Using a natural flood management approach for flooding and water quality control

Mark Wilkinson

The James Hutton Institute

Acknowledgements

- James Hutton Institute – Wendy Kenyon, Helen Watson, Steve Addy, Sohan Ghimire, Marc Stutter and the rest of the WP2.4 team.
- Tweed Forum – Luke Comins and Hugh Chalmers
- Newcastle University – Paul Quinn, Jennine Jonczyk, Alex Nicholson, Nick Barber and Gareth Owen
- Environment Agency – Peter Kerr and Phil Welton
- The landowners (very important!)

Introduction

- Floods are becoming more of a common occurrence
- 2012 wettest year on record (100 years) (and summer!)

Pictures from the BBC

Flooding realities – the Pitt Review

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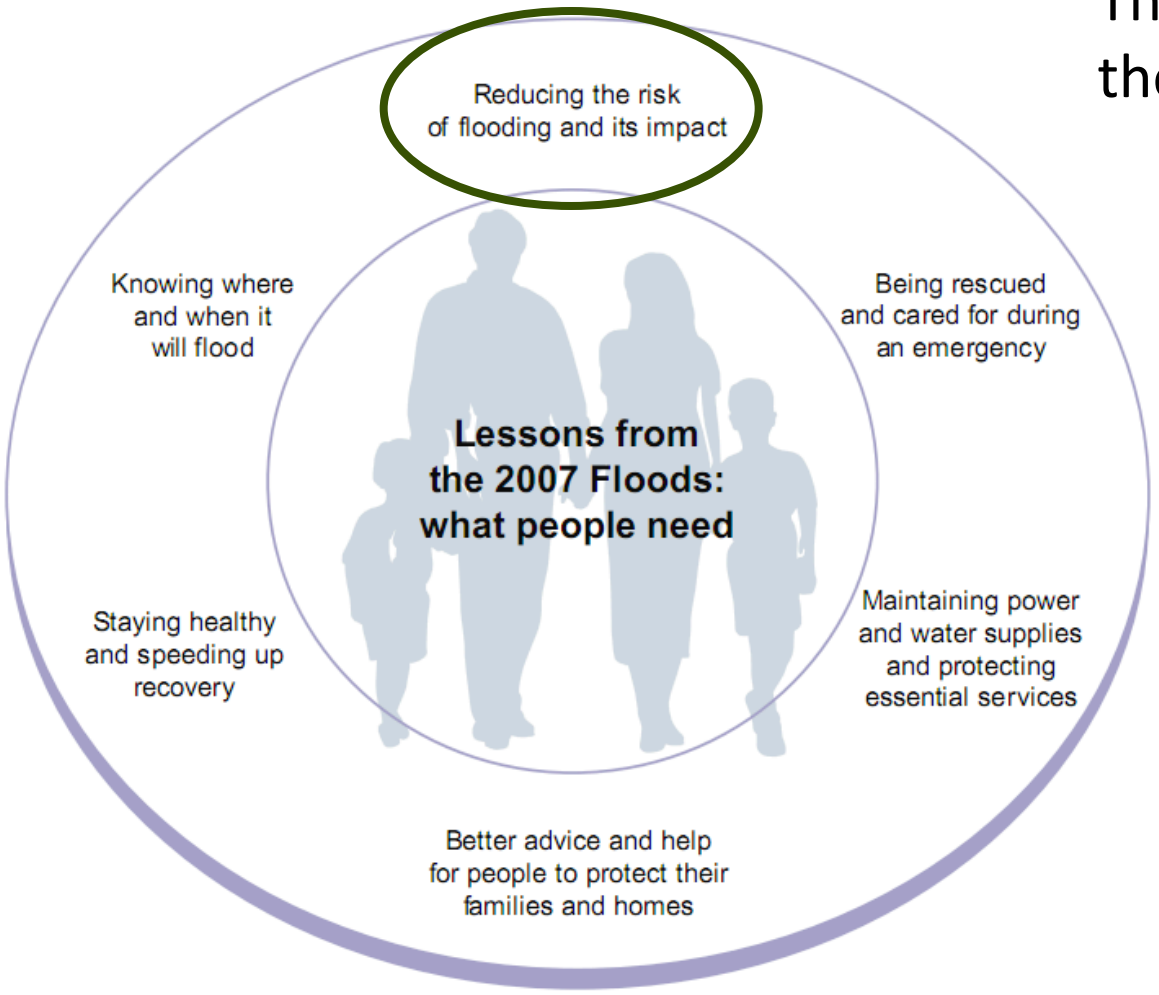
The Pitt review - a review of the 2007 UK summer floods



Sustainable flood risk management

- The Flood Risk Management (Scotland) Act 2009
- Look at alternative ways to managing flood risk alongside traditional “hard engineering” techniques.
- Sustainable flood risk management (reducing flood risk at source) -
  - Natural Flood Management (NFM)
  - Catchment Systems Engineering
  - Soft Engineering techniques
- Fundamentally, they all involve the same concept (reduce flood peaks and timing) and deliver multiple benefits
- SLOW, STORE, DISCONNECT AND FILTER

Definition of NFM

- NFM measures aim to work with natural hydrological and morphological processes, features and characteristics to manage the sources and pathways of flood waters. These techniques include the restoration, enhancement and alteration of natural features and characteristics, but exclude traditional flood defence engineering that works against or disrupts these natural processes."
- (SAIFF -The Scottish Advisory and Implementation Forum for Flooding, 2011)

Does it work?

- A key policy question is “to what degree does NFM reduce flood peaks at the catchment scale?”.
- We need to understand these measures by monitoring and modelling them.
- But catchments are complex – as scale increases so too does the complexity
- Communicating the uncertainty

Working with <u>all</u> catchment stakeholders is key – fundamental to delivery

Our work at the JHI on NFM

- Scottish Government Rural and Environment Science and Analytical Services Division (RESAS) work package at the James Hutton Institute
- WP2.4. “Methods for mitigating and adapting to flood risk” focuses on Natural Flood Management techniques
  - Demonstration sites (monitoring platforms)
    - Bowmont, Tweed catchment (Borders)
    - Tarland, Dee catchment (Aberdeenshire)
    - Logie Burn, Dee catchment (Aberdeenshire)
  - Barriers
  - Modelling
  - Multipurpose benefits

The Bowmont catchment

- Flows through Kirk and Town Yetholm (Borders) with an upstream catchment area of 80km2
- Suffered bad flooding in Sept 2008 (1 in 200 year) and July 2009
- Steep upland catchment and geomorphological active channel
- Widespread damage to infrastructure
- Tweed forum are installing NFM measures

In the catchment to address the flooding and fluvial geomorphological issues

Infrastructure damage

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Coarse sediment transport and deposition

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Issues:

