

River Restoration Centre

20th Annual Network Conference

River Restoration in Practice

30th April – 1st May 2019 – Britannia Adelphi Hotel, Liverpool

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Abstracts

2019

RIVER RESTORATION CENTRE 20TH ANNUAL NETWORK CONFERENCE

"River Restoration in Practice"

30th April and 1st May 2019 – Britannia Adelphi Hotel, Liverpool

PROGRAMME OF EVENTS

DAY 1: **- - - TUESDAY 30TH APRIL - - -**

REGISTRATION at Reception
Opens at 08:30

09:00	NETWORKING & EARLY VIEWING POSTER SESSION in Room TBC	60 mins

Session 1
Main Banqueting Room

CHAIR: Martin Janes (*the River Restoration Centre*)

10:00	**River Restoration Centre introduction & welcome** Martin Janes *(the River Restoration Centre)*	15 mins
10:15	**A process-based approach to restoring depositional river valleys, an anastomosing channel network** Johan Hogervorst & Paul Powers *(US Forest Service)*	15 mins
10:30	**River restoration in concrete channels** Jean-Noël Pansera *(Rhin-Meuse Water Agency)*	15 mins
10:45	**Discussion**	15 mins
11:00	SHORT BREAK with coffee and tea	35 mins
11:35	**Innovation, technology and knowledge transfer to support the enhancement of water quality, instream habitat and riparian management** Ruairí Ó Conchúir *(Waters and Communities Office (Ireland) – LAWCO)*	15 mins
11:50	**Westcountry Rivers Trust: 25 Years of managing at a catchment scale** Laurence Couldrick *(Westcountry Rivers Trust)*	15 mins
12:05	**After the Mersey Basin Campaign, what happened next?** Peter Batey *(Mersey Rivers Trust & Nature Connected)*	15 mins
12:20	**Discussion**	15 mins
12:35	LUNCH in **Room TBC**	60 mins

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Session 2

	Main Banqueting Room	**Kensington**	**Derby**	
	Delivering Natural Flood Management	Large-scale river engineering	Analysing the data	
	CHAIR: *Ann Skinner (River Restoration Centre Board)*	**CHAIR:** *Jenny Wheeldon (Natural England)*	**CHAIR:** *Phil Boon (River Restoration Centre Board/Freshwater Biological Association)*	
13:35	**Small scale Natural Flood Management interventions in Norfolk, Suffolk and Essex** Helen George *(Environment Agency)*	**A14 – Delivering habitat improvements at a grand scale!** Kevin Skinner *(Atkins, member of SNC-Lavalin Group)*	**A multiple catchment-scale analysis of historic upland river channel planform adjustments over the last 150 years: A case study in the Lake District, UK** Hannah Joyce *(Durham University)*	15 mins
13:50	**Natural Flood Management in practice: overcoming challenges faced by practitioners in two Nottinghamshire catchments** Josh Wells and Alan Graham *(Trent Rivers Trust)*	**Delivering major infrastructure, flood risk and biodiversity benefits through collaboration: the A120 Little Hadham bypass and Flood Alleviation Scheme** Nick Elbourne *(Environment Agency)*	**Looking forward, looking back: a catchment-based approach to the changing Dorset Stour** Antony Firth *(Fjordr Ltd.)*	15 mins
14:05	**Discussion**	**Discussion**	**Discussion**	10 mins

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Session 2 – continued…

14:15	**Missenden Stream Natural Flood Management and Restoration** Alex Back *(Buckinghamshire County Council)*	**"River Restoration in Practice" – Enhancement or just good design? A collaborative approach to river and wetland restoration** James Maddison *(Jacobs)*	**Dataset overload - processing methods to support effective catchment planning and assessment** Rosanna Griffiths *(Stantec)*	15 mins
14:30	**Floodplains – The sponges of our ecosystems: lessons learned from implementation** Hamish Moir *(cbec eco-engineering)*	**Glenridding flood alleviation scheme: combining natural flood management with traditional engineering to deliver flood resilience in complex upstream environments** Lyndon Baker *(Atkins)*	**Investigating channel sensitivity to morphological changes and impact on future flooding** Natasha Todd-Burley & Rebecca Ing *(JBA Consulting)*	15 mins
14:45	**Discussion**	**Discussion**	**Discussion**	10 mins
14:55	POSTER SESSION in Room TBC with tea and coffee *Vote for your top poster (not just your friends!)*			45 mins

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Session 3

	Main Banqueting Room Morphology & physical processes	Kensington Exploring the potential benefits of Natural Flood Management	Derby Involving stakeholders in catchment management	
	CHAIR: *Oliver Lowe (Natural Resources Wales)*	**CHAIR:** *Lydia Burgess-Gamble (Environment Agency)*	***CHAIR:*** *Jo Cullis (Jacobs/River Restoration Centre Board)*	
15:40	**The Stream Evolution Triangle: integrating the influences of geology, hydrology and biology** Janine Castro *(US Fish and Wildlife Service)*	**Modelling the effects of large woody dams on sedimentary processes** Matthew McParland *(University of Liverpool)*	**River Irwell: small streams, big WFD gains** Kimberley Jennings *(JBA Consulting)* and Katherine Causer *(Environment Agency)*	15 mins
15:55	**Dynamic waters full of life: letting rivers do the work** Glenn Maas and Mark Diamond *(Environment Agency)*	**Natural Flood Management in Upper Wharfedale: a collaborative and coordinated approach to creating a resilient landscape** Daniel Turner *(Yorkshire Dales Rivers Trust)*	**Taclo'r Tywi/Tackling the Tywi-working in partnership to restore an iconic river** Ioan Williams, Megan Herbert-Evans & Huw Williams *(Natural Resources Wales)*	15 mins
16:10	**Discussion**	**Discussion**	**Discussion**	10 mins

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Session 3 – continued…

16:20	**The science and 'Art' of geomorphology – how fluvial geomorphology contributions are developing and maturing over time** Katy Kemble *(Jacobs)*	**Evaluating NFM benefits : Keeping it simple** David Brown *(Environment Agency)* and Mike Norbury *(Mersey Forest)*	**Rivers and Wetlands Community Days - inspiring communities** Stuart Malaure and Dominic Martyn *(Environment Agency)*	15 mins
16:35	**Designing for instability: process-form restoration across our rivers and floodplains** George Heritage *(AquaUoS)*	**Estimating effectiveness of Natural Flood Management: Keeping it simple** Marc Huband *(Atkins)*	**Becoming impatiens with Balsam on our river banks** Nicola Craven *(Lincolnshire Rivers Trust)*	15 mins
16:50	**Discussion**	**Discussion**	**Discussion**	10 mins
17:00	SHORT BREAK TO MOVE TO KEYNOTE SESSION			10 mins

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Session 4

Main Banqueting Room

CHAIR: *Fiona Bowles (River Restoration Centre Board)*

17:10	**Restoration in Practice: Rivers for the Future, Rivers for Everyone** Colin Thorne *(University of Nottingham*)	25 mins
17:35	**Questions and reflections**	20 mins
17:55	**Poster competition prizes, final announcements and close** Martin Janes (*the River Restoration Centre*)	5 mins
18:00	END OF DAY 1	

UK River Prize

19:00 FOR 19:30 – UK RIVER PRIZE AWARDS DINNER

Main Banqueting Room

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DAY 2: **- - - WEDNESDAY 1ST MAY - - -**

Registration **Opens at 8:30 am**

Session 5

9:00	CHOICE OF ONE SITE VISIT OR ONE WORKSHOP	3 h 30 min

Workshop A:
Future planning for a changing climate: cities & catchments

Facilitator: David Hetherington & Sally German *(Arup)*

David Hetherington will lead on this workshop looking at the concepts from a new publication with IWA – integrating cities and water. Three topics based around key issues will be discussed in a 'world café' format, including presentations on NFM for cities, and Green Infrastructure as an influencer of catchment processes. This workshop aims to look at how we can better connect cities and catchments.

Land use change in response to climate change: outcomes for catchments from research for the Adaptation Sub Committee

Rachelle Ngai *(JBA Consulting)*

Workshop B:
Learning lessons from what goes wrong

Facilitator: Martijn Antheunisse *(Wessex Chalk Stream and Rivers Trust),* Brian Smith *(Environment Agency),* Tim Martin *(Greenfix)*

One of the most valuable tools for improving is learning from what does not work out as expected. Understanding what went wrong, why and how you would do it differently is critical, especially with the high levels of uncertainty in working with natural systems. Lessons from fixing or overcoming a developing problem also provide valuable insight.

This workshop will:

- Use case studies and examples of projects that did not go to plan;
- Give the thoughts and insights from project managers and practitioners;
- Explore the why and how it happened;
- Discuss how we can reduce the risk of failure;
- Suggest how each participant in a restoration scheme could better reflect on and evaluate their previous projects.

If you are also interested in contributing case studies, examples, insights and experiences please let RRC know.

12:30	LUNCH	65 mins

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Session 5

9:00	CHOICE OF ONE SITE VISIT OR ONE WORKSHOP continued…	3 h 30 min

Workshop C:
Protecting, managing and restoring small waterbodies: ponds and small lakes, headwaters, ditches, springs and flushes

Facilitator: Jeremy Biggs *(Freshwater Habitats Trust)* & Stewart Clarke *(National Trust)*

In this workshop we will review and discuss the importance of small waters for freshwater biodiversity and ecosystem services. The session will consider monitoring and assessment methods, practical measures for creating, protecting and restoring small waters, methods for enhancing ecosystem service delivery and opportunities for partnership. We will discuss the role of small waters in natural flood Management projects.

Assessing natural flood management opportunities and associated potential benefits in headwater catchment areas
Ryan Jennings & Steve Rose *(JBA Consulting)*

Workshop D:
Citizen science for impact

Facilitator: Marc Naura *(River Restoration Centre)* and MICS Project

This workshop will focus on the benefits and evidence of the inclusion of citizen science activities to enhance river restoration practices and its wider societal and economical aspects – how they provide a knowledge-base for the design, implementation and evaluation phase of river restoration practices and improve sustainability of restoration efforts through increased participation and accessibility of larger audiences.

We will highlight the potential of citizen science to contribute to the evidence base for well-grounded decision-making in policy through two short case-study presentations from the river monitoring realm. We will then discuss the experience of the audience on definitions, requirements and opportunities for participatory research approaches to complement or replace traditional research and evaluation procedures within river restoration.

The River Starts Here! Collaboration between a Rivers Trust and the Environment Agency to monitor, analyse and improve water quality in an urban headwater
Julie Wozniczka *(Trent Rivers Trust)* & Shelley Doe *(Environment Agency)*

Unlocking the Severn - for People and Wildlife
Jason Leach *(Canal & River Trust)* & Tim Thorpe *(Severn Rivers Trust)*

Extending beyond the reach: Engaging with evidence through citizen science
Lucy Shuker *(Thames 21)*

12:30	LUNCH	65 mins

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Session 5

9:00	CHOICE OF ONE SITE VISIT OR ONE WORKSHOP continued…	3 h 30 min

Workshop E:
Reinstating channel-wetland-floodplain systems to pre-disturbance condition

Facilitators: Colin Thorne *(University of Nottingham)*, Johan Hogervorst *(US Forest Service)*, Paul Powers *(US Forest Service)* & Janine Castro *(US Fish and Wildlife Service)*

Stream restoration is often based on creation or re-creation of a single thread, meandering channel with a bankfull discharge return period of 1.5 or 2 years. The channel is designed to achieve 'sediment-balance', in which all the sediment supplied from upstream and locally is transported downstream. This is appropriate in 'sediment transport or transfer' reaches, but not in reaches with active floodplains, which are net sediment sinks. There is now overwhelming geologic, historical, empirical and theoretical evidence that natural, sediment sink reaches are characterised by multi-threaded channels that are fully connected to wetland-floodplain complexes.

This workshop introduces a new approach to restoring degraded streams – generally referred to as 'Stage Zero' - into connected channel-wetland/ meadow-floodplain systems that replicate pre-disturbance conditions.

Presentations will cover the theory, case study demonstrations, strengths and limitations, and strategies for managing risk. The presenters aim to inform restoration professionals and practitioners about the opportunities associated with restoring full channel-floodplain connectivity.

Site visit 1:
Daylighting on the River Alt

Facilitators: Helen Rawlinson (Cass Foundation), Janet Hooke (University of Liverpool) & Phil Putwain

This case study centres on the reclamation of 8.2ha of brownfield land, 'daylighting' the River Alt into a newly engineered 900m section of river, mosaic of habitats and publically accessible greenspace known as 'Alt Meadows'. The project led to the creation of an enhanced environment providing a catalyst for positive change and regeneration. The visit will look into the project's economic and environmental drivers, the importance of genuine collaboration between project partners, contractors, University of Liverpool and the local community. In addition, facilitators will provide information on the ecological and physical design and monitoring as background to discussion about the channel morphology, processes and ecological development.

Site visit 2:
Working with Natural Processes (WwNP): Blackbrook Slow the Flow, St Helens

Facilitators: Mike Norbury (Mersey Forest) & David Brown (Environment Agency)

Blackbrook in St Helens, Merseyside, experiences repeat flooding from a combination of main river and surface water sources. Blackbrook has a 5% chance of flooding in any given year and sits in a low-lying bowl at the confluence of 5 rapid response catchments whose upstream area is 21km2. Capital solutions to reduce the flood risk are prohibitively expensive, as culvert enlarging would be required to reduce the flow constriction. This site visit will cover the NFM works that were undertaken upstream and will cover topics including the practical implementation, benefits, and the sediment and water quality implications.

