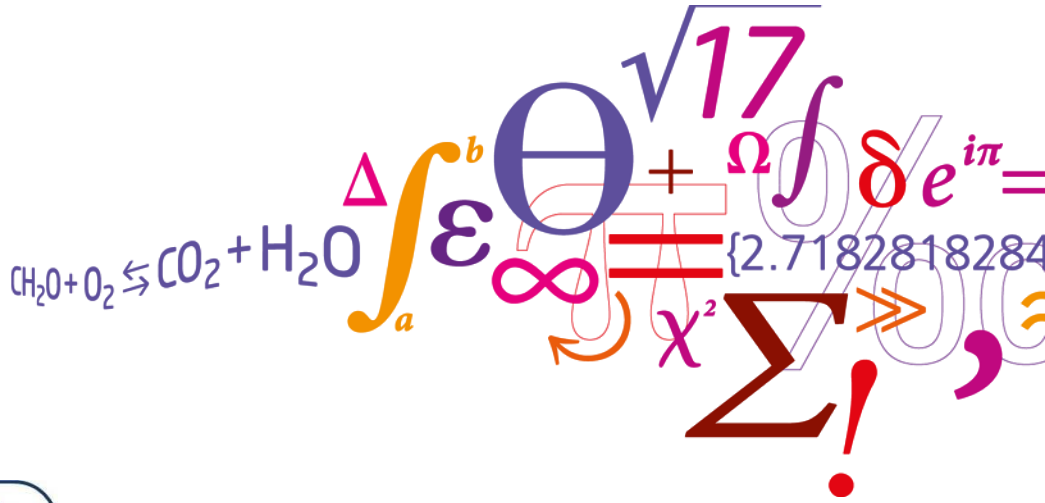
Linking of water and energy models and objectives in an urban context

Karsten Arnbjerg-Nielsen
Professor, Urban Water Systems Section

IEA Committee on Energy Research and Technology:
Addressing the energy-water nexus through R&D planning and policies



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DTU DHI KRÜGER VEOLIA RAMBØLL VandCenterSyd HOFOR aarhusvand BIOFOS DMI

Innovation Fund Denmark

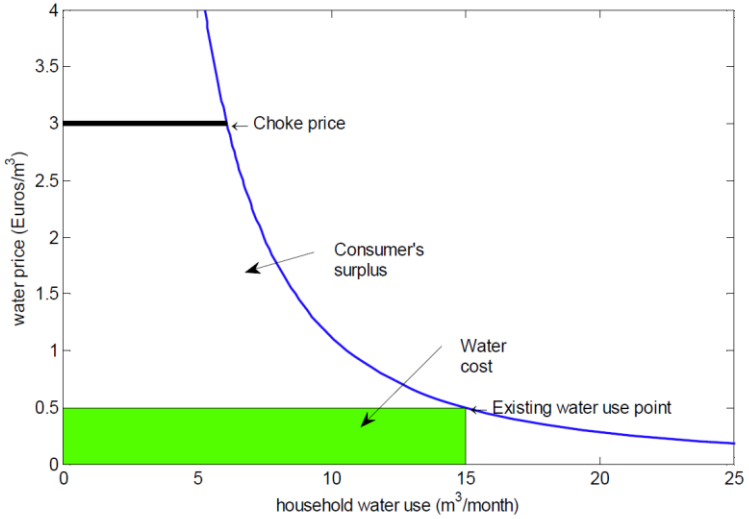
Agenda

- Point of departure
- Urban drainage 101
- Models for one hazard and one temporal scale (urban pluvial flooding)
- Summary and take-home messages

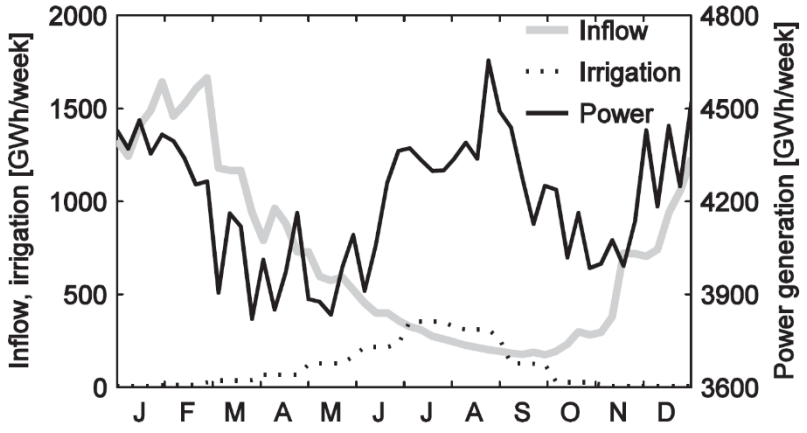
Point of departure (1)

Two PhD studies at DTU has formed my approach:

- Niels Riegels (hydro-economic models, Northern Greece)
  - Value of water: humans > industry >> agriculture
  - Economic regulation of water sector affects agriculture



- Silvio J. Pereira-Cardenal (power-water optimization, Iberian Peninsula)
  - Trade-off between irrigation and hydropower
  - Low hanging fruits have been harvested



