | | | | | |
| Culvert & screen | N/A | | | £3.50 | £17.52 | £1.04 | £0.00 | £22.06 | £20.72 |
| Control assets | Weir | | | | | | | | |
| | Pumping station | | | | | | | | |
| | Flood gate | | | | | | | | |
| | Outfall | | | | | | | | |
| | Flow barrier | | | | | | | | |
| Coastal protection | Wall | | | | | | | | |
| | Revetment | | | | | | | | |
| | Groyne | | | | | | | | |
| | Recharge | | | | | | | | |
| Flood storage | N/A | | | | | | | | |
| Flood warning and forecasting | Various | | | | | | | | |
| Temporary & demountable barriers | Various | | | | | | | | |
| Household resistance | Various | | | | | | | | |
| Household resilience | Various | | | | | | | | |
| SUDS and urban drainage | Various | | | | | | | | |
| Managed realignment | Various | | | | | | | | |
| Habitat creation | Various | | | | | | | | |
| Landuse & runoff management | Various | | | | | | | | |
| River Restoration | Various | | | | | | | | |
| User Defined 1 | Various | | | £0.00 | £3.75 | £0.00 | £0.00 | £3.75 | £3.62 |
| User Defined 2 | Various | | | £0.00 | £1.12 | £0.00 | £0.00 | £1.12 | £1.08 |
| User Defined 3 | Various | | | | | | | | |

**Whole Life and Present Value Cost Analysis**

| | PV factor | 29.813 | | | | | Total PVc (£k): | 48.4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Enabling £k** | **Capital £k** | **Annual O&M £k** | **Intermittent O&M £k** | **Other £k** | **TOTALS: Current price** | **PV (£k)** | |
| | **Total real cost** | 3.5 | 43.3 | 11.0 | 0.0 | 0.0 | 57.72 | **48.4** | |
| | **Total PV cost** | 3.5 | 41.8 | 3.1 | 0.0 | 0.0 | | **48.4** | **Cumulative** |
| **year** | **Discount Factor** | | | | | | | | **PV Costs (£k)** |
| 0 | 1.000 | 3.5 | 0.0 | 0.0 | 0.0 | 0.0 | 3.5 | 3.5 | 3.5 |
| 1 | 0.966 | 0.0 | 43.3 | 0.0 | 0.0 | 0.0 | 43.3 | 41.8 | 45.3 |
| 2 | 0.934 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 45.4 |
| 3 | 0.902 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 45.5 |
| 4 | 0.871 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 45.6 |
| 5 | 0.842 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 45.7 |
| 6 | 0.814 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 45.8 |
| 7 | 0.786 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 45.9 |
| 8 | 0.759 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.0 |
| 9 | 0.734 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.1 |
| 10 | 0.709 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.1 |
| 11 | 0.685 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.2 |
| 12 | 0.662 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.3 |
| 13 | 0.639 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.4 |
| 14 | 0.618 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.4 |
| 15 | 0.597 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.5 |
| 16 | 0.577 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.6 |
| 17 | 0.557 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.6 |
| 18 | 0.538 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.7 |
| 19 | 0.520 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.7 |
| 20 | 0.503 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.8 |
| 21 | 0.486 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.8 |
| 22 | 0.469 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.9 |
| 23 | 0.453 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 46.9 |
| 24 | 0.438 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.0 |
| 25 | 0.423 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.0 |
| 26 | 0.409 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.1 |
| 27 | 0.395 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.1 |
| 28 | 0.382 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.2 |
| 29 | 0.369 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.2 |
| 30 | 0.356 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.3 |
| 31 | 0.346 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.3 |
| 32 | 0.336 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.3 |
| 33 | 0.326 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.4 |
| 34 | 0.317 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.4 |
| 35 | 0.307 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.4 |
| 36 | 0.298 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.5 |
| 37 | 0.290 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.5 |
| 38 | 0.281 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.5 |
| 39 | 0.273 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.6 |
| 40 | 0.265 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.6 |
| 41 | 0.257 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.6 |
| 42 | 0.250 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.7 |
| 43 | 0.243 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.7 |
| 44 | 0.236 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.7 |
| 45 | 0.229 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.7 |
| 46 | 0.222 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.8 |
| 47 | 0.216 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.8 |
| 48 | 0.209 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.8 |
| 49 | 0.203 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.8 |
| 50 | 0.197 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.8 |
| 51 | 0.192 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.9 |
| 52 | 0.186 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.9 |
| 53 | 0.181 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.9 |
| 54 | 0.175 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.9 |
| 55 | 0.170 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 47.9 |
| 56 | 0.165 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.0 |
| 57 | 0.160 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.0 |
| 58 | 0.156 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.0 |
| 59 | 0.151 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.0 |
| 60 | 0.147 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.0 |
| 61 | 0.143 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.1 |
| 62 | 0.138 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.1 |
| 63 | 0.134 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.1 |
| 64 | 0.130 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.1 |
| 65 | 0.127 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.1 |
| 66 | 0.123 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.1 |
| 67 | 0.119 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.1 |
| 68 | 0.116 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.2 |
| 69 | 0.112 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.2 |
| 70 | 0.109 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.2 |
| 71 | 0.106 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.2 |
| 72 | 0.103 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.2 |
| 73 | 0.100 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.2 |
| 74 | 0.097 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.2 |
| 75 | 0.094 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.2 |
| 76 | 0.092 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.2 |
| 77 | 0.090 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.3 |
| 78 | 0.087 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.3 |
| 79 | 0.085 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.3 |
| 80 | 0.083 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.3 |
| 81 | 0.081 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.3 |
| 82 | 0.079 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.3 |
| 83 | 0.077 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.3 |
| 84 | 0.075 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.3 |
| 85 | 0.074 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.3 |
| 86 | 0.072 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.3 |
| 87 | 0.070 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.3 |
| 88 | 0.068 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.3 |
| 89 | 0.067 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.4 |
| 90 | 0.065 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.4 |
| 91 | 0.063 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.4 |
| 92 | 0.062 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.4 |
| 93 | 0.060 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.4 |
| 94 | 0.059 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.4 |
| 95 | 0.057 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.4 |
| 96 | 0.056 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.4 |
| 97 | 0.055 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.4 |
| 98 | 0.053 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.4 |
| 99 | 0.052 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 48.4 |

