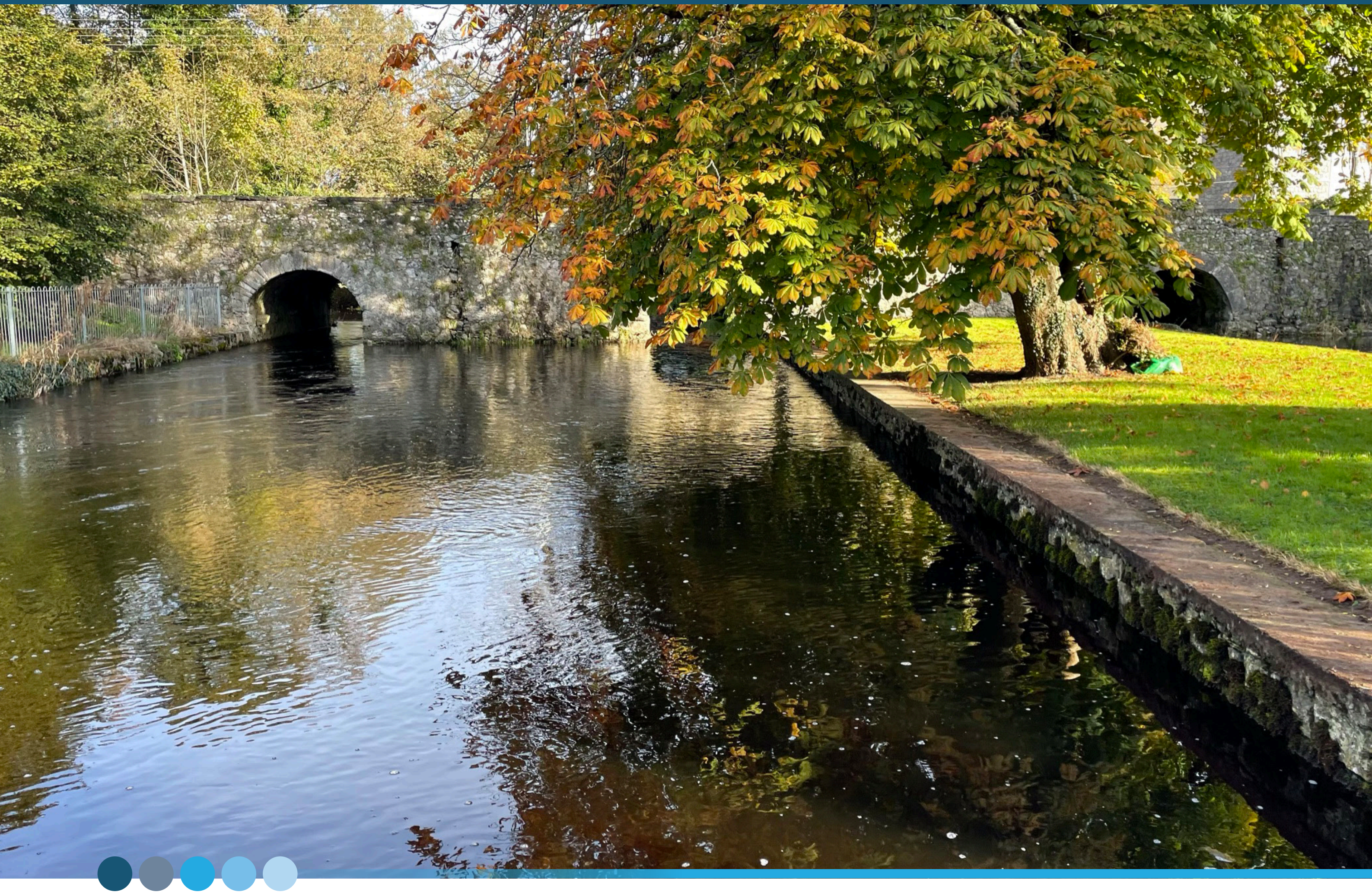
Oifig na nOibreacha Poiblí
Office of Public Works

Ballinasloe Flood Relief Scheme

Natural Water Retention Measures Feasibility Report

February 2022 | 271741-00



Comhairle Chontae na Gaillimhe
Galway County Council

ARUP

Office of Public Works

Ballinasloe Flood Relief Scheme

Natural Water Retention Measures Feasibility Report

V1.0 Final | 3 February 2022

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Contents

Appendices

1 Introduction

Arup has been commissioned by the Office of Public Works (OPW) to develop a Flood Relief Scheme (FRS) for Ballinasloe. The overall scheme will consist of flood alleviation measures along the River Suck and its tributaries which will offer the required standard of protection against fluvial flooding.

There are five stages to the project:

- Stage I - Development of a number of flood defence options and the identification of a preferred Scheme;
- Stage II - Public exhibition;
- Stage III - Detailed design, confirmation and tender;
- Stage IV – Construction;
- Stage V - Handover of works.

This report details the assessment undertaken of the potential for Natural Water Retention Measures (NWRM) to form part of the proposed flood relief scheme. This report is produced as part of Stage I of the project in accordance with Section 3.4.6 of the project brief.

Natural Water Retention Measures, also known as Nature-based Catchment Management (NbCM) or Natural Flood Management (NFM), involves implementing features to restore or mimic the natural functions of rivers, floodplains and the wider catchment to reduce flood risk downstream[1].

Traditional methods of reducing flood risk often involve large concrete and metal structures in and around towns, often including walls and embankments which create a divide between communities and our natural watercourses. However, there is an increasing demand to look at the wider landscape to manage flood risk, by slowing water down before it reaches our towns and cities, and temporarily storing it elsewhere during times of flood. NFM aims to store water in the landscape, where it will not cause damage to properties or infrastructure, and slow the rate at which water runs across the landscape and into rivers.

1.1 Study Area

The study area comprises the majority of the River Suck catchment, encompassing Castlerea in the north and Ballinasloe in the south, as shown in Figure 1. The River Suck joins the River Shannon approximately 13km downstream of the M6 at Shannon Bridge.

[1] Yorkshire Dales National Park Authority, Yorkshire Dales Rivers Trust and North Yorkshire County Council, with support from Natural England and the Environment Agency (2018) Natural Flood Management Measures – a practical guide for farmers.

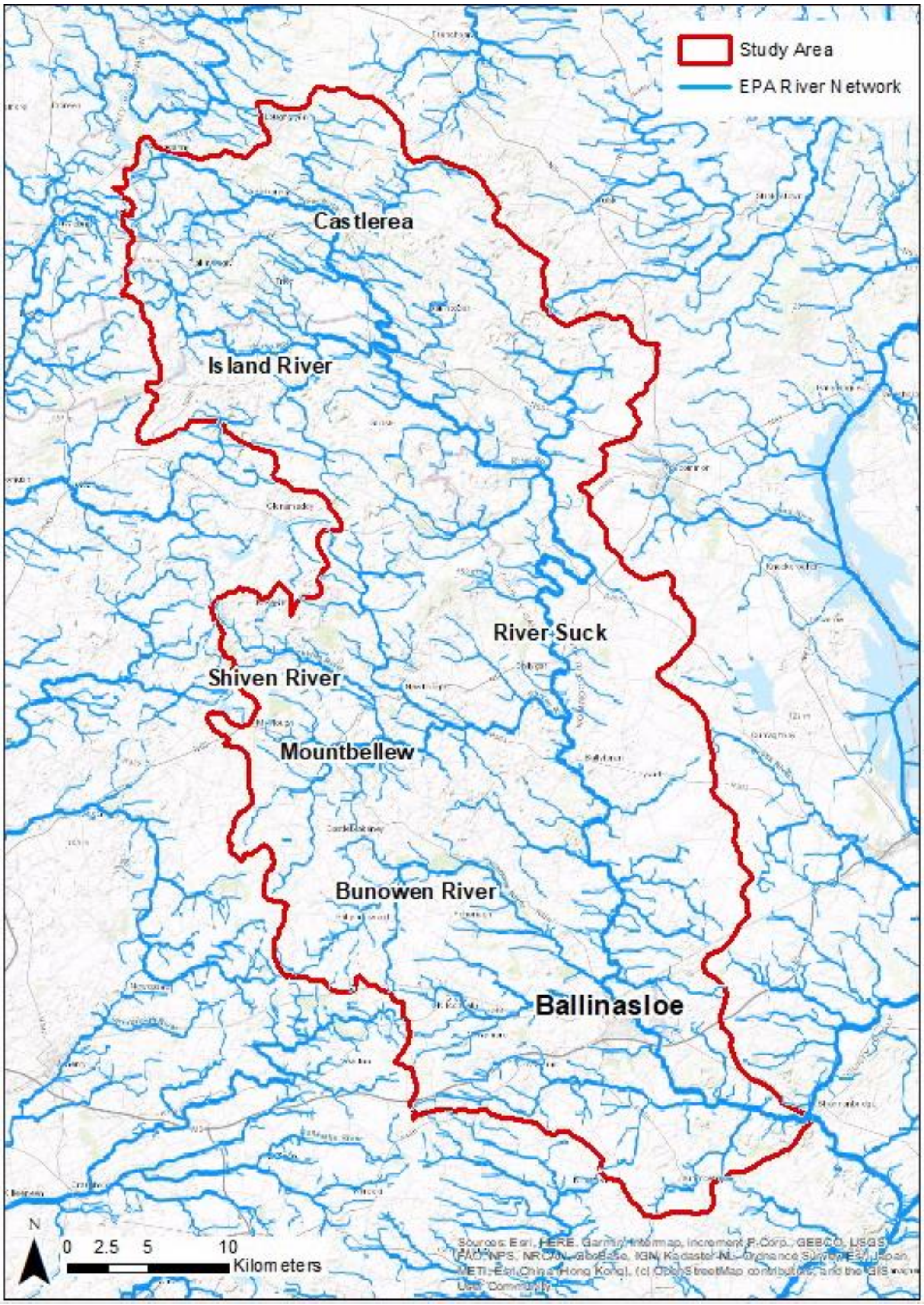

Figure 1 Ballinasloe study area and river network

Ballinasloe has a long history of flooding from the River Suck, Deerpark River and other local tributaries. In recent times, significant flooding occurred in November 2009 and during winter 2015/2016[2].

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[2] Flood Info (2021) Ballinasloe Flood Relief Scheme. Online. Available at: https://www.floodinfo.ie/frs/en/ballinasloe/home/ Accessed: November 2021

The catchment is associated with a long time to peak for flood flows, driven by the low relief and large expanses of land at relatively constant elevation within the catchment (see Figure 2).

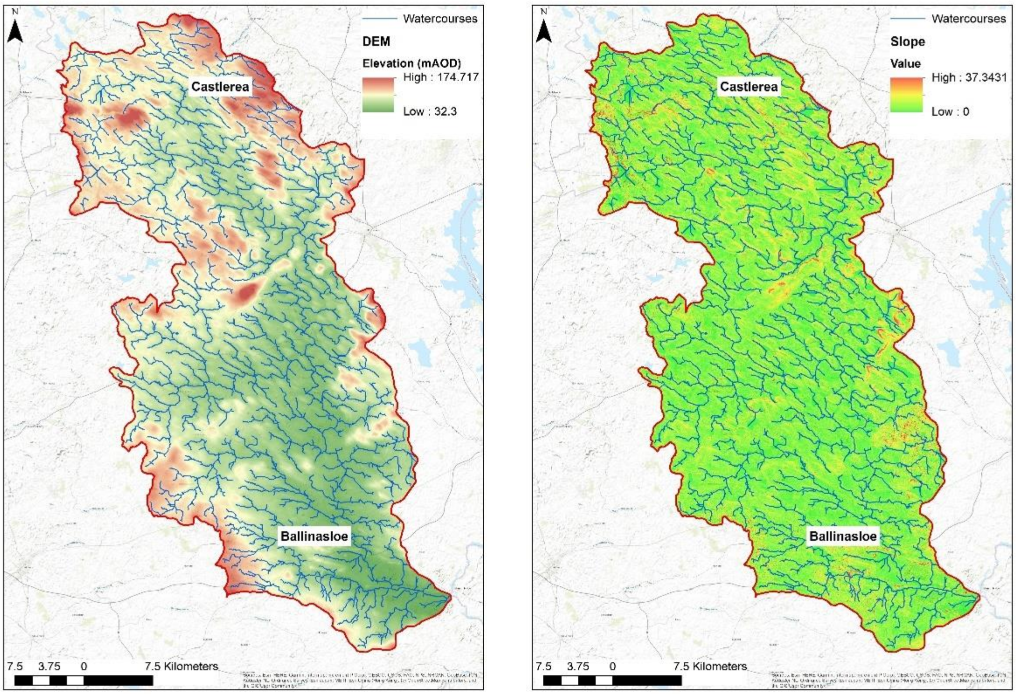

Figure 2: Topography (left) and Slope steepness in degrees (right) for the River Suck Catchment

The land cover of the catchment is predominantly agricultural pasture (70% of the catchment) and significant areas of peat (16% of the catchment). Woodland areas only accommodate approximately 5.5% of the catchment area. The land cover is broken down in Table 1.

