Warsaw University of Technology

BLUE INFRASTRUCTURE

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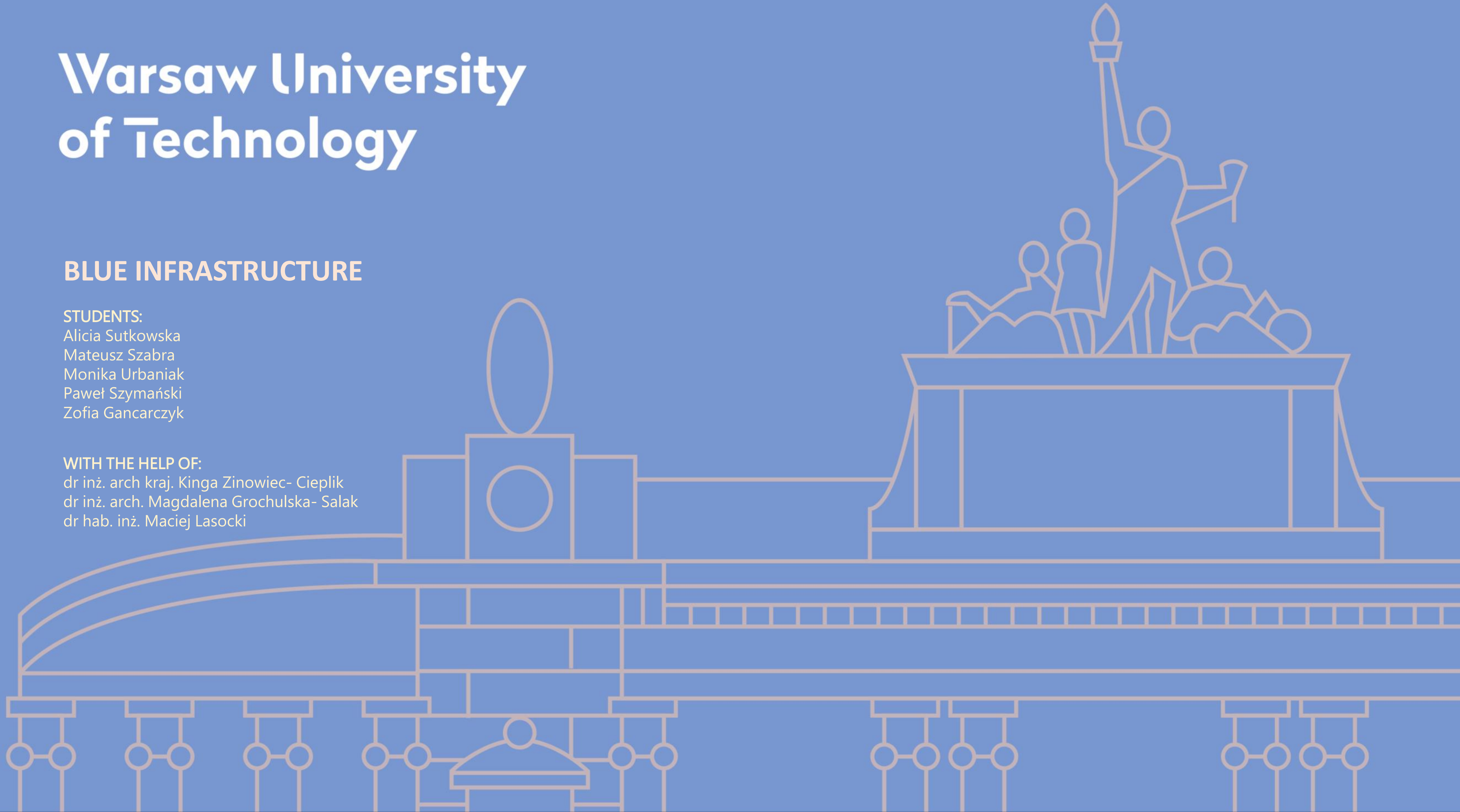


Water-based solutions

OPEN-AIR RETENTION TANKS / WATER GARDENS

GOALS

Open-air retention tanks and water gardens exhibit urban resilience by absorbing disturbances and adapting to environmental stresses.

These systems effectively absorb water and neutralize pollutants, contributing to cleaner urban water sources.

They are self-sufficient, managing stormwater while reducing urban temperatures.

URBAN FACTORS

Open-air retention tanks often require a large space and strongly influence the city landscape. The factors that need to be taken into account when designing such tanks are: biologically active area, site area, watershed area, functional public space index

SOLUTION EXAMPLE

France, Boulogne, Billancourt Park, designed by Agence Ter,

https://landezine-award.com/boulogne-park/

USE OF CANALS FOR RECREATIONAL PURPOSES

GOALS

Enhancing quality of life, creating community gathering spaces, promoting tourism and improving the city's attractiveness, creating a new landmark in urban structure, promoting green transport (kayaks, canoes)

URBAN FACTORS

The presence of a canal and access to water; Historical and cultural context; functional public space index;

SOLUTION EXAMPLE

Belgium, Bruges; The Floating Island / OBBA & Dertien12

https://www.archdaily.com/899820/the-floating-island-obba-and-dertien12

TEMPORARY WATER RESERVOIRS

GOALS

Removal of pollutants from flowing rainwater collected from the surface of roads, squares and roofs, less water flowing from impervious surfaces to the general sewage system (plants retain it in the landscape, thus increasing water retention).

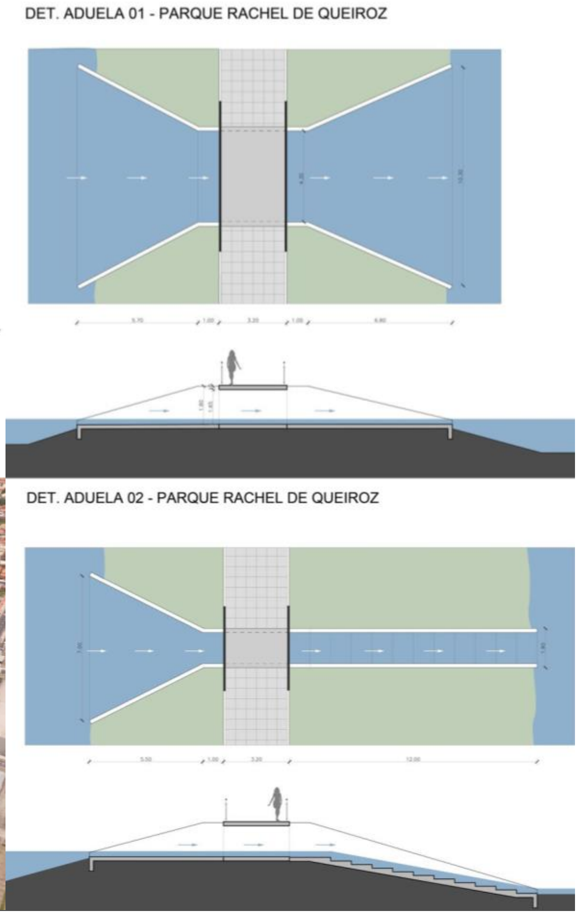
URBAN FACTORS

Highly urbanized area, with paved surfaces, without a biologically active surface and with a large surface runoff. Occurrence of flood risk.

SOLUTION EXAMPLE

Rachel de Queiroz Park in Fortaleza, Brazil

https://www.archdaily.com/985558/rachel-de-queiroz-park-architectus-s-s



RENATURATION OF WATER CHANNELS

GOALS

Improvement of flood safety, the river's continuity and its connectivity with floodplains, restoring natural environmental conditions and habitat diversity, inviting recreation and improving the river's accessibility and quality, increasing the amount of water left in the river bed.