12:30	LUNCH	65 mins

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Session 6

	Main Banqueting Room Best practice design	Kensington Catchment planning & delivery	Derby Fish passage & habitat restoration	
	CHAIR: *Will Bond (Alaska E.C. Limited/River Restoration Centre Board)*	**CHAIR:** *Pam Nolan (Environment Agency)*	**CHAIR:** *Judy England (Environment Agency)*	
13:35	**Investigating step-pool channels in the Highlands** Carolyn Cload *(University of the Highlands and Islands)*	**Riverlands. Partnership working - does the practice match the theory?** Antonia Scarr *(Environment Agency)* and Richard Higgs *(National Trust)*	**Highlights and low points from the five year saga to improve fish passage on the River Ehen** Jodie Mills *(West Cumbria Rivers Trust)*	15 mins
13:50	**Engineered Wood Structures - practical experience of design, implementation and monitoring from process restoration to sustainable bank protection applications** Eric Gillies *(cbec eco-engineering)*	**Developing a strategy for delivery of catchment wide Natural Flood Management** Thea Wingfield *(University of Liverpool)*	**Greater Thames estuary fish migration roadmap: A platform for identifying habitat restoration and creation opportunities** Wanda Bodnar *(Thames Estuary Partnership)*	15 mins
14:05	**Discussion**	**Discussion**	**Discussion**	10 mins

Session 6 – continued…

14:15	**Getting Down and Dirty with a Digger** Di Hammond *(Affinity Water)* and David Holland *(Salix River and Wetland Services)*	**Delivering Integrated Catchment Management - the Littlestock Brook pilot study in the Thames Basin** Joanne Old and David McKnight *(Environment Agency)*	**Habitat restoration at Powick Weir - A case study in saving King Henry III's favourite fish** Peter Brunner *(Royal HaskoningDHV)*	15 mins
14:30	**Construction Design for River and Floodplain Naturalisation** Seb Bentley *(AquaUoS)*	**Strategic approach to river restoration planning** Marc Naura *(River Restoration Centre)*	**Video monitoring of fish in rivers: research and management perspectives** Mickael Dubois *(Cranfield University)*	15 mins
14:45	**Discussion**	**Discussion**	**Discussion**	10 mins
14:55	MOVE TO GRAND FINALE!			15 mins

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Session 7

Long-term lessons for river management

Main Banqueting Room

CHAIR: *Kevin Skinner (Atkins/River Restoration Centre Board)*

15:10	**National assessment of the spatial distribution of river restoration projects in the UK: Monitoring, assessment and maintenance** Harriet Moore *(University of Lincoln)*	15 mins
15:25	**International guidance and case studies on using Natural and Nature-Based Features to reduce flood risk and improve the environment** Lydia Burgess-Gamble, Oliver Burns and Jo Guy *(Environment Agency)*	15mins
15:40	**Global challenges tackled through river basin restoration: A reappraisal of the importance of our work** David Hetherington *(Arup)*	15 mins
15:55	**Final words** *(River Restoration Centre)* **Questions, thoughts and parting insights**	20 mins

16:30	END OF CONFERENCE with tea and coffee

Day1: Tuesday 30th April

Session 1: Main Banqueting Room

A PROCESS-BASED APPROACH TO RESTORING DEPOSITIONAL RIVER VALLEYS, AN ANASTOMOSING CHANNEL NETWORK

J. HOGERVORST[1] & P. POWERS[1]

1 US Forest Service

Within the Pacific Northwest Region of the US Forest Service, adoption of the Stage 0 (Cluer and Thorne, 2013), or process-based restoration approach began on the arid, east side of the Cascade Mountain Range. The earliest projects of this type were designed and implemented in second order streams flowing through degraded meadow systems. As a result of anthropogenic disturbance coupled with the loss of beaver, these project areas had experienced head cutting and channel incision followed by a lowering of the alluvial aquifer and a transition from wetland to arid terrace. In these areas, the restoration design deviated from the historic approach of headcut stabilization and instead sought to recover the entire wetland complex by working at the valley scale. This resulted in the development of broad wetland complexes with no constructed stream channels.

The rapid succession of wetland features and attributes observed in these early projects prompted restoration specialists to expand this approach to larger, bedload dominated systems on a variety of landscapes ranging from lacustrine valleys in the Oregon Coast Range, to moderate gradient valleys in the West Cascades (1-2%) and Klamath Basin (6%). The same general approach was followed on all of these landscapes, which included the development and construction of a depositional valley as opposed to the design and construction of a “balanced” channel. These project types restore fluvial processes and in turn restore ecological benefits that have been largely lost in many river systems (Bellmore et al. 2013, 2015, 2017).

The design of these projects begins with the primary goal of maximum floodplain connectivity. Rather than design channels that are connected to the floodplain at a bankfull discharge event, this approach, instead, constructs valley surfaces and aims to maintain a base flow water surface and alluvial aquifer that is at or near the valley floor elevation. Development of this design relies heavily on the valley slope and connecting surfaces longitudinally and laterally. This presentation walks through how to design these Stage 0 projects and provides examples of the methodology (Powers et al., In Prep). Newly developed GIS mapping based on LiDAR derived elevations allows us to effectively display historic surfaces as well as interpret how the current valley matches or deviates from that historic condition.

RIVER RESTORATION IN CONCRETE CHANNELS

J. PANSERA[1]

1 Rhin-Meuse Water Agency

In order to maintain riverbanks, to control flood or to protect roads and habitations, some towns and villages have built concrete channels in the 19th or early 20th century. These concrete channels are more or less efficient, but above all they disconnect the river from its floodplain and the groundwater. Furthermore, the width is often oversized so that the water height isn’t sufficient most of the time, especially in summer.

The ideal restoration process would be to remove the concrete walls and bottom in order to set up natural riverbanks, reduce the riverbed and plant trees and shrubs. Unfortunately, when roads or habitations are built close to the concrete channel, it isn't possible.

A solution improved in different villages in North East of France consist in restoring river banks within the concrete channel, by setting up different facilities.

1. Groin systems to stock sands and gravels, so that a natural riverbank can be created and colonized by local plants
2. Natural riverbanks filled with earth, girdled by stones to prevent erosion and planted with helophytes and local plants
3. Stones and gravels riverbanks

INNOVATION, TECHNOLOGY AND KNOWLEDGE TRANSFER TO SUPPORT THE ENHANCEMENT OF WATER QUALITY, INSTREAM HABITAT AND RIPARIAN MANAGEMENT

R. Ó CONCHÚIR[1]

1 Waters and Communities Office (Ireland) – LAWCO

In the period November 2009 to May 2015 in work on the Lower Shannon (Ireland) the following was achieved: River Restoration & Instream Measures: Installed 28 rubble mats on 10km of the Mulkear River, helping to enhance habitat for salmonids and lamprey species, improving instream and riparian biodiversity. Enhanced over 15km of river channel through instream measures (random boulders, vortex and stone weirs) on the Clare-Annagh, Killeengarriff, Bilboa and Newport rivers. Researched, designed, manufactured and successfully installed fish passes to assist Sea Lamprey ascend major barriers opening up an additional 184km of habitat. Following 15 months of careful planning and consultation, removed Ballyclogh weir on the Lower Mulkear River as a barrier to salmonid and sea lamprey passage, thereby greatly improving upstream habitat and opening up the entire catchment.

Current Work - 2018 to 2021: The current work has continued to focus on the enhancement of habitat for Atlantic salmon, Sea lamprey and European otters in the catchment. It will also continue to focus on a greater awareness and understanding of issues affecting the SAC and how to manage these issues. The positive momentum developed by MulkearLIFE over the project time frame has been harnessed into the current work programme. This will ensure that the excellent work carried out on the ground, the tangible and intangible achievements, the partnerships built, and the outreach work conducted, will continue to be delivered to further enhance the conservation status of the Lower Shannon SAC. The focus on the current work programme is agriculture. The work has and will continue to deliver a catchment sensitive approach in a catchment which is "At Risk". It works with locals to support them to achieve good water quality and related instream habitat. The key objectives are to:

1. Build capacity within the farming community to identify and mitigate agricultural impacts on water quality through practical on-farm measures and shared learning in catchment sensitive farming discussion groups
2. Deliver a collaborative partnership model to enable partners, using the source-pathway-receptor model, to collectively identify key water quality concerns in the catchment

3. Collate data generated from local catchment assessments to mitigate the risk from the major sources and pathways identified while simultaneously developing baseline data for monitoring purposes
4. Deliver a highly innovative collaborative approach to catchment sensitive farming with local farmers inputting into the co-design and development of appropriate mitigation measures
5. Celebrate the Lower Shannon River SAC via a community based outreach programme based on improving local water quality, biodiversity and riparian management

WESTCOUNTRY RIVERS TRUST: 25 YEARS OF MANAGING AT A CATCHMENT SCALE

L. COULDRICK[1]

1 Westcountry Rivers Trust

The Westcountry Rivers Trust is one of the oldest Rivers Trust and was set up in 1994. It was set up due to significant diffuse pollution pressures damaging the aquatic habitats and species and from the early days knew it had to manage at a catchment scale to deal with water quality and quantity. Now 25 years old it has had some considerable successes but continued lack of enforcement, economic pressure and climate change means that there is still a huge problem in that over a third of farmed land and soils is seriously degraded.

Whilst this pressure on our soils is not new and we know the individual solutions it is still considered a 'wicked' problem as the collective solution is incredibly complex, requiring action on a large scale not just spatially but also socially pulling across multiple sectors. The presentation highlights the approaches and evidence needed to deliver change at both the small scale and the larger catchment scale.

This includes three themes:

1. The targeting of problems using cutting edge monitoring and modelling as well as low cost citizen science programmes to generate large data sets that can advise both advisory and regulatory effort. The Trust has kitted out over 200 members of the public with monitoring equipment, who have collectively taken over 1500 samples. This data including Total Dissolved Solids has been used to feed into the Environment Agency's (EA) Agile network under the Strategic Monitoring Review and has already led to targeting of advisory and regulatory resources. Alongside the use for targeting, high density lower quality data can also be used in combination with the lower density higher quality EA's Sentinel data network, to inform success.
2. The use of advisors and grant incentives, targeted to at risk areas, at a catchment scale. The work of the Trust has proved successful both at a small to medium scale but the complexities and nature pressures coming from poor soil management mean that it will always be a challenge to document change at a large catchment scale. This element explores the increasing evidence for instigating sustainable land use change.
3. The broadening of understanding of soils across a wider society. The Trust has taken on the responsibility of working through multiple partnerships to increase the profile of soils and negotiate the standardisation of advice and approach as an area level. This has been through groups like the Catchment Partnerships, Regional Flood and Coastal Committee, Local Nature Partnerships and Local Enterprise Partnerships and has developed into a Cornwall and Devon

Soils Alliance. This collective was instigated to pull together the 80 plus advisors across Devon and Cornwall as a way of increasing the capability and capacity of soils advice.

Through these three mechanisms the Trust and its partners and affiliates can take the small to medium scale successes and embed those in larger long term change at a catchment scale.

AFTER THE MERSEY BASIN CAMPAIGN, WHAT HAPPENED NEXT?

P. BATEY[1]

1 Mersey Rivers Trust & Nature Connected

As a government-sponsored 25-year initiative to clean up the rivers, canals and estuary of the Mersey River Basin in North West England, the Mersey Basin Campaign was a pioneer in public-private-voluntary sector partnership working and, in the period it was active (1985-2010), made great progress in improving water quality, promoting waterside regeneration, and engaging stakeholders, in a region with a history of severe industrial dereliction and pollution.

After 25 years the present author, as Chairman of the Campaign, made an honest assessment of what it had achieved and recommended to government that the Campaign had, to a large degree, fulfilled its original aims and, unlike some organizations which 'die a lingering death', should aim to make a well-planned, tidy exit in March 2010. The only exception was to be the Healthy Waterways Trust, the charitable arm of the Campaign.

With no full-time staff, and a very small budget inherited from the Campaign, the prospects for the Trust were not good. This paper describes how, contrary to expectations, a strategic partnership has been recreated, playing a new role as the Rivers Trust for the Mersey Basin and hosting three Defra Catchment Partnerships, with a full programme of projects. The paper outlines the main challenges faced by the Trust, notably:

1. Carrying forward some important lessons from the Campaign, including the need to link strategy and delivery in a balanced way and to maintain a consistent, long-term vision
2. Understanding the implications of the big changes in the institutional and funding context post 2010 and their adverse effects on partnership working
3. In the early years especially, being realistic about what the Trust could expect to achieve given its almost complete lack of resources
4. Being pragmatic in building and re-building partnerships, recognizing that, more so than in the past, working alone is unlikely to produce the desired results
5. Adopting a patient, diplomatic approach in bringing new partners on board
6. Ensuring that projects are properly costed and make an appropriate contribution to core funding
7. Nurturing good working relationships between the Trust and key partners such as the Environment Agency, the water company and a large land and property development company and being prepared to take on a mediating role, if necessary
8. Recognizing the differences in emphasis between the Campaign, with its strong urban regeneration theme, and the greater stress on environmental management associated with the catchment-based approach and the work of the Rivers Trust movement
9. Learning when to say no to projects

The paper reviews the process by which the Trust (now re-named the Mersey Rivers Trust), reached its present status, its current portfolio of projects and its future plans.

Session 2: Parallel Sessions

Main Banqueting Room: Delivering Natural Flood Management

SMALL SCALE NATURAL FLOOD MANAGEMENT INTERVENTIONS IN NORFOLK, SUFFOLK AND ESSEX

H. GEORGE[1]

1 Environment Agency

Seven Natural Flood Management (NFM) projects are taking place in East Anglia, as part of a national Defra pilot aimed at closing the evidence gap surrounding the impacts of NFM. Funding for the pilot was released in 2017 by Minister Coffey with 26 projects taking place across the country.

