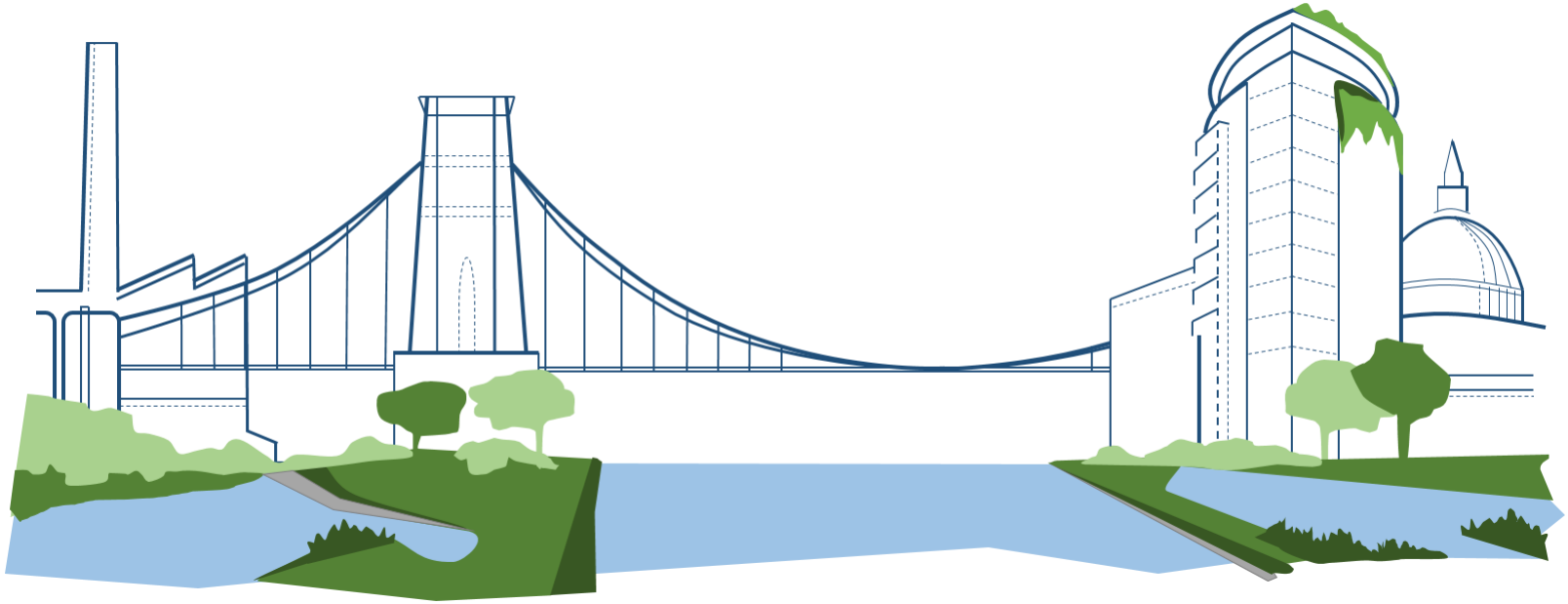
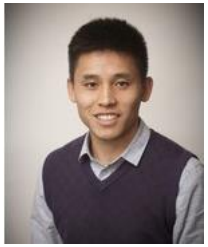
EPSRC
Pioneering research and skills

Assessment of long-term performance of Green infrastructure in urban catchments





Dr Sangaralingam Ahilan
Centre for Water Systems, University of Exeter

- Barriers to adoption of Blue-Green infrastructure
- Ouseburn catchment, Newcastle upon Tyne, UK
- East Lents floodplain restoration, Portland, USA

Grey to Green

- Grey infrastructure

Flood defence

- Green infrastructure

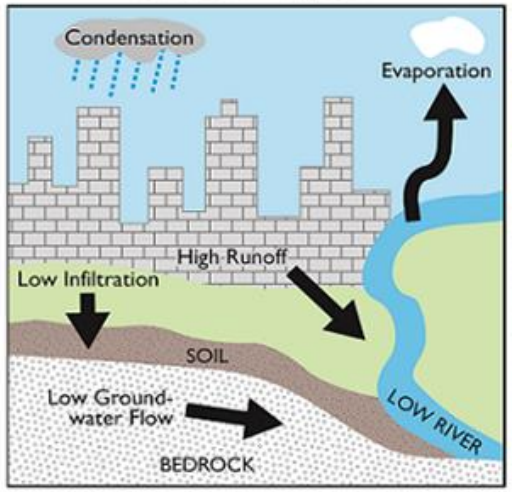
Flood risk management

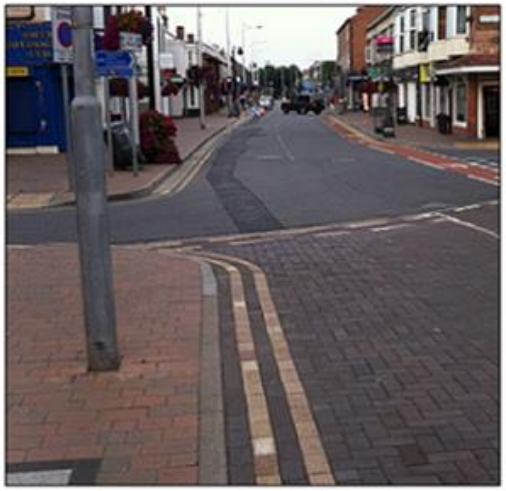
Blue-Green Cities

Hydrologic and environmental attributes in

Water Cycle | Streetscape

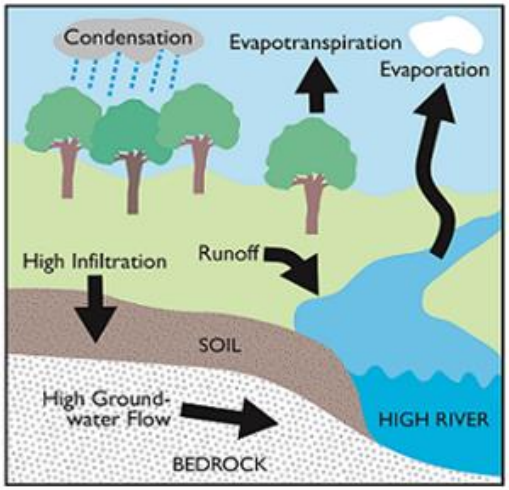
Urban





Grey

Natural



and Blue-Green Cities

Barriers to adaptation of Blue-Green infrastructure

- Physical science (preconceptions)
- Technical / technological

- Institutional
- Legal / regulatory
- Political
- Monetary
- Social – ‘hearts and minds’

Aim:

Investigate long-term flow and sediment dynamics of the green infrastructure.

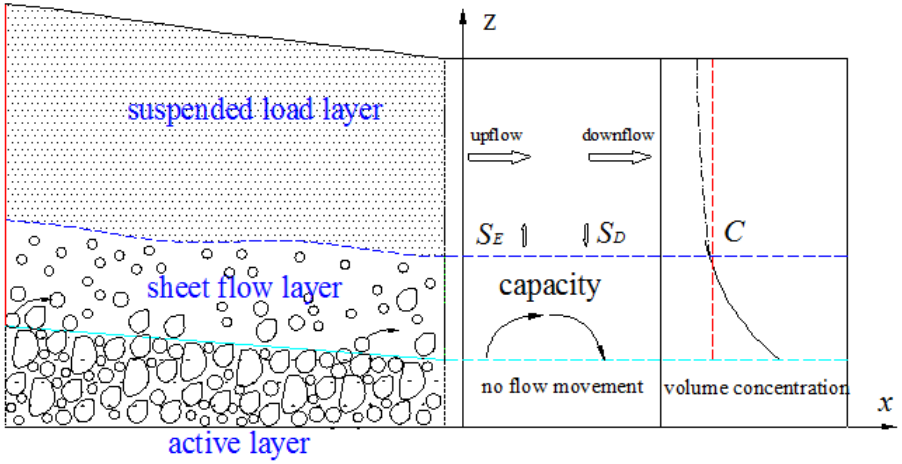
Approach

The hydro-morphodynamic model developed by (Guan *et al*, 2014, 2015) is used.