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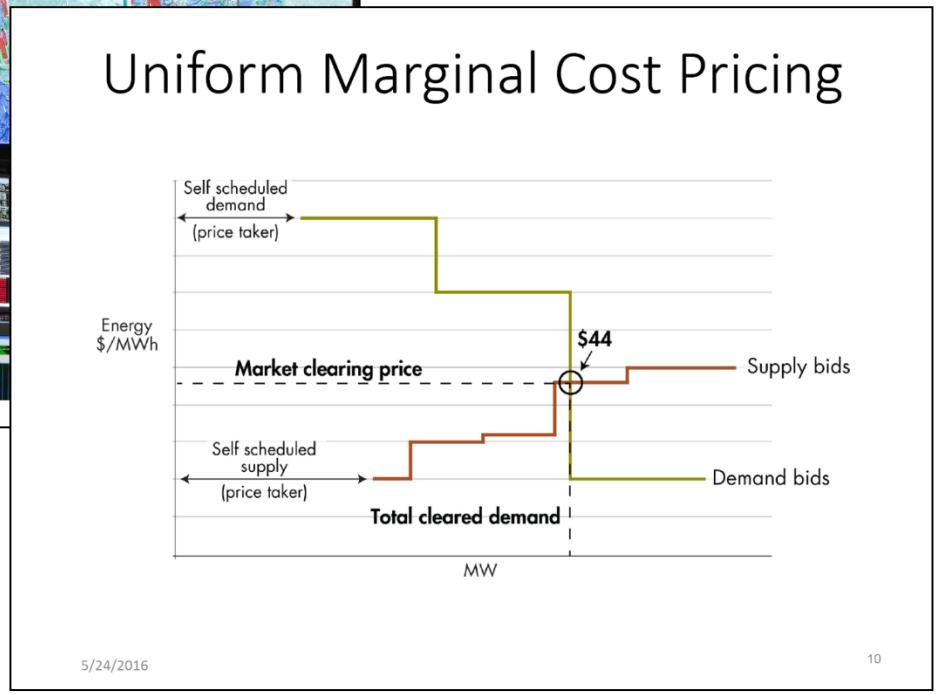
Riegels et al (2011) DOI:10.1016/j.jhydrol.2010.11.005
Pereira-Cardenal et al (2016):10.1016/j.advwatres.2016.04.004

Point of departure (2)

Difference between the water smart city and the smart city (my perception)

- Logos of the two largest DK funded R&D projects on (Water) Smart Cities



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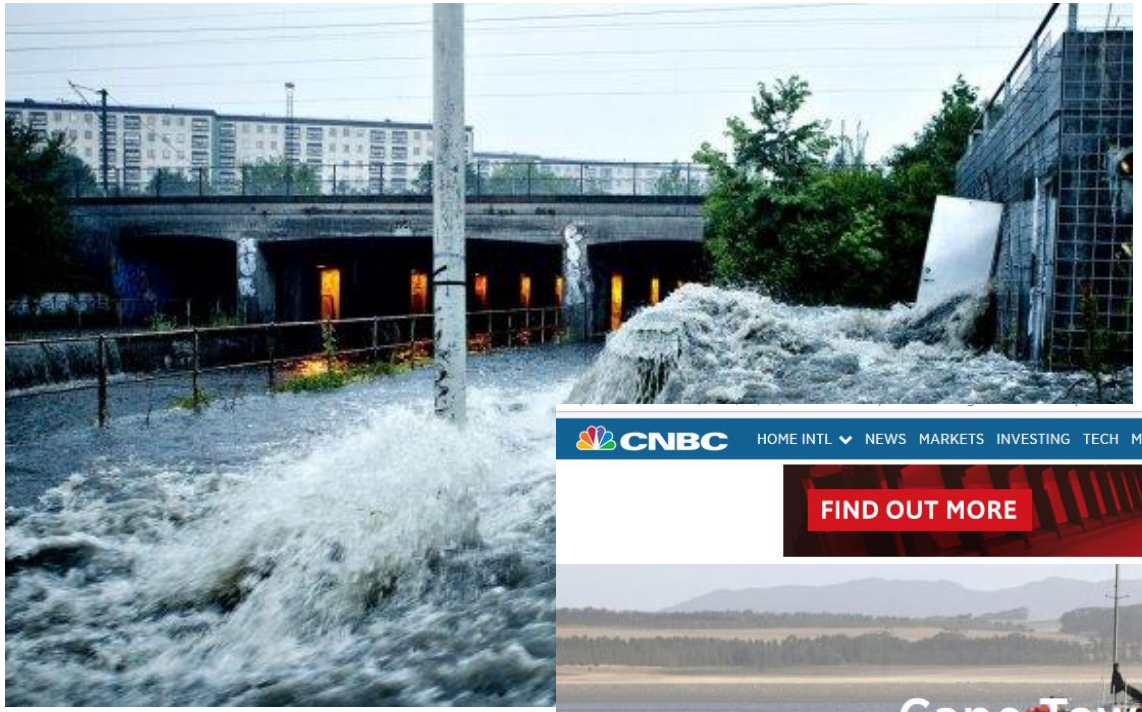
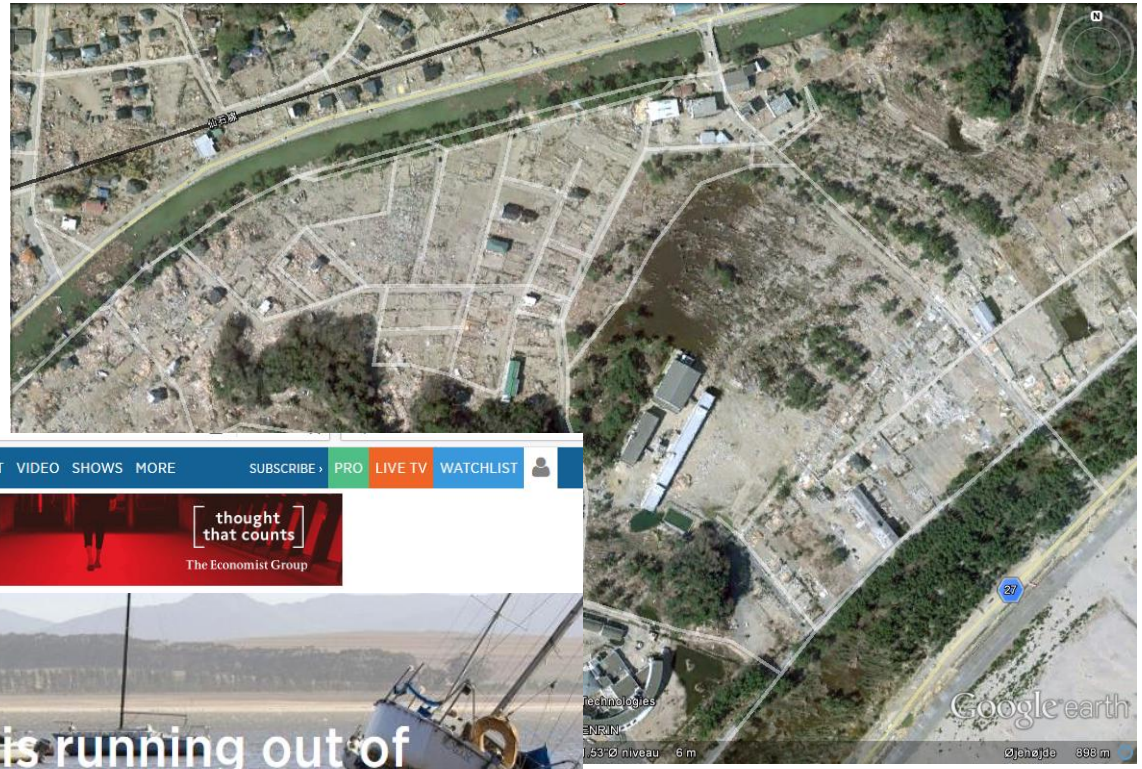
Urban drainage sector, high dynamics and low controlability