- Reconfiguration of channel morphology

- Loss of land and disruption of use

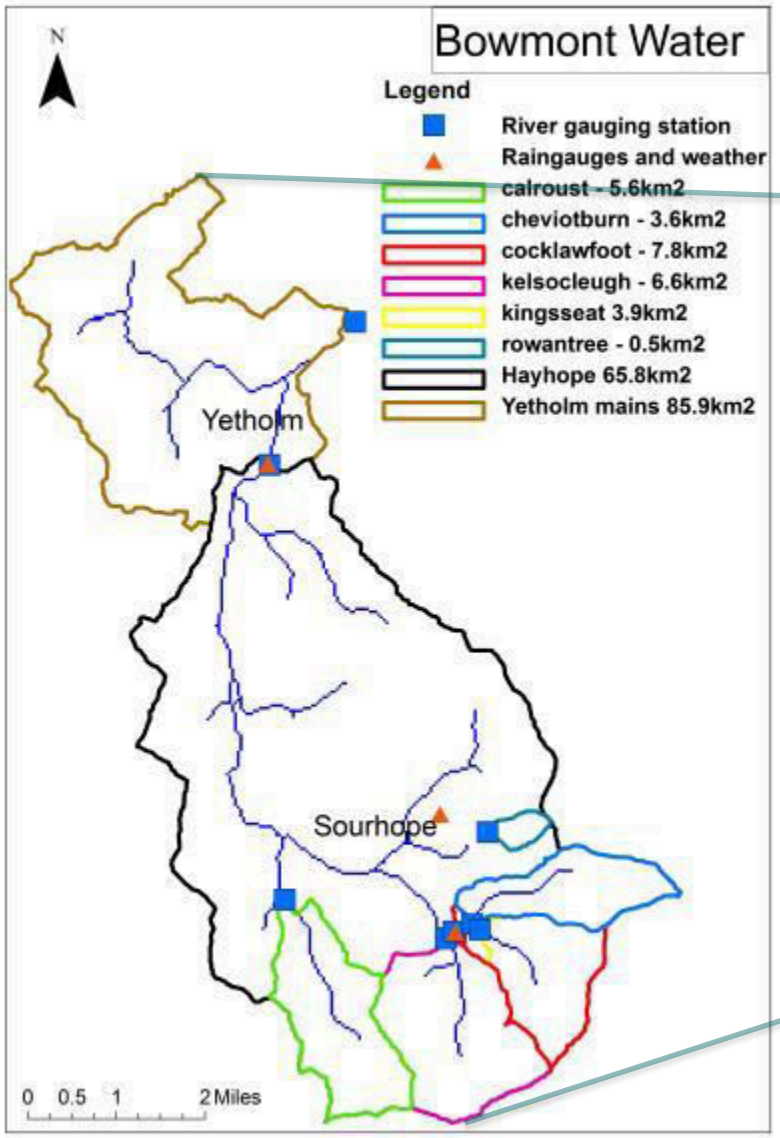
- Damage to infrastructure

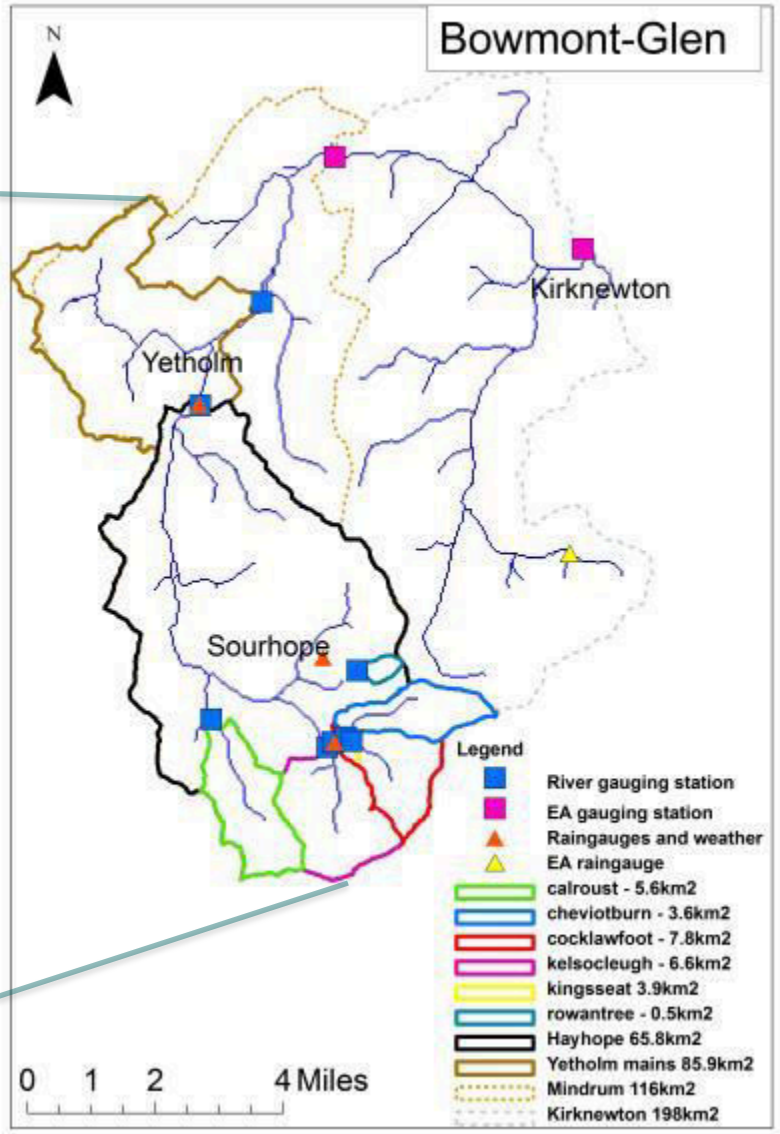
- Loss of water conveyance = increased flood risk


Channel reconfiguration

Deposition

Monitoring network





Storms (Goldscleugh – college burn)

- Sept 2008 – the largest flood (since 1994)
- However, July 2009 extreme owing to intensity

		Storm total	duration	24 max total	12 max total	FLOOD RANK
1st	07 September 2008	259	63	**166**	87.6	**1st**
2nd	18 July 2009	154	40	**141.8**	99.4	**2nd**
3rd	07 March 2001	126	47	**99.8**	73	**-**
4th	24 June 2004	128	40	**90**	54.4	**-**
5th	25 September 2012	120	46	**90**	73.2	**NEW SITE**
6th	09 September 1995	110	37	**89**	78.2	**-**
7th	29 May 1998	99	46	**87**	65	**5th**
8th	07 November 2000	166	65	**85**	48.8	**3rd**

Lag times – response from rainfall to peak

- Based on six events in 2012
- Flashy catchments – responding quickly to rainfall

Catchment	Area (km2)	Lag time (hh:mm)
Kingsseat	3.9	**02:25**
Cheviot	3.6	**02:42**
Cocklawfoot	7.8	**02:47**
Rowantree	0.5	**02:27**
Kelsocleugh	6.6	**02:57**
Calroust	5.6	**03:47**
Hayhope	65.8	**05:35**
Yetholm	85.9	**06:55**
Pawston	115	**08:22**

Upper Bowmont Catchment

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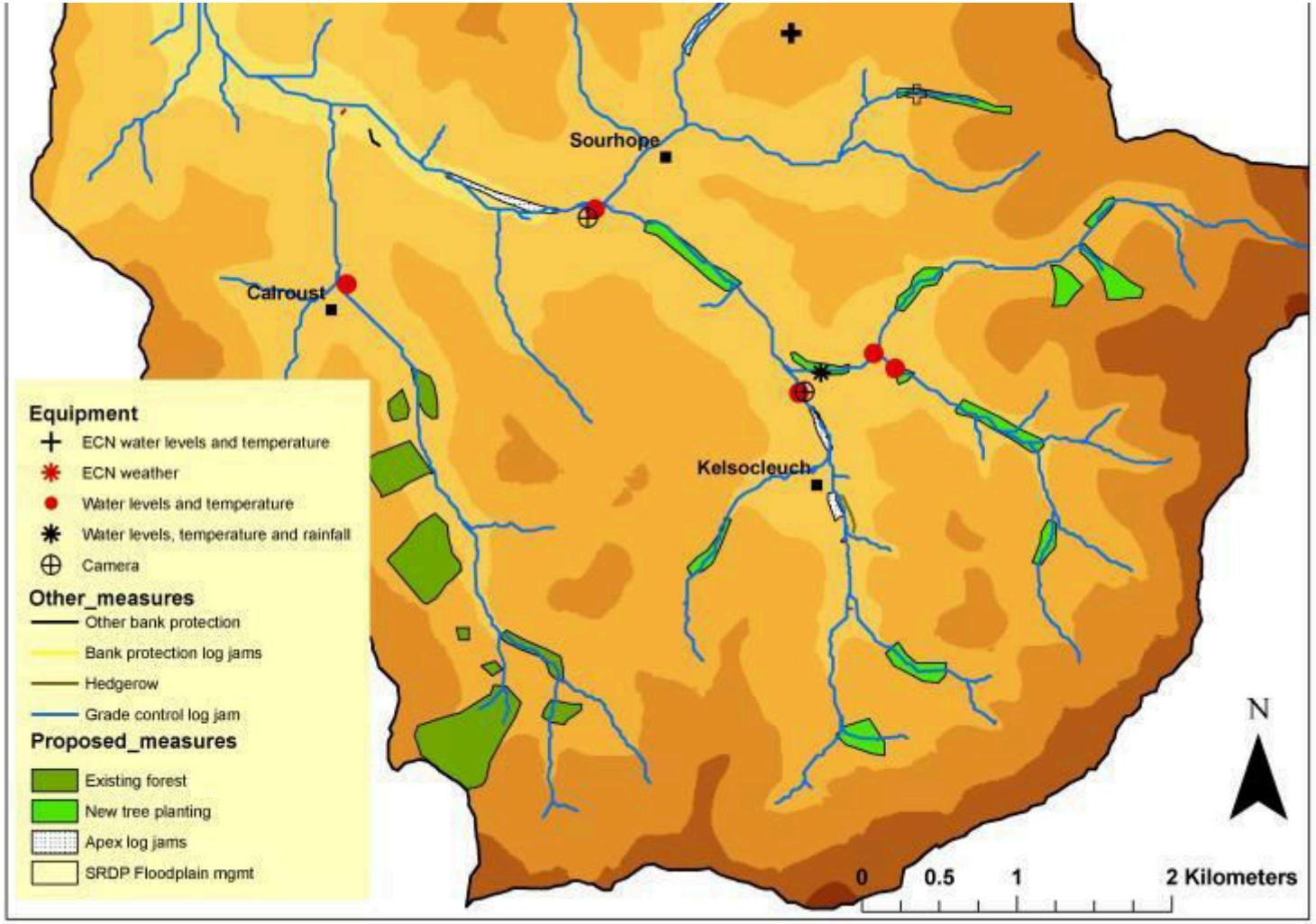
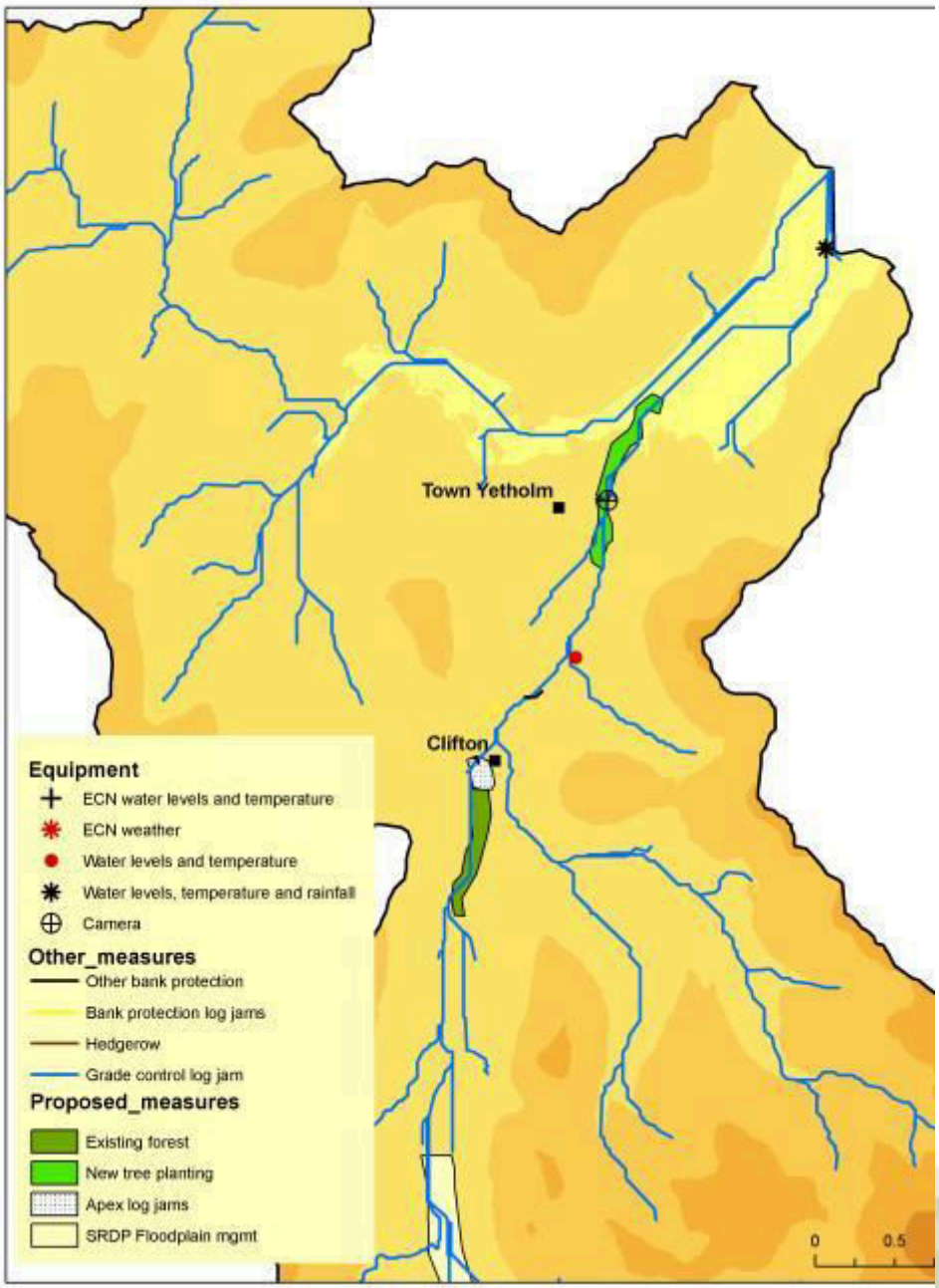




Lower Bowmont Catchment

Naturally occurring woody debris

- Capture sediment and delay its movement downstream
- Can create diverse habitats
- Also can be a problem

