River Restoration Centre

18th Annual Network Conference

River Restoration: Addressing Uncertainty

4th – 5th April 2017 – The Hilton Metropole Hotel, Brighton

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Abstracts

2017

RIVER RESTORATION CENTRE 18TH ANNUAL NETWORK CONFERENCE

"River Restoration: Addressing Uncertainty"

4th and 5th April 2017 – Hilton Brighton Metropole Hotel

PROGRAMME OF EVENTS

DAY 1: - - - TUESDAY 4TH APRIL - - -

REGISTRATION at Reception

09:00	NETWORKING & EARLY VIEWING POSTER SESSION in the Durham Suite	60 mins

Session 1
Oxford Suite

CHAIR: *Martin Janes (RRC)*

10.00	**River Restoration Centre introduction & welcome** Martin Janes *(the River Restoration Centre)*	15 mins
10.15	**Lessons for river restoration from understanding natural channel adjustment: 30 years of examples from the UK and Denmark** Andrew Brookes (*Jacobs*)	15 mins
10.30	**10 years of restoring English rivers with special designations for wildlife** Jenny Wheeldon (*Natural England*)	15 mins
10.45	**Discussion**	15 mins
11:00	SHORT BREAK *with coffee and tea*	35 mins
11:35	**5 years' achievement in unstable political times** Peter Barham (*Welland Rivers Trust*)	15 mins
11:50	**Progress in process-based rehabilitation: practitioner's perspective parsed by the pond** Chris Bowles (*cbec eco-engineering Ltd.*)	15 mins
12.05	**Restoration beyond the wall – Delivering success** TBC (*Scottish Environment Protection Agency*)	15 mins
12.20	**Discussion**	15 mins
12:35	LUNCH in **the Durham Suite**	60 mins

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Session 2

	Oxford Suite Hard engineering removal	**Stamner** Healthy rivers, healthy habitats	**Hall 4** Geomorphological design	
	CHAIR: *Kevin Skinner (Atkins)*	**CHAIR:** *Judy England (Environment Agency)*	**CHAIR:** *David Hetherington (Arup)*	
13:35	**Wandle weir removal** James Maclean (*Land & Water Services Limited*)	**Restoring an agricultural river: experience of the Pow Burn** Charles Perfect (*Scottish Environment Protection Agency*)	**Applications of geomorphology in engineering design: delivering substantial economic and environmental benefits** Helena Parsons (*Jacobs*)	15 mins
13:50	**Avon Water Barriers: supporting the return of Salmon to the Upper Clyde System** Rob Mitchell (*Scottish Environment Protection Agency*)	**Restoration & future management of the River Ems** Seeseana Wright (*Arun & Rother Rivers Trust*)	**How much "design" is required for a successful river restoration scheme?** Ian Dennis (*Royal HaskoningDHV*)	15 mins
14:05	**Discussion**	**Discussion**	**Discussion**	10 mins

Session 2 – continued…

14:15	**How have Pearls in Peril physical restoration measures performed?** Kenneth MacDougall (*EnviroCentre Ltd.*)	**River Slea, working with a dry river** Marie Jane Taylor (*Lincolnshire Rivers Trust*)	**The importance of in-channel feature creation when naturalising active river channels** George Heritage (*AECOM*)	15 mins
14:30	**Porter Brook de-culverting and Pocket Park creation** Paul Gaskell (*Wild Trout Trust*)	**The use of indigenous aquatic plants & floating ecosystems in river restoration** Bill Gush (*Land & Water Ltd.*) & Galen Fulford (*Biomatrix Water*)	**Flexibility in design & construction – success and challenges at Norton Bavant Mill** James Maddison (*CH2M*) & Alasdair Maxwell (*Environment Agency*)	15 mins
14:45	**Discussion**	**Discussion**	**Discussion**	10 mins
14:55	POSTER SESSION in the Durham Suite *with tea and coffee*			45 mins

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Session 3

	Oxford Suite Geomorphic surveying & modelling	**Stamner** Urban restoration	**Hall 4** Natural flood management	
	CHAIR: *Charlie Perfect (SEPA)*	**CHAIR:** *TBC*	***CHAIR:*** *Fiona Bowles (RRC Board)*	
15:40	**Mobile data collection for geomorphological survey work** Katie Atkinson (*Arup*)	**Clean streams and community teams** Bonnie Boulton *(Atkins & Manchester City Council)* & Pamela Bradley (*Manchester City Council*)	**Letting nature innovate – can natural processes manage flood risk?** Steve Rose *(JBA Consulting)*	15 mins
15:55	**Integrated riparian survey – A holistic survey technique** Kieran Sheehan (*JBA consulting*)	**Outfall safari: a way of working with volunteers to map and record the impact of polluted surface water outfalls in a river** Joe Pecorelli (*Zoological Society of London*)	**Upland drainage network extension: A prime target for NFRM** Neil Entwistle (*University of Salford*)	15 mins
16:10	**Discussion**	**Discussion**	**Discussion**	10 mins

Session 3 – continued…

16:20	**Putting the pieces together: Dynamic modelling of river restoration measures** Samantha Jane Hughes (*University of Trás-os-Montes e Alto Douro*)	**Multifunctional benefits of urban restoration – Stanmore Marsh** Kevin Skinner (*Atkins*) & Mick Bradshaw (*London Borough of Harrow*)	**Modelling, mapping and engaging with NFM in Cumbria** Barry Hankin (*JBA Consulting*)	15 mins
16:35	**Is morphodynamic sediment transport modelling a useful tool for piecewise restoration design?** Eric Gillies (*cbec eco-engineering Ltd.*)	**The River Alt Restoration Project – A catalyst for change** Helen Rawlinson (*The Cass Foundation*)	**Local authorities working with communities and landowners to restore streams and reduce flood risk using natural flood management** Chris Uttley (*Stroud District Council*)	15 mins
16:50	**Discussion**	**Discussion**	**Discussion**	10 mins
17:00	SHORT BREAK TO MOVE TO FINAL JOINT SESSION			10 mins

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Session 4

Oxford Suite

CHAIR: *Will Bond (Alaska)*

17:10	**Keynote address** Angela Gurnell (*Queen Mary University of London*)	25 mins
17:35	**Discussion** (Keynote and General)	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	

19:30 – PRE-DINNER DRINKS RECEPTION

Durham Suite

&

20:00 – UK RIVER PRIZE AWARDS DINNER

Oxford Suite

2017 UK RIVER PRIZE FINALISTS

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DAY 2: - - - WEDNESDAY 5TH APRIL - - -

Registration **Opens at 8:30 am**

Session 5

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

Oxford Suite **Workshop A:** How to implement adaptive management effectively	**Stamner** **Workshop B:** Managing silt: Muddy Waters or Clearwater Revival?
Hall 4 **Workshop C:** Green measures in river engineering	**Queens** **Workshop D:** Community delivery and capacity – Messages for policy makers
Preston **Workshop E:** The costs of river restoration	**Site visit 1:** **Woodsmill Stream** **Site visit 2:** **Twineham**

12:30	LUNCH	65 mins

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Session 6

	Oxford Suite Restoring rivers with trees and wood	**Stamner** Floodplain reconnection	**Hall 4** Community & partnership delivery	
	CHAIR: *Ann Skinner*	**CHAIR:** *Jo Cullis (CH2M)*	**CHAIR:** *Geraldine Wharton (Queen Mary University of London)*	
13:35	**Trees, roots and how we can use them** James Holloway (*Queen Mary University of London*)	**EcoCo Life: "Joining up nature" in the Glazert water catchment** Clare Rodgers (*Royal HaskoningDHV*) & Roberto Martinez (*Scottish Environment Protection Agency*)	**Working in partnership to deliver multiple benefits: integrated sub-catchment mapping in the River Ouse, Sussex** Peter King (*Ouse & Adur Rivers Trust*) & Sandra Manning-Jones (*Sussex Flow Initiative*)	15 mins
13:50	**Making use of dead wood** Joe Huddart (*Imperial College London*)	**Balancing benefits & disbenefits of river naturalisation: a case study from the Lake District** Lee Schofield (*Royal Society for the Protection of Birds*) & George Heritage (*AECOM*)	**Planning and delivery of a multi-landowner river restoration project on the River Avon in Wiltshire** A. Martijn Antheunisse (Wiltshire Wildlife Trust)	15 mins
14.05	**Discussion**	**Discussion**	**Discussion**	10 mins

Session 6 continued…

14:15	**Ystrad Mynach: tree revetment** David Penny (*Natural Resources Wales*)	**Improving habitat along a small headwater stream** Lev Dahl (*Wiltshire Wildlife Trust*)	**Letting the Dove flow – River restoration in a much loved landscape** Julie Wozniczka (*Trent Rivers Trust*)	15 mins
14:30	**Could beavers have a role in river restoration?** Martin Gaywood & Angus Tree (*Scottish Natural Heritage*)	**Changing minds on the River Test** Heb Leman (*Environment Agency*)	**Community mapping of the lost streams of London** Adam Broadhead (*Arup*)	15 mins
14.45	**Discussion**	**Discussion**	**Discussion**	10 mins
14.55	SHORT BREAK TO MOVE TO FINAL JOINT SESSION			10 mins

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Session 7

Oxford Suite

CHAIR: *Rob Mitchell (SEPA)*

15:05	**River restoration in Europe: A hobby or a planned action? (A Polish Perspective)** Ewelina Szalkiewicz (*Poznań University of Life Sciences, Poland*)	15 mins
15:20	**Bringing business into catchment management** Kathy Hughes (*WWF*)	15mins
15:35	**Sharing good practice and building capacity** Marc Naura (*the River Restoration Centre*)	15 mins
15:50	**Discussion and Close** RRC Speaker	30 mins

16.20 END OF CONFERENCE *with tea and coffee*

Day1: Tuesday 4th April
Session 1: Oxford Suite

LESSONS FOR RIVER RESTORATION FROM UNDERSTANDING NATURAL CHANNEL ADJUSTMENT: 30 YEARS OF EXAMPLES FROM THE UK AND DENMARK

A. BROOKES[1]

1 Jacobs

Research has shown that a majority of river channels that actively move their bed and banks in the UK and Denmark do so in response to man-made pressures such as the constriction created by a narrow bridge arch or artificial channel straightening to allow railway embankments to (historically) be built in the floodplain. The loss of floodplain forests and individual bankside trees have also made channels more active than might be expected in a humid-temperate climate of the present day. This paper identifies a wide range of channel types with "traits" of active bed and bank movement and suggests how these might be captured in the planning and execution of restoration projects.

Using examples of river restoration projects planned and completed over the past three decades this paper:

• Demonstrates the value of anticipating channel change in restoration

• Use of 'natural channel recovery' as a river restoration option

• Allowing natural channel change as part of a bespoke design

• Uncertainty in river channel restoration arising from channel change

Each of these presents challenges as well as unique opportunities. However by overcoming some of these obstacles then more exciting dynamic channels can be created and evaluated.

10 YEARS OF RESTORING ENGLISH RIVERS WITH SPECIAL DESIGNATIONS FOR WILDLIFE

J. WHEELDON[1] & C. MAINSTONE[2]

1 Natural England/Environment Agency, 2 Natural England

Natural England and the Environment Agency have an established strategic programme of physical restoration on a series of English rivers with special protection status. The programme is based on natural ecosystem function generated by natural riverine processes. Over a period of 10 years, decision-making processes have been developed to encourage long-term and ambitious thinking in tackling the damaging modifications that have affected these rivers.

The programme has developed strategic plans for most specially protected rivers in England, and practical implementation of measures is well underway and increasing each year. Whilst this is a major achievement, any plan is only of benefit if it is acted upon. Individual schemes within plans are now being implemented across the river SSSI series.

The approach has been voluntary, focussing on the biodiversity and societal benefits and the provision of incentives to affected landowners. A commonly occurring issue has been a lack of mechanism to

encourage the restoration of planform movement. To address this, a new agri-environment "Making Space for Water" option has been generated specifically to support freeing up rivers to move through agricultural land.

A useful by-product of the approach has been the opportunity for local interests to adjust to change. Demonstration sites have allowed people to see the benefits, which has allowed momentum to be built. There can be a tendency for restoration activity to re-fragment within the catchment, so that local interests can 'get on' with doing something. Maintaining the profile of the strategic plan, and vision for how to restore natural habitat function, is fundamental to managing this.

One area that has received variable attention within the SSSI programme to date is the strategic evaluation of benefits. As activity moves from planning to implementation, this is the time to put in place cost-effective monitoring programmes that contain sufficient resolution of ecological changes and extend over sufficiently long timescales. Partnerships with local universities are likely to be the most effective means of securing a lasting association between river restoration and monitoring.

Currently the UK economic outlook is bleak, but strategic restoration plans allow resources to be used as and when they become available. The timescales associated with plan implementation can be lengthened (if justified) without altering the objectives and measures. This flexibility is a major strength of the programme as long as a regulatory overview is maintained to ensure that progress is not unreasonably slowed. Arguably the greatest risk to continued progress is that resources may not be maintained for managing the programme in a coherent way. This must be avoided to ensure that a long-term and ecologically sustainable approach, fit for a changing climate, is maintained.

5 YEARS' ACHIEVEMENTS IN UNSTABLE POLICAL TIMES – A CRITICAL APPRAISAL

P. J. BARHAM[1] & C. STOATE[2]

1 Welland Rivers Trust, Peter Barham Associates, 2 Welland Rivers Trust, Game & Wildlife Conservation Trust

Additional Authors

L. SMALLWOOD[3] & D. M. HARPER[4]

3 Welland Rivers Trust, 4 Welland Rivers Trust, Aquatic Ecosystem Services

The Welland Rivers Trust was formed in 2010 and, as well as being one of the newest, is one of the smallest Trusts. Nevertheless, It has catalysed a very effective series of restorations throughout the catchment, from headwaters to Fenland lower reaches. It led on one of the 10 Pilot Catchments, which evolved into today's wide support by DEFRA for catchment partnerships.

