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Subject	Musselburgh Flood Protection Scheme LFRMP Actions and possible Natural / Catchment / Sustainable Flood Management Review		
Ref:	MFPS-S2-JEC-XXX-TN-Z-0002	Status	Final
Attention	Conor Price, East Lothian Council	Version	1.1
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Date	18/05/2018		
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1. Introduction

The Musselburgh Flood Protection Scheme (“the Scheme”) aims to satisfy 33 wide ranging specific project objectives, which were defined by East Lothian Council in April 2017. A number of these objectives relate to delivering flood protection in a sustainable and environmentally sensitive manner, including:

- “To deliver the Scheme in accordance with the agreed Local Flood Risk Management Plan.”
- “To ensure that the Scheme is sustainable.”
- “To ensure that the Scheme includes appropriate catchment and natural flood management measures.”

The aim of this document is to define Jacobs proposed approach to satisfying these objectives, with specific reference to Natural Flood Management (NFM), Sustainable Flood Management (SFM) and Engineered Catchment Flood Management (ECFM). The specific objectives of this document are:

- To review the Local Flood Risk Management Plan for the Musselburgh Potentially Vulnerable Areas (PVA) and consider which of the actions the Scheme may be able to discharge, or assist in discharging;
- To consider how potential NFM, SFM and ECFM measures could be included in the Scheme;
- Determining the information which is required to adequately assess the feasibility of NFM, SFM and ECFM measures;
- Identify if that information is already available and, if not, what steps are required to obtain it;

- Propose the way forward for assessing the feasibility of NFM, SFM and ECFM measures in Stage 3 of the project.

2. Local Flood Risk Management Plans

The Flood Risk Management (Scotland) Act 2009 focusses on taking a catchment-based approach to managing flood risk. It has been the driving force behind the development of the Local Flood Risk Management Plans (LFRMP), including the plan for the Forth Estuary¹, which identify flood risks within each catchment and set out actions to be undertaken to manage these risks. These plans were published by all Responsible Authorities (including East Lothian Council), in June 2016, and set out a time table of management actions that will be delivered for areas identified as being at risk of flooding.

Musselburgh is covered by two Potentially Vulnerable Areas (PVA):

- PVA 10/21: Musselburgh²
- PVA 10/22: Lasswade, Penicuik, Dalkeith and Musselburgh³

