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Learning from community led flood risk management

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Disclaimer: All indicative costs for measures quoted in this document are correct at time of writing (July 2015). These costs are subject to change.

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Images courtesy of: Kerry Waylen

Abbreviations and definitions

Abbreviations

AECS	Agri-Environment Climate Scheme
COS	Carse of Stirling
EFA	Ecological Focus Area
ES	Ecosystem Services
EU	European Union
FCS	Forestry Commission Scotland
FRM	Flood Risk Management
FRM Act	Flood Risk Management (Scotland) Act 2009
NFM	Natural flood management
SEPA	Scottish Environment Protection Agency
SNH	Scottish Natural Heritage
SRDP	Scottish Rural Development Programme
TCOSP	The Carse of Stirling Partnership
RSUDS	Rural Sustainable Urban Drainage Systems
WFD	EC Water Framework Directive

Definitions

Cultural services	In relation to ecosystem services, these are the *non-material benefits* (e.g. aesthetic appeal, recreation and education).
Carbon sequestration	The capture and long term storage of carbon from the atmosphere, mitigating climate change and improving air quality. For example, trees absorb and store carbon.
Ecosystem	A biological environment consisting of living organisms as well as all the non-living, physical components of the environment with which the organisms interact, such as air, soil, water and sunlight.
Ecosystem Services	The benefits that society obtains from the natural processes and ecological balances provided by ecosystems.
Flood hazard	The hazard arising from the depth, extent and speed of floodwater.
Flood mitigation	Management and control of flooding and reducing the potential damages.
Flood protection	Defence against flooding when it occurs.
Flood risk	A measure of the combination of the likelihood of flooding occurring and the associated impacts on people, the economy and the environment.
Fluvial flooding	Flooding that occurs from rivers overtopping their banks.
Hydraulic constrictions	Structures or blockages which cause flows to back-up.
Hydraulic roughness	Friction and resistance experienced by water.
Land manager	Any individual or group that manages or controls the use and development of land. Many land-managers are farmers.
Livestock poaching	Soil erosion and degradation of soil structure caused by livestock. Mostly occurs at the edge of water courses/ water bodies.
Morphology	The formation of shapes and structures. In relation to rivers, these are the formations created by the movement of water and sediment in rivers (for example- a meander) often referred to as "fluvial morphology".
Natural Flood Management	A set of flood management techniques that aim to work with natural processes (or nature) to manage flood risk.
Provisioning services	In relation to ecosystem services, these are the *products* obtained from ecosystems (e.g. food, timber and drinking water).
Regulating services	In relation to ecosystem services, these are the *benefits* gained from ecosystem *processes* (e.g. flood regulation, climate regulation and water regulation).
Supporting services	In relation to ecosystem services, these are the factors essential to *maintain all other ecosystem services* (e.g. nutrient cycling, soil formation and habitat).

Acknowledgements

We thank the four farmers involved in this project, for their time and willingness to share their views and experiences with the project team. We are also grateful to all those who attended the public meeting for this project, and for the input and impetus of the Carse of Stirling Partnership.

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Executive summary

What can be learnt from working with a community to identify what flood risk management measures are needed, are acceptable and which deliver the greatest multiple benefits?

Key findings

- While flood risk management (FRM) policy in Scotland requires the consideration of natural flood management (NFM), many landowners do not yet support their implementation. Since many measures to support NFM can only be carried out with the support and participation of land-managers, it is particularly important to understand the perceptions of these stakeholders.

- Many land-managers would consider implementation of NFM measures only if they were compatible with farm business strategies, financially viable and conformed to concepts of 'good' farming. Despite strong political drive to implement NFM to complement traditional approaches to FRM downstream, limited uptake of these measures by landowners still remains. Traditional approaches such as dredging and drainage are perceived as the most desirable options.

- In the case study catchment the flooding issues are waterlogging, fluvial flooding, standing water, insufficient drainage and hydraulic constrictions.

- The study identified the following FRM measures which may be useful in the case study catchment:
  - Two-stage channel
  - Re-meandering
  - Dredging
  - Removal of Constrictions
  - Riparian buffer strips
  - Retention ponds
  - Aeration/ mole ploughing
  - Tree planting
  - Hedgerows
  - Cover crops

- Key recommendations and suggestions for future steps to promote NFM include:
  - Trial land-manager led initiatives
  - Catchment-wide coordinated planning
  - Use of a facilitator
  - Long term continuation of community led approach coupled with demonstration visits to other sites
  - Tailoring of funding
  - Investment in community awareness engagement (e.g. public workshops)
  - Coordinated funding streams to enable "top-up" funding between different sources for one project and not be considered "double funding"
  - Learning from other disciplines to facilitate individual buy-in (e.g. water quality)
  - Localised dredging, in compliance with regulations, and coupled with NFM measures.

Research undertaken

The project team researched the Carse of Stirling (COS) area (focusing on the Goodie Water) collating relevant datasets, maps and publications from various sources. Following an initial and continual meetings with The Carse of Stirling Partnership (TCOSP), site visits to the selected four case study farms were used to collect information on flooding issues and consequential financial losses, as well as perceptions of the proposed FRM measures. The wider community perceptions of these flooding measures were also captured at a public workshop. A desk based study enabled maps to be created and the measures to be fully assessed in terms of their potential to deliver ecosystem services, their indicative costs and potential funding mechanisms available to implement them.

Recommendations

Financial incentives to encourage the implementation of NFM measures are invaluable as many of these are not financially viable for many land-managers. The Scottish Rural Development Programme (SRDP) is currently the principal source of funding for some of these measures and this study suggests the need for continued adjustment of payment rates to encourage uptake. However, adjusting the level and provision of financial subsidies for implementing FRM will be useful, but not by itself sufficient to encourage land managers to consider and implement NFM. A potential modification would be the integration of funding streams by enabling local authorities to "top-up" other funding mechanisms for specific purposes (e.g. Water Framework Directive focused funding, or capital works budgets could be considered in tandem without be considered as double funding) to achieve multiple policy objectives. The authorities responsible for FRM could also consider a dedicated fund to further incentivise FRM or coordinate existing funding streams. However, given the relatively long-term and often uncertain effects on flood risk ascribable to individual measures, it may be better to focus on incentivising NFM-type actions due to the other benefits they provide (e.g. for biodiversity, pollution control) which may be easier to demonstrate and monitor.

Reluctance to adopt NFM measures can arise from diverse reasons, not only due to their financial viability in the near term. These reasons can range from differing understandings of flooding, water systems and 'good farming', through to the constraints of existing farming infrastructure. Therefore, those leading implementation of FRM plans must consider if and how they could tackle these other barriers. Funding measures at demonstration farms and sites may be a practical and useful way that not only helps to understand how barriers can be overcome, but also provides a vital role in informing and persuading others that new measures can be compatible with a viable farm business.

Where community-led processes considering flooding already exist (as in the Carse of Stirling) it is particularly important to invest in engagement, so that communities and community-led plans may be represented in statutory processes and vice versa (i.e. connecting 'bottom up' with 'top down'). The Local FRM Plans required under the FRM Act are one obvious point where bottom up and top down priorities could be connected, which might entail reconsidering representation and mode of operation of Local Plan District Partnerships.

This study reinforced the calls for coordination in choosing and implementing any FRM measures, and so the SRDP's new Environmental Co-operation action fund should assist in this: tracking and supporting applications to this scheme should be a priority that could help integrated catchment management to assist in FRM, as well as other objectives.

Key words: flood risk management, natural flood management, funding mechanisms, community approach and land manager perceptions

1.0 Introduction

This report responds to the CREW call for research into how community led flood risk management (FRM) can contribute to the Scottish Government's natural flood management (NFM) policy development. The overall aim of the project was to use the Carse of Stirling (COS) as a case study area to work with the community, landowners and The Carse of Stirling Partnership (TCOSP) to assess NFM measures suitable for addressing flooding issues across the COS, additionally outlining any likely ecosystem service provision. The project used four case study farms to conceptualise general flood risk issues across the Goodie Water catchment (and the COS in general) and to suggest potential FRM measures which can address flood risk at the local and catchment scale. Whilst the project was based on four case study farms in COS, the generic findings of this report are considered applicable Scotland wide.

1.1 Carse of Stirling Project Area

The COS project area (Figure 1) is located to the east of Stirling and covers five distinct areas: the Carse, Gargunnock and Touch Hills, Kippen Muir, Forth-Teith ridge and the Lake of Menteith. These areas vary substantially in character from flat valley floors with drained agricultural land and little tree cover, through to peatbog, open moorland, upland forestry plantation and craggy escarpments. The Carse incorporates part of the River Forth catchment, the Goodie Water catchment, the Lake of Menteith and Loch Ruskie. Also within the COS is Flanders Moss National Nature Reserve, a large peat bog within the flat valley with an existing lag-fen project on the edges of the moss purposely constructed to improve habitat and mitigate flooding. Further downstream the River Teith joins the River Forth. During floods the confluence can contribute to flood levels upstream. No quantification of this influence was undertaken as part of this report.

Previously, Scottish Natural Heritage (SNH) and Scottish Environment Protection Agency (SEPA) conducted research to emphasise the ecosystems approach to land management and to understand how local people valued the Carse (LUC and STAR, 2014). This project prompted the creation of TCOSP, and its Flood Management and Carbon Sub-group who are developing a bottom up FRM approach to tackle flooding and drainage issues across the whole catchment (see Appendix 8 for background information). TCOSP had a key role in this project as the representatives from the community, facilitating initial

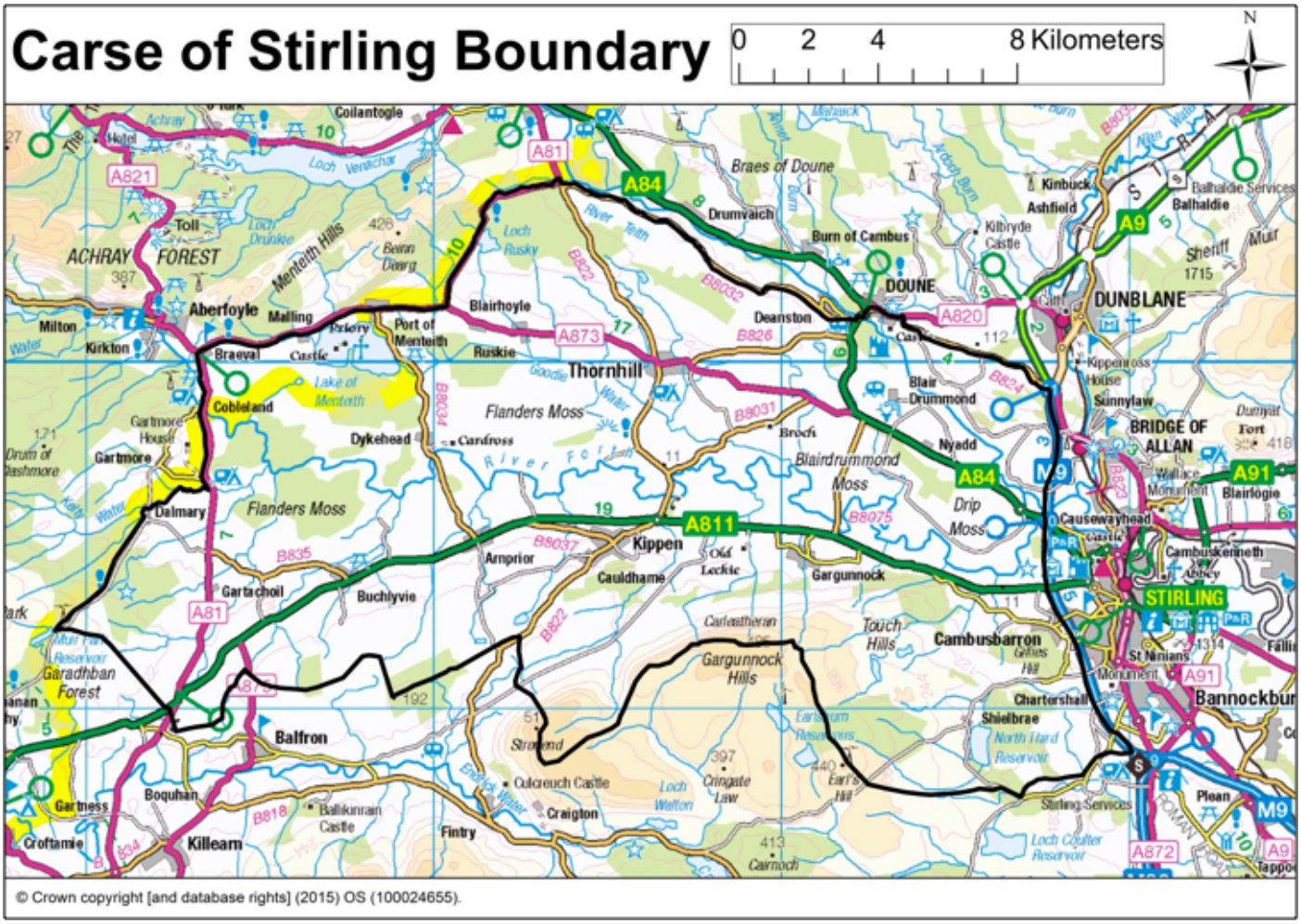


Figure 1 Carse of Stirling boundary and location from LUC and STAR (2014) report.

communication with the case study farmers, advertising and hosting the public meeting, and regularly meeting the project team for updates.

1.2 Flooding

Flooding is a natural phenomenon that occurs at different spatial and temporal scales across urban and rural environments. There are different types of flooding: from the coast, rivers, sewers and surface water, groundwater and flash floods. The risk of flooding is likely to increase with climate change as: rainfall occurs more frequently and intensifies; sea levels rise; land use changes; populations grow; and urban expansion increases (IPCC, 2014).

Flood risk is defined as a function of the potential danger from the flood *hazard* (the depth, extent and speed of the floodwater) and the consequences of flooding occurring (economic, social and environmental impact of the flood). Managing this flood risk is often done so at the *catchment* scale, which is essentially all the land that drains into each watercourse forming a main river channel, which flows to an eventual outlet at the coast.

Tackling flood risks has long been an important issue for Scotland, but it has recently been given new impetus by EC Floods Directive 2007 (European Commission (EC), 2012), which is transposed into Scots Law in the Flood Risk Management (Scotland) Act 2009 (FRM Act)). This Act requires a strategic approach to identifying and tackling flood risks, with a focus on measures that will be sustainable over the long-term. Other policies and requirements are also relevant to how water flows are managed. In particular, statutory obligations to achieve good water quality arise from the EC Water Framework Directive 2000, transposed into Scots Law by the Water Environment and Water Services (Scotland) Act 2003 and the Controlled Activities Regulations 2005.

Taken together, the requirement of different policies and societal priorities has stimulated a search for strategic approaches that can deliver multiple benefits, as well as being cost effective. A key concept in Scotland that offers the potential to achieve this is NFM. The FRM Act requires all statutory bodies to consider natural processes and features within the landscape.

1.3 Natural Flood Management

Natural flood management (NFM) is defined as the *alteration, restoration or use of landscape features* to mitigate flooding (POST, 2011). NFM is advocated as a suitable approach to FRM often in conjunction with other traditional hard engineered measures (e.g. flood walls and reservoirs). The key concept is to slow the flow of water within the catchment, store water where possible and utilise natural processes to do so, achieving cost effective multiple benefits and alleviating flood risk (Wilkinson et al., 2014, POST, 2014). NFM measures often entail changes in rural land-management, and so it is important to understand and work with 'land-managers'. Land-managers are any individuals or groups who find themselves managing or controlling land, primarily farmers.

NFM measures are becoming widely adopted across Scotland and the UK with demonstration sites in the Eddleston Water (http://www.tweedforum.org/projects/current-projects/eddleston), Tarland Burn (http://www.hutton.ac.uk/research/projects/aquarius-farmers-water-managers-within-tarland-catchment), Belford (http://research.ncl.ac.uk/proactive), Pontbren, Holnicote and Pickering and throughout Europe (see www.nwrm.eu).

2.0 Methods

The aim of this project was to learn from a community led FRM approach and how it can contribute to Scottish Government's NFM policy development. Using four farms in the COS as a case study, the objectives were to:

a) Collate existing catchment data
b) Explore perceptions through community engagement and initial assessment
c) Assess flooding problems
d) Develop potential mitigation measures
e) Identify sources of funding
f) Undertake community engagement to identify the measures needed and those that are practicable
g) Identify potential multiple benefits/ ecosystem service provision of proposed measures
h) Provide recommendations for policy

A desk-based study was conducted to investigate the area and collate existing catchment datasets where possible (Appendix 1) for mapping. This study also collected relevant publications of previous work relating to the COS (LUC and STAR, 2014, Harrison, 2003). Following field visits (Table 1) and the desk study, maps of the case study farms were created (Figure 2) to show any important overlaps with SEPA flood maps and River Basin Management Plan classifications, as well as to identify the prospective suitable locations for FRM measures within the case study farms. Using the framework adopted by McLean et al. (2013), likely ecosystem services delivered by the proposed FRM measures were identified. Funding mechanisms were researched in relation to the suggested FRM measures and land management practices within COS.

Information was collected on field visits to the COS catchment area and the case study farms (Table 1). These visits enabled flooding issues at the case study farms to be assessed, farmer perceptions to be captured during interviews, and financial costs and losses due to flooding on the case study farms to be captured. Through the meetings with TCOSP, case study farmers and wider community, flooding issues/concerns in the catchment were also captured and are outlined in section 3.

On 18th May 2015, a public workshop was held to scope the feedback and opinions about the measures from community members living within the Carse. This evening meeting shared information about measures, and provided an opportunity to explore to what extent the issues raised by the four case study farmers encompassed the ideas and opinions held by others. The meeting had forty-five participants, excluding the project team members. Most of these participants were farmers, but the group also included councillors and other local residents, some of whom were also members of TCOSP. A representative of SEPA and of the Scottish Government attended as observers. The agenda of the workshop is attached in Appendix 6.

Participants' views were collected in three ways. Firstly, participants were invited to leave comments about specific measures, by writing onto post-its and sticking them onto one of 10 posters representing each of the measures. Secondly, points raised during a subsequent general discussion were recorded on flipchart by the project team. Thirdly, participants were invited to fill in feedback forms to provide any additional feedback about the meeting and measures. Information collected at this meeting is captured in Appendix 7 and also discussed within section 6.

2.1 Case Study Farms

The four case study farms were proposed by TCOSP (see Figure 2) before the project started and each farmer had agreed to be part of the project. Each farm has a mixture of arable and pasture land use situated across various landscape types as illustrated in Table 2. The case study farms demonstrated flooding issues that are illustrative of the range of issues found in the wider COS area, and across similar landscapes in Scotland.

