# Integrating natural capital into flood risk management appraisal

Study Report

September 2020

Mott MacDonald
Ground Floor West
19A Canning Street
Edinburgh EH3 8EG
United Kingdom

T +44 (0)131 221 2300
mottmac.com

Tweed Forum
Old Melrose Dairy Steading
TD6 9DF

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# Acknowledgements

This document was prepared with significant guidance and direction from a Steering Group comprising of individuals representing the following organisations.

- Luke Comins – Tweed Forum
- Chris Spray – University of Dundee / Tweed Forum
- Debi Garft, Ian Chalmers & Michelagh O'Neill – Scottish Government
- Duncan Morrison – Scottish Borders Council
- Nicola Melville – Scottish Environment Protection Agency
- Mary Christie – Scottish Natural Heritage / NatureScot

The following individuals were also invited to comment on draft study outputs and, where appropriate, attend Steering Group meetings:

- Heather Forbes – SEPA, NFM policy lead
- Helen Panter – SEPA, Flood appraisal policy lead

# Glossary of key terms and anacronyms

The following key terms and anacronyms are used in this document.

| | |
|---|---|
| **Action,** or **flood risk management action** | Terminology used within Options appraisal for flood risk management; Guidance to support SEPA and the responsible authorities (Scottish Government, 2016). An action may consist of a single intervention (e.g. build a storage reservoir) or could be two or more interventions, where the presence of one is essential to the success of another (e.g. demountable defences and flood warning system). See also “flood risk management measure”. |
| **AEP** | Annual Exceedance Probability |
| **Appraisal Guidance** | Refers to the guidance within *Flood Risk Management (Scotland) Act 2009: Options appraisal for flood risk management: Guidance to support SEPA and the responsible authorities* (Scottish Government, 2016)**.** |
| **B£ST** | Benefits Estimation Tool released by CIRIA for the estimation of ecosystem services (CIRIA, 2019). It is a free tool that provides a structured approach to evaluating a wide range of benefits from blue-green infrastructure including SuDS and natural flood management. |
| **BCR**, or **benefit cost ratio** | The ratio of the present value of benefits to the present value of costs. If the ratio is greater than one, then the project is deemed to be viable. |
| **Eligible costs** | Local Authorities can only claim Capital Grant Funding for costs directly associated with the flood protection works (Scottish Government, June 2020). A local authority may add additional works such as public realm improvements to their scheme, but these additional costs do not attract flood element grant and should not be included when making returns for flood protection scheme grant allocation purposes. |
| **ESS,** or **ecosystem service** | The benefits people obtain from ecosystems. These include provisioning services such as food and clean water; regulating services such as flood protection, carbon sequestration and disease control; cultural services such as recreation and wellbeing. Refer also to multiple benefits. |
| **IBCR**, or **incremental benefit cost ratio** | The ratio of the additional benefit to the additional cost, when two options with different standards of protection are compared. |

| | |
|---|---|
| **Measure**, or **flood risk management measure** | Terminology used within the Flood Risk Management Scotland Act 2009, includes formal flood protection schemes, natural flood measures and blended approach. See also “flood risk management action”. |
| **Multiple benefits** | Improvements to the environment or community occurring through a specific intervention or process that have more than one benefit. Refer to ecosystem services. |
| **Natural capital** | Stocks of the elements of nature that have value to society, such as forests, fisheries, rivers, biodiversity, land and minerals. Natural capital includes both the living and non-living aspects of ecosystems. Stocks of natural capital provide flows of environmental or ‘ecosystem’ services over time. |
| **NFM**, or **natural flood management** | Flood risk management techniques that aim to work with natural hydrological and morphological processes, features and characteristics to manage the sources and pathways of flood waters. These techniques include the restoration, enhancement and alteration of natural features and characteristics, but exclude traditional flood defence engineering that works against or disrupts these natural processes. |
| **NPV**, or **net present value** | Net Present Value is the value of all future cash flows (positive and negative) over the entire life of an investment discounted to represent the equivalent present value. |
| **PV**, or **present value** | The value in the present of a sum of money, in contrast to some future value it will have when it has been invested at compound interest. |
| **SEPA** | Scottish Environment Protection Agency. |
| **Six capitals** | The six capitals are stocks of value that are affected or transformed by the activities and outputs of an organisation. Categorised as financial, manufactured, intellectual, human, social and relationship, and natural. |
| **SNH** | Scottish Natural Heritage. Note that SNH changed its name to NatureScot after the initial drafting of this document. |
| **SOP,** or **standard of protection** | The frequency of flooding that a flood risk management measure is designed to protect against flooding. |

# Contents

# Executive summary

The Eddleston Water Project is the Scottish Government's long-term study of the implementation and effectiveness of Natural Flood Management (NFM) measures to reduce flood risk, improve wetland habitats and to deliver multiple benefits in the Eddleston Water catchment. It is led by the Tweed Forum and has been undertaken with the support of the EU Interreg North Sea Region *Building with Nature* programme.

This study builds on ongoing research and previously installed NFM measures within the catchment by proposing and testing a standardised methodology for Responsible Authorities (primarily Local Authorities) and other relevant stakeholders to incorporate multiple (environmental and social) costs and benefits in flood risk management appraisals. This report documents how the proposed method can be effectively integrated into current flood risk management decision-making processes.

The main aim of this study is to identify how multiple benefits in the form of natural capital and ecosystem services can be most effectively integrated into current decision-making processes for appraisal of flood risk management measures in Scotland. The scope of the study is not limited to NFM and the methodology should also be suitable for traditional flood risk management measures, thereby allowing holistic appraisal of all flood risk management measures using a single consistent methodology.

This study aims to:

1. Review the potential methodologies for assessing multiple benefits that may accrue from the use of NFM measures in flood risk reduction
2. Identify the preferred methodology for valuing multiple benefits
3. Identify how the chosen methodologies for assessing multiple benefits can be most effectively integrated into current decision-making processes for appraisal of flood risk management measures in Scotland
4. Test the chosen process against different scenarios of NFM implementation and flooding in Peebles and Eddleston, as part of the Eddleston Water Project
5. Recommend a method that can be utilised elsewhere using readily accessible and available data sources and appropriate models, backed by a short practical guide

Following a review of best practice and a consultation exercise, involving a stakeholder survey and Steering Group workshops, B£ST (CIRIA, 2019) was identified as the leading appraisal tool to support the evaluation of multiple benefits within flood risk management projects.

The key factors for the selection of B£ST are:

- The tool is open access and does not require any specialist software.
- It is suitable for assessing the multiple benefits on a wide range of flood risk management action types and is not limited to the assessment of Natural Flood Management measures. Where appropriate it can be used to quantify disbenefits (detriment) in addition to benefits.
- It is applicable for use in appraisals considering all project scales and types of flooding including fluvial, coastal and surface water flooding.
- It is provided with an accompanying guidance document that provides relevant information and data requirements.

- It includes screening and coarse assessment tools which could be included earlier within the planning process to provide initial or high-level results.
- The tool is able to map value change across all six capitals, as listed within the integrated reporting framework, within the study area.
- The valuation methodology in the tool is in line with good practice, as well as with government appraisal guidance (HM Treasury, 2018) and consistent with other approaches in the sector.
- The latest release includes a comparison tool that enables the comparison of more than one assessment within a project.
- It is already the most well-known tool within the target user community (although the extent of the target community's experience in using the tool is thought to be low).
- The developer, CIRIA, reports that B£ST is not a single release and will be updated in the future.

Although identified as the most suitable tool, it is acknowledged that B£ST is not an all-encompassing solution to the assessment of multiple benefits. The identified limitations of the tool include:

- It does not currently incorporate a spatial element to the assessment of wider benefits (in March 2020 CIRIA announced plans to incorporate a spatial user interface in the next release).
- It has limited opportunity for supporting the identification of opportunities.
- B£ST does not specifically allow for the incorporation of peatland carbon sequestration and relies on an external tool to assess woodland carbon sequestration.
- As with all methods, it may be appropriate to obtain more detailed or locally based information when doing more detailed studies or where decisions are sensitive to small changes in the generalised national data within the tool.
- Following on from the preceding point, B£ST was primarily developed using English and Welsh data, therefore the B£ST guidance and tool terminology sometimes deviate from that used in Scotland. It is also necessary for users to select appropriate donor locations from those available from England and Wales in tool options.

Specific recommendations for the improvement of B£ST are detailed below. These improvements are likely to require the contribution of funding by a Scottish stakeholder i.e. SEPA, SNH or the Scottish Government.

- Developing functionality to support the spatial assessment and reporting of multiple benefits. At the time of writing, plans have been announced for the incorporation of a spatial tool in the next release of B£ST (CIRIA, 2020).
- Improving the tool to support the identification of opportunities.
- Extension of the terminology and geographic areas in B£ST to better align with Scottish needs. This is most notable in relation to:
  - The assessment of the aquatic environment (Water quality and Water Quantity in B£ST) where English and Welsh river basins, guidance and Water Framework Directive terminology is currently used.
  - The assessment of flood damages avoided within B£ST references the use of the English Partnership Funding Calculator and Flood Defence Grant in Aid for very rapid assessments in place of the Multi Coloured Handbook (Flood Hazard Research Centre, 2020). The text within B£ST should be updated to provide better direction to users outside England.

- Addition of an in-built methodology for assessing the carbon sequestration by peatlands and woodlands should be included. It would also be beneficial for guidance to be provided on the use of the Woodland Carbon Code calculator in Scotland.
- Increasing in the number of supporting references and papers to allow for a more diverse selection of values.

A review of the existing flood risk management appraisal guidance (Scottish Government, 2016), hereafter referred to as the Scottish Appraisal Guidance, identified opportunities for B£ST to be integrated into the current decision-making process and inform the appraisal of flood risk management options as detailed below.

1. **Setting objectives** - B£ST can encourage appraisals to set specific and measurable environmental enhancement objectives at the start of the appraisal process. While B£ST does not provide an integrated approach for the identification of opportunities or setting objectives, it does provide a means to set defined ways to measure objectives as well as recording evidence that options are likely to meet objectives.
2. **Long list appraisal** - The existing Scottish Appraisal Guidance for long list option screening provides a satisfactory approach for option screening and should be followed during the long list stage. B£ST incorporates three levels of assessments each targeted at different project scales and needs. The basic Screening and Coarse Assessment tools are rapid qualitative and quantitative approaches respectively. Both are suitable for the early stages of appraisals.
3. **Short list appraisal** - The Scottish Appraisal Guidance provides flexibility in the selection of the preferred option citing that issues should be balanced to identify the most sustainable solution. B£ST can be used to inform the decision-making criteria outlined in the Scottish Appraisal Guidance, as detailed below. It should be noted that B£ST, and ecosystem service analysis methods more generally, are not applicable to all appraisal steps.
    a. **Meeting objectives** - B£ST does not provide an integrated approach for the identification of opportunities or setting objectives. It does provide a way of testing and recording that options meet objectives.
    b. **Value for money** - Following consultation with the Scottish Government this project proposes that the assessment of “best value for money” should only consider flood damages avoided and “eligible costs” (Scottish Government, June 2020) . Additional benefits, not directly associated with a reduction in flood damages, should be reported within the separate “multiple benefits” metric. On the basis of not supporting the assessment of flood damages avoided there is no current role for B£ST, or other multiple benefit appraisal methods, when assessing value for money.
    c. **Multiple benefits** - The monetisation of multiple benefits using B£ST should be undertaken to inform the appraisal process in parallel with an assessment of “best value for money”. It is proposed that multiple benefits are considered within a cost benefit analysis considering all option benefits (sum of “multiple benefits” and flood damages avoided benefits).
    d. **Uncertainties and robustness** - B£ST manages uncertainty in multiple benefit assessments through the tool’s in-built sensitivity tests. It permits ranges of quantitative estimates and monetary values to be considered.
4. **Prioritisation** - B£ST could assist with providing evidence to support the prioritisation process.

A number of observed barriers to the incorporation of multiple benefits in the form of ecosystem services have been identified within the current Scottish Appraisal Guidance. Section 3 outlines

the key issues and presents some opportunities for improvement which should be considered in any future update of the Scottish Appraisal Guidance. The key identified issues are:

- The lack of a defined decision-making algorithm for the consideration of the four decision criteria. This means that decisions may not be transparent and could be open to challenge.
- The lack of definition on what types of benefits and costs are to be considered when assessing best value for money.
- The lack of clarity on how the delivery of multiple benefits should be considered in the decision-making process, i.e. should multiple benefit delivery be maximised via its own cost benefit analysis?
- There is the potential for the selected preferred options to be unaffordable and hence undeliverable. Specifically, there are issues around funding of flood risk management schemes that include non-eligible costs or have significant non-flood risk reduction beneficiaries.

When testing B£ST on the Eddleston Water as part of this project it was found to be intuitive to use with hyperlinks providing easy access to guidance material. B£ST was able to reliably quantify all significant multiple benefits in the form of ecosystem services and natural capital. The use of a single Excel file for each option appraised allowed for the rapid sharing and discussion of assessments. Within the assessment file there are ample boxes to record assumptions and comment on results. Two NFM sub-options were considered in the test:

1. NFM in place as of 2020
2. A hypothetical additional NFM case

Using a 100 year appraisal period the ecosystem services associated with the actually implemented NFM was estimated to be approximately £4.2M and £17.7M for the hypothetical additional NFM case. A side-by-side comparison of the assessment using B£ST with an earlier assessment of the Eddleston Water catchment undertaken by JBA indicates that the B£ST assessment generated ecosystem services which are approximately three times larger. The differences are primarily due to the inclusion of amenity in this assessment and a potential under-estimation of water environment benefits in the JBA assessment.

When comparing the appraised options using the Scottish Appraisal Guidance criteria, three leading options were identified. In line with the Scottish Appraisal Guidance the selection of the preferred option would be made by the project board based on consideration of all of the relevant information. The justification for the selection of the preferred option would need to be recorded. The test appraisal highlights how the four decision criteria can identify different leading options leading to a subjective decision by the project board to select the preferred option.

# 1 Introduction

## 1.1 Study overview

The Eddleston Water Project is the Scottish Government's long-term study of the implementation and effectiveness of Natural Flood Management (NFM) measures to reduce flood risk, improve wetland habitats and to deliver multiple benefits in the Eddleston Water catchment. It is led by the Tweed Forum and has been undertaken with the support of the EU Interreg North Sea Region *Building with Nature* programme.

This study builds on ongoing research and installed NFM measures within the catchment by proposing and testing a standardised methodology for Responsible Authorities (primarily Local Authorities) and other relevant stakeholders to incorporate multiple (environmental and social) costs and benefits in flood risk management appraisals. This report documents how the proposed method can be effectively integrated into current decision-making processes.

The Eddleston Water is a tributary of the Tweed with a catchment area of 70km$^2$ which joins the main river at Peebles. Over the last few centuries, the river and its catchment have been extensively changed, largely to improve agricultural production. Channelisation, land drainage and the creation of flood banks have led to a loss of natural habitats, such as wetlands and woodlands. This has reduced the ecological quality of the river system, and, together with climate change, increased the risk of flooding downstream in Eddleston and Peebles. These changes have degraded the river environment, leading to the loss in places of over 20% of the river's original main length, with a corresponding reduction in habitat and associated flora and fauna.

## 1.2 Aims and objectives of this study

The main aim of this study is to identify how multiple benefits in the form of natural capital and ecosystem services can be most effectively integrated into current decision-making processes for appraisal of flood risk management measures in Scotland. The scope of the study is not limited to NFM and the methodology should also be suitable for traditional flood risk management measures, thereby allowing holistic appraisal of all flood risk management measures using a single consistent methodology.

This study aims to:

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5. Recommend a method that can be utilised elsewhere using readily accessible and available data sources and appropriate models, backed by a short practical guide

The application of the recommendations of this report on how to integrate multiple benefits in the form of ecosystem services and natural capital into flood risk management appraisals requires input and oversight by practitioners experienced in natural capital, ecosystem services

and flood risk appraisal. It is the responsibility of the practitioners to check that the generated output is sensible and correct. There is no stipulation that the recommendations of this study must be used, and appraisals should be conducted using the means deemed most appropriate by the experienced practitioner in consultation with a wide range of stakeholders.

## 1.3 Overarching strategy and guidance

The *Flood Risk Management (Scotland) Act* (Scottish Government, 2009) outlines the Scottish Government's approach to managing flood risk. The Act requires the cyclic publishing of Flood Risk Management Strategies enabling Responsible Authorities to proactively coordinate their actions to manage flood risk in a systematic and prioritised way. Section 20 of the Act stipulates that due consideration must be given to the use of Natural Flood Management when appraising flood risk management measures. The Scottish Government's primary guidance on the appraisal of flood risk management measures is *Flood Risk Management (Scotland) Act 2009: Options appraisal for flood risk management: Guidance to support SEPA and the responsible authorities* (Scottish Government, 2016). Due to the potentially significant widespread changes to land use arising as a result of an increased adoption of Natural Flood Management techniques, there is now increased need and opportunity for the alignment of flood risk management strategy with the national land use and biodiversity strategies.

The Scottish Land Use Strategy, *Getting The Best From Our Land: A Land Use Strategy For Scotland 2016 - 2021* (Scottish Government, 2016), is a key commitment of the Climate Change (Scotland) Act 2009. The Strategy retains the long term Vision referencing the three Objectives relating to the economy, environment and communities and the ten Principles for Sustainable Land Use to guide policy and decision-making. The Tweed Forum and Scottish Borders Council piloted the Land Use Strategy in the Borders (Scottish Borders Council and Tweed Forum, 2014). The pilot included Natural Flood Management amongst other ecosystem services.

The protection and enhancement of Scotland's natural capital and biodiversity is outline in the *Scottish Biodiversity Strategy* (SNH, 2018). It consists of two documents: *Scotland's Biodiversity: It's in Your Hands* (Scottish Government, 2004) and *2020 Challenge for Scotland's Biodiversity* (Scottish Government, 2013). These set out the aims of the biodiversity strategy including protecting and restoring biodiversity on land and in our seas, and maximising the benefits for Scotland of a diverse natural environment. The Scottish Biodiversity Strategy clearly identifies that the aims of the Strategy and the biodiversity conservation calls for the adoption of an ecosystem approach. It acknowledges that nature provides us with many ecosystem services, though they are not always apparent. Adoption of an ecosystem approach can help to secure these benefits for future generations.

The obligation to incorporate biodiversity into decision-making and ensuring that the Scottish Government take a longer term view is outlined in the Scottish Government *Economic recovery Implementation Plan* (Scottish Government, 2020). This plan includes the commitment to 'developing the four capitals approach to ensure policy joins up effectively across the social, economic, human and natural capital. The four capitals approach to our economic recovery seeks to ensure that the Scottish Government invest in, preserve and grow our natural, human, social and economic capital in a way that delivers sustainable outcomes for the wellbeing of future generations

Key actions and tools that can be used to apply an ecosystem approach are provided in *An Evaluation Framework for applying the Ecosystem Approach* (SNH, Undated), *Getting The Best From Our Land: A Land Use Strategy For Scotland 2016 - 2021* (Scottish Government, 2016) and the Scottish Land Use Strategy (Scottish Government, 2016). The guidance provides a

structured methodology for incorporating ecosystem services into decision making and outlines three key steps:

- Involving people – especially those who benefit from ecosystem services and those who manage them
- Taking account of the services that ecosystems provide
- Taking account of how ecosystems work

While there is general alignment between the methods and terminology within the national approach to biodiversity and land use compared to those used within the flood risk management sector there would be benefit in further alignment. When making recommendations this study has sought to improve alignment where appropriate.

## 1.4 Study and project governance

This study was undertaken as part of the Scottish Government's Eddleston Water project, with the support of the EU Interreg North Sea Region *Building with Nature* programme. The project is being managed for the Scottish Government and Scottish Environment Protection Agency by the Tweed Forum. Tweed Forum is a charitable trust whose remit is to promote the sustainable use of the Tweed and protect and enhance the natural, built and cultural heritage of the region. Mott MacDonald Ltd was contracted by Tweed Forum to undertake this study as defined by the aims and objectives presented in Section 1.2.

The Eddleston Water Project Board appointed a Steering Group to oversee the technical quality of this study and to ensure outputs were successfully delivered as planned. The Steering Group was responsible for the definition of the scope of the study, providing technical direction during the study and reviewing deliverables. The Steering Group comprised of individuals representing the following organisations (individuals marked with * are also a member of the main Eddleston Water Project Board):

- Luke Comins* – Tweed Forum
- Chris Spray* – University of Dundee / Tweed Forum
- Debi Garft* & Michelagh O'Neill – Scottish Government
- Duncan Morrison* – Scottish Borders Council
- Nicola Melville – Scottish Environment Protection Agency
- Mary Christie – Scottish Natural Heritage (SNH). Note that SNH changed its name to NatureScot after the initial drafting of this document and prior to its finalisation.

The following individuals were also invited to comment on draft study outputs and, where appropriate, attend Steering Group meetings:

- Heather Forbes* – SEPA, NFM policy lead
- Helen Panter – SEPA, Flood appraisal policy lead

Chris Spray was appointed as the client's representative and the Steering Group chair for this study. Chris reported to Luke Comins as the Project Manager for the overall Eddleston Water project.

## 1.5 Steering Group engagement

At the study outset, the members of the Steering Group were engaged by Mott MacDonald staff through one to one phone calls to consult on the anticipated direction and outcomes of the study. The calls were also to support the collation of example projects and methods.

During the study, two Steering Group workshops were held online to consult on the ongoing direction of the study, present work to date and secure acceptance of the interim study findings. Draft versions of the study deliverables were sent to members of the Steering Group for comment prior to finalisation.

## 1.6 Wider stakeholder engagement survey

An online survey was conducted to explore the views of key stakeholders on the incorporation of multiple benefits in the form of ecosystem services into the Scottish flood risk management decision-making process. The primary purpose of the survey was to ascertain the views of the target user community (Local Authority flood risk management officers and their consultants) expanding the diversity of views available within the Steering Group, and thereby supporting the achievement of the project aims. The survey was also used to obtain and collate views from academics, regulators and government officers further extending on the groups represented by the Steering Group.

The survey was hosted online at Survey Monkey. Individuals were invited to take part by the circulation of an email to flood risk management officers in all Local Authorities. The Society of Chief Officers of Transportation in Scotland (SCOTS) flood risk management group representing all 32 Local Authorities was engaged to support the circulation of the survey. The survey was also sent to selected academics, consultants, regulators and government officers (including members of Scottish Advisory Implementation Forum for Flooding groups for NFM and appraisal) via the Steering Group members and Mott MacDonald staff. The survey was open for a 3 week period leading up to the 20th July 2020.

Appendix B presents the survey's nine questions and the submitted responses. It should be noted that the stated "purpose" of the survey must be considered if the data is to be re-used or disseminated beyond the members of the Steering Group. The responses submitted have been considered in the preparation of this report, specifically additional appraisal methods as considered in Section 2 and the integration into the current decision-making process as presented in Section 3.

