Managing Urban Flood Risk: the Blue-Green Approach

Dr Emily Lawson

18th December 2014

EPSRC Grant EP/K013661/1

Blue-Green Cities Research Aim

Develop and rigorously evaluate strategies for managing flood risk that deliver multiple benefits as part of urban planning and renewal

J4M8, Edinburgh

Hebden Bridge

Wortley Beck, Leeds

The Dings, Bristol

HERIOT WATT UNIVERSITY

Newcastle University

UNIVERSITY OF LEEDS

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

RIVERS Agency

UNIVERSITY OF CAMBRIDGE

THE RIVER RESTORATION CENTRE

Cranfield UNIVERSITY

UWE BRISTOL
University of the West of England

LSE

Case Study City: Newcastle

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Lecture outline

- Flooding facts and the main types of flooding
- Coincident flooding and winter 2013/14
- Historic and recent flooding in Nottingham
- Approaches to manage flood risk
  - grey infrastructure (traditional, hard engineering)
  - blue-green infrastructure (natural flood risk management)
- Blue-Green Cities and SuDS **(sustainable urban drainage systems)**
- Examples and case studies
- Benefits of Blue-Green (environmental, social, economic, adaptable to climate change)
- Multifunctional space

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2 December 2014 Last updated at 13:19

1.2K Share

Treasury announces which flood defence projects will share £2.3bn

Homes near Walton-on-Thames, Surrey, were surrounded by flood water in February

Flooding facts

Flooding is the UK's most serious natural hazard

Over 5 million properties (1 in 6) and large proportions of the UK's key infrastructure are at risk

Floods are expensive: the summer floods in 2007 cost the economy £3.2 billion

Average annual flood damages are between £500 million and £1 billion

May get worse with climate change (predicted wetter winters and more intense rainfall events)

Government autumn statement - more than 1400 flood defence projects are to receive funding to protect 300,000 homes (prevent £30 billion damages)

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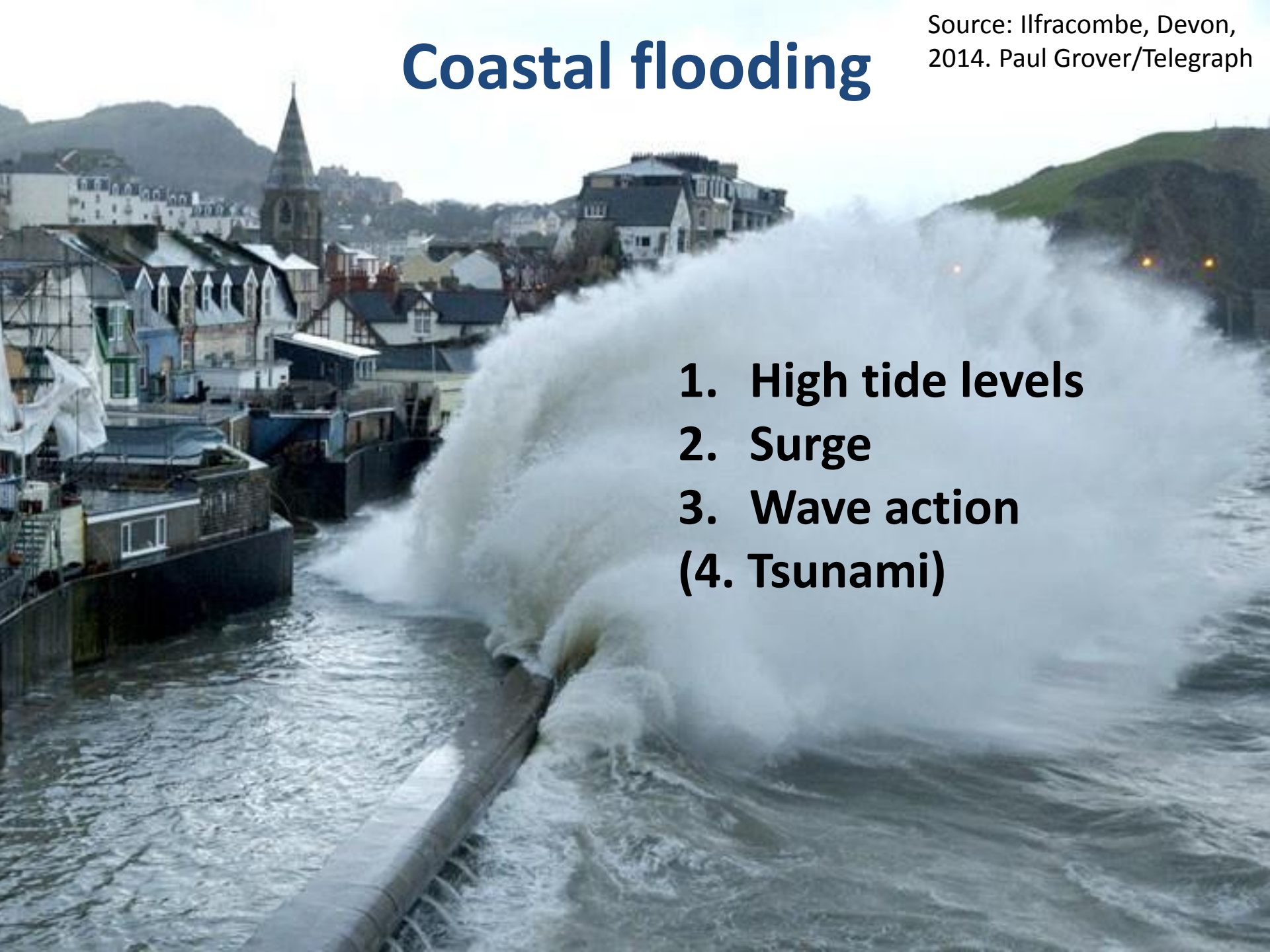
Fluvial (river) flooding

Source: Tewkesbury, Nov 2012.
David Goddard/Getty Images

Coastal flooding



Source: Ilfracombe, Devon, 2014. Paul Grover/Telegraph

1. High tide levels
2. Surge
3. Wave action

(4. Tsunami)

