Introduction

This document summarises an initial desk based assessment of potential natural flood management opportunities within the River Teviot catchment, including the Borthwick Water, Allan Water and Slitrig Water. The study is intended to complement the core engineering works which are proposed as part of the Hawick Flood Protection Scheme which is currently being progressed to the preferred scheme stage by Scottish Borders Council.

It is hoped that the findings of this study will assist in guiding local land managers in how to align their land management procedures with the principles of natural flood management through relatively minor changes. In many instances it is believed that these modifications can be self funding though the land manager directly benefiting from reductions in flood risk or reduced maintenance costs. In other instances it is hoped that the existing environmental service funding could provide funding such as the Scottish Rural Development Programme, the SEPA River Restoration Fund and the Tweed Forum.

Objectives of natural flood management in the Teviot catchment:

• To reduce flood risk across the Teviot catchment by attenuating flood flows and improving the geomorphological stability of watercourses

• To improve the resilience of the planned Hawick Flood Protection Scheme against future uncertainty. (Climate change, design exceedence events, bridge blockage and channel sedimentation)

• To improve the environment within the Teviot catchment (socially and ecologically)

Site Visit

A site visit was undertaken on 24 February 2012 to confirm the current land uses, habitat types, and general watercourse condition of the Teviot catchment upstream of Hawick. A meeting was held with Hugh Chalmers of the Tweed Forum primarily to discuss areas within the catchment where NFM measures have already been implemented or are planned. The Tweed Forum plays a key role in liaising with local landowners and as such are therefore often aware of small scale actions being undertaken, as well as the larger projects which may be publicised more widely. Through the meeting, a number of areas were identified where NFM measures have been implemented or are planned. In the majority of locations these were upstream
planting, however some examples of channel naturalisation and floodplain planting were also identified. In many cases these were not initially conceived or implemented solely as NFM measures, but nonetheless perform some NFM functions whilst satisfying other ecological, biodiversity or habitat objectives.

Landowner engagement, and funding sources were also discussed with specific respect to areas already planted, and support to implement measures have come from many sources: Borders Forest Trust, locational premium woodland planting payments, FLAG scheme, SEPA restoration fund, SRDP and others. A number of useful contacts were also provided for other catchment stakeholders such as the Southern Uplands Partnership, SNH, landowners and estates, should this scoping study be taken forwards to a more detailed stage.

A copy of the Craik NFM Demonstration Catchment Background Report was supplied, providing useful information about the scope of research work undertaken by MNV, since the final project reporting has yet to be published.

Moving forwards with NFM working within the Teviot catchment upstream of Hawick, during the meeting a number of areas of planting and other NFM measures were identified that have as yet not progressed beyond proposal stage; several small scale hydro scheme proposals were identified which should they be progressed may have NFM elements; and several areas with new native woodland potential were identified. These are highlighted in Drawing WBSBCB-TNFM-008.

Following the meeting, a catchment reconnaissance was undertaken and several of the areas of recent planting identified during the meeting were visited, most notably larger areas at Priesthaugh and north of Roberton, (see photos on following page) as well as numerous smaller schemes. Planting is generally at an immature stage of growth, with many of the tree still contained within tree protectors.
New planting between the Penmanshall Burn and Blind Burn near Borthwickshiels. Trees are currently immature, protected in mesh tubes and the area has been fenced off to prevent livestock grazing. The planted area extends back to tie in with the existing area of woodland. (Approximate NGR 344600, 615560)

At the confluence between the Howpasley Burn and Aithouse Burn, which join to form the Borthwick Water near Craik village, the high sediment load in the Howpasley Burn can clearly be seen to the left of the blue line. High sediment is often a symptom of forestry operations or slopes left exposed after felling. (Approximate NGR 335075, 608005)

The area of new planting at Priesthaugh, identified during the meeting with the Tweed Forum can be seen shaded in red. The trees are still immature and in tubes, and the area appears to be free from grazing sheep, which can be a significant threat to saplings. It continues some upstream to the left of the picture to tie in with existing forestry. (Approximate NGR 346710, 604340)
New floodplain planting adjacent to the Borthwick Water near Douglashaugh Plantation (Approximate NGR 338690, 610170)

