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Insch FPS Appraisal Report

Final Report

December 2019

Aberdeenshire Council

Aberdeenshire COUNCIL

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Contract

This report describes work commissioned by Gavin Penman, on behalf of Aberdeenshire Council, on 10 October 2017 by Purchase Order Number 1095192. Dougall Baillie's representative for the contract was Scott Macphail and Aberdeenshire Council's representative for the contract was Alistair Scotland. Briony McIntosh and Caroline Anderton of JBA Consulting carried out this work.

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Purpose

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Insch FRM Business Case

Context

Insch located in Aberdeenshire has a history of property flooding. JBA was commissioned in 2017 to carry out a review of past 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 Insch.

This report focusses on fluvial flood risk from the following watercourses: The Shevock, Valentine Burn, Mill of Rothney Burn and Newton of Rothney Burn.

A modelling exercise was carried out to estimate river levels on the above mentioned watercourses from approximately 1 km upstream of Shevock Farm to the A96 road bridge near the River Urie confluence. A range of possible flood events were modelled from the 50% AP (2 year) event to the 0.1% AP (1000 year) event. Increases to the flow due to predicted climate change was included to the 0.5% AP (200 year) event.

It was found that 42 properties are at risk of flooding from the 0.5% AP (200 year) event and 46 are at risk for the same event with a climate change allowance. A range of flood protection options were then reviewed and short listed based on their viability.

Risk metrics

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

Residential properties at risk	35 at the 200 year flood (39 with climate change)
Non-residential properties at risk	7 at the 200 year flood (7 with climate change)
Key receptors at risk	Properties along Mill Road, Rannes Street, Commercial Road and Market Street.

Flood Mitigation Options

Due to the number of watercourses investigated, Insch was split into three different areas and reviewed based on the different mechanisms of flooding:

- Area A (Mill Road) - Flood risk from The Shevock on the left bank.
- Area B (Market Street) - Flood risk from the Valentine Burn on both banks.
- Area C (Commercial Road) - Flood risk from the Mill of Rothney to the North Road industrial estate and Commercial Road.

A range of flood protection options were then reviewed and short listed for each area based on their viability. A range of different combinations of options were then put forward as a viable solution for the community of Insch as follows:

- **Option 1 (standard of protection 0.5% AP (200 year) plus climate change):**
  - Area A - Direct defences
  - Area B - Upstream storage, two-stage channel, channel reprofiling & culvert upgrades
  - Area C - Direct defences and open channel restoration
- **Option 2 (standard of protection 0.5% AP (200 year) plus climate change):**
  - Area A - Direct defences
  - Area B - Upstream storage, two-stage channel, culvert upgrades & direct defences
  - Area C - Direct defences and open channel restoration
- **Option 3 (standard of protection 0.5% AP (200 year) plus climate change):**
  - Area A - Direct defences
  - Area B - Upstream storage, two-stage channel, culvert upgrades & direct defences
  - Area C - Direct defences and culverting

- **Option 4 (standard of protection 0.5% AP (200 year)):**
    - Area A - Full PLP
    - Area B - Full PLP
    - Area C - Full PLP
- **Option 5 (standard of protection 0.5% AP (200 year) plus climate change):**
    - Area A - Direct defences
    - Area B - Direct defences, two-stage channel, channel reprofiling & culvert upgrades.
    - Area C - Direct defences and open channel restoration
- **Option 5b (standard of protection 0.5% AP (200 year) plus climate change):**
    - Area A - Direct defences & flood wall
    - Area B - Direct defences, two-stage channel, channel reprofiling & culvert upgrades
    - Area C - Direct defences and open channel restoration

Improving public awareness and resilience

In addition to these short listed options a number of non-structural options and good practice Flood Risk Management (FRM) measures have been investigated and recommended for implementation by Aberdeenshire Council. Some of these could be implemented either in the short term or alongside a Flood Protection Scheme. These include the following:

- Development of a full flood warning system.
- Community engagement should be continued to raise awareness of flood risk and potential short- and longer-term solutions.
- At risk properties could make use of the Council's PLP discount scheme in advance of any possible Flood Protection Scheme on the watercourse.
- 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. 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 Insch.

Expected benefits

A flood damage assessment has been undertaken for the present-day Do Nothing and Do Minimum scenarios and each of the above options. The Present Value flood damages calculated for the Do Nothing and Do Minimum scenarios are estimated to be £5 m and £3 m, respectively. The damages avoided for each option are in the range of £2 m to £5 m (depending on the option assessed). Total damages avoided for each option are provided in the investment appraisal summary table below.

Damages avoided:

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 5b
Standard of Protection (SOP) (years)	0.5% AP (200 year) +CC	0.5% AP (200 year) +CC	0.5% AP (200 year) +CC	0.5% AP (200 year)	0.5% AP (200 year) +CC	0.5% AP (200 year) +CC
Damages avoided (£k)	4,986	4,986	4,986	4,292	4,986	4,986

Working with natural processes

Natural Flood Management (NFM) is a method whereby wider catchment benefits could be achieved alongside potential reduction to flood flows within Insch. Opportunities within the upper catchment 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 but in the shorter term it may be possible to secure funding through other sources if the focus can be widened from flood risk management to catchment, environmental and land management benefits.

Costs

Costs for each option have been estimated using the Environment Agency's Long Term Costing tool (2012). An optimism bias factor of 60% has been added to the total costs to allow for uncertainties in design at this stage and is typical for schemes at an early stage of appraisal. Whole life present value costs range from £0.8 m to £5.7 m. Total costs for each option are provided in the investment appraisal summary table.

Investment appraisal

The investment appraisal is provided below. From a cost-benefit perspective Option 5 is the best of the structural options proposed with a cost benefit ratio of 1.32.

	Do Nothing	Do Min	Option 1	Option 2	Option 3	Option 4	Option 5	Option 5b
Total PV Costs (£k)	-	-	5,729	4,914	4,824	2,071	3,783	4,207
PV damage (£k)	5,201	3,110	214	214	214	87	214	214
PV damage avoided (£k)	-	2,091	4,986	4,986	4,986	4,295	4,986	4,986
Net present value (£k)	-	2,091	-743	72	162	2,224	1,203	780
Benefit-cost ratio	-	-	0.87	1.01	1.03	2.07	1.32	1.19

Residual risks and planning for future flooding

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

- Natural Flood Management (NFM) practices could aid in reducing flows experienced within Insch through good land management practices. In particular, it is recommended that wetland creation, leaky bunds and floodplain woodland planting be considered in the upper catchment, west of Shevock Farm.
- Continued watercourse maintenance is crucial as highlighted in the large difference between the Do Nothing and Do Minimum scenario damages.
- Increasing the dimensions of the Valentine Burn culverts under Option 2 and 3 would provide greater resilience to increases in future flows and blockage risks.

Conclusions and recommendations

The majority of properties within Insch currently have a high standard of protection and are therefore only predicted to flood during events greater than the 0.5% AP (200 year). The remaining properties have a very low standard of protection flooding from the 50% AP (2 year) to 10% AP (10 year) event onwards which results in relatively high damages, and therefore benefits the potential for hard engineering options.

From an economic perspective Option 5 is most cost-effective. Following public engagement Option 5b, which includes formalisation of a flood wall at Mill Road, should be taken forward for consideration. It has a slightly lower benefit-cost ratio of 1.19 compared to 1.32 but is still cost viable. This option has the benefit of both hard engineering and channel restoration opportunities, and does not involve the constraints associated with development of a flood storage area on the Golf Course (Area B). This option is however dependent on larger culverts being installed at Market and Drumrossie Street (Area B) which may not be viable, particularly as an electrical station may need to be relocated at Drumrossie Street, and the dependence on channel reprofiling being viable.

Options 1 to3 involve flood storage on Insch Golf Course which is associated with a number of constraints. Furthermore the benefit cost ratio of these options are much closer to unity, although this may be alleviated by the addition of other indirect flood damages such as vehicle damage and temporary accommodation and evacuation losses. If however, Option 5b is not considered viable e.g. due to objection to channel reprofiling and viability of larger culverts, Option 2 is the preferred option as this too combines hard defences with channel restoration and has a positive cost benefit ratio of 1.01. The Valentine Burn (Area B) culverts would be surcharged under this scenario. Further survey and ground investigations to determine the maximum feasible culvert dimensions would improve this option. The matrix overleaf gives an overview of the consideration of each option against different key criteria.

Option	Minimum standard of protection	Properties protected from the 0.5% AP (200 year) +CC	Environmental implications	Working with natural processes	Constraints/ limitations	Mitigating residual risks	Improved public awareness	Best use of public money	Wider benefits
Option 1 - Hard engineering with channel restoration and reprofiling	0.5% AP (200 year) + CC	All properties protected.	Two stage channel and reprofiling provide opportunity to improve physical and ecological condition. Disturbances during works. Orificing flow on the Valentine Burn is not good for ecological status.	Reconnection with the floodplain through two-stage channel. Physical and fluvial channel processes restoration across Insch.	High embankments required for the Valentine storage area. Replacement culvert capacities based on being able to move electrical station and lower channel bed elevations.	Protection up to the 0.5% AP (200 year) + CC	Recommend establishing a flood action group. Importance of flood warning being developed in the area.	Only just under a positive cost benefit ratio; ratio of 0.87.	Minimal impacts on community other than aesthetics from direct defences. Standard of protection against future increase in flow.
Option 2 - Hard engineering with reduced Valentine storage and no reprofiling	0.5% AP (200 year) + CC	All properties protected.	Two stage channel and channel restoration provide opportunity to improve physical and ecological condition. Disturbances during works. Orificing flow on the Valentine Burn is not good for ecological status.	Reconnection with the floodplain through two-stage channel. Physical and fluvial channel processes restored.	High embankments required for the Valentine storage area. Replacement culverts are surcharged and Drumrossie dimensions are based on being able to move electrical station.	Protection up to the 0.5% AP (200 year) + CC	Recommend establishing a flood action group. Importance of flood warning being developed in the area.	Cost benefit ratio of 1.01.	Minimal impacts on community other than aesthetics from direct defences. Standard of protection against future increase in flow.
Option 3 - Hard engineering with no reprofiling or channel restoration	0.5% AP (200 year) + CC	All properties protected.	Two stage channel and channel restoration provide opportunity to improve physical and ecological condition. Disturbances during works. Orificing flow on the Valentine Burn is not good for ecological status. Culverting the Mill of Rothney does not improve environmental status.	Reconnection with the floodplain through two-stage channel. Culverting the Mill of Rothney does not restore fluvial channel processes.	High embankments required for the Valentine storage area. Replacement culverts are surcharged and Drumrossie dimensions are based on being able to move electrical station.	Protection up to the 0.5% AP (200 year) + CC	Recommend establishing a flood action group. Importance of flood warning being developed in the area.	Cost benefit ratio of 1.03.	Minimal impacts on community other than aesthetics from direct defences. Standard of protection against future increase in flow.
Option 4 - Full PLP	0.5% AP (200 year)	One property not protected.	Little to no impact.	Little to no impact.	Social constraint where PLP is not accepted as a sole option. Lack of flood warning requires more expensive automatic systems.	No adaptation for mitigating future work.	Recommend establishing a flood action group. Importance of flood warning being developed in the area.	Cost benefit ratio of 2.07.	Aside from individual property works wider community not impacted.
Option 5 – Hard engineering with no upstream storage but channel restoration and reprofiling.	0.5% AP (200 year) + CC	All properties protected.	Two stage channel and reprofiling provide opportunity to improve physical and ecological condition. Disturbances during works.	Reconnection with the floodplain through two-stage channel. Physical and fluvial channel processes restoration across Insch. Negative physical condition impacts from constructing walls along river banks.	Replacement culvert capacities based on being able to move electrical station and lower channel bed elevations.	Protection up to the 0.5% AP (200 year) + CC	Recommend establishing a flood action group. Importance of flood warning being developed in the area.	Cost benefit ratio of 1.32.	Minimal impacts on community other than aesthetics from direct defences. Standard of protection against future increase in flow.

Option 5b - Hard engineering with no upstream storage but channel restoration and reprofiling.	0.5% AP (200 year) + CC	All properties protected.	Two stage channel and reprofiling provide opportunity to improve physical and ecological condition. Disturbances during works.	Reconnection with the floodplain through two-stage channel. Physical and fluvial channel processes restoration across Insch. Negative physical condition impacts from constructing walls along river banks.	Replacement culvert capacities based on being able to move electrical station and lower channel bed elevations.	Protection up to the 0.5% AP (200 year) + CC	Recommend establishing a flood action group. Importance of flood warning being developed in the area.	Cost benefit ratio of 1.19.	Minimal impacts on community other than aesthetics from direct defences. Standard of protection against future increase in flow.

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Abbreviations

1D	One Dimensional (modelling)
2D	Two Dimensional (modelling)
FEH.....	Flood Estimation Handbook
mAOD	metres Above Ordnance Datum
NGR	National Grid Reference
OS.....	Ordnance Survey
OS NGR.....	Ordnance Survey National Grid Reference
QMED	Median Annual Flood (with return period 2 years)
RBMP.....	River Basin Management Plan
ReFH.....	Revitalised Flood Hydrograph method
RR.....	Rainfall-Runoff
SEPA	Scottish Environment Protection Agency
NFM.....	Natural Flood Management
SoP.....	Standard of Protection
PLP.....	Property Level Protection
AP.....	Annual Probability

Supporting Documents

Hydrology report - AIZ-JBAU-IN-00-RP-HM-0002-Insch_Hydrology_Report_A1-C01.pdf

Information review - AIZ-JBAU-IN-00-RP-HM-0001-Information_Review-A1-C01.pdf

Asset condition assessment report - AIZ-JBAU-IN-00-RP-C-0001-Asset_Condition_Assessment-A1-C01pdf

NFM report - AIZ-JBAU-IN-00-RP-EN-0001-NFM_RBMP_Report-A1-C01.pdf

Preliminary Ecological Appraisal - AIZ-JBAU-IN-00-RP-EN-0002-Insch_PEAR-A1-C01.pdf

Modelling report - AIZ-JBAU-IN-00-RP-HM-0005-Insch_Model_Report-A1-C01.pdf

Flood maps - supplied as PDF's for the 2 year - 1000 year events including climate change runs for the Do Nothing and Do Minimum scenarios:

AIZ-JBAU-IN-00-RP-HM-0005-Insch_Model_Report-A1-C01_AppendixB1_DM

AIZ-JBAU-IN-00-RP-HM-0005-Insch_Model_Report-A1-C01_AppendixB2_DN

Option drawings - supplied as PDF's - AIZ-JBAU-IN-00-DR-HM-0020-All_Drawings-S3-P03.pdf

1 Introduction

1.1 Legislative framework

Insch is part of the North East Local Plan District (LPD) and is categorised as a Potentially Vulnerable Area (PVA) (06/11) with an area of approximately 40 km^2. The details for this LPD, are contained in the North-East Flood Risk Management Strategy (FRMS)[1] and the North East Flood Risk Management Plan (LFRMP)[2]. Within this PVA a number of recommendations were made to undertake site specific detailed flood protection studies (amongst other flood risk management activities) to better inform the current flood risk to these communities and to investigate options for mitigation. Nationally Insch is ranked 61 out of 168 PVA's and 3 out of 12 within the Aberdeenshire Council authority area.

Under the Flood Risk Management (Scotland) Act 2009, this report forms part of the appraisal study for Insch commissioned by Aberdeenshire Council and follows SEPA's Options appraisal for flood risk management guidance [3].

Background

This flood study was commissioned to gain a greater understanding of the flood mechanisms in each community, improve upon SEPA's flood risk maps, and provide an appraisal of options which could reduce flood risk.

The study aims to better assess current flood risks in the community by undertaking a review of past flood events; generating updated and detailed flood maps, determining the likely risk to different properties; and to propose a set of mitigation measures to reduce the flood risk to an acceptable level. A set of reports has been prepared to summarise the work undertaken and to provide a detailed explanation of the various steps carried out. The short listed and preferred options will be presented to the public to gain their input into the designs and to ensure that the preferred set of interventions offer a sustainable method of flood protection whilst seeking to benefit the environment and the community of interest.

The major watercourses which cause fluvial flood risk to Insch are The Shevock, Valentine Burn, Mill of Rothney Burn and Newton of Rothney Burn. The study area for Insch is shown in Figure 1-1.

1 North-East Flood Risk Management Strategy http://apps.sepa.org.uk/FRMStrategies/pdf/lpd/LPD_06_Full.pdf [accessed 10 November]

2 North East Flood Risk Management Plan http://www.aberdeenshire.gov.uk/media/17174/north-east-local-flood-risk-management-plan-2016-2022-web-version.pdf [accessed 10 November 2017]

3 Flood Risk Management (Scotland) Act 2009, Options appraisal for flood risk management: Guidance to support SEPA and the responsible authorities, First Edition, May 2016

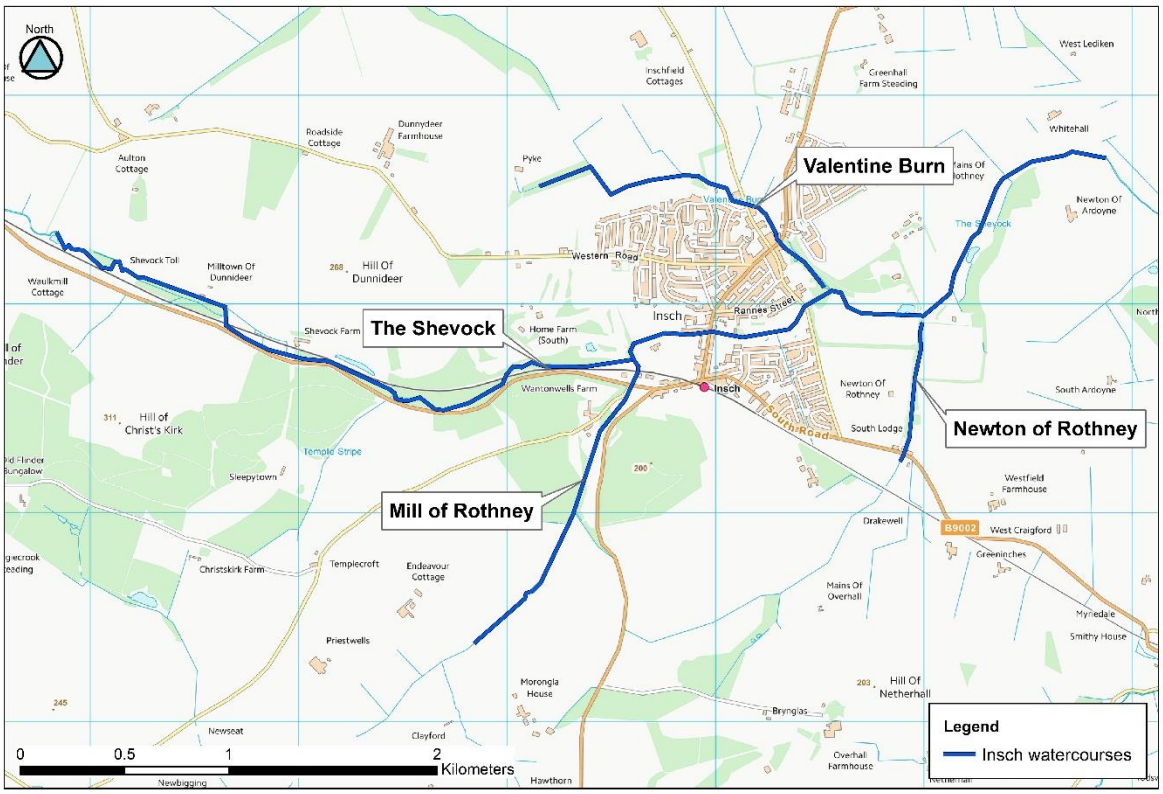

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Figure 1-1: Study Extent

There is a history of flooding within the area of Insch, the most significant event was experienced in November 2002. A review of the flood history is explained further in Section 2.1 with anecdotal evidence highlighting properties at Insch are at risk from fluvial flooding.

1.2 Aims and objectives

The options appraisal seeks to provide information appropriate to Aberdeenshire Council to inform their decision on the most sustainable strategy for flood risk management to the community of Insch that contributes, where possible, to achieving River Basin Management Planning (RBMP) objectives and is acceptable to key stakeholders and the community. This report describes the information used to form conclusions on the suitability, feasibility and economic viability of different options for flood risk mitigation.

Proposals and conceptual designs have been developed to:

a. Provide protection from a 0.5% AP (200 year) magnitude flood event with the inclusion of a 24% increase to flow from climate change, if feasible or a lower magnitude event in other cases.
b. Highlight opportunities to reduce river flows through Natural Flood Management practices and quick wins.
c. Provide recommendations on further supplementary studies required within Insch to understand the full flood risk to the properties.

2 Preliminary Investigations

The full reports for each of the sections below are referenced in the Supporting Documents section at the start of this report.

2.1 Flood history

The Shevock has been susceptible to flooding over the past several decades with the earliest recorded flooding occurring in 1864. Insch falls within PVA 06/11. The greatest risk is from The Shevock in addition to the Valentine Burn, Mill of Rothney Burn and Newton of Rothney Burn. The key events are summarised in Figure 2-1.

All watercourses are ungauged, there are no raingauges within the catchment and the exact date of the events highlighted in Figure 2-1 are unknown. The potential magnitude of the largest events were estimated from rainfall records at the two nearest raingauges - Rothienorman and Cabrach. For each, the period of most sustained rainfall in that month was considered as the event leading to flooding. It has been estimated the Nov 2002, June 2004, 2007 and Dec 2015/Jan 2016 events were 1 to 10 year, 2 to 4 year, 2 to 10 year and 1 year events respectively.

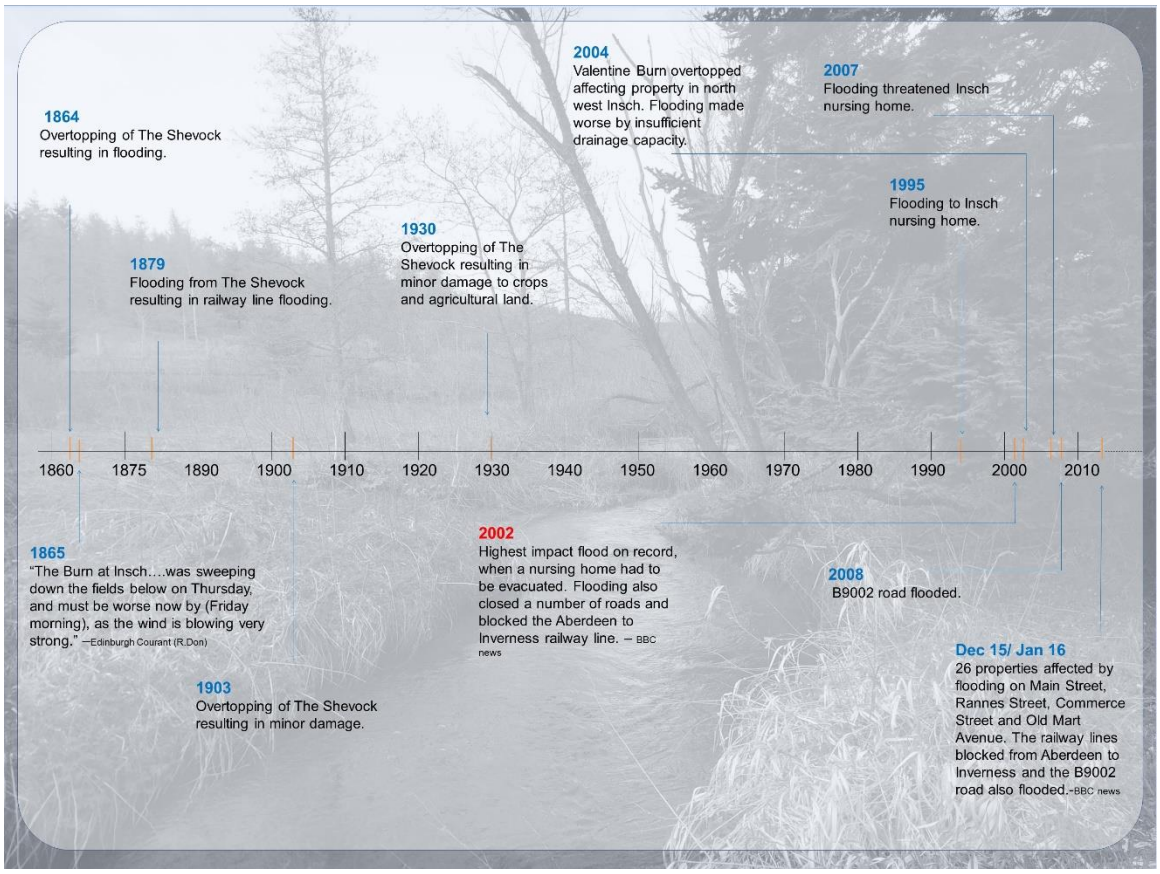

Figure 2-1: Key flood events in Insch

2.2 Hydrology

A summary of the flows derived from the hydrological analysis are shown in Table 2-1. The Shevock flows were achieved using the Flood Estimation Handbook (FEH) statistical method and applying a generalised extreme value (GEV) distribution to the pooling group analysis at the confluence with the River Urie. The tributaries were calculated using the using the FEH Rainfall Runoff approach.

Table 2-1: Hydrology Inflows

Annual Probability [AP] (%)	Return Period (years)	The Shevock at the River Urie confluence Statistical Pooling Method GEV flow (m^3/s)	Valentine Burn FEH Rainfall Runoff flow Storm duration 9.25 hours (m^3/s)	Mill of Rothney FEH Rainfall Runoff flow Storm duration 9.25 hours (m^3/s)	Newton of Rothney FEH Rainfall Runoff flow Storm duration 9.25 hours (m^3/s)
50	2	9.04	1.37	1.40	1.19
20	5	12.76	1.91	1.94	1.66
10	10	15.15	2.32	2.37	2.02
4	25	18.12	2.94	3.00	2.56
3.33	30	18.69	3.07	3.14	2.68
2	50	20.27	3.47	3.55	3.03
1.33	75	21.50	3.75	3.83	3.27
1	100	22.36	3.98	4.07	3.48
0.5	200	24.42	4.60	4.70	4.02
0.2	500	27.07	5.57	5.69	4.86
0.1	1000	29.03	6.58	6.73	5.75
3.33 +CC	30 +CC	23.17	3.81	3.89	3.32
0.5 +CC	200 +CC	30.28	5.70	5.83	4.98
Critical duration for modelling (h)		9.25	9.25	9.25	9.25

2.3 Survey data

JBA carried out a topographic channel survey in April 2018 as part of this study. This survey covers the full study reach within Insch including The Shevock, Valentine Burn, Mill of Rothney Burn and Newton of Rothney Burn, consisting of 111 cross sections in total. In general, 1 m resolution LiDAR has been used for the DTM flown in 2011 supplemented by 5 m resolution NEXTMap.

Property threshold levels were also surveyed by JBA in November 2018 for all properties falling within the 0.1% AP (1000 year) event flood envelope.

To gain a full appreciation of the study area an asset condition survey was also carried out in January/February 2018 to understand the condition of all the existing structures that cross the watercourse, including their risk of blockage.

2.4 Preliminary Ecological Appraisal

A preliminary ecology study was undertaken for The Shevock catchment and the following key conclusions identified. A range of habitats were identified on the site walkover, including extensive conifer plantations, agricultural and pastural fields, tall ruderal vegetation, marshy grassland and some areas of standing water. The ecological value of the site was determined to be moderate to high as the structural diversity across the surveyed area offers good foraging and refuge opportunities for birds, mammals, bats and invertebrate assemblages.

The data search identified no statutory designed nature conservation sites or local wildlife sites within a 2 km radius of the site extent. However, a Wildcat Priority Area overlaps the 2 km buffer at its western extent, and so consultation with Scottish Natural Heritage is advised prior to any works commencing in the western part of the study area.

Mature trees within the site are likely to be protected through a Tree Preservation Order (TPO), and details of TPOs can be sought from the Local Authority. If trees will be impacted by the works (including retained trees where roots may be impacted) then an arboriculture survey should be undertaken.

Within a 2 km radius of the site, the North East Scotland Biological Records Centre holds several records for protected and notable species. The ecological importance of the site to protect species in its current state was considered high for Badger, Scottish Wildcat, Freshwater Pearl Mussel and birds, and at least moderate for Otter, Red Squirrel, Water Vole, Bats, fish and reptiles and low for Great Crested Newt.

The following key points were identified from the desk study and site walkover:

- No Badgers, Red Squirrels, Water Voles, Otters or Bats observed during site visit.
- Ecological value for Badger, Scottish Wildcat, Freshwater Pearl Mussel and birds is high.
- Avoid the need for land-take in semi-natural habitats.
- Avoid tree and scrub removal (particularly for bats, birds, Red Squirrels).
- Minimise in-channel works (Otters, Water Voles, fish).
- No in-channel works between October and March (fish).
- Avoid night-working in the main active bat season (April - September).

2.5 Natural Flood Management

An NFM study of the entire Shevock catchment (Figure 2-3) was conducted.

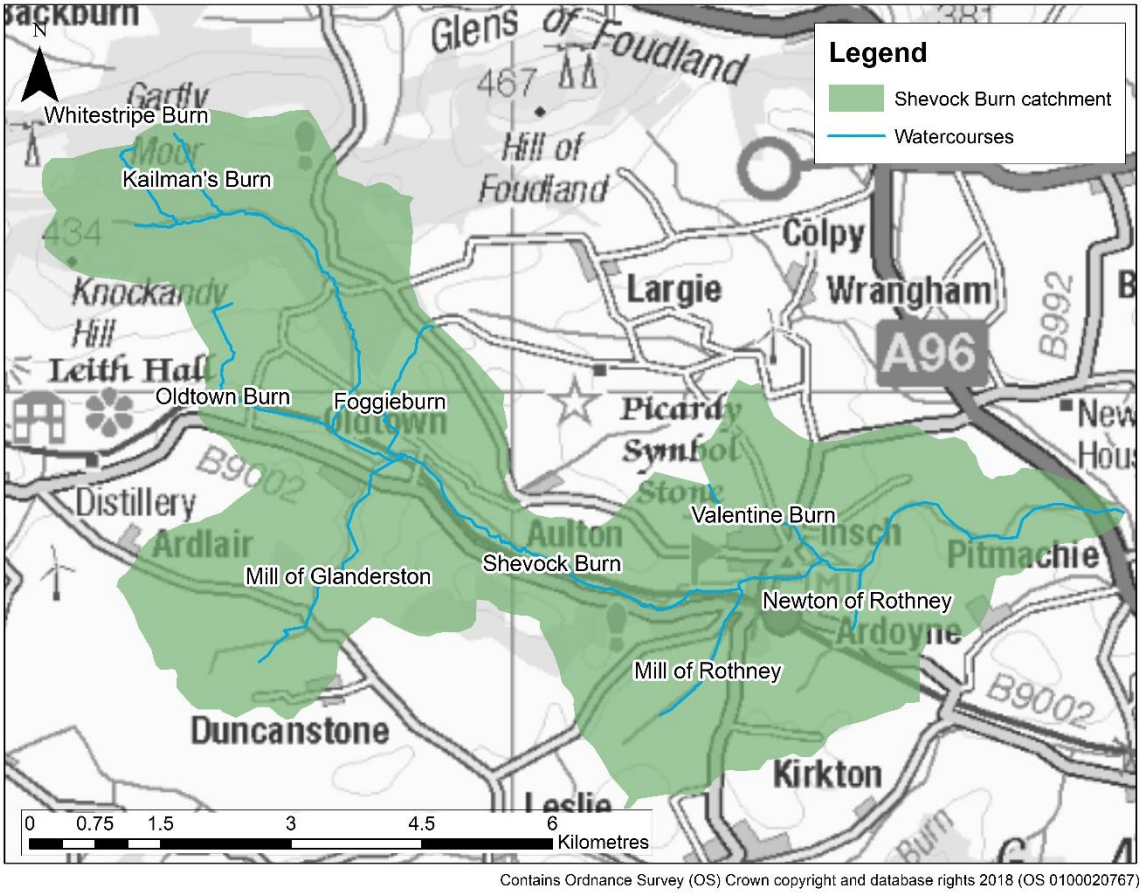

Figure 2-2: The Shevock catchment

An overview of the key areas that are recommended from the study are shown in Figure 2-4. Key recommendations include:

- Increased vegetation cover.
- Working within and on the banks of the channel.
- Land management.
- Runoff management.

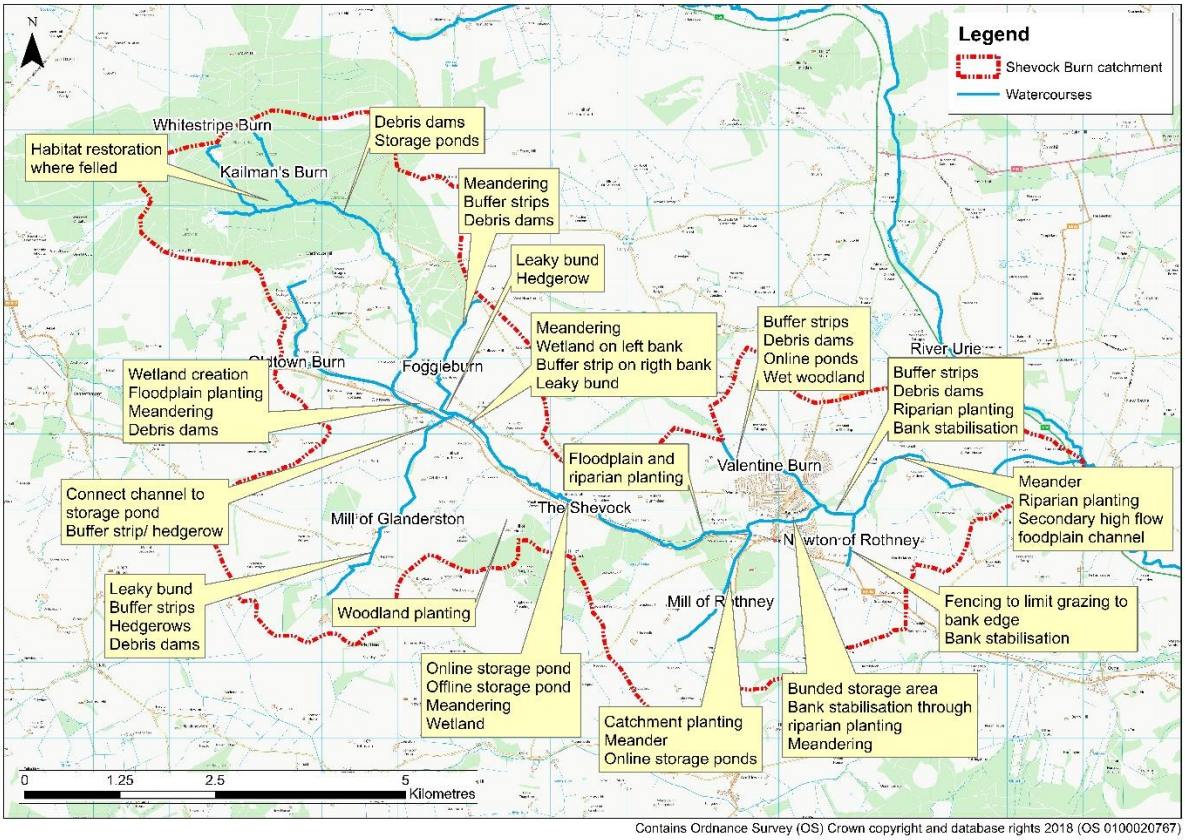

Figure 2-3: Summary of NFM options within The Shevock catchment

There is high NFM potential upstream of Insch within The Shevock catchment which may reduce flood risk to the downstream community. In particular, wetland creation and upstream storage options. The Valentine Burn, which also causes flood risk to Insch, could benefit from improved land management such as attenuation of runoff though leaky bunds, buffer strips and hedgerow planting could help to reduce the flows and increase sustainability of any scheme put in place.

2.6 Hydraulic modelling

The hydraulic model is a 1D/2D linked model, utilising Flood Modeller version 4.3.6458.29637 for the 1D and TUFLOW version 2016-03-AE-iDP-w64 for the 2D components respectively. The Shevock, Valentine Burn and Newton of Rothney have been modelled in 1D up to top of bank. The out of bank region has been represented in 2D for the extent. The Mill of Rothney Burn has been modelled in 1D only for the upper reaches. An overview of the 2D extent and different watercourses is shown in Figure 2-5.

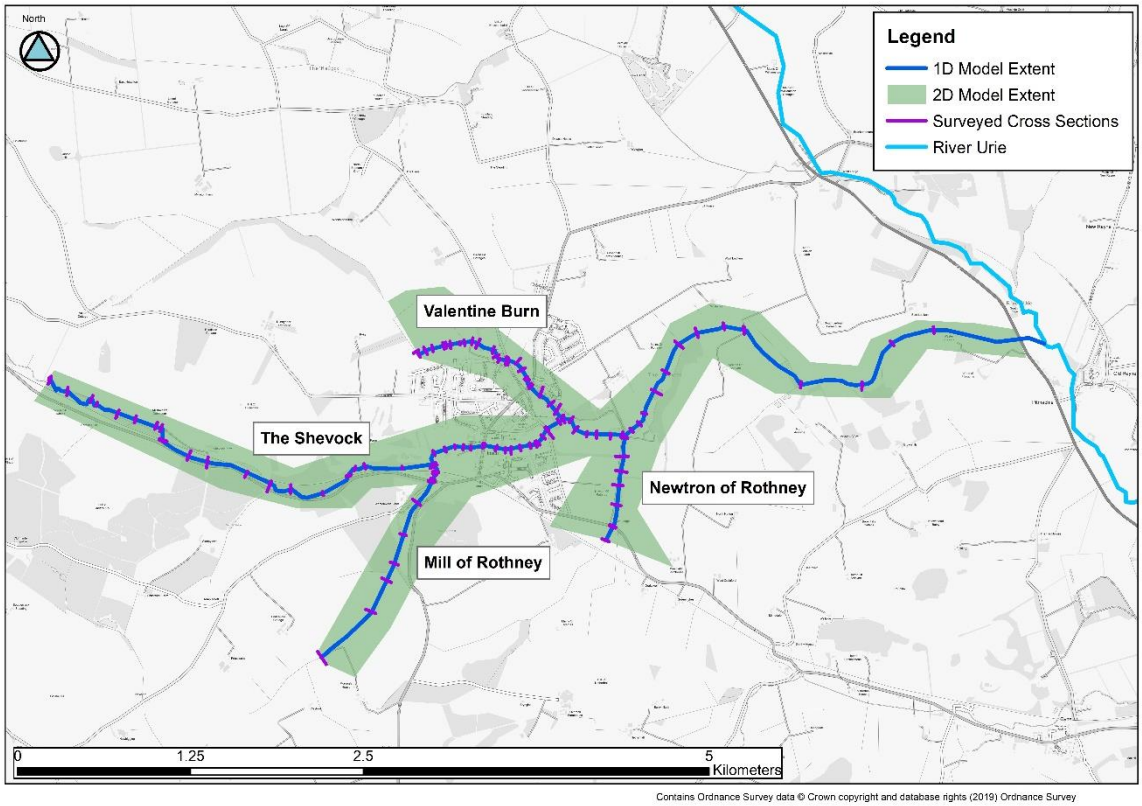

Figure 2-4: Watercourse locations and model extent

3 Appraisal Approach

3.1 Overview

The purpose of this report is to conclude and appraise the design options which will be taken forward to defend against the flood risk within Insch. A 1D/2D Flood Modeller and TUFLOW model has been built and calibrated to analyse flood risk within the study area of Insch. This model has been used to produce Do Minimum and Do Nothing flood maps as a baseline in order to analyse the damages and flood extent. A long list of options based on this mapping has been created for all potential options to defend the study area, this has then been broken down and feasible options have been shortlisted and then appraised.

