British Geological Survey

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GREATER MANCHESTER BRIEFING NOTE

VENTURA – virtual decision rooms for water neutral planning

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What is VENTURA?

The aim of VENTURA is to create and test a prototype digital tool for collaborative early-stage strategic planning for future water management.

VENTURA is a 24-month applied research project that started in September 2021 focusing on study areas in Greater Manchester and Enfield, London. The project is funded by the Engineering and Physical Research Council as part of their Digital Economies: Sustainable Digital Societies[1] programme. This Briefing Note covers work in Greater Manchester; a separate note has been produced for the Enfield study.

VENTURA is an interdisciplinary team of systems thinking and digital geoscience researchers from Imperial College London (ICL), University College London (UCL), and British Geological Survey (BGS). The Greater Manchester study is supported by Greater Manchester Combined Authority (GMCA), United Utilities (UU) and the Environment Agency (EA), and focuses on the Upper Mersey Catchment. This group formed an integrated water management trilateral partnership prior to VENTURA in 2021[2]. Their aim is to influence and deliver sustainable growth in Greater Manchester by improving flood risk resilience, enhancing the environment, driving circular economy approaches, and supporting regeneration.

Why is VENTURA important?

VENTURA aims to produce a common interactive digital evidence base for future integrated water management planning. This will be based on an integrated water systems model coupled to an interactive user-friendly web interface, collectively called a Virtual Decision Room.

Water management is a systems-of-systems challenge encompassing water consumption, use, discharge, treatment and its return to water bodies – in each case, water, sewerage, and associated infrastructure affects societal adaptation and resilience to surface water flooding and

[1] https://www.bgs.ac.uk/news/bgs-collaborates-on-new-1-million-epsrc-funded-digital-research-project-to-help-make-urban-growth-more-sustainable/

[2] https://democracy.greatermanchester-ca.gov.uk/documents/s16654/MOU%20Partnership%20FRM%2024%20September.pdf

water quality changes. The current policy space in the UK that is affecting future decisions is complex and involves a range of stakeholders and initiatives (Figure 1).

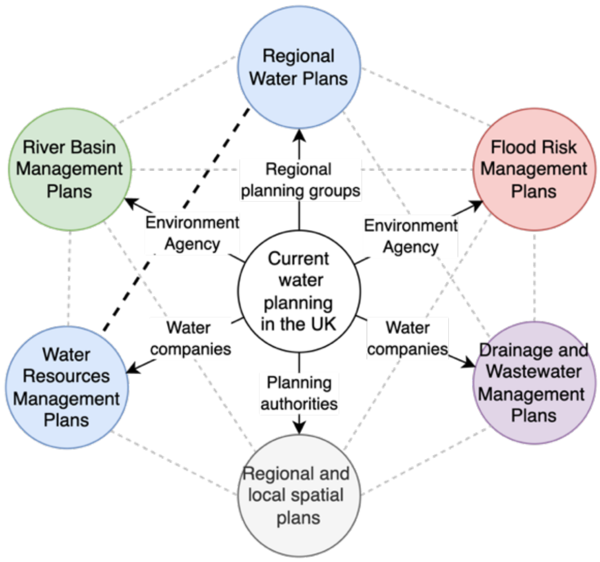

Figure 1 Overview of key plans and organisations in current UK water planning[3, 4]

Decision making for water management is organisationally siloed with governance needing to accommodate many roles and responsibilities. This involves interacting within the same geographical area but working towards different investment incentives and metrics but ultimately accountable to government and the public. There are often tensions between different stakeholder requirements, especially around funding, regulations, policy, liability and organisational goals. At a VENTURA workshop Greater Manchester partners listed the influential stakeholders, including central Government, OfWat, water companies, local / regional planning authorities, Lead Local Flood Authorities, Environment Agency, NGOs, and the public (Figure 2).

Examples of current policy drivers affecting water management in Greater Manchester include:

- Flood and coastal erosion risk management: an investment plan for 2021 to 2027;
- Schedule 3 of the Flood and Water Management Act 2010, soon to mandate sustainable urban drainage (SuDS) for all new developments;
- Ofwat's 2024 Price Review (PR24);
- Water Industry National Environment Programme;
- Defra's storm overflow consultation and action plan;
- Defra's review of Local Flood Risk Strategies;
- North West Regional Flood and Coastal Committee (RFCC) Business Plan;
- A range of catchment scale strategic management plans;
- Reducing the risk of surface water flooding report by the National Infrastructure Commission; and
- GM Integrated Water Management Plan.