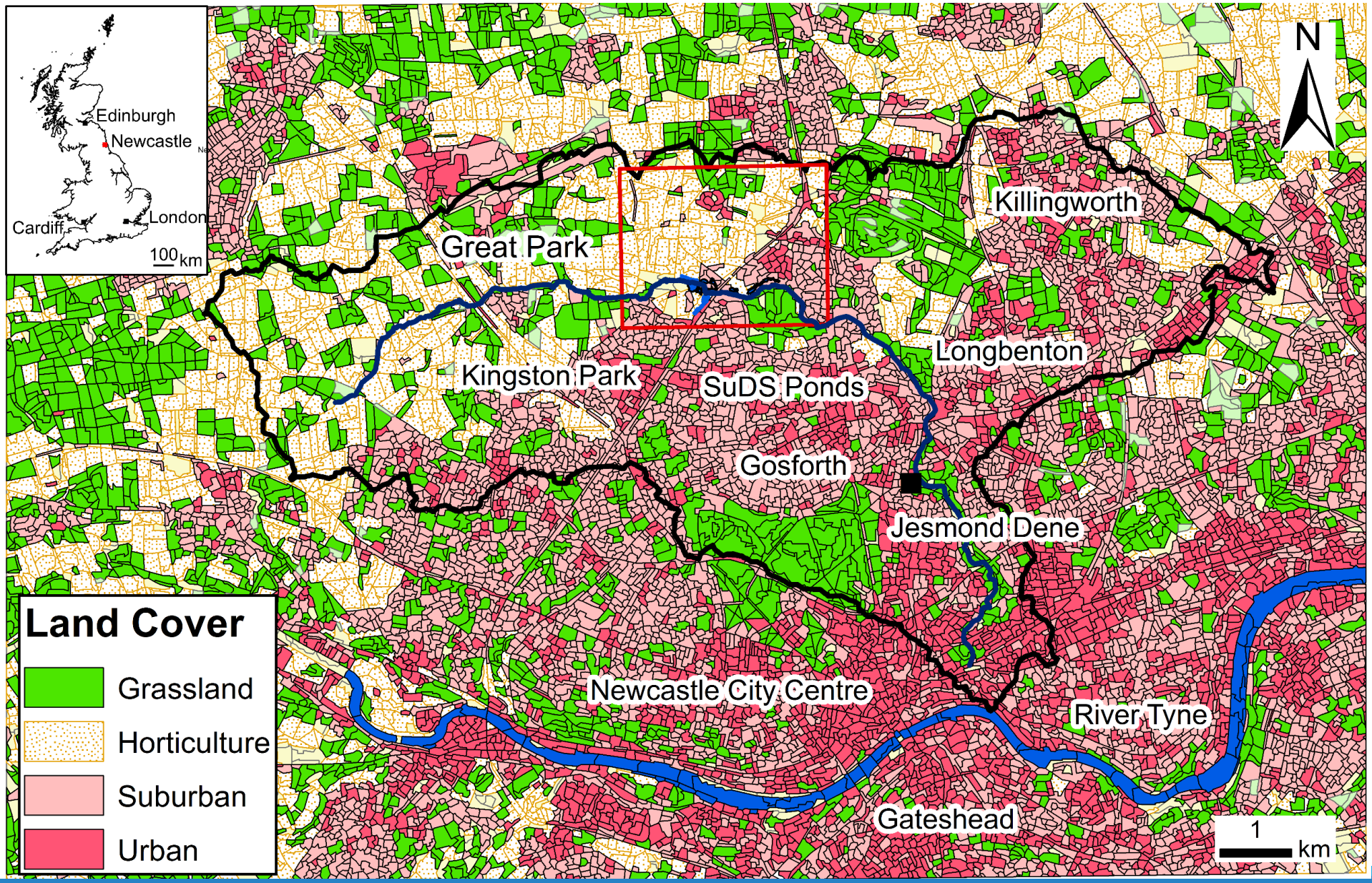
(1) full 2D shallow water equation, +

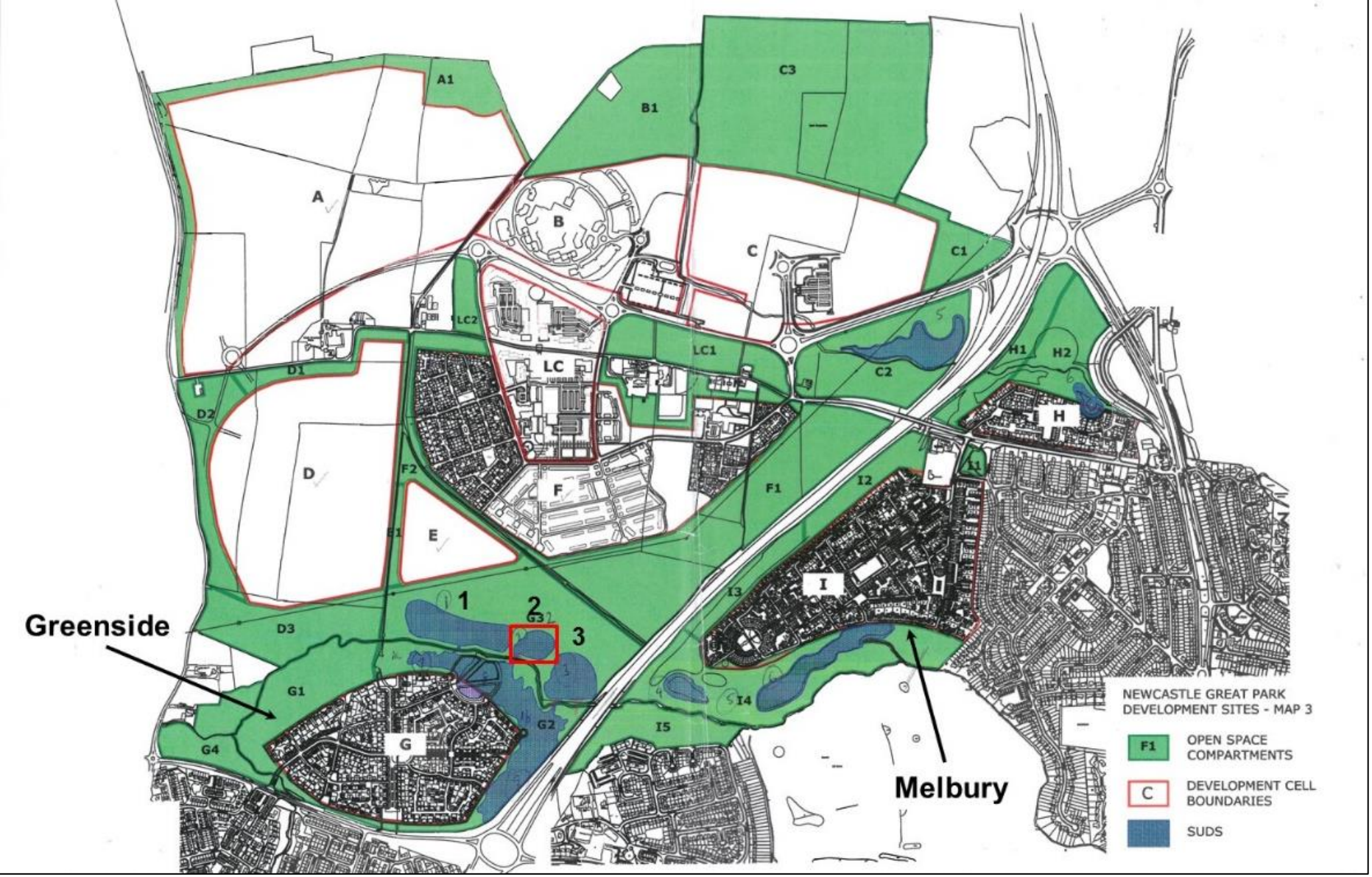
(2) dispersion-advection equation, +

(3) morphological evolution equation.

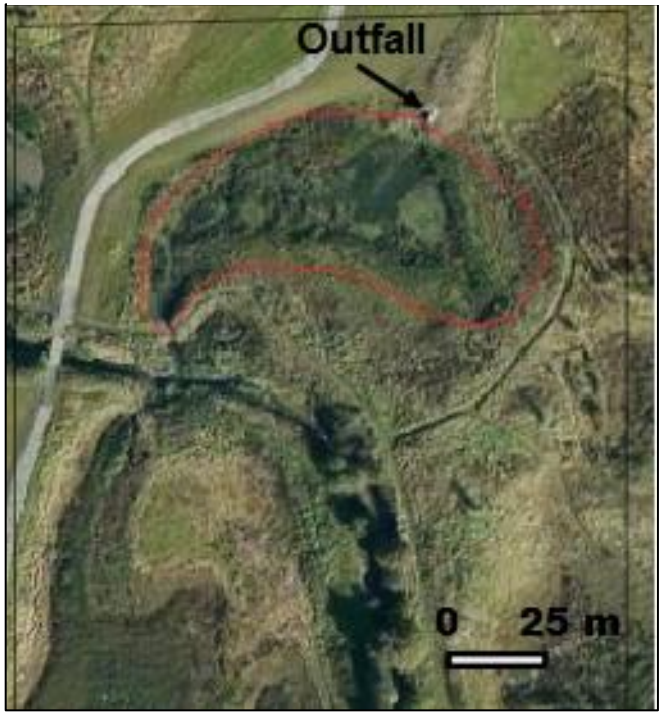


Ouseburn catchment

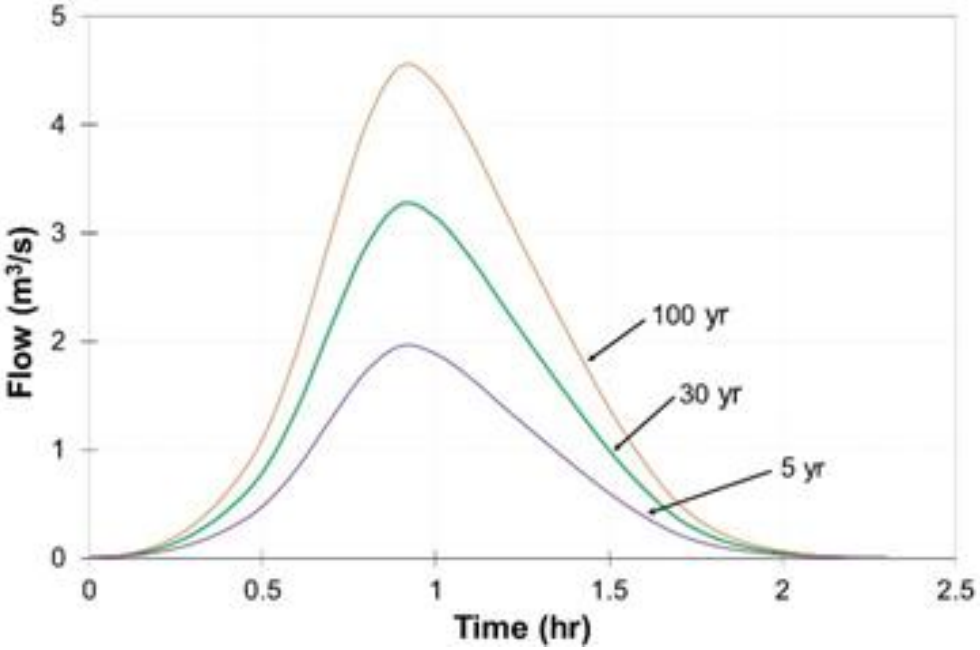



Greenside
Melbury
1
2
3
A
A1
B
B1
C
C1
C2
C3
D
D1
D2
D3
E
E1
F
F1
F2
G
G1
G2
G3
G4
H
H1
H2
I
I1
I2
I3
I4
I5
LC
LC1
LC2
NEWCASTLE GREAT PARK
DEVELOPMENT SITES - MAP 3
F1
OPEN SPACE
COMPARTMENTS
C
DEVELOPMENT CELL
BOUNDARIES
SUDS