Table 1 Project meeting and field visit dates

Date (2015)	Tasks	Purpose
18th February	Meet TCOSP	Steering group meeting TCOSP to contact case study farmers
4th March	Field visit- Case study farms	Visit case study farms and discuss flood issues
10th March	Field visit- Case study farms	Visit case study farms and discuss flood issues
16th March	Meet TCOSP	Steering group meeting TCOSP progress meeting
13th April	Field visit- Case study farms	Assess and discuss case study farms' flood issues and possible solutions. Record financial losses incurred due to flood issues
29th April	Field visit- Case study farms	Propose suggested FRM measures (included in report) and get feedback from case study farmers.
18th May	Open public workshop, TCOSP & Case study farmers	Obtain wider community perceptions on the various FRM measures proposed by the project

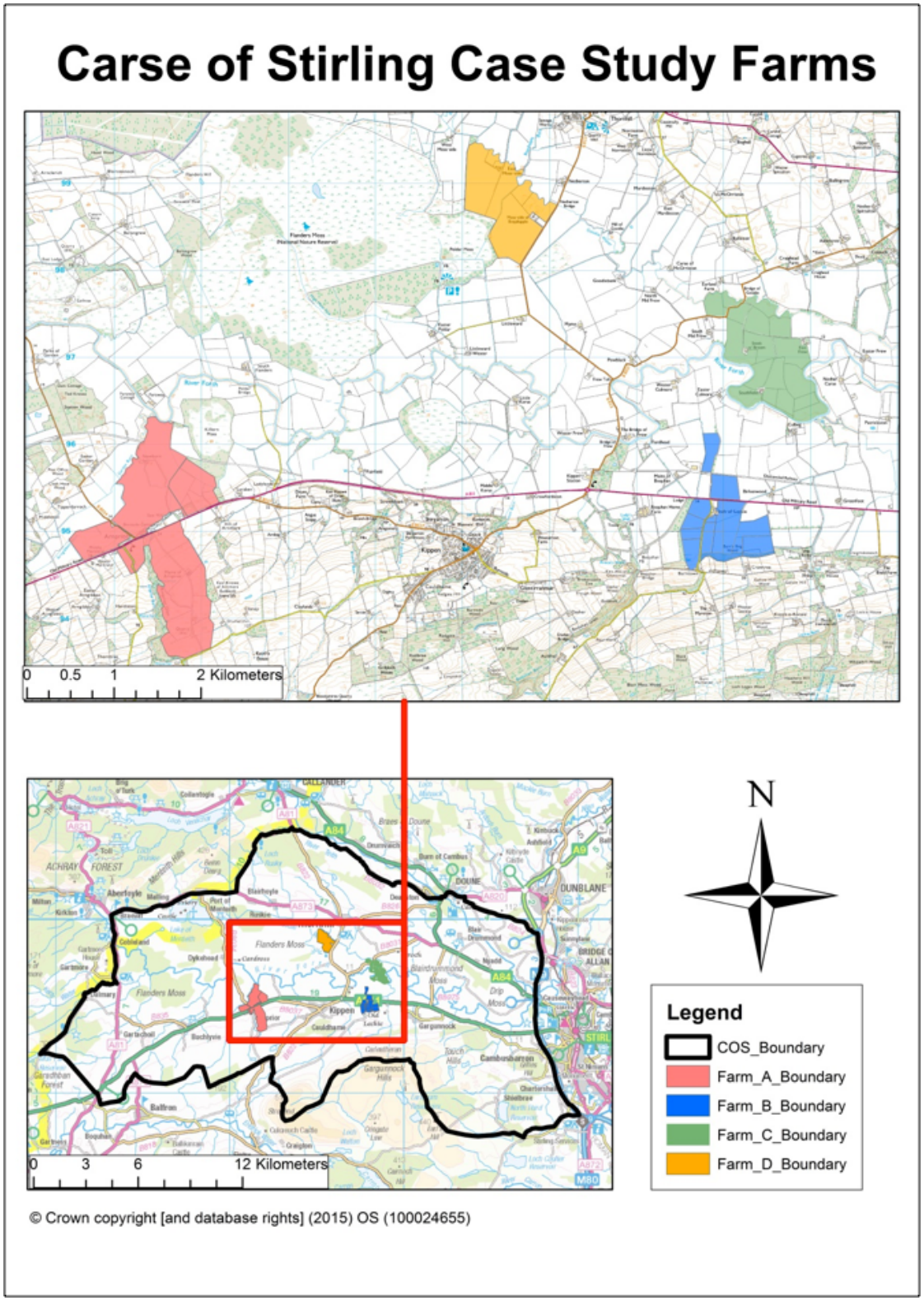


Figure 2 Location of the case study farms within the Carse of Stirling.

Table 2 Case study farm descriptions

Farm	Location and landscape features	Soils
A	The farm boundary incorporates undulating productive and pasture land to the south, a flat valley bottom as the farm boundary reaches the River Forth to the north. This farm incorporates three small streams and part of the River Forth.	Gley & Brown
B	The farm is solely located on flat land below the steep slope of Black Craig. This farm has no watercourses other than open drainage channels surrounding its boundary. There are two landowners between this farm and the River Forth.	Gley
C	This farm boundary sits mostly to the west of the B8031 and in between the Goodie Water and the River Forth. The land is very flat as it is situated on the Forth Valley floor.	Gley
D	Situated between Flanders Moss and Thornhill, this farm is situated on very flat land with some of the Moss within the farm boundary. The Goodie Water is the northern boundary for the farm.	Gley Peat

3.0 Flooding hazards and implications in the carse

The case study farmers provided the following details about flood hazard during the site visits. According to the farmers and wider community, flooding occurs across COS (both standing water and fluvial) at least six times a year, mostly during winter periods. The most notable previous floods occurred in 2006 and 2011. According to the farmers, when fluvial flooding does occur, generally the floodwater remains for 2-3 days. Surface water flooding associated with poorly draining soils flooding occurs more often (10 times per year) and can remain flooded in extreme cases for more than two weeks.

3.1 Case Study Farms and local flooding processes

The location of the farms and their proximity to watercourses dictate the type of flood hazard experienced (see Figure 2). The ensuing problems are outlined in Table 3 and detailed in the maps in Appendix 2; each case study farm experiences at least three of these.

3.2 Financial losses due to flooding

Based on the example of the case study farmers, a range of financial losses to arable land owners during flooding (standing water and fluvial flooding) for set periods of time were obtained. The costs were estimated by asking farmers to provide approximate values for the inputs to their land (seeding, labour time, spraying and fertiliser) and the value of the crops grown per acre. These values were combined to provide a potential total loss of £450 – £660 per acre (if the entire crop within the acre is lost). All farmers interviewed indicated that flooding for more than one day can be detrimental to the crop and result in partial loss, although will have greater impact during seed establishing period. Standing

Table 3 Flooding issues identified in COS and the likely consequences

Case study farm	Flood processes identified	Typical duration/ frequency	Consequences
ALL	Waterlogged soils[1]	10 times per year	• Crop does not establish or grow • Crops cannot be sown • Land cannot be grazed • Long periods of standing water on fields • Financial losses to land owners
ALL	Intermittent fluvial flooding from River Forth, Goodie Water and open drainage ditches	6 times per year	• Erosion of land • Deposition of trash/ debris carried in high flows • Loss of hay bales/ risk to livestock (danger of injury/death and fluke parasites) • Limited/ dangerous/ risky access to homes • Bridges become unsafe to cross, are scoured- could become structurally unsafe • Wash away riparian fencing • Homes become flooded • Financial losses to land owners
ALL	Standing water on productive agricultural land	6 times per year/ 2-3 days duration (up to 2 weeks in extreme cases)	• Crops become rotten & non-productive • Crops cannot be harvested • Crops do not establish after sowing • Risk of Liver fluke infection to livestock • Financial losses to land owners
B, D	Hydraulic constrictions: culverts/ bridges causing backing up of water, bridge overflow channels bricked up		• Can enhance fluvial flood risk from rivers and ditches (i.e. overtopping) • Increases flood risk to nearby adjacent homes • Can put structures at risk of failure or they become unsafe • Attenuates flood water from flowing downstream
B, D	Drainage: insufficient/ ineffective/ requires outlet management/ needs replaced		• Soils become waterlogged (resulting in consequences above for waterlogged soil) • Drains do not flow due to sediment build up at pipe exit • Land can give way- leaving very large voids

[1]According to one farmer, the removal of hedgerows is thought to have exacerbated the issue of waterlogged clay soils at one site.

Table 4 Agricultural economic losses during the 2007 and 2014 England floods		
	Economic loss – arable land	Economic loss – grassland
2007 England floods (Chatterton et al., 2010)	Per acre: £523 (±140) Per hectare: £1293 (±347)	Per acre: £261 (±168) Per hectare: £647 (±416)
2014 England floods (ADAS UK Ltd, 2014)	Per acre: £216 (£303 including additional costs) Per hectare: £534 (£748 including additional costs)	Per acre: £93 (£180 including additional costs) Per hectare: £229 (£443 including additional costs)
	Plus additional costs for labour, machinery, professional services etc. Per acre: £87 Per hectare: £214	
COS farmer estimates	£450-660 per acre £1112-1630 per hectare (mostly based on arable)	

water from flooding for more than a week will result in crop failure. In comparison to other UK studies which estimate agricultural economic loss due to flooding (see Table 4), the COS case study farmers experience similar arable losses to those during the 2007 floods in England, but more than that estimated for the 2014 floods in England.

3.3 Catchment wide issues which may affect flooding

According to the Forestry Commission Scotland (FCS) map viewer (Forestry Commission Scotland, 2015), there is a planned section of clear felling at Cardross woodland until August 2016. This is within the southern riparian zone of the Goodie Water, downstream of Lake of Menteith. This felling is being carried out because the trees are understood to affect the riverbank structure, and so are preventing the watercourse from achieving good ecological status. It is anticipated that the area will be restocked with broadleaved species in June 2018 (Forestry Commission Scotland, 2015). The clear felling may temporarily increase surface water runoff and sediment transport to the Goodie Water, and thereby may influence flood risk. However, FCS have stated that they will employ management regimes to mitigate any additional runoff or impact on the volume of water entering the Goodie Water (Personal Communication). Therefore, with this mitigation it is unlikely to significantly increase flood risk.

A further matter identified through community engagement and stakeholder meetings was the influence of water from the Lake of Menteith. The team investigated the outlet of the lake as part of the study. There is no sluice or any control on flow from Lake of Menteith. However, there is a debris trap, which takes the form of a wire mesh to stop fish being lost. Debris removal/ maintenance from the outflow point will affect the flows from the lake.

The drive to retain as much rainfall as possible on Flanders Moss National Nature Reserve plays a significant role in flood risk mitigation within the catchment. Restoration works have attempted to slow runoff from the moss, and have involved 30km of ditch blocking, 4km of trench damming (bunding) and the installation of hundreds of small peat dams as well as 30 larger dams. The other smaller SSSI's in the catchment (Killorn, Collymoon, Shirgarton, Ofference and Ochtertyre Mosses) have also undergone various levels of restoration works. Furthermore, the impact of the catchment mosses in slowing runoff looks set to increase, as Forestry Commission Scotland are currently removing conifers from 820 ha of the peatland known as Flanders Moss west (north of Buchlyvie), with a view to restoring the land back to peatland and wet woodland.

4.0 Flood mitigation measures and ecosystem service delivery

Flooding and its impacts can be managed or mitigated by various means ranging from hard engineered solutions (e.g. flood walls), soft engineered features (e.g. earth bund storage ponds and tree planting) to non-structural measures (e.g. flood warning systems). Each measure works to mitigate flood risk in a different way and has associated advantages and disadvantages for particular circumstances. In addition to flood risk benefits, other benefits such as improvements to water quality or habitat may be associated with certain measures. For this report those benefits have been quantified using an ecosystem service (ES) framework (McLean et al., 2013).

The ES which each measure may deliver is identified in section 4.1. ES are defined as the complex interactions between chemical, physical, biological and non-biological factors that create natural process and ecological balances in which society benefits from. These services are differentiated by four categories, which are referred to in section 4.1, and are as follows:

- Regulating Services: benefits gained from ecosystem processes (e.g. flood regulation, climate regulation and water regulation)
- Provisioning Services: the products obtained from ecosystems (e.g. food, timber and drinking water)
- Supporting Services: factors essential to maintain all other ES (e.g. nutrient cycling, soil formation and habitat)
- Cultural Services: non material benefits (e.g. aesthetic appeal, recreation and education)

The proposed FRM measures are not specific to any one of the case study farms, although in the following boxes applicability to the case study farms is indicated, and hence the measure can be applied across the COS catchment (and low lying areas of Scotland at risk to surface water and fluvial flooding) where the location and circumstances are suitable. These measures are presented and grouped into in-channel measures, riparian measures and catchment-wide measures. Within these groups, the measures cover physical changes, planting and management practices. Further guidance on suitable locations and design is available from SEPA's NFM handbook (in press), the Scottish River's Handbook (Perfect et al., 2013), the River Restoration Centre Manual (see http://www.therrc.co.uk/manual-river-restoration-techniques) and the Channel Management Handbook (Environment Agency, 2015).

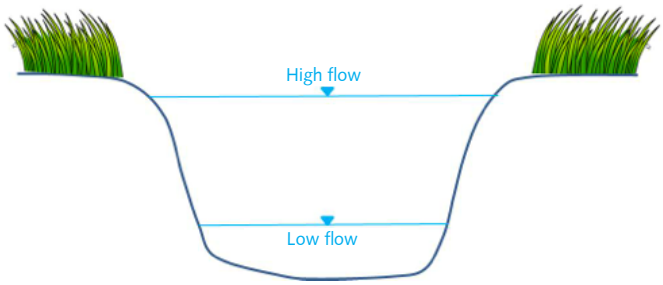
4.1 Suite of Flood Risk Management Measures

IN-CHANNEL

TWO-STAGE CHANNEL / SET BACK OF EMBANKMENT

How it works

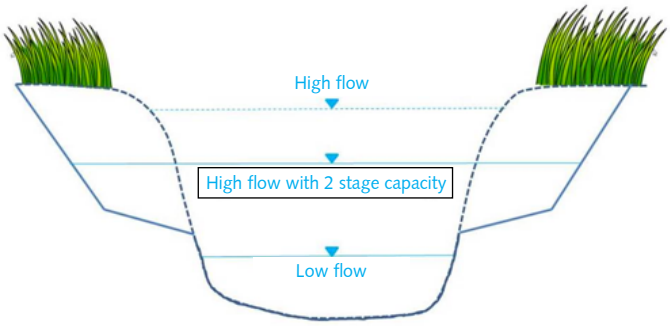
Bank material is removed to create a benched floodplain that is controlled and enclosed by setback banks to allow greater channel capacity for holding high flows.



Before creation of two-stage channel

Flood risk benefits

- Increases channel capacity
- Slows the flow
- Reduces erosion from fast flows
- Reduces fluvial flood risk
- Stabilises banks
- Sustainable alternative to dredging
- Allows channel to re-meander within banks



After creation of two-stage channel

Suitable Location(s)

Lower catchment area- relatively flat landscapes, however, is site specific and requires a morphological survey.

ALL FARMS

Potential Ecosystem Service delivery

Regulating Services – may improve:
- flood protection/ mitigation/ erosion protection
- water quality
- sediment cycling

Supporting Services – may improve:
- nutrient cycling
- hydraulic roughness
- habitat (in-stream and in adjacent land)

Potential disadvantages

- Initial capital costs
- Requires sacrificial land
- Requires engineering design inputs

Indicative capital costs

See indicative excavation costs- Appendix 5

Likely funding sources/ mechanisms

(see Appendix 4 for details)

SRDP Agri-Environment Climate Scheme:
- *River Embankment/ Breaching/ Lowering*
- *Management of Floodplains*

Example case study

Juottimenoja brook, Finland (Jormola et al., 2014)

Great Lakes, USA (*Witter* et al., 2011)

How it works

Straightened sections of river are restored to their natural sinuosity by creating meanders often where they previously were.

Photo credit: REFORM, 2014

Flood risk benefits

- Increases channel capacity
- Slows the flow
- Reduces erosion from fast flows
- Restores hydrological and morphological processes

Suitable Location(s)

Lower, flat valley parts of the catchment where rivers would naturally meander across floodplains. However, this work is site specific and would require a morphological survey.

FARM A

Photo credit: REFORM, 2015

Potential Ecosystem Service delivery

In the longer term, once site has recovered:

Regulating Services – may improve:
- flood protection/ mitigation
- sediment cycling
- hydrological and morphological processes

Provisional Services – may improve:
- fish stocks

Supporting Services – may improve:
- habitat (in-stream and riparian)
- nutrient cycling

Cultural Services – may improve:
- aesthetic appeal

Potential disadvantages

- Initial capital costs
- Requires engineering design inputs
- Requires sacrificial land
- Temporary disturbance to the river and adjacent landscape
- Temporary erosion, sediment and nutrient transport (during construction)
- Temporary loss of aquatic and terrestrial (riparian) species diversity and density

Indicative capital costs

See indicative excavation costs- Appendix 5

Likely funding sources/ mechanisms

(see Appendix 4 for details)

SEPA Water Environment Fund
(to upgrade WFD morphology classification)

Big Lottery Funding/ Garfield Weston Foundation
(both can be difficult to obtain)

Example case study

Eddleston Water, Scottish Borders (Tweed Forum, 2011)

River Skjern, Denmark (Alwan et al., 2001)

How it works

The removal of material from the river bed and its sides. Usually conducted using large machinery.

Flood risk benefits

- Increases conveyance of water
- Increases channel capacity (temporarily)

Suitable Location(s)

Where excessive sediment deposition occurs on mostly straightened sections of river. Please refer to the references for specific guidance on activities that may require licences, as well as best management practices (Environment Agency, 2015, SEPA, 2015a, CIWEM, 2014, Perfect et al., 2013) NFM handbook (in press).

Between FARM D and C (not shown on maps)

Potential Ecosystem Service delivery

Regulating Services – may improve:
- flood protection/ mitigation
- land drainage

Provisional Services – may improve:
- agricultural crop production (through land drainage)

Potential disadvantages

- Initial capital costs
- Ongoing costs (repeated actions required)
- Degrades morphological status
- Enhances channel incision/ erosion
- Disconnects river from floodplain
- Could increase flood risk downstream
- Destroys habitat/ biodiversity/ ecology

Indicative capital costs

See indicative excavation costs- Appendix 5

Likely funding sources/ mechanisms

(see Appendix 4 for details)

None in Scotland. Costs met by land owners.

Example case study

Somerset Levels (CIWEM, 2014)

Photo credit: Linsey McLean (top: before, bottom: after)

Photo credit: Land-Water Group, 2014

How it works

The removal of a structure, which inadvertently impedes the flow of a watercourse (e.g. bridges, overflows and culverts) and causes the flow to back up, overtopping river banks and causing flooding.

Photo credit: Linsey McLean

Flood risk benefits

- Mitigates fluvial flooding

Suitable Location(s)

Any structure (e.g. bridge or culvert) causing a watercourse to back up and cause flooding.

FARM B, C, & D

Potential Ecosystem Service delivery

Regulating Services – may improve:
- flood protection/ mitigation
- hydrological and morphological processes

Potential disadvantages

- Initial capital costs
- Ongoing costs (maintenance)
- Requires engineering design inputs
- May increase flood risk downstream

Indicative capital costs

Depends on size of structure

£500,000 and above

Likely funding sources/ mechanisms

(see Appendix 4 for details)

Cost would be met by landowner/ local authority depending on ownership:

Example case study

River Caldew, Carlisle (Harper, 2015)

How it works

A dedicated longitudinal area adjacent to watercourses is sacrificed to grow grasses/ wildflowers/ shrubs/ small trees (depending on circumstance) and can be fenced off to exclude livestock or to allow vegetation growth on banks.

