

Cities of the Future Turkey

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Sustainable Water Management for the City of the Future

SWITCH Focus Areas

Solution developed based on key concepts:

- **interventions over entire urban water cycle;**
- governance & financial management structures covering the entire urban water cycle.
- **resilience of urban water systems to global change pressures – flexible design;**
- reconsideration of the way water is used (and reused) – security through diversity;
- greater application of natural systems

32 partners from 15 countries

Netherlands, UK,
Germany, Israel,
Brazil, Colombia,
Peru, Spain, China,
Ghana, Greece,
Palestine, Egypt,
Poland, Switzerland

40 PhD's



SWITCH – A Tale of 12 Cities



Strategic Planning

Research

Demonstrations

SWITCH-Key Outputs

- Learning Alliance Handbook
- Global Training Package IUWM
- City Water Tool
- Sustainability Framework
- Transitioning manual
- GIS Stormwater Tool
- GL - Natural Systems for WT and WWT
- Manual on ecohydrological approaches in cities
- GL - Design, Operation & Maintenance of SAT systems
- GL - Sanitation systems with source separation
- Guidelines urban agriculture
- 12 City case studies
- Over 80 publications on IUWM



UNIVERSITY OF
SOUTH FLORIDA



DR. KIRAN C. PATEL CENTER FOR

Global Solutions

UNESCO-IHE
Institute for Water Education



SWITCH



*Latin America
& Caribbean*

SWITCH-LAC

Proposed demos include:

- Belo Horizonte
- Bogotá
- Cali
- Lima
- Mendoza
- Rio de Janeiro / Niteroi
- Tampa
- Tegucigalpa



SWITCH-*in*-Asia



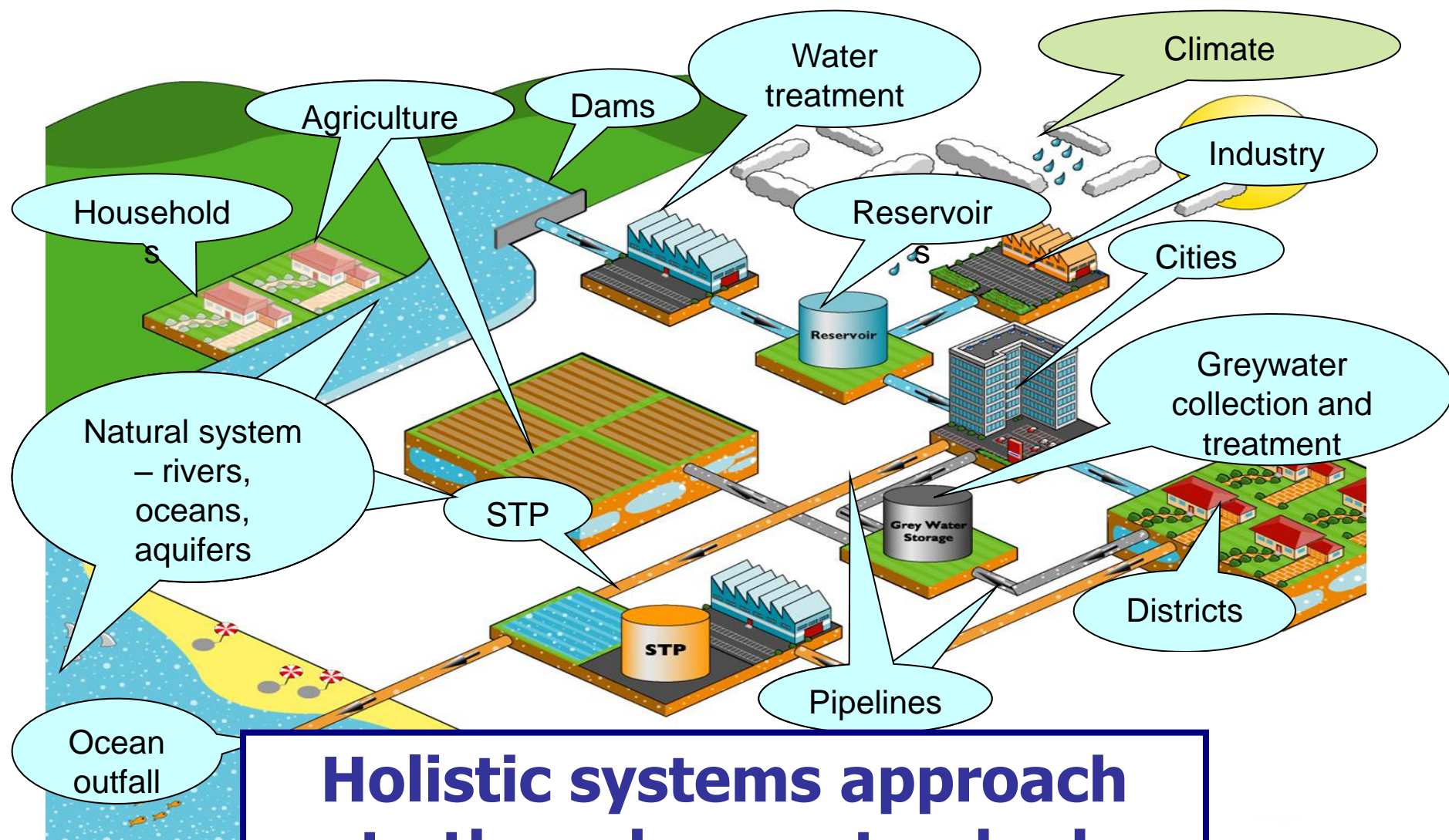
Structure of Talk

- **Integrated Urban Water**
- **Adaptive/Flexible Approaches**
- **Transitioning Process**

Structure of Talk

- **Integrated Urban Water**
- Adaptive/Flexible Approaches
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City of the Future - Integration



**Holistic systems approach
to the urban watershed**

SWITCH City Water



CITY WATER

A knowledge and information sharing platform to support global and integrated urban water planning

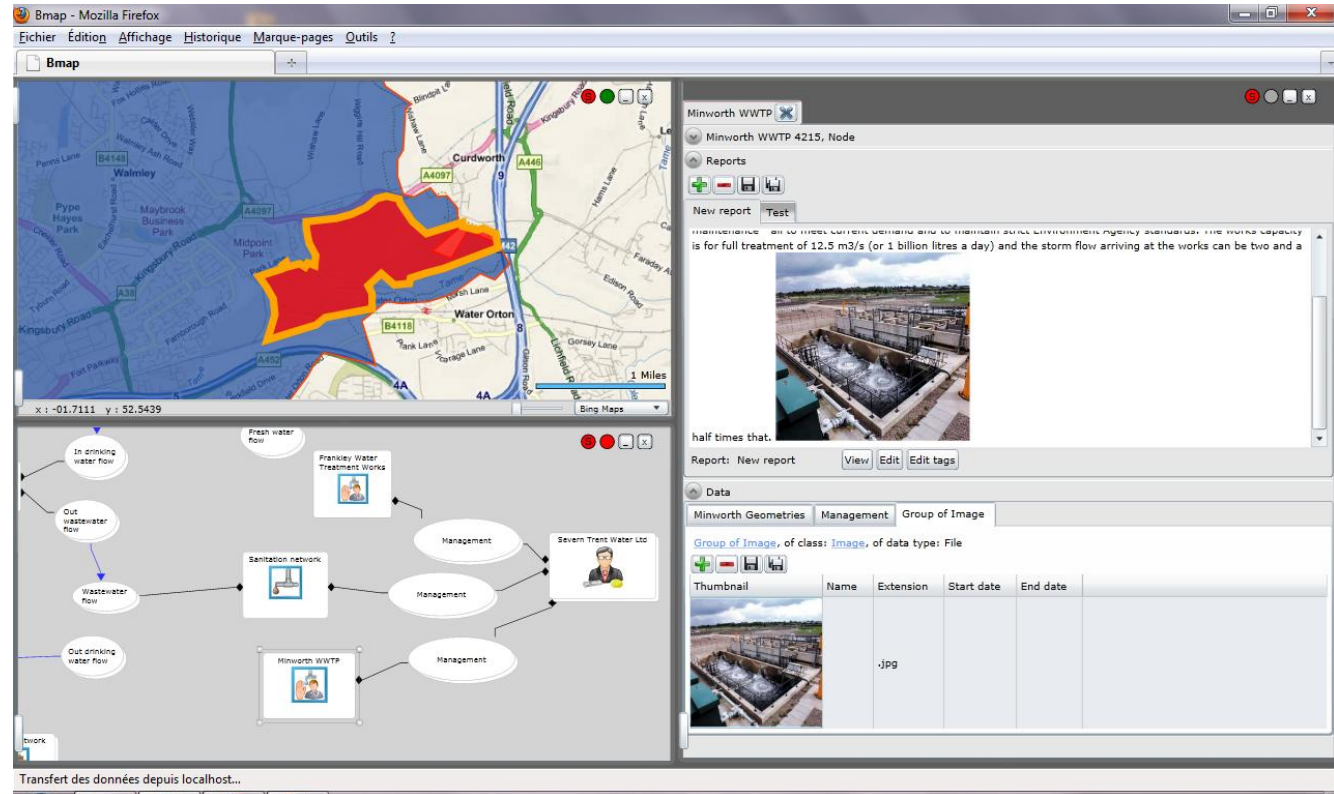
offering

A Combined Information System,

- Generic Database
- Geographic Viewer
- Reporting tool
- Systemic Viewer
- And more...

Linked to a Set of Screening Models

- City Water Balance
- City Water Economics
- City Water Drain
- And more...



SWITCH City Water

Bmap - Mozilla Firefox

Eichier Édition Affichage Historique Marque-pages Outils ?

http://localhost/Bmap.Web/bmap.aspx

simap.ch Canton de Vaud : site ... News (P) Section Sciences et Ing... English-French Diction... Calls for applications -... FP7 Seventh Framewor... European Commission... Collaborer avec nous

Bmap

Layout Manager

- Single Window
- One big one small
- Two Windows
- Four Windows
- Six Windows
- Eight Windows

Data source data

Projects

- Infos & docs
- Alexandria
- Thies

Marriout Lake

Evapotranspiration

Water outflow

Water flow

Marriout Lake

Underground water inflow

Salted water inflow

Water inflow

Outflow

El Mex pumping station

El Qila drain

El Omeim drain

Sea loola

Huberia canal

Alexandria_Gis

Search

Data

- Alexandria
- Canals
- Lakes
- Mini-clusters
- Unit blocks

Thies

Indicators

Layer overlay

Reports

Marriout Lake

Marriout Lake

Mariout Lake is a shallow lake covers a huge area to the south of Alexandria city. In 1801, Mariout Lake had an area exceeded 700 km². However, land reclamation and road construction decreased the area of the lake and it is currently less than 65 km² (Shaalán, et al. , 2009). The lake has an average water depth of 1.3 m with the water level around (-4) meter above mean sea level. There are no connection between Mariout Lake and the Mediterranean Sea but the water level is kept below (-3) meter above sea level by pumping the water to the sea from El-Mex pumping station. The lake receives water form

1 Kilometers

x : 29.8964 y : 31.1607

Google Satellite

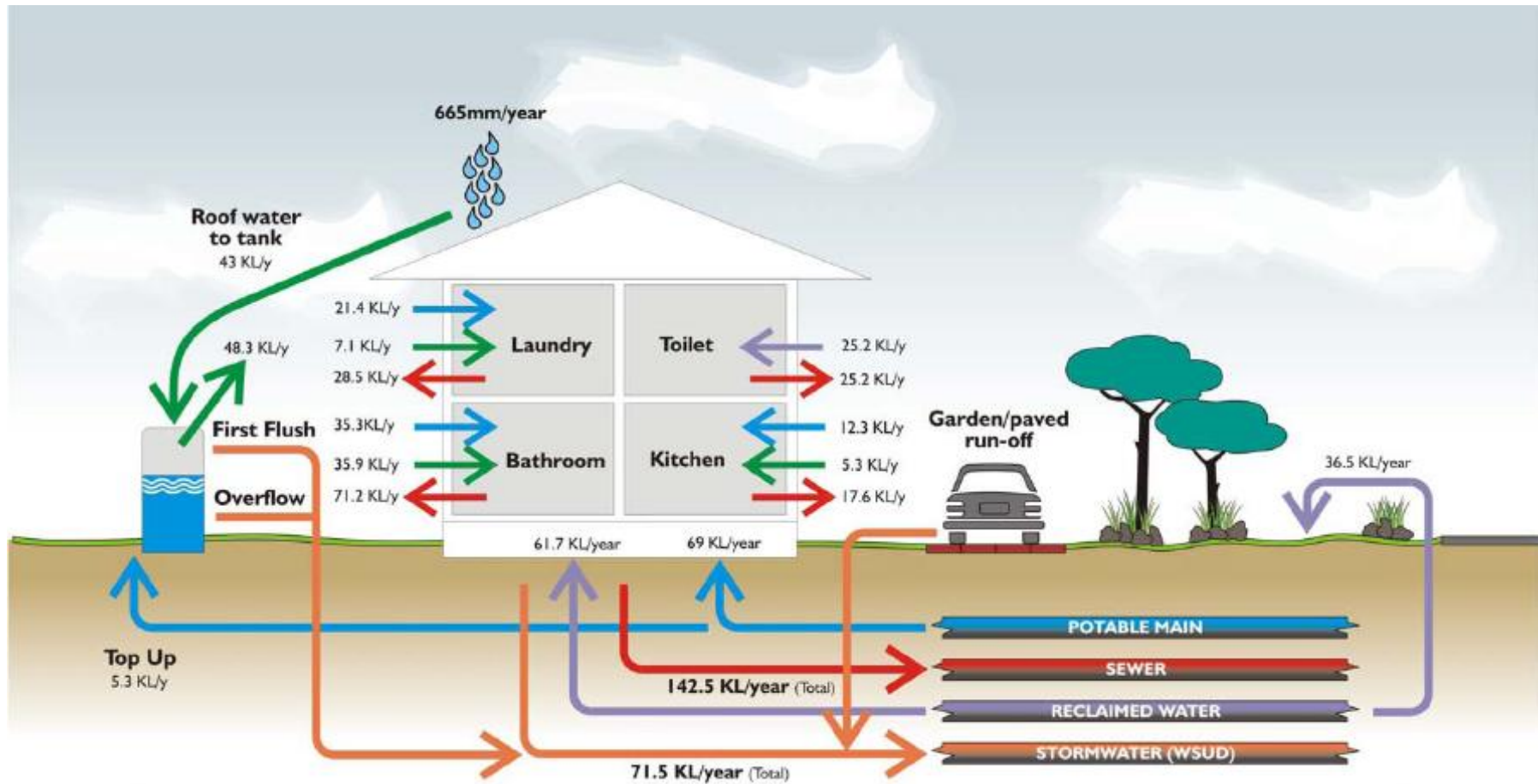
Transfert des données depuis localhost...

