The ROCKEFELLER FOUNDATION

THE RESILIENCE SHIFT

SIWI

ARUP

CITY WATER RESILIENCE APPROACH

CITY CHARACTERISATION REPORT

HULL

ACKNOWLEDGEMENTS

On behalf of the study team, I would like to thank The Rockefeller Foundation and The Resilience Shift for supporting this project.

The CWRA is a joint effort developed in collaboration with our project partners, the Stockholm International Water Institute (SIWI), along with city partners in Amman, Cape Town, Greater Miami and the Beaches, Mexico City, Kingston upon Hull, Greater Manchester, Rotterdam and Thessaloniki, and with contributions from 100 Resilient Cities and the Organisation for Economic Co-operation and Development (OECD).

This project would not have been possible without the valued guidance and support of the **CWRA Steering Group.** Our thanks to the following: Fred Boltz (Resolute Development Solutions), Casey Brown & Sarah Freeman (University of Massachusetts, Amherst), Katrin Bruebach & Andrew Salkin (100 Resilient Cities), Jo da Silva (Arup), Nancy Kete & Juliet Mian (The Resilience Shift), Diego Rodriguez & Maria Angelica Sotomayor (World Bank).

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CONTENTS

EXECUTIVE SUMMARY

The City Water Resilience Approach (CWRA) helps cities plan and implement actions to build resilient urban water systems. A critical first step in this process is understanding the local water system, and the factors that contribute to or detract from resilience.

This report details research undertaken in Kingston upon Hull (Hull) with the goals to:

1. Define the city water basin including natural basin(s), the urban water system and its governance structure, and the interdependencies with other systems
2. Identify the factors contributing to the resilience of the city water system and those increasing its vulnerability.

In developing this characterisation report, the team collected desktop data on the biophysical characteristics of the basin and key actors in the water system. Arup then undertook a field mission in Hull 18–30 June 2018 to build on the desktop work by engaging in-person with stakeholders.

KEY STAKEHOLDERS

Following the 2007 floods, Hull City Council (HCC), Yorkshire Water, the Environment Agency and East Riding of Yorkshire Council (ERYC) together formed an initiative called Living with Water Partnership (LWWP, 2018) to facilitate engagement with cross-sector stakeholders, citizens and the wider community. The LWWP is currently proposed to be the key governance vehicle for addressing water resilience for Hull.

All parties still function independently within their previous roles in Hull, HCC and ERYC are responsible for local flood risk and multiple linked assets such as transport, housing, etc. Yorkshire Water is responsible for wastewater and public water services, while the Environment Agency is responsible for major land drainage, coastal and fluvial flood defences.

Workshops were held with various other stakeholders of which all had a varying understanding of the Hull catchment and water systems. Their perception tended to be specific to their local geography and to issues immediately affecting their lives or work. A theme expressed amongst stakeholders was that the Hull catchment is a useful primary focus for planning and action for water resilience.

HULL'S WATER SYSTEM

Under current proposals, LWWP is the main acting governance body for water resilience initiatives moving forward. Yorkshire Water still acts as a local water authority across the Yorkshire region, responsible for wastewater, public water and surface water drainage. Yorkshire Water is regulated by the Office of Water Services (Ofwat), a body responsible for water and wastewater regulation across England and Wales. The Environment Agency (EA) is a government agency public body responsible for water quality, groundwater and surface water abstraction; the EA focuses on broader environmental issues across England and Wales.

SHOCKS AND STRESSES

During the CWRF workshop, participants were encouraged to think across all urban systems when contemplating the shocks and stresses that could impact Hull. Some of the critical issues raised during the fieldwork are identified below.

- Climate change: sea level rise and more intense storms
- Flooding from multiple sources including tidal surges, fluvial flows, surface water and groundwater.
- An energy crisis, due to the city's reliance on pumped systems to deal with flooding, water distribution and treatment.
- Increasing water demand.
- Ageing infrastructure.
- Limited infrastructure capacity.
- Lack of community engagement.

BUILDING RESILIENCE

Through engagement with Hull stakeholders, it was identified that there are a series of factors that would positively contribute to the resilience of the city's urban water system.

Some of the most frequently mentioned were:

- "Innovative Funding and Investment", more of it in in particular targeted at local resilience measures and nature based solutions.
- "Promoting Water Sensitive Developments" that promote health and wellbeing.
- "Transparent and accountable Government" that engages with stakeholders and the local community.

One of the main focuses of the CWRA is to understand who the city engages, not just within the basin it belongs to but also the other sectors that rely on water and that influence the use of water. The key interdependencies between the water system and city systems identified within Hull are Energy, Transport and Economy linked with its Socio-Cultural implications and Health and Wellbeing.

Case study

Blue-green infrastructure : Willerby Carr Culvert Daylighting and Community Garden

This Willerby Carr Culvert Daylighting and Coronation Road Community Garden scheme took action to improve the site of council owned school that was flooded in 2007. The damages and cost to repair the school were considered too high, so the school subsequently closed. The buildings were used as a training facility on a temporary basis before they were demolished. The vacant land, which is adjacent to a housing estate, then became a magnet for fly tipping, fly grazing of horses, and anti-social behaviour. Across the site was an old culvert in a poor state of repair and with little capacity. The City removed a section of culvert, opening up and restoring the watercourse, improving new and improved habitat, visual amenity and reducing local flood risk. Alongside this work, the community took action to improve the site and planted an orchard with paths through the site for dog walking, amenity, and recreation. During two periods of heavy rainfall the scheme has provided additional storage and helped to prevent flooding – this has given the community reassurance. The example underscores the Living with Water vision: the concept that an integrated approach at community-scale can enhance and create an attractive environment for people to enjoy whilst addressing water resilience . The project was nominated for a national CIRIA BIG Biodiversity award (CIRIA, 2016).

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BACKGROUND

Kingston upon Hull - normally abbreviated to Hull - is located on the north bank of the Humber Estuary in the heart of the East Riding of Yorkshire. Founded on reclaimed tidal marsh, the story of Hull has always been shaped by water, both as an opportunity and as a threat. Now the city faces significant resilience challenges, not least due to its low-lying coastal location, with more homes at risk of flooding than any other UK city apart from London. However Hull is showing strong signs of renewal and the city is embracing climate adaptation and water-resilience as an opportunity to shape a successful and sustainable future.

POPULATION

Hull has a population of 260,673 at 2017 (Population Overview (Hull), 2018). Despite its important role in the UK economy (See below), the City is the 3rd most deprived in the UK (Office for National Statistics, 2015). Median weekly wages in Hull are 2% lower than the regional median, and more than 10% lower than the UK median (Office for National Statistics, 2018). The city has proportionally higher levels of unemployment and economically inactive people than the Yorkshire and Humber Region and Great Britain as a whole, and lower levels of people with qualifications at all NVQ Levels. (Office for National Statistics, 2018). It has high rate of referrals for psychological therapies (Baker, 2018), and as life expectancy at birth and at age 65 for men and women which is lower than the national and regional average (Office for National Statistics, 2015).

View overlooking Kingston-upon-Hull

Over 90% of the city is below high-tide level, with 95-98% of dwellings and many businesses at risk of flooding. (Coulthard et al, 2007) Communities here are amongst the most vulnerable to climate risks in the UK (University of Manchester et al, 2018), (Coulthard et al, 2007)

However, Hull has a long history of bouncing back from challenges, adapting and moving forward. It is already addressing resilience across multiple sectors, from health and housing, to education, employment, water and climate adaptation.

Hull boasts a vibrant and growing university of more than 16,000 students (HESA, 2018) and, through hosting UK City of Culture 2017, (BBC, 2018) the city is building an international reputation for innovation, creativity, and openness to change.

Globally, Hull is already twinned with Freetown, Sierra Leone which faces similar water-resilience challenges. Hull is now extending this global knowledge exchange to learn from 100 Resilient Cities (100RC) network as part of the City Water Resilience Approach (CWRA).