Downstream of Craik village, the Borthwick Water floodplain is relatively wide and flat, with natural meanders, as well as one created as part of the MNV Craik demonstration project. (Approximate NGR 335170, 608205)

Bare winter vegetation allows the filed drainage furrows to be seen on Blackcleuch Rig (taken from Caerlan Rig), which run directly down the slope and potentially channel water directly into the River Teviot. Where they are no longer required, blocking drains can be used as a NFM measure, and where new drains need to be laid, their orientation should be carefully considered to balance drainage function with conveyance speed to the watercourse. (Approximate NGR 338690, 603230)
Views of the Teviot catchment, showing relative sparse upland vegetation. Clockwise from top left:

Muselee Hill near Chisholme (341420, 611705); Old Northhouse (345540, 607075); Cringie Law nr Roberton (334735, 618150); Limiecleuch Burn from Caerlan Rig (339330, 604080)

Evidence of recent bank slippage and erosion on the Frostlie Burn, at the Teviothead public toilets and information board lay-by. Bank slips deposit significant amounts of sediment into the watercourse which can then be washed downstream. (Approximate NGR 340215, 608005)

Areas of new planting shaded in red. Clockwise from top left:

Staneyhill – maturing planting (344715, 606860); Hoscoe new planting (339250, 611605); near Philhope – felling and replanting (338950, 609685); Muselee new planting (339835, 611550)
Identification of applicable NFM methods

3.1.1 Description of catchment

The River Teviot drains approximately 320 km$^2$ of the Southern Uplands to the southwest of Hawick. The catchment extent can be seen outlined in red.

The catchment is predominately rural with large swathes of moorland, upland grazing and commercial coniferous forests. Hawick is situated in the north east of the catchment, with the river Teviot running through the town. The River Teviot has three main tributaries. The Borthwick Water drains the northern section of the catchment, the Allan Water drains the southern section and the Slitrig Water drains the east section, joining the Teviot in Hawick town centre.

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Whole catchment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment area</td>
<td>318 km$^2$</td>
</tr>
<tr>
<td>Average annual rainfall</td>
<td>1220 mm/yr</td>
</tr>
<tr>
<td>Mean altitude</td>
<td>282 m AOD</td>
</tr>
<tr>
<td>Maximum altitude</td>
<td>582 m AOD</td>
</tr>
<tr>
<td>Forestation</td>
<td>92.6 km$^2$ (29%)</td>
</tr>
<tr>
<td>Urbanisation extents</td>
<td>0.018</td>
</tr>
<tr>
<td>Average slope</td>
<td>151 m/km</td>
</tr>
<tr>
<td>Average drainage path length</td>
<td>18.92 km</td>
</tr>
<tr>
<td>Standard percentage runoff</td>
<td>43.58%</td>
</tr>
<tr>
<td>Baseflow index</td>
<td>0.429</td>
</tr>
</tbody>
</table>

Table 1: Summary of the Teviot catchment

A selection of drawings has been produced showing key aspects of the catchment:
3.1.2 Development of NFM strategy for the Teviot catchment

The River Teviot is a geomorphologically active watercourse with evidence of deposition and erosion observed and anecdotally reported upstream and within Hawick itself. A number of theoretical measures could be implemented to reduce the volume of sediment entering the watercourse and stabilise banks, although the suitability of each measure is highly location specific:

- **Gully planting** to reduce sediment release from these sources
- **Decanalisation** to provide a more geomorphologically stable channel
- **Riparian planting and fencing** to assist in providing a more geomorphologically stable channel
- **Flood peak reducing measures** as listed below

To reduce flood peaks thus helping to counteract design exceedence through climate change or the occurrence of an extreme event the following activities could be employed:

- **Upland planting** of either cross contour shelter belts to provide improved infiltration opportunities or larger expanses of woodland
- **Setup of runoff sensitive areas** so that land managers can be made aware of high risk areas and adjust their land management practices to suite. Activities within runoff sensitive areas could include reducing stocking densities where applicable, minimising land left as bare earth over the wetter months, tree planting and limiting the extents of muirburn.
- **Floodplain woodland planting** (leaky barriers) to slow down flow as it moves over the floodplain thus increasing the volume of water that can be stored on the floodplain. These have the additional benefit of capturing flooding debris and reducing the risk of downstream structure blockage.