URBAN FACTORS

Ecosystem degradation, changes in hydrology, biological depletion, pollution, coastal erosion, hardened banks, restricted access for migratory organisms, habitat loss.

SOLUTION EXAMPLE

Isar River restoration in Munich, Germany

https://climate-adapt.eea.europa.eu/en/metadata/case-studies/isar-plan-2013-water-management-plan-and-restoration-of-the-isar-river-munich-germany/munich_document-2.pdf

Polish text: file:///C:/Users/DELL%20PRECISION/Downloads/16.pdf

RETENTION ROOFS

GOALS

Ensuring free runoff of rainwater and collecting water with the possibility of its reuse and air cooling. Increasing the attractiveness of urban space and the number of biologically active areas

URBAN FACTORS

Problem with excessive rainwater runoff, lack of green spaces, high temperature in the area.

SOLUTION EXAMPLE

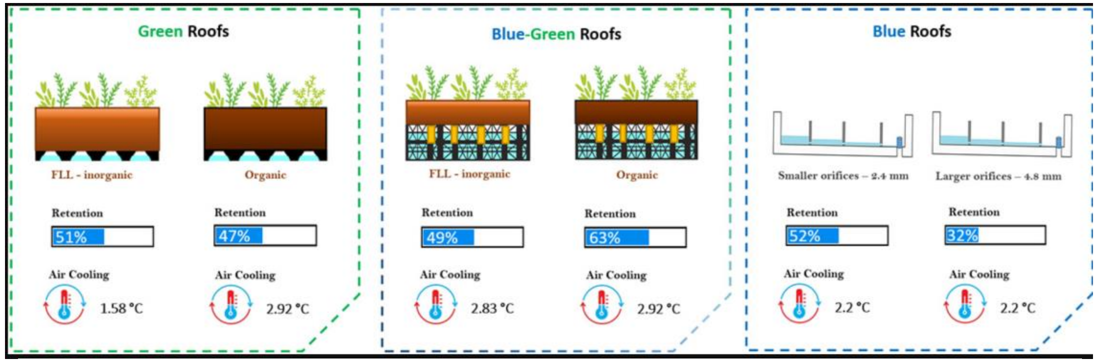
Example

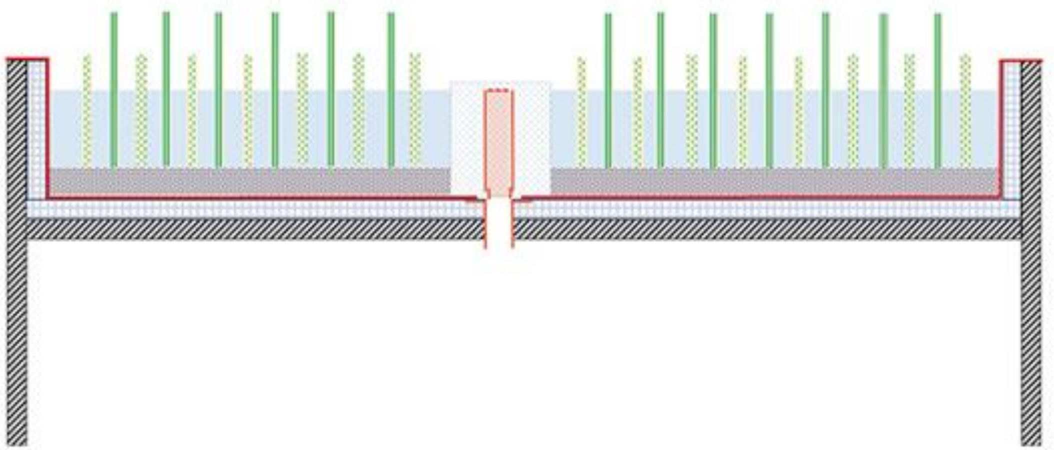
Green, Blue-Green and Blue Roofs. Swamp roof (MCER Marki, Poland), roof with floating plants (Repotex mat).

Example source

https://eurobuildcee.com/en/news/28222-first-passive-polish-school-in-marki

https://www.researchgate.net/publication/328081791_Helophyte_mats_wetland_roofs_with_high_evapotranspiration_rates_as_a_tool_for_decentralised_rainwater_management_-_process_stability_improved_by_simultaneous_greywater_treatment





SHARING THE FUNCTIONS OF URBAN SPACE (WATER RETENTION)

GOALS

Counteracting the effects of flooding and more efficient use of space by sharing various functions by the area (e.g., retention, recreation, transport). Designing a city which allow to retain, purify and reuse rainwater.

URBAN FACTORS

lack of recreational space by the water, need to reducing the effects of extreme weather conditions, dense urban space

SOLUTION EXAMPLE

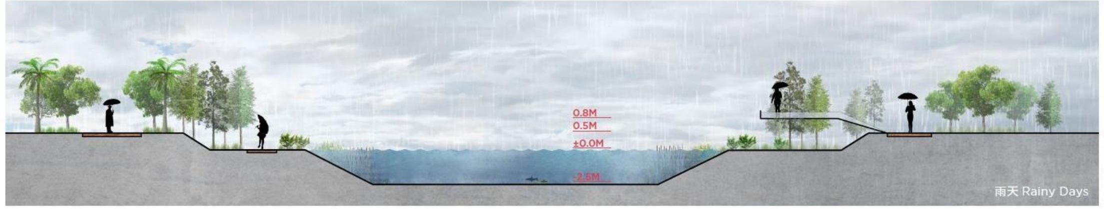
Water Plaza Rotterdam, Roads and ground level parking (sponge city Wuhan)

Example source:

https://www.mdpi.com/2073-4441/13/4/576

https://iopscience.iop.org/article/10.1088/1755-1315/295/3/032019/pdf

https://link-1springer-1com-1000096ut2a70.eczyt.bg.pw.edu.pl/article/10.1007/s12517-021-07706-y



UNDERGROUND RETENTION TANKS

GOALS

Temporary stormwater runoff storage and management of its flow during heavy rainfall events. The primary goal is to prevent flooding, reduce the risk of erosion, and control the release of stormwater into the sewer system or natural water bodies.

URBAN FACTORS

underground intensity index, rainwater runoff, site area and area with paved surfaces, watershed area, underground volume zone

SOLUTION EXAMPLE

Modular tank for either water detention (wrapped in geotextile)

or

retention where the modules are placed inside a welded PVC liner.