ECONOMY

The city's economy grew around farming, whaling, fishing and freight, then chemicals, pharmaceuticals and communications. The city and the wider Humber estuary region plays a key role in the UK economy. The Humber ports now support more than 23,000 jobs (Greenport Hull, 2018), while Hull has attracted more than £3bn investment and created more than 6,000 jobs since 2013 (Hull City Council, 2018). The Humber is the largest trading estuary in the UK (by tonnage) and the fourth largest in northern Europe, and is emerging as a world-leading centre for renewables (Invest Humber, n.d.). Hull and the East Riding has recently attracted major investment in offshore wind energy, including the recent Siemens development in Hull (Greenport Hull, 2018).

Significant housing needs are being delivered, with delivery requirements exceeded in the last two years. Hull has a robust forward supply of land for housing development, with a 5-year supply of 7.74 years (Hull City Council, 2018).

It is critical that Hull is seen in future as climate ready and resilient to support the recent upturn. The city is taking this as an opportunity to establish water-resilience as part of Hull's vision.

GOVERNANCE

Hull City Council is a unitary authority, with only one tier of local government below central government.

In the UK, unitary authorities have limited devolved powers but they are responsible for education, local highways and transport planning, passenger transport, social care, housing, libraries, leisure and recreation, environmental and public health, waste collection, waste disposal, planning applications, strategic planning and local taxation collection. Since the Flood and Water Management Act 2010, they also have increasing responsibility to manage local flood risk. (UK Government, 2018)

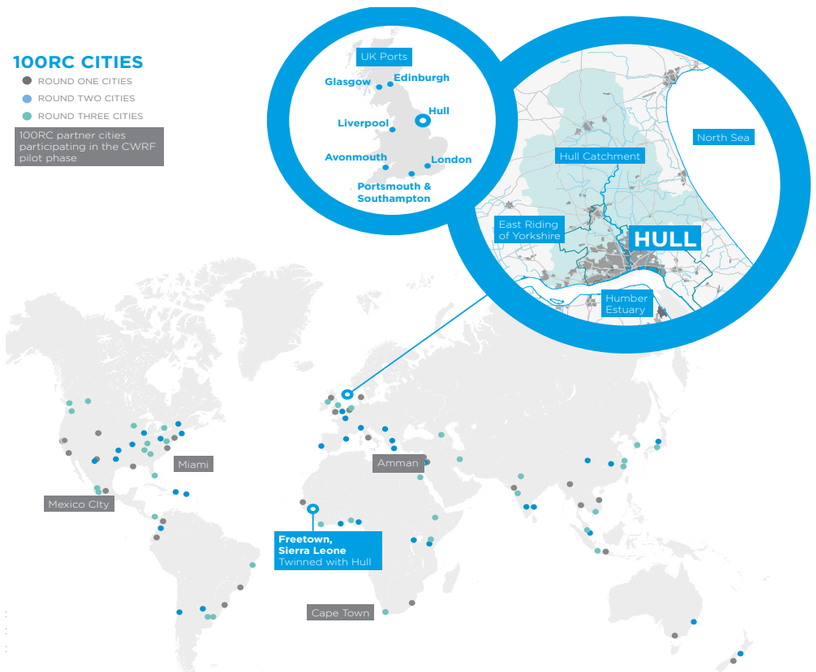
The boundary of the Hull City Council, coincides with the main urbanised area of Hull. The expansive rural areas and smaller settlements surrounding Hull are the responsibility of East Riding of Yorkshire Council – also a unitary authority. Thus governance of the basin is split across two local authorities.

At estuary scale, the Humber Local Enterprise Partnership (LEP) is a local business partnership between businesses and the four local authorities in the Humber region, leading on the strategy to maximise the opportunities in the Humber. To support this, the LEP lobbies for funding, devolution of powers, infrastructure support and policy change to break down the barriers to growth in the estuary area.

Certain aspects of critical infrastructure provision are managed by national level organisations. Highways England is responsible for the strategic road network which includes the A63 through Hull, while Network Rail operates and manages rail infrastructure. The Environment Agency has responsibility for most aspects of managing coastal and fluvial flood risk in the humber estuary. As stated above, local Authorities have responsibility for Local Flood Risk Strategy and Management.

Utility provision in the UK is privatised. Water and wastewater is managed regionally by Yorkshire Water, including aspects of surface water management, while the electricity and gas networks are operated respectively by Northern Powergrid and Northern Gas Networks. Healthcare in the UK is provided under the umbrella of the NHS; in Hull, primary care is organised by the NHS Hull Clinical Commissioning Group, while emergency and acute care is provided by Hull and East Yorkshire Hospitals NHS Trust.

Hull within the global context. Source: CWRF Fieldwork supporting material



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RESEARCH METHODOLOGY

Engagement with Hull was carried out over three stages:

STAGE 1	Desktop data collection on the biophysical characteristics of the basin and identification of key water governance actors.
STAGE 2	Arup's fieldwork in Hull during June 2018 focused on a better understanding of the local water systems, their limits, interdependencies, and the actors involved in the various water governance processes by engaging approximately 150 individuals. The visit included: - Ten focus groups on water, waste, insurance, emergency planning, flood wardens, local counsellors and community groups. - Fourteen semi-structured interviews (including business, water, waste, environmental planning, ports, regeneration & city planning, arts and culture, health & wellbeing, academia, Internal Drainage Board and regulators). - Two site visits – the first to a major habitat creation and flood storage scheme on the south bank of the Humber, the second to a small river restoration and community garden project in northwest Hull. - One full-day multi-sector CWRF workshop with 50-60 attendees; - One focussed governance workshop with senior leaders. - 35 questionnaires completed. - Work following the fieldwork involved summarising key findings from all activities and to determine general factors of water resilience.
STAGE 3	This report was created by combining the desktop study and the fieldwork results to provide a clear picture of the city's basin, its key stakeholders, its shocks and stresses, and its factors of resilience.

Engagement with 'Wave 1' cities included a two week field mission, where workshops, focus groups and interviews were conducted.

Engagement with 'Wave 2' cities included remote support to city partners where surveys and interviews were conducted.

3

UNDERSTANDING HULL'S WATER SYSTEM

Kingston-upon-Hull's urban water system

Hull is located at the southern end of the River Hull catchment, which stretches north to where the first chalk springs emerge from the Yorkshire Wolds, it sits alongside the Humber Estuary, which in turn is part of the wider Humber River Basin District. The Humber Estuary and parts of the Hull catchment, particularly the upland chalk streams, are Sites of Special Scientific Interest (SSSI) with multiple other designations under UK, European, and international law.

The catchment is underlaid by the Yorkshire Chalk Aquifer. Springs feeding the River Hull rise in the Yorkshire Wolds, a curved ridge of well-drained chalk that runs northwards from west of Hull then east to Flamborough Head.

Hull developed around the opportunities for connectivity and trade offered by ports at the confluence of Hull and Humber. This highly productive landscape has been created by reclamation of historic tidal marshland and intense water management.