The main thrust of our work has been through the Welland Valley partnership, which was formed jointly with the Environment Agency and which we provide the chair and secretariat. Partners consist of representatives of all interest groups in the Welland. Continued improvements in the River Welland rely on this partnership working, which is extraordinarily helpful in ensuring that money and resources are available. The WVP initially produced a Master Plan for the catchment, as part of the Pilot Catchment initiative, 2012. The Trust was also successful in two large Catchment Restoration Fund river restoration projects in 2012 and the benefits from each continue to flow to catchment communities.

Welland partners have continued to work together closely to prepare and agree a new five-year plan for the Welland. Integral to this is basing the plan on the advice and financial assistance provided by the EA. We have learnt to make the catchment-based approach successful over the last few years, but the time

has now come for an objective appraisal to examine whether the limited resources available for river improvement can be better employed. For example, we continue to experience extremely tight controls over flood defence issues so that considerable time and money is spent on very detailed evaluation of flood risk in projects which by definition are small and low risk. There will be considerable experience in the partnerships around the country that could be examined to identify clearer and more proportionate approaches to ensuring regulators and project managers work together more efficiently. This will be extremely important in a climate of uncertainty about funding and where the importance of maintaining and improving the confidence of charitable organisations and volunteers will be critical in taking river improvements forward.

In addition, we shall need to be aware of the development of the DEFRA 25 year environment programme and how we can influence the delivery of this either through more appropriate legislation or through better understanding of how we deliver existing legislation. The presentation will be a discussion of the key points in the evolution of Welland catchment restoration, seeking to share the experiences and learn from similar experiences from Trusts in other parts of the country.

PROGRESS IN PROCESS-BASED REHABILITATION: PRACTITIONER'S PERSPECTIVE PARSED BY THE POND!

C. BOWLES[1]

1 cbec eco engineering ltd.

Process-based rehabilitation is a science that has progressed rapidly over recent years and we have learned much through practice and experience. Process-based rehabilitation is a philosophy that aims to remove barriers to the natural evolution of a site's physical and ecological processes that help to promote healthy riverine ecosystems. Through these actions the fundamental causes of degradation are addressed using techniques appropriate to the surroundings and at a scale that is appropriate with the environmental problems that are experienced. Through this presentation, comparisons are made between process-based rehabilitation on the west coast of the United States (US) and Britain. While historically, environmental rehabilitation techniques and practices were more advanced in the United States up to ten or fifteen years ago, recently tremendous advances in the science have been made in Britain as a result of legislative drivers such as the Water Framework Directive (WFD). Emphasis will be given to environmental permitting and regulatory differences between the US and Britain, and how these can represent significant hurdles to progress and implementation of rehabilitation projects. Environmental permitting and regulatory requirements can take years in the US and come at substantial costs. In Britain, these processes are significantly streamlined. Generally, the cost of rehabilitation in the US is greater than in Britain in terms of area of floodplain or linear distance of river channel enhancements.

Up to two case studies will be presented from the US to illustrate some of the techniques utilized over the pond (aka Atlantic Ocean), and the regulatory hurdles that had to be overcome for successful implementation. The first, Cordova Creek in Sacramento, California, is located in a protected river parkway and, although heavily modified through anthropogenic impacts, has little in terms of physical constraints. An existing concrete lined trapezoidal channel was rehabilitated to a meandering riparian creek corridor sized appropriately to the geomorphic setting using bioengineering techniques that allow for future physical and ecological evolution of the site. The second, Arcade Creek, also in Sacramento, California, is located in a heavily urbanised environment with significant physical constraints, including

flood risks to surrounding urbanised areas. The existing heavily degraded creek channel was choked with non-native species and was heavily incised due to hydromodification as a result of dense urbanization. Rehabilitation techniques had to consider potential risks to surrounding urban areas including infrastructure such as a downstream bridge. Long term integrity of the site was a major consideration. Both projects had significant environmental and regulatory issues. Cordova Creek took 10 years from initial concepts to construction, while Arcade Creek took 4 years. Through these case studies problems and solutions are highlighted and conclusions are made on how practice in Britain can learn from experiences in the US.

RESTORATION BEYOND THE WALL – DELIVERING SUCCESS

S. MCCONNELL[1] & C. PERFECT[1]

1 SEPA

High ambition characterises Scotland's approach to tackling the degraded physical condition of rivers and barriers to fish migration - healthy, functioning river corridors being the goal.

This presentation will expand on this by:

- Showcasing examples of successful restoration projects that will serve as best practice case studies offering lessons on the delivery of ecological improvements together with wider 'multiple benefits'

- Highlighting the innovative approach SEPA is taking to define 'Good status' and 'Good potential' for morphology. The Morphology Impact Assessment Tool (MImAs) tool is being updated to better reflect current understanding of the real impact of morphological pressures. This is enabling us to work with partners on restoration projects that ensure targeted physical improvements have meaningful ecological benefits for Scotland's water bodies. This includes plans that target pressures and deliver improvements at an appropriate scale and level of intervention.

- Detailing how proposals for RBMP cycle 2 are being balanced with competing demands on funding and evolving priorities. A process of profiling and prioritising potential projects has been undertaken by SEPA following careful consideration of the balance between the ambition to deliver meaningful ecological improvements, the scale of the task both within individual sites and across Scotland, and constraints both in terms of funding and space (e.g. in an urban setting)

SEPA has put significant effort into evolving the way we work with project partners and contractors to ensure a robust delivery process and the case studies presented demonstrate the benefit of this approach.

Session 2: Parallel Sessions

Oxford Suite: Hard Engineering Removal

WANDLE WEIR REMOVAL

J. HORNSBY[1] & N. PICKFORD[1]

1 Land & Water Services Limited

Removal of the River Wandle half tide weir was conceived to mitigate the permanent loss of intertidal habitat resulting from the Thames Tideway Tunnel project. Removal will allow a natural river regime to re-establish within approximately 1 hectare of the tidal contributory and support the aim to return the tidal reach of the River Wandle to Good Ecological Status by 2027. The weir was constructed in the 1980s as part of a marina development plan which never materialised. The central section was then removed to allow the passage of boats, this means that fish passage is also possible at all states of the tide.

The remaining structure retains water at a higher level than would naturally occur and therefore has altered the salinity and hydrodynamic regime in the area. This has led to an accumulation of 'contaminated' sediment which needs to be removed to expose the underlying gravel substrates to create a more oxygenated condition.

The rest of this presentation will develop with the project but will cover:

- Pre-Tender – What is required to allow an accurate cost for the delivery
    - Feasibility study incl. stakeholders, full design brief (what is the aim and who will benefit/lose out)
    - Sediment sampling & analysis
    - Accurate construction drawings (what is already there)
    - Detailed scope of works
- Why Early Contractor Involvement is important
    - Budgeting – how much will this cost to build outside of the design
    - Risk analysis
    - Scope
    - Licensing
    - Disposal
- The works – how we did it
    - Planning – time etc. PLA/MMO/FDC/Community/Licences/H&S
    - Mobilisation – site restrictions etc.
    - Preliminaries – River wall & turbidity monitoring/stop log weir/welfare etc.
    - Dredging works – specialist equipment/programme/surveys
    - Disposal – where and why
    - Demolition works – specialist sub-contracts/equipment
    - Demobilisation and returning the site
- Legacy
    - The project will allow the area to be restored to a thriving environment for plants, wildlife and the community.

AVON WATER BARRIERS: SUPPORTING THE RETURN OF SALMON TO THE UPPER CLYDE SYSTEM

A. McCULLOCH[1]

1 SEPA

Additional Authors

R. MITCHELL[2], M. MUIR[3] & D. MCCOLL[4]

2 The Rivers & Fisheries Trust For Scotland, 3 South Lanarkshire Council, 4 Clyde River Foundation

SEPA's Water Environment Fund (WEF) was created to help achieve Scotland's River Basin Management Plan objectives for the physical condition of Scottish waterbodies – including the easement of removal of redundant fish barriers. Two of the highest priority barriers for WEF and its partners were Fernegair and Millheugh Weirs on the Avon Water in South Lanarkshire. The Avon Water is a tributary of the River Clyde and the Clyde has experienced a resurgence in recent decades with the return of Atlantic Salmon. This is due to the work of SEPA and its predecessor bodies but also the work of various other organisations such as the Clyde River Foundation. Through this work the impact of pollution on the Clyde has decreased to such an extent that Atlantic Salmon now regularly make it to the foot of these weirs. Combined, these structures restricted fish passage to approximately 150km of river habitat across the Avon Water and its tributaries.

Fernegair and Millheugh Weirs are both old redundant mill weirs. They were first constructed in the late 1800's and were associated with the once active textile industry in this part of Scotland. Since the decline of this industry they have been left alone and today serve no economic purpose. Both of these barriers are substantial structures with Fernegair being approximately 50m wide and 3 – 4m high and Millheugh being 30m wide and 5m high.

In 2013, led by the Rivers & Fisheries Trust for Scotland (RAFTS) the project team began the process of identifying options to ease fish passage across these two structures. The process followed included the following stages:

- Scoping
- Design
- Works

This presentation will examine that process, identifying and discussing the key issues that arose and what was learned from the project including:

- Stakeholder engagement
- Costs
- Delivery timescales

HOW HAVE PEARLS IN PERIL PHYSICAL RESTORATION MEASURES PERFORMED?

K. A. MACDOUGALL[1] & E. CLEMENTS[1]

1 EnviroCentre Ltd.

Additional Authors

J. WEBLEY[2], L. WILKIE[3], H. ROBSON[4] & D. BLEASE[4]

2 Scottish Natural Heritage, 3 RAFTS, 4 EnviroCentre Ltd.

The EU LIFE funded Pearls in Peril project undertook a number of river restoration projects during 2015-16 and here the performance of these measures within the Rivers Dee and South Esk in north eastern Scotland are reviewed. The projects removed over 1.1 km of hard bank armouring, 28 flow deflectors and 0.5 km of embankments, along with reconnecting relict channels. These works were exposed to extreme river flows through the winter of 2015-16 which were the highest recorded since at least the Muckle Spate of 1829. The changes observed at these sites are reviewed in terms of what was expected during the design phase, which were broadly similar although the timescales for change were faster. In addition to the physical changes, the views of the landowners on how they now view the works has been captured which will help inform future projects during the planning stages.

PORTER BROOK DE-CULVERTING AND POCKET PARK CREATION

P. N. GASKELL[1] & S. THORN[2]

1 The Wild Trout Trust, 2 Sheffield City Council

Buried for 160 years, a section of the Porter Brook at Matilda Street in Sheffield has been de-culverted and the surrounding land transformed into an urban “Pocket Park”. Sometimes termed parkettes, mini-parks, vest-pocket or vesty parks, these are small green-spaces accessible to the public. Pocket parks often use single vacant building lots or small, irregular pieces of land. Sheffield is developing a track record for incorporating them into sustainable urban drainage systems and innovating by creating flood-plain storage capacity for urban rivers. As with a previous project on the River Don at Nursery Street in Sheffield, the Matilda-Street/Porter Brook site contributes flood risk mitigation as well as creating urban green-space, increased biodiversity and puts the local community of Sheffield in direct contact with this previously buried stream. Development value and economic regeneration have both benefited. Principle partners involved in the delivery of this work include (but are not limited to) Sheffield City Council, The Environment Agency, South Yorks. Forestry Partnership and The Wild Trout Trust. Key challenges that were overcome included archaeological and potential contaminated land issues as well as logistical challenges of coordinating in-channel habitat creation within a large civil engineering project.

The park and riverside is being well-used by the public in what was previously a car-park, walled-off from the river. In addition, local conservation group and “Trout in the Town” affiliated project “SPRITE” (Sheffield Partnership for Rivers In Town Environments) are carrying out invasive plant species and litter removal – as well as monitoring aquatic invertebrate communities under the Anglers Riverfly Monitoring Initiative. After de-culverting, the first trout in over 160 years has been caught (and released) by a fly angler from this section of the Porter Brook. The observations of invertebrates and fish have validated the efforts and techniques used to create varied structural elements and incorporate native flora in a high energy, urban spate stream channel. Consequently, a broad range of societal benefits are easy to observe following the completion of the project (and are used to inspire similar best practice). This

project demonstrates that these multiple societal and ecological benefits – including enhanced geomorphological and ecological processes – can be achieved through innovative partnership work with relevant expert consultation. Incorporating this advice at an early stage and identifying the most appropriate partners enabled gains to be delivered with minimal additional cost to the existing plans for de-culverting and park creation. This successful format was greatly facilitated by the existence of the Sheffield Waterways Strategy Group and its attendant network of practitioners, governmental bodies and stakeholders and made possible by funding through Interreg North Sea Region, SCC Breathing Spaces (“section 106”), EA and further funding by partners such as South Yorkshire Forest Partnership/SEEDS and Wild Trout Trust contributions.

RESTORING AN AGRICULTURAL RIVER: EXPERIENCE OF THE POW BURN

C. PERFECT[1]

1 SEPA (Water Environment Fund)

The Esk Rivers and fisheries trust approached SEPA's Water Environment Fund in 2015 for support to deliver an ambitious restoration project aimed at improving the ecology of a 3km reach of the Pow Burn (nr. Montrose, Scotland). The Pow Burn is a typical agricultural river channel that has been extensively deepened and straightened with a riparian zone reduced to a few meters. This project demonstrates a range of restoration measures appropriate for improving the ecological processes along highly impacted rural rivers similar to the Pow. Land-use constraints meant that space for an extensive remeandering project was not available. However, SEPAs Morphological Impact Assessment Tool (MImMAS) indicated that meaningful ecological improvements could be achieved with a modest increase in river corridor width. The design team at Envirocentre proposed measures based on the opportunities and constraints present at the site. Phase 1 saw the implementation of these over a 1km reach including excavation of a two-stage channel, reconnection of paleochannels and installation of instream structures. A critical review of the completed works was then undertaken with the aim of identifying potential improvements that might increase project success in relation to the key objectives of the project.