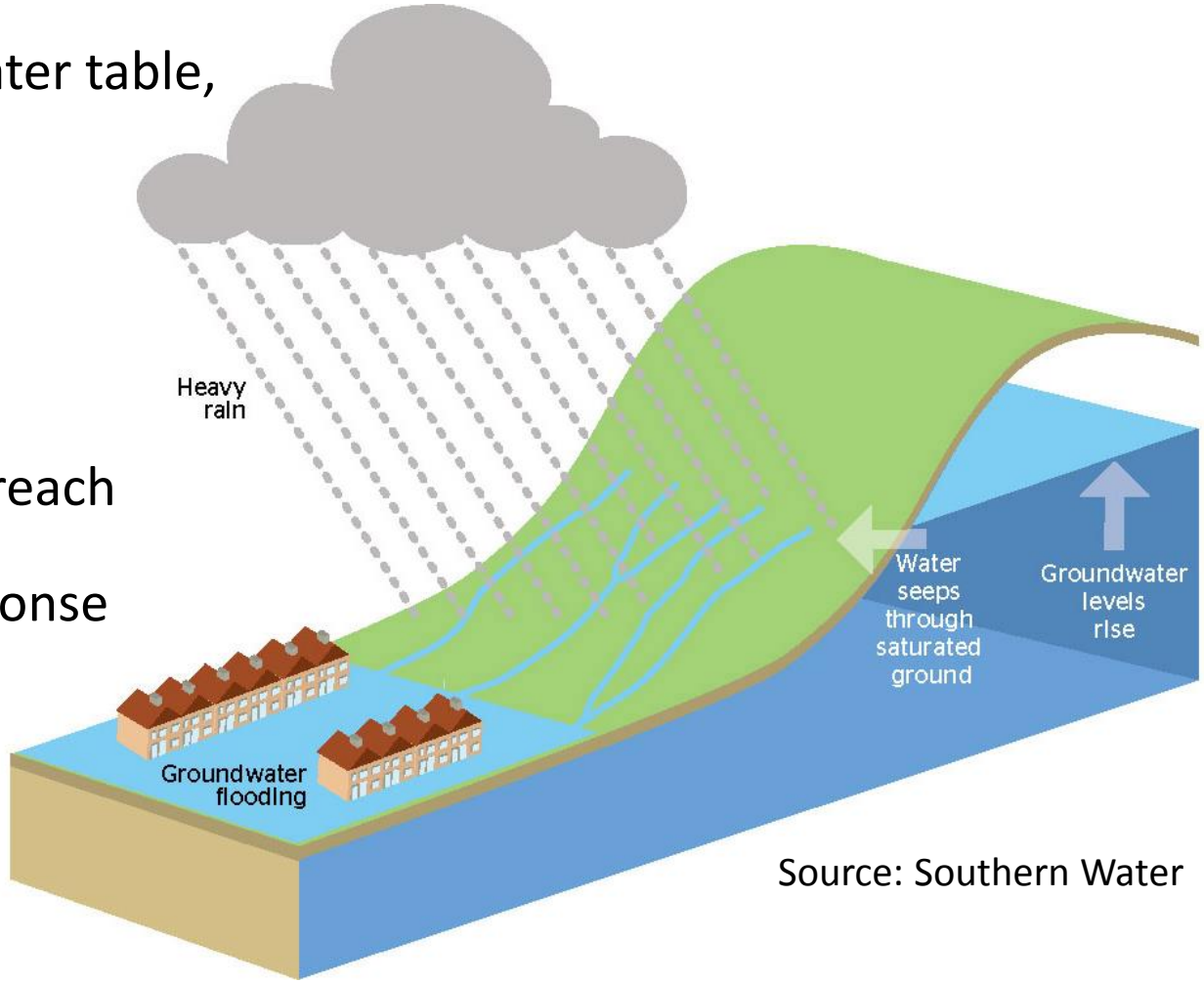
Pluvial (surface water) flooding

(from intense rainfall)

Newcastle “Toon Monsoon” June 2012 – hard to predict + difficult to manage

Other types of flooding

- Groundwater (rising water table, saturated ground)
- Drain and sewer
- Broken water mains
- Dam/levee/reservoir breach
- Flash floods (rapid response to a rainfall event)
- Secondary impact to a primary hazard, e.g. earthquake, landslide



Source: Southern Water

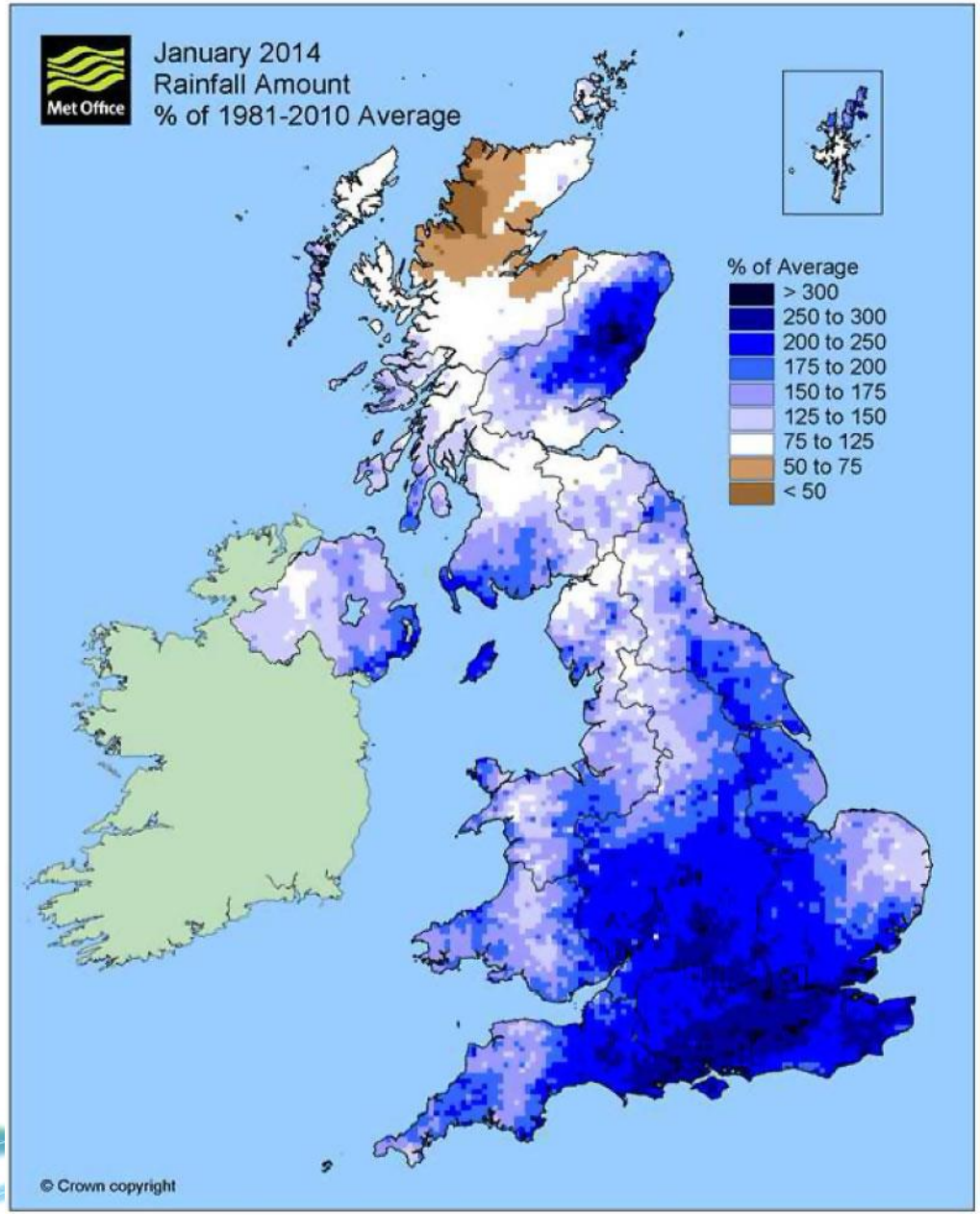
Coincident flooding (winter 2013/14)

Storm surge December 2013
Source: Reuters

Coincident flooding (winter 2013/14)

Intense storms across Southern England, December 2013
Source: BBC news

Coincident flooding (winter 2013/14)



Wettest January ever

In January 2014, rainfall in central, southern and southeast England was 2-3 times the long-term average, making it the wettest January since records began in 1766.