Flood risk benefits

- Increases hydraulic roughness
- Intercepts runoff & increases infiltration
- Stabilises banks
- Reduces erosion & livestock poaching
- Reduces sediment transport

Suitable Location(s)

Across the whole catchment, adjacent to watercourses.

FARM A, C & D

Potential Ecosystem Service delivery

Regulating Services – may improve:
- flood protection/ mitigation
- water quality
- sediment cycling

Provisional Services – may improve:
- potential food source

Supporting Services – may improve:
- habitat/ biodiversity
- nutrient cycling
- improve soil properties

Potential disadvantages

- Initial capital costs
- Ongoing costs (maintenance)
- Requires sacrificial land
- Excludes livestock from watercourse as a drinking source (according to case study farmers)
- Loss of fences in high flow events

Indicative capital costs

Stock fence £4.50/m

Planting costs vary depending on species. See Tree Planting for indicative costs of planting tree species.

Seed cost = £50-£100/ha

Likely funding sources/ mechanisms

(see Appendix 4 for details)

SRDP Basic Farm Payment
- *Greening: Permanent grassland, Ecological Focus areas*

SRDP Agri-Environment Climate Scheme
- *Water margins*
- *Creation of low-input grassland to convert arable land at risk of flooding and erosion*
- *Converting arable land at risk of erosion or flooding to low-input grassland*
- *Rural SUDS swales*

Example case study

Tarland Catchment (Cooksley et al., 2011)

Pickering Catchment (Nisbet and Marrington, 2012)

Photo credit: Linsey McLean

Photo credit: DEFRA, 2011

How it works

Stores flood flow from the river or intercepts and stores overland flow

Flood risk benefits

- Attenuates flood peaks
- Reduces flood risk by intercepting overland flow
- Reduced sediment loss to watercourses

Suitable Location(s)

Adjacent to watercourses/ within landscapes presenting with clear overland flow pathways/ agricultural land/ lower and middle catchment area.

FARM A & B

Potential Ecosystem Service delivery

Regulating Services – may improve:
- flood protection/ mitigation
- water quality
- sediment cycling/ recycling

Provisional Services – may improve:
- agricultural crop production (re-use of sediment

Supporting Services:
- habitat/ biodiversity (temporary)
- nutrient cycling
- pollution control

Potential disadvantages

- Initial capital costs
- Ongoing costs (maintenance)
- Requires sacrificial land (temporary during flood or permanent)
- Risk of liver fluke parasite in livestock

Photo credits: Mark Wilkinson

Indicative capital costs

~£1000 per retention pond based on a ~500m^3 temporary storage bund built from local soil on site. For earth bunds, excavation costs apply- see Appendix 5

Likely funding sources/ mechanisms

(see Appendix 4 for details)

SRDP Agri-Environment Climate Scheme

- *Wetland management/ creation*
- *RSUDS:*
  - Retention ponds
  - Wetlands
  - Sediment trap/ bunds
  - Swales

Example case study

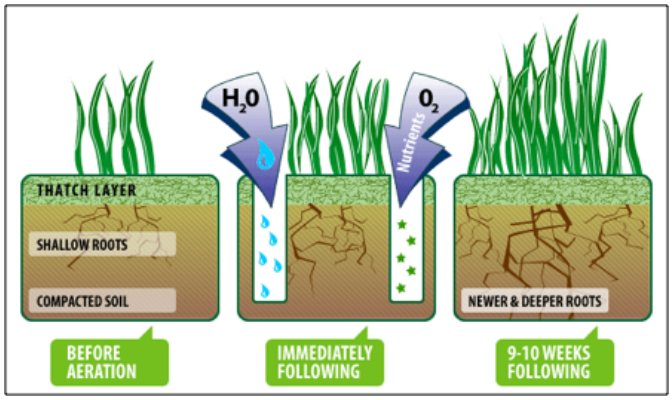
Belford Burn (photos shown above) (Wilkinson et al., 2008)

Pickering Catchment (Nisbet and Marrington, 2012)

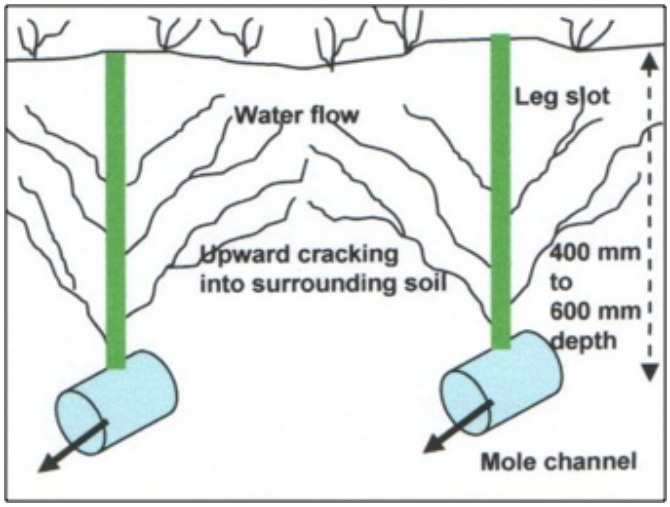
How it works

Aeration utilises aerator machinery/ attachments to remove (usually cylindrical) cores from the soil across an area to allow the soil to regenerate and be more productive.

Mole ploughing is a similar process with machinery attachments that creates small ploughed shallow drainage routes through the soil to encourage the soil to drain.



Soil Aeration (Blaney Agri Solutions, 2015)



Mole ploughing (TG Drains, 2015)

Flood risk benefits

- Improve soil drainage (temporarily), structure and productivity
- Reduces runoff and waterlogging (temporarily)

Suitable Location(s)

Agricultural land in middle and lower catchment. Topography and soil type significantly dictate suitability. Mole ploughing used in heavy clay soils..

ALL FARMS

Potential Ecosystem Service delivery

Regulating Services – may improve:
- flood protection/ mitigation (through soil infiltration)
- water quality (greater uptake of nutrients by crop)

Provisioning Services – may improve:
- agricultural crop production

Supporting Services – may improve:
- nutrient cycling
- soil formation/ properties

Potential disadvantages

- Initial capital costs (equipment)
- Ongoing costs (labour)
- Not suitable for all landscapes or soil types
- Risk of increased runoff to watercourses (mole ploughing)

Indicative capital costs

Approximately £28/ha

Likely funding sources/ mechanisms

(see Appendix 4 for details)

None. Costs met by land owners.

Example case study

Gascoigne Farm, Broughton (Fletcher, 2015)

How it works

Strategic tree planting in locations vulnerable to excessive storm runoff, erosion and waterlogging.

Flood risk benefits

- Intercepts rainfall
- Attenuates runoff
- Reduces soil erosion
- Increases infiltration
- Hydraulic roughness increased

Suitable Location(s)

Upland areas and riparian zones across the catchment.

FARM A

Potential Ecosystem Service delivery

Regulating Services – may improve:
- flood protection/ mitigation (improving infiltration)
- water quality (greater uptake of nutrients)
- climate regulation/ air quality/ carbon sequestration

Provisioning Services – may improve:
- timber production
- fuel/energy
- wild plants/ animals- food

Supporting Services – may improve:
- nutrient cycling
- soil formation/ properties
- habitat/ biodiversity

Cultural Services – may improve:
- recreation
- aesthetic appeal

Potential disadvantages

- Initial capital costs
- Requires sacrificial land
- Difficult to return to agricultural land due to root systems
- Negative side effects if poorly managed

Indicative capital costs

Contractor costs of planting 1ha of broadleaved trees (1200 trees per ha) includes costs for establishment, labour, stakes and shelter. Year 1 = £4840, Years 2-4 = £1184, Total = £6024 or £5.02 per tree. Extra costs for subsidiary requirements (e.g. rabbit proofing) may be necessary.

Likely funding sources/ mechanisms

(see Appendix 4 for details)

SRDP:

- *Forestry Grant Scheme: Small or Farm Woodlands/ Agroforestry/ Woodlands for water*
- *AECS: Small Tree and Shrub Planting*

Example case study

Pickering Catchment (Nisbet and Marrington, 2012)

Devon Catchment (Stirling) (WWF, 2005)

Photo credit: Scottish Cottages, 2015

Photo credit: Linsey McLean

Photo credit: Forestry Commission

How it works

Hedgerows intercept falling rainfall, making it take longer to reach the ground as it flows down stems or the water evaporates back to the atmosphere from the leaves. The root system enables better infiltration of water to the soil and its lower layers. The vegetation structure also holds water within it and some is released back into the atmosphere. All these processes prolong the runoff process.

Flood risk benefits

- Intercepts rainfall
- Attenuates runoff
- Reduces soil erosion
- Increases infiltration
- Hydraulic roughness increased

Suitable Location(s)

Most locations within an agricultural landscape where they can naturally grow. Best suited as field boundaries.

FARM A & B

Potential Ecosystem Service delivery

Regulating Services – may improve:
- flood protection/ mitigation
- climate regulation/ air quality/ carbon sequestration

Provisioning Services – may improve:
- wild plants – food
- fuel/energy
- craft resource
- shelter belts for livestock

Supporting Services – may improve:
- nutrient cycling
- soil formation/ properties
- habitat/ biodiversity

Cultural Services – may improve:
- aesthetic appeal
- cultural heritage

Potential disadvantages

- Initial capital costs
- Ongoing costs (maintenance)
- Requires sacrificial land
- Requires period of time to establish

Indicative capital costs

Approximately £5.40/m but extra costs for subsidiary requirements (e.g. rabbit proofing) may be necessary.

Likely funding sources/ mechanisms

(see Appendix 4 for details)

SRDP Agri-Environment Climate Scheme
- See section *Hedgerows* in Appendix 4
- Extra costs can also be covered (Appendix 4)

Example case study

Pontbren catchment (The Woodland Trust, 2013)

Photo credit: Countryfile Magazine, 2013

Photo credit: Hedgelink, 2015

How it works

These crops are grown, and then left unharvested and not sprayed with pesticides during the winter period.

Photo credit: DairyCo (2015)

Flood risk benefits

- Intercepts rainfall
- Attenuates runoff
- Reduces soil erosion
- Increases infiltration
- Hydraulic roughness increased

Suitable Location(s)

Catchment wide.

ALL FARMS

Photo credit: Game and Wildlife Conservation Trust, 2015

Potential Ecosystem Service delivery

Regulating Services – may improve:
- flood protection/ mitigation

Provisioning Services – may improve:
- agricultural crop production

Supporting Services – may improve:
- nutrient cycling
- soil formation/ properties
- habitat/ biodiversity

Cultural Services – may improve:
- aesthetic appeal

Potential disadvantages

- Initial capital costs (seeds)
- Ongoing costs (labour)
- Potential interference with primary crop (e.g. overshadowing)
- Potential pest problem
- Extra work

Indicative capital costs

Approximate costs (varies with seed choice)

Plough =£ 52.67/ha

Seeding = £52.71/ha

Seed cost = £50-£100/ha

Total= £180.38/ha avg

Likely funding sources/ mechanisms

(see Appendix 4 for details)

SRDP Agri-Environment Climate Scheme
- *Unharvested Conservation Headlands for Wildlife*
- *Retention of winter stubble for wildlife & water quality*

Example case study

Widely used across agricultural landscapes

4.2 Other approaches to reducing flood risk

This report focuses on those measures that can potentially reduce the size and severity of flood events, rather than measures that can help communities to prepare for and react to flood events. However it is worth noting that these other activities e.g. flood warning systems, community preparedness and response plans can all help to reduce the consequences of floods. Given that it is not possible to prevent all floods, they are an essential component of FRM.

Enhanced flood warning system

A flood warning system would usually consist of a telemetered monitoring system of various parameters, for example: river levels, storm intensity or culvert blocking. When these reach critical levels this can be communicated to residents in a number of ways such as, text message, email or online interfaces. At present, SEPA provide a flood warning system within the Forth at Bridge of Allan, Bridgehaugh and Callander. For an additional higher resolution system to be implemented by SEPA, a strategic selection and screening process is required and assessed alongside other shortlisted locations across Scotland. Alternatively, communities could collaborate and seek funding from various sources to implement a community flood warning system (for example the Big Lottery Fund or Garfield Weston Foundation outlined in Appendix 4). The costs of installing such systems vary widely with size of the landscape area, river size and type of system required.

Catchment communication plan

Informing others of actions that will be taken across a catchment that may influence river levels (or water quality) enables the opportunity for those who may be affected by adverse consequences to prepare. It also provides a greater overall view of water management practices within a catchment. Many of the measures presented above are best implemented in coordination with others. Within the COS, a strategy between TCOSP, landowners and other water based stakeholders (fisheries/reservoirs) to effectively communicate any actions that may result in influencing flood risk would be highly beneficial. An example is the maintenance and management of the outlet of the Lake of Menteith; it would connect the communities and could warn downstream stakeholders of any changes to practices and resultant risks.

4.3 Proposed NFM measures for the case study farms

Based on the field visits, and known flood issues occurring at each case study farm, bespoke NFM measures were proposed for each farm. These are shown on the maps in Appendix 3. The maps show locations of proposed NFM measures to alleviate flood risk at the case study farms. Table 5 summarises the different measures proposed for each farm. The efficacy of these measures is not quantified. Please note that not all measures identified in section 4.1 and 4.2 are utilised; only those deemed appropriate for the specific case study farms are shown. The others may be applicable to the remainder of the catchment and to specific locations in similar catchments in the Carse or the wider Scottish landscape.

Table 5 Farm and summary of proposed measures

Farm	Proposed measures
A	Two-stage channel Tree planting (tree shelter belts) Retention ponds Riparian buffer/ fencing off Re-meandering
B	Two-stage channel Removal/ remediation of constrictions Hedgerow Retention pond.
C	Two-stage channel Riparian buffer strips/ fencing off
D	Two-stage channel Riparian buffer strips/ fencing off Removal/ remediation of constrictions

5.0 Funding sources

Funding for implementing FRM measures would ideally be carried out as a collaborative catchment-wide effort as it may:

- Enable access to greater values of funding;
- Achieve greater success of implementation when considered/ implemented at a catchment-wide scale, and
- Have a greater influence on reducing flood risk locally.

Funding for collaborative working will become available from the *Environmental Co-operation Action Fund* within Scottish Rural Development Programme (SRDP) in autumn 2015. This will fund facilitation to produce a management strategy involving several participants (for example, to pay for a facilitator). Each landowner can also apply to SRDP Agri-Environment Climate Scheme and the Forestry Grant Scheme (or other SRDP and non-SRDP funding mechanisms) to fund the cost of management actions that are agreed upon by the collaborative group. Other collaborative funding sources include the Big Lottery Fund and the Garfield Weston Foundation, both can provide funding for community projects, although they are competitive. More information and contact information for all these schemes is provided in Appendix 4.

The SRDP offers potential funding in targeted areas which can support the capital cost of implementing FRM measures (highlighted in section 4.1 and Appendix 4 for each individual measure). The relevant funding opportunities for the measures outlined in this report as well as some specific options which may be relevant in the study area are summarised in Table 6. Some funding for measures used for reducing flood hazard can be obtained by applying through schemes that have an alternative focus, for example biodiversity, water quality or river basin management planning (all those schemes that are relevant to the proposed measures are outlined in Appendix 4). An example of this is SEPA's Water Environment Fund (another environmental restoration fund which is not part of the SRDP), of which more detail can be found in Appendix 4. It is important to note that many of the funding sources (e.g. woodland) have target areas in which only land within these areas are eligible to apply, therefore it is essential that funding applicants assess their individual situation according to the requirements for the funding.

Table 6 Flood risk management measures and likely funding sources. Refer to Appendix 4 for more details on each funding source	
Flood management measure/ purpose	Possible funding source
Two-stage channel	Agri-Environment Climate Scheme: • River embankment/ breaching/ lowering • Management of floodplains
Re-meandering	SEPA Water Environment Fund- non SRDP funding
Dredging	None
Riparian buffer strips/ fencing off	Basic Farm Payment Greening: • Ecological Focus Areas Agri-Environment Climate Scheme: • Water margins in arable fields
Earth bunds/ retention ponds	Agri-Environment Climate Scheme: • Pond creation for wildlife • RSUDS retention ponds • RSUDS sediment traps and bunds • RSUDS swales • RSUDS wetlands
Aeration/ mole ploughing	None
Tree planting	SRDP Forestry Grants Scheme • Small or farm woodlands • Agroforestry • Woodlands for water
Hedgerows	Agri-Environment Climate Scheme: • Planting or replanting of hedges • Coppicing of hedges (existing) • Laying of hedges (existing) • Stock fence (existing and newly planted hedges) • Rabbit proofing and existing or new stock or deer fence (newly planted hedgerows) • Vole, rabbit or hare guards (newly planted hedges) • Replacement or replanting of individual trees within an ancient wood pasture or hedgerows (existing hedgerows)
Cover crops	Basic Farm Payment Greening: • Permanent Grassland • Ecological Focus Areas Agri-Environment Climate Scheme: • Retention of winter stubble for wildlife and water quality • Unharvested conservation headlands for wildlife • Converting arable land at risk of erosion or flooding to low input grassland • Creation of low input grassland to convert arable land at risk of erosion or flooding
Reduce bank erosion/ poaching	Agri-Environment Climate Scheme: • Restoring (protecting) banks • Hard standings for troughs and gateways • Alternative watering
Reconnecting the river with the floodplain/ utilising floodplain storage	Agri-Environment Climate Scheme: • River embankment/ breaching/ lowering • Management of the floodplain • Converting arable land at risk of erosion or flooding to low input grassland • Creation of low input grassland to convert arable land at risk of erosion or flooding

6.0 Land manager perceptions

Many of the measures for water management, as described above, would entail a change in land-use, or a change in land-management practices. Therefore, it is important to understand the views of land-managers since their decisions and actions determine what measures may be carried out.

6.1 Views of the four farmers in the case study farms

This section summarises farmer views of the problems and perceptions of the possible measures based on discussions with each of the four farmers involved in this study. Some of the points below will seem obvious to the farmers themselves, or may echo messages from other studies, but are nevertheless important.

All four farmers appraised the measures in section 4 in terms of whether they could benefit their current farm business. Since reducing water logging and flood risk to farmland, is often key to increasing agricultural productivity, dredging, aeration and mole-ploughing were most favoured by the farmers. By contrast, many of the measures advocated as compatible with NFM are less likely to increase agricultural productivity. For example, re-meandering may offer no benefit to the farm business, and may even be associated with new risks (e.g. increased disease risk, or reducing flexibility in planning). Many NFM features may only be considered as a 'last resort' for unproductive land (for example in areas prone to prolonged waterlogging, as in parts of farm B) and/or when subsidies make them attractive for the business.