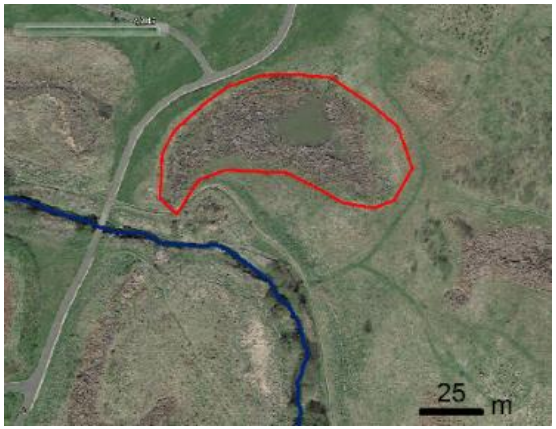
Stormwater pond

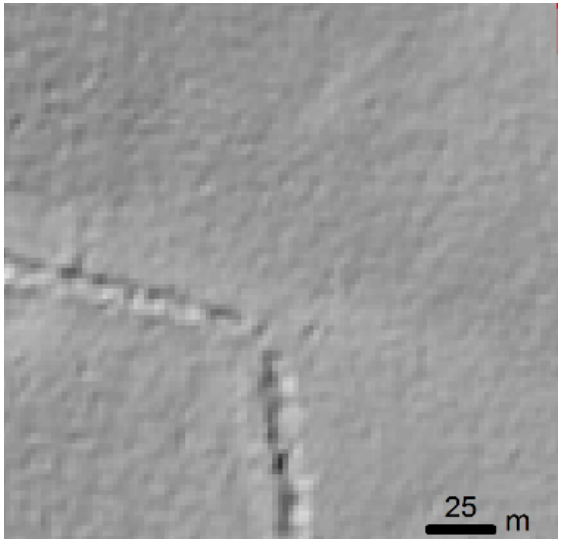


Event-based hydro-morphodynamic simulation

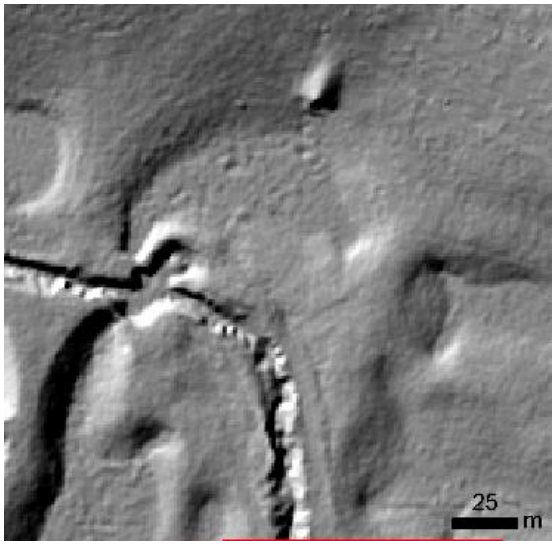


Aerial view





Topography



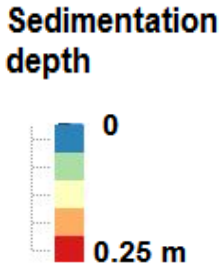
Predevelopment

Current

Event-based hydro-morphodynamic simulation

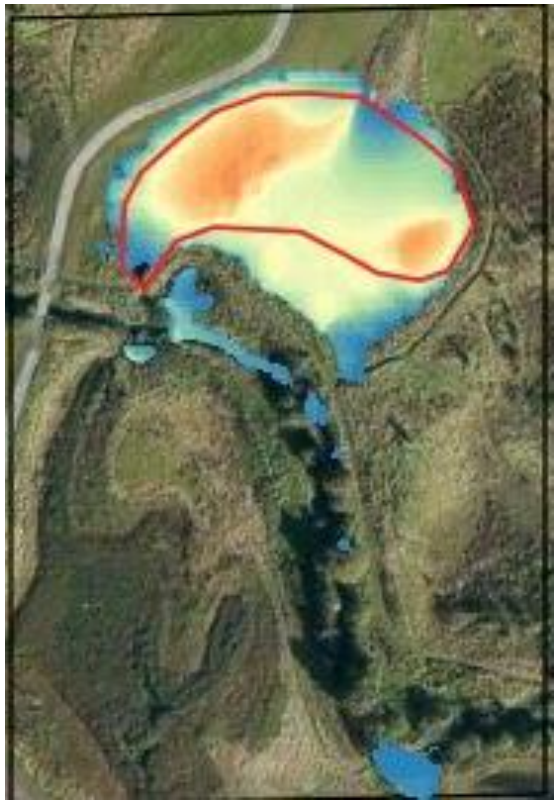
5-year ‘without’ pond

5-year ‘with’ pond

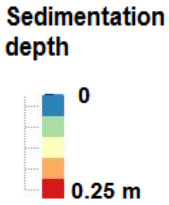


Input (SSL m^3)	7.35
Deposited in the Pond (SSL m^3)	4.58
% SSL deposit	62.03

30-year ‘without’ pond

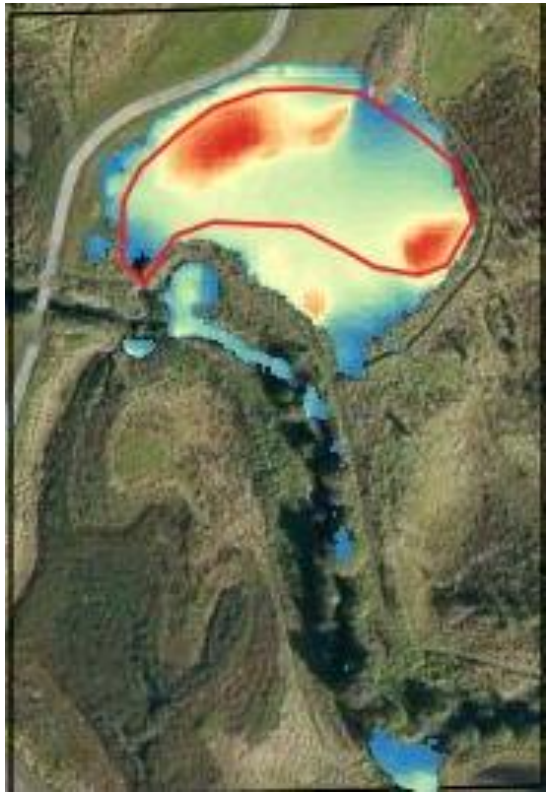


30-year ‘with’ pond

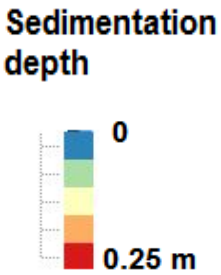


Input (SSL m^3)	16.71
Deposited in the Pond (SSL m^3)	7.29
% SSL deposit	43.63

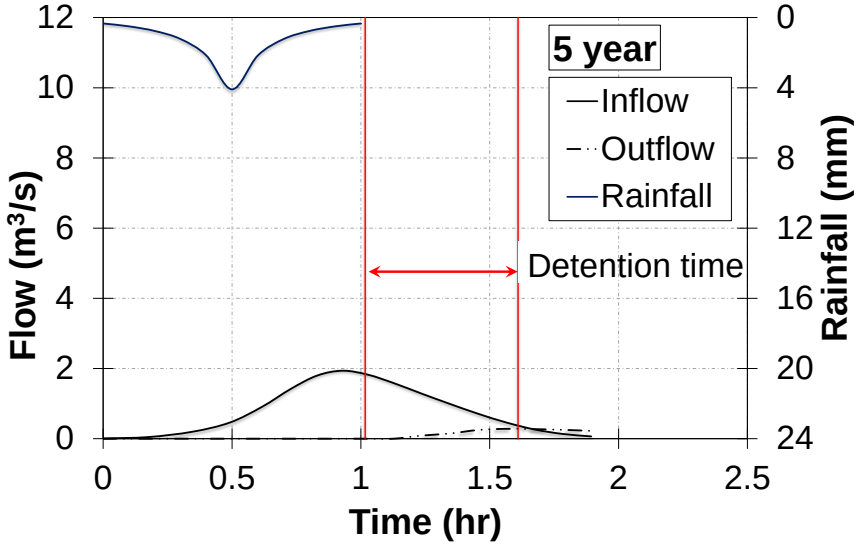
100-year ‘without’ pond

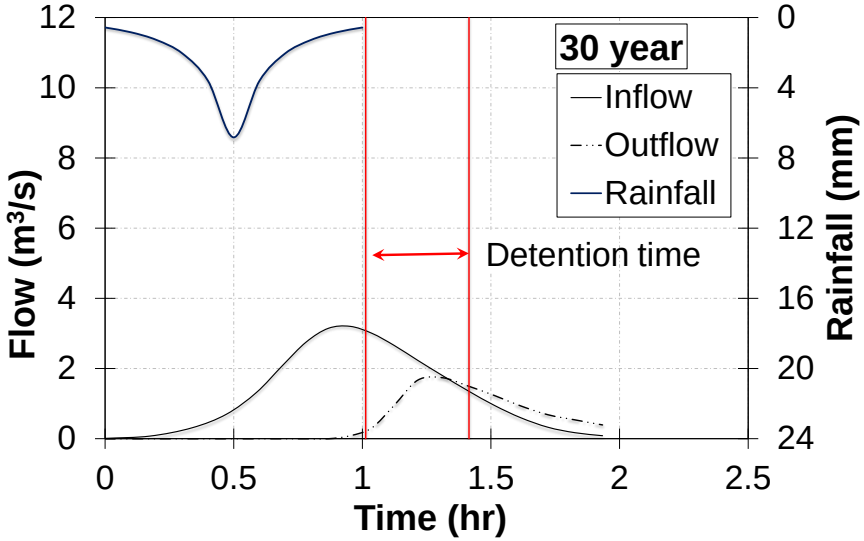


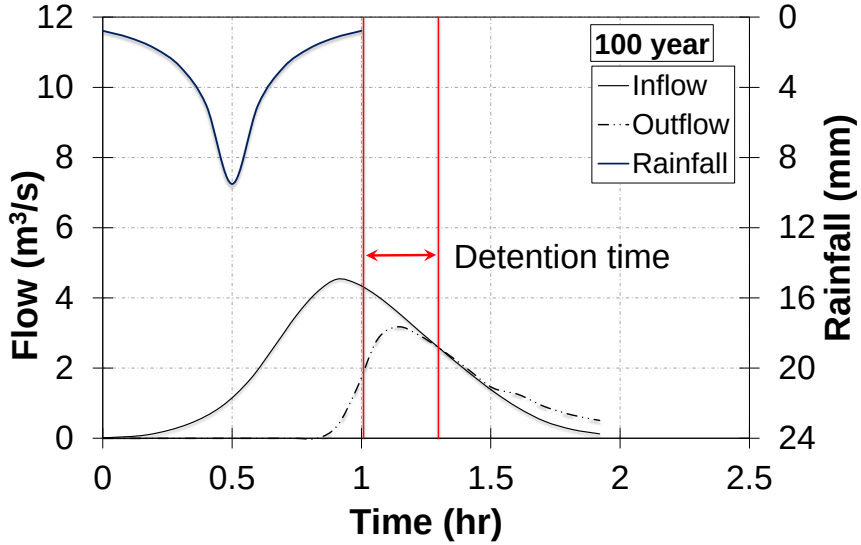
100-year ‘with’ pond



Input (SSL m^3)	28.41
Deposited in the Pond (SSL m^3)	7.50
% SSL deposit	26.40



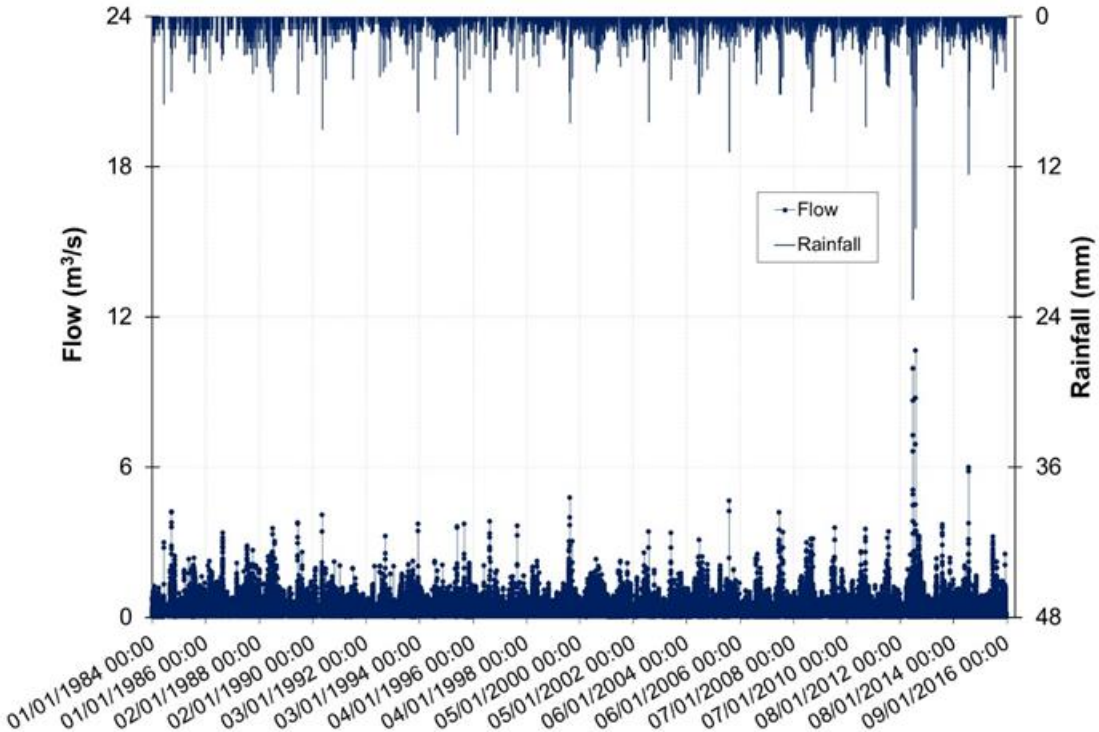


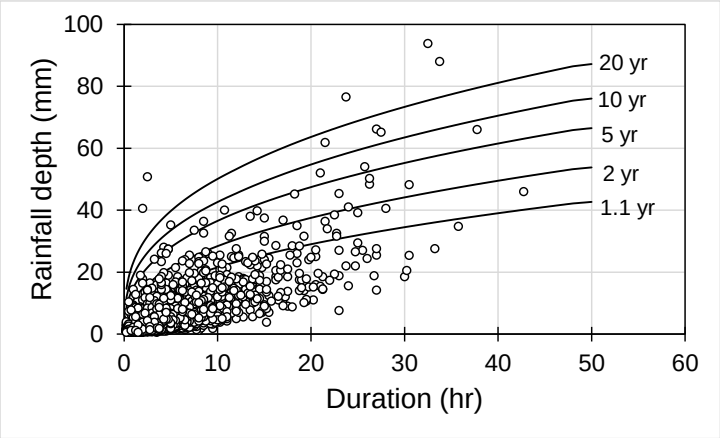


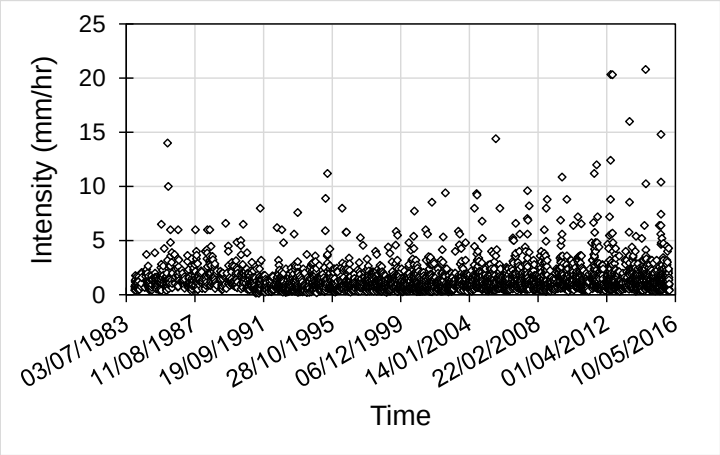
Hydraulic evaluation

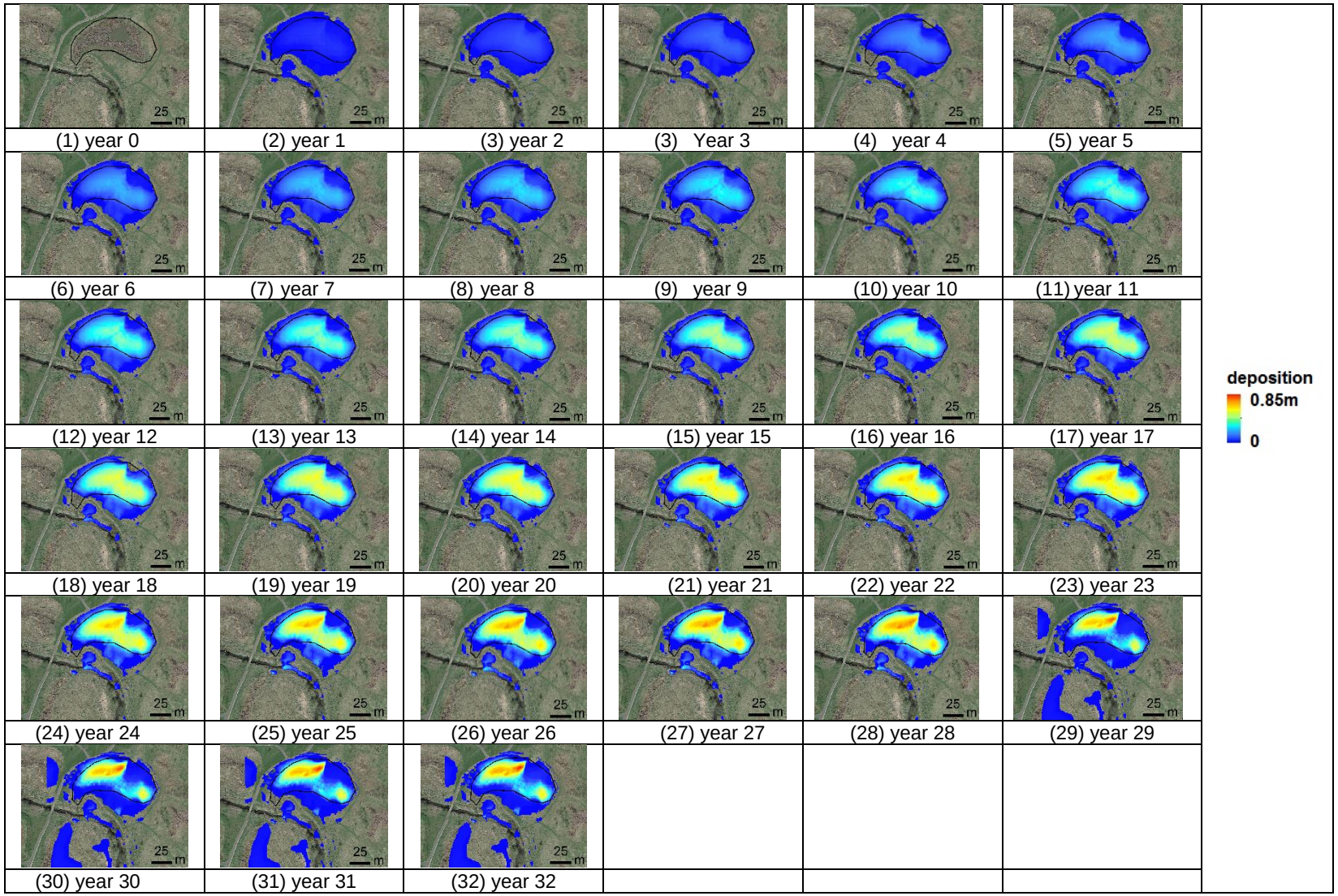
Pre-sedimentation

Long-term simulation








(1) year 0
(2) year 1
(3) year 2
(3) Year 3
(4) year 4
(5) year 5
(6) year 6
(7) year 7