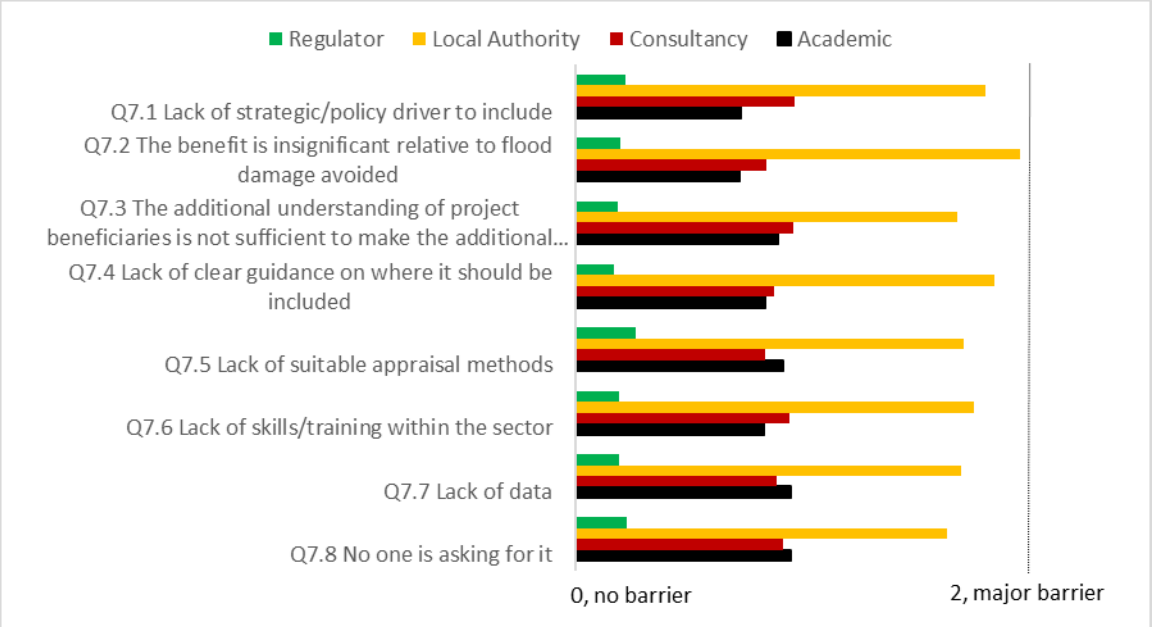
The key findings of the survey are listed below.

- Question 1 identified that in total 40 responses were received, of which 17 were from Local Authorities indicating a maximum coverage of 53% of Local Authorities.
- Question 2 identified that most responses, 93%, were provided by individuals reporting to work in the Scottish flood risk management sector.
- Based on question 3 on the seniority of respondents, the responses were equally split between team leader and mid-level officers/consultants suggesting an informed sample was engaged.
- Question 4 indicates there was approximately an equal split between respondents indicating they never, rarely and often were involved in projects where multiple benefits in the form of ecosystem services were evaluated as part of the appraisal.
- Question 5 highlighted that the most well-known (defined by "awareness") ecosystem services method is CIRIA B£ST with 60% of survey respondents reporting awareness. B£ST was most well-known across all surveyed groups. The second most well-known approach was Natural Capital Accounting with 30% of survey respondents reporting awareness of the approach. The review of case studies in Section 2.2 gives further insight into the methods which have been applied.

- A free text response field at the end of question 5 allowed the submission of additional appraisal methods. Details of the 10 additional methods submitted have been incorporated into this study's review, as reported in Section 2.
- Based on question 6, a majority (70%) of consultants perceive that appraising ecosystem services never or rarely impacted on Flood Risk Management Scheme appraisal outcomes. Conversely, Local Authority officers were approximately equally split between reporting that they did not know if ecosystem services would make a difference to appraisals, rarely/never make a difference or often make a difference. This may highlight a lack of understanding by consultants on the importance of local issues to at least some Local Authorities and the potential for flood risk management projects to bring about change.
- Question 7 showed that Local Authority officers perceive the largest number of barriers to the implementation of ecosystem services methods (Figure 1.1). Conversely those in a regulator role see the fewest barriers to using ecosystem services methods, with consultants and academics midway between the two extremes.

Questions 8 and 9 invited free text submissions on the perceived barriers and any other comments. These submissions highlight that many individuals feel lost in a jargon heavy process in what is a very complex and challenging field with many competing issues. There is a general desire to want to consider multiple benefits in appraisals but responses often cited that the methods are not accessible. The existence of silos inside and between organisations is also cited as a barrier. Where appropriate, the feedback submitted via these questions has been acted upon when considering the selection of the most appropriate method in Section 2 and integrating into the existing decision-making process as detailed in Section 3.

**Figure 1.1: Summary of responses to Q7 – 'What do you think the barriers are to considering "multiple benefits" in the form of ecosystem services and natural capital in flood appraisals?' Responses have been scored and weighted by the number of responses as follows; no barrier = 0, minor barrier = 1 and major barrier 2.**



# 2 Identification of preferred means of valuing NFM ecosystem services

## 2.1 Review of valuation methodologies

A detailed review of existing current environmental and social appraisal methodologies within the flood management sector was undertaken to identify areas of commonality and potential variations between the different approaches in the appraisal of environmental benefits.

The Ecosystems Knowledge Network Tool Assessor (JNCC, 2020) (ESKN) was used as the central source of information on the available assessment methods and case studies. The information from the ESKN tool assessor was supplemented by one to one telephone calls with the Steering Group members and the appraisal methods submitted via responses to the stakeholder survey.

A literature review of previous reports, best practice guidance and open source data was undertaken on the collated information. This literature review focused primarily on assessments of similar project types and in similar socio-economic regions as typical Scottish river catchments such as the Tweed. The review encompassed methodologies from other regions and disciplines such as water resource planning, flood and coastal risk management strategies.

## 2.2 Review of examples of best practise and case studies

To ensure that the review of methodologies for valuing NFM ecosystem services included examples of best practise and local knowledge, relevant case studies of ecosystem services assessment were included. The case studies differed to the valuation methodologies as they included bespoke approaches that were applied only once to a specific area and often involved detailed stakeholder consultation. Each case study was reviewed for examples of best practise, tools or methodologies used, and recommendations. A full list of case studies is provided in Table 2.1.

**Table 2.1: Ecosystem Services assessment Case studies**

| Title | Project Type | Partners | Weblink | Description |
|---|---|---|---|---|
| Strathard: a landscape to live, work and play | Land and water management | Forest Enterprise Scotland, Loch Lomond and the Trossachs National Park Authority, SEPA, SNH | https://www.forestresearch.gov.uk/research/strathard-a-landscape-to-live-work-and-play/ | This project aims to improve land and water management decisions in Strathard using an ecosystem approach. SEPA and other project partners are using a range of techniques to gather information on ecosystems and their services. An important part of the ecosystems approach is taking into account the views of different stakeholder groups and local communities. This is being done using surveys, participatory GIS mapping, and community events. The information gathered from stakeholders is being integrated with outputs from more detailed modelling of selected ecosystem services using approaches developed by Forest Research's LUES group. The results are being used to evaluate and compare the effects of different land and water management actions. Opportunity maps have been created to help target a range of priority management actions, including natural flood management, woodland planting, and improved water habitat connectivity. The first phase of this project started in October 2015 and action plans developed and took place during 2017-2019. This project is part of the wider LUES programme. |
| The Carse of Stirling Ecosystem Services Project Approach Demonstration Project | Land and water management | Scottish Natural Heritage, SEPA, LUC, STAR Development Group, Local land managers, farmers and community representatives | https://www.nature.scot/naturescot-commissioned-report-676-carse-stirling-ecosystems-approach-demonstration-project | In 2014, a group of local people and organisations worked together to develop a Vision and Action Plan for the future of land use in the Carse of Stirling. The Carse of Stirling Ecosystem Services Project brought together a stakeholder panel of local farmers, land managers and community representatives to consider the wide range of benefits that are derived from the land in the Carse of Stirling and how these can be developed and maximised in a balanced, integrated way. The project was commissioned by Scottish Natural Heritage and SEPA and was facilitated by a project team comprising LUC and STAR Development Group. The project aimed to explore the usefulness of the idea of ecosystem services as a way of thinking about the range of benefits provided by an area, and how these may be affected by different types of future change. Understanding these benefits will help ensure that they are properly recognised and managed in the future. A series of maps were produced, exploring different ways of mapping the benefits provided by the Carse of Stirling. For each topic, the maps show information derived from published sources, technical analysis, and stakeholder feedback. Topics include flood mitigation and water shortage; food; global climate; habitats and wildlife; recreation and tourism; scenic qualities and sense of place; soils, pollution & genetic resources; timber, wood fuel & renewables; community and education; and culture and history. |
| Aberdeenshire Regional Land Use Pilot. | Pilot of the Scottish Land Use Strategy (LUS) using an Ecosystems Approach | The Scottish Government<br>Aberdeenshire Council and The James Hutton Institute | http://publications.aberdeenshire.gov.uk/dataset/aberdeenshire-land-use-strategy-pilot | Scottish Government's Aberdeenshire Land Use Strategy Pilot ran from 2013-2015 and took an Ecosystem Approach focussing on issues of rural land use change. The Pilot aimed to: consider land use in an integrated way; guide decisions to optimise land use; and create an online tool to inform decisions about competing or conflicting land uses. The online mapping tool was developed, focussing specifically on woodland creation in Aberdeenshire in relation to six possible policy priorities: woodland expansion; prime land protection; reducing flood risk; improving water quality; woodland and landscape character; woodland and public access. The ecosystem services considered were: sediment export; carbon storage; and nitrogen retention. The tool allows users to map their own policy priorities and objectives and see how this effects ecosystem service provision. The tool can help planners to identify areas where land use |

| Title | Project Type | Partners | Weblink | Description |
|---|---|---|---|---|
| | | | | change could deliver multiple benefits, and to explore the consequences of pursuing different policy goals. |
| Irwell Catchment; Investigating Payment for Ecosystem Services. | Research into Payment for Ecosystem Services (PES) | Centre for Local Economic Strategies and Wildlife Trust for Lancashire, Manchester and North Merseyside | https://ecosystemsknowledge.net/sites/default/files/wp-content/uploads/Irwell%20catchment.pdf | The overall aim of the study was to explore the feasibility of establishing a new Payment for Ecosystem Services (PES) scheme funded by private sector businesses in Manchester and Salford City Centre adjacent to the River Irwell, Greater Manchester. PES is the term used to describe 'schemes in which the beneficiaries, or users, of ecosystem services provide payment to the stewards, or providers, of ecosystem services' (URS, 2013). The pilot study began by identifying saleable ecosystem services through desk-based reviews, site visits and engagement with key stakeholders. This led to the identification of six priority ecosystem services provided within the study area: cooling of the urban heat island; surface water/flood management; visual/aesthetic; recreation and green travel routes; water quality; and habitat and wildlife corridor provision. Site visits and desk-based reviews identified where enhancement of ecosystem services could be delivered and the benefits these services would provide to commercial businesses. The pilot study then identified prospective buyers and sellers and interviewed commercial property owners/businesses to explore perceptions of PES. Further dialogue with commercial property owners investigated opportunities and challenges that arose. |
| Ecosystem Service Benefits of Eddleston Water NFM Measures: Economic Analysis | Land and water management | Tweed Forum<br>JBA consulting | https://tweedforum.org/eddleston-project-database/ | This report forms part of the Eddleston Water Project which looks to provide a modelling strategy capable of testing the effectiveness of different Natural Flood Management (NFM) measures in Eddleston Water. This report presents the approaches taken to, and results of, valuing the potential benefits of NFM measures implemented within the Eddleston catchment, in terms of wider ecosystem service benefits. A value transfer methodology was employed to monetise relevant benefits. |
| The Borders Regional Land Use Pilot | Pilot of the Scottish Land Use Strategy (LUS) using an Ecosystems Approach | Scottish Borders Council, Tweed Forum and Dundee University, with Environment Systems Ltd. | https://www.scotborders.gov.uk/download/downloads/id/2216/lus_framework.pdf | Scottish Government's Borders Land Use Strategy Pilot took an Ecosystem Approach to potential land use change resulting from climate change. Based on extremely detailed mapping of key ecosystem services, and backed by extensive stakeholder consultation, the study developed a LUS Framework for use in decision-making. The ultimate aim of the land use planning framework is simply to enable more informed and integrated decisions to be made about how we use land in the Scottish Borders in a sustainable manner. It provides new information in mapped form on the multiple goods and services provided by land use in the Scottish Borders, some of which are possibly currently undervalued or overlooked. The project continued with further exploration of potential mechanisms to deliver this, through for example agri-environment support. |

Source: Mott MacDonald

## 2.3 Long list of environmental valuation methodologies

The long list of all environmental assessment methodologies identified following the Steering Group consultation and stakeholder engagement survey is shown below in Table 2.2.

**Table 2.2: Long list of valuation methodologies**

| Title | Project Type | Partners | Weblinks | Description |
|---|---|---|---|---|
| Natural Capital Accounting | Methodology / Tool | Office of National Statistics - issue national guidance | https://www.ons.gov.uk/economy/environmentalaccounts/methodologies/principlesofnaturalcapitalaccounting | Natural capital accounts are a series of interconnected accounts that provide a structured set of information relating to the stocks of natural capital and flows of services supplied by them. Accounts are of two kinds:<br>• physical accounts – classify and record measures of extent, condition and annual service flow<br>• monetary accounts – assign a monetary valuation to selected services on an annual basis and record an overall valuation of the natural asset's ability to generate future flows of services. |
| B£ST (Benefits Estimation Tool) (CIRIA, 2019) | Methodology / Tool | CIRIA | https://www.susdrain.org/resources/best.html | B£ST helps practitioners estimate the impacts and benefits of Sustainable Urban Drainage Systems (SuDS), Natural Flood Management (NFM) and other elements of blue-green infrastructure. B£ST is used to assess and monetise many of the financial, social and environmental benefits of blue-green infrastructure. The results enable users to understand and quantify the wider value of SuDS and NFM measures. This can support investment decisions and can help to identify stakeholders and find potential funding routes. |
| Natural Capital Planning Tool (CIRIA, 2019) | Methodology / Tool | Consultancy for Environmental Economics and Policy (CEEP), University of Birmingham and Northumbria | **http://ncptool.com/** | The Natural Capital Planning Tool (NCPT) is a free site assessment tool developed specifically for the planning context. The NCPT allows the indicative but systematic assessment of the likely impact of proposed plans and developments on Natural Capital and the ecosystem services it provides to people, such as recreational opportunities, air quality regulation and climate regulation. The NCPT was designed as a fit-for-purpose Excel tool which can be applied by non-specialists and in a short period of time; acknowledging the time- and resource constraints planners and developers face in everyday practice. |

| Title | Project Type | Partners | Weblinks | Description |
|---|---|---|---|---|
| | | University. | | |
| Green Infrastructure Valuation Toolkit (GI-Val) (Mersey Forest , 2011) | Methodology / Tool | The Mersey Forest | https://www.merseyforest.org.uk/services/gi-val/ | The Green Infrastructure Valuation toolkit provides a set of calculator tools to assess the value of a green asset or a proposed green investment. Where possible, the benefits of green infrastructure (GI) are given an economic value. Other quantitative contributions (e.g. number of jobs) and qualitative contributions (e.g. case studies or research) can also be provided to give a complete view of the value of an asset. |
| Co$ting Nature | Methodology / Tool | King's College London (applications, data, models), AmbioTEK (software, data, models), UNEP-WCMC (applications, data) | http://www.policysupport.org/costingnature | Co$ting Nature is a web-based policy-support tool for natural capital accounting and analysis of the ecosystem services provided by natural environments. The focus is on costing nature (understanding the resource, e.g. the land area, and the opportunity cost of protecting nature to produce ecosystem services) as opposed to valuing nature (i.e. how much someone is willing to pay for it). The tool estimates the current provision of water, carbon and tourism services and identifies the beneficiaries, then analyses current environmental pressures, future threats and conservation priority. Users can then apply scenarios for climate, land-use or land management change, and examine the impacts on ecosystem services and the implications for beneficiaries. The tool can be used to assess the impacts of human interventions for conservation prioritisation and planning. |
| Outdoor Recreation Valuation Tool (ORVal) (Not applicable to study area but could be reviewed for transferrable methodology) | Methodology / Tool | University of Exeter | https://www.leep.exeter.ac.uk/orval/ | ORVal is a freely accessible web-based tool that predicts the number of visits to existing and new greenspaces in England and estimates the welfare value of those visits in monetary terms. It is based on an econometric model of recreational demand derived from Monitor of Engagement with the Natural Environment (MENE) data. Users can examine the recreational value of existing green space and test how the number of visits and the value of these visits might change if the land cover was changed, or if new green spaces were created. Results can be grouped by local authority area or catchment and can be split by socio-economic group. |

| Title | Project Type | Partners | Weblinks | Description |
|---|---|---|---|---|
| Natural Environment Valuation Online tool (NEVO) (Not applicable to study area but could be reviewed for transferrable methodology) | Methodology / Tool | University of Exeter | https://www.leep.exeter.ac.uk/nevo/?x=405000&y=410000&z=1 | The NEVO Tool is a web application to help users explore, quantify and make predictions about the benefits that are derived from existing and altered land use across England and Wales. The tool is freely available to anyone and is designed to be easy to use, making it accessible to a wide range of users |
| Partnership Funding Supporting Guidance for Outcome Measure 4 and the Environment Agency's Partnership Funding Calculator (Environment Agency, 2020). | Methodology / Tool | Environment Agency | https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/879971/Partnership_funding_supporting_guidance_for_OM4.pdf | Outcome Measure 4 (OM4) provides additional funding to English flood and coastal erosion risk management (FCERM) projects that reduce the risk of flooding and coastal erosion in ways that provide additional environmental benefits. It is for projects that contribute to long-term community resilience to flood risk and coastal change, and adapting to and mitigating for climate change. The aim of OM4 is for flood risk projects that comprise a package of measures to reduce flood risk and provide additional environmental benefits. The package of measures could include engineering work, additional ecological benefits and/or enhancements to natural habitats that may also bring about natural flood management. The method for appraising ecosystem services is very generalised and much simplified. It is suitable for assessing funding eligibility on a wide range of project scales and therefore lacks the detail necessary to suitably appraise multiple benefits in medium and large projects |
| Environment Agency's scoring and weighting method (Environment Agency, 2010). | Methodology / Tool | Environment Agency | https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/487237/LIT_10350.pdf | The scoring and weighting methodology can be used to estimate monetary values for those impacts that are difficult to measure in monetary values. The approach requires scores to be assigned to each option and weights to be assigned to each category. Once all the scores and weights have been assigned, implied values can be calculated as a method for estimating the value of the intangible benefits relative to the tangible benefits. |
| The Green Book: appraisal and evaluation in central government; HM (HM Treasury, 2018) | Manuals & guidance | HM Treasury and Government Finance Function | https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent | The Green Book is guidance applicable to the entire UK issued by HM Treasury on how to appraise policies, programmes and projects including the assessment of ecosystem services. It also provides guidance on the design and use of monitoring and evaluation before, during and after implementation. The Scottish Flooding Appraisal Guidance states that appraisals should align with the Green Book. |

| Title | Project Type | Partners | Weblinks | Description |
|---|---|---|---|---|
| Scottish Public Finance Manual (Scottish Government, 2012)l. | Manuals & guidance | Scottish Ministers | https://www.gov.scot/publications/scottish-public-finance-manual/background-and-applicability/background-and-applicability/ | The Scottish Public Finance Manual (SPFM) is issued by the Scottish Ministers to provide guidance to the Scottish Government and other relevant bodies on the proper handling and reporting of public funds. It sets out the relevant statutory, parliamentary and administrative requirements, emphasises the need for economy, efficiency and effectiveness, and promotes good practice and high standards of propriety. The guidance does not provide a prescribed method on how to evaluate natural capital or ecosystem services. |
| Flood protection appraisals: guidance for SEPA and responsible authorities (Scottish Government, 2016) | Manuals & guidance | Environment and Forestry Directorate | https://www.gov.scot/publications/guidance-support-sepa-responsible-authorities/pages/1/ | The guidance sets out core principles which can be applied consistently across flood risk management planning to support decision-making at national, catchment and local scales. It also reflects the importance of proportionality in the level of detail of each appraisal. As such, some parts of the guidance provide an additional level of detail principally relevant to the appraisal of flood risk management schemes and works. The aim of appraisal is to identify and assess options that achieve flood risk management objectives whilst delivering other economic, social and environmental benefits. This helps to inform the decision-making process. The guidance does not provide a prescribed method on how to evaluate natural capital or ecosystem services. |
| Flood study checklist for responsible authorities (SEPA, 2018) | Manuals & guidance | SEPA | https://www.sepa.org.uk/media/375525/flood-study-checklist-for-las-3rd-version-final-2018-09-10.pdf | This document aims to highlight areas which local authorities should consider when commissioning a flood study. This document is suitable for scoping and appraisal stages leading to recommendations of preferred options to manage flood risk, but not outline or detailed design; for river, coastal and natural flood management studies. The guidance does not provide a prescribed method on how to evaluate natural capital or ecosystem services. |
| Flood and Coastal Erosion Risk Management: A Handbook for Economic Appraisal (Multi Coloured Handbook) (Flood Hazard Research Centre, 2020) | Manuals & guidance | MCM, Flood Hazard Research Centre, Middlesex University | https://www.mdx.ac.uk/our-research/centres/flood-hazard/projects/multi-coloured-manual | The Handbook is intended to be a stand-alone “Step-by-Step” guide to assessing the benefits of flood and coastal erosion risk management. It is referenced by the Scottish Appraisal Guidance as the preferred approach for appraising the flood risk benefits when completing flood risk management appraisals. When put together with the knowledge of the costs of the plans and schemes required, the user can assess the relationship between the benefits and costs of |

| Title | Project Type | Partners | Weblinks | Description |
|---|---|---|---|---|
| | | | | investment decisions. This comparison should enable the users to identify those risk management plans and schemes which maximise the economic return to England and Wales, and therefore, represent “best value for money” by being economically efficient. |
| Enabling a Natural Capital Approach (ENCA) (DEFRA, 2020) | Manuals & guidance | DEFRA | https://www.gov.uk/guidance/enabling-a-natural-capital-approach-enca | ENCA resources are data, guidance and tools to help the user understand natural capital and know how to take it into account. The ENCA guidance covers the natural capital framework, economic valuation of the environment, how project or policy appraisal can incorporate natural capital, natural capital accounting principles and methods, benefits and challenges, and applying natural capital at local level |
| Flood and Coastal Erosion Risk Management: appraisal guidance, (Environment Agency, 2010) | Manuals & guidance | Environment Agency | https://www.gov.uk/government/publications/flood-and-coastal-erosion-risk-management-appraisal-guidance | Use of this guidance is a requirement for all publicly funded FCERM strategies and projects developed operating authorities. The role of this guidance is to provide the user with the information needed to complete a FCERM appraisal in line with government policy. The policy context is set in DEFRA's policy statement (2009) for England or as amended for use in Wales by the WAG Ministerial Statement Feb 2007. |
| Payments for Ecosystem Services: A Best Practice Guide; DEFRA, 2013 | Manuals & guidance | DEFRA | https://www.cbd.int/financial/pes/unitedkingdom-bestpractice.pdf | The purpose of this guide is to help with the design and implementation of Payments for Ecosystem Services (PES) schemes, and its publication fulfils a UK? government commitment in the 2011 Natural Environment white paper. |
| How to do it: a natural capital workbook (Natural Capital Committee, 2017) | Manuals & guidance | Natural Capital Committee | https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/608852/ncc-natural-capital-workbook.pdf | The Natural Capital Committee for England has published a draft (version 1) workbook for natural capital assessment, along with a paper that sets out principles for selecting approaches to valuation of changes in the state of natural capital.<br>"This practical guide is aimed at anyone who wants to use natural capital approaches in making decisions about the natural environment. It is intended to support decision makers, including planners, communities and landowners, but has particular relevance for place-based decisions." |

| Title | Project Type | Partners | Weblinks | Description |
|---|---|---|---|---|
| Economic valuation and its applications in natural capital management and the Government's 25 Year Environment Plan, Natural Capital Committee. | Manuals & guidance | Natural Capital Committee | **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/608850/ncc-natural-capital-valuation.pdf** | In this note, the Natural Capital Committee (NCC) lays out the types of decisions for which natural capital values might be useful and some principles to guide the choice of approaches to valuation. The intention is to guide and encourage coherence across decision making contexts, particularly relevant for the public sector, and especially for projects related to the development and implementation of the Government's 25 Year Environment Plan. |
| Environment Impact Assessment | Manuals & guidance | | https://www.gov.scot/policies/environmental-assessment/environmental-impact-assessment-eia/ | Suggested in survey response, does not provide a unique methodology to monetise a suitable range of environmental benefits. |
| Social Return on Investment | Manuals & guidance | SROI Network | https://www.betterevaluation.org/en/approach/SROI | Social Return on Investment (SROI) is a systematic way of incorporating social, environmental, economic and other values into decision-making processes. |
| Future Flood Explorer | Manuals & guidance | Sayers and Partners | http://www.sayersandpartners.co.uk/future-flood-explorer.html | The Future Flood Explorer allows flood risk managers to understand risk under climate and socioeconomic change, and how effective adaptation policies are in offsetting these changes. It is a commercial product requiring the payment of fees to use on projects.<br>The Future Flood Explorer represents coastal, fluvial, surface water and groundwater sources of flooding, and can quantify risk to a wide range of receptors such as residential and non-residential properties, infrastructure sites, and transport links. Analysis is possible across a range of scales from national to neighbourhood. Suggested in survey response, this considers economic risk only and does not provide a means of evaluating environmental benefits. |
| iTREE, ASSET - | Tool | USDA Forest Service | https://www.itreetools.org/ | i-Tree is a promoted by the USDA Forest Service as a state-of-the-art, peer-reviewed software that provides urban and rural forestry analysis and benefits assessment tools.<br>Suggested in survey response, does not provide a unique |

| Title | Project Type | Partners | Weblinks | Description |
|---|---|---|---|---|
| | | | | methodology to monetise a suitable range of environmental benefits. |
| Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) software. | Tool | Natural Capital Project | http://data.naturalcapitalproject.org/nightly-build/invest-users-guide/html/ndr.html | InVEST models are spatially-explicit, using maps as information sources and producing maps as outputs. InVEST returns results in either biophysical terms (e.g., tons of carbon sequestered) or economic terms (e.g., net present value of that sequestered carbon). The spatial resolution of analyses is also flexible, allowing users to address questions at local, regional, or global scales. |
| Ecosystem services assessment: How to do one in practice | Manuals & guidance | Institute of Environmental Sciences | https://www.the-ies.org/resources/ecosystem-services-assessment | This document provides guidance on how to make an ecosystem services assessment. It explains what ecosystem services are, why an ecosystem services assessment needs to be made, and how it can add impact to your work. |
| The Ecosystem Service Assessment Support Tool (ESAST) | Tool | IPBES | https://ipbes.net/policy-support/tools-instruments/ecosystem-service-assessment-support-tool | The Ecosystem Service Assessment Support Tool (ESAST) has been designed to provide guidance to users who are new to ecosystem services and need assistance in designing an effective assessment process. It can also assist experienced users in providing detailed information about different concepts, methodologies and links to case study information |
| Mapping and Assessment of Ecosystems and their Services (MAES) approach: | Manuals & guidance | European Union | https://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/index_en.htm | This report makes proposals for measuring the condition of terrestrial, freshwater and marine ecosystem types based on a selection of indicators. A set with specific indicators is available for assessment of ecosystem condition per ecosystem type. A core set with key indicators is available to support an integrated ecosystem assessment across ecosystem type. |
| Natural Capital Protocol | Manuals & guidance | Capitals Committee | https://naturalcapitalcoalition.org/natural-capital-protocol/ | The Protocol provides a standardized framework for business to identify, measure and value their impacts and dependencies on natural capital. |

