

Case study 17. Blackbrook Slow the Flow, St Helens

Authors: Mike Norbury, Rick Rogers, David Brown

Main driver: Flood risk management – repeated flooding in the Blackbrook area of St Helens (October 2000, September 2012 and 26 December 2016)

Project stage: Seeking funding opportunities to implement a catchment-scale Natural Flood Management Plan



Photo1: Engineered dam 2 – attenuation and suspended sediment settlement during flood flows

Project summary:

Blackbrook in St Helens, Merseyside, experiences repeat flooding from a combination of main river and surface water sources. There are 18 properties at flood risk, 3 of which are businesses; a major truck A-road is also at risk. The current flood risk is high.

Blackbrook has a 5% chance of flooding in any given year and sits in a low-lying bowl at the confluence of 5 rapid response catchments whose upstream area is 21km². The property level protection put in place has had limited success, partly due to a failure in its operation at the time of the last flood (26 December 2016). Flooding also occurred on 28–29 October 2000 and 24–26 September 2012.

Capital solutions to reduce the flood risk are prohibitively expensive, as culvert enlarging would be required to reduce the flow constriction. Such considerable capital interventions do not qualify for full funding under HM Treasury rules on cost-benefit ratios. Significant additional funding would therefore be required.

Project Summary (continued):

Run-off attenuation features (RAFTs) installed upstream have helped reduce the flood risk. Four engineered log dams have been installed, which attenuate 2,500m³ (approximately the volume of an Olympic swimming pool). But while a considerable volume, this is less than 1% of the catchment volume required to reduce the risk of flooding to a 1% risk.

Since the first intervention, Local Levy money has funded a detailed hydrology and hydraulic modelling study. This modelling determined the effectiveness of a series of natural measures including:

- a flood relief wetland (7,000m³)
- de-culverting a reach of Black Brook
- further catchment attenuation on a rapid response tributary, Clipsley Brook

If these 3 measures and a flood defence bund are implemented, it is estimated that the overall floodwater depth would be reduced by 900mm in a 1 in 100 year event.

To eliminate a 1% flood risk, with a climate change legacy allowance of 20%, 300,000m³ of catchment attenuation is required. A series of 16 additional RAFTs would provide a further 17,000m³. If instigated, these 16 RAFTs together with the 3 measures listed above could deliver 24,000m³ of catchment attenuation. This volume would be capable of removing the 1 in 5 year flood risk and reducing depths for larger return period events such as a 1 in 20 year event.

St Helens Metropolitan Borough Council is currently working to identify possible locations to site sufficient catchment-scale interventions to attenuate the 1 in 100 year flood event, plus an allowance for the effects of future climate change.

This project has developed the reverse engineering concept by modelling a return period flood event which does not cause flooding but is near bankfull capacity (A) and then modelling an event to the design standard of protection (B). Subtracting the scaled hydrographs determines the required volume of catchment attenuation to reduce the flood risk.

Key facts:

Construction of 3 engineered log dams (also known as engineered log jams, sedimentation dams or hybrid dams) was funded by Natural England as part of a project to restore Stanley Bank Site of Special Scientific Interest (SSSI) and cost £1,200. The contractor, Groundwork, made use of Green Energisers, a back-to-work training initiative for unemployed young people. Two Environment Agency environment days resulted in the construction of a fourth log dam. The estimated cost of the 4 ELJs is £2,000, which gives a rough cost of £1.25 per 1m³ of attenuation and less than for conventional attenuation approaches. Photo 1 and Appendices 6 and 7 show the impact of the second ELJ.

The initiative aimed to improve habitat and reduce the risk of flooding, and came about due to collaborative, partnership working.

The scheme has also resulted in reduced levels of phosphate and nitrate in Black Brook. Average phosphate-P concentrations have fallen by 3.6mg L⁻¹ in flows through the natural dam filters (Figure 1); nitrate-N levels have also fallen (Appendix 11).

By 2035, it is estimated that ~790m³ of sediment will be stored in ponds 1, 2 and 3 (Figure 2), which in a small way will enhance the capacity of Black Brook and St Helens Canal (main river). Sediment limits the capacity of these watercourses, exacerbating flooding at constriction points such as bridges and culverts (Appendices 2 and 3).

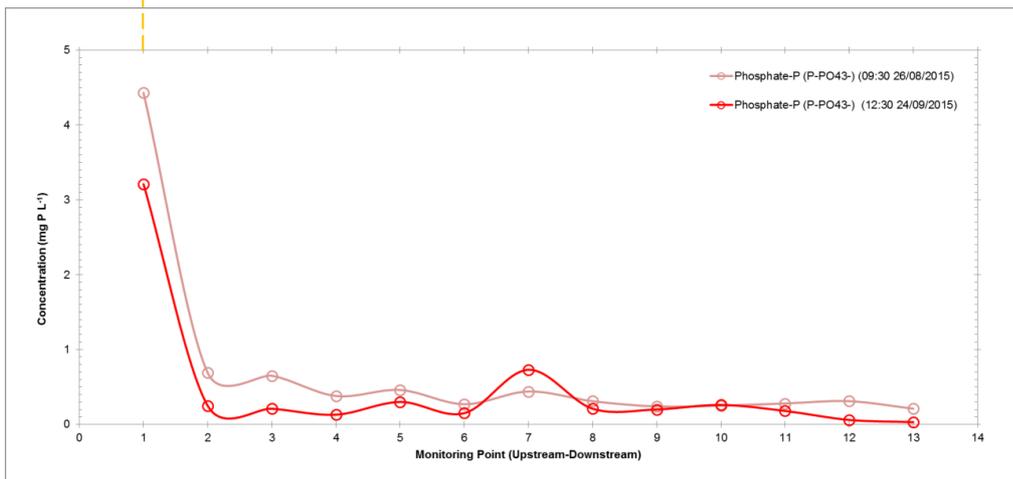
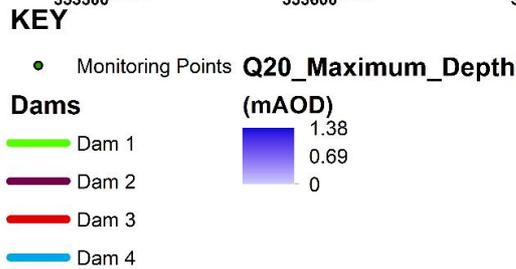
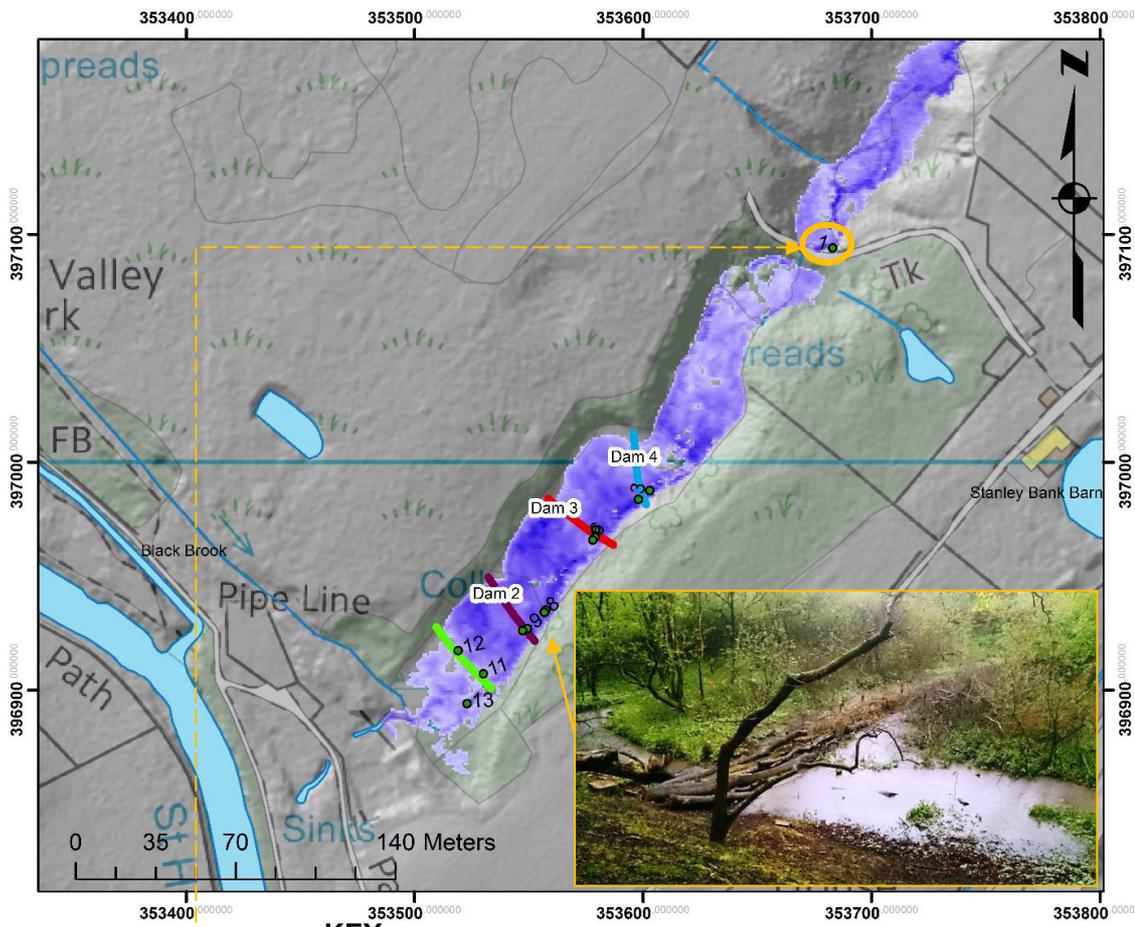