3.1.3 Initial identification of NFM opportunities

a) **Upland planting**
An initial screening of opportunities for upland planting has been undertaken using ArcGIS. This initial assessment has identified approximately 8700Ha of upland planting opportunities. The results of the analysis are shown on drawing WBSBCB-TNFM-005.

The following criterion was used to identify opportunities for upland planting and all areas complied with the following:

- Areas identified with the runoff sensitivity analysis with effective runoff rates exceeding 300m/hr (summarised on drawing WBSBCB-TNFM-006)
- All land is below 550m altitude, taken to represent an upper limit for successful tree growth in the absence of actual data. More detailed information on land suitability for tree planting is available from the Macaulay Land Use Research Institute.
- All land was identified as Neutral, Acid or Calcareous Grasslands or Bracken in the LCM2000 dataset. Other areas such as moorland, existing forest, improved grassland and wetlands were assumed to be generally inappropriate; however in specific locations or circumstances they may also be suitable.

The following items should be considered prior to the selection of upland planting sites:

- Altitude, exposure and soil conditions should be reviewed to confirm that suitable species have been selected and that the trees will grow. The Macaulay Land Use Institute publishes national data which would assist in this process.
- Further analysis could be undertaken using the POLYSCAPE GIS Tool (University of Bangor/CEH, 2010) to identify the potential cross contour tree planting opportunities
- As many of the sites are remote the ease of access, logistics of undertaken the planting and safe working practices should also be considered.
- Care should be taken during the planning and implementation of planting that no drains, grips or other channels, either temporary or permanent, should be created running down-slope. Any excavation should be cross-contour.
- Planting density should be selected to balance optimum growing conditions for selected species, creating sufficient vegetation ‘roughness’ to slow flood water and and effective network to help stabilise soils.
- The maturity of species should be taken into consideration, with a significant proportion of fast-growing varieties included to allow some natural flood management benefits to be realised within 5 to 10 years of planting (e.g willow and alder scrub). Slower growing species may also be included for biodiversity.
b) Floodplain planting (leaky barriers)

An initial screening of opportunities for floodplain planting has been undertaken using ArcGIS. This initial assessment has identified approximately 450Ha of land on which floodplain planting may be achievable. Assuming an average increase of 50mm in floodwater depth in these areas this represents approximately 220,000 cubic metres of potential additional flow attenuation storage. Allowing for many areas not being suitable due to the presence of prime agricultural land or properties a realisable ceiling may be significantly lower. It should be noted that floodplain planting is not about causing land to be flooded more frequently, it is about reducing the speed of flow on the floodplain thus increasing water depths on land that would currently be flooded. The results of the analysis are shown on drawing WBSBCB-TNFM-007.

The following procedure was used to identify opportunities:

• The Second Generation Indicative Flood Map (SEPA, 2007) was used to estimate the extents of the floodplain

• Locations within the identified floodplain with a ground surface slope between 1 in 25 and 1 in 50 were identified as having a high potential for floodplain planting and areas with slopes above 1 in 25 were identified as having limited potential. Areas with a slope shallower than 1 in 50 were also assessed, however are more likely to be currently used for arable farming, infrastructure, amenities and housing.

• The presence of existing woodland within the catchment was not considered as part of the analysis, since it was determined that this could result in areas being overlooked either following tree felling or by inaccuracies in mapping data. However, during the site visit, a number of areas of new planting and recent felling were identified and can be seen on drawing WBSBCB-TNFM-008, however this should not be taken as comprehensive or exhaustive since it was not possible to visit all areas of the catchment.