Example source

https://watercraftwa.com.au/rainwater-tanks/underground-tank-options/

NATURAL WASTEWATER TREATMENT SYSTEMS

GOALS

To achieve effective wastewater treatment while minimizing the environmental impact and energy consumption associated with traditional treatment methods. Reducing water consumption in households (indoor reuse), which translates into economic benefits in the form of reduced water consumption costs

URBAN FACTORS

Fertilization, surface permeability, plants, site area, groundwater level, improvement of wastewater quality

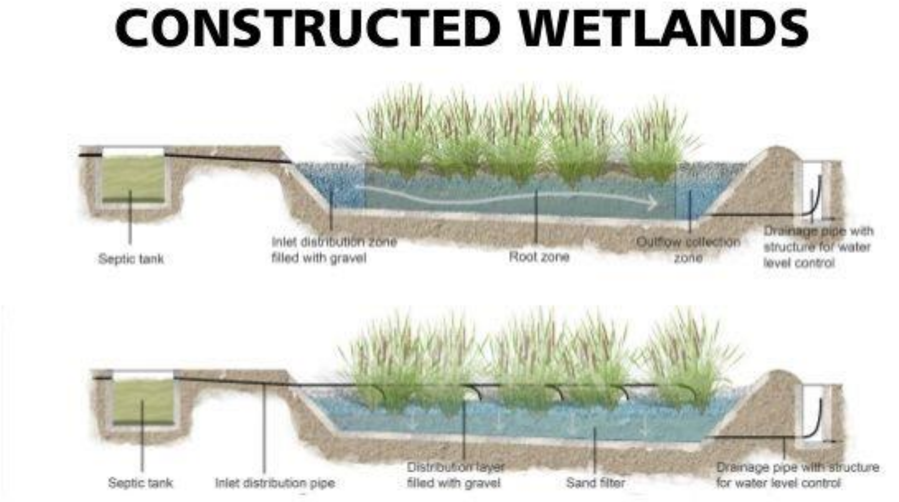
SOLUTION EXAMPLE

Example

Constructed Wetlands applied to the region of Curitiba and Paraná

Example source

https://www.biomatrixwater.com/msr-constructed-wetlands/



UNDERGROUND WATER RESERVOIRS WITH INFILTRATION POTENTIAL

GOALS

Enhance urban water sustainability by utilizing underground reservoirs capable of natural infiltration.

Balance urban water demands with the replenishment of groundwater supplies through these reservoirs.

Facilitate natural groundwater recharge processes in urban environments to combat water scarcity.

URBAN FACTORS

Changes in urban land use and its impact on groundwater recharge rates.

Increase of impermeable surfaces in urbanized regions limiting natural water infiltration.

The urban need for infrastructure that supports water infiltration and storage, balancing consumption with sustainability.

SOLUTION EXAMPLE

Permeable Pavements, eg. Stone paving in Santarém, Portugal

Example source:

https://extension.usu.edu/waterquality/ou-images/Urban-Stormwater/Additional-Resources-Stormwater-Resources/SWPermeable.jpg

https://www.flickr.com/photos/vribeiro/52625385450

ENERGY HARVESTING FROM WATER

GOALS

Capitalize on wastewater's inherent heat as a sustainable energy source for urban needs.

Harness the potential of waves as a renewable energy source for coastal urban centers.

Reduce carbon footprints of cities while ensuring consistent energy supply through water-based sources.

URBAN FACTORS

Urban wastewater heat, a byproduct of domestic and industrial activities.

The strategic advantage of coastal urban centers in tapping into wave energy.

The burgeoning energy demands of cities and the need for eco-friendly energy solutions.

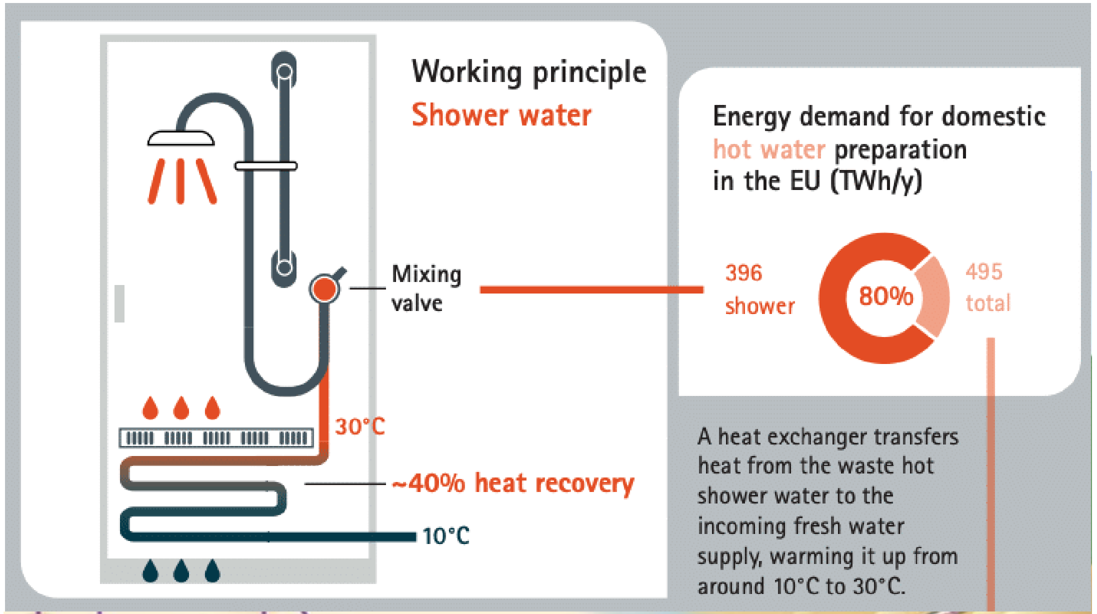
SOLUTION EXAMPLE

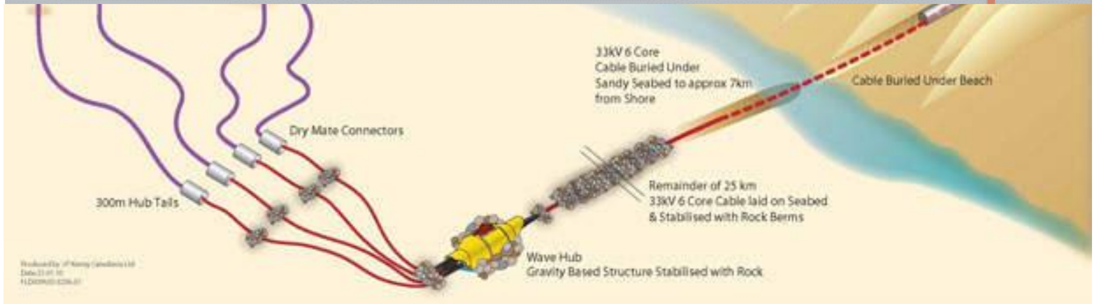
Wave Hub, Cornwall, UK

Example source:

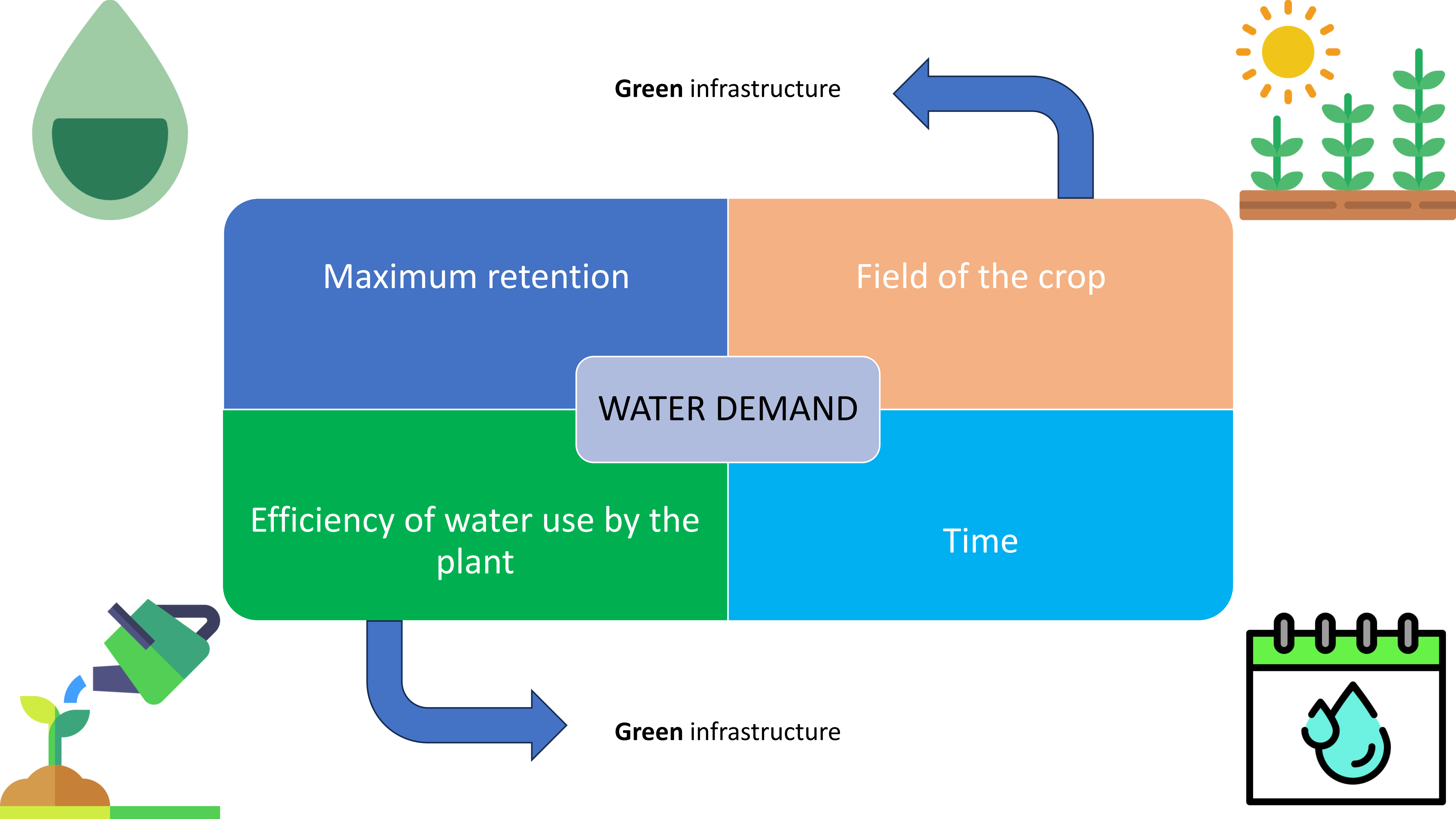
https://copperalliance.org/wp-content/uploads/2021/10/Screen-Shot-2021-10-11-at-11.50.54-AM.png

https://www.power-technology.com/projects/cornwallwaveenergyhu





Algorithms



Green infrastructure
Maximum retention
Field of the crop
WATER DEMAND
Efficiency of water use by the plant
Time
Green infrastructure

MODELING THE WATER DEMAND OF AN IRRIGATED FACILITY

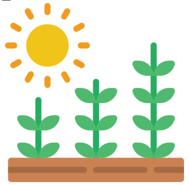
$$\textbf{POM} = \frac{10^{-3} \cdot POM_{net}[mm] \cdot 10^{4} \cdot F[ha]}{\eta[-] \cdot \Delta t[s]} \left[\frac{m^3}{s}\right]$$

TABLE 2. Average ET_o for different agroclimatic regions in mm/day

Regions	Mean daily temperature (°C)		
	Cool ~10°C	Moderate 20°C	Warm > 30°C
Tropics and subtropics			
- humid and sub-humid	2 - 3	3 - 5	5 - 7
-arid and semi-arid	2 - 4	4 - 6	6 - 8
Temperate region			
- humid and sub-humid	1 - 2	2 - 4	4 - 7
-arid and semi-arid	1 - 3	4 - 7	6 - 9

1. $\mathbf{POM_{net}} = \mathrm{Ret_{max}} - \mathrm{Ret_{F*}}\ [\mathrm{mm}]$

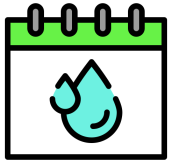
2. F[ha] – field of the crop



Green infrastructure

3. $\eta[-]$ – efficiency of water use by the plant **(0,7)** (depending on the method of irrigation)

4. $\Delta t[s]$ - length of time interval (day/month/year)



- Ret_max = <u>**60 mm**</u>
- $Ret_{F*} = P - ET_I\ [mm]$

(final retention forecast)

P- average precipitation (day/month/year)

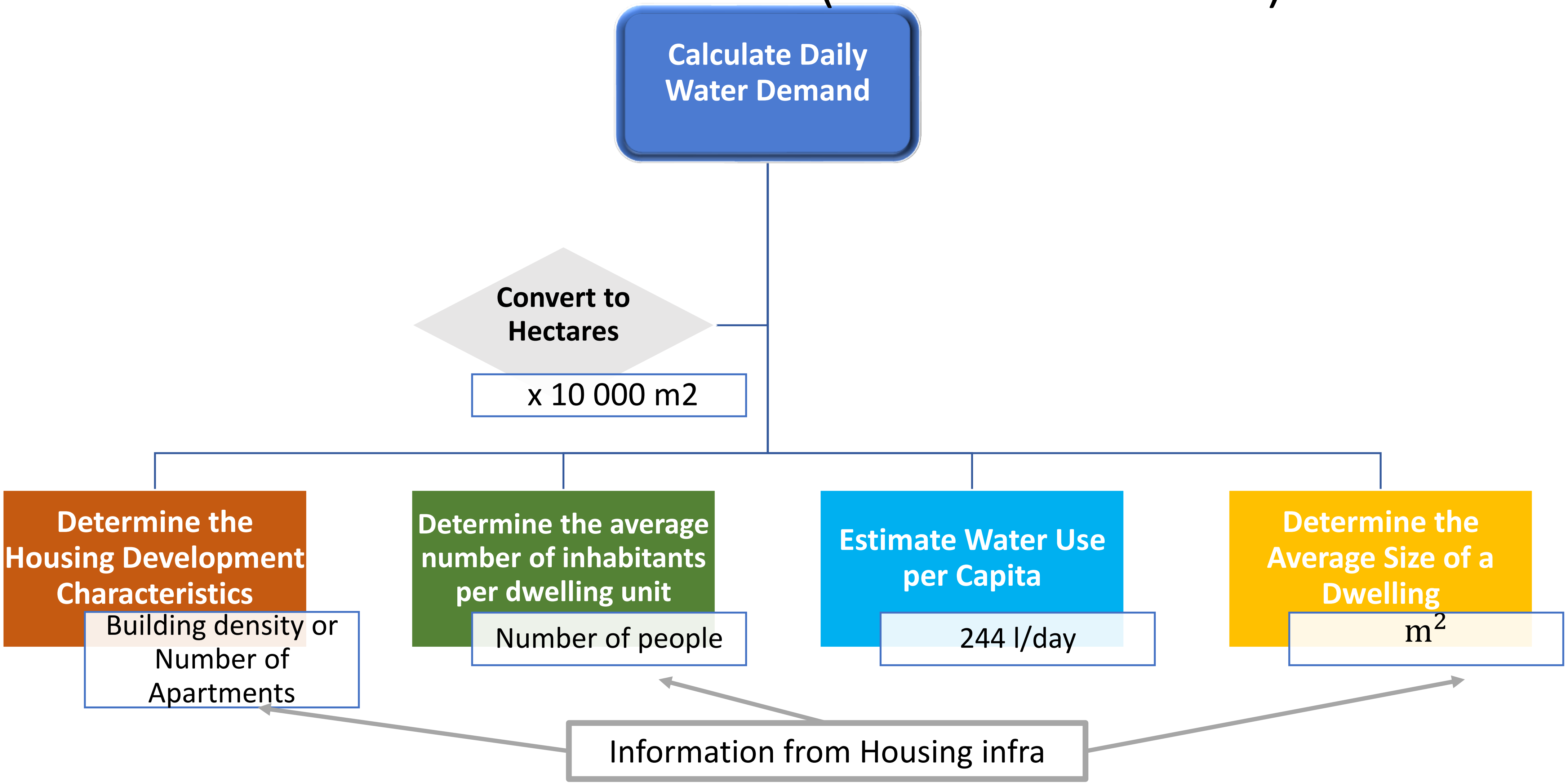
$\mathbf{ET_I}$ - Initial crop evapotranspiration