Table 1: Land Cover of the River Suck Catchment (Corine 2018)

Corine Land Cover Code	Description	Percentage
Code_112	Discontinuous Urban Fabric	0.500%
Code_122	Road and rail networks and associated land	0.016%
Code_131	Mineral Extraction sites	0.024%
Code_132	Dump Sites	0.000%
Code_142	Sport and leisure facilities	0.026%
Code_211	Non-irrigated arable land	0.275%
Code_231	Pastures	70.052%
Code_242	Complex cultivation patterns	0.053%
Code_243	Land principally occupied by agriculture, with significant areas of natural vegetation	3.955%

Code_311	Broad-leaved forest	0.393%
Code_312	Coniferous forest	4.338%
Code_313	Mixed forest	0.818%
Code_321	Natural grassland	0.153%
Code_324	Transitional Woodland Scrub	2.499%
Code_334	Burnt Areas	0.059%
Code_411	Inland marshes	0.404%
Code_412	Peatbogs	16.300%
Code_511	Water courses	0.002%
Code_512	Water bodies	0.131%

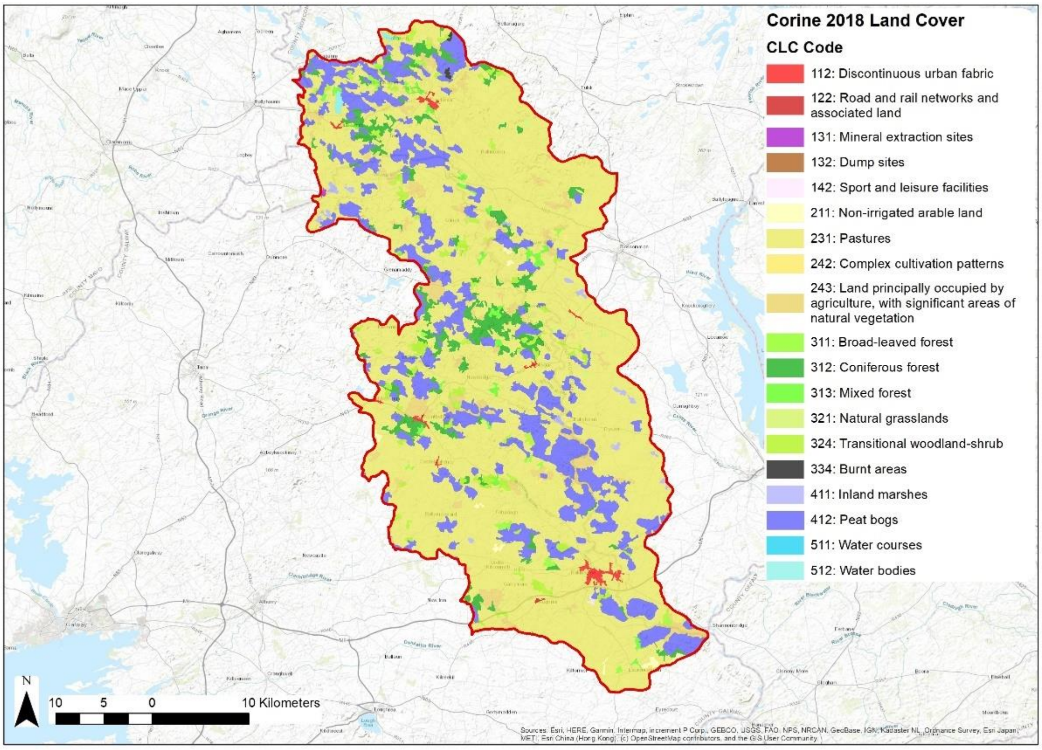

Figure 3: Corine (2018) Land Cover Map for the River Suck Catchment

1.2 Context

Man-made catchment influences such as agriculture, urbanisation and reservoir impoundments have altered natural hydrology of catchment systems. There is anecdotal evidence that these artificial influences have led to increased flood peaks and higher rates of sediment delivery to catchment outlets. It is thought that agricultural intensification may cause higher flood peaks in streams and rivers due to its impact on runoff processes.

For example, degradation of soil structure can lead to reduction in infiltration rates and available storage capacities, increasing rapid runoff in the form of overland flow[3,4]. Although flood hazard is greater in lower lying regions (i.e. areas where population is usually higher), the management of headwaters, with their generally higher precipitation rates and flashier response, is of particular interest for flood runoff generation[5].

NFM is the alteration, restoration or use of landscape features to reduce flood risk[6]. There are arguments that support the restoration of catchments through 'Rewilding', allowing natural processes and native species to reclaim their position in large areas of land. Traditional NFM can take a more 'engineered' approach to deliver many small landscape interventions that intercept and attenuate hydrological flow pathways to emulate natural processes and provide multiple benefits, including flood management and improving water quality. Put simply, the design philosophy is to create features that 'slow, store and filter' runoff and peak flow in the landscape[7]. Figure 4 shows an idealised storm hydrograph, which has had its shape altered through attenuation from NFM.

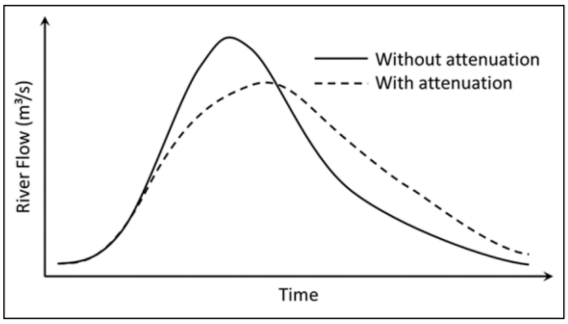

Figure 4: Attenuating flow in a hydrograph

NFM has limitations that should be understood by catchment stakeholders. Choosing locations for features, developing land-owner engagement and providing maintenance of numerous assets is not always straightforward. As a result, NFM should be considered as a wider catchment-based approach to work alongside traditional forms of flood defence.

NFM has the potential to increase resilience of other proposed measures by attenuating flood flow, capturing sediment before it enters the watercourse[8],

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[3] Heathwaite, A. L., Burt, T. P., & Trudgill, S. T. (1990). Land-use controls on sediment production in a lowland catchment, south-west England. In J. Boardman, I. D. Foster, & J. A. Dearing, *Soil Erosion on Agricultural Land.* John Wiley and Sons Ltd.

[4] Bronstert, A., Niehoff, D., & Burger, G. (2002). Effects of climate and land-use change on storm runoff generation: present knowledge and modelling capabilities. *Hydrological Processes, 16*, 509-529.

[5] Wheater, H., Reynolds, B., Mcintyre, N., Marshall, M., Jackson, B., Frogbrook, Z., Soloway, I., Francis, O. & Chell, J. (2008). *Impacts of upland land management on flood risk: Multi-scale modelling methodology and results from the pontbren experiment.* FRMRC Research Report UR 16.

[6] POST. (2011). Natural Flood Management POSTNOTE 396. London, England: Parliamentary Offices of Science and Technology.

[7] Nicholson, A. R., Wilkinson, M. E., O'Donnell, G. M. & Quinn, P. F., 2012. Runoff Attenuation Features: A sustainable flood mitigation strategy in the Belford Catchment, UK. Area, 44(4), pp. 463-469.

[8] Barber, N. J., & Quinn, P. F. (2012). Mitigating diffuse water pollution from agriculture using soft-engineered runoff attenuation features. *Area, 44*(4), 454-462.

creating habitat and increasing climate change resilience. Examples include better land use management and catchment-wide water storage (for example, the runoff attenuation approach in Belford, Northumberland[9]).

2 NbCM Opportunity Mapping

2.1 Mapping Methodology

ArcGIS software has been used to spatially analyse the catchments in the study area in order to undertake coarse opportunity mapping. This GIS analysis is based on a variety of data sources outlined below:

- IFSAR Digital Terrain Model (DTM) at 5m resolution provided by OPW;
- 1 in 100-year flood extent from Ballinasloe FRS predictive flood mapping;
- Corine land cover map (2018)[10]; and
- Background open-source mapping and satellite imagery.

These data were analysed together and used alongside the ‘Hydro-Tools’ within ArcGIS to determine a variety of catchment characteristics including flow direction and accumulation, stream order and runoff pathways. This spatial data was then characterised using a fishnet grid, dividing the study area into a grid of 250m by 250m, with a total of 25,978 grids squares across the study area to generalise the area. These geospatial analyses were then exported into an Arup developed NFM Feasibility Assessment Tool to assess potential application of a range of NWRM/NbCM/NFM types (herein referred to as NbCM). The method utilises a series of look ups which determine the feasibility of eight different NbCM intervention types, scored between one and five based on their suitability (five being most suitable) for each individual factor (such as slope, land cover use and presence of runoff pathways etc.)

2.2 Potential NbCM Interventions

The following NbCM interventions, based on their primary purpose, were analysed (see Appendix A for more detail):

Runoff reduction:

- Runoff Attenuation – a man-made structure that intercepts and attenuates a hydrological flow (runoff) pathway (e.g. an earth bund or ‘leaky barrier’);
- Large Woody Debris (LWD) – placement of wood across/within the channel to act as a dam and slow the flow. The use of full-span large woody debris would be limited to catchment headwaters with areas of

[9] Quinn, P. et al., 2013. Potential use of Runoff Attenuation Features in small rural catchments for flood mitigation: Evidence from Belford, Powburn and Hepscott, s.l.: Joint Newcastle University, Royal Haskoning and Environment Agency Report.
[10] CORINE land cover data. Available at [http://land.copernicus.eu/pan-european/corine-land-cover]

3km^2 or less. Beyond this scale alternative designs of LWD (partial-span) would be considered. All LWD should allow for fish passage to be maintained, by allowing low flow beneath the intervention; and

- Tree Planting – planting trees can intercept rainfall, reduce runoff by increasing infiltration and stabilise soils.

Floodplain Storage:

- Floodplain Reconnection – establishing a pathway between a watercourse and its natural floodplain, especially during high flows. This is identified either where flood waters were previously constrained to the channel or in locations that already flood, but that could hold a greater magnitude of water; and
- Wet Woodland – wooded areas that experience waterlogged conditions for at least part of the year to manage flood waters, erosion and water quality

Sediment and nutrient management:

- Buffer Strip – area of long grasses, trees and shrubs along field boundaries or across fields; and
- Contour Plough – agricultural practice of ploughing along the contours of the land (as part of normal cultivation practices) to prevent soil compaction and erosion and prevent runnels channelling water downstream.

Peatland Management:

- Peatland Restoration – A wide variety of management measures possible including, converting grassland to blanket bog, converting grassland to heath, improving existing peat condition, restoration burning and cutting to reduce heather dominance, rewetting of peat, the reintroduction of blanket bog species, as well as careful management of livestock grazing, to name but a few. This also includes Grip Blocking – restoring ecological, hydrological function and the peatland C-sink function by damming and infilling old gripping ditches.
- Notwithstanding the above, in the context of the large scale, long duration flood events typically seen in Ballinasloe, the following statement from the National Peatlands strategy[11] in relation to the flood risk management benefits of wetlands (including peatsoil wetlands), is relevant:

  "…generally the influence of wetlands in reducing flood peaks is greatest for high frequency, low to medium intensity rainfall events that occur when wetlands have a large capacity for storage. It is least for large magnitude events, particularly following a long period of prior rainfall, when soil and wetland storage are saturated. In this regard, a distinction can be made between "hydrological" floods (high frequency, low to

[11] *National Peatlands Strategy* Department of Arts, Heritage and the Gaeltacht, 2015, National Peatlands Strategy | National Parks & Wildlife Service (npws.ie) accessed 28 January 2022

medium magnitude rainfall events that occur commonly without economic damage) and "economic" floods (low frequency large scale rainfall events following antecedent wet periods, potentially causing economic damage). Wetlands by their nature will provide attenuation of runoff but the degree of that attenuation may be less for large scale rainfall events in saturated conditions."

- It is noted that in line with the National Peatlands Strategy, Bord na Móna is currently engaging in a programme of decommissioning and rehabilitation works across former commercial bogland. In the Suck catchment, the available information indicates that plans are currently progressing for two areas of bogland at Kellysgrove[12] and Castlegar[13].
- Kellysgrove bog is downstream of Ballinasloe town, and therefore any flood attenuation delivered through rehabilitation works cannot reduce flood flows entering the town.
- Castlegar bog is upstream of Ballinasloe, and therefore does have potential to attenuate runoff, which will help to reduce flood flows at Ballinasloe, albeit to a modest degree in the design 100 year flood scenario.

2.3 NFM Feasibility Analysis

The geospatial data analysed described in Section 2.1 were exported into an Arup developed NFM methodology to assess feasibility of a range of NFM types.

The method utilises a series of look-ups which determine the feasibility of eight different NFM intervention types, scored between one and five based on their suitability (five being most suitable) for each individual factor as shown in Appendix B. Note, these scores are estimates, based on in-depth technical understanding and previous project outcomes and can be amended where appropriate during any more detailed mapping analysis.

The criteria on which the NFM interventions were scored were assessed in an evaluation matrix to weight modelling results, spatial factors, costs, maintenance responsibilities and numerous ecosystem services. The full list of factors included in the matrix is explained in Table 2 below. Considering other factors in the ranking of opportunities has the potential to reduce the impact of modelling uncertainty. It also allows for the inclusion of other important factors into the analysis.

The weightings were designed to cover the most influential factors of successful NFM projects.

The purpose of the criteria is to identify the highest ranking NFM opportunities with, theoretically, the greatest potential to yield success in an NFM project and

[12] *Kellysgrove Bog Cutaway Bog Decommissioning and Rehabilitation Plan*, Bord na Móna, 2021 Kellysgrove Rehab Plan 2021 F03.pdf (bnmpcas.ie) accessed 28 January 2022
[13] *Castlegar Bog Cutaway Bog Decommissioning and Rehabilitation Plan*, Bord na Móna, 2020 Rehab Plan Castlegar Bog V6 2020.11.30.pdf (bnmpcas.ie) accessed 28 January 2022

identify relevant funding sources based on the biggest benefits likely to be achieved. The default weightings are intended to cover schemes with a good balance of criteria supporting NFM. Should a scheme's potential for receiving funding highly depend on the reduction in flood risk, more emphasis can be put on the modelling weightings.