Figure 1: Stanley Brook engineered log dams – flood risk and water quality evidence. Flood depths derived from 1D Flood Modeller, Environment Agency LiDAR (1m) topography and Ordnance Survey (OS) data. Phosphate-P (ortho-P PO₄³⁻) reduction through 4 dams.

Source: Mike Norbury (map, modelling and photo), Kate Harris (phosphate graph)

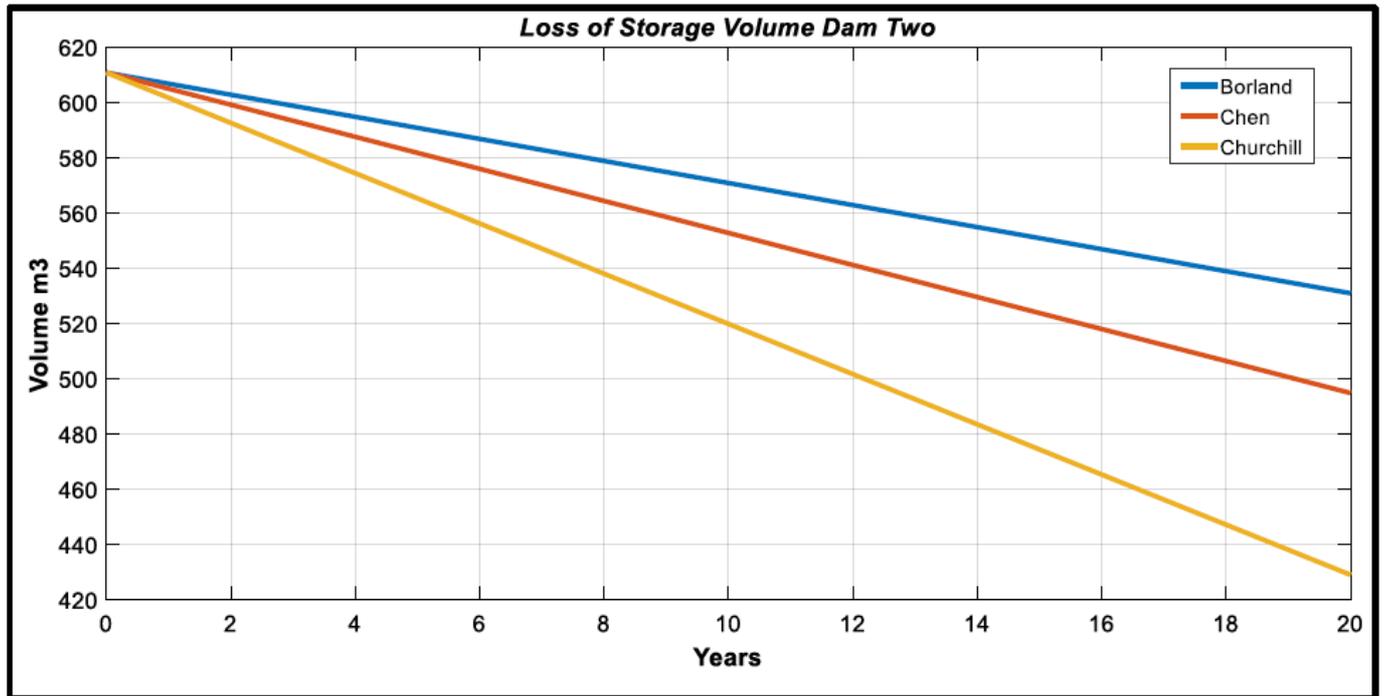


Figure 2: Predicted loss of storage volume due to deposition of sediment at engineered log dam 2 – calculation is based on the Borland, Chen and Churchill methods (source: McParland et al. 2016, Figure 3.5)

1. Contact details

Contact details	
Name(s):	Michael Norbury, Rick Rogers, Paul Thomas, David Shaw, Matthew McParland, Peter Jones, Brenden Cassin, David Brown
Lead organisation(s):	St Helens Council, Natural England, University of Liverpool (School of Environmental Science), Waterco Consultants, Groundwork, Environment Agency
Partners:	
e-mail address:	RickRogers@sthelens.govuk M.Norbury@liverpool.ac.uk david.j.brown@environment-agency.gov.uk

2. Location and catchment description

Catchment summary	
National Grid Reference:	353524, 396909
Town, County, Country:	St Helens, Merseyside, UK
Regional Flood and Coastal Committee (RFCC) region:	North West
Catchment name(s) and size (km²):	21km ²