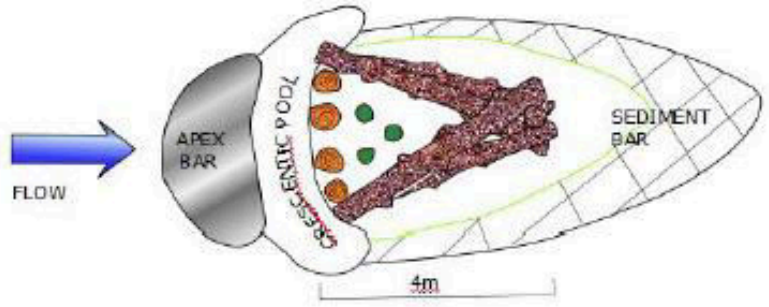
Engineered log jams (ELJs)

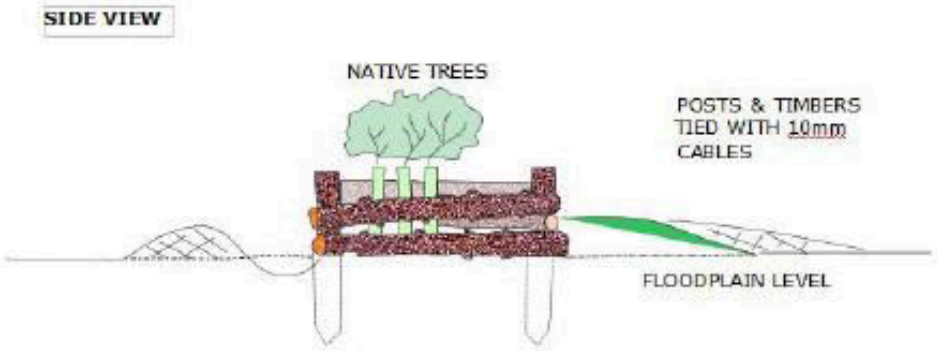
- 3 types of ELJ designed to trap sediment, reduce local erosion and improve habitat

- Initiated monitoring of local textural and morphological change

- What are the multiple benefits of this novel approach to sediment management?

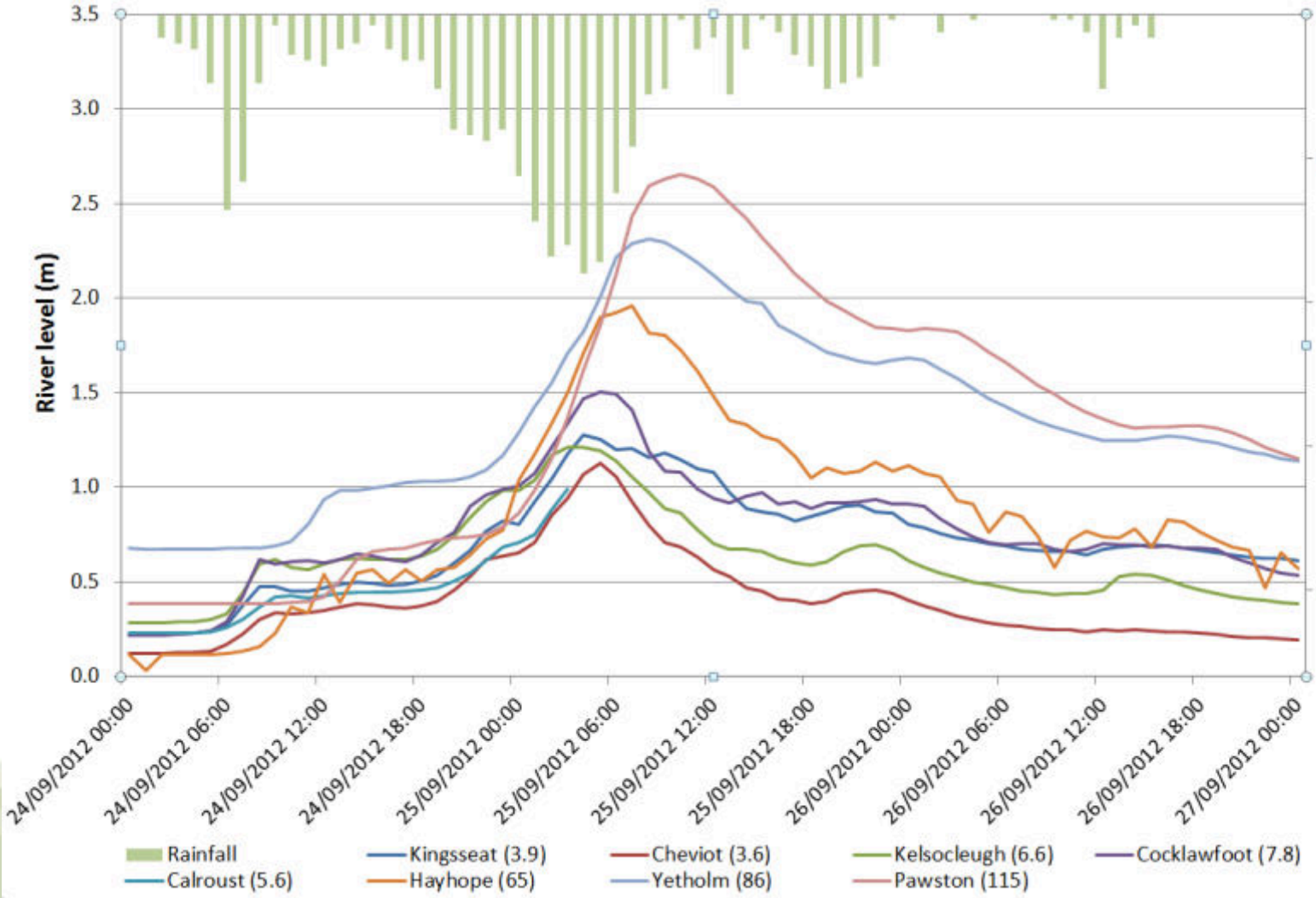
Bar apex log jam

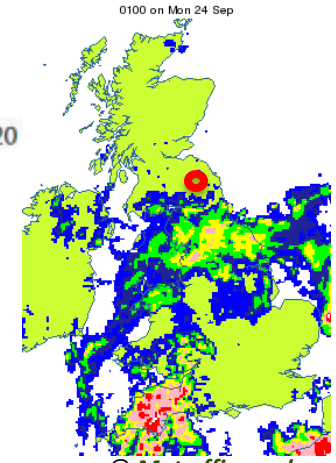




Focus Apex log jams NFM measures

Some initial data – 25th Sept 2012





© Met office radar

Pawston level gauge (next four slides): Contains Environment Agency information © Environment Agency and database right

Log jams

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Log jams: not standing so well

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Mean elevation change: +0.13 m
Sediment volume change: +154 m^3

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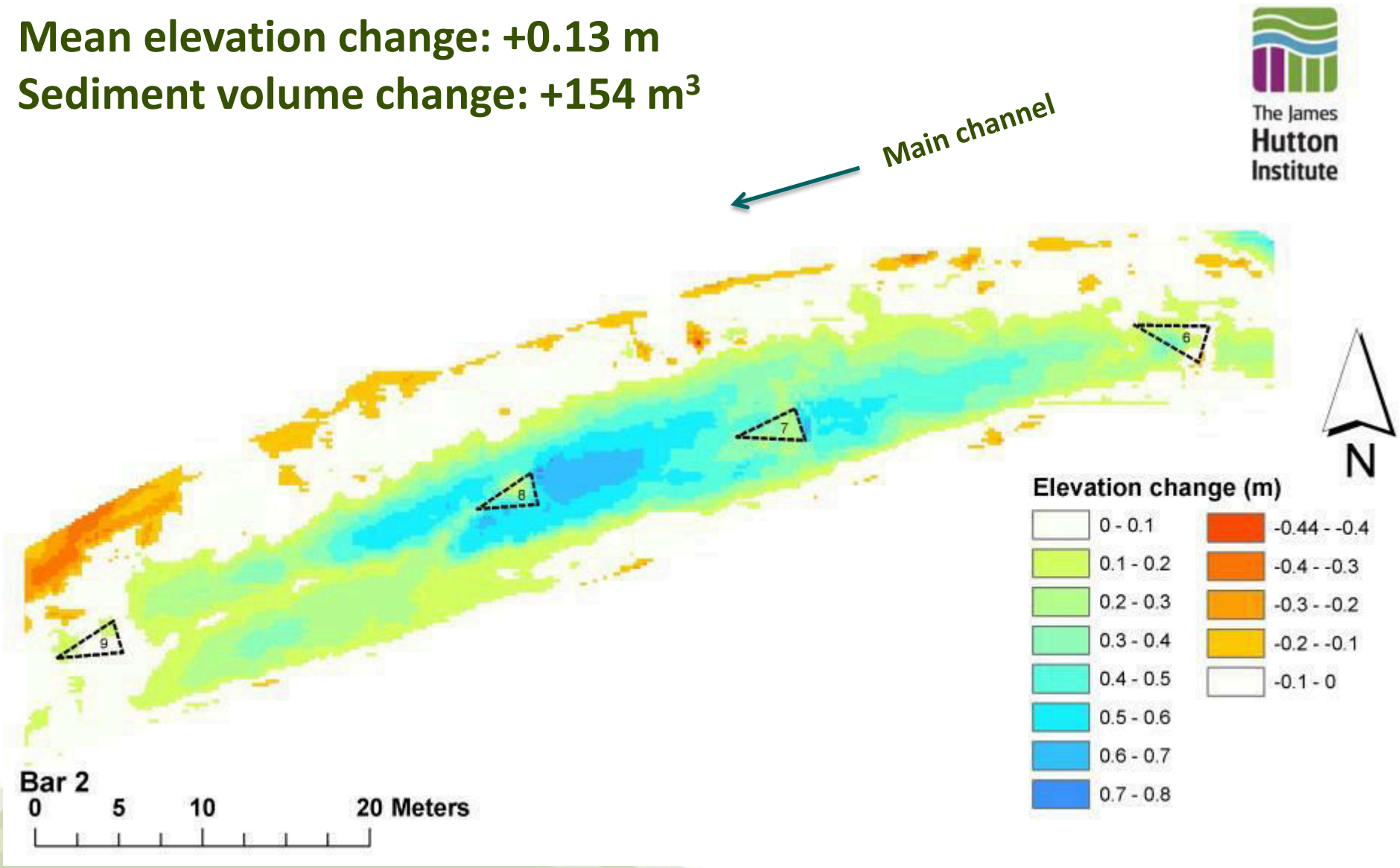