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Urban drainage 101:
High sunk investments

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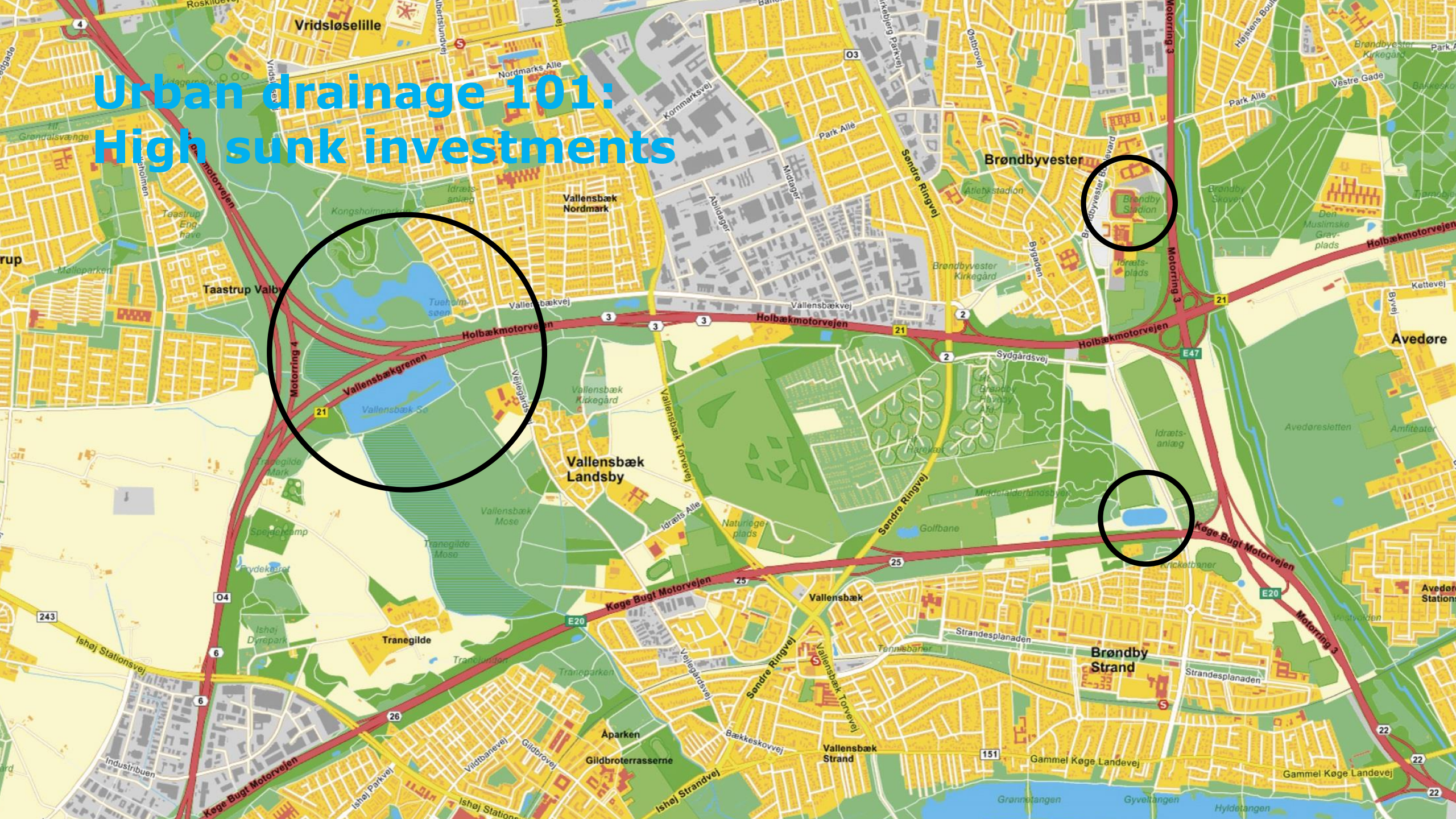


Urban drainage 101: Never forget priorities

BMJ readers choose sanitation as greatest medical advance since 1840

Annabel Ferriman BMJ

More than 11 300 readers of the *BMJ* chose the introduction of clean water and sewage disposal—"the sanitary revolution"—as the most important medical milestone since 1840, when the *BMJ* was first published. Readers were given 10 days to vote on a shortlist of 15 milestones, and sanitation topped the poll, followed closely by the discovery of antibiotics and the development of anaesthesia.

The work of the 19th century lawyer Edwin Chadwick, who pioneered the introduction of piped water to people's homes and sewers rinsed by water, attracted 15.8% of the votes, while antibiotics took 15%, and anaesthesia took 14%. The next two most popular were the introduction of vaccines, with 12%, and the discovery of the structure of DNA (9%).