3.2 Problem definition

There are 51 properties at risk from the 0.1% AP (1000 year) event and 42 properties at risk from the 0.5% AP (200 year) event under present conditions within Insch; from The Shevock, Valentine Burn, Mill of Rothney and Newton of Rothney. Flooding is estimated to begin at the 50% AP (2 year) event or smaller under existing conditions. There are no formal flood defences along the watercourses.

4 Do Minimum and Do Nothing

4.1 Do Minimum results and assumptions

The do minimum results represent the present-day scenario in which all of the watercourses and structures are maintained and replaced if they deteriorate to a point that is unacceptable. Manning's 'n' roughness represents current conditions and no bridge blockage is assumed. Figure 4-1 shows the 0.5% AP (200 year) + climate change results for the Do Minimum scenario.

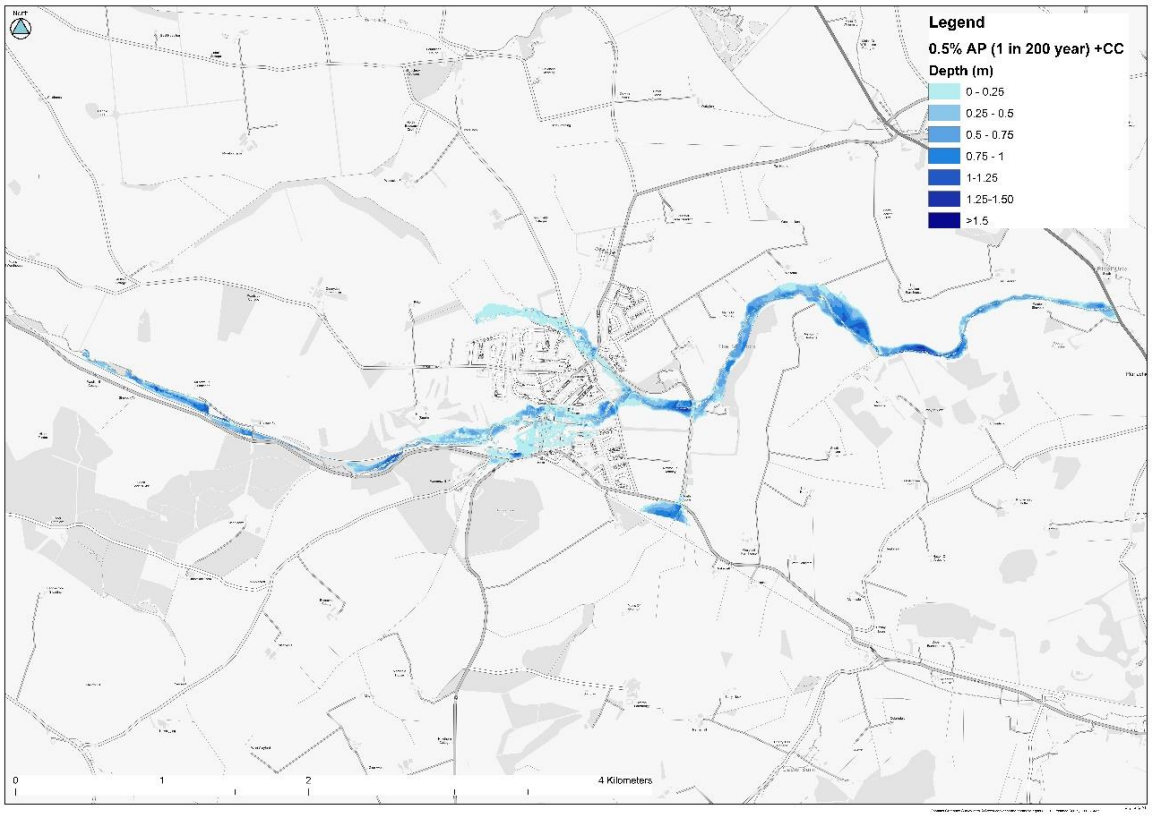

Figure 4-1: Do Minimum 0.5% AP + climate change flood extent

4.2 Do Nothing results and assumptions

The Do Nothing results represent the 'walk away' scenario where all watercourse and structure maintenance stops. This therefore represents a scenario with no intervention in the natural processes and serves as a baseline against all other options. The Do Nothing assumptions include an increase in Manning's 'n' roughness particularly where banks will no longer be maintained. It also includes blockage to structures at risk, see Appendix C for a full list of the Do Nothing assumptions on each of the watercourses in Insch. Figure 4-2 shows the 0.5% AP + climate change results for the Do Nothing scenario.

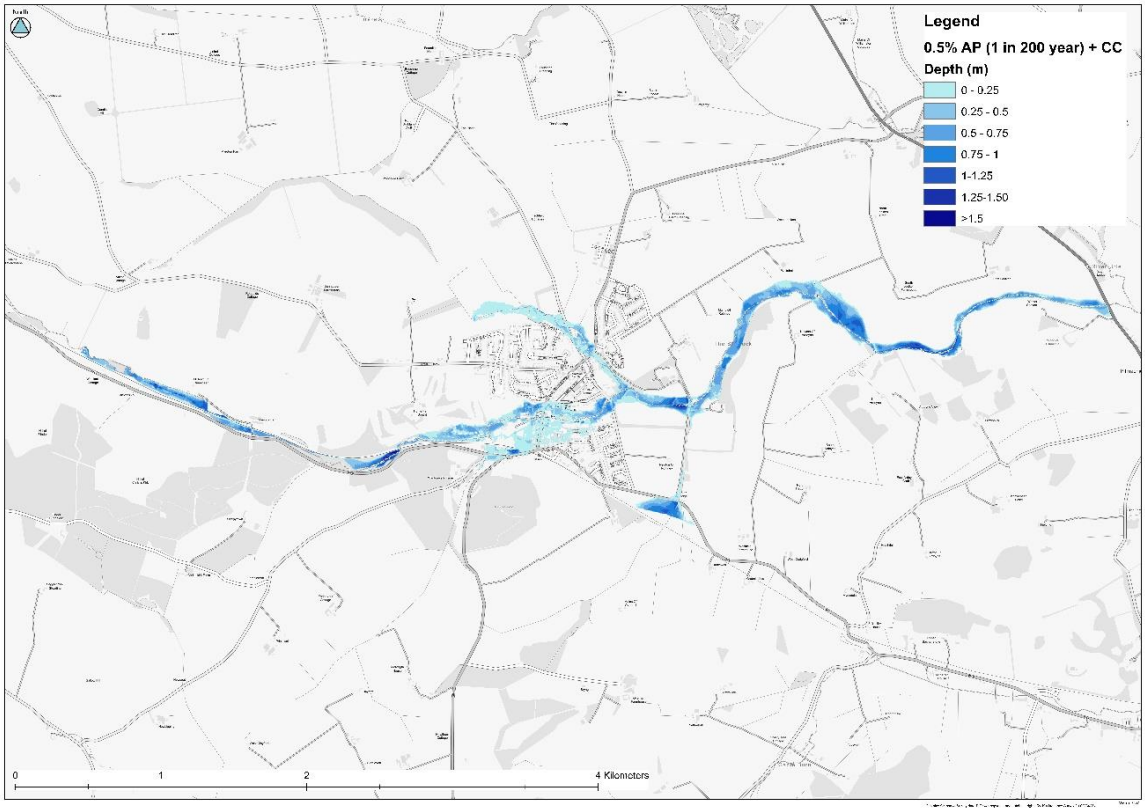

Figure 4-2: Do Nothing 0.5% AP + climate change flood extent

4.3 Current Standard of Protection (SoP)

The figures overleaf show the SoP each property within Insch is modelled to have from fluvial flood risk. SoP 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 3.33% AP (30 year) SoP would be expected to flood at the 2% AP (50 year) event. Flooding is said to occur when the modelled flood level exceeds the building floor level. Floor level (threshold level) data for all properties was collected by JBA's surveyors.

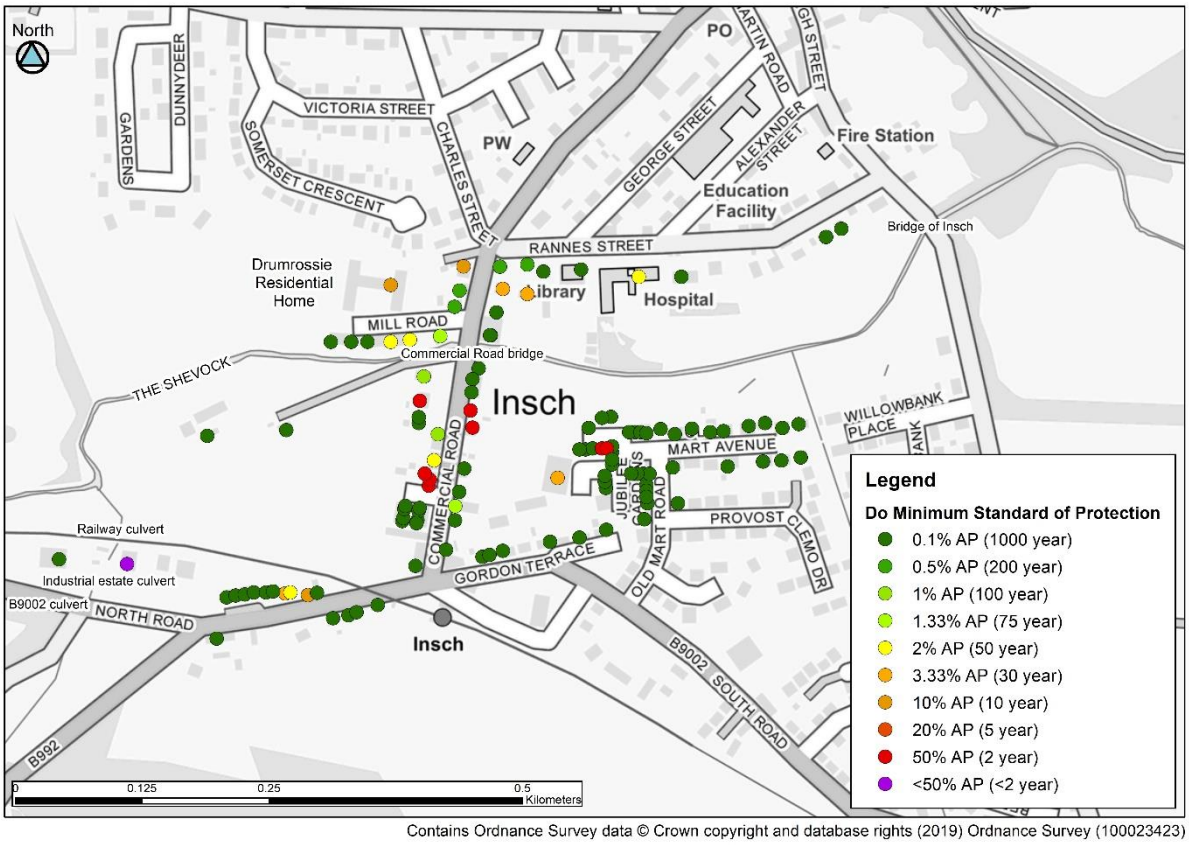

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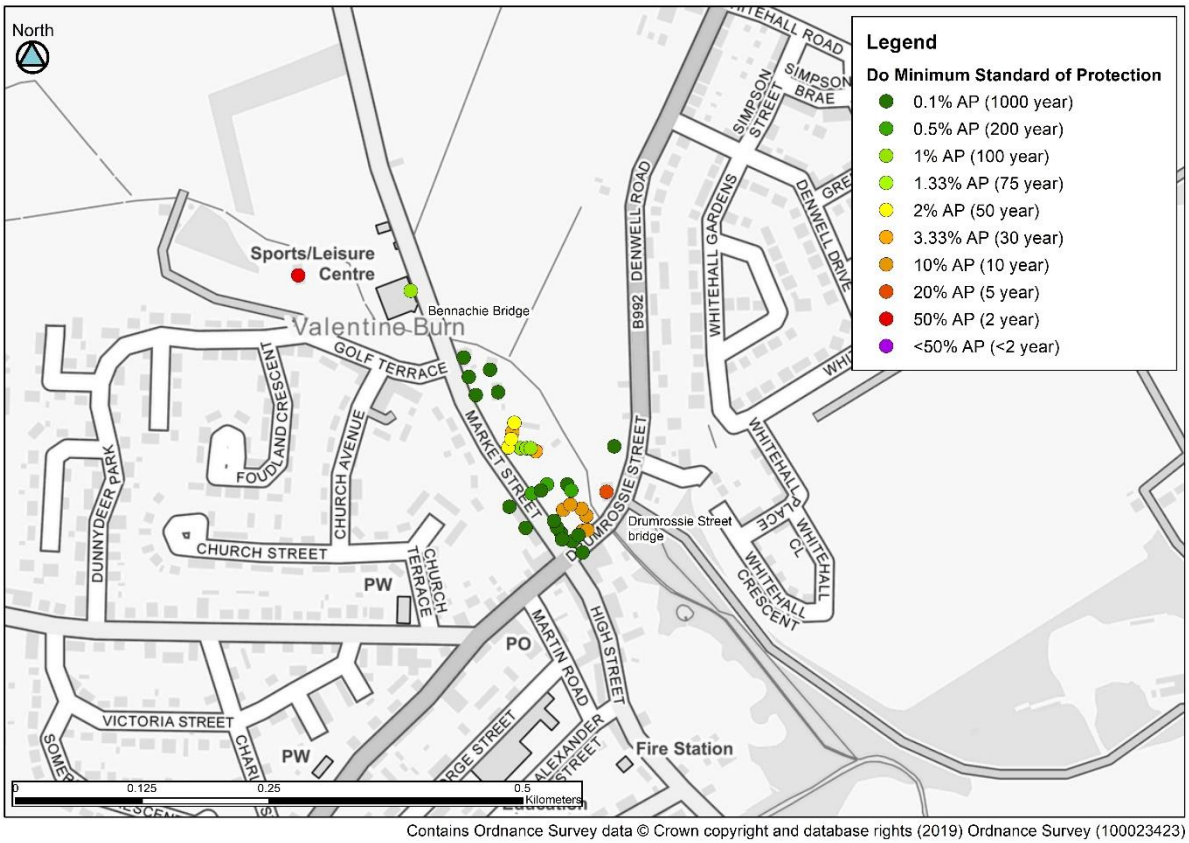
Figure 4-3: The Shevock and Mill of Rothney Standard of Protection



Contains Ordnance Survey data © Crown copyright and database rights (2019) Ordnance Survey (100023423)

Figure 4-4: Valentine Burn Standard of Protection

Figure 4-5: Mill of Rothney Standard of Protection

The SoP at Insch shows that the majority of properties within Insch are protected up to the 0.1% AP (1000 year) event. Out of the 51 properties at risk from the fluvial 0.1% AP event, 46 are not protected to the 0.5% AP + climate change event that this appraisal will look to defend against. A breakdown of where these properties are located are as follows:

- Valentine Burn - 17 properties
- The Shevock - 12 properties
- Mill of Rothney - 17 properties

5 Flood Risk Management Options

5.1 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 Benefit Cost Ratio (BCR) when measured in parallel with other success criteria.
7. Should incorporate National, Regional and Local agendas/objectives.

5.2 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 (200 year) flood. 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.

Based on the above guidance the aim of the scheme will be to assess options up to the 0.5% AP (200 year) plus climate change flood if possible, where 0.5% AP (200 year) will also be assessed as the lower standard.

5.3 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. They are summarised in Table 5-1.

The majority of the quick wins could be considered as maintenance activities under the CAR regime and hence consultation to the CAR practical guide for more information should be made before the works are carried out[4].

4 SEPA, The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended), A Practical Guide, Version 8.3, February 2019

5.3.1 Short term structural and channel maintenance and quick wins

Table 5-1: Short term structural and channel maintenance and quick wins for Insch.

Problem	Actions	Photo
Short cracks of arch, seeping joints, potential risk of scour very low.	Keep watercourse free of debris, regular monitoring of vegetation to limit blockage risk.	 **Commercial Road bridge (The Shevock)**
Minor spalling and moss growth on top.	Keep watercourse free of debris.	 **Bridge of Insch (The Shevock)**
Minor spalling of concreate, minor vegetation growth through minor cracks.	Keep watercourse free of debris. Add appropriately designed trash screen. Investigate capacity and bed levels. Monitor sedimentation.	 **Bennachie Bridge (Valentine Burn)**

Problem	Actions	Photo
Minor masonry material missing from arch downstream. Trash screen likely to be undersized.	Keep watercourse free of debris. Add new appropriately designed trash screen, increase capacity.	 **Drumrossie Street bridge (Valentine Burn)**
Minor cracks in arch. High vegetation growth of left bank downstream.	Keep watercourse free of debris and remove excess vegetation downstream.	 **B9002 culvert (Mill of Rothney Burn)**
Localised surface corrosion.	Keep watercourse free of debris and sediment to maintain channel capacity.	 **Industrial estate culvert (Mill of Rothney)**
Abutments show minor cracks.	Keep watercourse free of debris and clear blockages.	 **Railway culvert (Mill of Rothney)**

5.4 Non-structural flood risk management recommendations

5.4.1 Flood warning

The Insch community does not benefit from a flood warning system. A level gauge could be procured by SEPA or the Council and installed on The Shevock and/ or smaller tributary burns. A gauge would be beneficial in determining the rate of rise and therefore time required for properties at flood risk to prepare. It would also provide wider benefits by providing useable hydrometric data to improve hydrological estimates for future flood studies.

5.4.2 Emergency action plans

Aberdeenshire Council has an overarching Flood Response Plan, which is coordinated through the Responders identified under the Civil Contingencies Act 2004. The aim of the plan is to set out arrangements to deal effectively with flood risk. At predetermined trigger levels flood alerts and warnings will be issued through SEPA's flood forecasting and warning service (Floodline) and Aberdeenshire Council will conduct assessments at known hotspots and prepare resources as required. Aberdeenshire Council will also coordinate measures in conjunction with the other Responders. The emergency response process is coordinated through regional and local resilience partnerships. This response may be supported by the work of voluntary organisations[5].

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

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

Emergency planning should encourage communication at a community level to ensure good response rates during a flood. Examples of this include flood group leaders, flood wardens and buddy schemes that encourage communities to act together and to help provide assistance to those needing additional help (e.g. vulnerable residents).

5.4.3 Raising public awareness and community flood action groups

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

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

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

5 North East Local Plan District - Local Flood Risk Management Plan Insch, Aberdeenshire Council. https://www.aberdeenshire.gov.uk/media/17174/north-east-local-flood-risk-management-plan-2016-2022-web-version.pdf

5.4.4 Community sandbag stores

It is recommended that the Council considers the use of the flood 'pod' system: community storage boxes, which contain flood sacks which are purpose designed bags filled with absorbent material. The key advantage of this approach is that they can be distributed before a flood and are ideal for locations with limited warning or response times. It may also save the Council time in filling, distributing and delivering sandbags to communities when sandbag stores run out. 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 Insch. This approach would need to be combined once the flood warning system is fully developed and flood awareness campaign is provided by SEPA (i.e. flood alerts).

5.4.5 Property Level Protection (PLP)

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

5.4.6 Natural Flood Management (NFM)

Capitalising on NFM opportunities in the Insch catchment could provide flood attenuation on The Shevock and its tributaries. NFM opportunities have been summarised in Section 2.5 and may be considered by the Council in the future. Suggestions include wetland formation, storage ponds and improved land management through along contour ploughing, leaky bunds and buffer strips to reduce runoff rates (Figure 2-4).

The key area of the catchment where NFM could influence flood risk within Insch are upstream of Shevock Farm to the west of the town. This is due to the high floodplain storage and land management improvement potential.

5.4.7 Planning policy

Scottish Planning Policy and accompanying Planning Advice Notes set out Scottish Ministers' priorities for the operation of the planning system and for the development and use of land. In terms of flood risk management, the policy supports a catchment-scale approach to sustainable flood risk management and aims to build the resilience of our cities and towns, encourage sustainable land management in our rural areas, and to address the long-term vulnerability of parts of our coasts and islands. Under this approach, new development in areas with medium to high likelihood of flooding should be avoided[6].

5.5 Long list of options

The following tables provide an overview of potential flood alleviation options targeting the flood risk from the different watercourses within Insch. The tables have been derived using the non-exhaustive long list option from SEPAs guidance[7]. These have been separated into the four design areas based on source and mechanism of flood risk. A combination of options will be required to tackle all the flood mechanisms within Insch. Figure 5-1 below shows the four design areas; the Do Minimum 0.5% AP (200 year) event + climate change has been used to show the flood risk to these areas.

6 North East Local Plan District - Local Flood Risk Management Plan Ellon, Aberdeenshire Council, pva-06_12-ellon.pdf, https://www.aberdeenshire.gov.uk/media/17357/pva-06_12-ellon.pdf

7 Local Authority flood study checklist, Flood Risk Management (Scotland) Act 2009 (FRM Act), Version 3, 10 September 2018

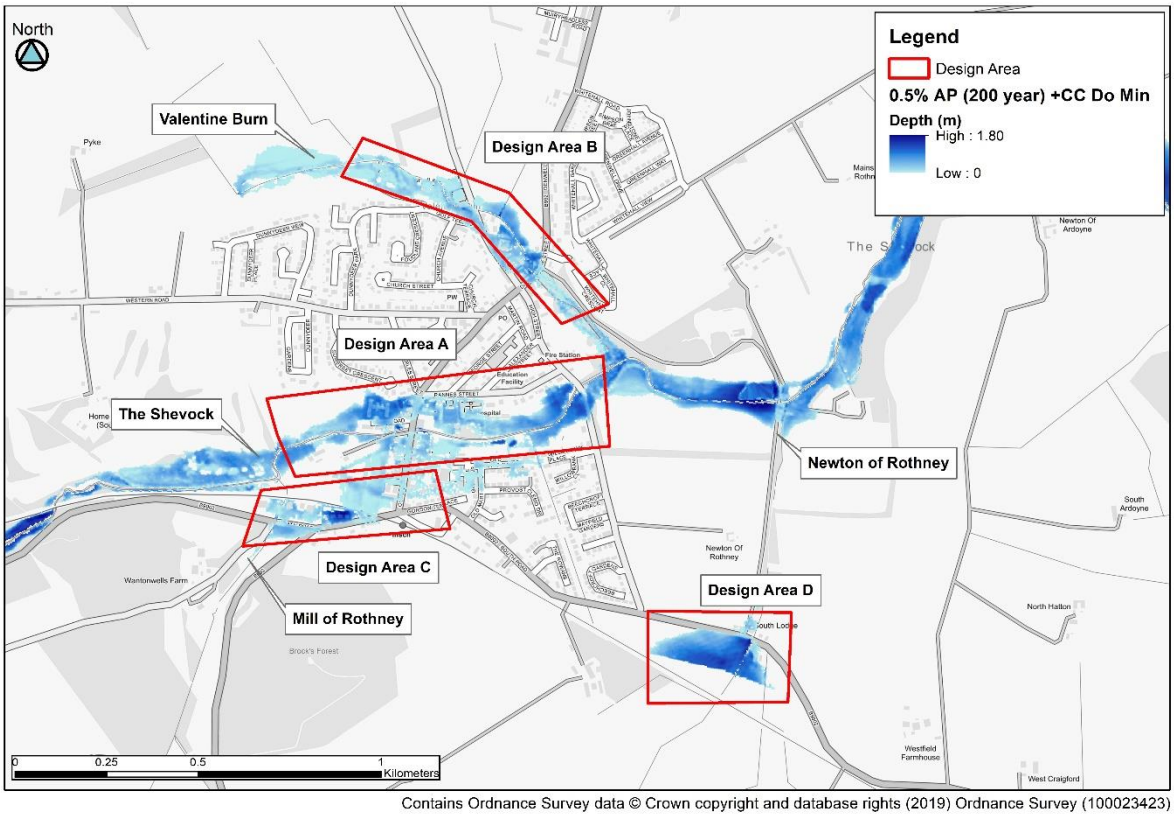


Figure 5-1: Insch design areas

The areas were selected as they each have different mechanisms which lead to flooding as follows:

- **Design Area A (The Shevock)** - The Shevock is subject to flooding around Commercial Road, Mill Road and Rannes Street due to out of bank flows.
- **Design Area B (Valentine Burn)** - This area covers the Valentine Burn and is subject to flooding upstream of Market Street bridge due to insufficient culvert capacity, the area surrounding the Leisure Centre due to out of bank flows and the properties upstream of Drumrossie bridge due to bank overtopping.
- **Design Area C (Mill of Rothney)** - This area covers the Mill of Rothney Burn and is subject to flooding from out of bank flow upstream of the B9002 road bridge and open channel sections which runs through the industrial estate. A major flow pathway forms as a result of overflow across North Road combined with the out of bank flow from the industrial estate which flows east towards the Insch properties on the right bank of The Shevock.
- **Design Area D (Newton of Rothney)** - This area covers the Newton of Rothney Burn and is subject to flooding of the road from insufficient culvert capacity at South Lodge. However, on assessment of SoP no properties are deemed to be at risk over a 0.5% AP (200 year) event thus no further appraisal of this design area has been undertaken.

Table 5-2: Long list of options for design area A (The Shevock)

Measure	Discussion
Relocation	**Technical:** Relocation or abandonment of properties not politically or socially viable. Option not cost effective as purchase costs will be the same as capped damages. **Environmental:** No significant environmental or RBMP impacts. **Constraints:** Multiple objections likely if carried out via a FPS. **Decision**: **Option discounted**.
Flood Warning	**Technical:** Currently no Flood Warning Alert (FWA) for the Shevock Burn. A gauge installation or monitoring would be required to inform alert stages. Unknown time to rise. **Environmental**: No significant environmental or RBMP impacts. **Constraints:** None Decision: **Shortlisted alongside other options.**
Property Level Protection (PLP)	**Technical:** This option could retrofit PLP to properties at risk of shallow flooding. **Environmental:** No significant environmental or RBMP benefits or impacts. **Constraints:** PLP is limited to flood depths of up to 600mm. If PLP temporary measures, warning would be required to allow residents to install the PLP to it to be effective. **Decision**: **Shortlisted.**
Local Planning Policies	**Technical:** Must comply with local plans such as the Scottish Planning Policy (SPP), local authority development plans, any conservation areas. The North East Local Flood Management Plan 2016-2022: Actions to avoid and reduce the risk of flooding and protect communities. The information in the flood risk management plans can be used to inform wider emergency response plans for flooding. The Plan defines that the flood protection study should consider how to avoid or minimise the potential negative effects to the environment and how recreational and tourism opportunities can be created. Aberdeenshire Council's Flood and Coastal Protection team will work directly and liaise with colleagues in the planning service to ensure appropriate policies and measures are put in place to reduce flood risk. **Environmental:** The Local Development Plan 2017 states that developments should identify measures to improve biodiversity and geodiversity. Furthermore, could contribute to health and wellbeing goals and access to greenspace. **Constraints:** The Local Development Plan 2017 has designated protected sites which may restrict development in Insch. Area R1 which is downstream of the Market Street Bridge and the land on both banks of The Shevock have been reserved for a town park. Area R2 and the right bank from the confluence with the Valentine Burn up to the confluence with the Newton of Rothney Burn is reserved land for a town park. Areas R4 is reserved for the possible expansion of the Insch War Memorial hospital. Area P2 is a protected area to conserve the bowling green. **Decision: Planning policies considered.**
Runoff (NFM)	**Technical:** **1. Woodland creation:** Opportunities for floodplain and riparian woodland planting in the golf course to the west of Insch and in the vicinity of the Shevock Farm which would slow flows and increase the time to peak. **2. Land management:** Along contour ploughing, hedgerow planting, buffer strips and bank fencing to limit livestock grazing and compaction. **3. Wetland creation/restoration:** Wetland creation downstream of the Little Main of Wardhouse and within the Mill of Rothney catchment. This could be incorporated as part of a recreational and wildlife zone. 4. **Drainage modifications:** block over-straightened forestry drainage channels. **Environmental:** There is the potential for habitat creation, diffuse pollution reduction and increase in biodiversity. This links to the local development plans by meeting their aim of improving biodiversity. **Constraints**: Potential land ownership constraints and would need farmers to actively participate in good land management practices. **Decision: Shortlisted alongside other options.**
River/floodplain restoration (NFM)	**Technical:** **1. River Morphology:** May be potential for increasing channel sinuosity upstream

Measure	Discussion
	of Insch. **2. Riparian woodland creation:** Upstream of the Shevock Farm. **3. Instream structures:** No areas identified. **4. Washlands/offline storage ponds**: There are opportunities for floodplain storage and indicative regions are primarily within the vicinity of Insch. There is a large pond on the left bank downstream of Shevock Farm. May be potential to create similar storage features upstream of Shevock Farm. There is potential for floodplain storage potential along the Mill of Glanderston upstream of Insch. **Environmental:** There is the potential for habitat creation, diffuse pollution reduction and increase in biodiversity. This links to the local development plans by meeting their aim of improving biodiversity. **Constraints:** Topography does not support channel diversion. Historical maps show the watercourses in Insch have been used for industrial mills through the 19th century and have followed the same course through the town that we see today. **Decision: Shortlisted alongside other options.**
Sediment Management (NFM)	**Technical:** **1. Managing channel instabilities:** Livestock fencing could protect from over grazing and compaction of the banks. **2. Overland sediment**: There are several areas within The Shevock catchment where there is potential for sediment management through the use of bunds, buffer strips and riparian vegetation planting. **3. Bank restoration:** Moderate levels of erosion are occurring in the upper headwaters of The Shevock and along the reach between Oldtown and Insch. Livestock grazing of the banks should be limited and re-vegetated to prevent excess sediment influx. **Environmental:** Supporting biodiversity, protecting habitats. **Constraints**: This option requires landowner co-operation to install livestock fencing, leaky bunds and plant buffer strips. **Decision: Shortlisted alongside other options.**
Storage (Engineering)	**Technical:** There is potential for the creation of storage ponds upstream of the Shevock Farm and at Insch Golf Course. Downstream of Little Mains of Wardhouse wetland storage could be utilised. **Environmental:** Some disturbance to wildlife during construction but potential benefits through new habitat creation and supporting biodiversity. **Constraints:** Potential land ownership constrains **Decision: Shortlisted for floodplain storage in the field west of Mill Road. Option considered in more detail in section 3.2**
Conveyance	**Technical:** **1. Channel modification:** There are opportunities for the restoration of sinuosity along the Shevock upstream of Shevock Farm. **2. Channel Diversion:** Limited area for channel diversion due to the urban area and the natural topography restrictions. **3. Hydraulic constrictions:** No significant constrictions. 4. Bridges/ Culverts: Increasing the capacity of some structures (SHEV01_3716 and SHEV01_4245) could contribute to a significant improvement to flood risk in Insch. Several concrete structures could be removed to improve watercourse condition alongside Mill House. **Environmental:** Channel modification may have significant environmental impact on sensitive habitats. E.g. fish spawning grounds. No significant environmental benefit. May remove valuable habitats of protected species. **Constraints:** Topography does not support diversion. Major restrictions to diversion as watercourse flows close to railway line. **Decision: Shortlisted for increasing culvert capacity of Commercial Road Bridge.**
Control structures	**Technical:** The implementation of new control structures would cause flooding upstream. **1. Sluice gate:** No sluice gates present. **2. Weir:** No weirs present.