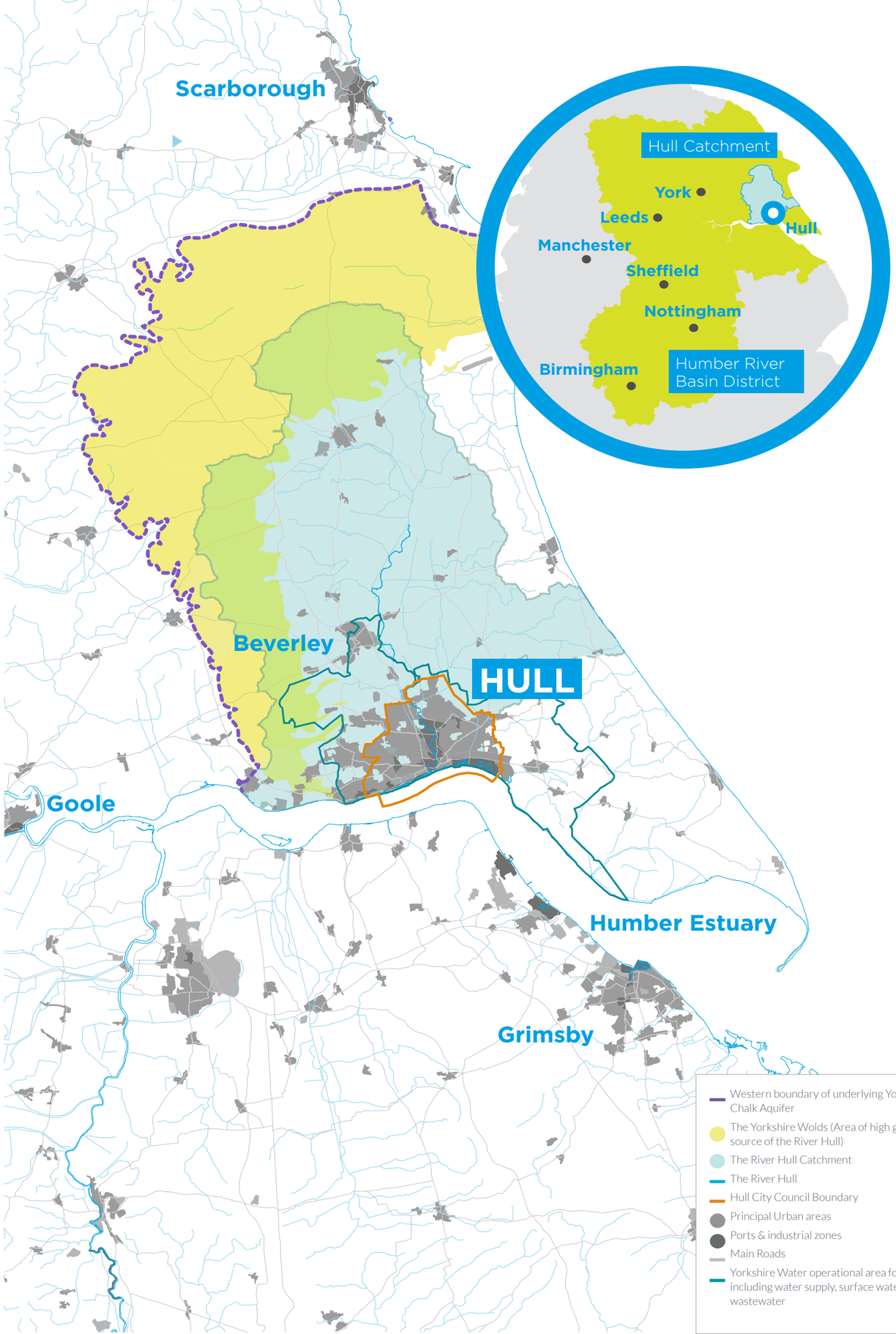
The low-lying land around the city is very flat and made up of relatively impermeable tidal deposits. This natural topography, coupled with the higher-level docks and coastal defences to the south, creates a 'bowl effect' preventing natural drainage of the city.

Productive agricultural land is key to the local economy. In the upper catchment, well-drained areas are used for arable and livestock farming. Further down the catchment, the reclaimed marshland provides high-quality arable land, surrounding the low-lying urban areas of Hull. Developing ports and industries are under increasing pressure to have land use changed from agriculture, to more commercial and industrial options, to grow the local economy.

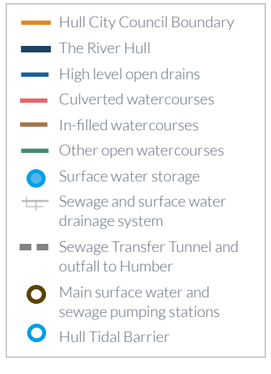
Its coastal location continues to underpin the economy and major opportunities going forward, but Hull also faces particular challenges due to its low-lying coastal context. With parts of the city below sea-level and a catchment that drains towards the estuary, it will always be a highly-managed landscape.

Green boxes indicate natural processes and the blue indicate human-made elements. It is acknowledged the boundaries between these categories are particularly complex in Hull where so much of the landscape has been highly modified over time. The dotted boxes acknowledge the fundamental role that flood management plays in controlling flows between different parts of the cycle.

Hull's Water Catchment



Hull city boundary and local water systems.



WATER SUPPLY

Water for Hull and the surrounding area is supplied both from surface water abstraction and from abstraction of the underlying chalk aquifer. The latter is recharged in the upper catchment from water falling on the Wolds. Groundwater abstraction is limited by the need to avoid saline intrusion from the estuary.

Rainfall is low, but the main challenge in maintaining the aquifer is not recharge levels but water quality. Within the city the aquifer is protected by an impermeable layer, but gaps in the layer outside the city limits present potential pathways for contamination. Source protection zones—managing raw water quality—are increasingly under pressure from urban development and agriculture, and some zones have been compromised by development. Nitrate contamination is a current issue. Any applications of green-blue infrastructure solutions that encourage infiltration or localised treatment would thus need to consider risk of groundwater contamination.

WASTEWATER TREATMENT

A single wastewater treatment works takes all sewage flows from the city and is fully reliant on pumping. A series of large pumping stations such as the Great Culvert Pumping Station lift land drainage into main drains and then into the Humber. Combined sewage flows are taken via a large tunnel and pumped to the wastewater treatment works to the east of the city, from where it flows to the Humber. Emergency storm overflows discharge into the Humber Estuary via the East and West Hull pumping stations.

Over time many watercourses within Hull have been in-filled and diverted to flow directly into the surface water drains or the combined sewage/stormwater system. Others have been contained in culverts. Options for disconnecting surface water and reducing sewage flows are complex and limited due to the nature of the catchment.

WATER DRAINAGE

Much of the surface water in Hull flows into a combined sewer, and from there to treatment as described in Section 4.2. Surface water from the Bransholme catchment is collected separately and discharged to the River Hull via the Bransholme Pumping Station and its stormwater balancing lagoon. High-level drains carry drainage from the mid-catchment through and around the city for discharge to the River Humber. Hull is 100% reliant on large pumped systems to remove surface water from the city.

A series of flood defences along the Humber Estuary and River Hull protect the low-lying city from tidal and fluvial flooding. A tidal barrier limits tidal flows up the River Hull during storm surge events.

Hull's pumped drainage systems are under increasing pressure. These support agriculture (through the extensive rural land drainage system), critical infrastructure and urban development (through surface water management) . Maintaining this system must be balanced with an increasing need to slow the water's flow into the city and find alternative ways to manage water within the city.