Table 2: NFM evaluation criteria and the weightings applied in the evaluation matrix

Evaluation Criteria	Sub-criteria	Sub-criteria weighting
Hydrology	Slope	10.00%
	% Floodplain	5.00%
	Runoff route length	5.00%
Funding & Future	Cost	2.50%
	Funding	2.50%
	Maintenance	2.50%
	Life Expectancy	2.50%
Land Use	Land Cover	40.00%
Ecosystem Services	Flood (Fluvial)	3.00%
	Flood (Surface water or Groundwater)	3.00%
	Air Quality	3.00%
	Health Access	3.00%
	Low Flows	3.00%
	Climate regulation	3.00%
	Habitat	3.00%
	Water Quality	3.00%
	Cultural Activity	3.00%
	Aesthetic Quality	3.00%

A variety of weighting controls were trialled for the catchments but, ultimately, the highest weightings were attributed to land use (40%) and ecosystem services (30%) given their strong influence on the possibility and type of NFM intervention and their overall impact on the environment.

Ecosystem services represent the direct and indirect contributions of ecosystems to our quality of life and well-being. This includes the provision of services such as food and water, regulating services such as climate regulation and water purification, habitat services and cultural services such as recreation and aesthetic value. The following ecosystem services were incorporated into the analysis to meet objectives other than flood risk management:

- Flood risk management (fluvial) (positive impact on fluvial flood risk reduction);
- Flood risk management (surface water or groundwater) (positive impact of surface or groundwater flood risk reduction);
- Air Quality (interventions leading to improvements in air quality);

- Health Access (creation of greater amenity for the public, thus generating improvements in terms of physical and mental health of local population);
- Low Flows (regulation of low flows through capture and infiltration);
- Climate Regulation (contribution to regulation of climate change);
- Habitat (provision of amenity to locally important species);
- Water Quality (potential to capture and/or filter polluted flow from farmland or other sources);
- Cultural Activities (potential to provide direct recreational benefit to the public such as facilitating angling by improving fish habitat); and
- Aesthetic Quality (interventions providing improvements to the local landscape).

Financial considerations (including cost, maintenance and life expectancy), localised flooding characteristics (floodplain extent and length of runoff routes) and angle of slope (and therefore storage potential) were assigned an equal weighting of 10% each. Note, weighting controls given to each criterion are flexible and can be adapted depending on the aspirations of the study. The scoring assigned to each NFM intervention for each variable is provided in Appendix B.

Using scores awarded to the variables, the weighting of each criterion and percentage / presence of each variable, the most suitable NFM intervention was selected for each grid cell. Selected interventions could then be visualised using ArcGIS cartography.

2.4 Aggregate Storage Model

The potential impact of the NbCM measures, identified from the method outlined above, on peak flows was analysed using an Arup-developed Aggregate Storage Model (ASM). This approach allows hydrological routing of flows, through industry standard hydrological equations, whilst simultaneously exploring the impact of the aggregated (summed) storage provided by the various NFM interventions within a given spatial area.

The ASM was developed to assess the synchronicity of flows from each of the sub-catchments in a wider catchment area and is based the Pond Network Model[14]. The tool allows the user to allocate a total (or aggregate) storage volume to each of the sub-catchments to assess the impact of storage on both the selected sub-catchment and the total downstream flow at the point of interest. The total storage may be made up of a number of feasibly-sized ‘ponds’ (or pond objects). The ponds are an essential component of the storage unit as the number of attenuation features dictates how rapidly the storage unit can drain. Mass-balance is conserved with the tool. Figure 5 shows a conceptual schematic, similar to a

[14] Nicholson AR, O'Donnell GM, Wilkinson ME, Quinn PF. The potential of runoff attenuation features as a Natural Flood Management approach. J Flood Risk Management. 2019;e12565. https://doi.org/10.1111/jfr3.12565

linear storage (bucket) model[15], which demonstrates the role of storage units within the tool.

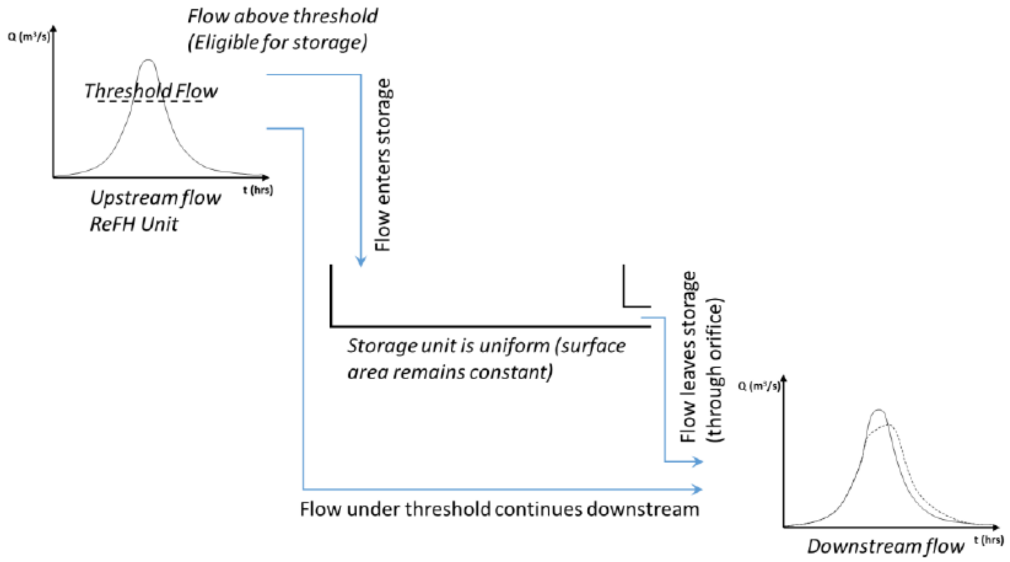


Figure 5 Conceptual model schematic of storage units.

The tool assesses the aggregate effects of new storage being added to sub-catchments in the form of attenuation. The tool simulates the effect of the total feasible storage quantities in a given sub-catchment (based on the mapped interventions) and calculates the peak volume of water discharging from each sub-catchment with the proposed storage features (Qp mitigated) and without the storage features (Qp unmitigated) based on a user-defined 'Threshold Flow'. The threshold flow is a level that assesses the impact of NbCM storage on each sub-catchment, that, once exceeded, will allow flow to enter the storage unit. A graph within the analysis tool shows the performance of the storage unit in the current configuration and allows the user to change the threshold flow and the number of ponds until they are satisfied that the storage unit is performing correctly within the sub-catchment.

The tool runs a variety of background calculations based on inputted data and flow data from the relevant Flood Studies Report (FSR) 1 in 100-year storm hydrograph.

2.5 NbCM Opportunity Mapping Results and Conclusions

Of the eight types of NbCM considered, the highest scoring "NbCM-type" was selected for each grid square. Figure 6 shows the most suitable NbCM intervention type for each grid cell throughout the study area. All eight interventions considered were identified as suitable for the River Suck Catchment. It should be noted for Figure 6 that each cell shows a NbCM intervention. This is

[15] Nash, J. E. (1957). "The form of instantaneous unit hydrograph." Int. Assn. Sci. Hydro. Publ.No. 51, 546-557, IAHS, Gentbrugge, Belgium.

simply to demonstrate the most suitable intervention identified in the analysis. Further refinement of the scores is demonstrated in the text and figures that follow.

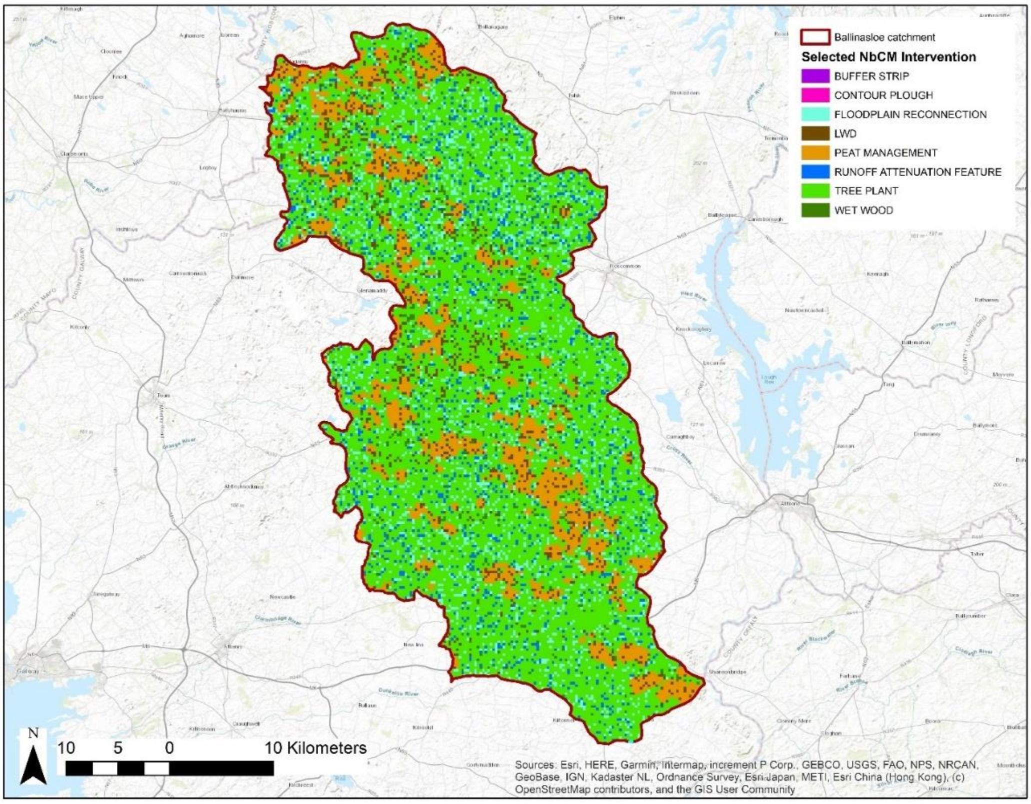


Figure 6 The most suitable NbCM intervention across the Ballinasloe study area

Without consideration of applying a threshold score, Tree Planting is the most commonly suitable NbCM feature across the majority of the catchment, accounting for ~60% of the study area, followed by Peat Restoration covering ~13% of the study area. This only shows the most suitable NbCM intervention and in many instances, more than one method could be applied to an area. The degree of suitability of the study area and the identified NbCM opportunities are indicated in Figure 7, which shows the score (out of 5) achieved by the highest scoring NbCM opportunity identified in Figure 6.

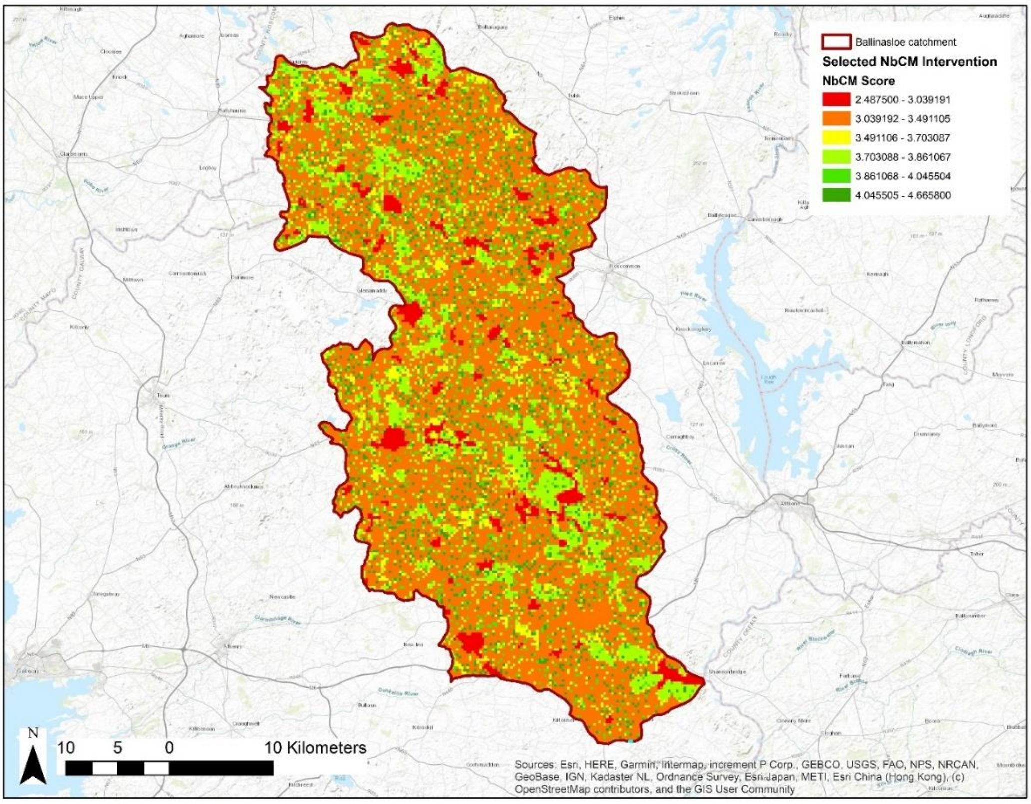


Figure 7 The score achieved by the most suitable NbCM intervention across the Ballinasloe study area

Figure 7 highlights that whilst certain interventions are considered the most suitable, some areas score relatively low in general and NbCM in these locations may not be the most effective. Therefore, a minimum score of 3.5 (out of 5) was assigned to all NbCM interventions before they can be recommended in an area of the catchment. This score has been determined through application of this approach on multiple projects. The output of these threshold scores in shown in Figure 8 and shows the prioritised grid cells with the most suitable intervention type identified. While a proportion of the catchment is blank, this does not mean NbCM is not feasible in these areas, only they are not the preferred locations for the selected NbCM interventions due to the catchment characteristics.