[3] Mijic, A., Bromwich, B., Crilly, D., Dobson, B., Forrow, D., Giambona, J., Kirk, S., Liu, L. and MacDonald, R. 2022. Systems Approach to Regional Water Planning, Centre for Systems Engineering and Innovation, Working Paper Series, No. 1
[4] Mott MacDonald. OxCam Integrated Water Management Framework. 2022. https://tinyurl.com/246xcbj7.

Figure 2 Stakeholder mapping with GM trilateral team in March 2022

Figure 3 Empathy mapping

There is currently no common digital evidence base (data, models, polices) for integrated water management decision making in Greater Manchester, or to our knowledge in the UK. This means there is no shared baseline and no overarching desired outcome for the main organisations (water companies/EA/Local Government) to coalesce around and work towards. The current approach is for the different stakeholders to produce evidence and then a plan in isolation followed by consultation. This means there are many plans, rather than a single shared vision for specific places or catchments. Work is currently in progress in Greater Manchester to develop one of the UK's first Integrated Management Plan.

Greater Manchester Challenges

The academic and Greater Manchester trilateral teams used workshops and discussions to understand which challenges were of mutual importance for VENTURA.

It was decided that the geographical focus of the research should be the Upper Mersey catchment (Figure 4). This area was chosen because it is located mainly in Greater Manchester, has large urban and rural components, and is host to a range of flooding and growth challenges that are relevant for each partner.

During the engagement activities a series of empathy maps for each of the stakeholders were produced (Figure 3). Using these, we collectively drafted long-term visions for the research from each perspective; these were then refined and combined over the course of several weeks after the initial design sprint meeting and used to create a shared vision (Table 1).

Table 1 Organisational and shared visions

GMCA vision	UU vision	EA vision
"Demonstrate with evidence how our 'Places for Everyone' spatial framework is water neutral over the life of the plan (present-2037)"	"Ensure all new developments (or off-setting from retrofits) contribute no new surface water to sewers, over fifty years, including potential impacts from climate change."	"Avoid any increase in downstream flood risk as a result of new developments (or off-setting from retrofits) and ensure that all developments achieve green field rates of run off"
Shared vision		
"To be water neutral by 2050 despite population growth, changes in climate and user behaviour"		

In scientific literature, water neutrality is defined as an avoidance of net gain in the water flow and net reduction in water quality, e.g. nitrates and phosphates, reaching water bodies at both catchment and sub-catchment scales[5]. This is important to the trilateral group because climate change and growth scenarios are both expected to increase the pressures on water systems in Greater Manchester. This is because increases in water flows within catchments can exceed the capacity of the sewerage infrastructure, leading to an increased risk of surface water flooding and impacts on in-river water quality.

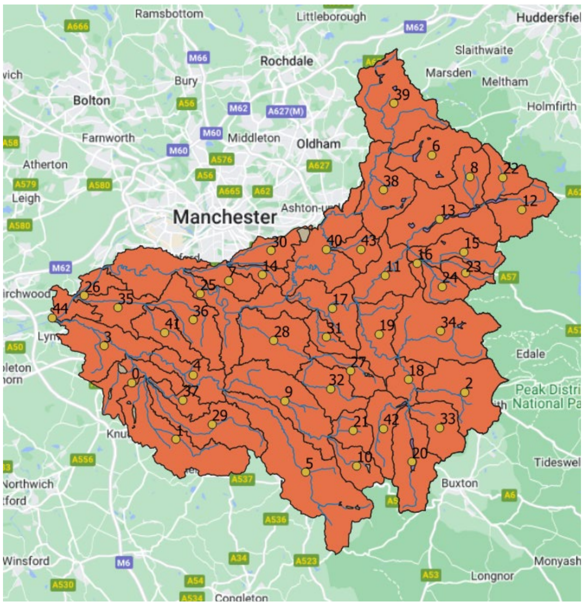

Figure 4 Upper Mersey catchment and 45 sub-catchments derived from topographic data for the purpose of the VENTURA project. Contains Google Maps data © Google.

