Case study 13

Lustrum Beck runoff attenuation modelling - Stockton on Tees

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1. Catchment summary

Study location

Lustrum Beck catchment, Stockton-on-Tees (Figure 1).

Catchment summary

The primary objective of this project is to store water in the upper catchment to reduce flood risk to more than 150 properties in Stockton-on-Tees. A number of infrastructure assets have been identified as significant sources of rapid run-off (Durham Tees Valley Airport and 10km of the A66).The impact of these on the flood peak is to be determined and sustainable urban drainage systems (SUDS) deployed if shown to be beneficial in reducing the peak. Lustrum Beck has a poor ecological status due to diffuse pollution.

Study summary

The project is a £3 million flood risk management scheme which will reduce the risk of flooding to over 150 properties in Stockton-on-Tees. The scheme consists of two phases and is being implemented by the Environment Agency working in partnership with Stockton Borough Council. Phase 1 is underway and involves the construction of hard defences in the urban area of the catchment. Phase 2 is under development and involves storing water in the rural part of catchment, with measures being put in place between 2015 and 2019.

Phase 2 will involve storing water at a range of scales in the catchment area upstream of Stockton (see Figure 1). The potential to store water through Working with Natural Processes (WwNP) in the upstream catchment, SUDS and a large traditional storage area in Stockton-on -Tees (though less than 10,000m3) is being investigated. Use of WwNP will require working with landowners within the catchment to slow and store surface run-off and peak flow from watercourses to ultimately reduce the peak flow in Lustrum Beck before it reaches Stockton-on-Tees.

Stockton Borough Council is contributing financially to the project and leading on the replacement of a bridge on Durham Road. The Council owns land at Sixfields and is developing a recreation regeneration plan for this site where it would like to include storage of water and habitat creation. It also owns land along Greens Back and a number of tenanted farms.

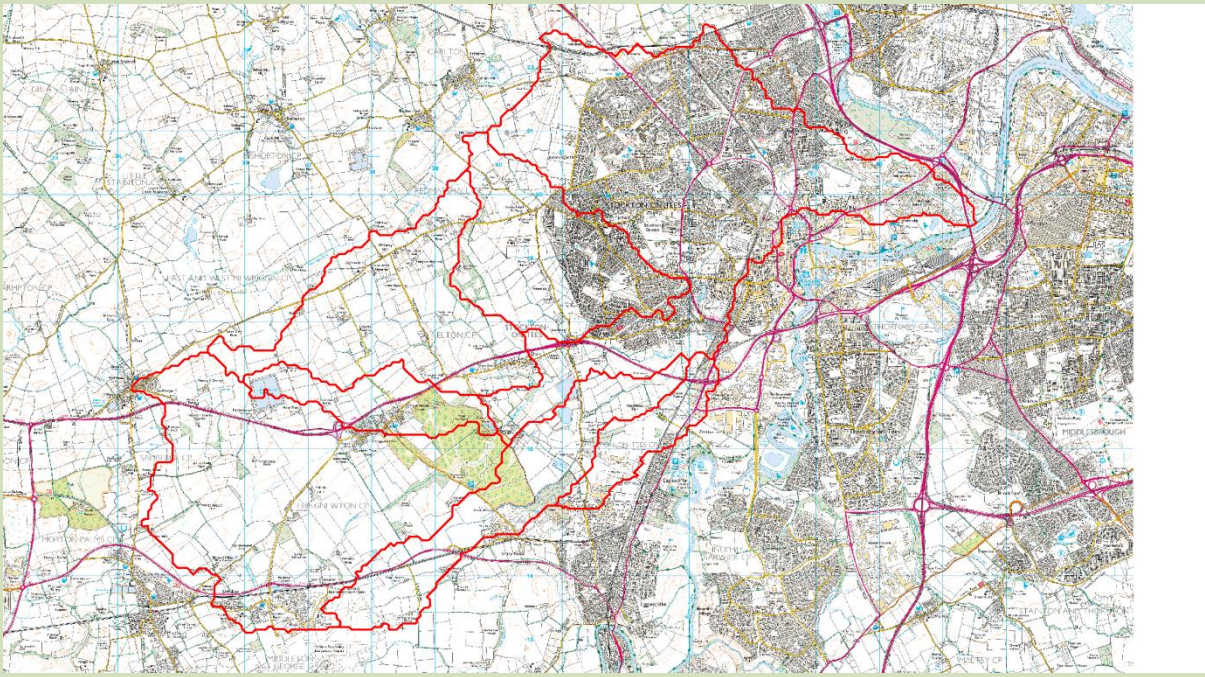

Figure 1: Catchment areas for Lustrum Beck – manageable sub-catchments have been highlighted for investigating natural flood management