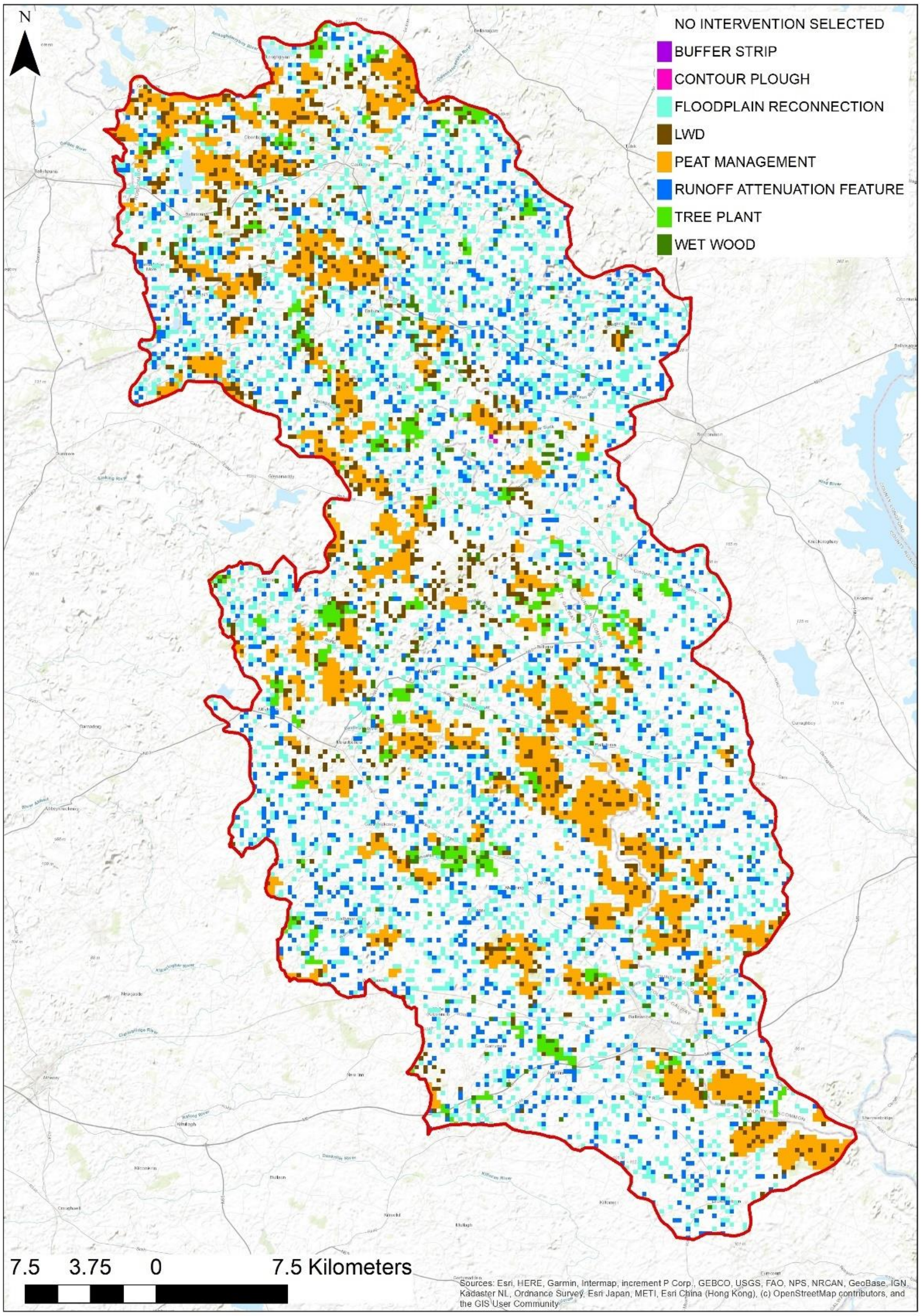


Figure 8 Prioritised NbCM across the Ballinasloe catchment, where a minimum score of 3.5 is achieved.

Of the most appropriate areas in the catchment for NbCM, Floodplain Reconnection was selected as the most suitable, scoring the highest across approximately ~10% of the study area and accounting for ~30% of the prioritised NbCM interventions. This is followed by RAFs and LWD covering ~7% and ~5% of the study area respectively. Tree Planting and Wet Wood were prioritised across <2% of the study area, whilst Buffer Strips and Contour Plough were only prioritised in one of the grid squares each across the study area. This is portrayed within Figure 9. This is a direct result of applying the threshold score to the opportunity mapping results.

The opportunities shown in Figure 8 have been reproduced in Appendix C to better show opportunities throughout the Suck catchment.

Meanwhile, ~64% of the study area achieved a score below 3.5 and are therefore not considered a priority from implementation of NbCM interventions. The highest scoring opportunity was 4.66 (out of 5) for Floodplain Reconnection and the lowest score was for Tree Planting at 2.48.

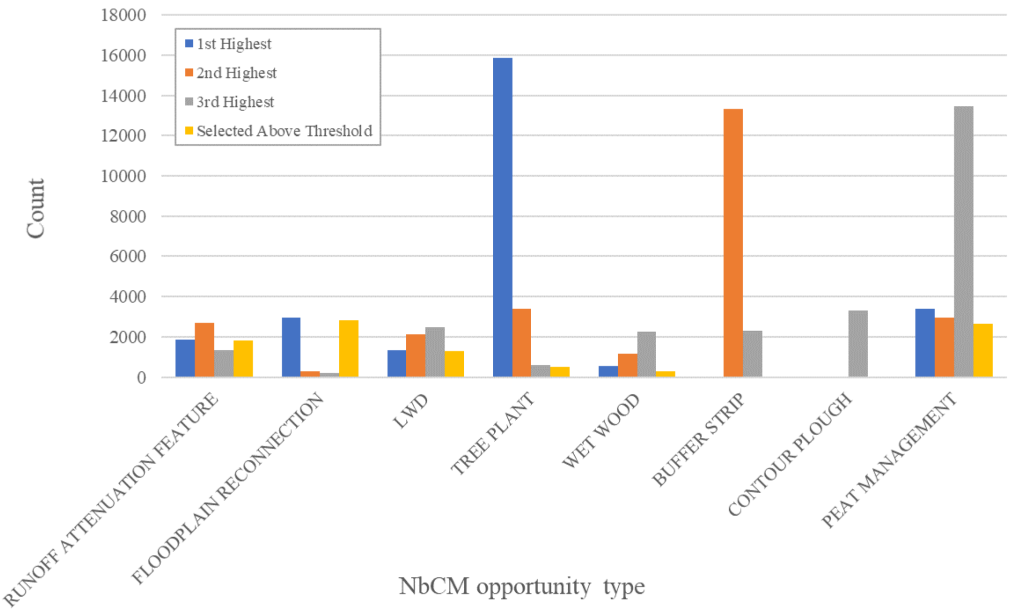


Figure 9 The number of selected NbCM interventions for the highest scoring, second highest scoring, third highest scoring and above the 3.5 threshold.

Generally, the study area scored highly and is indicative of a highly suitable catchment for NbCM <u>at the local scale</u>. However, it is noted that flooding towards the downstream end of the River Suck catchment at Ballinasloe is generated by long-duration, large volume, catchment-wide storm events. High-level calculations were undertaken to determine the magnitude of water required to reduce flow at Ballinasloe using the full catchment hydrology. From experience, this scale of design event would require intense catchment-wide NbCM interventions in order to have any measurable effect on peak flows through Ballinasloe. It is also anticipated that even if intensive NbCM measures are undertaken upstream of Ballinasloe, these would still need to be supplemented with structural flood relief measures through the town in order to achieve the required standard of protection. Therefore, NbCM on the River Suck upstream of Ballinasloe is not recommended as a measure which could meaningfully reduce the level of flood risk through the town. However, such measures may merit consideration in the context of other ancillary benefits such as improved water quality (refer to Section 4.2). NbCM opportunity mapping is proposed to be provided to the relevant agencies (e.g. EPA, LAWPRO, etc.) to help to inform any further study.

Based on the above analysis, two tributaries of the Suck were identified for further assessment.

- River Deerpark
- Ballyhugh Stream

The hydrology and hydraulic modelling undertaken for the Ballinasloe FRS indicates that both of these watercourses are a significant source of flood risk in Ballinasloe, independent of the main River Suck. These catchments are also of a similar scale to comparable NbCM schemes implemented in the UK, where the achievable reduction in flood flow can be a significant percentage of the baseline design flow. The detailed assessment of these two catchments is outlined in the following sections.

3 NbCM Feasibility Assessment for Identified Subcatchments

3.1 Localised NbCM Opportunities

Further to the conclusions drawn in Section 2.5 above, two study areas were analysed in more detail; the Deerpark watercourse and a small area draining to Ballyhugh (see Figure 10).

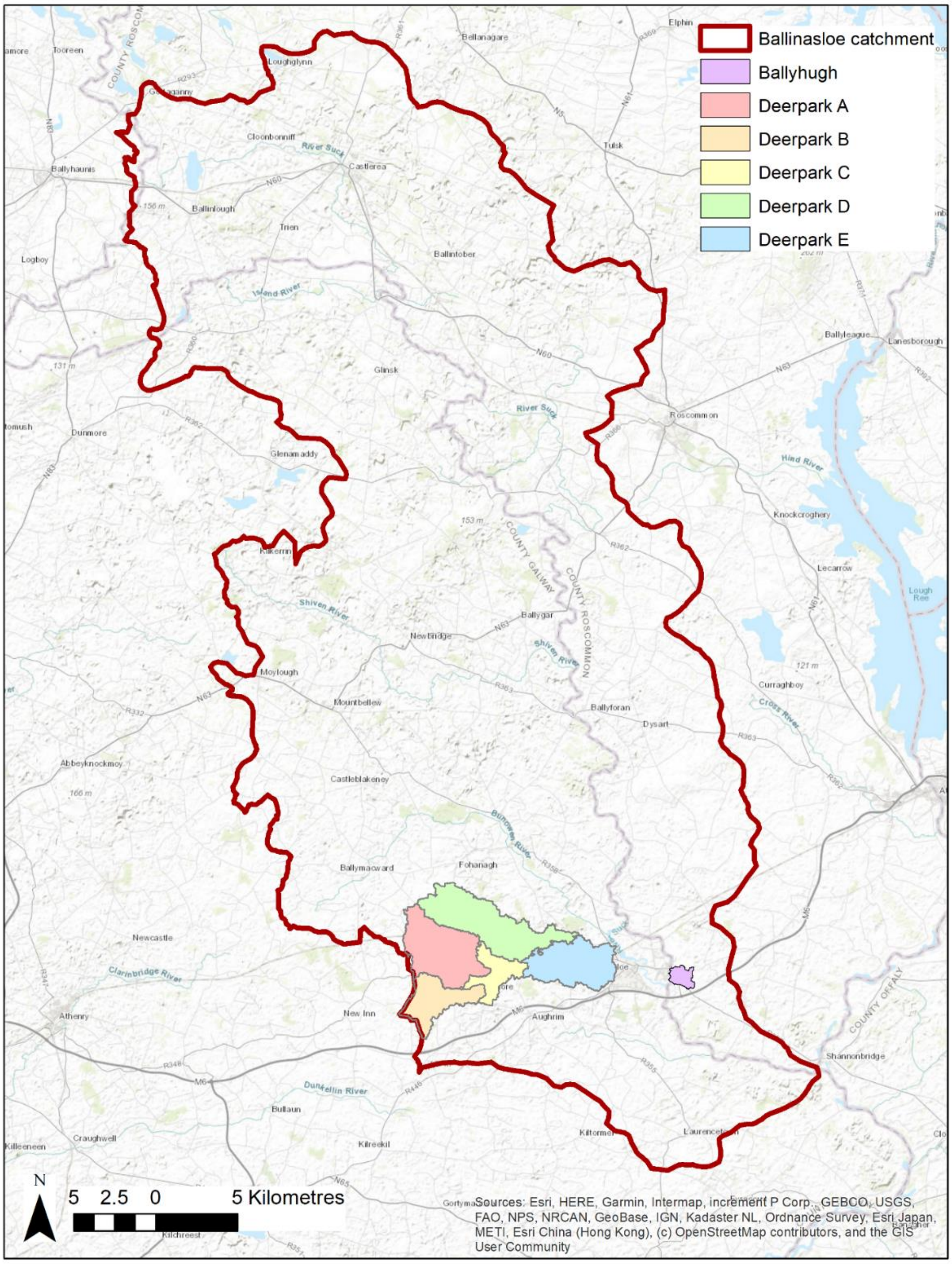


Figure 10 The wider Ballinasloe catchment showing the locations of the Deerpark study area and the Ballyhugh study area.

The Deerpark study area was separated into five sub catchments, see Figure 11. The NbCM interventions suited to these sub-catchments are shown in Figure 11 and Figure 12. In the Deerpark sub-catchments, Floodplain Reconnection and RAFs are the most suitable covering ~22% and ~15% of the study area respectively. LWD, Tree Planting, Peat Restoration and Wet Wood were also indicated to be suitable within these sub-catchments.