¹ http://apps.sepa.org.uk/frmstrategies/pdf/lpd/LPD_10_Overview.pdf

² http://apps.sepa.org.uk/frmstrategies/pdf/pva/PVA_10_21_Full.pdf

³ http://apps.sepa.org.uk/frmstrategies/pdf/pva/PVA_10_22_Full.pdf

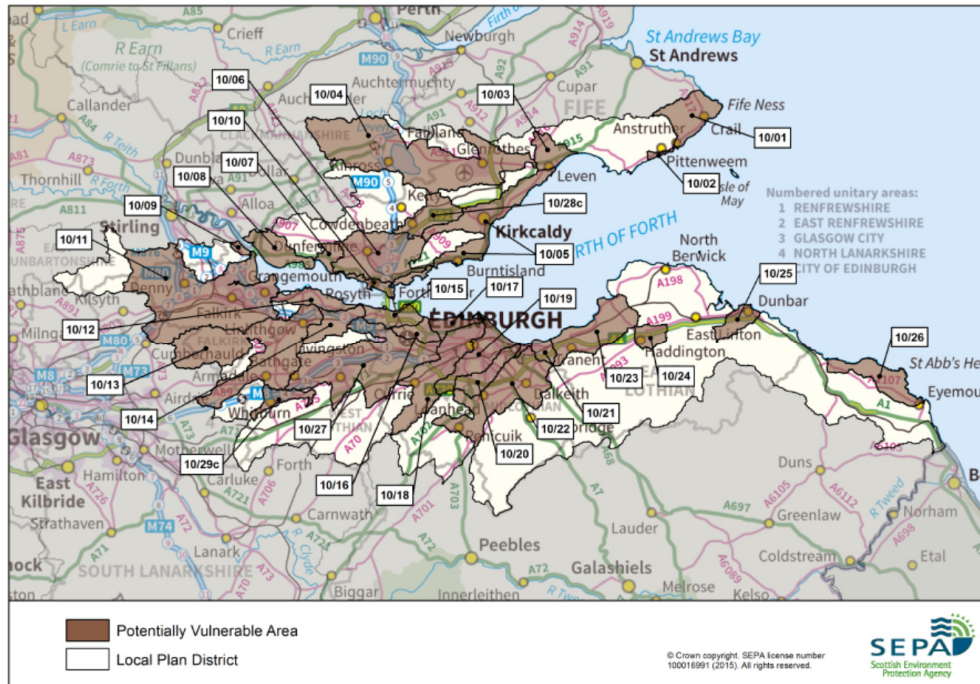


Figure 1: Forth Estuary Local Plan District and associated PVA locations

PVAs are areas that are identified as being at a significant risk of flooding from one or more sources. Musselburgh is noted as being at risk from coastal, surface water and river flooding. Within the LFRMP for the Forth Estuary, the plan objectives for each PVA have been linked to a shortlist of specific actions to address the flood risks identified. The actions identified for PVA 10/21 and 10/22 are summarised in Table 1.

The Scheme is focused on delivering the first action 'Flood protection scheme/works' (ID 100750006) through the Option Appraisal Process. However, there is scope for additional work to be undertaken alongside the project to deliver, or assist in delivering other actions, and for the outputs of the Scheme project to form key inputs to the remaining actions.

For PVAs 10/21 and 10/22 Table 2 identifies how works within the Scheme, including a stand-alone assessment of scoping assessment of SFM, may support/contribute to the delivery (in part) other actions and associated objectives.

Table 1: LFRMP Short List of Actions

PVA	Flood Protection scheme/works	Natural flood management works	New flood warning	Flood protection study	Natural flood management study	Surface water plan/study	Strategic mapping and modelling	Maintain flood protection scheme	Maintain flood warning	Flood forecasting	Property level protection scheme	Community flood action groups	Self help	Awareness raising	Maintenance	Site protection plans	Emergency plans/response	Planning polices
10/21	✓				✓	✓	✓	N/A	✓	✓		✓	✓	✓	✓		✓	✓
10/22	✓			✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓

Table 2: Scheme contribution to delivery of LFRMP actions

Action	Scheme Contribution to Delivery
Natural Flood Management Study	Coastal and fluvial baseline studies can be expanded to include identification areas that could reduce flood risk in Musselburgh and beyond through catchment/sustainable/NFM measures. It is noted that the LFRMP makes particular reference to wave attenuation, and whether it could reduce coastal risk, possibly as part of the Musselburgh FPS. Outputs of assessment would inform the location and scope of potential NFM studies and inform future models.
Surface Water Plan/Study	Identification of flood mechanisms within the catchment will inform the location and scope of potential Surface Water Management studies and plans.
Strategic Mapping and Modelling	Hydrological, hydraulic and coastal flood models built to inform the Scheme can be used by stakeholders to expand/update existing flood maps and models.
Maintain flood warning	Proposed actions within the Scheme will inform updates that may be required to existing flood warning schemes
Flood forecasting	Data collected and models built for the Scheme might be used to inform and update existing forecasting systems once measures are in place, including time to peak, peak flows/levels and optimal conditions for (coastal) flooding to occur).
Community Flood Action Groups	Identification of key flood mechanisms and extents within Musselburgh will help inform new/existing flood action groups of areas affected. Engagement with action groups as a stakeholder.
Self Help	Identification of key flood mechanisms and extents within Musselburgh will help inform people and businesses if they may be directly or indirectly affected by flooding, the likelihood and magnitude of potential impacts, enabling them to plan and take preventative steps/management actions.

Action	Scheme Contribution to Delivery
Awareness Raising	Through public/stakeholder engagement activities held throughout the Scheme development process, and through publication of report findings, will help raise awareness of flooding issues within Musselburgh and the River Esk catchment.
Maintenance	The Scheme will identify existing structures and, where suitable, undertake failure analysis of structures on flood risk. This data can be used to inform maintenance plans and schedules.
Emergency plans/response	In line with flood forecasting, outputs from the Scheme will also help identify timing/duration of flows, map velocity and depth of flows, which will help plan responses to managing risks to people, property and infrastructure during flood events.
Planning policies	Identification of flood risk area and proposed measures can be used to inform local planning policies to help prevent unsuitable development in 'at risk' areas, and to guide more sustainable development practices in key areas.

It is therefore proposed that, in order to satisfy the relevant key project objectives identified in Section 1 of this technical note, a study into the feasibility of including NFM / CFM / ECFM measures within the Scheme should be taken forward and should be included as part of the Scheme's remit. The scope of this study is discussed further in section 5 of this document. Whether any such measure is ultimately included as a FPS Operation is function of the feasibility study outputs and subsequent option appraisal process.

The results of the study can of course be shared with the relevant bodies involved in promoting and delivering NFM and SFM on a wider scale.