(8) year 8
(9) year 9
(10) year 10
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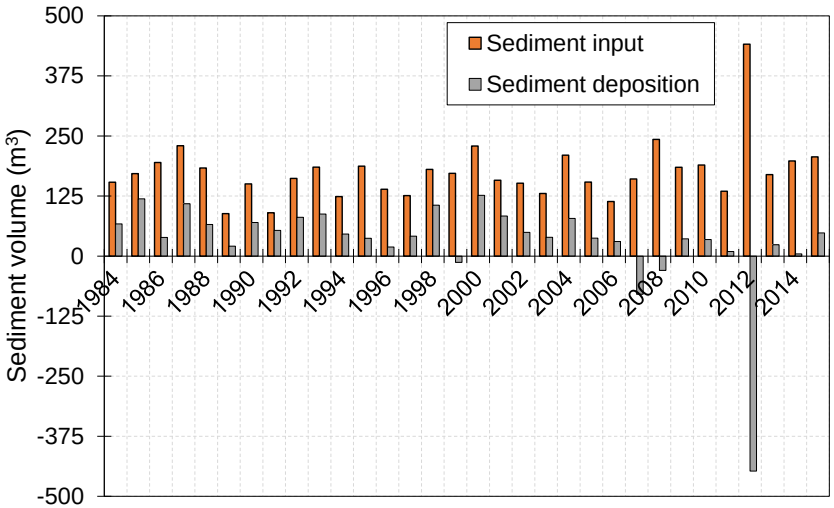
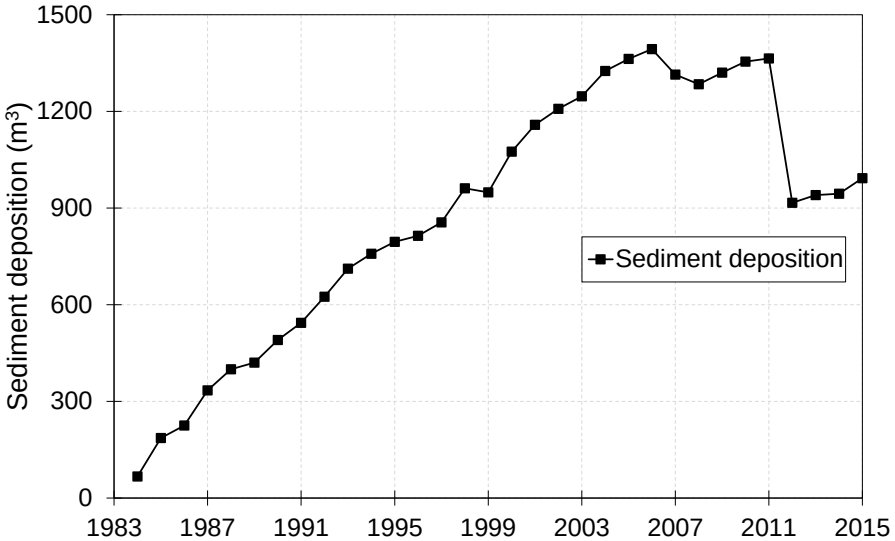
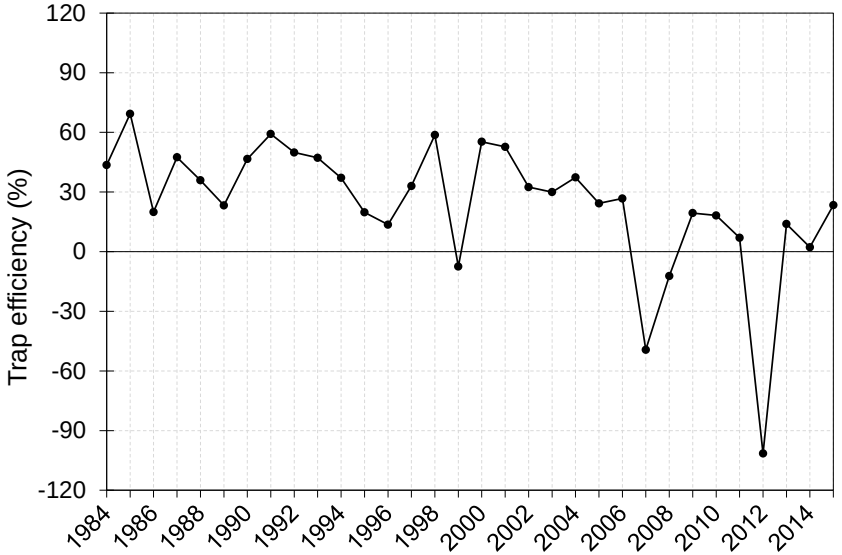
(22) year 22
(23) year 23
(24) year 24
(25) year 25
(26) year 26
(27) year 27
(28) year 28
(29) year 29
(30) year 30
(31) year 31
(32) year 32
25 m
deposition
0.85m
0





Cumulative sediment accumulation in the pond



Annual sedimentation and trap efficiency of the pond

	5-year		30-year		100-year	
	Relative Attn (%)	HRT (hr)	Relative Attn (%)	HRT (hr)	Relative Attn (%)	HRT (hr)
Pre-sedimentation	85.45	0.59	45.75	0.40	29.95	0.29
Post-sedimentation						
After 5 years	84.68	0.58	45.28	0.40	28.46	0.28
After 10 years	81.41	0.58	42.26	0.40	28.20	0.28
After 20 years	75.15	0.51	36.64	0.34	25.59	0.25
After 30 years	77.47	0.54	38.11	0.36	26.35	0.26

Journal of
Flood Risk Management
CIWEM

The influence of floodplain restoration on flow and sediment dynamics in an urban river

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2 Faculty of Technology, De Montfort University, Leicester, UK
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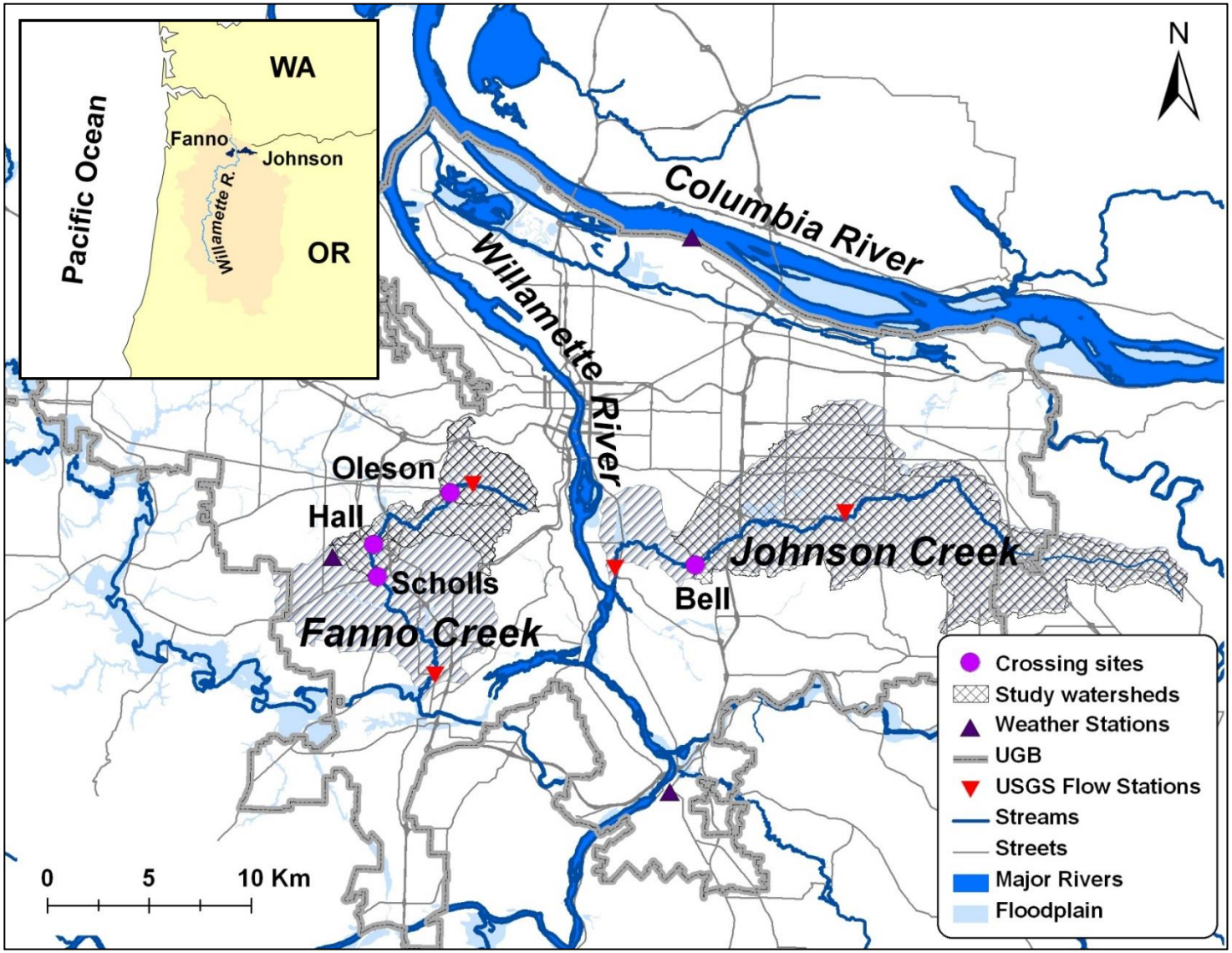
DOI: 10.1111/jfr3.12251

Key words
Floodplain; hydro-morphodynamic model; river restoration; sediment dynamics; urbanisation.

Abstract

A study of floodplain sedimentation on a recently restored floodplain is presented. This study uses a two-dimensional hydro-morphodynamic model for predicting flow and suspended-sediment dynamics in the downstream of Johnson Creek, the East Lents reach, where the bank of the river has been reconfigured to reconnect to a restored floodplain on a 0.26 km^2 (26-ha) site. The simulation scenarios include 10-, 50-, 100- and 500-year event-based deposition modelling of flood events and long-term modelling using the 64 historical flood events between 1941 and 2014. Simulation results showed that the restored floodplain significantly attenuates the upstream flood peak by up to 25% at the downstream. Results also indicated that approximately 20%–30% of sediment from the upstream is deposited on the East Lents floodplain. Furthermore, deposited sediment over the simulated period (1941–2014) is approximately 0.1% of the basin's flood storage capacity; however, the reduction in the storage does not offset the overall flood resilience impact of the flood basin. The sediment conservation at the East Lents flood basin as predicted by the model reduces the annual sediment loading of the Johnson Creek by 1% at the confluence with Willamette River, providing both improved water quality and flood resilience further downstream.