- $ET_I = k_c \cdot ET_0\ [mm]$

ETo - Reference crop evapotranspiration (based on meteorological parameters)

kc - crop coefficient [dimensionless] **(<u>for grass = 1</u>)**

THE DEMAND FOR DOMESTIC WATER IN RESIDENTIAL BUILDINGS (HA OPTIONAL)

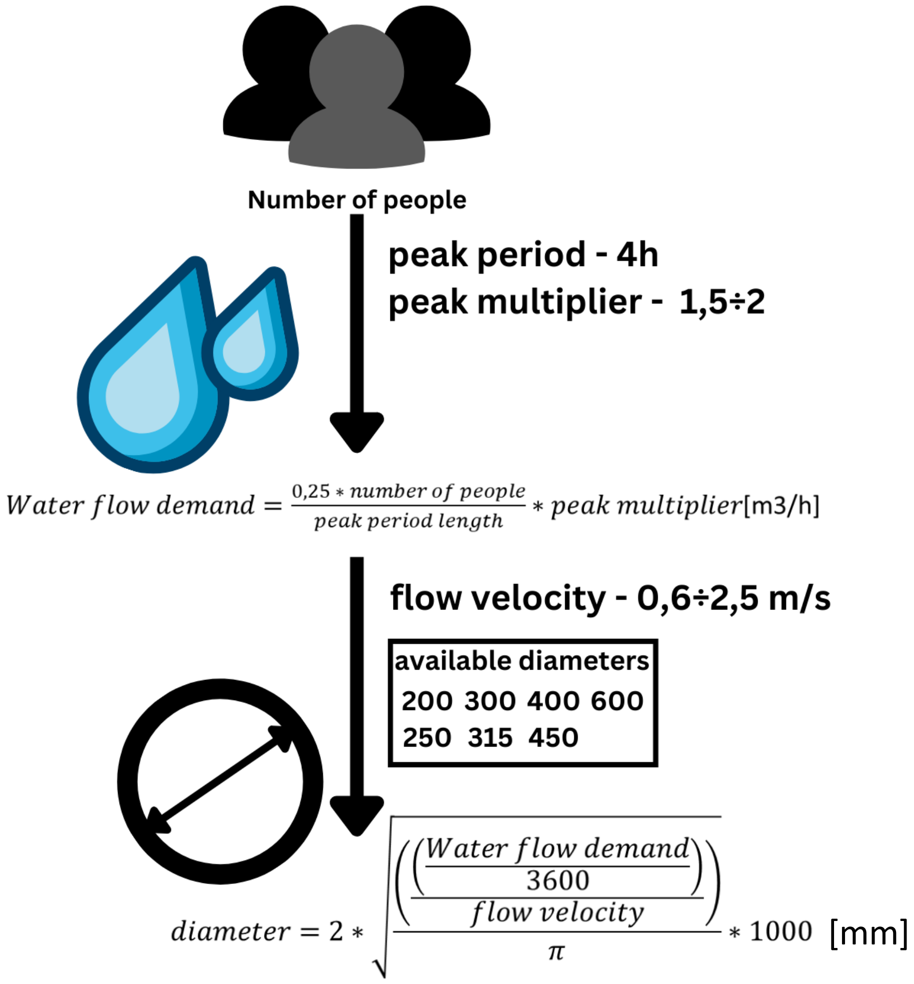


WATER SUPPLY DESIGN ALGORYTHM

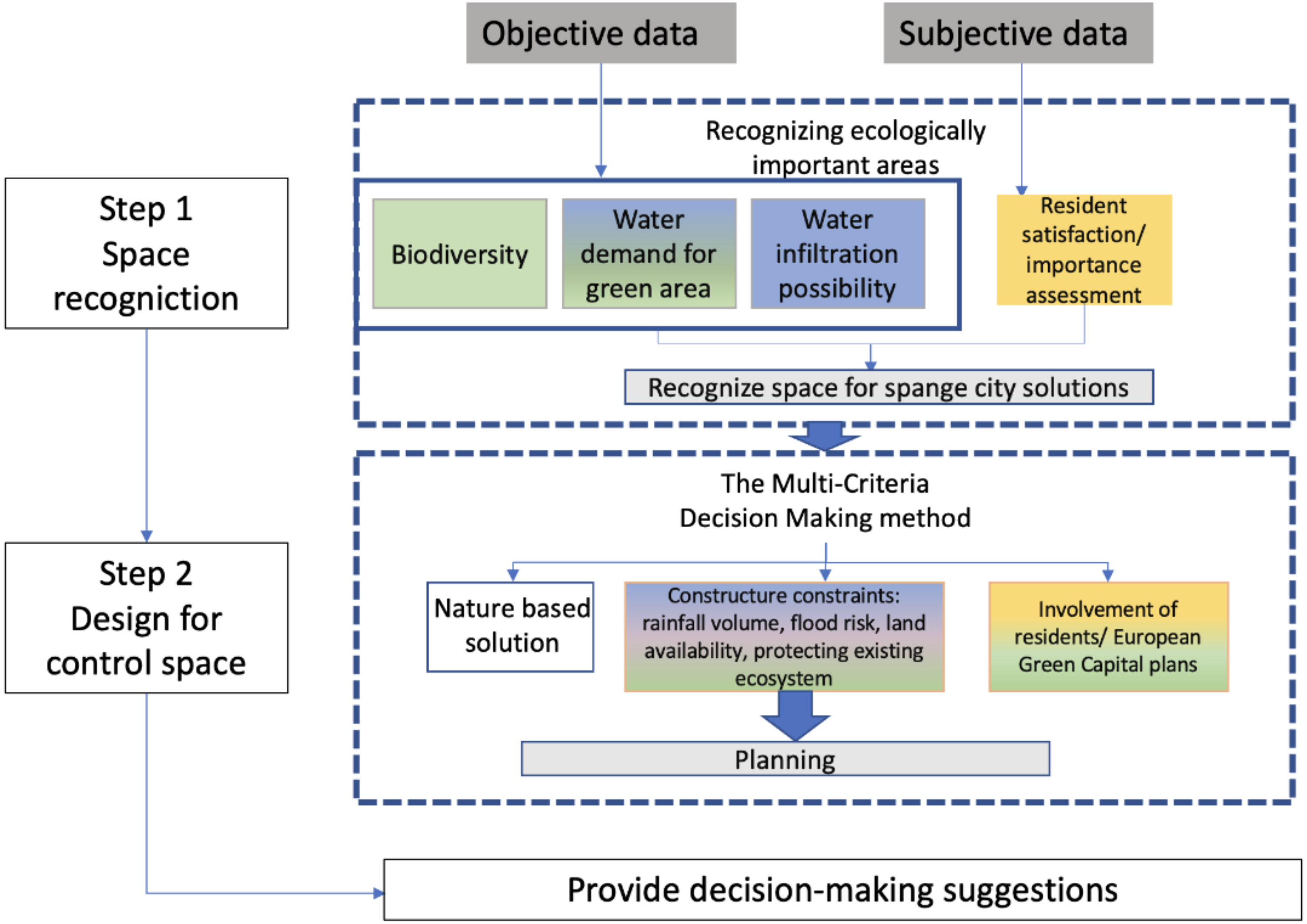
- Average Daily Water Demand
  - Estimated at 250 $\frac{liters}{\left(\frac{person}{day}\right)}$ = 0,25 $\frac{m^3}{\left(\frac{person}{day}\right)}$
  - For 10,000 inhabitants: 2,500 m^3/day.