River name(s) and typology:	Black Brook (Mersey Estuary) (GB112069061230) – low, small, calcareous St Helens Canal (GB71210088) – canal
Water Framework Directive water body reference:	GB112069061230, GB71210088
Land use, soil type, geology, mean annual rainfall:	<p>Topography: a low lying catchment of gentle relief, ranging from 178m above Ordnance Datum (AOD) to 20m AOD</p> <p>Soils: Coal Measures in the north overlain by sand and peat; Sherwood Sandstone in the south, overlain by Boulder Clay</p> <p>Land use: arable farmland predominates in the headwaters with sporadic small settlements and road infrastructure. As the catchment enters its lower reaches, it moves towards St Helens Central Business District which is increasingly urbanised; the Sankey Country Park is vital green infrastructure within this urbanised area.</p> <p>Seasonal average annual rainfall: 1,139mm for 1941 to 1970; 903mm for 1961 to 1990</p> <p>Factors affecting run-off:</p> <ul style="list-style-type: none"> • Run-off reduced by public water supply abstraction (P) • Run-off increased by effluent returns (E) • Run-off reduced by industrial and/or agricultural abstraction (I)

3. Background summary of the catchment

The Sankey Valley has a rich industrial heritage, with the conversion of Sankey Brook starting in 1755 by an Act of Parliament. Since the building of the Blackbrook branch of the Canal, the natural form of Black Brook watercourse has become heavily engineered to maintain levels in the canal via a mill pond (see Appendices 2 and 3). The mining legacy of area means that sections of the brook are culverted and walled to limit egress of ferruginous mine water into the water or erosion of abandoned shafts. Since the collapsed of a section of culvert in the 1970s, Black Brook was diverted to flow into St Helens Canal. During high levels, an inlet weir allows the canal to drain into Black Brook. The area now bears the hallmarks of a post-industrial landscape, with local notable employers including Pilkington Glass. However, unemployment affects some in the local community and Blackbrook is one of the most deprived wards in the UK (see Appendix 13).

Flood risk problem(s)

These arise from:

- the canal surcharging water into Black Brook at a culvert inlet adjacent to key properties (see Appendices 2 and 3)
- overbank topping of St Helens Canal, particularly in the area of Blackbrook where the road bridge is – the bridge deflects high flows which run-off down an embankment and flood nearby properties

Other environmental problems

- Point source and diffuse pollution arises from ochre and ferruginous discharges from abandoned mines.

- The area suffers from nutrient enrichment from agriculture and point source pollution from combined sewer overflow outfalls.
- Stanley Bank SSSI is affected by invasive Himalayan balsam (*Impatiens glandulifera*).
- Abstraction and wastewater discharge affect both the water resource balance and water quality.

4. Defining the problem(s) and developing the solution

What evidence is there to define the flood risk problem(s) and solution(s)

A previous ISIS 1D hydraulic model (2013) developed by Black and Veatch modelled the options of a long flood defence wall, but found that the length of wall required to reduce flood risk was not cost beneficial. Since the initial modelling study and further instances of flooding, St Helens Council has adopted a proactive approach to managing flood risk.

A Knowledge Transfer Partnership (KTP) between the University of Liverpool and Waterco consultants undertook a detailed study of flood generation mechanisms, and the catchment dynamics and hydrology. The KTP project provided the initial evidence that engineered log dams would be beneficial for water quality, habitat and flood risk (Figures 1 and 2, Appendices 6, 7 and 11). The findings from the KTP lead to St Helens Council commissioning Waterco to develop a detailed 1D-2D fully integrated ISIS-TUFLOW model. This demonstrated the benefit of a series of natural and engineered measures (Figure 1, Appendices 3, 4, 5 and 12).

Recently the Environment Agency, Waterco and St Helens Council have been working on a catchment-wide green infrastructure plan to address multiple objectives – water quality, water quantity, habitat creation and a sustainable travel transport corridor.

What was the design rationale?

- Hold water in the landscape (where feasible) and hold it in the headwaters first.
- Adopt measures that are sustainable and which use local materials and local labour.
- Design within social–ecological systems – focus on the use of volunteers and others.

Project summary

Area of catchment (km²) or length of river benefitting from the project:	21km ²
Types of measures/interventions used (Working with Natural Processes and traditional):	Hard engineering: property level resilience measures including waterproof doors and sump/pumps Soft engineering: engineered log dams
Numbers of measures/interventions used (Working with Natural Processes and traditional):	4
Standard of protection for project as a whole:	Presently, around 10mm of flood depth reduced, as the engineered log dams provide 1% of the attenuation for a 1% event. If the measures outlined above are implemented, the 20% event will be alleviated and depths reduced for a 5% event.
Estimated number of properties protected:	None, currently. The number of properties better protected will depend on the number of interventions (Appendix 4).

How effective has the project been?

See Figure 1 and Appendices 4 to 12 for evidence demonstrating the effectiveness of the existing and proposed measures.

5. Project construction

How were individual measures constructed?

To construct the engineered log dams, felled tree trunks were placed in the stream (2.5 times stream width). They were back-pinned with 200mm diameter fence posts, with two-thirds submerged and one-third protruding.

How long were measures designed to last?

The measures are expected to last about 20 years or longer through geomorphological-induced change.

Were there any landowner or legal requirements which needed consideration?

- Reservoir regulations
- Landowner consent

6. Funding

Funding summary for Working with Natural Processes (WWNP)/Natural Flood Management (NFM) measures

Year project was undertaken/completed:	Began in 2012 Still in progress
How was the project funded:	Natural England – funding of construction of engineered log dams Environment Agency – Local Levy money to St Helens Council to fund hydrology and hydraulic modelling study National Environmental Research Council (NERC) – funded KTP and monitoring work by Matthew McParland Waterco – part funded KTP Arup – part funding of Matthew McParland's research
Total cash cost of project (£):	£1,200 for 3 engineered log dams 1 engineered log dam constructed during 2 Environment Agency environment days – one using a Partnership and Strategic Overview (PSO) team and one using an Operations Delivery team
Overall cost and cost breakdown for WWNP/NFM measures (£):	Flood relief wetland: ~£300,000 Using the won material to construct a flood defence bund: ~£100,000 Stanley Brook engineered log dams: £2,000

WWNP/NFM costs as a % of overall project costs:	No information provided.
Unit breakdown of costs for WWNP/NFM measures:	No information provided.
Cost–benefit ratio (and timescale in years over which it has been estimated):	No information provided.

7. Wider benefits

What wider benefits has the project achieved?

- Water quality restoration: sediment retention, reduced nutrient concentration on Stanley Brook tributary
- Habitat creation: creation of wet woodland
- Employment: use of Groundwork's Green Energisers led to 2 days of work under the initiative

How much habitat has been created, improved or restored?

~400m² of wetland with reduction in phosphate (Figure 1), nitrate (Appendix aa) and suspended sediment concentrations downstream

8. Maintenance, monitoring and adaptive management

Are maintenance activities planned?

St Helens Council – maintenance of engineered log dams

Is the project being monitored?

Ad hoc monitoring is being conducted by Liverpool and Newcastle Universities via a KTP project and MPhil, BSc and PhD research.

Has adaptive management been needed?

Not yet

9. Lessons learnt

What did you learn and how could it be applied elsewhere?

Pros:

- Great demonstrator of what can be done through goodwill, good partnerships and limited financial and human resources
- Consultation and intervention from Environment Agency Operations teams aided the design and led the log dams to be more robust.
- The learning and acceptance of the method should lead to its wider take-up and application elsewhere.

Cons:

- Barriers in the cost–benefit analysis may prejudice future NFM projects.
- Building partnerships relies on good cooperation, time and unfailing commitment.
- A significant additional number of these interventions (around 200) would be required to really make a difference, but this project has demonstrated an approach that can be applied throughout the catchment and is a good start.