The projects in Norfolk, Suffolk and Essex consist of catchment-scale interventions above communities to varying degrees, at risk of fluvial flooding. Each project is trialling various slow the slow techniques that hold water back where it's safe and environmentally beneficial to do so, each with the aim of reducing local flood peaks and flood risk to people and properties. These projects have been designed to work with the natural processes in play at the various locations and include interventions such as floodplain reconnection, leaky debris dams and creation of storage features whilst evidencing the accompanying biodiversity benefits that follow when natural process are restored.

Each project is being delivered in partnership with a variety of organisations including Norfolk Rivers Internal Drainage Board, Norfolk Rivers Trust, National Trust, Natural England, Suffolk County Council and Essex Wildlife Trust. To understand the benefits of the interventions being trialled, extensive hydrometric, ecological and physical habitat monitoring is essential to meet the pilot objectives. Hydraulic modelling is also taking place to help understand how the interventions impact flood risk locally. Various Environment Agency functions and external partners are involved in this monitoring, collecting vital data which will be used to report back to Defra in 2021 when the environmental and flood risk impacts of these projects will be better understood.

This presentation will give a summary of the 7 projects taking place across Norfolk, Suffolk and Essex, with a more detailed overview focussing on one of the individual schemes being delivered. This will detail who's responsible for each aspect of the project from design, construction to monitoring and everything in-between.

NATURAL FLOOD MANAGEMENT IN PRACTICE: OVERCOMING CHALLENGES FACED BY PRACTITIONERS IN TWO NOTTINGHAMSHIRE CATCHMENTS

J. WELLS[1] & A. GRAHAM[1]

1 Trent Rivers Trust

Natural flood management (NFM) is becoming more widely used within UK Flood Risk Management (FRM) projects as a method to complement existing or planned structural interventions. With the launch of the Working with Natural Processes evidence base, the current scientific understanding of impacts that NFM has on flood risk has been compiled. However, it has been identified that there are still gaps within the evidence base needing to be addressed. The DEFRA allocation of £15 million towards NFM within the UK offers opportunity to achieve this, but practitioners of NFM still face challenges within FRM policy which hinder progress. Furthermore, engagement with landowners

presents its own challenges. With no current policy in place to recompense landowners for losses or to maintain interventions, policy is lacking behind practice.

This presentation focuses on two case studies within Nottinghamshire to discuss the NFM intervention process from the viewpoint of practitioners. Lowdham is part of the DEFRA funded Community NFM programme and is set within 10km2 of the upper catchment of the Cocker Beck. The land use is predominantly arable with cereal cropping. Improving flood resilience in Southwell is funded by INTEREGG FRAMES as part of a wider EU project. The project is set within the Potwell Dyke catchment, with an area of approx. 6km2. The catchment features a mixture of land uses but is dominated by arable cropping. The Potwell Dyke is a tributary of the Greet; both catchments flow into the River Trent. Both projects aim to install a mixture of NFM interventions, including earth bunds, leaky barriers and storage areas within private land.

The methods applied within opportunity mapping are presented, which include the use of ArcGIS to generate flow accumulations and an estimate of potential intervention storage volume. These methods have allowed for data to be shared with landowners to explain the aims of NFM, whilst demonstrating that intervention within their landholding would be successful in storing water.

Gathering scientific evidence is currently a main focus of NFM projects, but sharing challenges faced by landowners is often overlooked. The challenges faced by practitioners during the landowner liaison process, and how these have been overcome are explained, with issues highlighted by landowners during liaison discussed in detail.

A key point of the presentation is the lack of policy supporting NFM intervention within private productive land. Both projects lie in areas with minimal or no designation for landscape or biodiversity, meaning they attract no additional funding from existing Defra schemes. Positive steps within these projects have been taken to ensure that landowners do not suffer losses, with agreements offered to provide an income for a service. If NFM is to be successful within future FRM projects, policy will need to be put into place to reflect the challenges faced, and offer a sustainable method to overcome them.

MISSENDEN STREAM NATURAL FLOOD MANAGEMENT AND RESTORATION

A. BACK[1]

1 Buckinghamshire County Council

Buckinghamshire County Council are working on options for managing surface and groundwater flooding in the Pednormead End area of Chesham. As part of these works we identified an opportunity to restore a section of the Missenden Stream. This was completed in February 2018.

The restored reach is located along a 200m section of the Missenden Stream which flows through the Chesham 1879 Tennis and Squash Club. Historically, the river channel in this location has been widened, deepened and impounded by two concrete weirs. As a consequence, flow, when present, is sluggish and the reach acts as a sink for sediment, which overlies much of the gravel bed especially on the upstream side of the weirs and adjacent to the tennis courts, where the channel is at its widest. The Missenden Stream flows into the River Chess which is one of a number of chalk streams originating in the Chilterns. Chalk streams are a globally rare habitat, confined mainly to North West Europe. England has the majority of the world's chalk streams and as such, has a special responsibility to conserve this rare wildlife habitat. The river Chess rises at Pednormead End near Chesham and flows

for approximately 17km, through the Chilterns Area of Outstanding Natural Beauty, to its confluence with the river Colne at Rickmansworth.

By carrying out this restoration work, this section of the river Chess catchment will be returned to a more "natural" state. It will allow the natural chalk stream processes to re-create habitat, carry natural amounts of sediment and reconnect the channel and floodplain. Once the habitat is created the wildlife will come back to this reach of the river Chess.

FLOODPLAINS – THE SPONGES OF OUR ECOSYSTEMS: LESSONS LEARNED FROM IMPLEMENTATION

C. BOWLES[1] & H. MOIR[1]

1 cbec eco-engineering

For many hundreds of years we have been disconnecting our floodplains through a variety of anthropogenic activities. Traditional methods of flood control, through single function objectives, have partially protected our towns and cities, but have destroyed many ecosystems due to river straightening, channelisation, floodbanks, dams and other flood control structures. In the current era of climate change these traditional methods are being tested to failure. Additionally, rivers and streams have incised and widened, further exacerbating floodplain disconnection.

Floodplains are the "sponges" of our ecosystems. They soak up precipitation during storms and gradually release those flows back to the river after the storm passes. When floodplains are disconnected from their river systems, or are paved over with impervious surfaces (tarmac, concrete, etc.) as a result of urbanisation, precipitation directly runs off into the rivers, rather than gradually soaking into the floodplains. This effect has been called "hydromodification", literally, the process of anthropogenic impacts on changing the shape of the hydrograph. Precipitation runoff in systems heavily impacted by hydromodification results in substantially "flashier" hydrographs. The volume, duration, intensity and timing of runoff is dramatically affected. Extensive research on these effects has been conducted in countries such as the USA. Geomorphic principles show that the effects of hydromodification are to increase the volume and velocity of flows passing through our river and stream systems. This can result in dramatic geomorphic degradation through excessive bank and bed erosion.

Here an update of the largest floodplain lowering project in California is presented. Floodplain lowering is a technique that can be used to reconnect the floodplain to its river. This project is the Southport Levee Setback Project in Sacramento, California. The flood control elements of the project have now been constructed and the floodplain restoration components of the project are currently under construction. The resultant ecological consequence of this increased connectivity will be substantial, particularly for juvenile anadromous fish rearing, as well as riparian forest recruitment. Other floodplain functions include attenuation of flows through overland flow and seepage into the floodplain.

Also, a second technique to reconnect the floodplain using channel bed raising will be presented. This project, the Butano Floodplain Reconnection Project, is located on the California coast between San Francisco and Santa Cruz. Techniques to raise the bed included grade control structures (called Newbury Riffles) and engineered wood structures (also referred to as large woody debris). These

techniques result in gradual bed raising through sediment deposition and the resultant reconnection of the floodplain to the river at more frequent flows.

Kensington: Large-scale river engineering

A14 – DELIVERING HABITAT IMPROVEMENTS AT A GRAND SCALE!

K. SKINNER[1]

1 Atkins/A14

The £1.5 billion A14 Cambridge to Huntingdon Improvement Scheme is being delivered by the A14 Integrated Delivery Team (IDT), a joint venture between Costain, Skanska, Balfour Beatty and designers Atkins/CH2M, working on behalf of Highways England. The scheme supports both national and regional economic growth, improving access to jobs, reducing congestion and delays and keeping the right traffic on the right roads. The project includes a major new bypass and widened section of the current A14, widening a section of the A1 and demolition of a viaduct at Huntingdon, which will support improvements in the town. While all this is fantastic for the local economy a major component of the work has been the wide scale environmental improvements that have been taking place across the site. This includes:

- Creation of 217ha of new wildlife habitat
- Planting for two trees for every one cut down
- Creation of 13 new lakes
- Three ponds for Great Crested Newts
- Four large enhancement areas for water voles
- 200 bat boxes
- Five owl boxes
- 34 wildlife bridges going across the new road

The scale and the nature of the project meant that numerous regulators needed to consent to many different aspects of the scheme including the Environment Agency, Natural England, Cambridge County Council and the Internal Drainage Board.

Over the course of the scheme, eleven river realignments are being delivered using natural channel design creating significant improvements in the riverine habitat over a total length of 2.6km. This included significant realignments on both Alconbury Brook (195m) and West Brook (985m). Bank protection was only used where there was perceived to be a local risk to an asset. Where necessary, green bank protection was used to ensure that protection against erosion was provided but habitat opportunities maximised. The A14 IDT's ecologists worked closely with Salix to ensure that suitable bank protection methods were installed within the major risk areas.

The need for the realignments has been created from two main aspects of the highways design: a) a new section of road with a new scheme footprint and b) culvert extensions due to widening of the existing highway. The modifications also meant that there was a loss of water vole habitat which was compensated for through the creation of new habitat areas that offer improvements to the existing state. Each of the river realignments was designed to maximise habitat diversity, but in some locations were constrained by other scheme elements, which included major utilities.

The presentation demonstrates how large infrastructure schemes can not only meet their infrastructure requirements, but also deliver wide scale environmental improvements. River restoration delivered through realignments using naturalised channel is integral in this achievement.

The new bypass and widened A14 will open to traffic in December 2020, but the legacy of the works will last long afterwards.

DELIVERING MAJOR INFRASTRUCTURE, FLOOD RISK AND BIODIVERSITY BENEFITS THROUGH COLLABORATION: THE A120 LITTLE HADHAM BYPASS AND FLOOD ALLEVIATION SCHEME

N. ELBOURNE[1]

1 Environment Agency

This project is a once in a lifetime opportunity for Hertfordshire County Council and the Environment Agency to deliver multiple benefits to Little Hadham by jointly promoting a dual-purpose major capital scheme. Without this collaboration the flood alleviation aspects of the scheme would be unaffordable. We will achieve significant efficiencies by working together.

The scheme comprises a 3.9km single carriageway bypass around the historic village. The bypass crosses three main river watercourses and at two of these road embankments will be used to store floodwater. A fourth watercourse is being deculverted and diverted downstream of the village centre. Significant planning has been required to ensure that the Scheme will comply with the Water Framework Directive.

The objectives of the scheme are:

1. To decrease journey times along the A120 between Bishop's Stortford and the A10
2. To reduce the risk of fluvial flooding in Little Hadham and communities to the south
3. To reduce severance in the centre of Little Hadham and improve living standards for local residents

Best practice is being followed around new structures and along the new diversion channel.

The joint scheme was granted planning consent in January 2017. Works are due to commence on site in early 2019 subject to the outcome of the statutory processes for the Compulsory Purchase Orders to secure the land required for the scheme. The scheme is projected to be completed by 2021.

"RIVER RESTORATION IN PRACTICE" – ENHANCEMENT OR JUST GOOD DESIGN? A COLLABORATIVE APPROACH TO RIVER AND WETLAND RESTORATION

J. MADDISON[1], J. CULLIS[1], M. LANE[2] & C. GREEN[1]

1 Jacobs, 2 Environment Agency

In the United Kingdom, the restoration of rivers and wetlands is often carried out as part of large-scale flood defence schemes, as an enhancement or added benefit. Frequently, these elements of a scheme are the first casualties during the value engineering stages and where budget cuts are needed. However, recent changes to government funding for habitat restoration and creation in the UK have favoured a more integrated approach to large infrastructure and flood schemes where delivery of challenging habitat targets can be achieved.

The Exeter Flood Defence Scheme (Exeter FDS), which incorporates major upgrading of existing flood protection, is a good example of how well integrated design can work within the constraints of an urban environment. Incorporating new and restored wetland habitats has been a vital part of scheme design, promoted by the Environment Agency and supported by their project partners, including local councils. A model of habitat restoration, developed over many years by Environment Agency ecology and fisheries staff, accompanied by concept designs, was integrated into the initial Business Case Feasibility Report (known as a Project Appraisal Report, or PAR). Once funding was secured, a close-knit client-consultant team of river engineers, ecologists, fisheries experts, landscape architects and geomorphologists worked together to developed integrated designs that would deliver their primary purpose of protecting Exeter from flooding, whilst securing new areas of wetland and river habitat. Much of these habitat areas are necessary to mitigate for impacts across the whole scheme area, but a fundamental part of the design philosophy was also to incorporate a multifunctional integrated design, that met both flood risk management and river restoration objectives, wherever possible.

Part of the Exeter scheme has now been completed. Phase 1 delivers flood risk management improvements to the City Centre and Historic Quayside areas of Exeter, Devon (south west of England). An existing 7 hectare (17 acre) flood relief channel has been transformed into a diverse wetland habitat whilst improving flood conveyance capacity. A meandering low-flow channel, scrapes (shallow ponds) and backwaters form a mosaic of wetland habitats, whilst modifications to an existing side spill inlet weir structure have provided two new fish passes. The siting and size of the scrapes and backwaters were carefully considered to enhance the use of existing hydrogeological features in the exposed channel floor and a final covering of fine low-nutrient substrate was placed over the exposed formation material to allow desirable wetland plant species to flourish.