- Peak Hourly Demand
  - Consumption spikes often occur over 4-hour periods.
  - Assuming a 4-hour peak usage:
    - Base Peak Flow: 625 m^3/h (2,500 m^3 ÷ 4h).
    - 1.5x Peak Flow: 937.5 m^3/h (2,500 m^3 x 1.5 ÷ 4h).
    - 2x Peak Flow: 1,250 m^3/h (2,500 m^3 x 2 ÷ 4h).

- Flow velocity for supply network
  - 0,6 ÷ 2,5 m/s



SPONGE CITY CONCEPT



METHOD FOR SIZING MODULAR GREEN-BLUE ROOF

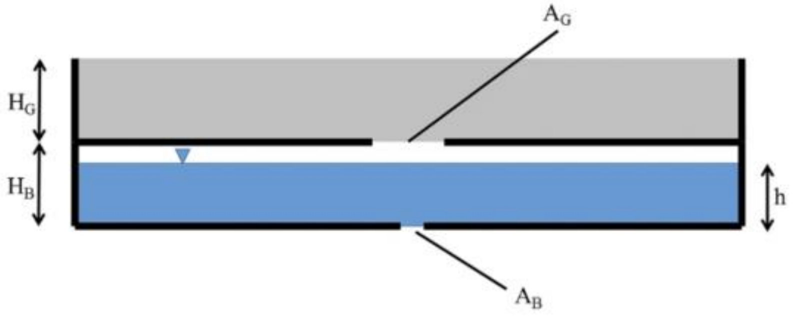
Total aveilable storage for the system:

$$S = A_R\,(\phi H_G + H_B) + \forall_{\text{soil}}$$

Roof's planned area

field capacity porosity (5%-25%)

Retencion storage volume



Schematic diagram of a modular green–blue roof system. $A_G = \Sigma A_{Gi}$ and $A_B = \Sigma A_{Bi}$ are the cumulative drain areas of the green roof and blue roof, respectively. H_G and H_B are the heights of the green roof and blue roof modules, and h is the height of water at time t in the blue roof module

WASTEWATER ABSORPTION BY THE SEWAGE SYSTEM

$$Qww = K \bullet \sqrt{\sum DU} \; [l/s]$$

SEWAGE FLOW RATE

(expected pipe diameter)

depends on the function of the building

discontinuous	0,5
periodic	0,7
collective	1
special	1,2

depends on the number of each sanitary equipment element

(e.g. housing infra)

RAINWATER ABSORPTION BY INFILTRATION TO THE SOIL

$$q_d = \psi \cdot A \cdot \frac{I}{10\,000} \quad [dm^3/s]$$

RAINWATER FLOW RATE

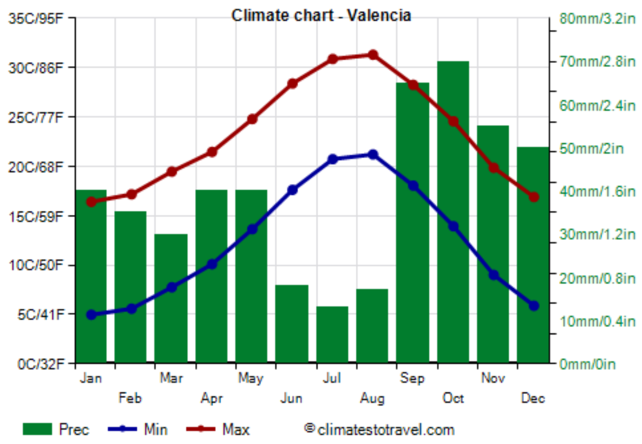
rainwater runoff factor

drainage surface

measured amount of expected rain

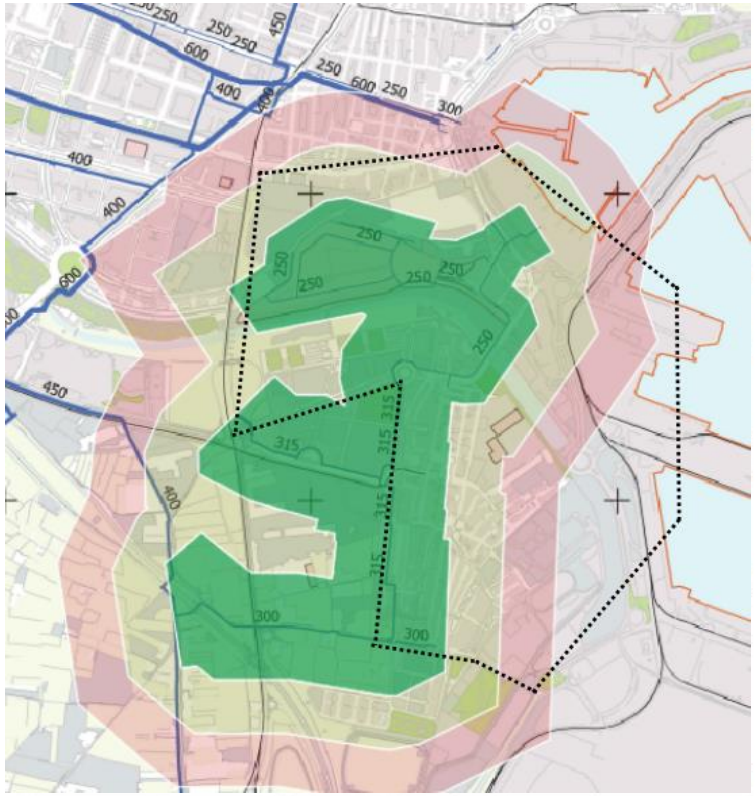
roofs >15 degrees	1
roofs <15 degrees	0,8
gravel roofs	0,5
roof gardens	0,3
ramps and car washes	1
sidewalks - slabs	0,6
sidewalks - courtyards, alleys	0,5
playgrounds, sports fields	0,25
gardens	0,1-0,15
parks	0,05

(e.g. green and social infra)