10. Bibliography

HARRIS, K., 2016. *Investigating the effects of engineering log jams on flood risk and aqueous nutrient concentration*. BSc thesis, University of Newcastle upon Tyne.

MCPARLAND, M.C., HOOKE, J., COOPER, J., LI, M., NORBURY, M., ROGERS, R. AND BROWN, D., 2016. *Modelling and Monte Carlo simulation of the trapping efficiency of multiple on-line flood storage areas in a peri-urban catchment*. MRes thesis, University of Liverpool.

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NORBURY, M., QUINN, P., BRACKEN, L. AND NICHOLSON, A., 2017. Managing flooding by working with nature. *Planet Earth*, Winter 2016-17, 6-7.

WATERCO, 2016. *Sankey Valley Park, St Helens Flood Management Study*. Waterco Consultants.

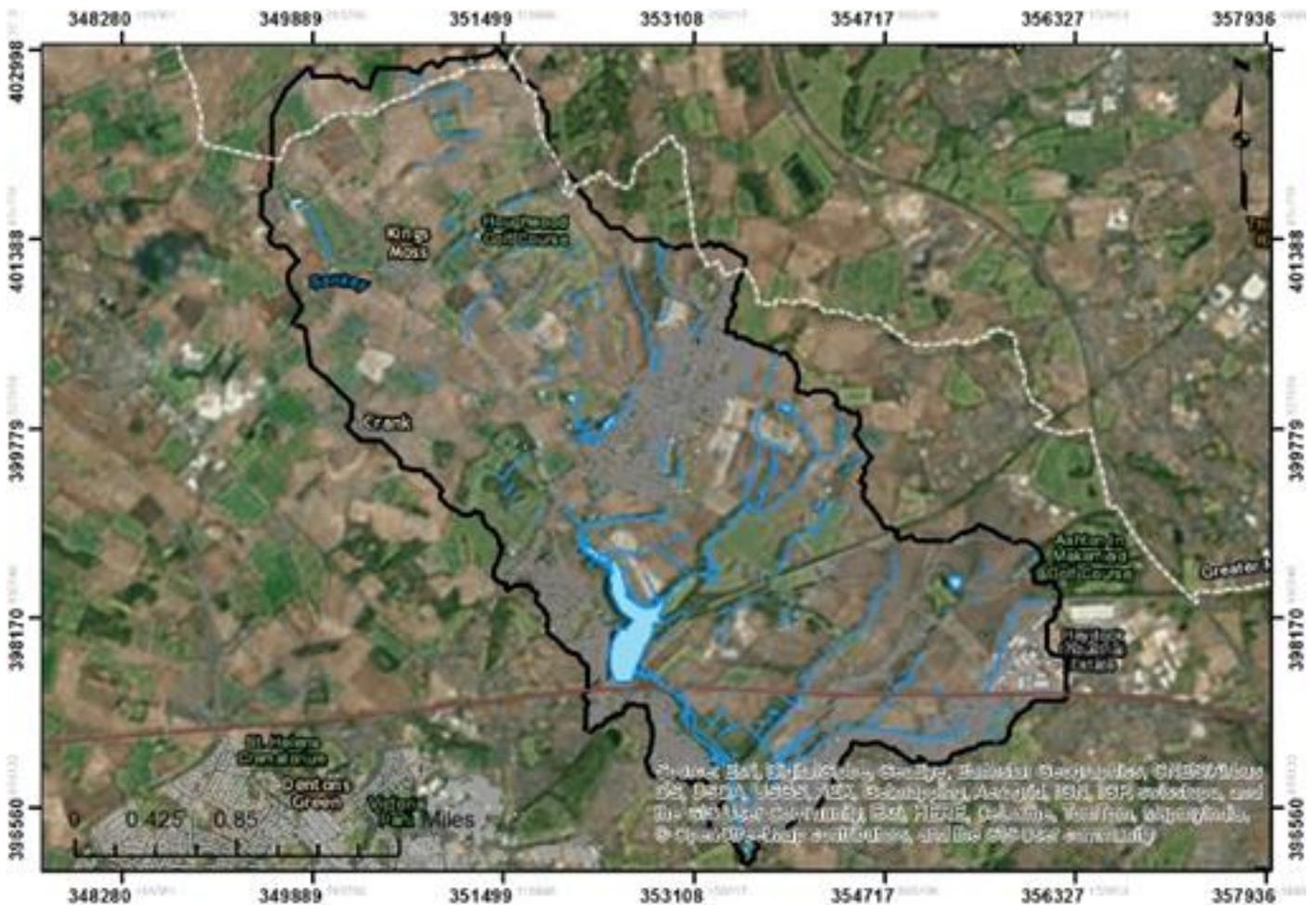
Project background

This case study relates to project SC150005 'Working with Natural Flood Management: Evidence Directory'. It was commissioned by Defra and the Environment Agency's [Joint Flood and Coastal Erosion Risk Management Research and Development Programme](#).

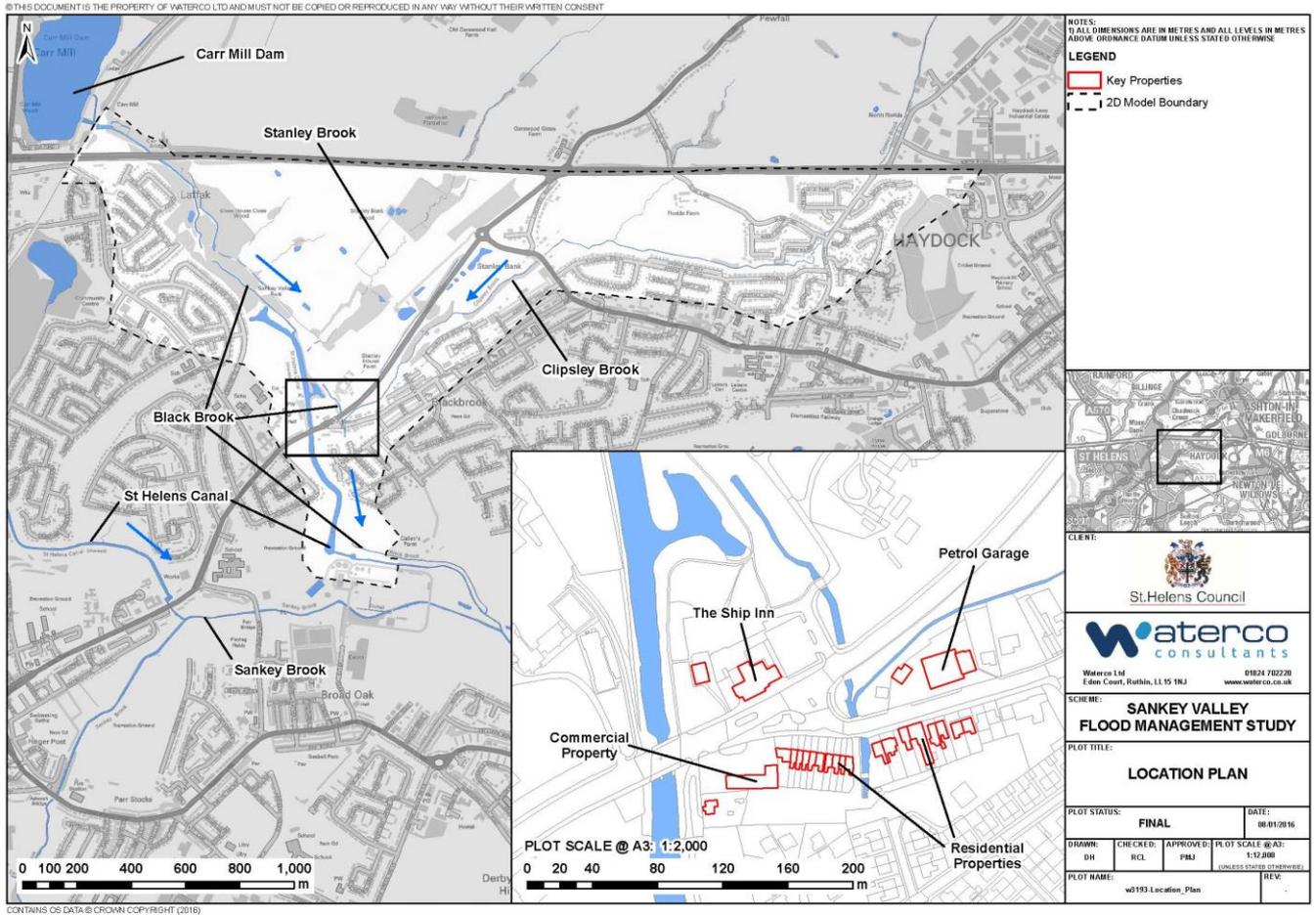
Appendix 1: Flooding in Blackbrook and the surrounding 21km² catchment