Involvement of ecological expertise during the earliest stages of scheme development is crucial and inclusion of an experienced restoration ecologist as part of the design team is vital for successful delivery of valuable habitat. Development of partnerships is also critical to successful delivery and future maintenance of habitats. Exeter FDS has provided a model of how this can be done successfully in the UK, and other schemes are already in development using a similar approach (for example, a major Flood Alleviation Scheme in the historic city of Oxford). If the UK is to deliver its challenging habitat restoration and creation targets, we must ensure that these are fully integrated into flood risk management projects – simply put, it is not enhancement, it is just good design.

Figure 1 - Trew's FRC (upstream) - Meandering Channel

Figure 2 - Trew's FRC (downstream) – Fish Pass

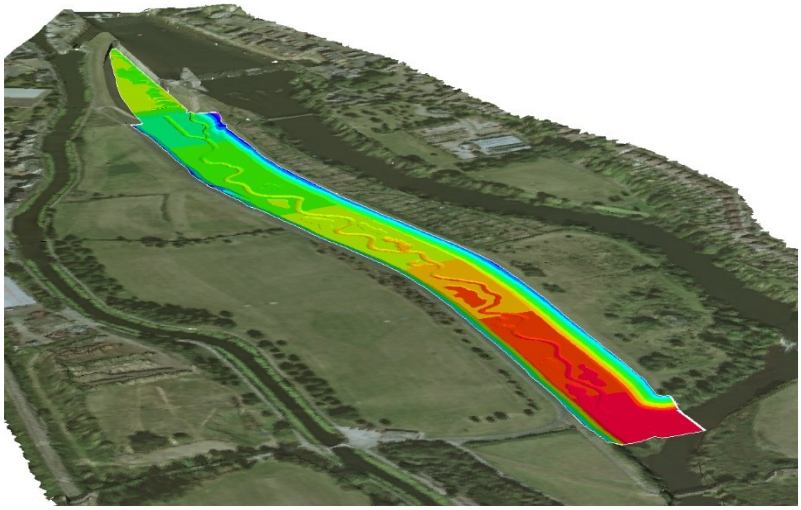

Figure 3 - 3D colour-contoured surface of the modified Trew's flood relief channel with proposed low flow channel and scrapes

Figure 4: Before (left) and after (right) photographs of the Trew's flood relief channel

Figure 5: Trew's weir flood relief channel

Figure 6: Shared footpath/cycle path and plant crossing adjacent to the FRC

GLENRIDDING FLOOD ALLEVIATION SCHEME: COMBINING NATURAL FLOOD MANAGEMENT WITH TRADITIONAL ENGINEERING TO DELIVER FLOOD RESILIENCE IN COMPLEX UPSTREAM ENVIRONMENTS

L. BAKER[1] & G. FOSTER[2]

1 Atkins, 2 Environment Agency

In December 2015, an exceptional high rainfall event affected much of northwest England, Scotland and Northern Ireland. This paper looks at the impacts to the village of Glenridding, in the Lake District. It will examine the effect of Storm Desmond, the (geomorphic) causes of flooding through the village and present ongoing and proposed remediation works aiming to improve the village's resilience to future events.

A record breaking amount of rain, coupled with a high supply of sediment and landslips further up the valley, transported a significant amount of gravel and boulder material. There were no formal flood defences in Glenridding, although much of the channel through the village and immediately upstream has been channelised or constrained by bank reinforcement, making it an efficient conveyor of sediment. This material deposited in the village and filled the entire channel to its brim, forcing flood waters to overtop the bank and devastate the surrounding residences and businesses.

In all, an estimated 20,000 tonnes of gravel was removed in the aftermath and formal flood walls have now been installed. However, in the following two years the bed was observed to be incising (via a knick-point), estimated between 300-500 mm, and was contrary to the previously depositional processes through the reach. This process was likely a result of reduced channel roughness and disruption to the armoured bed, resulting in an unconsolidated bed more prone to entrainment. Furthermore, there is a habitual practice of removing material from the channel, especially underneath the bridge.

In 2018 the Environment Agency and Atkins collaborated to design bed stabilisation works. The stabilisation works aim to prevent further incision and raise bed levels close to 'pre-flood levels'. The chosen option, a boulder rib structure, forms a series of bed checks along the channel. Deposition is expected upstream of the ribs, especially along channel margins, restoring the bed to a higher level and protecting the new flood walls from any further scour.

However, these options do not address the root-cause of the flooding. In parallel, a fluvial audit undertaken by Environment Agency geomorphologists identified significant stores of coarse sediment upstream. Another flood event could transport this sediment and result in a similar scenario to 2015. Working with the local community, several options are being considered, including natural flood management which aims to utilise natural materials to manage sediment and flow more sustainably. Measures such as floodplain reconnection, bed roughening, tree planting and vegetation to slow the flow and form erosion protection have all been considered.

This paper demonstrates the complexity of flooding in the Lake District and the challenges faced in mitigating for future flood events. A suite of measures are being considered to improve the channel's resilience to future flood events and requires a collaborative approach.

Derby: Analysing the data

A MULTIPLE CATCHMENT-SCALE ANALYSIS OF HISTORIC UPLAND RIVER CHANNEL PLANFORM ADJUSTMENTS OVER THE LAST 150 YEARS: A CASE STUDY IN THE LAKE DISTRICT, UK

H. JOYCE[1]

1 Durham University

Upland rivers are active geomorphic systems that undergo frequent channel planform adjustments in response to the steep channel gradients, flashy discharge regimes and high sediment supply. Planform adjustments can lead to management concerns relating to flood risk, damage to infrastructure and the loss of valuable land. Traditionally upland rivers have been studied and managed at a piecemeal, local scale. However, this approach fails to address the spatial or temporal factors driving planform adjustments. The study of historic river channel planform adjustments is important for understanding the current and future behaviour of a river. This research undertakes a multiple-catchment assessment of historic upland river channel planform adjustments to identify the patterns and factors controlling planform adjustments over a 150 year time period (from 1860 – 2011). The study is applied across ~250 rivers in 20 catchments in the Lake District upland region, UK (1000 km2); however, the methods are generally applicable to other upland regions globally. The approach makes use of readily available data sources including: historic maps, aerial photographs, digital terrain models, and geology maps in a GIS framework. The method involves identifying planform adjustment types over time (i.e. bend adjustments, width adjustments) and relating these to channel and catchment characteristics (slope, channel width, stream power, valley width, geology etc.). The outputs include quantitative data on the timing of planform adjustments and factors influencing the types of planform adjustments. The most common types of planform adjustment observed over the 150 year period across the catchments were associated with bar, and bend adjustments. Major adjustments, i.e. avulsions, were less common and occurred where the channels were unconfined, and there was a large upstream contributing area. For example, in the Wasdale catchment (45 km2), 123 adjustments were identified from 1860 – 2011; 40% of these adjustments were bar adjustments (n = 49), 37% were bend adjustments (n = 45), 16% were width adjustments (n = 20), and the remaining 7% were boundary adjustments (n = 9, i.e. avulsions or cut offs). Over the 150 year time period, the number of adjustments and length of channel affected by adjustments varied across the upland catchments. The results highlight the importance of considering both reach and catchment factors that control the location, type and extent of planform adjustments that needs to be used to better inform future holistic management actions and target river restoration.

LOOKING FORWARD, LOOKING BACK: A CATCHMENT-BASED APPROACH TO THE CHANGING DORSET STOUR

A. FIRTH[1]

1 Fjordj Ltd.

Fjordr Ltd. has been commissioned by Historic England to pilot a methodology that makes information about river history more readily accessible to watercourse managers. Historic England is the government's statutory adviser on the historic environment; Fjordr – a consultancy specialising in

heritage in inland, coastal and marine environments – developed the pilot to address a recommendation of an earlier project, Heritage Assets in Inland Waters (Firth 2015: Historic Environment Policy & Practice 6,3). Taking a catchment-based approach was central to the pilot, which has been carried out in conjunction with the Stour Catchment Initiative.

Historic mapping, LIDAR, archaeological and documentary sources have been integrated within a single GIS layer that indicates historic use of the river, changes to watercourses, and the presence of heritage features. Mapping has focussed on the river channel and its immediate environs in order to flag the historic characteristics of the river itself rather than just the surrounding land. The attributes of each mapped polygon include character type, monument type, period, description and details of the sources used, so that supporting data can be re-examined.

The character of rivers in England is usually the result of the action and interaction of both natural and human factors. On the Dorset Stour, major interventions stretch back several centuries, perhaps even millennia. The historic evidence also points to broader changes in river management and community approaches to living with water. Of particular note are the varying agricultural practices associated with the River Stour; major interventions for mills and, potentially, fish traps; and changes associated with designed landscapes for country houses. There is also good evidence for the importance of the river in prehistoric periods, including as a means of transport and communication.

The time-depth indicated by the GIS layer will help in planning interventions to improve river quality. The pilot demonstrates that the River Stour is a much-modified environment as a result of both 'capital' works and more general approaches to working with the river. It is hoped that this historical information will assist river managers in understanding how the river has acquired its present-day characteristics over long periods and will help, therefore, in arriving at effective and sustainable plans for the future. The pilot also flags the potential presence of sensitive heritage features in areas that might be earmarked for works, and identifies opportunities for heritage-based engagement with the public.

INVESTIGATING CHANNEL SENSITIVITY TO MORPHOLOGICAL CHANGES AND IMPACT ON FUTURE FLOODING

N. TODD-BURLEY[1] & R. ING[1]

1 JBA Consulting

JBA Consulting is currently undertaking a research project for the Environment Agency to improve our understanding of how flood frequency is affected by geomorphic changes to river channel capacity. The primary objective is to test and evaluate methods and models that enable the scale, nature and risk of in-channel geomorphological activity (erosion, transport, deposition) at the reach scale and investigate their capabilities for accounting for future hydrodynamic conditions. It is anticipated that the method will eventually be applied at a national scale for national decision support, particularly for identifying hotspots where channel changes are more likely and need local consideration. The methods will be applied in three test catchments as part of the assessment process – River Kent, River Wharfe and River Stour (Dorset).

Factors that could influence the scale and rate of morphological change during flood flows will also be examined from literature and this information will be used to indicate locations which may be

particularly sensitive to changes in channel morphology. Existing and relevant data on recent floods (2005 to 2016) will be collated to form case studies. Using the literature and case studies, key factors that could influence the scale of sensitivity will be examined by classifying the type of change (i.e. sedimentation, erosion) and relative degree of impact (i.e. change in channel capacity and discharge). Local factors could include typology, channel bed type, land-use, soil type, asset failures, landslides and presence of road and rail infrastructure.

The literature and evidence gathered will be used to indicate the significance of morphological changes on future flood hazard. The project will provide strategic guidance for using sensitivity of channel changes in Flood and Coastal Risk Management activities. The project will help demonstrate methods and analysis that could be widely undertaken to inform flood risk management activities, such as risk assessment modelling, channel maintenance plans, scheme design, catchment restoration and planning and permitting. The project will explore how the methods tested can be linked to existing flood hazard data to identify catchments where channel changes could have a significant impact on flood risk management activity.

Session 3: Parallel Sessions

Main Banqueting Room: Morphology & physical processes

THE STREAM EVOLUTION TRIANGLE: INTEGRATING THE INFLUENCES OF GEOLOGY, HYDROLOGY AND BIOLOGY

C. THORNE[1]

1 University of Nottingham

This talk will provide an overview of, and underpinning science for, the Stream Evolution Triangle (SET) -- a new approach to understanding stream evolution. The SET broadly integrates concepts geology, hydrology, and biology, and includes improved understanding of potential morphological "stream states" at the reach scale following both natural and anthropogenic disturbances. The SET includes the relative influence of geology, hydrology, and biology on an equal basis in determining stream morphology, which recognizes that streams may be dominated by any of these three drivers depending upon the landscape setting and geographic location. Rather than a deterministic approach, the SET recognizes that similar events can result in various stream morphologies, while dissimilar events can result in a single, dominant stream morphology. The probability of a particular future state is strongly predicated by the relative influence of geology, hydrology, and biology. The SET assumes dynamic morphological evolution through time and recognizes variable rates of change for both spatial and temporal scales, along with numerous potential trajectories. The impetus for the SET is grounded in both soil textural triangles, which describe various combinations of sand, silt, and clay particles, and ternary diagrams, which are commonly used in geology to visually describe combinations of minerals that are given specific rock names reflecting their proportional content.

Having introduced the SET, we will use evidence from completed projects as case studies for its application in innovative stream restoration. Potential utility of the SET in stream restoration planning and design stems from improved understanding and explanation of morphological "stream states", which provides insights into appropriate restoration strategies to counter adverse impacts from past disturbance while building resilience to future disturbance. The SET can do this because stream evolution is not framed as a deterministic series of stages.

DYNAMIC WATERS FULL OF LIFE: LETTING RIVERS DO THE WORK

G. MAAS[1] & M. DIAMOND[1]

1 Environment Agency

We will share our current thinking and open discussion on restoration, morphology and natural processes, and how rivers and their catchments can help achieve long-term goals for the environment.