## 2.4 Screening the long list of environmental evaluation methods

The long list of environmental evaluation methods underwent a high-level assessment to ensure that the methodologies considered were suitable. This assessment considered whether the methodology was accessible, monetised a suitable range of environmental benefits and was applicable to Scotland. In addition, where a guidance document did not provide its own original methodology, and referenced other methodologies considered in the list of methods, it was excluded for further consideration.

The following methodologies were excluded from further investigation:

- **Co$ting Nature** - More suitable to international assessments at a landscape scale. Does not assess to the required level of accuracy.
- **Economic valuation and its applications in natural capital management and the Government's 25 Year Environment Plan, Natural Capital Committee** – Does not provide the required detail to undertake the valuation assessment.
- **Environment Agency Scoring and Weighting Method** (Environment Agency, 2010) - Does not provide a suitable methodology to directly monetise the required range of environmental benefits. Note that scoring and weighting is recommended in Scottish Appraisal Guidance and within Section 2.5 of this document as a suitable approach where it is not practical or appropriate to monetise all significant benefits.
- **Environment Impact Assessment** – Suggested in survey response, does not provide a unique methodology to monetise a suitable range of environmental benefits.
- **Flood and Coastal Erosion Risk Management: appraisal guidance** (Environment Agency, 2010) **-** Does not provide a suitable methodology to monetise the required range of environmental benefits.
- **Flood protection appraisals: guidance for SEPA and responsible authorities** – Does not provide specific guidance on monetising benefits, references other methodology.
- **Flood study checklist for responsible authorities** (SEPA, 2018) - Does not provide a unique methodology to monetise a suitable range of environmental benefits.
- **Future Flood Explorer** – Suggested in survey response, this tool considers economic risk only and does not provide a means of evaluating environmental benefits. The commercial tool is not freely available.
- **IES**– Suggested in survey response, does not provide the required detail to undertake the valuation assessment.
- **IPBES tool** - Suggested in survey response. Does not provide the required detail to undertake the valuation assessment
- **InVEST** - Suggested in survey response, presents a complex methodology which may not be accessible to all and requires a large quantity of input data.
- **iTREE, ASSET** – Suggested in survey response, does not provide a unique methodology to monetise a suitable range of environmental benefits.
- **MAES approach**: Suggested in survey response. Does not provide the required detail to undertake the valuation assessment.
- **Natural Capital Planning Tool** - Does not provide a unique methodology to monetise a suitable range of Environmental benefits.
- **Natural Capital Protocol** - Suggested in survey response. Does not provide the required detail to undertake the valuation assessment.
- **Natural Environment Valuation Online tool (NEVO)** – Not applicable to Scotland.

- **Outdoor Recreation Valuation Tool (ORVal) –** Not applicable to Scotland.
- **Social Return on Investment –** Does not cover a suitable range of ecosystem services to be suitable.

## 2.5 Assessment of short list

The remaining methodologies were scored by the project team, and subsequently reviewed by the Steering Group, using a red-amber-green (RAG) scale or yes / no screening using defined categories as detailed below. The criteria for each screening question was agreed with the Steering Group prior to the assessment to improve the repeatability of the process and the scoring was reviewed by the Steering Group prior to finalisation. Further details are provided in Appendix A.

- Level of work required – RAG
- Accuracy of results – RAG
- Technical complexity –RAG
- Repeatability – RAG
- Compatibility with Scottish appraisal process – pass/fail
- Ability to consider energy water and materials use – yes/no

Each option was assigned a total suitability score according to the RAG results with green scoring 1 & red scoring 3. The methodology with the lowest score was then identified as the most suitable approach. It should be noted that all short list assessment approaches are applicable for appraisals in Scotland (depending on the specific needs of the project) and it is for project teams to decide which tool is most suitable based on project needs.

Full details of the RAG scoring tables for each assessment criteria and the full results are shown in Appendix A. The results of the assessment are summarised in Table 2.3.

**Table 2.3: Summary of the scoring (lowest score is most desirable)**

| Title | Overall Scoring | Rank |
|---|---|---|
| B£ST (Benefits Estimation Tool) (CIRIA, 2019) | **4** | **1st** |
| Green Infrastructure Valuation Toolkit (GI-Val) (Mersey Forest , 2011) | **6** | **2nd** |
| Partnership Funding Supporting Guidance for Outcome Measure 4 (Environment Agency, 2020) and the Environment Agency's Partnership Funding Calculator (Environment Agency, 2020). | **6** | **2nd** |
| Flood and Coastal Erosion Risk Management: A Handbook for Economic Appraisal (Multi Coloured Handbook); (Flood Hazard Research Centre, 2020) | **6** | **2nd** |
| The Green Book: appraisal and evaluation in central government; (HM Treasury, 2018) | **6** | **2nd** |
| Enabling a Natural Capital Approach (ENCA) (DEFRA, | **8** | **3rd** |

| Title | Overall Scoring | Rank |
|---|---|---|
| 2020) | | |
| Natural Capital Accounting | **9** | **4th** |
| How to do it: a natural capital workbook (Natural Capital Committee, 2017) | **10** | **5th** |
| Scottish Public Finance Manual (Scottish Government, 2012) | **11** | **6th** |

## 2.6 The selection of B£ST as the recommended approach

The shorted listed methods were presented to the project Steering Group with the scores and associated reasoning discussed and agreed by the Steering Group. The review of the short listed methods identified B£ST (CIRIA, 2019) as the leading appraisal tool to support the evaluation of multiple benefits within flood risk management projects.

B£ST is a free tool developed as a result of a CIRIA research project undertaken in collaboration with consultants and academics. The tool provides a structured approach to evaluating a wide range of benefits from blue-green infrastructure (particularly SuDS and NFM). It follows a simple structure, commencing with screening and qualitative assessment to identify the benefit categories to evaluate further. Where feasible, it provides support to help quantify and monetise the potential benefits and can help underpin collaborative working. The evaluation can be summarised using s a series of graphs and chart to present the benefits based on ecosystem services (ESS) and triple bottom line (TBL) criteria. B£ST was most recently updated in 2019 and CIRIA announced plans to update it further in March 2020 (CIRIA, 2020).

The key factors for the selection of B£ST are summarised below.

- The free tool is open access and does not require any specialist software.
- It is suitable for assessing the multiple benefits on a wide range of flood risk management action types and is not limited to the assessment of Natural Flood Management measures. Where appropriate it can be used to quantify disbenefits (detriment) in addition to benefits.
- It is applicable for use in appraisals considering all project scales and types of flooding including fluvial, coastal and surface water flooding.
- The assessment tool is provided with an accompanying guidance document that provides relevant information and data requirements.
- The tool includes a coarse assessment which could be included earlier within the option appraisal process to help set objectives and to provide initial or high-level results
- The tool is able to map value change across all six capitals, as listed within the integrated reporting framework, within the study area.
- The valuation methodology in the tool is in line with good practice, as well as with appraisal guidance (HM Treasury, 2018) and consistent with other approaches in the water (Environment Agency, 2013) and environment (SNH, Undated) sectors.
- The 2019 release includes a comparison tool that enables the comparison of more than one option within an assessment.
- It is already the most well-known tool within the target user community (although the extent of the target community's experience in using the tool is thought to be low)

- The developer, CIRIA, reports that B£ST is not a single release and will be updated in the future, i.e. CIRIA's announcement in March 2020 (CIRIA, 2020).

Following a review of B£ST, it was acknowledged that it is not an all-encompassing solution to the assessment of multiple benefits. The identified limitations of the tool include:

- It does not currently include a spatial element to the assessment of wider benefits. At the time of writing plans have been announced for the incorporation of spatial tool in the next release of B£ST (CIRIA, 2020).
- There are limited opportunity for supporting the identification of opportunities.
- B£ST does not specifically allow for the incorporation of peatland carbon sequestration and relies on an external tool to assess woodland carbon sequestration.
- As with all methods, it may be appropriate to obtain more detailed or locally based information when doing more detailed studies or where decisions are sensitive to small changes in the generalised national data within the tool.
- Following on from the preceding point, B£ST was primarily developed using English and Welsh data for an English and Welsh target user group. Therefore, the B£ST guidance and tool terminology sometimes deviate from that used in Scotland. It is also necessary for users to select appropriate donor locations from the available English and Welsh in tool options.

To address the limitations of B£ST, additional instructions have been included within the short practical guide (Mott MacDonald, 2020) which accompanies this report. The short guide includes key pointers on where stakeholder engagement should be undertaken to support the identification of opportunities, how to consider spatial variation and guidance on the incorporation of more detailed local information.

Specific recommendations for the improvement of B£ST are detailed below. These improvements are likely to require the contribution of funding by a Scottish stakeholder i.e. SEPA, SNH or the Scottish Government.

- Developing functionality to support the spatial assessment and reporting of multiple benefits. At the time of writing plans have been announced for the incorporation of spatial tool in the next release of B£ST (CIRIA, 2020).
- Improving the tool to support the identification opportunities.
- Extension of the terminology and geographic areas in B£ST to better align with Scottish needs. This is most notable in relation to:
  - The assessment of the aquatic environment (Water quality and Water Quantity in B£ST) where English and Welsh river basins, guidance and Water Framework Directive terminology is currently used.
  - The assessment of flood damages avoided within B£ST references the use of the English Partnership Funding Calculator for very rapid assessments in place of the Multi Coloured Handbook (Flood Hazard Research Centre, 2020). The text within B£ST should be updated to provide better direction to users outside England.
- Addition of an in-built methodology for assessing the carbon sequestration by peatlands and guidance on the use of the Woodland Carbon Code calculator in Scotland.
- Increasing in the number of supporting references and papers to allow for a more diverse selection of values.

Section 3 of this document presents how B£ST can be integrated into the existing flood risk management decision-making framework. Section 4 of this document provides a worked example of using B£ST to support the decision-making framework when evaluating flood risk management options for the Eddleston Water.

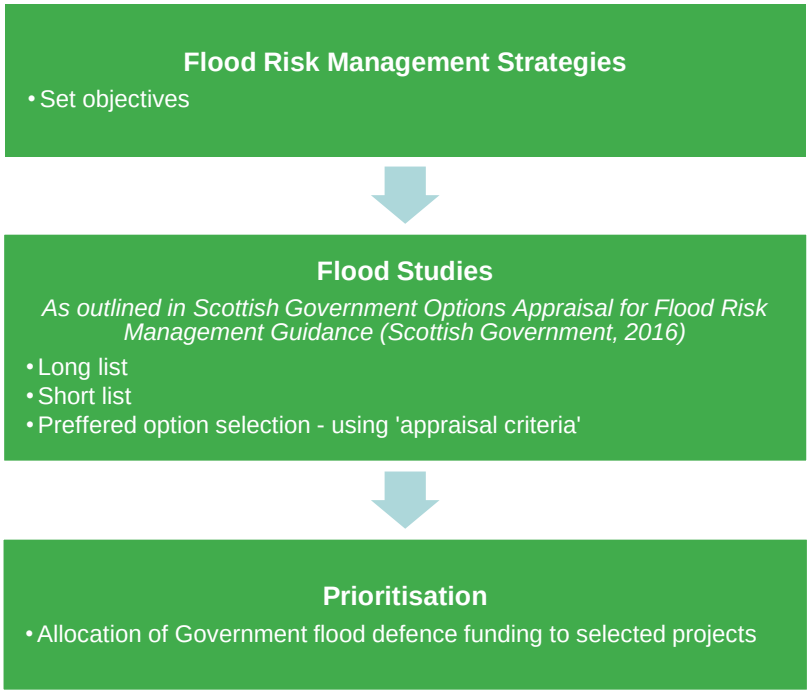
# 3 Integration into current decision-making processes

## 3.1 Overview of current decision-making process

The primary guidance detailing the current decision-making process is outlined in the Scottish Government '*Options appraisal for flood risk management: Guidance to support SEPA and the responsible authorities'* (Scottish Government, 2016), hereafter referred to as the Scottish Appraisal Guidance. Figure 3.1 summarises the current decision-making process.

This Section presents a review of the current decision-making process, incorporating inputs from the Steering Group meeting on 16th July 2020, and details how the preferred approach of using B£ST can be integrated into the decision-making process. In doing so, it also incorporates further discussion points raised at the Steering Group meeting on the 30th July 2020. Where identified, observations on relative weaknesses and potential improvements to the current decision-making process are also included in this Section.

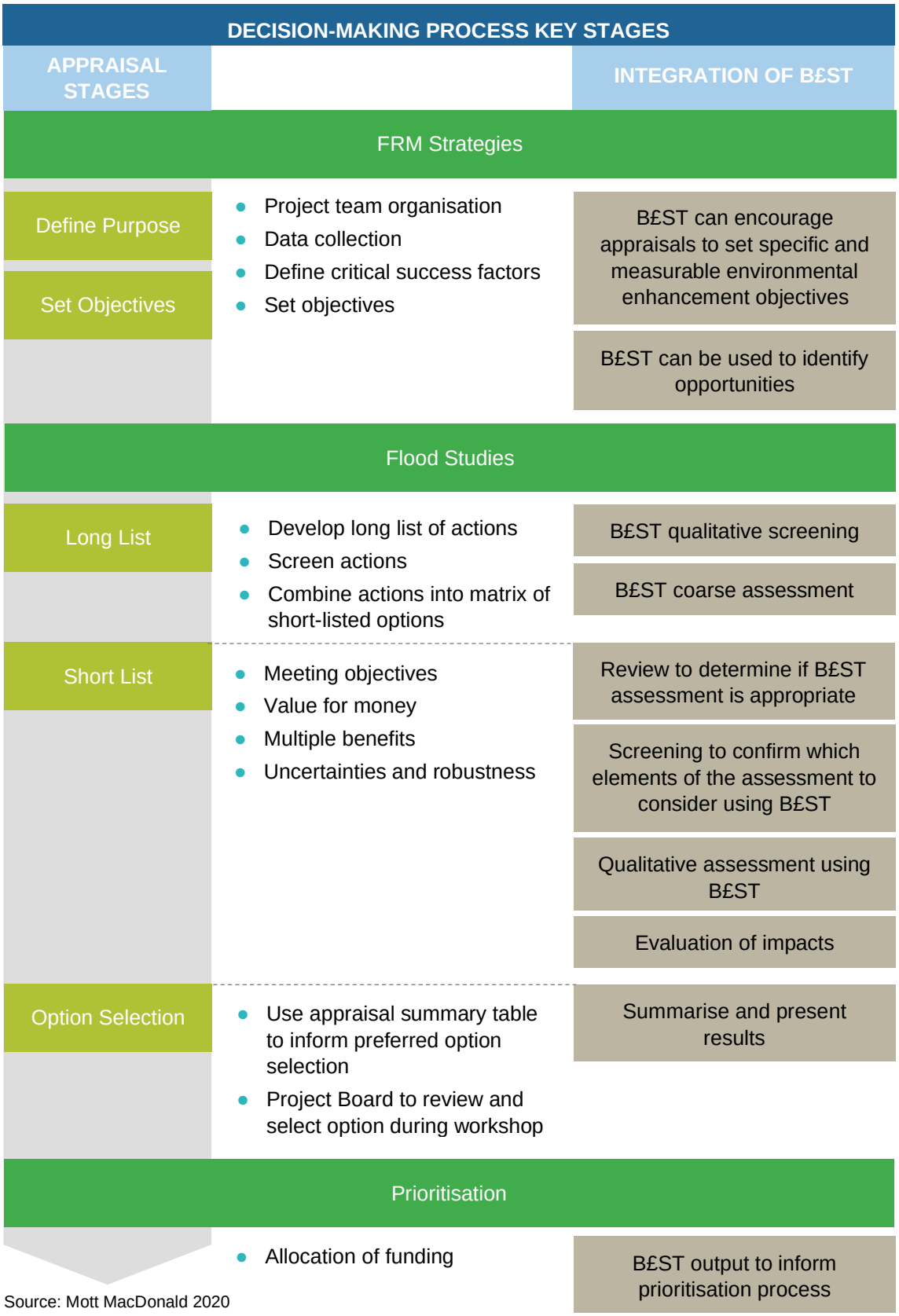
**Figure 3.1: Overview of the decision-making process (Scottish Government, 2016).**




Source: Mott MacDonald 2020.

Figure 3.2 summarises how B£ST can be integrated into the flood risk management decision-making process.

**Figure 3.2: B£ST integration into the flood risk management decision-making process**




Source: Mott MacDonald 2020

## 3.2 Setting and meeting the objectives

**Overview**

Scottish Appraisal Guidance highlights the importance of considering objectives and opportunities for delivering multiple outcomes early in the process (Scottish Government, 2016). The guidance indicates that local scale flood risk management actions should be developed in the context of the wider objectives and actions set out in the Flood Risk Management Strategies.

Flood Risk Management Strategies set out the short to long term ambition for flood risk management in Scotland detailing the objectives, as agreed by Responsible Authorities, for proactively managing flood risk. Example objectives from the Tweed Flood Risk Management Strategy (SEPA, 2016) include broad objectives to:

- "avoid an overall increase in flood risk"
- "reduce overall flood risk"

When undertaking appraisals, the guidance indicates that objectives should:

- Be aspirational and not set limits on what is desirable or achievable. For example, it should not be stated that the objective is "to develop a flood embankment with a 1% annual exceedance probability (AEP) design standard"
- Align with the flood risk management plan
- Be developed in partnership with stakeholders and partners
- Consider opportunities for delivering multiple benefits, i.e. non-flood damages avoided benefits

**How B£ST can be integrated into setting and meeting objectives**

B£ST does not provide an integrated approach for the identification of opportunities or setting objectives, however it does provide a way of testing and documenting that objectives have been met. The use of B£ST will encourage appraisals to set specific and measurable objectives in relation to environmental enhancement, i.e. objectives could move from the vague "enhance the local environment" to "significantly enhance local amenity provision by providing at least a 25% increase in amenity value within the catchment".

**Observed issues with objective setting**

There are barriers to the implementation of NFM measures from this objective setting decision-making step within the guidance that could be reduced or removed.

The Scottish Appraisal Guidance does not specify a standard of protection (SOP) for flood schemes. Instead, it advocates that a risk-based approach should be adopted, linking benefits to costs with the aim of maximising the reduction in overall risk. However, it recommends all appraisals should include an option that protects to a 1% AEP, plus allowances for climate change. It notes that other incremental levels of protection (higher and lower) should be considered during option development. Thus, although a minimum SOP is not specified, by requiring the consideration of a 1% AEP, project teams may be biased towards a high SOP as a requirement of success for a project. Further pressure is also introduced from the potential for flood risk management schemes to facilitate development (another Local Authority responsibility) which could be met via the adoption of an objective to achieve a 0.5% AEP SOP.

The inclusion of definitive objectives that recognise lower SOPs as success, could help to accommodate additional flexibility for schemes to deliver additional multiple benefits – e.g. "minimise number of homes at risk of flooding in 5% AEP". Consideration should be given to the

requirement for project boards to set minimum acceptable standards at the project outset via the definition of critical success factors, that is things that the project must achieve, e.g. “protect all homes from flooding in the 5% AEP”. With clear knowledge of what constitutes success or failure, project delivery teams will be able to efficiently progress desirable solutions.

## 3.3 Flood studies

### 3.3.1 Long list appraisal

**Overview of existing process**

Screening exercises are typically required to reduce a long list to a short list of viable flood risk management actions. The process removes any clearly unfeasible actions, leaving a smaller number for further appraisal. The guidance recommends that any actions that are technically impractical and actions that have insurmountable constraints should be screened out. Importantly, it notes that complex and integrated solutions, however, should not be shied away from – thus opening the door to NFM and hybrid options.

Reflecting the guidance’s terminology “long list screening” is typically a binary in-out approach to screen actions in isolation and not in combination.

**How B£ST can be integrated into the long list appraisal**

The existing guidance for long list option screening within the Scottish Appraisal Guidance provides a satisfactory approach for option screening and should be followed during the long list stage. B£ST incorporates a number of levels of assessments each targeted at different project scales and needs. The most basic is a rapid qualitative screening approach which is suitable for screening during the early stages of appraisals. The screening and coarse assessment tools can be used to efficiently test long list options allowing the decision process to be robust, repeatable and documented.

**Observed issues with current long list appraisal process**

Following discussions within the Steering Group, it was agreed that NFM measures frequently fail to progress through the long list option appraisal process to the short list, and hence fail to be included in the subsequent selection stages of appraisals for preferred options. Flood risk management measures such as NFM may not solve flooding in isolation and may need to be used to complement other approaches in a blended or hybrid fashion. Further study, and a more detailed review of the long list appraisal process, is recommended to facilitate the grouping of measures in combination so as to generate sustainable cost effective approaches. Consideration should also be given to rethinking how flood risk management measures can be appraised at the long list stage using a continuous scale rather than the binary in-out approach. The use of measures in combination would enable appraisals to outline options that comprise of “a lot” or “a little” of multiple flood risk management measures. A refined approach could consider the following four characteristics of each flood risk management action to create an optimised list of short list options with complementary weaknesses and strengths.