The scale of this challenge means mitigation, adaptation and resilience will require new policies, collaborative working, shared evidence, and funding for existing planned and urban infrastructure.

How will VENUTRA help

There are four parts to the VENTURA methodology:

1. A participatory system dynamics model of water neutrality concepts and decisions;
2. An integrated water system model which summarises water inputs and outputs within the Upper Mersey catchment;
3. A web-based user interface called a Virtual Decision Room; and
4. A Blueprint of the research process and findings.

Participatory systems dynamics (PSD)

PSD was used to understand and articulate the organisational goals and governance-controls on achieving water neutrality in the Upper Mersey catchment. The PSD model was framed by three components: the problem/goal identification, participatory mapping with the GMCA, EA and UU, and model comparison and integration. We have identified the three core stakeholder group

[5] Puchol-Salort *et al (2022)*. Water neutrality framework for systemic design of new urban developments. https://doi.org/10.1016/j.watres.2022.118583

perceptions by colour-coding the themes they consider important, allowing for quick comparison between them, through which an initial systems structure was developed (Figure 5).

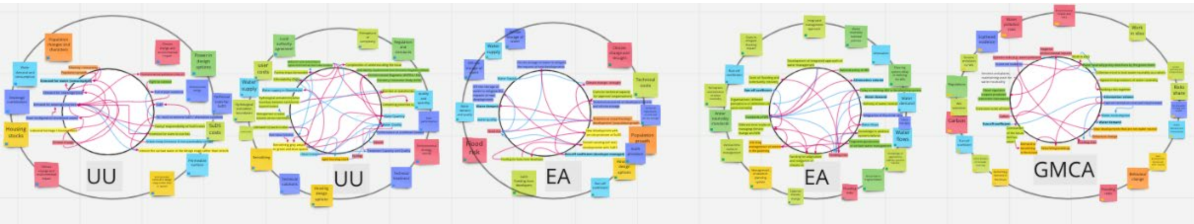

Figure 5 Diagrams summarising the links between a range of variables affecting partner organisation's understanding of water neutrality and its governance (text not intended to be readable)

Collaborative workshops were conducted in September 2022, where stakeholder perspectives have been mapped as a Causal Loop Diagram (CLD) (Figure 6). Relationships between variables affecting water neutrality decision making were explored in real-time to assess the effects of empowering and enhancing knowledge exchange between decision-makers. The CLD shows the complexity of managing the infrastructure and water system in the context of the emerging concept of water neutrality and potential future polices. Planned future work includes follow-up interviews with stakeholders with planning system perspectives to validate the PSD model to explore how governance scenarios might be reflected in the VDR and used as a decision support tool.