Further considerations prior to the selection of final floodplain planting sites:

• An assessment should be made of the extents of the backwater that would be introduced to confirm that no properties would experience an increase in flood risk

• An assessment should be made to ensure that the presence of the floodplain planting would not result in an unacceptable increase in flow velocity within the main channel which may lead to undesirable geomorphological changes

It is expected that the greatest benefit in floodplain planting would be realised by prioritising areas immediately upstream of flood risk areas where there is the greatest flow accumulation. However provided the above concerns are met all floodplain planting opportunities which become available should be considered.
c) Gully planting

An initial screening of opportunities for gully planting has been undertaken using ArcGIS. This initial assessment has identified 141km of steep upland watercourses which may benefit from gully planting. The results of the analysis are summarised in drawing WBSBCB-TNFM-009.

The following procedure was used to identify opportunities:

- The Spatial Analyst was used in ArcGIS to identify the flow accumulation network for the catchment.

- Using the flow accumulation grid watercourses with catchment areas of 5Ha to 10sqkm were identified.

- Watercourses with a gradient steeper than 1 in 25 were then identified as gullies or potential gullies which could benefit from tree planting.

Further considerations prior to the final selection of gully planting sites:

- Altitude, exposure and soil conditions should be reviewed to confirm the viability of tree growth and appropriate species.

- Watercourse condition on site (actual conditions may mean that gully formation is unlikely due to very coarse bed material or minor variations in ground slope resulting in the catchment area being notably smaller than predicted).

- Priority should be given where properties are located at the foot of a gully as the large sediment load can exacerbate deposition resulting in flooding either from the local or main watercourse. Some examples of settlements located at the foot of gullies are given below, however this list is by no means exhaustive. Their inclusion on this list does not imply that they necessarily are at risk from flooding or have suffered floods in the past, nor does the exclusion of other settlements imply they are not at potential risk.

  - Stirches, Hawick on the Stirches Burn
  - Whitehaugh and Wilton Dean on the Cala Burn
  - Branxholm on Branxholm Burn
  - Harden on Harden Burn
  - Craik Village on Aithouse and Howpasely Burns
  - Woodfoot on Barnes Burn
  - Shankend on Lang Burn/ Langside Burn
  - Teinside on Teinside/ Back Burn
- As areas of the catchment are remote, the ease of access for plant and people should also be considered in conjunction with safe working practices.

- The presence of confined culverts at the foot of planted gullies should also be determined and any changes to the risk of culvert blockage as a result of the tree planting should be appropriately assessed. It is recommended that screens are only placed on culverts as an act of last resort and that other more sustainable measures such as culvert removal or upsizing are given due consideration.

d) Setup of runoff sensitive zones

An initial screening of potential runoff sensitive zones was undertaken using ArcGIS using a variation of the method outlined in TR-55 (USDA, 1986) for assessing the time of concentration for sheet flows. In total approximately 14,000Ha has been identified as having very fast potential runoff rate (>400m/hr) and a further 10,000 with a fast potential rate (300-400m/hr). This initial analysis considers the catchment in a 'bare' state, i.e. without significant vegetation or forestation to represent the worst case due to habitat degradation or extensive commercial felling. The results of the analysis are presented in drawing WBSBCB-TNFM-006.

The following procedure was used to identify runoff sensitive areas:

- It was assumed that all land coverage had a Manning’s number of 0.2 representing a fair grass coverage. It should be noted that this roughness applies to flows up to a depth of approximately 30mm. A constant roughness has been used rather than a varied roughness relating to current land coverage as the analysis is to identify the risk presented by poor management and degradation of existing ground cover and vegetation.

- The applied slope was based on a slope identified using the available DTM

- The design rainfall event was one tenth of the estimated Standard Average Annual Rainfall which had been converted to inches

Further consideration and analysis should be taken in a number of areas prior to the setting up of runoff sensitive zones:

- Consideration should be given to local ground conditions and to existing land use. Corine Land Coverage, and Hydrology of Soil Types data sets, both available via the Macaulay Land Use Research Institute, could be used to conduct a more detailed analysis using the methods provided by TR55 to assess current runoff conditions and the changes which could occur as a result of poor land management (from a flood risk management perspective). This process may be also be supplemented with Phase 1 Habitat survey data which SBC hold.