Source: Arup

Community involvement

The Environment Agency is developing a strategy for engaging with the 70 different landowners in the catchment. This integrated strategy will involve one main contact communicating with landowners on a range of topics. This person would discuss potential opportunities for WwNP, including improved land management, countryside stewardship and larger water storage areas. The Environment Agency is also working with the Forestry Commission to discuss floodplain interventions within Coatham Wood, a relatively new Forestry Commission site of 1.7km2.

2. Data summary

Datasets and analysis techniques used

The catchment will be intensively monitored using telemetered level sensors and flow gauges at pond feature outfalls.

Data restrictions

The Environment Agency is the lead partner in this project, so obtaining data is not a problem.

3. Model summary

Catchment processes investigated

The simple modelling tool being used in this project is based on the mathematics behind the hypothetical Farm Pond Location Tool (PLOT) created for Belford in Northumberland (Nicholson et al. 2012). The tool represents physical storage by routing 'target' flow into offline storage, which returns to the model at a slower rate – depending on outflow pipe size, maximum storage depth and number of storage ponds. The Environment Agency is hoping to secure further funding for model development. Newcastle University will be measuring the water levels in the system in an attempt to track flood peaks and assess WwNP features.

Phase 1 of the Lustrum flood alleviation scheme is designed to achieve a standard level of protection of 1 in 75 years. The aim for Phase 2 is that the WwNP element of the work will be able to reduce flows from the 1 100 years event to below the threshold of flooding of the 1 75 years event. The WwNP scheme will therefore in theory raise the standard of protection from 1 in 75 years to 1 in 100 years, although it is part of a wider solution that includes other defences.

The synchronicity and timing of flood peaks from the subcatchments that make up the total catchment area are being considered. Subcatchments have been targeted based on the greatest potential benefit to downstream flood risk.

The following measures were investigated:

- Measures to intercept run-off on farmland in storage ponds:
- use of large woody debris in small channels
- planting and stewardship schemes
- Sediment – as above, with the added benefit of capturing sediment
- Effects of longitudinal barriers (these disconnect rivers from their floodplains during flood events)

Model assumptions

A bespoke 'PONDS' modelling tool has been developed to aid planning of WwNP features within the catchment. The tool's main assumption is that any physical storage added to the system will work perfectly for the design event and is added as the total storage for each subcatchment. The tool does not specifically locate storage within each subcatchment, but assigns a total storage for each one. The user changes the total storage and can vary the flow to target to storage (for example, flows greater than 5m3 per second are eligible for storage). It is intended that this tool will be made more generic for wider applicability, but it does not yet handle routing sufficiently accurately to understand the impacts further downstream.

Data and model outputs

Newcastle University has been commissioned to monitor the catchment for at least 2 years, though it has not yet released any data. Cameras will be used to assess WwNP features, many of which will aim to deliver habitat and increased biodiversity. Some of the initial findings in the JBA scoping report and from the Environment Agency modelling tool will be made available.

Figure 2 shows an example output from the bespoke modelling tool, identifying how a total storage of approximately 100,000m3 within the total catchment area (40,000m3 in subcatchment 1, 10,000m3 in subcatchment 2, 35,000m3 in subcatchment 3 and 10,000m3 in subcatchment 6) could reduce discharge from the 1 in 100 years return period event by 11.5%. This would reduce the peak flow of the 1 in 100 years to less than the 1 in 75 years event, thus increasing the standard of protection.

Model performance

The Environment Agency currently has two MSc students (one from Newcastle University and the one from Durham University) assessing the impacts of storm tracking and climate change on the proposals.