A total of 11 341 people voted on the shortlist, which was chosen by a panel of experts from a list nominated by readers. Almost a third of the voters were doctors, while a fifth were members of the general public, and one in seven were students. Another tenth were academic researchers. Almost two fifths of the voters were from the United Kingdom, and a fifth were from the United States.

Johan Mackenbach, professor of public health at Erasmus MC Medical Center, Rotterdam, who championed the cause of sanitation, said, "I'm delighted that sanitation is recognised by so many people as such an important milestone. The general lesson which still holds is that passive protection against health hazards is often the best way to improve population health.

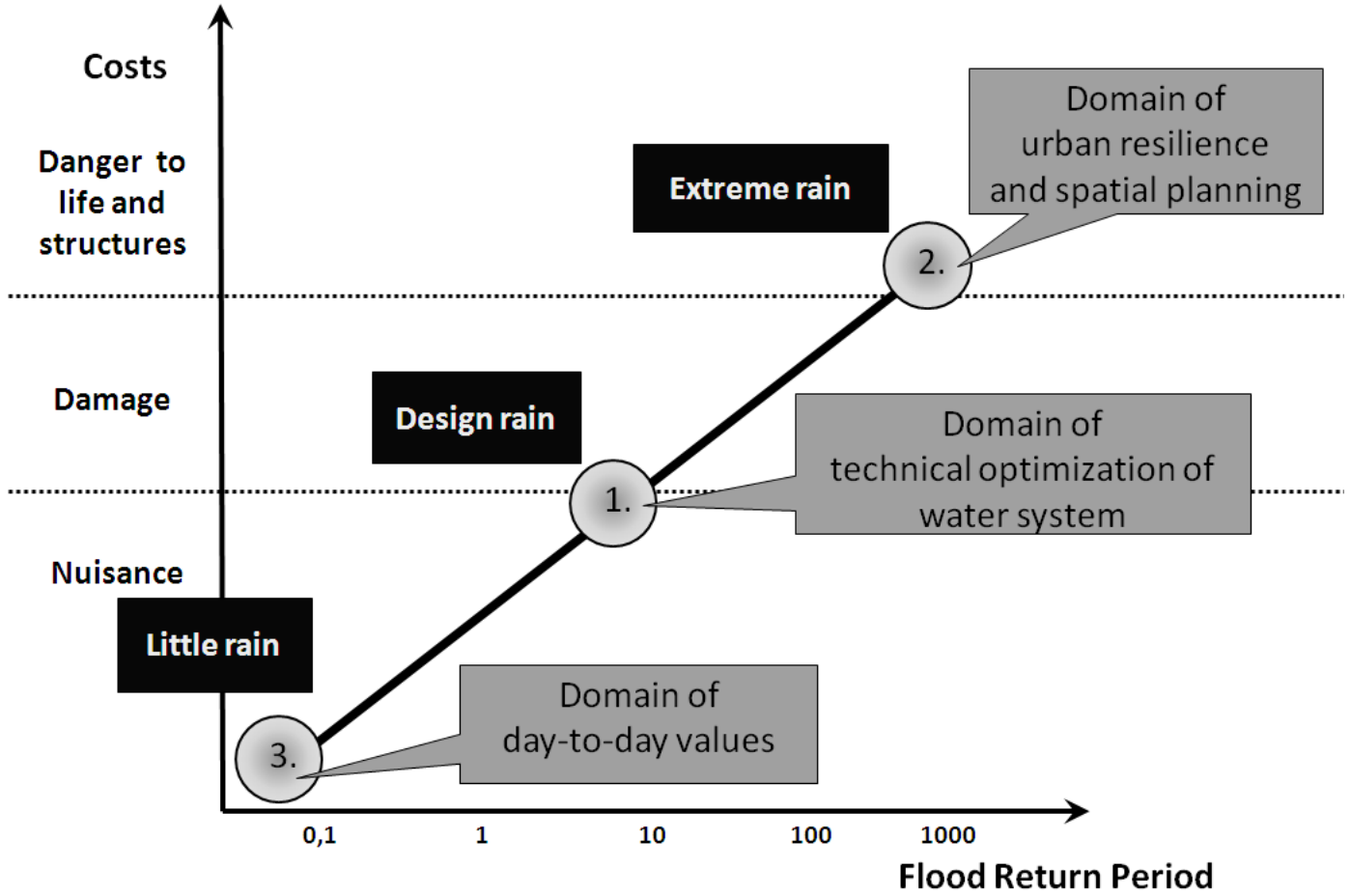
"The original champions of the sanitary revolution were John Snow, who showed that cholera was spread by water, and Edwin Chadwick, who came up with the idea of sewage disposal and piping water into homes.

"Inadequate sanitation is still a major problem in the developing world."

The *Medical Milestones* supplement is distributed with this week's *BMJ*.