1. Increase the morphological diversity of instream and riparian habitats
2. Reduce fine sediment input to the South Esk Special Area of Conservation.
3. Improve habitat for SAC species Salmon, Otters and Freshwater Pearl Mussels.
4. Localised management of, and increased resilience to, high flow events.

Phase 2 saw similar restoration measures installed. For each reach measures were reviewed, improvements were identified and designs were enhanced. This included increasing the length and naturalness of instream deflectors, increasing the area of two-stage channel and increasing the depth of river corridor features to ensure hydraulic connectivity under a greater range of flows.

RESTORATION & FUTURE MANAGEMENT OF THE RIVER EMS

S. WRIGHT[1] & A. THOMAS[2]

1 Arun & Rother Rivers Trust (ARRT), 2 Wild Trout Trust (WTT)

The main aim of the paper is to help disseminate information to people working on chalk streams and rivers to share experience and knowledge about some of the common pressures they face and techniques to restore and protect them as well as the benefits of partnership working. The late Professor Nigel Holmes surveyed the Ems in 2007 and identified measures for improvement, some of which were delivered after the survey was completed and others which we have endeavoured to honour during the recent habitat and channel improvement works (2015/16). While Holmes' survey provided invaluable information on how to restore parts of the Ems additional planning and thought was required as to how exactly the restoration works where to be delivered. Many questions required an answer, for example, we needed to know for proposed restoration reaches (i) what reduction in wetted width of the channel was required for low summer flows to function more sustainably? (ii) what number of pool and riffle sequences where required over selected reaches in order for them to be effective? and (iii) what depth and dimension of new pools were required in order to accommodate a degree of natural 'in-filling' over forthcoming winters and to also cope with low summer flows? There

was no funding available for modelling to help deliver these answers or 'reference reaches' against which to gauge what was required, instead pre-work site visits and measurement of the existing channel dimensions and flow (velocity and depth) were recorded to help calculate what was likely to work at the various reaches. Objectives set at the start of the Ems work also helped to define what type of restoration work was required; for example, what type and size of pools would be needed to accommodate different fish species throughout their life cycles.

Over twenty different organisations/individuals regularly attend the Arun & Western Streams Catchment Partnership with a joint interest in what they would like to see delivered within the catchment. This effective engagement enabled three different sources of funding to be directed to help resolve problems on the Ems; (i) National Environment Programme (NEP) funding via Portsmouth Water; (ii) Catchment Partnership Action Fund via the Government's Department for Food and Rural Affairs and (iii) Water Framework Directive (Grant-in-Aid) funding from the EA. It was felt that bringing stakeholders together helped deliver more effective river improvement works than would have been achieved separately; greater collaboration will also be required in the future with the likely need for a water management plan for the Ems and it is hoped that the successful engagement to date bodes well for this future need to help sustain the Ems as a high quality chalk stream for the long term.

RIVER SLEA, WORKING WITH A DRY RIVER

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The River Slea is an 18 mile long tributary of the River Witham, Lincolnshire. The River Slea is groundwater fed from Lincolnshire limestone aquifer and the flow depends on the on groundwater levels. Historically the River Slea flowed all year round. In the early 60s the flow of the river began to slow and ceased in 1962. This was due to a number of reasons such as over abstraction, increase in population and changes in weather cycles. After a public campaign in 1992, a pump was installed by the Environment Agency which delivers groundwater to the river at times of no flow. The Lincolnshire Rivers Trust (LRT) commissioned Clear Environmental to deliver the Sleaford Urban Opportunities Study, which was funded by Natural England. This study highlighted how the river would benefit from various rehabilitation techniques to enable wildlife to be more resilient during low flow periods and also contribute towards WFD objectives. Three sections of river were identified where restoration could be completed, this covered approximately 1.2km of river. Unfortunately, due to site constraints, work could only be completed on two sections (sections one and two). There were three phases to the works completed, these are detailed below;

Phase 1: Using an excavator, a low flow channel was created in section one and pools were created in section two. River bed material removed was used to create berms and meanders within the existing channel.

Phase 2: Brushwood bundles were installed, to construct berms which created pinch points, narrowing the channel to speed up the flow and maintain the pools created. This part of the project was made possible with the help of volunteers.

Phase 3: Planting of vegetation using coir matting and plug plants, to increase the rate of colonisation of berms and make them appear more natural.

In September 2015, section one of the river was completely dry, but following the creation of the low flow channel, in September 2016 there was still 1ft of water retained within that section.

Before the works were completed, a water vole survey carried out in 2015 only found old unused burrows, with no signs of water voles. In 2016 another water vole survey was carried out, detecting 12 feeding stations and four latrines.

In 2015 section two was completely uniform with no pools or any habitat features. Following the work, 22 berms were constructed providing cover for fish and providing deeper areas that would help maintain the depth during low flow periods. Planting was successful, and in time, the vegetation will grow and create a natural meandering flow. This was Lincolnshire Rivers Trust first rehabilitation project; the main lesson learnt was that further feasibility of options should be completed to identify constraints.

THE USE OF INDIGENOUS AQUATIC PLANTS & FLOATING ECOSYSTEMS IN RIVER RESTORATION

B. GUSH[1] & G. FULFORD[2]

1 Land & Water Ltd, 2 Biomatrix Water

Healthy Rivers are living rivers full of a diversity of aquatic species. A wide range of native plant species add to this eco-system and we will discuss the importance of using indigenous planting.

Establishing the plants in diverse and dynamic river environments can be challenging. We will demonstrate the use of the floating island planting systems which allow us to provide both fully aquatic as well as marginal and moist terrestrial conditions and indigenous planting in more challenging environments.

We will demonstrate the ability to successfully establish thriving habitats of regionally selected native plants in even the harshest river environments. The opportunity is to bring the process of river restoration in to new urban environments.

The benefits we will be demonstrating are:

- Improved water quality
    - Floating Ecosystems have been specifically developed to provide a concentrated natural solution to improve water quality.
- Habitat for aquatic species
    - The eco systems with indigenous plants provide an inviting habitat for birds, fish and other species, increasing biodiversity
- Aesthetic cover to hard engineering river revetments
    - Adding beauty and green space and sometime urban environments
- Environmental resilience
    - Allow green space to be added to urban environments
- Community involvement
    - How important this is to the ongoing success of the project

We will discuss and illustrate:

- Choosing the best plants
    - The importance of indigenous species and researching the environment
- Life cycle of the plants from seed to first establish through grown-on to planting
    - Why growing from seed is important
    - How to ensure the grown – on establishing plants that will thrive in the end environment
- The use of the plants in the floating habitat
    - How they are placed and why
    - Who will benefit
    - How to monitor and maintain

We have several live project example with progressive photographs and evidence charts.

The start of a project where pre-planted floating habitats are being used to hide steel pilings in an urban marina. We will have updated shots of this in our presentation.

Children from a local school actively involved in the planting and mobilisation of the floating habitats.

Hall 4: Geomorphological Design

APPLICATIONS OF GEOMORPHOLOGY IN ENGINEERING DESIGN: DELIVERING SUBSTANTIAL ECONOMIC AND ENVIRONMENTAL BENEFITS

H. PARSONS[1]

1 Jacobs

The Water Framework Directive (WFD) provides geomorphologists with the legislative framework for ensuring environmental best practice, sustainable management and protection of our rivers. The WFD enables geomorphologists to acquire a seat at the design table and to play an influential role in engineering design. As a direct consequence, numerous environmental benefits and protection have been realised for our rivers through iterative design solutions. Prior to the WFD, the involvement of geomorphologists in the design process was achieved on the grounds of best practise and not a guaranteed component of projects. This may have resulted in scheme designs being less sensitive to fluvial processes and, as a consequence, more likely to incur future asset maintenance costs, which could have been eliminated at the design table through consultation with geomorphologists.

Thus, in this changing economic and political environment, the benefits the WFD has provided should be used to influence and inform the future management of our rivers. This is vital to ensure geomorphologists retain the legislative driver to continue to influence engineering design. Through application of the WFD, geomorphologists have delivered considerable added value in the whole asset management life cycle, from feasibility, through design, construction and asset maintenance, delivering substantial economic and environmental benefits. This presentation draws on recent applications, which include the use of WFD and geomorphology in major infrastructure projects, asset management and erosion risk assessments. This includes using the WFD to divert the need for Article 4.7 and reduce the impacts of a major slope stabilisation scheme on a major English river. The WFD was used as a key driver for feasibility studies into the preferred location of a new river intake to supply drinking water to a major English city. Here, WFD and geomorphological evidence was a key influencing factor in the location of the river intake. In the absence of legislation requiring the need for geomorphologists, it is possible that an alternative location may have been selected, resulting in greater asset maintenance costs during operation due to inappropriate placement of the intake. Further examples are drawn from the erosion issues caused by recent storm events. A geomorphological erosion risk tool, developed by Jacobs, has been successfully applied on schemes in the UK to inform both design of schemes, appropriate asset placement and to identify exiting assets at risk from erosion.

Thus the application of the WFD and geomorphology in engineering design provides us with a compelling evidence base for influencing and informing future water management legislation. Its application is proven to deliver substantial cost-savings in the whole asset management life cycle and promotion of these benefits should be used to secure our future in the changing political and economic environment.

HOW MUCH "DESIGN" IS REQUIRED FOR A SUCCESSFUL RIVER RESTORATION SCHEME?

I. DENNIS[1]

1 Royal HaskoningDHV

The term "detailed design" is often used in the river restoration community. However, it is not necessarily used to mean the same thing and can refer to a spectrum of different outputs. At one end of the spectrum, all aspects of the scheme are specified, and detailed hydraulic and geomorphological calculations are used to support the design of a stable river channel. At the other end of the spectrum, a much "looser" approach can be adopted to inform the creation of initial conditions that will adapt naturally in the future.

This presentation will draw upon recent examples that Royal HaskoningDHV's river restoration team have delivered to compare the results of different approaches to "detailed design", focussing on recent integrated channel restoration and weir removal projects on the River Esk in Mid Lothian (Dalkeith Weir and Montagu Bridge Weir), River Cam in Gloucestershire (Cam Bridge Weir), Tarff Water in Dumfriesshire (Creamery Weir) and River Uck in East Sussex (Buxted Park Weir). In each case, this presentation will explore the approach used and the factors that contributed to the selection of the approach, including project objectives, landowner requirements, site specific constraints and the amount of "risk" (often with regards to geomorphological adjustment) that was acceptable in each case. The results of each project will be compared, and used to highlight the relative advantages and disadvantages of different approaches to detailed design. In addition, lessons learned for the applicability of different levels of design to future schemes will be highlighted.

The main conclusions will be that all approaches to detailed design are equally valid, and therefore should all have a place in the "designer's toolkit". The choice of approach should generally be defined by the amount of certainty required in the design and the degree of adjustment that is acceptable. "High risk" sites (i.e. those where constraints limit the amount of adjustment that can occur) typically require a more intensive design approach than "low risk" sites where natural processes can be allowed to operate more freely. However, when used properly, these approaches are all able to deliver significant benefits for fluvial geomorphology, river ecology by restoring natural processes and functionality.

THE IMPORTANCE OF IN-CHANNEL FEATURE CREATION WHEN NATURALISING ACTIVE RIVER CHANNELS

G. L. HERITAGE[1] & S. BENTLEY[1]

1 AECOM

Restoration of rivers in the UK has undergone a significant change over the last decade with approaches moving away from structural intervention in the form of deflectors, green bank protection to control unwanted erosion, 're-meandering' back into an historic planform through to restoration that is in line with current fluvial processes to increase the chances of longer term success. The recognition that a

river can do a lot of the restoration work itself has become recognised and river naturalisation where minimal targeted intervention is designed to rejuvenate fluvial features and processes has become a popular approach to improving our rivers. Often active channels have suffered straightening to increase flow efficiency and enable the floodplain to be utilised more effectively and constrained laterally by extensive bank protection of one form or another. Releasing the river from these constraints by creating a new unconstrained sinuous course has been popular of late. Here we review the short and medium term response of several of these schemes and argue that river response has been more dramatic than originally envisaged. This we suggest is linked to the imbalance in the sediment regime that existed following the naturalisation with the river eroding, transporting and depositing new sediment as flood driven pulses leading to transient stalled gravel features and associated flow concentration and bank erosion. In extreme cases this has seen the development of wandering channels in previously active sinuous single thread reaches.

Given the sediment / barform related issues highlighted above we suggest that it is necessary to impose not only a planform but also a set of embryonic morphological units along a naturalising channel in order to develop hydraulic and sediment transport conditions that will maintain the expected river form. Feature creation must be in line with the imposed planform and appropriate for the type of channel anticipated using sediment sized with the transport regime in mind. Such consideration was given to the naturalisation of Swindale Beck in the English Lake District. Evidence from the monitoring programme has measured erosional and depositional processes at the site revealing directional change in line with that anticipated for an active sinuous single thread channel with sediment movement integrated with the embryonic bar forms to produce a river in dynamic equilibrium with an undisrupted bedload transport regime. As such, continued morphologic development should see the previously constrained river once again behave as an active sinuous single thread channel functionally reconnected to its floodplain.