- Reflect on recent progresses in river restoration
- Highlight restoration within the context of local and much broader socio-economic priorities
- Demonstrate the importance of using the natural energy within geomorphological systems
- Share emerging thoughts and goals for river restoration, highlighting potential opportunities and some of the challenges that lie ahead

THE SCIENCE AND 'ART' OF GEOMORPHOLOGY – HOW FLUVIAL GEOMORPHOLOGY CONTRIBUTIONS ARE DEVELOPING AND MATURING OVER TIME

K. KEMBLE[1]

1 Jacobs

The application of geomorphology to help solve water-related problems in industry has developed considerably over the past decade, to the extent that it now often forms a key part of the design of projects (from strategy to concept, feasibility, design, construction and post-construction). Significantly it is pivotal in compliance with environmental assessments such as the Water Framework Directive. Geomorphology sits between conventional engineering approaches and traditional ecology disciplines and, therefore, has a key role in sustainable development. There are many examples of successes (shown in this paper).

However, numerous challenges to delivery of sustainable projects remain. These includes tight programmes and budgets, continued omission of geomorphology as a discipline early in the life of a project, lack of numbers of experienced/skilled geomorphologists and the need for training and awareness of the next generation of water managers. Geomorphology requires available scientific knowledge but also needs the application of that knowledge through the 'art' of informed professional judgement. A crucial part of this 'art' is understanding the environment in which the problem or issue lies and trying to select/adapt tools that can be applied. Geomorphology can provide a key spatial and temporal context that could be often overlooked by a more traditional engineering approach.

This paper focuses on two key project examples: a reservoir discontinuance near Glossop in north-west England, and, a collapsing road bridge near Ullapool in the north-west of Scotland. It then draws upon generic learning lessons from the authors experience in working on many projects and comes up with some good practice guiding principles for integrating geomorphology into industry.

DESIGNING FOR INSTABILITY: PROCESS-FORM RESTORATION ACROSS OUR RIVERS AND FLOODPLAINS

G. HERITAGE[1]

1 AquaUoS

Often the primary historic drivers for river restoration are linked to restoring a stable channel, repairing erosion scars, restoring local planform and returning pretty much to the status quo except for some minor and potentially temporary ecological gains. Decisions on channel geometry are governed by the desire for bank stability creating unnatural bank profiles to satisfy geotechnical stability criteria. Such approaches fail to address the more fundamental question of the cause(s) of the problem in the first place. More recently larger scale projects have had to consider the potential for river erosion and in many cases schemes seek to control this through hard and soft bank protection. Improvements to the hydromorphology of the river and floodplain are achieved through strategic intervention designed to rejuvenate dormant river and valley bottom features ensuring that the flow and sediment regime will operate to maintain these as functional units into the future.

With this approach comes a change of direction as regards restoration, moving from static design to approaches that introduce a dynamic aspect to the system. Key to this is an understanding and

acceptance of river and floodplain change linked to restored erosional and depositional processes that were formerly suppressed by engineering and management. Greater diversity of form is encouraged with directional change anticipated as part of the restoration and are must be exercised to ensure that the system evolves within bounds accepted by all parties involved.

This approach to naturalisation design must fully understand and integrate current controls on river and floodplain form, using this knowledge to encourage an appropriate river and valley morphology. This paper reviews several diverse projects that have followed this process illustrating the approaches used to develop a naturalisation template and the early response of the systems to restoration. It is clear from monitoring of initial change that dynamic sediment transport related changes are occurring but that the overall integrity of the river/floodplain systems remains. System dynamism has enhanced hydromorphic value and seen positive ecological response, feature diversity has been heightened and feature creation and evolution is occurring restoring lost change dynamics.

An acceptance of change and the active encouragement of appropriate change processes in the restoration design has brought with it a far more valuable and sustainable system than could have been achieved whilst maintaining a static system. Future restoration and naturalisation must follow this approach despite its move away from currently accepted notions of appropriate river form and this process will be aided by the slow but definite acceptance by those currently involved in dynamic restoration projects that the outcome is not unduly disruptive to their livelihoods given a thorough understanding of what restored systems will start to do to the landscape.

Kensington: Exploring the potential benefits of Natural Flood Management

MODELLING THE EFFECTS OF LARGE WOODY DAMS ON SEDIMENTARY PROCESSES

M. MCPARLAND[1]

1 University of Liverpool

A widely used technique for Natural Flood Management (NFM) is to construct Large Woody Dams (LWDs) in a river to slow the flow of water and create flood water storage areas. Research on LWDs has typically focused on quantifying the contribution LWDs make to attenuating flooding by modelling changes to a stream's hydrograph or assessing changes to hydraulics. Multiple papers have demonstrated that LWDs reduce peak mean discharge, delay time to peak discharge and lower flow velocity. However, research has tended to overlook how LWDs can modify sediment dynamics and as a result there are few tools available (especially quantitative models) that can be used to assess these effects adequately. The absence of effective quantitative tools means that it is hard to obtain accurate estimations of how increased sediment deposition or changes to erosion could alter the effectiveness of LWDs by decreasing the flood water storage capacity or by undercutting the damming structures. This makes it difficult to assess factors such as operational lifetimes, maintenance requirements and risks and uncertainties during the planning and design stages of LWD NFM projects.

To investigate the effects that LWDs have on sediment dynamics, post-project monitoring was carried out on a set of LWDs that were installed on a small steam in Northwest England. Monitoring involved conducting repeat cross section surveys and terrestrial laser scans, taking sediment samples as well as in-situ monitoring of flow velocity and crest stage. These data were also used as the basis for developing a numerical model that assesses changes to sedimentary processes based on the Bagnold sediment transport equations. The equations have been solved deterministically and using mixed Monte Carlo simulations to quantify uncertainty from which risk can be calculated.

A number of significant changes have already been observed. There has been a large amount of sediment deposited in the channel immediately upstream of the LWD, reducing the capacity of the flood water storage area and creating a channel constriction. The constriction has accelerated the flow of water as it approaches the dam, causing erosion of the stream bed, allowing the flow to undercut the LWD. These factors have contributed to lessening the effectiveness of the LWD.

The model that has been created to predict these changes has been developed so that it can be applied to LWDs that have been constructed in a range of different streams. As such, a tool is presented that can be used to model how the changes to channel hydraulics induced by a LWD can alter sedimentary processes. Associated uncertainties can also be calculated, allowing risks to be evaluated.

NATURAL FLOOD MANAGEMENT IN UPPER WHARFEDALE: A COLLABORATION AND COORDINATED APPROACH TO CREATING A RESILIENT LANDSCAPE

D. TURNER[1]

1 Yorkshire Dales Rivers Trust

The Yorkshire Dales Rivers Trust (YDRT) is working with farmers, landowners and the local community in Upper Wharfedale at a grassroots level to help facilitate and empower them with tools to create a landscape that is resilient to flooding and future climatic changes, while providing several other social, environmental and economic benefits. The Trust has achieved this by coordinating several smaller projects to create an overall initiative that has enabled it to deliver a long-lasting sustainable vision for the catchment. The overall initiative is called Naturally Resilient. Different sources of funding with different emphasise have been secured to allow a three-tiered approach to delivery.

At a catchment level, we have commissioned modelling of the catchment by JBA to identify and demonstrate the benefits which could be afforded by NFM interventions. Working with farmers as part of the Wharfedale farmer facilitation group, funded by Natural England, we then took this to the next level, working out which interventions would be practicable and desirable for farmers. Through funding from Prince's Countryside Trust we have been able to carry out individual farm walkovers, devising farm plans specific for each holding. Where farmers are unable to fund measures, we have used funding from People's Postcode Lottery and Yorkshire Water Services as measures have multiple benefits for water quality and ecology as well as providing economic and social benefits. Measures have been delivered by farmers, contractors and volunteers.

A key focus has been on improving soil health to both reduce runoff and increase agricultural productivity. We have carried out innovative soil analysis and compaction testing as well as holding soil workshops, the results of which are being used both by farmers and as part of an MSc project. Local farmers, residents and children have learnt about rivers and catchments with the aid of our mobile river classroom, funded by Heritage Lottery Fund as part of our Rivers 2U project.

From the outset, we were keen to share best practice more widely. This has taken several forms including the creation of an NFM demonstration site to show a variety of interventions, which has formed a hub for visits from a diverse range of individuals from farmers to policy makers. Our approach and, in particular our toolkit for conducting farm plans has been used by the WaterCOG pan-European project on water co-governance. Our website provides links to our guides to NFM techniques as well as guides and case studies completed by other organisations.

In the future, we will continue to carry out monitoring to increase the evidence base for NFM. We are also launching a new project which aims to connect downstream communities at risk of flooding with those upstream who are carrying out NFM measures.

EVALUATING NFM BENEFITS: KEEPING IT SIMPLE

D. BROWN[1] & M. NORBURY[2]

1 Environment Agency, 2 Mersey Forest

Understanding the benefits of NFM interventions is a current science gap. Much is underway to address this, but currently, in practice, it presents a considerable challenge. Combination of NFM interventions even within a relatively small catchment rapidly build up to form a complex set of interdependent intervention variables that present a problem to quantify.

An alternative, simpler approach is to consider the flood risk at the location itself, and the volume of water that can be contained in bank, and an exceedance point, above which are flood flows. Using simple techniques to understand this volume of floodwater, we can realistically assess the impacts of our proposed NFM interventions.

The approach we will be drawing on uses simple hydrograph analysis to look at the damaging floodwater volume. This is described in the attached document.

Once we've explained the approach we will give examples of where we have calculated the volumes required and then give practical examples of where we are implementing interventions that store the damaging flood water peak in locations upstream of communities at flood risk. We will draw on local levy-funded and the DEFRA funded catchment scale NFM projects in the Greater Manchester, Merseyside and Cheshire Area.

ESTIMATING EFFECTIVENESS OF NATURAL FLOOD MANAGEMENT: KEEPING IT SIMPLE

M. HUBAND[1]

1 Atkins

Expectations of natural flood management are high, whilst budgets available to deliver schemes are often very small. As a result delivery organisations often progress schemes rapidly to construction, with little time available for design or quantifying the benefits a scheme can yield. Comprehensive hydrological and hydraulic modelling of schemes is often not possible – either because of prohibitive expensive (a full-blown modelling study can sometimes cost as much as delivering a small NFM scheme on the ground) or access to skills. But is there a "happy medium", in which a simple hydrological assessment can be rapidly undertaken to inform key decisions about design and better understand the benefits a scheme might yield?

This paper will set out a simple workflow for developing Natural Flood Management schemes. It will then go on to explore how simple hydrological calculations might be used to assess the effectiveness of natural flood management measures in reducing flood risk. Using a small catchment in Essex upstream of a village vulnerable to frequent flooding as a case study, it compares the outputs of a) a full hydrological-hydraulic model setup with b) simple analysis of key hydrological indicators (e.g. comparison of bankfull and peak flow and hydrograph and design storage volumes) to explore how each approach informs the design and assessment of benefits. Key is whether the simpler hydrology based approach provides adequate information around which to understand the likely effectiveness and benefits of applying natural flood management.

The paper argues that simple hydrological assessment may be an appropriate technology for informing the design and benefits assessment of natural flood management schemes. It can be a cost-effective alternative to full modelling, enabling delivery organisations operating on limited budgets to make a) more informed decisions about design parameters fundamental to the effective functioning of schemes and b) a clearer case to support applications for funding.

Derby: Involving stakeholders in catchment management

RIVER IRWELL: SMALL STREAMS, BIG WFD GAINS

K. JENNINGS[1] & K. CAUSER[2]

1 JBA Consulting, 2 Environment Agency

Catchment Walkover Surveys on Singleton Brook, Slack Brook and Unity Brook, which are small tributary streams within the River Irwell Catchment, in Salford Greater Manchester were undertaken by commission of The Environment Agency.

The Irwell Catchment is one of the 55% of UK rivers that fails to reach the standards required under the Water Framework Directive (WFD). The main reasons for the River Irwell not achieving good status/potential are a result of diffuse pollution from contaminated land, transport and other urban sources and point source pollution from intermittent discharges.

Irwell tributaries are also suspected to have similar issues, with numerous small, but equally polluted watercourses contributing to an overall decline in the Irwell catchment. These tributaries can provide valuable breeding, feeding and refuge habitat for fish when in good condition, and can therefore contribute to the recovery of the main river by becoming important ecological corridors. In addition to diffuse pollution, many small channels have been significantly modified. Unlike the main river, action can often be taken on tributaries through smaller scale interventions that have multiple benefits for the wider catchment.

The main objective of the project was to identify the extent and causes of diffuse pollution sources in each tributary catchment, and to assess the geomorphological condition of each watercourse, in order to identify options to improve the WFD status of the Irwell catchment.

The study methodology utilised the standardised Catchment Walkover Survey (CWS) approach developed by the Environment Agency, focusing specifically on rural point and diffuse source pollution. A two-step approach was used, comprising an initial dry-weather and subsequent wet-weather survey. Each pollution occurrence was graded from 1 – 4, depending on severity and were categorised depending on the nature of the pollution source. In order to fully assess the tributaries, an ecological and geomorphological walkover was also carried out to determine any additional features which may be negatively impacting the watercourses.

During the initial dry weather survey 81 pollution sources were identified in total across all three tributaries. Frequently recorded issues included:

- Culverts
- Invasive non-native species such as Japanese Knotweed, Himalayan Balsam and Giant Hogweed
- Bank erosion
- Fly tipping

A second wet weather survey identified additional pollution sources including road run-off, over ground run-off and field drainage inputs.

A geomorphological walkover survey was also completed to establish the baseline geomorphological conditions of each watercourse. The site walkover involved mapping key morphological conditions including:

- Sediment sources and depositional zones

- Bed sedimentology
- Bank instability/erosion
- Identifying floodplain character
- Biotopes – flow and habitat characteristics
- Any forms of channel modification or bank protection

The results of the surveys were used to formulate options at a stakeholder meeting with the Irwell Catchment Partnership in 2018, including further stakeholder engagement and education, in-channel river restoration techniques and non-native invasive species treatment programmes to improve the existing WFD status of the Irwell tributaries.