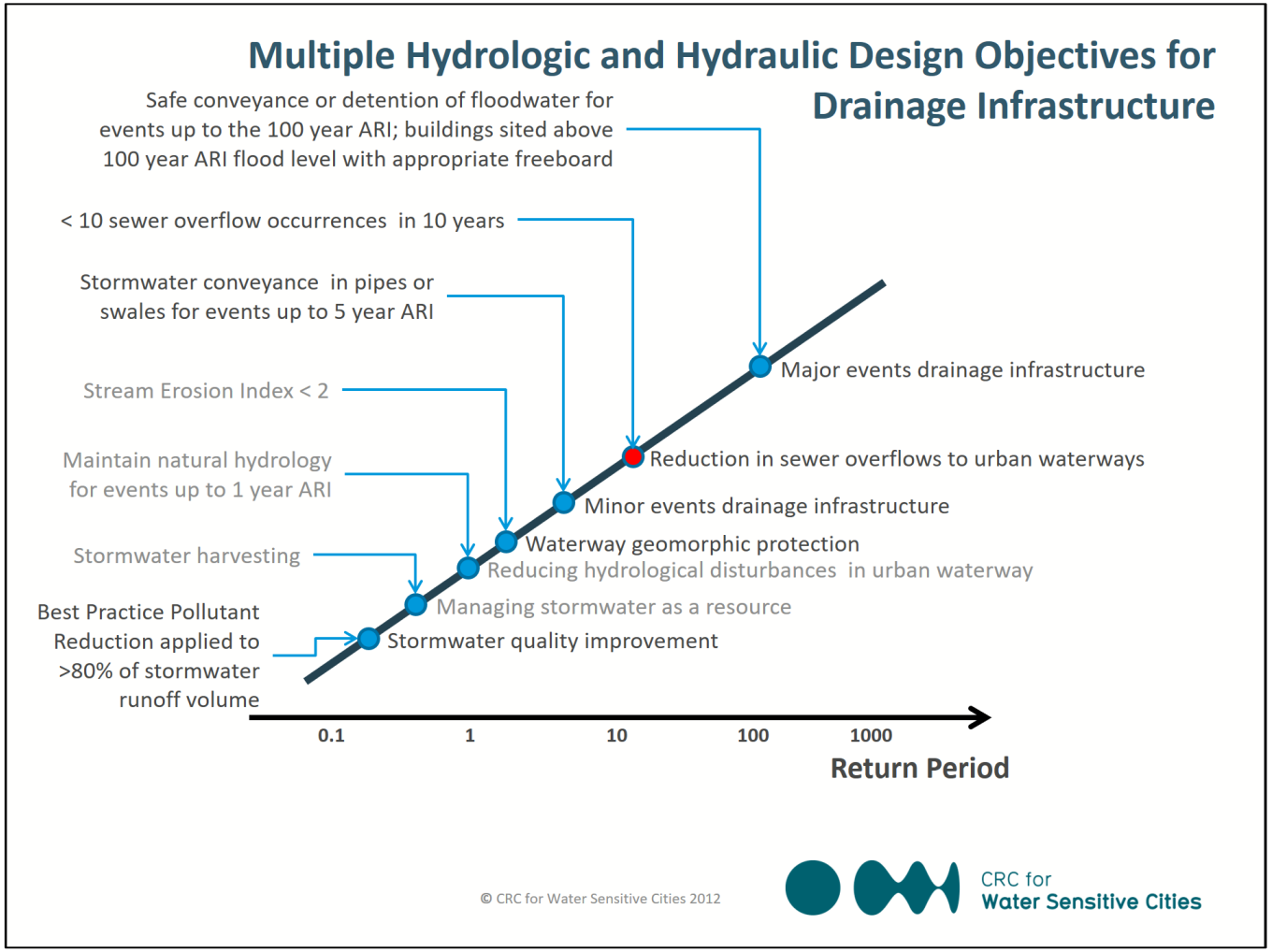
BMJ | 20 JANUARY 2007 | VOLUME 334

Urban drainage, typical design, hazards



Fratini et al (2012) DOI:10.1080/1573062X.2012.668913

Collection of hazard criteria, Australia



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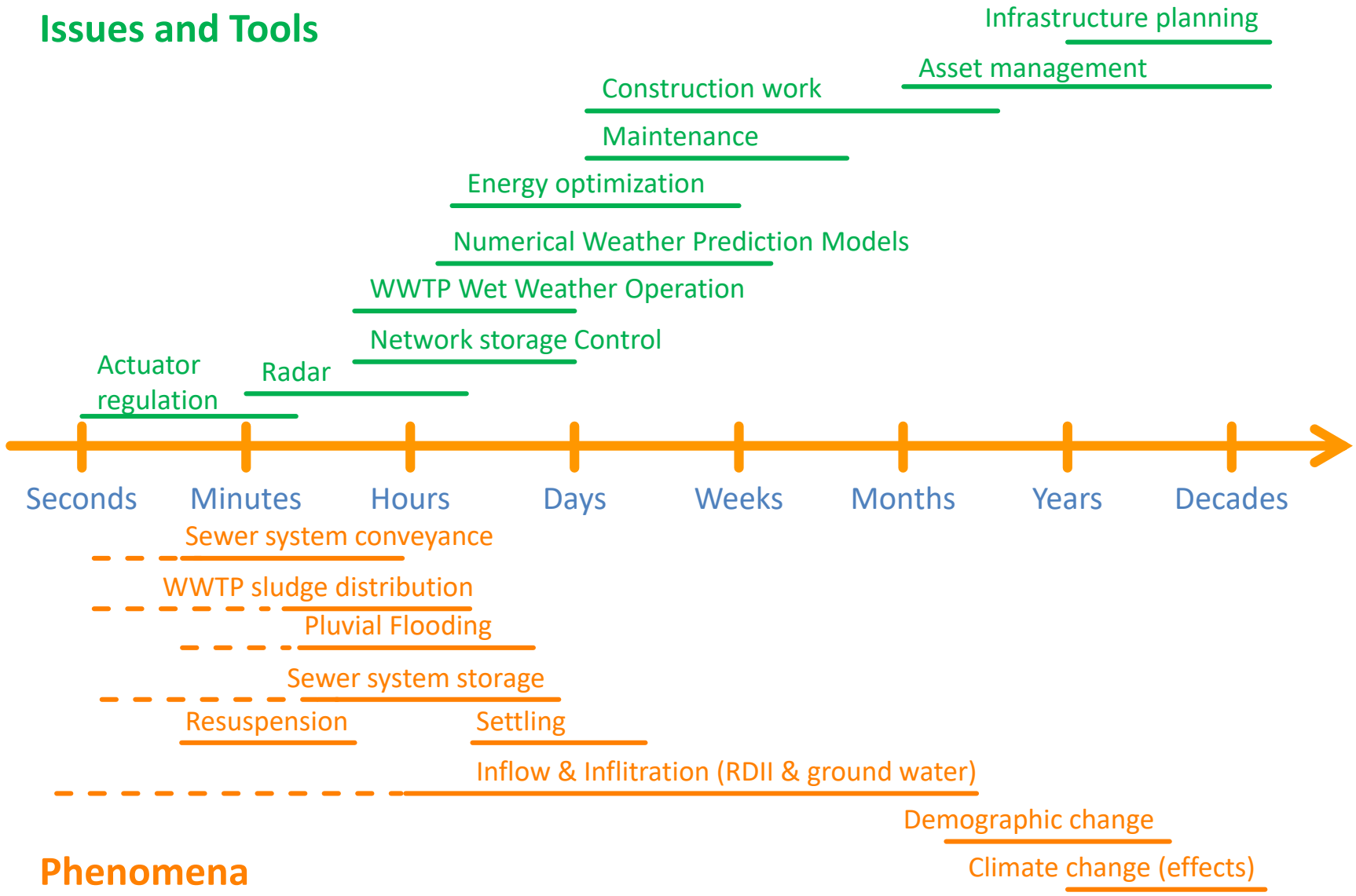
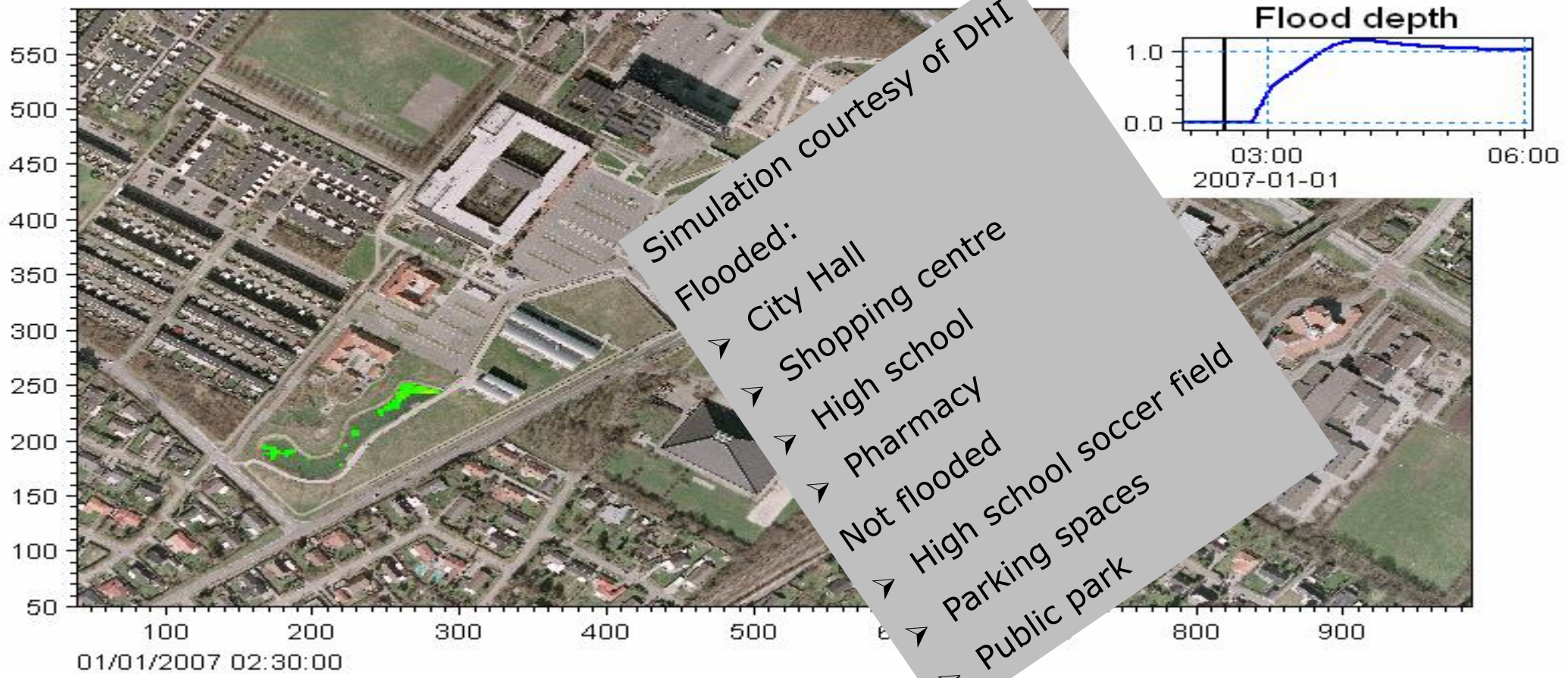
Wong (2012) Keynote UDM, Belgrade

DTU research agenda, temporal scale



Mikkelsen (2016)

Simulating urban pluvial flooding



Simulation courtesy of DHI

Flooded:

- City Hall
- Shopping centre
- High school
- Pharmacy

Not flooded

- High school soccer field
- Parking spaces
- Public park

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Costing of flooding

	Direct costs	In-direct costs
Tangible (Market)	Structural damage Cars Infrastructure Livestock Crops Evacuation and rescue operations Clean up costs	Disruption to transport Business interruption Temporary housing of evacuees Loss of industrial production
Non-tangible (Non-market)	Lives and injuries Diseases Loss of memorabilia and pets Damage to cultural or heritage Ecological damage Inconvenience	Stress and anxiety (PTSD) Disruption of living Loss of community Reduced house values Undermined trust in public authorities