4

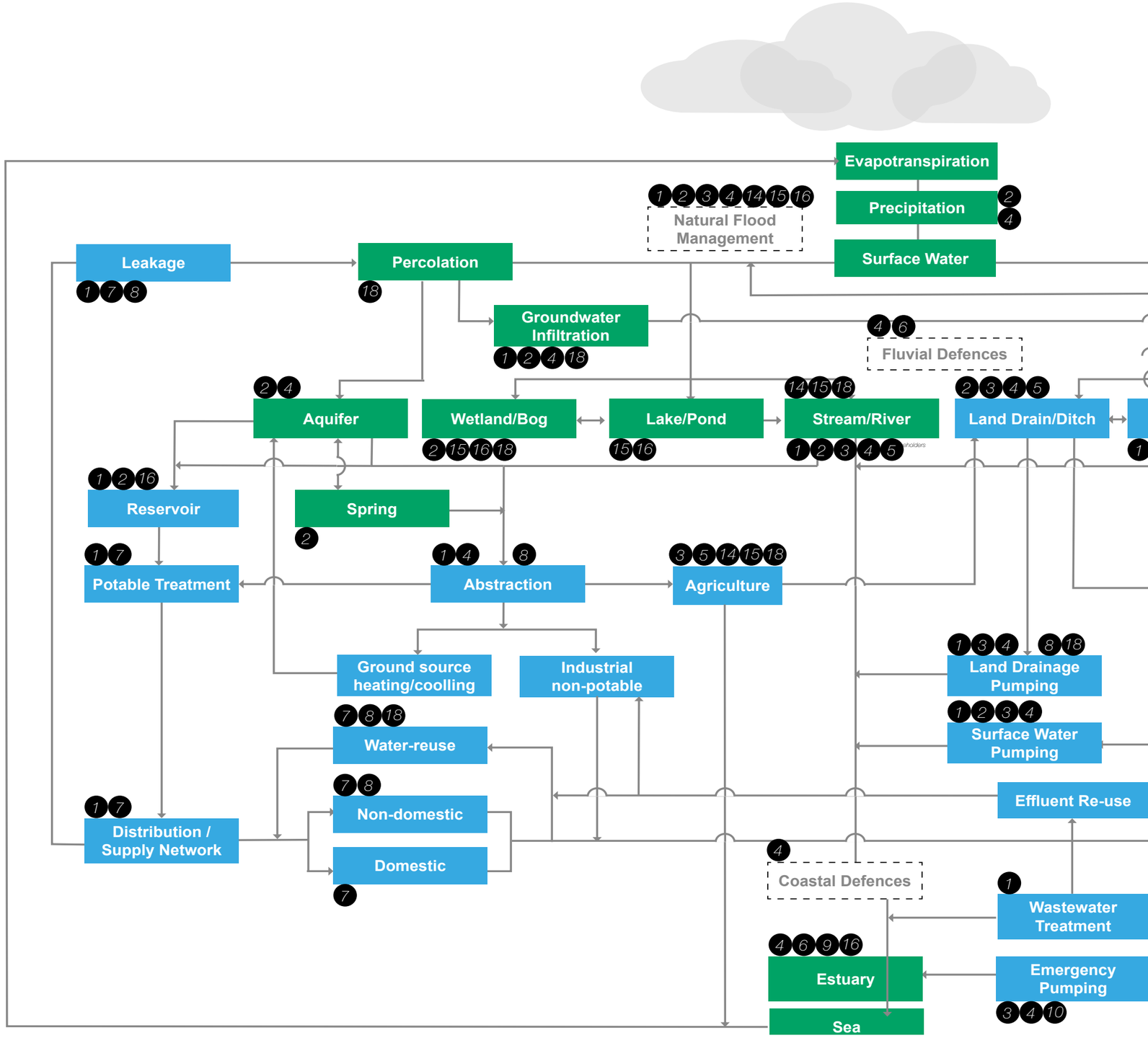
ENGAGEMENT WITH HULL'S STAKEHOLDERS

STAKEHOLDERS COMMENTARY

Collaboration with the Rockefeller Foundation, the Resilience Shift, SIWI and Arup to develop the CWRF is being led by a City team from Hull City Council and East Riding of Yorkshire Council. The team includes cross-sector representation to facilitate effective engagement across the various city departments and wider stakeholders—ensuring a fully integrated and efficient approach.

The diagram to the right highlights the governance structure by which the Hull City Team is working with the Living with Water Partnership (LWWP) to facilitate engagement with cross-sector stakeholders, citizens and the wider community throughout the process. The LWWP is proposed, in future, to be the main governance vehicle to address water resilience across the city.

During the fieldwork workshops, further detailed mapping of stakeholders was undertaken looking at various components of the water system.



For complete diagram see the Annex

As expected, stakeholders' understanding of the catchment and water systems varied significantly based on their level of expertise and area of specialisation. Their perceptions of the wider basin and the boundaries of water systems tended to be specific to their local geography and to issues immediately affecting their lives or work. For some this was hyper-local (street or property level perspective) while for others it was at the catchment or estuary-level. Overall there seemed to be broad consensus amongst stakeholders that the Hull Catchment is a useful primary focus for planning and action for water resilience.

BASIC SERVICE PROVISIONS

Yorkshire Water is the private-sector company responsible for public water and wastewater services - including surface water drainage - across Yorkshire. They are regulated by the Office of Water Services (Ofwat).

The Environment Agency (EA) is responsible for major land drainage, coastal and fluvial flood defences. Within the Hull catchment the Inland Drainage Board plays a critical role in operating and maintaining land drainage.

Hull City Council (HCC) and the East Riding of Yorkshire Council have responsibility for local flood risk assets and multiple linked assets such as transport, housing, public health etc

There are many interdependencies with other organisations such as regulated utilities or city authorities providing services relating to energy, transport, housing, healthcare and so on (see also Section 6).

RISK MANAGEMENT

Regionally, the Humber Local Resilience Forum is a key vehicle that brings together multiple agencies to manage risk and to plan emergency response and recovery, including police, fire and rescue, healthcare, city authorities and utilities.

The Environment Agency is the government agency with overarching responsibility for all flood risk. Yorkshire Water and other utilities and services providers undertake risk management in relation to their own assets and responsibilities.

Hull City Council (HCC) and the East Riding or Yorkshire Council, in addition to their other assets, have responsibility for Strategic Flood Risk Assessments and control of planning and development and own some flood risk and water management assets. Since the Flood & Water Management Act 2010 they also have responsibility for local flood risk. This is driving more collaboration with the Environment Agency, Yorkshire Water and other stakeholders as exemplified by the LWWP.

The planned new UK National Flood Resilience Centre at Hull University will build further expertise in emergency planning and response.

ENVIRONMENT

The Environment Agency is the government agency responsible for regulating, habitats, water quality, groundwater and surface water abstraction and other aspects of the water environment.

The Marine Management Organisation also has a role in regulation of the marine environment. Other organisations such as Natural England, and Heritage England have a role in protecting the natural and cultural landscape. NGOs such as the Yorkshire Wildlife Trust, RSPB and play a key role alongside other organisations such as the National Farmer's Union.

Umbrella organisations such as the Hull and East Riding Catchment Partnership and Humber Local Nature Partnership, represent multiple environmental and cross-sector stakeholders.

ECONOMIC AND SOCIO-CULTURAL

Hull City Council and the East Riding of Yorkshire Council play a key role in local economic planning and development. Regionally, the Humber Local Enterprise Partnership is a public / private / academic partnership that is the lead agency in developing economic strategy across the Humber and in making bids for funding and investment.

Multiple other city departments, NGOs, community organisations and businesses play a key role in shaping the economy and socio-cultural life of the city. The Hull UK City of Culture 2017 had a major impact and has developed a legacy programme to continue that work engaging communities and raising the profile of the city. LWWP are beginning work with volunteer cultural ambassadors as part of the LWWP community engagement programme. (Absolutely Cultured, 2018)

Case study

Living with Water Partnership

The Living with Water Partnership (LWWP, 2018)has been established to take a leading role in addressing water resilience within the city and its surrounding catchment. The pioneering partnership and governance structure has been established between the four agencies with primary responsibility for the water environment: Hull City Council, East Riding of Yorkshire City Council, Yorkshire Water and the Environment Agency. The group in turn works with a wide group of stakeholders and with citizens and communities.

The LWWP aims to take a fresh approach to addressing flood risk by making use of more sustainable solutions that work in harmony with the environment and which also provide wider benefits to the local community and economy, including access to green space, improved air quality, biodiversity and social benefits. Importantly the LWWP team includes a cross-sector representation bringing together water and environment professionals with other disciplines such as urban planning and regeneration, climate and sustainability, emergency planning and health and wellbeing. The LWWP is developing a pipeline of up to 70 potential projects to address water resilience going forward.