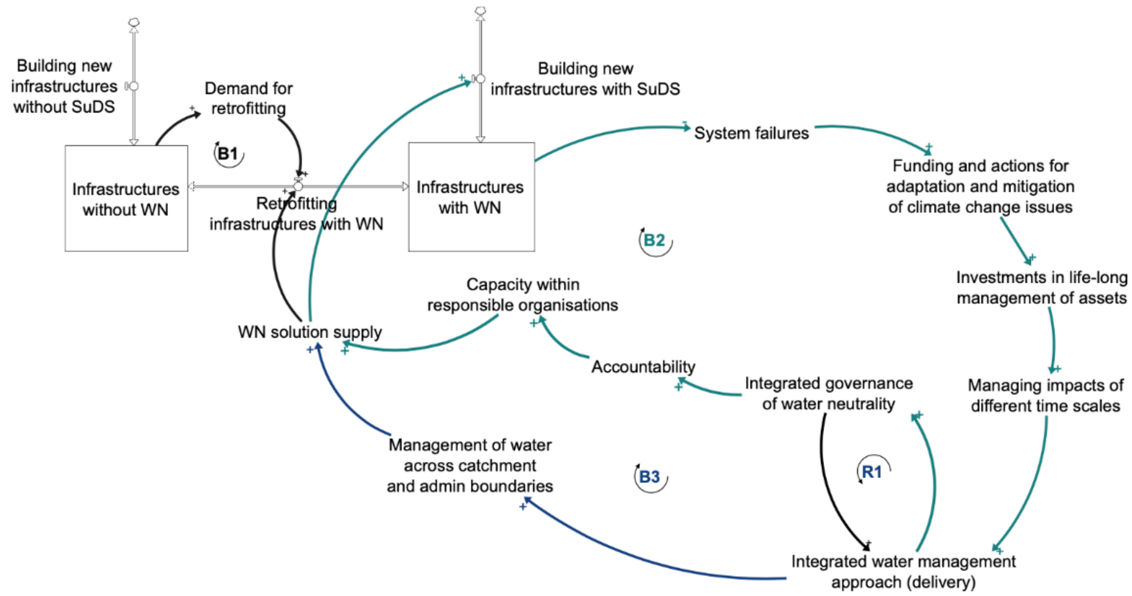

Figure 6 Simplified CLD. Full report is available on https://www.imperial.ac.uk/media/images/non-standard-dimensions/Manchester-Pre-showcase-report.pdf

The CLD shows that the system failures drive the decision-making in mitigating systems risks, which indicates that the decision-making is primarily dominated by a response-mode rather than proactive-mode. Funding and actions to mitigate against climate change are critical to trigger integrated management and governance in water neutrality. Investments in the lifelong management of assets are key outputs from the funding changes. Integrated water management involves working across catchment boundaries, administration boundaries, and also the impacts of different time scales, which indicates that the integrated approach to water neutrality needs to consider both temporal and place-based dimensions in water systems.

Water Systems Integrated Model (WSIMod)

WSIMod is an open source systems model that creates simultaneous estimates of the volumes and quality of water discharges to sewerage infrastructure and natural watercourses. The model currently uses open datasets for the development of a prototype. These are OS open data sources for levels (used to derive subcatchments), land use and population (used to estimate population and demands) and land cover (used for runoff coefficient). The complexity and detail of WSIMOD can be tailored depending on the availability and accessibility of datasets used to develop it. A summary of the WSIMOD framework is presented in Figure 7.

WSIMod breaks down the hydraulic system into topographically defined sub-catchments interconnected through a graph structure known as arcs. It then carries out water and nutrient pollutant balances on a time-step basis and evaluates final flows and pollutant loads at each connection for the entire duration of the simulation, which can range from days to years. The modelling software has been developed using the Python programming language.

For Greater Manchester, the model is built using 45 subcatchments which comprise the Upper Mersey catchment (Figure 7: right). It produces downstream outlet flows and water quality indicators for each catchment for the variables shown in (Figure 7: left). The model estimates these values for the current situation and user defined scenarios. For these future scenarios, the model assumes increased rainfall using published guidance and increased population based on targets set by GMCA in their Places for Everyone spatial development strategy. These scenarios are evaluated for business-as-usual case i.e. no improvements to the system) as well as options where the VDR user proposes improvements at the sub-catchment level (Figure 7: bottom left).