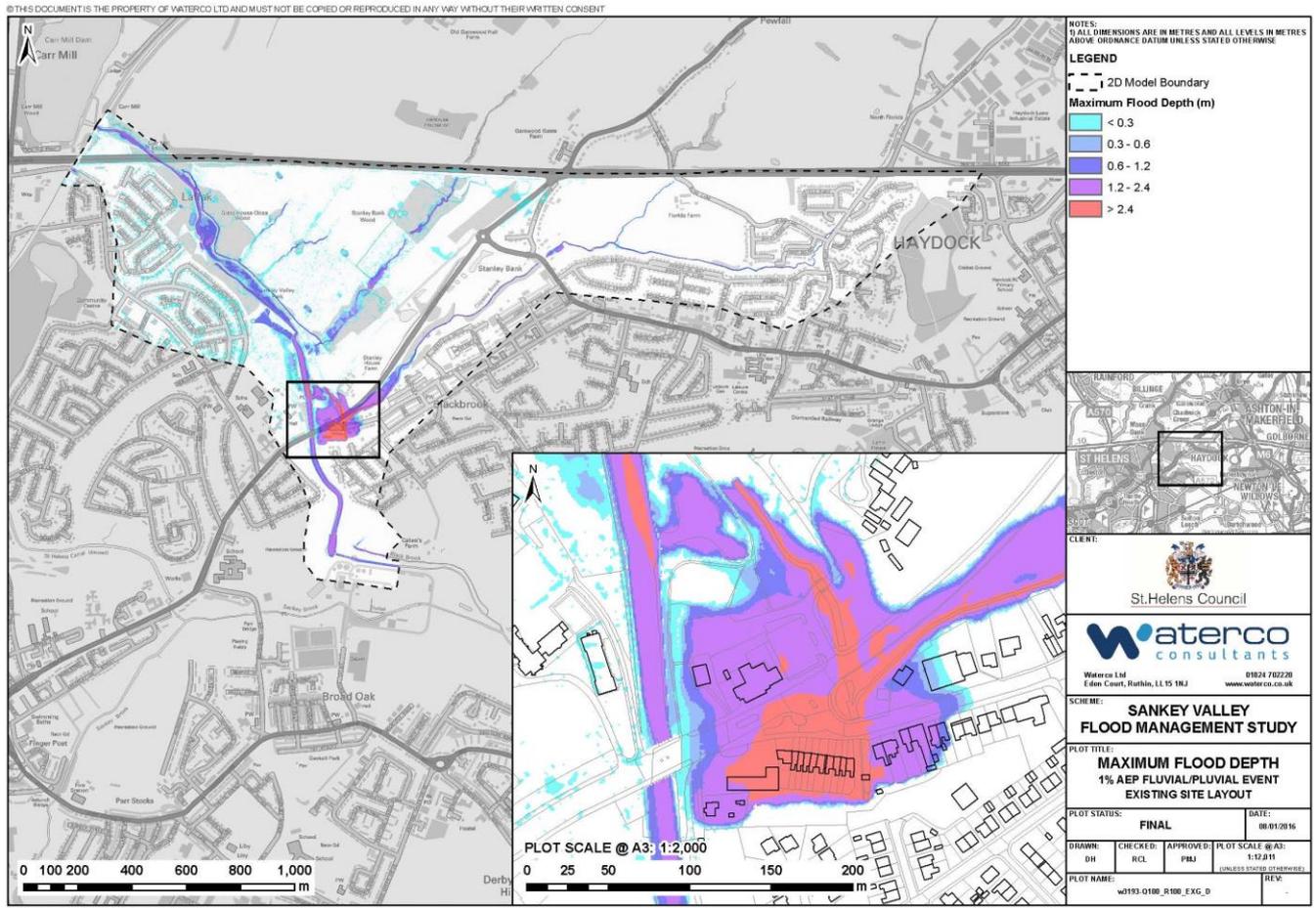
Photo taken during the September 2012 flooding, Blackbrook