- Benefit-time curve – showing how the benefits of an action change over the years
- Benefit-event probability curve – showing how effective the action is for low to high probability flood events
- Cost-benefit curve – showing the relationship between investing additional funds to implement more of a specific action and the benefits arising from the additional investment
- Benefit-location matrix – identifying the geographic locations which would and would not benefit from the action

Improvements of project objectives (Section 3.2) could also help to remove barriers to NFM arising from objectives that NFM may struggle to achieve (or where providing evidence of achieving the objective may not be feasible). Similarly, better tools for helping appraisal teams to proactively manage risk and uncertainty (Section 3.3.2.3) would encourage project teams to try higher risk approaches such as NFM.

As a further consideration, it is common practice for appraisals to target the consideration of approximately three “Do Something” options at the short list stage (the Flood Study Checklist provides an example comprising of five options). The typically limited short list is reflected by examples in the guidance and within referenced standard templates such as the Environment Agency’s FCERM Summary Spreadsheet. The Appraisal Guidance indicates that a range of SOPs should be considered, but once a range of potential flood risk actions are also considered it is apparent that progressing only three options to short list does not provide an adequate range. Replacing the two-step process of long list screening and short list appraisal with a four or even five step process of long list action appraisal, short list option definition, coarse short list appraisal, fine short list appraisal and preferred option refinement could also serve to allow a more progressive mix of flood risk management actions to be adopted.

### 3.3.2 Short list option appraisal

Section 11.2 of the Appraisal Guidance highlights the following criteria that should be considered when selecting the preferred option.

- Does the option meet the objectives (as discussed in Section 3.2)?
- Does the option represent best value for money?
- Does the option deliver multiple benefits and what are the adverse impacts?
- What are the uncertainties and robustness in the appraisal and what are the risks in implementation?

The following Sections provide a discussion on the four criteria and how B£ST can be integrated into the processes.

It should be noted that best value for money is not the sole decision factor when selecting the preferred option. Section 11.1 of the Appraisal Guidance provides flexibility in the selection of the preferred option citing that issues should be balanced to identify the most sustainable solution and that a well-designed appraisal summary table will support this process so that the decision is robust and it can be readily understood by those affected. It does however leave the decision as a subjective process. Switching to a prescribed formula for selecting the preferred option would provide more openness and be less prone to challenge. The prescribed method could utilise appraisal summary tables that incorporate a scoring and weighting approach (Department of Communities and Local Government, 2009). This would allow “best value” and “multiple benefits” to be considered on a level playing field as well as provide greater clarity, repeatability and openness for the appraisal process.

#### 3.3.2.1 Best value for money

**Overview**

The Scottish Appraisal Guidance separate “best value for money” and the delivery of “multiple benefits”. Following discussion with the Scottish Government, it is assumed that the benefits used when assessing “best value for money” should be limited to flood damages avoided. The maximisation of all benefits, including ecosystem services, is considered separately via “multiple benefits” in Section 3.3.2.2.

Box 5.2 of the Scottish Appraisal Guidance pragmatically indicates that it is worthwhile considering the economic impact to a receptor where damages are likely to be in excess of 10% of the property damages. Similarly, the guidance suggests that where the impacts to a receptor are similar across all of the options then it is not appropriate to invest significant effort appraising benefits related to this receptor as it will not result in alteration of the outcome of the appraisal.

**How B£ST can be integrated into identifying best value for money**

Best value for money can be identified as detailed by Section 11 and Box 5.1 of the Appraisal Guidance via cost benefit analysis using the Benefit-Cost Ratio and Incremental Benefit-Cost Ratio.

As set out in the preceding Section it is assumed that the benefits used when assessing best value for money should be limited to flood damages avoided. The maximisation of all benefits is considered separately via "multiple benefits" in Section 3.3.2.2.

B£ST incorporates rapid approaches to facilitate the estimate of benefits relating to flood damages avoided and it can be used in combination with alternative methods. It is anticipated that B£ST's rapid estimation of flood damages avoided would rarely be used – with the industry standard Multi Coloured Handbook (Flood Hazard Research Centre, 2020) remaining the recommended approach.

**Observed issues with identifying best value for money**

As highlighted in the introduction to Section 3.3.2 it would be beneficial for the Appraisal Guidance to provide a prescribed equation for the selection of the preferred option, possibly in combination with appraisal summary tables that incorporate a scoring and weighting approach. This would allow "best value" and "multiple benefits" to be considered on a level playing field as well as provide greater clarity and openness for the appraisal process.

The current decision criteria within Section 11 of the Appraisal Guidance lacks clarity on what should be considered within the estimation of "best value for money". By separating "multiple benefits" from "best value" in the Appraisal Guidance decision process the guidance implies, but does not overtly say, that "best value" should only consider flood damages avoided. It would be beneficial to clarify what benefits (and costs) should be considered when assessing best value for money.

The pragmatic advice within Box 5.2 of the Scottish Appraisal Guidance provides principles on when appraisals should seek to monetise flood damages avoided relating to options, i.e. where the value of flood damages avoided is expected to change by more than 10% allowing the differentiation between options. The 10% principle does not preclude project teams from evaluating small marginal gains arising from low value investments; however it is anticipated that on the basis of this principle most appraisals should not evaluate the normally minor flood damages avoided arising from NFM measures. This results in NFM adding cost to projects without adding flood reduction benefit. It is acknowledged that there are considerable gaps in the scientific knowledge of how NFM reduces flood damages, however projects with small quantities of NFM would benefit from published rules of thumb to allow appraisals below the 10% threshold to pragmatically claim flood damages avoided arising from NFM and therefore assist with meeting flood risk management objectives. For example, and only for the purpose of evaluating options, appraisals could assume that increasing tree cover in a catchment by 10% would reduce flood damages by 1%.

The Green Book (HM Treasury, 2018) recommends using Net Present Value over Benefit-Cost Ratio and Incremental Benefit Cost Ratio to select the most economic option. This approach

has already been adopted in Wales (Welsh Government, 2019). It is recommended that Net Present Value is used as it is generally more robust, and unlike the Incremental Benefit Cost Ratio, it does not require options to be correctly ordered making it more accessible to less experienced practitioners.

#### 3.3.2.2 Multiple benefits

**Overview**

The current Appraisal Guidance notes that where an option alters the quantity or quality of multiple benefits the impact of the changes should be comprehensively assessed and, where possible and proportionate, quantified and valued (this may be in monetary terms). Potentially viable options should not be dismissed just because some of the benefits may be difficult to value. Section 8.4.1 of the Scottish Appraisal Guidance indicates that for many appraisals the use of non-monetised assessments of environmental benefits is likely to be sufficient for decision-making.

Section 3.3.2.1 of this report proposes that although multiple benefits should be considered in the options appraisal process, non-flood benefits should not be included in the assessment of "best value for money".

**How B£ST can be integrated into maximising the delivery of multiple benefits**

It is proposed that multiple benefits are considered within a second cost benefit analysis considering all option benefits (sum of "multiple benefits" and flood damages avoided benefits). In most cases the use of B£ST would permit all significant benefits to be monetised in line with the 10% significance threshold provided within the Appraisal Guidance allowing Benefit-Cost Ratio, Net Present Value and Incremental Benefit Cost Ratio to be used. Where project teams determine that all significant benefits cannot be monetised a scoring and weighting approach (Department of Communities and Local Government, 2009) could be incorporated within the appraisal summary table.

When appraising multiple benefits using B£ST alongside flood damages avoided it is essential that consistent appraisal options, appraisal periods, discount rates and appraisal extents are considered.

**Observed issues with considering multiple benefits**

As highlighted in the introduction to Section 3.3.2, it would be beneficial for the Appraisal Guidance to provide a prescribed equation for the selection of the preferred option, possibly in combination with appraisal summary tables that incorporate a scoring and weighting approach. This would allow "best value" and "multiple benefits" to be considered on a defined level playing field as well as provide greater clarity and openness for the appraisal process.

The Appraisal Guidance lacks definitive advice on what triggers should be considered for detailed assessment of ecosystem services such as via the B£ST methodology. It is recommended that future guidance defines cascading thresholds where more quantitative detailed evaluation processes such as B£ST could, should or must be employed.

The Appraisal Guidance terminology of multiple benefits is unclear, and no definition is provided in the guidance. There would be greater clarity if terminology simply referred to "flood benefits" and "other benefits".

For multiple benefits to be fully integrated into the short-list appraisal process, consideration should be given to providing guidance on what baseline case should be considered. In the majority of cases it is anticipated that the differences between the Do Nothing, Do Minimum and

existing case will have no significant impact on the appraisal, however it will not be the case universally.

#### 3.3.2.3 Uncertainties and robustness

**Overview**

There is a high degree of uncertainty associated with NFM in terms of both flood damage reduction and provision of ecosystem services. This can present a barrier to the implementation of NFM given that project teams are mandated to deliver a project that will, rather than might, reduce flooding. Uncertainties can arise from:

- Successfully engaging with sufficient land managers to enable the required scale of change to be achieved
- Scientific knowledge gaps relating to the hydrological effectiveness of NFM
- Community acceptance of NFM as a solution
- Confidence that NFM will be maintained and changed land use practices will be sustained in the medium and long term

The uncertainties of flood risk management and option appraisal are however not limited to NFM measures and appropriate methodologies can be adopted to manage the risks and uncertainties of NFM benefits. Sections 11.6 and 11.7 of the Appraisal Guidance outlines how uncertainties and risk can be managed using sensitivity analysis and robustness testing.

**How B£ST can be used to consider uncertainty and robustness**

Section 6 of the B£ST guidance (CIRIA, 2019) details how uncertainty can be considered and the tool's in-built functionality used for undertaking sensitivity tests. The tool considers uncertainty in two ways for monetised benefits:

1. Ranges of quantitative estimates and monetary values are permitted
2. User-defined confidence scores relating to both quantified estimates and monetary values

Through presenting "confidence scores" for each category, users are able to identify areas of uncertainty enabling project teams to target available resources to improving the evaluation of categories with high significance but low confidence. Project teams are also able to use confidence scores to inform the sensitivity and robustness testing.

The use of ranges and confidence scores helps to ensure outputs are repeatable, reliable in reality and consistent with expectations. However, for greater investments such as major developments more complex techniques to assess the uncertainty and manage its consequences on the decision process are recommended.

It is noted that the sensitivity analysis within B£ST is not complete, and consultation is on-going. This presents an opportunity to engage with CIRIA on how this could be shaped for the needs of Scottish appraisals.

**Observations**

As detailed earlier in Section 3.3.2.3 relying on NFM is more uncertain than traditional flood defences. This uncertainty frequently results in solutions that incorporate NFM not being selected as the preferred option. It is recommended that approaches are incorporated into the Appraisal Guidance to give project teams tools to manage this uncertainty.

Adaptive pathways, as commonly used to manage climate change uncertainty, could be used to give space for NFM to be trialled within a catchment over a set number of years. If triggers

occur such as land managers fail to engage, the public does not accept it, or the benefits fail to realise, then a defined alternate course of action could be taken.

Monte Carlo Analysis is routinely used to manage cost uncertainty on public sector projects. The probabilistic principles can be used to actively manage the uncertainty of NFM adoption, implementation and benefit generation (Mott MacDonald, 2018). It would enable uncertainties to be actively managed and allow the direct integration of uncertainty within the quantitative "best value for money" and maximisation of "multiple benefits" further reducing subjective decision-making within the appraisal process.

### 3.3.3 Selecting the preferred option using an appraisal summary table

**Overview**

Section 11.1 of the Appraisal Guidance indicates that the preferred option should be selected by balancing the economic, social and environmental impacts with the costs, risks and uncertainties. The decision should be made in a clear, justifiable and transparent way using appropriate and robust information so that it can be readily understood by those affected. The Appraisal Guidance recommends that a well-designed appraisal summary table should be used referencing the Environment Agency's template (Environment Agency, 2010).

**How B£ST can be used to create an appraisal summary table**

The B£ST tool is packaged with an accompanying tool for comparing multiple options via its own appraisal summary table. This can be used to transparently and robustly compare options. The tool does not report non-monetised benefits although free text space is provided to facilitate the reporting of other categories, these could be used to report other information including a narrative on risk and uncertainty or monetised risk from Monte Carlo analysis.

**Observations**

The Appraisal Guidance indicates that the preferred option selection is to be based on the subjective consideration of the available information. As such there is a risk that the decision is not robust, transparent or repeatable meaning that outcomes could be hard to defend when challenged. Affected stakeholders may not be able to follow how the decision was made. Consideration should be given to adopting a weighting approach to balance the four decision criteria and if non-monetised values are considered these should be converted to monetary values via scoring and weighting (Environment Agency, 2010) (Department of Communities and Local Government, 2009) .

## 3.4 Prioritisation

**Overview**

The flood component of Capital Grant Funding provides up to 80% of the up-front capital cost to deliver flood risk management works. Funding can be used to pay for "eligible costs" (Scottish Government, June 2020). Information captured during the option appraisal process is used to support the subsequent prioritisation and allocation of funding.

**How B£ST can be used to support the prioritisation process**

The output of B£ST could assist with providing evidence (in the form of monetised values) to support the prioritisation and allocation of funding process.

**Observations relating to prioritisation**

Following consultation with the project Steering Group, it is understood that the prioritisation process actively promotes options with multiple benefits and suggests schemes with high

ecosystem service provision, such as those incorporating NFM, would perform well in the prioritisation process and would therefore be likely to receive funding.

In the absence of affordability from the short list decision-making criteria and the limitation of funding to only “eligible costs” associated with flood protection works (Scottish Government, June 2020) there is the potential for the preferred option to not be affordable. Alternatively if there is flexibility in what costs are considered eligible for funding it could result in the limited flood defence capital grant being used to primarily deliver environmental enhancements without bringing about a significant reduction in flood damages.

By identifying and monetising ecosystem services, B£ST could assist with the identification of beneficiaries allowing organisations with non-flood risk management remits to be approached for funding, e.g. carbon offset, health, education or economic development. This approach would align with the Partnership Funding Policy (Environment Agency, 2020) adopted in England where a “beneficiaries pay” principle is employed.

Prioritisation criteria could be defined to align with outputs from B£ST and streamline the transfer of information from the options appraisal to prioritisation process. Linking funding to the outputs generated by the tool would encourage wider adoption.

Consideration could be given to alterations to how Capital Grant is allocated. There is a range of potential alternate approaches for allocating funding. Two approaches are presented below.

- Allowing projects to select options which maximise the delivery of multiple benefits but limiting flooding Capital Grant funding to the most cost effective (i.e. lowest cost) means of achieving the same flood risk outcome. In this case partnerships would have to be formed to close the funding gap. This approach would align with the Local Choices Policy used in England (Environment Agency, 2020).
- Funding could be awarded for delivering Outcomes, e.g. benefits arising from flood damages could be paid at one rate, e.g. 80%, and multiple benefits could be paid at a lower rate, e.g. 25%, allowing sustainable projects to be fully funded by Capital Grant and hence encouraging appraisal teams to select more sustainable solutions. The payment for Outcomes aligns with the principles of the English Partnership Funding Calculator (Environment Agency, 2020).

Both approaches would represent significant changes to the allocation of funding and would need to be considered in detail due to the potential for unintended consequences, budget impacts and the potential for flood defence funding to being used for non-flooding outcomes.

# 4 Testing the process on the Eddleston Water catchment

## 4.1 Overview

To understand the suitability of the proposed integration of B£ST into the current decision-making processes a test appraisal was carried out using the Eddleston Water catchment.

The demonstration flood risk management appraisal was undertaken following the outlined methodology for integrating the use of B£ST into the existing decision-making process presented in Section 3.

It is not recommended that the findings of this test appraisal are used to inform future flood risk management investment due to the requirement to make a large number of potentially significant assumptions in this assessment.

## 4.2 Data

Data and information required to undertake the demonstration appraisal was based on readily available information from the following sources:

- Actual outturn cost data for the implementation of NFM in the Eddleston catchment (Tweed Forum, 2020).
- GIS shapefile with the locations and characteristics of the interventions in the catchment (Tweed Forum, 2020). An overview of the project and associated interventions is shown in Figure 4.1.
- Costs and flood damages avoided benefits for traditional in town engineered flood defences within *Peebles Flood Study Summary Appraisal* (Mott MacDonald, 2019).
- Flood damages avoided benefits for the installed NFM within *Eddleston Water Hydrologic and Hydraulic Modelling of NFM: Phase 2* (JBA, July 2020).
- Additional data for the assessment of multiple benefits within *Ecosystem Services Benefits of Eddleston Water NFM Measures: Economic Analysis* (JBA, March 2020).

The demonstration appraisal has been based on the flood risk management measures presented in the above reports. The information presented has also been used to estimate the impact of additional in-town and NFM flood risk management investment.

A range of hybrid options comprising the combination of in-town and catchment NFM sub-options have been agreed with the Tweed Forum. To test the effectiveness of an in-town measure with a higher SOP, the cost and flood damage benefits have been extrapolated to consider a 0.5% AP SOP. The following in-town engineered sub-options have been considered within Peebles:

- Baseline – Do Nothing (assumed to be the same as the Do Minimum)
- Sub-option 1 – 1.3% AP SOP direct defences
- Sub-option 2 – 0.5% AP SOP direct defences (extrapolated using sub-option 1 data)
- Sub-option 3 – Property Level Protection

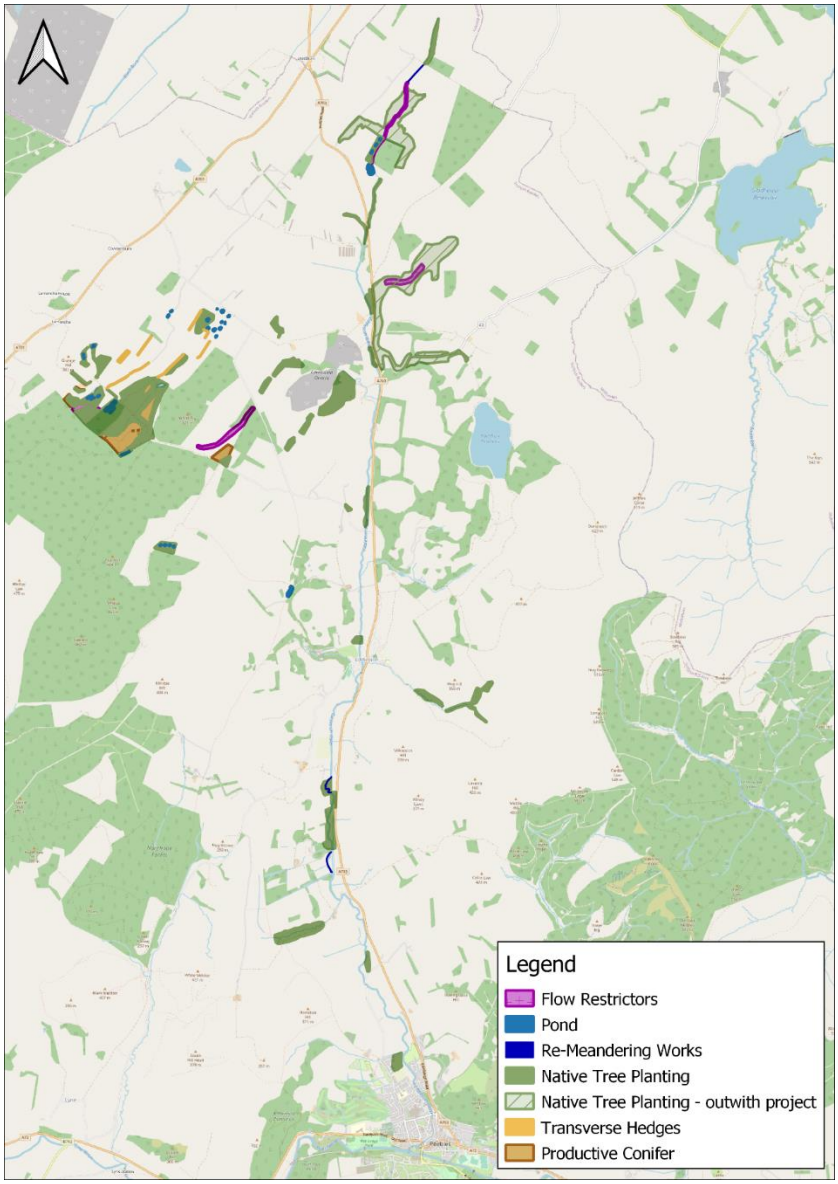
To increase the range of NFM options considered the available NFM data has been used to create three sub-options. The three adopted catchment NFM sub-options considered are listed below:

- Sub-option A – No NFM. Consistent with the catchment in 2010.
- Sub-option B – The actual NFM implemented within the catchment as of 2020
  - 207Ha of hillslope/non-riparian tree planting
  - 33Ha of riparian/near watercourse tree planting
  - 2.9km of river re-meandering
  - 116 'flow restrictors'
  - 29 runoff attenuation features and ponds
- Sub-option C – Further NFM measures to those already implemented within the catchment
  - Further forestation of 25% of the Eddleston catchment relative to sub-option A (1,750Ha of tree planting)
  - Double the length of channel works already implemented (5.8km of river re-meandering)
  - Five times the number of flow restrictors and log jams already implemented (580 'flow restrictors')
  - Five times the number of runoff attenuation features and ponds already implemented (145 runoff attenuations features and ponds)

In compliance with Scottish Government guidance (Scottish Government, 2016), a 100-year appraisal period has been used for the economic appraisal. The appraisal extent has been defined as the whole Eddleston Water catchment.

The assumptions used to derive benefits and costs are presented within the remainder of this Section. While it is appropriate for all appraisals to make assumptions, it is anticipated that real appraisals would undertake additional analysis to remove some of these assumptions.

**Figure 4.1: Eddleston Water NFM project overview**




Source: Mott MacDonald 2020. Contains Open Street Map data. © OpenStreetMap contributions

## 4.3 Integration into the decision-making process

### 4.3.1 Setting objectives

Objective setting was not undertaken as part of this demonstration. Section 3.2 presents an overview of how, through the provision of the ability to measure, B£ST can encourage appraisals to set specific and measurable objectives in relation to environmental enhancement.

### 4.3.2 Long list appraisal

This demonstration appraisal is limited to working with a predefined short list of options due to data availability, programme and budget constraints. As such the long list development and appraisal process has not been repeated for the Eddleston Water.

To create a range of test options, a matrix of 12 hybrid options was agreed with the Tweed Forum as presented in Table 4.1. The matrix consists of traditional in town flood defence sub-options from the *Peebles Flood Study Summary Appraisal Report* (Mott MacDonald, 2019) in combination with NFM sub-options based on the actual NFM implemented in the Eddleston Water by the Tweed Forum.

In this demonstration, for simplicity the baseline Do Nothing is assumed to be the same as the Do Minimum – Scottish Borders Council is assumed to provide only the legal minimum level of maintenance and flood risk management works in the baseline scenario.

The in town sub-options 1 and 3 are taken from the *Peebles Flood Study Summary Appraisal Report* (Mott MacDonald, 2019). Sub-option 2 has been adapted from sub-option 1 to test the impact of providing a greater level of protection. Additional assumptions have been made to estimate the costs and benefits of sub-option 2, as this was not considered in the *Peebles Flood Study Summary Appraisal Report* (Mott MacDonald, 2019). The assumptions are detailed in Appendix C.

NFM sub-option B represents the actual NFM measures implemented by the Tweed Forum. sub-option C builds upon the work of the Tweed Forum and considers the impact of providing further NFM measures.