> *"If it's flooded for a day, if it's hay and it's cut: that's the field and the hay ruined."*
>
> Farmer D explained why he needs to move water off his property

Financial incentives via the SRDP can encourage uptake of some of these measures. For example, Farmer A already had experience of taking a variety of agri-environmental options under the SRDP. He suggested SRDP may be useful for encouraging uptake of measures such as winter cover crops. Unfortunately, very often the current structure of payments was judged to be inappropriate or insufficient to incentivise the measures presented in section 4. To judge whether applying for an SRDP option will be worthwhile, the payments and other benefits resulting must be weighed against the known costs (e.g. capital costs, potential forgone productivity), but also against other possible risks to the business: in particular, the prevalence of liver fluke and other diseases, if more land is allowed to flood regularly. The inconvenience of applying for SRDP options can also be off-putting. For further general information on farmer perceptions to payment rates please refer to the CREW report 'Land management for increased flood resilience' (due to be published summer 2015).

The timescale and permanence of effects also affected attitudes towards the measures. All four farmers were cautious towards any measure that would take land out of production for a long period (e.g. tree-planting), or risked reducing its productivity (e.g. allowing land to occasionally flood). This is associated with many of the measures designed to store or slow flow on land, e.g. buffer strips, re-meandering, hedgerows, tree-planting. This can be understood in terms of business-planning, as committing land to a certain use constrains future options. In addition, Farmer A pointed out that tenant farmers may need to convince their land-owner, to obtain permission to install some measures.

> *"It's not what I signed up for."*
>
> Farmer B on the idea of tree-planting instead of growing crops
>
> *"It's against our way of working"*
>
> Farmer C's reactions to fencing-off river banks, and two-stage channels. These measures were felt to be irrelevant or unnecessary, and dredging was preferred

Reluctance to adopt certain measures can also reflect a farmer's conception of farming itself and what it is 'for'. For example, Farmer C said he was reluctant to apply for subsidies for any sorts of measure, irrespective of the effect on the farm business. For him, measures that were not about maximising crop or livestock yield were simply irrelevant. The position relates to underlying views about how farming should operate and what it should produce. This means that relying on the SRDP – even if restructured or primed with additional money – would not, by itself, see many of the above measures adopted.

Farming decisions were not based solely on financial costs-benefit analyses, they also depended on the interests and experience of the individual farmer. For example, Farmer A mentioned interests in understanding the long-term history of the land and geology, that shaped how he saw present land-uses and water management. In addition he received ideas from consultants; and he was also open to considering any measure or subsidy that might prove financially viable. Each such source of information and ideas interacted to inform his awareness and opinions on potential options. Another significant source of influence can be other farmers. It was mentioned that other farmers might provide experience and ideas about new techniques and measures, but could also provide a source of 'peer pressure' as to what a well-managed farm should look like.

> *"People here are generally very traditional – they like to do what their grandfathers did"*
>
> Farmer A discussed how other farmers perceive those who take agri-environment SRDP options

Another factor that tended to disfavour adopting new measures was tradition and memories of past practices. Three of the farmers' families have farmed the same land for generations, which provided a sort of 'intergenerational memory'. Farmer D recalled being encouraged and assisted to dredge, and so judged current controls on dredging as inconsistent, illogical and unfair. These experiences also shaped attitudes to other farmers and organisations. For example, Farmer D ascribed problems with flooding to poor management and neglect by agencies, whilst Farmer B had experienced problems due to nearby farm drainage ditches and pipes not being maintained. Farmers also stated that past developments can place a direct practical constraint on new or potential practices. For example, Farmer B observed that replanting hedgerows or shelter belts may not be possible with the larger farm machinery now in use.

6.2 Feedback from the wider Community

From the workshop held on 18th May 2015, community feedback and opinions on the proposed FRM measures were obtained and examined in relation to the views of the case study farmers. The full list of comments and feedback is provided in Appendix 7. This section highlights some of the main themes.

Overall, the information and ideas provided in the meeting resonates with many of the points raised during conversations with the case study farmers. For example, farmers evaluate and query ideas for new measures in terms of whether they can support the viability of their existing farm business. However, a few of the meeting participants were land-owners without a history or goal of production-oriented farming. These individuals were open to any use of the land that may bring income, including any of the above measures (and others - even solar farms), especially if these measures could be SRDP funded. The views of this minority could be quite different to those of some more 'traditional' farmers. This helps to explain the diversity and potential contradictions between some of the comments in Appendix 7. For example, one farmer commented that dredging "should be banned in shorter rivers" whereas most farmers supported use of this measure.

Because dredging was widely supported by many, it was the subject of several questions during discussion. Many were interested to establish if, when, and how this could take place. The need for controls or restrictions on this activity was queried – effectively challenging the negative effects associated with dredging. In the view of many farmers, SEPA appears to be an organisation that unreasonably opposes a necessary practice. This does not necessarily mean that these farmers are generally unsympathetic to the idea of environmental stewardship, or discussions about adopting new measures, but dredging can dominate thinking and potentially act as a sticking point in discussion.

Much of the feedback around this and other measures requested more context-specific information: e.g. about where a measure may be implemented, how it should be designed, and the consequences of doing so. For example, there were several questions about exactly how a two-stage channel would be designed and created. Most in-channel measures require detailed surveys to ensure they are fit for purpose for the site and this was beyond the scope of the project. In the meeting there was not enough time to communicate the detail of how every measure could be selected and applied in specific situations: however, generic descriptions of the measures could seem rather vague, unsatisfactory or unconvincing.

Many questions by participants were focused on understanding the potential adverse consequences of some actions, including for other areas and in the future. For example, it was highlighted that re-meandering could have knock-on effects on downstream, and/or future effects on the river course that are hard to predict or prevent.

6.3 Reflections

All issues that were described by the four farmers and in the public meeting echo issues reported by previous studies of farms (e.g. Sutherland, 2010) and/or attitudes to water management measures (e.g. Waylen et al., 2010). These other studies point to the importance of financial costs and benefits but also other interests (e.g. Wilson and Hart, 2000), timescales (e.g. Falconer, 2000), traditions and ideas of farming (e.g. Burton et al., 2008), and peer influence (e.g. Burton, 2004). A particularly relevant study is a short briefing by (Holstead and Kenyon, 2011) about farmers' views of NFM measures, together with a related longer report that discusses the issues in more detail (Holstead et al., 2012). An adapted summary of the issues they identify is shown in the box below. All these issues were mentioned to some extent in this project.

What also seems important in this study, but has been less emphasised by other reports, is the importance of how water and hydrological systems are understood to function. These understandings vary. For example, Farmer D described water channels as analogous to veins in the body, and followed this analogy to conclude that it was natural to keep water channels cleared and free flowing, to avoid becoming clogged up. By contrast Farmer A perceived that much of the land in the Carse was naturally boggy with slow-flowing rivers, so had tendency to revert to this: whilst the creation of drainage channels and ditches had enabled agriculture, it had also changed the functioning of rivers, and it was better to "work with the land, not against it". Accompanying these views were different ideas about the controllability of water and flood events. For example, Farmer C stated that he accepted a certain frequency of overtopping of riverbanks as "only natural" whereas Farmer D said that these events should be avoided. Differing ideas can even cause different ideas about the meaning of the term "flooding problem". These judgments about how water systems should function, and how they could and should be managed, affected attitudes to any potential measures. In particular, dredging was seen as the main option to keep river channels free and "clean".

In conclusion, although all individuals participating in this study had diverse and differing ideas, conversations with them highlighted some common issues that shape attitudes and likely implementation of the measures presented in section 4. The main and important point is that compatibility with farm business planning and economic and financial viability is necessary – but not by itself sufficient – to ensure a measure is considered. Ultimately, whether or not a measure is considered – let alone implemented – will also depend on a farmer's conceptions of 'good' farming, the water system itself, and their perceptions and relationship with other farmers and organisations associated with land and water management.

- Economic factors affecting a viable farm business
- Funding and relationship with organisations promoting new measures
- Availability of support, advice, and help if things go wrong
- Policy landscape such as the volume of regulations
- Social factors such as tradition and what other farmers think
- Pests and parasites potentially resulting from NFM
- Catchment-scale issues, including existence of plan, involvement of other farmers and urban areas

Key issues that may affect how measures linked to 'natural flood management' are considered, adapted from Holstead and Kenyon, 2011 "Natural Flood Management - The Farmer's View".

7.0 Summary and recommendations

7.1 Summary

This project has collated and produced information for landowners and stakeholders within the COS. In doing so there have been lessons learned from the community led approach for FRM, which are useful to inform policy of on-the-ground challenges and perceptions.

The main flooding issues identified were waterlogging, fluvial flooding, standing water and insufficient drainage of land. In response to these flooding issues, various FRM measures were proposed, some of which were NFM measures. These measures included: two-stage channels, re-meandering, dredging, riparian buffer strips, earth bunds/ retention ponds, aeration/ mole ploughing, tree planting, hedgerows, and cover crops. In order to identify linkages with other policies and assess the benefits of these measures, their potential ecosystem services were summarised. Approximate costs to implement these measures and the potential funding sources identified could support the community implement any of these measures.

7.2 Recommendations

A key issue highlighted by this report is that while policy requires the consideration of NFM and promotes this approach to FRM, many stakeholders are not yet supportive of, or able to implement, NFM measures. The lack of local experience with natural flood management can act as a further barrier to considering these new measures. The following interconnected recommendations suggest future steps for promoting NFM and coordinated catchment management.

- Foster coordination and cooperative planning with land manager/ catchment groups to ensure effectiveness and avoid unintended or unfair side effects.
  - Encourage and support land manager-led initiatives to maximise uptake.
  - Ensure all parties across the catchment (upstream and downstream users) are involved in the planning process.
- Use independent/neutral mediators/facilitators.
  - Develop skill-sets within community groups, such as TCOSP, and ensure that such groups are representative of catchment stakeholders.
  - Explicitly discuss issues of responsibility for FRM.
- Support learning and site visits to other farms and catchments.
  - Provide information about demonstration sites and catchments with experience of planning and implementing new approaches to FRM
  - Enable visits to exemplar farms and share experiences of trialling independent measures.
  - Make accessible information available (for example, key datasets and guidance).
- Continue to tailor funding/subsidies (including but not only SRDP) for NFM measures and for partnership working
  - While SRDP has started to do this, refinement may be necessary as the programme evolves and more funding becomes available, for example:
    - Some scheme structures or payment rates may need adjustment to ensure uptake.
  - Authorities responsible for FRM could consider a dedicated fund to further incentivise NFM.
  - Coordinated funding streams for multiple benefits that encompass various policy objectives (e.g. biodiversity, morphology and flood risk) out-with SRDP for example, enabling "top-up" funding between River Basin Management Planning, biodiversity/ conservation and local authorities and not be considered "double funding".
  - Consider targeting support for NFM measures at demonstration farms/ sites.
  - Provide funding to enable cross-farm/ cross-catchment visits, in order to show when and how measures can be practically feasible and compatible with other land management priorities.
  - For those that do implement new NFM measures, track these experiences in order to understand the specific implications and future opportunities for enabling new approaches to FRM. This can demonstrate when and how these measures fit with other land management priorities, and if current perceptions and expectations fit with actual benefits and problems.
- Invest in engagement
  - Enable communities and community-led plans to be considered in statutory processes to link "bottom-up" and "top-down" approaches.
  - Encourage community events that enable the community to share and discuss different views and have input to any proposals.
  - Recognise that the community-led approach is important and must be long-term.

More research is needed as to when and how community-level processes relevant to FRM can best dovetail with the statutory processes, in particular the ongoing processes to create Flood Risk Management Plans (FRMP) under the FRM Act. The act specifies that SEPA (the lead 'competent authority') and a number of 'responsible authorities' (e.g. local authorities and Scottish Water), must collaborate in flood risk planning, so it may seem unduly challenging to attempt to also collaborate or connect with community-led processes. However, adopting new approaches to FRM will eventually require the involvement and buy-in of multiple individuals and groups across society, not just organisations previously involved in 'traditional' approaches to tackling and reducing flood risks. Confronting this challenge is therefore essential. Ongoing experiences and lessons from other domains and issues (e.g. water quality management), may offer help to identify practical, efficient and/or effective means by which communities may be represented and involved in statutory planning processes, and vice versa.

7.3 Possible activities to promote Flood Risk Management in the Carse of Stirling

The following points outline possible future activities for TCOSP to consider:

- Continued community communication and discussion about water, flooding and land management, which represents and involves as many individuals and interests from throughout the catchment as possible.
- Develop a catchment management plan to establish catchment objectives for many elements including flood risk (e.g. biodiversity and water quality).
- Use the catchment management plan to:
  - Harness the *Environmental Co-operation Action Fund* (which will be available in autumn-winter of 2015) to finance a responsible facilitator to manage the progress and implementation of the catchment management plan.
  - Identify roles and responsibilities of all catchment stakeholders in water management.
  - Highlight key barriers for landowners adopting FRM measures
  - Identify strategic priorities for future work and community involvement.

References

ADAS UK LTD 2014. Impact of 2014 winter floods on agriculture in England. Online.

ALWAN, A. A., APPIAH-KUBI, G. & MAJLAND-KRISTENSEN, P. 2001. The possible impact of the restoration of River Skjern. Århus universitet, Denmark: Miljølære,.

BLANEY AGRI SOLUTIONS. 2015. *Aerator* [Online]. Online: Blaney Agri. Available: http://www.blaneyagri.com/machinery/aerator/ [Accessed 05 May 2015.

BURTON, R. J. F. 2004. Seeing Through the 'Good Farmer's' Eyes: Towards Developing an Understanding of the Social Symbolic Value of 'Productivist' Behaviour. *Sociologia Ruralis,* 44**,** 195-215.

BURTON, R. J. F., KUCZERA, C. & SCHWARZ, G. 2008. Exploring Farmers' Cultural Resistance to Voluntary Agri-environmental Schemes. *Sociologia Ruralis,* 48**,** 16-37.

CHATTERTON, J., VIAVATTENE, C., MORRIS, J., PENNING-ROWSELL, E. & TAPSELL, S. 2010. The cost of the summer 2007 floods in England. Online: Environment Agency.

CIWEM 2014. Floods and Dredging- A Reality Check. Online.

COOKSLEY, S. L., STUTTER, M., I, DEMARS, B. O. L., ADDY, S., STOCKAN, J. & LANGAN, S. J. Tarland Catchment Initiative: Lessons for Assessing the Multiple Benefits of Catchment Restoration. Catchment Science, 2011 Wexford, Ireland. Teagasc/ Defra.

COUNTRYFILE MAGAZINE. 2013. *UKs Hedgerows Need Protecting* [Online]. Online: Immediate Media Company Ltd. [Accessed 05 May 2015.

DEFRA. 2011. *Catchment Sensitive Farming: Practical Tip - Fencing* [Online]. Online: Agricultural Document Library, University of Hertfordshire. [Accessed 05 May 2015.

ENVIRONMENT AGENCY 2015. Delivering Benefits Through Evidence- Channel Management Handbook. Online: EA.

EUROPEAN COMMISSION (EC). 2012. *A New EU Floods Directive* [Online]. European Commission. Available: http://ec.europa.eu/environment/water/flood_risk/index.htm [Accessed 19th June 2012 2012].

FALCONER, K. 2000. Farm-level constraints on agri-environmental scheme participation: a transactional perspective. *Journal of Rural Studies,* 16**,** 379-394.

FLETCHER, K. 2015. *Machines which get to the root of grassland problems* [Online]. Online: The Scottish Farmer. Available: http://www.thescottishfarmer.co.uk/arable/arable-news/machines-which-get-to-the-root-of-grassland-problems.26542417 [Accessed 04 May 2015.

FORESTRY COMMISSION SCOTLAND 2015. Forestry Commission Scotland Map Viewer. Online: FCS.

GARFIELD WESTON FOUNDATION. 2015. *Frequently Asked Questions* [Online]. Online: Garfield Weston Foundation. [Accessed 26 April 2015.

HARPER, M. 2015. *10 years from the Cumbrian and Carlisle floods of 2005* [Online]. Online: Environment Agency. Available: https://environmentagency.blog.gov.uk/2015/01/08/10-years-on-from-the-cumbrian-and-carlisle-floods-of-2005/.

HARRISON, J. G. 2003. A historical background to Flanders Moss. Scottish Natural Heritage.

HEDGELINK. 2015. *Hedgelink news and events* [Online]. Online. Available: http://www.hedgelink.org.uk/hedgelink-news-and-events.htm [Accessed 05 May 2015.

HOLSTEAD, K. L. & KENYON, W. 2011. Natural Flood Management - The Farmer's View. CREW Research Summary.

HOLSTEAD, K. L., KENYON, W. & ROUILLARD, J. J. 2012. Factors that affect uptake of natural flood management features by farmers in Scotland: A review. Aberdeen, UK: CREW - Scotland's Centre of Expertise for Water.

IPCC 2014. *Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of theIntergovernmental Panel on Climate Change* New York, Cambridge UniversityPress.

JORMOLA, J., HÄMÄLÄINEN, L. & KASVIO, P. 2014. Environmentally Friendly Drainage Measures: The use of two-stage profiles to improve diversity and water quality agricultural streams. Online: European River Restoration Centre.

LAND-WATER GROUP. 2014. *Dredging Rivers Parrett and Tone: Aerial Footage* [Online]. Online. Available: http://www.land-water.co.uk/dredging-rivers-parrett-and-tone-aerial-footage [Accessed 05 May 2015.

LUC AND STAR 2014. Carse of Stirling – An Ecosystems Approach Demonstration Project: Technical Report.

MCLEAN, L., BEEVERS, L., PENDER, G., HAYNES, H. & WILKINSON, M. 2013. Natural Flood Management in the UK: Developing a Conceptual Management Tool. *35th IAHR World Congress 8-13th September.* Chengdu, China: IAHR.

NISBET, T. & MARRINGTON, S. Experience of NFM on the Ground: Slowing the Flow at Pickering. SNIFFER Flood Risk Management Conference, 2012 Dynamic Earth Centre, Edinburgh. SNIFFER.

PERFECT, C., ADDY, S. & GILVEAR, D. 2013. The Scottish Rivers Handbook A Guide to the Physical Character of Scotland's River. CREW, Scottish Government, James Hutton Institute, Centre for River EcoSystem Science.

POST 2011. Post Note 396: Natural Flood Management. The Parliamentary Office of Science and Technology.

POST 2014. Post Note 484: Catchment-Wide Flood Management. The Parliamentary Office of Science and Technology,.

REFORM. 2014. *Spree - Restoration and remeandering of the Müggelspree - downstream Mönchwinkel* [Online]. Online: REFORM. Available: http://wiki.reformrivers.eu/index.php/Spree_-_Restoration_and_remeandering_of_the_M%C3%BCggelspree_-_downstream_M%C3%B6nchwinkel [Accessed 05 May 2015.

REFORM. 2015. *The River Regge (the Netherlands): from meandering river to canal and back* [Online]. Online: REFORM. Available: http://www.reformrivers.eu/news/148 [Accessed 05 May 2015.

SCOTTISH COTTAGES. 2015. *Aberdeenshire* [Online]. Online. Available: http://www.scottish-cottages.co.uk/highlands-islands/aberdeen-grampian [Accessed 05 May 2015.