Appendix 2: Key properties at risk from flooding in Blackbrook area of St Helens

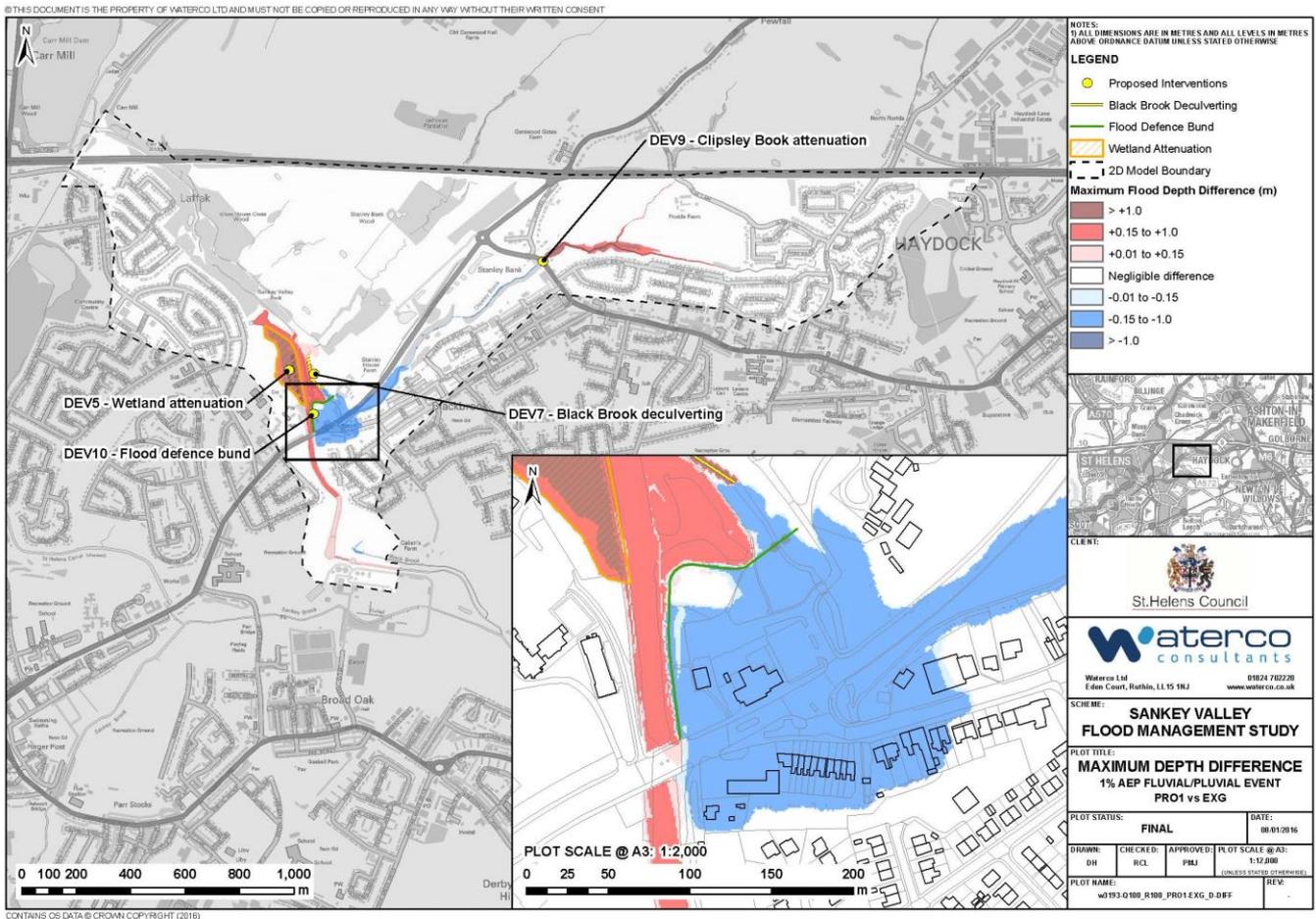


Appendix 3: 1 in 100 year (1% AEP) flood risk in Blackbrook, St Helens

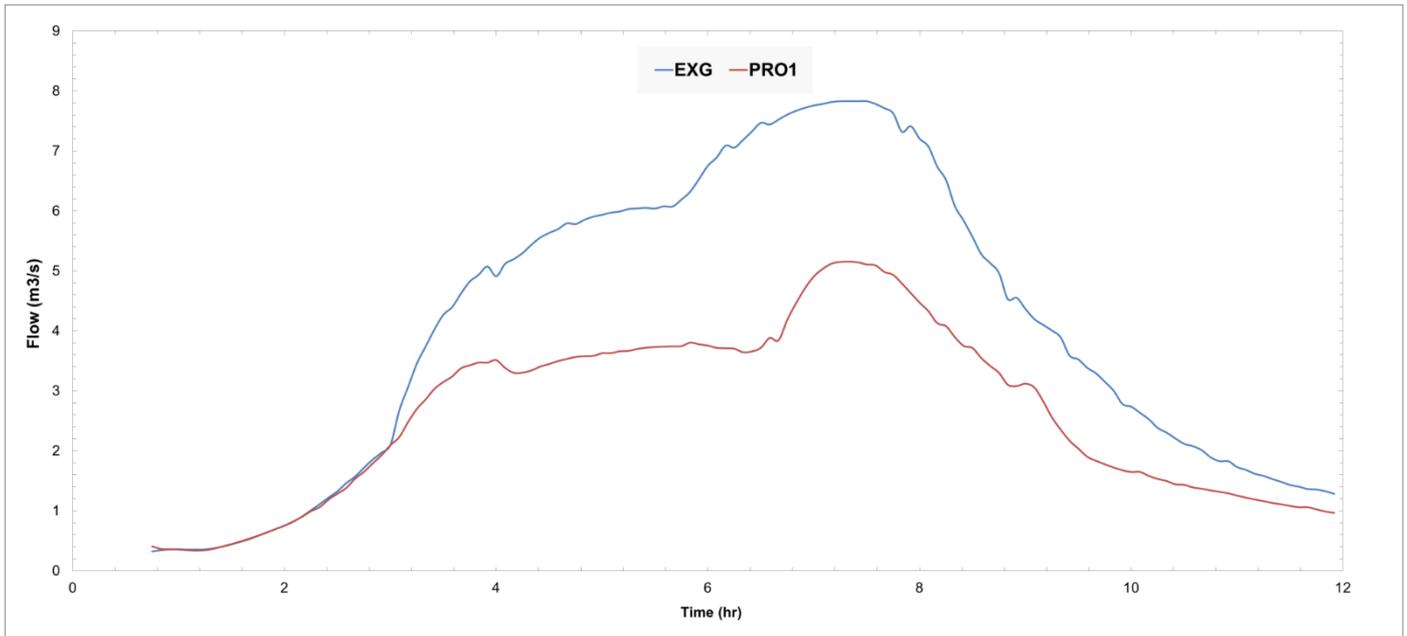


AEP = annual exceedance probability

Appendix 4: 1 in 100 year (1% AEP) reduced flood risk in Blackbrook, St Helens – by the measures annotated on the map



Appendix 5: 1 in 20 year (5% AEP) existing flood risk (EXG) and catchment attenuation and defence (PRO1) hydrograph.



Hydrograph extracted from the upstream model node of the Black Brook culvert inlet.

EXG = existing 5% flood risk hydrograph at Black Brook culvert inlet

PRO 1 = 5% flood risk hydrograph with Dev 9 (Clipsley Brook attenuation), Dev 7 (Black Brook de-culverting), Dev 10 (flood defence bund), Dev 5 (wetland attenuation) - see Appendix 4.

The 4 engineered log dams provide 1% of the catchment attenuation for a 1% event, and so do not alter the 5% hydrograph. They reduce flood depths by ~10mm at most.

Appendix 6: Engineered log dam 2 – attenuation of flood flows during a summer spate



Dam location and corresponding Q20 flood depths are shown in Figure 1.
Photograph taken on 8 May 2015; courtesy of Matthew Catherall.

Appendix 7: Engineered log dam 2 – attenuation and suspended sediment during winter high flows