This was due to six Atlantic depressions tracking further south than usual

Source: Met Office (2014a), in *Geographies of UK flooding in 2013/4,* Colin Thorne, The Geographical Journal

Coincident flooding (winter 2013/14)

Flooding in Southern England continues into 2014

UK Space Agency images showing how flooding in Somerset worsened from 8th Jan (left) to 10th Feb (right) 2014

Source: BBC news

This has happened before…

In the 2014 flood, ~10% of the Levels were submerged **YET** in 1919 floods, more than a third of the area was under water

Much of the Somerset Levels are below high water level on spring tides, maximum altitude =25 ft (8 m) above sea level

Historic flooding in Nottingham

Images courtesy of University of Nottingham Archives and Manuscripts and Nottingham Post

(more recent) Nottingham flooding

Source: Nottingham Post, 2014, Shakespeare Street, City Centre


Source: BBC News Nottingham, 2012, Lambley


Source: itv news, 2013, Hucknall Town Centre

Source: Andrew Philips, 2012, Boating Lake, University Park campus

Risk of Flooding from Rivers and Sea

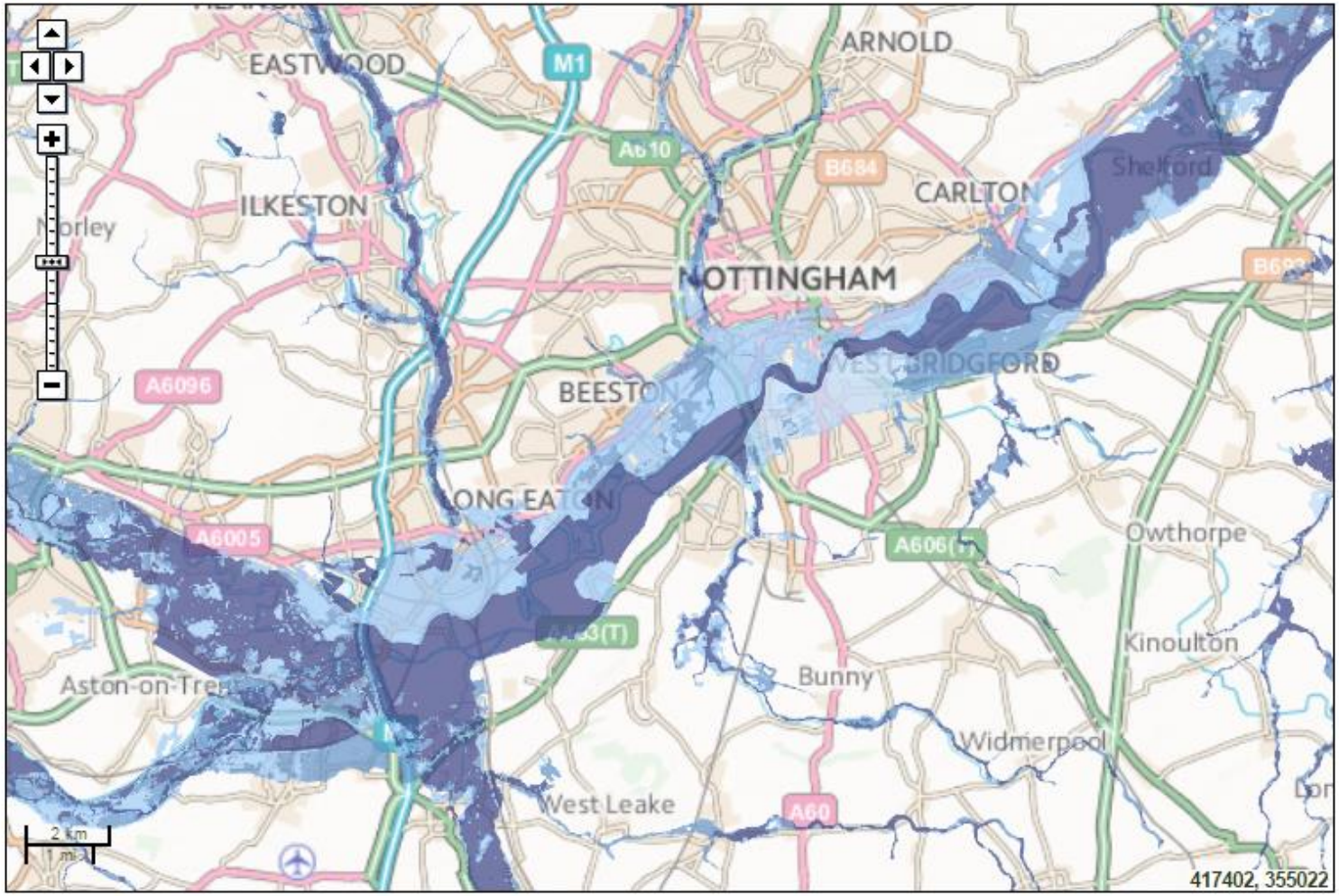
Environment Agency

Map legend

- Risk of Flooding from Rivers and Sea
- High
- Medium
- Low
- Very Low

Map of X: 454,232; Y: 336,101 at scale 1:125,000

Data search



Flooding terminology

Recurrence intervals, probability of flooding, return periods, exceedance probability…

A **one-hundred-year flood** is a flood event that has a 1% probability of occurring in any given year. Also called the 1 in 100 year event or 1% chance flood

A **one-year flood** has a 100% probability of occurring in any given year

EA maps – high flood risk (> 1 in 30, 3.3% chance of occurring in any given year)
medium flood risk (between 1 in 100 and 1 in 30)
low flood risk (between 1 in 1000 (0.1%) and 1 in 100)

UK defences – river (1 in 100 year event), sea (1 in 200 year event), Thames Barrier (1 in 1000 year event), blue-green infrastructure (1 in 30 year event)

BUT…if you get flooded in 2014 by a 1 in 100 year flood, you cannot assume that you are safe for the next 99 years. You could be flooded the next day (very low probability but not impossible)