FLEXIBILITY IN DESIGN & CONSTRUCTION – SUCCESSES AND CHALLENGES AT NORTON BAVANT MILL

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A river and floodplain restoration scheme, completed in October 2016 at Norton Bavant Mill, forms part of the strategic **River Avon Restoration Project**, which has been delivering projects across the catchment since 2010. Historically, the reach of the River Wylye downstream of Warminster was impounded for approximately 500m upstream of the mill, resulting in uniform, deep and slow flow conditions. The river was poorly connected to the floodplain and the habitat upstream was heavily silted, with little ecological value and sluggish geomorphology. Flow over the main hatches was fast and shallow, preventing fish passage for all but the strongest swimmers.

In January 2014, flood water (which had been overtopping the embankment for some time) caused a breach, resulting in the river bypassing the hatches and the mill. However, upstream complexities meant that the river couldn't just be left to adjust naturally. This presented the opportunity to re-meander the 260m reach of the mill channel with the multiple benefit aims of improving river and floodplain connectivity and functionality, improving fish passage and re-establishing more sustainable chalk stream communities. The project would also provide the natural infrastructure (ditches, scrapes etc.) to enable planting of native floodplain woodland.

The project developed *flexible* detailed design drawings which were critical to the success of the scheme. This flexibility allowed the contractor and design team to work together during construction, and fine-tune channel and floodplain features. This is recommended as an important element of any river and floodplain restoration project that seeks to work with existing river processes.

The design of a new channel in the floodplain was agreed by the 3 key landowners involved, following extensive discussions between them and the Environment Agency, as the existing land boundary would move with the river. The presence of water voles required early ecological support, mitigation and monitoring during construction and the historical nature of the site required archaeological support at key times. Supportive landowners, and a well-balanced design and construction support team ensured delivery was as seamless as possible.

The new channel was constructed with a varied profile and meandering planform, to maximise morphological diversity and habitat features. Marginal shelves, riffles and pools were incorporated into the channel, and tree root-balls, retained from previous scrub and tree clearance, were used in the banks to provide some bank/channel stability. River gravels and Ranunculus plants were moved from the existing to the new channel, to ensure continuity of species and sediment and to achieve a cut-fill balance for the scheme, achieving cost savings and improving sustainability.

A more natural, functioning floodplain was created, through infilling of the old channel, embankment lowering and creation of floodplain habitat features to enhance habitat for species such as water vole and otter.

Session 3: Parallel Sessions

Oxford Suite: Geomorphic Surveying & Modelling

MOBILE DATA COLLECTION FOR GEOMORPHOLOGICAL SURVEY WORK

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1 Arup

An understanding of the geomorphological context of a fluvial system is fundamental for well-informed river rehabilitation projects. Geomorphological surveys are a key tool to acquire such an understanding, and can often require large amounts of detailed information to be collected for vast distances of river channel. Previously, most of these surveys have been completed using paper maps and forms, having to manage multiple pieces of paper under all weather conditions and requiring the time-consuming process of digitizing the information after surveys have been completed prior to the analysis of the data.

Arup have developed a methodology that allows these surveys to be collected digitally in the field using hand held devices. The information is then sent directly to a database on a server. The mobile application on ArcGIS Collector directs surveyors through the data entry process, guiding them through the fields to be completed for all the required data, already in the right format. Given the complexity of these surveys, this leads to an increase in accuracy and homogeneity between surveyors. Arup and partners are using this application for nearly 5500km of MImAS/STR:EAM surveys in Scotland, as well as undertaking a number fluvial audits and targeted geomorphological walkovers which are being used to inform the understanding of geomorphological form and process, and in turn helping to deliver river restoration objectives and WFD requirements for a number of settings.

The mobile application has created significant efficiencies by enabling multiple companies to complete surveys with the same structure offline before the data is synced back to a central database, with limited post-processing requirements and avoiding the need for manual digitization back in the office. This approach also has environmental benefits, for example in the reduction in paper required for the surveys as well as practical and health and safety advantages for the surveyors. This presentation will explore the challenges of data collection for geomorphological surveys and the techniques adopted by Arup to optimise this process and increase the efficiencies for this type of work. The presentation will also consider the potential of the approach for future opportunities and further development to respond to demands in this field.

INTEGRATED RIPARIAN SURVEY – A HOLISTIC SURVEY TECHNIQUE

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The Integrated Riparian Survey is a new survey technique that combines the best components of River Corridor Survey, Fluvial Audit and standard mapping techniques, such as Phase 1 Habitat Survey (or NVC, CSM if needed). Developed following our extensive experience of surveying rivers, including the entire River Teme and extensive reaches of, for example. The Wharfe, Ribble, Stour, Black Devon and Hull, the methodology was initially devised as a way of better integrating the ecology and geomorphology elements of these surveys. The experience on the Ribble was instrumental in this as, with two surveyors working together on site, there was extensive discussion surrounding features, their development and likely succession. This led to cross-disciplinary ideas for river restoration and the identification of loci where these could be employed. A key benefit was, rather than just recording the vegetation across the river at set intervals and mapping the floodplain, the overall nature of the vegetation cover was assessed and how this was affecting and was affected by the river processes. In some cases autogenic succession was the key to the development of features in the channel whereas in other situations the succession was entirely allogenic. Key species governing succession on different substrates were identified and the presence or absence of these upstream and downstream allowed an assessment of what successional process were likely to be dominant. This allowed relatively accurate predictions of what vegetation communities were likely to develop following interventions and whether these were suitable for target species, such as wintering/breeding waders on reconnected floodplains. The IRiS survey method requires a minimum or two surveyors, one a geomorphologist practiced in using Fluvial Audit and River Habitat Survey, and an ecologist with a detailed knowledge of riparian vegetation, River Habitat Survey, terrestrial ecology and GIS. The surveyors work together recording the features in the river and on the banks (as normal) but will also view the floodplain as a whole, noting features, such as palaeo-channels, scrolling and levees and recording the vegetation communities and land use through the use of georeferenced Target Notes. Within the river corridor, the vegetation is recorded by transect every 250m with this being extended across features, such as islands and bars, in tandem with the fluvial audit; noting the nature of the vegetation, how permanent or otherwise it is and what processes are governing the deposition and colonisation of these features, including INNS. The data is then recorded, reported and mapped, showing opportunities and constraints along the survey reach and allowing a greater understanding of the biotic and abiotic processes operating across the river and floodplain.

PUTTING THE PIECES TOGETHER: DYNAMIC MODELLING OF RIVER RESTORATION MEASURES

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River restoration covers a range of measures and techniques, often implemented across different spatial and temporal scales, ostensibly to improve environmental conditions. Investment in river restoration measures aims to provide multiple benefits that sustain aspects of governance such as improved ecological status (Water Framework Directive), protected sites or species status (e.g. the Habitats Directive or SSSI) and reduce the economic and social impacts of stochastic extreme events (e.g. floods). However, the holistic nature of river restoration, applied in highly dynamic systems, makes it hard to assess which measures are more suited to meet certain objectives under certain conditions. We present the case for using the Stochastic Dynamic Methodology (StDM) to anticipate the outcome of river restoration measures and how model outputs can be used in decision support processes. Using dedicated modelling software (STELLA), StDM is a sequential modelling process that can capture and model change in ecosystems through the use of relevant datasets and indicators. The StDM is a powerful and versatile modelling approach that can be designed around project aims and complexity; it has already been used to build and test scenarios to answer questions concerning impacts of alterations to ecosystems such as mountains, islands, estuaries, reservoirs and rivers. The StDM approach can be used to develop and run river restoration scenarios using relevant data gathered from diverse sources such as online open access databases, RiverWiki contributors, Statutory environmental agencies, student research projects and citizen science projects as Before-After-Control-Impact (BACI) datasets for river restoration measures are rare. Output from simulations run over relevant periods of time can be coupled with Geographical Information Systems to provide spatial projection of change that can be provided in the form of maps, graphs or tables. This can be used to help end users identify the best management procedures, the most suitable indicators of certain restoration measures, data requirements and how combinations of measures can benefit target species or objectives, such as improved WFD status of waterbodies. We present case studies of StDM and river restoration projects to demonstrate the relevance of the approach and the potential for developing such a tool.

IS MORPHODYNAMIC SEDIMENT TRANSPORT MODELLING A USEFUL TOOL FOR PIECEWISE RESTORATION DESIGN?

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When a restored river reach is tied into a previously perched channel, the initial 'break-out' slope into the lower floodplain is high, potentially causing head cut and instability. Similarly, if grade control structures are removed, channel bed sediment is unlikely to be static during moderate flows. While restoration designers have basic guidelines regarding channel geometry and sediment size in their toolbox, sediment transport modelling is a powerful additional tool to investigate the design and the only technique that might predict future conditions. However, sediment transport modelling is expensive: models are time consuming, have to be based on detailed topographic data, mapped sediment distribution and upstream sediment supply. Such modelling is a significant effort for results that are sometimes only accurate within a factor of two or three. What can be learned from such models and are they useful? We present a number of case studies to illustrate these issues.

CLEAN STREAMS AND COMMUNITY TEAMS

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Manchester City Council is currently working to restore its urban watercourses through activities that also support community revitalisation. A number of ordinary watercourses in Manchester suffer poor water quality and increased flood risk as a result of fly-tipping, overgrown vegetation, blocked and undersized culverts and historic modification. Some of the watercourses are open channels (approximately 38km) but the majority are culverted (approximately 107 km). Six open channels were initially selected and designed for restoration based on risk of flooding to properties and highways, the potential to engage with local stakeholders, and space to deliver small-scale green-infrastructure.

The initial objective was to engage with the local schools, businesses and residents to carry out a one-off clearance of the most affected open channel sections of watercourses to raise awareness of the project and instil some community ownership and pride for the future state of their local environment.

Following the communities' involvement a contractor was brought in to implement a suite of measures to reduce flood risk, increase habitat diversity and make the neighbourhood a more appealing place to live. Measures include:

i) regrading the channel banks to provide additional capacity and increase morphological diversity;

ii) the installation of woody debris in areas of low flood risk, to provide in-channel habitat and hold flows back to prevent flooding downstream;

iii) the creation of backwaters and offline storage areas to provide additional flood storage during peak flow conditions and improve the marginal habitat diversity.

Working again with the local community, additional enhancement measures were carried out such as in-channel planting, seeding the banks with local wild seed mixes, and bankside tree planting. Local schools were involved in a competition to design the artwork for interpretation panels to be installed adjacent to the newly restored streams and open days held to celebrate the work done.

It is hoped that by involving the community this will help deter future fly-tipping and result in a greater appreciation for, and enjoyment of, the local environment. There has been a lot of positive feedback to date which is satisfying and reassuring. The measures implemented by the project also help to reduce flood risk whilst also offering habitat and morphological benefits, thereby taking steps towards fulfilling the WFD and the Council's responsibilities as Lead Local Flood Authority for ordinary watercourses since the introduction of the Flood and Water Management Act (2010).

OUTFALL SAFARI: A WAY OF WORKING WITH VOLUNTEERS TO MAP AND RECORD THE IMPACT OF POLLUTED SURFACE WATER OUTFALLS IN A RIVER

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Background: Citizen Crane water quality data indicates that phosphate and particularly ammonia, derived in significant part from surface water outfalls, are found at concentrations in the river that are damaging to its ecology. Misconnected domestic waste water pipework and potentially cross connected sewers, feeding into the surface water drainage system, is considered to be a key source of the chronic pollution load. Once in the surface water system, the pollution enters rivers via surface water outfalls. Assessments of various databases by the Crane Valley Partnership (CVP) in 2014 identified 154 outfalls in the catchment. In 2015 Thames Water started a clean-up of 64 of these surface water outfalls as part of their regional Surface Water Outfall Programme (SWOP) due for completion in 2020.

The Outfall Safari was devised by the Citizen Crane steering group following the Citizen Crane Outfall Monitoring Feasibility Study, conducted between May and August 2015. The aims of the OS are to:

- Record and map the dry weather condition behavior of surface water outfalls across the Crane Catchment
- Develop a low cost method that can be used periodically in the catchment to inform ongoing catchment management decisions. In particular to help identify (and potentially prioritize) outfalls for inclusion in the AMP 7 Thames Water SWOP, due to start in 2020
- Further engage the existing Citizen Crane network and recruit more volunteers in the delivery of the Catchment Management Plan.

Method: The presentation will include a description of the survey method and the app developed for data collection from the river. The app was created using Epicollect which is open source and available to all. Once a project is set up in Epicollect it provides an App for remote data collection and upload, usable on GPS enabled smart phones, and a web portal to access and download the data. The outfall assessment form created in the App for volunteers to fill in at each outfall consisted of 8 questions. The questions were duplicated from the form that Thames Water use for assessing the impact of outfalls.

In order to allow prioritisation of the outfalls, the Environment Agency (EA) provided a method of converting the assessment data to a numeric impact score for each outfall.

Results and Conclusion: Both Thames Water and the EA are currently using the data from the Outfall Safari to tackle pollution in the Crane Catchment and to help prioritize work on the remediation of surface water outfalls. The presentation will conclude with lessons learnt from the first Outfall Safari and news of how ZSL plan to work in partnership with the Catchment Partnerships in London (CPiL) to gather data on polluting surface water outfalls across the Thames region.

MULTIFUNCTIONAL BENEFITS OF URBAN RESTORATION – STANMORE MARSH

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London Borough of Harrow Infrastructure Team, in their role as Lead Flood Local Authority, identified Stanmore Marsh as a location where there was an opportunity to develop a scheme that could meet the s.106 and local plan requirements whilst additionally improving the amenity and social value of the park while incorporating environmental improvements through the restoration of Edgware Brook and accompanying wetlands. Following earlier work by other consultancies, Atkins was commissioned to take early concepts into detailed design followed by construction supervision. A multidisciplinary team was used in the design process including experts in fluvial geomorphology, aquatic ecology, landscape architecture, contaminated land, flood risk modelling and civil engineering. Thames 21 was separately commissioned to undertake the community engagement for the project. The marsh was split into two sections, the northern and southern marsh.