Uncertainty factor 2-5

Higher uncertainty

Higher uncertainty

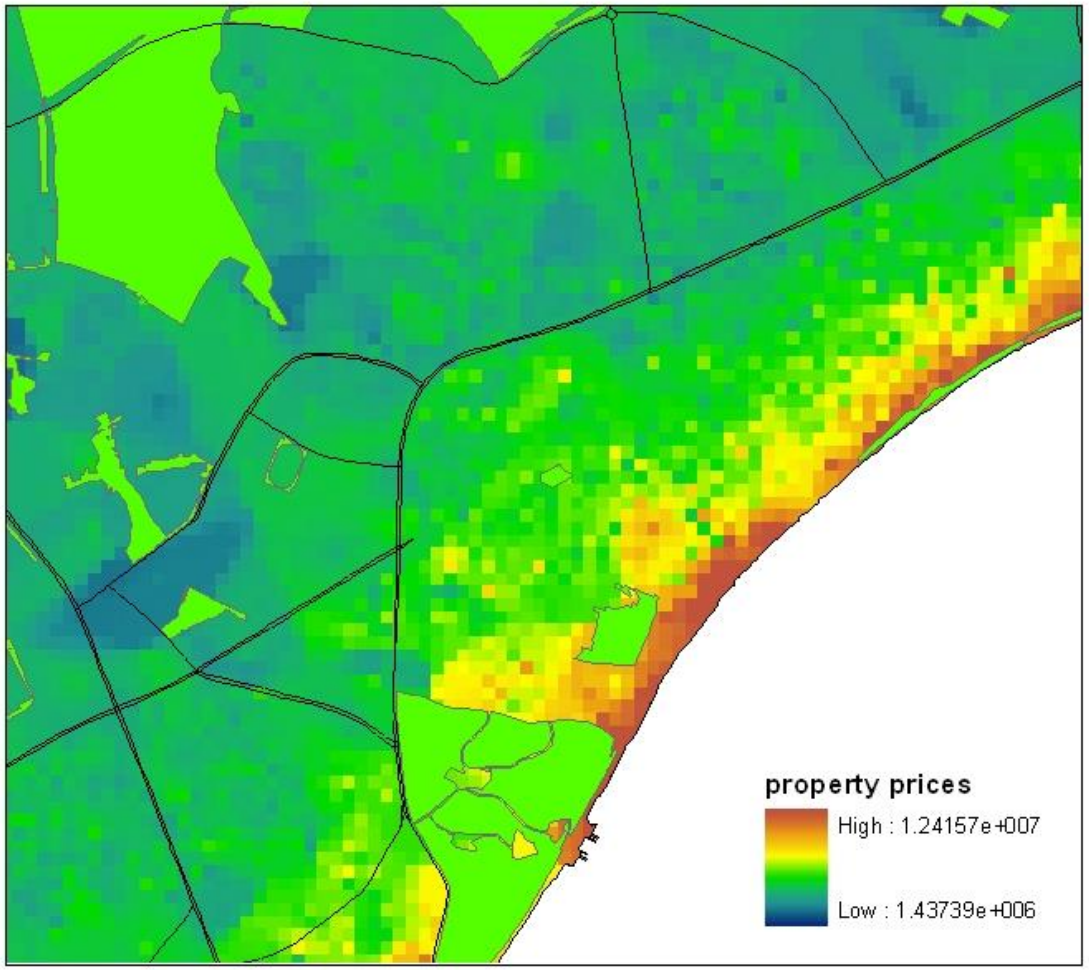
Unknown

Valuation of measures

NPV = f(Investment cost, ΔO&M, reduced flood cost, services to society)

	Possible direct benefits	In-direct benefit
Tangible (Market)	Improved infrastructure ??	??
Non-tangible (Non-market)	Better eco-systems ??	Human health ??