Risk of Flooding from Surface Water

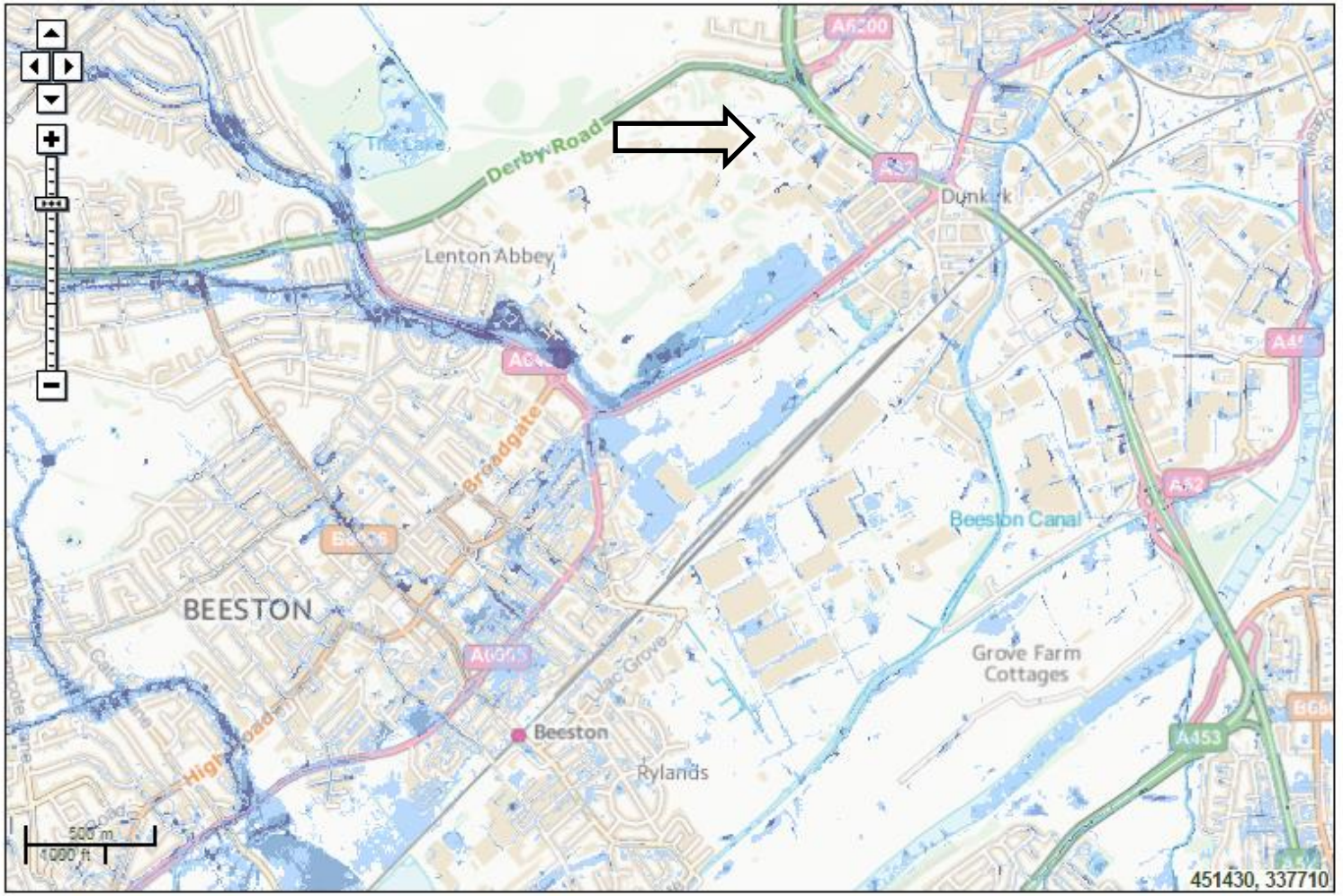
Environment Agency

Map legend

- [x] Risk of Flooding from Surface Water
- High
- Medium
- Low
- Very Low

Map of X: 454,000; Y: 337,386 at scale 1:20,000

Data search



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Grey infrastructure (traditional drainage)

Remove rainwater as quickly as possible from where it falls, treating water as a nuisance rather than a resource

Surface water in urban area → directed into public sewers

Some sewers may be combined (surface and foul water) → additional surface water at times of heavy rainfall places a significant burden on the piped system (and WWTW)

Combined sewer overflows alleviate this burden (excess water discharged into watercourses)

Were not designed for sustainability or to manage water quality and biodiversity

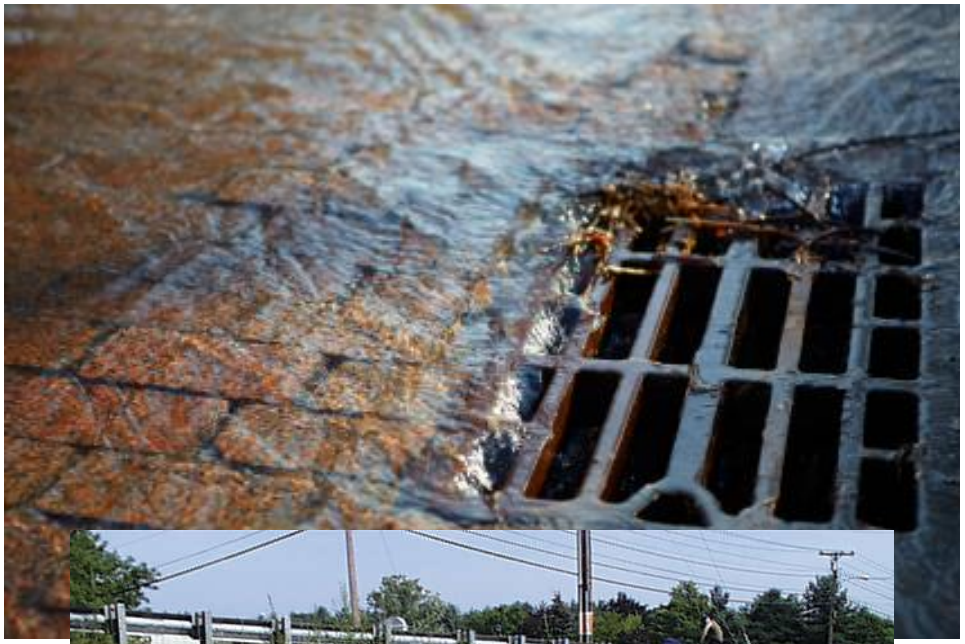
<u>Future risks</u>

Increasing stress on subsurface grey infrastructure due to;

1. expansion of impermeable surfaces in urban environments (economic + population growth)
2. increased rainfall due to climate change

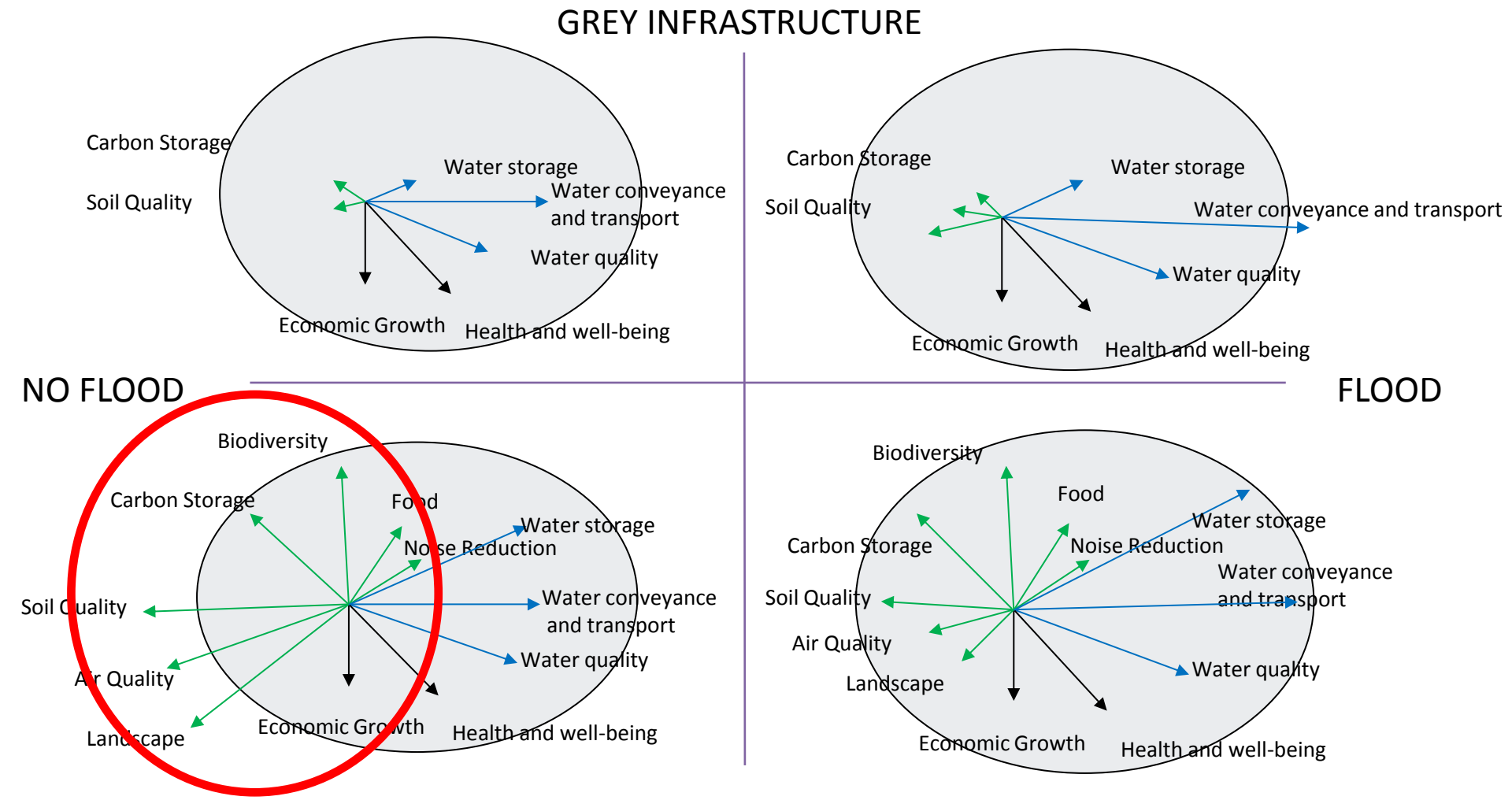
Q. Future flood defence – walls and barriers – how big (and ugly) do they need to be?