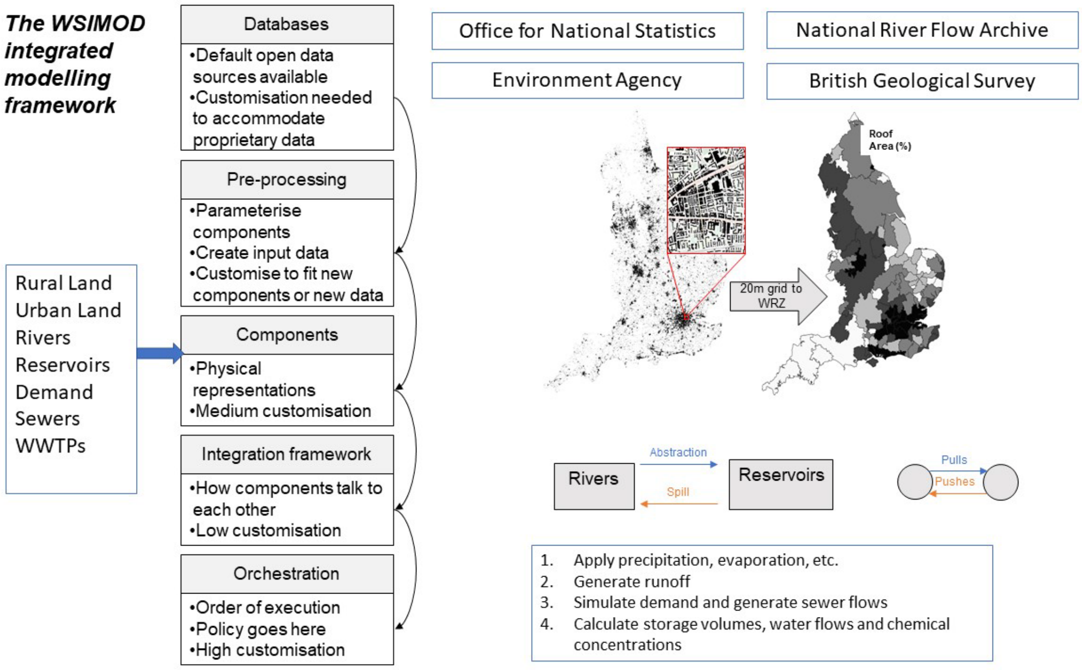

Figure 7: Summary of the WSIMOD modelling framework. WRZ=Water Resources Zone. Contains OS data © Crown copyright and database rights.

Virtual Decision Room (VDR)

In Spring 2023, VENTURA produced a high-fidelity live data prototype Virtual Decision Room (VDR). The VDR is coupled to WSIMod via an application programming interface (API), which allows the two to communicate. It was designed for the trilateral group to explore 'what-if' growth and climate change scenarios in the Upper Mersey catchment. Climate impacts can be 'offset' using variables built into the VDR and linked back to WSIMod.

The three variables that can be altered for both new build and retrofit development areas in the VDR are:

i. Water demand per household (litres per person per day);

ii. Surface water run-off (m^3/day) as a function of the area of permeable surfaces; and

iii. Attenuation (m^3/day) by sustainable drainage system (SuDS).

WSIMod feeds almost real-time outputs of the underpinning model to the VDR via the API. These results are presented live to users for fixed population and climate change forecasts, each of which have been defined by ICL's water system experts. WSIMod produces two main outputs for the 45 sub-catchments in the Upper Mersey:

i. Water flow (m^3/day); and

ii. Water quality (mg/L for nitrates and phosphates)

The VDR includes user friendly controls to alter these variables with summary plots and data on the effects of change each or all of the parameters. The variable selections made in the VDR are sent to WSIMod and results returned for presentation in the VDR in almost real-time. A prototype of the web interface for the VDR has been created (Figure 8).