SCOTTISH GOVERNMENT 2015a. Basic Payments Scheme-Greening. *In:* AGRICULTURE, F. A. R. C. D. (ed.). Online.

SCOTTISH GOVERNMENT. 2015b. *Rural Payment and Services: Guidance for Restoring River Banks* [Online]. Online: Scottish Government. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/restoring-river-banks/guidance-for-restoring--protecting--river-banks/ [Accessed 26 April 2015.

SCOTTISH GOVERNMENT. 2015c. *Rural Payments and Services: Agri-Environment Climate Scheme* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/ [Accessed 01 June 2015.

SCOTTISH GOVERNMENT. 2015d. *Rural Payments and Services: Alternative Watering* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/alternative-watering/ [Accessed 13 May 2015.

SCOTTISH GOVERNMENT. 2015e. *Rural Payments and Services: Converting Arable at Risk of Erosion or Flooding to Low-input Grassland* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/converting-arable-land-to-grassland/ [Accessed 01 June 2015.

SCOTTISH GOVERNMENT. 2015f. *Rural Payments and Services: Coppicing of Hedges* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/coppicing-of-hedges/ [Accessed 09 May 2015.

SCOTTISH GOVERNMENT. 2015g. *Rural Payments and Services: Creation of Low-input Grassland to Convert Arable Land at Risk of Erosion or Flooding* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/creation-of-low-input-grassland-to-convert-arable-land/ [Accessed 08 May 2015.

SCOTTISH GOVERNMENT. 2015h. *Rural Payments and Services: Greening* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/basic-payment-scheme/basic-payment-scheme-full-guidance/greening---bps/ [Accessed 01 June 2015.

SCOTTISH GOVERNMENT. 2015i. *Rural Payments and Services: Hard Standings for Troughs and Gateways* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/hard-standings-for-troughs-and-gateways/ [Accessed 13 May 2015.

SCOTTISH GOVERNMENT. 2015j. *Rural Payments and Services: Laying of Hedges* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/laying-of-hedges/ [Accessed 09 May 2015.

SCOTTISH GOVERNMENT. 2015k. *Rural Payments and Services: Management of Floodplains* [Online]. Online: Scottish Government. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/management-of-floodplains/ [Accessed 26 April 2015.

SCOTTISH GOVERNMENT. 2015l. *Rural Payments and Services: Management, Restoration or Creation of Hedgerows* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/management--restoration-or-creation-of-hedgerows/ [Accessed 09 May 2015.

SCOTTISH GOVERNMENT. 2015m. *Rural Payments and Services: Planting or Replanting of Hedges* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/planting-or-replanting-of-hedges/ [Accessed 09 May 2015.

SCOTTISH GOVERNMENT. 2015n. *Rural Payments and Services: Pond Creation for Wildlife* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/pond-creation-for-wildlife/ [Accessed 22 May 2015.

SCOTTISH GOVERNMENT. 2015o. *Rural Payments and Services: Rabbit-proofing an Existing or New Stock or Deer Fence* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/rabbit-proofing-existing-or-new-stock-or-deer-fence/ [Accessed 09 May 2015.

SCOTTISH GOVERNMENT. 2015p. *Rural Payments and Services: Restoring River Banks* [Online]. Online: Scottish Government. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/restoring-river-banks/ [Accessed 26 April 2015.

SCOTTISH GOVERNMENT. 2015q. *Rural Payments and Services: Retention of Winter Stubbles for Wildlife and Water Quality* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/retention-of-winter-stubbles-for-wildlife-and-water-quality/ [Accessed 01 June 2015.

SCOTTISH GOVERNMENT. 2015r. *Rural Payments and Services: River Embankment Breaching, Lowering or Removal* [Online]. Online: Scottish Government. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/river-embankment-removal/.

SCOTTISH GOVERNMENT. 2015s. *Rural Payments and Services: Rural Sustainable Drainage Systems – Retention Pond* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/rural-sustainable-drainage-systems---retention-pond/ [Accessed 13 May 2015.

SCOTTISH GOVERNMENT. 2015t. *Rural Payments and Services: Rural Sustainable Drainage Systems – Swales* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/rural-sustainable-drainage-systems---swales/ [Accessed 01 June 2015.

SCOTTISH GOVERNMENT. 2015u. *Rural Payments and Services: Rural Sustainable Drainage Systems – Wetland* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/rural-sustainable-drainage-systems---wetland/ [Accessed 14 May 2015.

SCOTTISH GOVERNMENT. 2015v. *Rural Payments and Services: Rural Sustainable Drainage Systems- Sediment Traps and Bunds* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/rural-sustainable-drainage-systems---sediment-traps-and-bunds/ [Accessed 14 May 2015.

SCOTTISH GOVERNMENT. 2015w. *Rural Payments and Services: Small-scale Tree and Shrub Planting (on a site not exceeding 0.25 hectares)* [Online]. Online: Scottish Government. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/small-scale-tree-and-shrub-planting [Accessed 24 July 2015.

SCOTTISH GOVERNMENT. 2015x. *Rural Payments and Services: Stock Fence* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/stock-fence/ [Accessed 09 May 2015.

SCOTTISH GOVERNMENT. 2015y. *Rural Payments and Services: Supporting Guidance for Management of Floodplains* [Online]. Online: Scottish Government. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/management-of-floodplains/guidance-for-management-of-floodplains/ [Accessed 26 April 2015.

SCOTTISH GOVERNMENT. 2015z. *Rural Payments and Services: Supporting Guidance for River Embankment Breaching, Lowering or Removal* [Online]. Online: Scottish Government. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/river-embankment-removal/guidance-for-river-embankment-breaching--lowering-or-removal/ [Accessed 26 April 2015.

SCOTTISH GOVERNMENT. 2015{. *Rural Payments and Services: Supporting guidance for Rural Sustainable Drainage Systems – Swales* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/rural-sustainable-drainage-systems---swales/guidance-for-swales/ [Accessed 01 June 2015.

SCOTTISH GOVERNMENT. 2015l. *Rural Payments and Services: Unharvested Conservation Headlands for Wildlife* [Online]. Online. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/unharvested-conservation-headlands-for-wildlife [Accessed 01 June 2015.

SCOTTISH GOVERNMENT. 2015}. *Rural Payments and Services: Wetland Management* [Online]. Online: Scottish Government. Available: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/wetland-management/ [Accessed 26 April 2015.

SCOTTISH WATER. 2014. *SLM Incentive Scheme* [Online]. Online: Scottish Water. Available: http://www.scottishwater.co.uk/about-us/corporate-responsibility/sustainable-land-management/slm-incentive-scheme [Accessed 26 April 2015.

SEPA 2015a. The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) A Practical Guide. Online: SEPA.

SEPA. 2015b. *Water Environment Fund* [Online]. Online: SEPA. Available: http://www.sepa.org.uk/environment/water/water-environment-fund [Accessed 26 April 2015.

SUTHERLAND, L.-A. 2010. Environmental grants and regulations in strategic farm business decision-making: A case study of attitudinal behaviour in Scotland. *Land Use Policy,* 27**,** 415-423.

TG DRAINS. 2015. *Mole Drainage* [Online]. Online. Available: http://www.tgdrains.com.au/page5.htm [Accessed 05 May 2015.

THE NATIONAL LOTTERY. 2015. *Awards for All Scotland: Funding- Big Lottery Fund* [Online]. Available: https://www.biglotteryfund.org.uk/global-content/programmes/scotland/awards-for-all-scotland [Accessed 09 May 2015.

THE NATURE CONSERVANCY. 2015. *Two-Stage Ditch Slideshow* [Online]. Online. Available: http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/indiana/two-stage-ditch-slideshow.xml [Accessed 03 May 2015.

THE WOODLAND TRUST 2013. The Pontbren Project: A farmer led approach to sustainable land management in the uplands. Online: The Woodland Trust.

TWEED FORUM. 2011. *The Eddleston Water Project* [Online]. Online: Tweed Forum. Available: http://www.tweedforum.org/projects/current-projects/eddleston [Accessed 23 May 2015.

WAYLEN, K. A., DUNGLINSON, J., BLACKSTOCK, K., SKURAS, D. & PSALTOPOULOS, D. 2010. Barriers to uptake of measures designed to improve water quality and quantity: Review of literature and initial conceptual model. *Report for Project REFRESH (Adaptive Strategies to Mitigate the Impacts of Climate Change on European Freshwater Ecosystems). Refresh Milestone 1.10.* Aberdeen, UK: Macaulay Land Use Research Institute.

WILKINSON, M. E., QUINN, P. F., BARBER, N. J. & JONCZYK, J. 2014. A framework for managing runoff and pollution in the rural landscape using a Catchment Systems Engineering approach. *Science of The Total Environment,* 468–469**,** 1245-1254.

WILKINSON, M. E., QUINN, P. F. & WELTON, P. 2008. Belford catchment proactive flood solutions: storing and attenuating runoff on farms. *BHS 10th National Hydrology Symposium.* Exeter: British Hydrological Society.

WILSON, G. A. & HART, K. 2000. Financial imperative or conservation concern? EU farmers' motivations for participation in voluntary agri-environmental schemes. *Environment and Planning A,* 32**,** 2161-2185.

WITTER, J. D., D'AMBROSIO, J. L., WARD, A., MAGNER, J. & WILSON, B. 2011. Considerations for implementing two-stage channels. USDA & The Great Lakes Regional Water Program.

WWF 2005. The River Devon Project Slowing the Flow. Online: WWF.

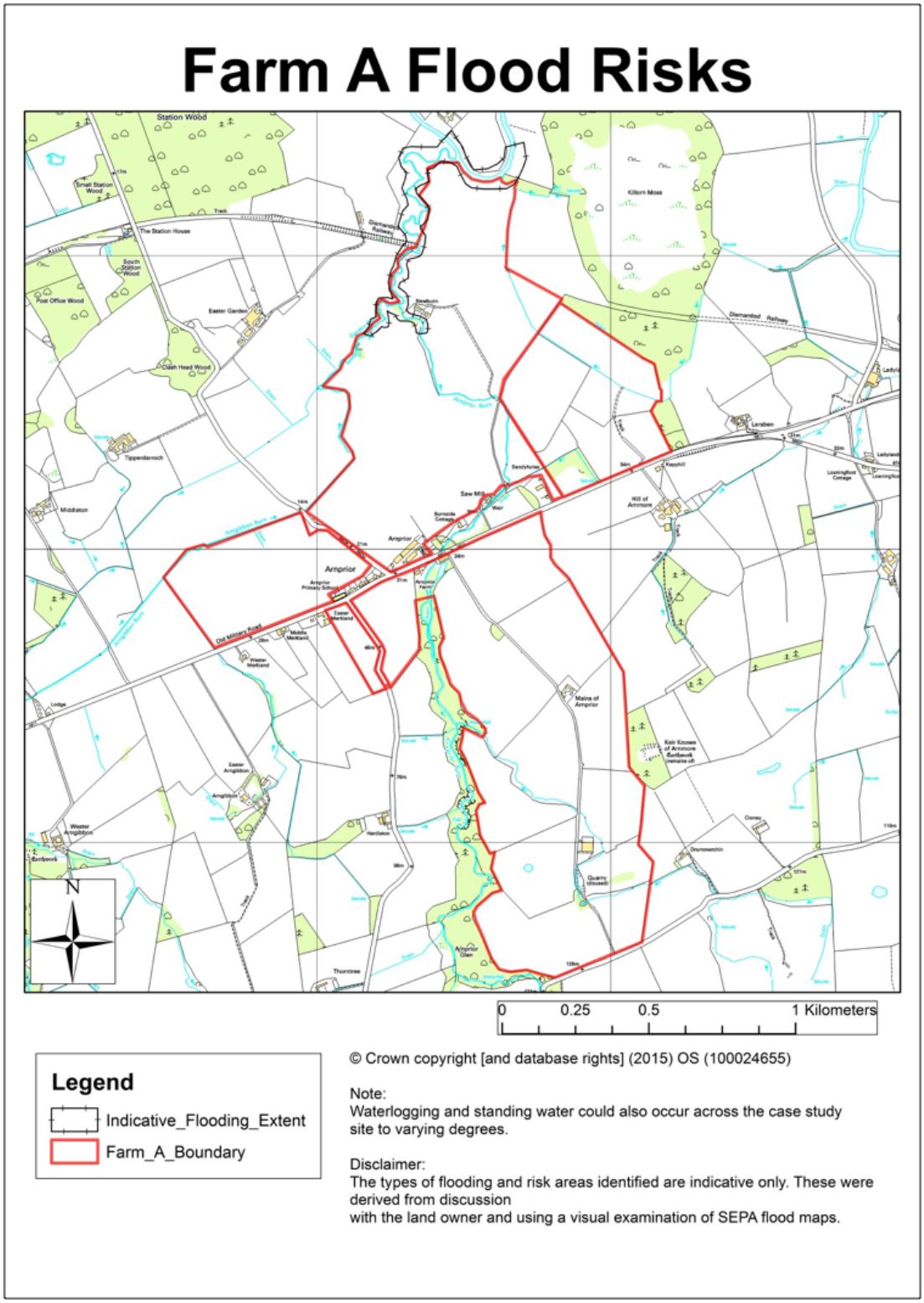
Appendices

Appendix 1: Carse of Stirling Data

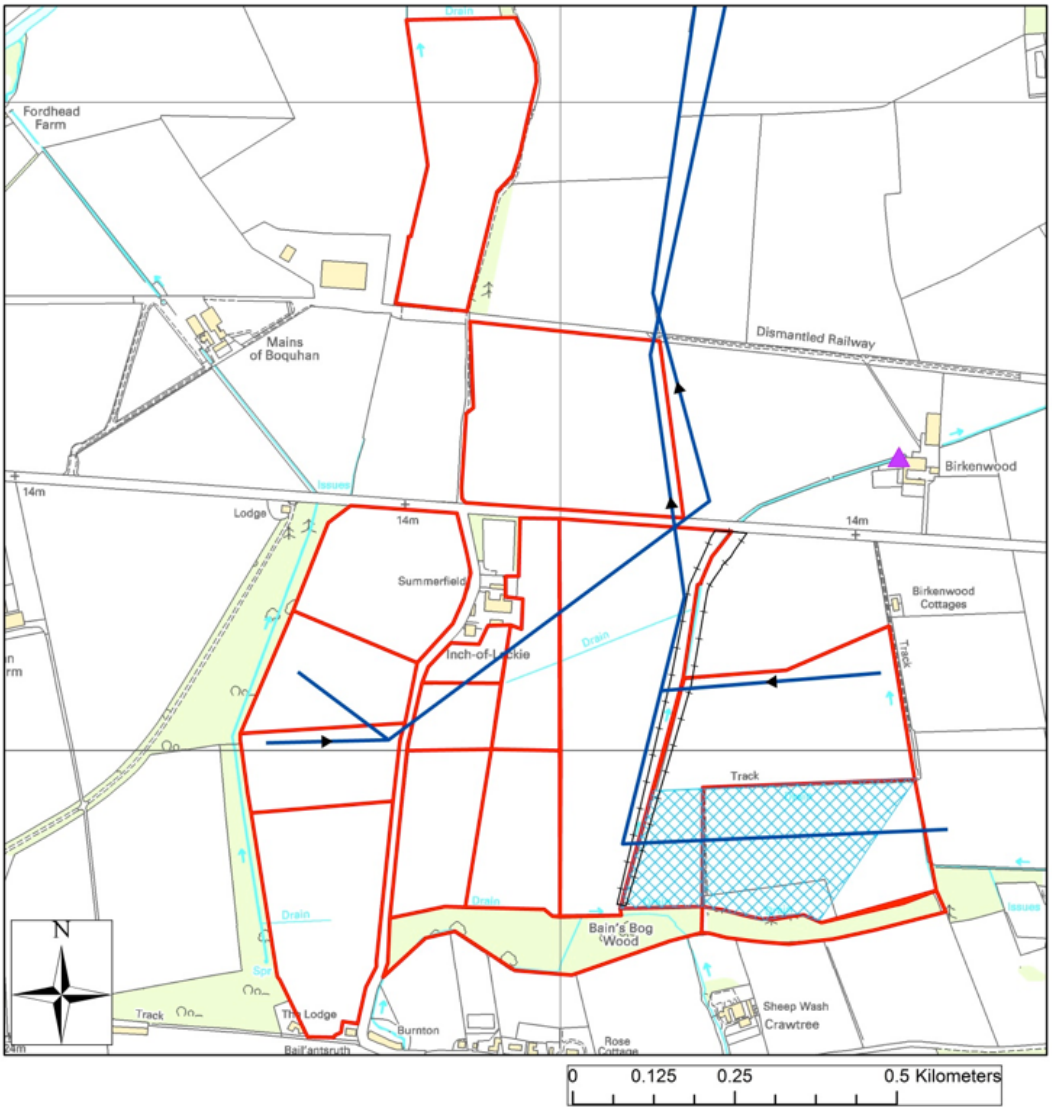
Table 7 Carse of Stirling datasets identified and acquired during the project

Data	Source	Availability
Flood extent maps	Scottish Environment Protection Agency	Online interactive map & GIS dataset under licence
NFM potential areas		
WFD classification		
Potentially Vulnerable Areas		
Forestry Grant Scheme (FGS) Target Areas	Forestry Commission Scotland	Online interactive map & GIS dataset from Forestry Commission directly
FGS site suitability		
Felling licences		
Soils	James Hutton Institute	Licenced GIS dataset from JHI/ Scottish Government
COS boundary map	Stirling Council	PDF maps online or GIS datasets from Stirling Council under licence
COS Culture & history map		
COS Flood mitigation and water storage map		
COS Land Cover, Food Production & Land Capability for Agriculture maps		
COS Global climate maps		
COS Habitats and wildlife maps		
COS Recreation and Tourist maps		
COS Soils, Pollination and Genetic Resource maps		
COS Timber, wood fuel and renewables map		
Historical maps	National Library of Scotland	Purchase online. Can also be viewed online free of charge. Also shown in SNH report (Harrison, 2003)