Johnson Creek, Portland



Source: Chang *et al*. 2010 *Annals of the Association of American Geographers*

Why study about Johnson Creek

- Regular Flooding

Creek has flooded 37 times since 1942

- Water Quality Issues
  - High **faecal coliform**
  - Chronically **low dissolved oxygen** (DO)
  - High water temperatures in the summer
  - Low pH (elevated water acidity)

Johnson Creek management strategies

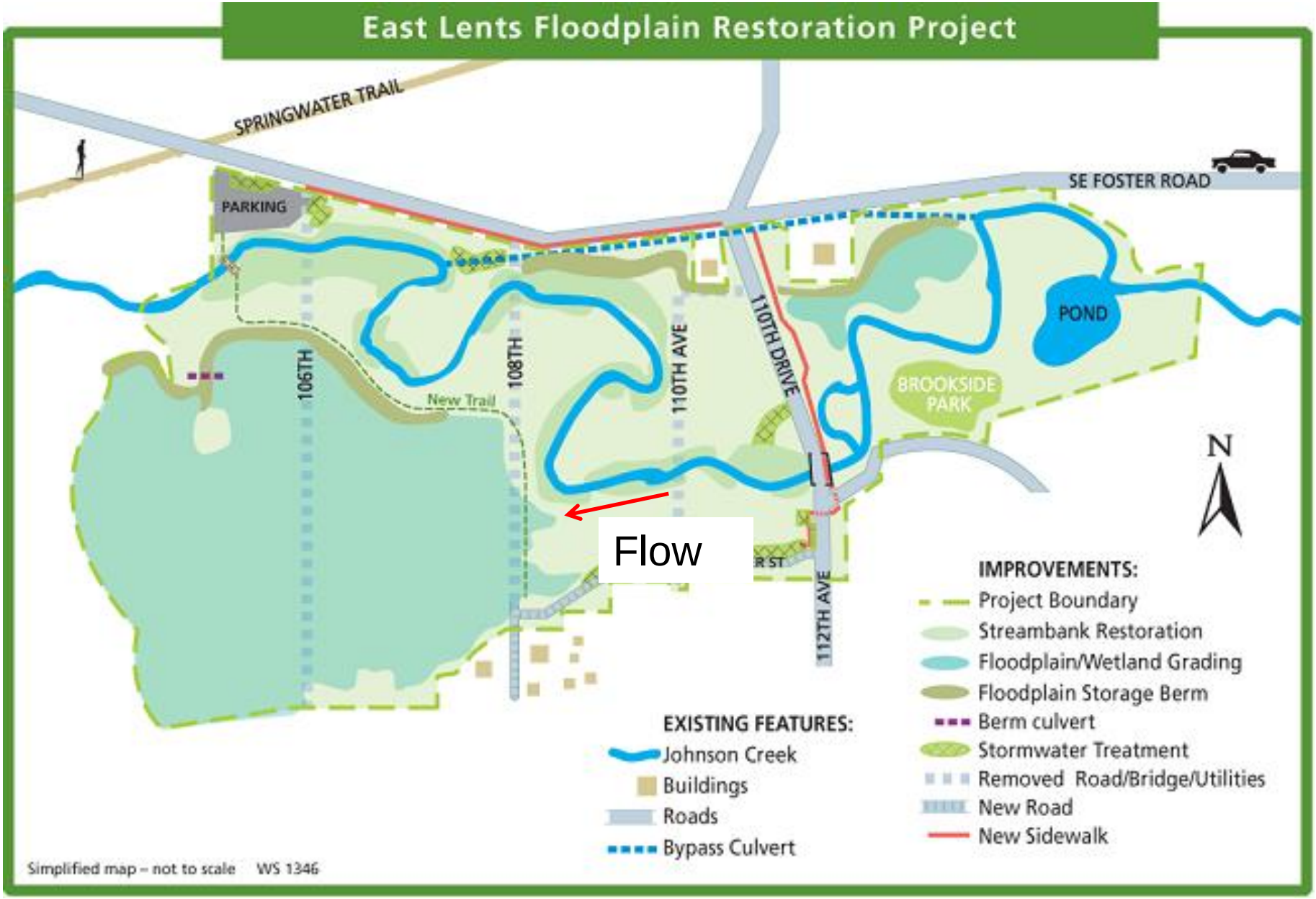
Grey Infrastructures

1) Widening
2) Deepening
3) Rock-lining the creek
4) Creating a trapezoidal channel

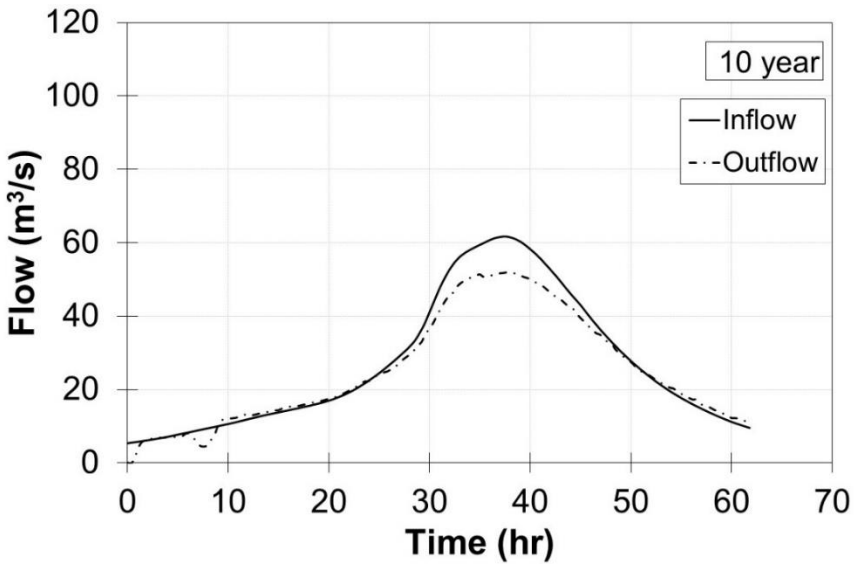
Green Infrastructures

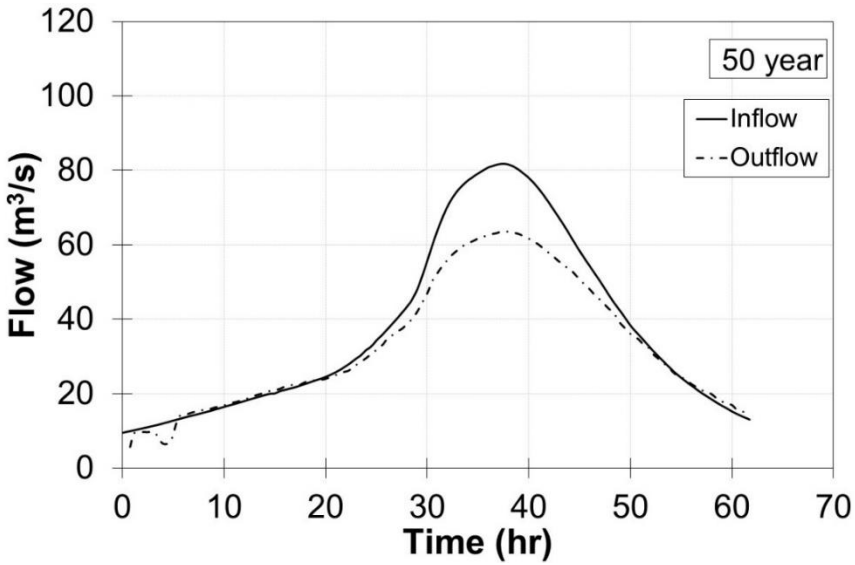
1994, Pre Land Acquisition

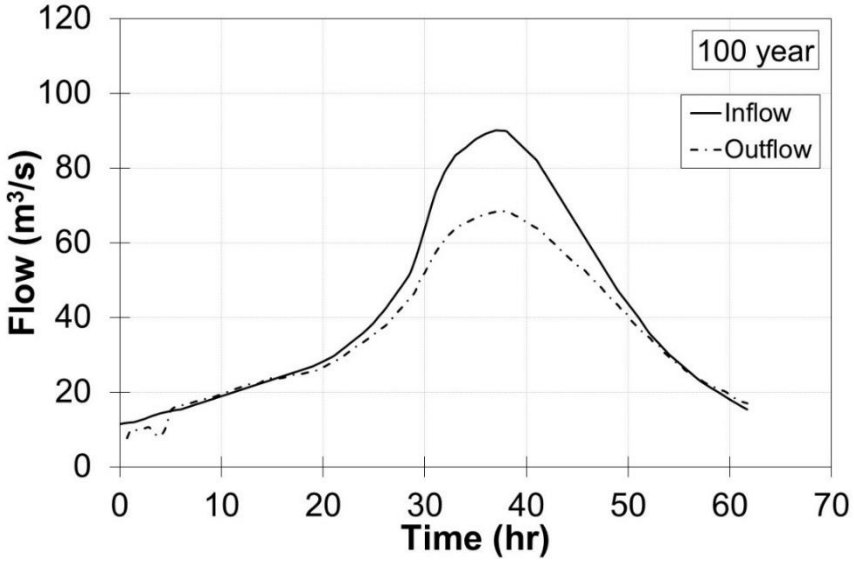
2011, Post Phase I Restoration

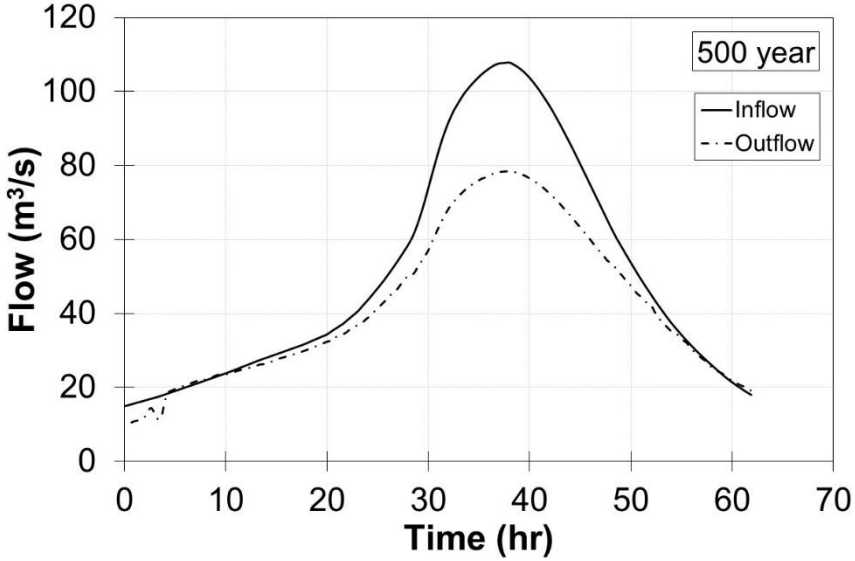

East Lents Floodplain Restoration Project
SPRINGWATER TRAIL
SE FOSTER ROAD
PARKING
106TH
108TH
110TH AVE
110TH DRIVE
112TH AVE
New Trail
POND
BROOKSIDE PARK
N
Flow
IMPROVEMENTS:
Project Boundary
Streambank Restoration
Floodplain/Wetland Grading
Floodplain Storage Berm
Berm culvert
Stormwater Treatment
Removed Road/Bridge/Utilities
New Road
New Sidewalk
EXISTING FEATURES:
Johnson Creek
Buildings
Roads
Bypass Culvert
Simplified map – not to scale WS 1346