In the northern section, prior to the scheme the area was largely an open grassland area with a small natural ephemeral marsh which was heavily shaded. Work concentrated on improving recreational amenity value with a new children's play area, a rain garden and access paths being created. In addition, a new SuDs scheme linked into a small tributary that crossed into the Southern Marsh. The trees around the marsh were thinned to provide more light into the wetland area to encourage vegetation growth.

In the Southern Marsh, Edgware Brook had been historically modified. Initially, Edgware Brook opened up from a culvert into a straightened channel with concrete bed and banks flowing over a gas pipeline. To address this modification, a new channel was cut with natural banks and bed with only localised protection installed over the gas pipeline. Further downstream, the channel was previously protected by timber revetment along both banks and was relatively shaded. The revetment was removed along the right bank and the bank battered back while on the left bank the revetment was removed and replaced with Flex MSE (green bank geotextile) to protect an electricity cable. The small tributary was moved across to join the channel at the end of the cable to form a natural wet boundary to discourage public access to the lower part of the park.

In the lowest section of the park the channel ran along the boundary and was previously lined with timber revetment. The brook was moved and restored into the centre of the park with new wetland areas being created. In total, around 200m of channel was restored in this highly urbanised area. This was part of much wider improvements to the park benefiting both the community and habitat. The whole project was managed using a catchment and partnership based approach so that the community, habitat and education benefits could be realised in the longer term.

THE RIVER ALT RESTORATION PROJECT – A CATALYST FOR CHANGE

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Against a backdrop of cuts to Local Authority funding, challenging delivery of non-statutory services, and city wide campaigns to save local greenspaces, at risk of development, The River Alt Restoration Project posed social, political and technical challenges. The case study centres on the reclamation of 8.2 ha of brownfield land, the diversion of c900m of the River Alt, from culvert, and the creation of a new section of river, mosaic of habitats and publically accessible greenspace. The £1.7m project was funded by DEFRA's Catchment Restoration Fund, via the Environment Agency, and Liverpool City Council. Whilst the River Alt Restoration Project aims focussed improving biodiversity and contributing towards the River Alt achieving 'Good Ecological Potential', the scope for delivering multiple benefits, within a deprived urban setting, were also clear from the outset.

This presentation sets the scene in terms of the projects economic and environmental drivers, the importance of genuine collaboration, technical challenges and beneficial outcomes providing a catalyst for positive change. The Cass Foundation worked closely with the University of Liverpool to model the **fluvial geomorphology** of the new reach, incorporating gradient and level changes and assessment of potential flood risk to inform the channel design. The University, together with Ecological Restoration Consultants, also examined the diversity and impact of in-channel and riparian vegetation, sediment composition and dynamics of the new channel and assessed the morphological diversity.

The project aimed to create diverse riparian habitats to enhance the **biodiversity** of fauna and flora. Within two growing seasons, biodiverse natural habitats have developed in the riparian zone including floodplain ledges and aquatic margins colonised by emergent plants, typical of river margins and tall herb communities and characteristic of wet meadows and ditches. Species, introduced in pre-planted coir rolls/pallets, have established rapidly and natural colonisation, by species of submerged and emergent flora plus abundant fauna, have been observed

A brief overview of The Mersey Forest's assessment of **green infrastructure,** pre and post construction, considers the presence and distribution of different GI types, twenty eight GI functions, an assessment of GI need and an economic valuation aimed at quantifying the benefits of GI.

Since the transformation of the River Alt, in Croxteth, there has a catalytic impact on local **regeneration and investment** with > £26mil of development within the strategic Mayoral Development Zone; an area where development had been static for almost a decade. Lastly, the project brought together a broad range of the community through regular conversation and activity that led to the Friends of Croxteth Greenspaces being established. By effectively resourcing **community engagement** there is a lasting legacy and a sense of pride and ownership of new greenspace that the community named 'Alt Meadows'.

Hall 4: Natural Flood Management

LETTING NATURE INNOVATE – CAN NATURAL PROCESSES MANAGE FLOOD RISK?

L. BURGESS-GAMBLE[1], S. ROSE[2], S. MASLEN[2] & R. NGAI[2]

1 Environment Agency, 2 JBA Consulting

Additional Authors

M. WILKINSON[3], M. ROSS[1], P. QUINN[4], M. WHITLING[1], R. HARVEY[2], K. KIPLING[1], T. NISBET[5], B. HANKIN[2], K. BEVEN[6] & M. HEMSWORTH[2]

3 James Hutton Institute, 4 Newcastle University, 5 Forest Research and 6 Lancaster University

A working with Natural Processes (WWNP) approach to reduce flood risk involves taking action to manage fluvial and coastal flood and coastal erosion risk by protecting, restoring and emulating the natural regulating functions of catchments and coasts. Interest in this greener approach to engineering has soared in recent years following a spate of significant flooding events across the UK. If properly assessed, planned, and executed, this approach can help to reduce the risk of flooding to people, property, businesses and infrastructure. It could also increase the resilience of traditional hard engineering flood defences to projected climate change effects and generate multiple other benefits for the environment and society.

However, to date, the application of this innovative component of the flood risk management toolbox has yet to become fully mainstream. This lack of widespread acceptance is due to a number of reasons, including: definitive scientific evidence to support the implementation of the full spectrum of catchment and coastal WWNP measures is still being developed; the formal quantification of the ecosystems services being provided by these types of measures is still in its infancy, and the range of tools currently available to help interested parties to make strong business cases for funding these types of schemes is limited.

This presentation will showcase early outcomes from the new WWNP Evidence Directory being developed for the UK - a resource, derived from a comprehensive literature review, that will describe 'what we know' and 'what we don't know' about the effectiveness of different WWNP measures and include the provision of detailed case studies that describe the practical implementation of these measures across a range of catchment and coastal situations. We will also discuss the development of a new national WWNP mapping toolbox for England and Wales, which is designed to help practitioners identify key locations within a catchment where the implementation of WWNP measures could be most effective.

The WWNP Evidence Directory and mapping toolbox therefore aim to provide practitioners with a guide to developing scientifically, economically and socially viable WWNP-based schemes, or more traditional flood defence schemes that incorporate appropriate WWNP elements. Hopefully, they will also aid the justification of future schemes of this type that fully embrace the principles of integrated catchment or coastal management and the partnership approach.

UPLAND DRAINAGE NETWORK EXTENSION: A PRIME TARGET FOR NFRM?

N. S. ENTWISTLE[1] & G. L. HERITAGE[2]

1 University of Salford, 2 AECOM

Additional Author

S. BENTLEY[3]

3 AECOM

Gripping has long been an area for debate regarding its impact on catchment hydrology. Less attention has been focussed on the headward extension of the primary streams which also act to increase the drainage density and efficiency in upland areas. It is suggested here that historic alterations to the land use and hydrology in the upper catchments of many UK watercourses is altering flood response and may be exacerbating the severity of downstream flooding. This study compares historic first epoch (1880-1890) Ordnance Survey mapping with the current mapped river network of several upland catchments in the north of England including, the Greta, Trawden Beck and the upper Eden tributaries. Channel extension was seen to be widespread with new headwater streams extending up to several hundred metres into areas previously exhibiting no overland drainage. The causes for this dramatic channel extension may have been physical channel creation or headcut erosion and piping triggered by other activities within the catchment, evidence of which can still be seen in the study catchments today. Coarse empirical relationships exist between drainage density and flow measures such as mean annual discharge and the impact of altered drainage density is shown to be significant on flood generation. Similarly HecHMS simulation of altered hydrological processes also suggests an increase in peak discharge and a more intensely peaked hydrograph for the current watercourses compared to their historic state. Given the link between increased drainage and flood discharge and the general severity of modification revealed by the study, it is suggested that reducing this upland network to something approaching more natural densities is a priority and that Natural Flood Risk Management measures should be strongly targeted towards this over smaller more scattered measures which may not be effective during large floods.

MODELLING, MAPPING AND ENGAGING WITH NFM IN CUMBRIA

B. G. HANKIN[1] & D. JOHNSON[2]

1 JBA, 2 Rivers Trust

Additional Authors

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3 Lancaster Environment Centre

This paper brings together advances in modelling and mapping opportunities for better working with natural processes in three Cumbrian catchments that were impacted terribly in the winter of 2015. The paper will seek to put in context the relative contribution that can be made through Natural Flood Risk Management, alongside a suite of flood risk management measures to reduce the risk in these badly impacted catchments.

Taking a whole catchment approach, with a fully distributed 2d overland flow model plus ReFH losses model, we look at the relative difference in hydrograph peaks and timing with and without measures at different locations and sub-catchments around the Derwent, Eden and Kent catchments. Use of GPU enhanced processing, means that we are now able to model 500km^2 catchments at 2m resolution. Opportunities for distributed storage are initially taken from new techniques for data mining the updated surface water flood map, and from the locations identified as opportunities from the 'woodlands for water' dataset. These features are enhanced with local knowledge and the Cumbrian Flood Plan, plus research on potential for peat restoration in parts of the catchment. Features are modelled using evidence of how mitigations map onto the parameter space, such as increased roughness for tree-planting. Results are then demonstrated using a set of interactive PDFs, allowing catchment users to appreciate the location of the opportunities at the small scale, but also the relative benefits at the sub catchment scale.

Following catchment engagement workshops facilitated by the Rivers Trust, these opportunities are modified using local knowledge as constraints, given for example land ownership issues. The consultation results in the distributed opportunities being modified and re-modelled to reflect catchment knowledge, and the realistic benefits then being re-computed. The re-modelling includes outputs from a new Dynamic Topmodel with Routing (DTMR) developed at LEC, that has been specifically adapted to model NFRM features.

DTMR has been used to quantify potential risk reduction in the Brompton catchment, and the proposed NFM instream barriers have now been implemented at a few locations. We will be extending the analysis for 100km2 sub-catchments of the Kent, Eden and Derwent, modelling measures that include tree planting, distributed storage and soil structure improvement.

The outputs for this study will be supplemented with the additional probabilistic modelling of extreme events in the Eden catchment simulated as part of JBA's entry to the Defra competition. This includes the results of whole catchment modelling of the 'Desmond plus' Met Office event. To build in resilience, we argue that modelling multiple events, and complex double peaked events is a more reliable measure of performance than modelling the typical single peaked design event. This is especially the case where we have multiple distributed small runoff attenuation features.

LOCAL AUTHORITIES WORKING WITH COMMUNITIES AND LANDOWNERS TO RESTORE STREAMS AND REDUCE FLOOD RISK USING NATURAL FLOOD MANAGEMENT

C. UTTLEY[1]

1 Stroud District Council

Stroud District Council is working with communities and landowners to implement natural flood management and restore Cotswold streams and rivers for people and wildlife in the Stroud Valleys. I will discuss the potential role of local authorities in delivering NFM and in particular, how they are uniquely

placed to work in the right locations (Ordinary water courses), involve the right people (local communities, landowners and local contractors) and gain local political support to ensure projects move from theory to implementation on a large enough scale to make a difference. In an evolving political and economic landscape, local authorities offer new opportunities and ways of working to restore streams and watercourses.

Communities in rural areas are much more likely to fail to achieve the cost/benefit ratios needed to unlock FRM capital funding, meaning that community lead natural flood management is frequently the only viable option available. Local authorities are well placed to guide and help communities achieve good schemes that link with wider ecosystem restoration objectives.

Local authorities have responsibility for consenting and enforcement of drainage and flood risk management on most ordinary water courses. Ordinary water courses tend to include smaller streams and tributaries, which I propose are best suited to natural flood management interventions due to lower risk, lower costs and greater ability to influence flood peak generation and movement downstream. Catchment based river restoration should also start as far upstream as possible, since this is often where problems such as diffuse pollution, physical alteration and incision start.

Natural flood management often requires interventions to restore natural functioning so involves many similar measures undertaken to restore water courses to pre-impact states. Adding substantial amounts of woody material, (trunks, branches and brash), is an essential part of restoring natural functioning to streams, but can also reduce flood peak generation. Restoration projects that have flood risk benefits built in from the start are much more likely to gain political and community support, particularly if undertaken as part of a wider programme of flood risk management.

Our experience in Stroud demonstrates that community and local authority lead projects can achieve wide implementation of NFM, working directly with partners, local contractors and landowners to deliver projects that focus on a range of objectives at the right scale to make a local difference. We have built over 220 interventions within two years and have a growing list of landowners and partners willing to help out. Our projects include those aimed primarily at reducing flood risk by attenuating peak flows and reducing nutrient and sediment inputs, at habitat enhancements for fish and White Clawed Crayfish and restoration of natural drainage processes.

Day 2: Wednesday 5th April

Session 5: Workshops

Oxford Suite: Workshop A:- How to implement adaptive management effectively

DURLEIGH RESERVOIR ADAPTIVE MANAGEMENT TRIAL

C. TATTERSALL[1] & A. HOUSE[1]

1 Wessex Water

Durleigh Reservoir is a hypereutrophic reservoir near Bridgwater in Somerset. Under the Water Framework Directive (WFD), Durleigh Reservoir and the downstream Durleigh Brook are Heavily Modified Water Bodies (HMWB). The WFD requires that HWMBs are at 'good ecological potential' (GEP), defined as the best ecological condition feasible whilst maintaining their intended use. If a HMWB is not at GEP, mitigation measures should be implemented to help the water body achieve GEP.

Between 2010 and 2015 Wessex Water investigated the impact of impoundment at Durleigh Reservoir on the WFD status of the brook. Macroinvertebrate indices indicated a significant impact of the impoundment on flow, silt and water quality. The macroinvertebrate biomass immediately downstream was also found to be higher than at upstream and downstream monitoring sites and dominated by detritivores and predators. This imbalance in the macroinvertebrate community appeared to be linked to the rapid settlement of phytoplankton present in the compensation flow in the downstream watercourse. The investigation concluded that the brook was not at GEP and that mitigation measures were needed.