Measure	Discussion
	3. Trash screens: No trash screens present. **4. Pumping station:** Limited feasibility for a pumping station. **Environmental:** Low environmental impact. Overall neutral impact. Replacement works could cause disturbances to wildlife. **Constraints:** Flood risk downstream (pass forward flow) would need to be considered. **Decision: Discounted**
Direct defences	**Technical:** **1.Embankment:** An embankment would require more space than a wall. **2.Wall/ Adaptable wall:** This option would help confine flow to the open channel sections of the watercourse. There are possible areas for direct defences along the Shevock at the south of Insch Hospital along to the High Street bridge. **Temporary**: 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. However, flood warning would be required. **Environmental:** Permanent: Direct defences likely to have negative RBMP impact through increased morphological pressure on the watercourse. Direct defences, in the form of walls may disconnect river from land for some species. Temporary: No significant environmental or RBMP benefits or impacts although likely to be preferred from an environmental standpoint when compared to direct defences. **Constraints:** Some objections possible at public consultation. **Decision: Shortlisted for an adaptable wall on the left bank of the Shevock Burn.**
Watercourse Maintenance	**Technical:** Maintenance to remove man made debris is recommended. Asset owners and riparian landowners are responsible for the maintenance and management of their own assets. **Environmental**: Channel and bank maintenance may have significant impacts on protected wildlife. **Constraints:** Possible stretching of council resources if further inspection/ maintenance is proposed. **Decision: Shortlisted alongside other options.**
Self Help	**Technical:** Introduction of a local flood action group and awareness raising. Flood Insurance for high risk properties/areas. Individual property owners can sign up to Floodline. Self help can be used in conjunction with other methods of prevention. **Environmental:** No significant environmental or RBMP benefits or impacts. **Constraints:** Unlikely to be accepted as the only flood prevention measure. **Decision: Shortlisted alongside other options.**
Emergency Plans	**Technical:** Aberdeenshire Council has an overarching Flood Response Plan, co-ordinated through the responders identified under the Civil Contingencies Act 2004. Warnings issued through Floodline and predetermined trigger level set. The emergency response is coordinated through regional and local resilience partnerships. The operational Flood Response Plan will undergo annual review to reflect operational or responsibility changes. **Environmental**: No significant environmental or RBMP benefits or impacts. **Constraints**: Limited flood warning time. **Decision: Shortlisted alongside other options.**

Table 5-3: Long list of options for design area B (Valentine Burn)

Measure	Discussion
Relocation	**Technical:** Relocation or abandonment of properties not politically or socially viable. **Environmental:** No significant environmental or RMBP impacts. **Constraints**: Multiple objections likely if carried out via a FPS. **Decision: Discounted**
Flood Warning	**Technical:** Currently no Flood Warning Alert (FWA) for the Valentine Burn. A gauge installation or monitoring would be required to inform alert stages. Lead time expected to be low. **Environmental:** No significant environmental or RMBP impacts. **Constraints:** Currently no gauge and likely insufficient lead time. **Decision: Discounted**
Property Level Protection (PLP)	**Technical**: **Permanent:** This option could retrofit PLP to properties at risk of shallow flooding. **Temporary:** Option would not be feasible due to no flood warning. **Environmental:** No significant environmental or RMBP impacts. **Constraints:** **Permanent:** Unlikely to be accepted by the community as the only flood protection measure. **Temporary:** Likely insufficient lead time or flood warning in place. **Decision: Shortlisted**
Local planning policies	**Technical:** Must comply with local plans such as the Scottish Planning Policy (SPP), local authority development plans, any conservation areas. The North East Local Flood Management Plan 2016-2022: Actions to avoid and reduce the risk of flooding and protect communities. The information in the flood risk management plans can be used to inform wider emergency response plans for flooding. The Plan defines that the flood protection study should consider how to avoid or minimise the potential negative effects to the environment and how recreational and tourism opportunities can be created. Aberdeenshire Council's Flood and Coastal Protection team will work directly and liaise with colleagues in the planning service to ensure appropriate policies and measures are put in place to reduce flood risk. **Environmental:** The Local Development Plan 2017 states that developments should identify measures to improve biodiversity and geodiversity. Furthermore, could contribute to health and wellbeing goals and access to greenspace. **Constraints:** The Local Development Plan 2017 states 3 areas alongside the Valentine Burn which are protect or reserved. P1 which is situated surrounding the Leisure Centre is protected to conserve the playing fields. P2 which is situated on the left bank on the Valentine Burn downstream of the Market Street Bridge is reserved for a replacement primary school. Area R2 lies on the left bank of the Valentine Burn is on the right bank downstream of the Drumrossie Street Bridge is reserved for a town park. **Decision: Planning Policies considered.**
Runoff (NFM)	**Technical:** **1. Woodland creation:** Limited scope for woodland creation on the Valentine Burn. **2. Land management:** Along contour ploughing, hedgerow planting, buffer strips and leaky bunds. **3. Wetland creation:** Opportunity for wetland creation on the left bank in the area reserved for a primary school. **4. Drainage modification:** Reed bed planting in field drains to reduce polluting runoff and slow flows. **Environmental:** The environmental benefits associated with this option include habitat creation, diffuse pollution reduction, increase in biodiversity, creating green corridors, recreational and educational areas. **Constraints:** Reserved or protected areas near Leisure Centre. Involves cooperation of land owners. **Decision: Shortlisted alongside other options.**
River/floodplain	**Technical:**

restoration (NFM)	**1. River morphology/ restoration:** Limited scope for modifications of river morphology due to urban extent. **2. Riparian woodland creation:** Limited space for woodland creation. **3. Instream structures:** This option would not reduce flood risk. **4. Storage ponds:** See storage section. **Environmental:** Environmental impacts include disturbances to wildlife and wildlife habitats. Monitoring and removal of invasive species prior to works. **Constraints:** Limited space due to urban extent and protected/ reserved land constrictions. **Decision: Discounted**
Sediment management (NFM)	**Technical:** **1. Managing channel instabilities:** vegetation planting to stabilise highly eroding sections of bank. **2. Overland sediment:** Leaky bunds, debris dams and buffer strips recommended in the upper catchment **3. Bank restoration:** Bank stabilisation recommended in the upper catchment and newly cut drainage channel tributary. **Environmental:** Environmental impacts include disturbances to wildlife and wildlife habitats. Monitoring and removal of invasive species prior to works. Reducing sediment input will improve water quality and condition of existing aquatic habitats. **Constraints:** Landowner cooperation required in bund construction and vegetation planting. **Decision: Shortlisted alongside other options.**
Storage (engineering)	**Technical:** A wetland storage option could be designed on the left bank of the Valentine Burn downstream of the Market Street Bridge. This could be incorporated into the plans for the replacement primary school as an educational and recreational wetland. **Environmental:** Some disturbance to wildlife during construction but potential benefits through new habitat creation and wetland area. Furthermore, reed beds could offer some pollution removal. **Constraints:** Land ownership constraints. From the local development plan there are several areas which are protected. Area surrounding Leisure Centre protected to conserve playing fields. Area on the left bank downstream of the Leisure Centre protected for a replacement primary school. **Decision: Shortlisted for storage area either on the golf course or downstream of the Largie road culvert on the left bank. Section 3.2 looks at this in further detail.**
Conveyance	**Technical:** **Channel modification:** There are opportunities for channel modification around Insch Golf Course to increase sinuosity and improve floodplain connectivity. Two stage channel to be considered downstream of Leisure Centre. Channel re-meandering in places would be recommended. **Channel diversion:** Limited scope for channel diversion due to presence of an urban area and topographic constrictions. **Channel realignment:** Limited scope for channel realignment due to presence of urban area and topographic restrictions. **Hydraulic constrictions:** The removal of the trash screen on Drumrossie Street bridge would help improve channel conveyance. **Bridge/Culverts:** There are several structures (VAL01_0622; VAL01_0354) which could benefit from modification to increase capacity. Environmental: **Channel modification:** May have significant environmental impact on sensitive habitats. E.g. fish spawning grounds. **Channel diversion:** May remove valuable habitats but if bypass naturalised then could provide new habitats. **Channel realignment:** No significant environmental benefits or impacts. **Constraints:** Topography and urban area does not support diversion or channel realignment. **Decision: Shortlisted for improvements to increase capacity of Drumrossie Street bridge and Largie Road culvert and Two Stage channel.**

Control Structures	**Technical:** No control structures on the Valentine Burn. **Environmental:** No environmental impacts. **Constraints:** No constraints. **Decision:** **Discounted**
Direct Defences	**Technical:** **Embankment:** Due to space availability embankments would be less feasible than walls. **Wall/adaptable wall:** This option may be feasible along the watercourse at the back of Market Street in the form of a wall. Walls should be made adaptable where possible to accommodate future storm intensification due to climate change. In some other locations, existing walls be raised/improved to provide a better standard of protection. **Temporary:** Ensuring constant availability of trained personnel capable of deployed defences may be put excessive pressure on council. Residents may be able to assist but reliability of defences deployment may be reduced. **Environmental:** Some object possible at public consultation. Demountable defence not suitable as not enough time on small watercourse with a fast time to peak. **Constraints:** Some objections at public consultation. Demountable defences not suitable as not enough time on small watercourse with a fast time to peak. **Decision:** **Shortlisted for wall along the Valentine Burn at the back of the Market Street properties.**
Watercourse Maintenance	**Technical:** Maintenance to remove man made debris from the watercourse is recommended. Bank stabilisation where it is eroding downstream of Market Street bridge is also recommended. Asset owners and riparian landowners are responsible for the maintenance and management of their own assets including those which help to reduce flooding. **Environmental:** Channel and bank maintenance may have significant impacts on protected wildlife. **Constraints:** Possible stretching of council resources if further inspection/maintenance is proposed. **Decision:** **Shortlisted alongside other options.**
Self Help	**Technical:** Introduction of a flood action group and awareness campaign. Flood insurance for high risk properties. Individual property owners can sign up to Floodline. **Environmental:** No significant environmental or RMBP benefits or impacts. Constraints: Requires individual and community buy in. **Decision:** **Shortlisted alongside other options.**
Emergency Plans	**Technical:** Aberdeenshire Council has an overarching flood response plan, co-ordinated through the responders identified under the Civil Contingencies Act 2004. Warnings issued through the Floodline and predetermined trigger level set. The emergency response is coordinated though regional and local resilience partnerships. The operational Flood Response Plan will undergo annual review to reflect operational or responsibility changes. **Environmental:** No significant environmental or RMBP benefits or impacts. **Constraints:** Requires adequate flood warning time. **Decision:** **Shortlisted alongside other options.**

Table 5-4: Long list of options for design area C (Mill of Rothney)

Measure	Discussion
Relocation	**Technical:** Relocation of industrial property in the lowest reach of the Mill of Rothney and watercourse could be culverted through the site. **Environmental:** No significant environmental or RBMP impacts. **Constraints:** Multiple objections and would require land owners agreement and new area of development for relocated properties. **Decision:** **Discounted**
Flood Warning	**Technical:** Currently no Flood Warning Alert (FWA) for the Mill of Rothney. A gauge installation or monitoring would be required to inform alert stages. **Environmental**: No significant environmental or RBMP benefits or impacts.

Measure	Discussion
	Constraints: Limited flood warning time as no gauge installed. **Decision:** **Discounted.**
Property level protection	**Technical:** Properties would benefit due to being within the 0-0.6m depth range, which falls within the PLP boundary. **Environmental:** No significant environmental or RBMP benefits or impacts. **Constraints:** Unlikely to be accepted by the community as the only flood protection measure. Multiple objections likely if carried out via a FPS. Flood warning would be required for temporary PLP. **Decision:** **Shortlisted**
Local planning policies	**Technical:** Must comply with local plans such as the Scottish Planning Policy (SPP), local authority development plans, any conservation areas. The North East Local Flood Management Plan 2016-2022: Actions to avoid and reduce the risk of flooding and protect communities. The information in the flood risk management plans can be used to inform wider emergency response plans for flooding. The Plan defines that the flood protection study should consider how to avoid or minimise the potential negative effects to the environment and how recreational and tourism opportunities can be created. Aberdeenshire Council's Flood and Coastal Protection team will work directly and liaise with colleagues in the planning service to ensure appropriate policies and measures are put in place to reduce flood risk. **Environmental:** The Local Development Plan 2017 states that developments should identify measures to improve biodiversity and geodiversity. Furthermore, could contribute to health and wellbeing goals and access to greenspace. **Constraints:** The Local Development Plan 2017 shows area OP1 to lie to the east of the Mill of Rothney. OP1 is an opportunity area for housing development so there may be restrictions to any flood risk development in this area. **Decision:** **Planning Policies considered.**
Runoff (NFM)	**Technical:** There is medium potential within the Mill of Rothney sub catchment for runoff reduction. **1. Woodland creation:** Could be potential for along contour planting in the upper catchment. **2. Land management:** Along contour ploughing and hedgerows in the upper catchment. **3. Wetland creation:** Opportunity in the land south of North Road. **4. Drainage modification:** There is potential for agricultural drainage modifications in the upper catchment. **Environmental:** Woodland and wetland creation would provide new habitats, diffuse pollution reduction and increase in biodiversity. This links to the local development plans by meeting their aim of improving biodiversity. **Constraints:** Potential land ownership constraints and would need farmers to actively participate in good land management practices. **Decision:** **Shortlisted alongside other options.**
River/floodplain restoration (NFM)	**Technical:** **1. River morphology/restoration:** Limited opportunity. **2. Riparian woodland creation:** This could be carried out in the upper catchment **3. Instream structures:** Limited opportunity. **4. Online storage ponds:** There is medium potential within the Mill of Rothney sub catchment for floodplain storage in the lower reaches of the watercourse e.g. in the land south of North Road. Alternatively this area could be made into a wetland. **Environmental:** Riparian woodland, and wetland creation would provide new habitats, reduce diffuse watercourse pollution and increase biodiversity. This links to the development plans by meeting their aim of improving biodiversity. **Constraints:** None. **Decision:** **Shortlisted alongside other options.**
Sediment management (NFM)	**Technical:** **1. Managing channel instabilities:** Installation of livestock fencing to protect banks from over grazing. **2. Overland sediment**: Leaky bunds, debris dams, hedgerows and buffer strips recommended.

Measure	Discussion
	3. Bank restoration: Bank stabilisation recommended in the industrial estate to prevent sediment and diffuse pollution being washed toward The Shevock. **Environmental:** Livestock fencing and bank stabilisation will help prevent channel degradation and protect habitats of water voles. **Constraints:** Landowner buy-in required. **Decision: Shortlisted alongside other options.**
Storage (engineering)	**Technical:** **Online:** Online storage ponds could be created along the reach of the burn. Potential areas for this could be south of North Road/B9002. **Offline**: Limited opportunity. **Environmental:** Some disturbance to wildlife during construction but potential benefits through new habitat creation. **Constraints:** Land ownership constraints and limited space availability. **Decision**: **Shortlisted for storage upstream of North Road. Section 3.2 discussed this in more detail.**
Conveyance	**Technical:** **Channel modification:** There is potential for channel re-meandering to increase sinuosity in the channel. **Diversion:** No suitable diversion route would be cost effective for the number of properties at risk. **Structure modification:** The capacity of the pipe culvert through the industrial yard could be increased. **Environmental:** There is the potential for disruption to wildlife and habitats, if bypass naturalised then could provide new habitats. **Constraints:** No suitable diversion routes would be economically viable. Increasing the capacity of the railway culvert would incur substantial costs and potential disruptions to both the community and the railway. **Decision: Shortlisted for upgrade or removal of the pipe culvert through the industrial estate. Section 3.2 discussed this in more detail.**
Control structures	**Technical:** The installation of control structures in not likely to significantly reduce flood risk to the community. **Environmental:** There is potential to disrupt wildlife and habitats. **Constraints:** Unlikely to be cost effective due to limited available space for large volumes of water to be controlled. **Decision: Discounted**
Direct defences	**Technical:** There are limited available areas for direct defences. **Environmental:** A wall could be constructed along the banks of the watercourse from the B9002 road culvert to the railway culvert. **Constraints:** Direct defences likely to have negative RBMP impact through increased morphological pressure on the watercourse. Direct defences, in the form of walls may disconnect river from land for some species. **Decision: Shortlisted**
Watercourse Maintenance	**Technical**: Maintenance unlikely to reduce flood risk to a useful degree but maintenance schedule should be adhered to. Could play a minor role in reducing flood risk if combined with more substantial options. Asset owners and riparian landowners are responsible for the maintenance and management of their own assets including those which help reduce flooding. **Environmental:** Channel and bank maintenance may have significant impacts on protected wildlife. **Constraints**: Possible stretching of council resources if further inspection/ maintenance is proposed. **Decision: Shortlisted alongside other options.**
Self Help	**Technical:** Introduction of flood action group and awareness campaign. Flood insurance for high risk properties. Individual property owners can sign up to Floodline. **Environmental:** No significant environmental or RBMP benefits or impacts. **Constraints:** Requires individual and community buy in. **Decision: Shortlisted alongside other options.**
Emergency	**Technical:** Aberdeenshire Council has an overarching Flood Response Plan, co-

Measure	Discussion
Plans	ordinated through the responders identified under the Civil Contingencies Act 2004. Warnings issued through Floodline and predetermined trigger level set. The emergency response is coordinated through regional and local resilience partnerships. The operational Flood Response Plan will undergo annual review to reflect operational or responsibility changes. **Environmental:** No significant environmental or RBMP benefits or impacts. **Constraints:** Limited flood warning time. **Decision:** **Shortlisted alongside other options.**

5.6 Feasibility study

5.6.1 Storage analysis on The Shevock

The feasibility of storage upstream of the confluence of The Shevock with the Mill of Rothney has been considered. As some properties within Insch have an SoP of the 50% AP (2 year) event, the storage was assessed to hold the 0.5% AP (200 year) event plus climate change with a controlled outlet structure allowing only the 50% AP (2 year) event downstream. The tested location of the proposed storage option can be seen in Figure 5-2.

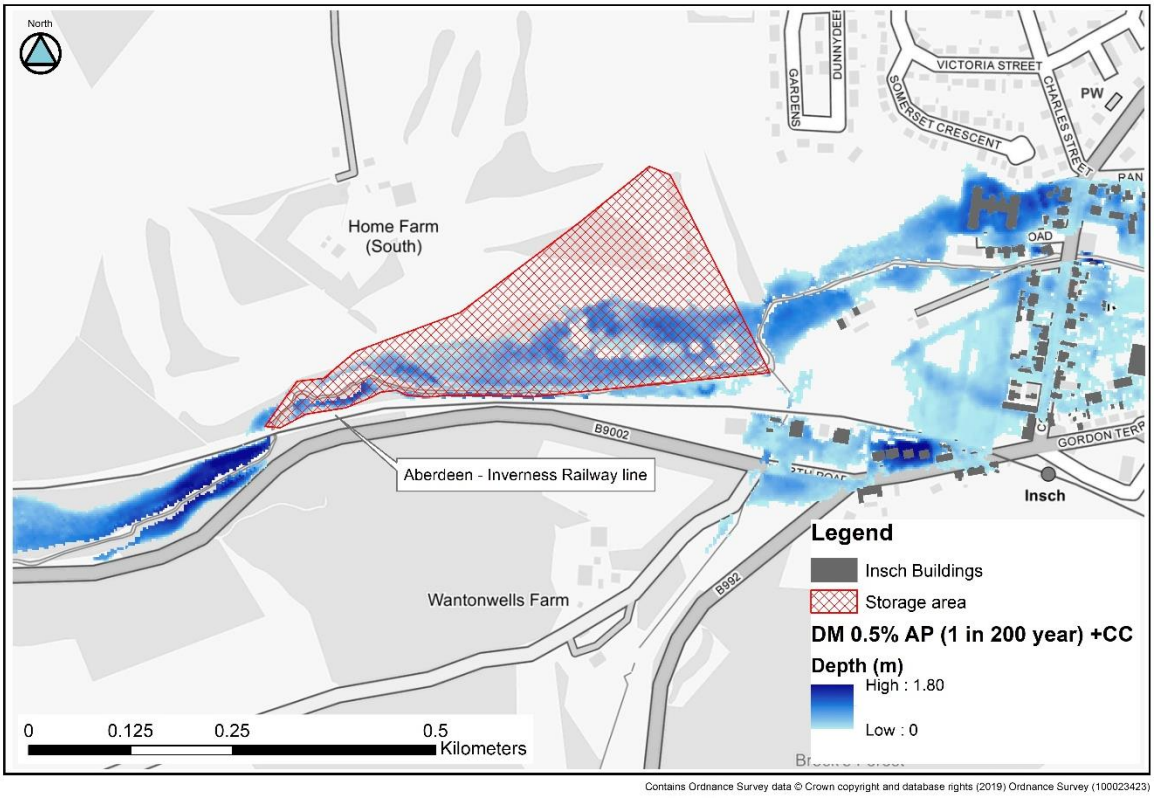


Figure 5-2: The Shevock storage area

A storage area was tested with a basic Flood Modeller reservoir model restricting the flow in the channel to the 50% AP (2 year) with a flow constriction orifice. The dimensions of the orifice were calculated to allow the 50% AP (2 year) flow to pass through and the 0.5% AP (200 year) event plus climate change flow would attenuate within the storage area. The storage area boundary is shown on Figure 5-2 by the red hatched area. The storage behind the wall was based on an area/ elevation relationship extracted from the available LiDAR data.

The results of the feasibility tests have found that in order to store the flows for a 0.5% (200 year) event plus climate change a reservoir defence level of 135 mAOD would be required. This equates to an embankment >5m in height and of considerable length. This would be associated with very high capital and ongoing maintenance costs. The embankment would run parallel to the railway line which sits at an elevation of 129 mAOD and would likely be unacceptable. A large area of land take would be required including land take of Insch Golf Course which would result in public objection.

Environmental constraints include the potential for high sediment build up behind the orifice and a fish pass would be needed through the orifice.

Storage as a standalone option has therefore been **discounted**. This is because:

- Very high and extensive embankments, with high land take at Insch Golf Course would be required.
- The proposed area is in very close proximity to the railway line making it not an ideal location.
- This area is not far enough upstream of Insch to capture enough flow to mitigate flood risk. For storage to be most effective (as a standalone option) it needs to be as near as possible to the area at risk.
- Construction costs would be high.
- Large environmental impacts.
- Current conditions show The Shevock already has good floodplain connectivity and storage in the area proposed for a reservoir.

5.6.2 Storage analysis on the Valentine Burn

Feasibility of storage on the Valentine Burn, either upstream on the golf course or downstream of Largie Road bridge on the left bank have been tested. As some properties along the Valentine Burn start to flood at the 20% AP (5 year) event, it was tested to hold the 0.5% AP (200 year) event plus climate change with a controlled outlet structure allowing only the 20% AP (5 year) event downstream. The location of the proposed storage area is shown in Figure 5-3.

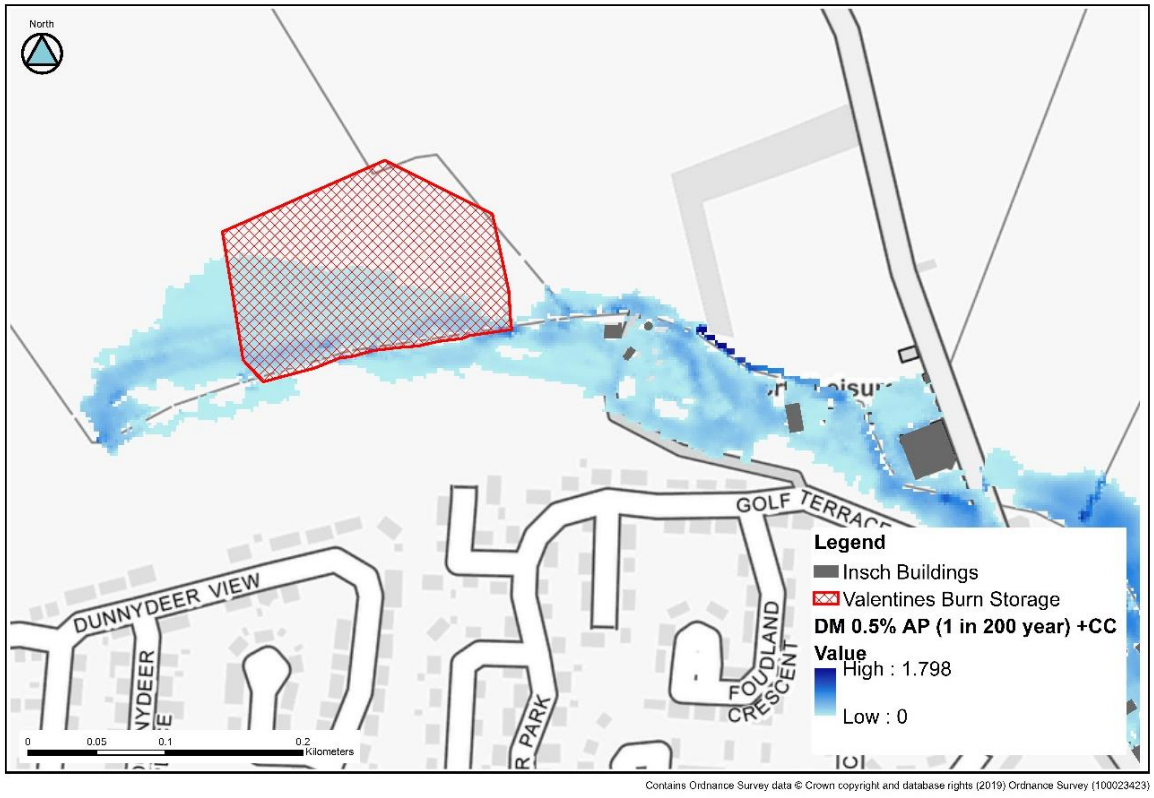


Figure 5-3: Valentine Burn storage area.

A storage area has been tested with a basic reservoir storage model in Flood Modeller. The model is designed to restrict the flow in the channel to the 20% AP (5 year) by a flow constriction orifice. The storage behind the wall was based on an area/ elevation relationship extracted from the available LiDAR data

The results of this feasibility test indicate that in order to attenuate the 0.5% AP (200 year) plus climate change event, an embankment with a minimum elevation of 130 mAOD which would be required which equates to a height of approximately 4 m. The key constraints to this option are

public acceptance of use of the golf course for floodwater storage and the environmental constraints including the need for a fish pass to allow movement either side of the orifice and the possibility of sediment build up behind the orifice.

Discounted as standalone but has been **shortlisted** for further testing.

5.6.3 Storage analysis on the Mill of Rothney

Feasibility of storage upstream of the North Road culvert has been considered. As some properties within Insch have a 50% AP (2 year) SoP, it was tested to be a storage solution to hold the 0.5% Ap (200 year) event plus climate change with a controlled outlet structure allowing only the 20% AP (5 year) event downstream. The location of the proposed storage area is shown in Figure 5-4.

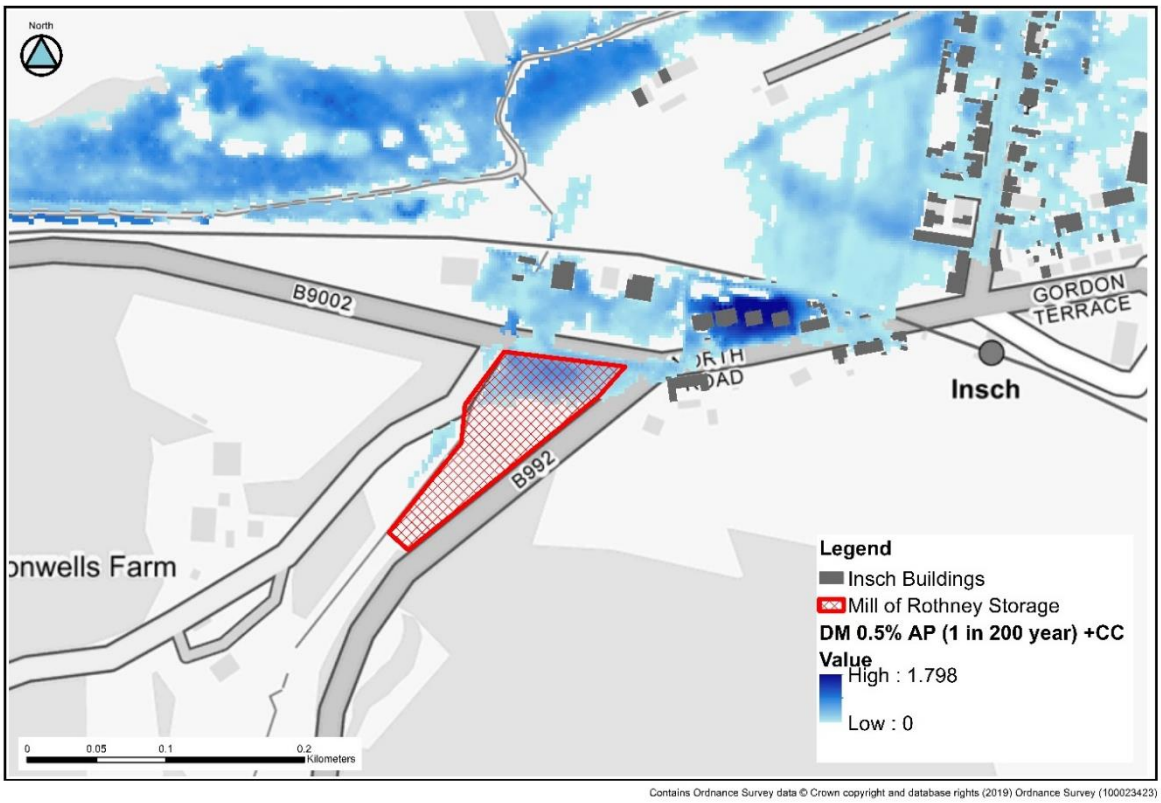


Figure 5-4: Mill of Rothney storage area.

A storage area has been tested with a basic reservoir storage model in Flood Modeller. This model is designed to restrict the flow in the channel to the 20% AP (5 year) with a flow constriction orifice. In order to attenuate the 0.5% AP (200 year) event plus climate change event, on the rigth bank upstream of North Road, an embankment approximately 10 m in height (level 137.9 mAOD) would be require based on an area/ elevation relationship extracted from the available LiDAR data.

The height of the embankment required is excessively high, would be very expensive with high capital and ongoing maintenance costs, would likely face public objection and require high land take. Additionally there are a number of environmental constraints including sediment build up behind the orifice and the need for a fish pass to allow fish through the orifice.

This option has therefore been **discounted as a standalone option** as:

- The height required to store significant amounts of flood water would be excessively high.
- Large environmental impacts.

5.7 Short list of options

Watercourse maintenance and NFM shall be implemented to some extent with all short-listed options. Following the consideration of the long list and feasibility in Sections 5.5 and 5.6, the following options have been shortlisted:

- Design area A (The Shevock)
  - Direct defences.
  - Property Level Protection (PLP)
- Design area B (Valentine Burn)
  - Upgrades to the Largie Road culvert (VAL01_0622) and Drumrossie Street culvert (VAL01_0354) to increase capacity.
  - Direct defences in the vicinity of the Market Street properties.
  - Direct defences in the vicinity of the Market Street properties in conjunction with culvert upgrades.
  - Two stage channel (a channel which incorporates a low flow section for low flows and a high flow section to function as floodplain) downstream of Largie Road culvert.

    Property Level Protection (PLP).
- Design area C (Mill of Rothney)
  - Embankment to prevent overflow across North Road.
  - Removal of the existing pipe culvert and bank raising.
  - New culvert for the entire length of the industrial estate.
  - Property Level Protection (PLP)

Each option should be taken forward alongside non-structural options such as flood warning, emergency planning and setting up a local flood group to increase community preparation for flood events.

5.7.1 Designing for climate change

In line with Scottish Planning Policy a 0.5% AP (200 year) standard of protection for any scheme was the goal throughout the short listing process. Wherever possible, options have been short-listed that at least aim to mitigate flooding to this standard and strive to meet the design standard for this event with an allowance for climate change, a 24% increase in the peak river flow.

Where a 0.5% AP (200 year) standard is not feasible interventions will be considered to allow for the greatest flood risk benefit possible after consideration of technical, environmental and social limitations and opportunities. River flood flows are expected to rise and where possible this will be accounted for in the design, for example by allowing for adaptable defences (which can for example be raised in height in the future) or by targeting a slightly higher SoP than may be ideal at the current time.

Within The Shevock catchment there are key opportunities for NFM, which are discussed within the NFM report. It is unknown if NFM would sufficiently mitigate the flood risk at Insch without the need for additional works. However, NFM options would help mitigate some of the impacts of climate change.

5.8 Flood Mitigation Options - Design Areas

The following section details the constraints and benefits of the shortlisted options for Insch. This has initially been analysed within the three design areas separately in order to conclude the most feasible option in each area. These will then be combined to find the most viable solution for Insch as a whole.

5.8.1 Design area A - The Shevock

The key properties at risk lie along the left bank of The Shevock in the vicinity of Mill Road. Flooding commences from the 10% AP (10 year) event as a result of out-of-bank flow upstream of Mill Road, which travels east towards the Insch residential home, War Memorial Hospital and residential properties. A property upstream of Commercial Road bridge floods as a result of southerly flow from the primary flow pathway north of Mill Road. Properties along the right bank of The Shevock and

along Commercial Road flood as a result of out of bank flow from the Mill of Rothney and will be discussed in Section 5.8.3. In order to protect the left bank properties from the 0.5% AP (200 year) plus climate change event, the primary flow pathway originating upstream of Mill Road must be stopped.

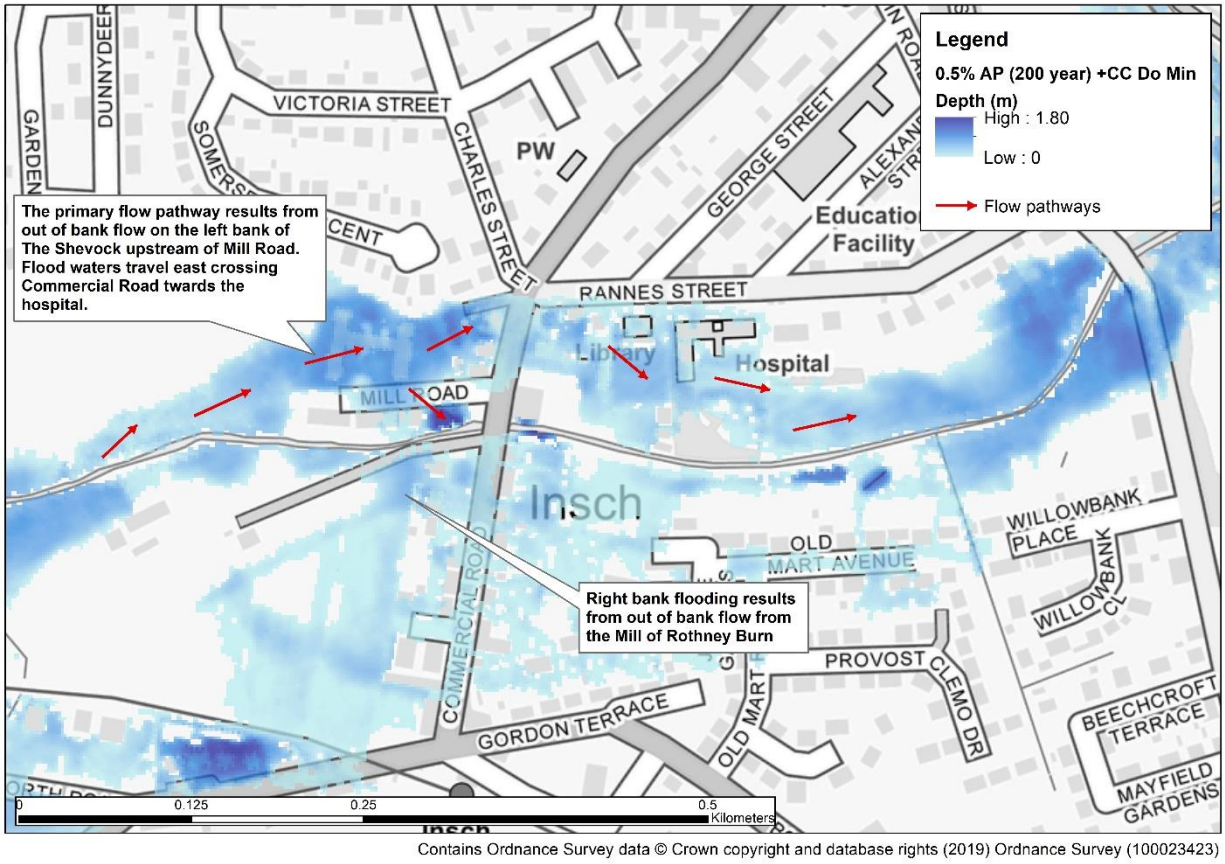


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Figure 5-5: Design Area A - The Shevock flow pathway

Option A1a:
Direct Defences (Embankment)

Option A1b:
Direct Defences (Embankment and formalisation of wall)

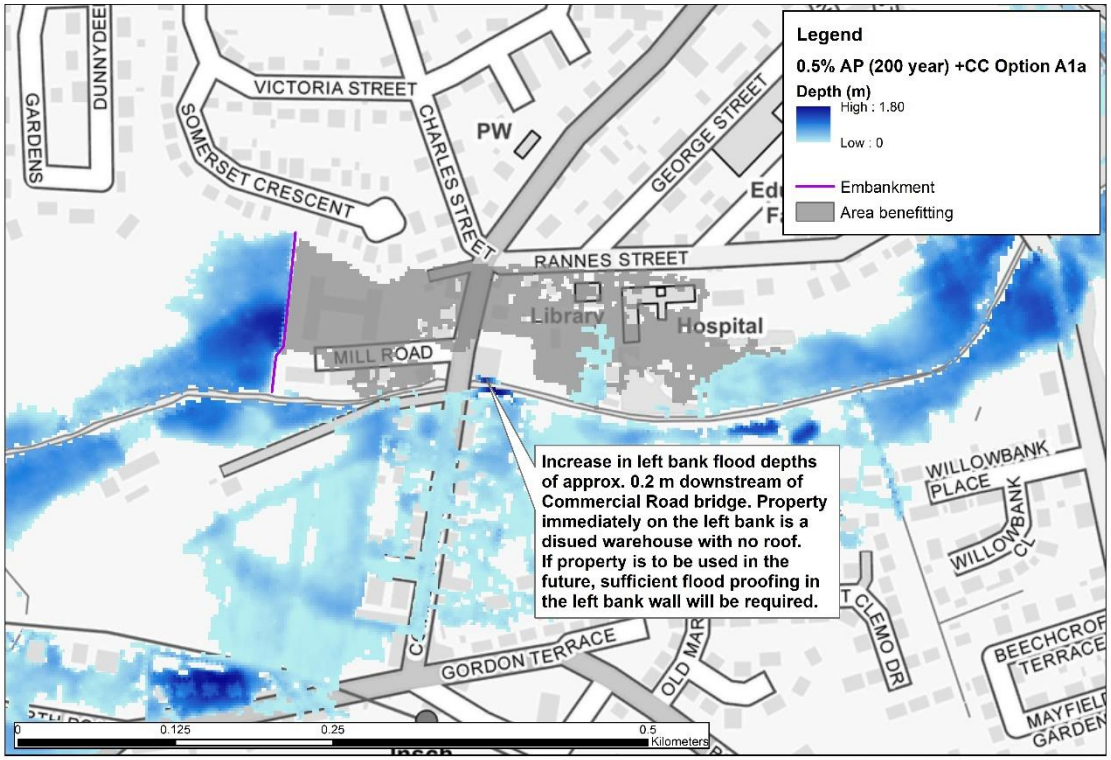
Option A2:
PLP

Option A1a - Direct Defences

Description

This option aims to block the key flow pathway on the left bank of The Shevock improving floodplain storage in the land to the west of Mill Road. This will offer a 0.5% AP (200 year) + climate change standard of protection plus freeboard to the left bank properties. The proposed works are as follows:

- Construct an embankment to the west of Insch residential home approximately 130 m in length and 1.75 m in height including 0.6 m freeboard.



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Standard of protection (SoP)

The results of modelling of this option have shown it is possible to provide a 0.5% AP (200 year) + climate change standard of protection to all 12 properties at risk under the Do Minimum scenario.

Alternative quick wins/ Preliminary investigations

- The embankment required is not particularly high but may block views from the residential homes. A smaller embankment could be built if there are objections which would offer a lesser standard of protection.
- Investigation into the condition of the left bank Mill Road wall is needed (upstream of Commercial Road bridge). This is not a formal flood wall and its failure would lead to a less than 0.5% AP (200 year) +CC standard of protection. Consideration of the wall forms Option 1b.

Geotechnical issues

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

Services

A full survey identifying overhead and underground services will be required at a later stage in the project.

Construction access/ issues

Construction access may be challenging. Key issues include:

- Construction of the embankment would require heavy machinery access to the rough ground west of Mill Road and south of Somerset Crescent. This is not currently accessible

by road.

- Construction will entail heavy machinery working near the banks.
- Temporary storage of topsoil and subsoil in heaps and stockpiles.
- Groundworks and construction vehicles are likely to cause noise and vibrations.

Waste

- Nature (inert, non-hazardous, hazardous): no known details of significant industry thus soil expected to be inert,
- Proposed disposal: All waste produced during construction should be contained and prevented from entering the watercourse. Stock piles of soil and nontoxic spoilt during construction waste should be located away from the river (at least c. 10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works.
- Further investigation required through ground investigation into the level of contamination.

Proximity of defense to other structures

- **Houses:** the proposed embankment runs close to properties on Mill Road and the Drumdarroch residential home.

Environmental issues

- **Habitats:** additional surveys required to assess potential impact on Scottish wildcat, Brown Hare, water vole and fish habitats. In particular sediment influx to the channel during works should be minimised. Consultation with SNH and SEPA may be required.
- **Listed buildings:** Mill House on the corner of Commerce Street and Mill Road is a Grade B listed building. Any potential works should not damage or impact the mill, e.g. if the wall is to be upgraded (Option A1b), and may require consultation with SNH.
- **Non-native invasive species:** Invasive Non Native Species (INNS) have been identified by NESBReC within the study area including Giant Hogweed and Himalayan Cotoneaster. The field survey conducted by JBA primarily identified Giant Hogweed and Cotoneaster Cotoneaster along the banks of The Shevock. It is an offense to spread these invasive non-native species therefore control measures should be put in place during construction.

Health and safety hazards noted

- **Geotechnical and evacuation works:** in channel works, falling into excavations, collapse of the sides of excavations, damage to underground services.
- **Construction:** flooding of works and working near the river bank.

Social and community issues

- Aesthetic issues - the embankment will block views west from the Drumdarroch residential home and [redacted] Mill Road. It may also impact the views south from the Somerset Crescent. There may be public objections to this.
- Potential disruptions on Mill Road and / or Somerset Crescent during construction.

Impact on other reaches

Modelling suggests water levels increase downstream of the embankment but are not anticipated to put any further properties at risk. A non-residential property lies on the left bank immediately downstream of Commercial Bridge where water levels are indicated to increase. This building is currently abandoned with no roof and is therefore not considered an asset at risk. The increased water levels are as a result of greater flow in the channel due to the embankment preventing floodplain flow. This has the potential to increase shear stress and therefore erosion of the channel banks and may require additional work to reinforce/ stabilise the downstream banks. Further investigation of this will be required at the detailed design stage.