**Whole life cost charts**

# B Public Consultation Questionnaire

# Innerleithen Flood Questionnaire Report

## Purpose

In order to gain an insight into the reaction of the public to the proposed flood protection schemes, a questionnaire was available to be filled in at the Innerleithen Flood Study Exhibition on the 4th October 2018. Local knowledge and feedback is key to influencing decisions on flood protection schemes and out of 28 people who attended the exhibition, 9 questionnaire responses were received (32%).

## Questionnaire Format

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

****Scottish Borders Council comments in red*

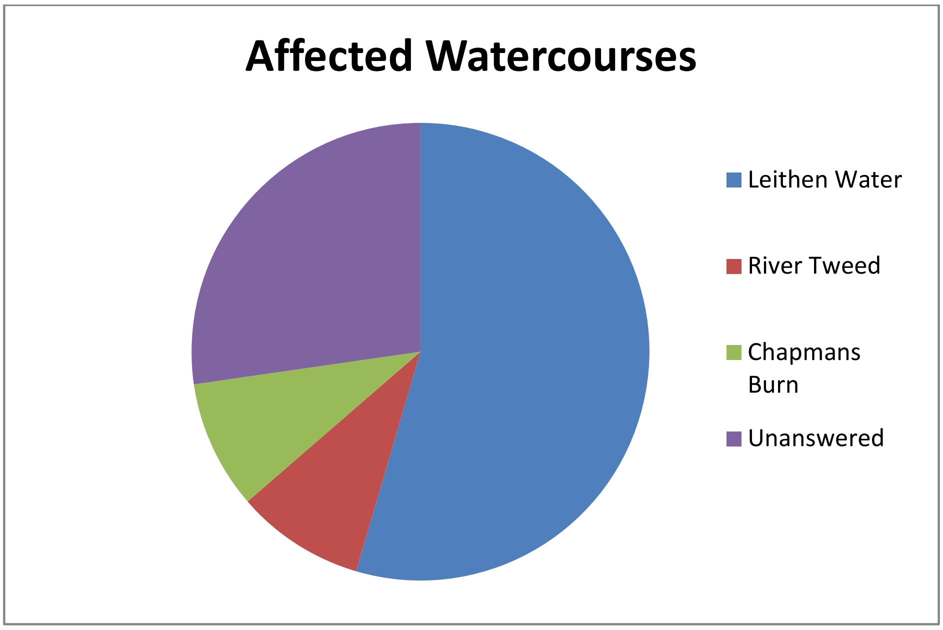
**Question 1**

**Please circle the watercourse/s which impact upon you?**

In Innerleithen there are four main watercourses (including the Mill Lade) 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, Leithen Water and Chapmans Burn**. There was also an 'N/A' option to circle if the resident was 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; the responses are reflected in the table below.

| Affected watercourse | Number of people affected |
|---|---|
| River Tweed | 1 |
| Leithen Water | 6 |
| Chapmans Burn | 1 |
| N/A or Unanswered | 3 |

As shown from the data collected, the members of the public who took part in the questionnaire were mostly affected by the Leithen Water watercourse.



**Question 2**

**Have you previously experienced flooding?**

Out of the 9 participants, 3 had experienced flooding in the past and 5 answered that they had not. Of those that answered 'Yes', there were a variety of comments, mostly explaining what date they experienced the flooding. The majority of comments related to flooding in the 1940's; one resident noted that they experienced flooding in 1948 – 1949 from the Leithen Water and River Tweed.