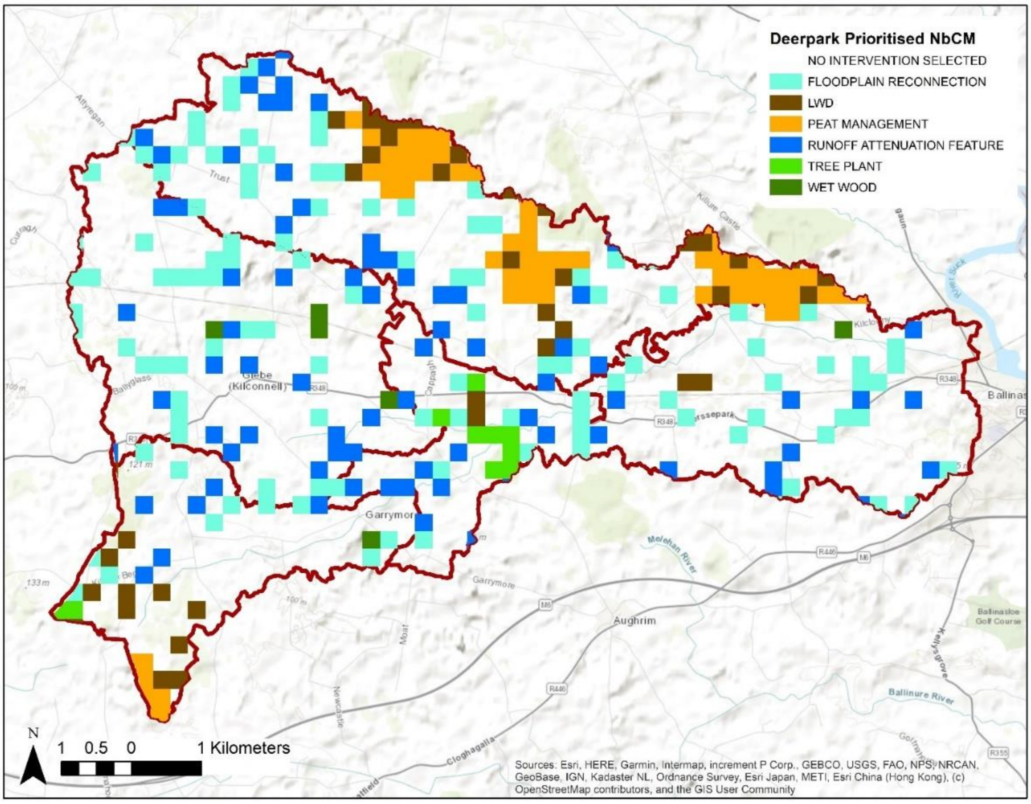


Figure 11 The selected NbCM interventions across the Deerpark study area based on the highest scoring NbCM intervention achieving a score of at least 3.5 out of 5 in the feasibility assessment tool.

The second study area was Ballyhugh, see Figure 12. This also illustrates that Floodplain Reconnection and Runoff Attenuation Features, as well as Wet Wood, are the most suitable across this area.

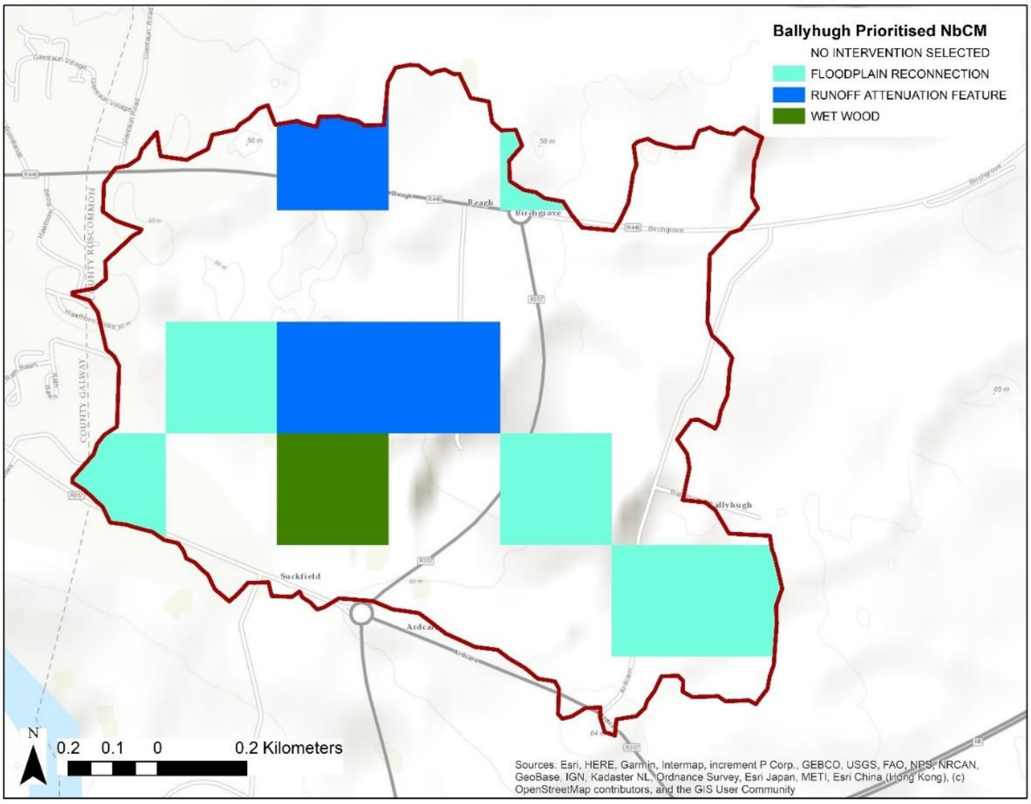


Figure 12 The selected NbCM interventions across the Ballyhugh study area based on the highest scoring NbCM intervention achieving a score of at least 3.5 out of 5 in the feasibility assessment tool.

3.2 Potential Impact on Peak Flows

To assess the hydrological impact of the watercourses in the study area, the overall study catchment focused on two areas. The first was the Deerpark study area which was divided up into five sub-catchments representing hydrological units, shown in Figure 13, and the second was the Ballyhugh study area, shown in Figure 10. The peak flow data uses the modified triangular hydrograph method, as detailed in Section 9.6 the Ballinasloe FRS Hydrology Report[16].

[16] Arup and Hydro Environmental Ltd. (2021) Ballinasloe Flood Relief Scheme Hydrology Report. March 2021. Draft. OPW.

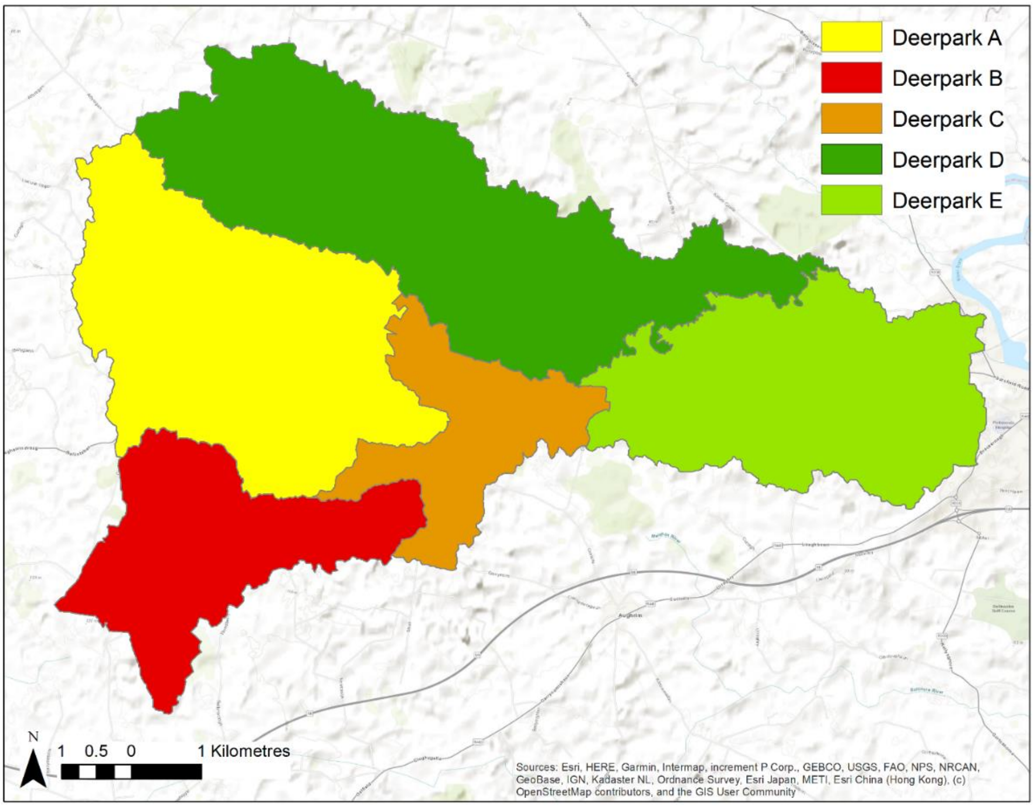


Figure 13 The identified sub-catchments within the Ballinasloe catchment area, colour coded in a green to red scale showing the greatest reduction in peak flows (green) to the least (red).

The analysis utilises the NbCM interventions identified in the Deerpark and Ballyhugh catchments shown in Figure 11 and Figure 12, to analyse the potential impact of these interventions on peak flood flows at the sub-catchment level. The analysis assumes that one storage based NbCM intervention, i.e. Runoff Attenuation Features, Wet Woodland or Floodplain Reconnection, are implemented in each of the grid squares in which they were identified as an opportunity and are capable of storing 500 m^3 (for RAFs and Wet Woodland) and 1,000 m^3 (for Floodplain Reconnection) of water each.

The resulting NbCM impact on Peak Flow for the Deerpark sub-catchments and Ballyhugh is outlined in Table 3. This represents the storage potential and subsequent impact on the peak flow of water at the downstream of each sub catchment, based on an approximation of the sub-catchment area draining into each proposed feature.

Table 3 Results from the ASM analysis indicating the impact of the proposed NbCM features on peak flow for Deerpark sub-catchments and Ballyhugh.

Sub catchment	**Catchment area (km^2)**	**Number of features**	**Total storage potential (m^3)**	**Percentage reduction in peak flow (%)**	**Actual reduction in peak flow (m^3/s)**
Deerpark A	15.72	56	43,500	10	0.713
Deerpark B	8.64	16	13,000	5	0.304
Deerpark C	5.84	23	17,000	9	0.168
Deerpark D	18.73	61	49,000	18	1.126
Deerpark E	12.92	35	29,000	11	0.620
		Total	**151,500**	**10.6**	**2.967**
Ballyhugh	1.56	10	8,000	19.5	0.210

The final two columns in the table show the achievable reduction in percentage peak flow at the outlet to each sub-catchment and the associated reduction in peak flow, respectively. They indicate that implementation of the identified storage based NbCM interventions in the Deerpark sub catchments can have a significant impact in reducing the peak flow at the downstream extent of each sub-catchment in the order of 4 – 18%. They can also have a significant impact of in reducing local flows in Ballyhugh of up to ~19%.

The overall reduction in peak flows at the Deerpark study area in Ballinasloe was 10.6% and at Ballyhugh it was 19.5%. This was achieved through the total storage of 151,500 m^3 from 191 NbCM storage interventions across Deerpark and the total storage of 8,000m^3 from 10 NbCM interventions across the Ballyhugh sub-catchment. These outputs have not been optimised to determine the best downstream solutions. Further analysis could determine more significant reductions downstream.

4 Delivering NbCM in Ballinasloe

4.1 High-level Cost Estimates

A high-level costing exercise has been undertaken using relevant information from the UK Environment Agency's 'Cost estimation for land use and run-off – summary of evidence'[17], other literature and SPON's Civil Engineering and Highways Pricing Book 2017[18]. These cost estimates have been provided for the Deerpark and Ballyhugh study areas only. Although these costs have been estimated using literature and databases, they are comparable to outrun capital costs for delivering similar NbCM schemes in the UK.

It is assumed that RAFs have the potential to be constructed using either a soil bund (a cheaper structure) or a timber leaky dam (a more expensive structure, which uses a negligible footprint and requires no soil for construction) as indicated in Appendix A. Therefore, an upper and lower cost estimate has been provided, where the upper cost assumes the RAFs are half soil and half timber while the lower estimate assumes they are soil only. The derivation of the costs outlined below are based on the assumption that RAFs comprise 1 m high structures which are 40 m long, while LWD structures are 1 m high and 3 m wide.

Table 4 shows the typical costs per unit based on the interventions considered. The unit cost of the runoff attenuation features were estimated using SPON's Civil Engineering and Highways Pricing Book[17] whilst all other costs were derived from the Environment Agency literature[17] and then converted to Euros using the following ratio £1 : €1.12.