TACLO'R TYWI/TACKLING THE TYWI – WORKING IN PARTNERSHIP TO RESTORE AN ICONIC RIVER

I. WILLIAMS[1], M. HERBERT-EVANS[1] & H. WILLIAMS[1]

1 Natural Resources Wales

The Taclo'r Tywi Project is a catalyst for bringing together new partnerships to develop a "bottom-up" approach to sustainably managing one of Wales's most iconic rivers. Rising in the Cambrian Mountains, the Tywi River is regarded as one of the most diverse and important river catchments in Wales. Water abstraction by Dwr Cymru/Welsh Water (DC/WW) supplies over half a million people across South and West Wales. The upper catchment supports traditional beef and sheep farming and extensive conifer plantations, while the valley bottom is dominated by a significant number of intensive dairy farms. The river itself is famous for sea trout fishing, while the historic landscape with its castles and stately homes is a honeypot for tourism. Add to this an upper catchment of European importance, designated as a Special Area of Conservation (SAC) and a Special Protected Area (SPA) with the Tywi itself being a SAC in its own right, for much of its length.

The project was devised as a common purpose for local staff of the three legacy bodies making up Natural Resources Wales to work together influencing a change of mind set with relevant land managers and user groups throughout the catchment. Taclo'r Tywi aims to agree and implement a resilient sustainable management plan for the catchment, future proofing the area against political, economic and climatic changes for future generations.

To date the project has secured funding for a project lead, set up a liaison board of stakeholders and a dairy group focusing on nutrient management and improving water quality. Fishermen and farmers are working together in actively managing INNS and identifying river habitat improvement opportunities. The project is also collaboratively working on Coleg Sir Gâr's slurry project, developing a dewatering system, reducing slurry volume by up to 80% and hopefully purifying the remaining water to a suitable quality for recycling or discharging to a clean watercourse. The remaining solid material will then be analysed for nutrient content and best practices developed to allow it to be utilised as good quality fertiliser or pelleted for export. DC/WW are working with landowners on improved pesticide and herbicide use. Bespoke training has also been delivered through WG Farming Connect scheme, with sharing of best practices all forming part of a comprehensive sustainable management plan for the catchment. The project is giving stakeholders the confidence to identify problems and empowering them to devise and deliver practical solutions to safeguard the catchment's natural resources.

RIVERS AND WETLANDS COMMUNITY DAYS – INSPIRING COMMUNITIES

S. MALAURE[1] & D. MARTYN[1]

1 Environment Agency

Rivers and Wetlands Community Days initiative is a nationally unique and exciting programme of events restoring, improving and maintaining rivers, lakes, wetlands and local environments. This was devised by Thames River Basin Liaison Panel, Thames Regional Flood and Coastal Committee and catchment partnerships.

This Thames Water funded initiative was split over 6 tranches from autumn 2014. A Delivery Partnership comprising the Wild Trout Trust, Angling Trust, Environment Agency, River Restoration Centre and the Thames River Basin District Liaison Panel oversaw applications and awarded bursaries.

A total of £192k was awarded to 62 projects across the Thames Water catchment area. Match funding of £655k was contributed from successful organisations with a return of 1:3.4 on investment. 118 events were held over 20 sub catchments over the 3 years directly involving over 1800 volunteers.

This initiative provided funding for a wide variety of projects including the very successful Outfall Safari project by Zoological Society for London, London's first Rivers Week in 2016, "train the trainer" days in the Brent catchment, Loddon Rivers Week, and many river restoration projects across 20 Thames catchments.

The main objectives of the scheme were to:

- Inspiring others to get energised and enthused about caring for their local water environment, leading to new environmental stewardship opportunities
- Building capability among community teams on environmental and flood risk management awareness
- Improving habitats for wildlife in local rivers and wetlands
- Instill greater knowledge of the water environment, impacting factors and best practice enhancement interventions
- Improve physical fitness and wellbeing and a chance to make a real difference to the local environment
- Increase practical skills for individuals and collectively for the participant community groups e.g. local conservation volunteers, angling clubs, businesses and local authorities

Future plans for attracting continuing funding are to take this collaboration approach with communities to the wider business sector including Thames Water.

BECOMING IMPATIENS WITH BALSAM ON OUR RIVER BANKS

N. CRAVEN[1]

1 Lincolnshire Rivers Trust

Himalyan balsam is widespread and the impacts on rivers are well documented. With balsam bashing now a regular activity for many Rivers Trusts and community groups, Lincolnshire Rivers Trust (LRT) are going one step further and taking on the mammoth task of eradicating this plant from the River Witham.

Evidence has shown that this plant is out competing around 30 native species along the river. However, the LRT, in partnership with the Environment Agency are within the second year of a strategy for controlling this invasive species. Working logically from upstream, we can now demonstrate what a difference this approach has achieved, and how this project underpins our ambitions for the Lower Witham in the future.

Day 2: Wednesday 1st May

Session 5: Workshops

Workshop A – Future planning for a changing climate: cities & catchments

LAND USE CHANGE IN RESPONSE TO CLIMATE CHANGE: OUTCOMES FOR CATCHMENTS FROM RESEARCH FOR THE ADAPTATION SUB COMMITTEE

R. NGAI[1]

1 JBA Consulting

The Adaptation Sub-Committee (ASC) of the Committee on Climate Change (CCC) assessments of the National Adaptation Programme have found that although low-regret climate adaptation actions are being implemented, vulnerability to climate change in the natural environment is still increasing.

Consequently, the CCC wanted to examine whether transformational change by anticipating land use change in rural England could manage the risks of climate change and deliver benefits in both resilience to climate change and the provision of natural capital. Furthermore, this study wanted to understand the social costs and benefits associated with land use change scenarios. The work explored approaches to examine transformation change in four case study locations. A case study approach was used since climate change impacts occur at local scales and the costs and benefits of different choices about land use will vary by location. The case study locations scoped for this research was: the Petteril catchment, Cumbria; Somerset; Norfolk Broads; and Moor House and Upper Teesdale.

Different methods were tested to analyse a plausible set of land use change case study scenarios for each of the four areas to deliver net benefits for climate change resilience under different future climate scenarios set out to 2100. These different approaches provided in-sight to the complexities and nuances surrounding land use, land use change, and scenario-making. The study tested these methods using both local and national stakeholders. The method tested to explore the economics of land use was a threshold analysis which used extreme plausible climate hazards identified in academic research, projections, or historical records to understand how land use change may avoid or mitigate the impacts of the climate hazards, in regards to carbon sequestration, agricultural productivity, recreation, and others.

The results from local and national stakeholders showed that different low-regret and transformative adaptive measures were applicable across case studies with similar land use; however, the application of these changes will vary greatly across regions and communities. Both low-regret and transformative adaptive measures were identified in an abrupt and disruptive change in land use which may look like a climate threshold. However, climate change can slowly alter land use and management to catalyse a land use change. The economic assessment also concluded that early adaptation would have greater total benefits than both the business as usual and reactionary scenario throughout the 100-year appraisal period for all four case studies. This research attempts to help policy makers, regulators, practitioners, and others to understand the importance of thinking about the long-term viability of current land use, and the benefits of early adaptation to improve the resilience of landscapes before climate impacts occur.

Workshop C – Protecting, managing and restoring small waterbodies: ponds and small lakes, headwaters, ditches, springs and flushes

ASSESSING NATURAL FLOOD MANAGEMENT OPPORTUNITIES AND ASSOCIATED POTENTIAL BENEFITS IN HEADWATER CATCHMENT AREAS

R. JENNINGS[1] & S. ROSE[1]

1 JBA Consulting

Following a fluvial audit of the River Wyre, JBA Consulting were commissioned by the Environment Agency to conduct a Natural Flood Management (NFM) scoping study in the headwaters of the Wyre Catchment within the Forest of Bowland Area of Outstanding Natural Beauty (AONB). The overall aim was to identify and evaluate the potential for NFM interventions within the headwaters to reduce flood risk to downstream vulnerable communities and deliver other environmental benefits. The study area contains extensive peat moorlands that have suffered from considerable natural and anthropogenic pressures over centuries that have led to their gradual degradation. In more recent years the AONB, working with partners and landowners, have gradually been undertaking phases of remedial activities to reduce and hopefully halt/reverse the peat degradation through the implementation traditional peat restoration techniques.

This study consisted of an initial desk review and in-situ assessment of the size, characteristics and condition of moorland grips, gullies, drains and streams across the study area. A broad scale surface water flood model of the catchment was developed that demonstrated that the extensive system of moorland gullies and drains, form a well-connected drainage system that can quickly convey water downslope from the moorlands and into the receiving river network. However, there is considerable potential to intervene in multiple places within this headwater drainage network and landscape to intercept, slow and temporarily store run-off, thereby increasing the time it takes for the runoff to reach the main river network. The modelling work also informed the ranking of opportunities for a wide range of potential NFM interventions across the whole headwater area, including Peat Gully/Grip Restoration, Online Runoff Attenuation Features, Leaky Dams to disperse flows, and targeted scrub/woodland creation.

Two sub-catchments (Tarnbrook Fell and Hawthornthwaite) were subsequently modelled at a much greater resolution to show the most accurate representation of the moorland microtopography, which had been specifically surveyed for the study using a remotely controlled Unmanned Aerial Vehicle (UAV). A 20cm digital elevation model (DEM) of the study site, as well as high resolution georeferenced digital aerial imagery were captured. The implementation of the new DEM in the model resulted in the production of a flashier flood response in the sub-catchments for the same rainfall event compared to the initial model as the higher resolution DEM much more accurately identified the true extent and connectivity of the drainage system, together with multiple surface flow pathways. In turn, the greater level of detail also provided a better insight into where NFM interventions should be targeted to help maximise their effectiveness in terms of flood attenuation. The outcomes of the work are helping to inform the long-term restoration plan across the study area.

Workshop D – Citizen science for impact

THE RIVER STARTS HERE! COLLABORATION BETWEEN A RIVERS TRUST AND THE ENVIRONMENT AGENCY TO MONITOR, ANALYSE AND IMPROVE WATER QUALITY IN AN URBAN HEADWATER

J. WOZNICZKA[1] & S. DOE[2]

1 Trent Rivers Trust, 2 Environment Agency

Urban headwaters can be important sources of diffuse pollution but these small streams can also be a manageable target for collaborative action to improve water quality. 'The River Starts Here!' brings businesses, organisations and communities together to improve Alfreton Brook; a key WFD failing tributary in the Derbyshire Derwent catchment.

Alfreton Brook flows through former coalfields with towns and villages, industrial estates, a landfill, pumped minewater, the M1 and A38. It fails WFD targets for phosphate, invertebrates, macrophytes and fish.

The aims of our monitoring were to:

- determine the nature and causes of pollution
- engage stakeholders with improving the brook
- demonstrate change

Nine sondes were deployed in 2016 to pinpoint sources, with detailed investigation using 3 sondes in 2017. These provided continuous data on 6 determinants. The EA deployed them, analysed the results and provided a summary which TRT disseminated to partners and community events.

TRT carried out an Outfall Safari (devised by the Zoological Society of London) working closely with Severn Trent in 2017. Volunteers used an app to record 101 outfalls over 22km. 28 outfalls were found to be polluting.

Volunteers also use RiverLife, developed by the EA in collaboration with the Riverfly Partnership to record aquatic invertebrates, including those more tolerant of pollution, on a website. TRT support the volunteers and the EA provide feedback.

Finally, TRT have taken spot samples at key locations to supplement the sonde data, and will continue a regular spot sampling monitoring programme to measure Phosphate.

It is important to think scientifically and analytically about your monitoring. What do we want to know, and why? What questions are we trying to answer? Which methods can best provide those answers? Who else is interested? Are they interested enough to get involved and use the results meaningfully? Should we involve them in monitoring design at the start? If it is a Citizen Science method, what balance are we aiming for between engaging people, quality of data and its end use to follow up issues? Being clear on these questions is key.

Through building a shared understanding of the issues in a key area, monitoring in partnership and sharing results, we have built excellent working relationships. We are realistic about our respective workloads and priorities and now have a good platform for project work to address the issues identified which includes:

- River-Friendly Business Awards
- Brook Champions
- A set-back outfall
- Design for a restored river reach aimed at improving water quality

Collaborative monitoring is not a quick fix, but if embedded from the start in a carefully targeted area, can deliver real dividends.

UNLOCKING THE SEVERN – FOR PEOPLE AND WILDLIFE

J. LEACH[1] & T. THORPE[2]

1 Canal & River Trust, 2 Severn Rivers Trust

A major project to reopen the UK's longest river, the River Severn, has secured almost £20 million of funding – £10.8 million from the Heritage Lottery Fund and £6 million from the European Union LIFE programme. The project was developed as part of a three year long collaborative partnership between the Severn Rivers Trust, the Canal & River Trust, the Environment Agency (EA) and Natural England. The project – the largest of its kind ever attempted in Europe – will remove weirs and install five state-of-the-art fish passes on the River Severn and its major tributary, the River Teme, over the next three years to secure the long-term future of many of the UK's declining and protected fish species by substantially increasing access to important spawning grounds. The project is predominately focused on the once abundant and now threatened twaite shad (Alosa fallax) but will also benefit other critically declining species such as sea lamprey (Petromyzon marinus), salmon (Salmo salar L.) and the European eel (Anguilla anguilla).