Community resilience and awareness is key to managing flood risk and this has been a key focus for LWWP. The LWWP has already been working with schools, youth services and multiple other agencies to understand how water impacts on communities the health and wellbeing of citizens. In addition to training, Hull City of Culture volunteers spread the message across the city and beyond, LWWP are running events such as the Hulltimate Challenge - a water-themed obstacle race and resilience fair and family fun day in the centre of the city. LWWP has developed the "Humbrella" concept (see below) reflecting the holistic approach to water resilience and how it touches all aspects of community and city life. See https://livingwithwater.co.uk/ for more information about LWWP.

KEY PROGRAMMES

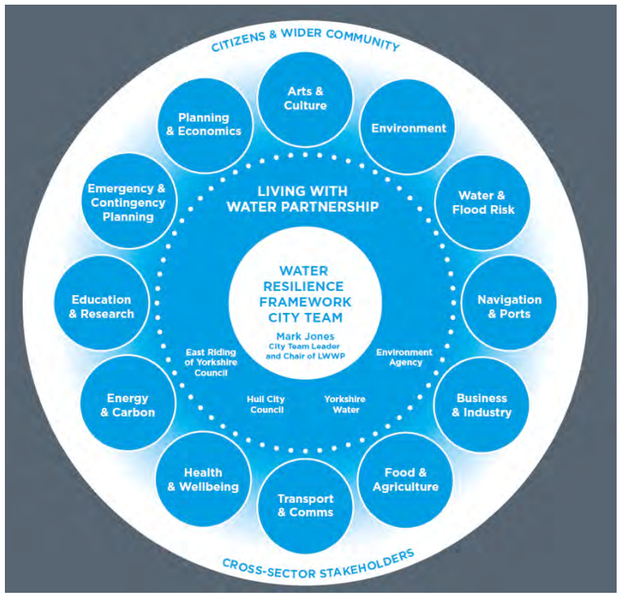
Hull and the LWWP have been doing great work to address resilience already. Below are some of the programmes that are under way or planned.

WATER AND FLOOD RISK-RELATED INVESTMENT

1. Living with Water Partnership (LWWP): Partnership investment to catalyse visioning and governance functions, developing a pipeline of projects and undertaking an extensive stakeholder engagement programme. (LWWP, 2018) (Highlighted in Section 7 Case Studies.)
2. Hull Strategic Flood Risk Assessment (Hull City Council , 2016): One of the most comprehensive flood risk assessments in the UK looking at multiple sources of flooding. East Riding of Yorkshire Council has also produced a highly comprehensive flood risk assessment and Local Flood Risk Management strategy(ERYCC, 2015).
3. Water-sensitive planning and development: Increasingly being integrated with the city planning process, including expanding the Aquagreens green-blue infrastructure programme, Paull Phase 1 and 2 Employment Sites – as part of the Humber Enterprise Zone, and community scale interventions such as Willerby Carr culvert daylighting and Community Garden (highlighted in Section 7 Case Studies).
4. Ark - The UK National Flood Resilience Centre (Ark Flood Centre, n.d.): This centre will be delivered at Hull University with full-scale physical simulation of disaster events, and leading in the management of and resilience against catastrophic flooding.
5. Yorkshire Water Operational and Investment Programme to 2030 and future 25-year strategy (Yorkshire Water, 2017).
6. Environment Agency Humber Hull Frontages coastal flood defence scheme (Environment Agency, 2018), the River Hull flood defence scheme (UK Government, 2016) and a rang of Local Flood Alleviation Schemes being delivered by the LWWP partners (ERYCC, 2018)
7. Ongoing environmental programmes linked to the EU Water Framework Directive and Habitat Regulations.
8. Natural Flood Management: an ongoing programme of research, study and investment into the potential benefits of natural flood management within the wider Hull catchment (highlighted in Section 7 Case Studies).

OTHER RELATED INVESTMENT PROGRAMMES

9. Humber LEP Strategic Economic Plan 2014-2020: this incorporates in their vision the estuary as an opportunity not just a threat (Humber Local Enterprise Partnership, 2014).
10. Hull and East Riding Local Nature Partnership: the vision and strategy seeks to work together throughout Hull and East Riding to achieve a healthy natural environment and sustainable green economy (Hull and East Riding Nature Partnership, 2016).
11. Humber Strategy Comprehensive Review: following the 2013 tidal surge, the Environment Agency was asked by Defra to work with local authorities and the LEP to undertake a comprehensive review of the existing Humber Flood Risk Management Strategy (Todd, 2017).
12. Hull 2020 Making a Better Future Together: this vision is led by nine public sector organisations to drive effective working together to improve health and wellbeing outcomes (Hull CCG, 2014).
13. Hull UK City of Culture 2017 Legacy Programme. Established to continue to deliver impact following the highly successful year of culture. LWWP is already working the volunteer groups established for the City of Culture to raise awareness of water resilience issues. (Absolutely Cultured, 2018)



Overview of Stakeholder Context for the Hull CWRF Engagement. Source: Hull City Council and the LWWP

5

CHARACTERISING RESILIENCE

Hull triathlon swimmers

CRITICAL INTERDEPENDENCIES

The urban water system does not exist in a vacuum, there are other systems within the city that rely on water and that influence the use of water. Fieldwork in Hull revealed direct connections between water and energy, transport, housing and development, food industry, agriculture and wider catchment practice. Some of the more significant interdependencies are described below.

- **Energy:** Perhaps the most direct interdependency is with the energy systems, due to the high reliance on pumped systems to deal with flooding and for water distribution and treatment. Back-up systems are typically reliant on fuel supplies. Coal and bio-fuels required for local and regional energy production are delivered through local ports.
- **Transport:** Transport systems play a key role in operating and maintaining the critical infrastructure needed to support water resilience – there are major interdependencies between water and all of the transport systems. Consideration of the role of ports and navigation within the Humber and wider UK economy highlights how water resilience impacts far beyond the local system boundaries.
- **Socio-cultural implications:** The strong socio-cultural role of water also emerged: it can bring communities together, for example through collective identity and action around water, or literally around a new water space or amenity; it can also divide communities, either physically, as the River Hull divides the city into east and west, or through differing exposure to risks or inequitable investment between communities.
- **Economy:** The impact of water resilience on strategic inward investment and local economic strategy was clear, both as a threat and as an opportunity for the city. Attracting investment, business continuity and insurance were key issues, as was householder insurance. For some stakeholders, impacts were as much about workforce resilience or supplier continuity as about physical systems. The strong links between local economic development and climate vulnerability emerged, raising issues of inclusive growth both within the city but also across urban/rural boundaries.
- **Health and wellbeing:** The impact of flooding on mental health and wellbeing of communities, and the potential opportunities to improve health and wellbeing through innovative water resilience measures, came through strongly in the fieldwork. This links to economic and socio-cultural context, in particular issues of inequality and deprivation across the city. Vulnerability to shocks and stresses, including the capacity to respond and recover, generally increases with higher levels of deprivation.
- **Rural vs. urban:** Interdependencies between urban and rural areas was a key theme throughout the fieldwork. This cut across all systems from physical water systems to economic and investment, planning and regulation, political, and socio-cultural issues. The two groups can be quite disconnected and be part of different planning and investment cycles. For example, understanding the relative value of investment in sustainable drainage systems (SuDS) within the city versus investment in upper catchment measures. This also includes questions around how to manage land use for local economic stability, food production and sustainable growth.
- **The Water Environment:** Strong dependencies between Hull and the wider estuary context also emerged. For example, estuary-wide trade-offs in terms of accommodating water storage or creating new compensatory habitat to facilitate development in urban industrial areas whilst also enhancing the rural economy.