Wessex Water is undertaking Adaptive Management Trials at Durleigh, introducing spate flows to simulate summer rain storms and flush sediment from the brook. Spate flow releases used the reservoir scour valve during summer 2015 as the compensation valve could not provide sufficient volume. Thirteen monitoring sites were established over a 1.5 km reach downstream of the reservoir. At each site, sediment bed load using a stilling well approach and flow velocity were measured pre and post spate. Water quality was monitored at the sites furthest upstream and downstream. The spate flow increased turbidity and reduced levels of soft sediment on the stream bed by remobilising settled sediment however, interpretation of the results was complicated by additional sediment released through the scour valve.

In summer 2016 less turbid water from the Bridgwater and Taunton Canal was used in the spate trial and monitoring extended over the entire 3km reach from reservoir to the tidal River Parrett. This allowed a clearer understanding of how much sediment was remobilised and the velocity required to achieve this. In the most recent trial, sediment was remobilised from the WFD monitoring site around 100m downstream of the reservoir. However, vegetation growing in the lower half of the brook restricted this effect to the upper reaches, preventing the sediment reaching the River Parrett.

It is hoped that the spate flows will decrease macroinvertebrate biomass, particularly the number of detritivores and predators causing the low indices, and shift the community closer to that observed at a site upstream of the reservoir. The investigation will inform whether Adaptive Management can be used to drive improvements in the WFD status of watercourses downstream of this impounding reservoir.

GEOMORPHIC CHANGE DETECTION: CONSTRAINING UNCERTAINTY IN RESTORATION MONITORING

R.D. WILLIAMS[1]

1 School of Geographical and Earth Sciences, University of Glasgow

River restoration schemes are typically sensitive to morphological adjustment during the first set of high-flow events that they are subjected to. Quantifying elevation change associated with morphological adjustment can contribute to improved adaptive decision making if interventions are necessary to ensure scheme objectives are achieved. This presentation provides an overview of the different survey data that can be used to map restoration scheme topography, the approaches that can be used to constrain uncertainty when mapping geomorphic change, and how different temporal frequencies of analysis can yield different insights into morphological dynamism. These themes are illustrated using data from six topographic surveys of the Whit Beck restoration scheme, Cumbria, which were acquired between August 2013 and September 2016, using a variety of geomatics technologies. Maps of geomorphic change quantify adjustment: (i) in the immediate aftermath of realignment; (ii) due to the 2015 flood event; and (iii) after in-channel works.

MANAGING SEDIMENTATION, INGENUITY DRIVEN BY CHALLENGES TO NAVIGATION

W. COULET[1] & W. MANNING[2]

1 Exo Environmental Ltd.

Estuaries are the complex interface of terrestrial, freshwater and marine environments. In Essex and the surrounding waters of East Anglia and the Thames, there is a rich cultural and traditional link to the usage of these estuaries as historic waterways. However, as a result of many complex factors such as geology and changes in land usage, the safe operation and navigation of these areas is under threat from erosion and sedimentation processes.

The presentation on "managing sedimentation, ingenuity driven by challenges to navigation" by Exo Environmental, aims to discuss how employing an adaptive management approach to dredging projects, supported by predictive modelling and a balanced monitoring survey programme, allows the project to be more robust to uncertainty and minimise the economic and environmental impact of dredging activity within complex environments, where processes are not fully understood.

The successful completion of a project involving the dredging of approximately 11,000m3 of accumulated sediment from within a marina within the River Colne estuary, Essex, will be used as a case study. In this project, the arising dredged material was to be dispersed, whereby the controlled release of sediment into the water column utilises the natural water movement to transport and disperse the sediment throughout the system. Whilst there are many benefits to this method, a detailed understanding of the hydro- and geomorphological dynamics of the system is critical to minimise environmental impact.

This presentation will highlight the importance and process of collecting baseline data and describe how this data was utilised to create a hydrodynamic and morphodynamic 2D model. The model design and how the results of the predictive model resulted in the optimisation of the project will be discussed. It will then address the concept of adaptive management in dredging works and explain how the combined use of predictive modeling and monitoring surveys during the execution of the works, can be used to provide feedback information on the activities impact and corroborate the models predictive accuracy and areas for refinement. The presentation will conclude with an analysis of the model accuracy and how the successful prediction of the sediment dispersal resulted in the successful completion of the project.

The conclusions and key messages of the presentation are:

- Adaptive management provides a good framework for dredging activities within complex environments by facilitating flexible decision making.

- The use of predictive modelling and balanced monitoring survey programmes can allow significant optimisations within dredging projects, resulting in economic and environmental benefits.
- The dredging and dispersal of 11,000m^3 of accumulated sediment from a marina within the River Colne estuary, Essex provides a successful case study for this approach and allowed an accurate prediction and successful management of the project.

SILT CONTROL: APPLICATION OF WATER LYNX

R. HAINE[1] & L. O'DEA[2]

1 frog environmental

Sediment is the main pollutant generated on construction sites and arises from the erosion of exposed soils and pumping excavations. Traditional interventions such as settlement ponds do not have a capability of removing fine silt and clay particles, however the addition of Water Lynx can significantly improve their efficacy.

Water Lynx is an environmentally safe flocculant. It enables the smallest of silt particles to stick together so that they can be more easily captured to prevent their release into the environment, completing the treatment process and protecting downstream receptors. The removal of sediments supports water quality improvement as nutrients and heavy metals are attached fine silts and mobilised in the river system.

Water Lynx is formulated to perform across a broad range of environmental conditions. Application is varied and several techniques have been developed that enable the flocculants to be used directly in streams or applied with a mixing device.

Direct application of solid blocks within ditches and streams supports the entrapment and collection of material on treated natural fibre products such as geo jute fabric or floc mats as well as enhancing the function of settlement ponds. The use of treated silt net to distribute flow and increase sedimentation in settlement ponds has also been shown to be effective.

Pipe Reactor is a mobile water treatment system that can connect into any 3" or 2" pump hose, ideal for dewatering excavations. At less than 8' long and 10" in diameter the pipe reactor is capable of treating up to 560 litres of contaminated water per minute, consistently reducing total suspended solids from 880mg/l to 9mg/l following polishing over natural fibres.

Silt mats previously considered to be applied in river systems to support sediment capture have been redesigned and field tests show that their optimal performance is not the capture of fine particles but the prevention of their resuspension during storm water or high flow events. This makes them a superb device to use in combination with flocculants or in a storm water scenario where previously captured sediments must be retained.

BUBBLE CURTAINS: A SILT CONTROL SOLUTION

L. O'DEA[1] & D. PENNY[2]

1 frog environmental, 2 Natural Resources Wales

Sediment released through essential flood maintenance and restoration activities on rivers may have a number of deleterious water quality and habitat effects. Controlling silt suspended during in channel operations in often deep, high flow velocity environments where conventional physical structures to slow the flow aren't appropriate is challenging.

Bubble Tubing®, a micro bubble linear diffuser was deployed on the River Rhymney at Ystrad Mynach to create a curtain of sub-surface air bubbles. Two lines of 1/2" self-sinking Bubble Tubing were positioned downstream of the work activities in an area of natural deposition with a depth of 1m. The intention is that the air barrier would reduce silt transfer downstream and encourage sedimentation

The installation was quick and easy, with no moving parts the flexible self-sinking lines lay flat on the bed and the lines were positioned approximately 20cm apart from each other. Air was introduced via feeder lines from a compressor unit situated on the bank.

There was an observed reduction in turbidity even in the faster flow velocities of 0.4m/s and high dissolved oxygen levels were maintained. In the channel profile where flow velocities were less than 0.2m/s there was a greater effect and the bubble curtain also held back floating debris.

Whilst the fine silt and clay was not removed from suspension and passed the bubble curtain unhindered there were a number of ancillary benefits to the Bubble Tubing® deployment including a reduction in the transfer of noise and vibration as the bubbles absorb and refract sound and providing aeration at a time when dissolved oxygen may be inhibited to maintain both a healthy microbial system that supports a balanced ecosystem following disturbance and protecting the fishery.

Further trials on Natural Resources Wales operational sites in partnership with frog environmental are planned for winter 2016/17 to determine the optimal air pressure, tubing dimensions, position and number of lines in a variety of flow velocities and depths.

Hall 4: Workshop C – Green measures in river engineering

HOW TO SELECT GREEN MEASURES TO PROTECT RIVERS FROM EROSION?

M. ROCA[1] & J. SIMM[1]

1 HR Wallingford

Additional Author

M. ESCARAMEIA[1]

Green river engineering approaches are fundamental to improve the quality, morphology and ecology of our waterbodies and as part of an overall strategy to help people and communities adapt to the negative effects of climate change. There are however, procedural and technical barriers which prevent and obstruct the implementation of green solutions as part of river engineering protection schemes. Frequently, these types of solution are perceived as having higher risk of failure than grey (or hard) engineering solutions and as being insufficiently supported by design and maintenance guidance and procedures or by evidence-based approaches.

A NERC research funded project was developed last year with the objective to support asset managers, decision-makers, engineers and other end-users to identify the critical success factors that will permit the selection and application of green options for engineering protection in the fluvial environment. The project focused on measures to stabilize the river banks protecting both the bank and the toe (considering measures such as turf and coir mattings, root wads and willow spilling) and to modify the river shape by changing the longitudinal profile (e.g. restoring meanders), the cross-section (e.g. regrading banks or removing embankments) or the in-stream structures (e.g. removing weirs).

The project developed a decision support framework for selection and application of green approaches to fluvial flood defence and erosion risk management in rivers. The purpose of the framework is to enable evidence-based decisions to be made to support the selection of green approaches and enhance the value of river schemes through a range of environmental, social and economic benefits.

Information on case studies was also compiled across England and Wales to provide sound evidence for the different aspects that need to be considered in the decision stages, such as constructability and maintenance requirements. The case studies provide examples of what went well (or not) and why, and support the better understanding of the performance of the measures.

The information generated by the project, which includes the decision support framework and the case study factsheets, is made freely available on different platforms.

ENGINEERING RIVER NATURALISATION FOR THE BRENT CROSS CRICKLEWOOD URBAN REGENERATION: CHALLENGES AND GEOMORPHOLOGICAL SOLUTIONS

N.D. WILLIAMS[1]

1 AECOM

This presentation will describe a case study of some of the challenges of designing and building a river diversion for a major development scheme in a heavily engineered environment. Challenges include delivering naturalisation, amenity and Water Framework Directive objectives, whilst sustaining waterbody uses by managing flood risks, scour, slope stability, and major commercial drivers.

AECOM is responsible for all aspects of river engineering of a 900m river diversion and naturalisation as part of the >150 ha, £4bn Brent Cross regeneration project to create a new town centre for North London. The site masterplan includes improvement of a heavily modified river that flows through the site, presently as a concrete drainage channel.

Site pressures make the waterbody very constrained, and effectively mean that an historic floodplain river needs to be fully contained within a narrow corridor. A particular challenge is to reinstate pre-urbanisation habitats that would thrive under 'normal' flow conditions, whilst also making the new substrate channel resilient to peak flow and scour events that are concentrated within the river corridor instead of being dissipated across a floodplain.

We are using a geomorphological design, with civil engineering, geotechnical, flood management and ecological techniques. These include detailed analysis of channel sustainability, environmental flow hydraulics, scour, sediment transport, bank / slope stability and planform stability, across a full range of flow conditions. This is to engineer a resilient and sustainable river, that fully integrates Water Framework Directive ecology and biodiversity objectives with landscape architecture and 'soft' and 'hard' engineering.

The presentation will summarise our approach of using geomorphology to design the river, the existing river modifications and degradation, pre-modification river design targets, and our numerical approach to engineering a sustainable, Good Ecological Potential channel within a range of challenging site constraints.

Session 6: Parallel Sessions

Oxford Suite: Use of Trees/Wood

TREES, ROOTS AND HOW WE CAN USE THEM

J. V. HOLLOWAY[1] & A. M. GURNELL[1]

1 Queen Mary University of London

Perhaps the most cost-effective and sustainable restoration measure, where space allows, is to encourage the re-establishment of natural riparian tree cover. River specialists such as willows and poplars have evolved not only to thrive in ever-changing river corridors, but to become ecosystem engineers, actively generating and maintaining the full complement of physical habitats upon which different stages of their life cycles depend. Far beyond simply 'slowing the flow' in floods, riparian woodlands are an integral part of hydromorphological dynamics and key drivers of diversity.

By intervening to establish the appropriate species and patchy age structure seen in in-tact systems, we may be able to jump start the rewilding of river corridors. At smaller scales, we could use trees to design erosion control solutions which mimic and harness the sediment stabilisation afforded by the roots of natural bank-top forest, or to design more realistic in-stream wood flow disturbance structures. For such approaches to succeed and become mainstream, however, deep knowledge is required of the specific mechanisms by which trees engineer river form 'in the wild'.

After providing a very brief practitioner-focused 'digest' of current research directions in the field, highlighting their restoration implications, this presentation explores a hitherto neglected part of the story: *underground* riparian wood. Original research is presented which identifies some of the key predictors of root distributions in riverbanks, and reveals the massive, complex buried structures which develop when resilient, re-sprouting trees are subjected to the punishing forces of floodwaters. The extreme variability uncovered in root profiles within just one species on one river system illustrates the dangers of assuming simple root depth distributions when assessing bank erosion potential. However, the influence of site moisture availability and sediment properties on root proliferation is pervasive, and patterns emerge. As for the large and often elaborate buried stem and coarse root structures, these forms typically record a history of several floods, including the tree's local context at the time, demonstrating the means by which they regenerate and just how capable they are of 'clinging on'. 3D modelling allows us to look into the details of the processes leading to the development of these features. Furthermore, the persistence of such debris- and sediment-trapping structures has far reaching implications for overall morphological trajectories of active rivers.