Additional information required

- A detailed topographic survey.
- Detailed buried services survey, plotting their position with regard to site works.
- Ground investigations.
- Seepage analysis should be undertaken prior to detailed design.
- Authorisation from SEPA will be required prior to construction under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (CAR).

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

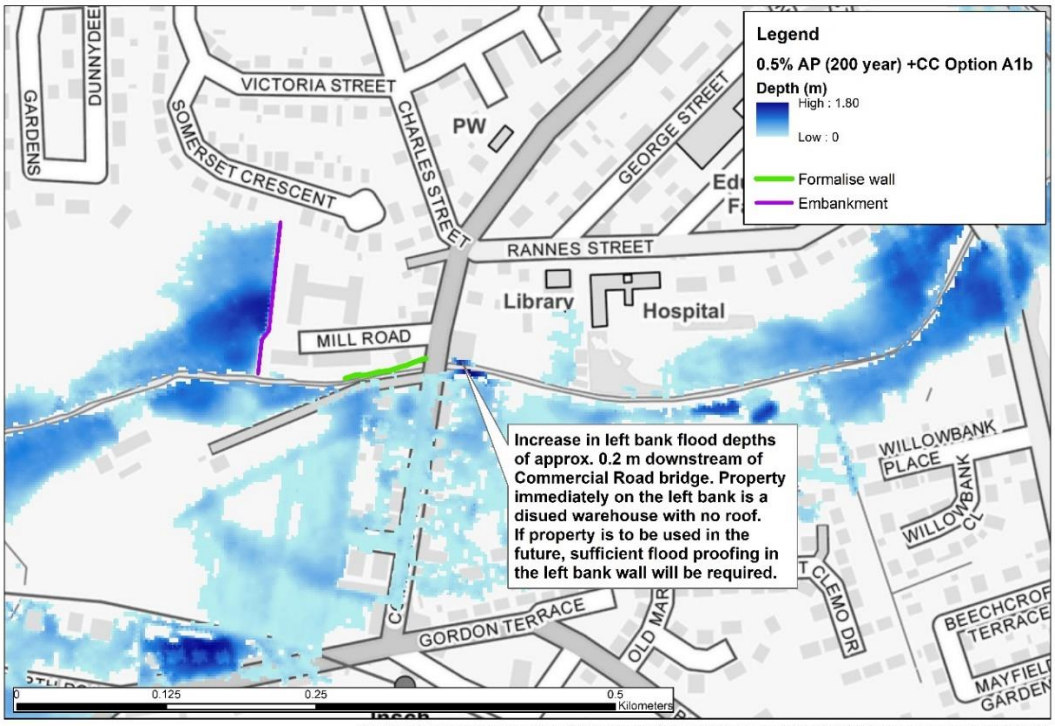
- Consider making the embankment adaptable so it could be easily raised in the future.
- Consider formalising the Mill Road wall and constructing it to a uniform elevation in order to ensure the 0.5% AP +CC / future climate change standard of protection to the Mill Road residential properties.
- If the commercial property immediately downstream of Commercial Road bridge is to be renovated and used in the future, the wall immediately backing into the left bank will require suitable flood proofing and no openings to flood level of 123 mAOD.

Option A1b - Direct Defences

Description

This option aims to block the key flow pathway on the left bank of The Shevock improving floodplain storage in the land to the west of Mill Road. This will offer a 0.5% AP (200 year) + climate change standard of protection plus freeboard to the left bank properties. The proposed works are as follows:

- Construct an embankment to the west of Insch residential home approximately 130 m in length and 1.75 m in height including 0.6 m freeboard.
- Formalise the left bank flood wall which runs for approximately 60 m between [redacted] Mill Road and Commercial Street bridge. It is estimated the wall would need to be 2 m in height (125 mAOD).



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Standard of protection (SoP)

The results of modelling of this option have shown it is possible to provide a 0.5% AP (200 year) + climate change standard of protection to all 12 properties at risk under the Do Minimum scenario.

Alternative quick wins/ Preliminary investigations

- The embankment required is not particularly high but may block views from the residential homes. A smaller embankment could be built if there are objections which would offer a lesser standard of protection.
- Investigation into the condition of the left bank Mill Road wall (upstream of Commercial Road bridge) is needed and further survey would improve the estimated height of the defence required.

Geotechnical issues

- A full ground investigation will be required at a later stage in the project.
- A cut-off or piling is likely to be needed to avoid seepage beneath all defences. Piling may be difficult in this material and other forms of cut-off may need to be investigated. Due to lack of GI information a cut-off assumption of 0.5 m depth has been made, the cut-off depth will require further investigation at detailed design.

Services

A full survey identifying overhead and underground services will be required at a later stage in the project.

Construction access/ issues

Construction access may be challenging. Key issues include:

- Construction of the embankment would require heavy machinery access to the rough ground west of Mill Road and south of Somerset Crescent. This is not currently accessible by road.
- Construction will entail heavy machinery working near the banks.
- Construction of the wall may be difficult due to the steep sided banks and may require in channel works.
- Temporary storage of topsoil and subsoil in heaps and stockpiles.
- Groundworks and construction vehicles are likely to cause noise and vibrations.

Waste

- Nature (inert, non-hazardous, hazardous): no known details of significant industry thus soil expected to be inert.
- Proposed disposal: All waste produced during construction should be contained and prevented from entering the watercourse. Stock piles of soil and nontoxic spoilt during construction waste should be located away from the river (at least c. 10 m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works.
- Any waste materials removed from the site must be disposed of at a suitably licensed or exempt waste management facility under the Waste Management Licensing (Scotland) Regulations 2011. All waste should be carried off site by registered carriers and should be aware of the furnishing and keeping of waste transfer notes.
- Further investigation required through ground investigation into the level of contamination.

Proximity of defenses to other structures

- **Houses:** the proposed embankment runs close to properties on Mill Road and the Drumdarroch residential home. Wall construction would involve works within the private residential gardens.

Environmental issues

- **Habitats:** additional surveys required to assess potential impact on Scottish Wildcat, Brown Hare, water vole and fish habitats. In particular sediment influx to the channel during works should be minimised. Consultation with SNH and SEPA may be required.
- **Listed buildings:** Mill House on the corner of Commercial Street and Mill Road is a Grade B listed building. The left bank wall may fall under this listing. Formalisation of the wall as a flood defence, and any potential impact to protected properties on Mill Road as a result of the works will require consultation with SNH.
- **Non-native invasive species:** Invasive Non Native Species (INNS) have been identified by NESBReC within the study area including Giant Hogweed and Himalayan Cotoneaster. The field survey conducted by JBA primarily identified Giant Hogweed and Cotoneaster Cotoneaster along the banks of The Shevock. It is an offense to spread these invasive non-native species therefore control measures should be put in place during construction.

Health and safety hazards noted

- Geotechnical and evacuation works: in channel works, falling into excavations, collapse of the sides of excavations, damage to underground services.
- Construction: flooding of works, working within the channel which has very steep banks.

Social and community issues

- Aesthetic issues - the embankment will block views west from the Drumdarroch residential home and [redacted] Mill Road. It may also impact the views south from the Somerset Crescent. There may be public objections to this. Residents may also object to replacement of the original Mill wall with a concrete flood wall.
- Potential disruptions on Mill Road and / or Somerset Crescent and the private track on the right bank of The Shevock during construction.

Impact on other reaches

Modelling suggests water levels increase downstream of the embankment but are not anticipated to put any further properties at risk. A non-residential property lies on the left bank immediately downstream of Commercial Bridge where water levels are indicated to increase. This building is currently abandoned with no roof and is therefore not considered an asset at risk. The increased water levels are as a result of greater flow in the channel due to the embankment preventing floodplain flow. This has the potential to increase shear stress and therefore erosion of the channel banks and may require additional work to reinforce/ stabilise the downstream banks. Further investigation of this will be required at the detailed design stage.

Additional information required

- A detailed topographic survey
- Detailed buried services survey, plotting their position with regard to site works.
- Ground investigations
- Seepage analysis should be undertaken prior to detailed design.
- Authorisation from SEPA will be required prior to construction under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (CAR).

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

- Consider making the embankment adaptable so it could be easily raised in the future.
- If the commercial property immediately downstream of Commercial Road bridge is to be renovated and used in the future, the wall immediately backing into the left bank will require suitable flood proofing and no openings to flood level of 123 mAOD.

Option A2 - Property Level Protection

Description

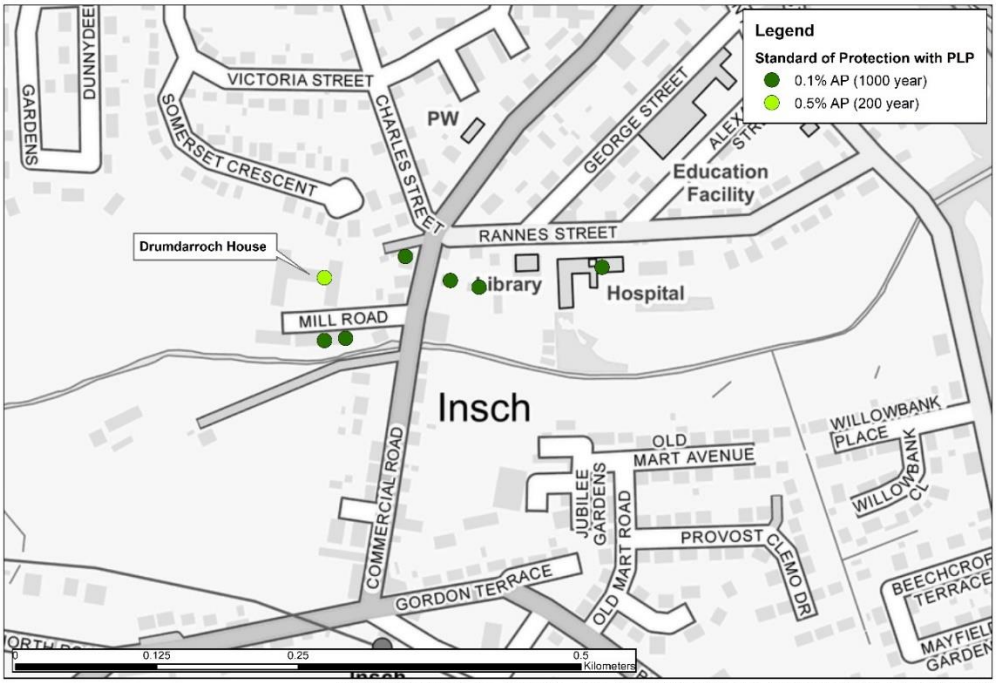
This option aims to provide an increase in standard of protection for all properties where possible by protecting them up to a maximum flood depth of 0.6 m. Beyond this water depth a building's integrity can be compromised. This option includes the survey, design and implementation of relevant PLP products to each property experiencing flooding. PLP could take the form of built in flood doors and self-closing airbrick covers or it may be appropriate to provide or convert an existing garden wall into a flood protection wall with a floodgate for each individual property.

Standard of protection (SoP)

The number of properties expected to benefit from PLP within Area A:

- 3 residential properties at the 0.1 % AP (1000 year) event.
- 3 non-residential properties at the 0.1 % AP (1000 year) event.
- 1 non-residential properties at the 0.5 % AP (200 year) event.

A property on Mill Road does not flood until the 1% AP (100 year) event. At this point it floods to a depth of 1 m which is greater than the maximum 0.6 m flood depth suitable for PLP. It cannot therefore be protected from flooding via PLP alone and remains at a SoP of 1.33% AP (75 years).



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Alternative quick wins/ Preliminary investigations

- Preventing the left bank flow pathway entirely would negate the need for PLP.
- One property on Mill Road floods as a result of out of bank flow originating on Mill Road to the north, not out of bank flow from the burn to the south. A low point in the garden (as seen in the LiDAR) would appear to be the cause of the high flood depths, and thus low SoP, compared to the adjacent properties. Construction of a small flood wall fronting the property and a flood gate across the driveway may be a viable PLP solution to increase the SoP.

Technical issues

All properties would require surveying by competent parties to determine which products are appropriate. Properties with non-standard or large entrances e.g. commercial properties may require bespoke options which can significantly increase costs. The Scottish Government's Blueprint on PLP[8] should be considered when implementing this option.

The use of passive (automatic) measures is recommended as a result of the lack of flood warning within the catchment. These measures are more expensive but would increase the effectiveness of the protection.

Construction access/ issues

Gaining owner consent to install these products for all properties at risk may be challenging.

Environmental issues

None expected.

Health and safety hazards noted

None expected during construction.

Kitemarked products and approved suppliers/installers should eb sued to ensure safe installation that provides the expected benefits.

Residents should be warned of the risk of becoming trapped within their home and the possibility that PLP products become overwhelmed by flood depths greater than their design standard.

Social and community issues

Property owners further from the burn may never have experienced flooding and therefore may not approve of these measures that could affect their properties value.

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

Impact on other reaches There would likely be negligible impact on the roads further downstream which may see slightly larger flows since less water would be expected to flow through properties.
Additional information required • Flood risk reviews for each property. • Public engagement meetings.
Additional works required to account for increase in flow due to climate change The PLP option is capable of mitigating against climate change but only for some properties due to flood depths at some properties increasing beyond their 0.6 m limit. The option could therefore generally provide flood protection over the longer-term but due to the short life of PLP products, replacement every 20-25 years needs to be considered since it makes the options less sustainable. This regular replacement does give the opportunity to protect only those properties most frequently at flood risk in the present day and add more properties that are at less frequent flood risk as they become more at risk in the future.

5.8.2 Design area B - Valentine Burn

Insch Golf Club and Community Centre upstream of Market Street, and a number of residential properties between Market and Drumrossie Street are at risk of flooding. Flooding commences from the 50% AP (2 year) event at Insch Golf Club and 20% AP (5 year) event at the downstream residential properties as a result of low channel capacity and thus bank overtopping. Low capacity at the Market Street (Largie Road) culvert causes water to back up and overtop flowing south along Market Street exacerbated flooding at the right bank properties. 17 properties are a risk from the 0.5% AP (200 year) + climate change event.

In order to protect against the 0.5% AP (200 year) +CC event, several options were tested. These included:

- Upstream storage on Insch Golf Course
- No storage but upgrades to the Market Street and Drumrossie Street culverts
- Creation of a two-stage channel downstream of Market Street
- Direct defences along both banks upstream of Drumrossie Street culvert
- Channel reprofiling between Market Street and downstream of Drumrossie Street culvert

It was found a combination of upstream storage, a two-stage channel, direct defences and upgrades to both culverts were required. Proposed combinations are detailed in the options below.

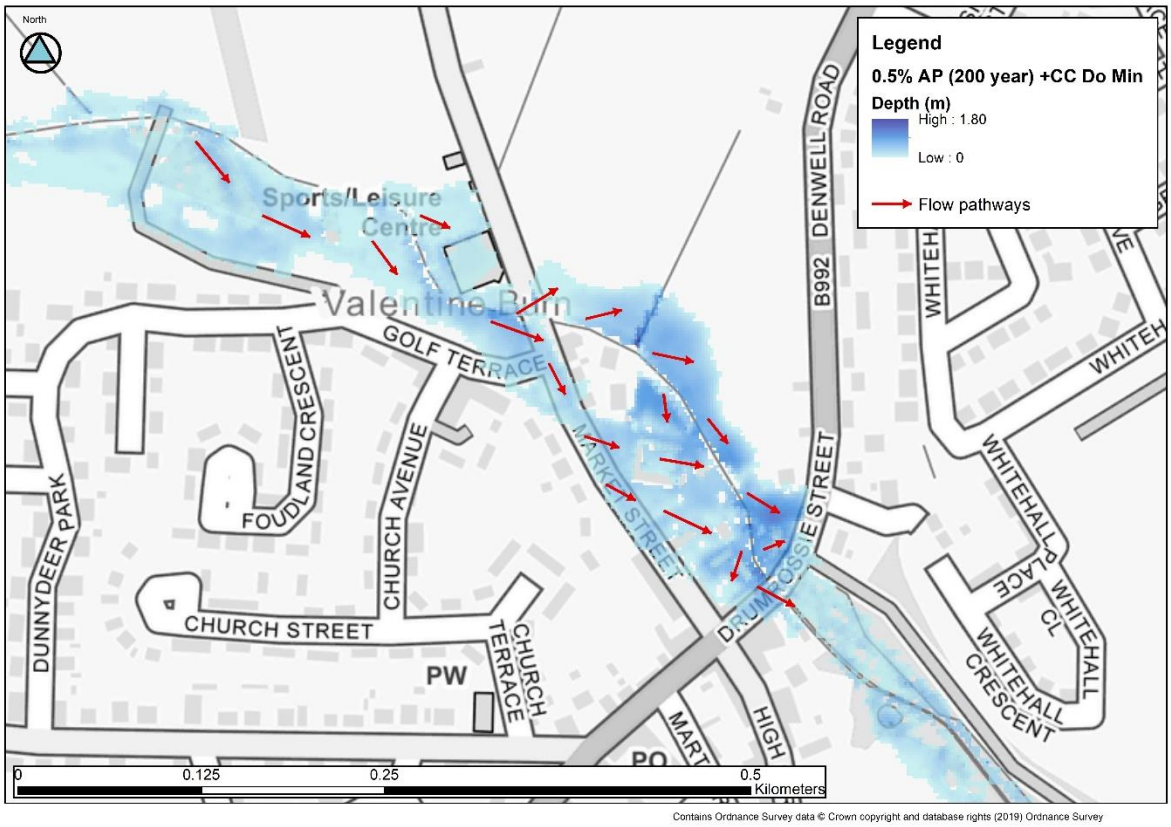


Figure 5-6: Design Area B - Valentine Burn flow pathways

Option B1:	Option B2:	Option B3:	Option B4:	Option B5a:	Option B5b:
US storage (50yr), two-stage channel, channel reprofiling & culvert upgrades.	US storage (25yr), two-stage channel & smaller culvert upgrades.	US storage (50yr), two-stage channel, smaller culvert upgrades & embankment.	PLP	Direct defences, two-stage channel & culvert upgrades	Direct defences, two-stage channel, channel reprofiling & culvert upgrades

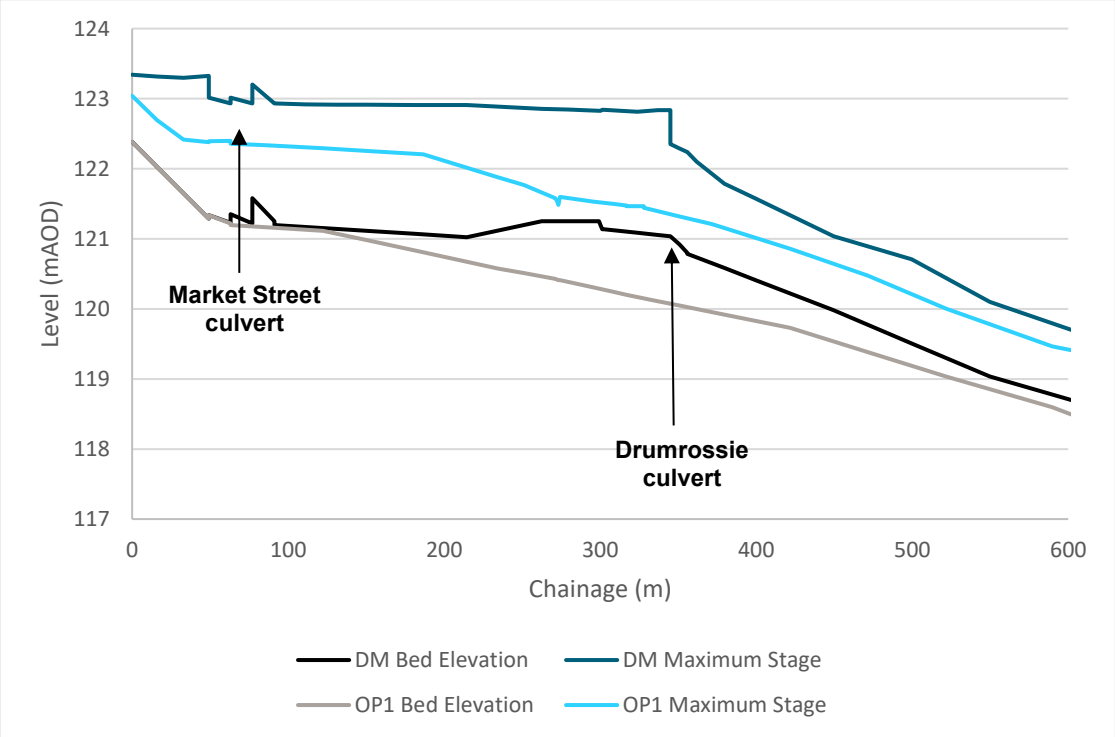
Option B1 - Upstream storage, two stage channel, channel reprofiling and culvert upgrades

Description

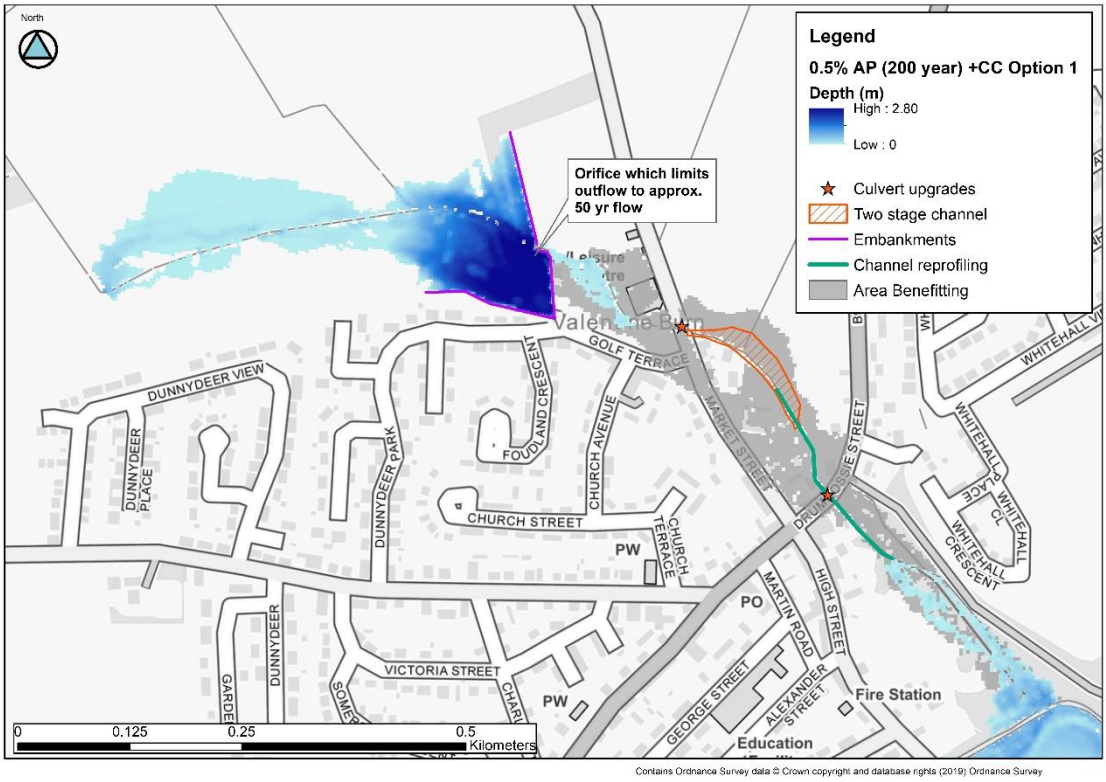
This option aimed to reduce flood risk through upstream storage within Insch Golf Course, creation of a two-stage channel downstream of Market Street, channel reprofiling and upgrading the Market and Drumrossie Street culverts to their ideal dimensions. This will offer a 0.5% AP (200 year) + climate change standard of protection plus freeboard. The proposed works are as follows:

- Upstream storage within Insch Golf Course. Discharge is restricted to approximately the 2% AP (50 year) flow by installing an orifice 1 m in diameter. Embankments would run north and south of the orifice creating the storage area. A northern embankment would run parallel to the community playing field with a maximum height of ~ 3 m (including 0.6 m freeboard), maximum width and be 130 m in length. A southern embankment would run south behind the Insch golf clubhouse and then west parallel to the Golf Terrace properties. It would be ~ 3.6 m high (including 0.6 m freeboard) and 240 m in length.
- Creation of a two-stage channel between Market Street bridge downstream for approximately 170 m to within the vicinity of the Recycling Centre, utilising the area of open grassland on the left bank. For the appraisal process the channel has been modelled with an approximate top width of 29 m and depth 1.5 m. A channel this wide uses a considerable area of the floodplain. A refined two-stage channel geometry should be designed if this option is taken forward.
- Upgrades to the Market Street and Drumrossie Street culverts to 4 m (l) x 1.5 m (h) box culverts. Upgrading the Drumrossie Street culvert will require relocation of the outflow pipe and electrical station on the left bank. The current Market Street culvert consists of three pipes 1 m, 1m and 0.3 m in diameter, and the Drumrossie Street culvert is 1.52 m (l) x 0.75 m (h).

Channel reprofiling between section VAL01_0484 and VAL01_0249 (downstream of the Drumrossie culvert). A rise in bed elevation between section VAL01_0484 and the Drumrossie culvert results in increased water levels and out of bank flow (see figure below). Reprofiling to smooth the bed slope reduces water levels negating the need for hard defences along the banks upstream of Drumrossie culvert and allows for a larger replacement culvert. The bed level here is not believed to be controlled by bedrock but by the culverts in this reach.



Option 1 flood outline:



Standard of protection (SoP)

Modelling results have shown this will provide a 0.5% AP (200 year) + climate change standard of protection to the 17 properties at risk under the Do Minimum scenario.

Alternative quick wins/ Preliminary investigations

- A larger orifice would decrease the volume of water stored and thus the height of the embankments required but the increased flow downstream would result in direct defences being required.
- Investigation of the electrical station on the downstream left bank of the Drumrossie culvert is required to assess whether this can be relocated. If not this will limit the dimensions of any replacement culvert.

Geotechnical issues

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

Services

A full survey identifying overhead and underground services will be required at a later stage in the project. It is noted there is an electrical station located on the downstream left bank of the Drumrossie Street culvert.

Construction access

May be difficult between the Recycling Centre and Drumrossie Street culvert. Key construction issues include:

- Storage on the Golf Course would require closure and relocation of the public footpath, and closure of the Golf Course during construction.
- Reprofiling of the channel would require heavy machinery access to the channel upstream of Drumrossie Street culvert which may be difficult as both banks are urbanised to bank top, the channel is narrow and there is no road access.
- Culvert replacement would require road closure.

Waste

- Nature (inert, non-hazardous, hazardous): no known details of significant industry thus soil expected to be inert.
- Proposed disposal. All waste produced during construction should be contained and

prevented from entering the watercourse. Stock piles of soil and nontoxic spoilt during construction waste should be located away from the river (at least c. 10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works.

- Any waste materials removed from the site must be disposed of at a suitably licensed or exempt waste management facility under the Waste Management Licensing (Scotland) Regulations 2011. All waste should be carried off site by registered carriers and should be aware of the furnishing and keeping of waste transfer notes.
- Further investigation required through ground investigation into the level of contamination.

Proximity of defense to other structures

- **Public and private:** Public footpath into Insch Golf Course will need to be relocated following embankment construction. The footprint of the storage embankment is large and will result in the loss of a proportion of the Golf Course.
- **Bridges:** Both the Market and Drumrossie Street bridges are to be replaced. This will require road closure during their upgrade.
- **Houses:** all works would be in the vicinity of a number of residential homes.
- **Buildings:** works would be in the immediate vicinity of Insch Golf Clubhouse.

Environmental issues

- Additional survey required to assess the impact of the works on habitats including Scottish Wildcat, otter, bats, birds and fish.
- Reprofiling and two-stage channel creation are opportunities to improve the physical condition of the heavily modified watercourse which may make it more favourable for wildlife e.g. fish. They will however, have short term negative impacts during works.
- Geomorphology surveys will be required to assess the potential impacts of reprofiling and a two stage channel.
- Invasive Non Native Species (INNS) have been identified by NESBReC within the study area including Giant Hogweed and Himalayan Cotoneaster. The field survey conducted by JBA primarily identified Giant Hogweed and Cotoneaster Cotoneaster along the banks of The Shevock. It is an offense to spread these invasive non-native species therefore control measures should be put in place during construction if INNS are also found along the Valentine Burn.

Health and safety hazards noted

- **Geotechnical and excavation works:** in-channel works, falling into excavations, collapse of the sides of excavations, damage to underground services and undermining of nearby structures.
- **Construction:** flooding of works, working in watercourse, working on roads.

Social and community issues

- **Aesthetic issues:** the southern Golf Course embankment will extend west along the back of several residential properties blocking their view of the Golf Course. This is likely to result in objections.
- **Land take:** a relatively large area of land take is required for the storage embankments and a potentially large area of land take downstream of Market Street to accommodate the two-stage channel.
- **Road closure:** will be required during the culvert upgrades. Drumrossie Street is a key road into/ out of Insch.

Impact on other reaches

- Water levels (and flood extents) are increased within Insch Golf Course as a result of the flow constriction. This will result in flooding of the Golf Course storage unit which will need to be relocated.
- Water levels and flow downstream of the Golf Course are reduced under this option compared to the Do Minimum runs as a result of the upstream storage.

Additional information required

- A detailed topographic survey.
- Detailed buried services survey, plotting their position with regard to site works.
- Ground investigations.

- Seepage analysis should be undertaken prior to detailed design.
- Authorisation from SEPA will be required prior to construction under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (CAR).

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

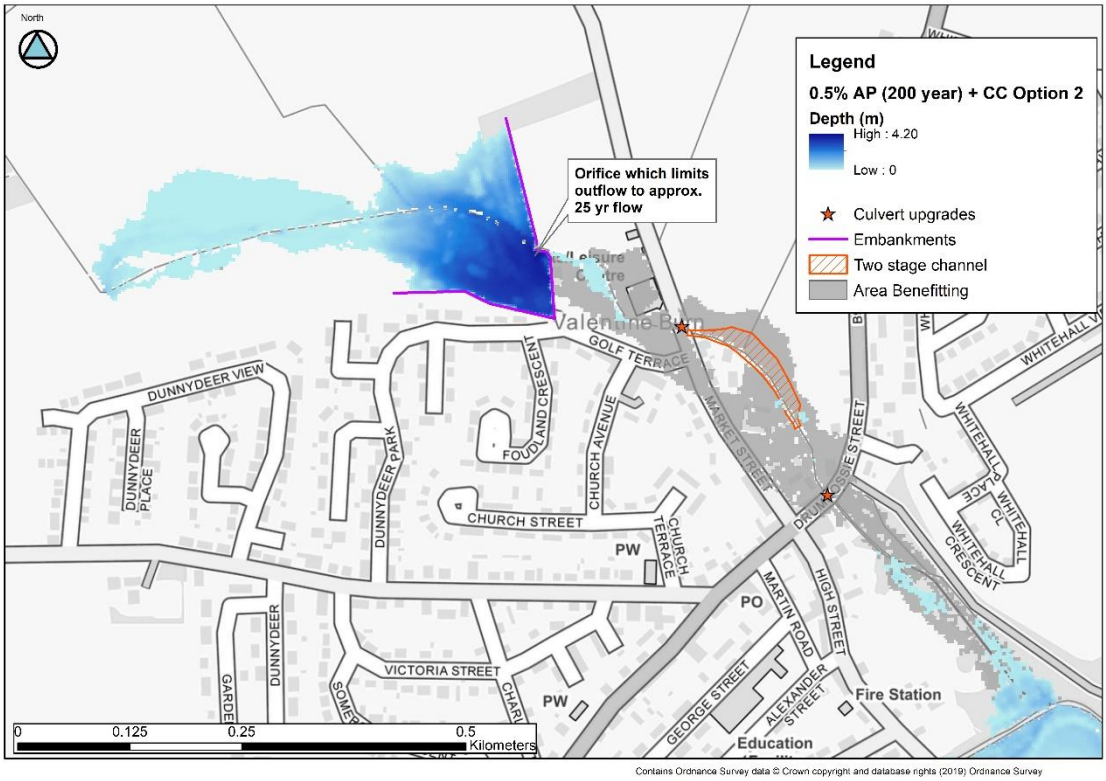
This option depends on maintenance of the watercourse and culvert condition. Sedimentation is a problem at the Market Street culvert under present day conditions, monitoring and sediment clearance may be required in the future to maintain culvert capacity.

Option B2 - Upstream storage to the 4% AP (25 year) event, two stage channel and culvert upgrades

Description

This option aimed to reduce flood risk through upstream storage within Insch Golf Course, creation of a two-stage channel downstream of Market Street and upgrading the Market Street and Drumrossie Street culverts based on present day channel geometries and road elevations. This will offer a 0.5% AP (200 year) + climate change standard of protection. The proposed works are as follows:

- Upstream storage within Insch Golf Course. Discharge is restricted to approximately the 4% AP (25 year) flow by installing an orifice 0.85 m in diameter. Embankments would run north and south of the orifice creating the storage area. A northern embankment would run parallel to the community playing field with a maximum height of ~ 3.8 m (including 0.6 m freeboard) and be 140 m in length. A southern embankment would run south behind the Insch golf clubhouse and then west parallel to the Golf Terrace properties. It would be ~ 4 m high (including 0.6 m freeboard) and 260 m in length.
- Creation of a two-stage channel between Market Street bridge downstream for approximately 170 m to within the vicinity of the Recycling Centre utilising the area of open grassland on the left bank. For the appraisal process the channel has been modelled with an approximate top width of 29 m and depth 1.5 m. A channel this wide uses a considerable area of the floodplain. A refined two-stage channel geometry should be designed if this option is taken forward.
- Upgrades to the Market Street culvert to a 4 m (l) x 1 m (h) box culvert and the Drumrossie Street culvert to a 3.5 m (l) x 0.75 m (h) box culvert. This will require relocation of the outflow pipe and electrical station on the left bank. Both culverts will be surcharged under this scenario. The existing Market Street culvert consists of three pipes 1 m, 1 m and 0.3 m in diameter, and the Drumrossie Street culvert is 1.52 m (l) x 0.75 m (h).



Standard of protection (SoP)

Modelling results have shown this will provide a 0.5% AP (200 year) + climate change standard of protection to the 17 properties at risk under the Do Minimum scenario.

Alternative quick wins/ Preliminary investigations

- Channel reprofiling would prevent the small areas of flooding still occurring on the left and right bank towards the end of the two-stage section of channel. It would also create space for a larger dimension culvert at Drumrossie Street which is surcharged under this option.
- Investigation of the electrical station at the downstream face of the Drumrossie culvert is required to assess whether this can be relocated. If not this will further limit the dimensions of any replacement culvert.

Geotechnical issues

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

Services

A full survey identifying overhead and underground services will be required at a later stage in the project. It is noted there is an electrical station located in the vicinity of the Drumrossie Street culvert.

Construction access

Key issues include:

- Culvert replacement would require road closure. Drumrossie Street is a key route into/ out of Insch.
- The Golf Course embankment would require closure and relocation of the public footpath and closure of the Golf Course during construction.

Waste

- Nature (inert, non-hazardous, hazardous): no known details of significant industry thus soil expected to be inert.
- Proposed disposal. All waste produced during construction should be contained and prevented from entering the watercourse. Stock piles of soil and nontoxic spoilt during construction waste should be located away from the river (at least c. 10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works.

- Any waste materials removed from the site must be disposed of at a suitably licensed or exempt waste management facility under the Waste Management Licensing (Scotland) Regulations 2011. All waste should be carried off site by registered carriers and should be aware of the furnishing and keeping of waste transfer notes.
- Further investigation required through ground investigation into the level of contamination.

Proximity of defense to other structures

- **Public and private:** Public footpath into Insch Golf Course will need to be relocated following embankment construction. The footprint of the storage embankment is large and will result in the loss of a proportion of the Golf Course.
- **Bridges:** Both the Market and Drumrossie Street bridges are to be replaced. This will require road closure during their upgrade.
- **Houses:** all works would be in the vicinity of a number of residential homes.
- **Buildings:** works would be in the immediate vicinity of Insch Golf Clubhouse.

Environmental issues

- Additional survey required to assess the impact of the works on habitats including Scottish Wildcat, otter, bats, bird and fish.
- Two-stage channel creation would be an opportunity to improve the physical condition of the heavily modified watercourse which may make it more favourable for wildlife including fish.
- Geomorphology surveys required to assess the potential impacts of a two-stage channel.
- Invasive Non Native Species (INNS) have been identified by NESBReC within the study area including Giant Hogweed and Himalayan Cotoneaster. The field survey conducted by JBA primarily identified Giant Hogweed and Cotoneaster Cotoneaster along the banks of The Shevock. It is an offense to spread these invasive non-native species therefore control measures should be put in place during construction if INNS are also found along the Valentine Burn.

Health and safety hazards noted

- **Geotechnical and excavation works:** in-channel works, falling into excavations, collapse of the sides of excavations, damage to underground services and undermining of nearby structures.
- **Construction:** flood of works, working on/ in watercourse, working on/ near roads.

Social and community issues

- **Aesthetic issues:** the southern Golf Course embankment will extend west along the back of several residential properties blocking their view of the Golf Course. This is likely to result in objections.
- **Land take:** a relatively large area of land take is required for the storage embankments and a potentially large area of land take downstream of Market Street to accommodate the two-stage channel.
- **Road closure:** will be required during the culvert upgrades. Drumrossie Street is a key road into/ out of Insch.
- **Safety:** only releasing the 4% AP (25 year) flow results in flood depths up to 3 m, access to the Golf Course will have to be restricted as a result.

Impact on other reaches

- Water levels (and flood extents) are increased within Insch Golf Course as a result of the flow constriction. This will result in flooding of the Golf Course storage unit which will need to be relocated.
- Water levels and flow downstream of the Golf Course are reduced under this option compared to the Do Minimum runs as a result of the upstream storage.

Additional information required

- A detailed topographic survey.
- Detailed buried services survey, plotting their position with regard to site works.
- Ground investigations.
- Seepage analysis should be undertaken prior to detailed design.
- Authorisation from SEPA will be required prior to construction under the Water Environment

(Controlled Activities) (Scotland) Regulations 2011 (as amended) (CAR).