This demonstration assumes that the 12 options are the output of the long list process. These options will be considered in more detail via the short list appraisal in the next Section.

**Table 4.1: Matrix of 12 options arising from the long list appraisal.**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | DM - A * | DM - B ^ | DM - C |
| | Sub-Option 1 - 1.3% AP SOP direct defences | 1 - A | 1 - B | 3 - C |
| | Sub-Option 2 - 0.5% AP SOP direct defences | 2 - A | 2 - B | 3 - C |
| | Sub-Option 3 - Property Level Protection | 3 - A | 3 - B | 4 - C |

Source: Mott MacDonald 2020

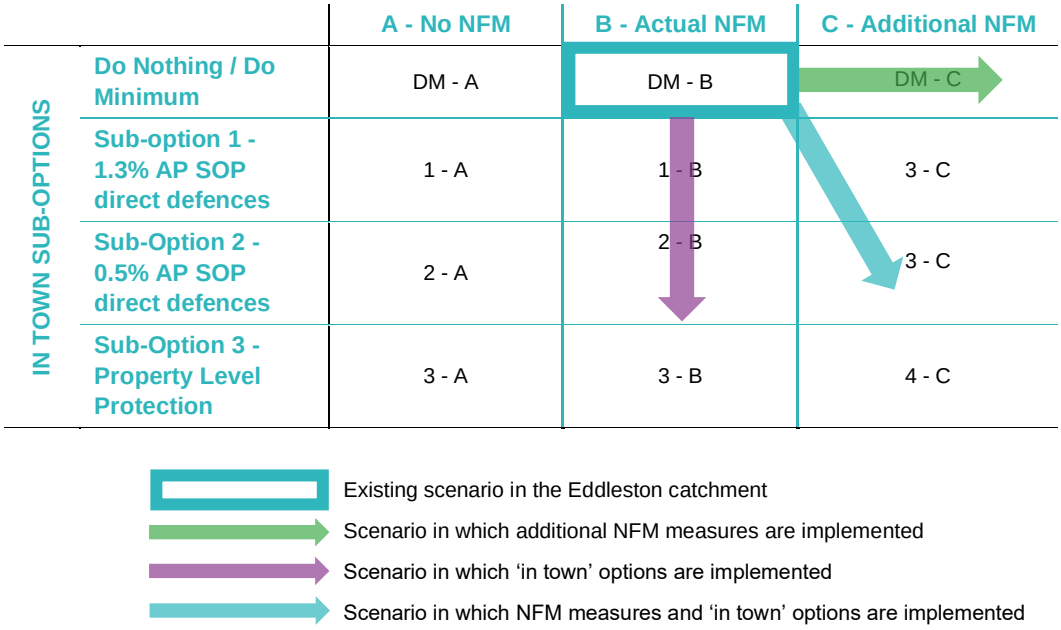
* Situation on the ground in 2010 prior to the Eddleston Water Project and with no defences in place.

^ Current situation on the ground in 2020 following the Eddleston Water Project and with no defences in place.

Table 4.2 presents the short list matrix of options and is overlain with markers that illustrate possible strategies that could be implemented by the project team. Note that the mark-up acknowledges that this is a partially retrospective appraisal.

**Table 4.2: Short list matrix options and illustration of potential strategies**

| | NFM SUB-OPTIONS |
|---|---|




Source: Mott MacDonald 2020

### 4.3.3 Short list appraisal – meeting objectives

It is assumed that the short listed options all help to meet the project objectives as they have been agreed in consultation with the Tweed Forum.

### 4.3.4 Short list appraisal – best value for money

The matrix of options presented in Table 4.1 has been appraised for value for money using the guidance presented in the Scottish Government '*Options appraisal for flood risk management: Guidance to support SEPA and the responsible authorities'* (Scottish Government, 2016).

In compliance with Scottish Government guidance (Scottish Government, 2016), a 100-year appraisal period has been used for the economic appraisal. All costs and benefits over the appraisal period have been discounted in compliance with the Green Book (HM Treasury, 2018).

As proposed in Section 3.3.2.1, only flood damages avoided and allowable costs have been considered in the assessment of best value for money.

Note that an assessment of multiple benefits alongside all costs is demonstrated in Section 4.3.5.

#### 4.3.4.1 Estimation of whole life costs

The estimation of the whole life costs of the in town flood defence sub-options Do Minimum, sub-option 1 and sub-option 3 have been extracted from the *Peebles Flood Study Summary Appraisal Report* (Mott MacDonald, 2019). The cost of sub-option 2 has been extrapolated by increasing the cost from sub-option 1 by a third to account for the increased flood wall height and length required to provide a 0.5% AP SOP. The whole life costs of the NFM sub-options A and B have been estimated using actual cost data from the Eddleston Water NFM study,

provided by the Tweed Forum. Operational and maintenance costs for the NFM measures have been estimated using available information provided by the Tweed Forum and using assumptions agreed with the Tweed Forum. The cost of sub-option C has been extrapolated using supporting data from sub-option B. Further details on the assumptions made, including a breakdown of costs is provided in Appendix C.

Table 4.3 presents a summary of the option costs for the four traditional in town flood defence sub-options and NFM sub-options in combination.

**Table 4.3: Matrix of option costs (£k, Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | 2,131 | 12,017 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | 8,014 | 10,145 | 20,031 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | 10,685 | 12,817 | 22,703 |
| | Sub-Option 3 - Property Level Protection | 1,964 | 4,095 | 13,981 |

Source: Mott MacDonald 2020

#### 4.3.4.2 Estimation of whole life benefits

With the exception of sub-option 2, an estimation of the flood damages avoided for each of the traditional in town flood defence options has been extracted from the *Peebles Flood Study Summary Appraisal Report* (Mott MacDonald, 2019). Sub-option 2 was not assessed in the *Peebles Flood Study Summary Appraisal Report* (Mott MacDonald, 2019) and therefore the flood damages avoided for sub-option 2 has been estimated using sub-option 1 damage estimates and assuming no damages below a 0.5% AP event. This simplification has been deemed satisfactory for the purposes of this test only.

An assessment of the number of properties with reduced flood risk and flood damages avoided arising from the Eddleston NFM works has been estimated and reported within *Eddleston Water Hydrologic and Hydraulic Modelling of NFM: Phase 2* (JBA, July 2020). Table 8-2 of the report identifies that the Average Annual Damage reduces by £32k/yr. Figure C.2, in Appendix C, reproduces Table 8-2 from the report. Based on property counts the majority of the benefit relates to properties in Peebles with only a small reduction in properties at risk in Eddleston. In the absence of specific information, it is assumed that 90% of flood damages avoided benefits relate to Peebles and 10% to Eddleston. It should be noted that the report highlights that the damage assessment considers surface water runoff and has a different extent to the Peebles Flood Study (Mott MacDonald, 2019) therefore the damage assessment is not directly comparable with the values reported in the Peebles Flood Study. The NFM sub-option C was not assessed in *Eddleston Water Hydrologic and Hydraulic Modelling of NFM: Phase 2* (JBA, July 2020) and therefore the flood damages avoided for sub-option C have been estimated as three times the sub-option B flood damages avoided. This simplification has been deemed satisfactory for the purposes of this test only. When considering options in combination, only the NFM flood damages avoided above the in-town engineered standard of protection have been considered.

Table 4.4 summarises the flood damages avoided for the four traditional in town flood defence sub-options and three NFM sub-options in combination.

**Table 4.4: Matrix showing option flood damages avoided benefit (£k, Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | 950 | 2,850 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | 4,704 | 4,908 | 5,317 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | 5,633 | 5,790 | 6,103 |
| | Sub-Option 3 - Property Level Protection | 4,792 | 5,468 | 6,821 |

Source: Mott MacDonald 2020

#### 4.3.4.3 Identification of the best value option

A summary of the economic analysis is presented in Table 4.5 and Table 4.6. The tables present the Benefit Cost Ratio (BCR) and Net Present Value (NPV) respectively. An assessment using the Incremental Benefit Cost Ratio (IBCR) has not been conducted due to the challenges of calculating IBCR for a matrix of options.

**Table 4.5: Matrix showing option BCR based on best value flood damages avoided (Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | 0.45 | 0.24 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | 0.59 | 0.48 | 0.27 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | 0.53 | 0.45 | 0.27 |
| | Sub-Option 3 - Property Level Protection | **2.44** | 1.34 | 0.49 |

Source: Mott MacDonald 2020

**Table 4.6: Matrix showing option NPV based on best value flood damages avoided (£k, Present Value, 100-year Appraisal Period)**

| | NFM SUB-OPTION | | |
|---|---|---|---|
| | A - No NFM | B - Actual NFM | C - Additional NFM |

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | -1,181 | -9,167 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | -3,310 | -5,237 | -14,714 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | -5,052 | -7,027 | -16,600 |
| | Sub-Option 3 - Property Level Protection | **2,828** | 1,373 | -7,160 |

Source: Mott MacDonald 2020

The assessment indicates that Property Level Protection (PLP) with no NFM has best value for money in terms of both BCR (2.44) and NPV (£2.8M).

### 4.3.5 Short list appraisal – multiple benefits

A second cost benefit analysis considering all benefits (sum of flood damage avoided benefits and multiple benefits evaluated using B£ST) has been completed to identify the most favourable option in terms of the delivery of all benefits. This multiple benefits analysis incorporates the flood risk management costs and benefits reported in Section 4.3.4 in combination with the value of ecosystem services estimated using B£ST.

#### 4.3.5.1 Evaluation of ecosystem services using B£ST

The assessment of the multiple benefits in the form of ecosystem services arising from the NFM has been assessed using B£ST. The assessment was undertaken following the methodology provided in the B£ST Guidance (CIRIA, 2019).

The B£ST assessment process is split into five stages:

- Review to determine in an assessment is appropriate
- Screening to confirm which elements of the assessment are appropriate
- Qualitative assessment
- Evaluation of impacts
- Summarise and present results

Following a review, in compliance with the B£ST Guidance notes it was concluded that an assessment was required and considered appropriate for the NFM measures of the project but not for the in-town engineered defences.

#### 4.3.5.2 Screening and qualitative assessment of benefits

On confirmation that an assessment was appropriate, a series of screening questions was applied to identify which benefit categories to consider later within the detailed evaluation of impacts. A full list of screening questions is provided in the B£ST tool and an example is shown in Table 4.7

**Table 4.7: Example screening question**

| Benefit category | Question | Generic Sub Question |
|---|---|---|
| Air Quality | Will the Scheme significantly change the level of air quality? | Is the site in an air quality management area?<br>Will the scheme involve green infrastructure (e.g. tree planting, green roofs)?<br>Is the scheme in a populated area or a transport corridor? |

Source: (CIRIA, 2019)

Using the B£ST Screening Questions the services scoped in for further assessment, and justification for their inclusion, are summarised in Table 4.8. B£ST guidance provides prescriptive descriptions where ESS benefits should be scoped in for evaluation.

To aid comparison, Table 4.8 also references the initial ESS benefits assessment presented within *Ecosystem Services Benefits of Eddleston Water NFM Measures: Economic Analysis* (JBA, March 2020).

**Table 4.8: Screening and qualitative assessment of Ecosystem Services (screening of all NFM measures)**

| Ecosystem Service | Assessed significance by this study | Benefits evaluated by this study | JBA assessment* | This study's reasons /evidence for choosing the scale of the impact |
|---|---|---|---|---|
| Air Quality | 0 | NO | Low importance – valuation not included | Using project records in combination with Ordnance Survey mapping, negligible air benefits due to remoteness of scheme |
| Amenity | + | YES | Low importance – valuation not included | NFM measures are likely to improve the attractiveness of the Sustrans Eddleston Water Path. However, using project records in combination with Ordnance Survey mapping, planting of trees and river restoration will have only a marginal increase in the attractiveness of the already attractive area. Property prices unlikely to be impacted by improvements considering catchment remoteness. |
| Biodiversity & Ecology | ++ | YES | High importance – valuation included | Using project records in combination with Ordnance Survey mapping and aerial photograph, replanting of native woodland will have sizeable impact on ecological communities. The creation of wet habitats at flow restrictors and ponds will also have a small improvement. Note that water environment biodiversity changes are assessed within Water Quality. |
| Carbon Sequestration | ++ | YES | High importance – valuation included | Using project records in combination with Ordnance Survey mapping and aerial photograph, 239 hectares of riparian and headwater woodland created comprising over 330,000 trees planted. Significant area of afforestation and thus carbon value likely. Approx. 10Ha of additional floodplain restoration (assumed) and 29 (assumed 0.1Ha total) of runoff attenuation features will act as further carbon sinks. |
| Education | + | YES | High importance – valuation included | Using project records, the Pioneering Eddleston Water Project is a primary destination for educational visits within the |

| Ecosystem Service | Assessed significance by this study | Benefits evaluated by this study | JBA assessment* | This study's reasons /evidence for choosing the scale of the impact |
|---|---|---|---|---|
| | | | | sector. |
| Health | + | NO | Low importance – valuation not included | NFM measures are likely to improve the attractiveness of the Sustrans Eddleston Water Path and increase recreational visitor numbers leading to additional physical activity. In compliance with B£ST guidance, to avoid double counting, this benefit has been evaluated within the 'amenity' ecosystem service B£ST module. |
| Recreation | + | NO | Low importance – valuation not included | NFM measures are likely to improve the attractiveness of the Sustrans Eddleston Water Path and increase recreational visitor numbers. In compliance with B£ST guidance, to avoid double counting, this benefit has been evaluated within the 'amenity' ecosystem service B£ST module. |
| Water Quality of receiving water and Flows in watercourse | + | Yes | High importance – valuation included | Although the overall WFD status reported by SEPA on the Water Classification Hub has not changed over the life of the project, we assume the project has helped work towards improving the status. The WFD status impact has been assessed against the following components: Fish, Other animals (e.g. invertebrates), Plant communities, Clarity of water, Condition of the river channel and flow of water, Safety of the water for recreational contact. |
| Angling | + | NO | Medium importance – valuation not included | Channel restoration works will likely impact positively on fish stocks – this has been considered within the B£ST assessment of the anticipated WDF status improvements. However, capacity for fishing is limited within the Eddleston Water itself. |
| Timber production | + | NO | Medium importance – valuation included | Felling of planted woodland is unlikely although thinning may provide some benefit. The cost of thinning is likely to be offset by the benefit of timber production, with any residual benefit likely negligible. |
| Agriculture (income forgone) | + | NO | High importance – valuation included | Although a considerable area of pasture is to be converted to woodland, B£ST does not provide a unique, internal or distinct method for the value of agricultural land and encourages the use of external sources such as the land value estimate. For example, when expecting impacts on productive agricultural land, the value of these impacts can be estimated by multiplying the change in probability (e.g. number of additional 'flood free days' per year as a result of the scheme) by the value of the land. Value of land estimates can be obtained from the Land Value Estimates for Policy Appraisal dataset (https://www.gov.uk/government/publicatio |

| Ecosystem Service | Assessed significance by this study | Benefits evaluated by this study | JBA assessment* | This study's reasons /evidence for choosing the scale of the impact |
|---|---|---|---|---|
| | | | | ns/land-value-estimates-for-policy-appraisal-2017) |
| Game management | 0 | NO | Low importance – valuation not included | Relatively low site elevation means that heather is not a dominant habitat and therefore grouse shooting benefits are likely negligible. |

Source: Mott MacDonald

Significance rating: 0 (Not significant), + (Minor positive), ++ (Significant positive). * Table 2-1, Ecosystem Service Benefits of Eddleston NFM Measures: Economic Analysis (JBA, March 2020)

The benefits scoped in for further evaluation where assessed within B£ST using the methodologies detailed below:

**Amenity – B£ST "Am"**

The proposed NFM measures are anticipated to improve the attractiveness of the Sustrans Eddleston Water Path. For the purposes of this test, it is assumed the Eddleston Water Path has already been completed and NFM provides additional ESS benefit by increasing the attractiveness and hence the amenity value by 10% for sub-option B and 25% for sub-option C. The character of the space has been assumed to align with the 'commonly visited local park or green space' assessment provided by B£ST (AM2). The monetary reference values for visits encompass general recreation and therefore recreation has not been separately assessed avoiding double counting. The baseline annual visitor numbers of the path have been estimated at 70,000 visits, aligning with the visitors recorded on the nearby former railway line route between Peebles and Innerleithen (Scottish Borders Council, 2016). In compliance with the B£ST guidance the quantity and valuation confidence scores have been set at 50%.

Flood walls are proposed in Peebles as part of the in town sub-options 1 and 2. These defences have the potential to negatively impact the accessibility, visibility and hence amenity value of the Eddleston Water. This has not been monetised in this assessment. However, B£ST can accommodate assessments of disbenefits. The assumption that the negative impact of walls was not significant in changing the preferred option was reviewed at the end of the short list appraisal. As neither sub-option was identified as a leading sub-option, including the negative benefit would not have altered the outcome of the appraisal.

**Biodiversity and ecology – B£ST "BE"**

To quantify the benefits to biodiversity and ecology, the area (hectares) of improved habitat types present were entered for the proposed options.

- Sub-option B – actual NFM
  - 239Ha changed from "Improved grassland" to "Native woodland" representing all forms of woodland.
  - 0.145Ha changed from "Improved grassland" to "Wet reed beds" representing the habitat created by 116 flow restrictors and 29 ponds. It is assumed that each of these features alters habitat with an approximate 10m by 10m footprint.
- Sub-option C – additional NFM
  - 1750Ha changed from "Improved grassland" to "Native woodland" representing all forms of woodland.

- 0.725Ha changed from “Improved grassland” to “Wet reed beds” representing the habitat created by 580 flow restrictors and 145 ponds. It is assumed that each of these features alters habitat with an approximate 10m by 10m footprint.

Note that the ecological improvements of riparian woodland on the water environment are assessed separately within the water quality and flows B£ST module.

The confidence score for biodiversity relates to certainty of existing land use, reliability of data used to assess the baseline position. In compliance with B£ST guidance a confidence score of 50% was applied for the confidence in quantity and 75% was applied to the monetary value.

**Carbon sequestration – B£ST “CS”**

Carbon has been assumed to be sequestered due to the following two NFM measures:

- Improved floodplain connectivity
- Creation of woodland

To quantify the amount of carbon sequestered for NFM measures relating to the restoration of floodplain, an assumed 10Ha and 20Ha for sub-options B and C respectively of floodplain restored was entered into B£ST (CS3). A quantity confidence score of 50% was used to account for the risk of the floodplain restoration being reverted to other uses that undermine its carbon sequestration potential. A valuation confidence of 75% was also set. The confidence scores were set in compliance with the B£ST guidance.

To estimate the value of carbon stored within woodlands created as part of the NFM options, the Forestry Commission Woodlands Carbon $CO_2$de Calculator was used in compliance with the B£ST guidance to provide cumulative net carbon values over time. Confidence values of 100%, for the quantity and price were deemed appropriate due to the use of the Woodlands Carbon Code. The quick assessment approach was used within the $CO_2$de Calculator and it was assumed that riparian woodland would not be thinned, while the non-riparian woodland would be thinned. The output from the $CO_2$de Calculator was entered into the B£ST (CS4).

**Education – B£ST “Edu”**

The estimate of educational visits per year created because of the scheme has been based on the average annual visitors for the last three years (4.667 per year) (JBA, July 2020). The source of monetary values to support this assessment, were based on the reported average cost of the visits (£7,525 per visit). This approach does not provide an estimate of the welfare benefit of the knowledge gained in nature visits or projects, but rather an indication of outlay that is made in the acquisition of the education. Confidence scores of 75% for quantity and monetary value, respectively, were deemed appropriate due to the likelihood of such visits occurring and the cost of investment, respectively.

**Water quality and flows – B£ST “WQ” and “QW1”**

The water quality (WQ) and flow (QW1) modules in B£ST support the estimation of the impact on the water environment. They are based on the expected change in status of the principal Water Framework Direct (WFD) water body. The assessment should be aligned with the WFD status classification system (e.g. poor to moderate, moderate to good) and based on the descriptions of status shown in Appendix E of the B£ST guidance (CIRIA, 2019) (from Environment Agency (2013)). The assessment has been completed using data accessed from the *Water Environment Hub* (SEPA, 2020) in reference to water body 5307.

The components that are assessed within B£ST are based on categories presented in *Valuing the Benefits of Storm Discharge Improvements for use in Cost-Benefit Analysis* (Water UK, 2017):

- Fish
  - For sub-option B, although the Water Environment Hub reports no change during the project lifespan to date. We assume the project has helped work towards improving this component from Moderate to Good. In recognition of the partial achievement the quantity has been set at 25% and the value 100% for the full 19.2km length of the water body within B£ST (WQ2).
  - For sub-option C, it is assumed that it is improved from Moderate to Good. Both the quantity and value have been set to 100% within B£ST for the full 19.2km length of the water body within B£ST (WQ2).
- Other animals such as invertebrates
  - No change in the WFD status reported within the Water Environment Hub during the project lifespan and the water body is already classified as Good.
- Plant communities
  - No change in the WFD status reported within the Water Environment Hub during the project lifespan and the water body is already classified as Good.
- The clarity of water
  - No change in the WFD status reported within the Water Environment Hub during the project lifespan and the water body is already classified as Good.
- The safety of the water for recreational contact
  - No change in the WFD status reported within the Water Environment Hub during the project lifespan and the water body is already classified as Good.
- The condition of the river channel and flow of water
  - For sub-option B, WFD status reports no change across the project lifespan to date. We assume the project has helped to improve the channel morphology from Poor to Moderate. Following B£ST guidance, the improvement of the river channel morphology and flow of water have been considered within the 'Quantity of water' module (QW1). In recognition of the partial achievement the quantity has been set at 50% and the value 100% for the full 19.2km length of the water body within B£ST (QW1+F2).
  - For sub-option C, it is assumed that it is improved from Poor to Good. Both the quantity and value have been set to 100% within B£ST for the full 19.2km length of the water body within B£ST (WQ2). Note, to achieve a change from Poor to Good in B£ST it is necessary to divide the improvement into two steps, an initial improvement of Poor to Moderate, followed by a Moderate to Good improvement.

The monetary values in this assessment are based on the results of the *National Water Environment Benefits Survey* (Environment Agency, 2013) (NWEBS). This reports values from a major study for the benefits of improving water bodies and achieving compliance with WFD objectives.

The results of the detailed assessment are shown in Table 4.9 and Table 4.10. If the appraisal had identified significant benefits which have not been monetised (e.g a reduction in crime), it would also be necessary to record the un-monetised benefit alongside the monetised benefits.

**Table 4.9: Estimated ecosystem services benefits for the NFM options (£k, Present Value, 100-year Appraisal Period)**

| Benefit category | No NFM | Actual NFM (£k) | Additional NFM (£k) |
|---|---|---|---|
| Amenity | - | 1,489 | 7,724 |
| Biodiversity and ecology | - | 627,451 | 4,594 |
| Carbon sequestration | - | 717 | 4,857 |
| Education | - | 383 | 383 |
| Flows in watercourse | - | 365 | 2,678 |
| Water quality and pollution | - | 628 | 1,425 |
| **Total** | **-** | **4,201** | **17,660** |
| Value reported in *Ecosystem Service Benefits of Eddleston Water NFM Measures: Economic Analysis* (JBA, March 2020) | - | 1,475 | Not assessed |

Source: Mott MacDonald

**Table 4.10: Estimated ecosystem services benefits for the NFM options (£k, Present Value , 100-year Appraisal Period)**

| | No NFM | Actual NFM (£k) | Additional NFM (£k) |
|---|---|---|---|
| PV (Baseline) | - | 4,201 | 17,660 |
| PV (Lower Sensitivity ESS) | - | 1,290 | 5,501 |
| PV (High Sensitivity ESS) | - | 7,317 | 26,763 |

Source: Mott MacDonald

A side-by-side comparison with the JBA (2020) estimated ecosystem services for the actually implemented NFM over a 100 year appraisal period is presented in Table 4.11. Although the underlying principles of the two assessments are broadly consistent there are a number of areas where there is significant difference. The most notable differences relate to the value of amenity, which arises due to the consideration of the Sustrans cycle path by this study, and the assessment of the water environment (flows in watercourse and water quality), where there are very notable differences.