Table 4: NbCM intervention cost ranges per unit

Intervention	Lower Estimate	Upper Estimate
Runoff Attenuation feature (1m high 40m long)	€ 4,464	€ 10,406
Large Woody Debris (1m high and 3m wide)	€448	€840
Contour Ploughing	€3 per ha	€6 per ha
Tree Planting *	€2,576 (mean cost per plantable ha)	€4,262 (mean cost per plantable ha)
Wet Woodland*	€2,576 per ha	€ 4,262 per ha
Floodplain Reconnection	€14,926 per ha	€22,389 per ha
Buffer Strips	€36 per ha	€56 per ha
Peat Restoration**	€ 112 per ha	€ 1,120 per ha

*Assumes 25% of each grid square planted with density 1,110 to 2,250 trees per ha

**Assumes 50% of grid square being converted from 'degraded' peat to 'improved' peat.

17 Environment Agency, UK (2015) Cost estimation for land use and run-off – summary of evidence.

18 SPON Press (2017) Civil Engineering and Highway Works Price Book, edited by AECOM.

It should be noted that the cost of tree planting varies considerably as a function of three parameters:

- The existing land use within each grid square;
- The percentage of each grid square on which it is assumed that trees would be planted; and
- The tree planting density.

These three parameters are linked. For example, the existing land use within each grid square is used to determine the tree planting density. Moreover, the percentage of each grid square available for planting would also depend on the existing land use. Background assumptions have been made regarding the percentage of each grid square available for tree planting, and the planting density, based on the existing land use; for example, the achievable planting density within an area predominantly comprising coniferous forest would be significantly less that the potential available planting density within an area predominantly comprising pastures. This has been reflected in the upper and lower cost estimates.

4.1.1 Deerpark Cost Estimates

The identified NbCM interventions in Figure 11 have been translated into the number features identified in Table 5, whereby we have assumed one intervention per grid square or where the area of the grid square (6.25 ha) contributes to the total area of the intervention.

Table 5 Cost Estimates for the implementation of the interventions identified in Deerpark

NbCM Intervention	No. of Interventions in the Deerpark Study Area	Upper Cost Estimate	Lower Cost Estimate
RAF	79 features	€ 822,104	€ 352,672
Floodplain Reconnection	115 ha (1 per 1,000m^3)	€ 2,574,712	€ 1,716,475
LWD	42 features	€35,280	€18,816
Wet Woodland	10.9 ha	€ 46,611	€ 28,175
Tree Planting	18.75 ha	€ 79,905	€ 48,300
Peat Restoration	206 ha	€ 231,000	€ 23,100
	Total	€ 3,789,612	€ 2,187,538

The figures in Table 5 represent the costs of implementing the features identified with Deerpark, however, this does not account for the total costs of implementation. The breakdown of likely construction and maintenance are shown in Table 6, over the 30-year life of the scheme. It should be noted that this does not cover any land purchases that may be required.

Table 6 Summary of whole-life cost estimates for the implementation of the identified NbCM in Deerpark

Stage	Cost	Upper Cost Estimate	Lower Cost Estimate	Average
Construction	Initial construction Costs	€ 3,789,612.10	€ 2,187,537.88	€ 2,988,574.99
	Mobilisation and site offices (assume 30% of construction)	€ 1,136,883.63	€ 656,261.36	€ 896,572.50
	Total initial capital costs (assume upper estimate)	€ 4,926,495.73	€ 2,843,799.24	€ 3,885,147.48
	Average Cost of initial construction			€ 3,885,147.48
	Average Cost plus optimism bias			€ 5,594,612.38
Maintenance	Annual Maintenance (assuming €2,800 per 10 km^2 per year)			€ 17,360.00
Total	TOTAL COST OF NbCM (Over life of scheme - including maintenance)			€ 6,019,711.66

4.1.2 Ballyhugh Cost Estimates

The identified NbCM interventions in Ballyhugh in Figure 12 have been translated into the number features identified in Table 7.

Table 7 Cost Estimates for the implementation of the interventions identified in Ballyhugh

NbCM Intervention	No. of Interventions in the Deerpark Study Area	Upper Cost Estimate	Lower Cost Estimate
RAF	3 features	€31,219	€13,393
Floodplain Reconnection	4 ha (1 per 1,000m^3)	€ 94,033	€ 62,689
Wet Woodland	1.56 ha	€ 6,648	€ 4,019
	Total	€ 131,900.19	€ 80,099.82

The breakdown of likely construction and maintenance are shown in Table 8, over the 30-year life of the scheme. It should be noted that this does not cover any land purchases that may be required.

Table 8 Summary of whole-life cost estimates for the implementation of the identified NbCM in Ballyhugh

Stage	Cost	Upper Cost Estimate	Lower Cost Estimate	Average
Construction	Initial construction Costs	€ 131,900.19	€ 80,099.82	€ 106,000.00
	Mobilisation and site offices (assume 30% of construction)	€ 39,570.06	€ 24,029.94	€ 31,800.00
	Total initial capital costs (assume upper estimate)	€ 171,470.25	€ 104,129.76	€ 137,800.00
	Average Cost of initial construction			€ 137,800.00
	Average Cost plus optimism bias			€ 198,432.00
Maintenance	Annual Maintenance (assuming €2,800 per 10 km^2 per year)			€ 436.80
Total	TOTAL COST OF NbCM (Over life of scheme - including maintenance)			€ 206,902.45

4.2 Wider benefits

This report has not included a quantitative assessment of potential wider benefits (ecosystem services) delivered by the NbCM scheme. For the various interventions, there are significant benefits such as habitat creation, carbon sequestration, water quality improvements and amenity improvements that need to be considered as part of a well-rounded cost-benefit analysis. Assuming carbon sequestration rates of 0.77TCO2/ha/yr[19] for restored peatland and 19.5TCO2/ha/yr for tree planting (assuming density of 1,500 trees per ha with a carbon sequestration rate of 13kg CO2 per tree per year[20]) means that for Deerpark there is potential to sequester 525 TCO2/year from Peatland Restoration and Tree Planting alone. This does not account for the baseline carbon sequestration, however. There are also carbon sequestration rates from floodplain reconnection, runoff attenuation features and wet woodland to consider, as well as the biodiversity net gain and habitat creation potential of these interventions.

[19] Clymo RS, Turunen J, Tolonen K (1998) Carbon accumulation in peatland. Oikos 81(2):368–388. https://doi.org/10.2307/3547057

[20] Ibid., pp. 1, 16; sequestration per tree calculated assuming 500 trees per hectare, from UNEP Trillion Tree Campaign, "Fast Facts," at www.unep.org/billiontreecampaign, viewed 10 October 2007; growing period from Robert N. Stavins and Kenneth R. Richards, The Cost of U.S. Forest Based Carbon Sequestration (Arlington, VA:Pew Center on Global Climate Change, January 2005), p. 10.

4.3 Delivering NbCM in Ballinasloe

Delivery of NbCM schemes is still a relatively new concept in Ireland and requires development of appropriate funding and institutional arrangements.

4.3.1 Policy

Flood risk management policy in Ireland is outlined by the National Flood Risk Policy (2004) and the Inter-Departmental Flood Policy Coordination Group[21]. While the adopted policy does not specifically mention Natural Flood Management, it does promote a 'catchment-based' approach and greater emphasis on 'non-structural' flood relief measures.

Core components of national flood policy and the EU Flood Directive[22] are being delivered under the national Catchment Flood Risk Assessment and Management (CFRAM) programme. The CFRAM programme aimed to provide a clear picture of flood risk in areas of potentially significant flood risk and to set out how to manage the flood risk effectively and sustainably. The process included a Preliminary Flood Risk Assessment (2012), preparation of flood maps (2015) and preparation of 29 Flood Risk Management Plans (FRMPs). The FRMPs set out the whole of Government approach to managing flood risk, all have a specific measure regarding NWRM as follows:

'The OPW will work with the Environment Protection Agency, Local Authorities and other agencies during the project-level assessments of physical works and more broadly at a catchment-level to identify any measures, such as natural water retention measures (such as restoration of wetlands and woodlands), that can have benefits for Water Framework Directive, flood risk management and biodiversity objectives.'

The OPW are progressing with three actions to implement this measure; delivering Flood Relief Schemes, the NWRM Working Group, and Research and Pilot Studies. Refer to Appendix D for further details.

4.3.2 Potential Delivery Routes

There are numerous possible project delivery options based on the route chosen at each decision level (project lead, consenting route, funding pathway and maintenance responsibilities) as outlined in Figure 14.

[21] OPW (2020) Flood Risk: Policy and Co-ordination. Online. Available at: https://www.gov.ie/en/policy-information/aba306-flood-risk-policy-and-co-ordination/. Accessed on: 13/08/20
[22] European Directive on the Assessment and Management of Flood Risks (2007/60/EC) and Irish Law (Statutory Instrument No. 122 of 2010)

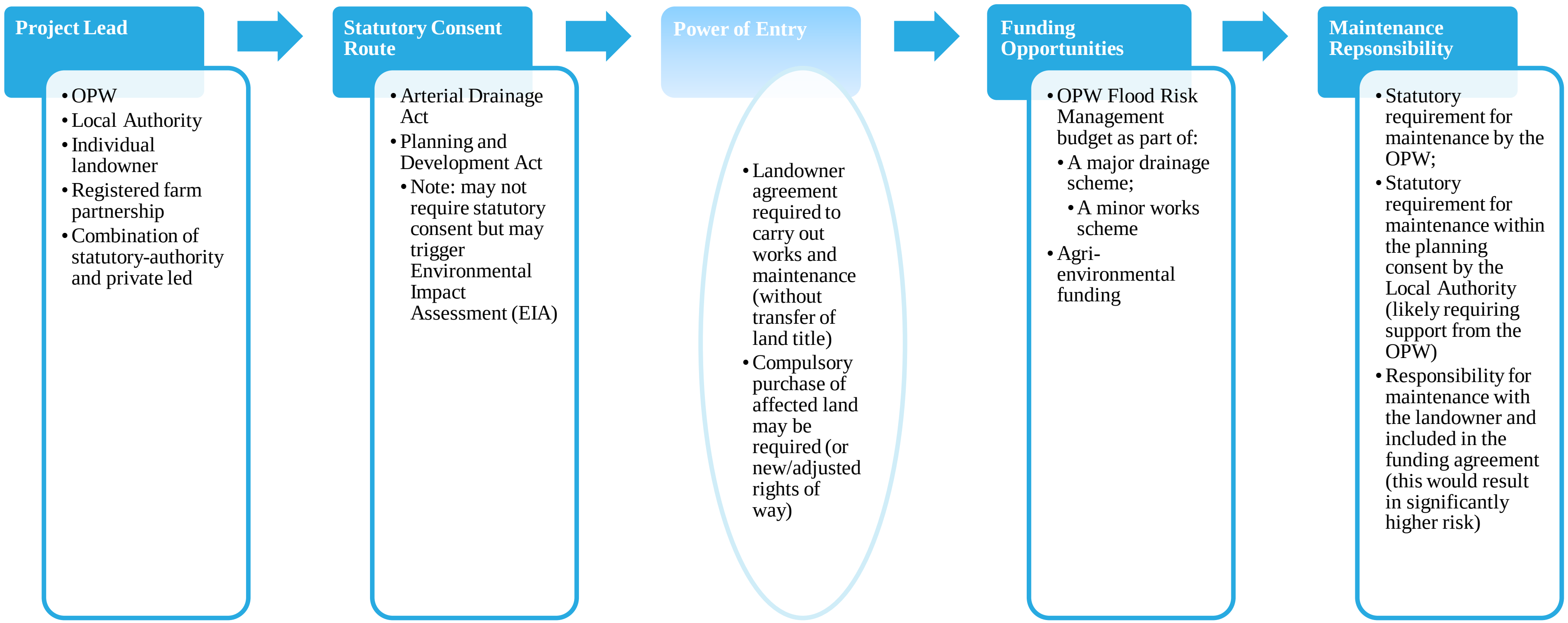


Figure 14: Outline of the potential delivery routes for NbCM in Ballinasloe

There are differing levels of risk and requirements associated with different delivery routes, with privately led schemes having less control and less certainty in the delivery of the desired outcome compared to a statutory led scheme. In terms of funding, agri-environmental funding through the Rural Development Programme 2014 - 2020 is one potential route, with two main funding streams that farmers can access:

[1] The Green, Low-carbon, Agri-environment Scheme (GLAS); and

[2] Basic Payment Scheme (BPS), that can be coupled with the Greening Payment.

Generally, the maximum GLAS payment is €5,000 per year. However, some farmers undertaking particularly challenging actions may qualify for GLAS+ and for a top-up payment of up to €2,000 per year. For example, measures that address NbCM include minimum tillage, planting a grove of native trees, planting new hedgerows and creating riparian margins[23]. For the BPS, payment value is determined annually based on payments for the previous financial year, land area and the subsequent amount of entitlements with a minimum amount of €100. This can be topped up with the Greening Payment, with an average payment of €100 per hectare, based on measures such as crop diversification, ecological focus areas and protection of permanent grassland.

However, agri-environmental funding is unlikely to be available at the scale required to effect significant change in the Ballinasloe catchment and the timescale of funding is relatively short. It is therefore considered likely that the majority of funding would still need to be sourced from OPW flood risk management budget.

Considering the lack of example studies in Ireland and established landowner-led delivery guidance and funding, it may be difficult to establish a privately led NbCM scheme in Ballinasloe. For a scheme to have reliable benefits, it would need to be delivered through a strong statutory mechanism such as the Arterial Drainage Act or the Planning Acts, accompanied by legal instruments granting powers of entry for construction and maintenance. Anything less robust carries a significant risk of the scheme not being fully deliverable or falling into disrepair.