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

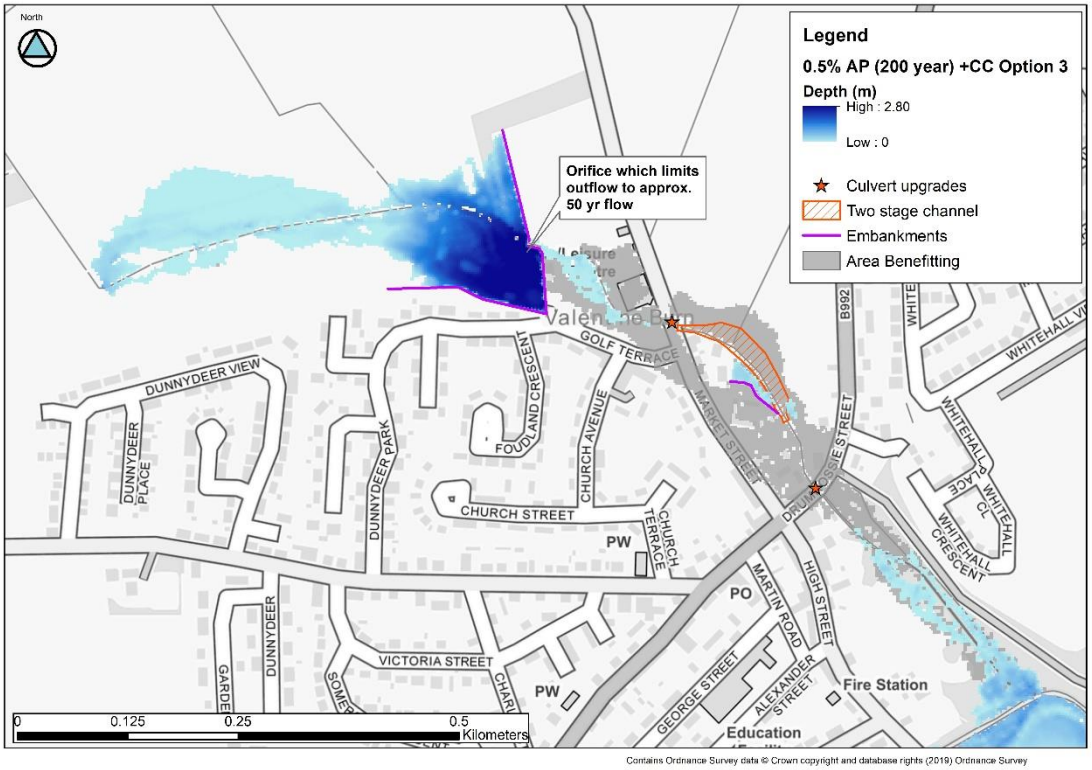
This option depends on maintenance of the watercourse and culvert condition. Sedimentation is a problem at the Market Street culvert under present day conditions, monitoring and sediment clearance may be required in the future to maintain culvert capacity.

Option B3 - Upstream storage to the 2% AP (50 year), two stage channel, culvert upgrades and direct defences

Description

This option aimed to reduce flood risk through upstream storage within Insch Golf Course, creation of a two-stage channel downstream of Market Street, upgrading the Market Street and Drumrossie Street culverts based on present day channel geometries and road elevations and a right bank embankment to protect the Market Street properties. This will offer a 0.5% AP (200 year) + climate change standard of protection. The proposed works are as follows:

- Upstream storage within Insch Golf Course. Discharge is restricted to approximately the 2% AP (50 year) flow by installing an orifice 1 m in diameter. Embankments would run north and south of the orifice creating the storage area. A northern embankment would run parallel to the community playing field with a maximum height of ~ 3 m (including 0.6 m freeboard) and be 130 m in length. A southern embankment would run south behind the Insch Golf Clubhouse and then west parallel to the Golf Terrace properties. It would be ~ 4 m high (including 0.6 m freeboard) and 240 m in length.
- Creation of a two-stage channel between Market Street bridge downstream for approximately 170 m to within the vicinity of the Recycling Centre utilising the area of open grassland on the left bank. For the appraisal process the channel has been modelled with an approximate top width of 29 m and depth 1.5 m. A channel this wide uses a considerable area of the floodplain. A refined two-stage channel geometry should be designed if this option is taken forward.
- Upgrades to the Market Street culvert to a 4 m (l) x 1 m (h) box culvert and the Drumrossie Street culvert to a 3.5 m (l) x 0.75 m (h) box culvert. This will require relocation of the outflow pipe and electrical station on the left bank. Both culverts will be surcharged under this scenario. The existing Market Street culvert consists of three pipes 1 m, 1 m and 0.3 m in diameter, and the Drumrossie Street culvert is 1.52 m (l) x 0.75 m (h).
- Construction of a set back embankment east of the Market Street properties approximately 1 m in height (including 0.6 m freeboard) and 65 m in length.
- Bank levels drop minorly on the left bank between section VAL01_0420 and VAL01_0400 which results in out of bank flow. Bank levels will need raised to ensure the 0.5% AP +CC level of protection and prevent flooding of 6 Drumrossie Street.



Standard of protection (SoP)

Modelling results have shown this will provide a 0.5% AP (200 year) + climate change standard of protection to the 17 properties at risk under the Do Minimum scenario.

Alternative quick wins/ Preliminary investigations

- Channel reprofiling would negate the need for direct defences downstream of Market Street and would create space for a larger dimension culvert at Drumrossie Street which is surcharged under this option.
- Investigation of the electrical station at the downstream face of the Drumrossie culvert is required to assess whether this can be relocated. If not this will limit the dimensions of any replacement culvert.

Geotechnical issues

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

Services

A full survey identifying overhead and underground services will be required at a later stage in the project. It is noted there is an electrical station located in the vicinity of the Drumrossie Street culvert.

Construction access

Key issues include:

- Culvert replacement would require road closure. Drumrossie Street is a key route into/ out of Insch.
- The Golf Course embankment would require closure and relocation of the public footpath and closure of the Golf Course during construction.

Waste

- Nature (inert, non-hazardous, hazardous): no known details of significant industry thus soil expected to be inert.
- Proposed disposal. All waste produced during construction should be contained and prevented from entering the watercourse. Stock piles of soil and nontoxic spoilt during construction waste should be located away from the river (at least c. 10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works.
- Any waste materials removed from the site must be disposed of at a suitably licensed or

exempt waste management facility under the Waste Management Licensing (Scotland) Regulations 2011. All waste should be carried off site by registered carriers and should be aware of the furnishing and keeping of waste transfer notes.

- Further investigation required through ground investigation into the level of contamination.

Proximity of defense to other structures

- **Public and private:** Public footpath into Insch Golf Course will need to be relocated following embankment construction. The footprint of the storage embankment is large and will result in the loss of a proportion of the Golf Course.
- **Bridges:** Both the Market and Drumrossie Street bridges are to be replaced. This will require road closure during their upgrade.
- **Houses:** all works would be in the vicinity of a number of residential homes.
- **Buildings:** works would be in the immediate vicinity of Insch Golf Clubhouse.

Environmental issues

- Additional survey required to assess the impact of the works on habitats including Scottish Wildcat, otter, bats, bird and fish.
- Two-stage channel creation would be an opportunity to improve the physical condition of the heavily modified watercourse which may make it more favourable for wildlife including fish.
- Geomorphology surveys required to assess the potential impacts of a two-stage channel.
- Invasive Non Native Species (INNS) have been identified by NESBReC within the study area including Giant Hogweed and Himalayan Cotoneaster. The field survey conducted by JBA primarily identified Giant Hogweed and Cotoneaster Cotoneaster along the banks of The Shevock. It is an offense to spread these invasive non-native species therefore control measures should be put in place during construction if INNS are also found along the Valentine Burn.

Health and safety hazards noted

- **Geotechnical and excavation works:** in-channel works, falling into excavations, collapse of the sides of excavations, damage to underground services and undermining of nearby structures.
- **Construction:** flood of works, working on/ in watercourse, working on/ near roads.

Social and community issues

- **Aesthetic issues:** the southern Golf Course embankment will extend west along the back of several residential properties blocking their view of the Golf Course. This is likely to result in objections.
- **Land take:** a relatively large area of land take is required for the storage embankments and a potentially large area of land take downstream of Market Street to accommodate the two-stage channel.
- **Road closure:** will be required during the culvert upgrades. Drumrossie Street is a key road into/ out of Insch.

Impact on other reaches

- Water levels (and flood extents) are increased within the Golf Course as a result of the flow constriction. This will result in flooding of the storage unit within the Golf Course which will need to be relocated.
- Water levels and flow downstream of the Golf Course are reduced under this option compared to the Do Minimum runs as a result of the upstream storage.

Additional information required

- A detailed topographic survey.
- Detailed buried services survey, plotting their position with regard to site works.
- Ground investigations.
- Seepage analysis should be undertaken prior to detailed design.
- Authorisation from SEPA will be required prior to construction under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (CAR).

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

This option depends on maintenance of the watercourse and culvert condition. Sedimentation is a problem at the Market Street culvert under present day conditions, monitoring and sediment clearance may be required in the future to maintain culvert capacity.

Option B4 - Property Level Protection

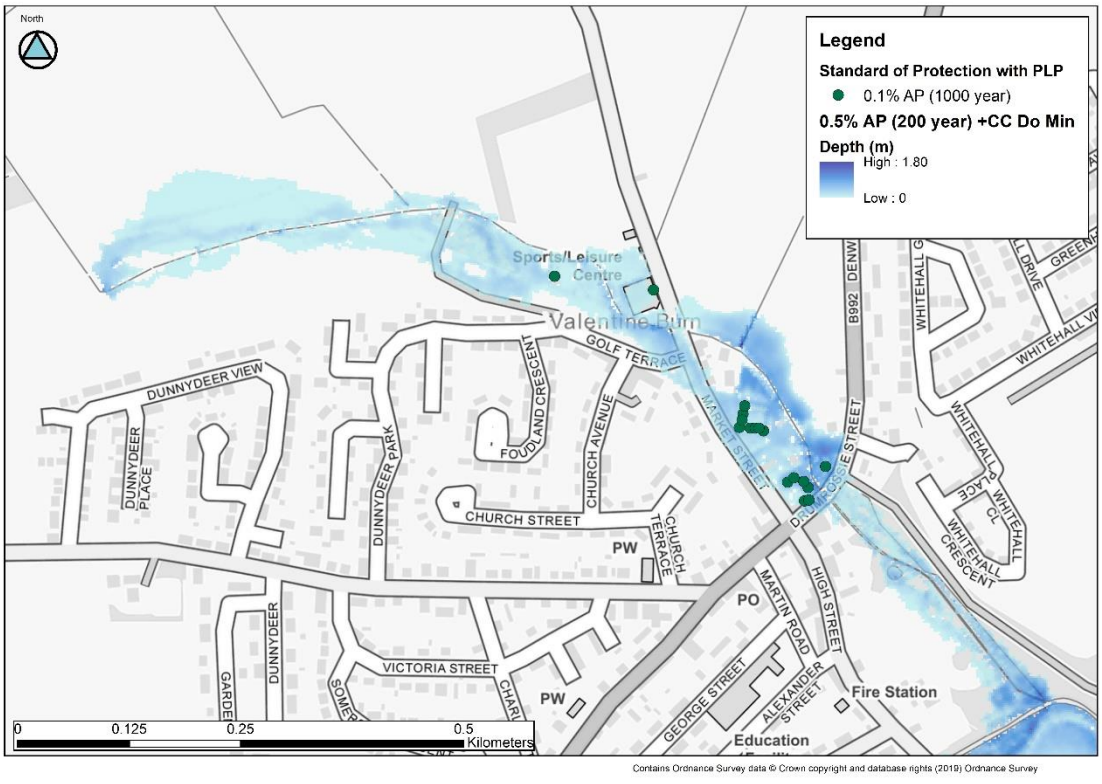
Description

This option aims to provide an increase in standard of protection for all properties where possible by protecting them up to a maximum flood depth of 0.6 m. 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. PLP could take the form of built in flood doors and self-closing airbrick covers or It may be appropriate to provide or convert an existing garden wall into a flood protection wall with a floodgate for each individual property.

Standard of protection (SoP)

The number of properties expected to benefit from PLP within Area B:

- 15 residential properties at the 0.1% AP (1000 year) event.
- 2 non-residential properties at the 0.1 % AP (1000 year) event.



Alternative quick wins/ Preliminary investigations

- Upgrades to the culverts would prevent the Market Street flow pathway and along with a two-stage channel, lower water levels within the channel making PLP more adaptable to future climate change.

Technical issues

All properties would require surveying by competent parties to determine which products are appropriate. Properties with non-standard or large entrances e.g. commercial properties may require bespoke options which can significantly increase costs. The Scottish Government's Blueprint on PLP[8] should be considered when implementing this option.

The use of passive (automatic) measures is recommended as a result of the lack of flood warning within the catchment. These measures are more expensive but would increase the effectiveness of the protection.

Construction access/ issues

Gaining owner consent to install these products for all properties at risk may be challenging.

Environmental issues

- None expected.

Health and safety hazards noted

- None expected during construction.
- Kitemarked products and approved suppliers/installers should be used to ensure safe installation that provides the expected benefits.
- Residents should be warned of the risk of becoming trapped within their home and the possibility that PLP products become overwhelmed by flood depths greater than their design standard.

Social and community issues

Property owners further from the burn may never have experienced flooding and therefore may not approve of these measures that could affect their properties value.

Impact on other reaches

There would likely be negligible impact on the roads further downstream which may see slightly larger flows since less water would be expected to flow through properties.

Additional information required

- Flood risk reviews for each property.
- Public engagement meetings.

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

The PLP option is capable of mitigating against climate change but only for some properties due to flood depths at some properties increasing beyond their 0.6 m limit. The option could therefore generally provide flood protection over the longer-term but due to the short life of PLP products, replacement every 20-25 years needs to be considered since it makes the options less sustainable. This regular replacement does give the opportunity to protect only those properties most frequently at flood risk in the present day and add more properties that are at less frequent flood risk as they become more at risk in the future.

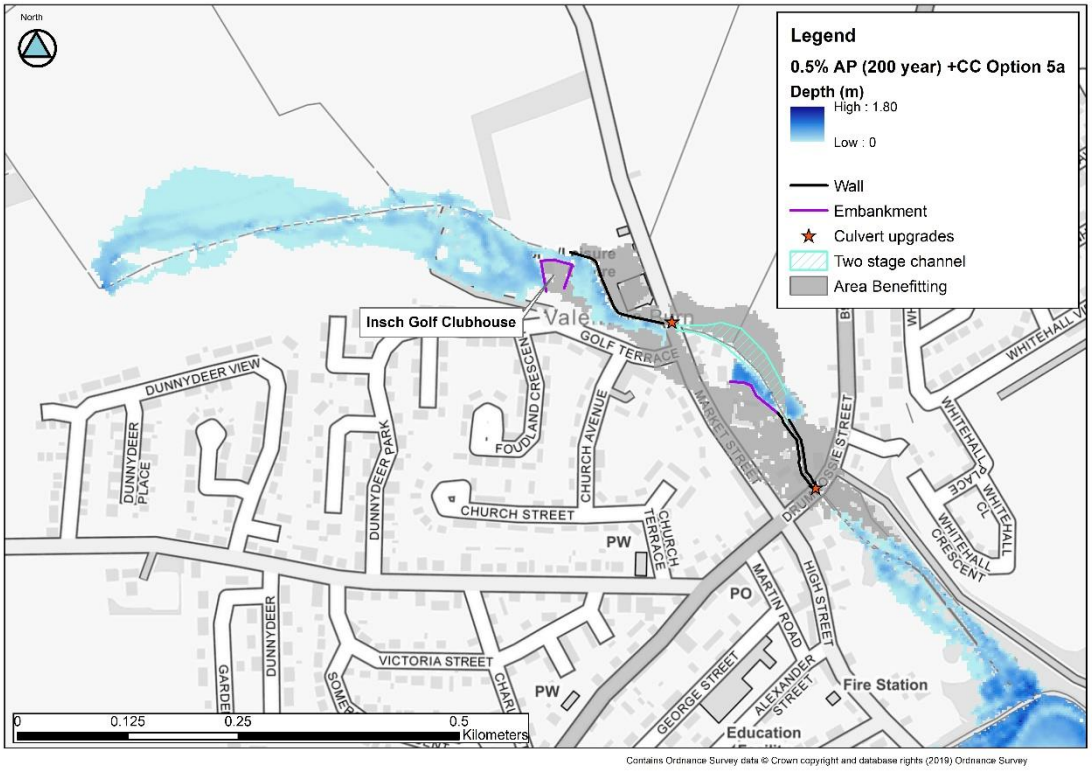
Option B5a - Direct defences, two stage channel & culvert upgrades

Description

This option aimed to reduce flood risk through direct defences to protect Insch Golf Clubhouse, community centre and Market Street residential properties, creation of a two-stage channel downstream of Market Street, upgrading the Market Street culvert to optimal dimensions, and enlarging the Drumrossie Street culvert based on present day channel geometry and road elevation. This will offer a 0.5% AP (200 year) + climate change standard of protection without the need for upstream storage. The option aims to minimise the impacts to the Golf Course but may conversely have negative aesthetic impacts to riparian owners in the Market Street reach. The proposed works are as follows:

- Embankment construction around Insch Golf Clubhouse approximately 1.55 m in height (including 0.6 m freeboard) and 100 m in length.
- Construct a wall along the left bank of the Valentine Burn just upstream of the pedestrian access bridge to the Market Street culvert. This would block two access bridges across the Valentine towards the community centre. The wall would be approximately 1.06 m high (including 0.3 m freeboard) and 150 m in length.
- Creation of a two-stage channel between Market Street bridge downstream for approximately 170 m to within the vicinity of the Recycling Centre utilising the area of open grassland on the left bank.
- Upgrades to the Market Street culvert to a 4 m (l) x 1.5 m (h) box culvert and the Drumrossie Street culvert to a 3.5 m (l) x 0.75 m (h) box culvert. This will require relocation of the outflow pipe and electrical station on the left bank. Both culverts will be surcharged under this scenario.
- Construction of a set-back embankment east of the Market Street properties approximately 1.3 m in height (including 0.6 m freeboard) and 70 m in length.

- Construct walls along the left and right banks immediately upstream of Drumrossie Street. The right bank wall would be approximately 0.5 m high (including 0.3 m freeboard) and 97 m in length. The left bank wall would be approximately 0.5 m high (including 0.3 m freeboard) and 82 m in length.



Standard of protection (SoP)

Modelling results have shown this will provide a 0.5% AP (200 year) + climate change standard of protection to the 17 properties at risk under the Do Minimum scenario.

Alternative quick wins/ Preliminary investigations

- Channel reprofiling would negate the need for the walls immediately upstream of the Drumrossie St culvert and would allow a larger dimension culvert to be installed which is highly surcharged under this option.
- Investigation of the electrical station at the downstream face of the Drumrossie culvert is required to assess whether this can be relocated. If not this will limit the dimensions of any replacement culvert.
- Relocation of Insch Golf Clubhouse should be considered either in the short term to negate the need for the embankment or in the long term if relocation now is controversial.

Geotechnical issues

- A full ground investigation will be required at a later stage in the project.
- A cut-off or piling is likely to be needed to avoid seepage beneath all defences. Piling may be difficult in this material and other forms of cut-off may need to be investigated. Due to lack of GI information a cut-off assumption of 0.5 m depth has been made, the cut-off depth will require further investigation at detailed design.

Services

A full survey identifying overhead and underground services will be required at a later stage in the project. It is noted there is an electrical station located in the vicinity of the Drumrossie Street culvert.

Construction access

Key issues include:

- Culvert replacement would require road closure. Drumrossie Street is a key route into/ out of Insch.
- Access is very constrained for constructing the walls immediately upstream of Drumrossie

Street.
Waste • Nature (inert, non-hazardous, hazardous): no known details of significant industry thus soil expected to be inert. • Proposed disposal. All waste produced during construction should be contained and prevented from entering the watercourse. Stock piles of soil and nontoxic spoilt during construction waste should be located away from the river (at least c. 10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works. • Any waste materials removed from the site must be disposed of at a suitably licensed or exempt waste management facility under the Waste Management Licensing (Scotland) Regulations 2011. All waste should be carried off site by registered carriers and should be aware of the furnishing and keeping of waste transfer notes. • Further investigation required through ground investigation into the level of contamination.
Proximity of defense to other structures • **Bridges:** Both the Market and Drumrossie Street bridges are to be replaced. This will require road closure during their upgrade. The left bank wall to protect the community centre would require removal of two pedestrian access bridges across the burn. • **Houses:** all works would be in the vicinity of a number of residential homes. • **Buildings:** works would be in the immediate vicinity of Insch Golf Clubhouse and community centre.
Environmental issues • Additional survey required to assess the impact of the works on habitats including Scottish Wildcat, otter, bats, bird and fish. • Two-stage channel creation would be an opportunity to improve the physical condition of the heavily modified watercourse which may make it more favourable for wildlife including fish. • Geomorphology surveys required to assess the potential impacts of a two-stage channel. • Constructing walls along significant reaches of the watercourse does not benefit the RBMP status of the watercourse. • Invasive Non Native Species (INNS) have been identified by NESBReC within the study area including Giant Hogweed and Himalayan Cotoneaster. The field survey conducted by JBA primarily identified Giant Hogweed and Cotoneaster Cotoneaster along the banks of The Shevock. It is an offense to spread these invasive non-native species therefore control measures should be put in place during construction if INNS are also found along the Valentine Burn.
Health and safety hazards noted • **Geotechnical and excavation works:** in-channel works, falling into excavations, collapse of the sides of excavations, damage to underground services and undermining of nearby structures. • **Construction:** flood of works, working on/ in watercourse, working on/ near roads.
Social and community issues • **Aesthetic issues:** the flood walls upstream of Drumrossie Street will immediately back onto a number of private residential gardens. The Golf Terrace properties do not lose views across the Golf Course. • **Land take:** a relatively large area of land take downstream of Market Street is required to accommodate the two-stage channel. • **Road closure:** will be required during the culvert upgrades. Drumrossie Street is a key road into/ out of Insch. • **Community:** this does not require utilisation of Golf Course land and should be a more acceptable option for these users and the Golf Course business.
Impact on other reaches • As a result of the two-stage channel, water levels are reduced downstream of Market Street. • Water levels upstream of Market Street are increased as a result of the left bank wall but does not increase flood risk to any more properties.

Additional information required

- A detailed topographic survey.
- Detailed buried services survey, plotting their position with regard to site works.
- Ground investigations.
- Seepage analysis should be undertaken prior to detailed design.
- Authorisation from SEPA will be required prior to construction under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (CAR).

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

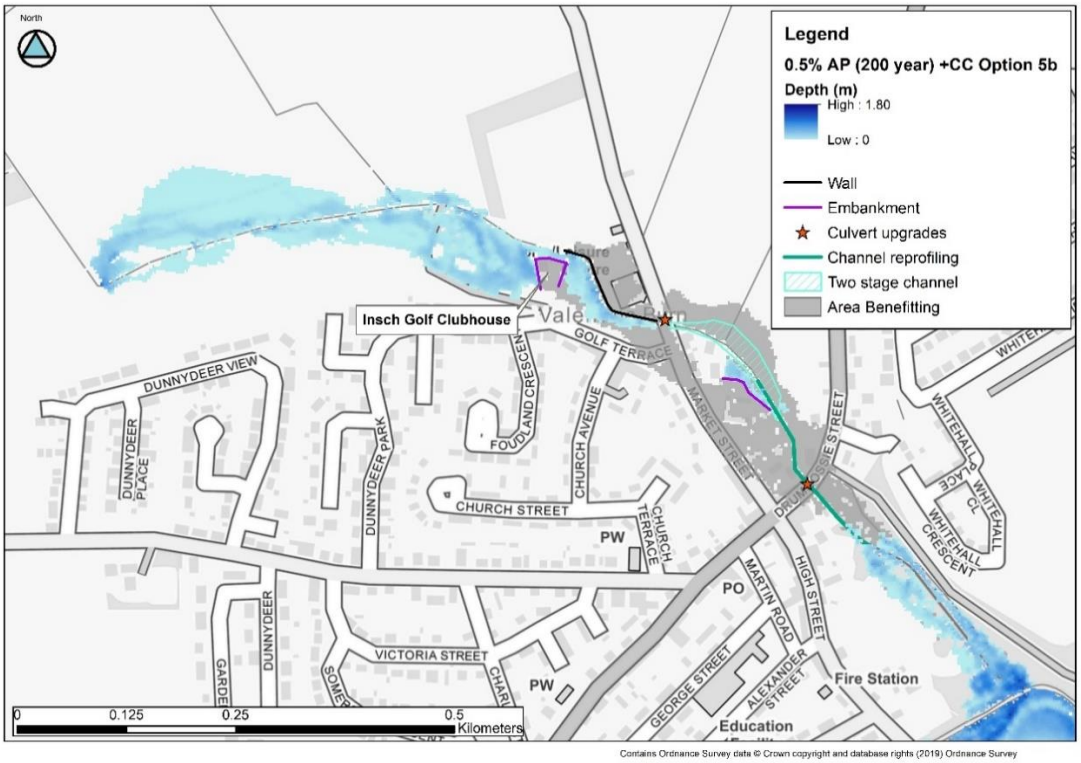
This option depends on maintenance of the watercourse and culvert condition. Sedimentation is a problem at the Market Street culvert under present day conditions, monitoring and sediment clearance may be required in the future to maintain culvert capacity.

Option B5b - Direct defences, two stage channel, channel reprofiling & culvert upgrades

Description

This option aimed to reduce flood risk through direct defences to protect Insch Golf Clubhouse and community centre, creation of a two-stage channel downstream of Market Street, channel reprofiling and upgrading the Market and Drumrossie Street culverts to their ideal dimensions. This will offer a 0.5% AP (200 year) + climate change standard of protection without the need for upstream storage. The option aims to minimise the impacts to the Golf Course and maximise the flow conveyance in the Market Street reach, minimising the negative aesthetic impacts to riparian owners. The proposed works are as follows:

- Embankment construction around Insch Golf Clubhouse approximately 1.55 m in height (including 0.6 m freeboard) and 100 m in length.
- Construct a wall along the left bank of the Valentine Burn just upstream of the pedestrian access bridge to the Market Street culvert. This would block two access bridges across the Valentine towards the community centre. The wall would be approximately 1.06 m high (including 0.3 m freeboard) and 150 m in length.
- Creation of a two-stage channel between Market Street bridge downstream for approximately 170 m to within the vicinity of the Recycling Centre utilising the area of open grassland on the left bank.
- Upgrades to the Market and Drumrossie Street culverts to 4 m (l) x 1.5 m (h) box culverts. The Drumrossie Street culvert will be minorly surcharged under this option and upgrading will require relocation of the outflow pipe and electrical station on the left bank.
- Construction of a set-back embankment east of the Market Street properties approximately 0.9 m in height (including 0.6 m freeboard) and 70 m in length.



Standard of protection (SoP)

Modelling results have shown this will provide a 0.5% AP (200 year) + climate change standard of protection to the 17 properties at risk under the Do Minimum scenario.

Alternative quick wins/ Preliminary investigations

- Investigation of the electrical station at the downstream face of the Drumrossie culvert is required to assess whether this can be relocated. If not this will limit the dimensions of any replacement culvert.
- Relocation of Insch Golf Clubhouse should be considered either in the short term to negate the need for the embankment or in the long term if relocation now is controversial.
- Consideration could be given to channel diversion north of the community centre, or relocation of the community centre. This would remove the need for the embankment and wall although there would be alternative costs associated with a diversion channel and relocation.

Geotechnical issues

- A full ground investigation will be required at a later stage in the project.
- A cut-off or piling is likely to be needed to avoid seepage beneath all defences. Piling may be difficult in this material and other forms of cut-off may need to be investigated. Due to lack of GI information a cut-off assumption of 0.5 m depth has been made, the cut-off depth will require further investigation at detailed design.

Services

A full survey identifying overhead and underground services will be required at a later stage in the project. It is noted there is an electrical station located in the vicinity of the Drumrossie Street culvert.

Construction access

Key issues include:

- Culvert replacement would require road closure. Drumrossie Street is a key route into/ out of Insch.
- Access is very constrained upstream of Drumrossie Street for channel reprofiling.

Waste

- Nature (inert, non-hazardous, hazardous): no known details of significant industry thus soil expected to be inert.

- Proposed disposal. All waste produced during construction should be contained and prevented from entering the watercourse. Stock piles of soil and nontoxic spoilt during construction waste should be located away from the river (at least c. 10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works.
- Any waste materials removed from the site must be disposed of at a suitably licensed or exempt waste management facility under the Waste Management Licensing (Scotland) Regulations 2011. All waste should be carried off site by registered carriers and should be aware of the furnishing and keeping of waste transfer notes.
- Further investigation required through ground investigation into the level of contamination.

Proximity of defense to other structures

- **Bridges:** Both the Market and Drumrossie Street bridges are to be replaced. This will require road closure during their upgrade. The left bank wall to protect the community centre would require removal of two pedestrian access bridges across the burn.
- **Houses:** all works would be in the vicinity of a number of residential homes.
- **Buildings:** works would be in the immediate vicinity of Insch Golf Clubhouse, community centre and a number of residential properties.

Environmental issues

- Additional survey required to assess the impact of the works on habitats including Scottish Wildcat, otter, bats, bird and fish.
- Reprofiling and two-stage channel creation would be an opportunity to improve the physical condition of the heavily modified watercourse which may make it more favourable for wildlife including fish. This could have short term negative ecological impacts while the work takes place.
- Geomorphology surveys required to assess the potential impacts of a two-stage channel.
- Constructing walls along the banks does not benefit the RBMP status of the watercourse.
- Invasive Non Native Species (INNS) have been identified by NESBReC within the study area including Giant Hogweed and Himalayan Cotoneaster. The field survey conducted by JBA primarily identified Giant Hogweed and Cotoneaster Cotoneaster along the banks of The Shevock. It is an offense to spread these invasive non-native species therefore control measures should be put in place during construction if INNS are also found along the Valentine Burn.

Health and safety hazards noted

- **Geotechnical and excavation works:** in-channel works, falling into excavations, collapse of the sides of excavations, damage to underground services and undermining of nearby structures.
- **Construction:** flood of works, working on/ in watercourse, working on/ near roads.

Social and community issues

- **Aesthetic issues:** the Golf Course embankment will block views to and from the clubhouse. The Golf Terrace properties do not lose views across the Golf Course.
- **Land take:** a relatively large area of land take downstream of Market Street is required to accommodate the two-stage channel.
- **Road closure:** will be required during the culvert upgrades. Drumrossie Street is a key road into/ out of Insch.
- **Community:** this does not require utilisation of Golf Course land and should be a more acceptable option for these users and the Golf Course business.

Impact on other reaches

- As a result of the two-stage channel and reprofiling, water levels are reduced downstream of Market Street.
- Water levels upstream of Market Street are increased as a result of the left bank wall but does not increase flood risk to any more properties.

Additional information required

- A detailed topographic survey.
- Detailed buried services survey, plotting their position with regard to site works.
- Ground investigations.

- Seepage analysis should be undertaken prior to detailed design.
- Authorisation from SEPA will be required prior to construction under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (CAR).

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

This option depends on maintenance of the watercourse and culvert condition. Sedimentation is a problem at the Market Street culvert under present day conditions, monitoring and sediment clearance may be required in the future to maintain culvert capacity.

5.8.3 Design area C - Mill of Rothney Burn

A number of properties along Commercial Road, Rannes Street and Mart Avenue are at risk of flooding. Flooding commences from the 50% AP (2 year) event as a result of out of bank flow from the Mill of Rothney. Flood waters originate upstream of, and then flow over, North Road and east towards the railway and residential properties. Out of bank flow within the industrial estate also flows east. 17 properties are at risk from the 0.5% AP (200 year) plus climate change event along with the railway line; the main route between Inverness and Aberdeen. In order to protect against the 0.5% AP (200 year) plus climate change event flood waters originating south of North Road need to be contained and the channel capacity and condition improved through the industrial estate.

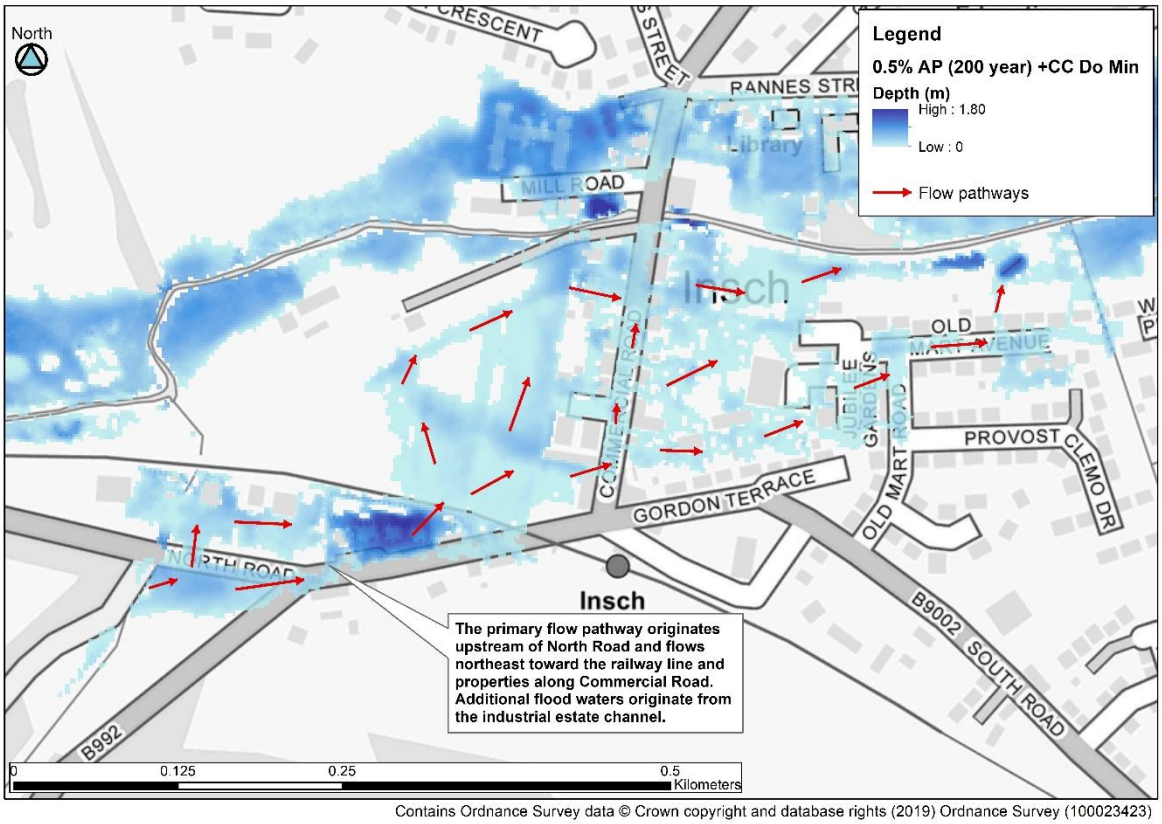


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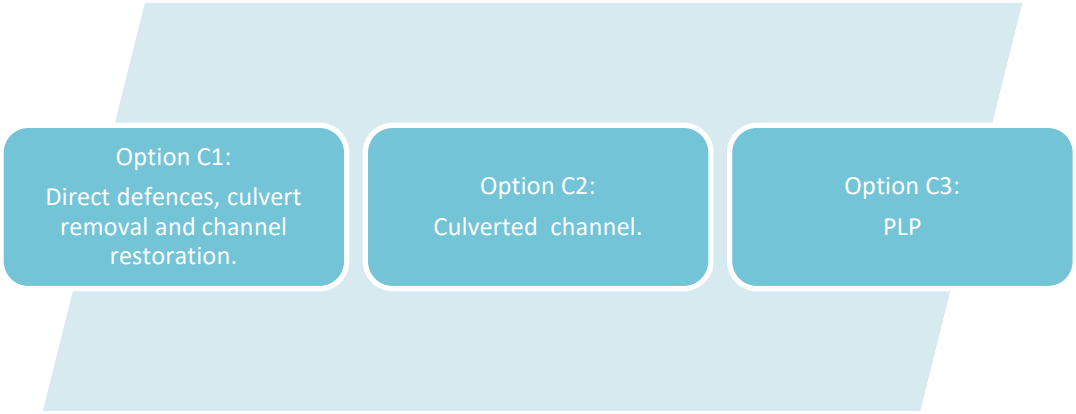
Figure 5-7: Design Area C - Mill of Rothney flow pathways

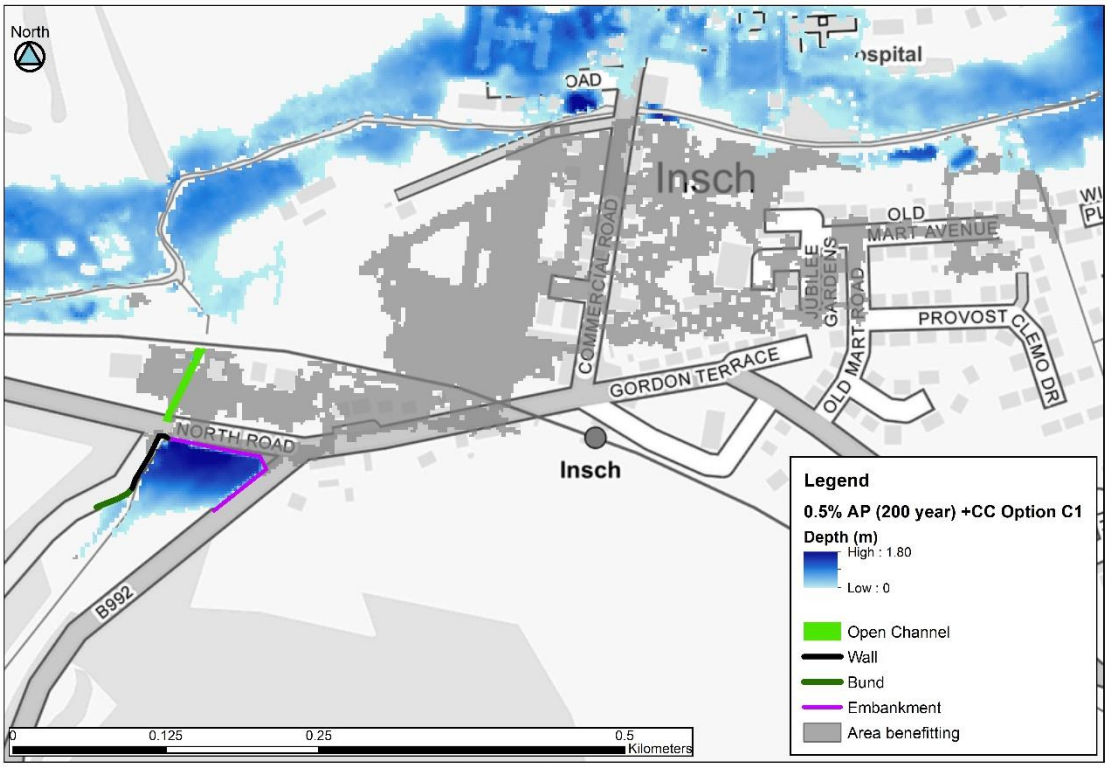


Option C1 - Direct defences, culvert removal & channel restoration

Description

This option aimed to reduce flood risk by increasing floodplain storage on the right bank upstream of North Road, preventing out of bank flow along the road on the left bank, removing the culvert within the industrial estate and reconstructing an open channel of sufficient capacity through the industrial estate. This will offer a 0.5% AP (200 year) + climate change standard of protection. The proposed works are as follows:

- Construct an embankment within the right bank field parallel to the B9002 (North Road) and B992. This will prevent overland flow crossing North Road towards the residential properties, railway line and Commercial Road properties. The embankment would be approximately 1.90 m high (including 0.6 m freeboard) and 140 m long.
- Construct a small embankment within the field on the left bank to prevent flow onto the minor road. The bund would be approximately 1.10 m high (including 0.6 m freeboard) and 35 m in length.
- Wingwall to the North Road bridge culvert tying the right bank wall into the right bank embankment and extending the left bank wall upstream adjacent to the road to prevent overland flow along the road. The wall would on average be 1.00 m high (including 0.3 m freeboard) and 56 m in length.
- Remove the culvert within the industrial estate and re-section an open channel of sufficient capacity with stable, vegetated banks between the North Road bridge and railway culvert. This will split the industrial site in two but access can be maintained to the eastern and western sites through existing entrance points from North Road. Survey indicates the current channel upstream and downstream of the culvert has sufficient capacity to convey the volume of water passed forward but dips in bank top elevations result in out of bank flow. Therefore, the re-sectioned channel would require consistent, uniform bank top levels of ~ 128.5 mAOD including 0.6 m of freeboard for the its full 67 m reach.