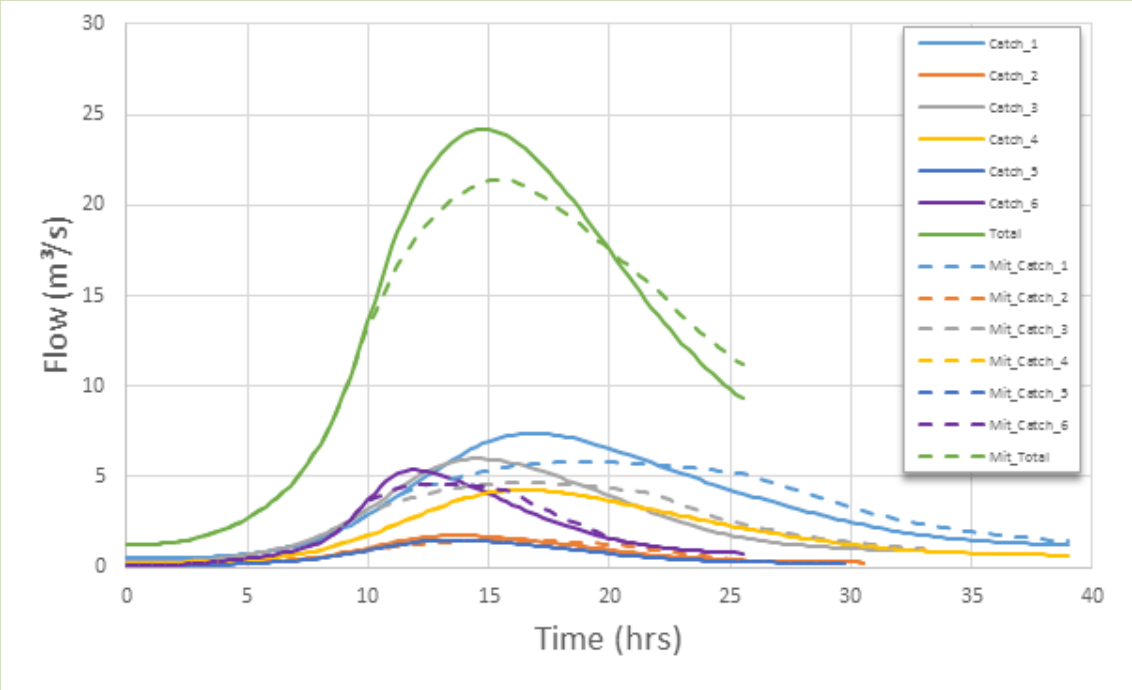

Figure 2: Theoretical reduction in peak floods using different scenarios

Source: Newcastle University

4. Lesson learnt

Choice of tools

The bespoke tool has not yet been developed sufficiently for further applications. However, it has been shown at a local level to be in agreement with a representation of the catchment using the ISIS modelling package.

Catchment scale and typology

The modelling approach lumps the additional storage from WwNP approaches for subcatchments rather than modelling every feature. The impact of this additional WwNP storage was considered up to point of interest for a 43km2 catchment.

Wider benefits

Wider environmental benefits are not being explicitly modelled although, for example, the use of pond storage will lead to areas being wetted more frequently, thus improving habitat.

Future research needs

The case study should help guide future projects by laying down a process for implementation. Example Environment Agency Project Assurance Board documents, which secured Flood Defence Grant in Aid funding for the scheme, will be useful in helping future schemes get off the ground. The integrated approach through discussions with Natural England should aid better understanding of the payments available to farmers. It is hoped that the bespoke modelling tools and mapping processes will also aid future projects.

5. Bibliography

NICHOLSON, A.R., WILKINSON, M.E., O'DONNELL, G.M. AND QUINN, P.F., 2012. Runoff attenuation features: a sustainable flood mitigation strategy in the Belford catchment, UK. Area, 44 (4), 463-469.

WILKINSON, M. AND QUINN, P., 2010. Belford catchment proactive flood solutions: a toolkit for managing runoff in the rural landscape. In Agriculture and the Environment VIII. Climate, Water and Soil: Science, Policy and Practice, Proceedings of the SAC and SEPA Biennial Conference (Edinburgh, 31 March to 1 April 2010), edited by K. Crighton and R. Audsley, 103-110.

WILKINSON, M., QUINN, P., BENSON, I. AND WELTON, P., 2010a. Run-off management: mitigation measures for disconnecting flow pathways in the Belford Burn catchment to reduce flood risk. In Managing Consequences of a Changing Global Environment, Proceedings of 3rd BHS International Conference (Newcastle, 19–23 July 2010). British Hydrological Society.

WILKINSON, M., QUINN, P. AND WELTON, P., 2010b. Runoff management during the September 2008 floods in the Belford catchment, Northumberland. Journal of Flood Risk Management, 3 (2010), 285-295.

Project background

This case study relates to information from project SC120015 'How to model and map catchment processes when flood risk management planning'.

It was commissioned by the Environment Agency's Evidence Directorate, as part of the joint Flood and Coastal Erosion Risk Management Research and Development Programme.

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