Appendix 2: Case Study farms – Identification of flooding issues



Farm B Flood Risks



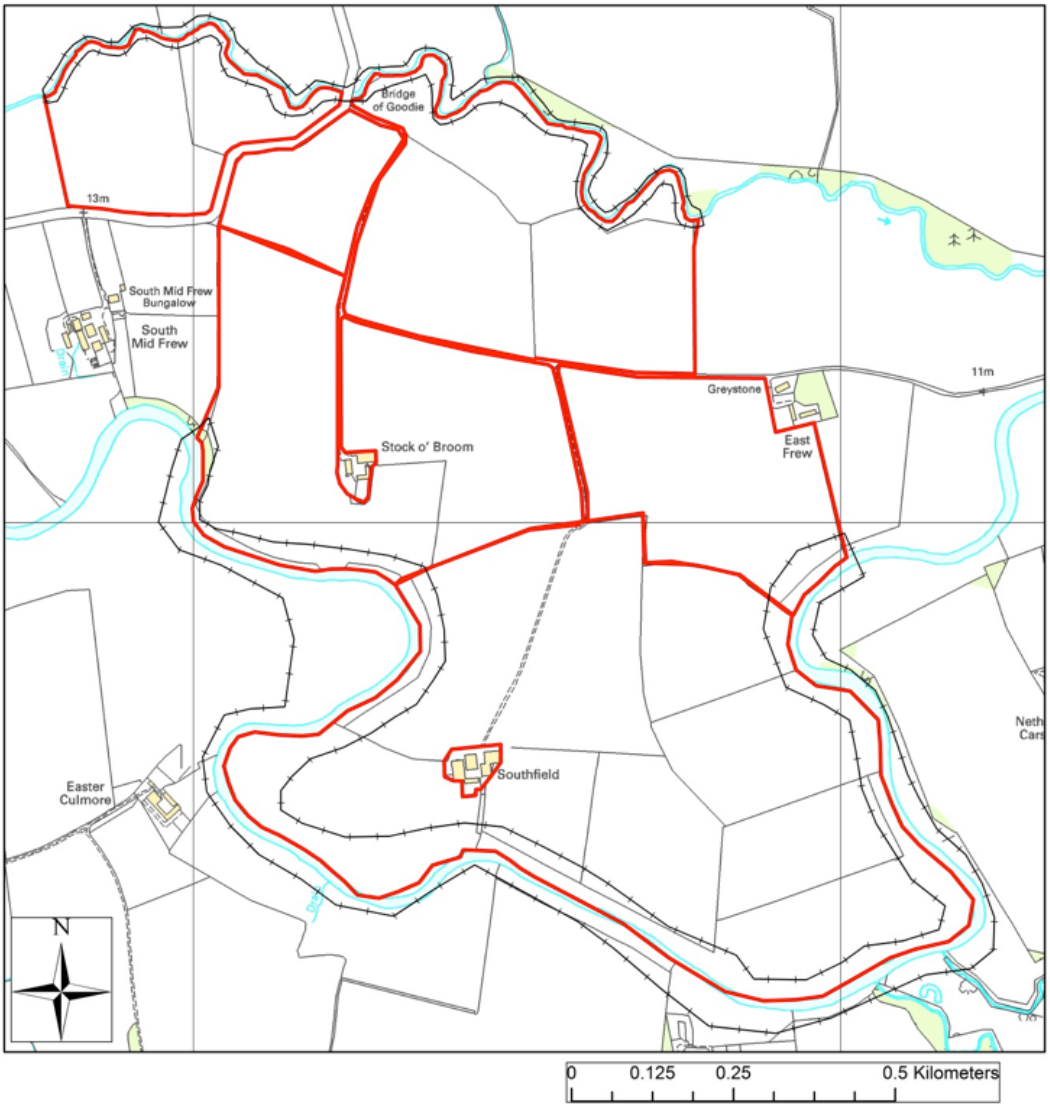
Legend

- Current_Leader_Drains
- Constriction
- Indicative_Flooding_Extent
- Waterlogging
- Farm_B_Boundary

Note:
Waterlogging and standing water could also occur across the case study site to varying degrees.
Area marked 'waterlogging' is continually in this condition.
The leader drains show where drainage could be improved or replaced

Disclaimer:
The types of flooding and risk areas identified are indicative only. These were derived from discussion with the land owner and using a visual examination of SEPA flood maps.

Farm C Flood Risks



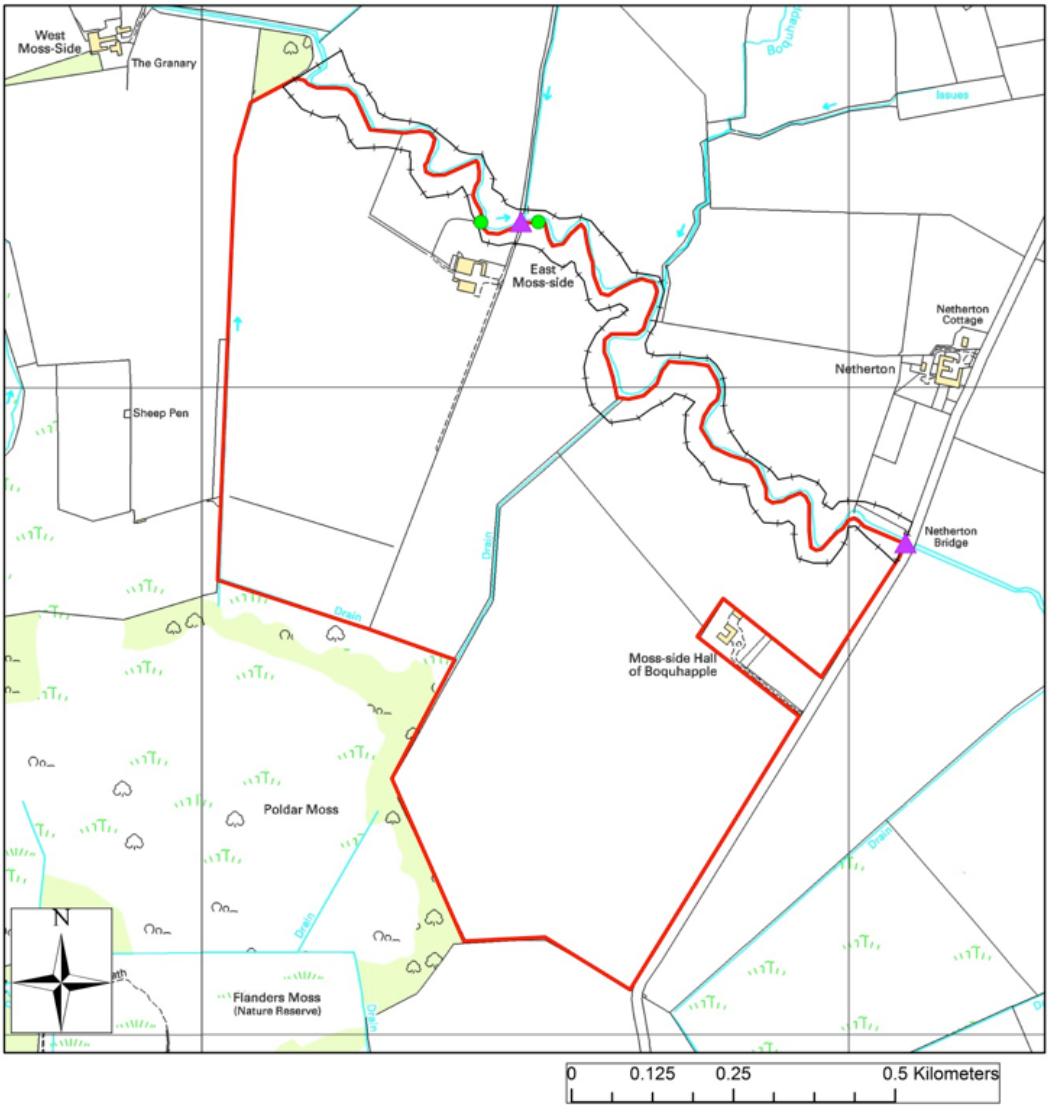
Legend

- Indicative_Flooding_Extent
- Farm_C_Boundary

Note:
Waterlogging and standing water could also occur across the case study site to varying degrees.

Disclaimer:
The types of flooding and risk areas identified are indicative only. These were derived from discussion with the land owner and using a visual examination of SEPA flood maps.

Farm D Flood Risks



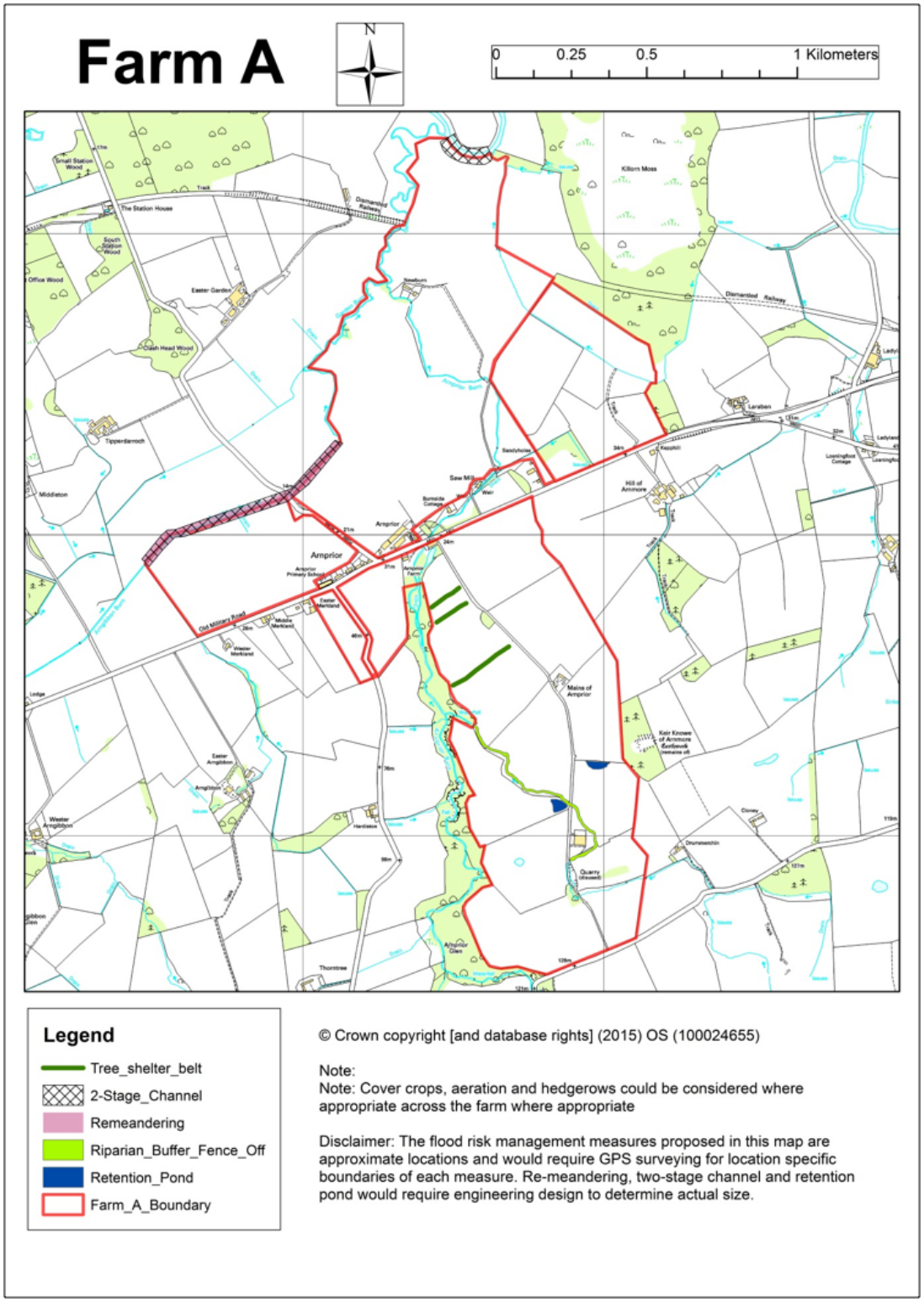
Legend

- Constriction
- Insufficent_Drainage_Point
- Indicative_Flooding_Extent
- Farm_C_Boundary

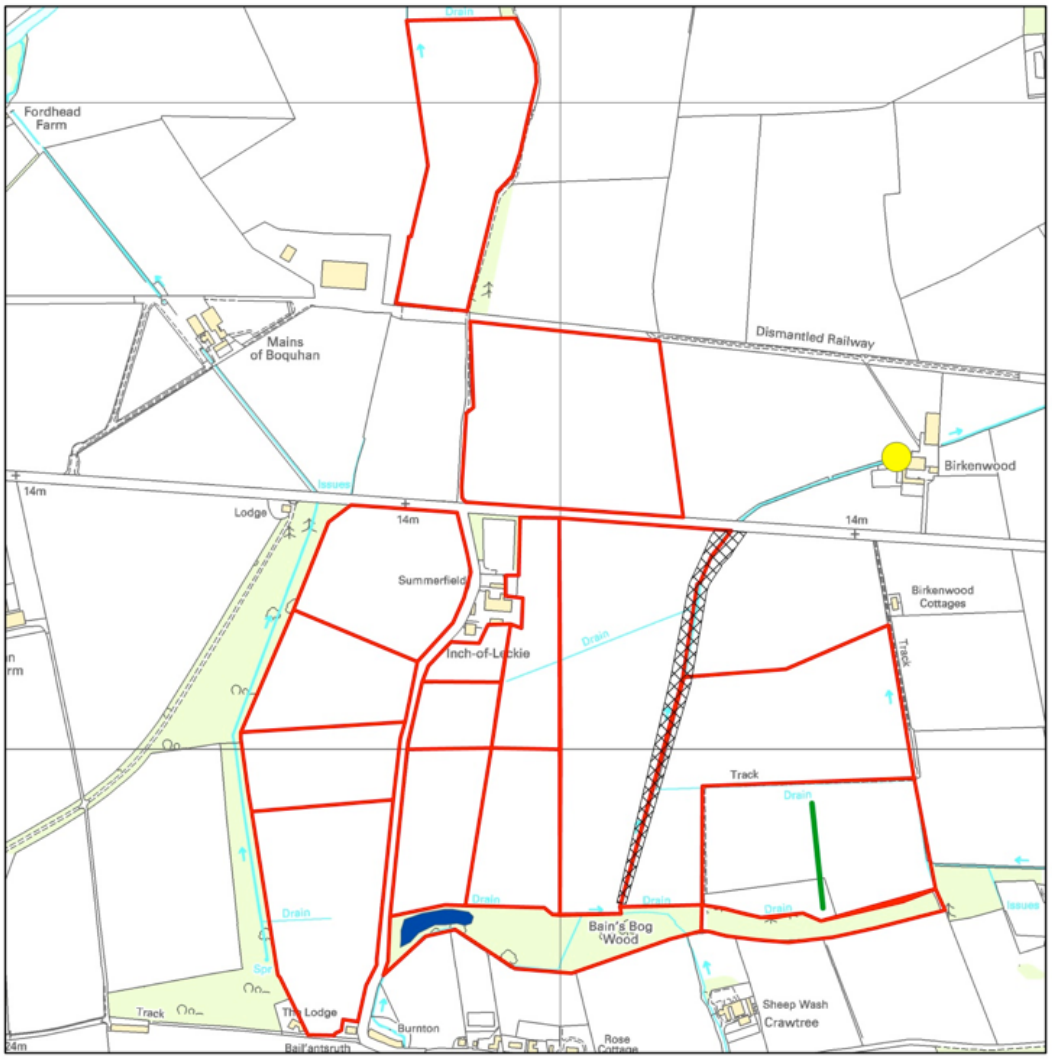
Note:
Waterlogging and standing water could also occur across the case study site to varying degrees.

Disclaimer:
The types of flooding and risk areas identified are indicative only. These were derived from discussion with the land owner and using a visual examination of SEPA flood maps.

Appendix 3: Case Study farms – Potential locations for NFM measures



Farm B



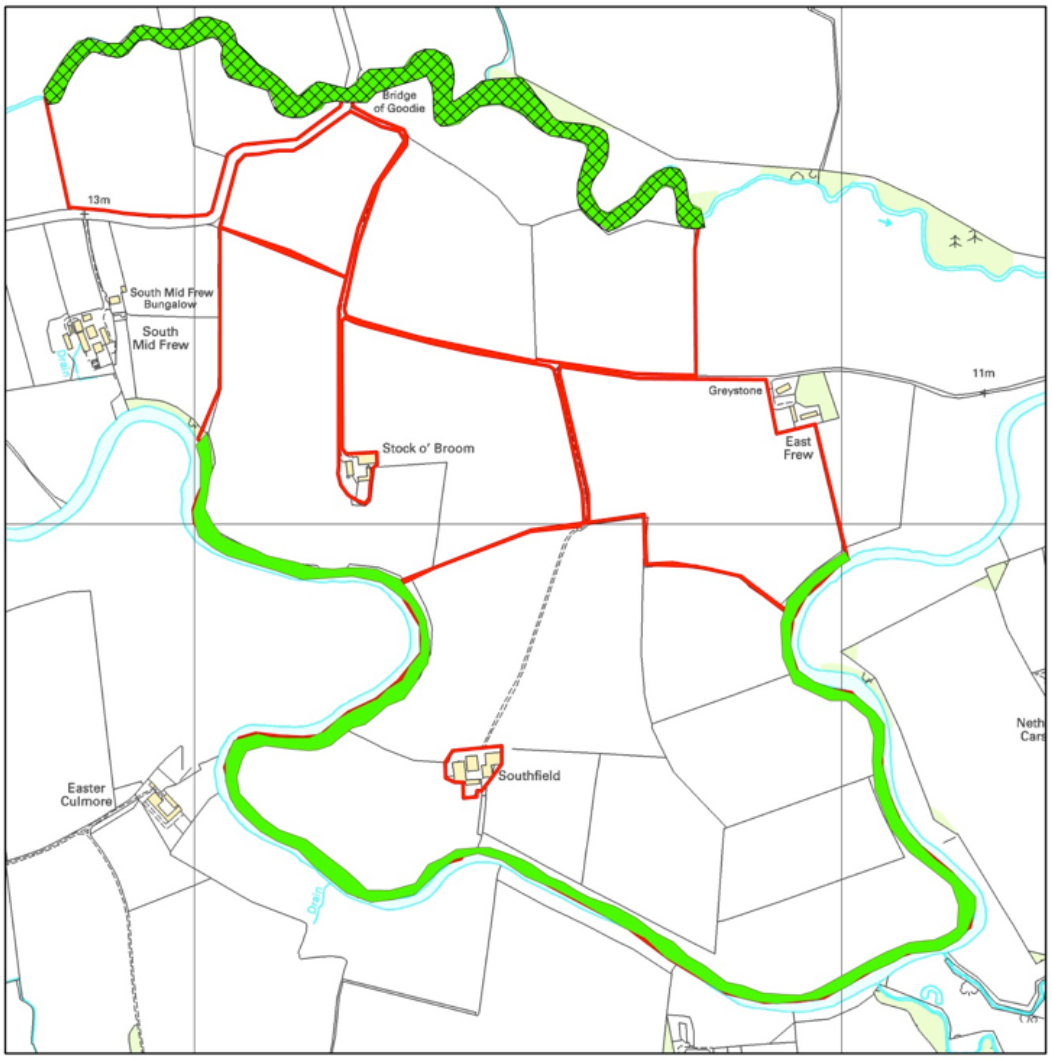
Legend

- Hedgerow
- 2-Stage_Channel
- Retention_Pond
- Remove_Remediate_Constriction
- Farm_B_Boundary

Note: Cover crops, aeration and hedgerows could be considered where appropriate across the farm where appropriate

Disclaimer: The flood risk management measures proposed in this map are approximate locations and would require GPS surveying for location specific boundaries of each measure. Re-meandering, two-stage channel and retention pond would require engineering design to determine actual size.