Grey infrastructure



London without the Thames Barrier during the December 2013 tidal surge (EA)

Grey vs. Blue-Green



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Back-to-nature flood schemes need 'government leadership'

By Roger Harrabin
Environment analyst

Natural flood defences, like felling trees into rivers to slow their flow, have

theguardian

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Environment › Flooding

Flood defenders go back to nature to keep vulnerable homes dry

Experiments set up after floods of 2007 are exploring alternatives to costly concrete defences as funding dries up

Damian Carrington
The Guardian, Friday 10 January 2014 16.03 GMT
Jump to comments (46)

www.gov.uk/defra

Department for Environment Food & Rural Affairs

Department for Communities and Local Government

Consultation on delivering Sustainable Drainage Systems

A summary of responses to the consultation and the government response

18 December 2014

Department for Environment Food & Rural Affairs

Llywodraeth Cymru Welsh Government

Cyfoeth Naturiol Cymru Natural Resources Wales

Environment Agency

delivering benefits through evidence

Working with natural processes to reduce flood risk

R&D framework: initiation report

Report – SC130004/R1

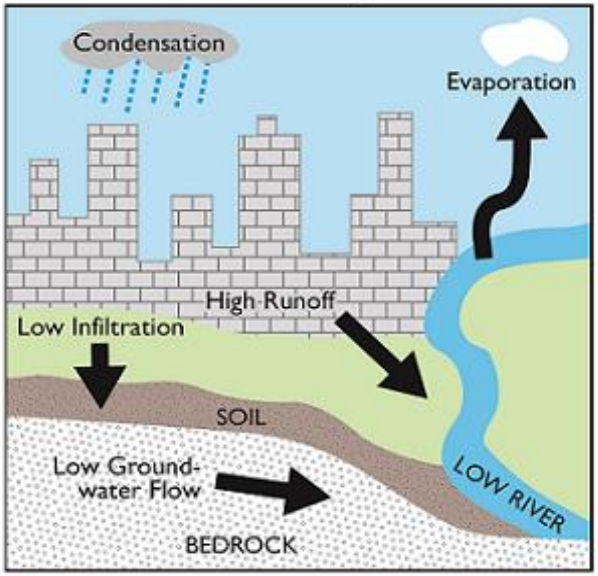
Flood and Coastal Erosion Risk Management Research and Development Programme

CITIES

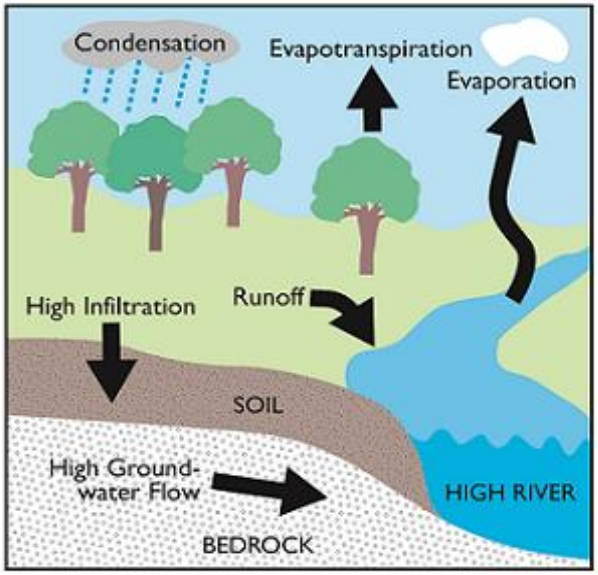
Water Cycle

Streetscape

Urban



Natural



Hydrologic and environmental attributes in Grey and Blue-Green Cities

Includes elements of Sustainable Urban Drainage Systems **(SuDS)**

BLUE- **GREEN**

blue green CITIES

How Blue-Green Infrastructure manages water

Reducing the amount of water entering man-made drainage systems via infiltration, interception, transpiration, storage (temporary and longer term)

Controlling the water at source + slowing the conveyance + attenuation and storage (reducing peaks in rivers, slower controlled release of water)

<u>Governmental Drivers</u>

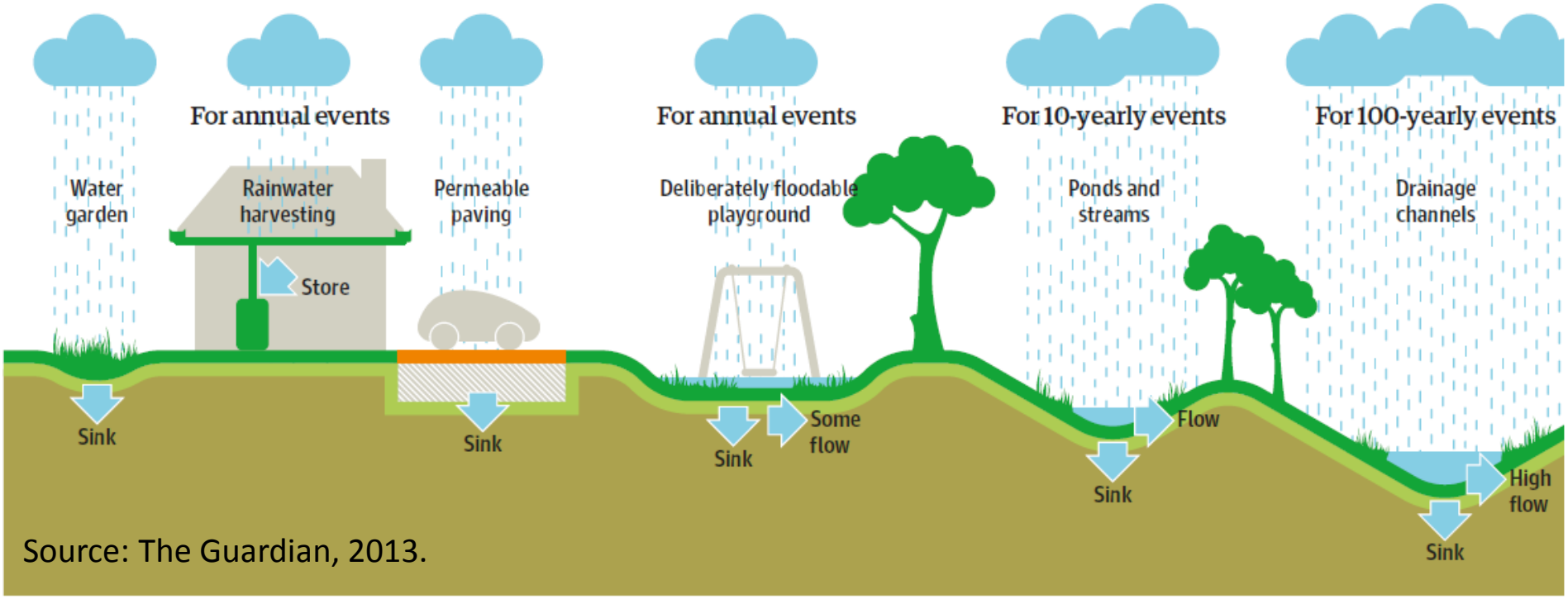
Pitt Review 2008 : review of the 2007 flooding, comprehensive appraisal of flood risk management in England. **SuDS = effective way to reduce the risk of "flash-flooding"**

The Flood and Water Management Act (2010) - includes far-reaching changes to improve flood risk management and encourages the use of SuDS

Introducing SuDS for new developments

Soaking it up slowly: drainage to limit flooding

Sustainable urban drainage (SUDS) will be mandatory for developments of more than one home from April 2014. Instead of running off hard surfaces or saturated land to flood homes nearby or disgorging through drains into rivers which burst their banks, the flow of heavy rain is attenuated through the local landscape and back into the system slowly to avoid floods



Source: The Guardian, 2013.