This presentation will be of interest both to those working on rivers at the whole system level and those interested in the technical aspects of bioengineering and ecological↔hydro-morphological interactions. Irrespective of this, barely anyone has ever seen what lies beneath riparian trees, and the pictures speak for themselves!

MAKING USE OF DEAD WOOD

J. HUDDART[1] & G. WOODWARD[1]

1 Imperial College London

Additional Author

S. BROOKS[2]

2 Natural History Museum

The need for effective river restoration could not be more urgent, as rivers rank among the most ecologically impoverished systems globally, and thus, the scope for restoration is vast and river restoration has become a billion dollar industry, with interventions implemented at an exponential rate. However, robust biomonitoring continues to remain exceptional, with the majority of projects rarely assessed beyond qualitative reviews. Habitat restorations are among the most common interventions, underpinned by the "Field of Dreams Hypothesis" in which biodiversity responds positively to restored habitats. However, studies using robust biomonitoring methodologies have reported mixed results, meaning the scientific evidence base to support the underlying habitat heterogeneity - biodiversity tenet, remains equivocal at best. Only via rigorously monitoring river restoration techniques using multiple-before-after-control-impact (MBACI) designs can we disentangle responses to restoration from wider environmental noise.

Large woody debris (LWD) is a widespread habitat restoration measure, with studies supporting its effectiveness for improving fish stocks and macroinvertebrate abundances, however our understanding of the mechanisms and processes by which LWD operates to increase biodiversity remains limited. Working with local stakeholders, a local angling association and landowners, we designed and implemented 4 x100m LWD installations along the River Great Stour in Kent. We used standardised and quantitative methods to monitor the fish, invertebrates and diatoms and standing stock of algae over a 3-year period. This allowed us to compare changes to community structure (abundance and average body size for species) in the more traditional bioindicator groups (fish and invertebrates), i.e. abundance, diversity and mass, typical metrics used to assess river restoration success. Additionally, by monitoring the major biotic components of the river system we are able to construct food webs to see how LWD habitat influences trophic interactions. This approach has been used to provide insight into how environmental factors such as nutrient enrichment and temperature influence community structure in other studies but its use in restoration has been limited. However, this has provided mechanistic insight into the role of habitat in influencing stream food webs, how changes in species abundances and biomass are facilitated and maintained, as well as revealing potential bottlenecks for biodiversity recovery. Our results show an increase in abundance of piscivorous species (perch and pike), indicating an increase in resource availability (i.e. production of smaller fish species), as a result of the LWD interventions.

Restoration science is still rudimentary in terms of understanding, with highly variable outcomes in terms of expected and realised biotic responses. In order to improve the likelihood of successful ecological restoration, there presently is a clear need to understand the methodological,

environmental and biological factors that influence restoration outcomes. This will only be achieved by using highly resolved, standardised and quantitative monitoring, to test restoration techniques.

YSTRAD MYNACH: TREE REVETMENT

D. PENNY[1]

1 Natural Resources Wales

Natural Resources Wales' purpose is to pursue sustainable management of natural resources in all of its work, including the undertaking of its Flood Risk Management duties. This paper provides an example of some essential maintenance work undertaken on a flood risk asset employing these values using alternative innovative solutions and 'green engineering' techniques.

NRW recently completed de-shoaling and essential maintenance of the flood bank on the River Rhymney at Ystrad Mynach as part of its Capital works programme. Approximately 900-ton of shoal material had accumulated, funnelling flows down a narrow, deep channel parallel to the west bank, a flood defence structure. This was having a detrimental effect on the bank, eroding soils and exposing root systems, creating an unstable vertical profile.

It was identified at an early stage that sediment management would be required to minimise the impact of works on downstream receptors. The shoal was removed using a 'Dry Shoal' technique, diverting water around the shoal to enable the excavator to work in a dry environment, minimising the mobilisation of silt. Silt mats were deployed in shallow channels across the shoal to interrupt the water being released and capture sediments. Natural silt wattles made from a source of untreated recycled wood chip used to slow the flow and Bubble Tubing®, a fine bubble linear diffuser were trialled with Frog Environmental. The curtain of air bubbles helps to manage silt by facilitating sedimentation. This technique also has a number of other benefits; it is proven to be an acoustic barrier, absorbing and refracting sound waves in the water and; it provides aeration, oxygenating the water to protect fish and support healthy microbial life, important in returning the ecosystem balance following disturbance.

To improve access and the health of the river, large riverside trees were felled. These tree trunks were used to create a natural timber revetment, protecting the flood bank and deflecting and refracting energy of the river to prevent further erosion. This also helped stabilise and nurture the existing trees, protecting their root system and hopefully extending their longevity. Shoal material from within the river was used as fill, with care taken around tree roots to avoid root compaction. Bank re-profiling, redistribution of topsoil and placement of V-max erosion matting established the final ground levels. Increased natural light onto the bank resulting from the tree felling will also encourage native shade tolerant grass and wildflower mix, helping to bind the soil and reduce future erosion from rain and flood events.

A geomorphologic survey is planned to identify the ideal position to create a groyne in order to deflect flow and create equilibrium through the bridge piers. Hopefully this will prevent shoal from accumulating and reduce future costs in removal work and most importantly be beneficial to the ecosystem of the river.

COULD BEAVERS HAVE A ROLE IN RIVER RESTORATION?

M. GAYWOOD[1] & A. TREE[1]

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The European or Eurasian beaver *Castor fiber* is a large, semi-aquatic rodent that is believed to have died-out in Britain about three centuries ago. It inhibits broadleaved riparian woodland or scrub bordering standing fresh waters or slow-moving streams or rivers. It occurs from Western Europe eastwards to the Chinese-Mongolian border region. Work has been underway in Scotland, and more recently in England, to study the desirability of reintroducing the species. It is frequently claimed that beavers can have a significant influence on ecosystem function and health.

In June 2015, Scottish Natural Heritage (SNH) reported to the Scottish Government on the issues surrounding beavers. This report ('Beavers in Scotland', see www.snh.gov.uk/beavers-in-scotland) was used to inform a decision on the future of beavers in Scotland, including wild-living populations that already occur in Argyll and Tayside.

The report included assessments of:

- Beaver interactions with the natural environment
- Beaver interactions with the human environment
- Legal and management issues
- A range of possible future scenarios for beavers in Scotland

Subsequently, the Scottish Government made the decision to retain beavers in Scotland. As a result, a new agent of river restoration, and wider environmental benefits, has officially arrived. However, beavers also present a range of management challenges with associated costs.

We therefore summarise our experiences with beaver and beaver reintroduction issues gained over 20 years in Scotland, with a particular focus on their interaction and impacts on riverine features. Our work has been informed by a number of significant projects including a scientifically monitored trial reintroduction in Argyll, an examination of the implications of beaver presence on land use in the River Tay catchment, an examination of potential beaver interactions with salmonid fish, GIS-based studies of potential habitat availability and future population expansion, and extensive reviews of European and North American work on beavers.

The potential role of beavers in natural flood management and river restoration is frequently highlighted by some environmentalists as a significant benefit arising from their reintroduction. We present some of the evidence that supports this assumption. We also look at the evidence of negative impacts of beavers on a range of environmental features, particularly some land uses, and the types of management techniques available.

It seems clear that there is the potential for a range of environmental benefits, including river restoration, that may arise from beaver presence. However, there will also be complex management challenges in not only mitigating potential harmful effects, but also in trying to 'steer' potential benefits.

It seems timely to further engage river restoration specialists in considering the issues, opportunities and risks associated with beaver reintroduction and recolonisation in Britain.

Stamner: Floodplain Reconnection

ECOCO LIFE: "JOINING UP NATURE" IN THE GLAZERT WATER CATCHMENT

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The EcoCo Life+ project is about joining up nature across central Scotland, delivering improvements so that the freshwater habitats are 'bigger, better quality, and better connected'. In the Glazert Water pilot catchment, river restoration experts from Royal HaskoningDHV have been working with SEPA to apply these principles to develop options that will improve lateral connectivity between the river and the floodplain, mitigate barriers to fish and create the conditions for instream habitats to thrive.

A combination of detailed geomorphological surveys, landowner meetings and desk-based assessments have been undertaken to date to verify and develop solutions to river habitat fragmentation and degradation across the catchment. Through the Glazert Water case study, our presentation will discuss the mutual benefits of river restoration for biodiversity and ecological connectivity, alongside the more widely appreciated benefits for geomorphology and natural flood risk management.

The presentation will also discuss the importance of effective landowner engagement to remove objections and allow restoration work to go ahead. Different approaches to engagement will be discussed, and the techniques used to maintain open communication and obtain agreement for restoration works will be outlined. In particular, the importance of flexibility in the design process and the ability to compromise to reach a balance between delivery of river habitat and biodiversity improvements and natural flood management benefits without compromising agricultural productivity will be highlighted using real-world examples from the catchment.

BALANCING BENEFITS & DISBENEFITS OF RIVER NATURALISATION: A CASE STUDY FROM THE LAKE DISTRICT

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Restoration of rivers in the UK remains a largely conservative practice linked primarily to a lack of money, tight regulation and a risk-averse approach to design. As a result many schemes fail to achieve significant long term environmental gains with system functionality often remaining at levels similar to the pre-

restored system. The view that our rivers are largely static systems continues to pervade the restoration environment with the desire to minimise change expressed by regulators and practitioners alike, actions targeted at bank stabilisation are testament to this. Such an attitude probably stems from the 'successful' engineering and management of our watercourses over historic time that has created a perception of stability with rivers constrained by revetment and confined by flood banks and dredging. Such an attitude extends to the floodplain too with many remaining unconcerned over the widespread and severe loss of floodplain character and functionality along our rivers.

Great benefit in terms of restored river and floodplain functionality and an associated increase in ecological diversity can, however, be achieved by considering rivers as dynamic systems, restoring erosional and depositional processes and re-establishing severed river-floodplain hydrologic and hydraulic links. This ethos underpins the naturalisation of Swindale Beck in the English Lake District where the historically constrained watercourse has been realigned and reprofiled to create the planform and morphologic template encouraging active meandering across the upland SSSI floodplain. The project has been driven by the RSPB with project partners including United Utilities, Natural England and the Environment Agency. Plans to create an active meandering channel were initially received negatively with issues around the likely loss of SSSI hay meadow and the release of fine sediment into the watercourse downstream highlighted as major concerns. However, the recognition that the proposed naturalisation was in line with natural processes in the upper catchment and the understanding of fine sediment dynamics in similar upland watercourses elsewhere allowed the project to go ahead.

The early success of the works is clear at the site with the river quickly adopting the new course and morphology following a series of bankfull flow events. Erosion, deposition and sediment movement has been dramatic compared to the former watercourse but the basic morphology remains that of an active meandering system. Monitoring of the fine sediments downstream has shown an expected increased load but no significant change to the bed sediment character. The strong resolve of the RSPB and project partners in pushing the project forward and the courage and far sightedness of staff in Natural England and the Environment Agency who have balanced the positive project aspects against short term potentially negative effects downstream has resulted in dramatic early environmental gains and a similar ethos and attitude is encouraged for future opportunities across the UK.

IMPROVING HABITAT ALONG A SMALL HEADWATER STREAM

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Wiltshire's iconic chalk streams and associated habitats are home to a wide range of plant and animal species; however the quantity and quality of these habitats has decreased significantly as a result of agricultural intensification and urban expansion. On the edge of the village of Wroughton near Swindon, Wiltshire Wildlife Trust manages a nature reserve that is partially owned by the Trust and partially

leased from the Diocese of Bristol. The reserve is bisected by Markham Hill Stream – a small chalk stream that makes up part of the source of the river Ray in the Upper Thames catchment. In 2015 the opportunity arose to undertake a unique habitat restoration project funded by Swindon Borough Council, Tesco Community Grant and the local community.

Due to the location and ownership of the site, there was scope to achieve a variety of benefits for people and the environment. The river runs through an area that was historically native wet woodland; however past management and then a lack of management has led to the ecology changing significantly over time. A number of non-native trees, such as white Poplar (*Populus alba*) had been planted within the woodland and historic water control structures were failing.

In order to restore the wet habitat and associated ecology, a number of log jams were placed at appropriate points along the channel and side channels. At one section logs were used to line the channel to prevent cattle poaching. In addition, repairs were made to a water retaining structure that had a number of breaches and allowed the area behind to dry up and be overtaken by Field horsetail – *Arvicola arvense.* Downstream in Diocese Meadow, bank regrading was undertaken to reconnect the channel with its floodplain and restore floodplain meadow habitat. Skylighting (i.e. the removal of a large number of shade trees) also took place to encourage marginal and in-channel macrophyte growth.

The interventions and methods used within this project will provide an array of benefits for people and wildlife. The channel will be returned to a more natural, braided state. The woodland area will be restored to native wet woodland and the meadow re-wetted and turned back into floodplain meadow. All of which will allow for a greater diversity of plants and animals historically associated with these habitats. In addition to this, the slowing down of winter floodwaters and the increased retention upstream of the village of Wroughton will decrease flood risk to the village's residents and those further downstream where Markham Hill Stream reaches the River Ray in Swindon.