Interventions over urban water cycle

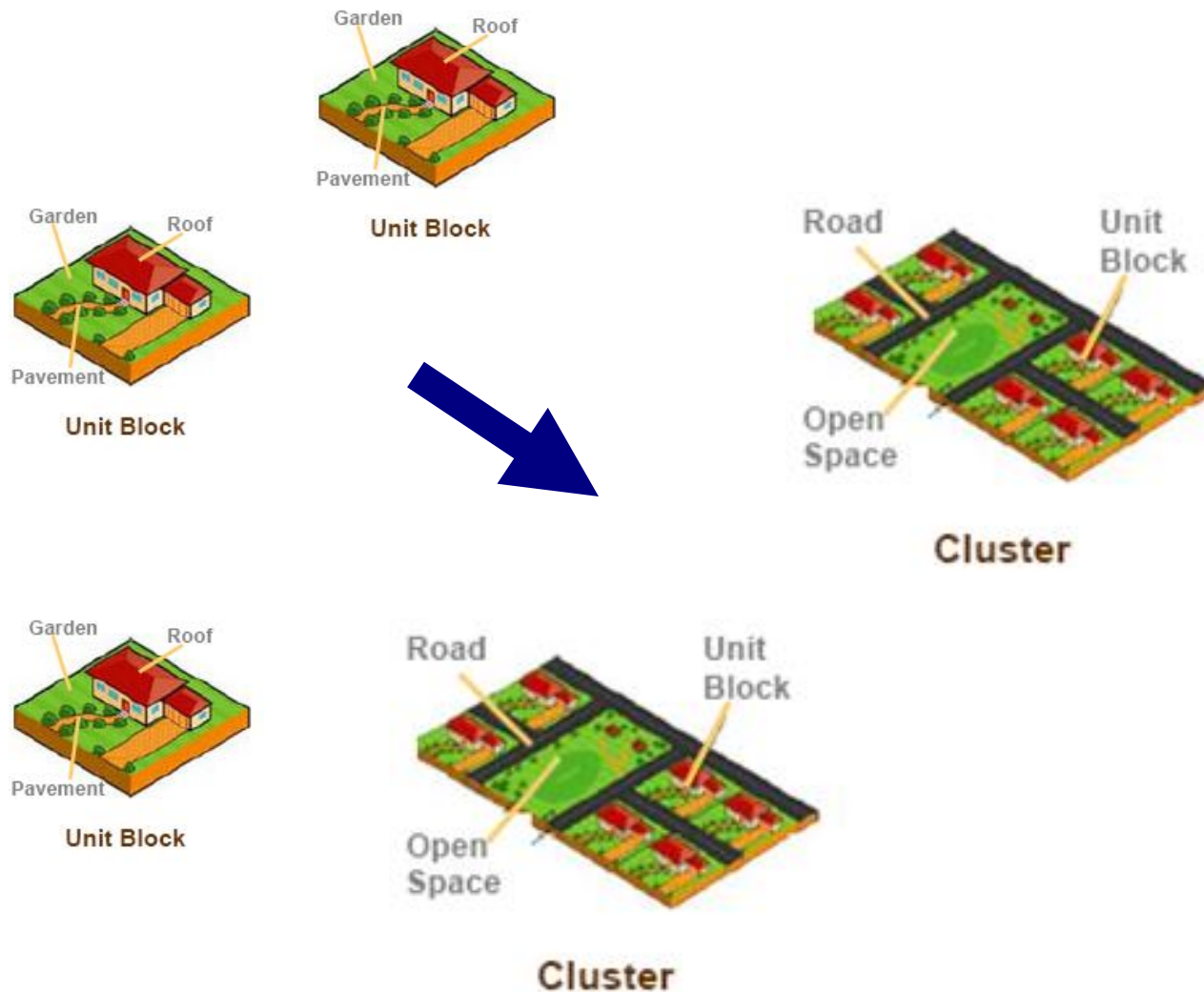


Unit Block

Interventions over urban water cycle

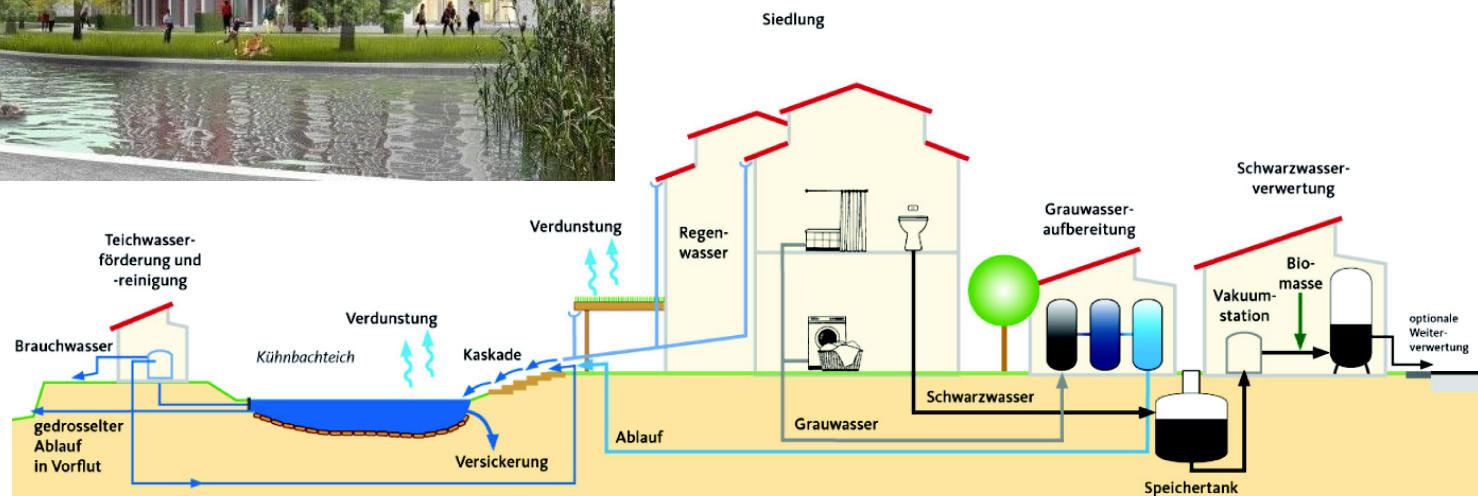


Interventions over urban water cycle

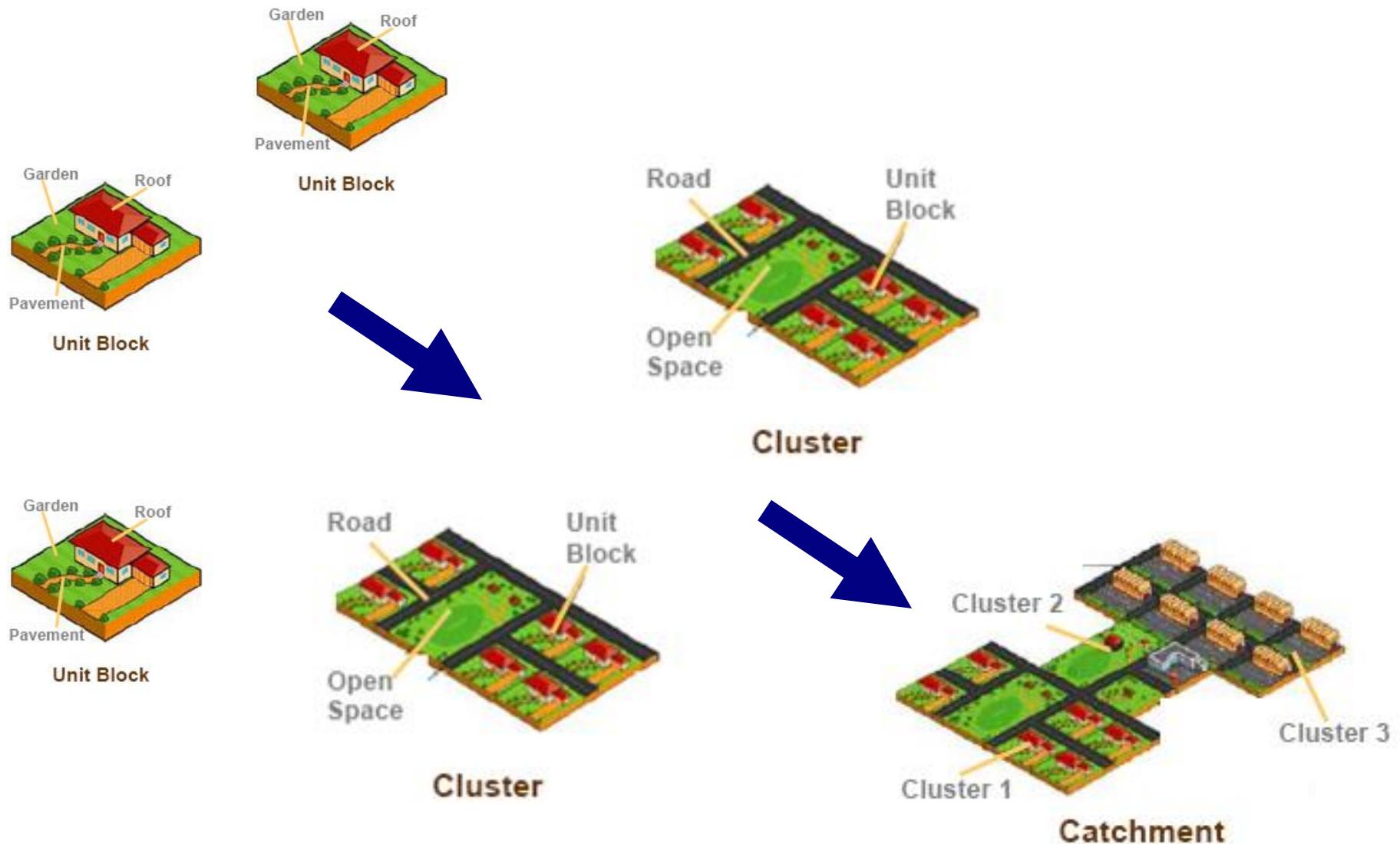


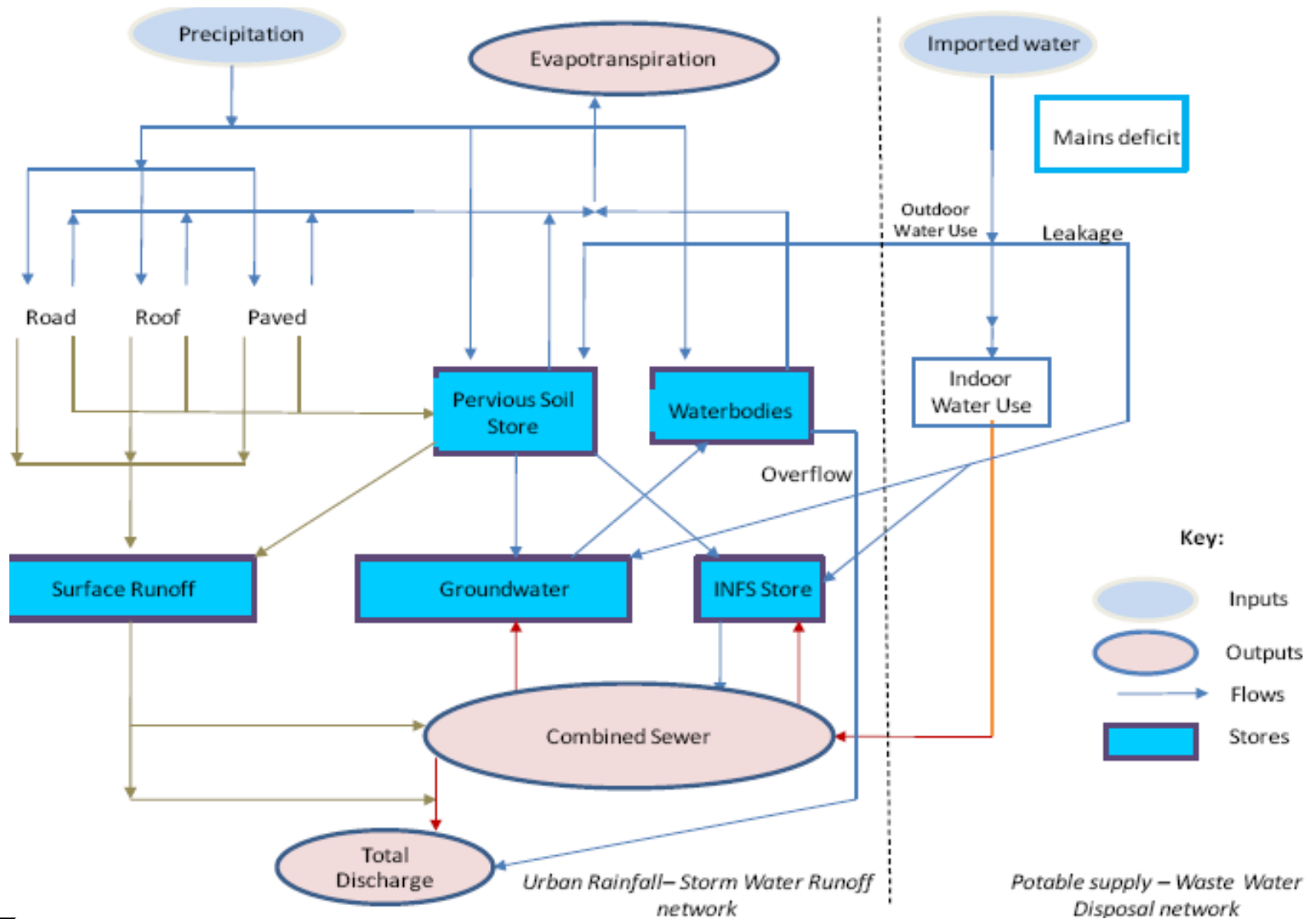
Cascading Uses of Water- Hamburg

Hamburg Water Cycle - Demonstration Project Jenfeld

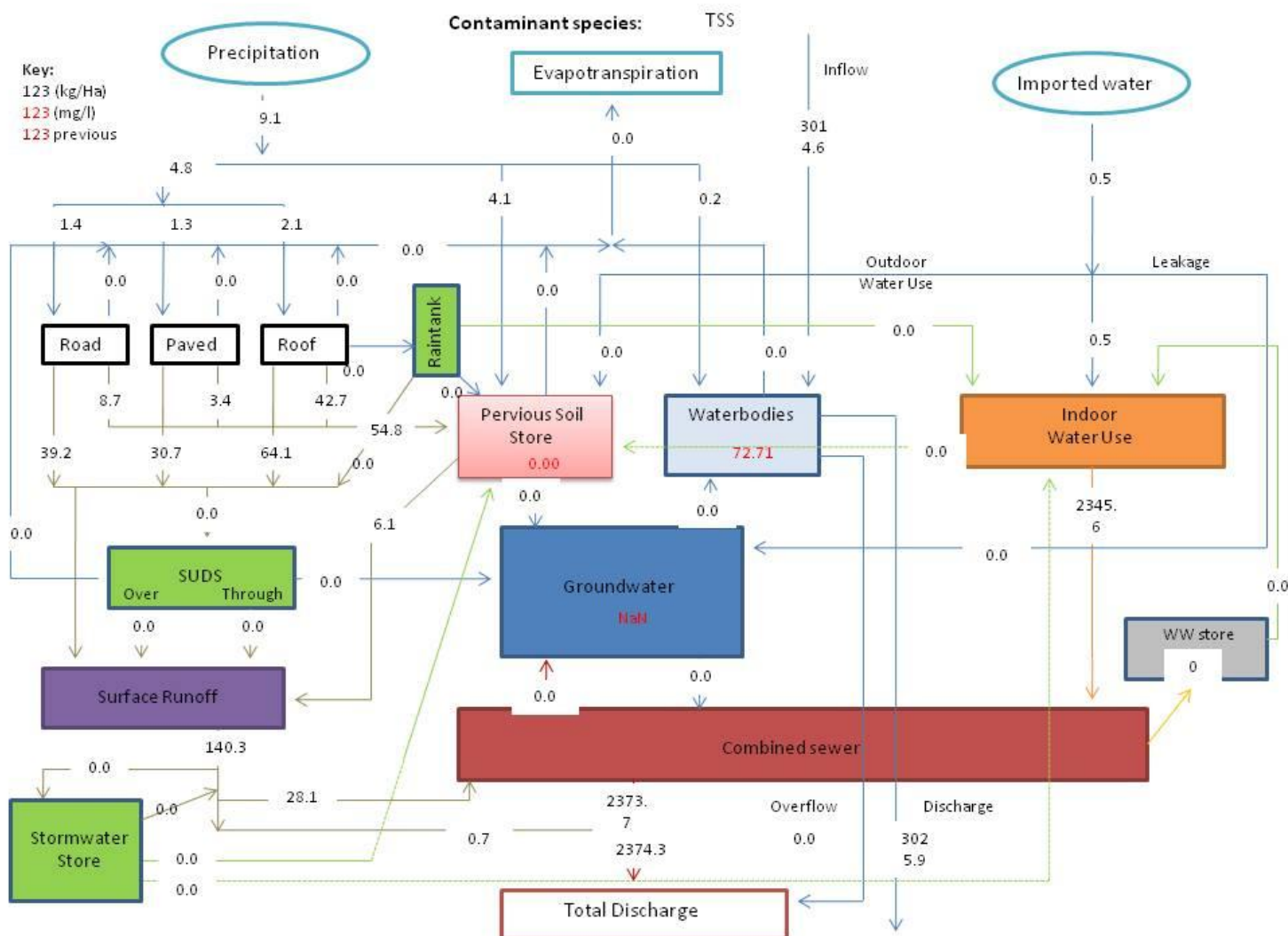


Interventions over urban water cycle



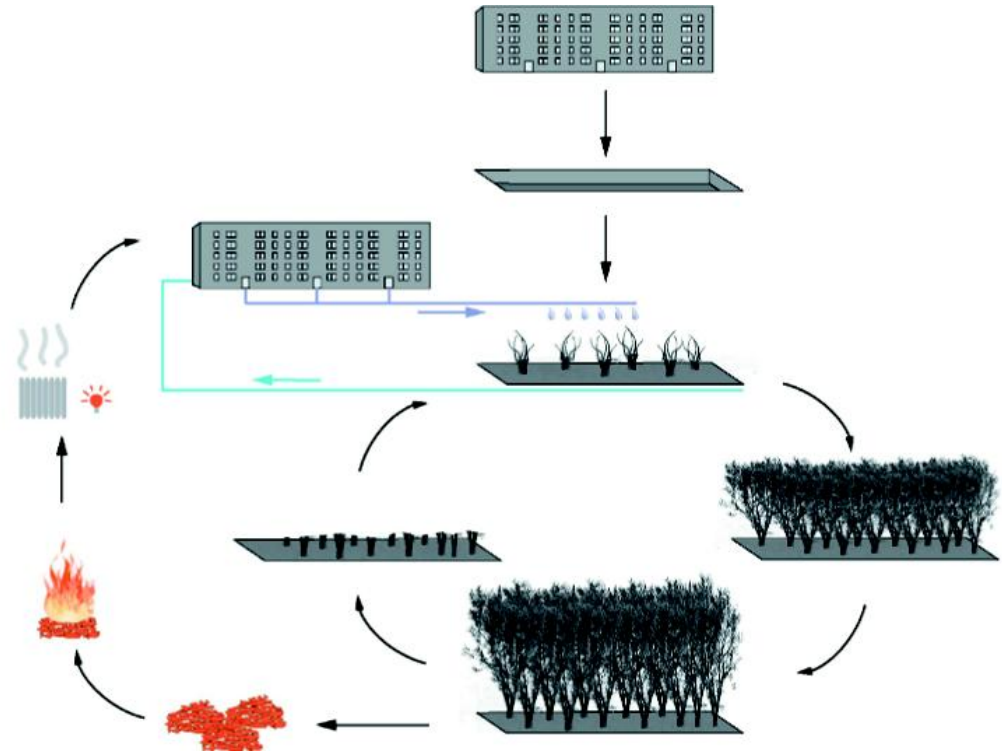


CWB Output – Flows

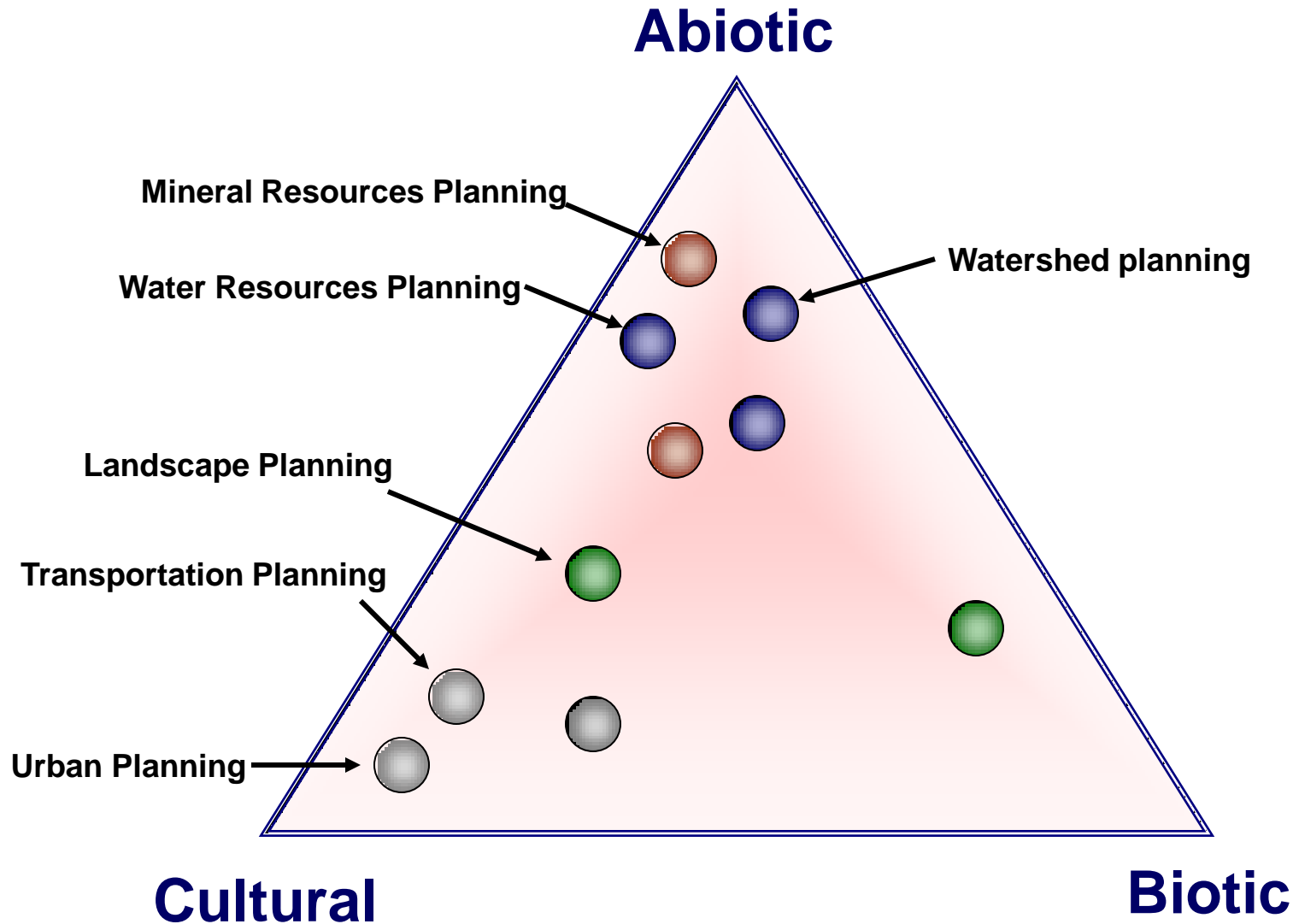


Reuse of Resources - Rostock

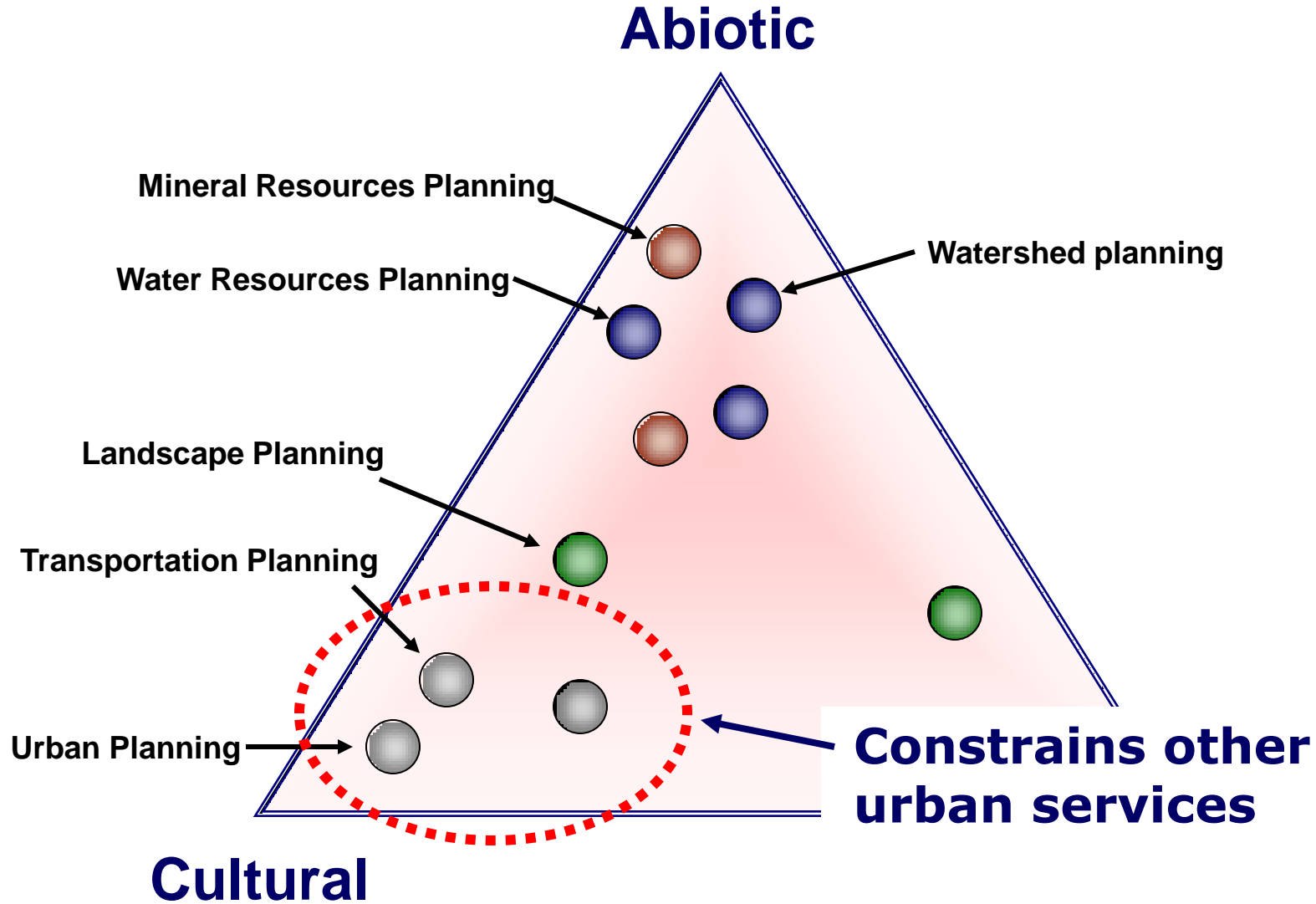
Case Study Mueßer Holz - Infrastructural landscape approach within shrinking cities



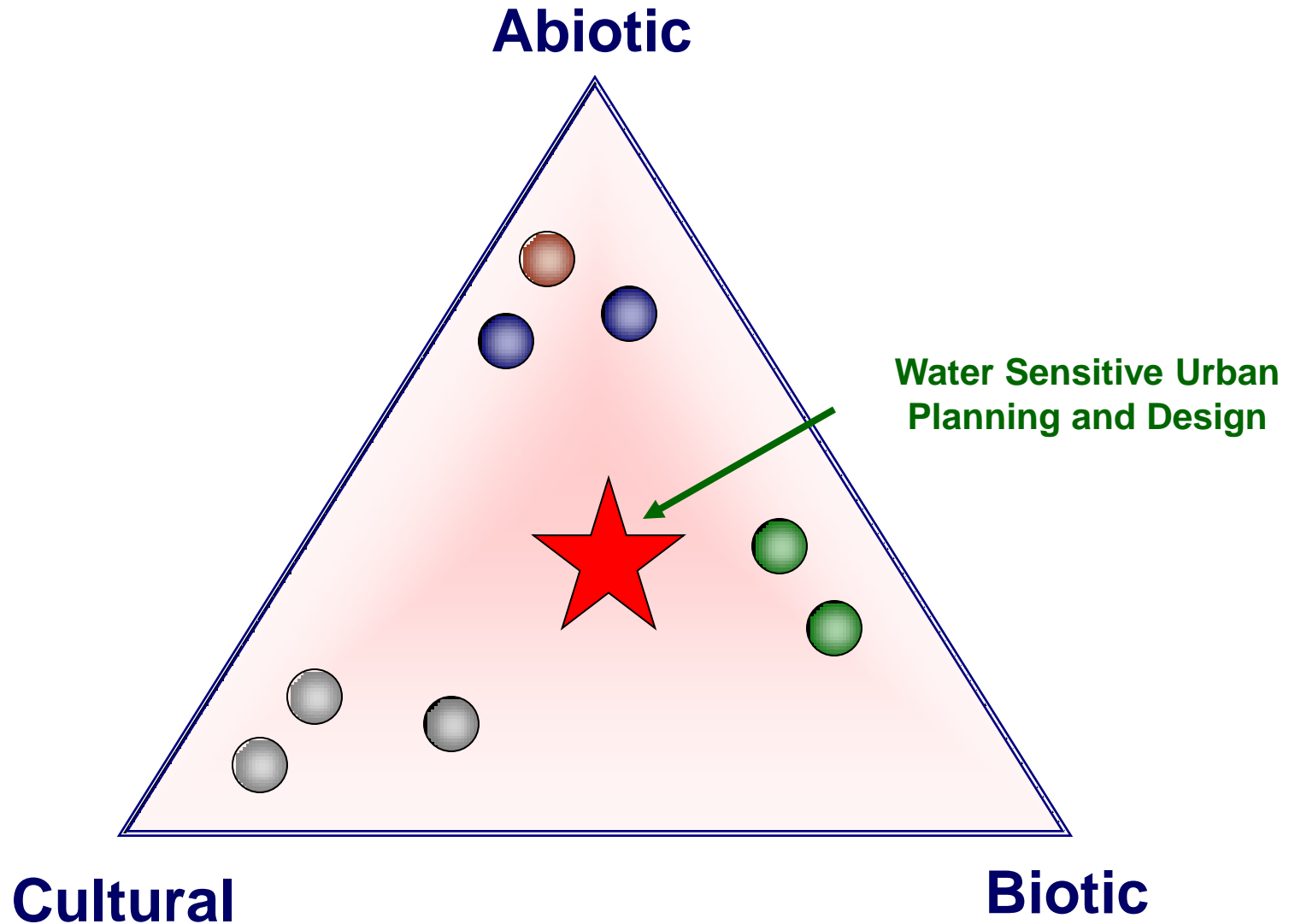
Greater Integration



Planning - Lack Integration



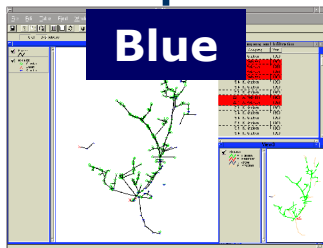
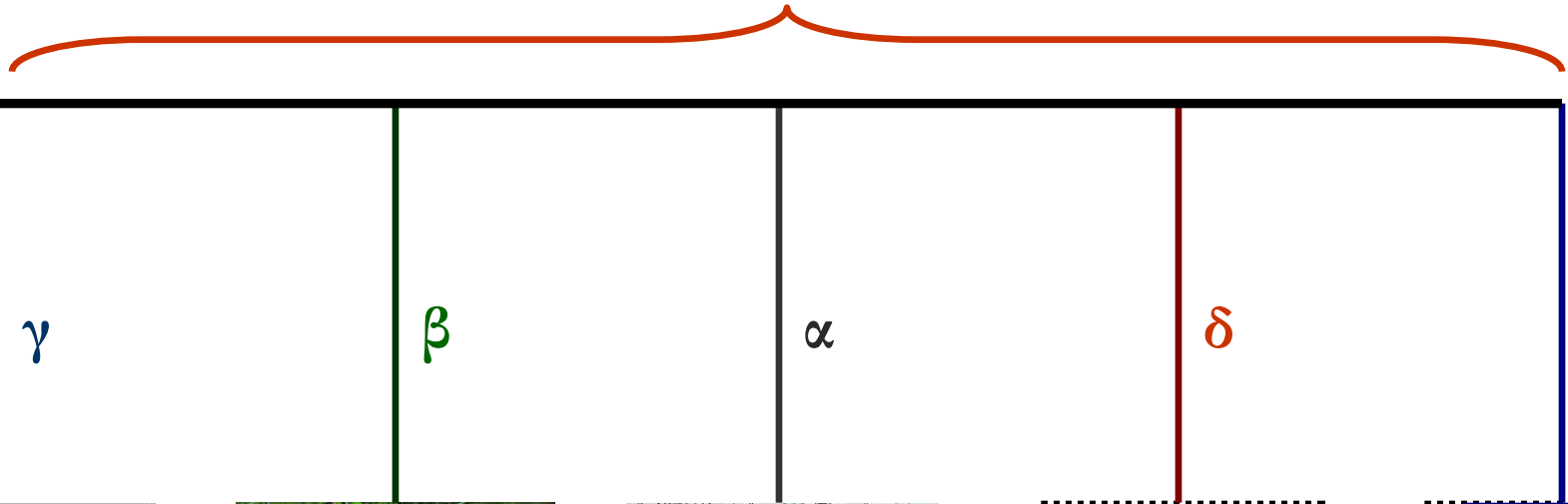
Greater Integration



New challenges – New Thinking

- Multi-objective urban planning (what should drive the urban plan?)

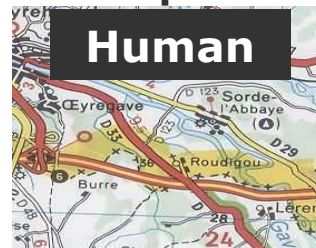
$$Z = (\gamma.u + \beta.v + \alpha.w + \delta.x + \varepsilon.y)$$



$$u = f(v, w, x, y)$$



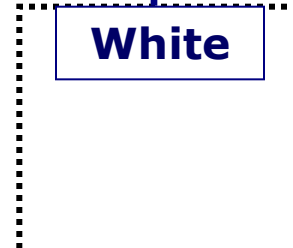
$$v = f(u, w, x, y)$$



$$w = f(u, v, x, y)$$



$$x = f(u, v, w, y)$$



$$y = f(u, v, w, x)$$



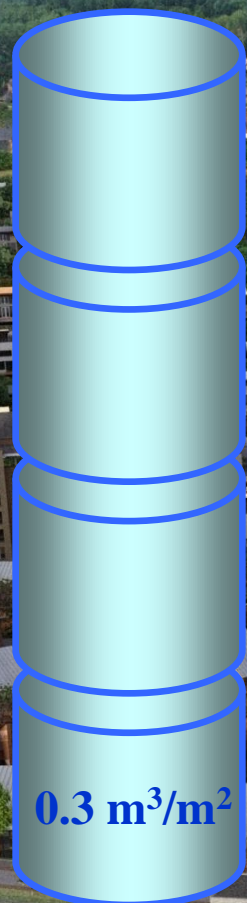
$0.3 \text{ m}^3/\text{m}^2$



$0.3 \text{ m}^3/\text{m}^2$



$0.3 \text{ m}^3/\text{m}^2$



$0.3 \text{ m}^3/\text{m}^2$

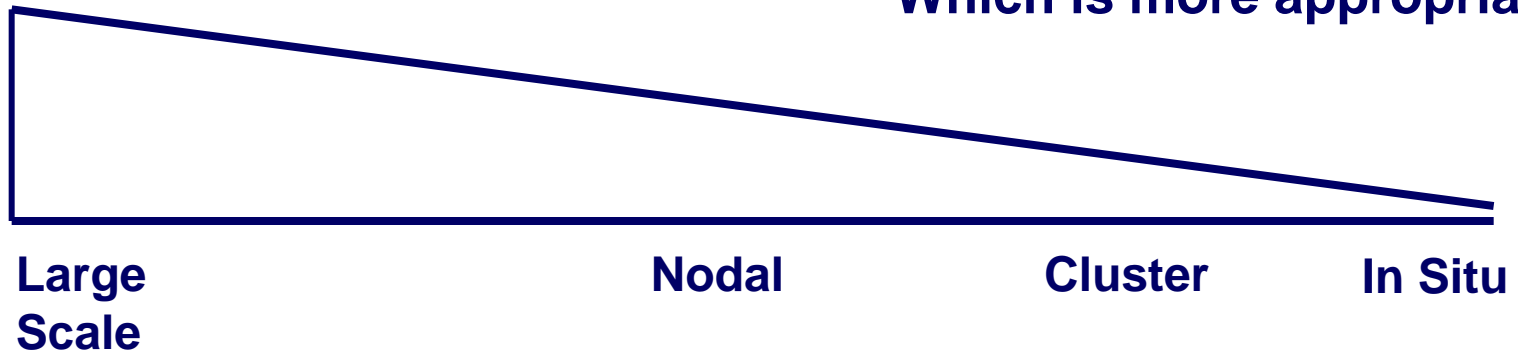
Greater Integration

**Allows optimizing
within a continuum
of options**

Which is more efficient?

Which is more sustainable?

Which is more appropriate?



Need for Interfaith Dialog !

Highly
Centralized

Highly
Decentralized

The water sector can't do it alone



Need to create **Utilities of the Future that lead innovation**

- **Direct utility investments towards integration**
- **Advocate for funding, regulations and incentives**

**Land planners
Architects
Developers**

**Gov't officials
Financiers
Energy experts**

Structure of Talk

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- **Adaptive/Flexible Approaches**
- **Transitioning Process**

Structure of Talk

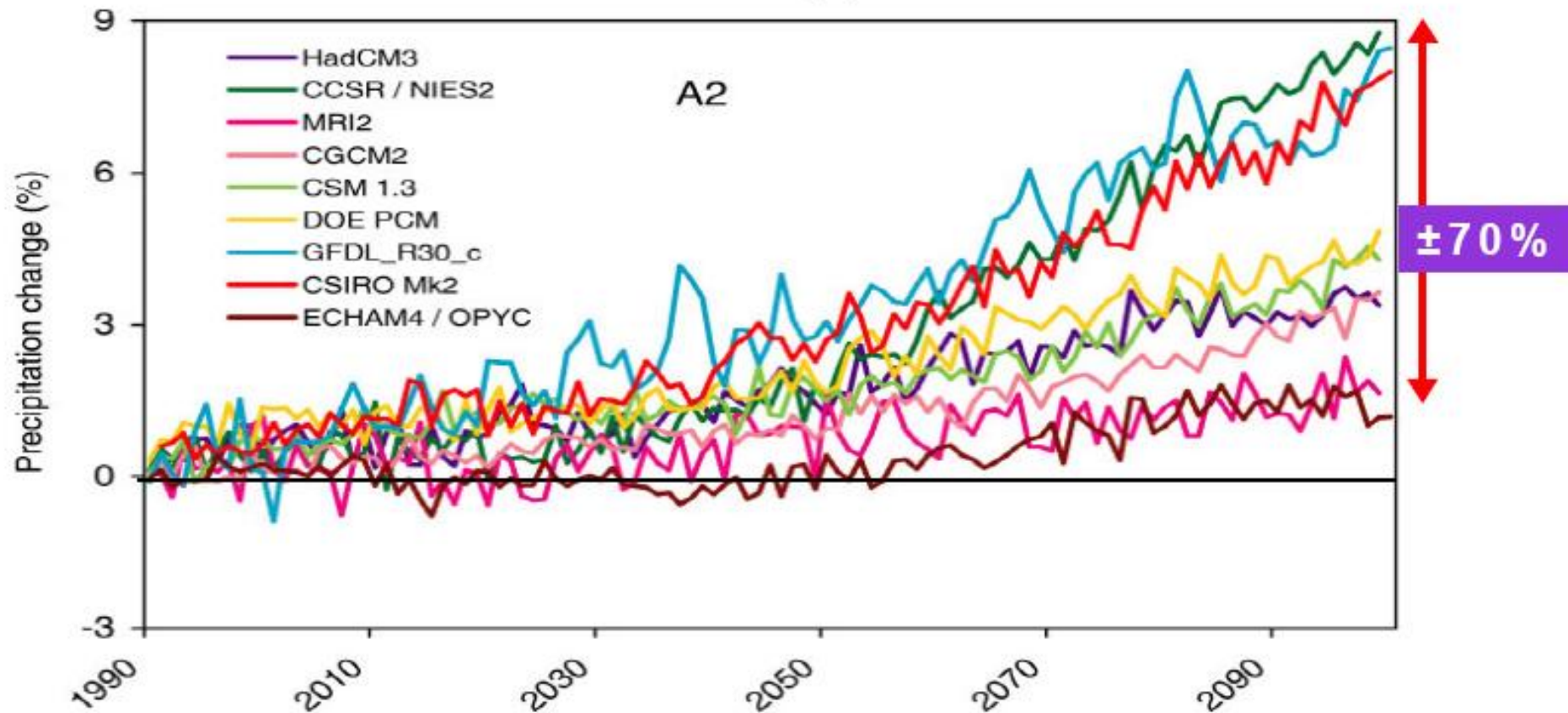
- Integrated Urban Water
- **Adaptive/Flexible Approaches**
- Transitioning Process

Hazards - New challenges

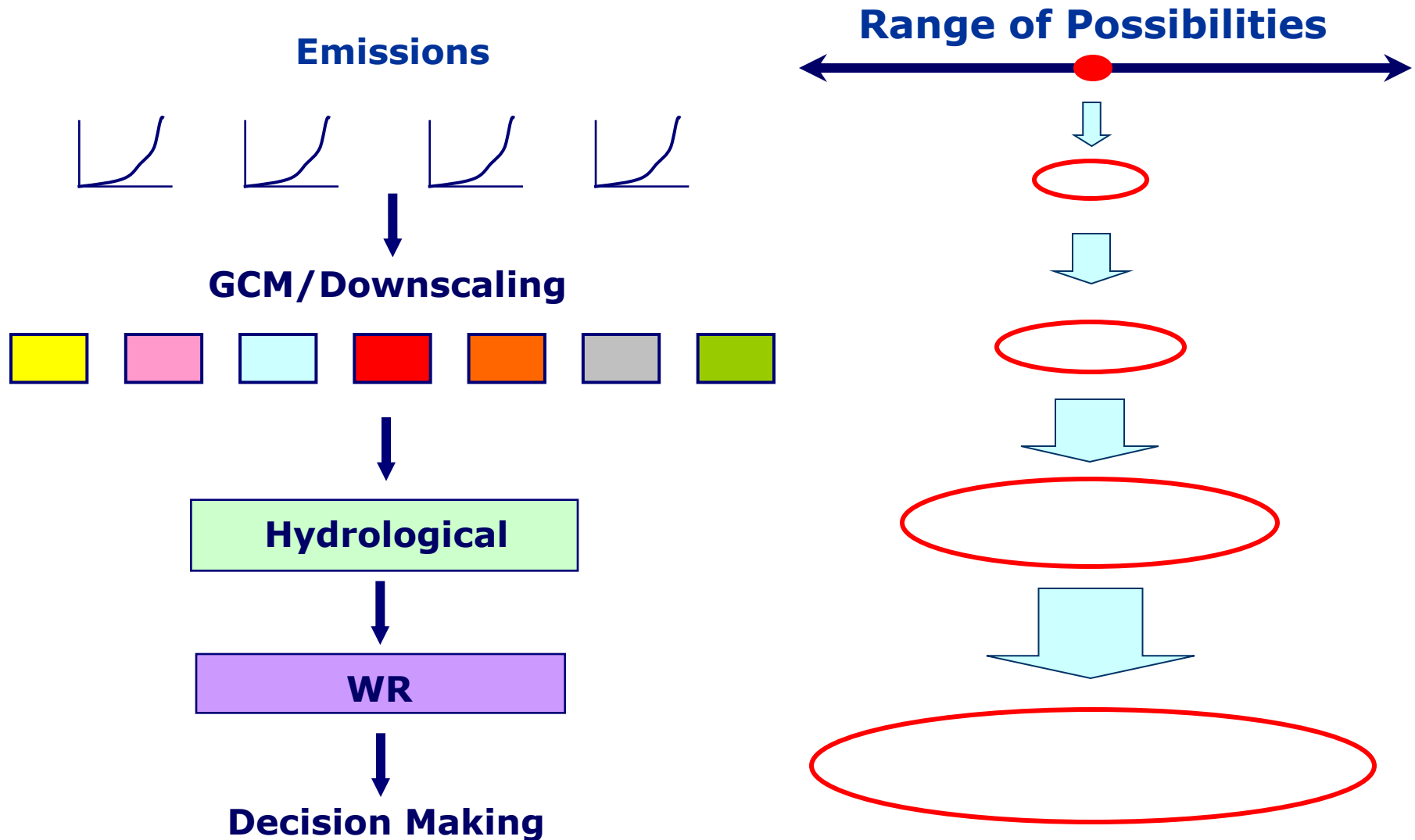
- **Entire earth system is changing!**



Changes - Uncertainties



Uncertainties in predictions



Let's Tally Up

Population Growth + Urbanization
+ Rising Standards (Health, Environ)
+ Climate Change
+ Ensemble of Models
= **Major Change and Uncertainty**

Let's Tally Up

- Many Future Change Drivers
- + Unknown Trends Of the Drivers
- + Many Sources of Uncertainties
(Inputs, Parameters, & Models)
- = **Major Change and Uncertainty**

New challenges – New Thinking

- Entire earth system is changing!