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Standard of protection (SoP)

The modelling results have shown this will provide a 0.5% AP (200 year) + climate change standard of protection to the 17 properties at risk under the Do Minimum scenario.

Alternative quick wins/ Preliminary investigations

- Smaller embankments, walls and bunds could be constructed but would offer a lesser standard of protection.
- Re-survey to determine exactly where the burn enters the field is required to determine exact length of wall and embankment required.
- Relocation of the channel to run entirely within the right floodplain and not adjacent to the road may alleviate the need for the wall along the minor road, although an embankment within the field may still be required but this would allow greater floodplain storage and may be a cheaper, more aesthetically pleasing option.

Geotechnical issues

- A full ground investigation will be required at a later stage in the project.
- A cut-off or piling is likely to be needed to avoid seepage beneath all defences. Piling may be difficult in this material and other forms of cut-off may need to be investigated. Due to lack of GI information a cut-off assumption of 0.5 m depth has been made, the cut-off depth will require further investigation at detailed design.

Services

A full survey identifying overhead and underground services will be required at a later stage in the project. It is noted there is a pipe present beneath the North Road bridge.

Construction access

Construction access is not considered a problem but may require road closure during the works. Key issues include:

- Embankment construction would require heavy machinery access to the field south of North Road.
- Road closure of the minor road may be required during wingwall and left bank wall construction.
- Disruption to the industrial estate access during channel improvement works.

Waste

- Nature (inert, non-hazardous, hazardous): no known details of significant industry thus soil expected to be inert.
- Proposed disposal. All waste produced during construction should be contained and prevented from entering the watercourse. Stock piles of soil and nontoxic spoilt during construction waste should be located away from the river (at least c. 10m) and covered. SEPA pollution prevention guidelines should be adhered to throughout the works.
- Any waste materials removed from the site must be disposed of at a suitably licensed or exempt waste management facility under the Waste Management Licensing (Scotland) Regulations 2011. All waste should be carried off site by registered carriers and should be aware of the furnishing and keeping of waste transfer notes.
- Further investigation required through ground investigation into the level of contamination.

Proximity of defense to other structures

- **Private and public:** The proposed channel improvements are within the boundary of the industrial estate and be close to non-residential properties. Establishment of stable, vegetated banks and bank tops may require temporary fencing off of the channel to prevent erosion by an estate users.
- **Bridges:** The wingwall and left bank wall will directly impact North Road bridge. Channel improvement works are immediately upstream of the railway culvert and should not block or damage the structure.
- **Walls/ embankments:** Existing headwalls are present on the upstream and downstream face of North Road bridge.
- **Houses:** Residential properties are located a short distance to the east of proposed works.

Environmental issues

- Additional surveys required to assess impact of the works south of North Road on habitats e.g. Scottish Wildcat, red squirrel, bats, birds etc.
- Geomorphology surveys may be required for the new channel to assess potential erosion impacts.
- Invasive Non Native Species (INNS) have been identified by NESBReC within the study area including Giant Hogweed and Himalayan Cotoneaster. The field survey conducted by JBA primarily identified Giant Hogweed and Cotoneaster Cotoneaster along the banks of The Shevock. It is an offense to spread these invasive non-native species therefore control measures should be put in place during construction if INNS are also found along the Mill of Rothney Burn.

Health and safety hazards noted

- **Geotechnical and evacuation works:** in-channel works, falling into excavations, collapse of the sides of excavations, damage to underground services and undermining of nearby structures.
- **Construction:** flooding of works and working on/ near roads.

Social and community issues

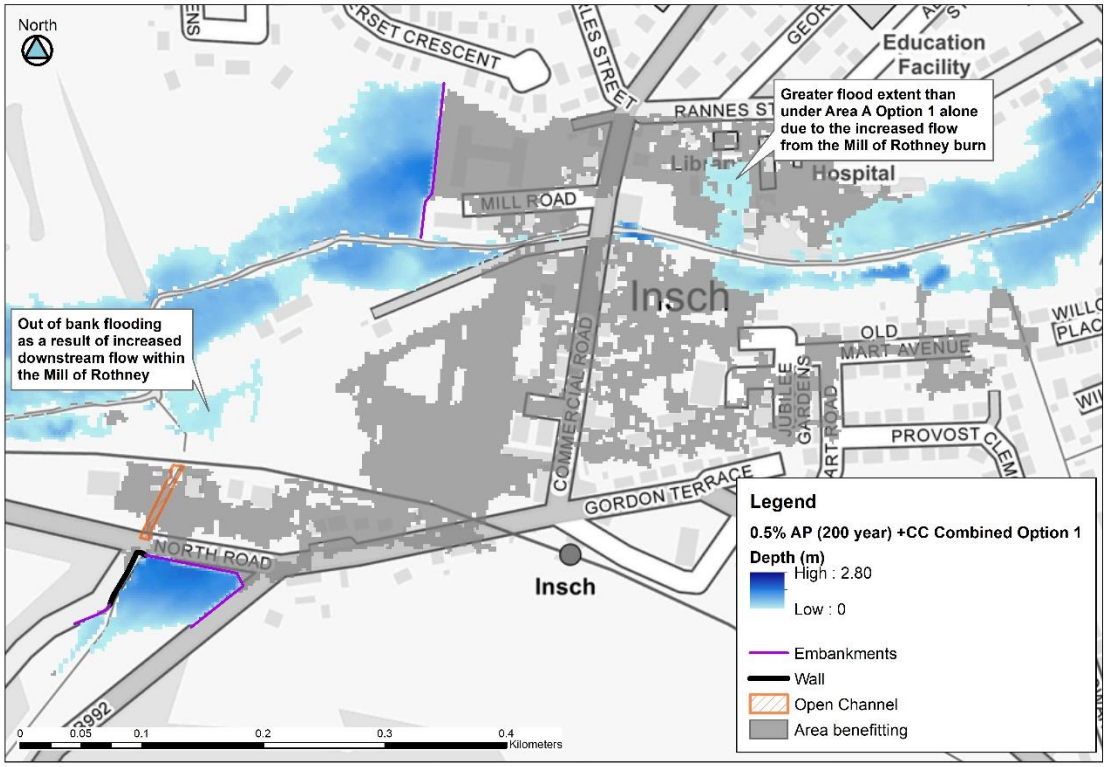
- **Aesthetic issues** - the large North Road embankment to be constructed in an area which is currently open grassland but it should not directly impact any residential views. A new channel would improve aesthetics through the industrial estate.
- **Land take** - may be relatively large for the North Road embankment.
- **Road closure** - residents may object.

Impact on other reaches

Flows increase downstream of North Road bridge and the railway culvert as a results of reduced eastern overland flow. This results in out of bank flooding on the right floodplain near the confluence with The Shevock.

The impact of increased flows discharging into The Shevock (Area A) was tested by combining Area A Option A1 (Mill Road embankment) and this Area C Option C1. It was found the increase in discharge from the Mill of Rothney does not undermine the protection offered by the embankment, but does increase the flood extent on the left bank of The Shevock in the vicinity of the Library. Flood depths are however very small and not expected to cross the threshold of the library and cause damages.

Increased in channel flow has the potential to increase shear stress and therefore erosion of the channel banks and may require additional work to reinforce/ stabilise downstream banks. Further investigation of this will be required at the detailed design stage.



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Additional information required

- A detailed topographic survey.
- Detailed buried services survey, plotting their position with regard to site works.
- Ground investigations.
- Seepage analysis should be undertaken prior to detailed design.
- Authorisation from SEPA will be required prior to construction under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (CAR).

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

This option is dependent on the maintenance of the road and rail culverts. Channel maintenance will be required through the industrial estate. It may take time to establish well vegetated stable banks.

Option C2 - Culverted burn through the industrial estate

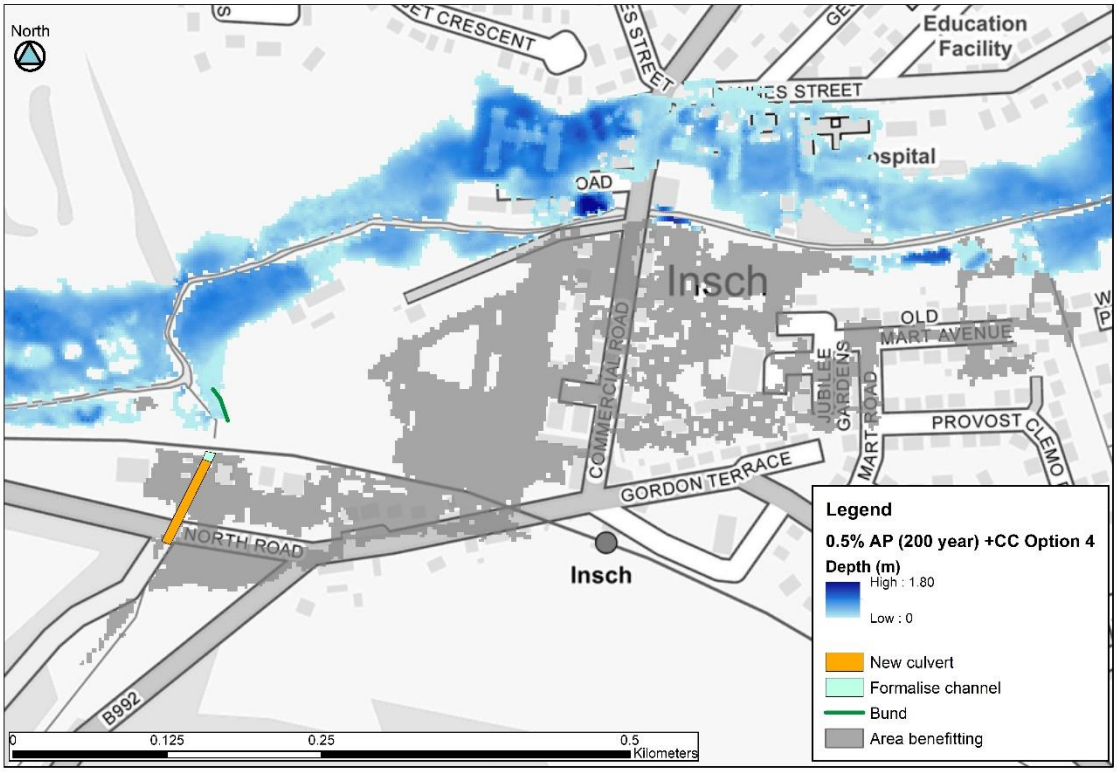
Description

This option aimed to reduce flood risk by culverting the Mill of Rothney from North Road bridge to just before the railway culvert, increasing the capacity of North Road bridge and, preventing out of bank flow and retaining access between the eastern and western areas of the industrial site. This will offer a 0.5% AP (200 year) + climate change standard of protection. The proposed works are as follows:

- Replace North Road bridge (currently a small arch culvert) with a 4 m (w) by 1.5 m (h) x 44 m (l) box culvert with wingwalls. This would involve lowering the bed of the existing channel (and new culvert invert) to reduce the slope of the watercourse between the road and rail culverts, and widening the channel to increase capacity.
- The downstream railway culvert is of smaller dimensions (2 m (w) by 1 m (h)) than the proposed new upstream culvert. Thus to avoid its replacement, which would be costly and may result in railway line closure, an area of open channel between the structures was retained. The railway culvert would be surcharged under this option as a result of increased flows through the larger replacement culvert, but was not modelled to come out of bank

based on existing bank levels. This section of open channel should be formalised and have stable, vegetated banks with bank top elevations of 128 mAOD (including 0.6 m freeboard) to prevent overtopping and flow towards the industrial properties. The open channel would allow for culvert maintenance and inspection.

- The increase in flow downstream of the railway culvert result in out of bank flooding immediately upstream of The Shevock confluence. A small, set-back embankment will be required on the right bank of the Mill of Rothney to prevent flow towards the new development site. This would be approximately 0.8 m in height (including 0.6 m freeboard) and 28 m long. Although the purpose of this appraisal is to protect existing properties, as this area has already been granted planning permission the downstream bund has been included in the appraisal process. Without a scheme in place the development area is at risk of flooding from the Mill of Rothney Burn. Under Option 2, without the additional downstream bund the site is still at risk of flooding. If a scheme was to go ahead, and if the development of the new site could be limited to avoid the new area of flooding to the west as a result of Option 2, this downstream bund may not be required.



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Standard of protection (SoP)

The results of modelling indicate this option will provide a 0.5% AP (200 year) + climate change standard of protection to all 17 properties at risk under the Do Minimum scenario. In addition, the embankment downstream of the railway will protect the new development area to the west of Commercial Road.

Alternative quick wins/ Preliminary investigations

- A smaller culvert could be installed which would offer a lesser standard of protection and may require an embankment parallel to North Road and a wall along the left bank if overtopped.
- A 0.15 m diameter pipe runs through the North Road bridge arch. This may prevent culvert replacement if it cannot be relocated.

Geotechnical issues

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

Services

A full survey identifying overhead and underground services will be required at a later stage in the project. In particular investigation of the pipe beneath North Road bridge prior to this option being viable.

Construction access

Construction access is not considered difficult but will require road closure and will disrupt the industrial site access during construction. Construction of the embankment will require access through the greenfield land west of Commercial Road where there is no road access.

Waste

- Nature (inert, non-hazardous, hazardous): no known details of significant industry this soil expected to be inert.
- Disposal will be in accordance with SEPA guidance. All waste produced during construction should be contained and prevented from entering the watercourse. Stock piles of soil and non-toxic spoil during construction should be located away from the river (at least c. 10 m) and covered. SEPA pollution prevention guidelines should be adhered to throughout works.
- Any waste materials removed from the site must be disposed of at a suitably licensed or exempt waste management facility under the Waste Management Licensing (Scotland) Regulations 2011. All waste should be carried off site by registered carriers and should be aware of the furnishing and keeping of waste transfer notes.
- Further investigation required through GI into level of contamination and ownership.

Proximity of defense to other structures

- **Public and private:** The proposed culvert will run through the industrial estate in close proximity to a number of commercial buildings.
- **Bridges and culverts:** The proposed culvert will replace North Road bridge and terminate in close proximity to the railway culvert.
- **Walls/ embankments:** the existing headwalls on North Road bridge will need replaced.
- **Houses:** Residential properties are located a short distance east of proposed works.

Environmental issues

- Additional surveys required to assess impact of works on habitats e.g. bats, birds, otters.
- Geomorphology surveys may be required to assess the potential downstream erosional impacts of increased conveyance.
- Invasive Non Native Species (INNS) have been identified by NESBReC within the study area including Giant Hogweed and Himalayan Cotoneaster. The field survey conducted by JBA primarily identified Giant Hogweed and Cotoneaster Cotoneaster along the banks of The Shevock. It is an offense to spread these invasive non-native species therefore control measures should be put in place during construction if INNS are also found along the Mill of Rothney Burn.

Health and safety hazards noted

- **Geotechnical and excavation works:** in-channel works, collapse of excavation sides, damage to underground services and undermining of nearby structures.
- **Construction:** flooding of works and working on/ near roads.

Social and community issues

- **Aesthetic issues:** eroding channel through the industrial estate replaced with culvert which will be aesthetically better but this option is not good for the environmental status of the watercourse.
- **Land take:** the new culvert is considerably wider than the existing North Road bridge and downstream channel. This will require land take on both banks to widen the channel.
- **Road closure:** will be required to replace North Road bridge and the industrial estate access may be disrupted during culvert removal and installation.

Impact on other reaches

- Water levels upstream of the new culvert (upstream of North Road bridge) are lower due to increased culvert capacity. This removes the need for the embankment parallel to North Road as per Option C1.
- Water levels however increase immediately upstream, and downstream of the railway culvert as a result of increased culvert capacity.
- The impact of increased discharge into The Shevock was again tested and found not to undermine Area A Option A1 (Mill Road embankment) and not put the Library at increased risk of flooding.

Additional information required

- Detailed topographic survey.
- Detailed services survey particularly to identify the pipe under North Road bridge.
- Detailed buried services survey, plotting their position with regards to site works.
- Ground investigation.
- Authorisation from SEPA will be required prior to construction under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (CAR).

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

This option is dependent on the maintenance of the culverts ensuring the do not become blocked or filled with sediment.

Increased in channel flow has the potential to increase shear stress and therefore erosion of the channel banks and may require additional work to reinforce/ stabilise downstream banks. Further investigation of this will be required at the detailed design stage.

Option C3 - Property Level Protection

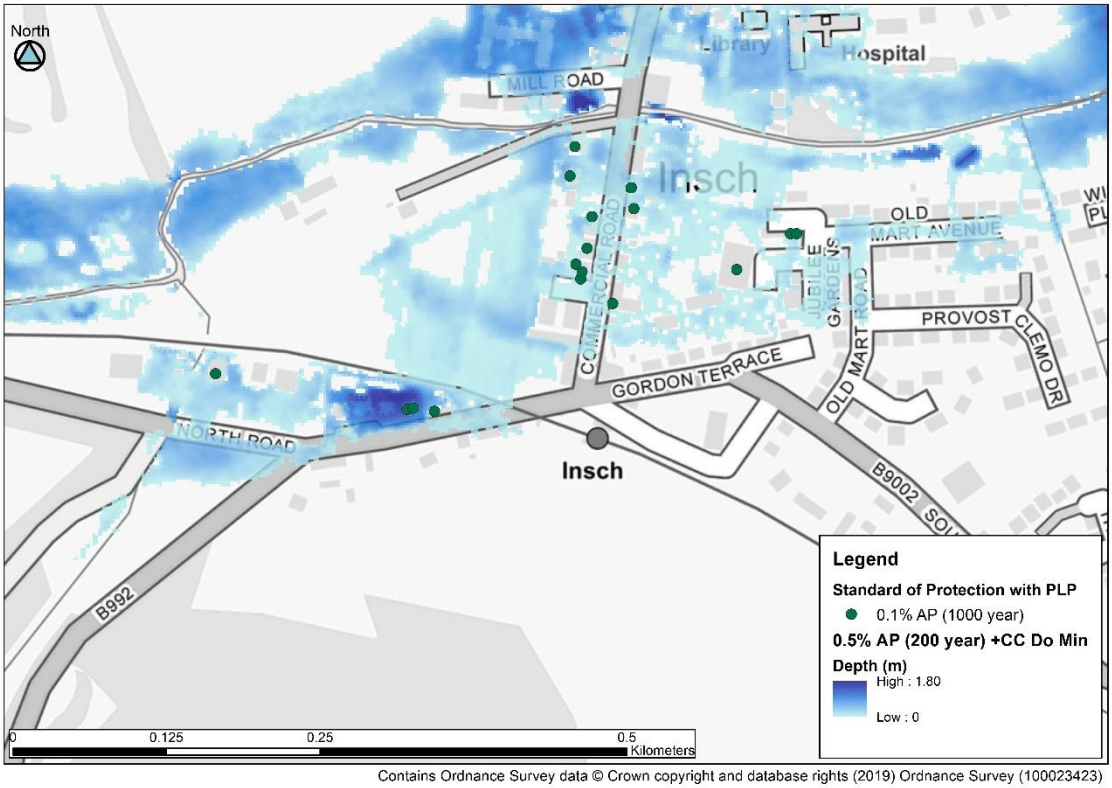
Description

This option aims to provide an increase in standard of protection for all properties where possible by protecting them up to a maximum flood depth of 0.6 m. 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. PLP could take the form of built in flood doors and self-closing airbrick covers or It may be appropriate to provide or convert an existing garden wall into a flood protection wall with a floodgate for each individual property.

Standard of protection (SoP)

The number of properties expected to benefit from PLP within Area B:

- 16 non-residential properties at the 0.1% AP (1000 year) event.
- 1 residential property at the 0.1 % AP (1000 year) event.



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Alternative quick wins/ Preliminary investigations

- Containing flow within the channel and preventing flow pathways across North Road either via a newer larger culvert or new channel and embankment combination would alleviate the need for PLP.

Technical issues

All properties would require surveying by competent parties to determine which products are appropriate. Properties with non-standard or large entrances e.g. commercial properties may require bespoke options which can significantly increase costs. The Scottish Government's Blueprint on PLP[10] should be considered when implementing this option.

The use of passive (automatic) measures is recommended as a result of the lack of flood warning within the catchment. These measures are more expensive but would increase the effectiveness of the protection.

Construction access/ issues

Gaining owner consent to install these products for all properties at risk may be challenging.

Environmental issues

- None expected.

Health and safety hazards noted

- None expected during construction.
- Kitemarked products and approved suppliers/installers should eb sued to ensure safe installation that provides the expected benefits.
- Residents should be warned of the risk of becoming trapped within their home and the possibility that PLP products become overwhelmed by flood depths greater than their design standard.

Social and community issues

Property owners further from the burn may never have experienced flooding and therefore may not approve of these measures that could affect their properties value.

Impact on other reaches

There would likely be negligible impact on the roads further downstream which may see slightly larger flows since less water would be expected to flow through properties.

Additional information required

- Flood risk reviews for each property.
- Public engagement meetings.

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

The PLP option is capable of mitigating against climate change but only for some properties due to flood depths at some properties increasing beyond their 0.6 m limit. The option could therefore generally provide flood protection over the longer-term but due to the short life of PLP products, replacement every 20-25 years needs to be considered since it makes the options less sustainable. This regular replacement does give the opportunity to protect only those properties most frequently at flood risk in the present day and add more properties that are at less frequent flood risk as they become more at risk in the future.

5.8.4 Summary of mitigation options

The following section details the flood mitigation options for the full study area taking different combinations of options from the previous section in each design area, these will ultimately be used as the decision for the preferred option in Insch.

Option 1:

- Option A1a: Direct defences (embankment).
- Option B1: Upstream storage, two-stage channel, channel reprofiling and culvert upgrades.
- Option C1: Direct defences and channel restoration.

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

- AIZ-JBAU-IN-00-DR-HM-0002-Option1_A1a
- AIZ-JBAU-IN-00-DR-HM-0003-Option1_B1
- AIZ-JBAU-IN-00-DR-HM-0004-Option1_C1

Option 2:

- Option A1a: Direct defences (embankment).
- Option B3: Upstream storage, two-stage channel, direct defences and smaller culvert upgrades.
- Option C1: Direct defences and channel restoration.

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

- AIZ-JBAU-IN-00-DR-HM-0005-Option2_A1a
- AIZ-JBAU-IN-00-DR-HM-0006-Option2_B3
- AIZ-JBAU-IN-00-DR-HM-0007-Option2_C1

Option 3:

- Option A1a: Direct defences (embankment).
- Option B3: Upstream storage, two-stage channel, direct defences and smaller culvert upgrades.
- Option C2: Direct defences and culverting.

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

- AIZ-JBAU-IN-00-DR-HM-0008-Option3_A1a
- AIZ-JBAU-IN-00-DR-HM-0009-Option3_B3
- AIZ-JBAU-IN-00-DR-HM-0010-Option3_C2

Option 4:

- Option A2: PLP.
- Option B4: PLP.
- Option C3: PLP.

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

- AIZ-JBAU-IN-00-DR-HM-0011-Option 4_A2-PLP
- AIZ-JBAU-IN-00-DR-HM-0012-Option 4_B4-PLP
- AIZ-JBAU-IN-00-DR-HM-0013-Option 4_C3-PLP

Option 5:

- Option A1a: Direct defences (embankment).
- Option B5b: Direct defences, two-stage channel, channel reprofiling and culvert upgrades.
- Option C1: Direct defences and channel restoration.

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

- AIZ-JBAU-IN-00-DR-HM-0021-Option5_A1a
- AIZ-JBAU-IN-00-DR-HM-0022-Option5_B5b
- AIZ-JBAU-IN-00-DR-HM-0023-Option5_C1

Option 5b:

- Option A1b: Direct defences (embankment & wall).
- Option B5b: Direct defences, two-stage channel, channel reprofiling and culvert upgrades.
- Option C1: Direct defences and channel restoration.

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

- AIZ-JBAU-IN-00-DR-HM-0025-Option5b_A1b
- AIZ-JBAU-IN-00-DR-HM-0026-Option5b_B5b
- AIZ-JBAU-IN-00-DR-HM-0027-Option5b_C1

6 Investment appraisal

6.1 Damage methodology

Flood damage assessment can include direct, indirect, tangible and intangible aspects of flooding, as shown in Figure 6-1. Direct damages are the most significant in monetary terms, although the FHRC Multi Coloured Manual (MCM)[9] and additional research provide additional methodologies, recommendations and estimates to account for the indirect and intangible aspects of flood damage.

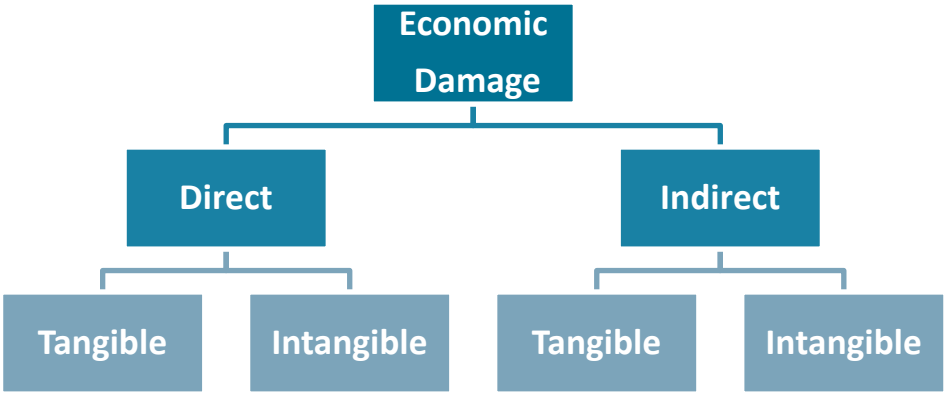

Figure 6-1: Aspects of flood damage

Flood damage estimates have been derived for the following items:

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

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

6.2 Baseline damages

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

Do Nothing

Assumptions:

Maintenance ceased, increasing hydraulic roughness due to vegetation growth and degradation of banks.

Bridges and culverts are blocked using a risk-based approach by either widening their piers or lowering their soffits.

Properties at risk:

The total number of properties inundated above threshold level for the Do Nothing scenario within Insch has been assessed and is provided in the table below:

Return period (years)	2	5	10	30	50	75	100	200	200 CC	1000
Residential	0	10	17	24	30	35	36	39	42	47
Non-residential	1	3	5	7	7	7	7	7	7	8

9 Handbook for economic appraisal, MCM, Flood and coastal erosion risk management, 2017

Total	1	13	22	31	37	42	43	46	49	55

Key beneficiaries:

The flood damages derived have been ranked and assessed in terms of the proportion of flood damages per property. This highlights key beneficiaries of the scheme and is a useful auditing tool. The top ten properties are listed in the table below.

Rank	Property address	PVd (£k)	Percentage of total PVd
1	DRUMDARROCH HOUSE CARE HOME, AB52 6JA	1407.59	29.5
2	INSCH GOLF CLUB, GOLF TERRACE, AB52 6JY	367.92	7.7
3	[redacted], DRUMROSSIE STREET, AB52 6LB	301.68	6.3
5	[redacted], COMMERCIAL ROAD, AB52 6JP	152.17	3.2
6	[redacted], COMMERCIAL ROAD, AB52 6JN	151.22	3.2
6	[redacted], COMMERCIAL ROAD, AB52 6JN	151.22	3.2
8	INSCH WAR MEMORIAL HOSPITAL, 11, RANNES STREET, AB52 6JJ	149.87	3.1
9	[redacted], COMMERCIAL ROAD, AB52 6JP	146.18	3.1
10	HARPERS TRANSPORT, 0, NORTH ROAD, AB52 6XP	145.37	3.0

Event property damages:

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

Return period (years)	2	5	10	30	50	75	100	200	200 CC	1000
Residential	0	165	274	481	760	857	932	1,091	1,228	1,356
Non-residential	88	172	366	536	616	697	745	851	952	1,005
Total	88	337	640	1,017	1,376	1,554	1,676	1,942	2,180	2,361

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.

Indirect and intangible damages:

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

Do Nothing flood damages (£k):

Property PVd	Capped Property PVd	Indirect PVd	Intangible PVd	Total Capped PVd
6,530	4,773	284	257.8	5,031

Do Minimum

Assumptions:

Maintenance continued in the channel and on the banks. No bridge blockage assumed.

Properties at risk:

The total number of properties inundated above threshold level for the Do Minimum scenario within Insch has been assessed and is provided in the table below:

Return period (years)	2	5	10	30	50	75	100	200	200CC	1000
Residential	0	8	9	17	21	28	30	25	39	44
Non-residential	1	2	2	3	5	6	6	7	7	7
Total	1	10	11	20	26	34	36	42	46	51

Key beneficiaries:

The flood damages derived have been ranked and assessed in terms of the proportion of flood damages per property. This highlights key beneficiaries of the scheme and is a useful auditing tool. The top ten properties are listed in the table below.

Rank	Property address	PVd (£k)	Percentage of total PVd
1	DRUMDARROCH HOUSE CARE HOME, AB52 6JA	456.47	16.4
2	INSCH GOLF CLUB, GOLF TERRACE, AB52 6JY	370.57	13.3
3	[redacted] COMMERCIAL ROAD, AB52 6JN	301.68	10.8
4	[redacted] COMMERCIAL ROAD, AB52 6JN	151.22	5.4
5	[redacted], COMMERCIAL ROAD, AB52 6JN	147.72	5.3
6	HARPERS TRANSPORT, 0, NORTH ROAD, AB52 6XP	145.37	5.2
7	[redacted], COMMERCIAL ROAD, AB52 6JN	138.50	5.0
8	[redacted], COMMERCIAL ROAD, AB52 6JP	130.93	4.7
9	[redacted], COMMERCE STREET, AB52 6JB	126.23	4.5
10	[redacted] COMMERCE STREET, AB52 6JB	125.11	4.5

Event property damages:

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

Return period (years)	2	5	10	30	50	75	100	200	200CC	1000
Residential	0	120	149	260	402	564	714	903	1,146	1,242
Non-residential	83	129	136	323	432	517	556	709	895	964
Total	83	249	285	583	834	1,081	1,269	1,612	2,041	2,206

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.

Indirect and intangible damages:

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

Do Nothing flood damages (£k):

Property PVd	Capped Property PVd	Indirect PVd	Intangible PVd	Total Capped PVd
4,244	2,786	226	150.5	2,937

6.3 Options

The flood damages for each option were calculated for each return period up to the 0.1% AP (1000 year) event. Average annual flood damages were converted to present value damages using the discount factor and the residual damages for each option were compared against the flood damages estimated for the Do Nothing scenario. This comparison shows the damages avoided as a result of the options' interventions, also known as the benefit.

In line with current guidance[10] the PLP option was factored to account for the effectiveness and performance of measures and availability of homeowners to install and operate the measures. PLP was assumed to be 84% effective.

10 Post-Installation Effectiveness of Property Level Flood Protection, Final Report FD2668, (2014) DEFRA

6.4 Damage benefit summary

The table below summarises the damages avoided for each option. The results show that each of the options assessed significantly reduce flood damages in the order of £2 m - £5 m, leaving comparatively low residual present value damages in the range £0.21 m-£3 m. The Do Minimum option reduces the Do Nothing damages by roughly 40 % and the defended options reduce this further by varying degrees.

Table 6-1: Damage benefit summary

	DN	DM	Option 1	Option 2	Option 3	Option 4	Option 5	Option 5b
Option name	Do Nothing	Do Minimum	Full hard engineering with channel improvements in Area's B&C	Full hard engineering with channel improvements in Area C	Full hard engineering	Full PLP	Full hard engineering with no upstream storage in Area B, and channel improvements in Area B & C	Full hard engineering with no upstream storage in Area B, and channel improvements in Area B & C
Standard of Protection	<2	<2	0.5% AP (200 year) + climate change	0.5% AP (200 year) + climate change	0.5% AP (200 year) + climate change	0.5% AP (200 year)	0.5% AP (200 year) + climate change	0.5% AP (200 year) + climate change
BENEFITS:								
PV monetised flood damages (£k)	5,201	3,110	214	214	214	87	214	214
Total PV damages avoided/ benefits (£k)	-	2,091	4,986	4,986	4,986	4,295*	4,986	4,986
***Note:** PLP benefits are scaled down by 16% to account for the likelihood of PLP products only being 84% effective								

7 Cost estimates

7.1 Price Base Date

The price base date is January 2019. The costs and benefits have been discounted over the 100 year life of the scheme to determine present values.

7.2 Whole life cost estimates

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

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

The Environment Agency's 'Long Term Costing' tool (2012) was the basis of all costs for this assessment to provide a uniform approach to costing across the flood studies.

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.

7.3 Maintenance costs

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

The costs used assume efforts are made to maintain assets at condition grade 2 (Good) using the grading system described in the Environment Agency's asset condition assessment manual[11]. Average costs were used - between lower and upper bounds reproduced in the report - given the absence of detailed maintenance plans at this early design stage of development.

7.3.1 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. An optimism bias of 30% has been applied to the PLP options as there is greater certainty in the costs and risks. This uplift is applied to present value capital and present value maintenance costs after their calculation.

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

7.4 Option 1 - Hard engineering with channel restoration and reprofiling

This option consists of the following:

- Area A1a
  - Embankment to the west of Mill Road approximately 130 m in length and 1.80 m in height.
- Area B1
  - Upstream storage on Insch Golf Course which lets the 2% AP (50 year) flow pass forward. This requires an orifice 1 m in diameter; a northern embankment 130 m in length and 3.1 m in height; and a southern embankment 240 m in length and 3.6 m in height.
  - Creation of a two-stage channel over a 170 m reach.
  - Channel reprofiling over a 235 m reach.
  - Replacement of the Market and Drumrossie Street culverts with 4 m (w) x 1.5 m (h) box culverts. This will require relocation of the electrical station and outflow pipe on the left bank.
- Area C1
  - Embankment running parallel to the B9002 (North Road) and B992 approximately 140 m in length and 2 m in height.
  - Embankment on the left bank upstream of North Road approximately 35 m in length and 1 m in height.
  - Flood wall/ wingwall along the left bank approximately 56 m in length and 1 m in height.
  - Culvert removal and open channel restoration through the industrial estate over an approximate 67 m reach.

Costs are based on achieving a 0.5% AP (200 year) plus climate change standard of protection and on near immediate initiation of works.