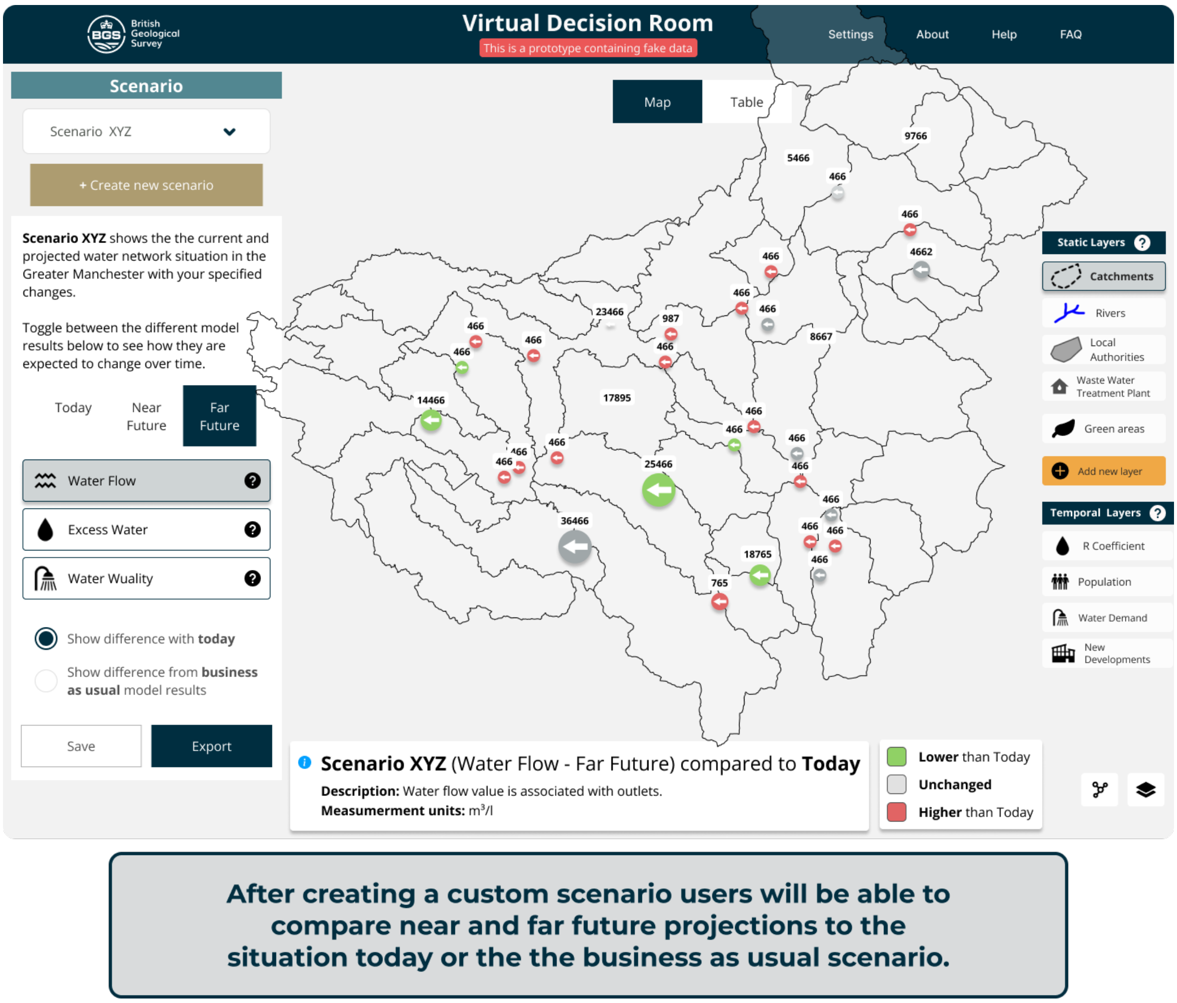

Figure 8 Example screenshot from the VDR showing some key functions

Examples of ‘what-if’ scenarios that might be explored in the VDR:

> *“What happens if we attenuate all the extra water consumed and discharged by full build out of the Places for Everyone homes in existing developed parts of the Upper Mersey e.g. through retrofit SuDS?”*
>
> *“What happens to river flows if we build out homes in line with Places for Everyone without any mitigation?”*
>
> *“What happens to river flows in selected catchments if we reduced the daily water consumption rate from 110 L/ person to 80 L/ person and increase the permeable area by 50%? What effect does this have in different sub-catchments and in the overall catchment?”*

Being able to experiment with the effect of consumption, area of permeable surfaces and attenuation by SuDS for new build and retrofit in the VDR is expected to help users to understand what combination of policy-based interventions might be required to move towards water neutrality in the Upper Mersey.

The VDR will be tested and used by the trilateral group later in 2023. The use cases for testing will be determined collaboratively and will be informed by the trilateral vision, the results of the PSD and the functionality of WSIMod and the VDR.

Expected outcomes and impacts of VENTURA

VENTURA will help to demonstrate how an interdisciplinary approach to future water management decision making might be achieved by developing an integrated water systems model and a system dynamics model coupled to a novel virtual decision room. This will create a unique understanding of how current and future catchment and sub-catchment decision making could be approached using user-led digital tools including:

- An open-source integrated water systems model to quantify how water neutrality might be achieved in the Upper Mersey 2025 through a combination of new build and retro fit interventions including water consumption, attenuation and run-off for forecast climate change and population assumptions;
- A systems dynamics model which will describe the factors involved in governance and decision making as well as how these interact;
- A new prototype digital service called a Virtual Decision Room where the water systems model and systems dynamic model will be coupled virtually, and mechanisms for achieving water neutrality explored and documented; and
- A VENTURA blueprint document illustrating the process, methods, results and findings of the project partners and wider networks use to inform the development of shared digital solutions and new ways of working to achieve sustainable water management. The document is likely to include a bespoke section for both Greater Manchester and Enfield of take-home points and lessons learned.

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