Uncertainty in
storm events



Uncertainty in carrying
capacity/breakage rate



Uncertainty in
runoff response



Uncertainty in
demand

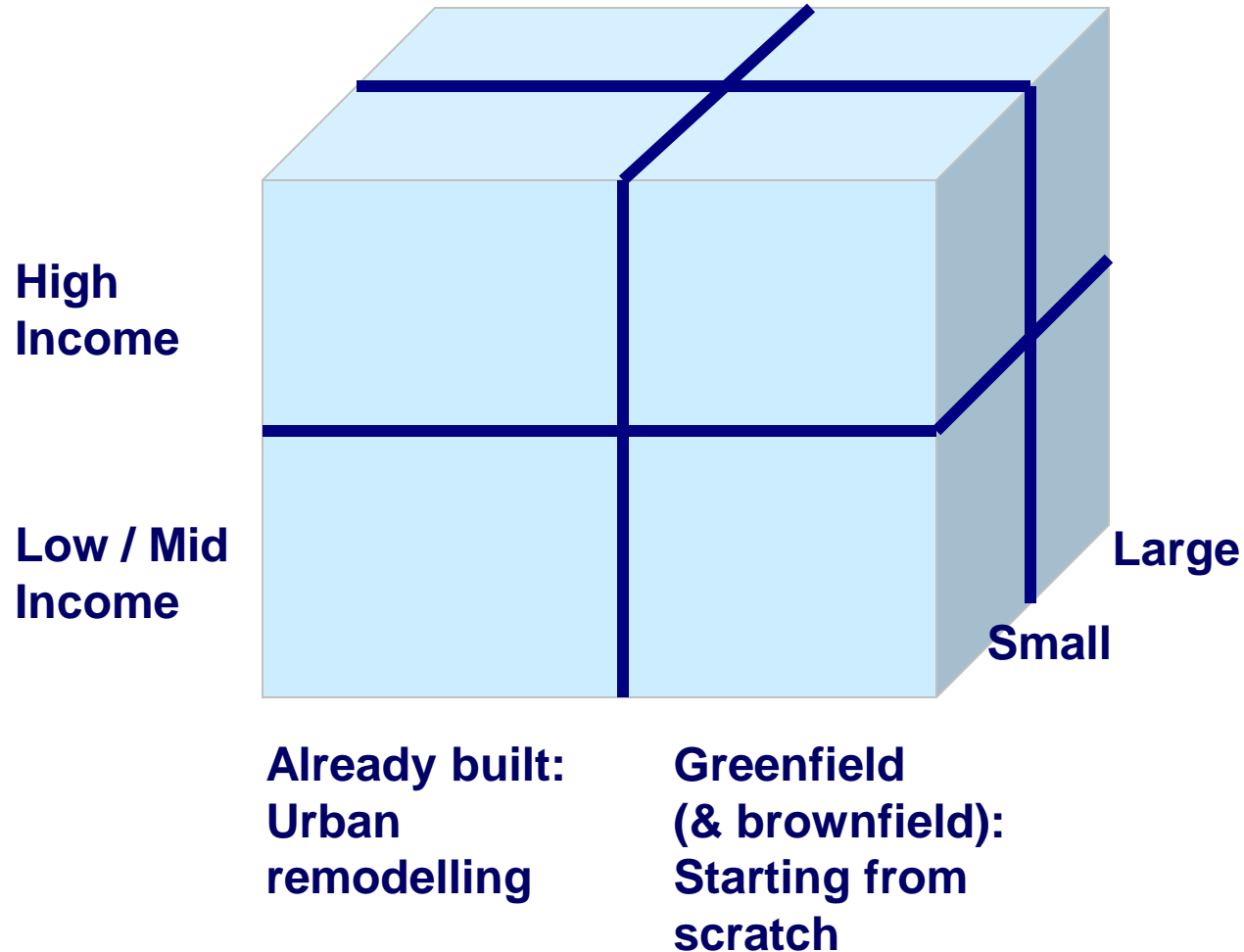


Uncertainty in
quantity & quality

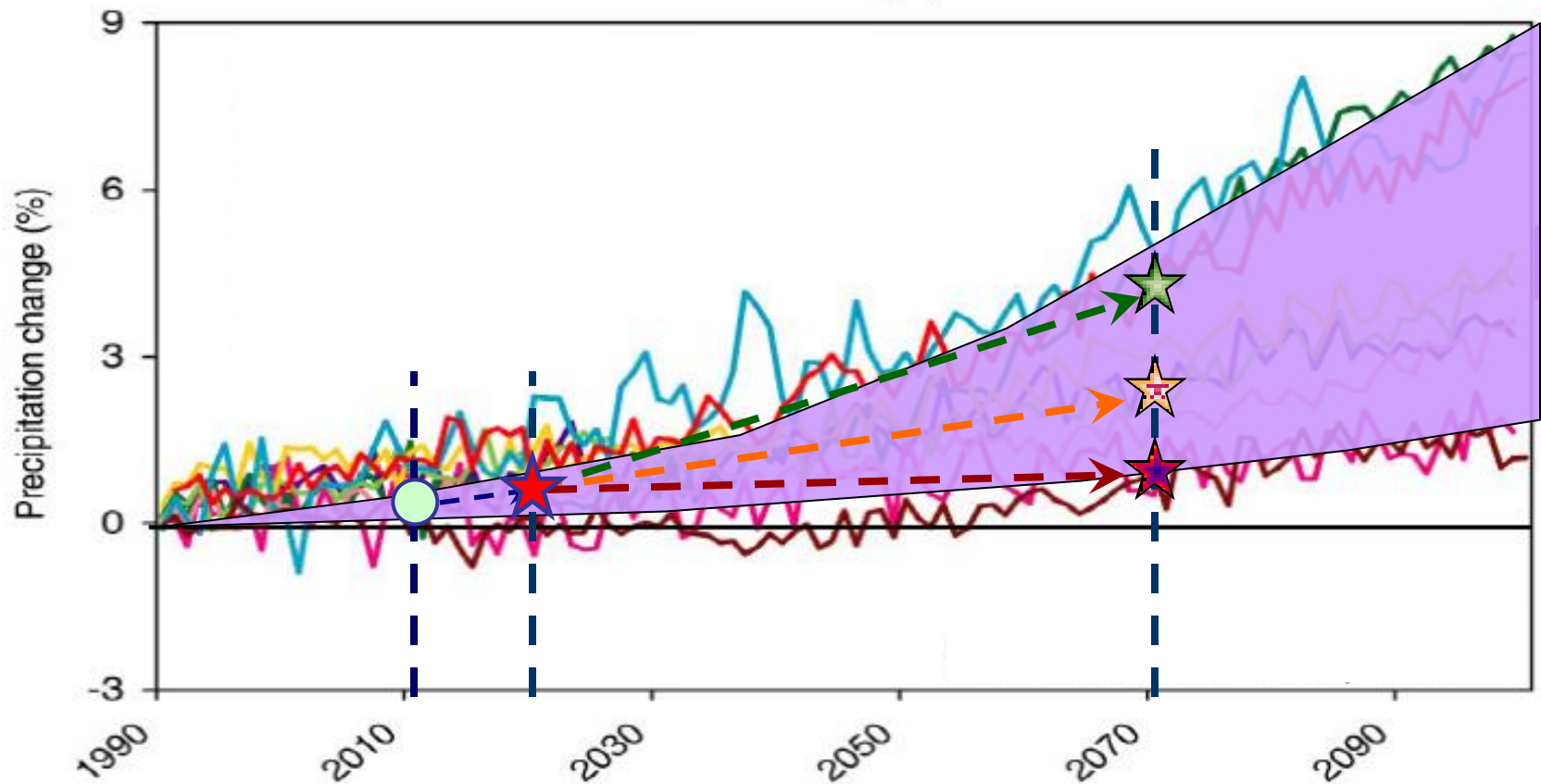


Uncertainty in
quantity & quality

The Application Space



Decision Making in Uncertain World



Flexibility Assessment

**Flexibility is the ability of urban water systems to use
their**

**active capacity to act to respond on relevant alterations
in a performance efficient, timely and cost effective way**

Flexibility Assessment

Flexibility is the ability of urban water systems to use

their

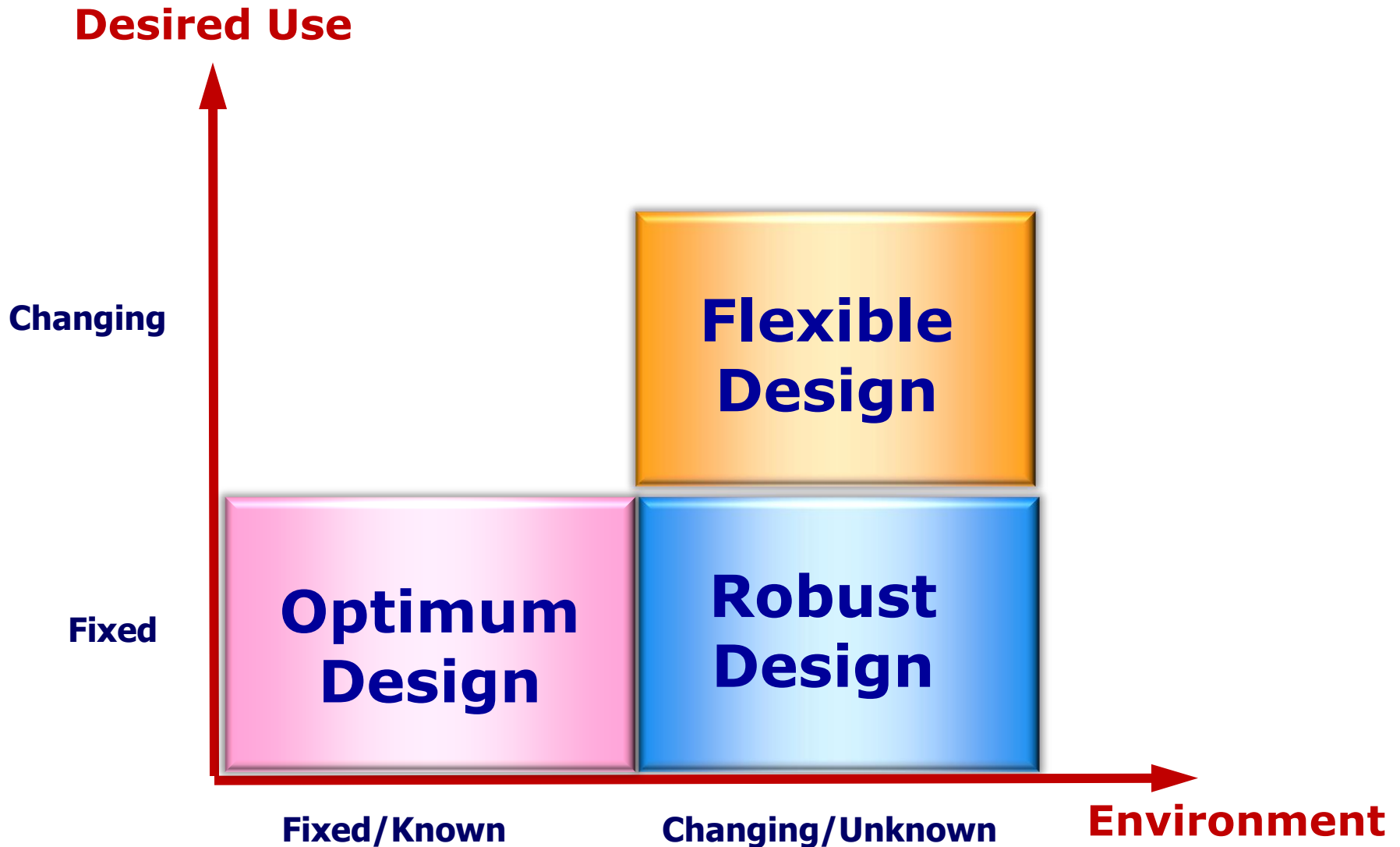
active capacity to act to respond on relevant alterations
in a performance efficient, timely and cost effective way

Characteristics of the
change process

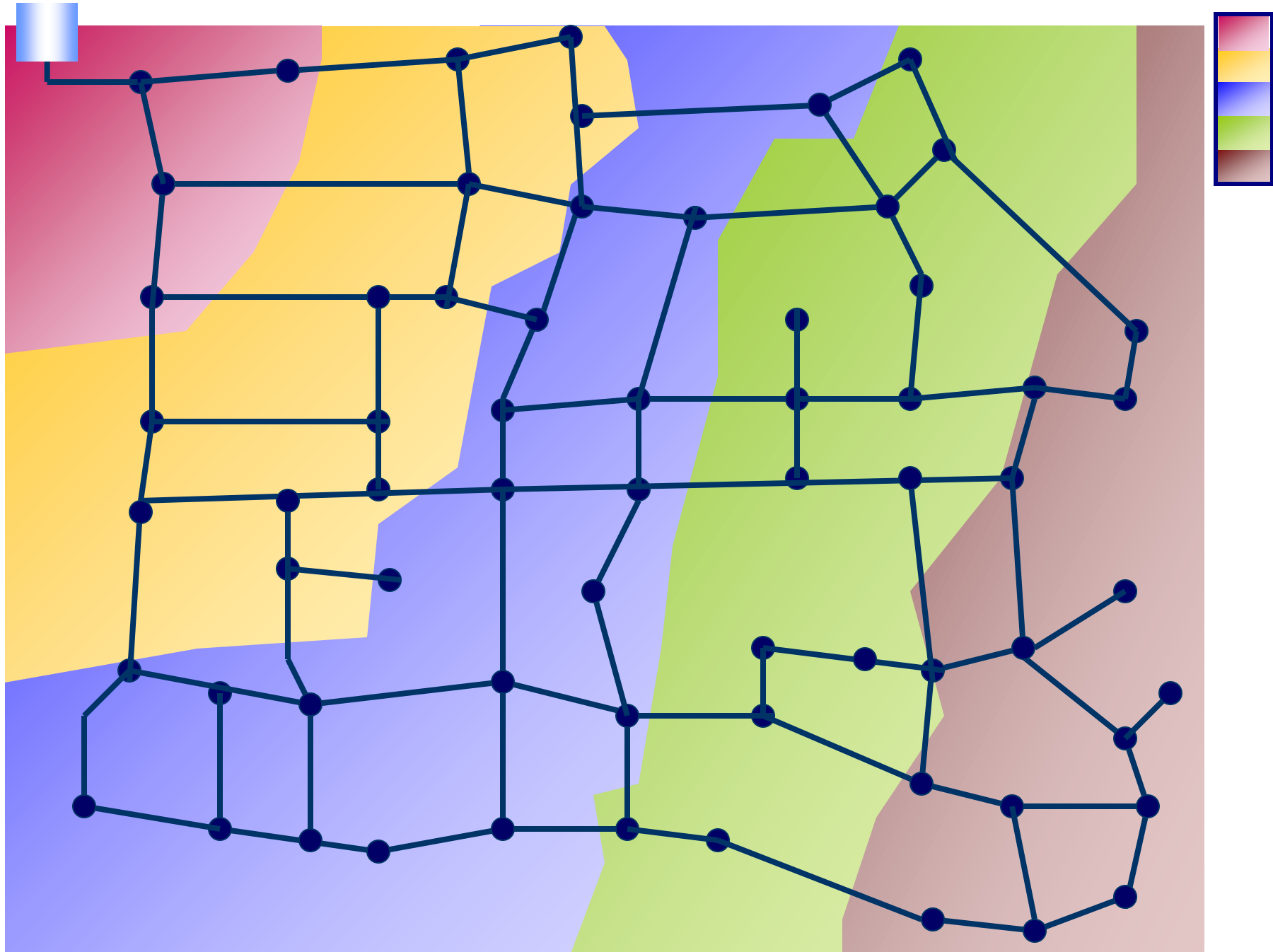
Capability for active
change of system

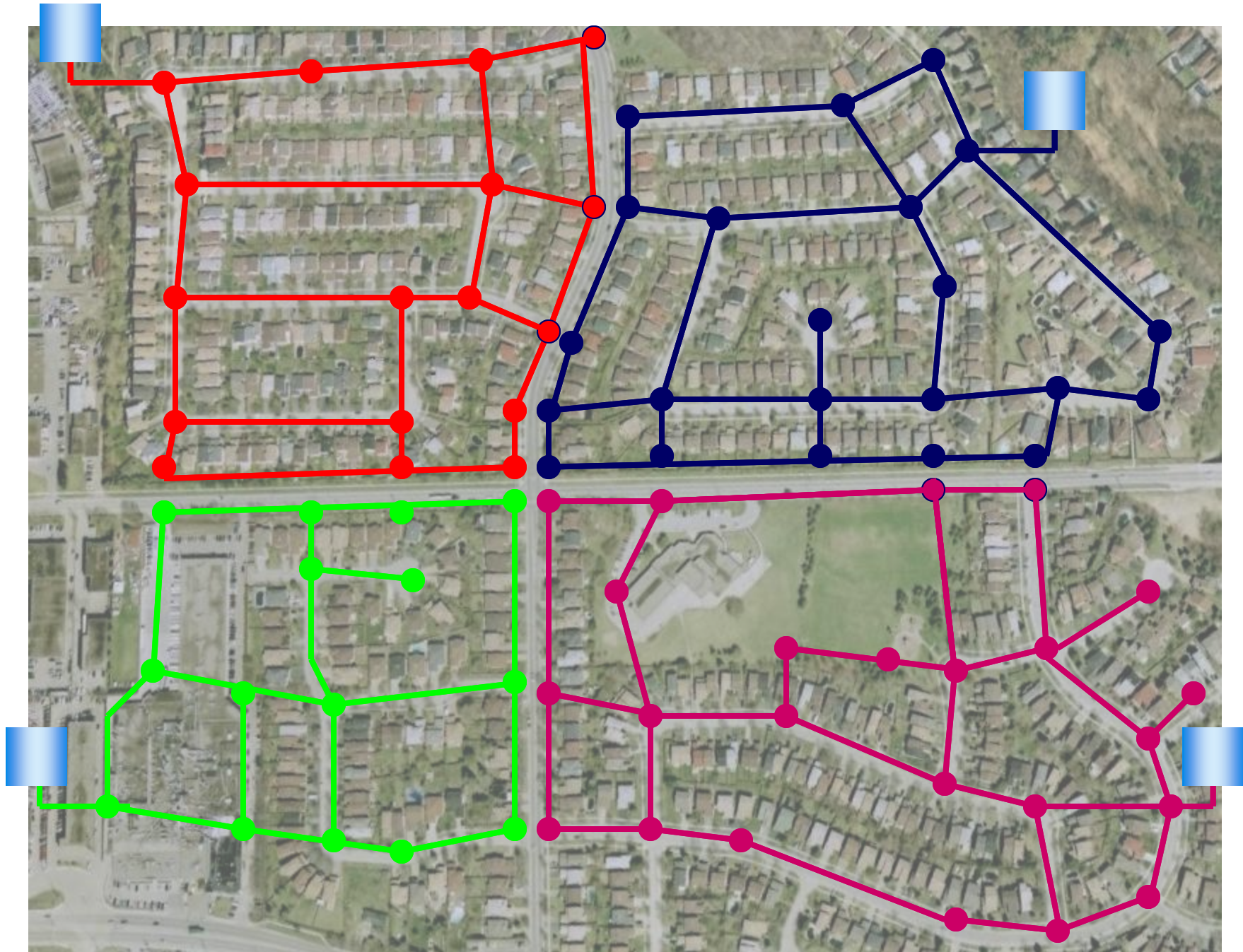
Deal with future
uncertainties

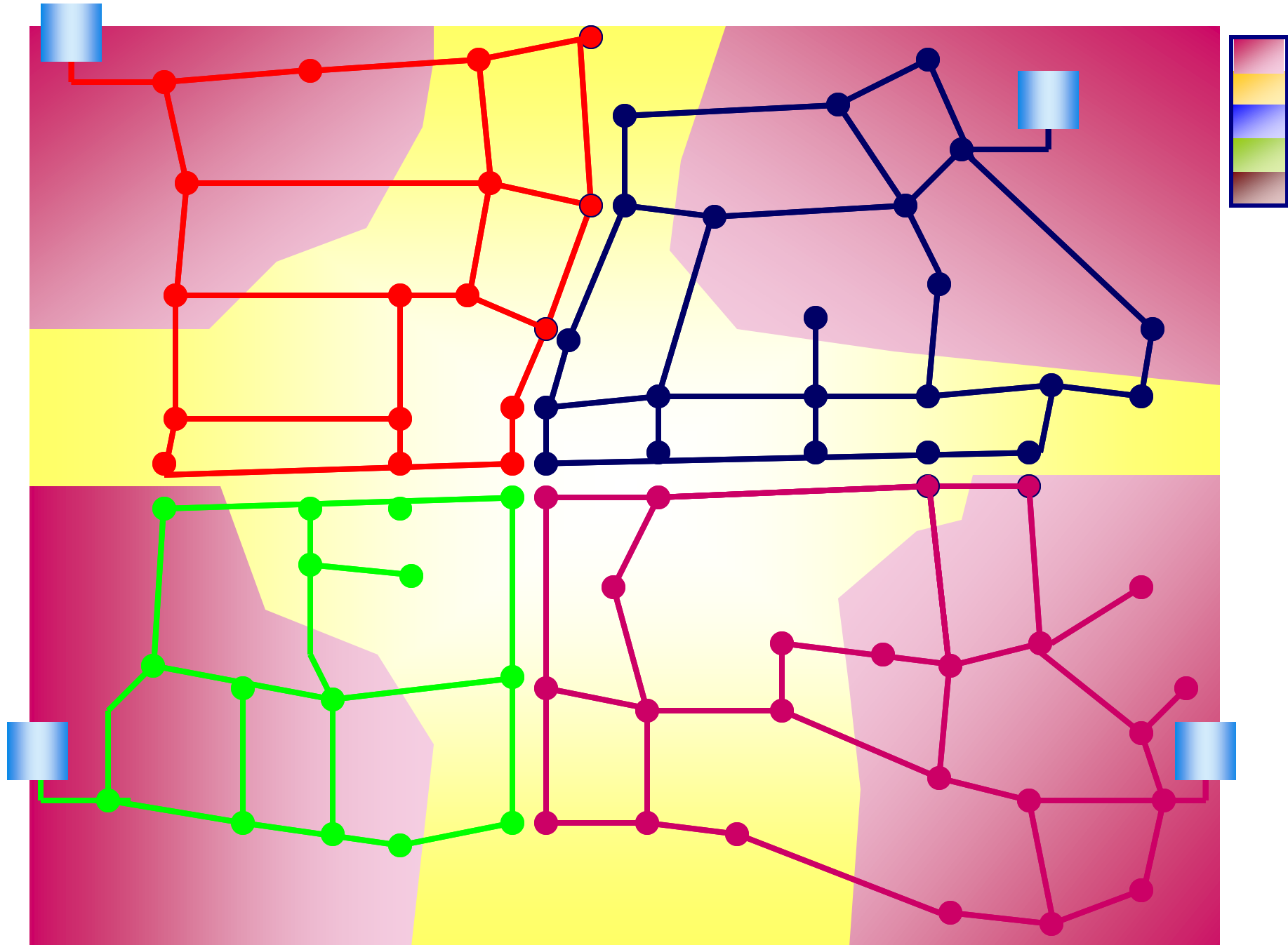
Flexibility VS Robustness

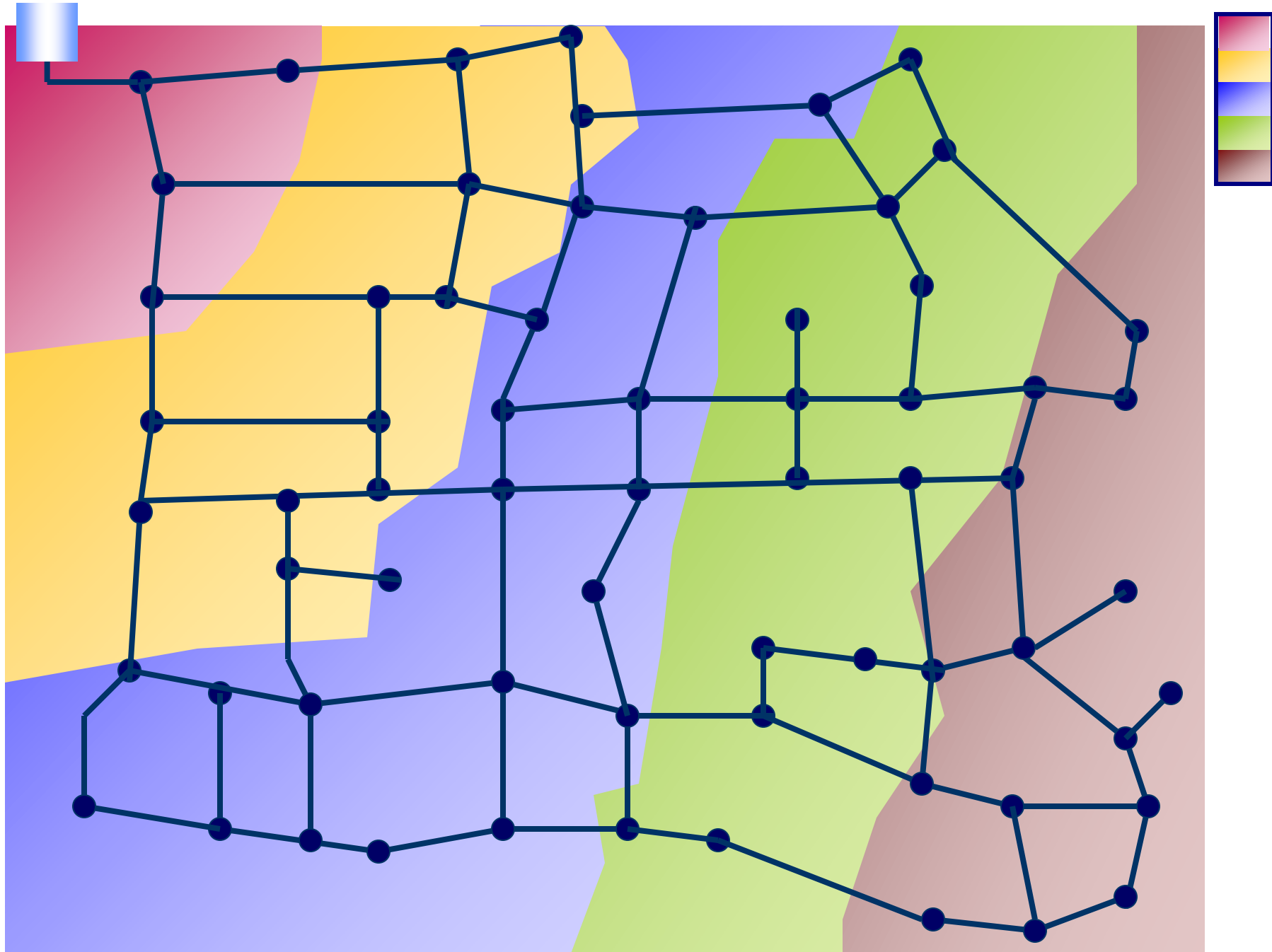


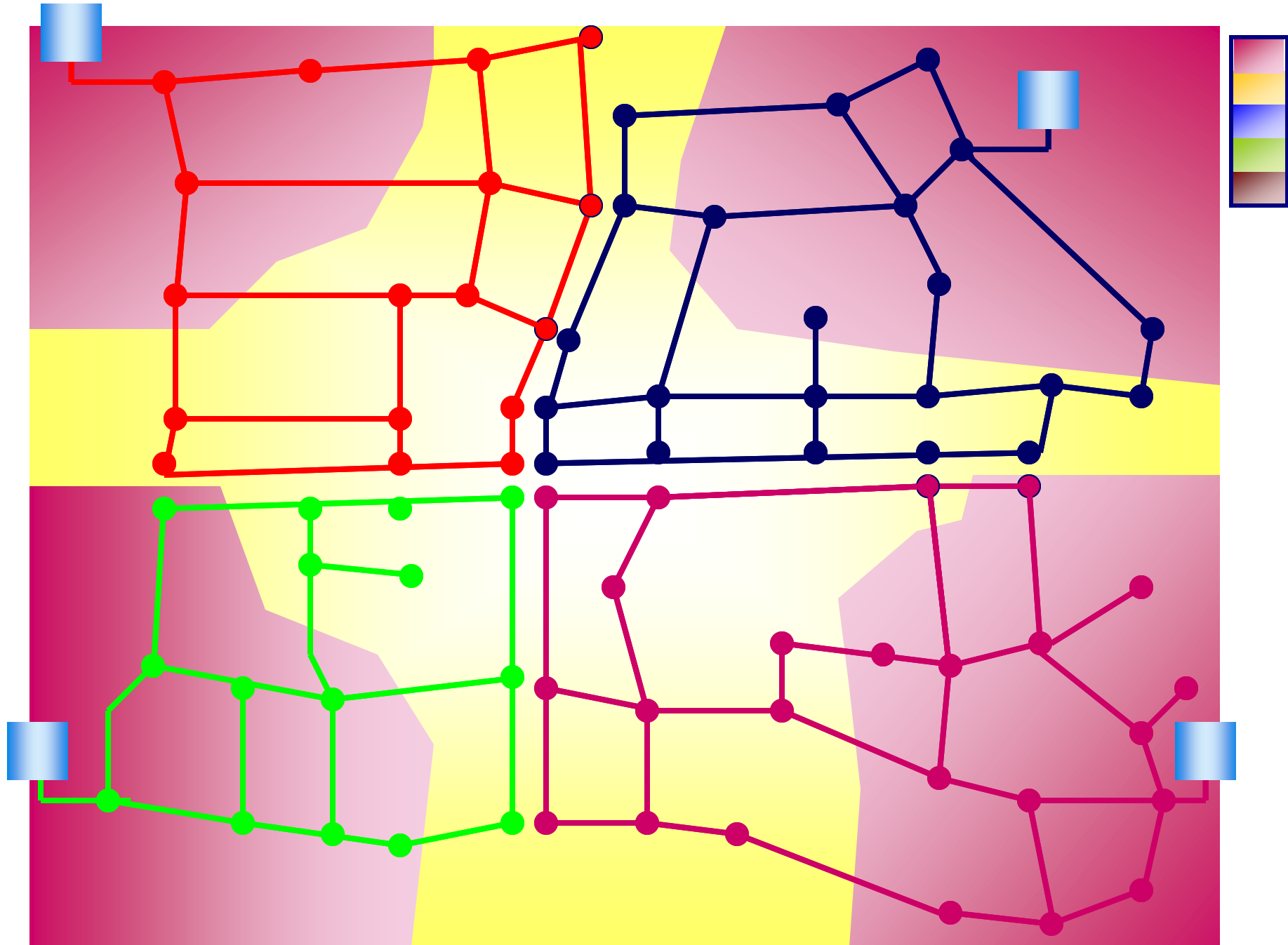












- 
- An aerial photograph of a residential neighborhood with a network diagram overlaid. The diagram consists of dark blue lines connecting black dots, representing nodes. The lines follow the layout of streets and property boundaries. There are four yellow double-headed arrows pointing to specific nodes: one on a horizontal street in the upper middle, one on a vertical street in the lower middle, one on a horizontal street on the left, and one on a vertical street in the center. Two large green circles are also present: one in the upper right corner and one in the lower left corner. A white rectangular box with a dark blue border is centered in the lower half of the image, containing a bulleted list of four terms. The background is a grayscale aerial view of houses and trees.
- Real Options Theory
 - Net Disturbance Propagation (NDP)
 - Range of Resemblance (RR)
 - Communality Index (CI)

Sustainable Urban Drainage



ecological
treatment

A photograph showing a natural water filtration system. A bundle of green reeds or similar aquatic plants is placed in a shallow, dark water channel. The surrounding area is filled with various green plants and grasses, suggesting a wetland or constructed pond environment for water treatment.



green roofs

A photograph of a modern building with a curved, arched roof. The roof is covered in a dense layer of green vegetation, including grasses and small plants. The building has large glass windows and a balcony, and is situated in a landscaped area with trees and a small pond in the foreground.



pervious
pavement

A photograph of a paved area, likely a sidewalk or parking lot. The pavement is made of light-colored, rectangular tiles. A rectangular section of the pavement is covered with a grid of small, green plants, demonstrating a pervious pavement system designed for water infiltration.



infiltration
trench

A photograph of a grassy area next to a paved road. A long, narrow, rectangular trench has been dug into the ground, filled with a layer of green grass. This is an infiltration trench designed to allow rainwater to seep into the ground and recharge the aquifer.



stormwater
harvesting

A diagram illustrating a stormwater harvesting system. It shows a cross-section of a building with a red-tiled roof. A pipe runs from the roof down to a storage tank or cistern located below the ground level. The diagram also shows a toilet and a sink, indicating that the harvested water can be used for non-potable purposes.