Blue-Green examples and case studies

Blue-Green infrastructure

- Bioretention systems
- Swales and buffer strips
- Storage ponds, lakes and reservoirs
- Controlled storage areas, e.g. car parks, recreational areas, minor roads, playing fields, parkland and hard standing in school playgrounds and industrial areas
- Permeable paving
- Rain gardens
- De-canalisation of river corridors and re-introduction of meanders
- Constructed wetlands
- Property level strategies to reduce surface water and manage runoff, such as water butts
- Open green space, parks, pocket parks and gardens designed for strategic water retention and infiltration
- Street trees
- Vegetated ephemeral waterways
- Planted drainage assets (green roofs and green walls)
- Restored, rehabilitated and enhanced urban watercourses offering green erosion protection (river restoration)

…any many more!

Bioswales (green streets) – source control

Green streets – traffic calming

Siskiyou Street Curb Extension Swales


Car park rain
garden (school)

Eco-roof (green roof)

Orchard Hotel Nottingham green roof

River re-meandering

Floodplain restoration project


Downspout
disconnections
(26K since 1993,
Portland, OR)

Other examples (limited water management function but greens the city)

Does the Blue-Green approach actually work?

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Stormwater management in Portland, Oregon, US

Primary drivers = cost effective way to control urban stormwater, reduce combined sewer overflows, provide relief to grey infrastructure capacity, improve water quality

- $1.4 billion invested in physical infrastructure in last 20 years (“Big Pipe”)
- $55 million “Grey to Green” programme

- Investment in BG strategies = reduce big pipe diameter (28 to 22 foot) = saving of $65-145 million (factoring in operating and maintenance costs)

Slowing the Flow project, Pickering, UK

'Hard' engineering (embankments, channel widening) = not cost effective or acceptable to local community

Natural flood management used to retain more flood water in the upper and middle parts of the catchment and reduce flood peaks in downstream Pickering, e.g. large woody debris dams

- Helped avoid a flood in November 2012

Resilience to Extreme Weather, The Royal Society Report, Nov 2014.

Schools in Leicester, rain gardens in Nottingham

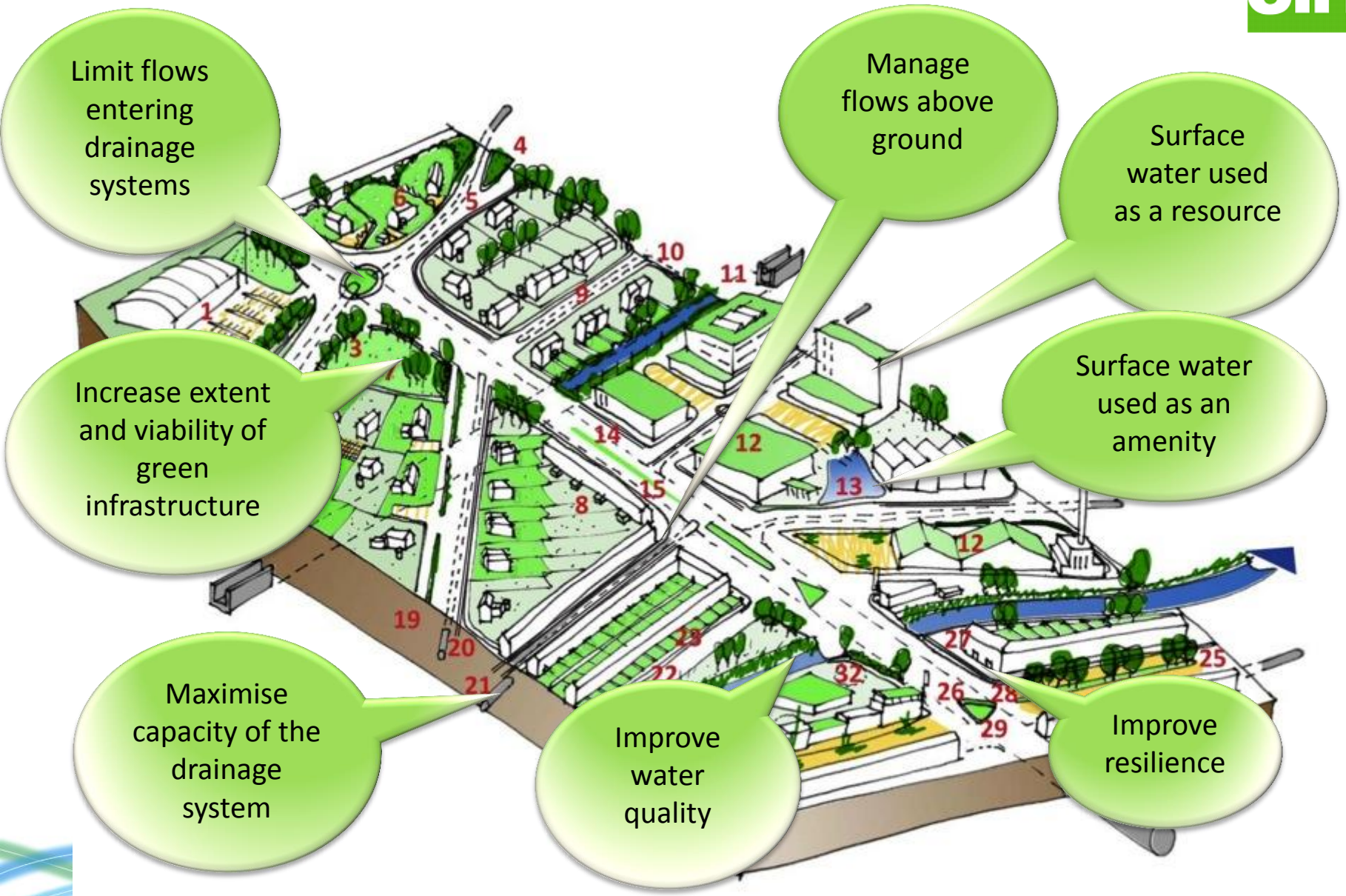
Images from Susdrain

Challenges and barriers to implementation

- Finding suitable areas for green streets (publicly-owned land, fulfil multiple objectives)
- Institutional (planning laws/politics)
- Data scarcity
- Feasibility
- Social acceptability
- Cost of implementation
- Who benefits vs. who pays
- Political will
- Time lag to benefit creation

We need evidence to support the case for multiple benefits

Multiple benefits of Blue-Green: water management



Multiple benefits of Blue-Green: environmental

Multiple benefits of Blue-Green: environmental

Reduction of the urban heat island effect, improved water quality, habitat enhancement, increased biodiversity (including reintroduction of native species)