3. Natural, Sustainable and Catchment Flood Risk Management

The Flood Risk Management (Scotland) Act, 2009: Delivering Sustainable Flood Risk Management⁴ guidance states:

"In recognition of the range of potential benefits that can be obtained from working with our natural landscape, all reasonable and practical efforts should be made to enhance the (urban and rural) landscapes natural ability to slow and store flood waters"

When assessing options to tackle flooding in urban areas it is considered necessary, as part of the appraisal of potential flood management measures, to identify and understand all flood mechanisms and physical and ecological interactions within the catchment in which areas of flood risk are located. Table 3 considers some of the possible measures (not exhaustive) within the Natural, Sustainable and Catchment Flood Risk Management categories (fluvial and coastal) to provide context to this technical note. Table 3

⁴ <http://www.gov.scot/Resource/Doc/351427/0117868.pdf>

also highlights examples of such measures which have been implemented elsewhere, and which should be part of the desk study activity within the feasibility study scope (see section 5 of this note for details)

Table 3: Examples of NFM, SFM and ECFM measures which could be considered for the Scheme

Natural Flood Management measures	Sustainable Flood Management measures	Engineered Catchment Flood Management measures
Mesoscale tree and vegetation planting (e.g. hectares of planting to increase interception and infiltration rates in sensitive runoff areas) (Pickering Beck N Yorks)	Engineered Log Jams (ELJs) to attenuate and translate hydrograph peaks on small tributaries to the major river systems (e.g. Long Philip Burn in Selkirk, Belford FAS< Northumberland))	Flood Storage Areas, comprising large earth embankments constructed across floodplains to store large volumes of water through deliberate flooding of agricultural land (e.g. White Cart FPS, Pickering Beck, N Yorks)
Microscale tree and vegetation planting (e.g. riparian buffer strips or LWD leaky barriers on flood plains) (Pickering Beck, N Yorks)	Adaption of existing waterbodies or reservoirs for the purposes of increasing their flood storage potential (e.g. St Mary's Loch, Selkirk)	Catchment transfer – construction of open channels or tunnels to transfer flow from one catchment to a less sensitive adjacent catchment
Reduce or rotate livestock density in runoff sensitive fields to increase vegetation cover, slowing runoff rates	Recoupling of the channel to the floodplain by removing existing man-made levees, increasing the storage capacity of flood plains during low to moderate flood events	Dune reinforcement techniques to build on establishment and enhancement through provision of engineered backstop or core to the dunes to provide confidence on the standard of protection achieved
Dune establishment techniques to encourage natural accretion of sand dunes through targeted vegetation establishment in candidate areas where natural sand accretion is predicted or observed	Re-meandering of channels which have been historically artificially straightened for the benefits of agriculture, thus slowing down the flow and arrival of the peak (e.g. River Peffery (proposed) Dingwall and Eddleston Water, Scottish Borders)	Pumping Stations to well point areas prone to ground water flooding and / or to deal with areas at risk from surface water flooding
Wetland enhancement by reducing the ability of existing wetland areas to drain (expand wetted area), naturally encouraging typical wetland vegetation to establish with time	Dune enhancement to build on dune establishment techniques, by virtue of artificially depositing sand from other sources to encourage dune accretion (e.g. Hightown dune restoration, Liverpool)	
Saltmarsh establishment and / or re-establishment to help with wave attenuation (various studies into the effectiveness of this approach in Norfolk)	Provision of Sustainable Urban Drainage Systems (SUDS) on smaller urbanised catchments to attenuate flood peaks and improve water quality (various urban developments)	

Within the Musselburgh FPS ITT document, Item 1.7 within the project Activity Schedule and Section 2.17.2 states:

"It is envisaged that at this early stage of the project that the principal areas (within existing information) that the new Design Consultant need consider are...3. The possible sources and mechanisms of flood risk to the town and whether these have been suitably investigated and/or understood to date..."

Therefore, in order deliver this objective, the hydrological baseline assessment to inform the Scheme should be undertaken at the catchment scale to enable the identification of existing flooding mechanisms across the catchment, examine how these interact as they move downstream, and how they contribute to flooding within Musselburgh. This baseline hydrological assessment is one of the critical path actions in Stage 3 and will be used to provide one of the key data sets in analysing the feasibility of fluvial NFM / SFM / ECFM measures above Musselburgh.

Many of the principles that apply to catchments also apply to coastal areas, with actions in one place potentially affecting other areas of the coastline. In order to delineate appropriate management units for coastal areas, careful consideration should be given to coastal and estuarine processes and interactions. Therefore, the coastal baseline assessment should be undertaken at the coastal unit scale when identifying existing coastal mechanisms that contribute to flooding in Musselburgh.