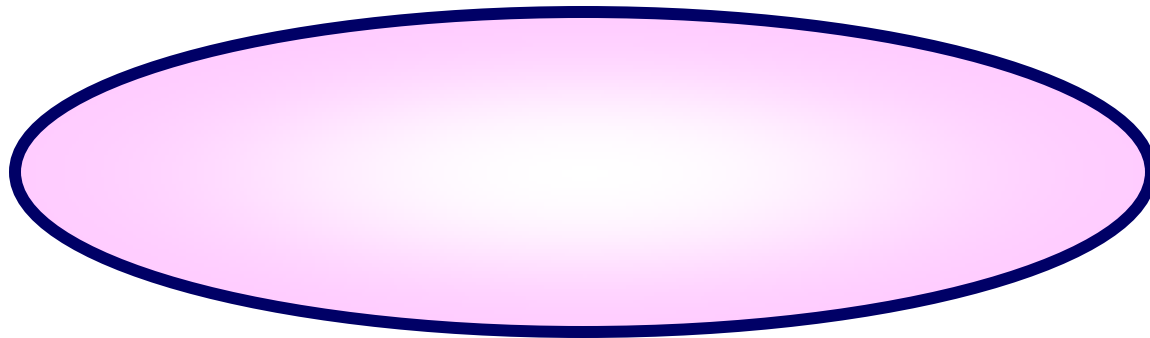
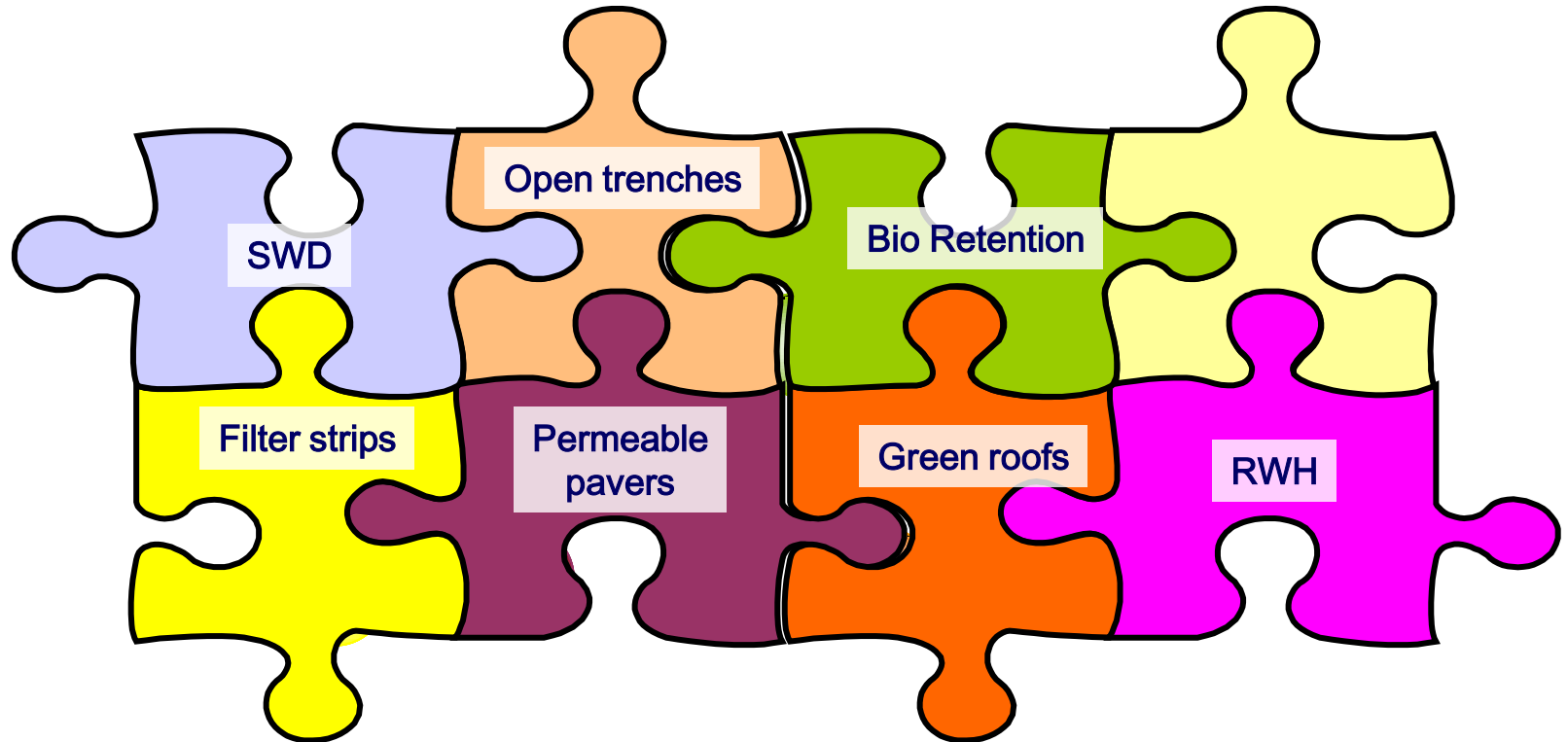
retention
pond

A photograph of a modern, multi-level retention pond. The pond is constructed with concrete walls and has a series of steps or terraces. Water is flowing over the steps, creating a cascading effect. The pond is surrounded by a paved area and some greenery.

**SUDs provides modular diversity
that increases flexibility resulting
in a complex adaptive system**

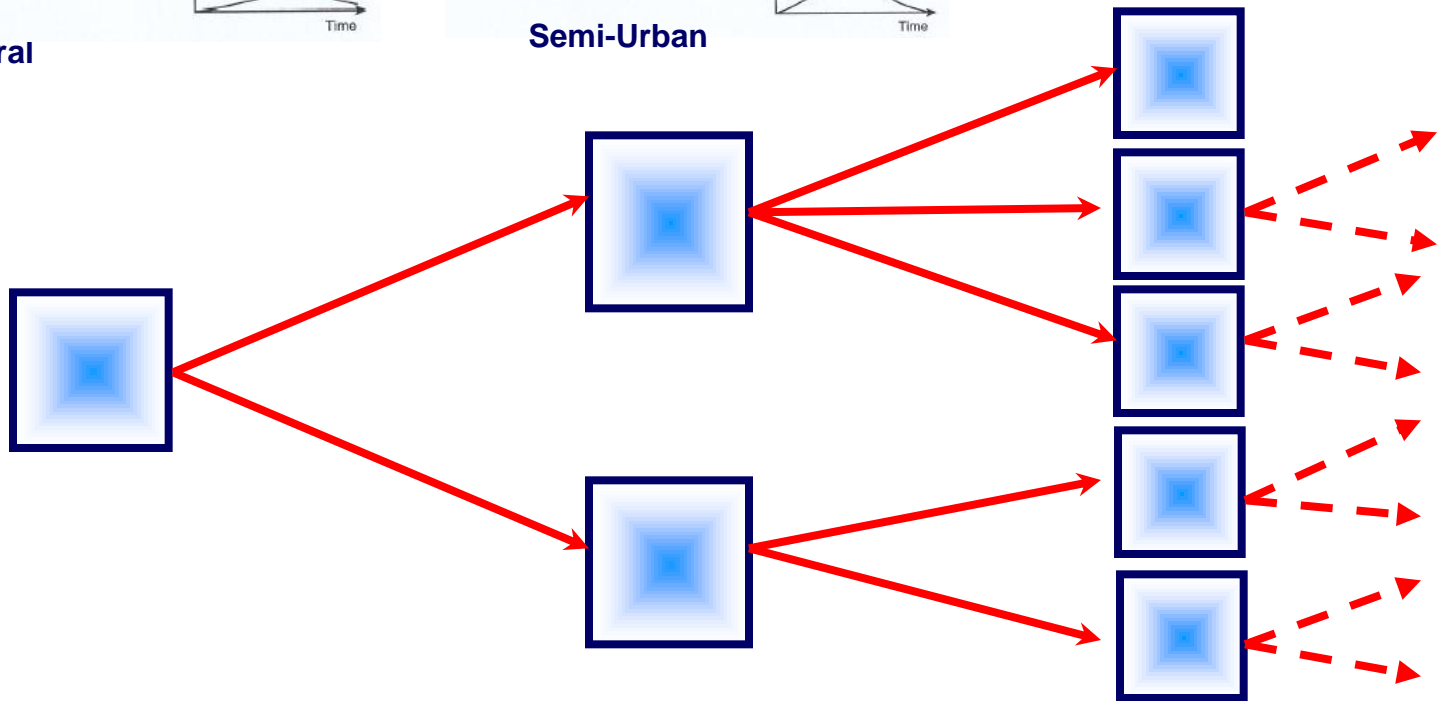
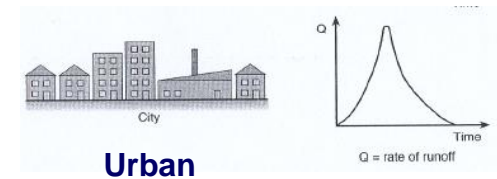
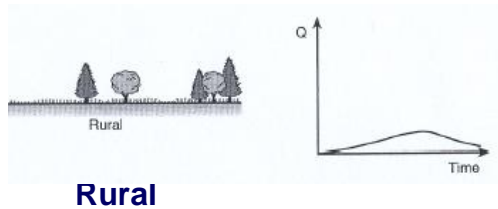
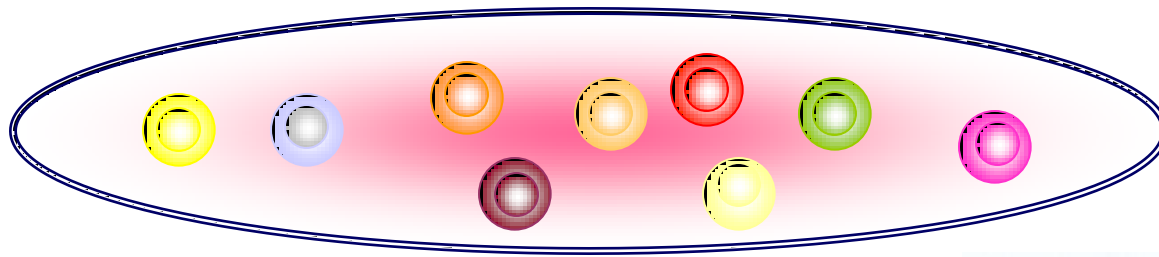
(Sieker et al., 2008, Eckart, 2008)

Examples of activities



Suite of Options

Urban Drainage Modular System



Flexibility Design Framework

Define UWS
(incremental change)

**Uncertainty
Identification &
Characterization**

**Flexibility
Assessment**

**City Water
Simulation Tool**

Modify UWS

Optimisation

**System
Acceptable ?**

**Flexible System
Proposed**



Yes

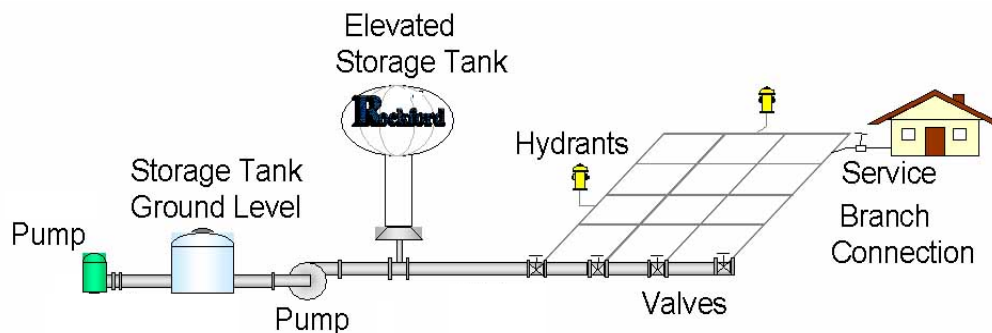


Flexibility Design Framework

**Define UWS
(incremental change)**

Platform Design, Modular System, Scalability,
Retrofitting, Investment deferral, Multistage
Deployment, System Expansion

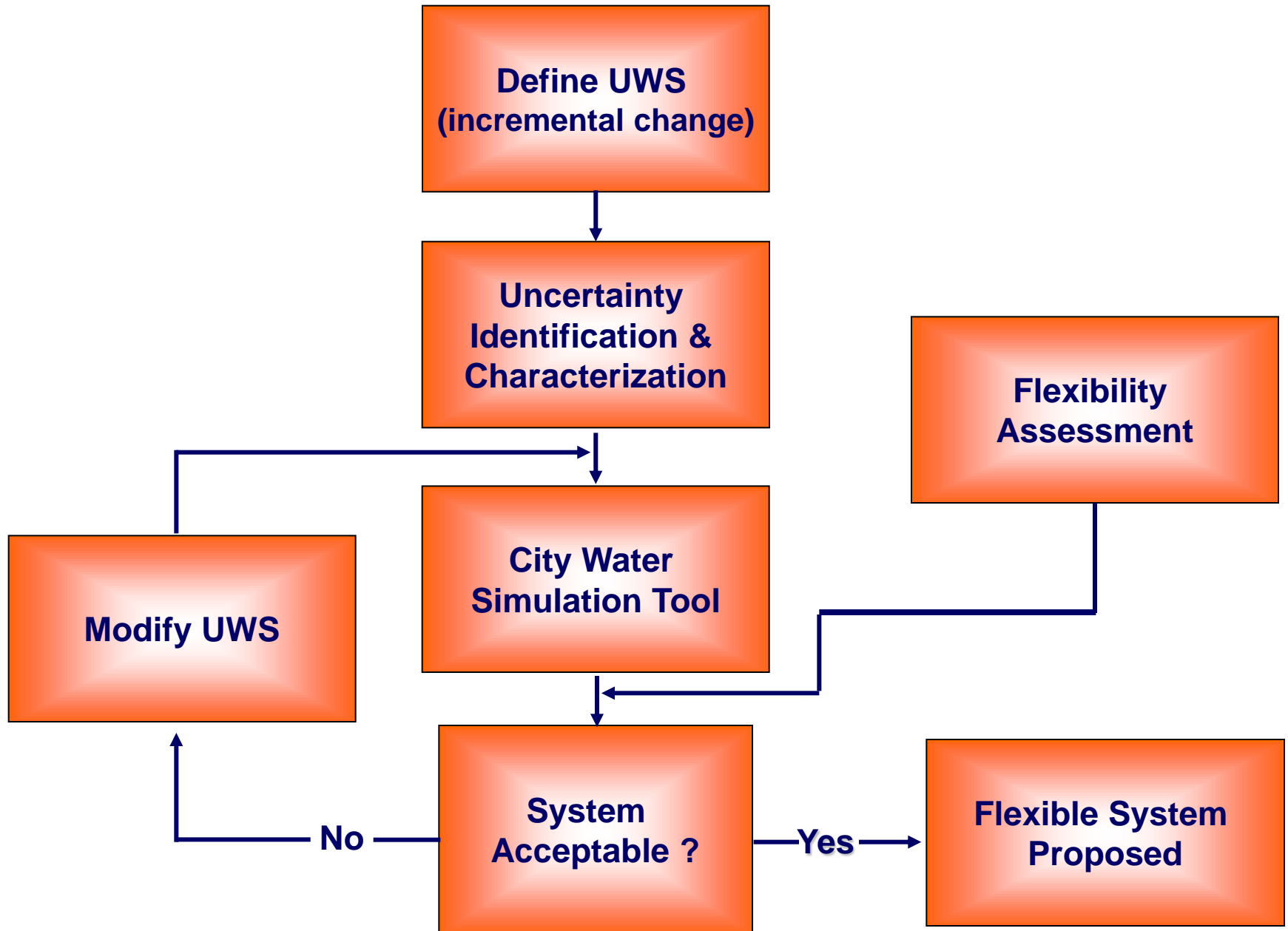
Reservoirs, Pumps, Valves,
Pipes, RT Control etc.



Modular, Decentralized
Multiple Use, RT control

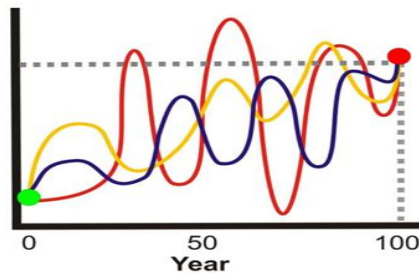
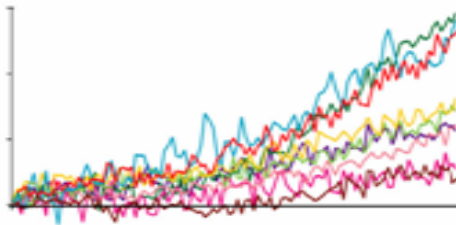


Flexibility Design Framework



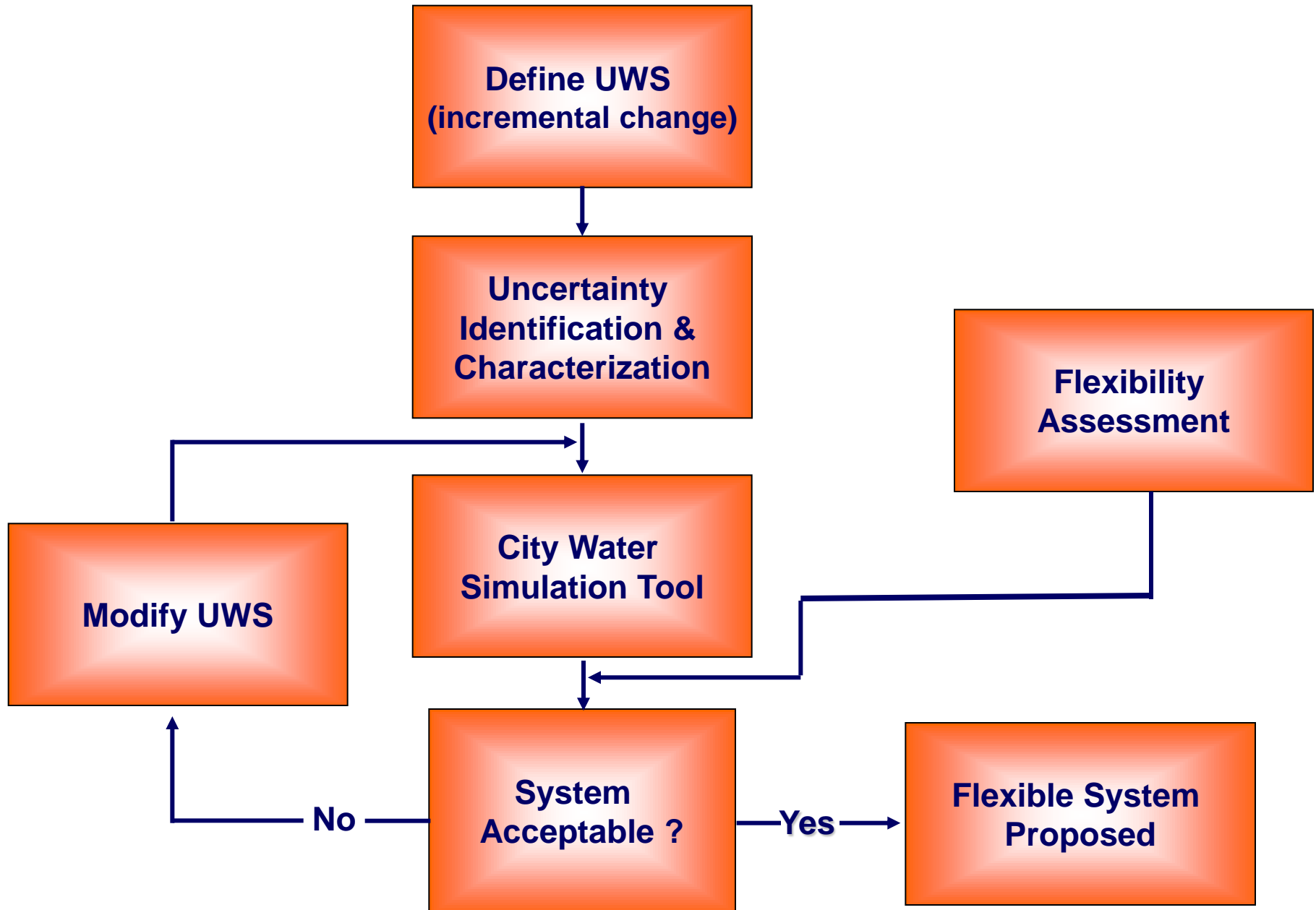
Flexibility Design Framework

**Uncertainty
Identification &
Characterization**

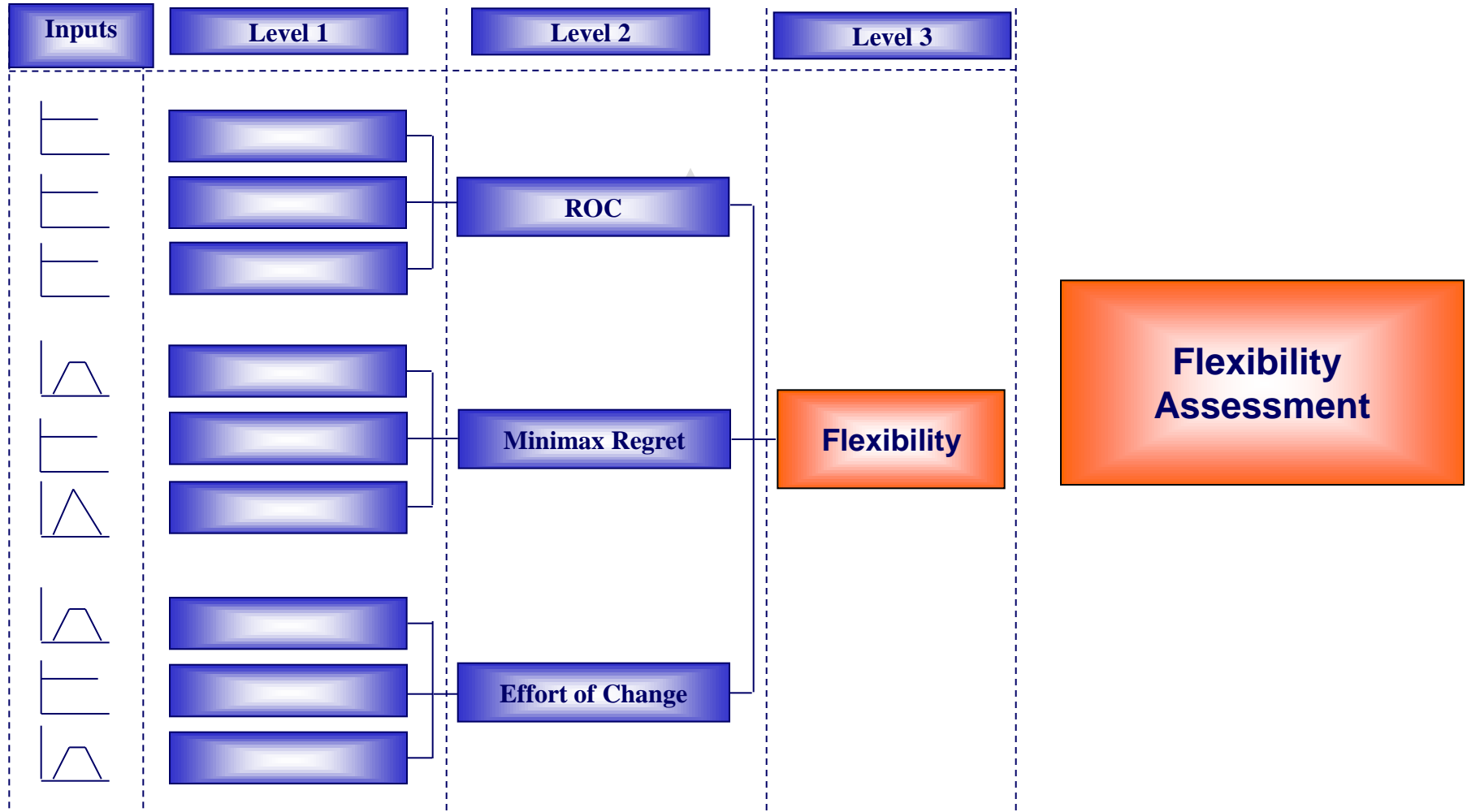


Probability, Possibility, Info-gap

Flexibility Design Framework



Flexibility Design Framework



Flexibility Assessment

Flexibility is the ability of urban water systems to use

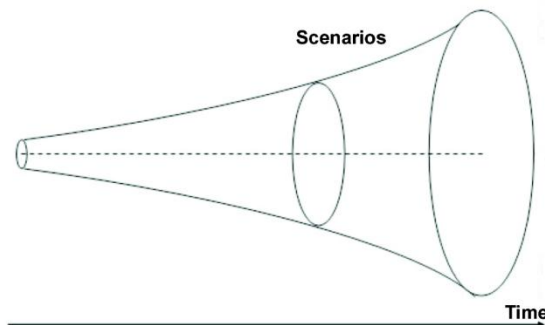
their

active capacity to act to respond on relevant alterations
in a performance efficient, timely and cost effective way

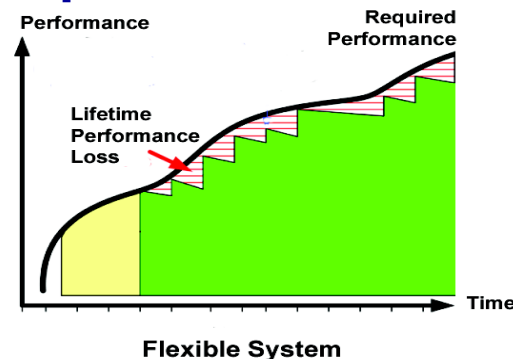
**Capability for active
change of system**

**Characteristics of the
change process**

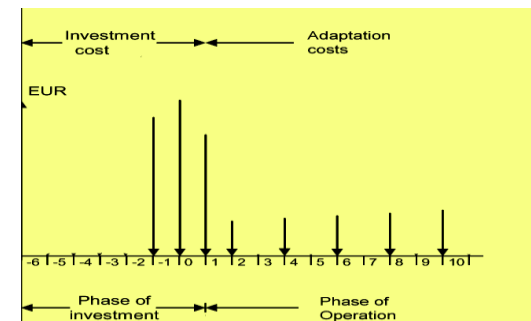
**Range of change
system can cope with**



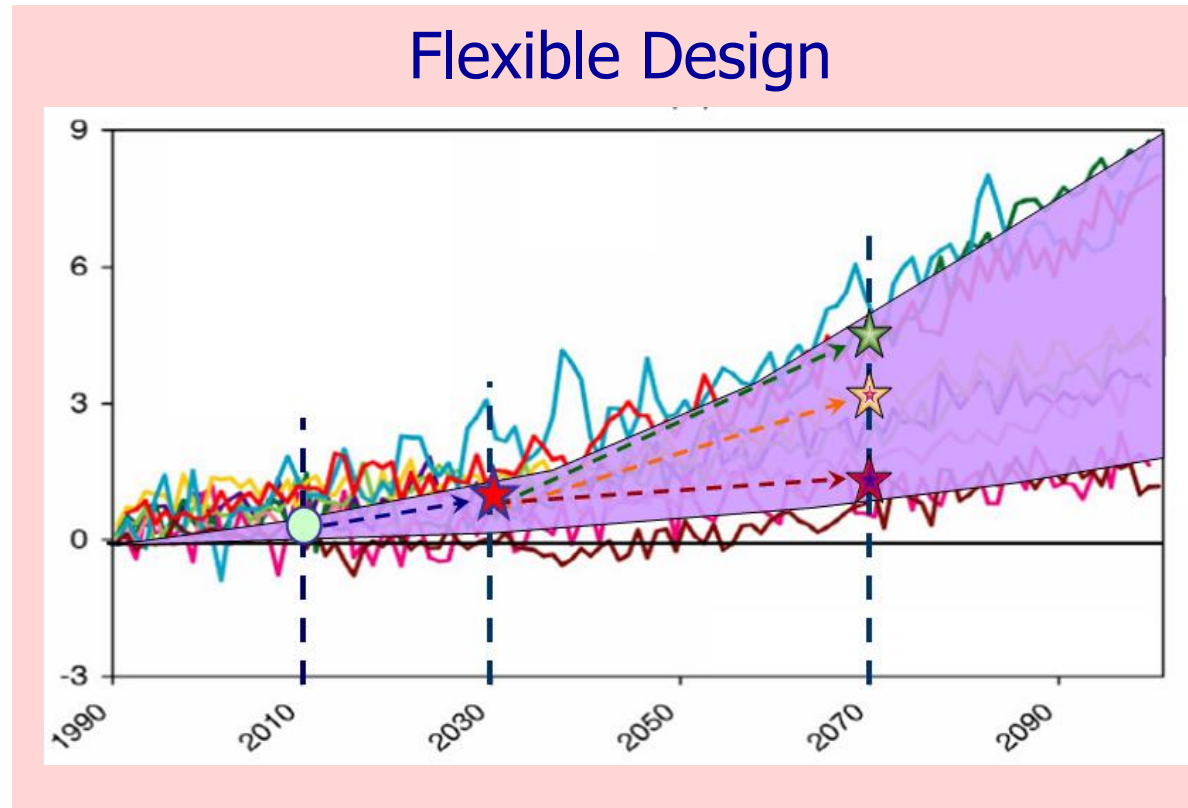
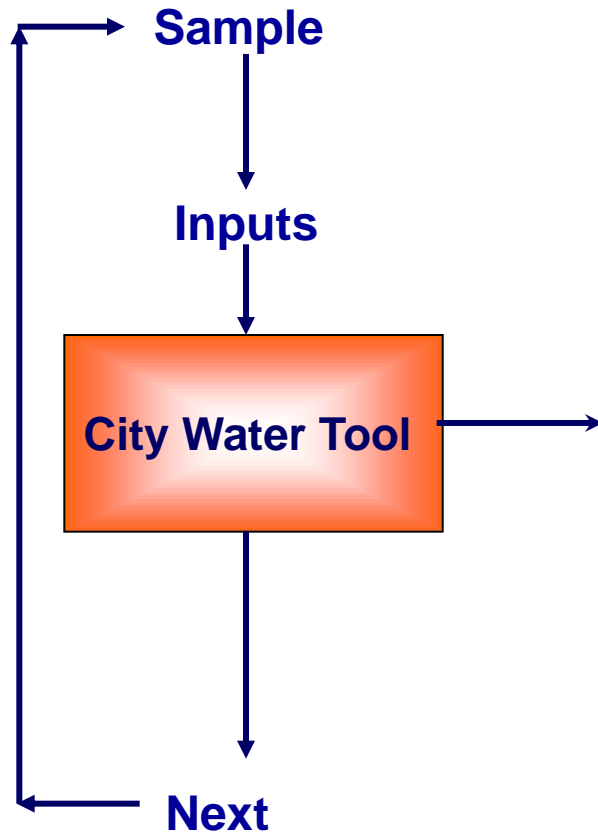
**Minmax regret
performance**