Kelsocleuch bank protection structure

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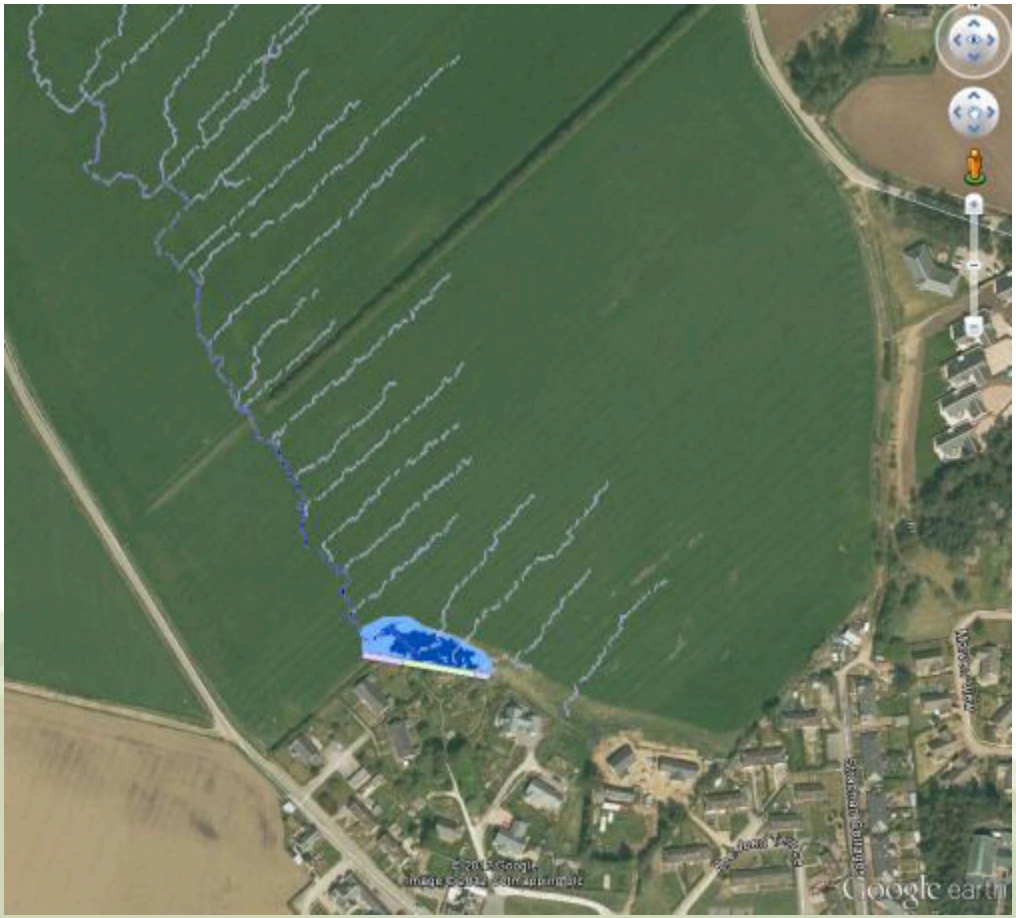
Bowmont Hydrology conclusions

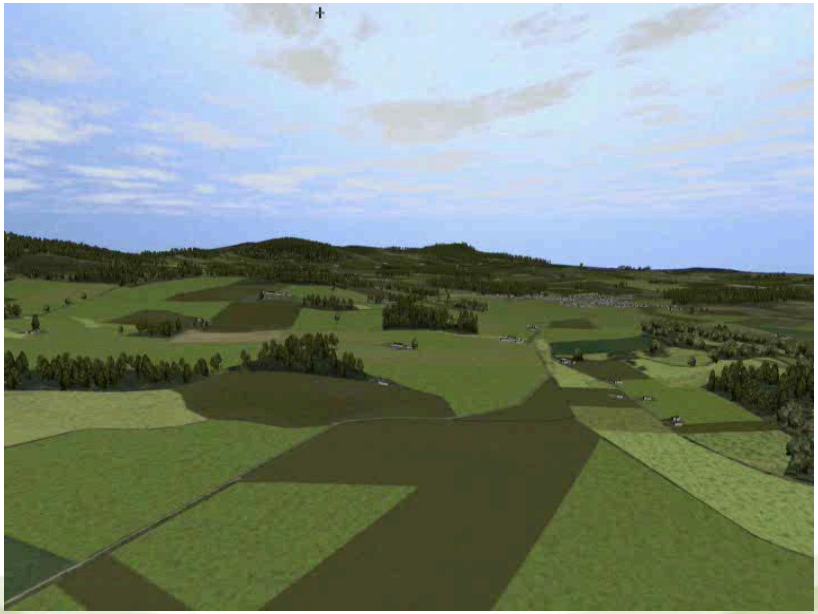
- Difficult to quantify the degree of sediment capture – small relative to sediment supply and naturally occurring bar deposition
- Future monitoring to assess long term storage – i.e. how effective are the structures?
- Potential lessons to be learnt on the placement and design
- Catchment is very flashy; responds quickly to rainfall.
- There is no evidence yet to suggest the NFM measures in the Bowmont water catchment have:
  - Delayed the flood peak
  - Reduced the flood peak – owing to the features just being put in place
- The multiscale nested network will provide data to hydrologic and hydraulic models allowing an assessment of potential NFM impact at catchment scale

HTTP://BOWMONT.HUTTON.AC.UK

Tarland catchment (Dee)

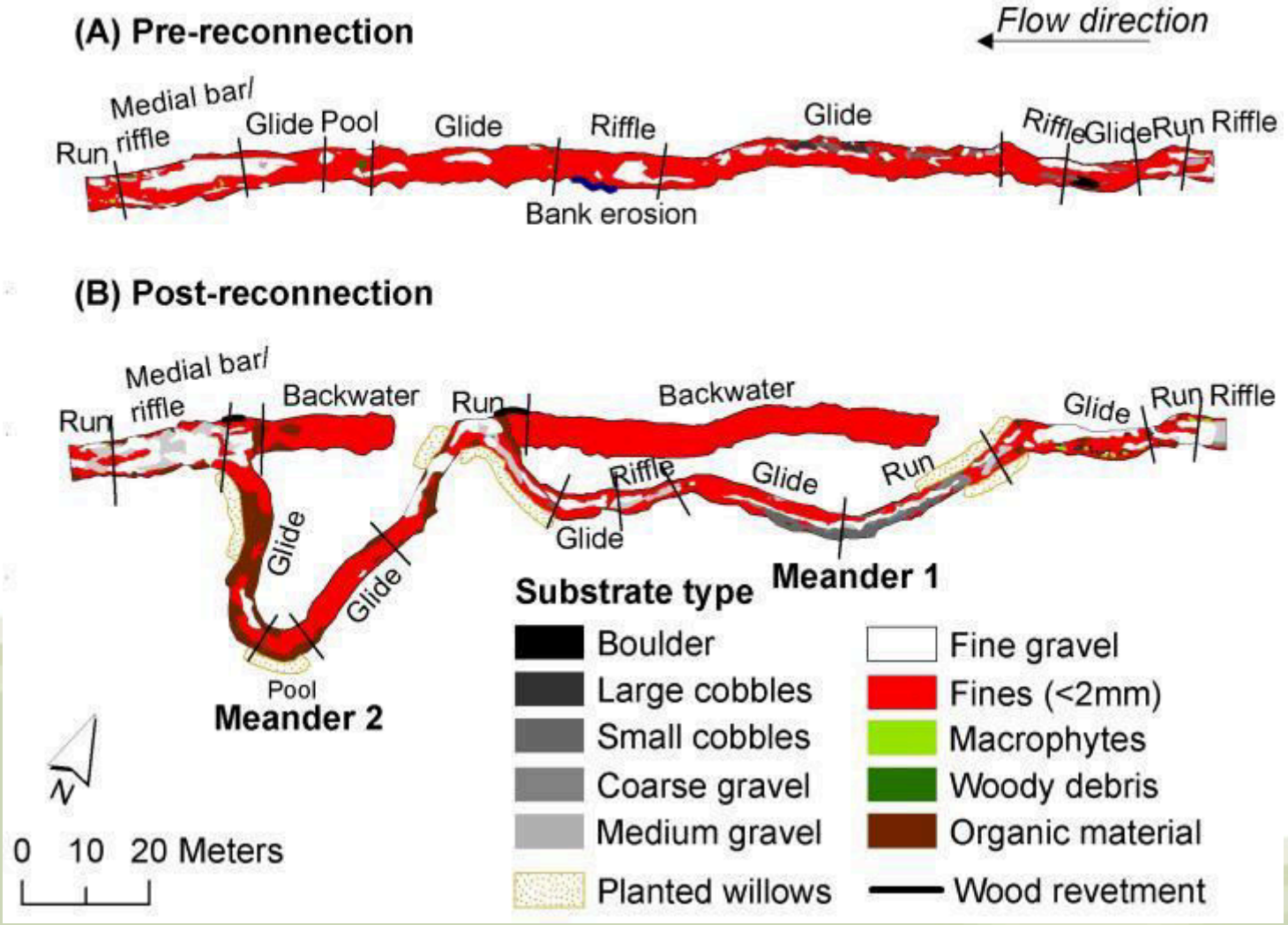
- Working with farmers and Aberdeenshire council to install Runoff Attenuation Features at pilot sites within catchment (a long term JHI monitoring site).





Logie burn (Dee catchment)

- Re-meandering scheme



Case study: The Belford Burn

Mark Wilkinson, Paul Quinn, Jennine Jonczyk, Alex Nicholson, Gareth Owen and Nicholas Barber – Newcastle University

Phil Welton and Peter Kerr – Environment Agency

Newcastle University

Civil Engineering and Geosciences

in partnership with Environment Agency

Belford case study

The village of Belford, Northumberland, UK – Many flood events (6km^2 catchment)

When sandbags and sympathy are not enough...Belford 'bereft' after floods

Belford finds itself under water — and not for the first time either..!

Belford – Background

- Environment Agency looked at the feasibility of a traditional flood defence scheme for Belford
- High costs meant economics did not stack up
- Alternative approach of **managing runoff** in the catchment put forward
- The scheme was funded by the Environment Agency's North East Local Levy, raised by the Northumbria Regional Flood Defence Committee though Local Authorities

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Last Updated: Monday, 13 August 2007, 15:43 GMT 16:43 UK

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Flood plan for town is approved

Flood prevention works costing £600,000 have been announced for the Belford area of Northumberland.

The Environment Agency says the works will include ways of preventing blockages in the stream which runs through Belford.

Staff will also work with local farmers so fields upstream of Belford can act as wet areas to allow surface water to drain away.

Work is expected to begin on initial phases of the project later this year.

An Environment Agency spokesman said: "Our climate is changing, which means that extreme weather will become more frequent in the future.

"We need to find new ways of dealing with our streams and rivers rather than only trying to wall up the water with flood defences.