This exciting project is about more than fish migration, though, and will work closely with local communities and schools in order to reconnect millions of people with the natural, cultural and industrial heritage of the river. Along with the UK's first Shad Fest, England's only fish viewing gallery at Diglis Weir in Worcester, World Fish Migration Day events and hosting a Dam Removal conference, a major citizen science program will also get people involved in the preservation of this lesser-known UK fish. In reconnecting people with the river, the project will raise awareness of the value of UK rivers, not only for enhancing biodiversity, tourism and fishing, but ensuring the River Severn system is protected for our future generations to enjoy as part of our natural and historic heritage.

The Programme Director will be joined by the project Volunteering Officer to focus in on the community science element of the project. This enables people with no previous experience to gain insight into, and contribute to, world class scientific research.

We take a creative approach to enable volunteer data collection, first considering how to reduce the barriers that often prevent non-specialists from becoming involved such as lack of technical knowledge, time commitments or confidence. Our citizen science programme provides opportunities for people to learn, enjoy and take ownership over their river, while generating valuable data. For example, volunteers use simple observational methods to estimate the annual shad spawning run and map spawning locations. We have shown that there is an appetite for community participation in fisheries and freshwater research and now plan to build a network of people who champion the river and its species into the future.

Session 6: Parallel Sessions

Main Banqueting Room: Best practice design

INVESTIGATING STEP-POOL CHANNELS IN THE HIGHLANDS

C. CLOAD[1]

1 University of the Highlands and Islands

Many upland rivers on steep slopes (i.e. < ~3%) naturally form step-pool channels. A stepped channel characteristically has regularly spaced lines of boulders across the full width of the channel. These form steps over which the water cascades into a pool below, dissipating energy. This form-process interaction provides a stable channel form that also encourages biodiversity and fish passage. Many rivers in the Scottish Highlands exhibit this morphology. In order to provide channel stability and maintain habitat integrity, river rehabilitation projects on steep slopes often attempt to reproduce a step-pool morphology. However the hydraulics of step-pool channels are not well understood and there is an element of trial and error when constructing such bedforms. This research project, conducted through the Rivers & Lochs Institute at UHI with the assistance of cbec Ltd, aimed to identify how the variables in the step geometry interact to achieve a stable step-pool channel.

The mechanisms by which the step-pool morphology provides stability in a steep channel is discussed. Four empirical equations (identified from the academic literature) that relate channel geometry and expected particle size variables are applied to five sampled rivers (three engineered and two natural) and the research methodology is described.

The five rivers investigated are all located in the north of Scotland. The natural channels are in two quite distinct environments; the Allt Dubhaig is a high mountain stream at the Drumochter pass whereas Inshewan Burn is lower-lying, located in woodland in Perthshire. The three engineered channels are located between Inverness and Aberdeen. For each of the five channels, survey data was collected that described the length and height of the steps and the size of particles they comprised. Each watercourse was modelled in HEC-RAS to allow the relationship between geometry and flow regime to be analysed. Historic survey data was available for one engineered channel, so it was possible to investigate changes to its geometry over time.

The investigation identified that, overall, the engineered steps showed greater regularity and had larger step particles than would be expected for a natural channel. The natural rivers had longer gaps between steps than engineered rivers (though also a greater variability in step length) and the step particle size was closer to the expected range.

Development of this research will be important to help inform and refine step-pool channel design in river restoration. This preliminary study determines that some engineered step-pool channels may be overly regular in design and may benefit from a more spatially varied step geometry; this would be more representative of nature and provide greater flow diversity, with associated implications for instream ecology.

ENGINEERED WOOD STRUCTURES – PRACTICAL EXPERIENCE OF DESIGN, IMPLEMENTATION AND MONITORING FROM PROCESS RESTORATION TO SUSTAINABLE BANK PROTECTION APPLICATIONS

H. MOIR[1] & E. GILLIES[1]

1 cbec eco-engineering

Engineered or Large Wood Structures (EWS or LWS) are increasing utilised in river restoration projects and for the purposes of channel/ bank stabilisation. There use in the latter application is often regarded by the environmental regulators as a more sustainable 'green' or 'soft' engineering alternative to more traditional rock armour/ rip-rap/ revetment bank protection and implementation of such structures is becoming more common. EWS/ LWS provide multiple benefits to a river environment that has a generally limited natural supply of large wood material to the active channel. Compared to more traditional bank protection measures, their more complex form helps dissipate rather than reflect potentially erosive hydraulic forces (through turbulence processes). Also, they are to some degree deformable, allowing adjustment in response to dynamic geomorphic processes. Furthermore, they also have significant ecological advantage, both in directly providing habitat (e.g. cover for fish within their structure) and through their role as catalysts for increased morphological heterogeneity (and, therefore, biodiversity) of the channel corridor.

We present case studies of projects in Scotland, England and Wales where EWS/ LWS was utilised for both bank/ channel stabilisation and river restoration (i.e. enhancement of physical process and improvement of ecological condition). We present the stages of implementation of these projects, from initial site assessment to modelling/ design to construction to monitoring. For river restoration applications, we demonstrate a reach-scale approach to identifying the optimal spatial distribution of different types of EWS/ LWS (e.g. 'bar apex' and 'medial' structures) for improvement to physical processes and associated ecological function. We then present detailed information on the influence on geomorphic form/ process (through detailed repeat topographic/ bathymetric surveys and 2D hydrodynamic modelling) and biotic response of the implementation of such structures. In terms of sustainable bank protection, we present approaches for identifying appropriate design specifications in rivers of varying energy regime and practical methods of construction to provide optimal levels of stability of the structures. This includes lessons learned in terms of construction methods where subsequent monitoring revealed damage to structures as a result of high flow events, allowing for subsequent refinement and improvement of design approaches.

GETTING DOWN AND DIRTY WITH A DIGGER

D. HAMMOND[1] & D. HOLLAND[2]

1 Affinity Water, 2 Salix River and Wetland Services

River restoration projects can take many years to come to fruition and even when the "on the ground" works starts there are inevitably issues/opportunities which occur, requiring adaptive management and a degree of flexibility. This paper will go through a number of examples of such occurrences and explain how they came about and what was done on the ground to deal with these.

Dealing with the natural world which has its own agenda, influences and time scales is by its very nature going to require flexibility in the design and build process. Many of our rivers are habitat for protected species which have specific legislation associated with working around these species. The

legal requirements for the protected species then have to marry up with onsite conditions such as low and high flows and siltation but the onsite conditions when the design was started can be very different from that experienced when the construction starts. We will present examples of the adaptive management that was required for a site where a protected species was present and went through something of a population explosion in the time between the design being completed and the construction started (a period of less than 6 month). As well as the changes with the protected species, there were changes in the hydrological status in that the area was experiencing a prolonged dry period which looked as though it was going to enter a serious drought. Changes in flow conditions also changed the channel morphology and presence of silts all of which had to be accommodated in the on the ground changes to the final construction. We will discuss what decisions needed to be made and how the final adaptive management was arrived at.

Other examples will also be discussed where construction changes needed to be made as a result of incorrect or inaccurate information coming from services maps. All services mapping comes with a caveat that they may not have millimeter accuracy and this has proved to be true. This example will show how the client, constructors and designers worked together to come up with a pragmatic solution which required the minimum of re-modeling of re-drawing of cross sections and long profiles. Examples of the benefits of Early Contractor Involvement (ECI) will also be demonstrated and how risk averse plans can be changed to more pragmatic, cost effective designs.

CONSTRUCTION DESIGN FOR RIVER AND FLOODPLAIN NATURALISATION

S. BENTLEY[1]

1 AquaUoS

The process of river restoration and naturalisation presents interesting challenges when projects reach the detailed design and construction phase. Nowhere is this more true than with the construction drawings. In the majority of cases, typical engineering oriented CAD type drawings, produced with exact dimensions and levels, are inappropriate to convey the concepts and processes behind the creation of natural river channels and floodplains whilst also adding very considerably to delivery costs.

This paper showcases a series of case studies and author experiences with regards the use, and potential over-use or reliance on formalised detailed design drawings to deliver / construct river restoration schemes. We argue that such drawings become a constraint to optimal scheme delivery recognising that the science behind the drawings is neither exact nor complete. Development of a more flexible design and construction arrangement based on comprehensive understanding of river processes gathered through a detailed Fluvial Audit should instead provide the foundations for development of functional and sustainable river restoration schemes and plans. Scheme design should be to a standard suitable for construction companies to be able to sensibly costs works and all design risks should still be made clear through the accompanying documentation. However, the construction phase must become more fluid. Minor changes to the design suggested by expert geomorphological supervision during construction works must be facilitated as a scheme evolves in order to optimise the final outcome. Risks associated with these changes must remain with the designer and contingency must be made for this on the part of the client to facilitate contractor flexibility.

Evidence of scheme delivery should come from as built survey with the final template being signed off by the designer rather than using this to compare to the construction drawings in order to confirm appropriate contractor input. Clearly this altered process must not be seen as an opportunity for radical design change without responsibility falling squarely on the designer, rather flexibility on site should be seen as facilitating opportunities to introduce improved form and functionality at little or no extra cost to the project.

Kensington: Catchment planning & delivery

RIVERLANDS. PARTNERSHIP WORKING – DOES THE PRACTICE MATCH THE THEORY?

A. SCARR[1] & R. HIGGS[2]

1 Environment Agency, 2 National Trust

The National Trust has launched Riverlands, a major partnership programme with the Environment Agency. This is a multi-million pound, long term programme of work that aims to explore how partnership working can deliver long term sustainable change. Rivers are the lifeblood of our landscapes, defining places and binding communities, and we believe that sustainable change will only be achieved through strong partnerships and a culture of participation. It is about being open, transparent, sharing decisions and acting together, about listening and valuing diversity where there will be a diverse range of perspectives and starting points. The presentation will describe the aims of the partnership, the challenges of two major organisations working together both nationally and locally and use examples to show how things are working so far, including the many other partnerships that are developing at a local level.

DEVELOPING A STRATEGY FOR DELIVERY OF CATCHMENT WIDE NATURAL FLOOD MANAGEMENT

T. WINGFIELD[1]

1 University of Liverpool

Critical and often overlooked in the debate around Natural Flood Management (NFM) is the act of balancing land and water resources. Delivering interventions for societal resilience against flooding requires navigating a complex socio-ecological system of housing, food, biodiversity, transport, flood defence, conservation and landownership.

Across England and Wales small charitable organisations have applied to take on the complex task of coordinating land and water resources as catchment partnership hosts. These partnerships are constructed of non-governmental organisations, water companies, local authorities, government agencies, landowners, special interest groups and local businesses. While they receive a small government payment, there is no defined strategy to guide structures and decision making. The diversity of membership should create a large pool of skills and resources to be drawn from, however, it is unclear whether there is a shared vision of how organisations within and outside of the partnerships should deliver NFM. Without this strategic approach the legitimacy of NFM has to be proven with each and every application for funding.

This study outlines a novel approach to explore the multiple perspectives and interconnections of different actors, through a shared analysis of the socio-ecological system. A broad consensus of concepts and processes that require consideration, in water and land resource management was revealed which include politics policy and planning, public perception, funding and infrastructure and evidence and technical knowledge. However it was found that there were differences of opinion as to which factors are the most important between flood risk management professionals and catchment partnerships. The results of this study have been tested in practice using three cases studies based in North West England, Ribble life together partnership, Merseyside strategic flood and coastal risk

management partnership with Mersey Rivers Trust and the Wyre NFM partnership. The results of both pieces of work have now been brought together in an NFM delivery framework guide, written to support practitioners to make decisions to optimise NFM planning and delivery on a catchment scale.

DELIVERING INTEGRATED CATCHMENT MANAGEMENT – THE LITTLESTOCK BROOK PILOT STUDY IN THE THAMES BASIN

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1 Environment Agency

Natural Flood Management (NFM) measures can have multiple benefits, not only increasing a catchment's resilience to climate change, but improving water quality, biodiversity and recreation. Defra, in its 25 Year Plan, is committed to understanding NFM and its benefits to the environment and people, investing £15million into 60 pilot schemes across England, one of which is in the Evenlode catchment.

The 16km2 Littlestock Brook tributary catchment of the Evenlode is the pilot lowland NFM scheme in the Thames Basin. It will assess the effectiveness of using natural river processes, land management and soft engineering approaches to reduce the risk of flooding in the village of Milton-under-Wychwood and improve water quality and biodiversity. The £640K scheme is funded by multiple partners (RFCC local levy, Environment and Flood Risk Grant-in-Aid, charity and private contributions), is community led and delivered by the Evenlode Catchment Partnership (ECP).

A Project Officer, appointed into the ECP, is working with the Bruern Estate and other landowners to implement NFM measures to slow and store overland flow and associated sediment and nutrient run-off under the guidance of seven partner organisations (Environment Agency, Wild Oxfordshire, Atkins, Thames Water, Local Authority, Wychwood Project and Windrush AEC). The delivery of the NFM project is also being integrated into a Thames Water phosphate reduction trial which has created an Evenlode Catchment Fund for land managers to reduce diffuse phosphate pollution.

In Phase 1 (2017/18), 10 field corner bunds were created with a combined storage capacity of 26,000m3. Woody dams installed at banktop height in the channel, divert high river flows along scrapes into these temporary flood storage areas. 100m of watercourse has been deculverted and 230m of new open watercourse has been created flowing through a series of 3 on-line ponds. The bunds and ponds have been delivered within a Forestry Commission 'Woodland Creation Grant' which has created 13 hectares of new riparian woodland. A second suite of bunds, which have a combined capacity of 19,000 m3 of flood storage, are planned for Winter 18/19 and will be delivered in association with a new Upper Tier Agri-environment Stewardship agreement and the Thames Water land management fund. Land management measures (including zero-tillage) are also being trialled on these same fields in the Bruern Estate. In addition, the local community (Parish Council) have funded £5K towards 12 woody dams as bed check weirs to reduce channel incision upstream of Milton-under-Wychwood and negotiated a 500m riparian woodland strip to be planted.