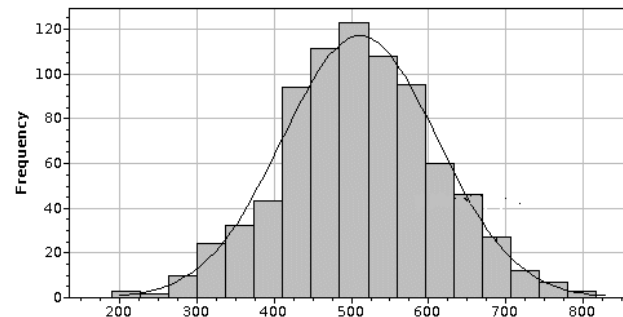
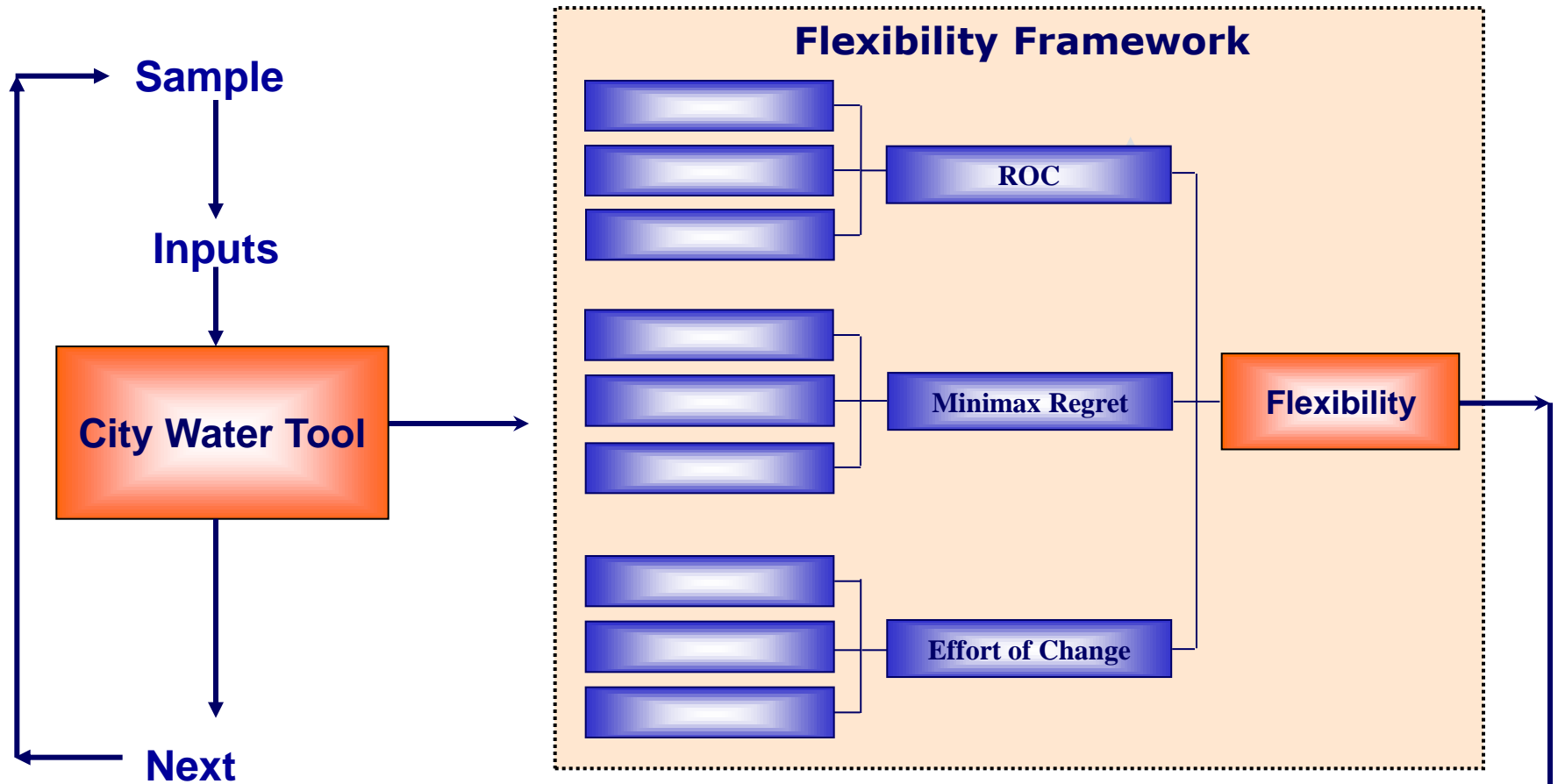
Effort of change



Flexibility Design Framework

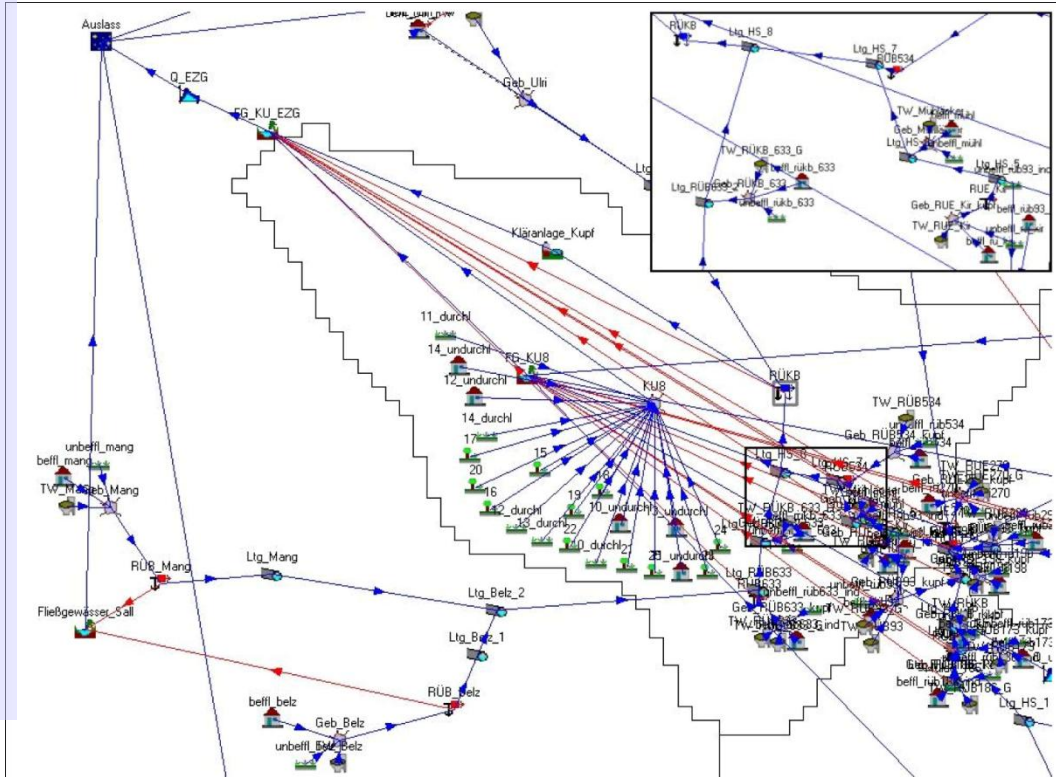


Flexibility Design Framework



Measurement of Flexibility - Case Study Kupferzell

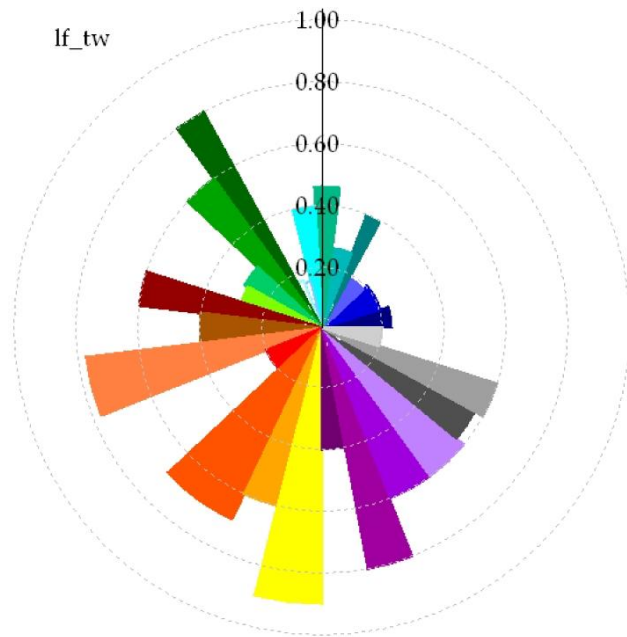
- **Stormwater master plan for Kupferzell, a small City in southern Germany**
- **4 futures scenarios have been developed**
- **4 different alternative solutions have been designed**



Homogeneity Performance

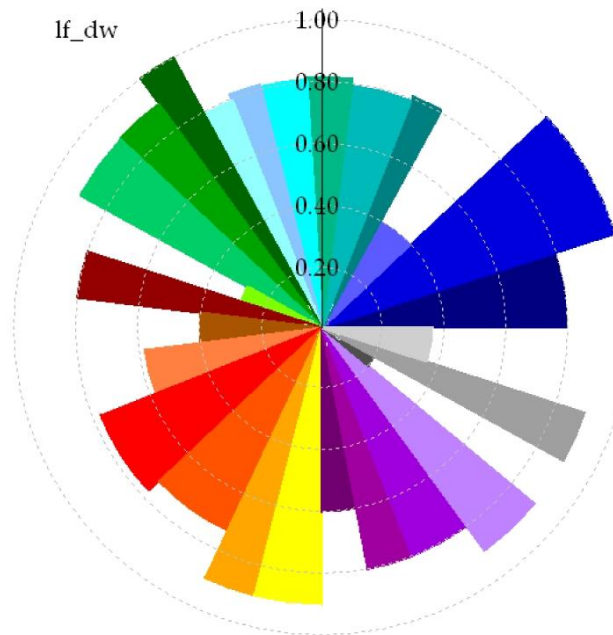
For different Objectives

Conventional Sewer



- 20-jähriges Hochwasser
- chem. Sauerstoffbedarf
- Phosphor
- Feuchtgebiete
- Verdunstung
- Überlauf aus Retention
- Ressourcen/Energieeinsatz
- Funktionswert
- Flächenverbrauch

SUDS



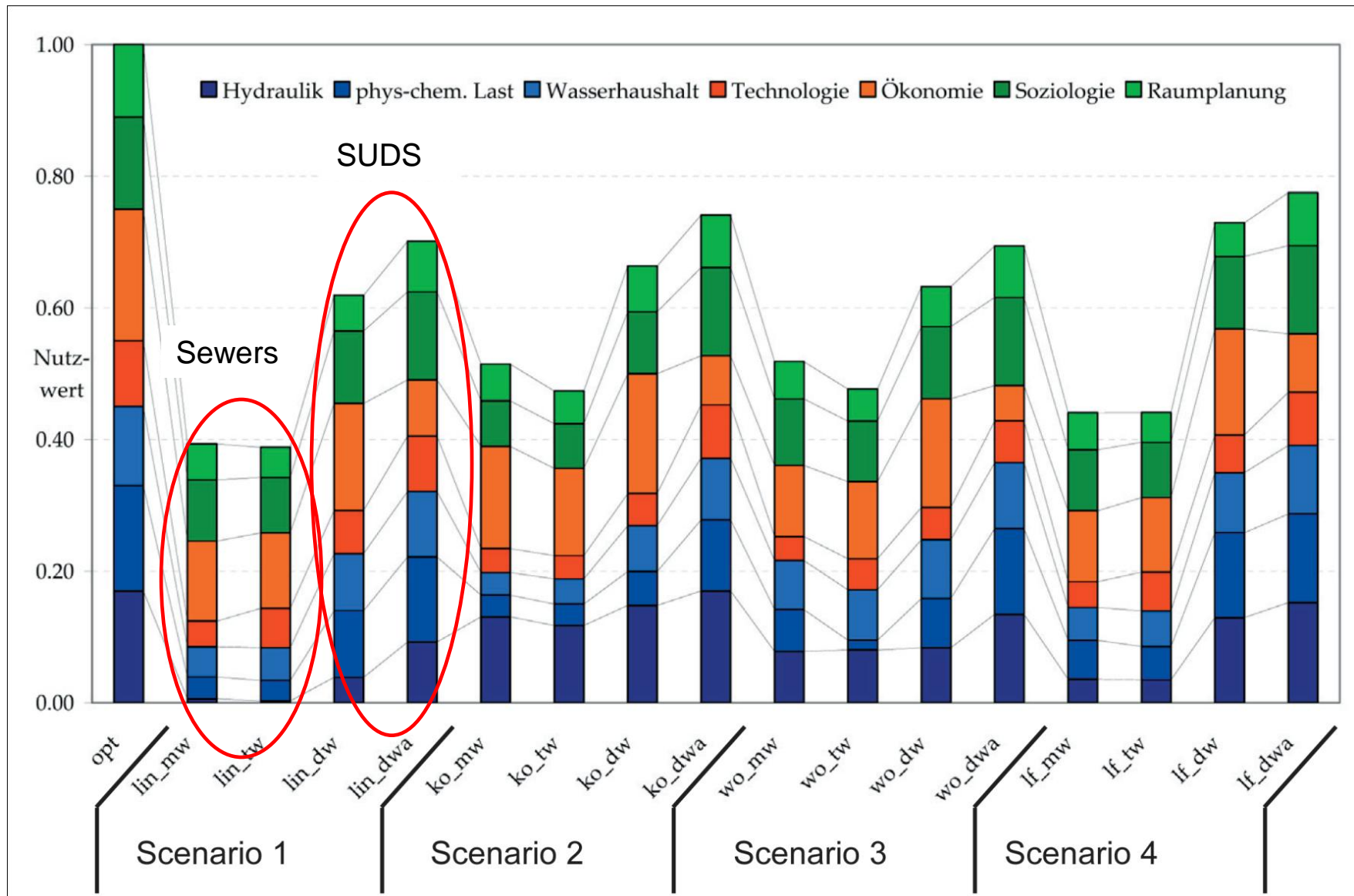
- mittleres Hochwasser
- abfiltrierbare Stoffe
- Kupfer
- Kleinklima
- Nutzbarkeit Ressourcen
- Investitionskosten
- Personaleinsatz
- Präsenz
- Kleinräumigkeit

- mittleres Niedrigwasser
- Stickstoff
- Blei
- Grundwasserneubildung
- Verfahrensvielfalt
- Betriebskosten
- Nutzwert
- Möglichkeiten der BB
- Planungshorizont

$$Hom = \begin{cases} 1 - \frac{\sigma}{tUV} & \text{where } \sigma \leq tUV \\ 0 & \text{where } \sigma > tUV \end{cases}$$

$$\sigma = \sqrt{\sum_{i=1}^n w_i (pUV_i - tUV)^2}$$

Case Study: Kupferzell Germany



Case Study Hamburg

Residential area with 400 living units and total area of 17 ha

4 different future scenarios

3 different alternative solutions

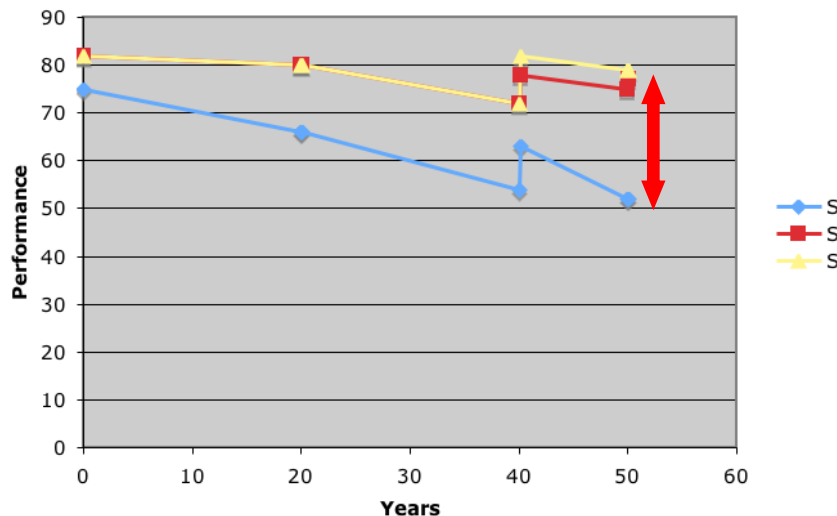
- **Conventional sewer systems**
- **SUDS I and**
- **SUDS II**



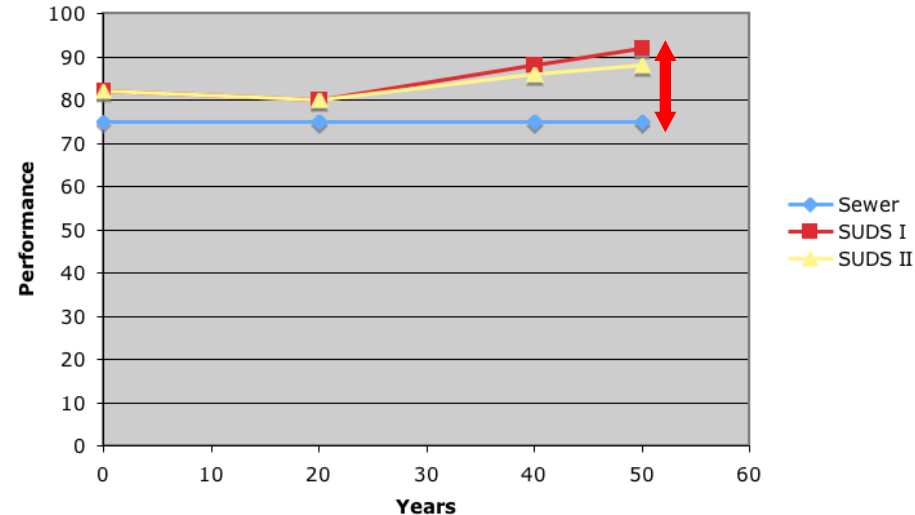
Regret System Performance

Minimax Regret System Performance for Altering Future Conditions

Regret Scenario 1



Regrete Scenario 2



	Scenario 1	Scenario 2	Scenario 3	Scenario 4
<u>Sewer</u>	30	16	20	32
SUDS I	5	0	2	0
SUDS II	0	4	0	1

Effort of Change

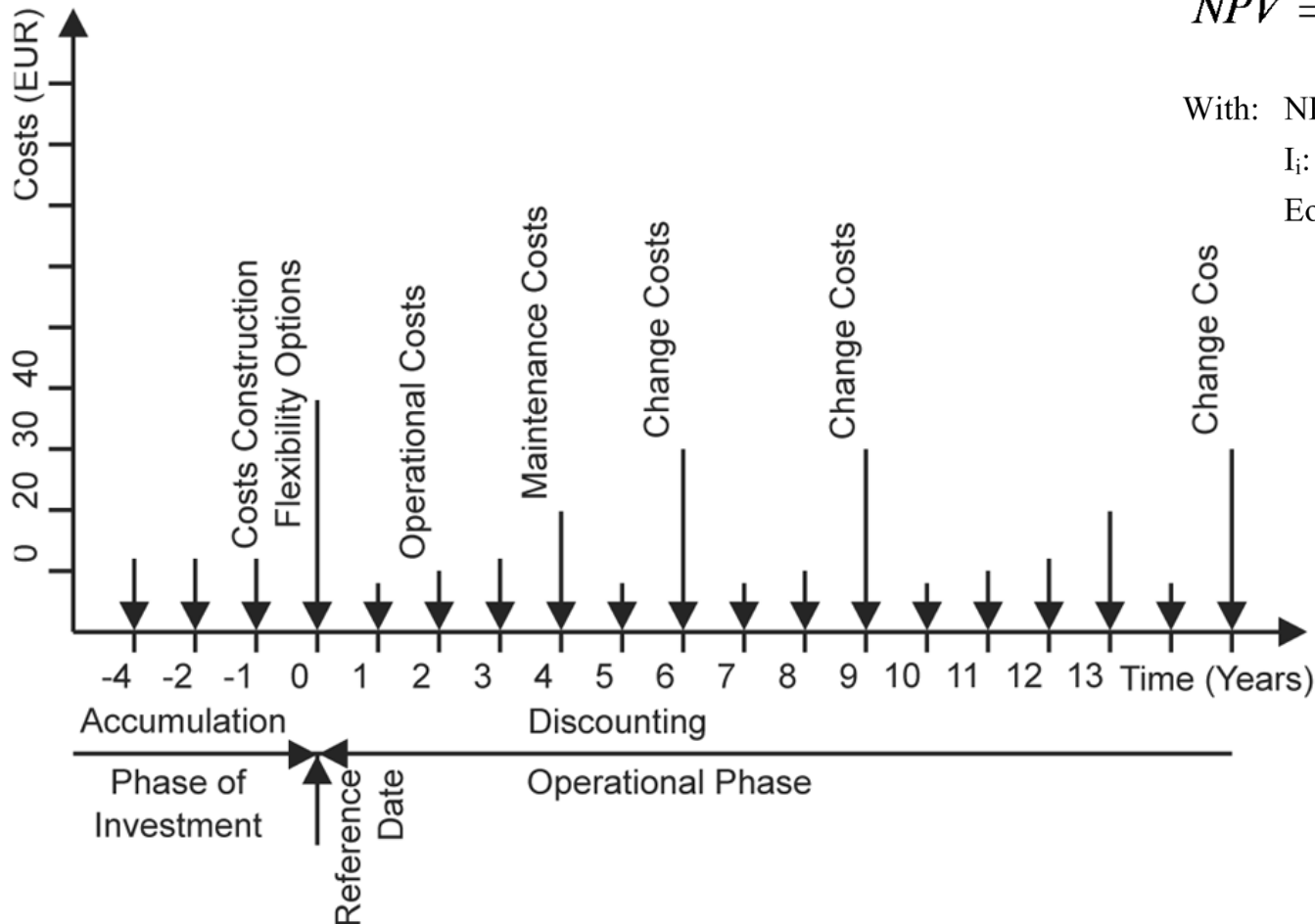
Costs of Change, Duration of Change etc.

$$NPV = I_i + \sum_{t=1}^{t=EoP} \frac{CF_t}{(1+r)^t}$$

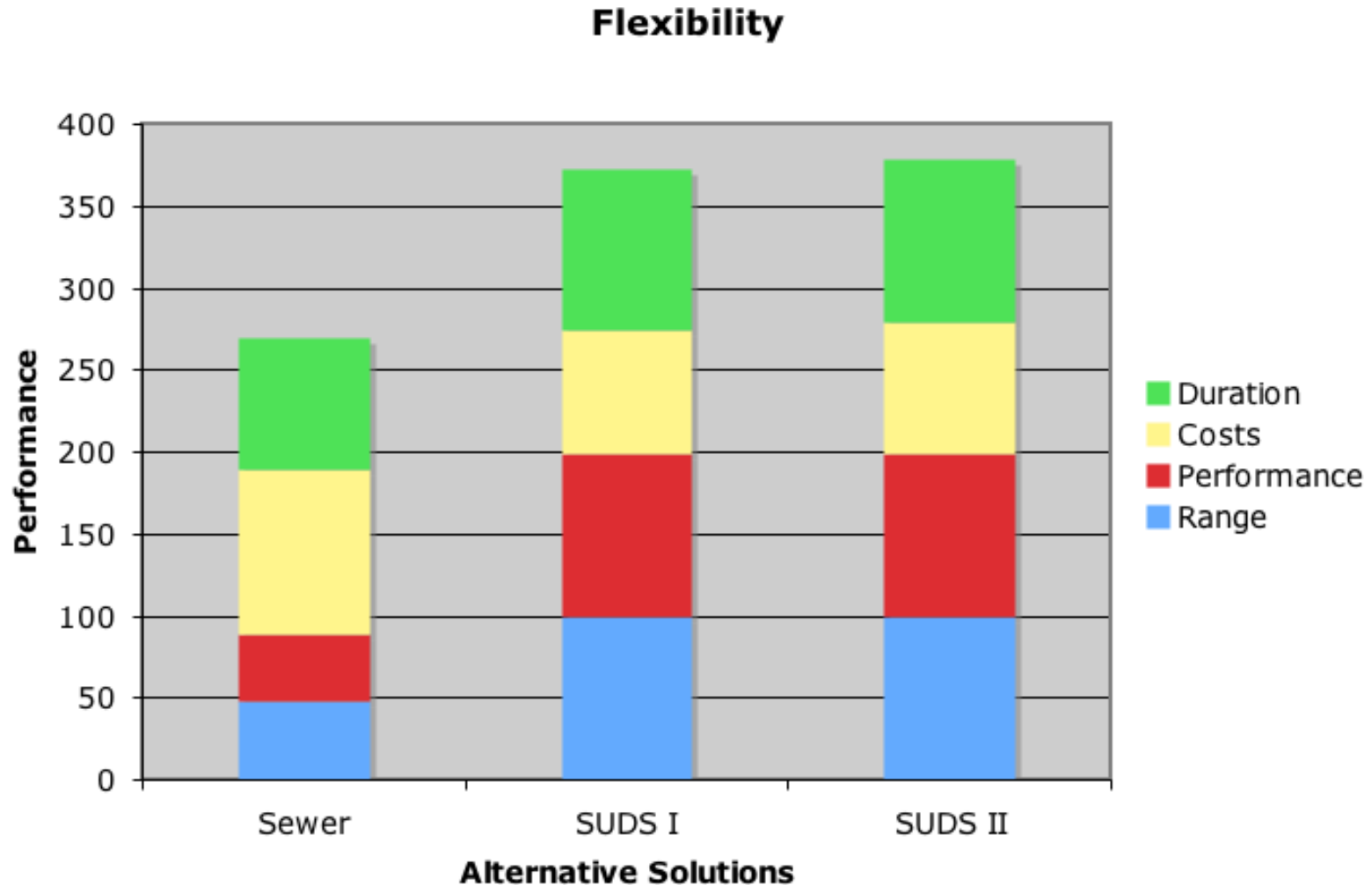
With: NPV: Net Present Value

I_i: Initial Investment

EoP: End of Project



Flexibility of Alternative Solutions



Where/what to retrofit on-site???