Farm C



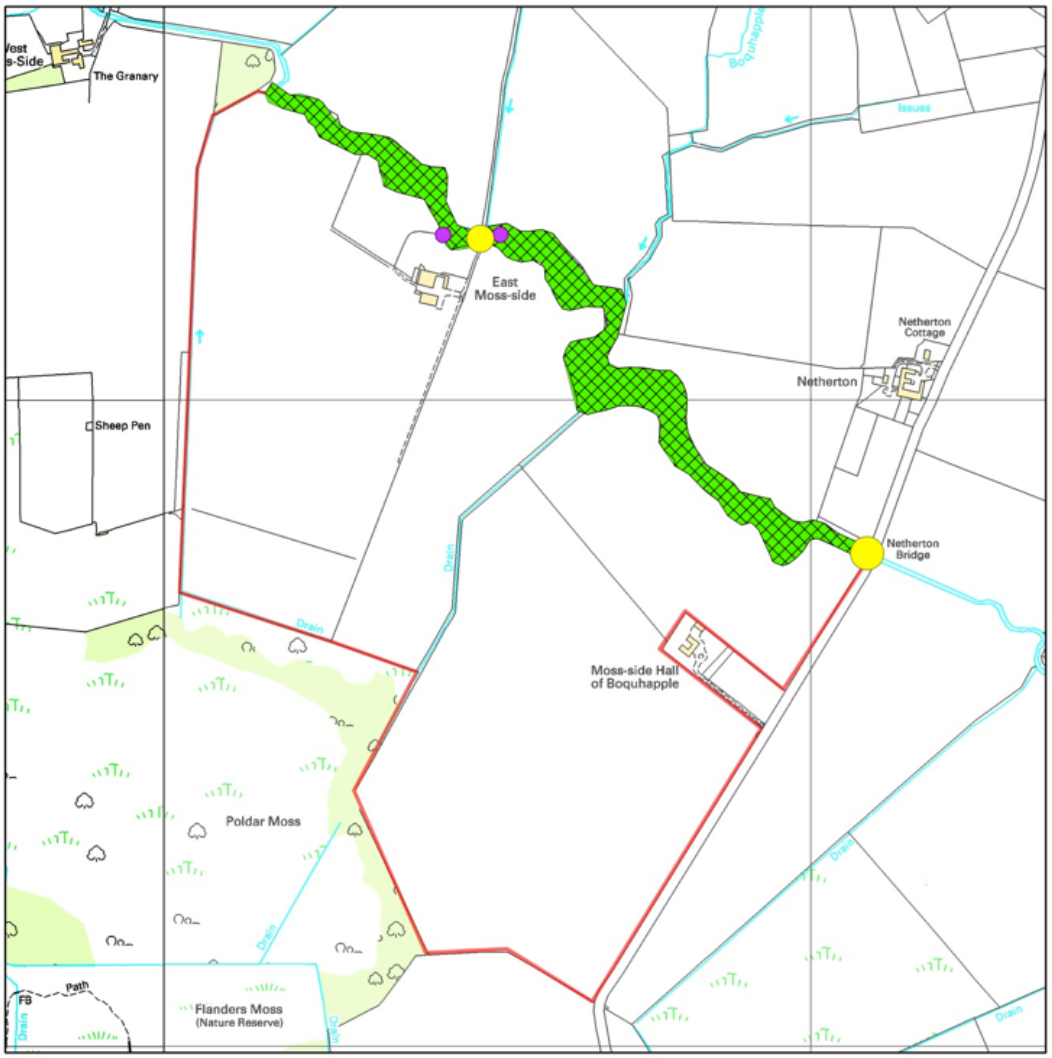
Legend

- Riparian_Buffer_Fence_Off
- 2-Stage_Channel
- Farm_C_Boundary

Note: Cover crops, aeration and hedgerows could be considered where appropriate across the farm where appropriate

Disclaimer: The flood risk management measures proposed in this map are approximate locations and would require GPS surveying for location specific boundaries of each measure. Re-meandering, two-stage channel and retention pond would require engineering design to determine actual size.

Farm D



Legend

- Insufficent_Drainage_Point
- 2-Stage_Channel
- Riparian_Buffer_Fence_Off
- Farm_C_Boundary

Note: Cover crops, aeration and hedgerows could be considered where appropriate across the farm where appropriate

Disclaimer: The flood risk management measures proposed in this map are approximate locations and would require GPS surveying for location specific boundaries of each measure. Re-meandering, two-stage channel and retention pond would require engineering design to determine actual size.

Appendix 4: Funding Sources

Please note that the following information is a synthesis of the funding options and will require further investigation into the minor details and requirements of individual land owners to obtain funding. This information is often very site specific and thereby requires further queries by the applicants.

4-A: SRDP Funding – Basic Farm Payment

This payment is a safeguard for farmers providing supplementary income to their main business income available from 1st January to 31st December each year and applied for through the Single Application Form. Within this branch of funding, farmers are required to undertake certain sustainable practices, otherwise known as "greening", in order to obtain additional payments from the Basic Payment Scheme. Greening is promoted to compliment Good Agricultural & Environmental Condition and is split into: permanent grassland, crop diversification and ecological focus areas (EFAs). Due to *crop diversification* being focused on the number of different crop species that should be planted rather than timing of planting, it has less relevance to flooding and will be excluded from this report. This payment aims to protect environmentally sensitive grasslands and encourage 5% of arable land to be managed sustainably for biodiversity (Scottish Government, 2015a, Scottish Government, 2015h). Please note, the following information on the Basic Farm Payment is a summary and only factors considered to be relevant to flooding (within the scope of this study) have been outlined. For more information please consult the website www.ruralpayments.org.uk.

Greening – Permanent Grassland

Permanent grassland is defined as land where grasses or herbaceous forage are grown naturally or through sowing which has not been included in crop rotation for five years or more. This type of *Greening* goes beyond the statutory requirements of The Environmental Impact Assessment (Agriculture) (Scotland) Regulations 2006. What permanent grassland greening requires is:

- No less than 5% of the total agricultural area is permanent grassland
- Conversion or ploughing of permanent grassland declared as *environmentally sensitive grassland* is prohibited
- If permanent grass is ploughed and immediately sown with grass ley the area will retain its status (if any crop is planted or the soil remains bare the status is lost)

Potential conflicts may occur with Agri-Environment Climate Scheme for example:

- Water margins (both arable fields and grassland fields)
- Creation of low-input grassland to convert arable land at risk of flooding and erosion
- Rural SUDS swales

Benefits to Reducing Flood Hazard:

- Slows runoff & allows longer infiltration of water through soils
- Traps sediment in runoff, thereby reducing build up in rivers and alleviating any reduction in channel capacity to hold water

Greening – Ecological Focus Area (EFA)

EFA is defined as *an area of land upon which you carry out agricultural practices that are beneficial for the climate and environment (Scottish Government, 2015a)* and aims to enhance biodiversity. EFA land must be located on arable land, or for field margins and buffers these can be adjacent to arable land (but must border the arable land). Requirements apply to partial or non-organic farms. Table 8 also outline a summary of land requirements for EFA, please refer to the www.ruralpayments.org.uk website for more detailed information.

EFA options have been allocated weighting factor to determine their degree of contribution to environmental benefits. These EFA options include: fallow, field margin, buffer strips, nitrogen-fixing crops and catch crops. Those relevant to flooding issues and their weightings have been outlined in Table 9. These weighting factors refer to area eligible for payment rates, for example where 1ha = 1.5ha, this translates to being paid for 1.5ha when only 1ha is being used for an EFA option.

4-B: SRDP Funding – Agri-Environment Climate Scheme

The Agri-Environment Climate Scheme (AECS) is available to encourage farmers to undertake management practices that will enhance Scotland's adaptation to climate change, including the control of flooding through natural flood risk management (Scottish Government, 2015c). The scheme also promotes public access, preservation of historical monuments, natural heritage and water quality elements. This funding was open for application between 30 March and 12 June 2015 and offers

Table 8 EFA Qualifying Land

Permanent Grassland	Arable Land	>75% TGRS, fallow, herbaceous forage or leguminous crops	>75% of business is grassland and herbaceous forage	Arable land less area of TGRS, fallow and herbaceous forage
None	>15 ≤30 ha	No	n/a	
None	>30 ha	No	n/a	≤30 ha
None	>30 ha	Yes or No	n/a	>30ha
Yes	>15 ≤30 ha	No	No	
Yes	>30 ha	No	No	≤30 ha
Yes	>30 ha	Yes or No	Yes or No	>30ha

Table 9 Summarised EFA classification, definitions, general rules and weighting factors			
EFA Option	**Definition - land eligible – general rules**	**Weighting Factor**	**Translates to**
Fallow	No crop production or grazing on an area of land	1	1 ha of fallow land = 1 ha of EFA commitment
	Min of 0.1ha area on arable land		
	Fallow in the preceding year or an arable crop		
	No agricultural production or maintenance, change of land cover, top the fallow, apply fertilizer or herbicide- all between 15 January and 15 July		
Field Margin	Contribute to habitat for farmland biodiversity & contribute to wildlife and ecological networks.	1.5	1 ha of field margin = 1.5 ha of EFA commitment
	Must be on or adjacent to arable land		
	Can be around the field margin or split two crops in one field		
	1-20m wide & 0.01ha in size		
	No grazing, agricultural production, herbicide or fertiliser (except basal), removal of cuttings after 31 August		
Buffer strips	Areas of land that benefit water quality & biodiversity.	1.5	1 ha of buffer strip= 1.5 ha of EFA commitment
	Must provide a buffer to a water course		
	Must be adjacent to or on arable land		
	Between 2-20m wide & 0.01ha in size		
	No grazing, agricultural production, herbicide or fertiliser		

annual payments as well as funding for capital costs. Future application deadlines can be found on the *Rural Payments and Services* website www.ruralpayments.org. The options available in this scheme are outlined in detail below.

It should be noted that for any water quality related management options a *farm diffuse pollution risk assessment* is required for applications. Furthermore, a *farm environment assessment* is needed for all the management options below except those marked with *. The management options that pose a risk of double funding with the Basic Farm Payment and EFAs are also applied for are highlighted with a †. A selection of AECS management options related to flooding issues identified in the Carse of Stirling project through field visits and farmer engagement are detailed below. Although some options may be for reasons other than flooding, often these options have the added benefit of reducing flooding in various ways and thereby have been outlined.

- **Restoring (Protecting) Banks*** (Scottish Government, 2015b, Scottish Government, 2015p)

This management option enables previously damaged and livestock poached banks to be restored by recreating natural bank profiles, vegetation and habitats. This bank re-profiling must be achieved by adopting one of the following techniques:

- Willow spilling – £185 per metre
- Plant roll revetment – £210 per metre
- Hurdle and coir matting – £65 per metre
- Engineered log jams (SEPA approved design) – Max £210 per metre

Other management options which can be supportive of *Restoring (Protecting) Banks* are:

- Water margins in grassland fields
- Grass strips in arable fields

- **River Embankment/ Breaching/ Lowering*** (Scottish Government, 2015r, Scottish Government, 2015z)

This management option aims to restore floodplains and can be utilised when an embankment for reducing flooding is being removed or lowered and replanted, reconnecting the floodplain. It can also be utilised when setting back the embankment, but funding will only cover embankment removal and not the reconstruction of a new one further back. Maintenance requires livestock to be excluded from the area while vegetation establishes and subsequent grazing ensures the area remains vegetated. There is possibility to combine the management options with this one to achieve added value and multiple benefits, for example:

- Wetland Management
- Species-rich Grassland Management
- Converting Arable at Risk of Erosion or Flooding to Low-input Grassland
- Management of Floodplains

Funding is made on an actual cost basis, after work has been completed.

- **Management of Floodplains (under review for 2016/17)** (Scottish Government, 2015k, Scottish Government, 2015y)

This funding option aims to assist in managing flood risk and benefiting biodiversity by means of managing the floodplain. This management option is especially useful in conjunction with *River Embankment/ Breaching/ Lowering* as it funds the cost of removing livestock from the flooded area, during floods. Any grassland or arable rotation land with newly created grass sward that is allowed to flood (e.g. after the removal of a bank) and is grazed by livestock is eligible for this funding. Funding – currently set at the rate of £57.43 per hectare (likely to be reduced by next year) – is available only for the area of land that is liable to flooding and is additional to funding for managing specific habitats.

- **Wetland Management** (Scottish Government, 2015})

This option is only suitable for wetlands which will be managed through cutting or grazing is for existing or newly created wetland habitats. These wetlands are good for biodiversity, habitat and reducing flooding by offering water storage.

Strict management regimes apply to this funding option and compulsory assessment of land suitability is needed to supporting funding applications. Claimants can receive annual payments of:

- £90.03 per hectare per year for management
- £284.80 per hectare per year for creation and management

Further capital items can be applied for in conjunction with *Wetland Management*:

- Ditch Blocking – Peat Dams
- Ditch Blocking – Plastic Piling Dams
- Wetland Creation – Field Drain Breaking
- Wetland Creation – Pipe Sluices
- Moving or Realigning Ditches
- Creation of Species-rich Grassland

- **Water Margins in Arable Fields**† (Scottish Government, 2015d)

The main aim of this option is to improve water quality and biodiversity but it could also be argued to have benefits for reducing flood risk. Vegetated water margins can potentially slow runoff, allowing better infiltration and reducing fast overland flow to water courses. They can also prevent soil erosion, promote bank stability and better soil structure.

Arable land (in crop for at least 3 of the last 5 years) in rotation and adjacent to water bodies or water courses is eligible for this option. The maximum width of margin eligible for payment is 18m and a maximum claim of £495.62 per hectare per year. However other restrictions on width of margins apply:

- Adjacent to a watercourse with a bed ≤ 1.2m – 3m wide margin
  - All livestock must be excluded
  - Any cutting must be complete by 15 August and cuttings removed
- Adjacent to a watercourse with a bed > 1.2m – 6m wide margin
  - Cutting is permitted - only the margin at top of bank
  - No cutting before 15 August and cuttings must be removed
  - Grazing of margin/ banking prohibited 1 May -15 August or 15 September if a bathing water catchment
  - No supplementary livestock feeding
- Adjacent to still water- 12m wide margin
  - No ploughing, cultivation or storage on the established margin
  - No poaching, vehicle tracks or new drainage
  - No spraying, fertilizer, slurry or manure
  - A diary is kept of management

- **Pond Creation for Wildlife** (Scottish Government, 2015n)

Although this funding option is aimed at benefitting wildlife, it does offer some scope to collect surface water and therefore attenuate runoff. Achieving a pond with a variety of flora and fauna is good for biodiversity. The requirement include: the pond must contain water during winter and spring, be stocked with plants to enable natural vegetation growth and if connected to a river/ stream/ ditch have SEPA approval. Available funding for this option is £4.50/ m^2.

- **RSUDS – Retention Ponds** (Scottish Government, 2015s)

This management option is primarily to improve water quality and reduce runoff by intercepting overland flow normally destined for water courses and enabling filtration, storage and biological processing of nutrients. This option is only available to those in a diffuse pollution priority catchment or a flooding target area and must be combined with *RSUDS – sediment trap and bunds*, and *stock fence.* The prerequisites for ponds include:

- Must have a length to width ration of 3:1 or 5:1
- Must have a sediment trap located to intercept runoff prior to its arrival into the pond
- Planning permission must be obtained (or confirm no permission is needed)
- No runoff from pesticide/ wash areas or slurry can be routed to the pond
- Existing ponds are ineligible

The capital payment available is £15.00/ m^2 excluding fencing costs, which can be obtained through the *stock fence* capital payment option.

- **RSUDS – Sediment traps & Bunds** (Scottish Government, 2015v)

This option must be used in combination with *stock fence* and is required to be used when utilising *RSUDS retention ponds* funding. These traps and bunds improve water quality by capturing runoff and sediment before it enters water courses. It is also an effective method for temporarily storing runoff, slowing the flow to rivers and attenuating flood peaks. Applicants must be within a diffuse pollution priority catchment/ focus area or a flooding target area, but it is possible to apply outwit these areas if there is justification which is validated by SEPA. Requirements include:

- Bunds more than 1.3m high must be designed by an engineer
- Fencing must be implemented to exclude livestock and people
- Slurry, pesticide or washing area runoff must not be routed to the bund area

Funding for excavation and the formation of sediment traps- £10.50/ m^2

Funding to create a bund – £7.20/ linear m

- **RSUDS – Wetlands** (Scottish Government, 2015u)

This wetland option aims to improve water quality by capturing and filtering runoff through natural processes within the wetland. This also attenuates runoff, thereby contributing to the slowing of flood peak in watercourses. Land within diffuse pollution/ focus area/ flooding target area is eligible, or SEPA must authorise eligibility. Payment for the capital costs are:

- £5/ m^2 – wetland with soil lining
- £9/m^2 – wetland with proprietary lining

- **RSUDS – Swales** (Scottish Government, 2015t, Scottish Government, 2015{)

Swales can improve water quality by providing a route for runoff to flow within a shallow vegetated depression in the land, usually leading to a treatment area such as a pond. The runoff is slowed and the vegetation encourages the deposition of sediment, uptake of pollutants/ nutrients and directs runoff to a subsequent treatment area. Swales are low maintenance and can easily be integrated into the landscape and can be visible when actively operating. There are various advisories on suitable location, design and works to be carried out, which can be found on the Rural Payments and Services website (www.ruralpayments.org). Payment for the capital works (excluding fencing) is £21.75/ m^2. It is more beneficial to use several rural RSUDS in combination across the landscape, using a "treatment train" approach.

- **Hard Standings for Troughs and Gateways** (Scottish Government, 2015i)

This funding option enables water and soil quality to be improved by mitigating soil and sediment loss to water courses. Reducing sediment loss also contributes to reducing the build-up of sediment in rivers and thereby reducing the capacity of river channels to carry water. This may be best used alongside fenced off riparian buffers strips (stock fence/ water margins) especially if livestock require an alternative watering solution to the water course. Funding is for: relocating gates or creating hard standings at gates or at watering troughs. This is a capital item and payments are outlined below:

- Gate relocation £230
- Implementing hard standings £12.50/ m^2

Alternative option would be to route runoff through a swale or sediment trap, funded under the RSUDS options.

- **Alternative Watering** (Scottish Government, 2015d)

This management option aims to safeguard water quality and biodiversity by promoting the use of other sources for drinking water for livestock other than from water courses. This is applicable to land already using an AECS management option or where the land is within a SEPA priority catchment/ action area (this does not apply to COS). Payment towards creating a water abstraction point, extracting the water and for troughs is available. See Table 10.

- **Retention of winter stubble for wildlife & water quality†** (Scottish Government, 2015q)

Retaining winter stubble enhances biodiversity and food sources for various wildlife species but it also mitigates soil erosion and provides a roughness to attenuate runoff and encourage increased infiltration. Spring or autumn sown cereal or oil seed crop qualifies for this funding option. No spraying, grazing, ploughing or cultivating is permitted before 1st March. Payment for this option is £299.44/ ha annually.

- **Unharvested Conservation Headlands for Wildlife†** (Scottish Government, 2015l)

This option is promoted for protection of soil and for wildlife value. However, it also has benefits for reducing flooding. The aim is to provide unharvested crop with no herbicides or insecticides in headland areas over winter to improve habitat and food sources for wildlife. However, this unharvested crop also stabilises soils, reducing sediment loss, and enhances the infiltration of rainfall into soil layers. The crop will provide interception to the rainfall and slow the runoff process, thereby likely to reduce flooding. Only arable headlands with spring or autumn-sown cereal or oil-seed crops are eligible.