"The innovative improvements will help to strengthen flood protection in the town. However flooding will become more of an issue in the future and everyone needs to take steps now to protect themselves."

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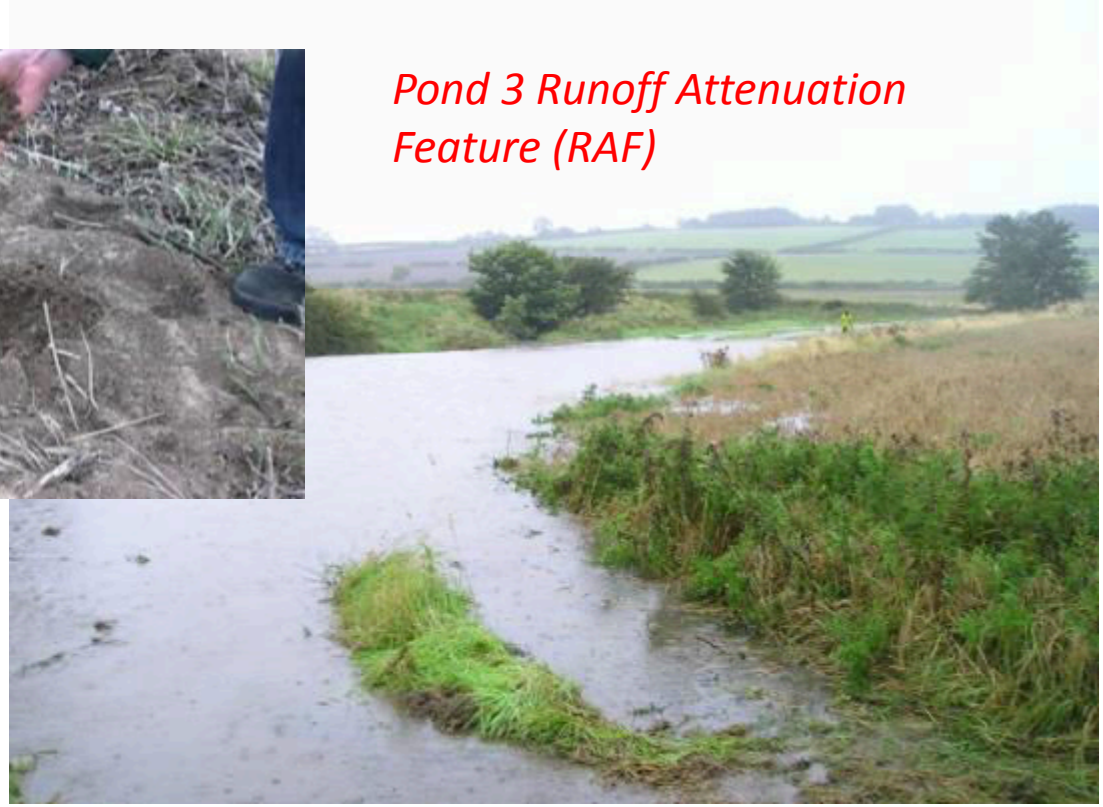
Catchment Systems Engineering

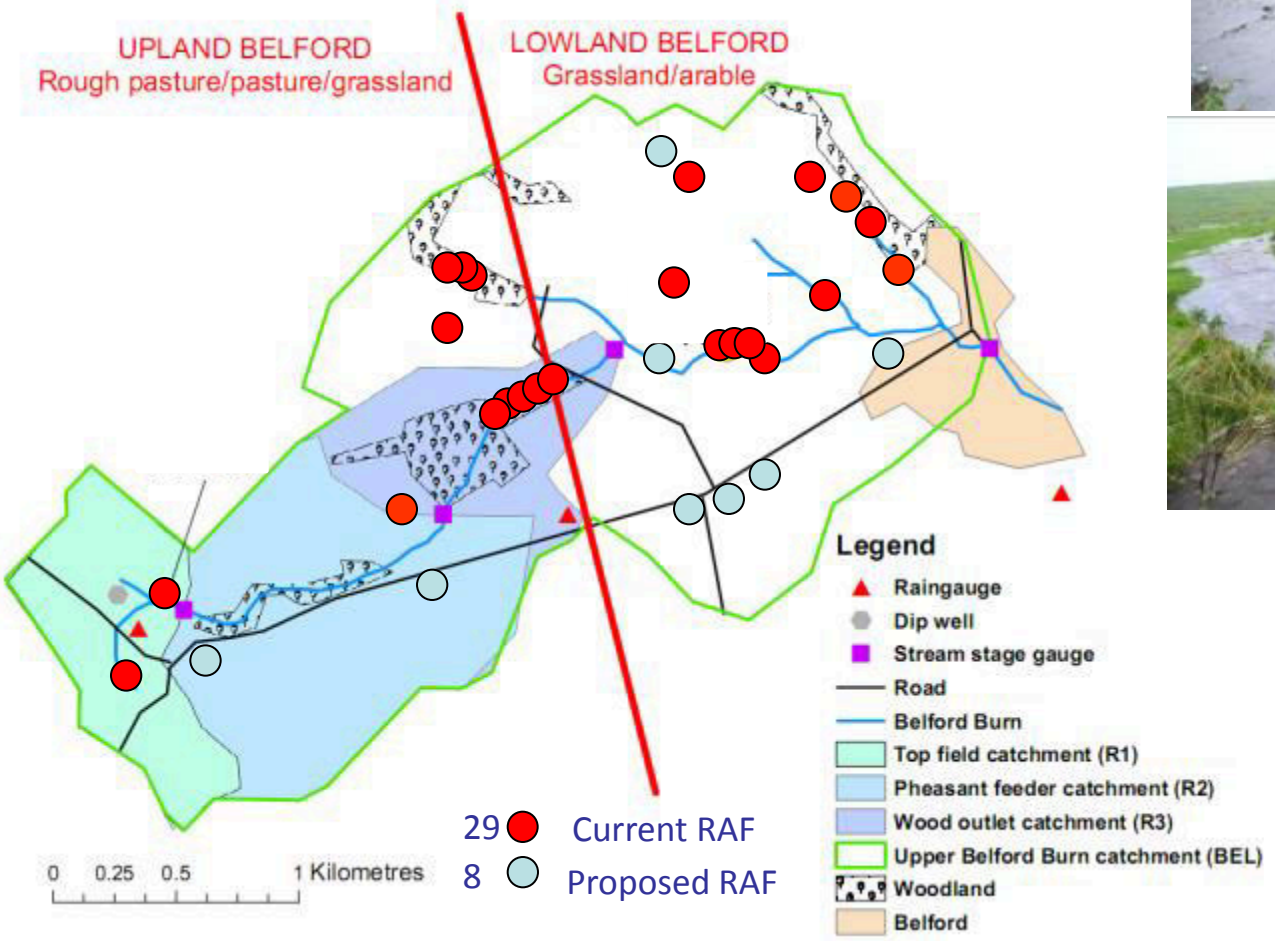
"Catchment Systems Engineering aims to sustainably manage water quantity and water quality at the catchment scale whilst not affecting agricultural productivity using an interventionist approach"

Pond 3 Runoff Attenuation Feature (RAF)



SLOW, STORE, FILTER --- For example, making buffer strips do more

Instrumentation and mitigation




Belford proactive flood solutions

Belford proactive flood solutions

Belford proactive flood solutions


Belford proactive flood solutions



Large Woody debris – a NFM technique

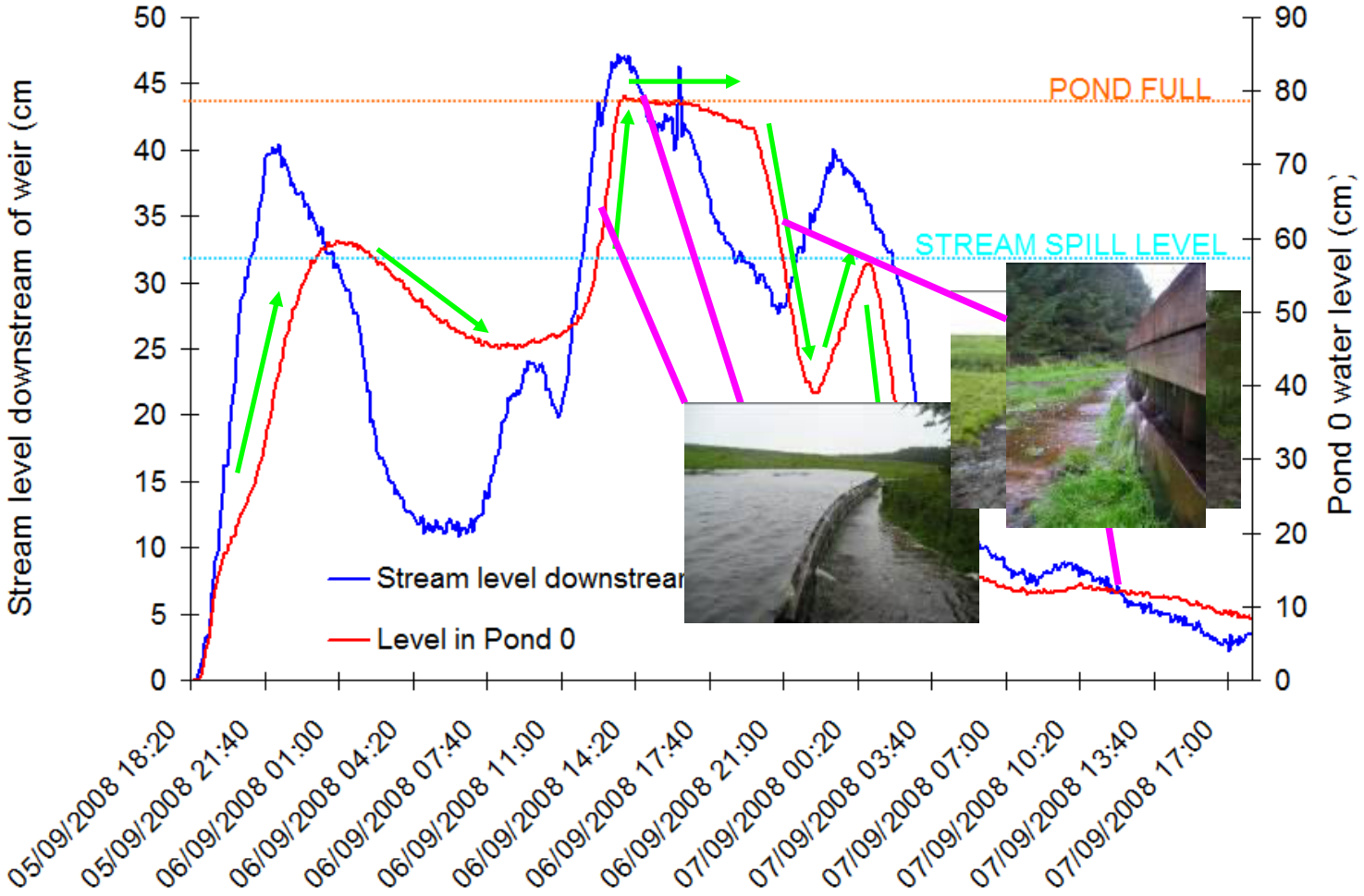
- The creation of large woody debris (LWD) dams can slow and divert flood flow onto the woodland floor and thereby make the flow follow a more tortuous route through the trees.
- Two large sycamore tree trunks laid in across formation across the channel to rest safely on both banks, wedged in position
- Timber pinned to the woodland floor or under-storey vegetation will increase roughness and aid attenuation