☒ Eastside_WL
 ☒ Rectifyeastside455m.tif
 ☐ StormwaterBMP_location_WL2

☒ Eastside_WL
 ☒ StormwaterBMP_location_WL2

Parameters
 Potential Areas
 SitebySite
 ADDStormwaterBMP
 Project properties
 Symbology

Storm Water BMP
 Retention basin
 Settlement tank
 Green roof
 Filter strip
 Swale

Select

Source: Day Water <http://www.daywater.cz/>

Show Potential Areas

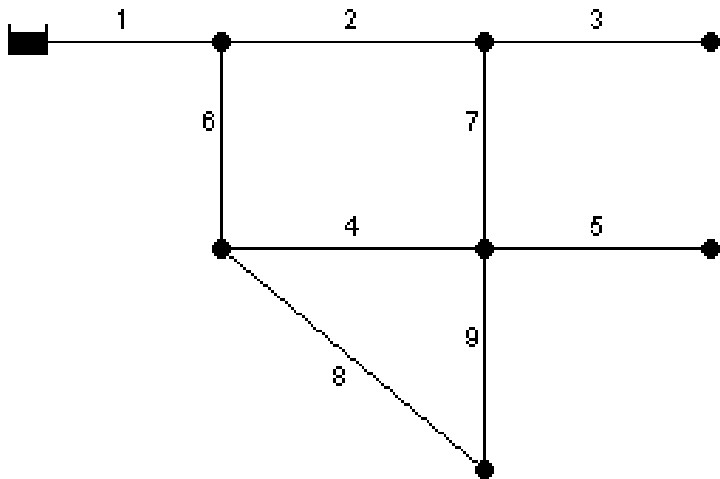
Sites Numbre
257

Total Surface
177

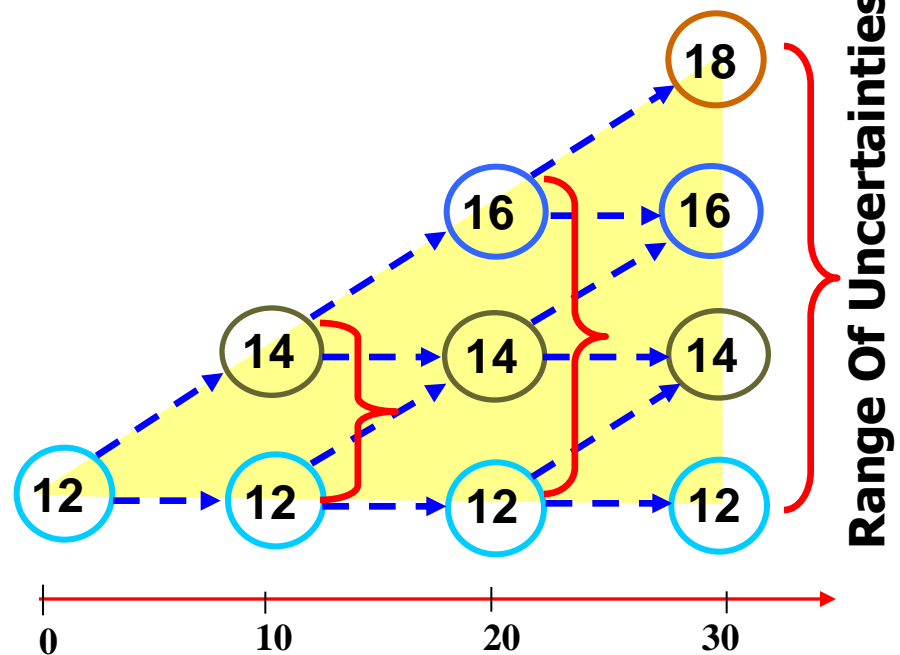
	Criteria	subcriteria	Green roof
►	Landuse	Railway	FALSE
	Landuse	Openspace	FALSE
	Landuse	Carpark	FALSE
	Landuse	Building	TRUE
	Landuse	Pavements	FALSE
	Landuse	Road	FALSE
	Landuse	Impermeable	FALSE
	Landuse	Verges	FALSE
	Landuse	Waterbody	FALSE
	Catchment	DrainageArea	999
	Catchment	DrainageArea	999
	DEM	SlopeMin	999
	DEM	SlopeMax	999

Flexible Design of UWDS

Hypothetical WDN

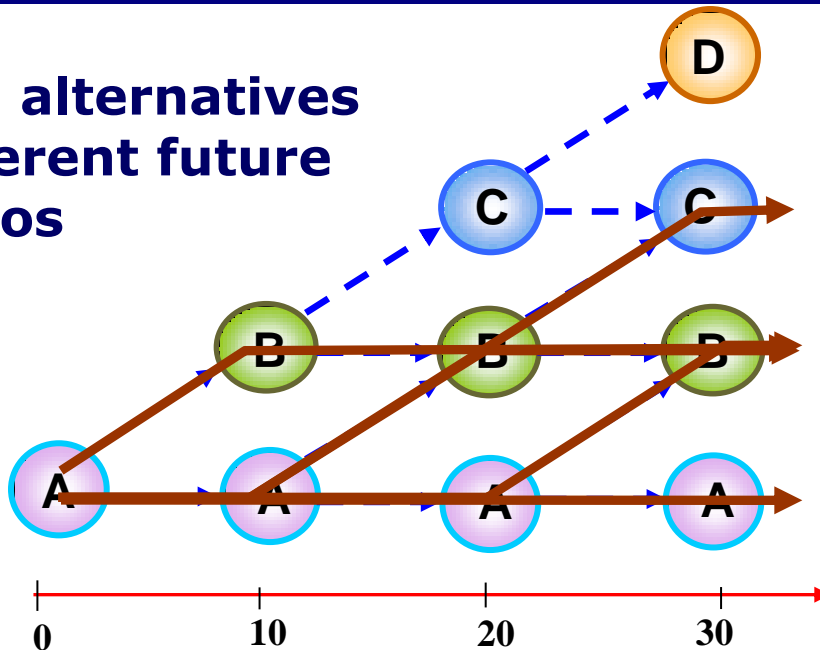


Range of possible future states
Water demand Scenarios (Q in L/s)



Flexible Design of UWDS

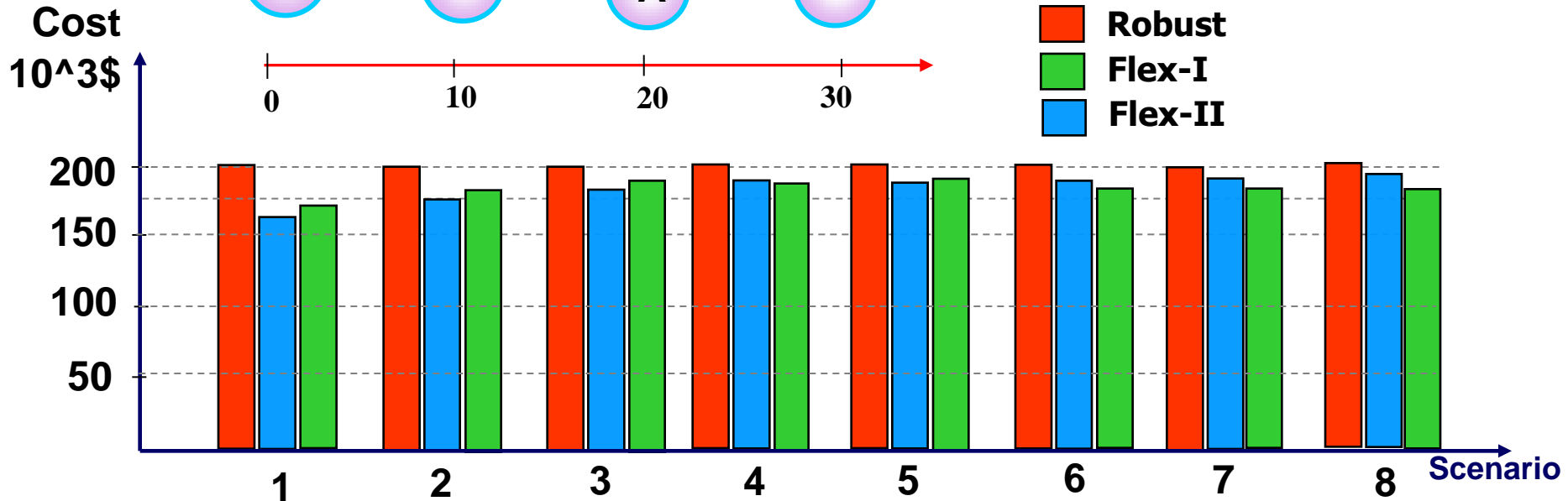
System alternatives
for different future
scenarios



Scenarios

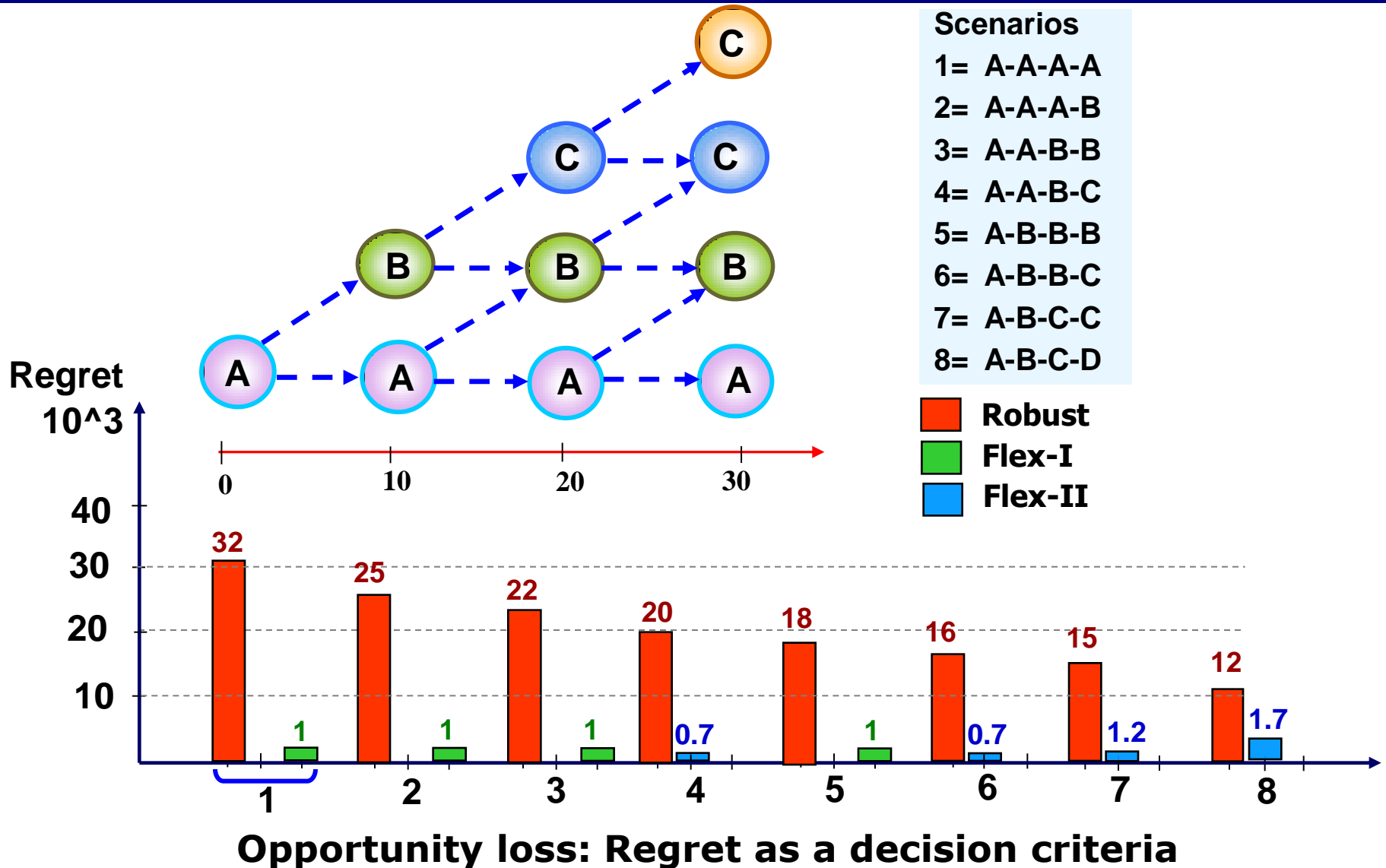
- 1= A-A-A-A
- 2= A-A-A-B
- 3= A-A-B-B
- 4= A-A-B-C
- 5= A-B-B-B
- 6= A-B-B-C
- 7= A-B-C-C
- 8= A-B-C-D

Robust
Flex-I
Flex-II

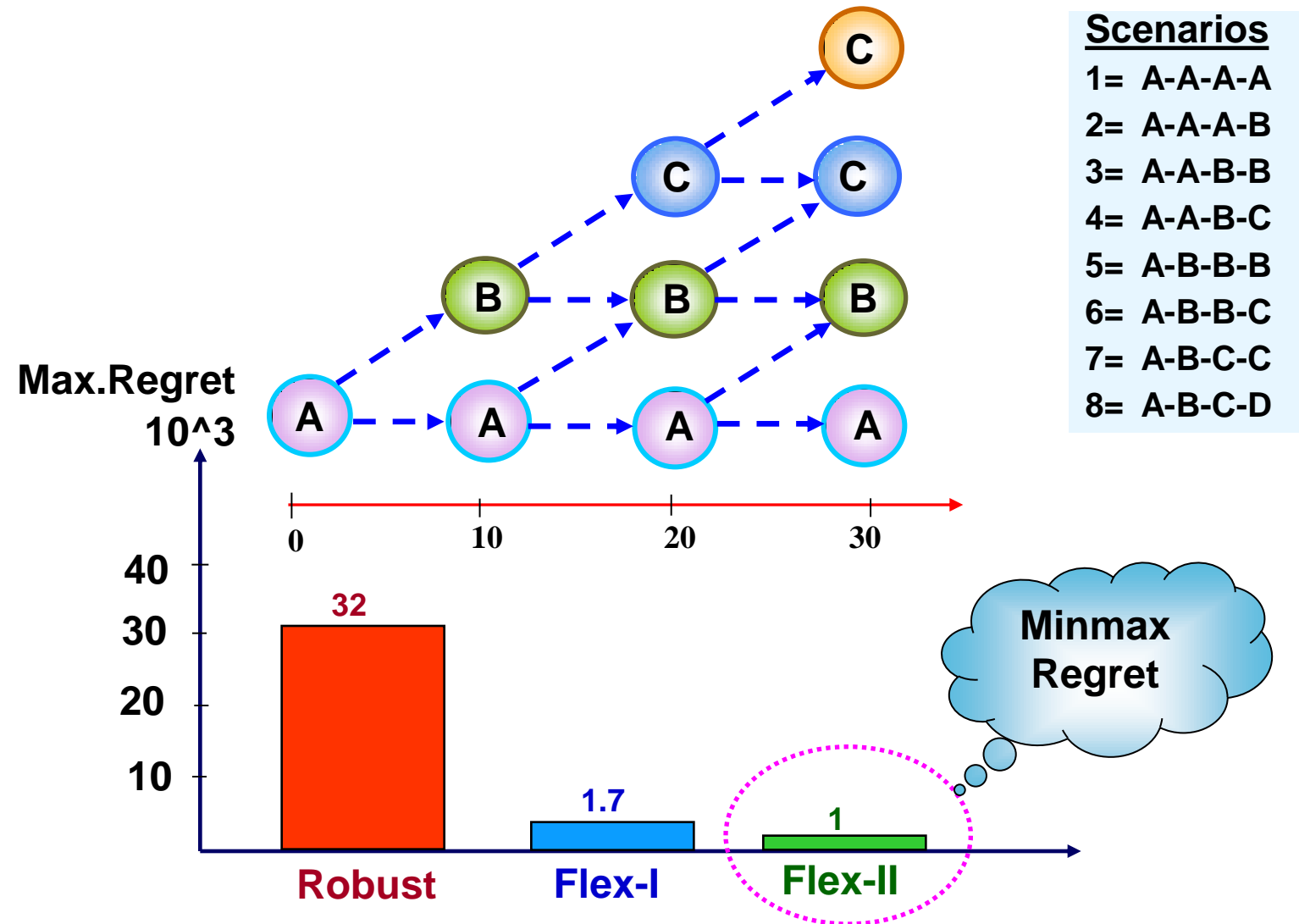


Cost Comparison using regret (Opportunity loss)

Flexible Design of UWDS



Flexible Design of UWDS



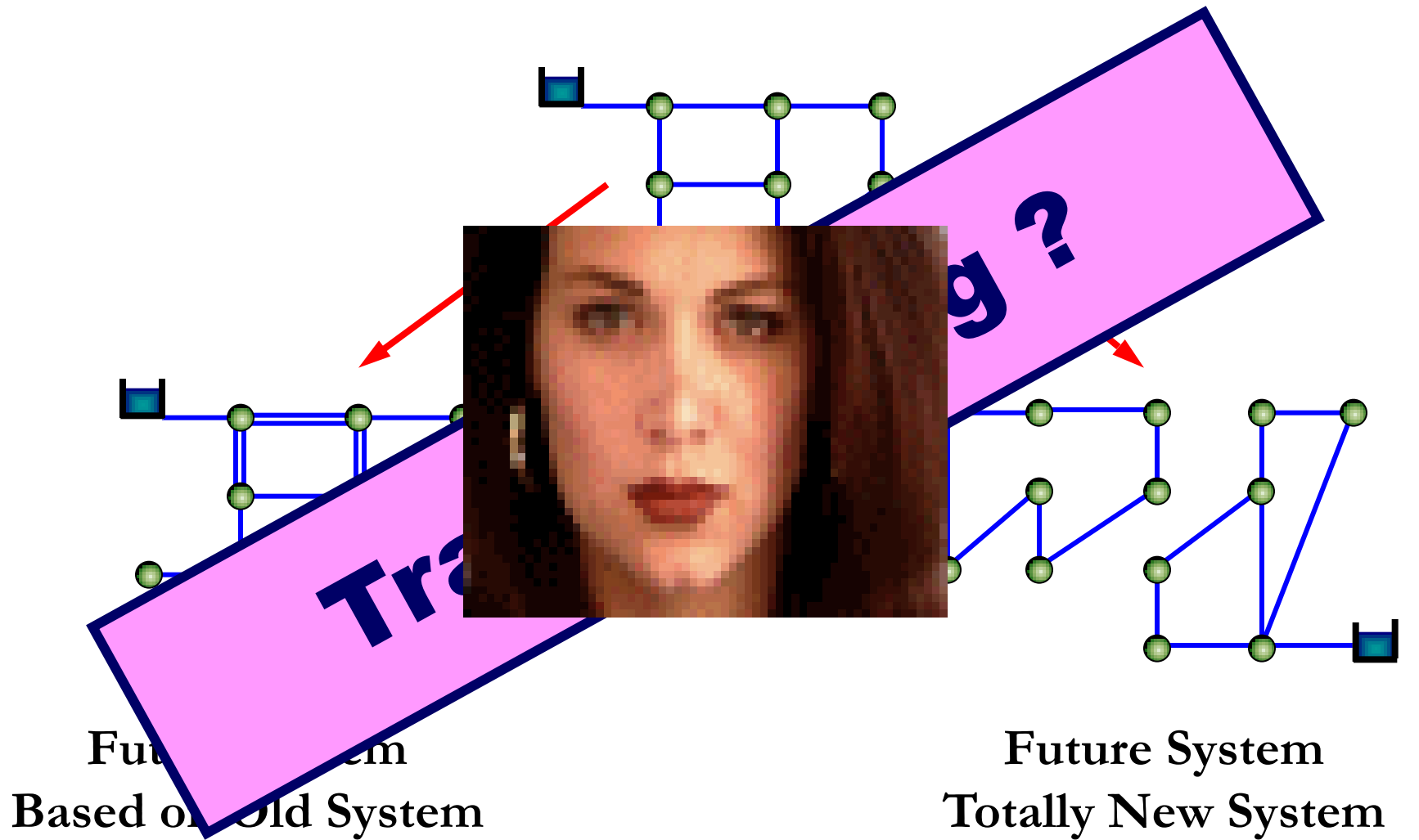
Structure of Talk

- **Integrated Urban Water**
- **Adaptive/Flexible Approaches**
- **Transitioning Process**

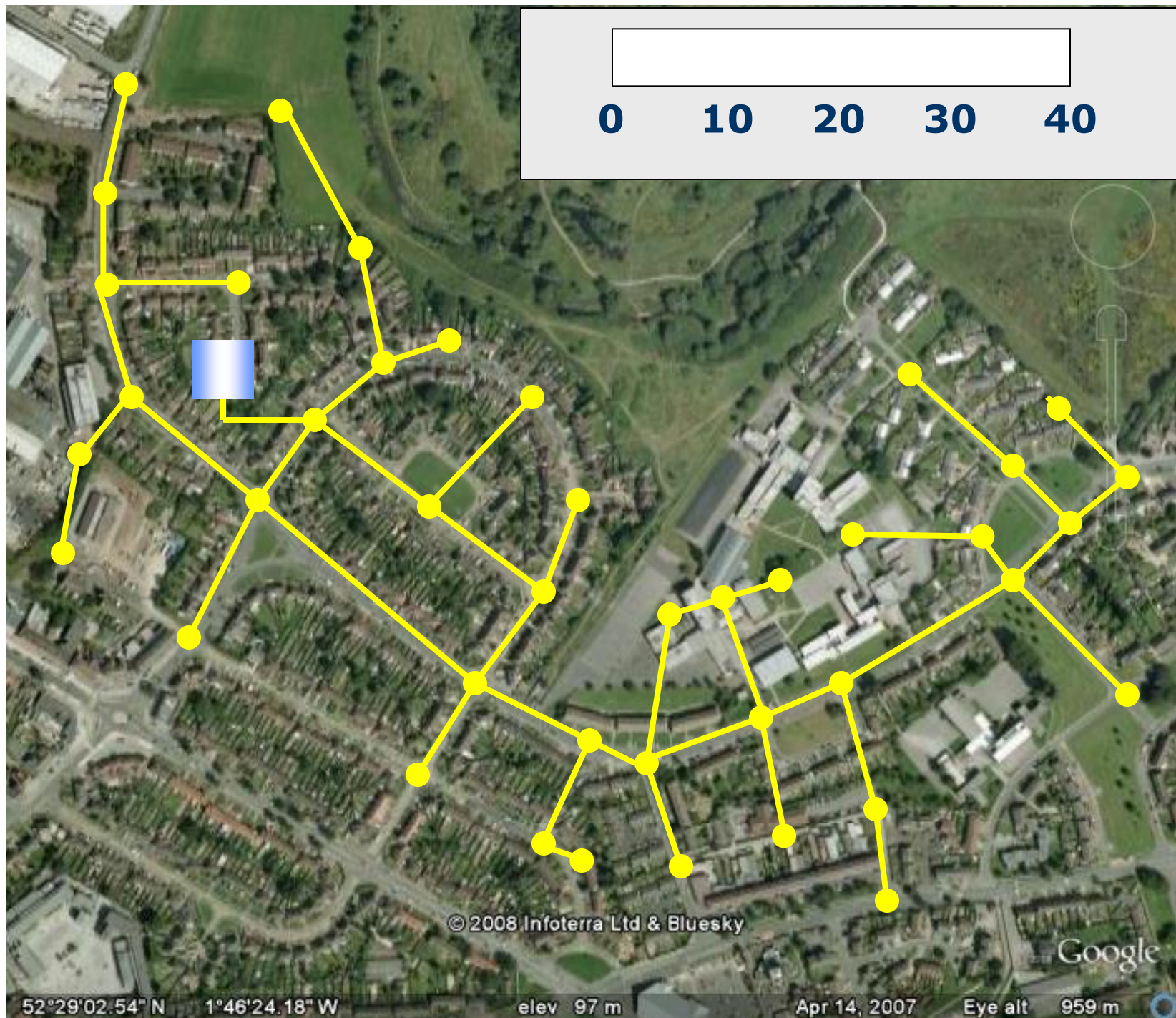
Structure of Talk

- Integrated Urban Water
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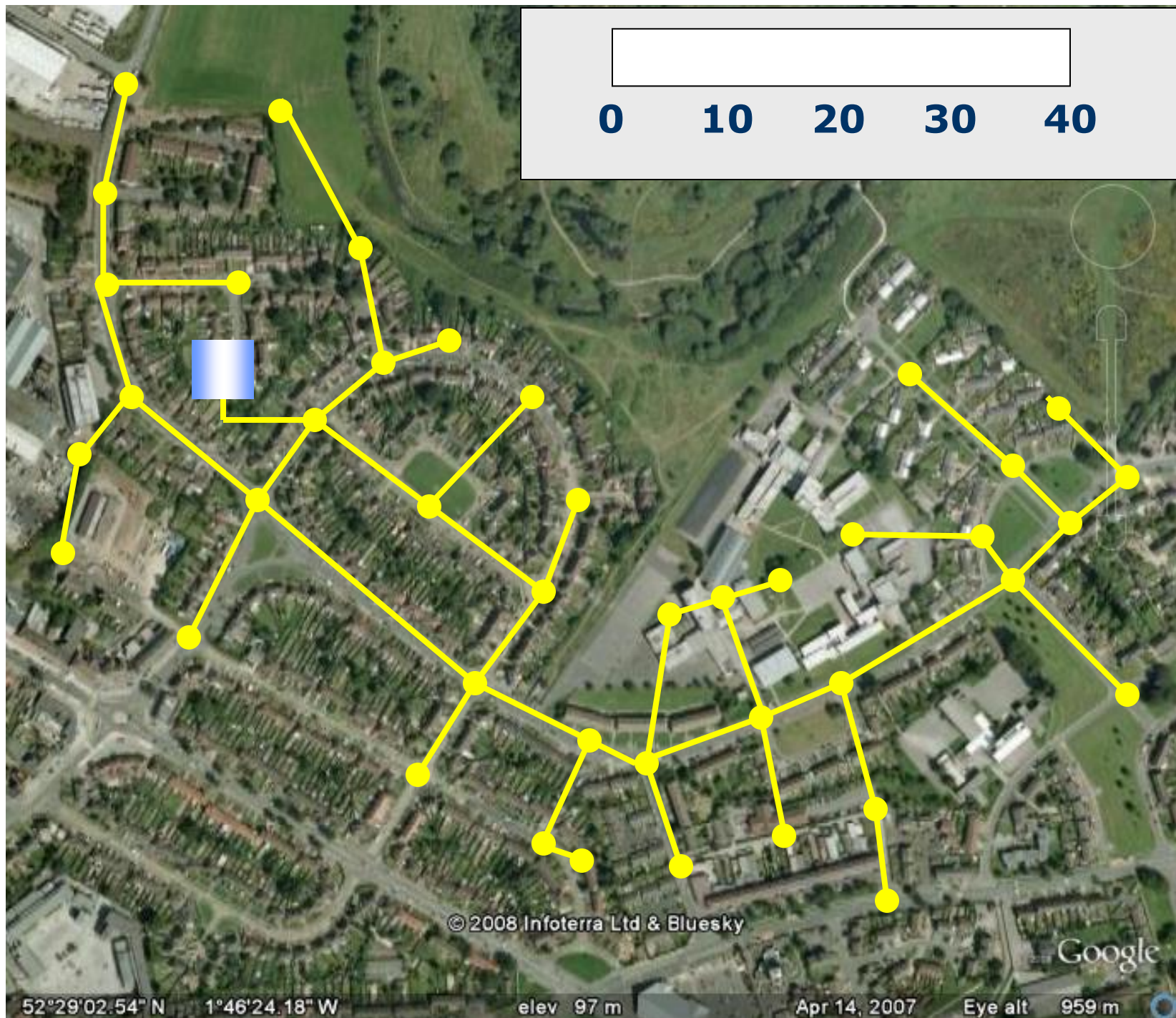
Transitioning