- Runoff sensitive areas upstream of actively incising gullies should be given priority as reduced runoff rates in these areas will assist in reducing gully
incision. Increased priority should be given where properties are located at
the foot of the gully, as discussed above.

- Where appropriate, modifications to the muirburn regime will need to be
consulted with SNH and other stakeholders to ensure minimal impact to the
ecological service this activity currently brings.

e) Decanalisation

A specific assessment of decanalisation opportunities across the Teviot catchment
upstream of Hawick has not been undertaken. The identification of floodplain
planting areas as shown on drawing WBSBCB-TNFM-007 could form a starting
place for the identification of decanalisation opportunities. The benefits of
decanalisation include a reduction in flow velocities, increased natural floodplain
linkage and response, and improvements to river and bank environments, and
ecological condition of the watercourse and riparian zone.

Measures which could be undertaken to reduce canalisations include:

- Placement of boulder clusters to increase the diversity of flow within the
channel. Boulders should be placed following the criteria provided in
General Binding Rule 14- The Water Environment (Controlled Activities) (Scotland)

- Adoption of a minimal intervention policy for the maintenance of
watercourses. Activities could include reassessing the need to undertake
dredging or maintain levees. In circumstances where such maintenance
activities provide protection to properties it may be necessary to continue the
current maintenance regime.

f) Riparian planting and fencing

Riparian planting and fencing are good means of stabilising the river channel and
reducing flow velocities within the channel. A secondary benefit of riparian planting
is that offers a good opportunity for habitat creation. Prior to the placement of
riparian planting the following items should be considered further:

- Riparian planting can result in an increase in flood depths with an associated
backwater being passed upstream. A hydraulic check should be conducted to
ensure no detriment to nearby properties.

- Local ground conditions should be assessed to enable the identification of
appropriate species.

- The provision of riparian fencing and the width of corridor along the
watercourse that can be given over to the riparian margin should be
considered. Where livestock are to be excluded from the watercourse
consideration should be given to how vegetation within the margin will be
managed.
Where there is evidence that the channel has been previously straightened and there is an opportunity to return the watercourse to a more natural plan form structured planting could be considered. Structured riparian planting is where clusters of trees are placed on alternate sides of a river at half the estimated wavelength of the natural channel form so as to encourage the reformation of meanders. The estimation of a river’s natural plan form is complex and this technique should only be attempted under the guidance of an experienced geomorphologist.

3.1.4 Comparison with EA method to identify catchments sensitive to land use change

The Environment Agency (EA) in England and Wales has undertaken a national runoff sensitivity assessment. It is a GIS based method which uses four key catchment variables to assess the sensitivity of a catchment to land use change: Soil type; Standard Annual Average Rainfall; Land Use and Slope.

It is applied on a coarse 1m grid resolution, and is designed as an initial assessment to identify areas which may then warrant more detailed analysis. Its primary function is not to identify areas with Natural Flood Management potential from a risk reduction perspective, but to identify areas that may be particularly sensitive to land use degradation, which often leads to an associated decrease in the hydrological condition of the catchment and increased runoff, therefore is of relevance to this study and in particular to the identification of runoff sensitive zones as described previously.


A vulnerability classification is undertaken for each variable, and each 1km grid cell within the catchment is assessed as High, Moderate, Low or Very Low sensitivity for that variable. These sensitivity scores are then averaged to generate an overall catchment sensitivity score.

Individual variable sensitivity scores for the catchment can be seen in Drawing WBSBCB-TNFM-010, and scoring summary for each variable is as follows:

- **Slope**: NEXTMap DTM data was used to classify the catchment slope as follows
  - <2 degrees – Very Low Sensitivity
  - 2-3 degrees – Low Sensitivity
  - 3-7 degrees – Moderate Sensitivity
  - >7 degrees – High Sensitivity

- **Rainfall**: Met Office SAAR Rainfall Data was used to classify the catchment annual average rainfall as follows
  - <600mm – Very Low Sensitivity
- Soil: Soils Survey data was used to determine the predominant HOST class for each cell, which were then classified as follows
  - HOST Class 24 – High Sensitivity
  - HOST Classes 7, 14, 15 and 19 – Moderate Sensitivity
  - HOST Classes 15, 26 and 29 – Low Sensitivity
  - There were no HOST Classes assessed as Very Low Sensitivity within the catchment