**Question 3**

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

All of the respondents answered yes to this question, indicating that there is a strong desire to have a flood protection scheme in Innerleithen. Most made comments regarding requiring a flood protection scheme in order to protect their homes and/or reduce insurance prices, examples of which are below;

- "Eliminates any concerns of flooding, reduced insurance costs hopefully."
- "Prevention is better than cure. Insurance considerations."
- "To safeguard our property in extreme conditions."

**Question 4**

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

Respondents spoke positively of the approach the Council are taking, with 8 out of the 9 participants answering yes to this question, with the other 1 leaving the question unanswered. Those who answered yes supported their answers with comments welcoming the approach that is being taken towards the development of a flood scheme:

- *"Consultation with the community and information provision seems like the sensible approach."*
- *"Size of the town increasing, many more residential properties along watercourses. Expansion only possible up Leithen (Water)."*
- *"Seems logical and methodical."*
- *"Acting pro-actively is a positive thing to do here"*

**Question 5**

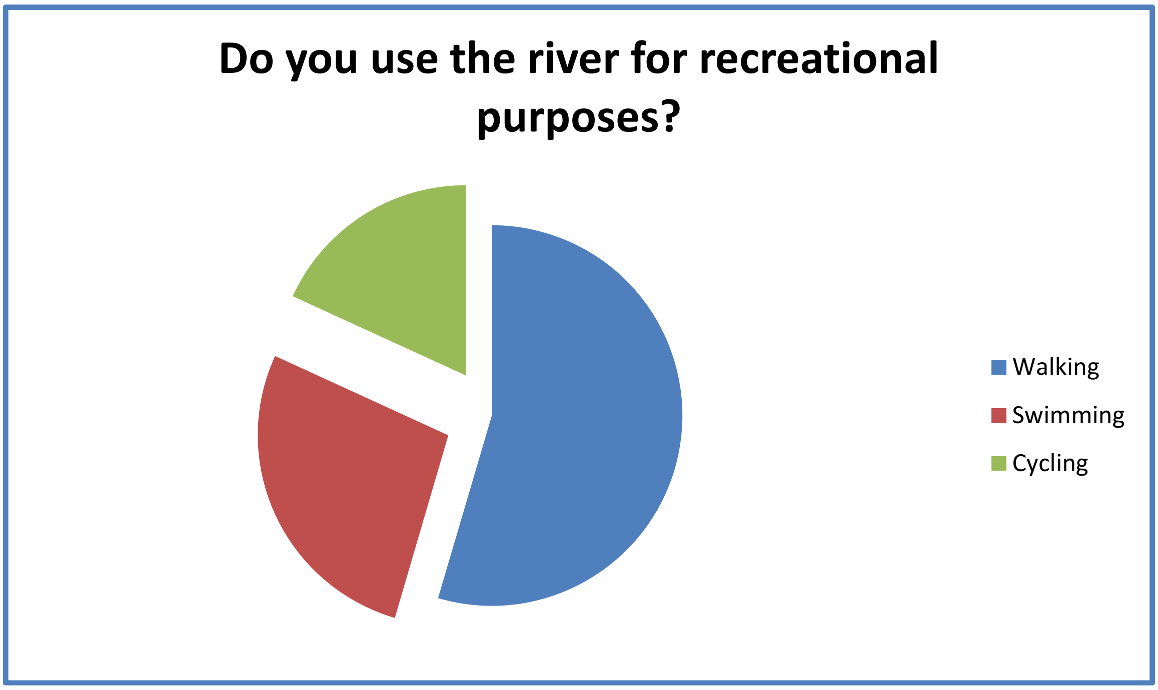
**Are there any flood related issues that you feel we have missed?**