The integration of EA resources, consultancy and academic links has established an intensive water-level and water-quality monitoring network, and is supporting hydraulic modelling of the tributary trial area to understand the effectiveness of the NFM measures. The catchment partnership has also engaged the local community in citizen science observations.

NFM requires multiple land management changes across a landscape, so working with Catchment partnerships (CaBA), with landowners and local communities is essential. This pilot project is identifying and integrating different funding sources for NFM, and exploring the opportunities, barriers and scales of different delivery mechanisms. Key to the widespread adoption of NFM within catchment management decision making, will be securing the inclusion of payments for flood management (and other public goods) within the new landowner payment schemes post 2021.

STRATEGIC APPROACH TO RIVER RESTORATION PLANNING

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1 River Restoration Centre

To be effective and sustainable and enable the achievement of Water Framework Directive and other targets, river restoration should ideally be carried out at the scale of river/water body or catchments using broad-scale assessment and planning techniques. Existing methods such as fluvial audits are often demanding in terms of resources, skills, technical and analytical abilities and are often not adapted to the objectives and requirements of decision-makers. The River Restoration Centre has worked towards the development of a framework for planning river restoration at catchment scale that can be used by a wide community of users with differing abilities and skills. We will present an application of a framework and methods on a case study catchment along with simple and innovative techniques for surveying, analysing data and reporting outputs.

Derby: Fish passage & habitat restoration

HIGHLIGHTS AND LOW POINTS FROM THE FIVE YEAR SAGA TO IMPROVE FISH PASSAGE ON THE RIVER EHEN

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Barriers to biotic movement remain one of the most significant impacts on river hydromorphology and hydroecology in the UK. Long lengths of watercourses remain inaccessible to salmonids and other fish, reducing habitat availability and restricting spawning to lower, often heavily modified reaches. Actions to restore or improve access through barrier removal or modification to facilitate fish passage are vital. However, these successes are rarely achieved easily and even modifying the simplest of structures can require numerous permissions. Competing interests from hydropower, angling and historical preservation groups further complicate matters. Buy-in must be achieved at a local scale. This paper reports on the five year process leading up to the removal of Ennerdale Mill Dam (EMD) on the River Ehen, close to the village of Egremont, Cumbria. This was a partnership project run by West Cumbria Rivers Trust through the Environment Agency's Cumbria River Restoration Strategy, funded by European Maritime and Fisheries Fund, James Fisher Nuclear (the weir owners) Natural England, EA and Natural Course (LIFE IP).

Initial feasibility studies found that it posed a significant barrier to fish passage impacting on populations of freshwater mussels (FWM) further up the catchment. Removal would open up 15.5 km of habitat upstream reconnecting the mussel and salmon populations. Despite these clear aims, a strong, local desire developed to retain the structure on the basis that the disruption to local fisheries outweighed the potential benefits and that flood risk would be increased for the town. Ascertaining weir ownership and the ownership of adjacent infrastructure was difficult, but once confirmed the weir owners proved a great asset, providing financial assistance and allowing the structure to be removed. Historic interest was also high, despite the structure not being listed.

Further studies provided sufficient evidence to secure a permit for works to remove the structure and restore the riverbed which were carried out in summer 2018. Construction (or destruction!) took less than two months but was not without its problems, mostly associated with the interpretation of soft engineering design and local vandalism. Fine sediment management was monitored and releases were within acceptable limits for the Environment Agency and Natural England and FWM relocations prior to the works meant that no issues were encountered with these species.

Although the works were recent the response of the river has been as anticipated with the installed riffle/rapid and wide, point bar features acting well to moderate the released gradient resulting from weir removal. The rapids now provide open fish passage through the reach and fine sediment release from upstream has been minimal (there was little present in the first place). Furthermore, bank protection measures have helped stabilise failing river banks, protecting critical infrastructure into the future.

GREATER THAMES ESTUARY FISH MIGRATION ROADMAP: A PLATFORM FOR IDENTIFYING HABITAT RESTORATION AND CREATION OPPORTUNITIES

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1 Thames Estuary Partnership

The Thames Estuary Partnership together with Nature At Work, the Environment Agency, the IFM and the Zoological Society of London have launched an exciting new project. The Greater Thames Fish Migration Roadmap is designed to bring together data relevant to improving fish migration routes and fish habitat in one place for the first time. Rivers in countries of the North Sea region are some of the most fragmented by human development in the world. Diadromous fish, such as the European Eel, bass, sea lamprey and flounder, totally depend on free migration between marine and freshwater habitats to complete their life cycle. Currently, river restoration and intertidal habitat enhancement is completed in an opportunistic way when either a development needs to mitigate for other damage or flood asset management needs addressing. Similarly, migration barriers such as weirs are only addressed in an ad hoc manner – where and when the opportunity arises and usually only single barriers addressed. As a result, many flood asset or development projects can miss opportunities to deliver multiple benefits as the information is not easily accessible and the other benefits are hidden. This project seeks to address the lack of an integrated approach by pulling together all the barrier, freshwater and marine intertidal habitat opportunity data and flood mitigation areas together in one place through a stakeholder and expert participatory process, and progress by looking at migratory routes as roads to identify the 'highways', 'a-roads' and 'b-roads' that migrating fish will use. This approach has already helped water authorities in the Dutch Rhine West Delta to prioritise their measures for lifting barriers to entire routes and the lead partner in that work plays a key role in this project allowing us to build on previous successes and for knowledge exchange. As well as helping to priorities where fish passes are needed, the completed roadmap will also provide a platform for identifying habitat restoration and creation opportunities for when opportunities within sea/flood defence and river restoration arise and contribute to data needed for both Water Framework Directive and Marine Spatial Planning reporting and planning. It will also provide a pathway for building relationships across the freshwater and marine boundary.

HABITAT RESTORATION AT POWICK WEIR – A CASE STUDY IN SAVING KING HENRY III's FAVOURITE FISH

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1 Royal HaskoningDHV

The River Teme is a major tributary of the River Severn, which is designated as a SSSI. Man-made structures such as Powick Weir have a considerable influence on the River Teme, changing flow patterns, encouraging sedimentation, degrading in-channel habitats and preventing the upstream migration of the twaite shad (many of which vanished after weirs were installed in the 1800s). This presentation will provide an insight on how a partnership of consultants, Rivers Trusts and Regulators have worked together with the community to design and implement effective habitat restoration solutions for Powick Weir. It will inform delegates on how effective fish and wildlife restoration solutions can be achieved through the careful consideration at the feasibility and detailed design phase, combined with stakeholder consultation to provide a WIN-WIN solution for the environment,

anglers and community. In addition, the presentation will also inform the delegates on innovative fish passage solutions for protected fish species, such as twaite shad and provide initial geomorphological and ecological results following the removal of Powick Weir.

VIDEO MONITORING OF FISH IN RIVERS: RESEARCH AND MANAGEMENT PERSPECTIVES

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Lotic fish assemblages respond to a broad scale of anthropic and natural perturbations, from flow to habitat changes in terms of quality and quantity. Often river restoration aims to protect or preserve fish population and their habitat, which requires fish monitoring techniques and a deep understanding of fish population ecology to either support or assess river restoration. Current knowledge on fish population, are mostly tailored to game fish like salmonids, with less attention paid to coarse fish, and few information are available on the in channel habitat utilisation at the community level. However, the fish community should be studied completely and not only focusing on one chain link.

The aim of this study is to test a novel fish monitoring approach to (i) conduct a fish census, (ii) quantify habitat utility and preferences, and (iii) assess the fish behaviour exhibited in those habitats. The study was conducted in the River Mimram (Hertfordshire, UK) and involved the deployment of 10 underwater cameras laid out in different habitats. Habitat was defined as unique combinations of the substrates encountered, the depth of the water column and the surface flow, and varied seasonally with changes in vegetation growth and river discharge. Data were acquired monthly for one year, for a four hour period starting at dawn, as it is a period of high activity for fish. The species present in the river have been identified through the video monitoring. The videos were analysed to identify the species present as well as the behaviours expressed and their duration. The record of fish expressed behaviour obtained, have been assigned to specific habitat conditions. This building up a database of expressed behaviour for each species encountered in specific habitat.

The results indicates a variation of proportion of the different habitats, associated to the number of fish present, habitat utilisation, and the behaviour expressed in the respective habitat. Seasonal trends of fish abundances and behaviour expression have been analysed. The outcomes of this study will support carefully designed river management to suit fish communities requirements in terms of habitats, in the River Mimram. The database of behaviour will be used to develop habitat suitability and selectivity model. The comprehensive understanding of the relationship between fish and their habitat will guide future river management decision. The technique developed, has the potential to be used, in other lotic and even in lentic systems, as well as to monitor the efficacy of restoration approaches for fish communities.

Session 7

Main Banqueting Room: Long-term lessons for river management

NATIONAL ASSESSMENT OF THE SPATIAL DISTRIBUTION OF RIVER RESTORATION PROJECTS IN THE UK: MONITORING, ASSESSMENT AND MAINTENANCE

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River management to mitigate flooding and improve degraded ecosystems is a world-wide endeavour that supports a large industry. This industry is routinely criticised for failing to review or evaluate the performance of projects (e.g., Palmer, 2005). Reviews of such projects have been carried-out in North America (Bernhardt et al., 2007), and Australia (Brooks & Lakes, 2007). A major data base of 4000 river projects compiled by the River Restoration Centre provides an exciting opportunity to classify and review this type of work in the UK. The introduction of the European Water Directive has shifted the focus of river management in the United Kingdom from mitigating the impact of flooding on populations, to ecological restoration. This trend was identified in a recent analysis of the above database by Smith and Mant (2014). Few studies have explored the changing spatial distribution of these projects. Our research describes and maps the proportion of projects of different type and theme, the amount of money invested, and the location in terms of stream order, channel size, and catchment area. We also examine the proportion, purpose, and location of projects that have undergone monitoring, assessment, and maintenance, and differences between projects in rural and urban areas. This will improve on earlier reviews of this type of data base conducted in the United States (Bernhardt et al., 2007), and Australia (Brooks & Lakes, 2007). Our analysis adds to the growing body of knowledge about the progress of river restoration in the United Kingdom, and globally. The outcomes of the research provide direction for future projects, and recommendations for the management and funding of projects to ensure they are successful over the long-term.

INTERNATIONAL GUIDANCE AND CASE STUDIES ON USING NATURAL AND NATURE-BASED FEATURES TO REDUCE FLOOD RISK AND IMPROVE THE ENVIRONMENT

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1 Environment Agency

Natural and Nature Based Features (NNBF) are being promoted internationally to help reduce flood risk whilst delivering a wide range of ecosystem services. They refer to those features that define natural coastal and fluvial landscapes and are either naturally occurring or engineered to mimic natural conditions.

The US Army Corps of Engineers (USACE) has been leading two pieces of work to develop international NNBF guidance and share case studies examples of their application globally. The Environment Agency has been working with USACE and Rijkswaterstaat to help write this guidance document and to provide case study examples.

We propose to discuss and share the content of this guidance document showing what is included in key chapters, such as:

- Framework for NNBF
- System Considerations and Combining Elements
- Analysis of NNBF Benefits
- Performance Quantification and Metrics
- Monitoring, Maintenance, and Adaptive Management
- Community Engagement and Involvement
- Coastal NNBF measures
- Fluvial NNBF measures
- Greening grey infrastructure measures

We have also been working with the same partners on a different project, the NNBF Atlas which show-cases exceptional case studies from across the globe. We will look in detail at some of these examples to give you an idea of what's included in this document and how to use it.

GLOBAL CHALLENGES TACKLED THROUGH RIVER BASIN RESTORATION: A REAPPRAISAL OF THE IMPORTANCE OF OUR WORK

D. HETHERINGTON[1]

1 Arup

Historically, river restoration has been predominantly driven by a desire to improve physical habitat to the benefit of biota and aesthetics. However, only relatively recently (approximately the last 10-15 years) has the true holistic value of river restoration been appreciated through the development and application of ecosystem services frameworks. Additionally, the increasing appreciation of restoration in the context of natural processes and the river basin unit has allowed projects to be designed at a scale that is more sustainable, meaningful and scientifically robust than earlier attempts at habitat improvement. This is demonstrated by the principles of river, and river basin, process restoration being increasingly applied to tackle regional scale problems in rural areas and cities through techniques such as Natural Flood Management (NFM), Blue Green Infrastructure and the strengthening rewilding movement. As the appreciation of the value and impact of the work of river basin specialists has grown, as has the size river restoration community.

The world is changing and it is likely that our roles will become ever more important in the context of emerging and critical global challenges. Climate Change is the only truly global challenge that covers every geography on Earth, and the associated impacts are becoming increasingly apparent. River basin process restoration in rural and urban areas is one of the key actions that society can undertake to tackle the impacts of climate change by reducing flood and drought risk, improving food security, regulating temperature and improving air quality, protecting vulnerable habitats and holding carbon in sustainable ecosystems. Additionally, the planet's population is growing and communities are becoming increasingly vulnerable to droughts, exacerbated by historical and new damage to river basin processes. This paper explains how our community of river restoration specialists has never been more essential, due to the role that we can play in tackling the challenges caused by climate change and population growth. It also explains how our work can be crucial in achieving progress towards Sustainable Development Goals (SDGs), and humanitarian process improvements.