Flood peak attenuation



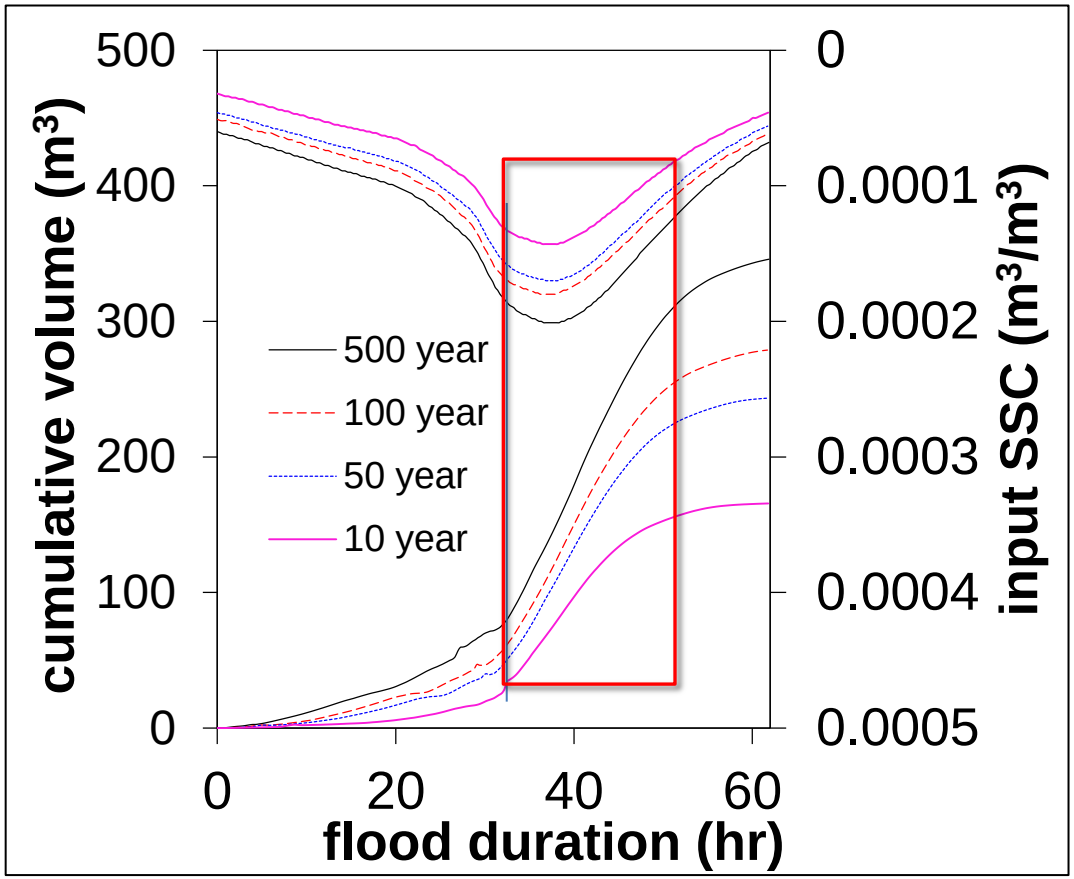


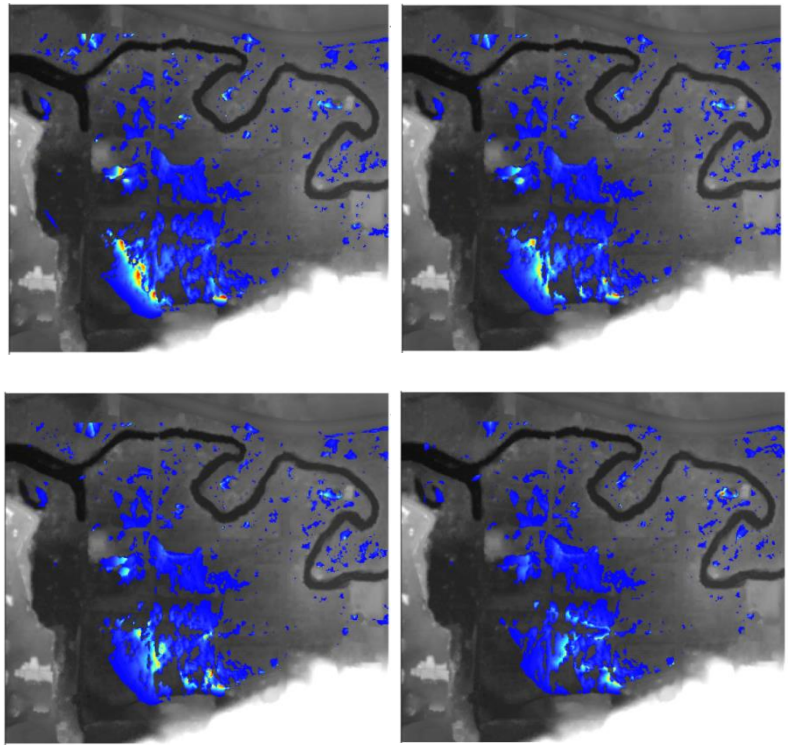




Event-scale deposition in the floodplain

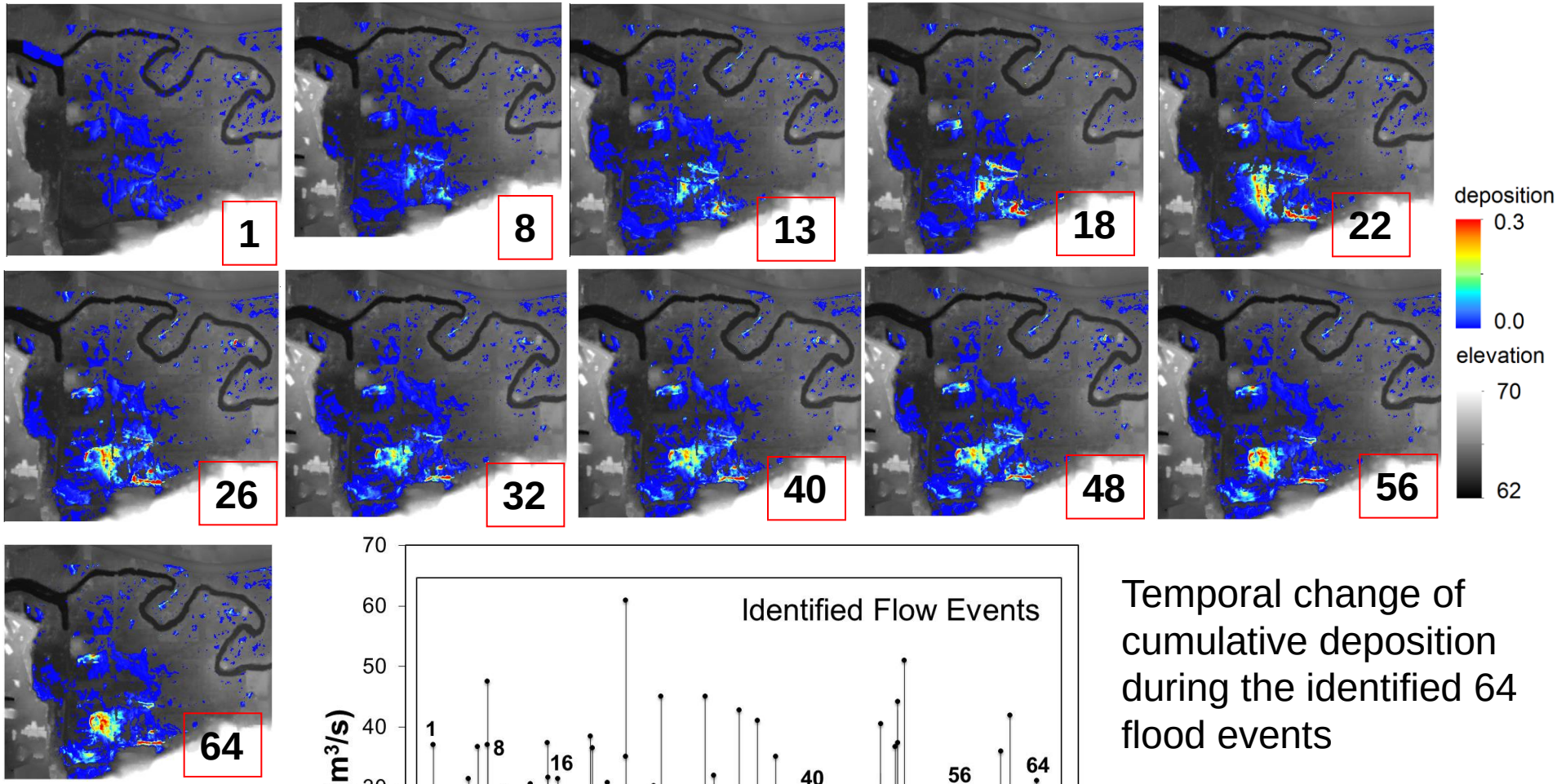
- Meanwhile, the overbank flow lead to amount of sediment deposition in the floodplain.
- Over 20% of total input sediment was deposited.
- A faster deposition rate during peak period.