Storm information

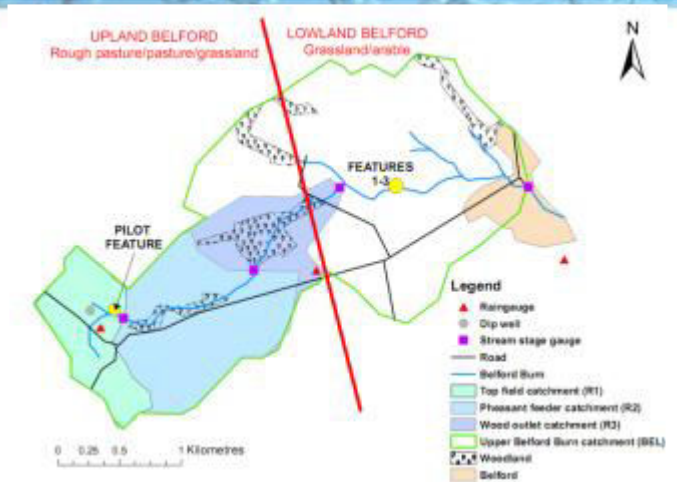
RANK	Name	Dates	Storm Duration	Rainfall (mm)	% of yearly average rainfall	BELFORD LEVEL
1st	**Mar-10**	29-30 Mar 2010	30	**62.4**	**9**	**1.54**
2nd	**Jul-09**	17th July 2009	43	**102.6**	**15**	**1.431**
3rd	**Sep-08**	5-7th Sept 2008	45	**99.6**	**14**	**1.375**
4th	**Jan-10**	16th Jan 2010	8	**12.4**	**2**	**1.32**
5th	**Nov-09**	1st Nov 2009	9.5	**32**	**5**	**1.075**
6th	**Sep-09**	2nd-4th Sept 2009	40	**65**	**9**	**0.865**
7th	**Feb-09**	3rd Feb 2009	17	**29.8**	**4**	**0.869**

We now find the use of return intervals inappropriate for this catchment

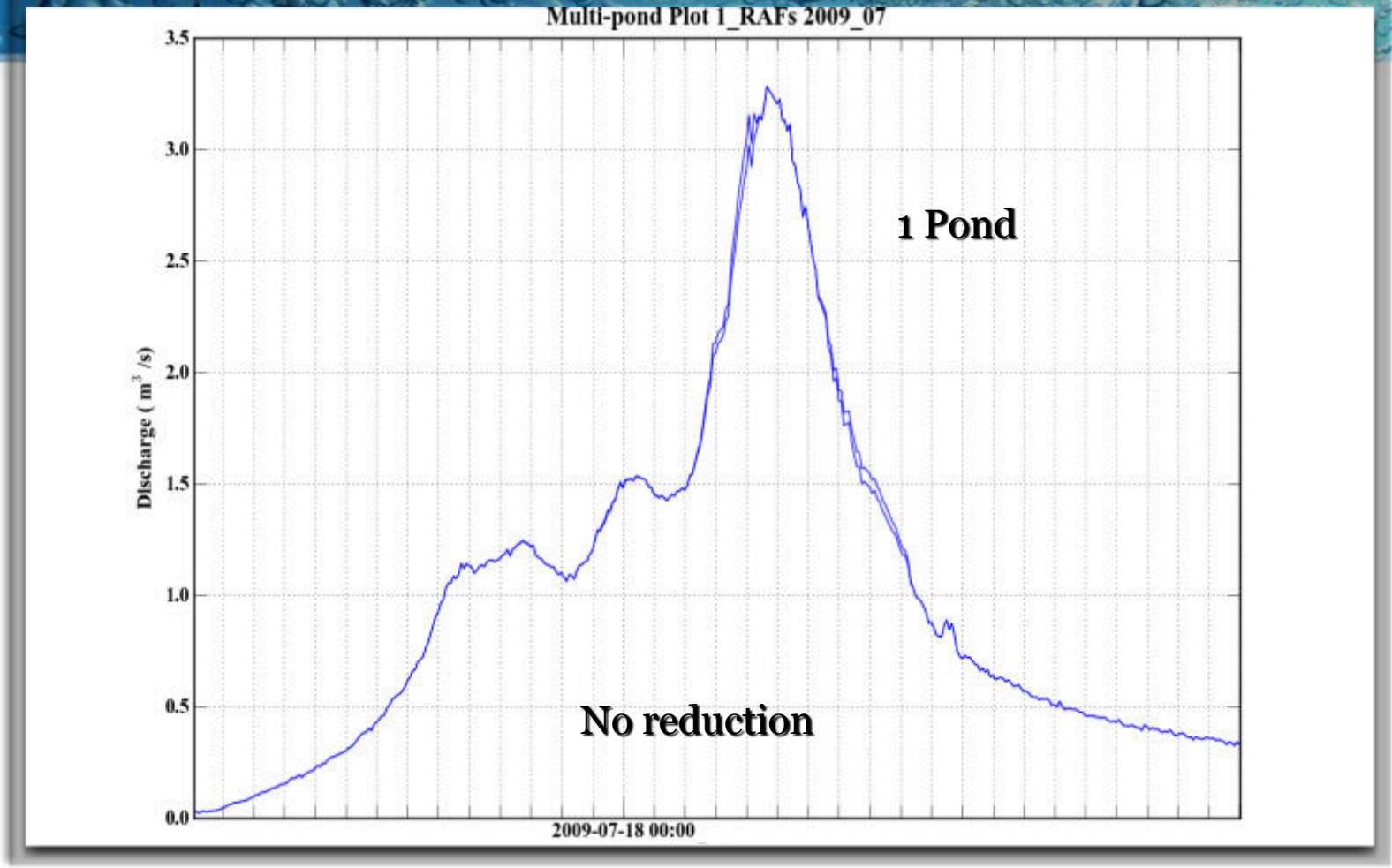
Pilot pond – Sept 2008 flood



Travel time of peak

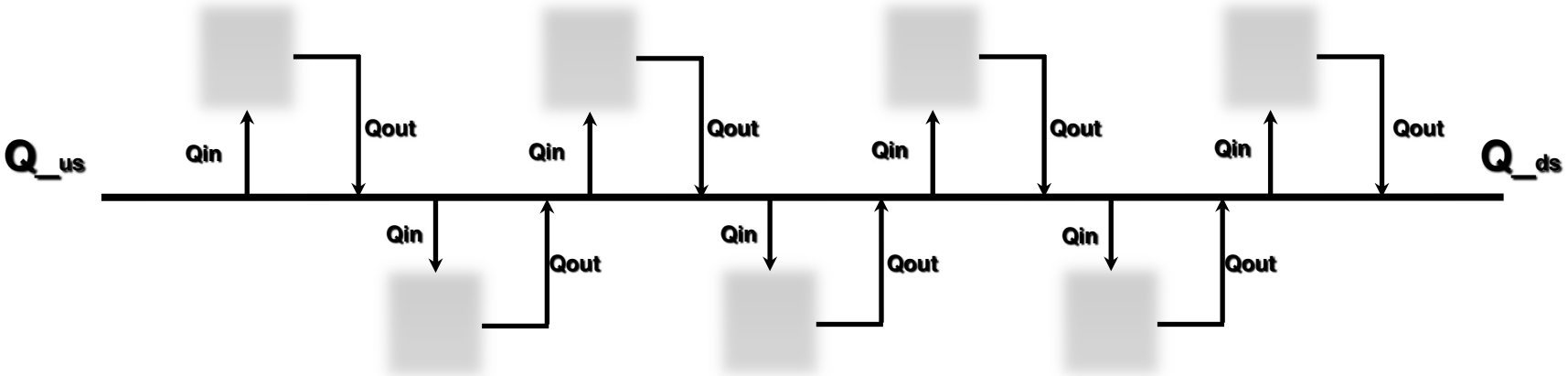


Impact of a Pond?



- Post change:
- Volume capacity = 560m3
- Inlet height = 0.55m

Pond Network Model:



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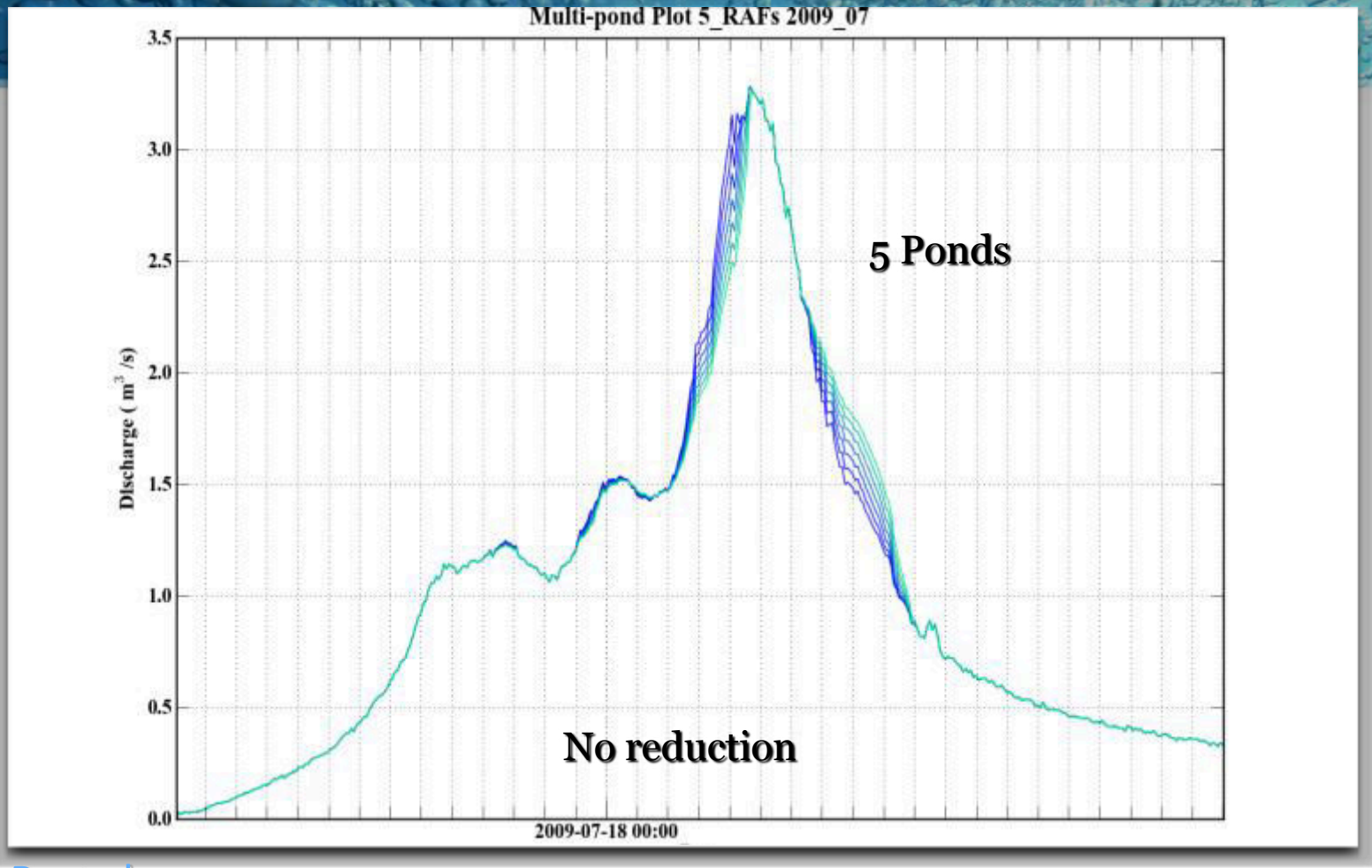
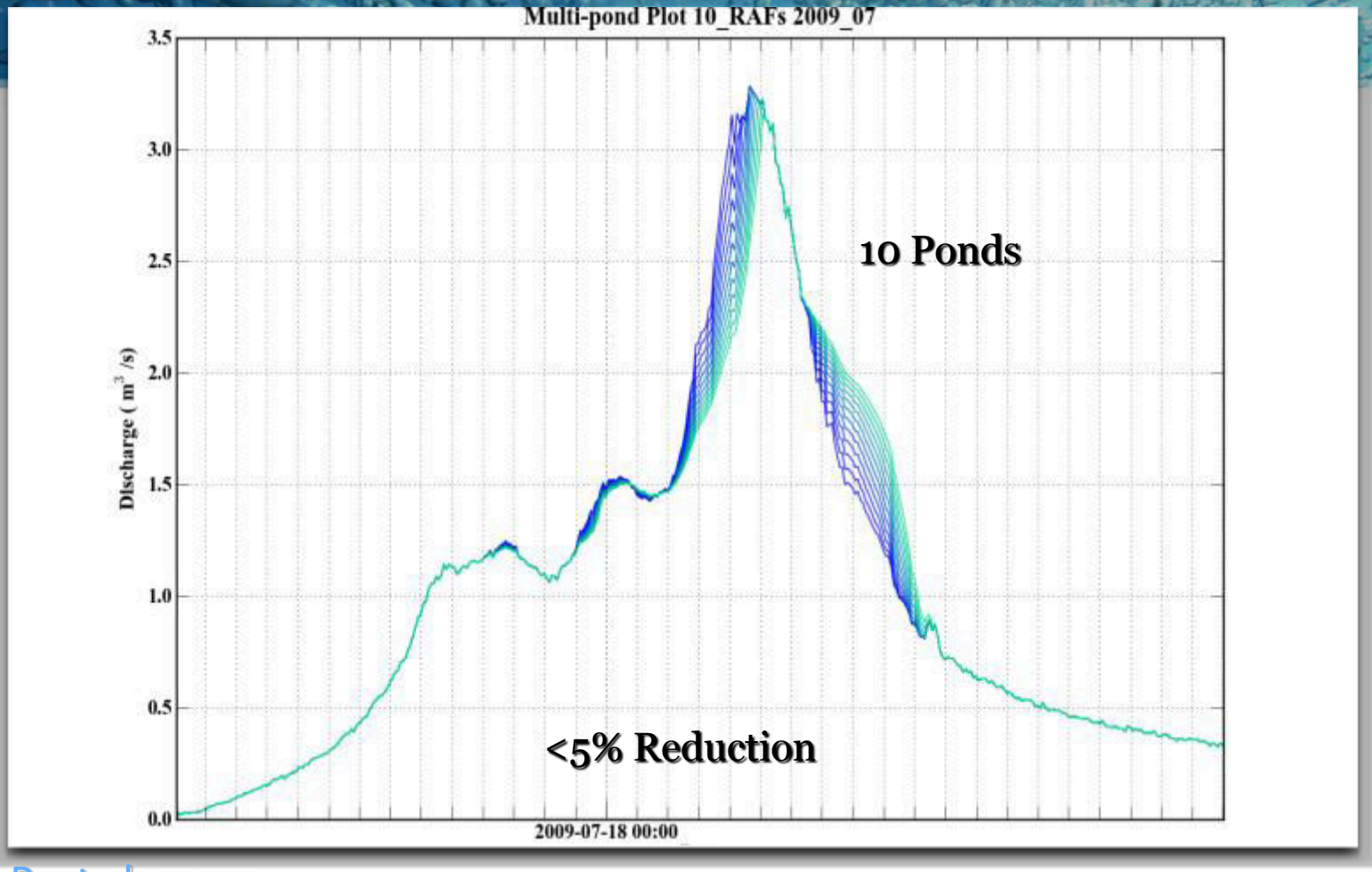


Post change:

Volume capacity = 560m^3

Inlet height = 0.55m

Pond Network Model:



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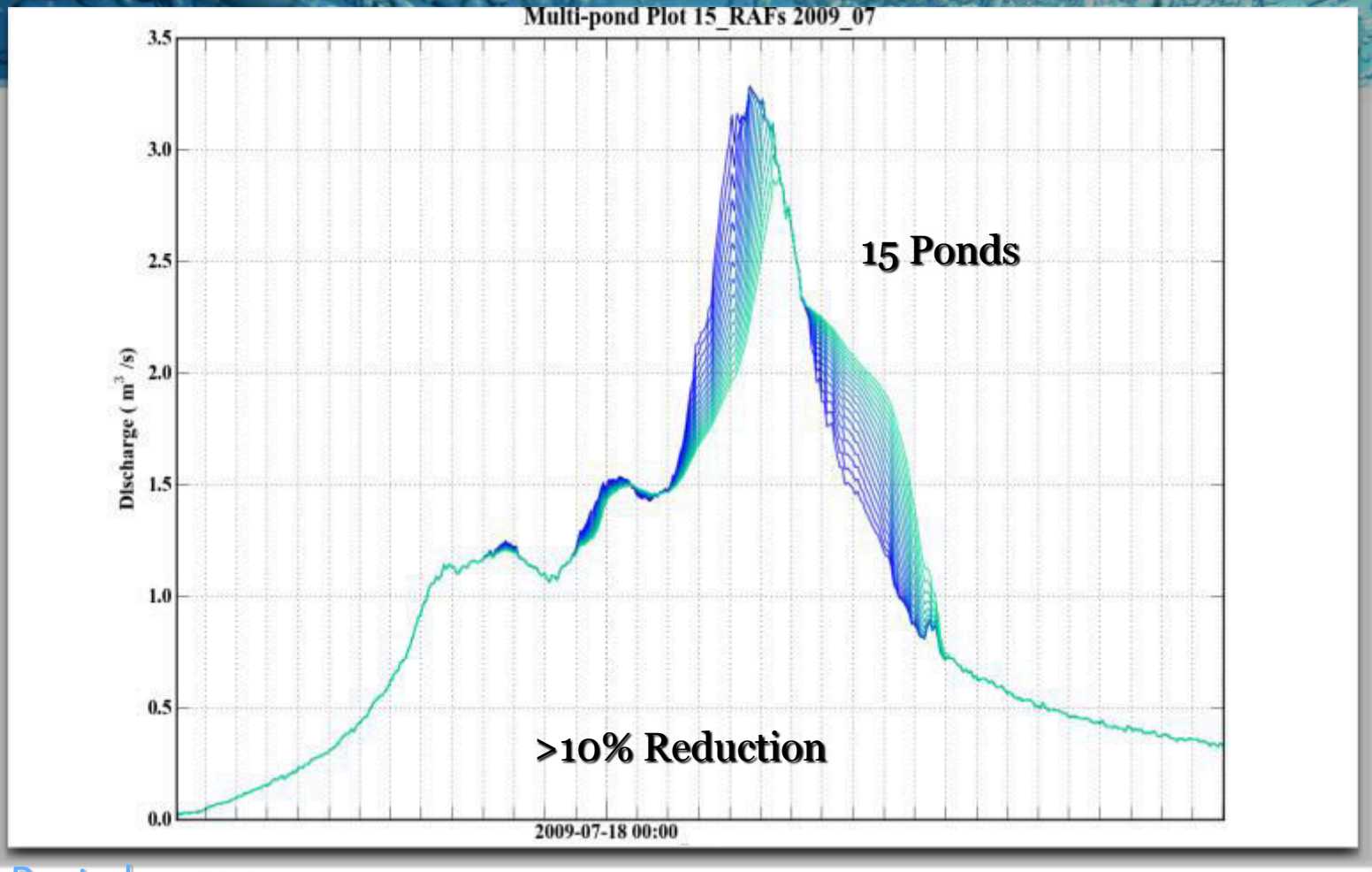