A Joint Probability Analysis (JPA) should also be undertaken to identify how fluvial and coastal flood mechanisms interact, identifying under what conditions smaller, more frequent events may combine and result in more significant flooding events within Musselburgh.

4. Data Requirements, Guidance Documents and Literature Review

In order to adequately inform the Stage 3 NFM / SFM / ECFM Study, a range of hydrological, topographical and land use data requires to be obtained. Much of this data is included in Jacobs March 2018 report entitled, "Stage 2 - Gap Analysis Report"; additional data requirements are set out in Table 4.

Table 4: Data gap analysis

Data Set / Report	Date	Source	Description
Literature/Case-Study Review			
Natural Flood Management Network Scotland		https://www.nfm.scot/	Network looking at sustainable flood management projects and a knowledge-sharing hub.
Green Infrastructure Forum		http://www.sgif.org.uk/	Forum looking at green infrastructure to manage surface water issues in urban areas across Scotland.
Working with Natural Processes		https://www.gov.uk/government/publications/working-with-natural-processes-to-reduce-flood-risk	Environment Agency knowledge-hub. Includes literature and case study reviews, which look at the evidence for the effectiveness of sustainable flood management techniques.
River Restoration Centre		http://www.therrc.co.uk/uk-projects-map	Maps and resources for river restoration projects (including those undertaken for flood management purposes) across the U.K.
Ecology			
All Environmental Designation information	Current	https://gateway.snh.gov.uk/sitelink/ https://map.environment.gov.scot/sewebmap/	Maps of international, national and local designated environmental sites within the study area.
Forestry Commission Scotland sites	Current	http://data-forestry.opendata.arcgis.com/datasets?t=Scotland	Locations of Forestry Commission Scotland sites and land ownership
Tree Preservation Areas	Current	http://www.spatialhub.scot/get-data/	Details of tree preservation areas across Scotland
Water Environment			
River Basin Management Plans	Current	https://map.environment.gov.scot/sewebmap/	Identification of water quality status of waterbodies within Scotland in relation to

		http://apps.sepa.org.uk/waterbodydatasheets/	the Water Framework Directive objectives, and waterbody data sheets.
Marine Habitats	Various	https://marinescotland.atkinsgeospatial.com/nmpi/	Online map with data sets available from Marine Scotland, used to inform the National Marine Plan
National Marine Plan	Current	http://www.gov.scot/Resource/0047/00475466.pdf	Strategy for the sustainable management of Scotland's marine environment.
Bathymetry	TBC	<u>TBC</u>	Bathymetric surveys of the nearshore area and up to the tidal limit at Mean High Water Springs if the LiDAR data is not able to deliver this.
Beach profiles	ELC	<u>TBC</u>	Any monitoring data held by ELC or other relevant bodies, that have recorded beach profiles over time within the study area.
Historic Environment			
Historic Sites	Current	http://pastmap.org.uk/map http://portal.historicenvironment.scot/spatialdownloads	Historic Scotland map identifying historic sites in Scotland, including Historic Marine Protected Areas. May be a need to purchase some maps.
Land, Soils, Geology			
Aerial photographs	TBC	TBC	Data would be most useful at low tide and also in winter when lowest vegetation coverage.
Land cover maps	LCM2015	https://www.ceh.ac.uk/services/land-cover-map-2015 http://gateway.snh.gov.uk/natural-spaces/index.jsp	Latest Land Cover Map released by CEH in 2017. Available for use under licence. EUNIS Land Cover Map from SNH
Land use maps	Scotland's Land Use Strategy	http://www.gov.scot/Topics/Environment/Countryside/Landusestrategy	Sets out the Scottish Government's Land Use Strategy for 2016 – 2021
Soil maps	Current	http://www.hutton.ac.uk/learning/natural-resource-datasets/soilshutton/soils-maps-scotland/download	Data downloads from the James Hutton Institute
Topography	Various	https://remotesensingdata.gov.scot/collections https://www.ordnancesurvey.co.uk/openadatadownload/products.html	LiDAR cover for Scotland available under an Open Data licence. OS Terrain 50, 1:50k scale contours, available under an Open Data licence. Any new lidar data flown should be undertaken at lowest tide (ideally mean low water springs).