Case study

Natural Flood Management Programme

The River Hull flows from the north, through the city and discharges into the Humber estuary. Although the surrounding land to the west and east of the city is higher, land to the north in the river catchment is predominantly low and has been intensively drained for agricultural purposes. This agricultural system relies on artificial drainage, such as a network of cut drains and watercourse and pumps to enable flow. The maintenance and operation of these systems has previously been from the public funds, but current government funding rules are based around protecting people and property, not agricultural land. Therefore, the case for continuing to sustain this drainage system through public funding is weak. Combined with a possible change in farming subsidies with Brexit and the government 25-year Environment Plan, opportunities now exist to look at different land management practices to provide flood, habitat, amenity, and value benefits through implementing natural measures to reduce reliance on pumps and energy. Arup and Hull University are currently partnering on this natural flood management (NFM) work to create a map to identify locations that could achieve the most significant benefits using NFM. This work will enable multiple partners to target relevant funding sources strategically rather than in a piecemeal fashion.

Case study

Ark—UK National Flood Resilience Centre

The University of Hull and the Humberside Fire and Rescue Services are developing the Ark project. (Ark Flood Centre, n.d.) Ark will be a purpose-built UK National Flood Resilience Centre. The first of its kind anywhere in the world, Ark will combine simulated full-scale urban and rural environments that can be inundated to provide flood emergency responders with realistic swift- and still-water training, and the research community with large-scale research and innovation infrastructure. Using the National Flood Resilience Centre as a vehicle, the Ark Project partners will make the UK a world-leader in the management of and resilience against catastrophic flooding.

The Centre will improve coordination and training, enable world-leading research, and create a business innovation hub. For more information see the Ark website http://arkfloodcentre.co.uk/

KEY SHOCKS AND STRESSES

The CWRF workshop and the facilitated discussion throughout the fieldwork encouraged participants to think across all urban systems when contemplating the shocks and stresses that could impact Hull. Some of the more critical ones identified during the fieldwork are described below. Several may manifest as both a shock and a stress.

CLIMATE CHANGE: SEA LEVEL RISE AND MORE INTENSE STORMS

Planning for coastal protection is complex and must balance sea level rise, coastal erosion and habitat protection, flood storage, navigation and industry. It must also balance the needs of urban and rural communities across the catchment. Sea level is forecast to rise by up to 1 metre by 2110, with increased intensity storms and tidal surges.

FLOODING FROM MULTIPLE SOURCES

Hull faces flooding risk from multiple sources: tidal surges, fluvial flows, surface water and groundwater. The city is fully reliant on pumping to remove flood water. Existing surface water systems are at or near capacity. Options for green-blue infrastructure solutions are limited but are being explored within the city. Solutions to keep water out of the city are sensitive because they could require trade-offs with development and loss of prime agricultural land and coordination across administrative boundaries.

ENERGY CRISIS

Local measures are in place in the form of alternative supplies and back-up generation for major pumping stations and treatment works and other infrastructure. However, due to the high reliance on pumped systems to deal with flooding and for water distribution and treatment, the city is highly vulnerable to energy crises, including power outages, industrial action and fuel shortages. Some local systems characteristics (locally based fuel companies and supply networks, access to ports etc) may increase the resilience of energy systems compared to other cities.

WATER RESOURCES AND SUPPLY

Raw water for Hull is supplied from surface water and from ground water from the underlying Yorkshire Chalk aquifer. The aquifer is recharged in the upper catchment from water falling on the Wolds.

Raw water quality is managed through source protection zones, but these are under increasing pressure from development and agricultural practice, with nitrate contamination being a particular issue.

Groundwater abstraction is limited by the need to avoid saline intrusion from the estuary, which may become a limiting factor in the future. New licences for groundwater abstraction are being limited.

INCREASING WATER DEMAND

Major industrial water users are based in Hull, in particular petro-chemical and health care. Few users have private supplies – most rely on central water supply networks. As with many UK cities, there is a general lack of awareness of the water supply system, both across industrial and domestic users.

Demand-side strategies for water efficient fixtures, grey-water recycling and water harvesting are limited through lack of regulation and incentives, generally being reliant on market forces.

Many properties do not have water meters, so lack incentives to reduce water consumption. Whilst affordability is a key issue, appropriate pricing and valuing of water is a constant debate – innovation in this area can be limited by regulation.

LACK OF COMMUNITY ENGAGEMENT

Despite the extent of flood risk and impact on almost 9000 properties during the 2007 floods (Coulthard et al, 2007), perception and awareness of flood risk is still relatively low, This may be partly due to socio-economic factors and capacity to engage with multiple issues, it may also be linked to the characteristics of the flood events – less frequent shock events rather than ongoing events that keep flood resilience front-of-mind in places like York and Calderdale.

Awareness of water supply issues is low with opportunity for further engagement.

AGEING INFRASTRUCTURE

Ageing infrastructure is an issue across the water cycle, from wastewater and surface water systems, to the nineteenth century adits supplying raw water, to flood defences and land drainage systems. Maintenance, upgrade and replacement of these assets is a key issue, strongly linked to infrastructure capacity, discussed in the next section.

LIMITED INFRASTRUCTURE CAPACITY

Surface and wastewater systems are close to capacity. Innovative green-blue solutions, mechanisms to separate surface water and hold water back within the catchment, coupled with demand-side strategies, are required to address this.

DEVELOPMENT PRESSURE ON FLOOD PLAIN AND WATER SOURCES

A key issue raised during the fieldwork is how to balance the need for housing and development with limited open space for surface water storage, the need to safeguard groundwater source protection zones, and the need for open green space for habitat and amenity. Tensions also arise between urban and rural development and priorities for land use.

SOCIO-SPATIAL VULNERABILITY

As mentioned before there is a wide variation across the catchment of socio-spatial vulnerability to flood risk. Areas with higher levels of deprivation have less capacity to absorb water-related shocks and stresses. They may also have reduced capacity to engage with water resilience issues alongside many other pressures. Inadequate insurance and financial resources for implementing property level flood insurance was raised as a repeated issue amongst more deprived communities with some unable to afford any insurance against flooding.

For example, areas with limited social mobility leading to multiple family members living nearby (e.g. east Hull) can develop strong social networks and supports – a key aspect of resilience which can reduce vulnerability to certain shocks and stresses. However, such communities can be highly vulnerable during a flood event if the whole social network is affected at once. These interactions are complex and more work is required to understand them, however, in general there is evidence that poverty, inequality and poor health increase vulnerability to climate risks, placing increased pressure on emergency planning, response and recovery services. There are also knock-on effects for other systems such as housing, social care and public health.

GOVERNANCE CHALLENGES

Water and in particular flooding is seen as an issue that encourages collaboration across political party lines and can act as a positive integrator. However, following shock events such as a flood or tidal surge aspects can become more political. Water supply and quality, whilst often not front-of mind, can also become highly political and sensitive when the system comes under stress

This can affect funding and investment decisions, sometimes leading to short-term responses and actions that may not align with long-term strategic planning. Widespread use of social media and availability of information from

multiple sources can exaggerate this issue, placing increasing pressure on political and other strategic decision-making processes.

Many of these governance challenges are place ongoing stresses on the system. Brexit is an example of a recent shock event, the impacts of which are still being assessed.

Major challenges still remain around aligning strategy, plans and funding pots across organisations and timescales, including aligning capital programmes with smaller-scale or revenue-based investments in local resilience, place-making and community engagement.