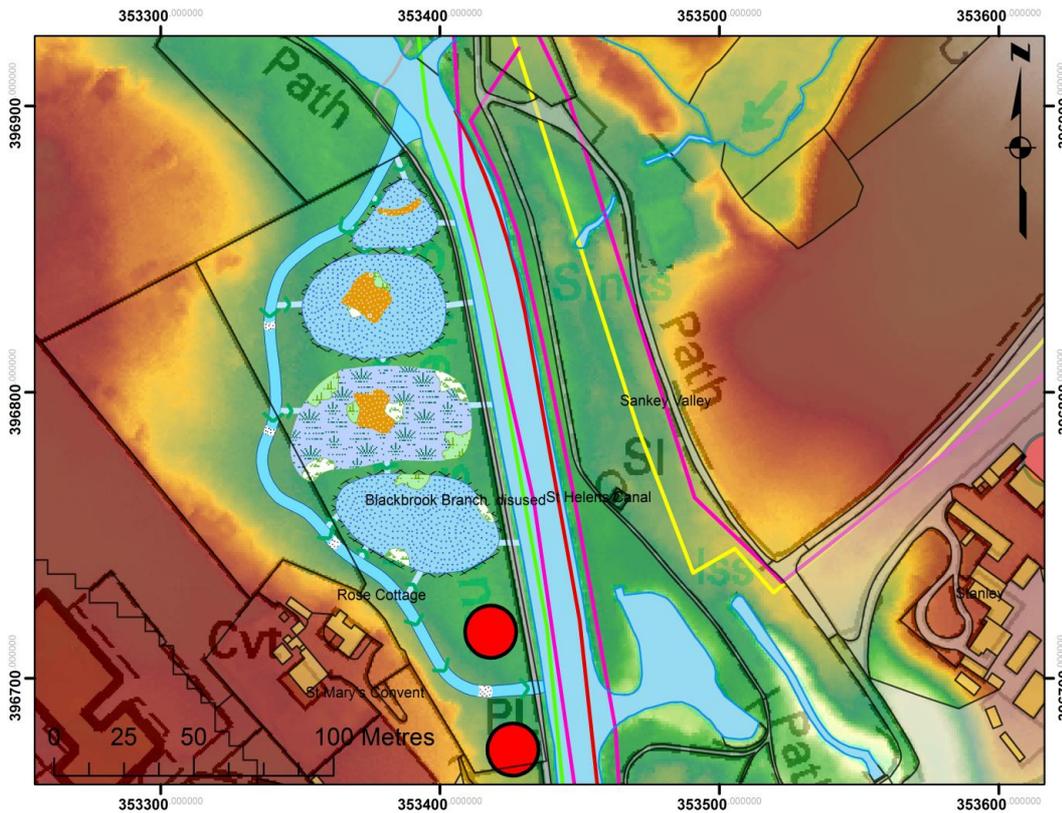


Note the difference in turbidity between the attenuated water inundated behind the dam crest and the water on both the floodplain and flowing downstream after the dam section.

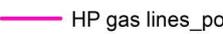
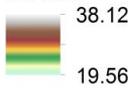
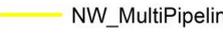
Dam location and corresponding Q20 flood depths are shown in Figure 1.

Photograph taken at 11:30 on 1 December 2015.

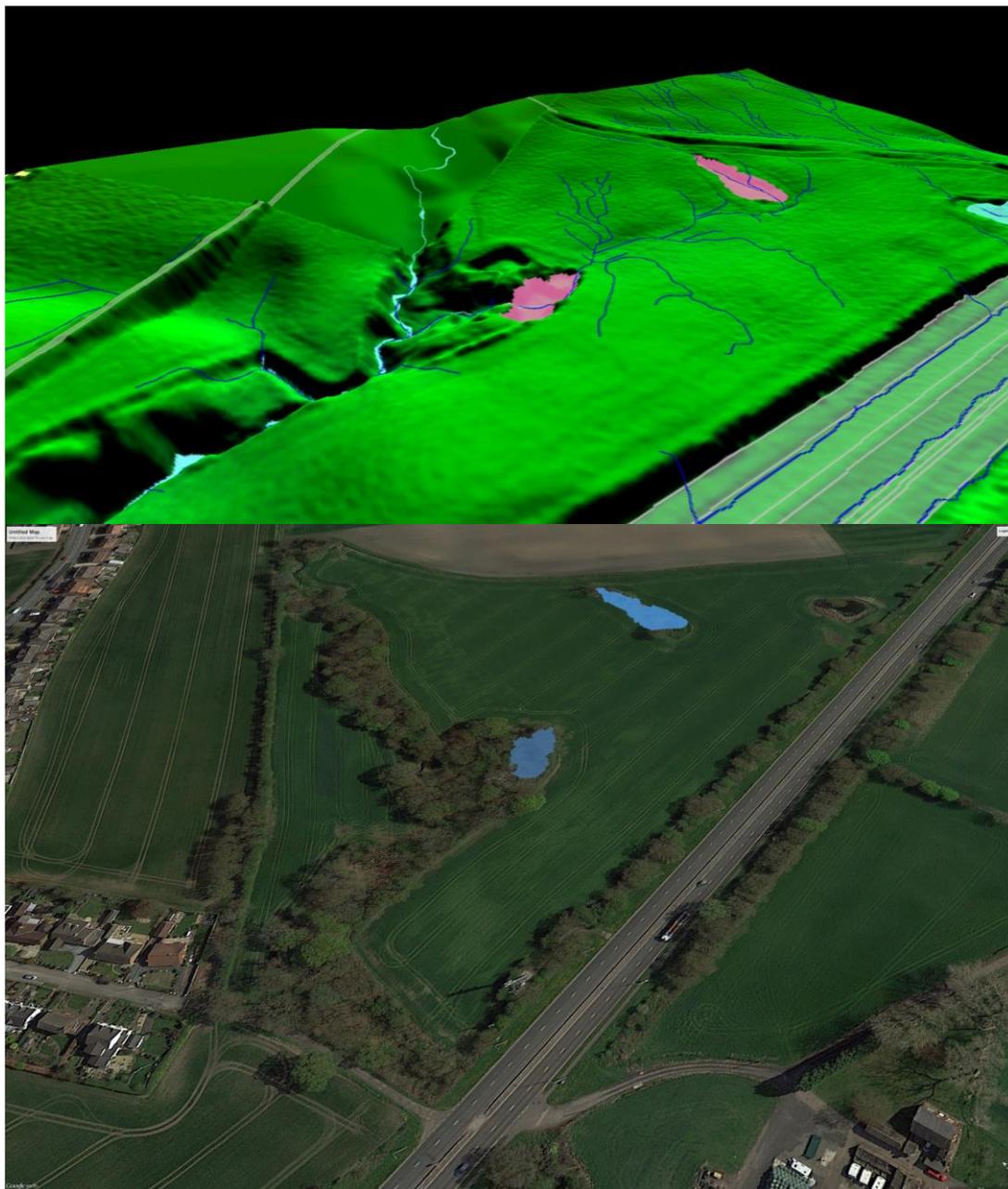
Appendix 8: Flood relief wetland (DEV 5) and surrounding constraints



KEY

 Medial Gravel Bar	 Riffle Pack	 24_GasPipeline	LiDAR (1DTM) mAO
 Phragmites	 Spillway	 8_GasPipeline	
 Typha	 Swale	 HP gas lines_polyline	
 Macrophyte Zone	 Wetland Path	 NW_MultiPipeline	38.12
 Willow Weir	 Mineshafts		19.56
 Ponds			