CHANGING MINDS ON THE RIVER TEST

H. LEMAN[1]

1 Environment Agency

The Test and Itchen River Restoration Strategy is a long term, joint project with the Environment Agency and Natural England to improve the status of the Test and Itchen SSSI. Working collaboratively with owners the goal is to improve the SSSI status from unfavourable to favourable condition. While historic dredging, industry, abstraction and numerous structures have all had a negative effect on the SSSI the presentation will start with the backdrop of over 100years of traditional management and the issues associated with it in today's ever changing environment. Showing examples of traditional management techniques and how these are now changing, the presentation will provide examples of the trials and tribulations of river restoration on a heavily managed system with multiple owners. While some are yet to be convinced, the project has to date completed 23 collaborative projects since 2012 for the benefit of the SSSI and hopefully provided appreciative anglers with a more naturally aesthetic fishing experience. The presentation will show before and after shots of various projects and some of the

‘problems’ associated with them and what we was learnt from them. With some local communities more and more under treat from flooding there is also pressure that river restoration provides ways of reducing this. With funding from the Environment Agency Flood and Coastal Risk Management function the Strategy always looks for ways that flood storage can be increased or flood risk reduced. The presentation will also show a couple of local examples were river restoration has benefitted local communities as well as the chalk stream environment.

Hall 4: Community & Partnership Work

WORKING IN PARTNERSHIP TO DELIVER MULTIPLE BENEFITS: INTEGRATED SUB-CATCHMENT MAPPING IN THE RIVER OUSE, SUSSEX

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The Ouse & Adur Rivers Trust and Sussex Flow Initiative have been working in partnership on the River Ouse in Sussex to combine landscape and river data across sub-catchments. This enables us to assess and recommend focal areas for river enhancements, flood mitigation, water quality improvements and land use adaptations in manageable sections. This provides ground-truthed information enabling us to focus current funding as well as develop projects for the future. This approach has been undertaken across 150km of the River Ouse catchment and has seen eight sub-catchment plans produced along with numerous landowner specific documents. This cost effective, simple exercise uses a simplified RHS methodology combined with GIS models to focus efforts and funding to achieve multiple benefits and a **"one**-visit**"** approach to landowners. Following the success of this approach, a local authority in the catchment has seen its value and is now funding continuation of this work to look at mitigation of flooding issues in their area whilst encouraging other local authorities to do the same.

Our method is simple consisting of walkover surveys and combining results with data accessible to all or easily created. We will talk through the method we are using and how it has been developed, show outputs and their relevance at a sub-catchment planning scale and provide information on our next steps.

PLANNING AND DELIVERY OF A MULTI-LANDOWNER RIVER RESTORATION PROJECT ON THE RIVER AVON IN WILTSHIRE

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The River Avon in Wiltshire has recently been identified as the most diverse and healthy chalk stream in England. Still, a significant number of the water bodies making up the catchment of the Hampshire Avon are failing to achieve WFD targets and the SAC/SSSI is not in a favourable condition. Historic, unsympathetic river management and maintenance practices (dredging, straightening) have resulted in parts in a bare, uniform and over-wide river channel that is in most places disconnected from its natural floodplain.

The Upper Avon in and around the village of Durrington was identified as in need of habitat improvement in the Hampshire Avon Restoration Strategy (2008). Along a stretch of 2.5 km, the river is lacking in-stream features, has unnatural high banks and along a 1 km stretch through the village a variety of hard revetments in different conditions is present. Several stands of Himalayan and Orange balsam were present, in some cases completely dominating the bankside vegetation.

In 2015, the Wessex Chalk Streams Project – a partnership between Wessex Water, local Environment Agency, Natural England, Wiltshire Fisheries Association, Wessex Chalk Streams & Rivers Trust and lead by Wiltshire Wildlife Trust – embarked on a project to improve the ecological quality of the River Avon in Durrington by reinstating natural morphological processes. The first year of the project was used to build and develop a relationship with the local community. More than 40 individual riparian owners, including the Ministry of Defence (the largest landowner) and private landowners were approached and individual meetings and site visits were undertaken. Several information evenings – involving the Town Council – were held as well as a guided walk to inform the wider community on the progress and to acquire as much local information as possible. A programme of balsam eradication was set up, and a number of balsam bashing tasks were carried out with members from the local community turning up to volunteer.

A draft improvement plan was set up and agreed with all stakeholders and landowners by June 2016. By that time approximately 75% of the landowners had given consent to carry out the works. A final design for phase 1 was submitted and a Bespoke Environmental Permit for Flood Risk Activities was granted.

The works of the first phase were carried out in October 2016. During this period several more landowners came forward and we are in the position to undertake the remaining river restoration works in 2017.

The project is funded by the Environment Agency as part of the River Avon Restoration Plan, with cash contributions from the riparian owners as well as donations resulting from fund-raising activities organised by the local community.

LETTING THE DOVE FLOW – RIVER RESTORATION IN A MUCH LOVED LANDSCAPE

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The River Dove in Dovedale runs through a unique landscape of high built and cultural heritage value. Dovedale has been loved by visitors and anglers for centuries and immortalised in the 1676 book “The Compleat Angler”1, claimed as the first environmental tourism destination beloved of romantic poets Byron and Tennyson and central to the UK’s first National Park.

The Dove is part of the Peak District National Park and a Site of Special Scientific Interest. It is highly modified with over 150 weirs in 10 kilometres of channel, and so requires an appropriate form of river restoration and rehabilitation. Unlike many SSSI rivers, Dovedale is highly publically accessible and receives around a million visitors per year 1. This presents a fantastic opportunity to engage the wider

public in rehabilitation of the river and to build the evidence base of the effect of river rehabilitation in such a modified river. It requires detailed consideration of the cultural and built heritage aspects, and crucially the emotional connection people have to the river.

The 'Letting the Dove Flow' restoration strategy (2015)[2] identifies and prioritises physical habitat restoration measures to help address key issues affecting the River Dove in Dovedale and Wolfscote Dale, based on a strategic assessment of the river. It is a long term plan, whose approach is to work with landowners and other interested parties to deliver gradual improvements, gathering information and carefully evaluating the work we do together.

The cultural and built heritage and landscape are a key consideration and have been integrated fully into the restoration plan and subsequent projects. We are working closely with archaeologists and historians to work out how the river may have looked before it was modified and looking in depth at all the structures. This has been captured in a recent cultural heritage report.

The high density of weirs and bank reinforcement on the Dove means we are dealing with a unique situation. Understanding how the river may react to change and monitoring what actually happens is a crucial aspect of Letting the Dove Flow. A monitoring strategy is being developed and implemented for the whole river SSSI, including continuous River Habitat Survey, cross section surveys, and a PhD looking at the sequencing of weir removal. After careful planning and with detailed consultation with those with responsibility for flooding, heritage and biodiversity, two weirs close to Lover's Leap in Dovedale were breached by Leek and District Fly Fishing Association in in July 2016. The resulting changes will be carefully monitored and written up as a case study to inform future projects.

COMMUNITY MAPPING OF THE LOST STREAMS OF LONDON

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1 Arup

Additional Authors

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In many UK towns and cities, watercourses and springs were historically culverted or have been completely "lost" into sewer and drainage systems. This can exacerbate local flood risk and damage aquatic ecosystems and catchments, increase the costs of wastewater treatment (Broadhead et al. 2013), and disconnect neighbourhoods from the socio-cultural heritage of watercourses that once flowed through them.

Arup was engaged by a Neighbourhood Forum, established under the Localism Act, to map the lost streams and natural springs of the Redington and Frognal neighbourhood in West Hampstead, London. We developed a way for the community to co-create and maintain a live online map, by combining local community-sourced knowledge collected by the Forum with a range of analyses undertaken by Arup. These desk-based analyses included topographic flowpath modelling, review of historical maps and records, and a review of hydrogeology to indicate the location of springlines. Local knowledge, such as

discovery of culverted watercourses beneath properties or boggy patches in gardens by residents, was reviewed and mapped, and often supported other lines of evidence.

The study identified that the neighbourhood was once home to the headwaters of London's most famous lost rivers: the Westbourne, Tyburn and Fleet. The study also demonstrated how the history of the area is intrinsically linked with the wells and springs that were exploited by Victorians for the perceived health benefits of the groundwater. While there are few visible clues to the public at street-level, the analysis indicates that the water is likely to still be flowing beneath the surface in pipes or sewers. The community map is now being used by the Neighbourhood Forum to raise awareness of the lost streams. It is also influencing neighbourhood planning policies that explore opportunities for river restoration through physical deculverting or through "cultural" daylighting, such as by marking the route of the lost watercourses to reconnect local people with water heritage.

Under the Localism Act, a manifestation of the Big Society concept, more and more communities are being encouraged to engage and lead on issues affecting their neighbourhoods; which would also apply to catchment management and river restoration. This study is an innovative demonstration of the value of citizen science in urban water management. Local knowledge can both support technical analyses as well as capture the interest and enthusiasm of communities to shape future opportunities for river restoration.

Broadhead, A.T., R. Horn and D.N Lerner (2013) 'Captured streams and springs in combined sewers: a review of the evidence, consequences and opportunities', *Water Research*, 47, 13, 4752-66.

Broadhead, A.T., R. Horn and D.N Lerner (2015) 'Finding lost streams and springs captured in combined sewers: a multiple lines of evidence approach', *Water and Environment Journal*, 29, 2, 288-97.

Session 7: Oxford Suite

RIVER RESTORATION IN EUROPE: A HOBBY OR A PLANNED ACTION?

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Economic development and ongoing, general increase of quality of life forces societies to improve the quality of the surrounding environment. Wise approaches to river restoration remain important not only due to re-establishing ecological functions of rivers: recent advances in ecological engineering have allowed scientists and managers to achieve improvement of flood risk management and ecosystem services supply by the restored rivers. Thus, benefits of river restoration have recently moved far beyond species and biocenoses, reaching more fundamental requirements of the society. However, in the EU most of the river restoration projects do not result from a planned national programme, reflecting the capabilities and enthusiasm of local stakeholders and low-level managers (land owners, fishery managers, national parks and reserves). We hypothesize that wishing to make river restoration successful in a scale larger than the river stretch, the projects have to be induced and implemented as a planned and scheduled process resulting either from the legal regulations (e.g. country-wide or regional plan of river restoration) or general, high level of social development (having multiple dedicated low-level, local stakeholders).

We conducted an international survey in order to verify the involvement of the authorities (public governance bodies) in river restoration projects in the EU. We examined most of the European projects aimed at restoring rivers. We summarised total budget spent on river restoration projects in each of the countries examined. We investigated the involvement of public governance bodies (e.g. environmental directorates, ministries of environment, water management authorities), types of rivers being restored and lengths of restored river stretches. Our study revealed that the vast majority of European projects of river restoration are implemented by dedicated organisations and stakeholders, being at the same time local initiatives not relevant in a regional and country-wide perspectives. We also revealed that in most of the European countries there are no integrated plans for river restoration, which makes the finalized, ongoing or planned river restoration projects activities of dedicated people. We conclude that in some developed countries the lack of a country-wide river restoration plan can be balanced with the high number of well-educated stakeholders, which are capable to plan and implement river restoration projects. In developing countries, although river restoration projects are ongoing, it seems that the lack of a country-scale management of river restoration can result in inefficiency of river restoration actions applied. Results of our study highlight the urgent need of communication of rivers restoration projects to wider public in order to present them as required and efficient, and gain social acceptance and support for river restoration actions.

BRINGING BUSINESS INTO CATCHMENT MANAGEMENT

K. HUGHES[1]

1 WWF-UK

WWF-UK is leading the delivery of WaterLIFE, an EC LIFE funded project that started in July 2014. WaterLIFE is a three year project that started in July 2014 and is working with the Rivers Trust and Westcountry Rivers Trust. The aim of WaterLIFE is to develop the enabling conditions' (policy, guidance and legislation) needed to support wider delivery of the Water Framework Directive, particularly by supporting authorities through civil society and private sector delivery. The project will deliver tangible environmental benefits in five demonstration catchments, across England and Wales using Water Stewardship mechanisms (with corporate businesses) and Civil society engagement (through local and regional third sector groups). The project also includes a wide European knowledge exchange aspect and will network and host events across Europe to ensure project impacts are transferable and applicable across the EU. We will present the Water Stewardship theme of our WaterLIFE project and demonstrate:

1. The WWF Water Stewardship ladder – a framework for corporate water stewardship.

2. The case for business engagement in catchment management both globally and in England. We identify three drivers for engagement at the global scale – reputational, regulatory and operational risk. Our research indicates other drivers are at play within England where the language of risk is less widely appreciated. We will present the case of engagement in England.
3. Examples of business engagement: we will present our WaterLIFE Water Stewardship catchments – the Cam & Ely Ouse, Broadland Rivers including the 'asks' for participants and progress to date.
4. We will discuss how far water stewardship might be able to take conservationists in our goal towards healthy rivers in England through both direct implementation and financing of catchment management, and also through influencing of wider governance processes.
5. We would like to promote our Water Stewardship toolkit for catchment groups which includes our UK WWF Water Risk Filter adaptation (an online risk tool for businesses - http:/ / waterriskfilter.panda.org), two booklets, an advice leaflet and a short film (to

date). We have also created other tools to build capacity within the CaBA and I will point the audience towards these.

6. Our work to date and plans to scale up private sector and civil society partnerships across England. This will use bottom up and top down approaches to encourage partnerships at all levels.
7. The governance structures and enabling conditions we have identified as necessary for partnerships between civil society, business and the private sector.
8. The WaterLIFE Partnership Declaration: http:/ / waterlife.org.uk/ declaration/

Conclusions

Our work to date indicates that water stewardship approaches can make a large difference to catchment partnerships in terms of delivery and financing, but that a strong narrative is essential to secure long term sustainable partnerships that meet the aims of every one. We are now gearing up to create and demonstrate how these partnerships could be expanded across the whole of England and we will seek feedback from the audience about this ambition. If there was opportunity to host a short workshop to seek feedback and generate discussion on any of these topics, I would be pleased to do so also. WWF would also like to be a full conference sponsor – we will promote the tools mentioned in this presentation on our stand alongside some of our other work on chalk streams, and the wider work of the WaterLIFE project with the Rivers Trust. We would also like to show our three short films on rotation.