- Land Use: LCM2000 Land Use data was used to classify the catchment land use type as follows
  - Cereals (4.1) and Horticulture/non-cereal or unknown (4.2) – High Sensitivity
  - Arable (Not annual crop) (4.3) and Improved grassland (5.1) – Moderate Sensitivity
  - Dwarf Shrub Heath (10.1), Open Shrub Heath (10.2) and Bog (12.1) – Low Sensitivity
  - All other classes – Very Low Sensitivity

The overall catchment sensitivity scoring can be seen in Drawing WBSBCB-TNFM-011.

When compared with figure WBSBCB-TNFM-006, showing estimated worst case scenario catchment runoff rates per hour, it can be seen that there are some general similarities, however due to the additional parameters include in the EA method (soil and land cover) it also highlights an area in the middle of the catchment which is vulnerable to degradation, and therefore increased runoff rates.

3.1.5 SEPA and NFM

SEPA recently issued a position statement regarding NFM, which can be viewed on their website at the following link:
http://sepa.org.uk/flooding/flood_risk_management/working_with_nature.aspx

It outlines the responsibilities of SEPA and other parties in the consideration, implementation and management of Natural Flood Management measures within Scotland.

They are also currently undertaking a study into mapping national Natural Flood Management potential and areas of high runoff, and are likely to be publishing
further guidance on their desired way forward. This is likely to be of future significance to any detailed analysis undertaken in the Teviot catchment or elsewhere in the Scottish Borders.

4 Conclusion

The analysis undertaken during this scoping study has indicated that significant areas of the Teviot catchment upstream of Hawick, including the Borthwick and Slitrig Water tributaries show potential for natural flood management measures.

In particular, exposed slopes in the middle to upper catchment are likely to generate high runoff during storm events, and land use changes in these areas have the potential to mitigate against, or conversely exacerbate the problem.

A wide number of upper catchment gullies have been identified as planting locations, helping to slow the progression of runoff directly into the watercourses, and large areas of the mid to upper catchment have shown potential for upland planting. Significant areas of upland commercial forestry plantation are present within the catchment. These have been excluded as potential planting locations, however opportunities may arise during future felling and planting planning to include NFM elements to prevent the sudden creation of large cleared areas with high runoff generating potential.

The key to successful NFM implementation is working in cooperation with local landowners, therefore whilst this study has highlighted suitable areas from a purely analytical basis, it has not taken into account land boundaries, farming practices and local opposition. This should be considered of critical importance when planning any measures for further study or implementation.

Generally the lower catchment is not considered suitable for NFM measures for a number of reasons: it is too close to the main flood receptor (Hawick) to have any significant impact; land is generally developed, runoff generation is lower due to shallower catchment slopes and greater interception of surface flow (e.g. by vegetation, properties, drainage etc).

Given the nature of the catchment, with numerous tributaries contributing to the ultimate water levels experience on the Teviot in Hawick, care should be taken during the detailed consideration of any NFM proposals to ensure that measures on each watercourse do not cancel each other out, or inadvertently move contributing tributary flood peaks closer together, rather than apart.

SEPA is currently working towards national NFM screening for the whole of Scotland. Whilst a significant body of work has been undertaken and test catchments assessed with a proposed methodology, realistically this work may not be fully published until the end of 2013. Therefore depending on the timescale of the Hawick Direct Defences work, SBC may wish to progress NFM within the Teviot catchment prior to this date, in which case further analysis could be undertaken on either smaller tributaries with a known localised flood risk, or considering the whole catchment in general to quantify measures that may have a positive impact in Hawick.
<table>
<thead>
<tr>
<th>Technical note</th>
<th>River Teviot Natural Flood Management</th>
<th>Page 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>Hawick Flood Protection Scheme</td>
<td>Ref</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WBSBCB</td>
</tr>
</tbody>
</table>