The study will be progressed in accordance with current best practice and guidance, including:

- Natural Flood Management Handbook, SEPA 2015;
- Working with Natural Processes: Evidence Directory, Environment Agency, 2018
- Identifying Opportunities for NFM, SEPA, 2013
- Methods to Screen and Quantify Natural Flood Management Effects, SEPA and FCS, 2012
- Estuary Edges: Ecological Design Guidance⁵; Environment Agency, 2009.
- Flood Modelling Guidance for Responsible Authorities, v1.1, SEPA, 2015
- Technical Flood Risk Guidance for Stakeholders, SEPA, 2014
- Methods to screen and quantify NFM effects, Halcrow 2012 (Report to SEPA and FCS by Nutt, N)

Where it is proposed to follow new techniques or modelling methodologies, these will be discussed and agreed with the relevant technical stakeholders (e.g. ELC and SEPA) prior to the works being undertaken.

⁵ <http://www.ecrr.org/Portals/27/Publications/Estuary%20Edges%20-%20design%20advice.pdf>

5. Feasibility Study

In Stage 3, Activity Schedule Item 2.7 defines the requirement to undertake a review of flooding mechanisms that affect Musselburgh, and assess the potential for wider sustainable flood management measures to be used at a catchment and coastal scale to manage flood risk in Musselburgh. The data identified in Table 4 will be used to input to the following steps which will assist ELC in determining what catchment-wide land and water management measures might be considered to manage flood risk as part of the Scheme. It is envisaged that the study is taken forward in two phases, such that sufficient information is available at the end of phase 1 to input into the “early discounting of options” activity within the overall Scheme Stage 3 option appraisal process. This will reduce the risk of potentially abortive work in the event that NFM / SFM / ECFM measures are not feasible.

Phase 1

- Identification of the baseline fluvial and coastal study areas;
- Review of the inputs and conclusions from existing NFM / SFM / ECFM feasibility studies for the River Esk;
- Character of existing study area (e.g. topography, bathymetry, land use, geology, hydrology etc.);
- High-level literature and case-study review of catchment-based approaches to flood and coastal risk management, to illustrate best-practice and lessons learned that may be relevant to the Scheme;
- Construction of distributed hydrological model, coastal and JPA models to inform the identification of existing source-pathway-impact linkages for river and coastal flooding mechanisms;
- Qualitative assessment of the feasibility of using different measures/techniques within the natural and urban landscapes to slow and store water, including NFM measures and potential wave attenuation measures, for contributing to the management/reduction of flood risks within the catchment / shoreline and, ultimately, Musselburgh, as identified in the LFRMP;

Phase 2

- Consultation with key stakeholders on the possible options and their advantages and disadvantages (SEPA, RFFT, Mid Lothian Council, Scottish Water, Forestry Commission, major land owners, etc.);
- Assessing the potential opportunities to deliver wider benefits (to be taken forward by others where such measures are not part of the Scheme) through use of sustainable management measures within the study areas including:
 - Other LFRMP actions, e.g. Surface water management, community engagement, assessment of NFM potential in other towns/villages
 - Diffuse pollution modelling
 - WFD status improvement

- River, coastal and habitat restoration projects
- Green Infrastructure and Green Corridor assessments
- Summary of potential measures that can realistically be considered as part of the Scheme option appraisal process, and how these might be progressed to deliver LFRMP actions and associated objectives.
- Summary of potential NFM / SFM / ECFM measures that could progressed and funded by others as supplementary or stand-alone projects, with an outline of the next steps required to progress any potential opportunities identified with, or by, relevant stakeholders.

It is suggested, given the different requirements and focus, that the coastal and fluvial elements of the study are undertaken as separate work packages, progressed in parallel, once the boundary between the two study areas has been discussed and agreed. Both elements of the study should be undertaken in close collaboration with SEPA, other Responsible Authorities and relevant stakeholders.

As part of the feasibility study, it may be necessary to use different software to undertake various elements of the analysis. Where relevant licences are not already held for software, it may be necessary to obtain a licence for the purpose of the study, however these will only be obtained with the agreement of ELC.

6. Conclusions and Recommendations

This technical note has reviewed the main factors which influence the feasibility of including Natural, Sustainable and Engineered Catchment Flood Risk Management measures within a flood protection scheme.

The principal conclusion is that, given the Client's desire to deliver a sustainable and environmentally acceptable Scheme (as defined by the project objectives), a Stage 3 feasibility study for potentially including such measures within the Scheme should be taken forward and should be included as part of the Scheme's remit.

It is recommended that the Stage 3 feasibility study is taken forward in stages, with the main feasibility review work undertaken following completion of the desk based study and coastal and fluvial hydrology. Introducing this hold point ensures that if the high-level outputs derived from the hydrology and desk studies show that NFM / SFM / ECFM measures are not feasible, then such options can be considered as "early discounted" options within the overall option appraisal process.