For the water environment changes, despite both assessments being based on NWEBS values, the reported JBA values appear questionably small and it may be that annual benefits have not been correctly converted to Present Values. Alternatively, the difference in values may have arisen from differing interpretation of the guidance for valuing benefits associated with the water environment. The assessment of benefits within this study considered impacts across the water body as a whole (19.2km) for the six NWEBS categories, whilst the JBA estimate may have considered impacts within the extent of channel directly changed by the project (2.9km) for only the overall water body status (i.e. one single overarching category).

The assessment reported in this document did not assess timber production and agricultural income foregone, the JBA assessment highlights lost agricultural income is approximately offset by timber production.

**Table 4.11: Side-by-side comparison of two studies considering the estimated ecosystem services benefits for the actually implemented NFM (£k, Present Value, 100-year Appraisal Period)**

| Benefit category | Actual NFM assessed by Ecosystem Service Benefits of Eddleston Water NFM Measures: Economic Analysis (JBA, March 2020) | Actual NFM assessed using B£ST (this study) (£k) |
|---|---|---|
| Amenity | No included in valuation | 1,489 |
| Biodiversity and ecology | 110 | 627 |
| Carbon sequestration | 1,044 | 717 |
| Education | 143 | 383 |
| Flows in watercourse | 20 | 365 |
| Water quality and pollution | | 628 |
| Timber production | 633 | Not assessed |
| Agricultural income forgone | -476 | Not assessed |
| **Total** | **1,475** | **4,201** |

Source: Mott MacDonald

#### 4.3.5.3 Estimation of total whole life benefits including flood damages avoided and multiple benefits

The monetised ecosystem services benefits have been added to the flood damages avoided to generate an estimate of the total whole life benefits as summarised in Table 4.12.

**Table 4.12: Matrix of options showing all monetised benefit (flood damages avoided and ESS benefit) (£k, Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | 5,151 | 20,510 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | 4,704 | 9,109 | 22,977 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | 5,633 | 9,991 | 23,763 |
| | Sub-Option 3 - Property Level Protection | 4,792 | 9,669 | 24,481 |

Source: Mott MacDonald 2020

The monetised ESS benefit has been added to the economic assessment of flood damages avoided. A summary of the economic analysis is presented in Table 4.13 and Table 4.14, which present the Benefit Cost Ratio (BCR) and Net Present Value (NPV) respectively.

**Table 4.13: Matrix of options showing BCR based on all monetised benefit (Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | 2.42 | 1.71 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | 0.59 | 0.90 | 1.15 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | 0.53 | 0.78 | 1.05 |
| | Sub-Option 3 - Property Level Protection | **2.44** | 2.36 | 1.75 |

Source: Mott MacDonald 2020

**Table 4.14: Matrix of options showing NPV based on all monetised benefit (£k, Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | 3,020 | 8,493 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | -3,310 | -1,036 | 2,946 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | -5,052 | -2,826 | 1,060 |
| | Sub-Option 3 - Property Level Protection | 2,828 | 5,574 | **10,500** |

Source: Mott MacDonald 2020

Table 4.13 identifies the Property Level Protection (PLP) in combination with no NFM has the highest BCR of 2.44. However, Table 4.14 identifies PLP in combination with additional NFM measures as providing the highest NPV, with an NPV of approximately £10.5million.

### 4.3.6 Short list appraisal – Uncertainty and robustness

#### 4.3.6.1 Consideration of project uncertainties and risk

Throughout the short list stage the project team should review and manage project risks via the use of a project risk register. On high value projects Monte Carlo analysis should be used to quantify and actively manage risk.

#### 4.3.6.2 Sensitivity testing

Sensitivity testing has been conducted to test the uncertainty and robustness in the appraisal of the NFM options. The following sensitivity tests have been conducted on the appraisal of all monetised benefits:

- Increasing the total cost of the NFM options by 100%;
- Decreasing flood damages avoided by 50% and using the lower confidence score results for ESS benefit provided by B£ST; and
- Increasing flood damages avoided by 50% and using the higher confidence score results for ESS benefit provided by B£ST.

Appendix C.4 presents all results tables for the sensitivity testing.

Table 4.15 summarises the results of the sensitivity testing on the estimation of best value for money.

Table 4.16 summarises the results of the sensitivity testing on the estimation of all monetised benefits. Monte Carlo analysis could be explored to further test uncertainty and robustness in the appraisal.

**Table 4.15: Summary of sensitivity testing on best value for money**

| Sensitivity test | Highest BCR option | Highest NPV option | Commentary |
|---|---|---|---|
| Baseline | PLP + No NFM | PLP + No NFM | |
| Sensitivity Test 1 – Increasing NFM costs by 100% | PLP + No NFM | PLP + No NFM | The test does not change the leading option based on BCR or NPV and therefore provides confidence in the robustness of the baseline appraisal. |
| Sensitivity Test 2 – 50% damages avoided and using the lower confidence score results for ESS benefit | PLP + No NFM | PLP + No NFM | The test does not change the leading option based on BCR or NPV and therefore provides confidence in the robustness of the baseline appraisal. |
| Sensitivity Test 3 – 150% damages avoided and using the higher confidence score results for ESS benefit | PLP + No NFM | PLP + No NFM | The test does not change the leading option based on BCR or NPV and therefore provides confidence in the robustness of the baseline appraisal. |

Source: Mott MacDonald 2020

**Table 4.16: Summary of sensitivity testing on all monetised benefits**

| Sensitivity test | Highest BCR option | Highest NPV option | Commentary |
|---|---|---|---|
| Baseline | PLP + No NFM | PLP + Additional NFM | |
| Sensitivity Test 1 – Increasing NFM costs by 100% | PLP + No NFM | PLP + Actual NFM | The test reduces the desirability of NFM measures slightly when considering BCR and NPV – the preferred option changes to PLP + Actual NFM, reducing the robustness of the appraisal. |
| Sensitivity Test 2 – 50% damages avoided and using the lower confidence score results for ESS benefit | PLP + No NFM | PLP + No NFM | The test does not change the leading option based on BCR – providing some confidence in the robustness of the appraisal. However, the test reduces the desirability of NFM measures when considering NPV – the preferred option changes to PLP + No NFM, reducing the robustness of the appraisal. |
| Sensitivity Test 3 – 150% damages avoided and using the higher confidence score results for ESS benefit | Do Minimum + Actual NFM | PLP + Additional NFM | The test changes the leading option based on BCR but not NPV and therefore highlights uncertainty in the robustness of the appraisal. |

Source: Mott MacDonald 2020

### 4.3.7 Appraisal summary table

In compliance with Scottish Appraisal Guidance an appraisal summary table should be used to record the key outputs from the appraisal and to support the selection of the preferred option. As an example, the three leading options have been chosen to demonstrate how an appraisal summary table should inform the preferred option selection. This is presented in Table 4.17.

**Table 4.17: Appraisal summary table**

| Category | Do Minimum + Actual NFM | PLP + No NFM | PLP + Additional NFM |
|---|---|---|---|
| **CRITERIA 1 – Meeting the objectives** | | | |
| Meets objective 1 | ✓ | ✓ | ✓ |
| Meets objective 2 | Partial | Partial | ✓ |
| Meets objective 3 | X | X | ✓ |
| Objectives comment | Meets or partially meets all the objectives | Meets or partially meets all the objectives | **Meets all the objectives** |
| **CRITERIA 2 – Assessing best value for money** | | | |
| Whole life cost (£k) | 2,131 | 1,964 | 13,981 |
| Flood damages avoided (£k) | 950 | 4,792 | 6,821 |
| Value for money BCR | 0.45 | **2.44** | 0.49 |
| Value for money NPV (£k) | -1,181 | **2,828** | -7,160 |
| Value for money comment | PLP with no NFM measures provides best use of capital budget to reduce flood risk | | |
| **CRITERIA 3 – Assessing multiple benefits** | | | |
| Air quality (£k) | 0 | 0 | 0 |
| Amenity (£k) | 1,489 | 0 | 3,724 |
| Biodiversity and ecology (£k) | 627 | 0 | 4,594 |
| Carbon reduction and sequestration (£k) | 717 | 0 | 4,857 |
| Education (£k) | 383 | 0 | 383 |
| Water Quality (£k) | 356 | 0 | 1,425 |
| Flows in watercourse (£k) | 628 | 0 | 2,678 |
| Health (£k) | 0 | 0 | 0 |
| Recreation (£k) | 0 | 0 | 0 |
| Total multiple benefits (£k) | 4,201 | 0 | 17,660 |
| Total benefit (£k) | 5,151 | 4,792 | 24,481 |
| Total benefits BCR | 2.42 | **2.44** | 1.75 |
| Total benefits NPV (£k) | 3,020 | 2,828 | **10,500** |
| Commentary on non-monetised benefits | No significant non-monetised benefits | No significant non-monetised benefits | No significant non-monetised benefits |
| Multiple benefits comment | PLP with additional NFM measures provides the most desirable option considering NPV and all monetised benefits | | |
| **CRITERIA 4 – Managing risk and uncertainty** | | | |
| Commentary on risk and uncertainty | Comment on risk and uncertainty | Comment on risk and uncertainty | Comment on risk and uncertainty |
| **Preferred option selected by the Project Board** | **This table will be presented to the Project Board at the Preferred Option Selection Workshop where the Board will review the and select the Preferred Option based on their consideration of the four criteria. The justification for their selection should be recorded here.** | | |

### 4.3.8 Prioritisation

Outputs from the B£ST assessment and the appraisal summary table, presented in Table 4.17, can be used to inform the prioritisation process and allocation of funding.

# 5 Summary and conclusion

## 5.1 Summary of identifying a preferred means of valuing NFM ecosystem services

Following a review of best practice and consultation exercise, involving a stakeholder survey and Steering Group workshops, B£ST (CIRIA, 2019) was identified as the leading appraisal tool to support the evaluation of multiple benefits within flood risk management projects.

The factors for the selection of B£ST are:

- The tool is open access and does not require any specialist software.
- It is suitable for assessing the multiple benefits on a wide range of flood risk management action types and is not limited to the assessment of Natural Flood Management measures. Where appropriate it can be used to quantify disbenefits (detriment) in addition to benefits.
- It is applicable for use in appraisals considering all project scales and types of flooding including fluvial, coastal and surface water.
- It is provided with an accompanying guidance document that provides relevant information and data requirements.
- It includes screening and coarse assessment tools which could be included earlier within the appraisal process to provide initial or high-level results.
- The tool is able to map value change across all six capitals, as listed within the integrated reporting framework, within the study area.
- The valuation methodology in the tool is in line with good practice, as well as with government appraisal guidance (HM Treasury, 2018) and consistent with other approaches in the sector
- The latest release includes a comparison tool that enables the comparison of more than one assessment within a project.
- It is already the most well-known tool within the target user community (although the extent of the target community's experience in using the tool is thought to be low).
- The developer, CIRIA, reports that B£ST is not a single release and will be updated in the future.

Although identified as the most suitable tool, it is acknowledged that B£ST is not an all-encompassing solution to the assessment of multiple benefits. The identified limitations of the tool include:

- It does not currently incorporate a spatial element to the assessment of wider benefits (in March 2020 CIRIA announced plans to incorporate a spatial user interface in the next release)
- It has limited opportunity for supporting the identification of opportunities
- B£ST does not specifically allow for the incorporation of peatland carbon sequestration and relies on an external tool to assess woodland carbon sequestration
- As with all methods, it may be appropriate to obtain more detailed or locally based information when doing more detailed studies or where decisions are sensitive to small changes in the generalised national data within the tool
- Following on from the preceding point, B£ST was primarily developed using English and Welsh data, therefore the B£ST guidance and tool terminology sometimes deviate from that

used in Scotland. It is also necessary for users to select appropriate donor locations from those available in England and Wales in tool options.

Specific recommendations for the improvement of B£ST are detailed below. These improvements are likely to require the contribution of funding by a Scottish stakeholder i.e. SEPA, SNH or the Scottish Government.

- Developing functionality to support the spatial assessment and reporting of multiple benefits. At the time of writing, plans have been announced for the incorporation of spatial tool in the next release of B£ST (CIRIA, 2020).
- Improving the tool to support the identification opportunities.
- Extension of the terminology and geographic areas in B£ST to better align with Scottish needs. This is most notable in relation to:
  - The assessment of the aquatic environment (Water quality and Water Quantity in B£ST) where English and Welsh river basins, guidance and Water Framework Directive terminology is currently used.
  - The assessment of flood damages avoided within B£ST references the use of the English Partnership Funding Calculator for very rapid assessments in place of the Multi Coloured Handbook (Flood Hazard Research Centre, 2020).
- Addition of an in-built methodology for assessing the carbon sequestration by peatlands and guidance on the use of the Woodland Carbon Code calculator in Scotland.

## 5.2 Summary of integration into the current decision-making process

A review of the existing flood risk management Appraisal Guidance as documented in '*Options appraisal for flood risk management: Guidance to support SEPA and the responsible authorities'* (Scottish Government, 2016), identified opportunities for B£ST to be integrated into the current decision-making process and inform the appraisal of flood risk management options as detailed below.

1. **Setting objectives** - B£ST can encourage appraisals to set specific and measurable environmental enhancement objectives at the start of the appraisal process. While B£ST does not provide an integrated approach for the identification of opportunities or setting objectives, it does provide a means to set defined ways to measure objectives as well as recording evidence that options are likely to meet objectives.
2. **Long list appraisal** - The existing Scottish Appraisal Guidance for long list option screening within the Scottish Appraisal Guidance provides a satisfactory approach for option screening and should be followed during the long list stage. B£ST incorporates three levels of assessments each targeted at different project scales and needs. The basic Screening followed by Coarse Assessment tools are rapid qualitative and quantitative approaches respectively. Both are suitable for the early stages of appraisals. The tool can be used to efficiently test long list options allowing the decision-making process to be robust, repeatable and documented.
3. **Short list appraisal -** It should be noted that best value for money is not the sole decision factor when selecting the preferred option. The Appraisal Guidance provides flexibility in the selection of the preferred option citing that issues should be balanced to identify the most sustainable solution. A well-designed appraisal summary table will support this process so that the decision is robust, and it can be readily understood by those affected. It does however leave the decision as a subjective process. B£ST can be used to inform the decision-making criteria as detailed follows:

a. **Meeting objectives** - While B£ST does not provide an integrated approach for the identification of opportunities or setting objectives, it does provide a way of testing and recording that options meet objectives.
b. **Value for money** - Following consultation with the Scottish Government this project proposes that an assessment of "best value for money" should only consider flood damages avoided and "eligible costs" (Scottish Government, June 2020). Additional benefits, not directly associated with a reduction in flood damages, should be reported within the separate "multiple benefits" metric. On the basis of not supporting the assessment of flood damages avoided there is no current role for B£ST, or other multiple benefit appraisal methods, when assessing this specific criteria of value for money.
c. **Multiple benefits** - The monetisation of multiple benefits using B£ST should be undertaken to inform the appraisal process in parallel with an assessment of "best value for money". It is proposed that multiple benefits are considered within a cost benefit analysis considering all option benefits (sum of "multiple benefits" and flood damages avoided benefits).
d. **Uncertainties and robustness** - B£ST manages uncertainty in multiple benefit assessments through the tool's in-built sensitivity tests. It permits ranges of quantitative estimates and monetary values to be used. User-defined confidence scores also allow users to identify areas of uncertainty enabling project teams to target available resources to improving the evaluation of categories with high significance but low confidence. Project teams are also able to use the confidence scores to inform the sensitivity and robustness testing. The functionality helps to ensure outputs are repeatable, reliable in reality and consistent with expectations. However, for greater investments such as major developments more complex techniques to assess the uncertainty and manage its consequences on the decision process are recommended. It is noted that the sensitivity analysis within the B£ST tool is not complete, and it is an identified area of planned improvement. This presents an opportunity to engage with CIRIA on how this could be shaped for the needs of Scottish appraisals.

4. **Prioritisation** - The output of B£ST could assist with providing evidence (in the form of monetised values) to support the prioritisation and allocation of funding process.

A number of observed barriers to the incorporation of multiple benefits in the form of ecosystem services have been identified within the current Appraisal Guidance. Section 3 outlines the key issues and presents some opportunities for improvement which should be considered in any future update of the Appraisal Guidance. The key identified issues are:

- The lack of a defined decision-making algorithm for the consideration of the four decision criteria. This means that decisions may not be transparent and could be open to challenge.
- The lack of definition on what types of benefits and costs are to be considered when assessing best value for money.
- The lack of clarity on how the delivery of multiple benefits should be considered in the decision-making process, i.e. should multiple benefit delivery be maximised via its own cost benefit analysis?
- There are issues around funding of flood risk management schemes that include non-eligible costs or have significant non-flood risk reduction beneficiaries. There is the potential for the selected preferred options to be unaffordable and hence undeliverable.

## 5.3 Summary of testing the process on the Eddleston Water catchment

Section 4 uses the Eddleston Water as a case study to test the process for integrating ecosystem service assessment, undertaken using B£ST, into the flood scheme appraisal process. The demonstration successfully tests the process against different scenarios of NFM implementation and traditional flood risk management options in combination.

When testing B£ST on the Eddleston Water as part of this project it was found to be intuitive to use with hyperlinks providing easy access to guidance material. B£ST was able to quantify all significant multiple benefits in the form of ecosystem services and natural capital. The use of a single Excel file for each option appraised with boxes for recording notes allowed for the rapid sharing and discussion of assessments. Two NFM sub-options were considered in the test:

1. NFM in place as of 2020
2. A hypothetical additional NFM case.

Using a 100 year appraisal period the ecosystem services associated with the actually implemented NFM was estimated to be approximately £4.2M and £17.7M for the hypothetical additional NFM case. A side-by-side comparison of the assessment using B£ST with an earlier assessment of the Eddleston Water catchment undertaken by JBA indicates that the B£ST assessment has generated ecosystem services which are approximately three times larger. The differences are primarily due to the inclusion of amenity in this assessment and the calculation of water environment benefits in the JBA assessment.

When comparing the appraised options using the Scottish Appraisal Guidance criteria, three leading options were identified as summarised in Table 5.1. In compliance with the Scottish Appraisal Guidance the selection of the preferred option would be made by the project board based on consideration of all of the relevant information. The justification for the selection of the preferred option would need to be recorded. The test appraisal highlights how the four decision criteria can identify different leading options leading to the requirement for a subjective decision by the project board to select the preferred option.

**Table 5.1: Appraisal summary table**

| Benefit category | Do Minimum + Actual NFM | PLP + No NFM | PLP + Additional NFM |
|---|---|---|---|
| **CRITERIA 1 – Meeting the objectives** | | | |
| Objectives comment | Meets or partially meets all the objectives | Meets or partially meets all the objectives | **Meets all the objectives** |
| **CRITERIA 2 – Assessing best value for money** | | | |
| Whole life cost (£k) | 2,131 | 1,964 | 13,981 |
| Flood damages avoided (£k) | 950 | 4,792 | 6,821 |
| Value for money BCR | 0.45 | **2.44** | 0.49 |
| Value for money NPV (£k) | -1,181 | **2,828** | -7,160 |
| Value for money comment | PLP with no NFM measures provides the best use of capital budget to reduce flood risk | | |
| **CRITERIA 3 – Assessing multiple benefits** | | | |
| Total benefit (£k) | 5,151 | 4,792 | 24,481 |
| Total benefits BCR | 2.42 | **2.44** | 1.75 |
| Total benefits NPV (£k) | 3,020 | 2,828 | **10,500** |
| Multiple benefits comment | PLP with additional NFM measures provides the most desirable option considering NPV and all monetised benefits | | |
| **CRITERIA 4 – Managing risk and uncertainty** | | | |
| Commentary on risk and uncertainty | Comment on risk and uncertainty | Comment on risk and uncertainty | Comment on risk and uncertainty |
| **Preferred option selected by the Project Board** | **This table will be presented to the Project Board at the Preferred Option Selection Workshop where the Board will review the and select the Preferred Option based on their consideration of the four criteria. The justification for their selection should be recorded here.** | | |

Source: Mott MacDonald 2020

## 5.4 Conclusion

The findings of this project have demonstrated that B£ST performs effectively at valuing the benefits associated with flood risk management in Scotland. B£ST was reviewed against other potential methodologies and was recommended as the preferred approach to support the integration of multiple benefits into the existing flood risk management decision-making process. The well-known, easy to use and freely available tool will support the accurate assessment of multiple benefits on a wide range of project scales, flooding types (fluvial, coastal and surface water) now and into the future.

Following testing on the Eddleston Water it has been confirmed that the tool can be effectively integrated into the current flood risk management decision-making process.