7 people answered no to this question, indicating that the majority are satisfied that there are no major flood related issues that have been overlooked. The one participant who stated there was something missed commented "Flooding at - beyond bridge on Traquair Road leading to Traquair Road - no houses as risk but cuts off access/ school transport."

**Question 6**

**Do you use the river for recreational purposes?**

Many of the respondents used the river for recreational purposes; 6 of whom stated that they used the riverside for walking – the most popular recreational activity. Other uses included 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?**

8 of the 9 respondents were not concerned about the flood defences affecting any of their riverside recreational activities. 1 left the question unanswered and provided a comment which indicated they are worried about how the proposed flood defence wall would block access to the river;

- *"Wall would prevent access from back of property. Steps/stile would be needed to maintain access."*

*As stated above, a step/stile could be incorporated into the wall as the wall heights would allow for this and allow for access to the Leithen Water by this method.*

**Question 8**

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

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. However, all participants of the questionnaire answered no to this question and had no access issues.

**Question 9**

**Are you particularly concerned with any of the proposed options?**

3 respondents raised concerns with the proposed options, representing approximately 33 percent of respondents. Concerns and issues that were raised are shown in the table below. It should be noted that although the residents raised some specific concerns, there was still a generally positive outlook on the scheme as evidenced in previous questions and within the start of response 1 below which states "I fully support the proposed flood walls".

| Response no. | Watercourse area | Comments |
|---|---|---|
| 1 | Leithen Water | *"I fully support the proposed flood walls. A concern would be the positioning of the carpark on Leithen road. As the current red line would block access to our driveway."* *The line of any potential wall would be assessed at the detailed design phase and it is very unlikely that any access to driveways would be blocked, including this respondent's property.* |
| 2 | Unanswered | *"The wall around Leithen Road would prevent us accessing our driveway."* *As above in Response 1.* |
| 3 | Leithen Water | *"(I am concerned) as I live in Princes Street."* |

**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. 1 person raised their concerns, 3 left the question unanswered but some provided additional comments and 5 had no issues to raise. The concerns highlighted by residents are detailed below;

| Response no. | Watercourse area | Comments |
|---|---|---|
| 1 | Leithen Water | *"Once the measures are in place will the areas be re-designated for insurance purposes?"* *On completion of a flood protection scheme, a formal letter would be provided from Scottish Borders Council to those that are now protected outlining their new flood risk; this can be provided to their insurance provider.* |
| 2 | River Tweed<br>Leithen Water | *"Raising footbridge at Princes Street/ Montgomery Street by 400mm. Please ensure proper disabled access."* *Disabled access to footbridges is required and will be considered; details of this will be considered during the detailed design phase.* |
| 3 | Unanswered | *"Perhaps the wall would go along the back of the carpark to stop Mountain bikers using the river as a toilet. We would also still be able to access our drive."* *The final line of the proposed wall would be finalised during the detailed design phase – these comments will be considered.* |
| 4 | Leithen Water | *"Consideration of the ongoing maintenance and upkeep of the mill lake throughout the town."*<br><br>*Any flood protection scheme would on the Leithen Water or Chapman's Burn as shown within the proposals. Any scheme would ensure that there is no detrimental impact on the Mill Lade.* |

A participant who did not raise an issue included a comment displaying their positive thoughts about the flood defences:

- "Glad to see tree/ hedgerow planting in proposal. Too many trees and hedgerows lost in the last couple of decades. All help with water absorption."