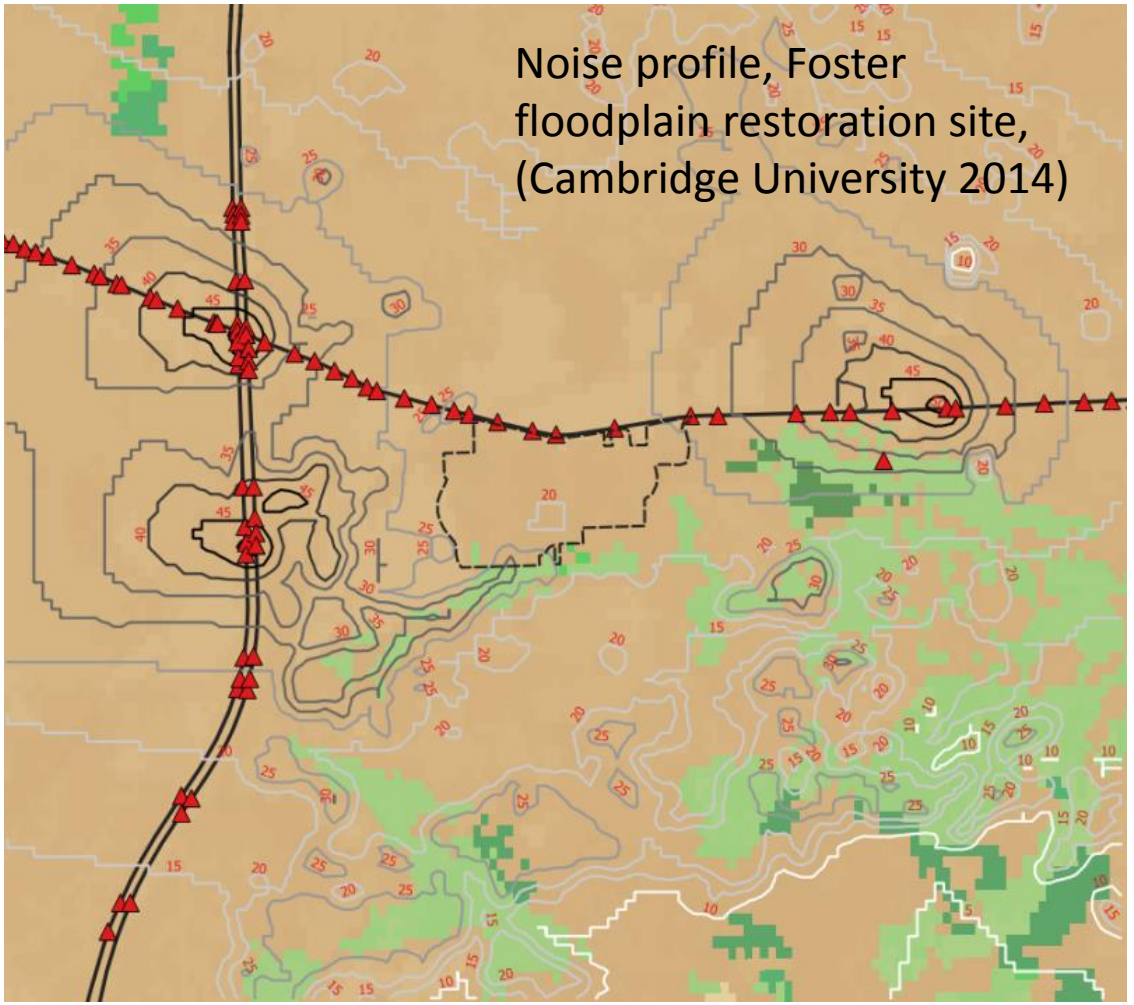
Improved air quality, e.g. accumulation of PAHs (Joureava et al., 2002)

Reduction in noise

CO_2 sequestration (carbon storage, tree = 100 kg C yr^{-1}) *Charlesworth and Warwich 2011*)

Improved soil quality and nutrient cycling

Reduced energy consumption, e.g. reducing conductive heat loss and providing shading, lowering air temperatures through transpiration



Noise profile, Foster floodplain restoration site, (Cambridge University 2014)

Multiple benefits of Blue-Green: social

Dis-benefits? Attracts anti-social behaviour?

→ Often subjective so difficult to quantify (and therefore value/compare)

Recreation

Aesthetics

Amenity

Wellbeing and liveability (stress relief, restoration)

Encourages **community cohesion**, social interaction

Physical health

– exposure to green space is associated with lower mortality rates and death from circulatory disease in low income areas (Mitchel and Popham 2008)

– buffer against negative health impacts of stressful life events (Van den Berg et al. 2010)

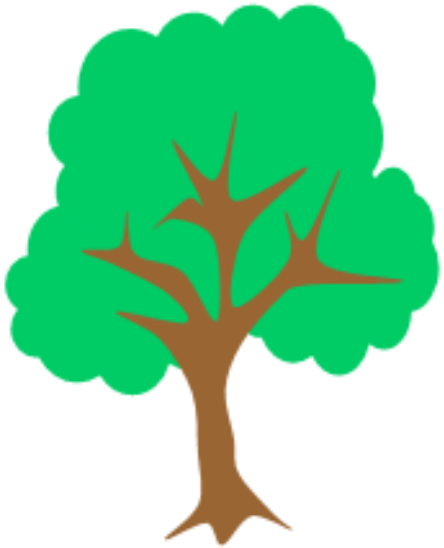
– increased physical activity of residents, reduced obesity (Nielsen and Hansen 2007)

Mental health

– reduction in mental fatigue and unhappiness (O'Campo et al., 2009)

Physical and mental health benefits of <u>not</u> being flooded

Multiple benefits of Blue-Green: economic



EVAPO-TRANSPIRATION	→	CLIMATE CHANGE ADAPTATION - URBAN COOLING	→	£ REDUCED AIRCONDITIONING COSTS/HEALTH
CARBON SEQUESTRATION	→	CLIMATE CHANGE MITIGATION	→	£ MARKET VALUE OF CO_2 STORED
PARTICULATE FILTERING	→	IMPROVED AIR QUALITY	→	£ REDUCED HEALTH COSTS

GREEN INFRASTRUCTURE ASSET / INTERVENTION	→	GREEN INFRASTRUCTURE FUNCTION	→	GREEN INFRASTRUCTURE BENEFIT	→	GREEN INFRASTRUCTURE VALUE (£)

+ avoided costs due to <u>not</u> flooding

+ increased house prices in areas near blue-green infrastructure (*Netusil et al. 2014*)

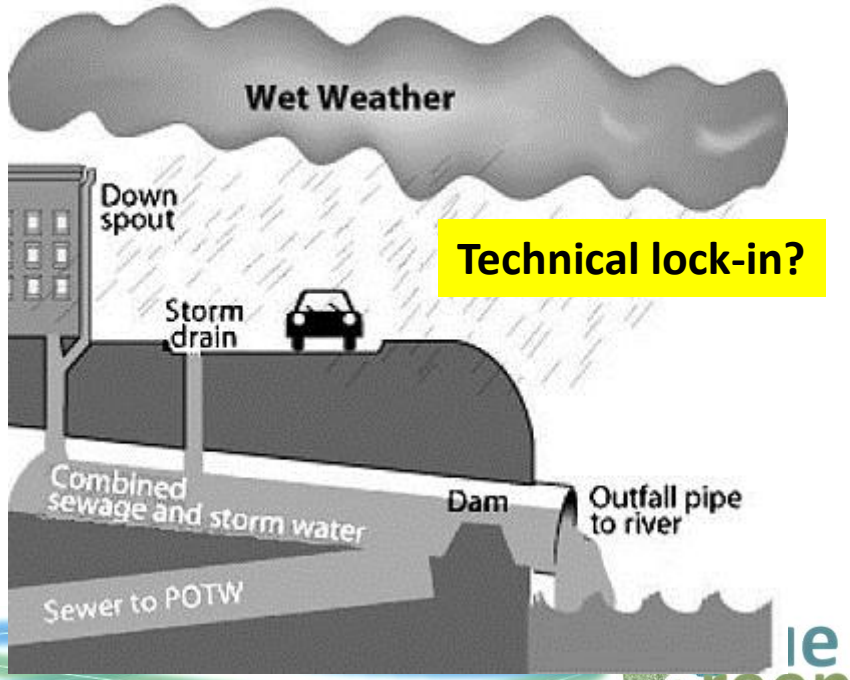
+ labour productivity + tourism

Multiple benefits of Blue-Green: adaptability and flexibility (for climate change)?