OTHER SHOCKS AND STRESSES

Alongside the main shocks and stresses highlighted above, a range of others were selected during the workshops for consideration. These are listed below to give a flavour of the wide-ranging discussions

- Drought
- Terrorism
- Cyber crime
- Emergency services failure
- Cold wave
- Communication infrastructure failure
- Social unrest/industrial action
- Sudden changes in funding and finance
- Inadequate funding and finance
- Current regulatory framework
- Changes in rural economy/agronomy
- Poor governance
- Economic instability
- Ecosystem degradation
- Digital transformation: impact of social media on political-decision making
- Increasing cost of water and water services
- Declining tolerance of service failures
- Food insecurity
- Poor planning
- Housing quality
- Poor education
- Risk of 'brain-drain' – loss of relevant skills
- Inadequate insurance
- Increasing deprivation/inequality
- Unemployment/loss of industry
- Lack of skills in resilience preparedness and recover

KEY FACTORS OF RESILIENCE

Some of the emerging factors of resilience identified through the fieldwork in Hull are discussed below.

INNOVATIVE FUNDING AND INVESTMENT

The unique nature of the catchment raises several challenges that require innovative approaches to governance, funding and delivery that are already being considered by the city and LWWP. Regulatory investment cycles are often out of alignment between sectors making it difficult to integrate programmes. Regulation can sometimes hinder innovative investment, for example making it difficult to capture total value across all systems and integrate into a business case or preventing transfer of benefits between urban and rural areas (see also below).

A key challenge is in balancing the needs of different stakeholders and ensuring equity of investment and impacts between who benefits and who pays (both positive and negative).

INVESTMENT IN LOCAL RESILIENCE MEASURES

Investment for capital revenue-based interventions is often not aligned. The current appraisal rules and regulatory framework favours capital investment, often delivered over relatively short timescales rather than longer term more dispersed solutions, the benefits of which can be complex and harder to model and quantify. Mechanisms to facilitate investment in local resilience measures, and capacity building alongside capital programmes, will be important going forward.

STAKEHOLDER AND COMMUNITY ENGAGEMENT

There is a need to reconnect the city with its water story, to build a shared understanding, particularly between urban and rural communities and also connecting across the city, including engaging immigrant and disadvantaged communities.

As described in this report, the LWWP is already undertaking an extensive engagement programme across the city. Community-scale interventions, such as the Willerby Carr Daylighting and Community Garden programme described later, can play a key role in engaging communities.

Such initiatives could not only increase the uptake of resilience measures, they may increase acceptance and participation in alternative solutions, facilitate behaviour change and may also influence considerations of 'willingness to pay'.

PROMOTING NATURE-BASED SOLUTIONS

Due to the nature of Hull's reclaimed landscape, there will always be a need to manage the water environment using a variety of green and grey solutions. However, despite significant challenges based on Hull's unique catchment characteristics, there are many opportunities for nature-based solutions to water resilience, such as improved land management and natural flood management across the catchment, and innovative approaches within the city. These ideas need to be balanced with the complex needs of urban and rural development, ongoing land drainage strategy and the need to protect sensitive environmental habitats.

PROMOTING HEALTH & WELLBEING

Addressing the wider determinants of health and wellbeing, such as living environment, inequality, lifestyle, and mental health will be a key to a water resilient future. This includes

developing the capacity to understand the social and psychological factors influencing behaviours and investment around water and flood risk, and developing ways to account for these in investment decisions. It will also include addressing deprivation to reduce socio-spatial vulnerability to climate risks. There are many opportunities for improving health and wellbeing outcomes linked to addressing water resilience.

WATER SENSITIVE DEVELOPMENT

Hull has one of the most comprehensive Strategic Flood Risk Assessments in the UK (Hull City Council , 2016), based on detailed understanding of integrated drainage systems to inform future development. The East Riding of Yorkshire Council has also developed a comprehensive flood assessment and risk management strategy (ERYCC, 2015). There will be increasing pressure on land use as the city grows. Balancing this demand with making space for water presents an opportunity for effective resilience planning. Implementation will require innovative approaches to spatial planning, urban design and development, including new planning mechanisms, incentives and design guidelines.

INTEGRATING RURAL AND URBAN DEVELOPMENT

Productive agricultural land is key to the local and regional economy. In the upper catchment the well-drained areas are used for arable and livestock farming. The reclaimed marshland lower down the catchment provides very high quality arable land, surrounding the low-lying urban areas of Hull. There is increasing pressure on the pumped drainage systems supporting agriculture, critical infrastructure and urban development. Maintaining land drains and main rivers within the catchment is also a key challenge.

Trade-offs are already happening in terms of compensatory habitats and provision of space for flood water outside of developed areas. New mechanisms to pay farmers for capital investments and ongoing services in flood risk management and water resilience services are being developed and could be extended.

Balancing land use and equity of investment in infrastructure across urban and rural areas will be key challenge going forward, requiring an integrated catchment-wide approach. LWWP partners have recently collaborated to deliver flood alleviation schemes to the west of Hull, outside of the city boundary. Such approaches may involve creating a catchment-scale case for investment, in future.

TRANSPARENT AND ACCOUNTABLE GOVERNANCE

It is important to develop and own a shared multi-agency vision and plan, with a collaborative governance structure backed up by legal basis and funding. LWWP is already working towards this.

The complexity of governance and decision-making, finance and stakeholder engagement often increases with more innovative approaches to water resilience, such as delivery of blue-green solutions within urban areas, or smaller-scale local resilience measures. Indeed the level of complexity can sometimes be inversely proportional to the size of the project. This is an opportunity and a challenge requiring new and innovative ways to engage and deliver projects.

Many of these issues depend on decisions made at national level, linked to planning policy, finance and regulation. The potential to influence government and drive change comes through as a need and an opportunity for Hull. The LWWP is already taking an active role in this.

Image courtesy of Hull City Council

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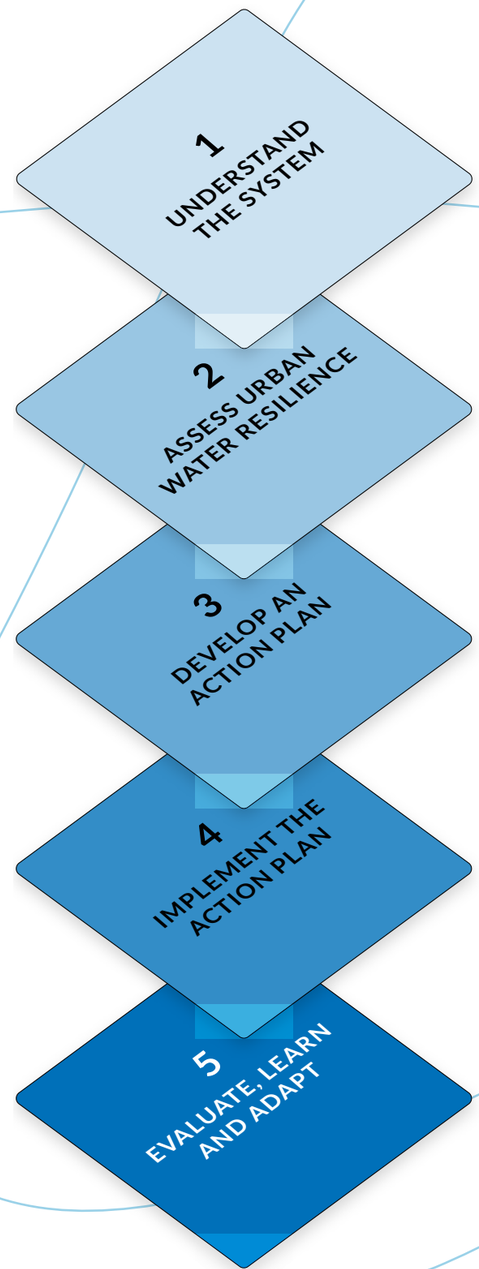
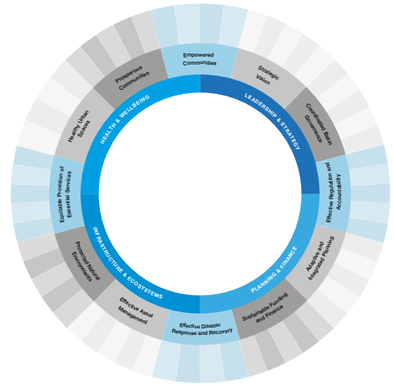
REFLECTIONS ON THE CITY WATER RESILIENCE APPROACH (CWRA)



PERSPECTIVES ON THE CWRA ASSESSMENT TOOL

During the various interviews and focus groups participants discussed the potential benefits of the CWRA and its potential role in urban resilience. One main perk of using CWRA that participants found was sharing learning and building collaboration with other cities within the city network. They said the framework also helps create consensus because everyone works towards a common goal—building a shared vision of resilience. CWRA highlighted the value in understanding interdependencies and thus supports collective learning, advocacy, and engagement. The results of the framework, including new and strengthened relationships, could help drive change and influence government for regulations, policy and funding. Hull participants felt CWRA would work well alongside existing initiatives such as Living With Water Partnership (LWWP).