*Natural Flood Management opportunities have been highlighted within the Leithen Water catchment that could help reduce flood risk by slowing flow and storing water, including woodland planting. Primarily, the flood defences would consist of the formal options presented at the exhibition but could be supported by natural flood management techniques, dependent on their effectiveness, appropriateness and cost.*

## Outcome / Conclusion

As shown from the data collected within the questionnaires, there has been a generally positive response to flood defence options presented in Innerleithen and an enthusiasm for potential flood protection works. Issues have also been highlighted that will be considered at the next stages of the process, including issues such as the proposed line of the flood wall and disabled access.

# C Model cross section location map

Figure C-2: Leithen Water Cross Section Location Map

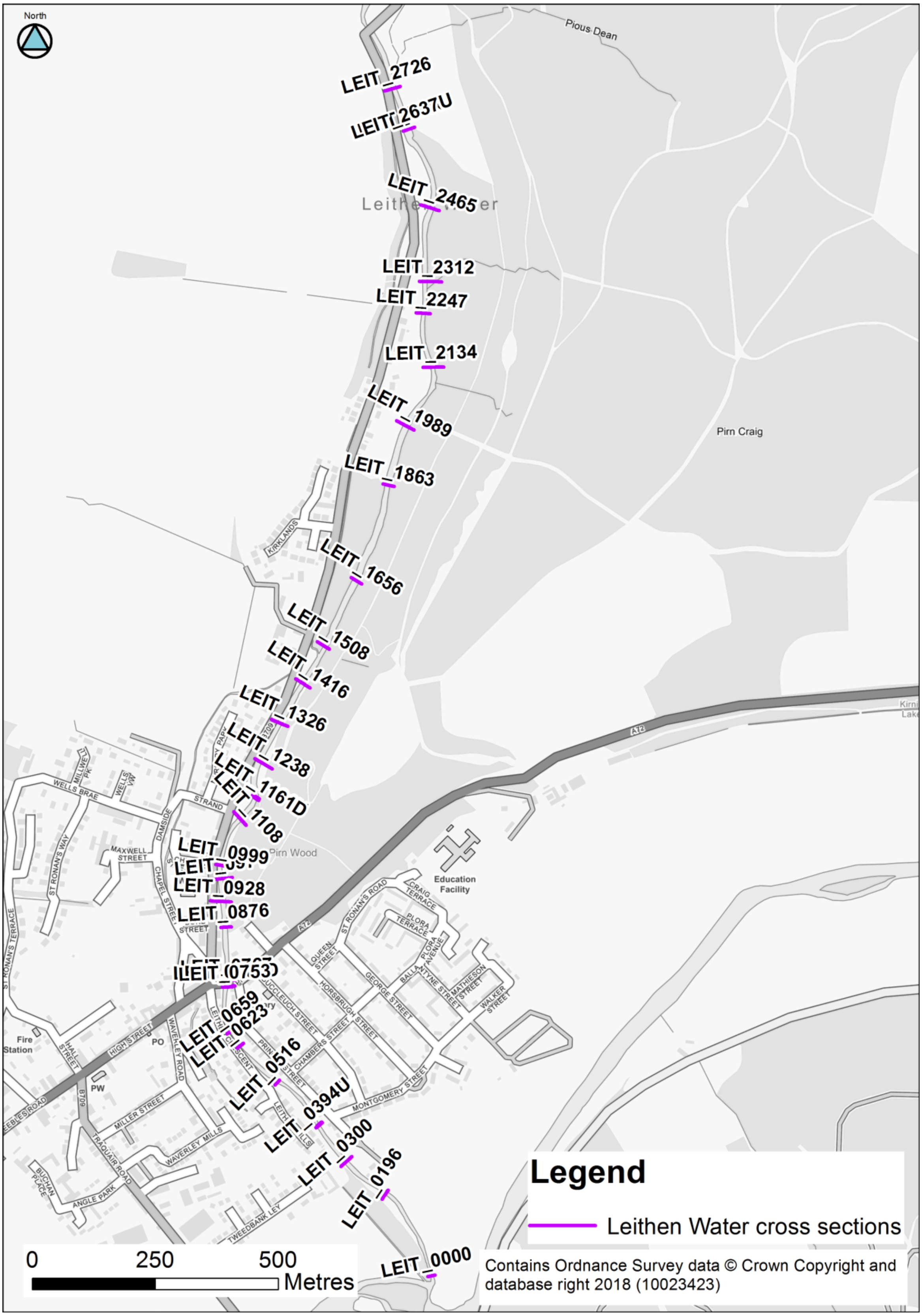
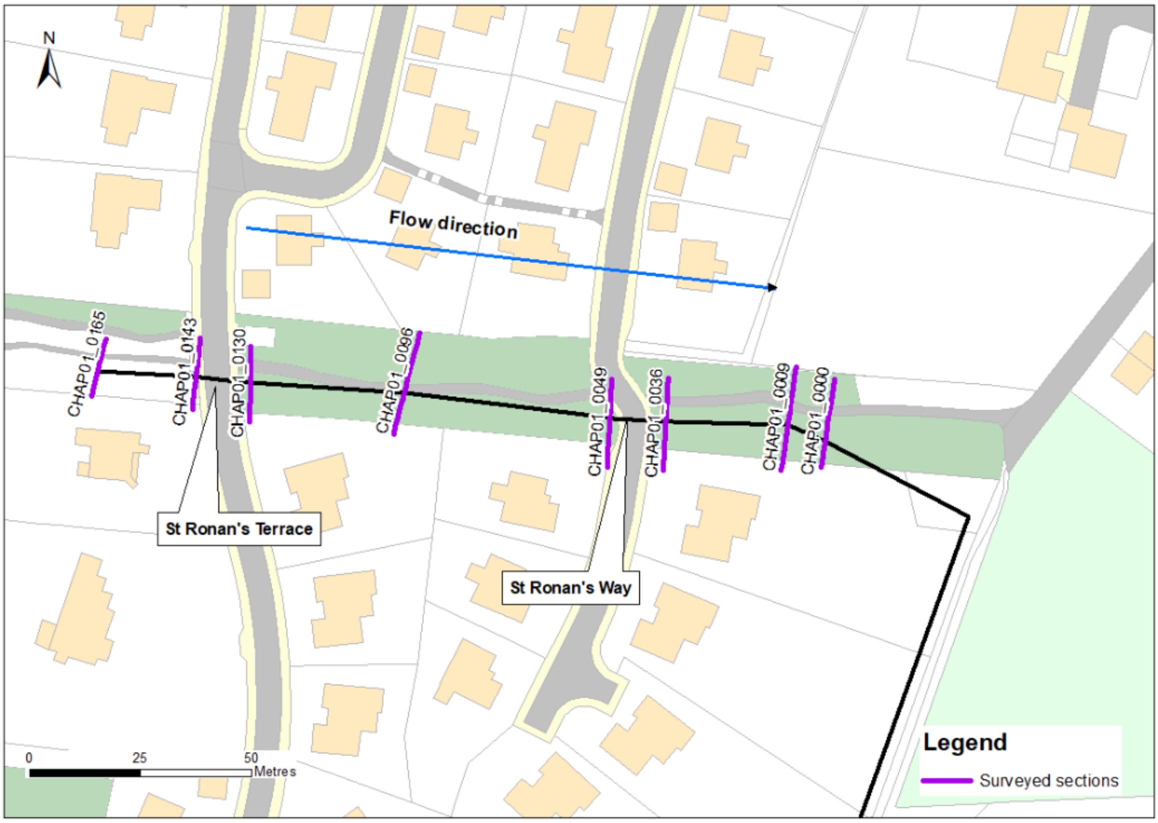


Figure C-3: Chapman's Burn Cross Section Location Map



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