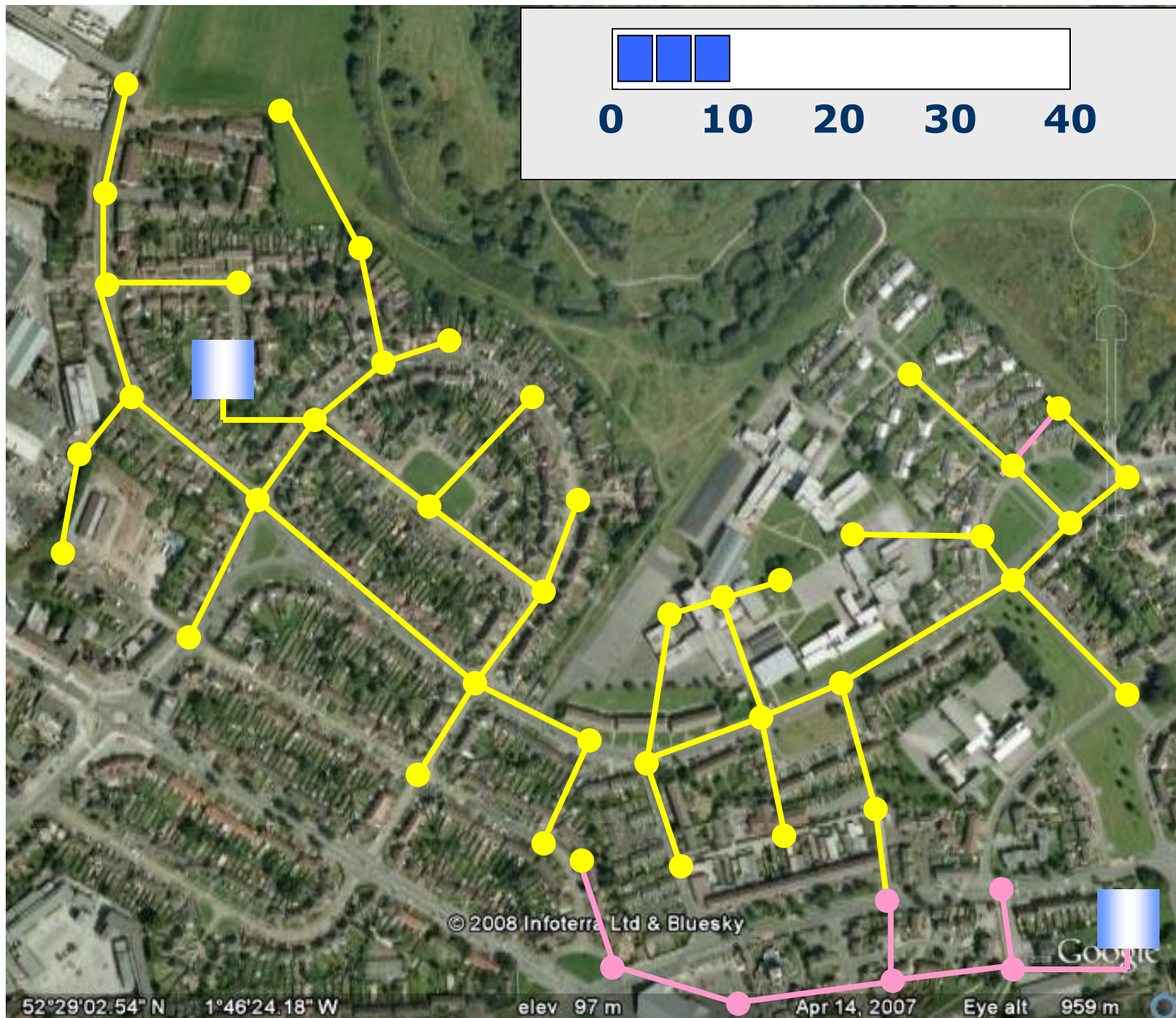


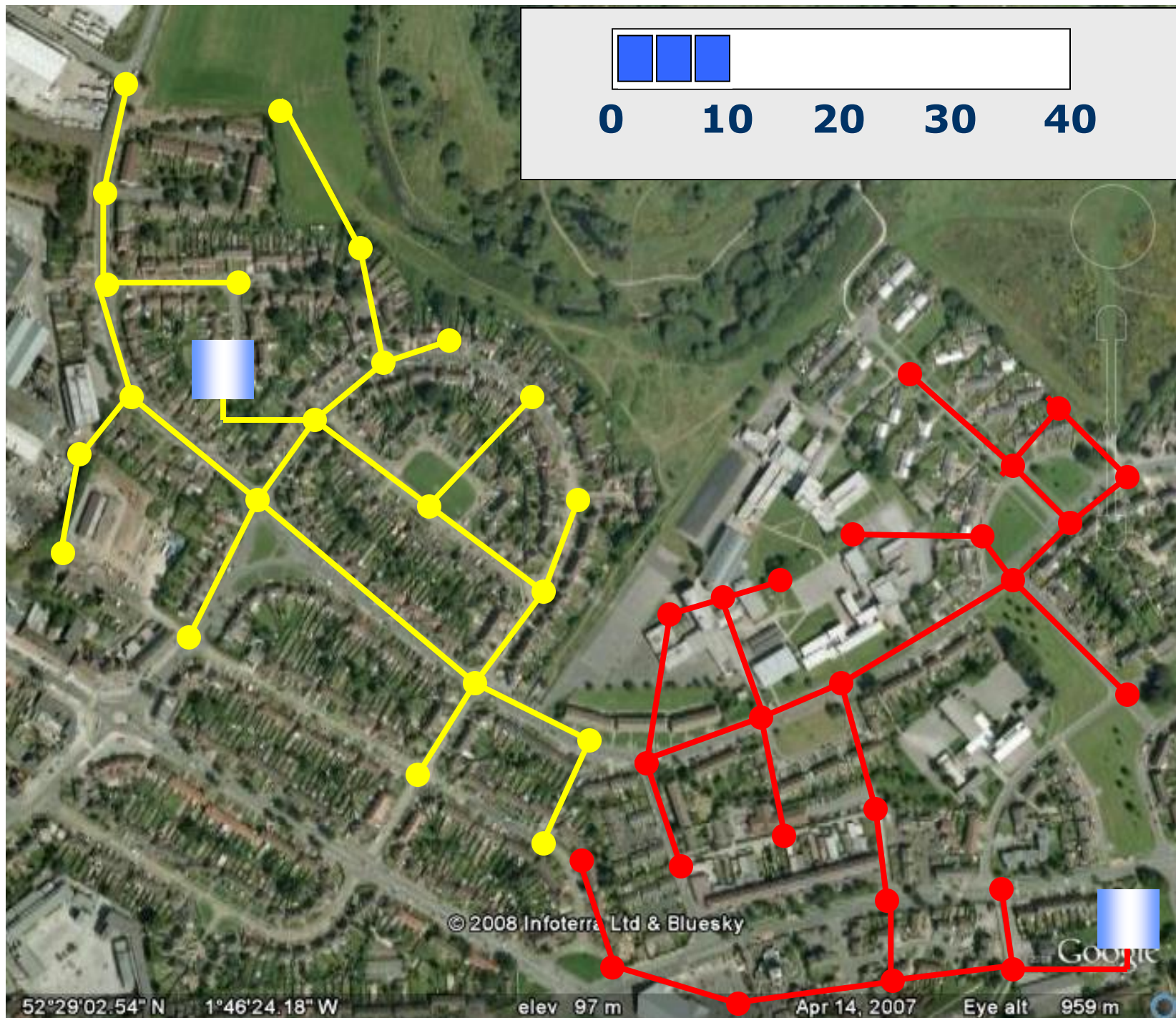
Graph Theory Transition Systems

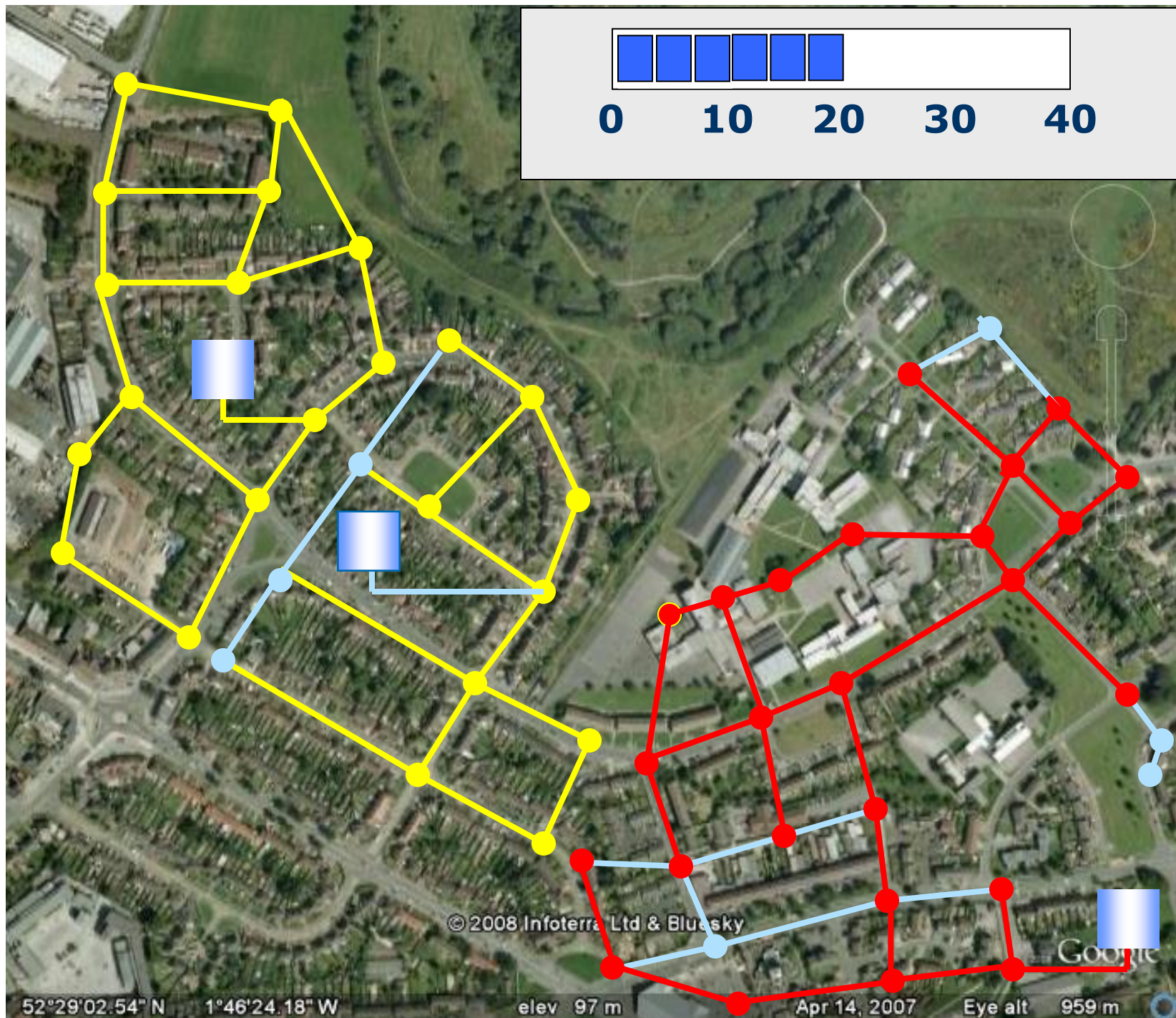


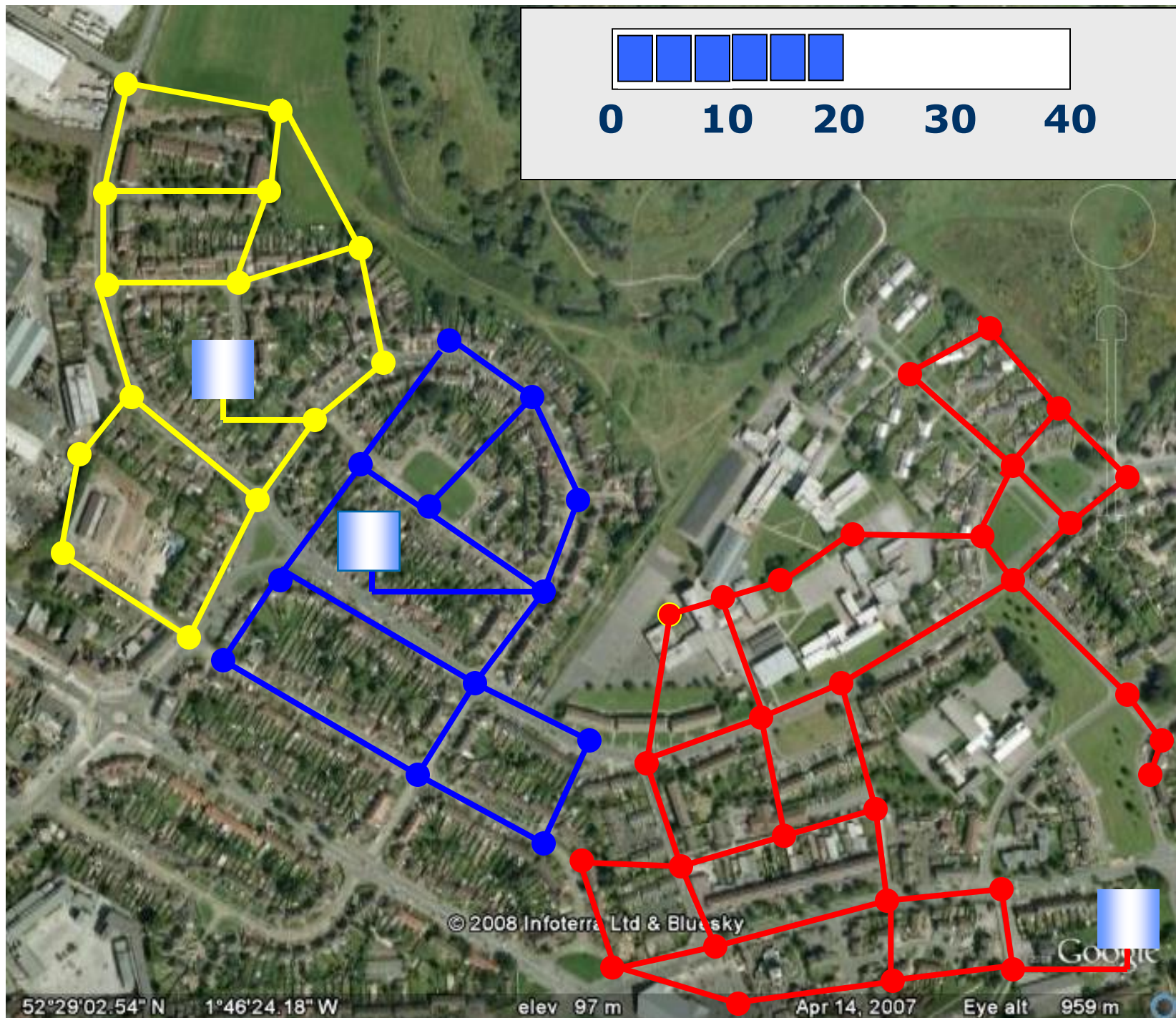


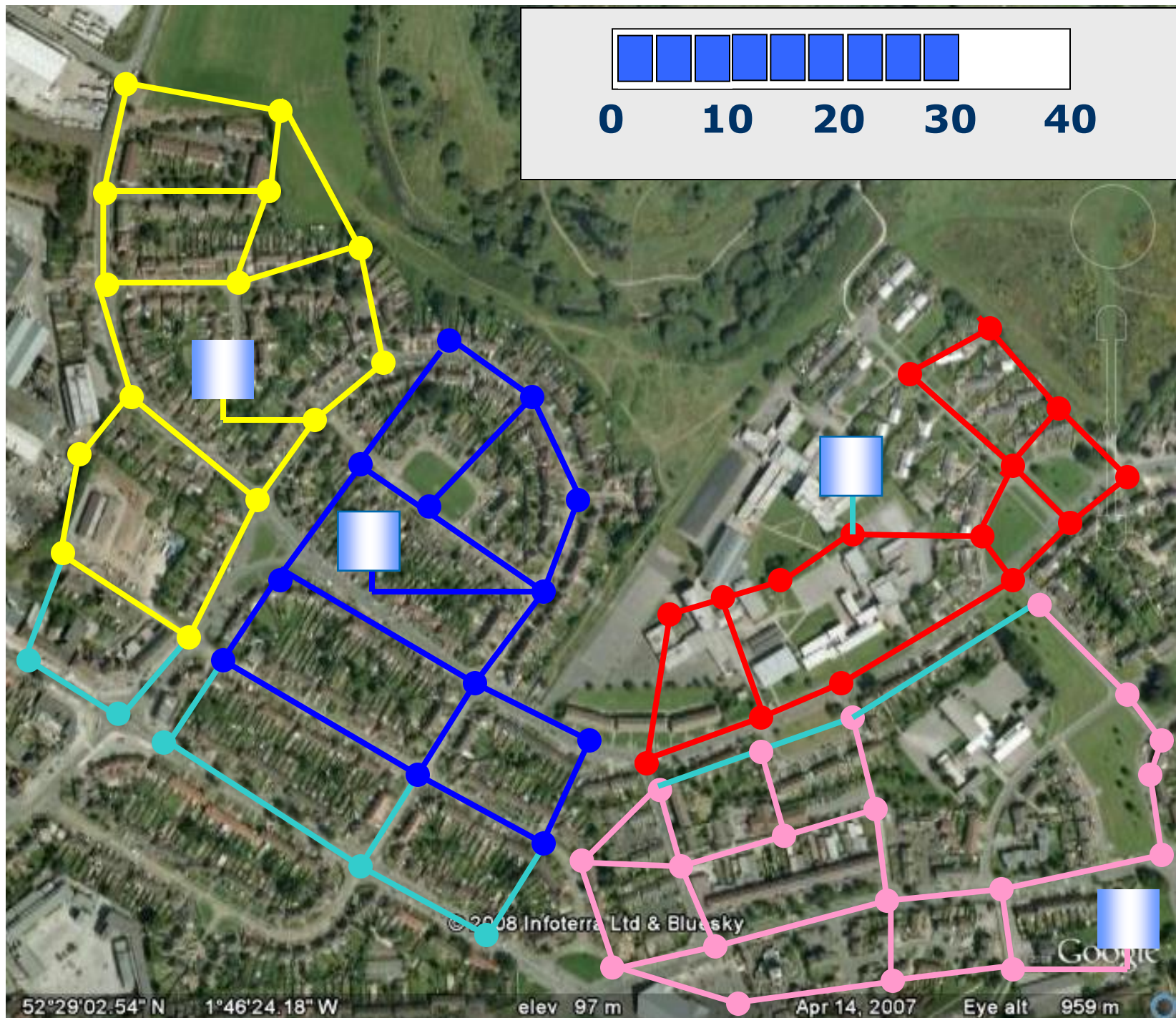


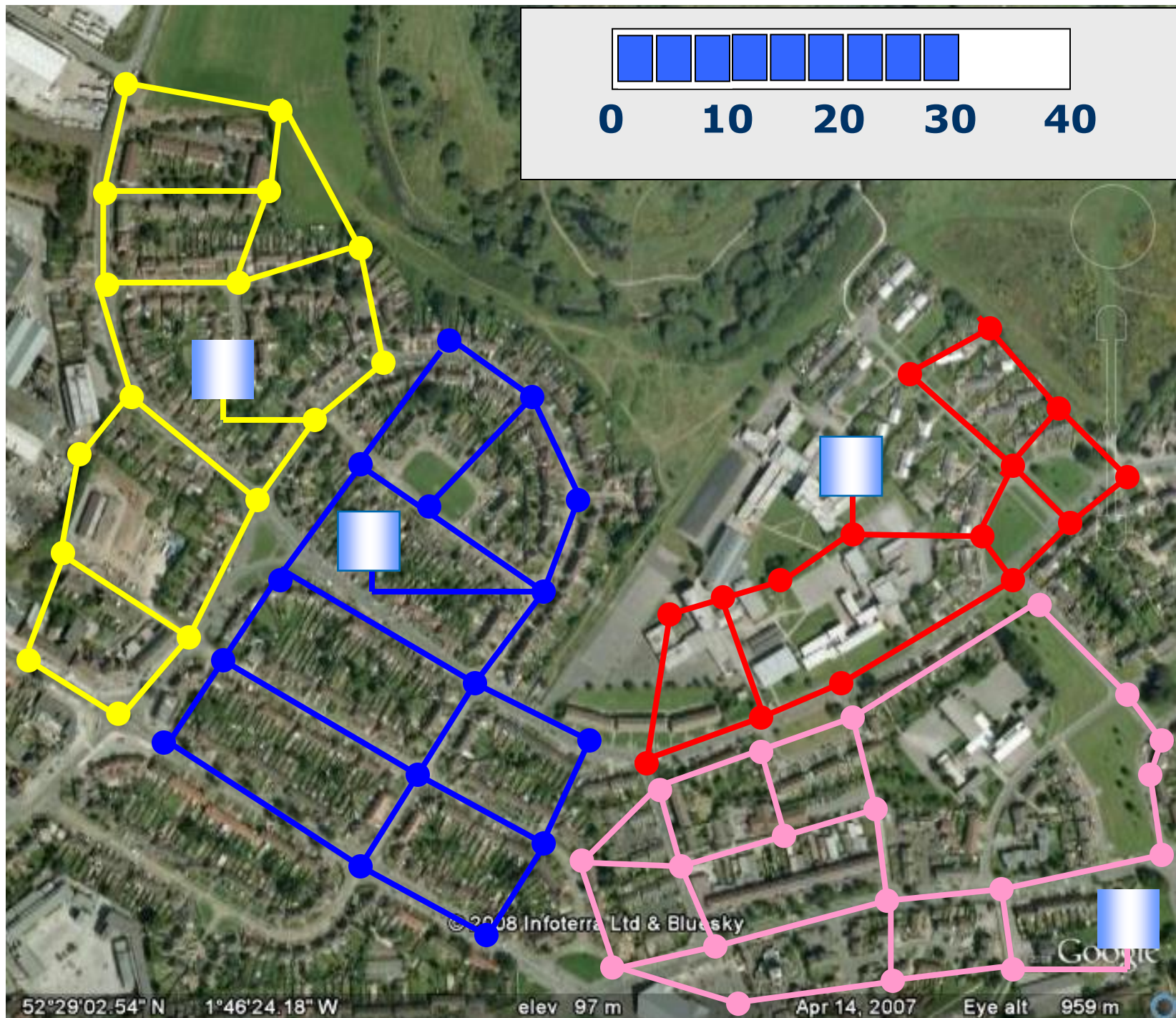


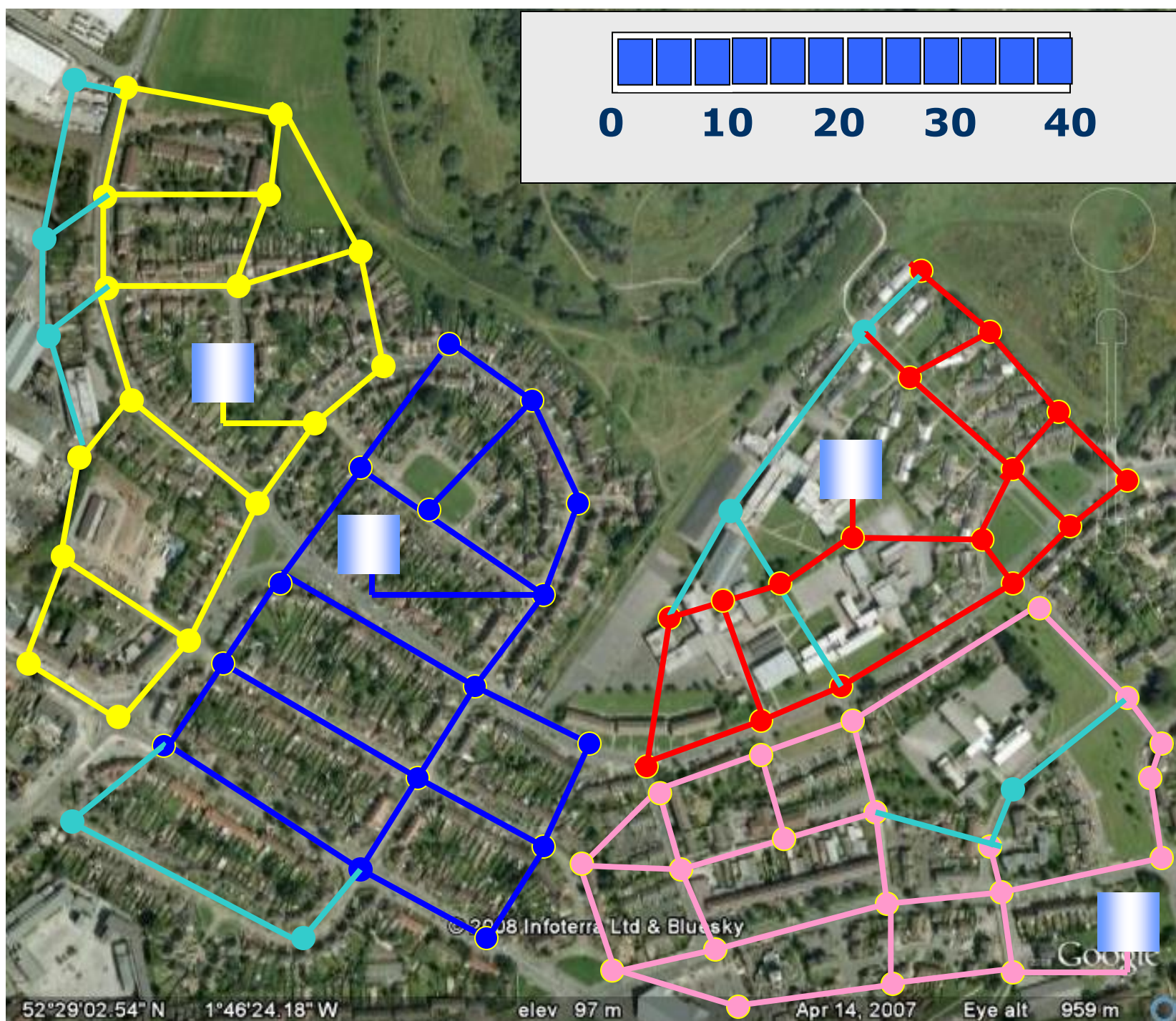


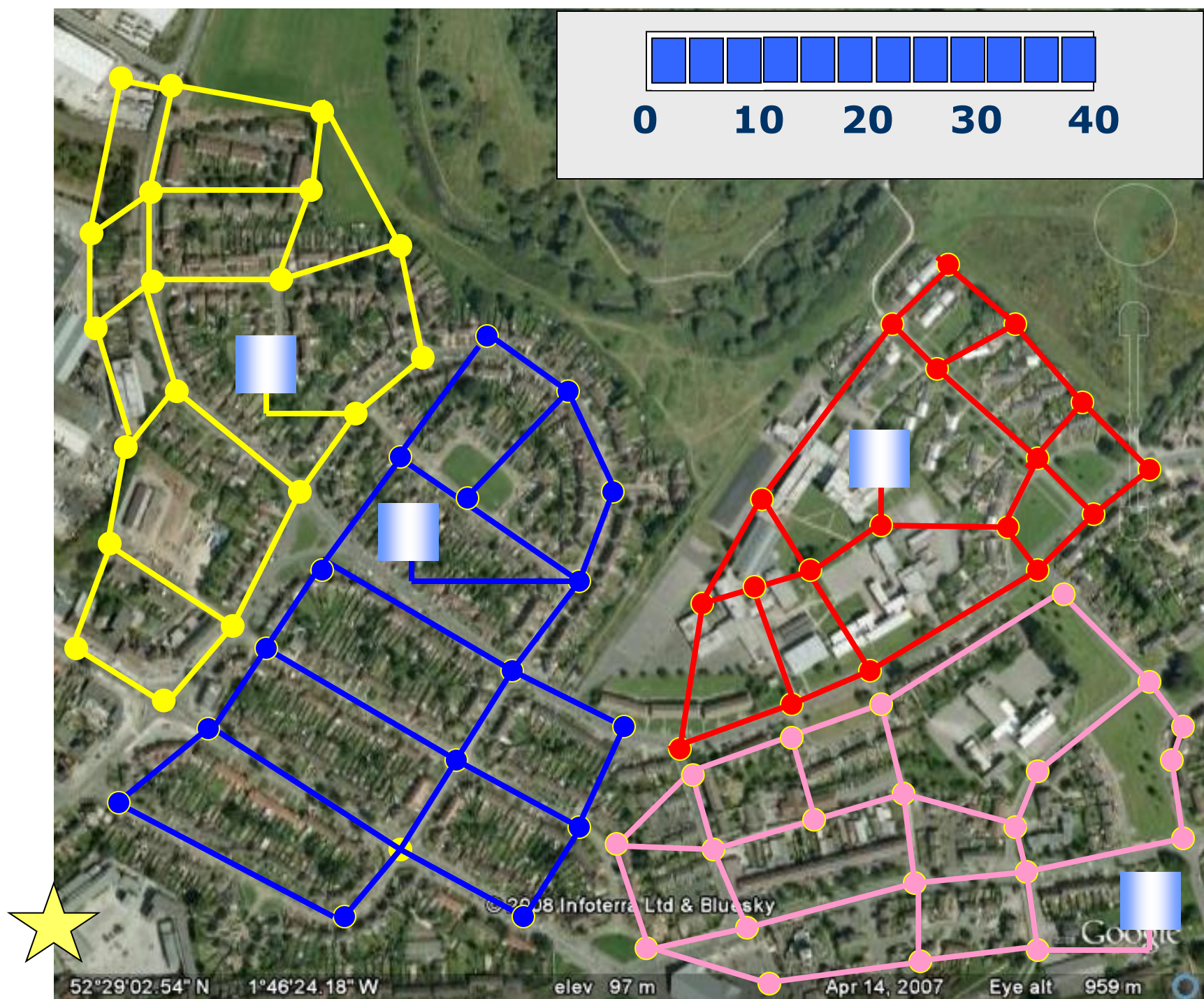












SWITCH Emscher - SUDS

Transition Emschersystem

Emscher River around ...