5 Conclusions and Recommendations

This study seeks to provide an evidence base to demonstrate the extent to which NbCM measures could reduce and attenuate peak flows in the Suck catchment and provide flood risk mitigation in Ballinasloe, located downstream. Using GIS analysis, the Suck catchment has been mapped to show prioritised locations for eight types of NbCM opportunities. Hydrological modelling using an Arup-developed Aggregate Storage Model (ASM), was then undertaken in two study

[23] Department of Agriculture, Food and Marine. GLAS Structure. Available at: https://www.agriculture.gov.ie/media/migration/farmingschemesandpayments/glastranche1/GLASStructure240215.pdf. Accessed 13/08/20.

areas, Deerpark and Ballyhugh, to quantify the potential impact of the NbCM measures on peak flow.

The mapping analysis showed that Floodplain Reconnection and Runoff Attenuation features (RAFs) are the most suitable NbCM interventions within this catchment, covering approximately 10% and 7% of the study area respectively. This indicates that runoff reduction and floodplain storage in the Suck catchment are appropriate. However, Buffer Strips and Contour Plough were only prioritised in one of the grid squares each across the study area, indicating that sediment and nutrient management opportunities are limited in the Suck catchment. Given the spatial scale and distribution of suitable NbCM interventions across the Suck catchment, with over 9,400 features identified over a 1,584 km^2 area, the implementation of NbCM across the Suck catchment is not considered feasible.

Two smaller scale study areas, Deerpark and Ballyhugh, were therefore analysed to assess a more localised approach for NbCM to reduce peak flows to Ballinasloe. Deerpark comprised approximately 320 NbCM interventions over ~62 km^2 while Ballyhugh comprised 10 NbCM interventions over ~1.6 km^2. These features resulted in a 10.6% and 19.5% reduction in peak flow from Deerpark and Ballyhugh respectively. In terms of actual peak flow reduction, the NbCM interventions in Deerpark resulted in a reduction of 2.967 m^3/s, compared to 0.210 m^3/s from Ballyhugh.

NbCM interventions have adaptive capacity to mitigate climate change by increasing a catchment's resilience to climate change. NbCM can reduce peak flows and increase the time to peak creating a buffer to help mitigate the adverse impacts of climate change.

When considering the runoff reduction, floodplain storage and peat management NbCM inteventions identified in the Deerpark study area, a reduction in peak flows of 10.6% could be achieved for ~€ 6m project total cost. However, it should be noted that there are very few properties at risk from a Deerpark-only event, as properties close to the confluence with the Suck would not see any benefit. Wider benefits of a scheme in the Deerpark study area could be significant, with potential gains in carbon sequestration of 525 TCO2/year considering only the peatland restoration and tree planting opportunities. Implementation of the identified NbCM interventions in Ballyhugh could be achieved for ~€ 207k. While the potential reduction in peak flows from Ballyhugh will not be sufficient to alleviate the flood risk on its own, it could potentially be implemented in combination with structural works. It is recommended that the following activities are undertaken to achieve this:

- More detailed modelling to refine the design storms; and
- In-depth geospatial analysis to determine site-specific locations suitable for NbCM interventions, taking into account landowner access, environmental, geotechnical and ecological constraints as well as potential benefits.

Appendix A

NWRM Interventions

An overview of the different NFM options and their benefits is presented below.

Intervention Type | **Description**

Runoff attenuation (©Newcastle University)

Overland flow over bare soil or heavily poached fields can be slowed to reduce peak flows entering the watercourses. A runoff attenuation feature can be built to trap overland flow and form a pond or pool behind. Low bunds or other ground reprofiling can slow or divert flow to disconnect the pathways and divert them into low points, ponds, buffer zones or woodlands.

Floodplain Reconnection (©National Trust)

Floodplains can be restored or optimised to store large volumes of water for flood risk and ecological benefits. Floodplain areas would typically be flooded during high intensity events; floodplain reconnection aims to restore the hydrological connection between rivers and floodplains so that floodwaters inundate the floodplains and store water during times of high flows. This can involve removing flood embankments and other barriers to floodplain connectivity.

Large Woody Debris (©Newcastle University)

LWD are pieces of wood, occasionally combined with some living vegetation, that accumulate in river channels as well as on riverbanks and floodplains. LWD can occur naturally along rivers as a result of trees falling locally into watercourses through snagging of natural wood or occasionally due to beaver activity. Similar structures can also be engineered by humans to restore rivers and floodplains to slow and store flood waters.

Tree Planting (© Environment Agency)

Increasing tree cover has the potential to reduce flood risk by promoting soil infiltration, intercepting water on the canopy and increasing soil roughness, thus, slowing down the flow of surface runoff. The degree of benefit provided by tree planting can vary depending on the woodland, with coniferous being generally more efficient compared to broadleaved woodland. However, a mixed native woodland would provide the greatest benefits for biodiversity, providing a variety of food sources all-year-round.

Wet Woodland (© London Wildlife Trust)

Wet woodland is woodland located in the floodplain subject to intermittent, regular planned or natural flooding regime. It has the capacity to slow down and hold back flood flows within the floodplain and enhances sediment deposition and thereby reduces downstream siltation. It typically comprises broadleaved woodland and can range from productive woodland on drier, intermittently flooded areas to unmanaged, native, mixed wet woodland in wetter areas.

Contour Plough (© USDA-NRCS)

Contour ploughing is a farming practice which

involves ploughing and/or planting across a slope following its natural contour lines. This helps conserve rainwater and reduce soil losses from surface erosion

Buffer Strip (©The James Hutton Institute)

Buffer strips are areas adjacent to rivers, which are also referred to as ditches, dykes, becks, watercourses, where woody planting or grass buffers can be created to increase roughness and slow runoff. Due to their permanent vegetation, buffer strips promote effective water infiltration and slow surface flow.

Appendix B

NFM Scoring Criteria

Corine Land-Use Code	Description	RUNOFF ATTENUATION FEATURE	FLOODPLAIN RECONNECTION	LWD	TREE PLANT	WET WOOD	BUFFER STRIP	CONTOUR PLOUGH	PEAT MANAG-EMENT
Code_112	Discontinuous Urban Fabric	0	0	0	2	0	0	0	0
Code_122	Road and rail networks and associated land	1	0	0	1	0	3	0	0
Code_131	Mineral Extraction sites	2	1	1	5	1	2	2	0
Code_132	Dump Sites	0	0	0	3	0	3	0	0
Code_142	Sport and leisure facilities	2	3	1	1	2	2	0	0
Code_211	Non-irrigated arable land	3	2	3	3	2	5	5	0
Code_231	Pastures	5	4	4	3	3	4	0	0
Code_242	Complex cultivation patterns	4	2	3	3	2	4	3	0
Code_243	Land principally occupied by agriculture, with significant areas of natural vegetation	5	5	4	4	3	5	4	0
Code_311	Broad-leaved forest	3	3	5	3	5	0	0	0
Code_312	Coniferous forest	3	3	5	3	3	0	0	0
Code_313	Mixed forest	3	4	5	3	5	0	0	0
Code_321	Natural grassland	5	5	3	4	4	1	2	0
Code_324	Transitional Woodland Scrub	4	4	5	4	4	2	0	0
Code_334	Burnt Areas	3	3	3	5	5	3	3	0
Code_411	Inland marshes	3	4	5	3	5	1	1	3
Code_412	Peatbogs	2	3	4	0	0	1	0	5

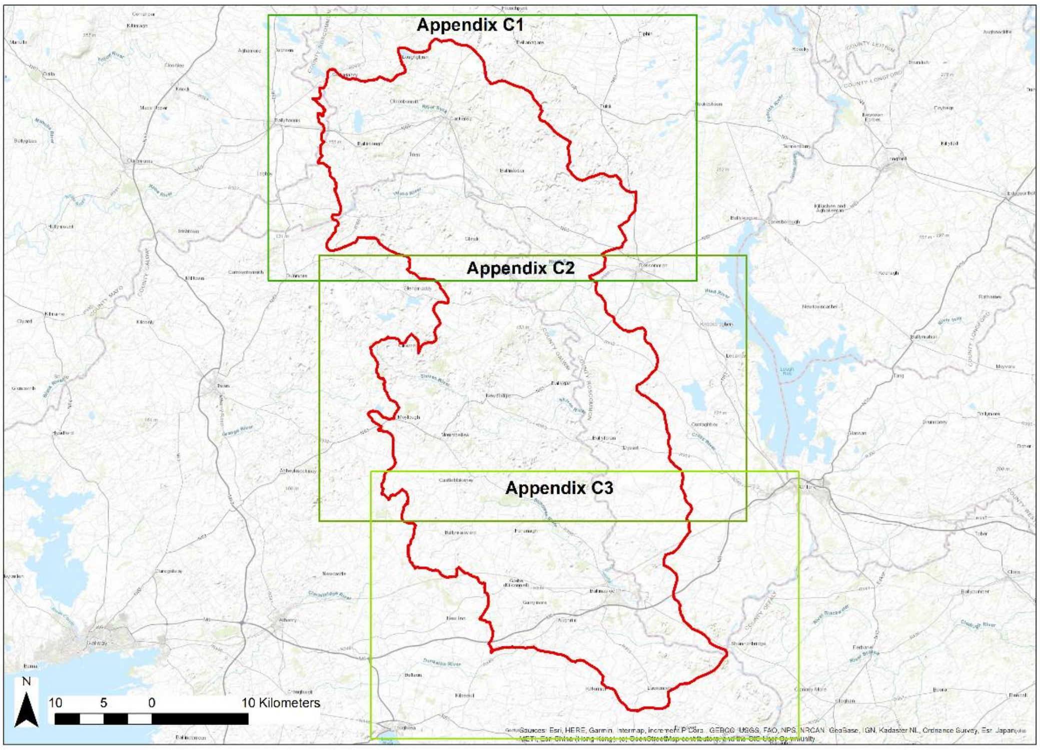
Runoff route length (m)	RUNOFF ATTENUATION FEATURE	FLOODPLAIN RECONNECTION	LWD	TREE PLANT	WET WOOD	BUFFER STRIP	CONTOUR PLOUGH
0	1	1	3	3	3	3	3
<500	2	2	3	3	3	3	3
<1000	3	3	3	3	3	3	3
<1500	4	4	3	3	3	3	3
>1500	5	5	3	3	3	3	3

Ecosystem Service	RUNOFF ATTENUATION FEATURE	FLOODPLAIN RECONNECTION	LWD	TREE PLANT	WET WOOD	BUFFER STRIP	CONTOUR PLOUGH
Cost	3	1	4	5	5	5	5
Funding	1	1	3	5	3	5	5
Maintenance	5	3	3	5	4	5	4
Life Expectancy	3	3	1	3	5	5	5
Flood (Fluv)	4	5	4	2.5	4	2	1
Flood (SW or GW)	5	4	4	4	4	2	3
Air Quality	1	1	1	4	3	2	2
Health Access	1	2	1	4	2	2	1
Low Flows	2	3	3	3	4	1	1
Climate regulation	2	3	4	5	5	2	2
Habitat	3	4	4	5	5	2	2
Water Quality	4	3	5	4	4	5	5
Cultural Activity	1	2	2	4	3	2	2
Aesthetic Quality	1	4	4	4	4	2	2