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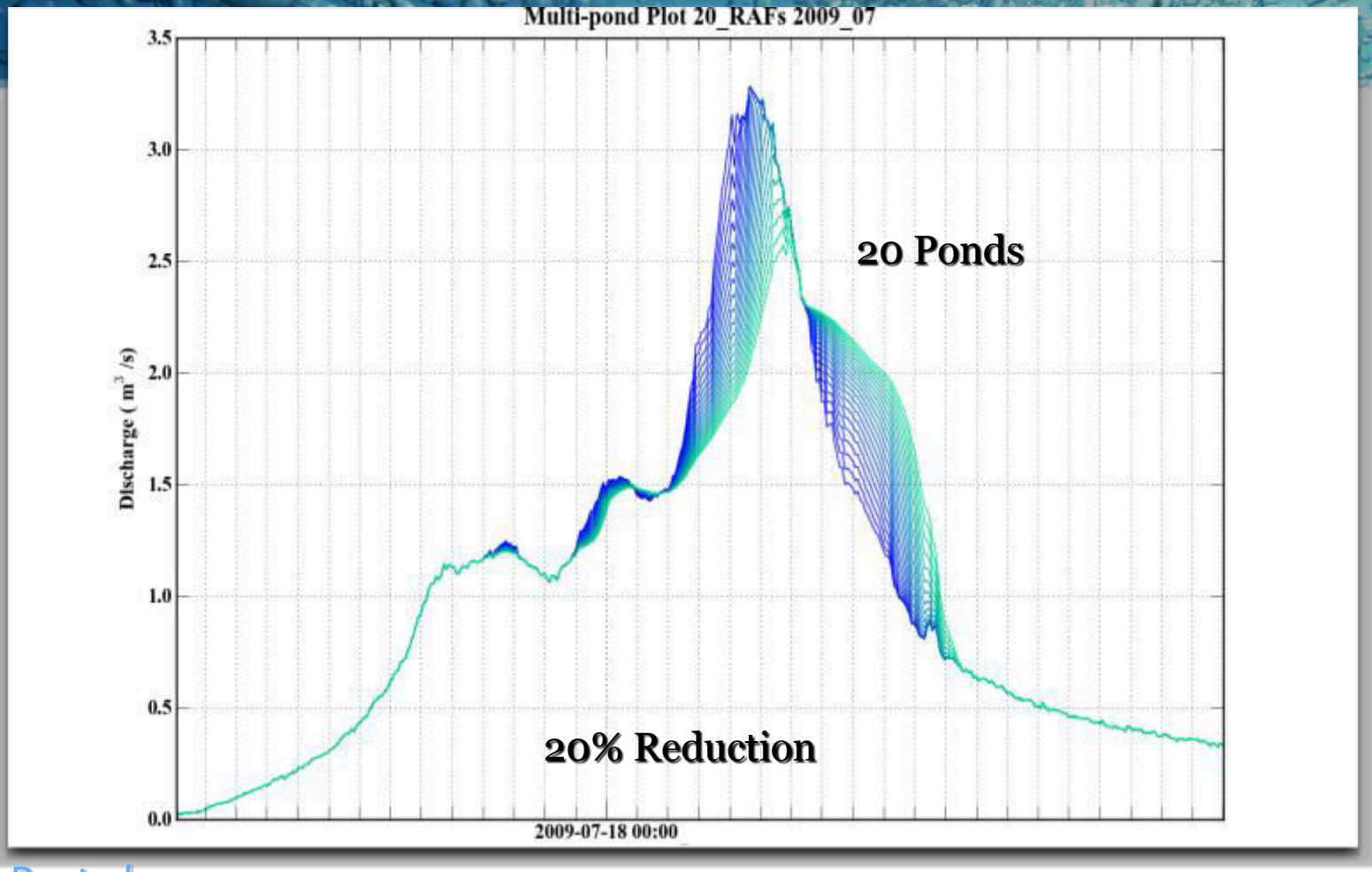

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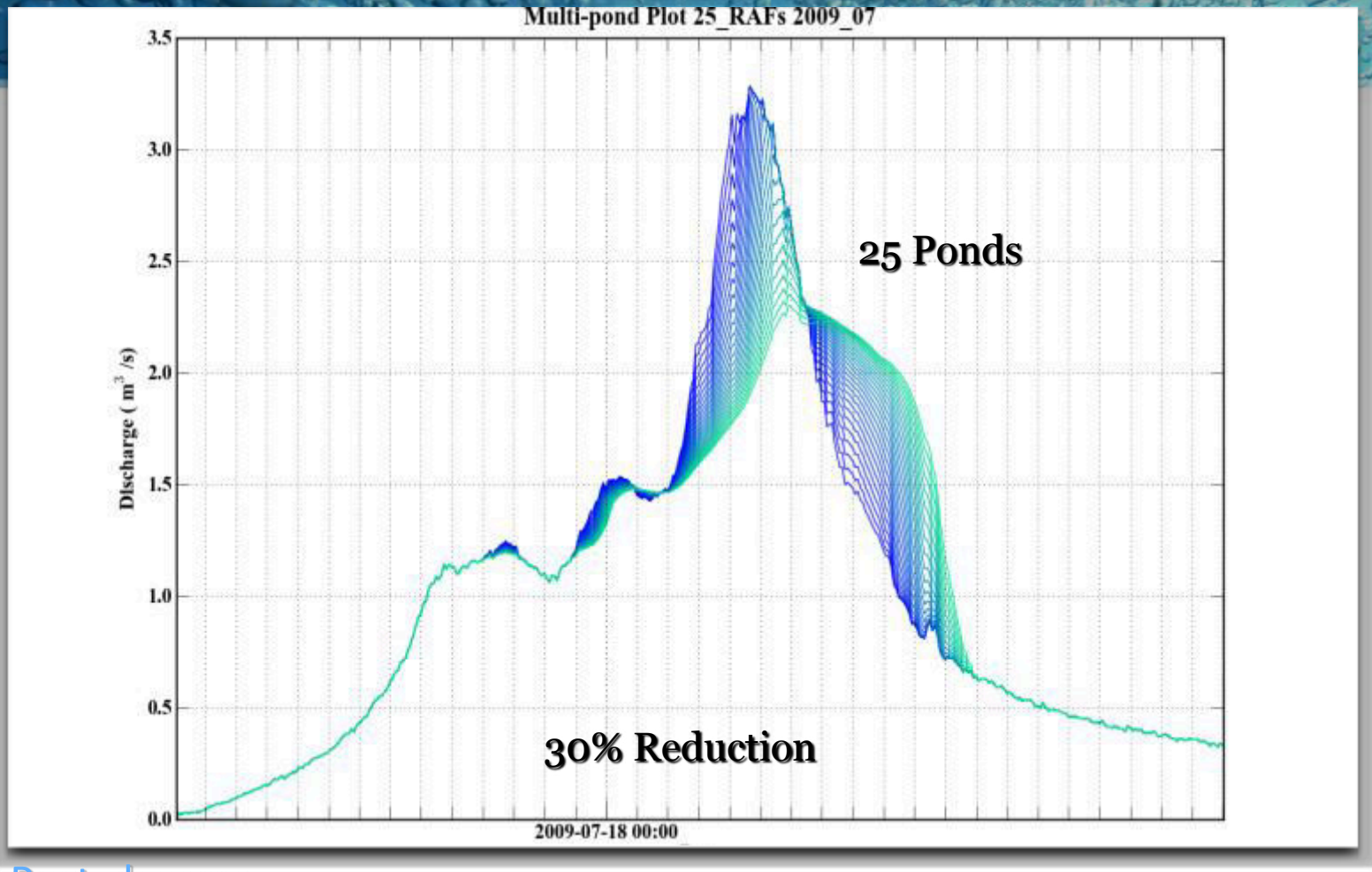

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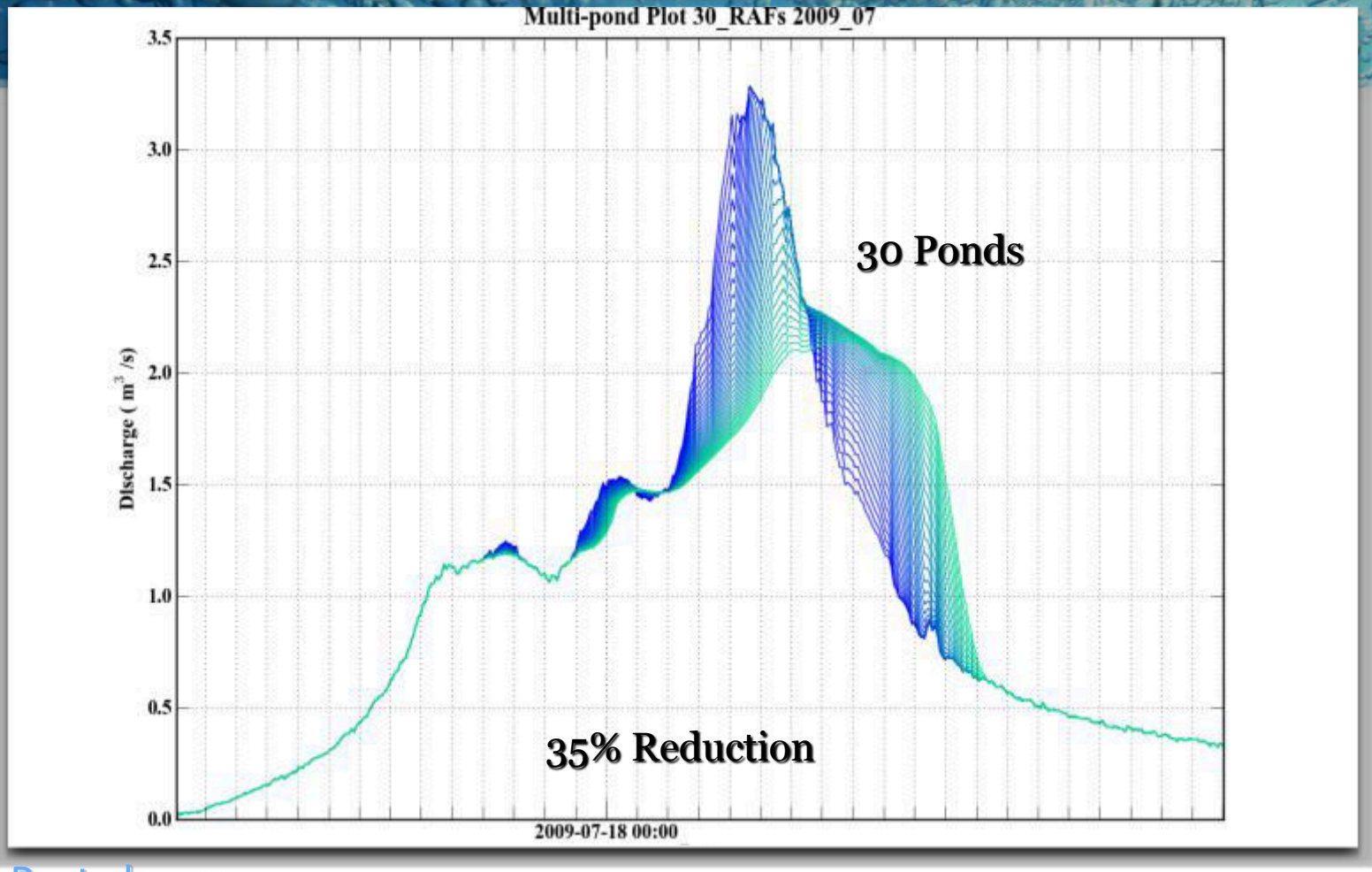

Post change:

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Inlet height = 0.55m

Optimisation of RAFs for WQ

Nicholas Barber's PHD work

SLOW, STORE AND FILTER ---- An example of an in-stream intervention

Summary

- **Hands on**, multi-objective work is a cost effective way to catchment management
- Different Runoff Attenuation Features (controlling fast runoff pathways, while tackling water quality and other issues) have been implemented in the catchment **in partnership with farmers and local landowners**
- Visual observations and preliminary data show the effectiveness of the features locally
- However, more data, data analysis and modelling are required to quantitatively assess the impacts of the features at the catchment scale

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Questions?

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