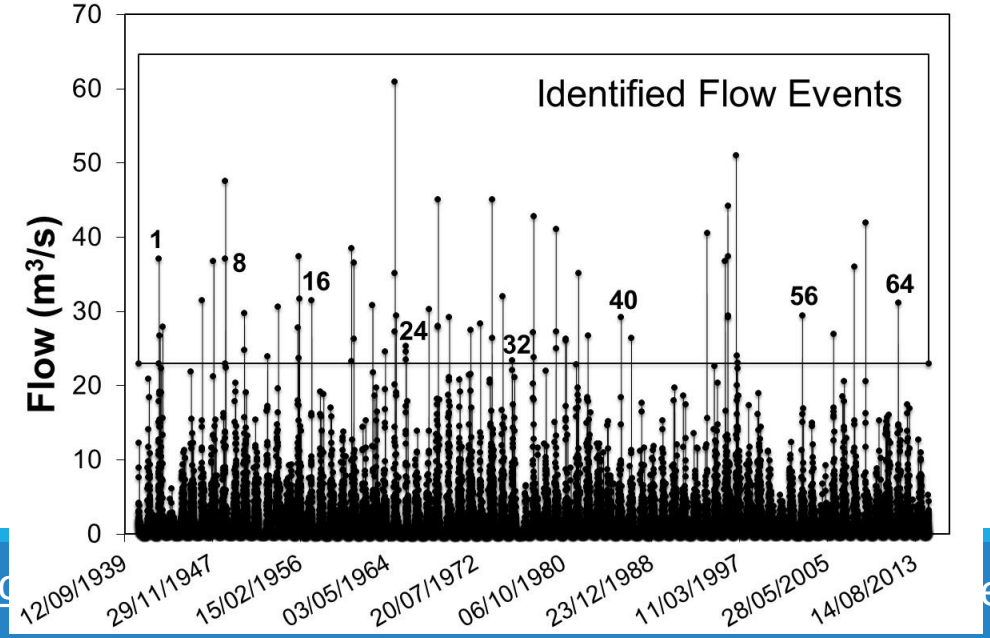




Final cumulative sediment deposition in the floodplain

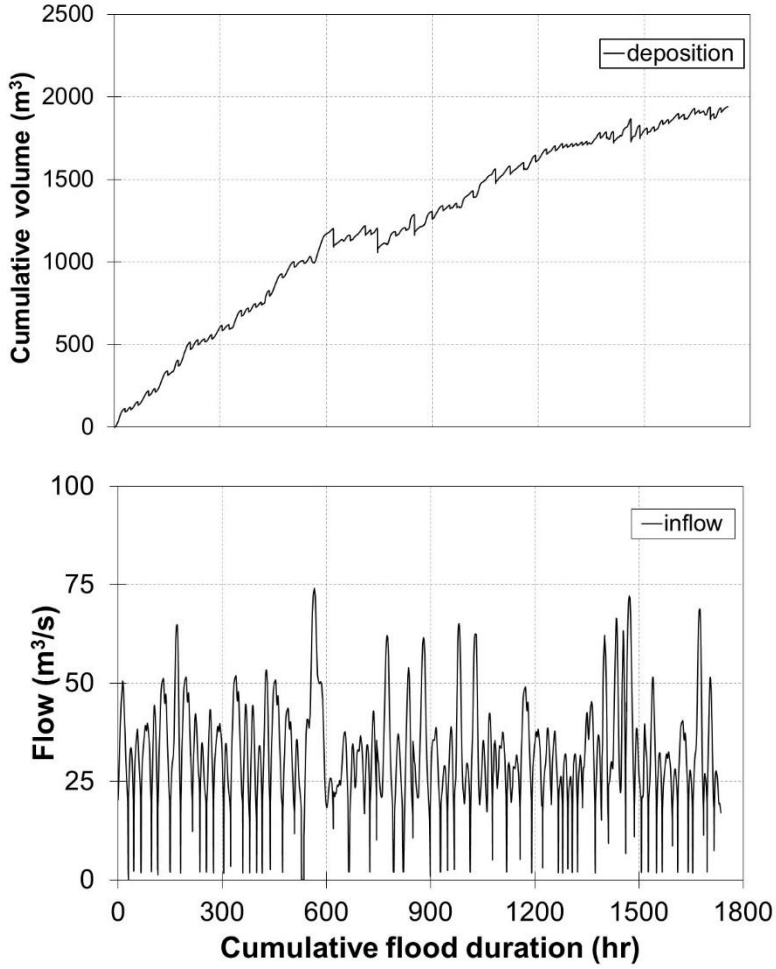
Sediment deposition in East Lents floodplain during continuous flooding





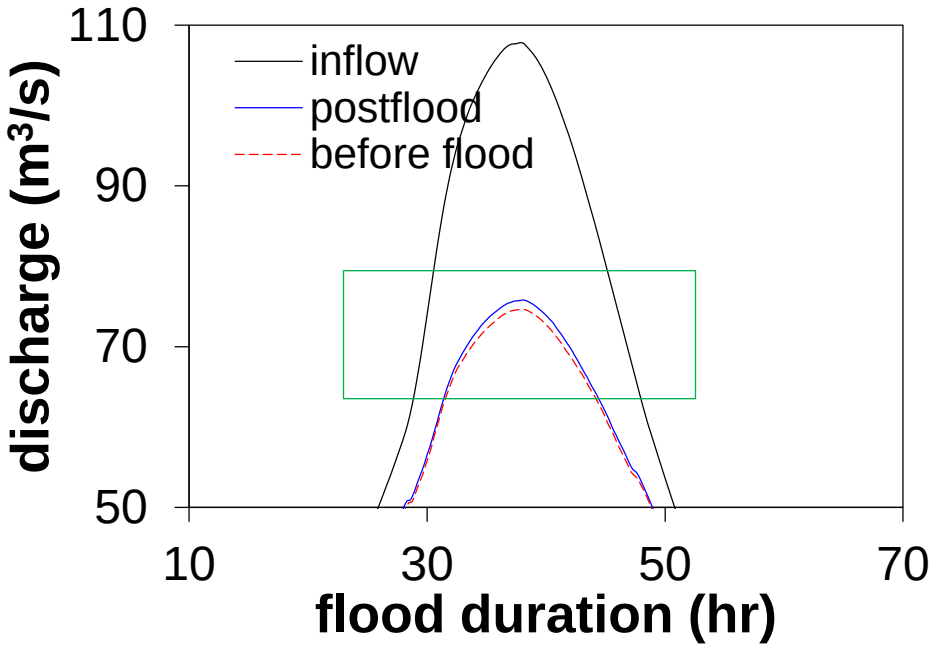
Temporal change of cumulative deposition during the identified 64 flood events

Cumulative sediment deposition in East Lents floodplain during continuous flooding

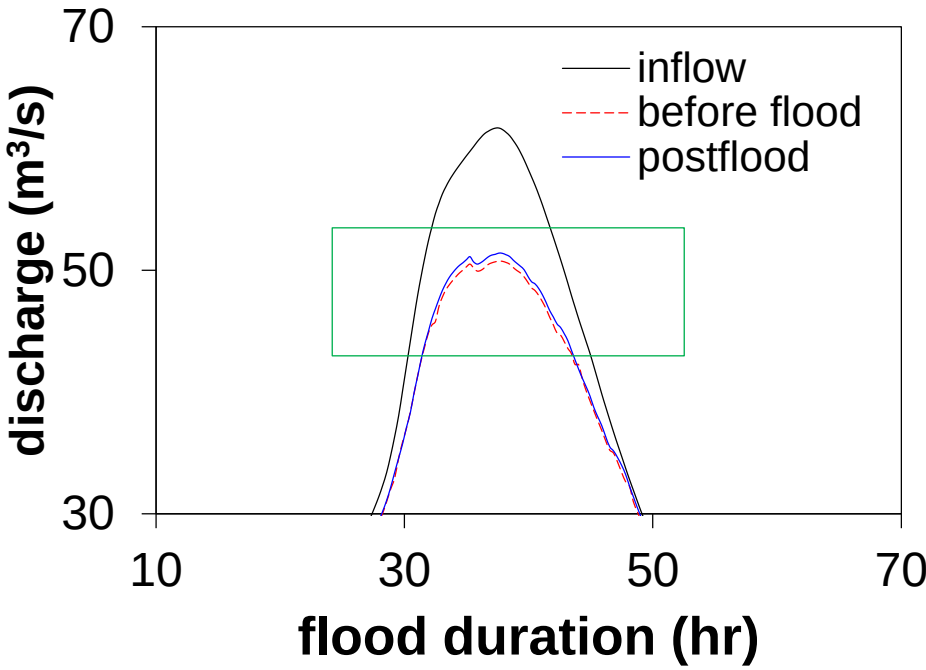


Effect of sediment deposition on downstream flood peak

It does increase downstream flood peak, but just slightly because of the small deposition volume in the floodplain.



500-year



10-year

Floodplain restoration:

- Working with river's natural dynamics is essential for long term sustainability.
- Restored East Lents floodplain provides up to 30% flood peak reduction.
- Floodplain provides up to 20-30% sediment trapping.
- Sediments tend to concentrate during the moderate (5-25 year) flow events at lower elevations. Larger events re-suspended the previously deposited sediments.
- At the end of the 64 long-term simulation, 2000m^3 of sediment was deposited in the floodplain.


Welcome
WITAMY
Добро Пожаловать
Tervetuloa
Üdvözlet
MALIGAYANG PAGDATING
歡迎
Soo Dhawoow
Chào mừng
خوش امدی
आपका स्वागत है
Bienvenido
YISHINEUH
WILLKOMMEN
歡迎
FOSTER FLOODPLAIN
NATURAL AREA
ENVIRONMENTAL SERVICES
CITY OF PORTLAND
working for clean rivers
PORTLAND
PARKS & RECREATION
Healthy Parks, Healthy Portland
FEMA
More fish. Less flooding.
Thank You Portland!