Participants acknowledged that clarity about 'ownership' and implementation of the framework process would be required to move forward.



PERSPECTIVES ON THE CWRF

A rapid review of City Water Resilience Framework (CRWF) dimensions and draft goals was undertaken during the main CWRF workshop and also during a brief discussion at the Governance Workshop. Participants felt the dimensions were generally clear but some goals required further explanation. This was an example of the take-home message about the importance of language, including consideration about how terms translate in different global contexts. Therefore, descriptors should 'tell the story' at dimension and goal levels, not being dependent on the sub-goals or indicators for explanations. That said, Hull participants felt indicators would be useful to bring more clarity to each goal.

During the workshop, participants were invited to suggest alternative goals for the CWRF. Their suggestions are listed below.

- Adaptability
- Ability to recover, rebuild and grow
- Environmental sustainability, including respect for natural systems/resources
- Recognising the wider determinants of health and wellbeing, in particular mental health

Some groups felt the following concepts were relevant across the dimensions:

- Effective management of interdependencies
- Comprehensive security
- Reliable mobility and communication
- Adaptability

ACKNOWLEDGEMENTS

This characterisation report was made possible by the support and input of the following organisations:

This City Characterisation Report and the fieldwork that supports it has been made possible by the support and input of the following organisations:

- Hull City Council
- East Riding of Yorkshire Council
- Yorkshire Water
- Environment Agency

Thanks in particular to the members of the Hull City Team and the Living with Water Partnership team for their role in supporting this project and in helping to organise, host, and facilitate the fieldwork, subsequent analysis and CWRF development. Thanks also for their time in attending the Global Knowledge Exchange event in 2018, providing valuable insights and feedback.

Thanks also to all those who participated in the many interviews, focus groups and workshops from DEFRA, Ofwat and Hull University, to city officers, elected councillors, community members, flood wardens, local and international businesses, members of the insurance industry and a range of other public, private and third-sector organisations.

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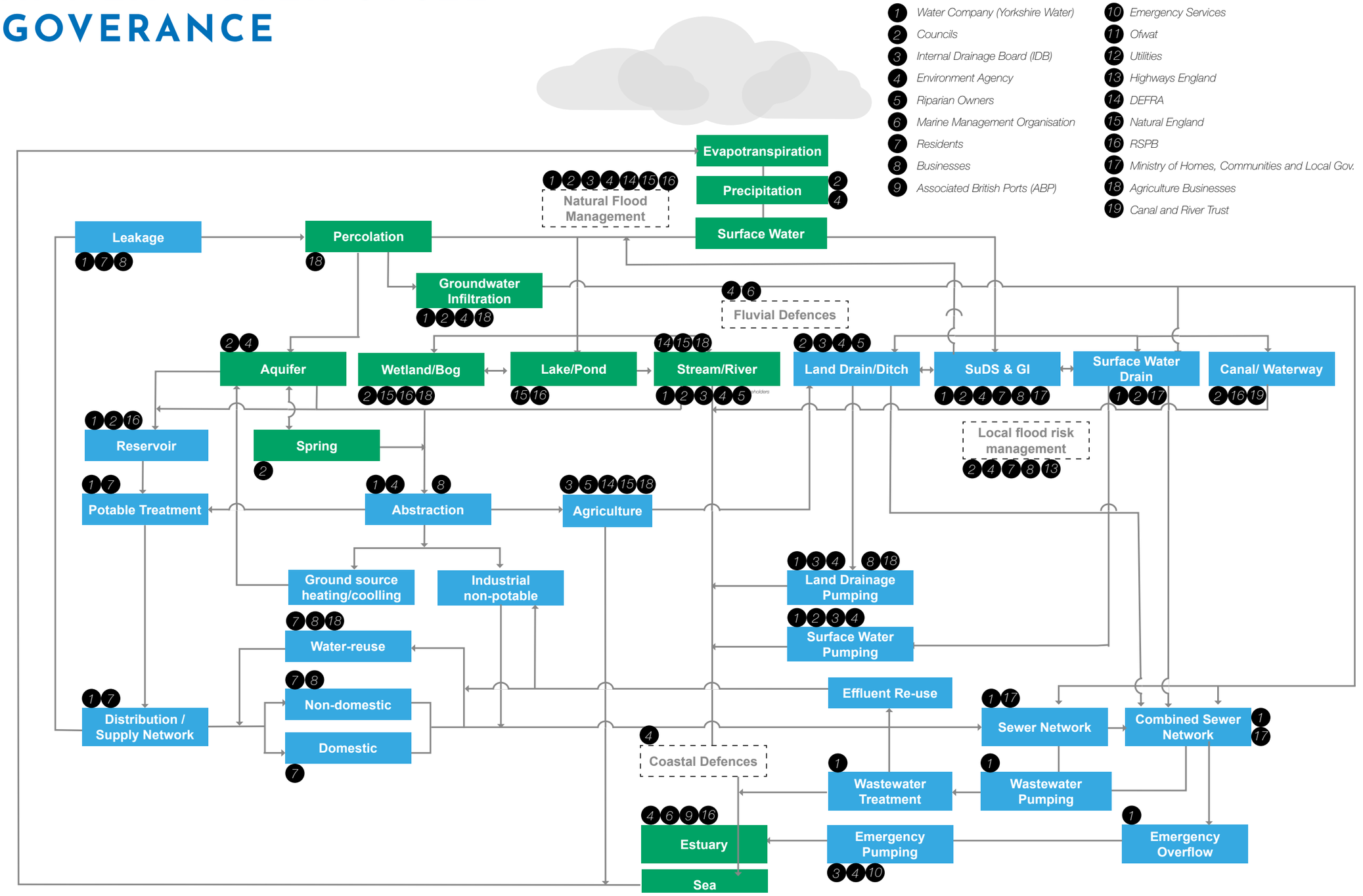
City Water Resilience Approach workshops at the Global Knowledge Exchange event in August 2018

ANNEX: WATER CYCLE GOVERANCE

Key

1. *Water Company (Yorkshire Water)*
2. *Councils*
3. *Internal Drainage Board (IDB)*
4. *Environment Agency*
5. *Riparian Owners*
6. *Marine Management Organisation*
7. *Residents*
8. *Businesses*
9. *Associated British Ports (ABP)*
10. *Emergency Services*
11. *Ofwat*
12. *Utilities*
13. *Highways England*
14. *DEFRA*
15. *Natural England*
16. *RSPB*
17. *Ministry of Homes, Communities and Local Gov.*
18. *Agriculture Businesses*
19. *Canal and River Trust*



Overview of the Governance of the City Water Cycle.

Green boxes indicate natural processes and the blue indicate human-made elements. It is acknowledged the boundaries between these categories are particularly complex in Hull where so much of the landscape has been highly modified over time. The dotted boxes acknowledge the fundamental role that flood management plays controlling flows between different parts of the cycle.

This water governance diagram is an initial draft based on workshops undertaken during the field mission to Hull. It should be reviewed and agreed upon by all key stakeholders.