Table 7-1: Option 1 - Unit and total estimated costs

Location	Typical defence height	Length / Volume/ Diameter	Unit cost (Rounded)	Total Cost (Rounded)
Area A: embankment	1.80 m	2082.3 m^3	£115	£240,263
Area B: N embankment	3.10 m	4230.6 m^3	£115	£488,141
Area B: S embankment	3.60 m	11721.3 m^3	£79	£920,825
Area B: Land purchase	-	-	-	£50,000
Area B: orifice (+ weighted adjustment factor of 117%)	-	1 m	£78,494	£91,577
Area B: two-stage channel (+50% contingency & 60% additional construction costs)	-	170 m	£150	£61,200
Area B: channel reprofiling	-	235 m	£1,864	£438,130
Area B: Market St culvert (+20% contingency)	1.5 m (h) x 4 m (w)	14 m	£8,204	£137,833
Area B: Drumrossie St culvert (+20% contingency)	1.5 m (h) x 4 m (w)	11 m	£8,204	£108,298
Area C: North Road embankment	2.0 m	3101.6 m^3	£115	£357,877
Area C: upstream embankment	1.0 m	285.1 m^3	£231	£65,794
Area C: flood wall	1.0 m	56 m	£1,377	£77,125
Area C: culvert removal	-	233 m^2	£36.65	£8,539
Area C: channel restoration *Riverbed restoration*	-	67 m 67 m	£15 £27	

Location	Typical defence height	Length / Volume/ Diameter	Unit cost (Rounded)	Total Cost (Rounded)
Bank reprofiling *Channel re-sectioning* (+50% contingency & 60% additional construction costs) *Willow spilling* (+50% contingency)		67 m 67 m	£60 £100	 £26,452
			Total Capital cost	£3,072,054

Table 7-2: Option 1 - Total cash and Present Value (PV) costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	302	302
Capital cost	3,072	3,072
Maintenance cost	711	207
Total	**4,084**	**3,581**
Total incl. Optimism Bias	-	5,729

7.5 Option 2 - Hard engineering with reduced Valentine storage and no reprofiling

This option consists of the following:

- Area A1a
  - Embankment to the west of Mill Road approximately 130 m in length and 1.80 m in height.
- Area B3
  - Upstream storage on Insch Golf Course which lets the 2% AP (50 year) flow pass forward. This requires an orifice 1 m in diameter; a northern embankment 130 m in length and 3.1 m in height; and a southern embankment 240 m in length and 3.6 m in height.
  - Creation of a two-stage channel over a 170 m reach.
  - Market Street embankment approximately 65 m in length and 0.90 m in height.
  - Replacement of the Market Street culvert with a 4 m (w) x 1 m (h) box culvert.
  - Replacement of the Drumrossie Street culvert with a 3.5 m (w) x 0.75 m (h) box culvert. This will require relocation of the electrical station and outflow pipe on the left bank.
- Area C1
  - Embankment running parallel to the B9002 (North Road) and B992 approximately 140 m in length and 2 m in height.
  - Upstream embankment on the left bank approximately 35 m in length and 1 m in height.
  - Flood wall/ wingwall along the left bank approximately 56 m in length and 1 m in height.
  - Culvert removal and open channel restoration through the industrial estate over an approximate 67 m reach.

Costs are based on achieving a 0.5% AP (200 year) plus climate change standard of protection and on near immediate initiation of works.

Table 7-3: Option 2 - Unit and total estimated costs

Location	Typical defence height	Length / Volume/ Diameter	Unit cost (Rounded)	Total Cost (Rounded)
Area A: embankment	1.80 m	2082.3 m^3	£115	£240,263
Area B: N embankment	3.10 m	4230.6 m^3	£115	£488,141
Area B: S embankment	3.60 m	11514.4 m^3	£79	£904,561
Area B: Market St embankment	0.90 m	311.1 m^3	£231	£71,782
Area B: Land purchase	-	-	-	£50,000
Area B: orifice (+ weighted adjustment factor of 117%)	-	1 m	£78,494	£91,577
Area B: two-stage channel (+50% contingency & 60% additional construction costs)	-	170 m	£150	£61,200
Area B: Market St culvert (+20% contingency)	1 m (h) x 4 m (w)	14 m	£7,134	£119,855
Area B: Drumrossie St culvert (+20% contingency)	0.75 m (h) x 3.5 m (w)	11 m	£7,134	£94,172
Area C: North Road embankment	2.0 m	3101.6 m^3	£115	£357,877
Area C: upstream embankment	1.0 m	285.1 m^3	£231	£65,794
Area C: flood wall	1.0 m	56 m	£1,377	£77,125
Area C: culvert removal	-	233 m^2	£36.65	£8,539
Area C: channel restoration *Riverbed restoration* *Bank reprofiling* *Channel re-sectioning* (+50% contingency & 60% additional construction costs) *Willow spilling* (+50% contingency)	-	 67 m 67 m 67 m 67 m	 £15 £27 £60 £100	£26,452
			Total Capital cost	£2,657,338

Table 7-4: Option 2 - Total cash and Present Value (PV) costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	260	260
Capital cost	2,657	2,657
Maintenance cost	528	154
Total	**3,446**	**3,071**
Total incl. Optimism Bias	-	4,914

7.6 Option 3 - Hard engineering with no reprofiling or channel restoration

This option consists of the following:

- Area A1a
  - Embankment to the west of Mill Road approximately 130 m in length and 1.80 m in height.
- Area B3
  - Upstream storage on Insch Golf Course which lets the 2% AP (50 year) flow pass forward. This requires an orifice 1 m in diameter; a northern embankment 130 m in length and 3.1 m in height; and a southern embankment 240 m in length and 3.6 m in height.
  - Creation of a two-stage channel over a 170 m reach.
  - Market Street embankment approximately 65 m in length and 0.90 m in height.
  - Replacement of the Market Street culvert with a 4 m (w) x 1 m (h) box culvert.
  - Replacement of the Drumrossie Street culvert with a 3.5 m (w) x 0.75 m (h) box culvert. This will require relocation of the electrical station and outflow pipe on the left bank.
- Area C2
  - Re-culvert the Mill of Rothney between North Bridge and the railway culvert. The culvert would be approximately 4 m (w) x 1.5 m (h). The bed level (and invert) of the channel should be lowered to reduce the slope between North Road and the railway culvert.
  - Open channel restoration between the North Road and railway culverts over an approximate 1 m reach.
  - Embankment construction downstream of the railway line approximately 28 m in length and 0.8 m in height.

Costs are based on achieving a 0.5% AP (200 year) plus climate change standard of protection and on near immediate initiation of works.

Table 7-5: Option 3 - Unit and total estimated costs

Location	Typical defence height	Length / Volume/ Diameter	Unit cost (Rounded)	Total Cost (Rounded)
Area A: embankment	1.80 m	2082.3 m^3	£115	£240,263
Area B: N embankment	3.10 m	4230.6 m^3	£115	£488,141
Area B: S embankment	3.60 m	11514.4 m^3	£79	£904,561
Area B: Market St embankment	0.90 m	311.1 m^3	£231	£71,782
Area B: Land purchase	-	-	-	£50,000
Area B: orifice (+ weighted adjustment factor of 117%)	-	1 m	£78,494	£91,577
Area B: two-stage channel (+50% contingency & 60% additional construction costs)	-	170 m	£60	£61,200
Area B: Market St culvert (+20% contingency)	1 m (h) x 4 m (w)	14 m	£7,134	£119,855
Area B: Drumrossie St culvert (+20% contingency)	0.75 m (h) x 3.5 m (w)	11 m	£7,134	£94,172
Area C: embankment	0.80 m	147.2 m^3	£292	£42,982
Area C: culvert removal (+ £20k channel works)	-	233 m^2	£36.65	£28,539
Area C: new culvert (+20% contingency)	1.50 m (h) x 4 m (w)	44 m	£8,204	£433,190

Location	Typical defence height	Length / Volume/ Diameter	Unit cost (Rounded)	Total Cost (Rounded)
			Total Capital cost	£2,626,262

Table 7-6: Option 3 - Total cash and Present Value (PV) costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	257	257
Capital cost	2,626	2,626
Maintenance cost	455	132
Total	**3,338**	**3,015**
Total incl. Optimism Bias	-	4,824

7.7 Option 4 - Full PLP

This option consists of PLP as the only option for all properties. Costs have been estimated assuming replacement every 25 years.

Table 7-7: Option 4 - PLP total estimated costs

Property type	Cost range	Cost type	Number	Unit Cost	Total Cost
Residential	High	Premium*	34	£14,088	£478,992
Non-residential	High	Premium*	7	£23,196	£162,372
				Total Capital Cost	£641,353
				Total Capital Cost Including Replacement	£2,242,400

*Assumes automatic PLP defences

Table 7-8: Option 4 - Total cash and Present Value (PV) costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	79	79
Capital cost + replacement cost	2,242	1,146
Maintenance cost	1,270	370
Total	**3,591**	**2,364**
Total incl. Optimism Bias (30%)	-	2,071

7.8 Option 5 - Hard engineering, no upstream storage, channel restoration and reprofiling

This option consists of the following:

- Area A1a
  - Embankment to the west of Mill Road approximately 130 m in length and 1.80 m in height.
- Area B5b
  - Embankment to protect Insch Golf Clubhouse approximately 100 m in length and 1.6 m in height.
  - Construction of a left bank flood wall fronting Insch community centre approximately 150 m long and 1.1 m high.
  - Set-back embankment east of Market Street approximately 70 m in length and 0.9 m in high.
  - Creation of a two-stage channel over a 170 m reach.
  - Channel reprofiling over a 235 m reach.

- Replacement of the Market and Drumrossie Street culverts with 4 m (w) x 1.5 m (h) box culverts. This will require relocation of the electrical station and outflow pipe on the left bank.

- Area C1
  - Embankment running parallel to the B9002 (North Road) and B992 approximately 140 m in length and 2 m in height.
  - Embankment on the left bank upstream of North Road approximately 35 m in length and 1 m in height.
  - Flood wall/ wingwall along the left bank approximately 56 m in length and 1 m in height.
  - Culvert removal and open channel restoration through the industrial estate over an approximate 67 m reach.

Costs are based on achieving a 0.5% AP (200 year) plus climate change standard of protection and on near immediate initiation of works.

Table 7-9: Option 5 - Unit and total estimated costs

Location	Typical defence height	Length / Volume/ Diameter	Unit cost (Rounded)	Total Cost (Rounded)
Area A: embankment	1.80 m	2082.3 m^3	£115	£240,263
Area B: clubhouse embankment	1.55 m	1799.1 m^3	£115	£207,582
Area B: community centre wall (+ £20k for access gates)	1.06 m	150 m	£1,377	£226,585
Area B: Market St embankment	0.88 m	532.8 m^3	£115	£61,475
Area B: two-stage channel (+50% contingency & 60% construction costs)	-	170 m	£150	£61,200
Area B: channel reprofiling	-	235 m	£1,864	£438,130
Area B: Market St culvert (+20% contingency)	1.5 m (h) x 4 m (w)	14 m	£8,204	£137,833
Area B: Drumrossie St culvert (+20% contingency)	1.5 m (h) x 4 m (w)	11 m	£8,204	£108,298
Area C: North Road embankment	2.0 m	3101.6 m^3	£115	£357,877
Area C: upstream embankment	1.0 m	285.1 m^3	£231	£65,794
Area C: flood wall	1.0 m	56 m	£1,377	£77,125
Area C: culvert removal	-	233 m^2	£36.65	£8,539
Area C: channel restoration *Riverbed restoration* *Bank reprofiling* *Channel re-sectioning* (+50% contingency & 60% additional construction costs) *Willow spilling* (+50% contingency)	-	 67 m 67 m 67 m 67 m	 £15 £27 £60 £100	£26,452
			Total Capital cost	£2,017,153

Table 7-10: Option 5 - Total cash and Present Value (PV) costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	199	199
Capital cost	2,017	2,017
Maintenance cost	509	148
Total	**2,725**	**2,364**
Total incl. Optimism Bias	-	3,783

7.9 Option 5b - Hard engineering, no upstream storage, channel restoration and reprofiling

This option consists of the following:

- Area A1b
  - Embankment to the west of Mill Road approximately 130 m in length and 1.80 m in height.
  - Formalisation of the Mill Road wall to a flood wall approximately 45 m in length and 2 m in height.
- Area B5b
  - Embankment to protect Insch Golf Clubhouse approximately 100 m in length and 1.6 m in height.
  - Construction of a left bank flood wall fronting Insch community centre approximately 150 m long and 1.1 m high.
  - Set-back embankment east of Market Street approximately 70 m in length and 0.9 m in high.
  - Creation of a two-stage channel over a 170 m reach.
  - Channel reprofiling over a 235 m reach.
  - Replacement of the Market and Drumrossie Street culverts with 4 m (w) x 1.5 m (h) box culverts. This will require relocation of the electrical station and outflow pipe on the left bank.
- Area C1
  - Embankment running parallel to the B9002 (North Road) and B992 approximately 140 m in length and 2 m in height.
  - Embankment on the left bank upstream of North Road approximately 35 m in length and 1 m in height.
  - Flood wall/ wingwall along the left bank approximately 56 m in length and 1 m in height.
  - Culvert removal and open channel restoration through the industrial estate over an approximate 67 m reach.

Costs are based on achieving a 0.5% AP (200 year) plus climate change standard of protection and on near immediate initiation of works.

Table 7-11: Option 5 - Unit and total estimated costs

Location	Typical defence height	Length / Volume/ Diameter	Unit cost (Rounded)	Total Cost (Rounded)
Area A: embankment	1.80 m	2082.3 m^3	£115	£240,263
Area A: wall	2.00 m	45 m	£5,278	£237, 518
Area B: clubhouse embankment	1.55 m	1799.1 m^3	£115	£207,582
Area B: community centre wall (+ £20k for access gates)	1.06 m	150 m	£1,377	£226,585
Area B: Market St embankment	0.88 m	532.8 m^3	£115	£61,475
Area B: two-stage channel (+50% contingency & 60% construction costs)	-	170 m	£150	£61,200
Area B: channel reprofiling	-	235 m	£1,864	£438,130
Area B: Market St culvert (+20% contingency)	1.5 m (h) x 4 m (w)	14 m	£8,204	£137,833
Area B: Drumrossie St culvert (+20% contingency)	1.5 m (h) x 4 m (w)	11 m	£8,204	£108,298
Area C: North Road embankment	2.0 m	3101.6 m^3	£115	£357,877
Area C: upstream embankment	1.0 m	285.1 m^3	£231	£65,794
Area C: flood wall	1.0 m	56 m	£1,377	£77,125
Area C: culvert removal	-	233 m^2	£36.65	£8,539
Area C: channel restoration *Riverbed restoration* *Bank reprofiling* *Channel re-sectioning* (+50% contingency & 60% additional construction costs) *Willow spilling* (+50% contingency)	-	 67 m 67 m 67 m 67 m	 £15 £27 £60 £100	£26,452
			Total Capital cost	£2,254,671

Table 7-12: Option 5 - Total cash and Present Value (PV) costs

Element	Cash cost (£k)	PV Cost (£k)
Enabling cost	223	223
Capital cost	2,255	2,255
Maintenance cost	520	151
Total	**2,998**	**2,629**
Total incl. Optimism Bias	-	4,207

7.10 Summary of whole life costs

Table 7-13 summarises all Present Value costs for all of the short-listed options:

Table 7-13: Summary of PV costs for all options

Option	PV Cost (£k)
Option 1 - Hard engineering with channel restoration and reprofiling	5,729
Option 2 - Hard engineering with reduced Valentine storage and no reprofiling	4,914
Option 3 - Hard engineering with no reprofiling or channel restoration	4,824
Option 4 - Full PLP	2,071
Option 5 - Hard engineering, no upstream storage and channel restoration and reprofiling	3,783
Option 5b - Hard engineering, no upstream storage and channel restoration and reprofiling	4,207

8 Benefit-cost analysis

8.1 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 Minimum scenarios. The benefits of any particular Do Minimum option can then be calculated by deducting the Do Minimum damages from the Do Nothing damages.

8.2 Benefit-cost results

The benefit cost results for the shortlisted options are provided in the Table 8-1.

Table 8-1: Benefit cost ratio for options on the Insch (£k)

	Do Nothing	Do Min	Option 1	Option 2	Option 3	Option 4	Option 5	Option 5b
Total PV Costs (£k)	-	-	3,581	3,071	3,015	1,594	2,364	2,629
Optimism Bias (60%) (30% for PLP OP4)	-	-	2,148	1,843	1,809	478	1,419	1,577
Total PV Costs (£k)	-	-	5,729	4,914	4,824	2,071	3,783	4,207
PV damage (£k)	5,201	3,110	214	214	214	87	214	214
PV damage avoided (£k)	-	2,091	4,986	4,986	4,986	4,295	4,986	4,986
Net present value (£k)	-	2,091	-743	72	162	2,224	1,203	780
Benefit-cost ratio	-	-	0.87	1.01	1.03	2.07	1.32	1.19

Options 2-5 give a cost benefit ratio of above 1 meaning these options are cost effective. Option 1 has a cost benefit ratio of 0.87 making it just under a positive ratio. The flood damage assessment currently includes all direct flood losses and a subset of indirect losses. Additional flood damages such as vehicle damage and temporary accommodation and evacuation losses could be included to enhance the overall benefit cost ratio. It is recommended that if this scheme goes ahead these additional losses are included to determine if Option 1 is cost viable.

Despite being cost-effective the full PLP option does not provide a holistic long-term form of flood protection and drainage interaction of flood waters with properties may vary under observed events. Due to this the hard defences in options 1 - 3 and 5 are preferable.

8.3 Residual risks

Options 1 - 3 and 5 can protect to the 0.5% AP (200 year) +CC event. Uncertainty in the peak flow estimates remains due to lack of gauged data and there is no flood warning scheme. This leaves a degree of uncertainty in the effective deployment of PLP. It is highly recommended a river gauge be installed, particularly on The Shevock at Commercial Road bridge and the Valentine Burn where there are a high number of constraints on potential options, and the Mill of Rothney which has the potential to impact the railway line and new development site. NFM should be considered as a future option to address the impact of climate change.

8.4 Testing of climate change inclusion in damages

As a starting point for appraisal was to achieve a SoP of 0.5% AP (200 year) plus climate change, a sensitivity check was conducted to determine whether including climate change in the do nothing and do minimum scenarios would be beneficial to the study, increasing the damages and ultimately the BCR. The climate change uplift being used in this study is 24% which is in line with the updated climate projections as of 2019 for the North East[12]. A sensitivity check was conducted where the current probability for each storm event was recalculated using the 24% uplift to determine how much more frequently it would occur e.g. the damages incurred during the 1% AP (100 year) event now has a probability of occurring during the 2.17% AP (46 year) event. A new baseline damage was then calculated; £6,517,000. The damages have increased by roughly £1,316,000 which results in the options defending against climate change becoming more cost effective. In the case of Option 1 this pushes the BCR from 0.87 to 1.10. However, as all other options presently have positive BCR's, including the preferred Option 5b, inclusion of a full climate change analysis was not undertaken.

12 Climate change allowances for flood risk assessment in land use planning, Version 1, SEPA, 26/04/2019

9 Scheme Impact on Water Levels

Option 5b has been recommended as the preferred option, where the option is described in more detail in Section 7.9. Changes in water level from the scheme using the 0.5% AP (200 year) plus climate change event have been outlined in Figure 9-1 to Figure 9-4 below.

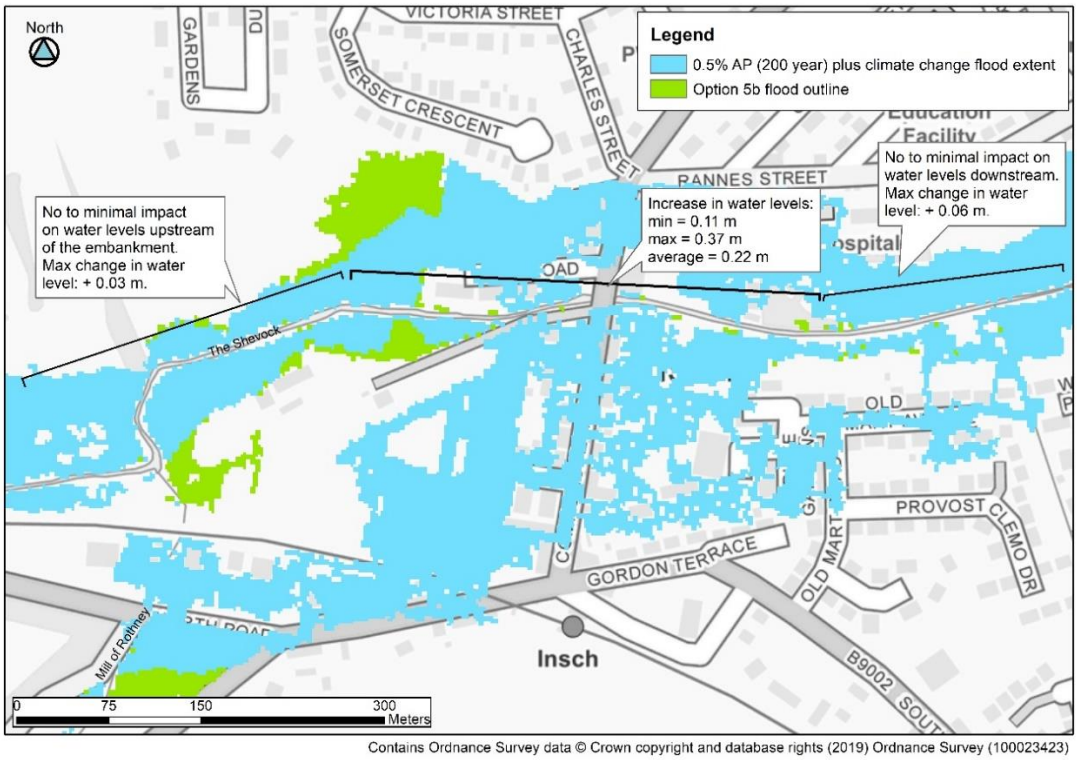

Figure 9-1: Change in water levels around Mill Road and Rannes Street

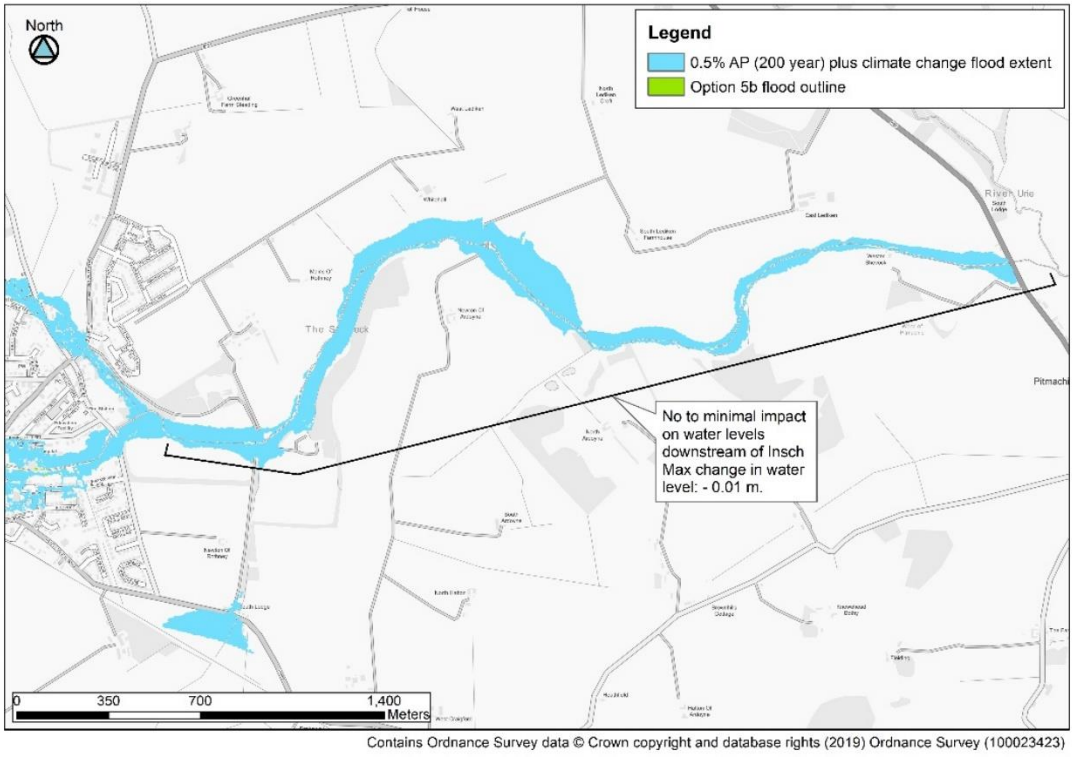

Figure 9-2: Change in water levels downstream of the proposed scheme extent

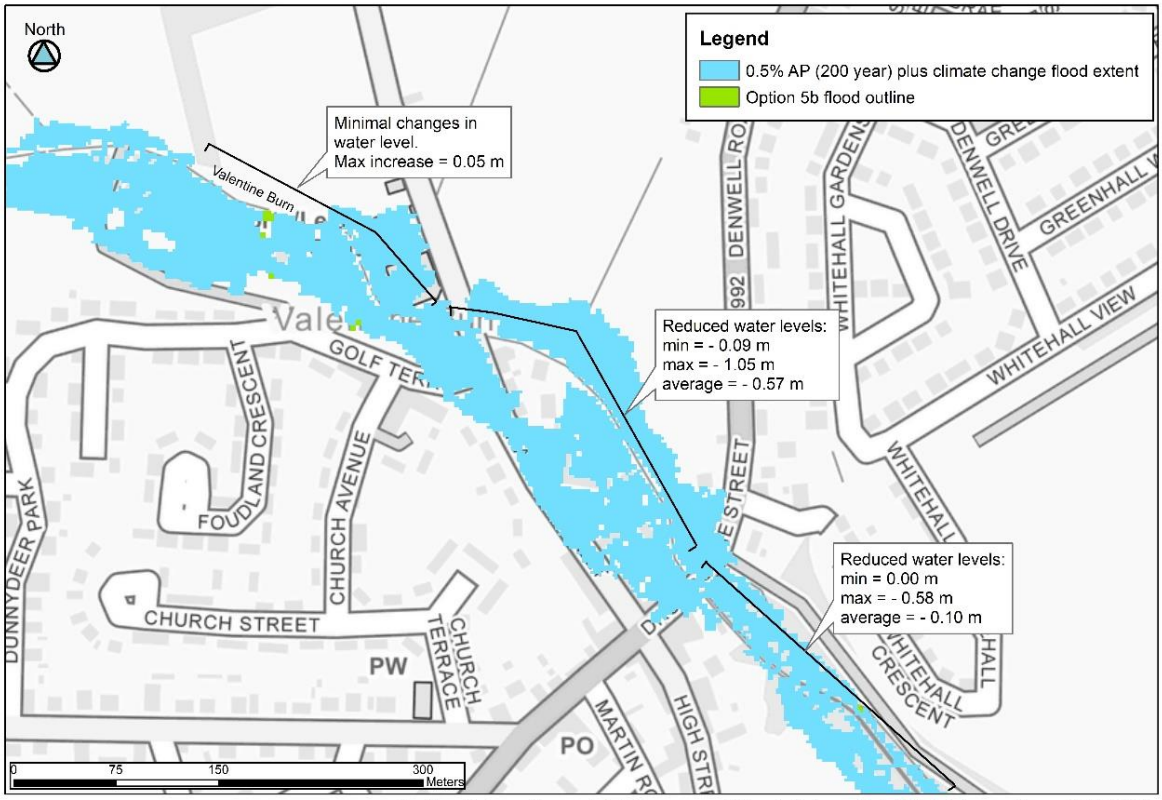

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Figure 9-3: Change in water levels around Market Street

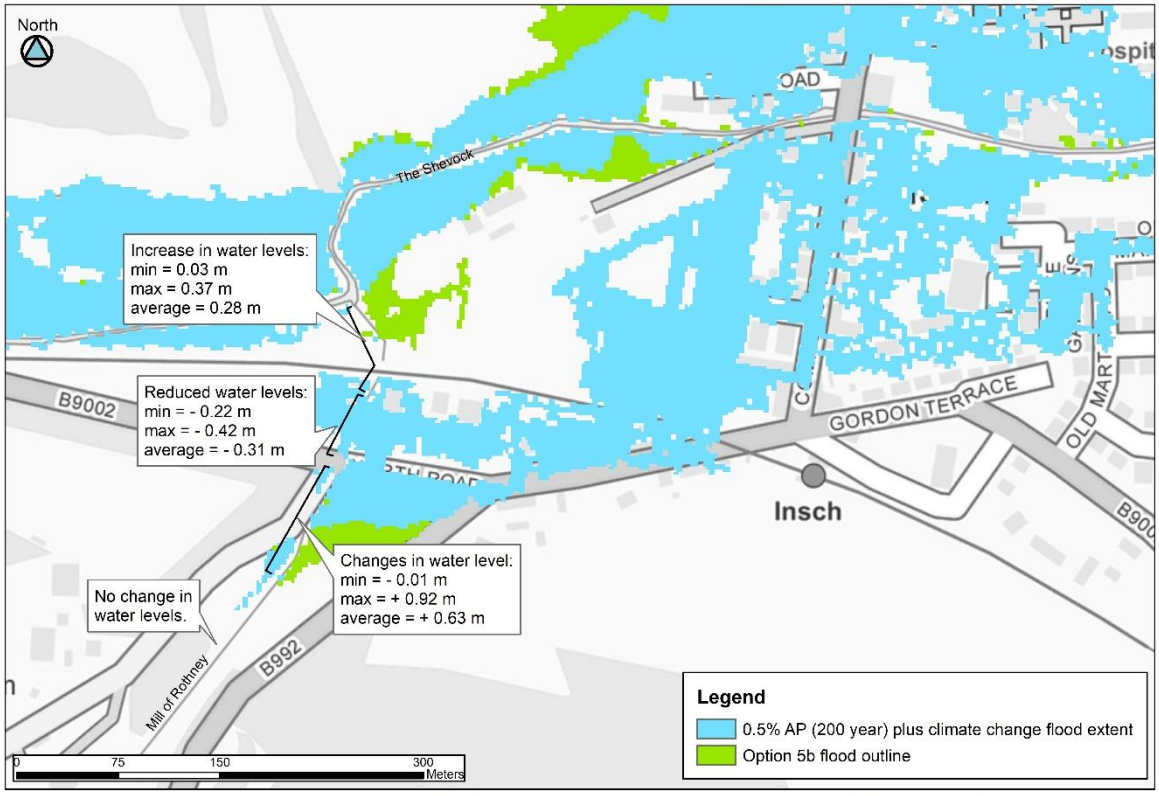

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Figure 9-4: Change in water levels around Insch industrial estate

The above figures show that the scheme changes water levels in different locations. Water levels immediately upstream and downstream of the Mill Road embankment increase (Figure 9-1). This is to be expected as the flow pathway along the left bank has been cut off and there is greater discharge from the Mill of Rothney into The Shevock. Higher water levels in the lower reaches of the Mill of Rothney are a result of the flow pathway towards Commercial Road being prevented (Figure 9-4). Water levels in The Shevock return towards pre-scheme levels downstream of Insch War Memorial Hospital (Figure 9-2). Due to the increase in water levels at Commercial Road Bridge further investigation into the effects of this through a detailed scour assessment would be required at detailed design stage. Large reductions in water level are seen downstream of Market Street culvert along the Valentine Burn as a result of the introduction of a two-stage channel and channel reprofiling (Figure 9-3). Water levels also reduce in the vicinity of the Drumrossie Street culvert as a result of the new culvert having greater capacity and thus not causing water to back up.

10 Stakeholder engagement

A stakeholder engagement meeting took place on 16 May 2019 to get a better understanding of how key stakeholders respond to the options that have been proposed by this study.

The options within the different design areas were presented and the following comments were made:

- Incorporation of damages to the railway was raised as this is a busy line and known to flood. Preventing flooding of the line would have high social and community benefits.
    - *We have undertaken a high level basic damages assessment not including damages to the railway line. If this is included there is potentially an additional £100k of disruption losses assuming flood risk to the rest of the line isn't affected.*
- It was noted an embankment on The Shevock may have a detrimental impact on the field to the south where there is approved planning permission, and to properties upstream and downstream of Commercial Road as a result of increased in-channel volumes.
    - *Flooding on the left bank in the proposed development area is a result of flooding from the Mill of Rothney, not The Shevock. Modelling the embankment by the residential home does not result in increased flood risk to the proposed new development site.*
    - *In-channel waters levels do increase downstream of the proposed embankment but did not increase flood risk to any properties.*
- Reprofiling of the channel through Insch Golf Course to improve the environmental and RBMP status of the watercourse was raised.
- The industrial site is a key business in the area and would not likely relocate.
- Culverting the Mill of Rothney through the industrial estate was raised and what size of culvert would be required.
- SEPA support the opportunity to de-culvert the Mill of Rothney through the industrial estate.

Two further engagement meetings were held with Scottish Water on 13 June 2019 and Network Rail on the 5 September 2019. Scottish Water highlighted a non-return valve was put in place near the Recycling Centre at Market Square 15 years ago. Network Rail stated they did not hold records of flooding to any of the structures within Insch, with no records of flooding for 7-8 years. This includes the under-bridge to the west of the station which would be part of any Area C options. At the time of the telecon Network Rail were unable to confirm if there were records of the line previously flooding.

11 Public Engagement

A public engagement event was held in Insch on 7 October 2019 to gauge public opinion on the flood mitigation options proposed as part of this study. Approximately 11 residents attended the event, and many offered their views on the options proposed. Of the residents who attended the breakdown of attendance by area was as follows:

- Area A (The Shevock) - 6
- Area B (Valentine Burn) - 2
- Area C (Mill of Rothney) - 3

Feedback was provided through both verbal conversations and returned written feedback forms. Key comments from the public meeting are summarised below:

- **Area A (The Shevock):** In general the residents were happy with the solution proposed for Area A. Residents indicated inspection and maintenance of the High Street bridge due to the risk of blockage, and previous flooding to the adjacent fields/ gardens running parallel to Rannes Street was discussed. An asset inspection, which included the High Street bridge, was carried out as part of this study and regular maintenance to prevent blockage has been recommended as a 'quick win'.
- **Area B (Valentine Burn):** Residents were happy with the proposed solutions for Area B. Residents highlighted a wall was historically constructed to protect the Dunchapel complex cottages (Market Street) in the 1980s. It was also noted Market Square regularly floods with a request to investigate drainage in this area.
- **Area C (Mill of Rothney):** Residents were happy with the proposed solutions for Area C. Gravel discharge into drains as well as culvert maintenance were noted as issues resulting in flooding in this area. Surface water flow down Premnay Road was indicated to be a source of flooding causing ponding on the corner of the B9002. There is a planning application for construction of a footpath south of North Road. This would be within the storage area proposed as part of Option C1.
- **General comments:**
    - Anecdotal evidence from residents verified the model outputs. For example the flow pathway from Drumdarroch residential home did result in flooding to a Mill Road property in February 2002.
    - Drainage was highlighted as being a problem in a number of areas in Insch with blocked and insufficient drainage resulting in flooding. Surface water flooding in Rannes Street gardens up to 30 cm in depth were noted.
    - Surface water flooding was indicated to affect the cottages on North Road. Sandbags were previously deployed to protect the cottages and flood waters affected the railway line at the Insch level crossing.
    - Structure maintenance to prevent blockage was raised. Blockage has been considered as part of this study and structure maintenance recommended as a 'quick win' to prevent flooding.
    - It was noted the Insch & District War Memorial Hospital is pumped 24/7 due to the high water table.
    - Local businesses and the Drumdarroch Residential Home were contacted about the public engagement event, but were unable to attend. These are key businesses that would be affected by proposed works.

12 Conclusions and recommendations

12.1 Summary

This report presents the results of a detailed flood risk appraisal for the community of Insch, focussing on the risk from four different watercourses; The Shevock, Mill of Rothney Burn, Newton of Rothney Burn and Valentine Burn. There is a history of flooding within the area of Insch with a particularly extreme event in 2002. During the Do Minimum scenario which follows conditions experienced today 46 properties are at risk from the 0.5% AP (200 year) plus climate change event.

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

The hydraulic model, consisting of a 1D/2D Flood Modeller and TUFLOW model covering an area from upstream of Shevock Farm to the A96 road bridge, immediately upstream of the River Urie confluence, 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. Once these maps were produced it was possible to review flood flow pathways and progress from a wide-ranging long-list of potential flood protection options to a short-list of feasible solutions tailored to Insch's flood risk problem. A feasibility analysis was conducted on a number of options which were likely to be unrealistic, any feasible options were taken forward into the shortlist appraisal.

Insch was split into 3 different design areas to tackle the flood risk based on differing flood mechanisms, after extensive review of the shortlisted options the following options for each design area were taken forward where different combinations were analysed to reach a preferred solution:

- **Design area A - The Shevock**
  - A1a: Embankment to the west of Drumdarroch residential home.
  - A1b: Embankment to the west of Drumdarroch residential home and formalisation of the Mill Road flood wall.
  - A2: Property Level Protection (PLP).
- **Design area B - Valentine Burn**
  - B1: Storage on Insch Golf Course, creation of a two-stage channel, culvert upgrades and channel reprofiling.
  - B3: Reduced storage on Insch Golf Course, creation of a two-stage channel, culvert upgrades and direct defences (embankment at Market Street).
  - B4: Property Level Protection (PLP).
  - B5b: No upstream storage, direct defences, creation of a two-stage channel, culvert upgrades and channel reprofiling.
- **Design area C - Mill of Rothney Burn**
  - C1: Direct defences and open channel restoration through the industrial estate.
  - C2: Culverting the Mill of Rothney between North Road bridge and the railway line along with a downstream set-back embankment.
  - C3: Property Level Protection (PLP).

A benefit-cost analysis has been undertaken for the present-day (Do Minimum) scenario and each of the above options. Costs for each option have been estimated using the Environment Agency's Long Term Costing tool (2012). An optimism bias factor of 60 % (or 30% for PLP) has been added to the total capital costs to allow for uncertainties in design at this level of appraisal and is typical for schemes at an early stage of appraisal.

12.2 Additional information and regulation requirements

If an option is taken forward the additional information outlined in the option descriptions in Section 5.8 should be addressed. As well as this the following regulations should be adhered to alongside all options:

- Should any options be taken forward the SEPA local regulatory team should be promptly contacted to discuss the design proposals in order to aid with completion of an environmental standards test to show how the works will not cause deterioration to any of the watercourse statuses.
- A future assessment will likely be required to investigate the morphological impact of the option and if any impacts can be further mitigated.
- Continued engagement with the Fisheries Board is advised to ensure the desired proposal does not impact fish spawning habitats.
- A Controlled Activities Regulations (CAR) construction site licence will be required for management of surface water run-off from a construction site, including access tracks, which:
    - Is more than 4 hectares,
    - Is in excess of 5 km, or
    - Includes an area of more than 1 hectare or length of more than 500 m on ground with a slope in excess of 25˚.
- It is strongly encouraged that pre-CAR application engagement with a member of the regulatory services team is made as early as possible.
- Below the thresholds listed above will need to comply with the CAR general binding rule 10[13] which requires, amongst other things, that all reasonable steps must be taken to ensure that the discharge does not result in pollution of the water environment.