Example of valuation of other benefits
Blue and green spaces



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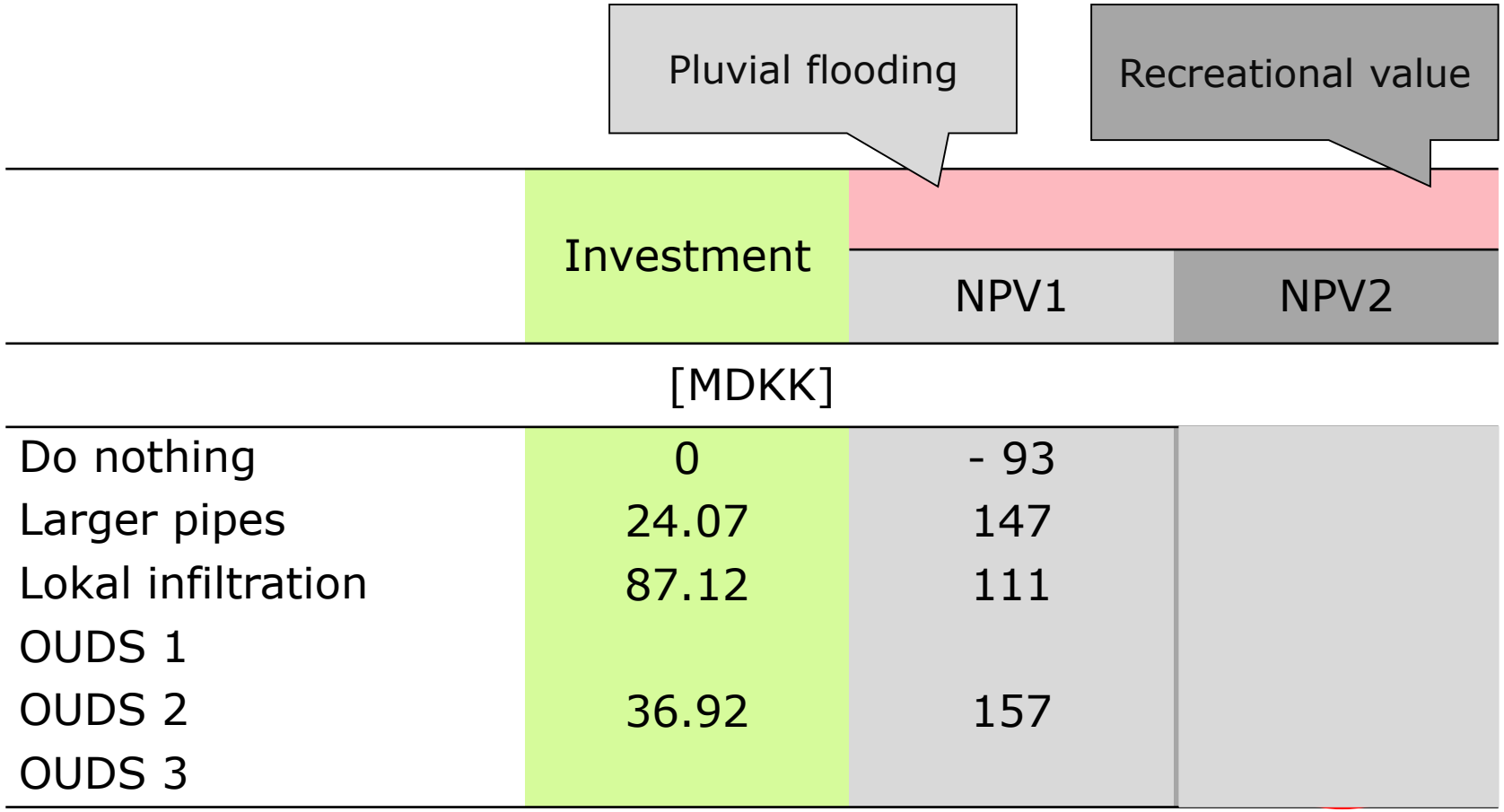
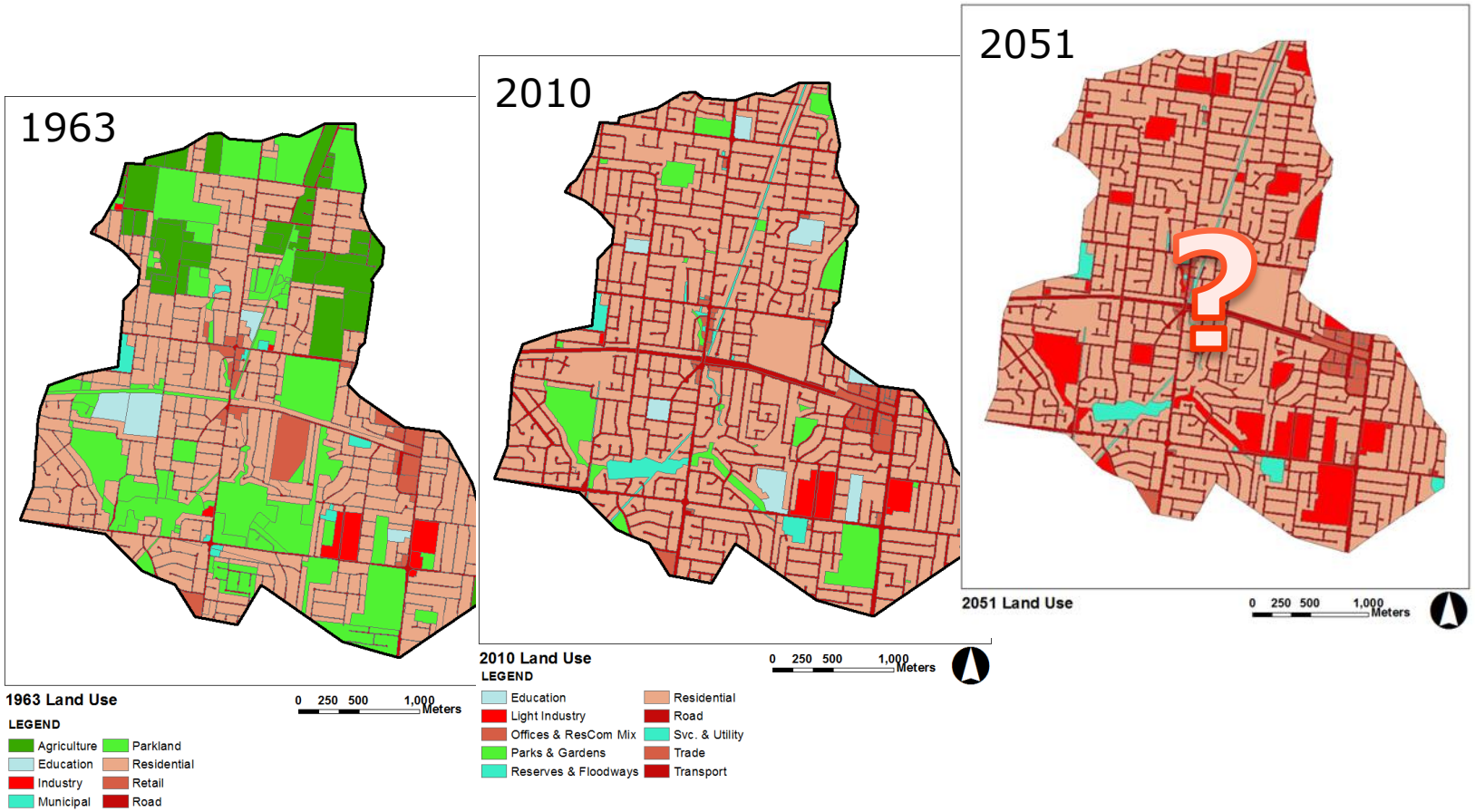
Århus, incl. "other impacts"



	[MDKK]		
Do nothing	0	- 93	
Larger pipes	24.07	147	
Lokal infiltration	87.12	111	
OUDS 1			
OUDS 2	36.92	157	
OUDS 3			

Zhou et al (2013) DOI 10.1007/s00267-012-0010-8

Key Question:
Will water inform urban development?



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~ Löwe et al (2017). DOI: 10.1016/j.jhydrol.2017.05.009

Summary & take home messages

Bear in mind that I am a water guy ☺

- We must be careful that saving money does not prevent us from creating value:
  - Water sector: Lacks a clear business model
  - Energy sector: Savings are low for water sector

- There are clear synergies, but also clear conflicts
  - Ideal for supporting each other technically (storage vs. transportation)
  - Different aims for city planning (dense vs. space for water)
  - Most important values to water sector does not have a market