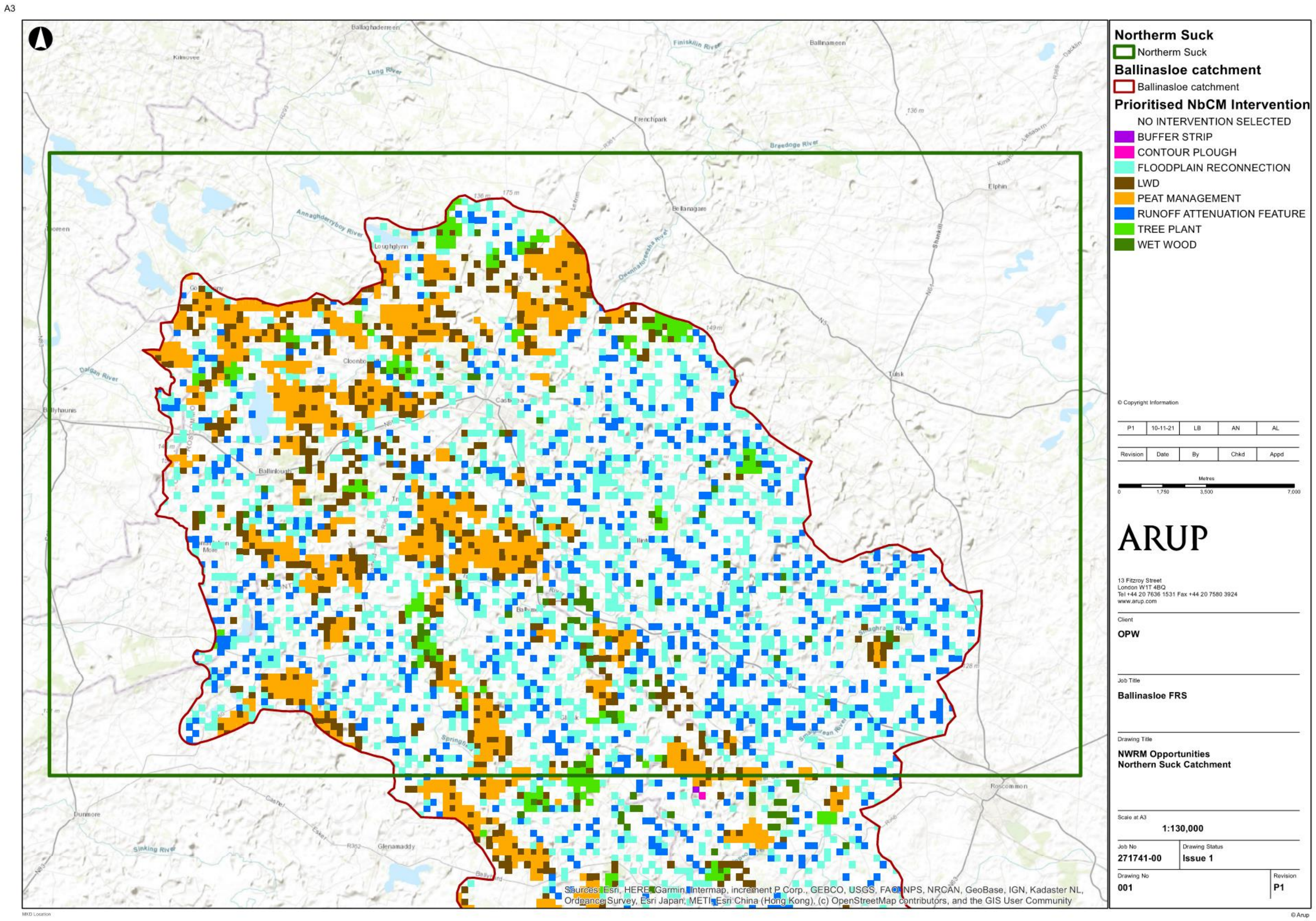
Appendix C

NFM Opportunity Maps

Overview map

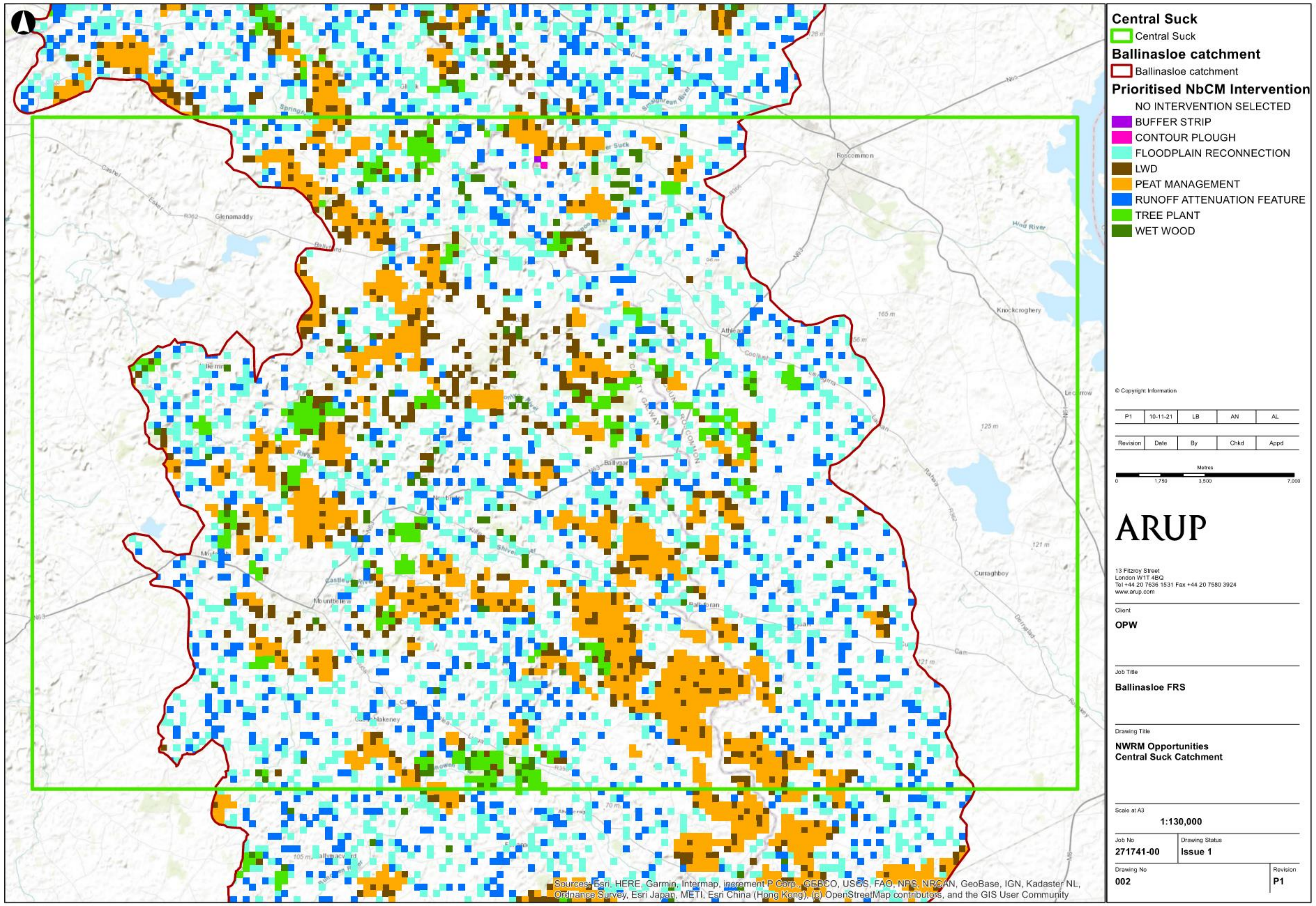


C1 Northern Suck



C2 Central Suck

A3

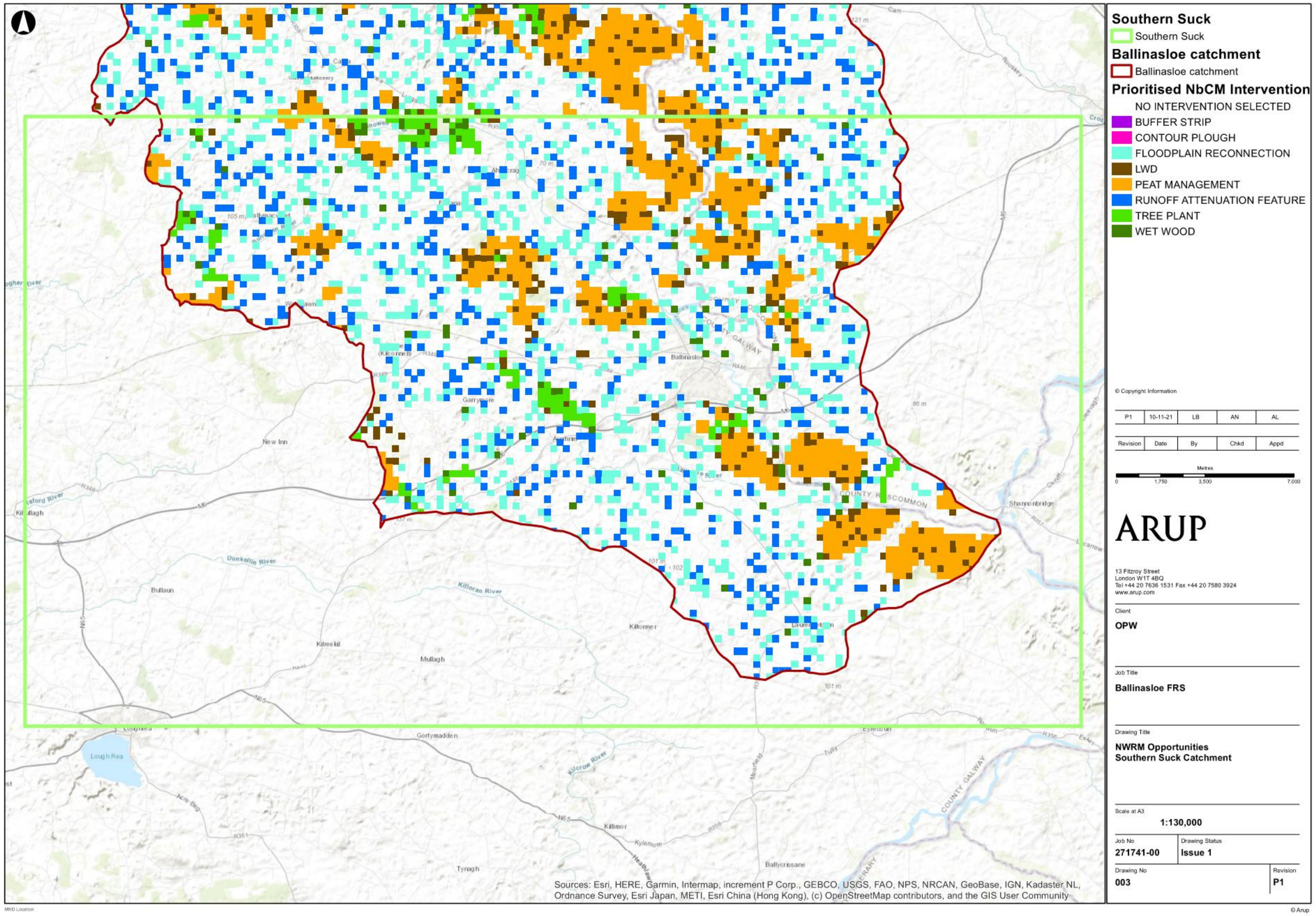


MXD Location

© Arup

C3 Southern Suck

A3



Appendix D

Nature based Catchment
Management – National Context

D1 OPW Status Update (2nd Feb 2021)

As the lead State body for the coordination and implementation of Government policy on the management of flood risk in Ireland, the OPW recognise that NWRM has a part to play in managing flood risk.

In May 2018 the Office of Public Works (OPW) published 29 Flood Risk Management Plans to address flood risk in Ireland. The Plans, which set out the whole of Government approach to managing flood risk, all have a specific measure regarding NWRM as follows:

'The OPW will work with the Environment Protection Agency, Local Authorities and other agencies during the project-level assessments of physical works and more broadly at a catchment-level to identify any measures, such as natural water retention measures (such as restoration of wetlands and woodlands), that can have benefits for Water Framework Directive, flood risk management and biodiversity objectives.'

The OPW are progressing with three actions to implement this measure; delivering Flood Relief Schemes, the NWRM Working Group, and Research and Pilot Studies.

Flood Relief Schemes

The OPW in partnership with the respective local authorities are currently progressing 57 of the 118 Floor Relief Schemes recommended in the Flood Risk Management Plans.

The first in a five stage process to deliver a flood relief scheme is to carry out scheme development and design, building upon the work already carried out in the National CFRAM Programme. During this phase, the scheme designers are required to carry out a NWRM feasibility assessment. This assessment will look at the feasibility of NWRM to form part of the flood relief scheme and also at the potential to achieve co-benefits.

The progression of these flood relief schemes is an opportunity for the implementation of NWRM to complement traditional engineering solutions.

NWRM Working Group

A NWRM Working Group was established to advise the River Basin Management Plan (RBMP) National Technical Implementing Group (NTIG) on proposals for including NWRM as part of a broader suite of mitigation measures that could contribute to the achievement of environmental objectives set out in the second RBMP.

In September 2020 the NWRM Working Group set out their recommendations in a report for the NTIG. The recommendations were as follows:

At the national level, utilise and/or enhance existing policies and measures to achieve maximum multiple benefits from NWRM within existing funding mechanisms.

At the catchment level, conduct a pilot study to assess the feasibility and cost-benefit of implementing NWRM at the catchment scale and recommend strategies for their implementation. Use the learnings gained as a springboard to roll out implementation nationally.

At the local level, prepare a simple best practice guidance document for Ireland to help community groups undertake local scale

Consideration should be given to development of a land use strategy or plan for Ireland that takes account of the principles of slowing the flow to achieve multiple environmental benefits. Similarly, any national river restoration guidance for Ireland should include the findings of this study.

Provide input to any future national drainage policy to incorporate NWRM as an integral part of the overall strategy.

A multiagency group under the NTIG to continue a forum to co-ordinate efforts for implementation of NWRM.

Rebrand NWRM in Ireland as: "Nature Based Catchment Management Solutions".

Research and Pilot Studies

The principal NWRM research being undertaken in Ireland is the SLOWWATERS project: 'A Strategic Look at Natural Water Retention Measures'. This four-year duration research, which is being carried out under the EPA Research programmes Water Research Call 2018, commenced in February 2019 and has a budget of €508,000. The research will assess the benefits of Natural Water Retention Measures for agricultural catchments in Ireland. The project outputs will provide recommendations for the management of specific catchment types relevant to the Irish environment by quantifying the magnitude of NWRM required to reduce flood peaks. Two demonstration sites in Cork and Wexford will show how to design, build and instrument NWRM. It is envisioned that the demonstration sites will be visited by numerous stakeholder groups to evaluate the practicalities of uptake of NWRM on Irish farms.

The research is being led by Professor Mary Bourke of Trinity College Dublin and the team includes authors of the Environment Agencies (UK) Working with Natural Processes - Evidence Directory from Newcastle University and The James Hutton Institute in Scotland as well as participants from University College Cork.

Research is also being carried out to assess the potential for NWRM in forested catchments in Ireland. The OPW through the Irish Research Council Enterprise Partnership Scheme are co-funding PhD research, titled 'The ecosystem services of Ireland's forests for flood protection and water quality'. The aim of the proposed project is to test the potential role of specifically-designed NWRM within conifer plantations to attenuate the flux of water, sediment and soluble pollutants to receiving waters and thereby reduce the flood risk and environmental impact of forestry operations to sensitive catchments. This research commenced in March 2019 and will use GIS-based mapping techniques, hydrological modelling, and full-scale field demonstration sites.

Through these three actions the NWRM measure in our Flood Risk Management Plans will be substantially complete and will provide us with an additional suite of measures to compliment traditional engineering solutions to flood risk management while also achieving multiple-benefits in other sectors.