Climate change mitigation: CO_2 sequestration, reduction in energy usage

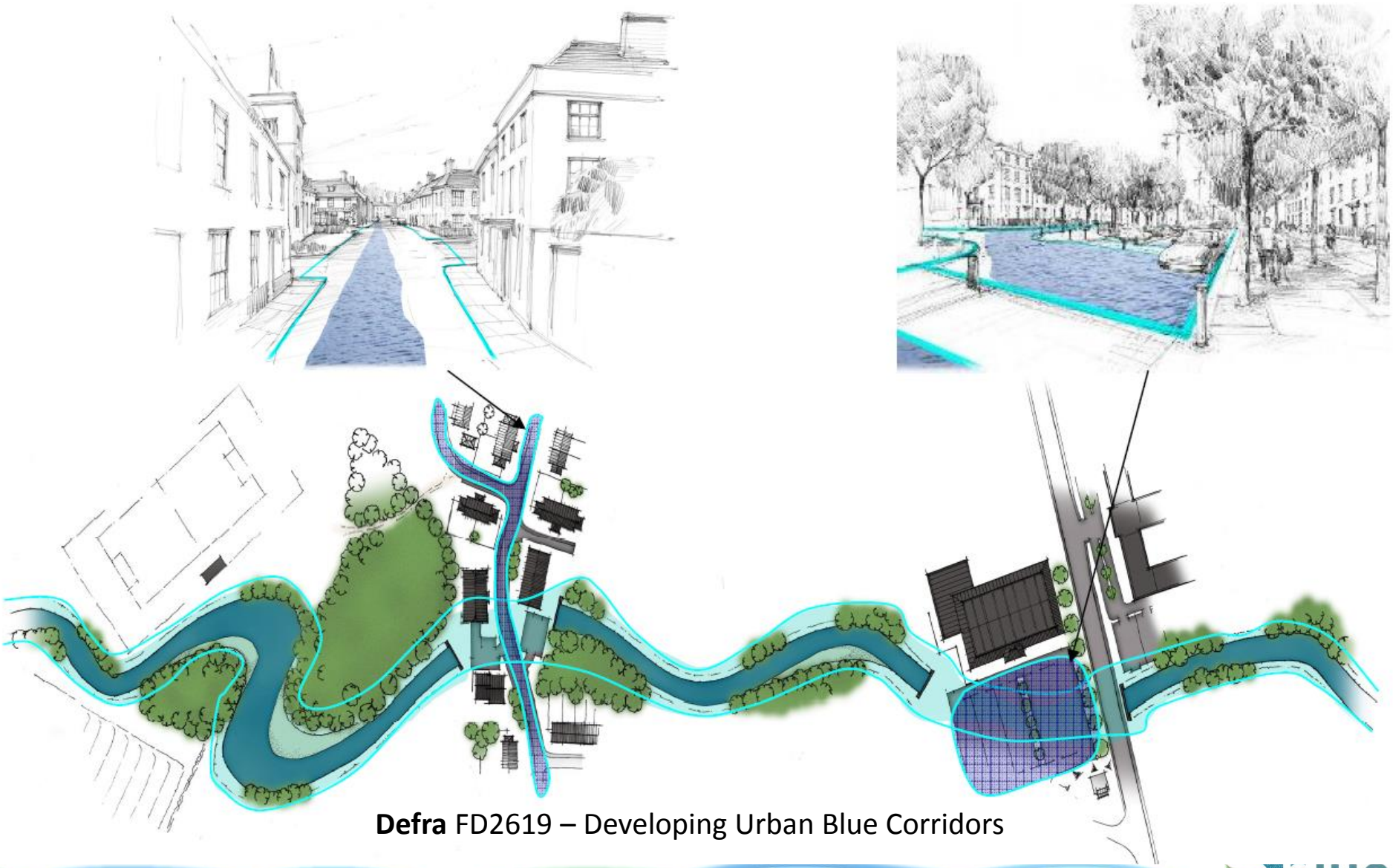
Climate change adaptation: reducing temperatures, shading, infiltrating stormwater

Increasing the capacity – which is easier (and cheaper?)



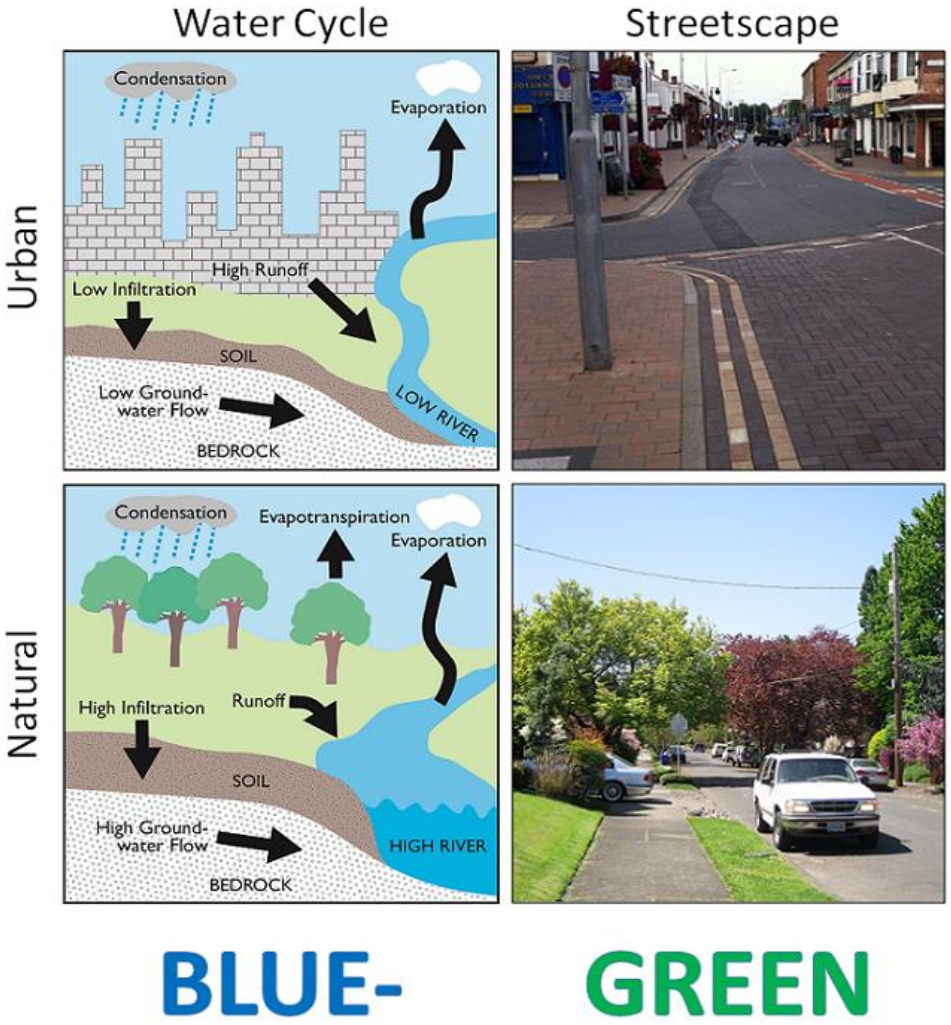
Technical lock-in?

Multifunctional space, connections and corridors



Defra FD2619 – Developing Urban Blue Corridors

The Blue-Green approach to flood risk management



→ Working with nature to manage water and deliver a range of other benefits to society, the economy and the environment

→ We still need grey infrastructure ***but*** we can supplement this with Blue-Green to improve the landscape and liveability of our cities

→ Most of the time we are not under flood conditions - **so why not design the landscape to be multifunctional and accrue numerous benefits?**

Thank you for your attention

Any questions?

Managing Urban Flood Risk: the Blue-Green Approach

Dr Emily Lawson 18th December 2014

bluegreencities.ac.uk

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