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# A. Table of ecosystem services analysis methods

**Table A.1: Ecosystem services analysis methods**

| Title | Monetisation of Environmental Impacts | Level of work | Accuracy of results | Technical Complexity | Repeatability | Total |
|---|---|---|---|---|---|---|
| B£ST (Benefits Estimation Tool) | Yes | 1 | 1 | 1 | 1 | 4 |
| Co$ting Nature | Yes | 2 | 4 | 2 | 2 | 10 |
| Economic valuation and its applications in natural capital management and the Government's 25 Year Environment Plan, Natural Capital Committee. | Yes | 3 | 4 | 3 | 3 | Screened out |
| Enabling a Natural Capital Approach (ENCA): DEFRA, 2020 | Yes | 1 | 3 | 2 | 2 | 8 |
| Environment Agency's scoring and weighting method. | No | | | | | Screened out due not monetising environmental impacts |
| Flood and Coastal Erosion Risk Management: A Handbook for Economic Appraisal (Multi Coloured Handbook); FHRC, 2020. | Yes | 1 | 1 | 2 | 2 | 6 |
| Flood and Coastal Erosion Risk Management: appraisal guidance, EA, 2010. | Yes | 1 | 4 | 2 | 2 | Screened out |

| Title | Monetisation of Environmental Impacts | Level of work | Accuracy of results | Technical Complexity | Repeatability | Total |
|---|---|---|---|---|---|---|
| Flood protection appraisals: guidance for SEPA and responsible authorities; Scottish Government, 2016. | Yes | 1 | 4 | 1 | 2 | Screened out |
| Flood study checklist for responsible authorities; SEPA, 2018. | No | | | | | Screened out |
| Green Infrastructure Valuation Toolkit (GI-Val) | Yes | 1 | 3 | 1 | 1 | 6 |
| How to do it: a natural capital workbook, Natural Capital Committee. | Yes | 2 | 2 | 3 | 3 | 10 |
| Natural Capital Accounting | Yes | 3 | 1 | 3 | 2 | 9 |
| Natural Capital Planning Tool | No | | | | | Screened out due not monetising environmental impacts |
| Natural Environment Valuation Online tool (NEVO) (Not applicable to study area but could be reviewed for transferrable methodology) | Yes | 1 | 4 | 1 | 2 | Screened out |
| Outdoor Recreation Valuation Tool (ORVal) (Not applicable to study area but could be reviewed for transferrable | Yes | 1 | 4 | 1 | 2 | Screened out |

| Title | Monetisation of Environmental Impacts | Level of work | Accuracy of results | Technical Complexity | Repeatability | Total |
|---|---|---|---|---|---|---|
| methodology) | | | | | | |
| Partnership Funding Supporting Guidance for Outcome Measure 4 (2020) and the Environment Agency's Partnership Funding Calculator. | Yes | 1 | 2 | 2 | 1 | 6 |
| Payments for Ecosystem Services: A Best Practice Guide; DEFRA, 2013 (Not applicable to study area, very small range of benefits) | Yes | 4 | 4 | 1 | 4 | Screened out |
| Scottish Public Finance Manual. | Yes | 2 | 3 | 3 | 3 | 11 |
| The Green Book: appraisal and evaluation in central government; HM Treasury, 2018 | Yes | 1 | 1 | 2 | 2 | 6 |

Source: Mott MacDonald 2020

# B. Wider stakeholder survey

## B.1 Survey introduction

The survey was hosted online via Survey Monkey during a 3-week period up to the 20th July. Individuals were approached via email from the Steering Group and the SCOTS flood risk management group. The survey had the following introduction:

*"The Tweed Forum is currently working with Mott MacDonald, Scottish Government, SNH, SEPA and others to identify how "multiple benefits" in the form ecosystem services and natural capital can be most effectively integrated into current decision-making processes for appraisal of Flood Risk Management Measures in Scotland, and how this can be achieved. The study will look at the identification, development and testing of a standardised methodology that can be used to assess the costs and benefits that are derived from the implementation of different Natural Flood Management (NFM) measures, as demonstrated in the Eddleston Water Project, a major partnership research project to assess the effects of river restoration and natural flood management techniques. This forms part of the research component of the international project Building with Nature (BwN), funded by the Scottish Government and the European Union's INTERREG North Sea Region Programme.*

*Key terms used in this survey:*

*Natural Capital includes certain stocks of the elements of nature that have value to society, such as forests, fisheries, rivers, biodiversity, land and minerals. Natural capital includes both the living and non-living aspects of ecosystems. Stocks of natural capital provide flows of environmental or 'ecosystem' services over time.*

*Ecosystem Services are the benefits people obtain from ecosystems. These include provisioning services such as food and clean water; regulating services such as flood protection, carbon sequestration and disease control; cultural services such as recreation and wellbeing.*

*The personal data that you provide by completing this survey shall be used for improving understanding of attitudes to flood risk management appraisal methods (the "Purpose"). Please be aware that we may share your personal data with Tweed Forum, SEPA, Scottish Government, Scottish Borders Council and SNH for the Purpose.*

*Personal data provided to Mott MacDonald Limited ("Mott MacDonald") in this survey is subject to the provisions of the General Data Protection Regulation ((EU) 2016/679) and any national implementing laws, regulations and secondary or successor legislation as amended or updated from time to time. Mott MacDonald will retain your personal data in accordance with our Privacy Policy which can be found on our website (https://www.mottmac.com/privacy-policy).*

*By providing us with your personal data, you consent to the collection and use of any personal data you provide in accordance with our Privacy Policy and the Purpose."*

## B.2 Survey responses

**Table B.2: Q1/2 Does your work relate to flood risk management in Scotland? / What type of organisation do work for? (Response counts)**

| | Academic | Consultancy | Government | Local Authority | Regulator | Grand Total |
|---|---|---|---|---|---|---|
| No | 1 | 1 | | | 1 | **3** |
| Yes | 9 | 9 | 1 | 17 | 1 | **37** |
| **Grand Total** | **10** | **10** | **1** | **17** | **2** | **40** |

Source: Mott MacDonald 2020

**Table B.3: Q3 How would you describe your role in your organisation? (Response counts)**

| | Academic | Consultancy | Government | Local Authority | Regulator | Grand Total |
|---|---|---|---|---|---|---|
| Other | | | | | | |
| 4 | | | | 1 | 5 | |
| Junior officer/support | 0 | 0 | 0 | 0 | 0 | 0 |
| Officer/consultant | | 5 | 1 | 11 | 1 | 18 |
| Team leader/director | 6 | 5 | | 6 | | 17 |
| **Grand Total** | **10** | **10** | **1** | **17** | **2** | **40** |

Source: Mott MacDonald 2020

**Table B.4: Q4 Are you involved in flood risk management projects where "multiple benefits" in the form ecosystem services and natural capital have been evaluated as part of the appraisal? (Response counts)**

| | Academic | Consultancy | Government | Local Authority | Regulator | Grand Total |
|---|---|---|---|---|---|---|
| Don't know or would prefer not to say | 1 | | | | | **1** |
| No - I am not involved in flood risk management projects | 2 | 1 | 1 | 2 | | **6** |
| No - these techniques are never used on my projects | 2 | | | 4 | | **6** |
| Often - these techniques are often used on my projects (>20% of projects) | 4 | 3 | | 4 | | **11** |
| Rarely - these techniques are rarely used on my projects (<20% of projects) | 1 | 6 | | 7 | 2 | **16** |

| | Academic | Consultancy | Government | Local Authority | Regulator | Grand Total |
|---|---|---|---|---|---|---|
| **Grand Total** | **10** | **10** | **1** | **17** | **2** | **40** |

Source: Mott MacDonald 2020

**Table B.5: Q5 What ecosystem services methods are you aware of? (Response counts, note that individuals could mark zero or more responses)**

| | Academic | Consultancy | Government | Local Authority | Regulator | Grand Total |
|---|---|---|---|---|---|---|
| Count of Natural Capital Planning Tool | 4 | 2 | | 2 | | **8** |
| Count of Benefit of SuDS Tool B£st | 4 | 8 | | 11 | 1 | **24** |
| Count of Green Infrastructure Valuation Toolkit (GI-Val) | 2 | 4 | | 6 | | **12** |
| Count of Natural Capital Accounting | 6 | 3 | 1 | 3 | 1 | **14** |
| Count of Benefits Inventory Tool EVL tool ENCA guidance | | 1 | | | | **1** |
| Count of Co$ting Nature | 1 | 2 | | 2 | | **5** |
| Count of Natural Environment Valuation Online tool (NEVO) | 1 | 3 | | 1 | | **5** |
| Count of Environment Agency Partnership Funding Calculator (2020) | 2 | 6 | | | 1 | **9** |
| Count of Outdoor Recreation Valuation Tool (ORVal) | 1 | 3 | | 1 | 1 | **6** |
| Count of Other | 2 | 2 | | 1 | | **5** |
| **Grand Total** | **23** | **34** | **1** | **27** | **4** | **89** |

Source: Mott MacDonald 2020

"Other" responses for Q5 are detailed below:

- Local Authority respondent: *"Social Return on Investment"*
- Consultancy respondent: *"EIA"*
- Consultancy respondent: *"I know most - but [I don't] necessarily applied them all in anger. As part of the UK CCRA we have assessed the economic benefit of NFM to the UK - using the Future Flood Explorer - this is not a detailed scheme appraisal assessment and only single benefit (economic risk reduction)"*
- Academic respondent: *"Natural Capital Protocol, bespoke modelling approaches, socio-cultural valuation methods"*
- Academic respondent: *"iTREE, ASSET - https://assist.ceh.ac.uk/asset-assist-scenario-exploration-tool, InVEST: http://data.naturalcapitalproject.org/nightly-build/invest-users-guide/html/ndr.html , IES https://www.the-ies.org/resources/ecosystem-services-assessment, ES assessment and mapping: https://ecosystemsknowledge.net/about/themes/mapping; IPBES tool: https://ipbes.net/policy-support/tools-instruments/ecosystem-service-assessment-support-tool; MAES approach: https://biodiversity.europa.eu/maes ... and more....."*

**Table B.6: Q6 Are you involved in flood risk management projects where you think that the inclusion of "multiple benefits" in the form of ecosystem services and natural capital in the appraisal would have made a significant difference to the appraisal findings?**

| | Academic | Consultancy | Government | Local Authority | Regulator | Grand Total |
|---|---|---|---|---|---|---|
| Don't know or would prefer not to say | 3 | | | 6 | | 9 |
| No - I am not involved in flood risk management appraisal projects | 2 | 1 | 1 | 2 | | 6 |
| No - none of my project appraisals would have different outcomes if the techniques were used | | 3 | | 2 | | 5 |
| Often - many of my project appraisals would have different outcomes if the techniques were used (>20% of projects) | 2 | 2 | | 5 | 1 | 10 |
| Rarely | 3 | 4 | | 2 | 1 | 10 |
| **Grand Total** | **10** | **10** | **1** | **17** | **2** | **40** |

Source: Mott MacDonald 2020

**Table B.7: Q7.1 What do you think the barriers are to considering "multiple benefits" in flood appraisals? Lack of strategic/policy driver. Response counts.**

| | Academic | Consultancy | Government | Local Authority | Regulator | Grand Total |
|---|---|---|---|---|---|---|
| Don't know / Not applicable | 3 | 1 | 1 | | | 5 |
| Major barrier | 4 | 5 | | 9 | 1 | 19 |
| Minor barrier | 3 | 2 | | 6 | | 11 |
| No issue | | 2 | | 2 | 1 | 5 |
| **Grand Total** | **10** | **10** | **1** | **17** | **2** | **40** |

Source: Mott MacDonald 2020

**Table B.8: Q7.2 What do you think the barriers are to considering "multiple benefits" in flood appraisals? The benefit is insignificant relative to flood damage avoided. Response counts.**

| | Academic | Consultancy | Government | Local Authority | Regulator | Grand Total |
|---|---|---|---|---|---|---|
| Don't know / Not applicable | 2 | 2 | 1 | | | 5 |
| Major barrier | | 5 | | 11 | | 16 |
| Minor barrier | 3 | 1 | | 4 | 1 | 9 |
| No issue | 5 | 2 | | 2 | 1 | 10 |
| **Grand Total** | **10** | **10** | **1** | **17** | **2** | **40** |

Source: Mott MacDonald 2020

**Table B.9: Q7.3 What do you think the barriers are to considering "multiple benefits" in flood appraisals? The additional understanding of project beneficiaries is not sufficient to make the additional analysis worthwhile. Response counts.**

| | Academic | Consultancy | Government | Local Authority | Regulator | Grand Total |
|---|---|---|---|---|---|---|
| Don't know / Not applicable | 1 | 1 | 1 | | | 3 |
| Major barrier | 5 | 2 | | 11 | 1 | 19 |
| Minor barrier | 2 | 6 | | 3 | | 11 |
| No issue | 2 | 1 | | 3 | 1 | 7 |
| **Grand Total** | **10** | **10** | **1** | **17** | **2** | **40** |

Source: Mott MacDonald 2020

**Table B.10: Q7.4 What do you think the barriers are to considering "multiple benefits" in flood appraisals? Lack of strategic/policy driver. Response counts.**

| | Academic | Consultancy | Government | Local Authority | Regulator | Grand Total |
|---|---|---|---|---|---|---|
| Don't know / Not applicable | 1 | 1 | 1 | | | 3 |
| Major barrier | 5 | 3 | | 12 | 2 | 22 |
| Minor barrier | 4 | 6 | | 2 | | 12 |
| No issue | | | | 3 | | 3 |
| **Grand Total** | **10** | **10** | **1** | **17** | **2** | **40** |

Source: Mott MacDonald 2020

**Table B.11: Q7.5 What do you think the barriers are to considering "multiple benefits" in flood appraisals? Lack of suitable appraisal methods. Response counts.**

| | Academic | Consultancy | Government | Local Authority | Regulator | Grand Total |
|---|---|---|---|---|---|---|
| Don't know / Not applicable | 1 | 2 | 1 | 2 | | 6 |
| Major barrier | 2 | 2 | | 8 | 2 | 14 |
| Minor barrier | 4 | 4 | | 4 | | 12 |
| No issue | 3 | 2 | | 3 | | 8 |
| **Grand Total** | **10** | **10** | **1** | **17** | **2** | **40** |

Source: Mott MacDonald 2020

**Table B.12: Q7.6 What do you think the barriers are to considering "multiple benefits" in flood appraisals? Lack of skills/training within the sector. Response counts.**

| | Academic | Consultancy | Government | Local Authority | Regulator | Grand Total |
|---|---|---|---|---|---|---|
| Don't know / Not applicable | | 1 | 1 | | | 2 |
| Major barrier | 4 | 2 | | 11 | 2 | 19 |
| Minor barrier | 6 | 6 | | 5 | | 17 |
| No issue | | 1 | | 1 | | 2 |
| **Grand Total** | **10** | **10** | **1** | **17** | **2** | **40** |

Source: Mott MacDonald 2020

**Table B.13: Q7.7 What do you think the barriers are to considering "multiple benefits" in flood appraisals? Lack of data. Response counts.**

| | Academic | Consultancy | Government | Local Authority | Regulator | Grand Total |
|---|---|---|---|---|---|---|
| Don't know / Not applicable | | 1 | 1 | | | 2 |
| Major barrier | 6 | 3 | | 11 | 1 | 21 |
| Minor barrier | 4 | 3 | | 4 | 1 | 12 |
| No issue | | 2 | | 2 | | 4 |
| **Grand Total** | **10** | **9** | **1** | **17** | **2** | **39** |

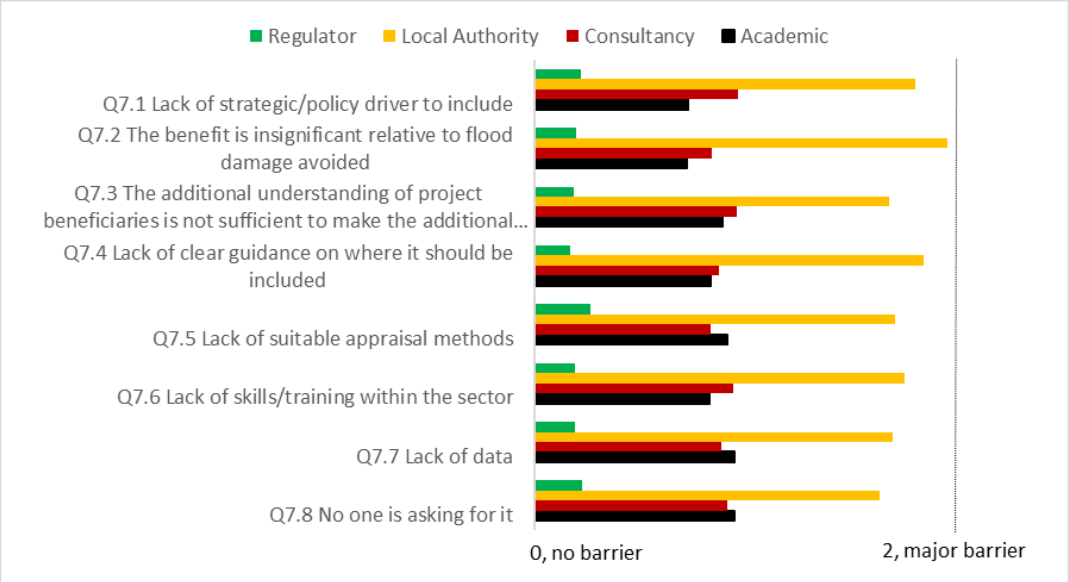
Source: Mott MacDonald 2020

**Table B.14: Q7.8 What do you think the barriers are to considering "multiple benefits" in flood appraisals? No one is asking for it. Response counts.**

| | Academic | Consultancy | Government | Local Authority | Regulator | Grand Total |
|---|---|---|---|---|---|---|
| Don't know / Not applicable | | 1 | 1 | 1 | | 3 |
| Major barrier | 2 | 4 | | 8 | | 14 |
| Minor barrier | 4 | 2 | | 3 | 2 | 11 |
| No issue | 3 | 2 | | 3 | | 8 |
| **Grand Total** | **9** | **9** | **1** | **15** | **2** | **36** |

Source: Mott MacDonald 2020

**Figure B.1: Summary of responses to Q7 What do you think the barriers are to considering "multiple benefits" in the form of ecosystem services and natural capital in flood appraisals? Responses have been scored and weighted by the number of responses as follows no barrier = 0, minor barrier = 1 and major barrier 2.**




Source: Mott MacDonald 2020

**Table B.15: Q8 Would you like to comment on other barriers?**

| Organisation | Response |
|---|---|
| Local Authority | *"Local Authorities are most likely to include elements of a flood scheme only where there is external funding. Currently Scottish Government provide 80% funding for eligible flood schemes, but only for elements that reduce flood risk. Other parts of a scheme (such as improvements to the ecological status or social benefits are not automatically funded. These can be significant proportions of a scheme cost and unless funded elsewhere, then LA's may well drop these elements due to budgetary constraints."* |
| Local Authority | *"Organisations and funding streams are heavily siloed. It is difficult to align several separate funds. Funding. and some funders' decision gates make it difficult or impossible to rely on funding packages from the outset. Delivering multiple-benefits projects with separate funding streams does increase complexity and risk in what may already be a complex project."* |
| Local Authority | *"I believe one of the barriers is that projects by different parties often run at the same time but there is a lack of sharing of these project details. This is internally within organisations and often between stakeholders, if there was a list of upcoming projects (register) then you could potentially tie up with other internal/external and improve the likelihood of achieving multiple benefits. i.e.: LA leisure looking at improved walkways, Flood teams looking at walls/embankments /Scottish Water Project all the same location all separate but multiple benefits if each were award of the other project."* |
| Local Authority | *"Council Area is heavily urbanised being a city area only, with limited green field sites to implement NFM. A lot of data would need to be gathered for very small dispersed projects. At [university] I was aware of this approach being used on trial projects in the borders but as far as I am aware they have not been applied elsewhere. With tight financial budgets to achieve flood risk management solutions, additional costs in recovering this information are not desirable."* |
| Consultancy | *"It depends on the type of project. It is most useful when considering projects that incorporate options that consider habitat change, NFM, managed realignment, river restoration etc."* |
| Local Authority | *"There is a clear appetite for NFM to be incorporated into schemes but there is no clear way to determine its benefits at the moment. Therefore, it is very difficult to include in a scheme and get both of; 1) gain prioritisation through SEPA's process and 2) gain Council support."* |
| Consultancy | *"A nationally adopted policy and guidance is required to help incorporate natural capital into viability assessments of schemes earlier in the appraisal process to help implement stronger drivers for "green" elements of schemes."* |
| Regulator | *"To clarify my answer to question 3 - I think the lack of direct link to funding is a major barrier. Funding seems to focus single issues (e.g. flooding or restoration) and so the appraisal will naturally focus on these single issues too. (But I still think the additional understanding of project beneficiaries is worthwhile.)"* |
| Consultancy | *"A system to clearly add monetary gain, like the EA OM4s would allow a better comparison, and clear guidance where the funding for ecosystem works would come from."* |
| Academic | *"Honestly, just doing 'good' comprehensive flood risk assessment with even basic risk information is a major challenge, but incorporating these important yet missing elements of assessment should be a focus for research that feeds practice but I feel that it is currently under resourced. Capacity to analyse and then apply the results is vital. Demonstrating the use and value of this information is really important and capacity building for decision makers must include this and data collection standards."* |
| Consultancy | *"I have answered n/a approach because this is a perception - the perception of this is a major barrier.* |
| Regulator | *Language used can often be a barrier as not always completely understood by range of stakeholders."* |

Source: Mott MacDonald 2020

**Table B.16: Q9 Would you like to comment on anything else related to this survey such as the benefits of these approaches?**

| Organisation | Response |
|---|---|
| Local Authority | *"Whilst it is clear that the review and prioritisation of flood schemes by SEPA and their Consultants are due to take into account added benefits of a flood scheme (non flood risk benefits), it is not clear what weighting these added benefits will have and therefore it is difficult to identify a preferred option. It also appears that a scheme may be highly ranked in the national prioritisation process due to inclusion of natural flood management elements and hence may attract Scottish government funding, yet there is no guarantee that any of the NFM elements will be taken forward by the authority in their final design."* |
| Local Authority | *"This authority has long recognised the benefits and of cross-cutting, multiple benefits projects and has dipped its toes into a few but cautions that the more difficult it is made to demonstrate these benefits, the greater the risk of officers retreating to their silos and in order to manage risk and avoid slippage."* |
| Local Authority | *"I think funding is a major hurdle - it may be useful to have some sort of grant system where it encourages stakeholders to bid for money to undertake a "multiple benefit" project. When I say stakeholders I mean multiple stakeholders for one project (make people look to see if other projects in same area). A percentage of the cost of the project to encourage this type of project. Obviously the more certainty of the benefits and appraisal methods the stronger the multiple benefits the higher the chance of funding. Its a suggestion."* |
| Regulator | *"The approaches often focus on capturing benefits of NFM - without putting it into a framework where NFM can be compared with other types of actions. The potential disbenefits of other (more concrete-y) actions are rarely included in economic appraisal. For more informed decision making, I think we need better capturing of natural capital across all types of actions."* |
| Consultancy | *"Public perception that NFM will provide the required SOP on its own is a big issue during consultation."* |
| Consultancy | *"The EIA system assesses ecosystems, just hard to quantify. Many ecosystem services are cross departments in councils which could be a barrier."* |
| Local Authority | *"This survey seems to be based upon analysis of multiple benefits on a large scale (catchment or sub catchment) but guidance to those working at the scale of developments or streets would be beneficial. At the smaller scale, concerns over maintenance cost are a major stumbling block. Help to persuade those responsible for maintenance of the benefits and value would be useful."* |
| Consultancy | *"so much but a lack of performance tools and a 'perception' that they are uncertain and an inability to demonstrate performance"* |
| Academic | *"Sometimes I feel there is too much emphasis on using these jargony, anthropocentric terms to explain and describe nature in monetary terms (which is rather subjective anyway surely?). Should we not just try and understand how nature works and use that knowledge to better safeguard and restore nature for the benefit of nature and ourselves rather than getting bogged down/distracted by these concepts?"* |
| Regulator | *"Win win projects are a key shared goal now - the language used is clunky and can get overly academic - streamlining discussions with others is also important!"* |

Source: Mott MacDonald 2020

# C. Testing on the Eddleston Water catchment

## C.1 Flood Damages Avoided

### C.1.1 Flood Damages Avoided arising from in town engineered defences

The flood damages avoided benefits for the in town engineered defences in Peebles have been estimated using values reported in Table 11 of *Peebles Summary Appraisal Report* (Mott MacDonald, 2019).

**Table C.17: Extract of Peebles Summary Appraisal Report summarising the whole life damages and benefits for each of the Eddleston Water options (£k, Present Value, 100-year appraisal period)**

| Option | Option Description | Damages (PV, £k) | Flood Damage Avoided Benefits (PV, £k) |
|---|---|---|---|
| Baseline | Do Legal Minimum | 6,960 | 0 |
| Comparator | Do Minimum - Business as Usual | 6,662 | 298 |
| Option 1 | 3.3% AP SOP direct defences with weir removal | 4,750 | 2,210 |
| Option 2 | 3.3% AP SOP direct defences without weir removal | 4,750 | 2,210 |
| Option 3 | 1.3% AP SOP direct defences with weir removal and bridge raising | 2,257 | 4,704 |
| Option 4 | 5% PLP | 2,168 | 4,792 |

Source: Extracted from Table 11, *Peebles Summary Appraisal Report* (Mott MacDonald, 2019)

From the *Peebles Summary Appraisal Report* (Mott MacDonald, 2019), the Do Legal Minimum has been used to form the baseline scenario in this demonstration. For the purposes of this demonstration, it is assumed that SBC currently operate by undertaking the minimum amount of maintenance and flood risk management action needed to meet the statutory requirements.

The 1.3% AP SOP direct defences with weir removal and bridge raising option has been extracted to form the in town sub-option 1 scenario in this demonstration.

The flood damages avoided for sub-option 2 has been recalculated using sub-option 1 damage estimates and assuming no damages below a 0.5% AP event.

The 5% PLP option has been extracted to form the in town sub-option 3 scenario in this demonstration.

Table C.18 summarises the whole life flood damages avoided benefits for each of the in town sub-options.