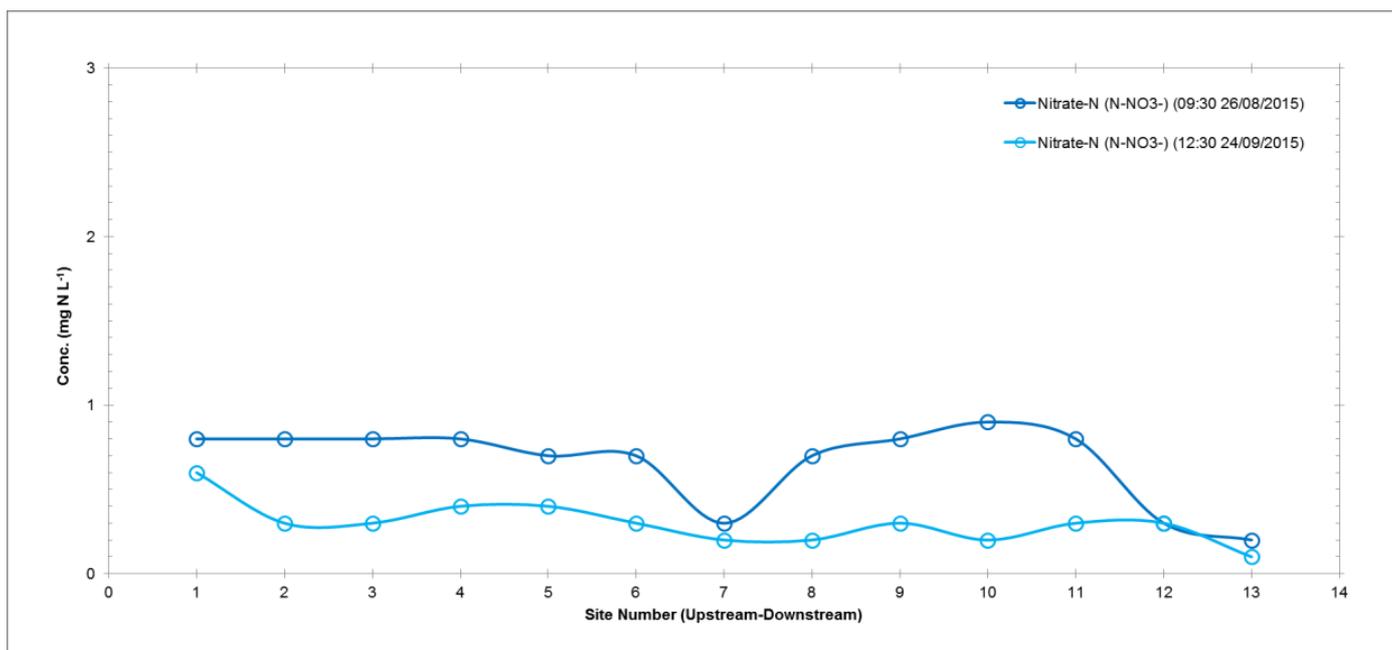
Appendix 9: Further sighting of catchment attenuation – Clipsley Brook tributary



Appendix 10: Further sighting of catchment attenuation – Goyt tributary



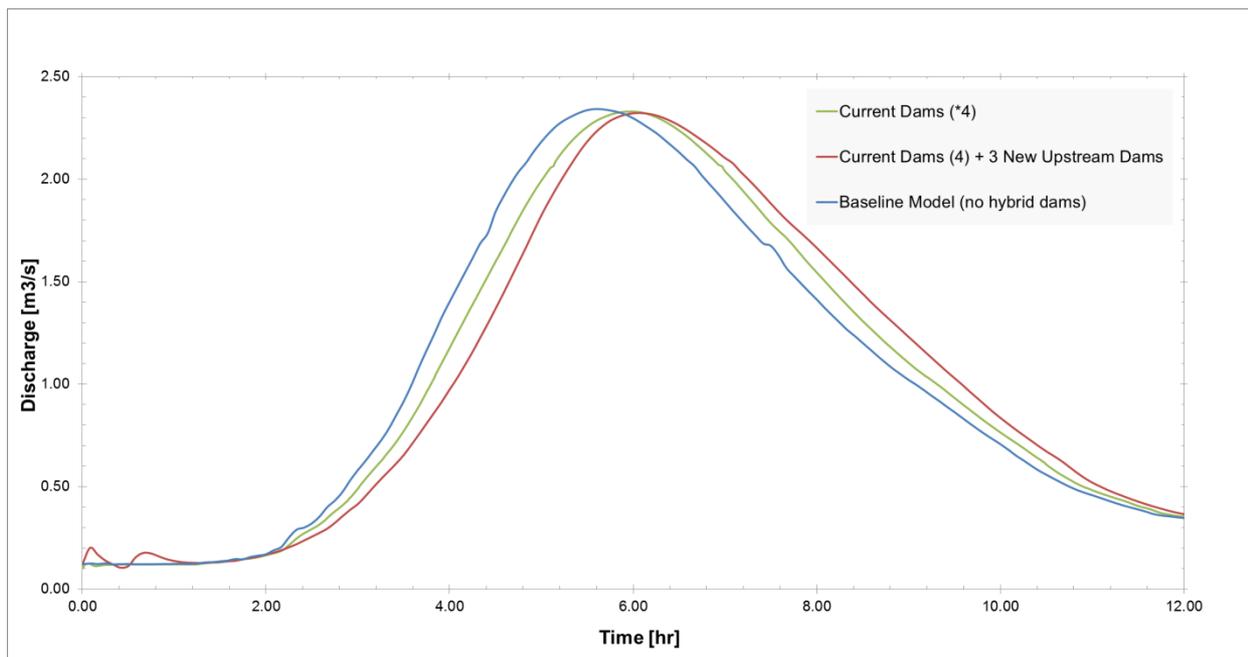
Appendix 11: Nitrate-N (NO_3^-) reduction through 4 engineered log dams on Stanley Brook



Monitoring points are shown in Figure 1.

Source: Kate Harris, Newcastle University, in collaboration with the Knowledge Transfer Partnership

Appendix 12: Stanley Brook 1 in 20 year (5% AEP) hydrograph – effect of 4 and 7 engineered log dams on flows



Q20 peak flow delays with and without engineered log dams

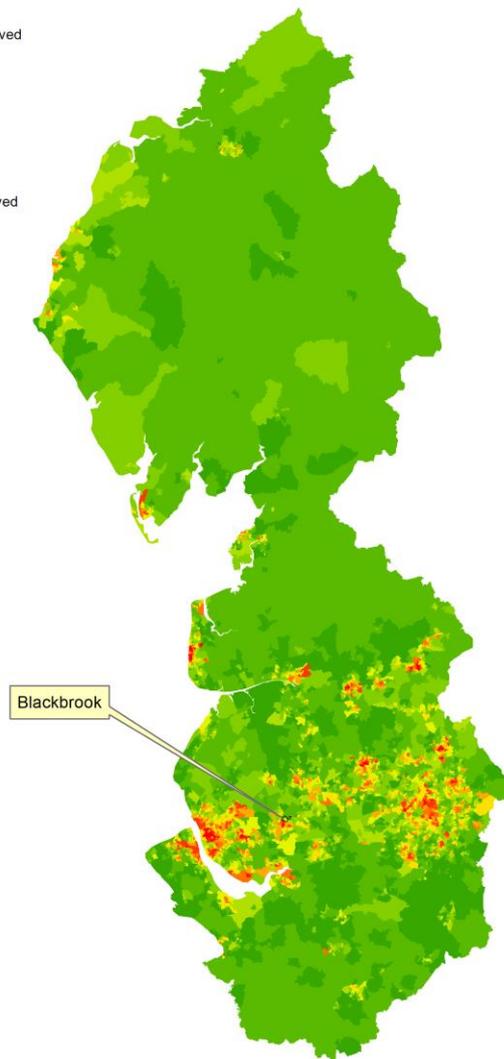
Data derived from Flood Estimation Handbook (FEH)/Revitalised Flood Hydrograph (ReFH) predictions and 1D Flood Modeller. Options are presented for:

- a baseline scenario where no dam exists
- a scenario with the current 4 dams
- a scenario with 3 new additional dams upstream

Appendix 13: OS Indices of Multiple Deprivation, Blackbrook St Helens

Indices of Multiple Deprivation

Total



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