This payment option provides: £657.57/ ha/ year but a limitation of 250ha applies and payment may vary with location codes.

- **Converting Arable Land at Risk of Erosion or Flooding to Low-input Grassland†** (Scottish Government, 2015e)

Using this funding option enables continual year-round vegetative cover to improve soil structure and organic matter, but reduce runoff and erosion. This also has water quality and wildlife benefits. This option is available on land that has been cropped for all five years previous. Requirements include:

- No fertilisers, only manure can be used
- No spraying. Spot treatment of weeds is allowed with consent.
- No poaching or vehicle tracked

Capital costs can be acquired for the creation the grassland through *Creation of Low-Input Grassland to Convert Arable Land at Risk of Flooding or Erosion* funding option. There is a risk of double funding if *Greening Ecological Focus Area* is also utilised. This payment offers annual payment of £284.80/ ha.

- **Creation of Low-Input Grassland to Convert Arable Land at Risk of Erosion or Flooding** (Scottish Government, 2015g)

This is a capital option and must be utilised in combination with:

- Converting Arable at Risk of Erosion or Flooding to Low-input Grassland
- Management of Floodplains
- Wetland Management

This funding mechanism offers improved soil structure, water quality and attenuation of runoff but requires evidence that the conversion will provide this. The capital payment rate is £333.51/ ha.

- **Hedgerows** (Scottish Government, 2015f, Scottish Government, 2015j, Scottish Government, 2015l, Scottish Government, 2015m, Scottish Government, 2015o, Scottish Government, 2015x)

This option enables the creation, restoration and management of hedges to improve habitat, biodiversity, soil erosion and carbon storage. Hedgerows also provide shelter for livestock and hydrologically, can slow the process of runoff by intercepting rainfall, absorbing water and enhancing soil infiltration. Hedgerow creation can be funded if access at both sides is available and payments include: £1.20 per metre per year for hedgerow creation. Management of hedgerows is paid a lesser rate of £0.11 per metre per year.

In order to obtain capital funding for hedgerows the following options are viable within SRDP:

Table 10 Alternative watering: capital payments for items

Item	Capital payment
Creating an abstraction point	£476
Solar powered pump system	£2000 – £3100 (additional £150 available for mast)
Water powered pump system	£1350
Water transfer (pipes, fittings and trough connection)	£7.70/ m
Water meter for mains supply	£150
Stock powered pump (with bowl and mounting plinth)	£450

Table 11 Indicative Forestry Grant Scheme rates

Woodland creation type	Initial planting grant	Annual maintenance grant	Rate if in Woodlands for water target area	Increased maintenance costs
Small or Farm woodland	2400/ha	400/ha/yr	2700/ha	450/ha/yr
Agroforestry	3600/ha (400 trees)	84/ha/yr (400 trees)		
NO ADDITONAL CAPITAL GRANTS	1860/ha (200 trees)	48/ha/yr (200 trees)		

- Planting or replanting of hedges
  - £5.40 per metre of planted hedge
- Coppicing of hedges (existing)
  - £3.75 per metre of coppiced hedge
- Laying of hedges (existing)
  - £12.50 per metre of hedge laid
- Stock fence (existing newly planted hedges)
  - £5.50 per metre
- Rabbit proofing an existing or new stock or deer fence (newly planted hedgerows)
  - £2.00 per metre
- Vole, rabbit or hare guards (newly planted hedges)
  - £1.20 per metre for vole guards for hedge planting
  - £1.80 per metre for rabbit or hare guards for hedge planting
- Replacement or planting of individual trees within ancient wood pasture or hedgerows (existing hedges)
  - £100 per tree planted

- Small Scale Tree and Shrub Planting (less than 0.25ha) (Scottish Government, 2015w)

This option enables capital payment for small scale planting of trees and shrubs in order to benefit: biodiversity, carbon sequestration, improved water quality (provided by shading to reduce water temperatures and a buffer area to filter sediments/ pollutants) and enhanced habitat. All land except areas classed as *sensitive* by the EIA (Forestry) (Scotland) Regulations 1999 are eligible.

This option *must* be utilised in conjunction with at least one of the following capital funding items:

- Stock Fence
- Vole, Rabbit or Hare Guards
- Scare and Temporary electric Fencing

Only native species must be planted and must be protected from any wildlife damage (as indicated by the aforementioned combination of funding sources). A maximum area of 0.25ha is permitted. The capital payment is £3.00 per tree or shrub but can simultaneously be combined with these management options:

- Managing Scrub of Conservation Value
- Water Margins in Grassland Fields
- Grass strips in Arable Fields

4-C: SRDP Funding – Forestry Grant Scheme

The Scottish Forestry Grant Scheme (FGS) has a range of measures that can be used to support woodland establishment on farms. Woodlands provide a range of benefits that include timber production, sporting interest, livestock shelter and reducing the effect of flooding and diffuse pollution. There is no maximum area of woodland that can be established, but there are thresholds for smaller areas. The grant is split into 3 parts and is a contribution towards costs – capital costs associated with fencing etc., planting costs, and annual maintenance (paid for 5 years). For smaller scale planting, the following options apply.

1. Small or farm woodlands – woodlands must be a minimum of 15 m wide covering an area of at least 0.25ha. The maximum size of an individual block is 5ha, and there is a limit of 10ha/farm business under this measure. If you want to plant a bigger area, then this will be accommodated under one of the other schemes.
2. Agroforestry – This measure will allow you to plant wide spaced trees at either 200/ha or 400/ha. All trees must be individually protected as per the published guidelines, and the area can only be used for sheep grazing (initially). The maximum area for this is 5ha /farm business. This can be made up from a variety of smaller blocks.
3. Woodlands for water – If you are in a priority area, there is an extra payment available (approximately 10%) on the initial planting payment rate, but not on the capital.

Examples of capital costs

- Deer fence – £6.80/m
- 1.2m tree shelter £2.00 each
- Gate for deer fence – £172

For further information, go to wwwruralpayments.org and search through the 'schemes' or contact your local Forestry Commission Scotland office.

4-D: SEPA Water Environment Fund (SEPA, 2015b)

This fund aims to support projects that aim to *restore* catchments and their associated rivers and lochs, which have become degraded by previous land practices. The projects must assist in delivering River Basin Management Plans beyond statutory obligations, meaning they must restore morphology (physical condition of banks and beds) and/ or remove barriers to fish migration. This fund is being extended to include projects on agricultural land that seek to introduce fencing, improve tracks and infrastructure; specifically infrastructure based grants will be awarded only to river restoration or removal of fish barriers on agricultural land.

Application deadlines are as follows:

- <£10,000 are considered year round
- >£10,000 are considered 4 times per year:
  - 30 January 2015
  - 15 April 2015
  - 24 July 2015
  - 12 October 2015

Projects must be completed within the financial year in which funds were applied for. Projects that are considered higher priority will include one or more of the following:

- Assists in supporting/ contributing towards catchment approaches

- Addresses issues highlighted in River Basin Management Plans
- Delivers multiple benefits in relation to:
  - Flooding or droughts
  - Protected species, habitats and sites
  - Carbon emissions
  - Social benefits
  - Economic benefits
  - Developing creative techniques
- Offers value for money

4-E: Scottish Water – Sustainable Land Management (SLM) Fund (Scottish Water, 2014)

This funding is aimed at landowners who can manage their land in a manner which protects drinking water sources. By improving the quality of the water at source, Scottish Water will require less effort, energy and chemical usage when treating drinking water. Landowners can apply for SLM funding for introducing measures which will improve and protect water sources beyond those statutory compliance measures. Closing dates for 2015 are: 1 April and 1 October. SLM funding is only available in the following areas of Scotland:

- Ugie
- Deveron
- Lintrathen
- Ascog
- Winterhope

4-F: Big Lottery Fund – Awards for All (The National Lottery, 2015)

This funding source is aimed at community groups, small organisations and NGOs like TCOSP and aims to help improve local communities. The fund will accept applications for £500 – £10,000 and especially those which encourage local communities to work together, learning and improving local spaces. More specifically, activities that are considered include: events, purchase of equipment, improvements to community buildings, pay volunteer expenses, pay transport costs or staff costs. The likelihood of receiving funding is enhanced if:

- The organisation receives less that £250,000 annual income
- No previous awards for all grants within the last 3 years

This type of funding is challenging to obtain because of high demand.

4-G: Garfield Weston Foundation (Garfield Weston Foundation, 2015)

This funding avenue is suited to community groups and local organisations who wish to undertake projects either under £100,000 (main grant) or over £100,000 (major grant) that propose to carry out works that enhance the natural environment, habitats and biodiversity. The foundation seeks organisations with a clear plan for specific outcomes and benefits of projects and will fund capital projects as well as organisation core costs.

Appendix 5: Indicative Excavation Costs

Table 12 Indicative excavation costs	
Equipment/ Activity	Costs
Low loader/ delivery of plant	£200 each way
25 – 30 tonne Excavator plus operator	£40 – 45 per hour (assuming clay based soil with no rock and using a large excavator bucket, excavation rates of 50-60m^3 per hour should be achieved)
10 tonne dumper/ dump truck plus operator	£25 – 30 per hour
Labourer/ Banksman	£20 per hour
All in rate for reduced level excavation (based on a minimum one week duration with clay subsoil)	£2 – 2.50 per m^3

These excavation costs apply to all measures which require the removal of material from land, banks or in-channel. They are indicative costs and may vary, therefore quotes should be sought following the design phase of any flood measures being implemented. These costs can be reduced if landowners choose to do some or all of the work themselves, depending on equipment and time available.

Appendix 6: Public Meeting Agenda

Learning From Community Led Flood Risk Management: Public Meeting

7-9pm on Monday 18th May 2015
Venue: Briarlands Farm, Blairdrummond (off A84 at the Safari Park turn-off)

Background
CREW (Scotland's Centre of Expertise for Waters), is a Scottish Government funded partnership that has funded the Heriot-Watt University and James Hutton Institute to work with the Carse of Stirling Partnership to assess potential measures that could assist in Flood Risk Management. The project is based on the example of four farms, which encompass different flooding and land management issues: this meeting provides an opportunity to learn about the measures suggested as relevant for different situations, but also provides a key opportunity for wider community engagement to provide feedback to the project.

Objectives of the meeting

- To present potential flood risk management (FRM) measures which provide opportunities to mitigate flooding problems in the study area, including information on potential sources of grants, and likely financial and/or other benefits of these measures.
- To discuss the measures with attendees, in particular the opportunities and challenges for applying these measures to similar land areas throughout the Carse.

Expected output of meeting
Opinions and feedback received during the meeting will feed into the project report, due in June 2015. This report will be delivered to the CREW Steering Group (whose members include representatives to the Scottish Government and Statutory Agencies) and will be publicly available for use by the Carse of Stirling Partnership and beyond.

Agenda

Timing	Item
6.45-7.05	Registration and refreshments
7.05-7.10	Welcome from Carse of Stirling Partnership
7.10-7.20	Introduction to the project and its rationale
7.20-8.00	Overview of the flood management measures considered by the project
8.00- 8.45	Opportunity for interaction, discussion and feedback about these measures
8.45-9.00	Wrapup and thanks

Appendix 7: Synthesis of feedback and questions by workshop participants

This table captures the feedback provided on post-its, during group discussion, and comments and questions subsequently provided in feedback forms. This table displays the comments in relation to each of the flood management measures (as per section 4), and then finally collates other comments and ideas. Comments provided by post-it are copied verbatim (with grammatical corrections). For brevity, longer comments from discussion and feedback forms are summarised

Measure	What circumstances or situations affect when this measure may be carried out?	Other comments about this measure	Questions
Two-stage channels	Stepped ditches are no good if lower ground has not done it. Even short lengths of 2-stage channels can hold more water (much more than dredging). Needs expert/morphological survey.	This can be a practical solution, in some locations. Use reverse valves to allow water to flow out of ditches (at high water levels) through levees or bunds onto fields to slowly drain over days.	Isn't there a risk of bank collapse/reverting to previous shape? What can be done with the material dug out? How big can the channel be? What locations are suitable for this? If only one farmer does this, will it still help on a stretch of burn or river? Would the use a Gabion Baskets, on bends where there is erosion by the river and the risk of the banking slipping down, be an appropriate measure to help bank stabilisation?
Remeandering	Could be used on land not in agricultural production (forestry? Peatland?) Ideally this needs two sides of a river. Some meanders on the Goodie are clearly still visible. Will impact on boundaries. Highly impractical for farming land. Has potential but capital costs are probably prohibitive. Water Environment Fund might fund this.	Good idea to have meanders – also needs smaller streams/burns to slow the flow.	Meanders may be natural but so are erosion and deposition – could these be made worse by remeandering, causing more problems for land-managers?
Dredging	Should be banned in Scottish shorter rivers. Dredging is only required every 20 years.	Could work. Thought to be the answer by most farmers. Not going to happen even if it would be effective. Unlikely to be supported by SEPA but certainly the most expedient solution When farmers talk about flooding it is drainage they are worried about. Dredging would help the drains. Could work, very feasible. Bespoke measures on every stretch of the Goodie.	What is the difference between cleaning and dredging? How do SEPA's controls/permissions work?
Removal of constrictions	Water should be lowered at the Old Drip Bridge by 18 inches – would help upstream. Kippen station – Stirling needs to speed up flow. Teith faster and gets away. Cleaning hydraulic constrictions is counter-intuitive unless in villages/towns. Allow localised flooding upstream in extreme weather, rather than increase of flow. Unlikely due to cost and listed status of many existing bridges.	This is essential now – culverts for bridges. Possible additional channels in old bridges, e.g. in illustration used on poster, and WMS bridge structure.	Is there a constriction at Machar Bridge?
Riparian buffer strips/ fencing off	Very dependent on what vegetation is encouraged: willow has been tried but doesn't have a 'spreading' root system.	This could increase the risk of giant hogweed and himalayan basalm invading. Keep cattle away from ditch banks but allow temporary access by winter sheep to clear grass growth.	What is the right type of vegetation to plant?

Measure	What circumstances or situations affect when this measure may be carried out?	Other comments about this measure	Questions
Earth bunds/ retention ponds	Can be used on peatland sites where it benefits bog restoration as well.	Storage ponds don't benefit the land-owner, but benefit lower land-owner.	Are these normally installed with a drain? Why are there not more reservoir built on uplands to hold water? As we do have droughts. Would there be a negative effect if there was a heavy rain event and the waterline flooded over the bunds, so thereby making the flooding worse?
Mole ploughing/ soil aeration	This has been shown to work well on a Carse monitor farm. There are capital costs but they are not too bad.	A skilled job, but the best option also to reduce soil compaction.	Does it work with clay soil?
Tree planting/ upland planting	Expense of planting – high capital costs, even with grants. Care needs to be taken to avoid important habitats e.g. peat. Will cause loss of cropping and grazing land. Need to not remove ancient broadleaf trees (Raploch Burn planning proposal for quarry).	Must be no hill ploughing for tree planting as this exacerbates water flow. Mounding is much better. Blockage of historical drainage- ditched plantings of pine trees to hold water on hillside.	What are the capital costs? Need to make sure that the correct tree species are proposed – what are these? Can deforestation of Gillies Hill/ Murrayshall Quarry cause more water in Raploch Burn and more flooding on the Forth? Why are flood risks so high if the Carse now has more trees than ever before? Would the AECS option "small scale tree and shrub planting" be a funding option?
Hedgerows	Great for stock shelter. Cost implication. Requires a long-term commitment.	This would be of great benefit for wildlife and landscape on some our gappy Carse hedges. Hedges should be cut correctly – wider at the bottom than at the top, to encourage growth at ground level which improves fencing effort and water catching and evaporation.	What are the capital costs? Do we need to cut these properly to get SRDP funding? Do stock fencing get SRDP funding?
Cover crops	Farmers will concentrate on crops with a return e.g. Timothy. If doing an agri-environment scheme, this is an excellent option for wildlife as not much fodder crops grown in some areas. These can interfere with primary production and if so will not be favoured.	SRDP doesn't favour the Scottish version/ variety of the Timothy crop.	

Synthesis of other comments raised during discussion or in feedback forms, that do not directly relate to above measures

Ideas about other measures to consider

Need to improve and coordinate drainage

- Mains drains service more than individual farms but not all owners maintain them, causing water to back up.
- Land drainage rather than flood management is needed. Channels need maintaining so drains have good outfall.

An inverted weir in all streams and ditches

- Allow some flow in spate conditions, but prevent excess flow in extreme conditions (holding back water,. even if it causes localised flooding on farm land, rather than in towns

Ideas about what to do next

Encourage a 'collaborative' and coordinated approach to natural flood management across catchment ('source to sea')

- Recognise/ demonstrate that different land is appropriate for different approaches
- Require all land-owner to create water-holding measures (in proportion to acerage) to reduce peak flow downstream
- Enforce water storage /slowed flows from upstream including the Lake of Menteith
- Liaise with other organisations especially upstream e.g. Lake of Menteith, National Park, Forestry Commission etc.
- Encourage field bunds, hedges, dykes, shelter-belts along contour lines. Field bunds good.
- All 'greening' measures should include water-retention features.

Consider a water framework fund bid with two stage channel over a part of the Goodie water.

Identify at risk river systems and pay a subsidy to farmers who allow significant flooding of low-lying fields (with reduced flow outlets)- making wet areas financially beneficial.

Increase understanding of the problems, how water flows across catchment, and how upstream streams affect downstream

Locals with expertise on drainage are willing to participate in discussing and planning water management.

Contribute to consultation on Flood Risk Management Plan for the Forth.

Comments on challenges

Many actions seem to require consent or regulation by SEPA: too many restrictions simply inhibit people taking any action at all.

Attitudes (e.g. Goodie area) that say "dredge, straighten & increase flow- get water quickly away from here". Each house, farm, local area & region should hold excess water for a time locally.

It is difficult to get people to work together - takes time and money

Incentivisation through tax relief or grants would help.

Other questions

If/how do tidal forces impact flooding in the Carse?

We need to look upstream to the Lake of Menteith. What are they doing? Do they/can they take downstream issues into account?

Appendix 8: Background information on The Carse of Stirling Partnership

The Carse of Stirling Partnership (TCOSP) was established during the stakeholder meetings for a previous project conducted by the LUC and STAR Development Group on behalf of Scottish Natural Heritage (SNH) (LUC and STAR, 2014), which focused on understanding ecosystem services within the Carse area and local preferences and priorities for these. These stakeholder meetings clarified that the most important ecosystem service benefit was food production and that flooding and water logging were major issues in this endeavour. The objective of farmers and land managers is to improve the efficiency of food production and to do so in a way which improves the economic and financial viability of their farms. In this connection, improving flood management and reducing water logging is crucial. The aim of the *Learning from Community Led Flood Risk Management* was to assess what flood risk management measures might be applicable and how this community-driven approach to catchment management could contribute to the Scottish Government's natural flood risk management policy development.

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