**Table C.18: Summary of the whole life flood damages avoided benefits for each of the in town sub-options (£k, Present Value, 100-year appraisal period)**

| Option Ref | Option Description | Flood Damage Avoided Benefits (PV, £k) |
|---|---|---|
| Baseline | Do Nothing / Do Minimum | 0 |
| Sub-option 1 | 1.3% AP SOP direct defences with weir removal and bridge raising | 4,704 |

| | | |
|---|---|---|
| Sub-option 2 | 0.5% AP SOP direct defences with weir removal and bridge raising | 5,633 |
| Sub-option 3 | 5% PLP | 4,792 |

Source: Mott MacDonald 2020

### C.1.2 Flood Damages Avoided arising from Natural Flood Management measures

An assessment of the number of properties with reduced flood risk and flood damages avoided arising from the Eddleston NFM works has been estimated and reported within *Eddleston Water Hydrologic and Hydraulic Modelling of NFM: Phase 2* (JBA, July 2020). Table 8-2 of the report, presented in Figure C.2, identifies that the Average Annual Damage reduction from the NFM options. For this assessment it has been assumed that 90% of damages relate to properties in Peebles and 10% relate to Eddleston.

**Figure C.2: Damages avoided using NFM – Extract from Table 8-2, *Eddleston Water Hydrologic and Hydraulic Modelling of NFM: Phase 2* (JBA, July 2020)**

| Return Period | Pre-NFM Damages (£k) | Post-NFM Damages (£k) | Difference (£k) |
|---|---|---|---|
| 5 | 2,562 | 2,494 | -68 |
| 10 | 2,644 | 2,567 | -78 |
| 25 | 2,801 | 2,680 | -121 |
| 30 | 2,869 | 2,728 | -140 |
| 50 | 3,040 | 2,855 | -185 |
| 75 | 3,200 | 2,998 | -202 |
| 100 | 3,307 | 3,103 | -204 |
| 200 | 3,622 | 3,383 | -239 |
| 1000 | 4883 | 4,291 | -592 |
| Annual average damage | 937 | 905 | -32 |

Source: *Eddleston Water Hydrologic and Hydraulic Modelling of NFM: Phase 2* (JBA, July 2020).

Flood damage avoided benefits have been recalculated for options that combine in town defences with NFM by considering the SOP provided by the engineered defences.

The flood damages avoided benefit from sub-option C have been estimated as three times the sub-option B flood damages avoided.

Table C.19 summarises the whole life flood damages avoided benefits for each of the NFM sub-options.

**Table C.19: Summary of the whole life flood damages avoided benefits for each of NFM sub-options (£k, Present Value, 100-year appraisal period)**

| Option Ref | Option Description | Flood Damage Avoided Benefits (PV, £k) |
|---|---|---|
| Sub-option A | No NFM | 0 |
| Sub-option B | Actual NFM implemented in Eddleston catchment | 950 |
| Sub-option C | Additional NFM measures | 2,850 |

Source: Mott MacDonald 2020

## C.2 Calculation of multiple benefits

### C.2.1 Calculation of multiple benefits arising from in town engineered defences

It has been assumed the engineered in town defences will not generate significant changes in multiple benefits (i.e. less than 10% of the overall benefits).

### C.2.2 Calculation of multiple benefits arising from Natural Flood Management

The multiple benefits arising from the NFM measures have been evaluated using B£ST (CIRIA, 2019).

Two excel files are supplied with this report:

- B£ST – actual NFM.xlsm
- B£ST – additional NFM.xlsm

A brief description of the valuation method used for the calculation of multiple benefits is presented within Section 4.3.5 of the report body and within each excel files.

## C.3 Option Costing

### C.3.1 Option Costing for in town flood defences

Whole life costing of the short-listed matrix options has been estimated to inform the options appraisal. Costing of the traditional in town flood defence options has been extracted from the *Peebles Summary Appraisal Report* (Mott MacDonald, 2019) and is presented in Table C.20.

The costs presented in *Peebles Summary Appraisal Report* (Mott MacDonald, 2019) include a 30% optimism bias applied to the enabling, capital and maintenance costs. No allowance for end of life replacement or decommissioning was included within the cost estimates.

**Table C.20: Extract of Peebles Summary Appraisal Report summarising the whole life costs for each of the Eddleston Water options (£k, Present value, 100-year appraisal period) (Excludes VAT)**

| Option | Option Description | Whole Life Cost (PV, £k) |
|---|---|---|
| Baseline | Do Legal Minimum | 0 |
| Comparator | Do Minimum – Business as Usual | 121 |
| Option 1 | 3.3% AP SOP direct defences with weir removal | 5,651 |
| Option 2 | 3.3% AP SOP direct defences without weir removal | 6,543 |
| Option 3 | 1.3% AP SOP defects with weir removal and bridge raising | 8,014 |
| Option 4 | 5% PLP | 1,964 |

Source: Peebles Summary Appraisal Report, Mott MacDonald 2019

From the *Peebles Summary Appraisal Report* (Mott MacDonald, 2019), the Do Legal Minimum has been used to form the baseline scenario in this test.

The 1.3% AP SOP direct defences with weir removal and bridge raising option has been extracted to form the in town sub-option 1 scenario in this test.

The cost of sub-option 2 has been extrapolated by increasing the cost from sub-option 1 by a third to account for the increased flood wall height required to provide a 0.5% AP SOP.

The 5% PLP option has been extracted to form the in town sub-option 3 scenario in this demonstration.

Table C.21 summarises the whole life cost for each of the in town sub-options.

**Table C.21: Summary of the whole life costs for each of the in town sub-options (£k, Present Value, 100-year appraisal period) (Excludes VAT)**

| Option Ref | Option Description | Whole Life Cost (PV, £k) |
|---|---|---|
| Baseline | Do Minimum | 0 |
| Sub-option 1 | 1.3% AP SOP direct defences with weir removal and bridge raising | 8,014 |
| Sub-option 2 | 0.5% AP SOP direct defences with weir removal and bridge raising | 10,685 |
| Sub-option 3 | 5% PLP | 1,964 |

Source: Mott MacDonald 2020

### C.3.2 Option Costing for Natural Flood Management Measures

Costing of the three NFM options has been informed by data collected by the Tweed Forum. A summary of the costs is presented in Table C.22. Table C.23 provides more detail on the estimation of these costs for the actual NFM measures already implemented in the Eddleston catchment. These costs have been used to inform the estimate of the whole life cost of the additional NFM measures proposed in sub-option C – a breakdown for which is presented in Table C.24.

The present value costs are estimated for the following cost categories:

- Enabling costs – These costs relate to the project set up, scoping, project management, planning and design of the options
- Capital costs – These costs relate to the construction of the flood mitigation measures
- Operation and maintenance costs – These costs relate to operations that ensure the assets remain fit for purpose, will continue to support the realisation of the identified benefits and to limit asset deterioration. Costs may include inspections, maintenance and intermittent asset repairs/replacement
- Other costs – These costs relate to compensation provided to landowners for loss of grazing land

End of life decommissioning costs have not been included in this assessment.

All capital costs have been assumed to occur in the first year of the appraisal.

No optimism bias has been included for supplied costs based on actual recorded costs for the Eddleston Project provided by the Tweed Forum. An optimism bias of 30% has been applied where no actual recorded costs have been provided. This is detailed in Table C.23 and Table C.24.

**Table C.22: Summary of the whole life costs for each of the NFM sub-options (£k, Present value, 100-year appraisal period) (Excludes VAT)**

| Cost Category | Sub-option A – No NFM | Sub-option B – Actual NFM | Sub-option C – Additional NFM |
|---|---|---|---|
| Enabling Costs | 0 | 616 | 1,662 |
| Capital Costs | 0 | 848 | 6,649 |
| Operation and Maintenance Costs | 0 | 657 | 3,608 |

| | | | |
|---|---|---|---|
| Other Costs | 0 | 10 | 99 |
| **Total Costs** | **0** | **2,131** | **12,017** |

Source: Mott MacDonald 2020

**Table C.23: Breakdown of the whole life costs and assumptions for the actual NFM measures proposed in sub-option B (Present value, 100-year appraisal period) (Includes VAT unless stated)**

| Cost Category | Cost | | Notes |
|---|---|---|---|
| **ENABLING COSTS** | | | |
| Project set up | | £306,000 | Actual project cost provided by Tweed Forum. |
| Scoping | | £49,000 | Actual project cost provided by Tweed Forum. |
| Project management | | £215,776 | Actual project cost provided by Tweed Forum. |
| Planning Fees | | £5,616 | Relates to river meandering works. Actual project cost provided by Tweed Forum. |
| Design and modelling (Remeandering) | | £81,000 | Relates to river meandering works. Actual project cost provided by Tweed Forum. |
| Design (Other) | | £81,780 | Assumed design cost for remaining features is 10% of capital cost. |
| **Total Enabling Cost** | | **£739,272** | An optimism bias has not been included, as this is based on actual recorded cost data. |
| | | | |
| **CAPTIAL COSTS** | | | |
| Remeandering | | £199,280 | Total cost has been broken down by site below. |
| *Cringletie* | *£62,586* | | |
| *Lakewood* | *£15,752* | | |
| *Shiphorns* | *£36,728* | | |
| *Craigburn* | *£18,322* | | |
| *Nether Kidston* | *£10,289* | | |
| *Milkieston* | *£55,602* | | |
| RAFs/Ponds | | £48,098 | Total cost has been broken down by site below. |
| *North Cloich* | *£4,981* | | |
| *Cloich Farm* | *£2,832* | | |
| *Kidston Mill Field Pond* | *£16,344* | | |
| *Ruddenleys* | *£18,480* | | |
| *Westerdeans* | *£4,554* | | |
| *Shiphorns* | *£907* | | |
| *Darnhall* | *£3,705* | | |
| *Craigburn Forest* | *£2,000* | | |
| Fencing | | £81,970 | Total cost has been broken down by site below. |
| *Cringletie* | *£15,850* | | |
| *Lakewood* | *£10,722* | | |
| *Nether Kidston* | *£2,917* | | |
| *Kidston Mill* | *£4,368* | | |
| *Winkston Field* | *£4,368* | | |
| *Westerdeans* | *£25,625* | | Cost includes transverse hedges. |
| *Shiphorns* | *£12,088* | | |
| *Cloich* | *£2,268* | | |
| *Milkieston* | *£3,764* | | |
| Planting | | £670,394 | Total cost has been broken down by site below. |
| *Cringletie* | *£8,507* | | |

| Cost Category | Cost | | Notes |
|---|---|---|---|
| *Lakewood/Wormiston Farm* | *£4,026* | | |
| *Shiphorns* | *£3,585* | | |
| *North Cloich* | *£5,758* | | |
| *Middleburn* | *£5,107* | | |
| *Portmore* | *£20,609* | | |
| *Nether Kidston* | *£25,998* | | |
| *Burnhead Farm* | *£6,947* | | |
| *Waterheads* | *£5,166* | | |
| *Craigburn Farm* | *£14,554* | | |
| *Nether Falla* | *£38,990* | | |
| *Westerdeans* | *£24,149* | | |
| *Ruddenleys (Native)* | *£150,596* | | |
| *Ruddenleys (Conifer)* | *£49,940* | | |
| *Shiplaw* | *£69,350* | | |
| *Cloich farm* | *£1,500* | | |
| *Violet Bank (Wet)* | *£3,304* | | No actual costing information recorded. Have assumed an average cost of £3k/ha, based on an area of approximately 1.1ha. |
| *Violet Bank (Dry)* | *£4,196* | | No actual costing information recorded. Have assumed an average cost of £3k/ha, based on an area of approximately 1.4ha. |
| *West Loch* | *£200,000* | | No actual costing information recorded. Have assumed an average cost of £4k/ha, based on an area of approximately 50ha. |
| *Darnhall (Eddleston)* | *£7,402* | | |
| *Darnhall (Middle Burn - Native)* | *£3,684* | | |
| *Darnhall (Middle Burn - Conifer)* | *£11,097* | | |
| *The Burrow* | *£5,929* | | |
| Flow restrictors | | £13,445 | Total cost has been broken down by site below. |
| *West Loch* | *£2,723* | | |
| *Middleburn* | *£5,250* | | |
| *Ruddenleys* | *£2,472* | | |
| *Craigburn* | *£3,000* | | |
| Fish rescue/electrofishing | | £3,897 | Total cost has been broken down by site below. |
| *Miklieston* | *£783* | | |
| *Lakewood* | *£768* | | |
| *Tweed Foundation - Electrofishing Longcote* | *£1,173* | | |
| *Tweed Foundation - Electrofishing Shiplaw* | *£1,173* | | |
| **Total Capital Cost** | | **£1,017,084** | An optimism bias has not been included, as this is based on actual recorded cost data. |
| | | | |
| **OPERATION AND MAINTENANCE COSTS** | | | Operation and maintenance costs have been converted to present day costs using discounting factors. |

| Cost Category | Cost | Notes |
|---|---|---|
| Remeandering | £52,169 | Occasional repair of bank protection works. £9743 has already been spent during the project. Assume this is repeated every 5 years. |
| RAFs/Ponds | £0 | Maintenance costs are likely negligible and have not been accounted for in this assessment. |
| Fencing | £81,784 | Assumed fencing will be replaced every 20 years. |
| Planting | £360,830 | FCS provide a maintenance contribution to landowners every 5 years, at a rate of £282/ha. |
| Fish rescue/electrofishing | £0 | n/a |
| Flow restrictors | £31,355 | After 5 years in operation, £20,000 has been allocated to upgrade flow restrictors in Eddleston Water. Assumed this cost is repeated every 10 years for the first 30 years. After which flow restrictors will be self-sustained by riparian planting. |
| Monitoring | £80,533 | The Eddleston Water NFM project is an academic study, with high monitoring costs (approximately £800k). A cost of 10% of this was assumed more representative of typical NFM schemes. |
| Sub Total | £606,671 | |
| Optimism bias and risk adjustment | £182,001 | An uplift of 30% has been added to account for optimism bias and risk. |
| **Total Operation and Maintenance Cost** | **£788,673** | |
| | | |
| **OTHER COSTS** | | |
| Loss of grazing land compensation | £12,500 | Total cost has been broken down by site below. |
| *Nether Kidstone* | *£5,000* | |
| *Milkieston* | *£7,500* | |
| **Total Other Costs** | **£12,500** | An optimism bias has not been included, as this is based on actual recorded cost data. |
| | | |
| **TOTAL COST** | **£2,557,529** | **INCLUSIVE OF VAT** |
| **TOTAL COST** | **£2,131,274** | **EXCLUSIVE OF VAT** |

Source: Mott MacDonald 2020

**Table C.24: Breakdown of the whole life costs and assumptions for the additional NFM measures proposed in sub-option C (Present value, 100-year appraisal period)**

| Cost Category | Cost | | Notes |
|---|---|---|---|
| **ENABLING COSTS** | | | |
| Project set up | | £306,000 | Assumed same as actual project cost provided by Tweed Forum. |
| Scoping | | £49,000 | Assumed same as actual project cost provided by Tweed Forum. |
| Project management | | £431,552 | Scaled up based on actual capital project cost provided by Tweed Forum. |
| Planning Fees | | £11,232 | Relates to river meandering works. Scaled up based on increase in meandering works and actual project cost provided by Tweed Forum. |
| Design and modelling (Remeandering) | | £162,200 | Relates to river meandering works. Scaled up based on increase in meandering works and actual project cost provided by Tweed Forum. |
| Design (Other) | | £573,911 | Assumed design cost for remaining features is 10% of capital cost. |
| Sub Total | £1,533,895 | | |
| Optimism bias and risk adjustment | | £460,169 | An uplift of 30% has been added to account for optimism bias and risk. |
| **Total Enabling Cost** | | **£1,994,064** | |
| | | | |
| **CAPTIAL COSTS** | | | |
| Remeandering | | £398,559 | Scaled up based on increase in meandering works and actual project cost provided by Tweed Forum. |
| Planting | | £5,013,750 | Have assumed an average cost of £2,865/ha (estimated from actual costing data provided by the Tweed Forum), based on an area of 1,750Ha. |
| Flow restrictors | | £67,225 | Scaled up based on increase in flow restrictor works and actual project cost provided by Tweed Forum. |
| Fish rescue/electrofishing | | £7,794 | Scaled up based on increase in meandering works and actual fish rescue project cost provided by Tweed Forum. |
| RAFs/Ponds | | £240,490 | Scaled up based on increase in runoff attenuation features/ponds and actual project cost provided by Tweed Forum. |
| Fencing | | £409,852 | Scaled up based on increase in channel works and actual project cost provided by Tweed Forum. |
| Sub Total | | £6,137,670 | |
| Optimism bias and risk adjustment | | £1,841,301 | An uplift of 30% has been added to account for optimism bias and risk |
| **Total Capital Cost** | | **£7,978,971** | |
| | | | |
| **OPERATION AND MAINTENANCE COSTS** | | | Operation and maintenance costs have been converted to present day costs using discounting factors. |
| Remeandering | | £104,339 | Occasional repair of bank protection works. £9743 has already been spent during the project. This has been scaled up to £19,486 based on the increase in meandering works. Assume this is repeated every 5 years. |
| RAFs/Ponds | | £0 | Maintenance costs are likely negligible and have not |

| Cost Category | Cost | Notes |
|---|---|---|
| | | been accounted for in this assessment. |
| Fencing | £408,919 | Assumed fencing will be replaced every 20 years. |
| Planting | £2,642,476 | FCS provide a maintenance contribution to landowners every 5 years, at a rate of £282/ha. |
| Fish rescue/electrofishing | £0 | n/a |
| Flow restrictors | £94,066 | After 5 years in operation, £20,000 has been allocated to upgrade flow restrictors in Eddleston Water. This has been increased to £60,000 based on the increase in flow restrictors and assuming some economies of scale. Assumed this cost is repeated every 10 years for the first 30 years. After which flow restrictors will be self-sustained by riparian planting. |
| Monitoring | £80,533 | The Eddleston Water NFM project is an academic study, with high monitoring costs (approximately £800k). A cost of 10% of this value was assumed more representative of typical NFM schemes. |
| Sub Total | £3,330,333 | |
| Optimism bias and risk adjustment | £999,100 | An uplift of 30% has been added to account for optimism bias and risk. |
| **Total Operation and Maintenance Cost** | **£4,329,433** | |
| | | |
| **OTHER COSTS** | | |
| Loss of grazing land compensation | £91,146 | Scaled up based on increase in planting and actual project cost provided by Tweed Forum. |
| Sub Total | £91,146 | |
| Optimism bias and risk adjustment | £27,344 | An uplift of 30% has been added to account for optimism bias and risk. |
| **Total Other Costs** | **£118,490** | |
| | | |
| **TOTAL COST** | **£14,420,957** | **INCLUSIVE OF VAT** |
| **TOTAL COST** | **£12,017,465** | **EXCLUSIVE OF VAT** |

*Source: Mott MacDonald 2020*

## C.4 Managing uncertainty and robustness

**Table C.25: Sensitivity Test 1 – Increasing NFM cost, Matrix of option BCR based on best value flood damages avoided (Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | 0.22 | 0.12 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | 0.59 | 0.40 | 0.17 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | 0.53 | 0.39 | 0.18 |
| | Sub-Option 3 - Property Level Protection | **2.44** | 0.88 | 0.26 |

Source: Mott MacDonald 2020

**Table C.26: Sensitivity Test 1 – Increasing NFM cost, Matrix of option NPV based on best value flood damages avoided (£k, Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | -3,313 | -21,185 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | -3,310 | -7,368 | -26,731 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | -5,052 | -9,158 | -28,617 |
| | Sub-Option 3 - Property Level Protection | **2,828** | -758 | -19,178 |

Source: Mott MacDonald 2020

**Table C.27: Sensitivity Test 2 – Using the lower confidence score results for ESS benefit, Matrix of option BCR based on best value flood damages avoided (Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | 0.22 | 0.12 |
| | Sub-Option 1 - 1.3% AP SOP | 0.29 | 0.24 | 0.13 |

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| | direct defences | | | |
| | Sub-Option 2 - 0.5% AP SOP direct defences | 0.26 | 0.23 | 0.13 |
| | Sub-Option 3 - Property Level Protection | **1.22** | 0.67 | 0.24 |

Source: Mott MacDonald 2020

**Table C.28: Sensitivity Test 2 – Using the lower confidence score for ESS benefit, Matrix of option NPV based on best value flood damages avoided (£k, Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | -1,656 | -10,592 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | -5,662 | -7,691 | -17,373 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | -7,869 | -9,922 | -19,651 |
| | Sub-Option 3 - Property Level Protection | **432** | -1,361 | -10,571 |

Source: Mott MacDonald 2020

**Table C.29: Sensitivity Test 3 – Using the higher confidence score results for ESS benefit, Matrix of option BCR based on best value flood damages avoided (Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | 0.67 | 0.36 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | 0.88 | 0.73 | 0.40 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | 0.79 | 0.68 | 0.40 |
| | Sub-Option 3 - Property Level Protection | **3.66** | 2.00 | 0.73 |

Source: Mott MacDonald 2020

**Table C.30: Sensitivity Test 3 – Using the higher confidence score results for ESS benefit, Matrix of option NPV based on best value flood damages avoided (£k, Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | -706 | -7,742 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | -958 | -2,783 | -12,055 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | -2,235 | -4,132 | -13,548 |
| | Sub-Option 3 - Property Level Protection | **5,224** | 4,107 | -3,750 |

Source: Mott MacDonald 2020

**Table C.31: Sensitivity Test 1 – Increasing NFM cost, Matrix of option BCR based on all monetised benefits (Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | 1.21 | 0.85 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | 0.59 | 0.74 | 0.72 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | 0.53 | 0.67 | 0.68 |
| | Sub-Option 3 - Property Level Protection | 2.44 | 1.55 | 0.94 |

Source: Mott MacDonald 2020

**Table C.32: Sensitivity Test 1 – Increasing NFM cost, Matrix of option NPV based on all monetised benefits (£k, Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | 888 | -3,525 |
| | Sub-Option 1 - 1.3% AP SOP | -3,310 | -3,167 | -9,071 |

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| | direct defences | | | |
| | Sub-Option 2 - 0.5% AP SOP direct defences | -5,052 | -4,957 | -10,957 |
| | Sub-Option 3 - Property Level Protection | 2,828 | **3,443** | -1,518 |

Source: Mott MacDonald 2020

**Table C.33: Sensitivity Test 2 – Using the lower confidence score results for ESS benefit, Matrix of option BCR based on all monetised benefit (Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | 0.83 | 0.58 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | 0.29 | 0.37 | 0.41 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | 0.26 | 0.33 | 0.38 |
| | Sub-Option 3 - Property Level Protection | **1.22** | 0.98 | 0.64 |

Source: Mott MacDonald 2020

**Table C.34: Sensitivity Test 2 – Using the lower confidence score for ESS benefit, Matrix of option NPV based on all monetised benefit (£k, Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | -366 | -5,091 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | -5,662 | -5,687 | -11,872 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | -7,869 | -8,632 | -14,150 |
| | Sub-Option 3 - Property Level Protection | **432** | -71 | -5,070 |

Source: Mott MacDonald 2020

**Table C.35: Sensitivity Test 3 – Using the higher confidence score results for ESS benefit, Matrix of option BCR based on all monetised benefit (Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | **4.10** | 2.58 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | 0.88 | 1.45 | 1.73 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | 0.79 | 1.25 | 1.58 |
| | Sub-Option 3 - Property Level Protection | 3.66 | 3.79 | 2.65 |

Source: Mott MacDonald 2020

**Table C.36: Sensitivity Test 3 – Using the higher confidence score results for ESS benefit, Matrix of option NPV based on all monetised benefit (£k, Present Value, 100-year Appraisal Period)**

| | | NFM SUB-OPTION | | |
|---|---|---|---|---|
| | | A - No NFM | B - Actual NFM | C - Additional NFM |
| IN TOWN SUB-OPTION | Do Nothing / Do Minimum | - | 6,611 | 19,021 |
| | Sub-Option 1 - 1.3% AP SOP direct defences | -958 | 4,534 | 14,708 |
| | Sub-Option 2 - 0.5% AP SOP direct defences | -2,245 | 3,185 | 13,215 |
| | Sub-Option 3 - Property Level Protection | 5,224 | 11,424 | **23,013** |

Source: Mott MacDonald 2020

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