1890



1980

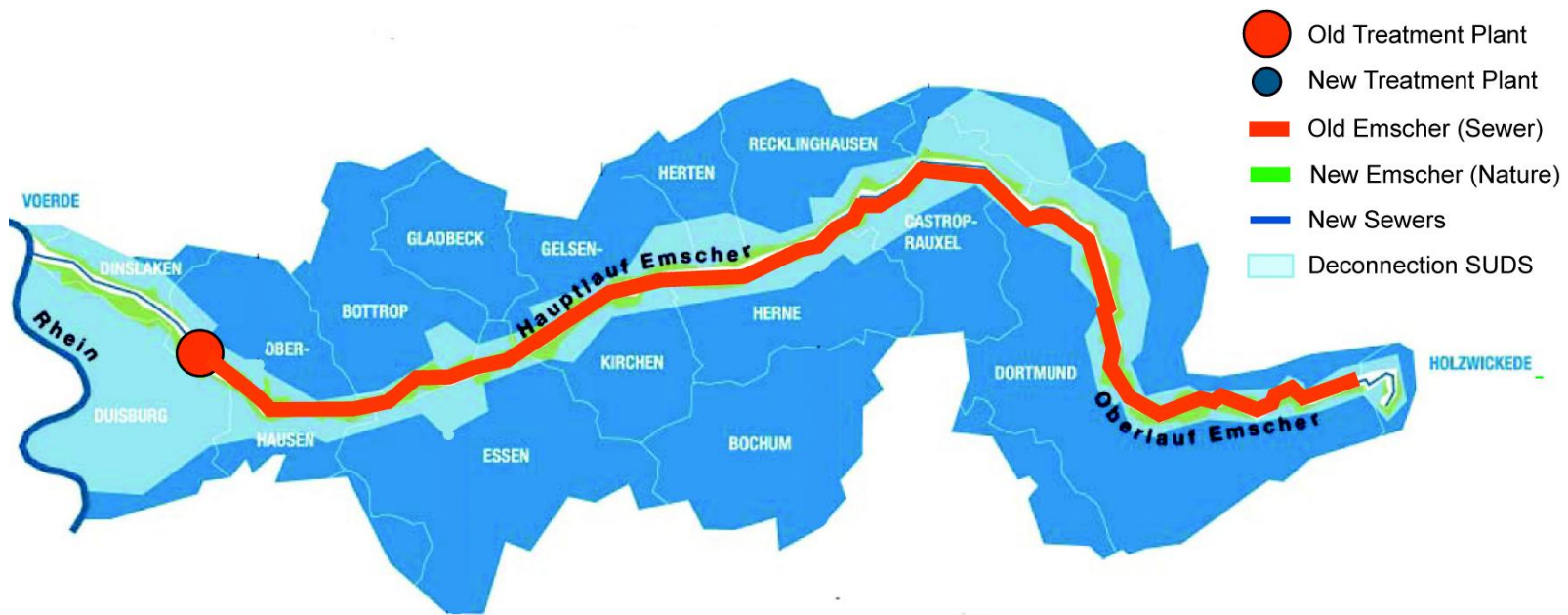


2010



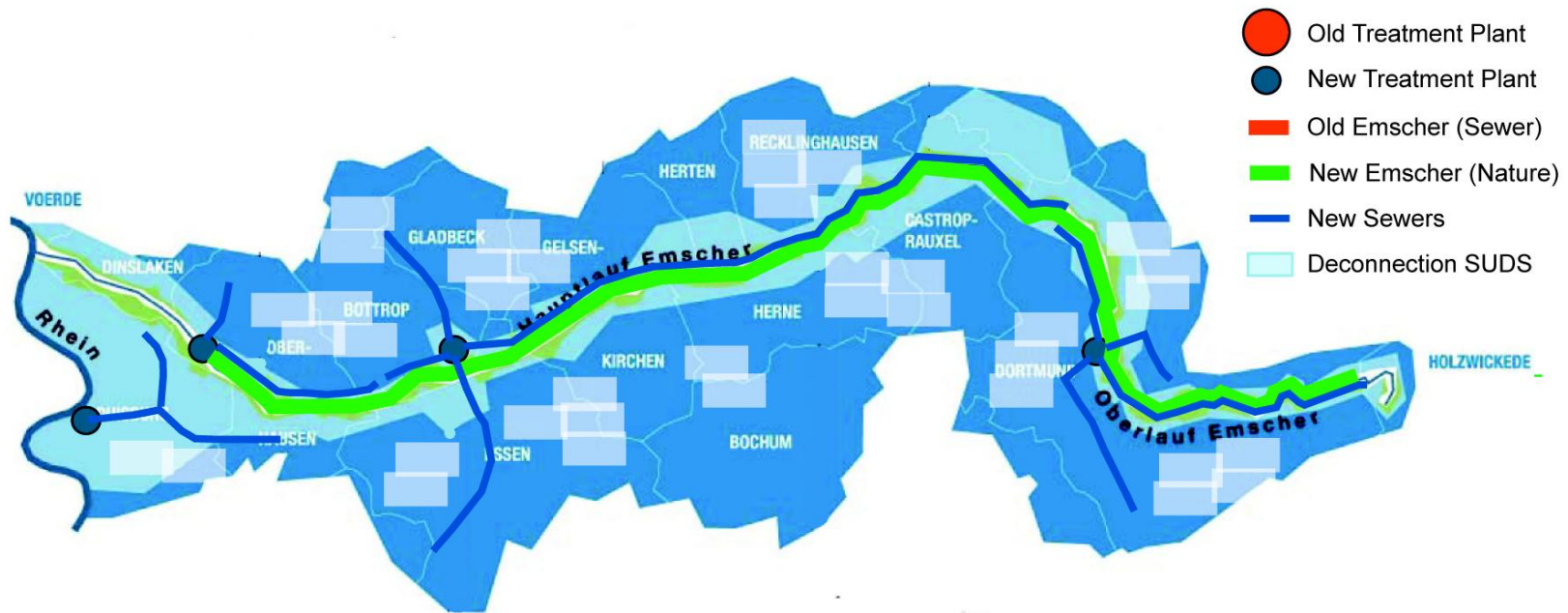
Transitioning SUDS

Transition Emschersystem 1990



Transitioning SUDS

Transition Emschersystem 2020



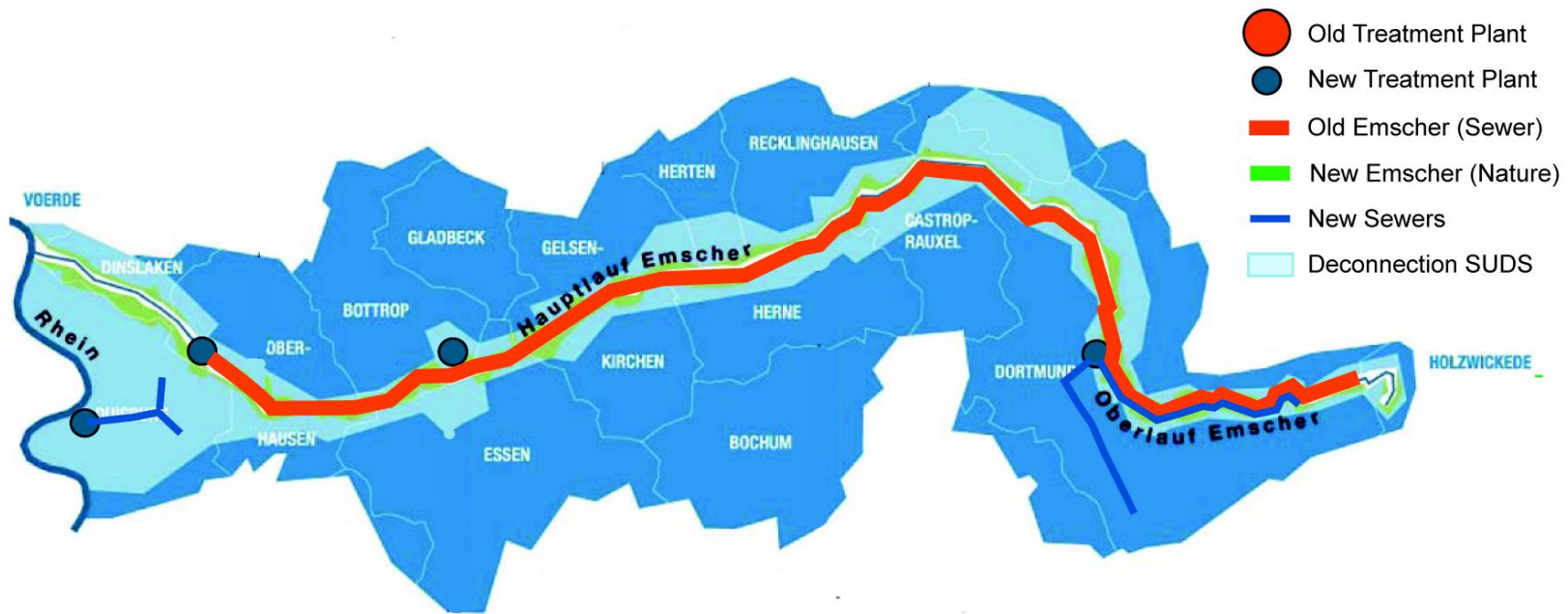
Transitioning SUDS

Transition Emschersystem 1990



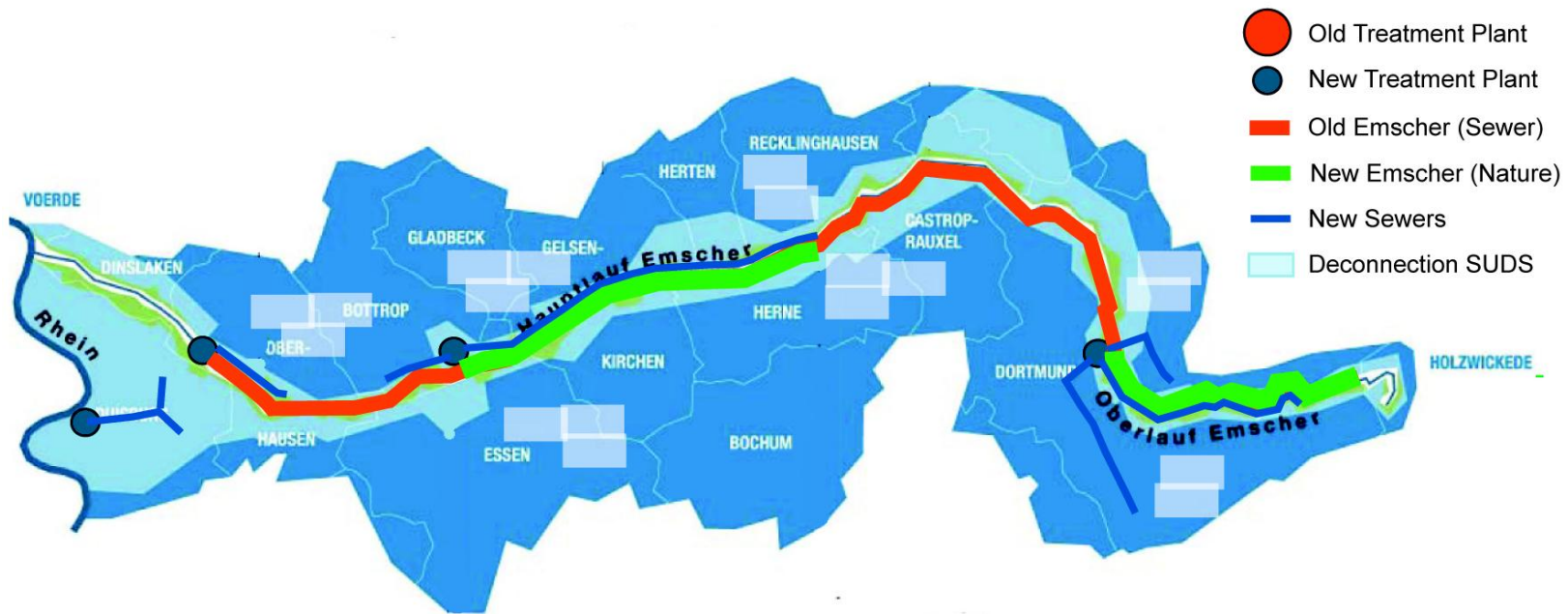
Transitioning SUDS

Transition Emschersystem 2000



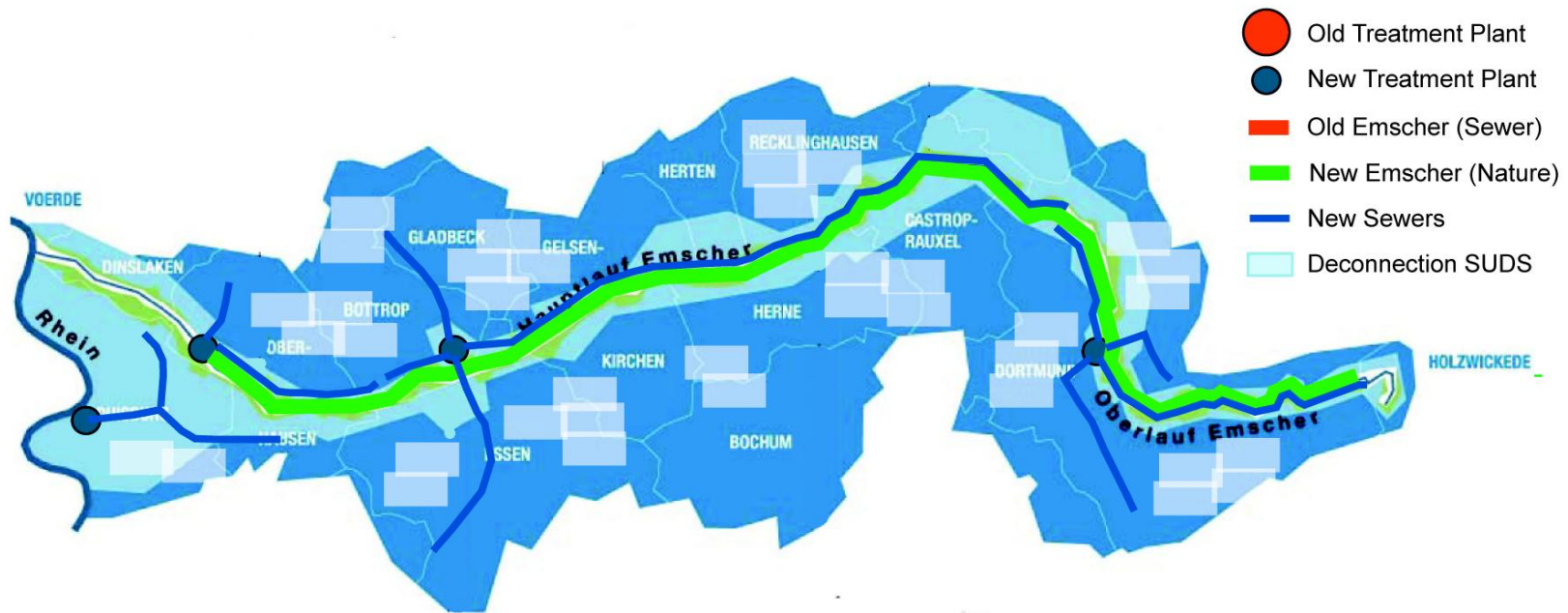
Transitioning SUDS

Transition Emschersystem 2010

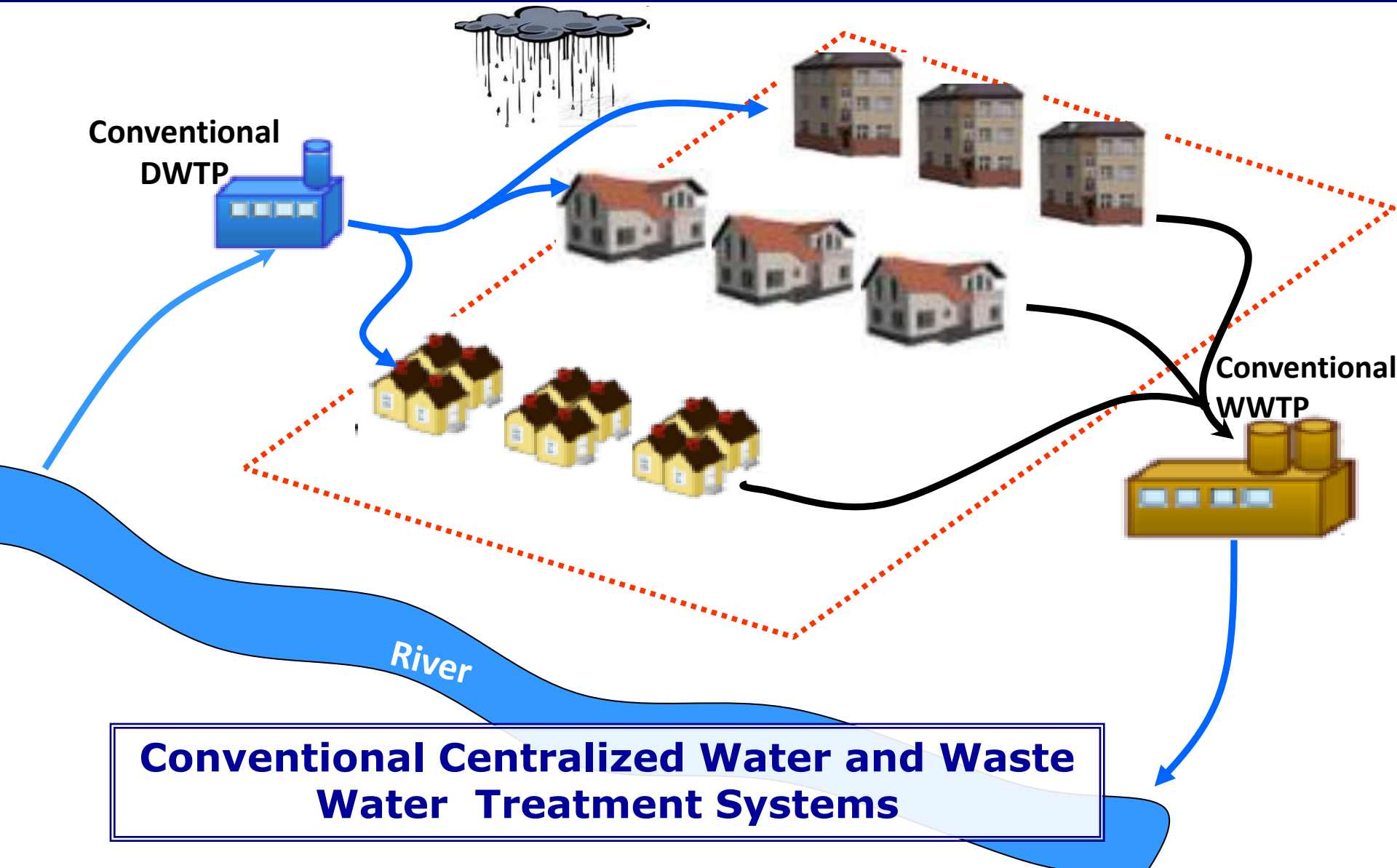


Transitioning SUDS

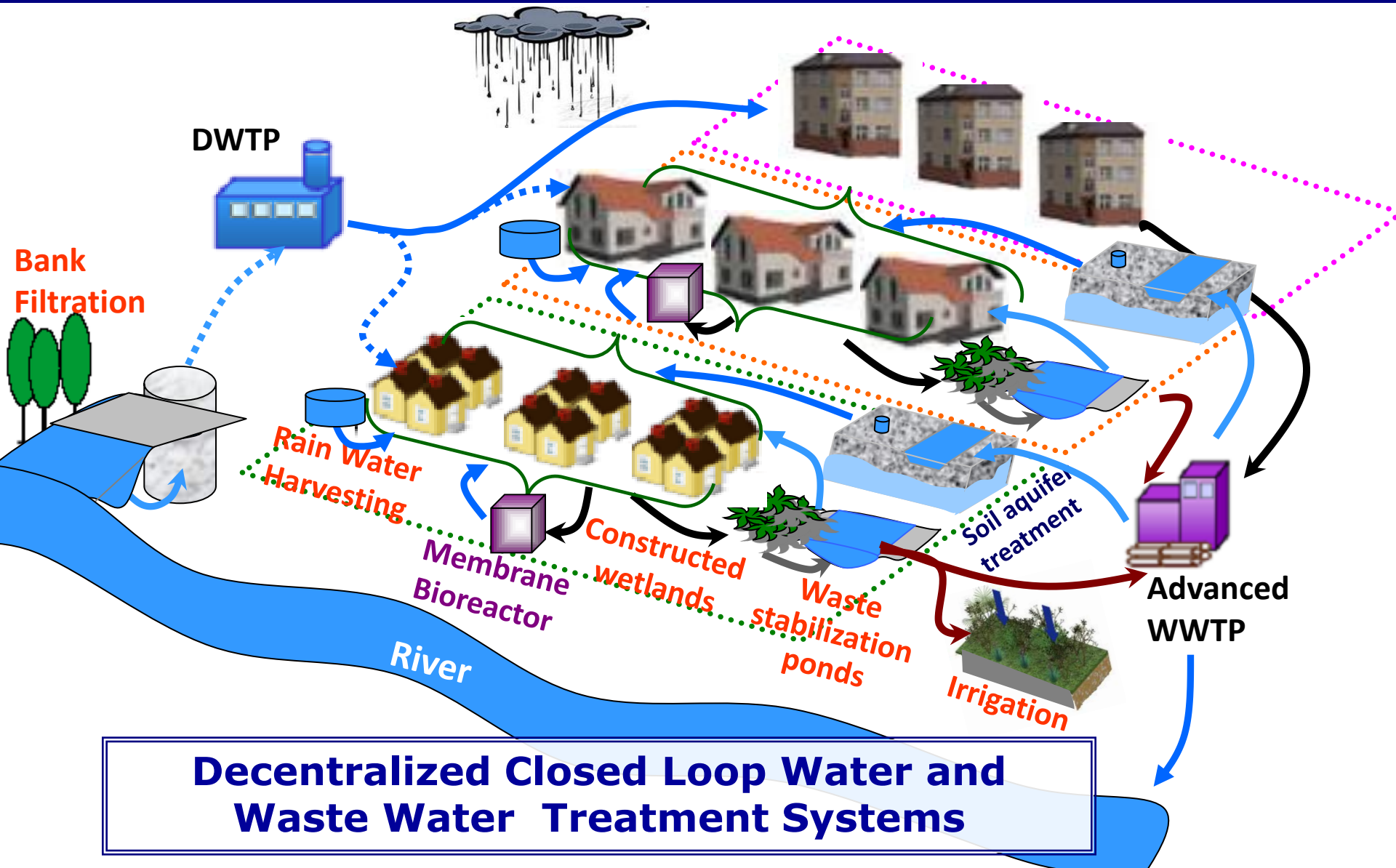
Transition Emschersystem 2020



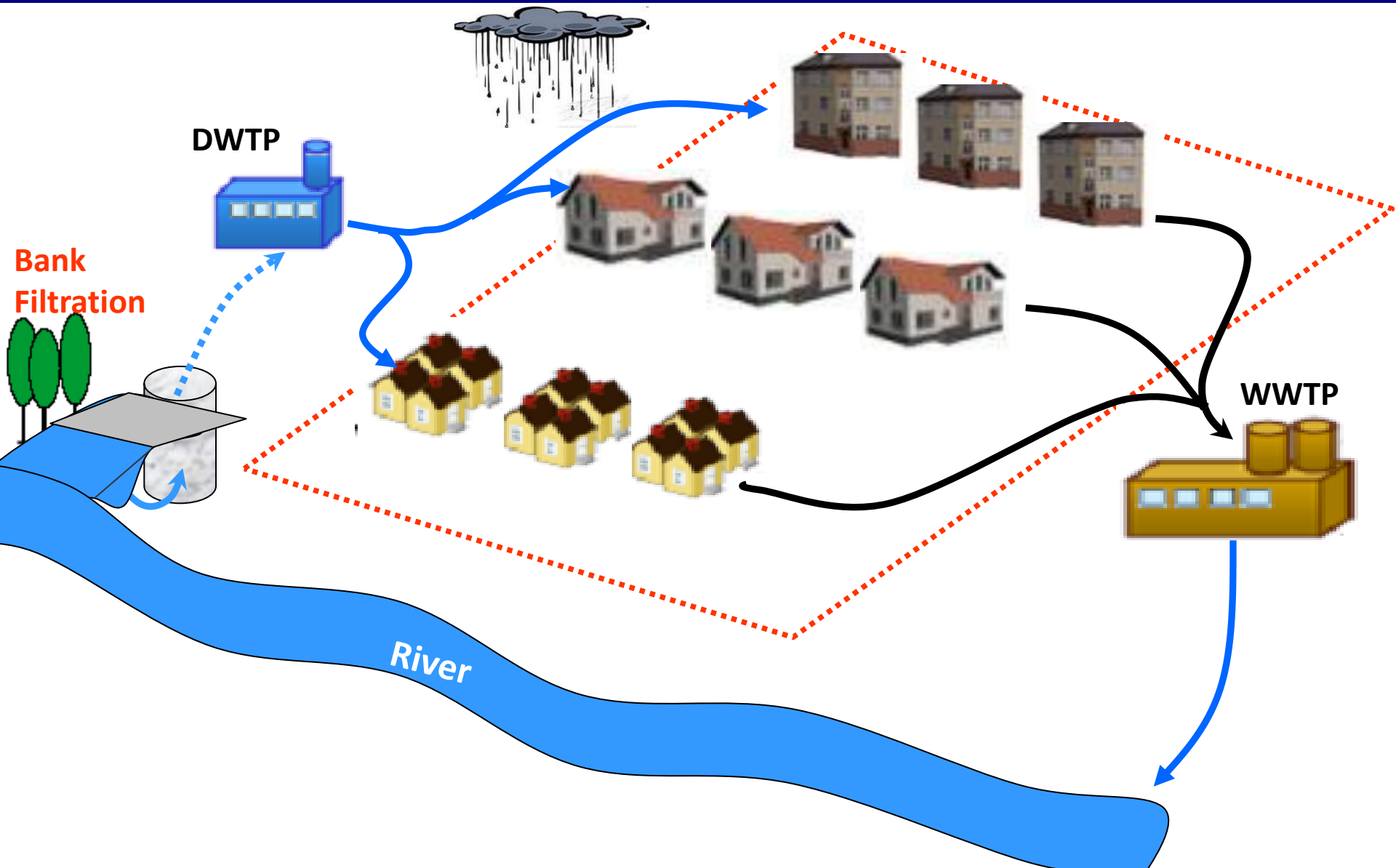
Transitioning -Treatment Systems



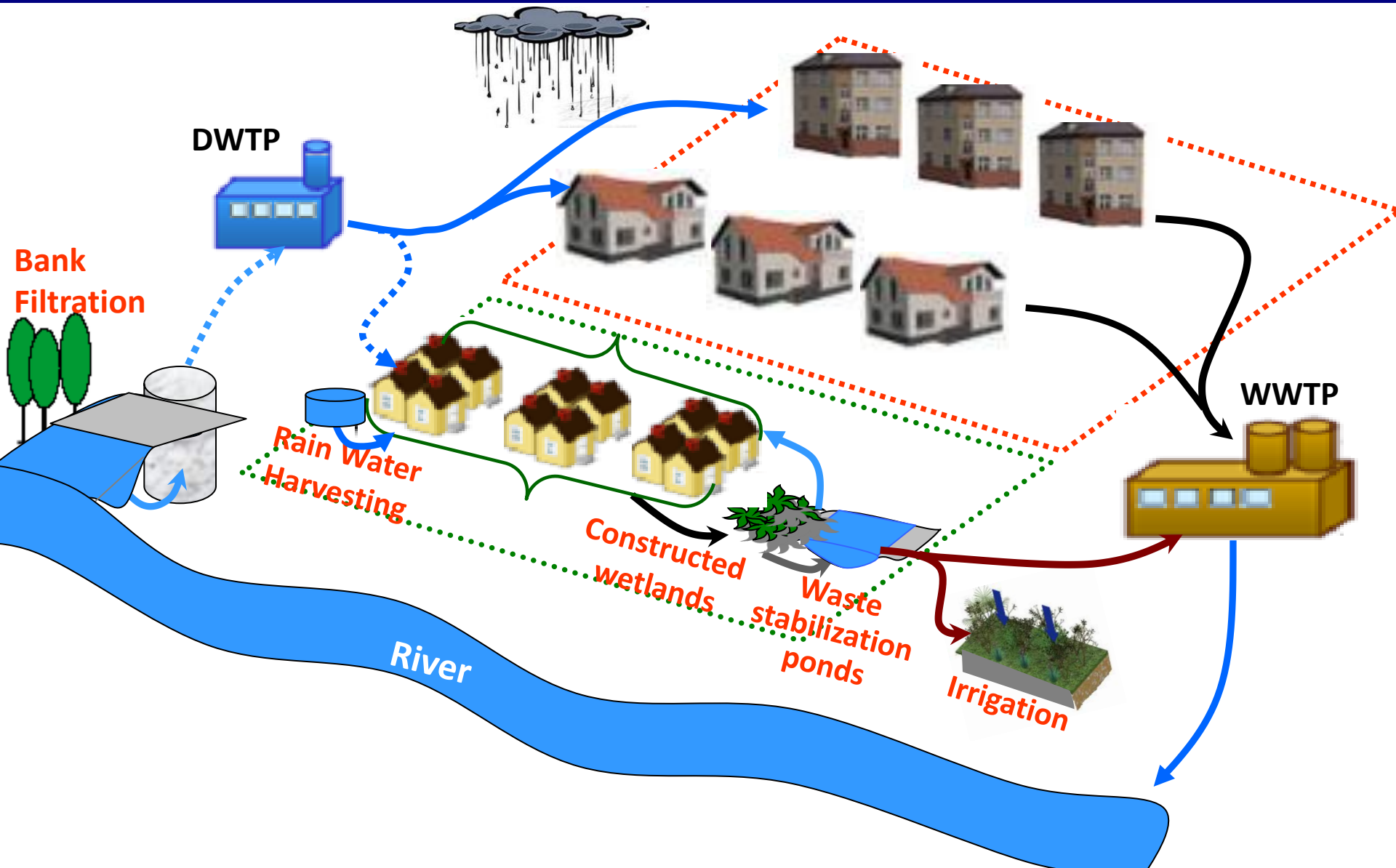
Transitioning -Treatment Systems



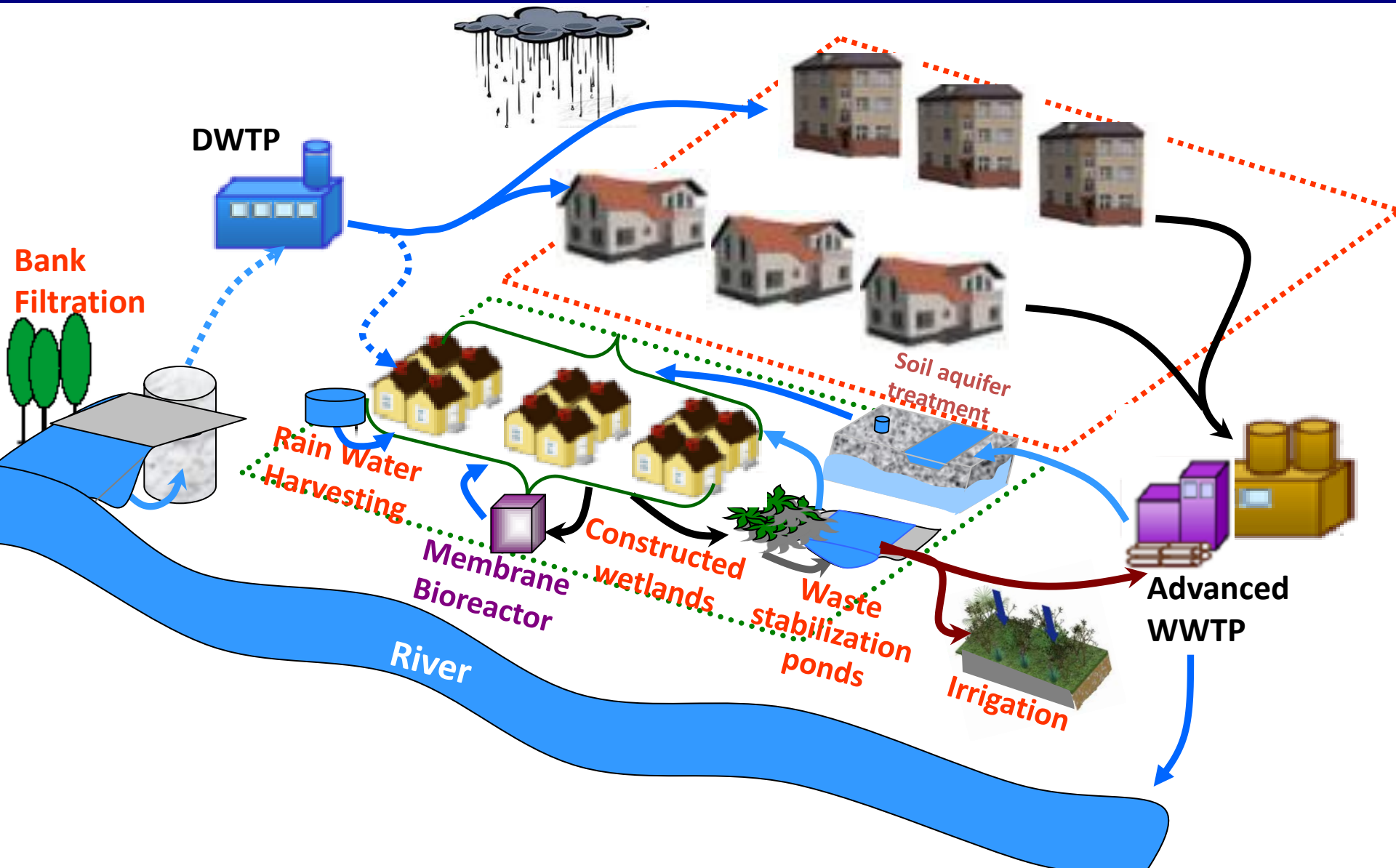
Transitioning -Treatment Systems



Transitioning -Treatment Systems

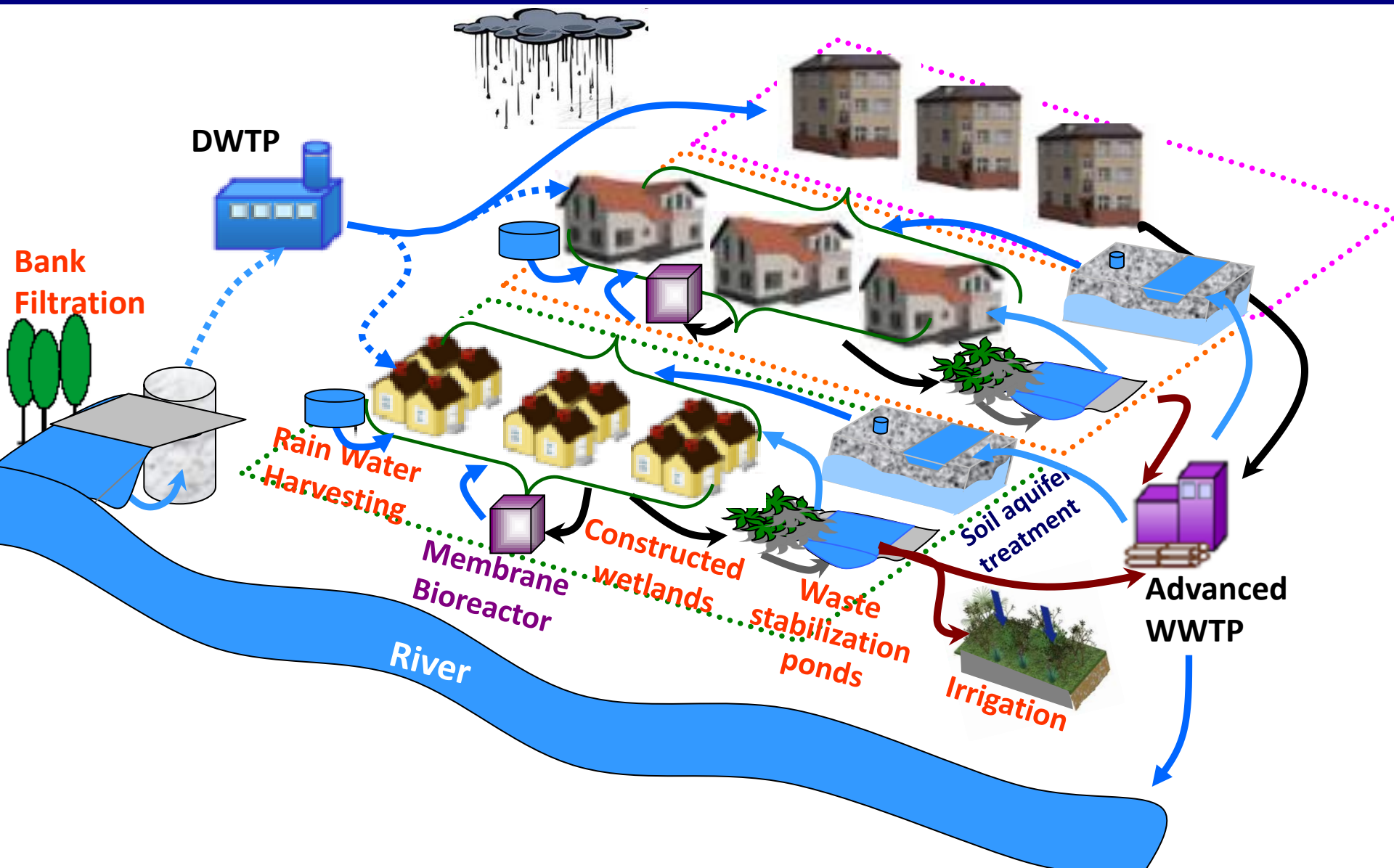


Transitioning -Treatment Systems



The diagram illustrates a comprehensive water management and treatment system. Key components and processes include:

- Water Sources:** Rain (precipitation), River, and Rain Water Harvesting from residential buildings.
- Treatment and Distribution:** DWTP (Drinking Water Treatment Plant), Bank Filtration, Membrane Bioreactor, and various distribution networks (solid and dotted lines) delivering water to houses and agricultural areas.
- Wastewater Management:** Wastewater from houses and the DWTP is collected and treated at an Advanced WWTP (Wastewater Treatment Plant).
- Environmental and Agricultural Features:** Constructed wetlands, Waste stabilization ponds, Soil aquifer treatment, and Irrigation fields are integrated into the system.



Choices Before Us

Stay in Lane -
Business as
Usual

Try Harder,
Spend More for
Traditional Sys

Truly Different
Approach



IWA CITIES OF THE FUTURE PROGRAM, TURKEY

Istanbul Special Topic Workshops, February 7 - 8, 2011

The Green Park Hotel, Merter



Thank You

Kalanithy Vairavamoorthy

Scientific Director of SWITCH-IP (EU-FP6)

vairavk@grad.usf.edu