12.3 Recommendations

The above analysis resulted in the following key recommendations for Insch:

Option 5 gives the best cost benefit ratio of 1.3 for the structural measures assessed and should be considered if a formal flood protection scheme is warranted. Following public engagement Option 5b is the recommended preferred option which includes the formalisation of a flood wall at Mill Road. This option incorporates both hard defences and channel restoration options, providing a 0.5% AP (200 year) +CC SoP. It is recommended a detailed investigation to determine the maximum possible size of culvert that could be installed at both Market and Drumrossie Street be carried out and the feasibility of relocating the electrical station as this will determine the ultimate viability of this option. The larger the culvert that can be installed the greater the climate change adaptability of this option. Relocation of the Golf Course Clubhouse and/ or community centre within Area B and potential for channel diversion could be alternative options in this area.

Of the storage options assessed Option 1 would be preferred as it maximises environmental benefits and flow conveyance within the Area B watercourse. However, there are constraints associated with development of a flood storage area on the Golf Course. Furthermore the cost benefit ratio for this option is below unity however, this could be alleviated by the addition of other indirect flood damages such as vehicle damage and temporary accommodation and evacuation losses.

If Option 1 and 5 cannot be achieved e.g. due to objection to reprofiling and/ or the proposed larger dimension culverts being unviable, Option 2 would be the preferred option. This combines hard defences with channel restoration opportunities providing a 0.5% AP (200 year) +CC level of protection but the Valentine culverts would be surcharged. It is therefore recommended a detailed investigation into the maximum possible size of culvert that could be installed, particularly at Drumrossie Street.

Option 4, PLP only, has a cost benefit ratio greater than one but is not a preferred long term sustainable option. This is because PLP cannot provide protection to all Mill Road properties making hard defences the only viable option of protection. PLP is not seen as a long-term solution where

13 SEPA, The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended), A Practical Guide, Version 8.3, February 2019

increases in flow from climate change is likely to surpass the 0.6 m threshold that a number of properties currently do not experience. There is still uncertainty into PLP funding. It is the responsibility of the homeowner to maintain the condition of PLP which cannot be guaranteed, and needs replaced every 25 years.

However, there may be merit in utilising PLP in the short term, particularly if a flood protection scheme is not progressed in the next FRM cycle. In order to implement this we would recommend that SEPA and the Council investigate installation of a flow gauge and development of a flood warning system for the town or wider catchment. Furthermore the Council could investigate a flood trigger alert for Commercial Bridge.

The process of Environmental Impact Assessment (EIA) ascertains the likely significant environmental effects from a proposal. An EIA screening opinion for the preferred option will be prepared and submitted to Aberdeenshire Council under The Flood Risk Management (Flood Protection Schemes, Potentially Vulnerable Areas and Local Plan Districts) (Scotland) Amendment Regulations 2017.

The difference in damages between the Do Minimum and Do Nothing scenario (roughly 40% reduction) highlights the need for watercourse maintenance within Insch showing its sensitivity to structure blockage and increased roughness. One key recommendation would be for routine maintenance in the area, in particular at the Market Street culvert which is prone to sedimentation and the Drumrossie Street culvert which has a trash screen.

Due to the high costing of the structured options investigation into the effectiveness of implementing more Natural Flood Management (NFM) into the area could be beneficial. The preliminary investigation highlighted multiple areas where NFM could be utilised well. In particular runoff reduction measures and increased storage within the Valentine Burn catchment, upstream of the proposed orifice, may reduce the height of the embankment required.

Appendices

A Appendix A - Damage Methodology

A.1 Direct damages - methodology

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

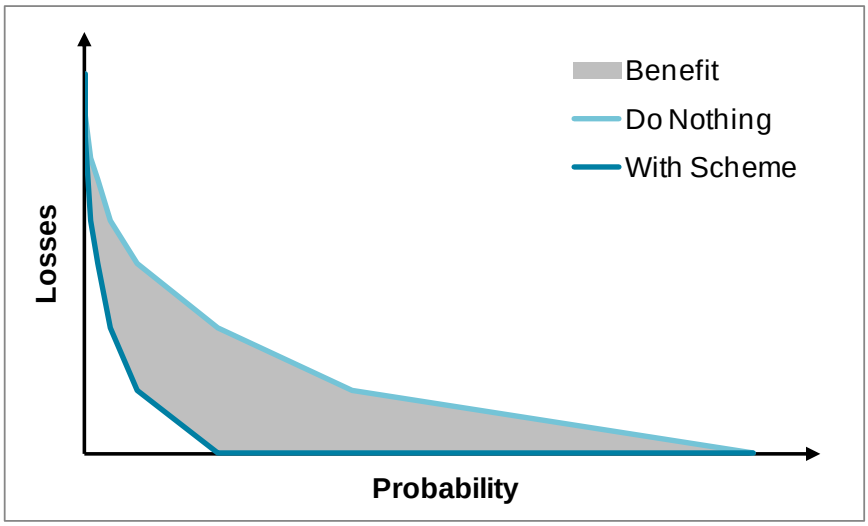

Figure A-1: Loss Probability Curve

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

A.1.1 Flood damage calculation and data

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

A flood damage estimate was generated using JBA's in-house flood damage tools. These estimate flood damages using FHRC data and the modelled flood level data. Each property data point was mapped on to its building's footprint. A mean, minimum and maximum flood level within each property is derived using GIS tools based on the range of flood levels around the building footprint. The inundation depth is calculated by comparing water levels with the surveyed threshold level. The mean (based on mean flood water level across the buildings floor area) flood damage estimates have been calculated and are presented in section 6.2.

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

Table A-1: Damage considerations and method

Aspect	Values used	Justification
Flood duration	<12hrs	Flood water is not anticipated to inundate properties for prolonged periods.
Residential 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 2017 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. These properties were visited by a JBA Surveyor during the threshold survey.

A.1.3 Capping

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

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

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

Rateable values for all available properties in Peebles were obtained from the Scottish Assessors Association website[14]. Equivalent yield varies regionally and temporarily, but is recommended to be a value of 10-12.5 for flood defence purposes[15]. A value of 12.5 was used.

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

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

A.1.4 Updating of Damage Values

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

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[16] 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.

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

B Appendix B - Economic Appraisal

Final Options Cost Benefit Summary

Client/Authority		Prepared (date)	
Aberdeenshire Council		Printed	18/10/2019
Project name		Prepared by	B.McIntosh
Insch FPS		Checked by	AEP
Project reference	2017s6743	Checked date	27/06/2019
Base date for estimates (year 0)	Jan-2019		
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 direct defences	60%		
Optimism bias adjustment factor PLP	30%		

Costs and benefits of options

Option number	Costs and benefits £k							
	Do Nothing	**Do Minimum**	**Option 1**	**Option 2**	**Option 3**	**Option 5**	**Option 5b**	**Option 4**
Option name	Do Nothing	Do Minimum	A - Option 1a (Embankment) B - Option 1 (US Storage, two-stage, reprofiling & culvert upgrades) C - Option 1 (Direct defences & new channel)	A - Option 1a (Embankment) B - Option 3 (US Storage, embankments, two-stage & culvert upgrades) C - Option 1 (Direct defences & new channel)	A - Option 1a (Embankment) B - Option 3 (US Storage, embankments, two-stage & culvert upgrades) C - Option 2 (Culvert & embankment)	A - Option 1a (Embankment) B - Option 5b (Direct defences, two-stage reprofiling & culvert upgrades) C - Option 1 (Direct defences & new channel)	A - Option 1b (Embankment & wall) B - Option 5b (Direct defences, two-stage reprofiling & culvert upgrades) C - Option 1 (Direct defences & new channel)	Full PLP
AEP or SoP (where relevant)			0.5% +CC	0.5% +CC	0.5% +CC	0.5% +CC	0.5% +CC	0.50%
COSTS:								
PV Enabling costs	0	0	302	260	257	199	223	79
PV Capital costs	0	0	3,072	2,657	2,626	2,017	2,255	1,146
PV operation and maintenance costs	0	0	207	154	132	148	151	370
Optimism bias adjustment	0	0	2,148	1,843	1,809	1,419	1,577	478
Total PV Costs £k excluding contributions	0	0	5,729	4,914	4,824	3,783	4,207	2,071
Total PV Costs £k taking contributions into account	0	0	5,729	4,914	4,824	3,783	4,207	2,071
BENEFITS:								
PV monetised flood damages	5,201	3,110	214	214	214	214	214	87
PV monetised flood damages avoided		2,091	4,986	4,986	4,986	4,986	4,986	4,295
Total PV damages £k	5,201	3,110	214	214	214	214	214	87
Total PV benefits £k		2,091	4,986	4,986	4,986	4,986	4,986	4,295
DECISION-MAKING CRITERIA:								
Based on monetised PV benefits (ex cludes benefits from scoring and weighting and ecosystem services)								
Net Present Value **NPV**		2,091	-743	72	162	1,203	780	2,224
Average benefit/cost ratio **BCR**			0.87	1.01	1.03	1.32	1.19	2.07
								Highest bcr IBCR>1
Best practicable environmental option (WPD)								

Brief description of options:

Do Nothing	Do Nothing
Do Minimum	Do Minimum
A - Option 1a (Embankment) B - Option 1 (US Storage, two-stage, reprofiling & culvert upgrades) C - Option 1 (Direct defences & new channel)	Option 1
A - Option 1a (Embankment) B - Option 3 (US Storage, embankments, two-stage & culvert upgrades) C - Option 1 (Direct defences & new channel)	Option 2
A - Option 1a (Embankment) B - Option 3 (US Storage, embankments, two-stage & culvert upgrades) C - Option 2 (Culvert & embankment)	Option 3
Full PLP	Option 4
A - Option 1a (Embankment) B - Option 5b (Direct defences, two-stage reprofiling & culvert upgrades) C - Option 1 (Direct defences & new channel)	Option 5
A - Option 1b (Embankment & wall) B - Option 5b (Direct defences, two-stage reprofiling & culvert upgrades) C - Option 1 (Direct defences & new channel)	Option 5b

Area A Cost Benefit Analysis

Client/Authority				Prepared (date)	
Aberdeenshire Council				Printed	06/08/2019
Project name				Prepared by	B.McIntosh
Insch FPS				Checked by	AEP
Project reference	2017s6743			Checked date	27/06/2019
Base date for estimates (year 0)	Jun-2019				
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 direct defences	60%				
Optimism bias adjustment factor PLP	30%				

Costs and benefits of options

	Costs and benefits £k					
Option number	**Do Nothing**	**Do Minimum**	**Option 1a**	**Option 1b**	**Option 2**	
Option name	Do Nothing	Do Minimum	Embankment	Embankment & wall upgrade	PLP	
AEP or SoP (where relevant)			0.5% +CC	0.5% +CC	0.50%	
COSTS:						
PV Enabling costs	0	0	24	48	16	
PV Capital costs	0	0	240	478	241	
PV operation and maintenance costs	0	0	24	27	78	
Optimism bias adjustment	0	0	173	332	101	
Total PV Costs £k excluding contributions	0	0	461	884	436	
Total PV Costs £k taking contributions into account	0	0	461	884	436	
BENEFITS:						
PV monetised flood damages	2,024	709	101	101	95	
PV monetised flood damages avoided		1,315	1,923	1,923	1,620	
Total PV damages £k	2,024	709	101	101	95	
Total PV benefits £k		1,315	1,923	1,923	1,620	
DECISION-MAKING CRITERIA:						
Based on monetised PV benefits (*ex* ***cludes benefits from scoring and weighting and ecosystem services)***						
Net Present Value **NPV**		1,315	1,462	1,039	1,184	
Average benefit/cost ratio **BCR**			4.2	2.2	3.7	
			Highest bcr IBCR>1			
Best practicable environmental option (WFD)						

Brief description of options:

Do Nothing	Do Nothing
Do Minimum	Do Minimum
Embankment	Option 1a
Embankment & wall upgrade	Option 1b
PLP	Option 2

Area B Cost Benefit Analysis

Client/Authority				Prepared (date)	
Aberdeenshire Council				Printed	06/08/2019
Project name				Prepared by	B.McIntosh
Insch FPS				Checked by	AEP
Project reference	2017s6743			Checked date	27/06/2019
Base date for estimates (year 0)	Jun-2019				
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 direct defences	60%				
Optimism bias adjustment factor PLP	30%				

Costs and benefits of options

	Costs and benefits £k							
Option number	**Do Nothing**	**Do Minimum**	**Option 1**	**Option 2**	**Option 3**	**Option 5a**	**Option 5b**	**Option 4**
Option name	Do Nothing	Do Minimum	Storage (50yr outflow), two stage, reprofiling & culvert upgrades	Storage (25yr outflow), two stage & culvert upgrades	Storage (50yr outflow), two stage, embankment & culvert upgrades	Direct defences, two stage & culvert upgrades	Direct defences, two stage, reprofiling & culvert upgrades	PLP
AEP or SoP (where relevant)			0.5% +CC	0.5% +CC	0.5% +CC	0.5% +CC	0.5% +CC	0.10%
COSTS:								
PV Enabling costs	0	0	222	200	181	114	120	32
PV Capital costs	0	0	2,296	2,068	1,881	1,183	1,241	460
PV operation and maintenance costs	0	0	150	91	97	27	92	149
Optimism bias adjustment	0	0	1,601	1,415	1,296	794	872	192
Total PV Costs £k excluding contributions	0	0	4,270	3,774	3,455	2,118	2,322	832
Total PV Costs £k taking contributions into account	0	0	4,270	3,774	3,455	2,118	2,322	832
BENEFITS:								
PV monetised flood damages	1,368	787	57	57	57	57	57	1
PV monetised flood damages avoided		580	1,311	1,311	1,311	1,311	1,311	1,148
PV monetised erosion damages	0	0	0	0	0	0	0	0
PV monetised erosion damages avoided (protected)		0	0	0	0	0	0	0
Total PV damages £k	1,368	787	57	57	57	57	57	1
Total PV benefits £k		580	1,311	1,311	1,311	1,311	1,311	1,148
DECISION-MAKING CRITERIA:								
Based on monetised PV benefits (*ex* ***cludes benefits from scoring and weighting and ecosystem services)***								
Net Present Value **NPV**		580	-2,959	-2,463	-2,144	-807	-1,011	316
Average benefit/cost ratio **BCR**			0.3	0.3	0.4	0.6	0.6	1.4
								Highest bcr
Best practicable environmental option (WFD)								

Brief description of options:

Do Nothing	Do Nothing
Do Minimum	Do Minimum
Storage (50yr outflow), two stage, reprofiling & culvert upgrades	Option 1
Storage (25yr outflow), two stage & culvert upgrades	Option 2
Storage (50yr outflow), two stage, embankment & culvert	Option 3
PLP	Option 4
Direct defences, two stage & culvert upgrades	Option 5a
Direct defences, two stage, reprofiling & culvert upgrades	Option 5b

Area C Cost Benefit Analysis

Client/Authority				Prepared (date)	
Aberdeenshire Council				Printed	06/08/2019
Project name				Prepared by	B.McIntosh
Insch FPS				Checked by	AEP
Project reference	2017s6743			Checked date	27/06/2019
Base date for estimates (year 0)	Jun-2019				
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 direct defences	60%				
Optimism bias adjustment factor PLP	30%				

Costs and benefits of options

Option number	Costs and benefits £k					
	Do Nothing	**Do Minimum**	**Option 1**	**Option 2**	**Option 3**	
Option name	Do Nothing	Do Minimum	Direct defences & new channel	New culvert & embankment	PLP	
AEP or SoP (where relevant)			0.5% +CC	0.5% +CC	0.10%	
COSTS:						
PV Enabling costs	0	0	55	52	31	
PV Capital costs	0	0	536	505	444	
PV operation and maintenance costs	0	0	32	11	143	
Optimism bias adjustment	0	0	374	341	185	
Total PV Costs £k excluding contributions	0	0	998	908	803	
Total PV Costs £k taking contributions into account	0	0	998	908	803	
BENEFITS:						
PV monetised flood damages	1,891	1,687	56	56	0	
PV monetised flood damages avoided		204	1,835	1,835	1,588	
PV monetised erosion damages	0	0	0	0	0	
PV monetised erosion damages avoided (protected)		0	0	0	0	
Total PV damages £k	1,891	1,687	56	56	0	
Total PV benefits £k		204	1,835	1,835	1,588	
DECISION-MAKING CRITERIA:						
Based on monetised PV benefits (*ex* ***cludes benefits from scoring and weighting and ecosystem services)***						
Net Present Value **NPV**		204	837	926	785	
Average benefit/cost ratio **BCR**			1.8	2.0	2.0	
				Highest bcr		
			IBCR>1			
Best practicable environmental option (WFD)						

Brief description of options:

Do Nothing	Do Nothing
Do Minimum	Do Minimum
Direct defences & new channel	Option 1
New culvert & embankment	Option 2
PLP	Option 3

Area A Option 1a Costing

Client/Authority		Prepared (date)	
Aberdeenshire Council		Printed	06/08/2019
Project/Option name		Prepared by	BM
Insch FPS 2017s6743		Checked by	AP
Project reference		Checked date	27/06/2019
Base date for estimates (year 0)	Jan-2019		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary	Costs in £k
Enabling Costs	£24.03
Capital Costs	£240.26
O & M Costs	£81.79
Other Costs	£0.00
Total Real Cost	£346.08
Total Cost PV	£288.09
Total Cost PV + OB	**£460.95**

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

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

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

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

Additional user notes:

Add additional user notes here.

FRM Measure	Asset	Open / Go to Costing Sheet	Delete Sheet	Enabling Costs	Capital Costs	O & M Costs	Other Costs	Total Cost Cash	Total Cost PV
Fluvial raised defence	Embankment			£24.03	£240.26	£81.79	£0.00	£346.08	£288.09
	Wall								
	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								
User Defined 2	Various								
User Defined 3	Various								

Area A Option 1b Costing

Client/Authority		Prepared (date)	
Aberdeenshire Council		Printed	06/08/2019
Project/Option name		Prepared by	BM
Insch FPS 2017s6743		Checked by	AP
Project reference		Checked date	27/06/2019
Base date for estimates (year 0)	Jan-2019		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary	Costs in £k
Enabling Costs	£47.78
Capital Costs	£477.78
O & M Costs	£93.55
Other Costs	£0.00
Total Real Cost	£619.11
Total Cost PV	£552.79
Total Cost PV + OB	**£884.46**

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			£24.03	£240.26	£81.79	£0.00	£346.08	£288.10
	Wall			£23.75	£237.52	£11.76	£0.00	£273.03	£264.69
	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								
User Defined 2	Various								
User Defined 3	Various								

Area A Option 2 Costing

Client/Authority		Prepared (date)	
Aberdeenshire Council		Printed	06/08/2019
Project/Option name		Prepared by	BM
Insch FPS 2017s6743		Checked by	AP
Project reference		Checked date	27/06/2019
Base date for estimates (year 0)	Jan-2019		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	30%		

PV Cost Summary	Costs in £k
Enabling Costs	£16.48
Capital Costs	£135.05
O & M Costs	£267.40
Other Costs	£445.66
Total Real Cost	£864.59
Total Cost PV	£335.51
Total Cost PV + OB	**£436.16**

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		Capital Costs	O & M Costs	Other Costs	Total Cost Cash	Total Cost PV
Fluvial raised defence	Embankment								
	Wall								
	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			£16.48	£135.05	£267.40	£445.66	£864.59	£335.51
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								
User Defined 2	Various								
User Defined 3	Various								

Area B Option 1 Costing

Client/Authority		Prepared (date)	
Aberdeenshire Council		Printed	06/08/2019
Project/Option name		Prepared by	BM
Insch FPS 2017s6743		Checked by	AP
Project reference		Checked date	27/06/2019
Base date for estimates (year 0)	Jan-2019		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary	Costs in £k
Enabling Costs	£222.31
Capital Costs	£2,296.00
O & M Costs	£516.97
Other Costs	£0.00
Total Real Cost	£3,035.27
Total Cost PV	£2,668.76
Total Cost PV + OB	**£4,270.02**

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

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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			£140.90	£1,458.97	£232.80	£0.00	£1,832.66	£1,667.62
	Wall								
	Sheet Piling								
Channel management	N/A			£43.81	£438.13	£223.43	£0.00	£705.37	£546.97
Culvert & screen	N/A			£24.61	£246.13	£7.18	£0.00	£277.92	£272.83
Control assets	Weir								
	Pumping station								
	Flood gate								
	Outfall			£9.16	£91.58	£53.56	£0.00	£154.29	£116.32
	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			£3.83	£61.20	£0.00	£0.00	£65.03	£65.03
User Defined 1	Various								
User Defined 2	Various								
User Defined 3	Various								

Area B Option 2 Costing

Client/Authority		Prepared (date)	
Aberdeenshire Council		Printed	06/08/2019
Project/Option name		Prepared by	BM
Insch FPS 2017s6743		Checked by	AP
Project reference		Checked date	27/06/2019
Base date for estimates (year 0)	Jan-2019		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary	Costs in £k
Enabling Costs	£199.55
Capital Costs	£2,068.47
O & M Costs	£312.41
Other Costs	£0.00
Total Real Cost	£2,580.44
Total Cost PV	£2,358.95
Total Cost PV + OB	**£3,774.32**

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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			£165.17	£1,701.67	£251.67	£0.00	£2,118.51	£1,940.08
	Wall								
	Sheet Piling								
Channel management	N/A								
Culvert & screen	N/A			£21.40	£214.03	£7.18	£0.00	£242.61	£237.52
Control assets	Weir								
	Pumping station								
	Flood gate								
	Outfall			£9.16	£91.58	£53.56	£0.00	£154.29	£116.32
	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			£3.83	£61.20	£0.00	£0.00	£65.03	£65.03
User Defined 1	Various								
User Defined 2	Various								
User Defined 3	Various								

Area B Option 3 Costing

Client/Authority		Prepared (date)	
Aberdeenshire Council		Printed	06/08/2019
Project/Option name		Prepared by	BM
Insch FPS 2017s6743		Checked by	AP
Project reference		Checked date	27/06/2019
Base date for estimates (year 0)	Jan-2019		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary	Costs in £k
Enabling Costs	£180.83
Capital Costs	£1,881.29
O & M Costs	£334.43
Other Costs	£0.00
Total Real Cost	£2,396.56
Total Cost PV	£2,159.45
Total Cost PV + OB	**£3,455.13**

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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			£146.45	£1,514.48	£273.70	£0.00	£1,934.63	£1,740.59
	Wall								
	Sheet Piling								
Channel management	N/A								
Culvert & screen	N/A			£21.40	£214.03	£7.18	£0.00	£242.61	£237.52
Control assets	Weir								
	Pumping station								
	Flood gate								
	Outfall			£9.16	£91.58	£53.56	£0.00	£154.29	£116.32
	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			£3.83	£61.20	£0.00	£0.00	£65.03	£65.03
User Defined 1	Various								
User Defined 2	Various								
User Defined 3	Various								

Area B Option 4 Costing

Client/Authority		Prepared (date)	
Aberdeenshire Council		Printed	06/08/2019
Project/Option name		Prepared by	BM
Insch FPS 2017s6743		Checked by	AP
Project reference		Checked date	27/06/2019
Base date for estimates (year 0)	Jan-2019		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	30%		

PV Cost Summary	Costs in £k
Enabling Costs	£31.65
Capital Costs	£257.71
O & M Costs	£510.26
Other Costs	£850.43
Total Real Cost	£1,650.04
Total Cost PV	£640.44
Total Cost PV + OB	**£832.57**

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		Capital Costs	O & M Costs	Other Costs	Total Cost Cash	Total Cost PV
Fluvial raised defence	Embankment								
	Wall								
	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			£31.65	£257.71	£510.26	£850.43	£1,650.04	£640.44
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								
User Defined 2	Various								
User Defined 3	Various								

Area B Option 5a Costing

Client/Authority		Prepared (date)	
Aberdeenshire Council		Printed	06/08/2019
Project/Option name		Prepared by	BM
Insch FPS 2017s6743		Checked by	AP
Project reference		Checked date	27/06/2019
Base date for estimates (year 0)	Jan-2019		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary	Costs in £k
Enabling Costs	£114.00
Capital Costs	£1,182.92
O & M Costs	£93.52
Other Costs	£0.00
Total Real Cost	£1,390.44
Total Cost PV	£1,324.14
Total Cost PV + OB	**£2,118.62**

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

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

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

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

Additional user notes:

Add additional user notes here.

FRM Measure	Asset	Open / Go to Costing Sheet	Delete Sheet	Enabling Costs	Capital Costs	O & M Costs	Other Costs	Total Cost Cash	Total Cost PV
Fluvial raised defence	Embankment			£30.51	£305.13	£74.33	£0.00	£409.98	£357.28
	Wall			£56.46	£584.59	£12.01	£0.00	£653.05	£644.54
	Sheet Piling								
Channel management	N/A								
Culvert & screen	N/A			£23.20	£232.01	£7.18	£0.00	£262.38	£257.29
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			£3.83	£61.20	£0.00	£0.00	£65.03	£65.03
User Defined 1	Various								
User Defined 2	Various								
User Defined 3	Various								

Area B Option 5b Costing

Client/Authority		Prepared (date)	
Aberdeenshire Council		Printed	06/08/2019
Project/Option name		Prepared by	BM
Insch FPS 2017s6743		Checked by	AP
Project reference		Checked date	27/06/2019
Base date for estimates (year 0)	Jan-2019		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary	Costs in £k
Enabling Costs	£119.82
Capital Costs	£1,241.10
O & M Costs	£315.14
Other Costs	£0.00
Total Real Cost	£1,676.05
Total Cost PV	£1,452.63
Total Cost PV + OB	**£2,324.22**

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			£26.91	£269.06	£74.33	£0.00	£370.29	£317.60
	Wall			£20.66	£226.59	£5.44	£0.00	£252.69	£248.83
	Sheet Piling								
Channel management	N/A			£43.81	£438.13	£228.18	£0.00	£710.13	£548.35
Culvert & screen	N/A			£24.61	£246.13	£7.18	£0.00	£277.92	£272.83
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			£3.83	£61.20	£0.00	£0.00	£65.03	£65.03
User Defined 1	Various								
User Defined 2	Various								
User Defined 3	Various								

Area C Option 1 Costing

Client/Authority		Prepared (date)	
Aberdeenshire Council		Printed	06/08/2019
Project/Option name		Prepared by	BM
Insch FPS 2017s6743		Checked by	AP
Project reference		Checked date	27/06/2019
Base date for estimates (year 0)	Jan-2019		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary	Costs in £k
Enabling Costs	£55.37
Capital Costs	£535.79
O & M Costs	£111.66
Other Costs	£0.00
Total Real Cost	£702.82
Total Cost PV	£623.66
Total Cost PV + OB	**£997.85**

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

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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			£42.37	£423.67	£110.11	£0.00	£576.14	£498.08
	Wall			£7.71	£77.13	£1.55	£0.00	£86.39	£85.29
	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			£1.03	£26.45	£0.00	£0.00	£27.48	£27.48
User Defined 1	Various			£4.27	£8.54	£0.00	£0.00	£12.81	£12.81
User Defined 2	Various								
User Defined 3	Various								

Area C Option 2 Costing

Client/Authority		Prepared (date)	
Aberdeenshire Council		Printed	06/08/2019
Project/Option name		Prepared by	BM
Insch FPS 2017s6743		Checked by	AP
Project reference		Checked date	27/06/2019
Base date for estimates (year 0)	Jan-2019		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary	Costs in £k
Enabling Costs	£51.89
Capital Costs	£504.71
O & M Costs	£38.32
Other Costs	£0.00
Total Real Cost	£594.92
Total Cost PV	£567.75
Total Cost PV + OB	**£908.40**

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

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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			£4.30	£42.98	£17.62	£0.00	£64.90	£52.41
	Wall								
	Sheet Piling								
Channel management	N/A								
Culvert & screen	N/A			£43.32	£433.19	£20.70	£0.00	£497.21	£482.54
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			£4.27	£28.54	£0.00	£0.00	£32.81	£32.81
User Defined 2	Various								
User Defined 3	Various								

Area C Option 3 Costing

Client/Authority		Prepared (date)	
Aberdeenshire Council		Printed	06/08/2019
Project/Option name		Prepared by	BM
Insch FPS 2017s6743		Checked by	AP
Project reference		Checked date	27/06/2019
Base date for estimates (year 0)	Jan-2019		
Scaling factor (e.g. £m, £k, £)	£k		
Optimism bias adjustment factor	60%		

PV Cost Summary	Costs in £k
Enabling Costs	£30.56
Capital Costs	£248.60
O & M Costs	£492.22
Other Costs	£820.37
Total Real Cost	£1,591.75
Total Cost PV	£617.83
Total Cost PV + OB	**£988.53**

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		Capital Costs	O & M Costs	Other Costs	Total Cost Cash	Total Cost PV
Fluvial raised defence	Embankment								
	Wall								
	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			£30.56	£248.60	£492.22	£820.37	£1,591.75	£617.83
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								
User Defined 2	Various								
User Defined 3	Various								

C Appendix C - Do Nothing Assumptions

C.1 Outline of the problem

Based on the 1000 year design event there are 51 properties at risk of flooding within Insch; 12 from The Shevock, 20 from the Valentine Burn and 17 from the Mill of Rothney Burn and 2 from the Newton of Rothney Burn. Flooding is expected to begin at the 2 year return period under the existing site conditions from the Valentine Burn, 5 year return period on the Mill of Rothney Burn and 30 year return period on The Shevock.

C.2 Consequences of Doing Nothing

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

C.3 Do Nothing

C.3.1 The Shevock

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

It is recommended that bridge blockage is included in the Do Nothing scenario. A full list of the structures to be blocked can be found in below which have been determined using a risk-based analysis.

C.3.2 Valentine Burn

Under the Do nothing scenario the watercourse would not be maintained. This would lead to a gradual degradation of the banks and vegetation growth. However, as the floodplain, in some areas, is used for recreational use on the golf course, it is likely to remain well maintained for non-flood reasons; thus the banks of floodplain roughness is not anticipated to increase significantly. The Do Nothing scenario is represented in the model as a 20% increase in Manning's 'n' roughness throughout the appraisal period.

It is recommended that bridge blockage is included in the Do Nothing scenario. A full list of the structures to be blocked can be found in below which have been determined using a risk-based analysis.

C.3.3 Mill of Rothney Burn

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

It is recommended that bridge blockage is included in the Do Nothing scenario. A full list of the structures to be blocked can be found in below which have been determined using a risk-based analysis.

C.3.4 Newton of Rothney Burn

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

C.4 Do Minimum

The Do Minimum scenario effectively represents the current scenario whereby the watercourse and all structures are maintained and replaced if they deteriorate to a point that is unacceptable. There are no flood defences within the community.

C.5 Blockage Scenario

A risk based analysis for all the structures in Insch was carried out to determine which structures are most likely to block in a Do Nothing Scenario. The tables below show the parameters and results that were evaluated as these are the most likely to pose a risk of blockage.

The following bridges or culverts, determined by either a B (bridge) or C (culvert) after the structure name, will be modelled using the following method:

- SHEV01_5362B - Central pier has been extended by 1 m in total.
- SHEV01_3085B - Soffit level dropped by 0.4 m.
- VAL01_0756B - Soffit level dropped by 0.3 m.
- VAL01_0702B - Soffit level dropped by 0.3 m.
- VAL01_0622C - Soffit level dropped by 0.1 m
- VAL01_0354C - Soffit level dropped by 0.2 m.
- TRIB01_0138B - Soffit level dropped by 0.4 m.
- TRIB01_0115C - Diameter of upstream conduit decreased by 0.3 m.
- TRIB01_0062B - Soffit level dropped by 0.3 m.
- TRIB02_0675C - Soffit level dropped by 0.3 m.

Blockage Scenario - The Shevock								
Structure	**Flow Area (m^2)**	**History of blockage**	**Screen**	**Central pier**	**Upstream land use**	**Would blockage pose a risk to upstream and downstream properties**	**To be included in blockage scenario**	**Explanation**
SHEV01_7499B	1	no	no	no	Arable farmland	no	no	No residential properties near by.
SHEV01_7325	1	no	no	no	Arable farmland	no	no	No residential properties near by.
SHEV01_7033	1	no	no	no	Arable farmland	no	no	No residential properties near by.
SHEV01_6903	3	no	no	no	Arable farmland	no	no	Low risk of blockage and good condition.
SHEV01_6530	2	no	no	no	Arable Farmland	no	no	Arable farmland no trees.
SHEV01_5362B	1	no	no	yes	Arable Farmland	no	**yes**	Central Pier may cause blockage and high vegetation growth upstream.
SHEV01_4245	4.3	no	no	no	Residential Area	no	no	Moderate risk of blockage but good condition.
SHEV01_4037	4	no	no	no	Residential Area	no	no	Low risk of blockage, high soffit and flow area.
SHEV01_3716	5.13	no	no	no	Scattered woodland	no	no	High soffit so unlikely to block.
SHEV01_3610	6	no	no	no	Woodland	no	no	Moderate risk of blockage but wide span.
SHEV01_3085B	10.5	no	no	no	Arable farmland	no	**yes**	Moderate risk of blockage and vegetation growth.
SHEV01_2494B	unknown	no	yes	no	Arable farmland	no	no	High risk of blockage but not close to residential property.
SHEV01_1763B	4.5	no	no	no	Arable farmland	no	no	High risk of blockage but not close to residential property.

Blockage Scenario - Valentine Burn								
Structure	**Flow Area (m^2)**	**History of blockage**	**Screen**	**Central pier**	**Upstream land use**	**Would blockage pose a risk to upstream and downstream properties**	**To be included in blockage scenario**	**Explanation**
VAL01_1324B	1	no	no	no	Golf course	no	no	Moderate risk of blockage but likely to be well maintained
VAL01_1267B	1	no	no	no	Golf course	no	no	Moderate risk of blockage but likely to be well maintained
VAL01_1214B	1	no	no	no	Golf course	no	no	Moderate risk of blockage but likely to be well maintained
VAL01_1131B	1	no	no	no	Golf course	no	no	Moderate risk of blockage but likely to be well maintained
VAL01_1114B	1	no	no	no	Golf course	no	no	Moderate risk of blockage but likely to be well maintained
VAL01_1081B	1	no	no	no	Golf course	no	no	Moderate risk of blockage but likely to be well maintained
VAL01_0979B	1	no	no	no	Golf course	no	no	Moderate risk of blockage but likely to be well maintained
VAL01_0920C	4	no	no	no	Golf course	no	no	High risk of blockage but likely to be well maintained
VAL01_0878C	2	no	no	no	Golf course	no	no	Moderate risk of blockage but likely to be well maintained
VAL01_0756B	3	no	no	no	Residential	yes	**yes**	Moderate risk of blockage
VAL01_0702B	2.25	no	no	no	Residential	yes	**yes**	Moderate risk of blockage
VAL01_0622C	1.28	no	no	no	Residential	yes	**yes**	High risk of blockage
VAL01_0354C	1.5	no	yes	no	Residential	yes	**yes**	High risk of blockage
VAL01_0018C	1	no	yes	no	Woodland	no	no	High risk of blockage but not close to residential property

Blockage Scenario- Mill of Rothney								
Structure	**Flow Area (m^2)**	**History of blockage**	**Screen**	**Central pier**	**Upstream land use**	**Would blockage pose a risk to upstream and downstream properties**	**To be included in blockage scenario**	**Explanation**
TRIB01_0138B	1	no	no	no	Mixed farmland	yes	**yes**	Small flow area
TRIB01_0115C	2	no	no	no	Industrial	yes	**yes**	Small flow area
TRIB01_0062B	unknown	no	no	no	Industrial	yes	**yes**	Small flow area

Blockage Scenario- Newton of Rothney								
Structure	**Flow Area (m^2)**	**History of blockage**	**Screen**	**Central pier**	**Upstream land use**	**Would blockage pose a risk to upstream and downstream properties**	**To be included in blockage scenario**	**Explanation**
TRIB02_0675C	1	no	no	no	Arable farmland	yes	**yes**	High risk of blockage and small flow area

Section number and bridge name (highlighted have been selected for blockage)	Structure unit type (highlighted have been selected for blockage)	Photo
The Shevock		
SHEV01_7499B Field Bridge	USBPR Bridge	
SHEV01_7325	USBPR Bridge	
SHEV01_7033	USBPR Bridge	

SHEV01_6903 ANI1 293/111 Railway bridge	USBPR Bridge	
SHEV01_6530 Masonry bridge	Arch Bridge	
SHEV01_5362B ANI1 293/109 Railway bridge	USBPR Bridge	
SHEV01_4245 Bridge of Rothney	Arch Bridge	

SHEV01_4037 Old Mart Footbridge	USBPR Bridge	
SHEV01_3716 Bridge of Insch	Arch Bridge	
SHEV01_3610 Insch Meadows Pedestrian Bridge	USBPR Bridge	
SHEV01_3085B Drumrossie House Bridge	Arch Bridge	

SHEV01_2494B Mains of Rothney Footbridge	USBPR Bridge	
SHEV01_1763B Vehicular bridge	USBPR Bridge	
Valentine Burn		
VAL01_1324B Golf Course pedestrian bridge	USBPR Bridge	
VAL01_1267B Golf Course pedestrian bridge	USBPR Bridge	

VAL01_1214B Golf Course pedestrian bridge	USBPR Bridge	
VAL01_1131B Golf Course pedestrian bridge	USBPR Bridge	
VAL01_1114B Golf Course pedestrian bridge	USBPR Bridge	
VAL01_1081B Golf Course pedestrian bridge	USBPR Bridge	

VAL01_0979B Golf Course pedestrian bridge	USBPR Bridge	
VAL01_0920C Golf Course culvert	Circular culvert	
VAL01_0878C Insch Golf Club Centenary Bridge	Sprung arch culvert	
VAL01_0756B Pedestrian Bridge	USBPR Bridge	

VAL01_0702B Golf Course pedestrian bridge	USBPR Bridge	
VAL01_0622C Bennachie Bridge	Circular culvert	
VAL01_0354C Drumrossie Street Bridge	Full arch culvert	

VAL01_0018C Insch Meadows culvert	Circular culvert	
Mill of Rothney Burn		
TRIB01_0138B Culvert B9002	USBPR bridge	
TRIB01_0115C Pipe upstream of Rothney Railway Bridge	Circular culvert	
TRIB01_0062B Railway Bridge	USBPR bridge	

Newton of Rothney Burn		
TRIB02_0675C South Road culvert B9002	Rectangular culvert	

D Appendix D - Options Drawings

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

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