Maps

WATER SUPPLY NETWORK QUALITY MAP



Legend

Green- good supply
Yellow-moderate supply
Orange- supply in need to improvement

based on the distance from the water supply network and pipe diameter

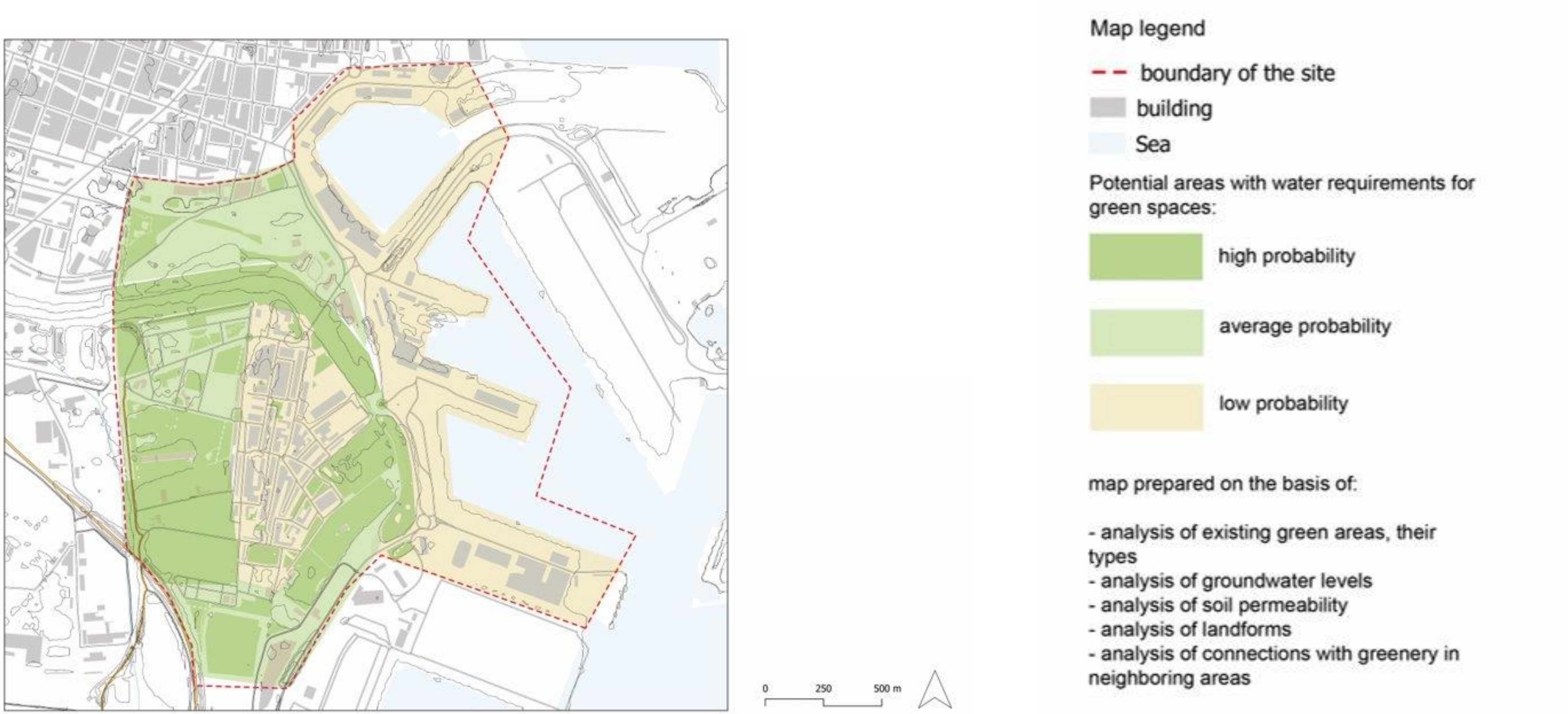
IRIGATION CHANNELS NETWORK QUALITY MAP

Legend

Green- good supply
Yellow-moderate supply
Orange- supply in need to improvement

based on the distance from the irigation channels network

WATER DEMAND - URBAN GREEN SPACES



WATER DEMAND - RESIDENTIAL DEVELOPMENT

Map legend

- - boundary of the site

building

Sea

Potential areas with water requirements for residential development:

high probability

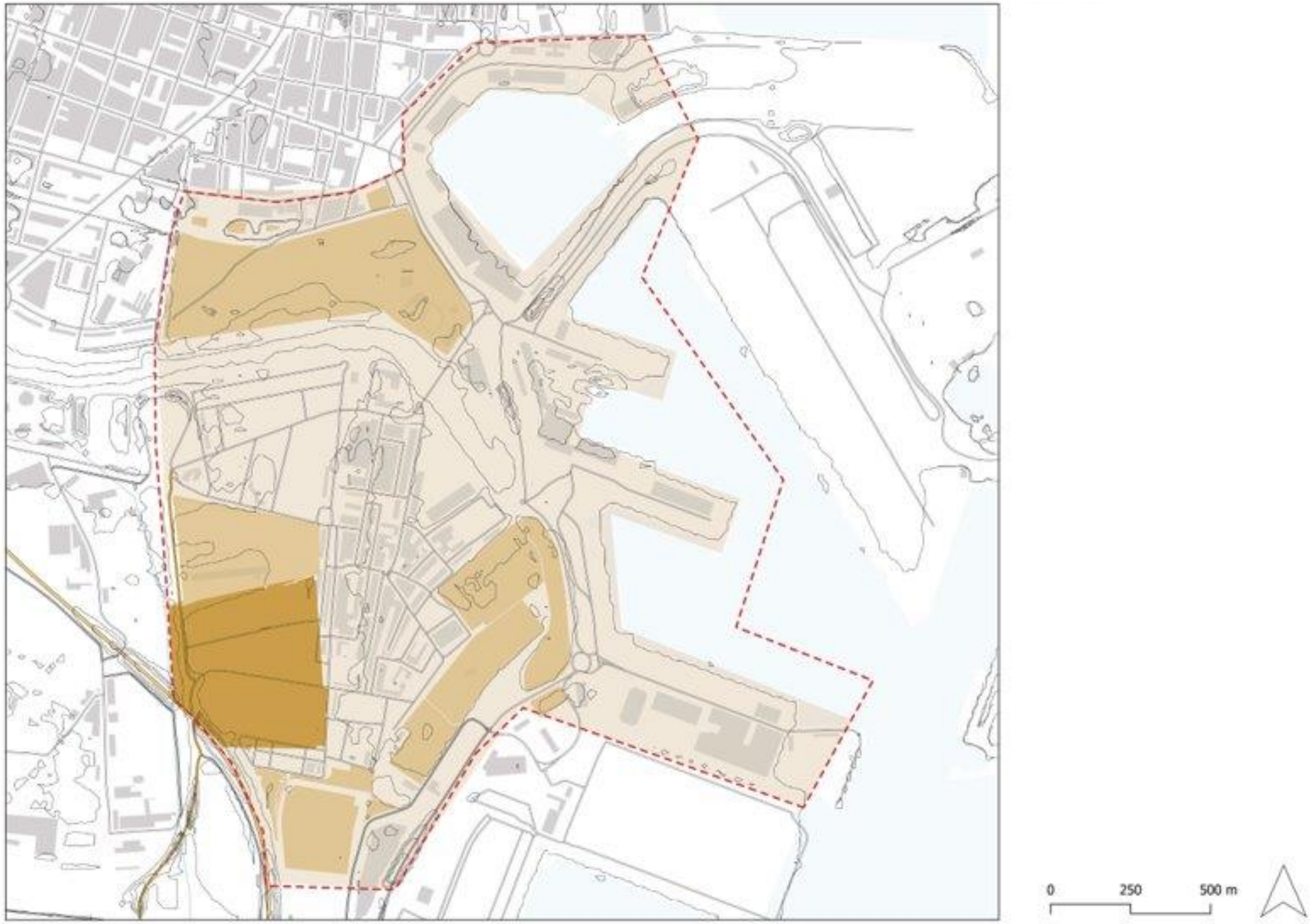
average probability

low probability

map prepared on the basis of:

- analysis of floodplains, protected areas, wetlands
- analysis of groundwater levels
- analysis of site functions
- land utilities analysis, analysing connections to all necessary utilities (water, electricity or gas)

WATER DEMAND - AGRICULTURAL FIELDS



Map legend

- - - boundary of the site

building

Sea

Potential areas with water requirements for agricultural fields:

high probability

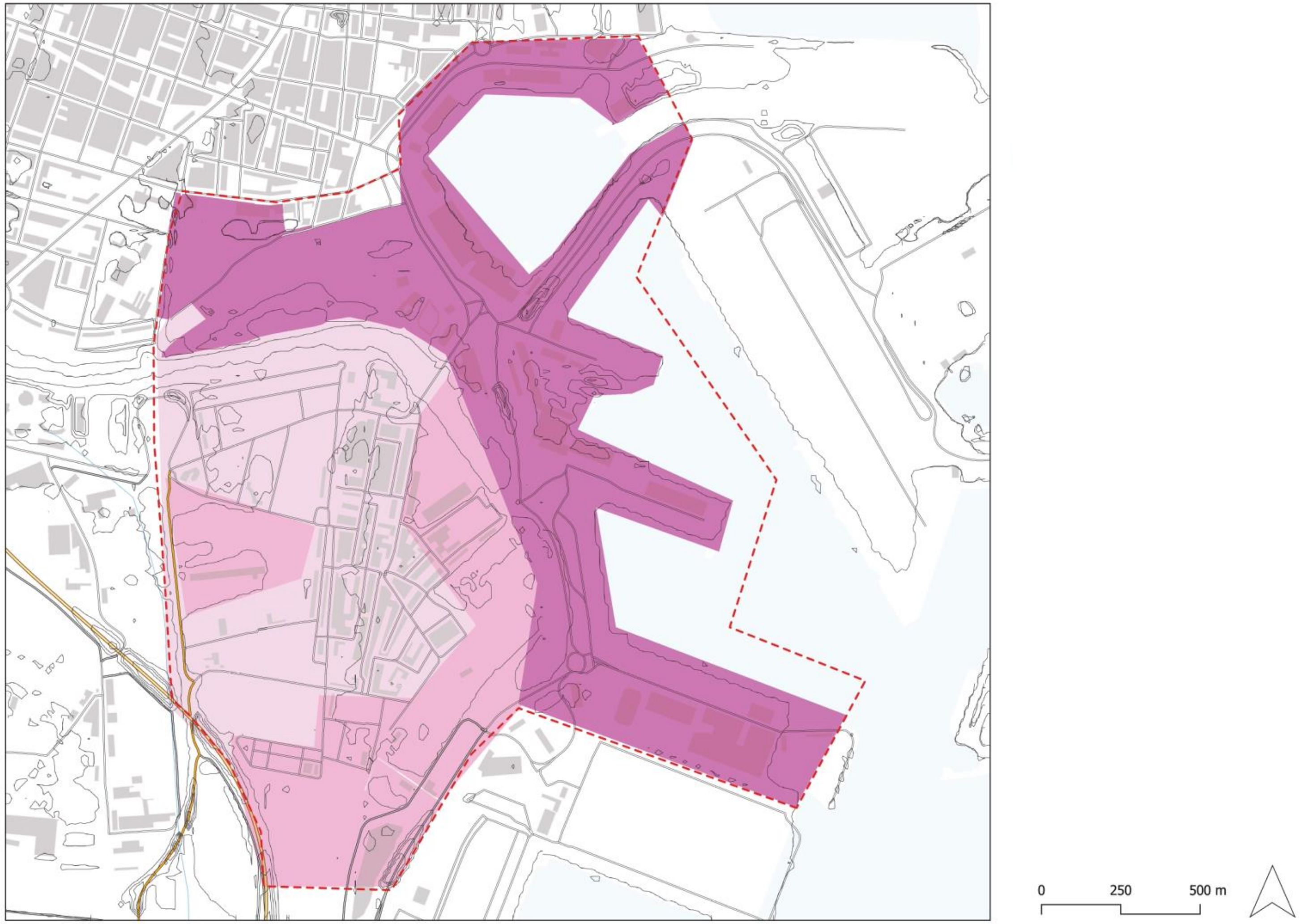
average probability

low probability

map prepared on the basis of:

- analysis of groundwater levels
- analysis of soil permeability
- analysis of landforms
- analysis of floodplains, protected areas, wetlands

WATER DEMAND - INDUSTRIAL AREAS



Map legend

- - boundary of the site

building

Sea

Potential areas with water requirements for industry:

high probability

average probability

low probability

map prepared on the basis of:

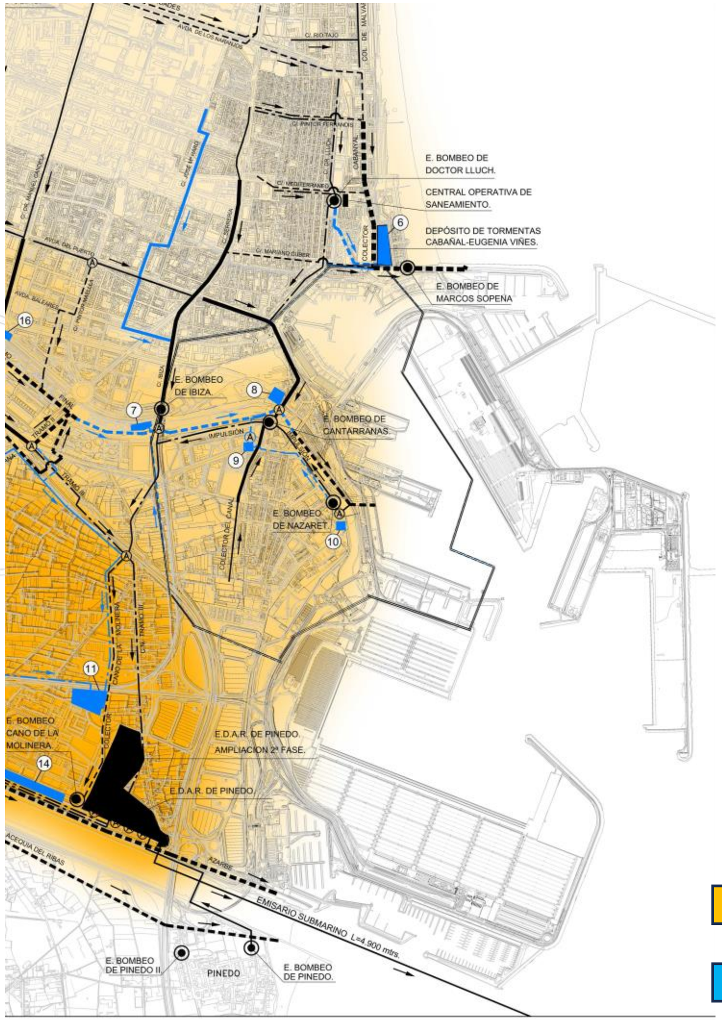
- analysis of groundwater levels
- analysis of soil permeability
- analysis of landforms
- analysis of floodplains, protected areas, wetlands

PURIFIED WASTEWATER MULTIPURPOSE USE

- Protected, recreation
- Residential, cultural, transport
- Climate, environment, green
- Agriculture
- Industry

AREAS SUPPORTED BY WATER RETENTION TANKS

AREAS SUPPORTED BY EDAR PINEDO
(sewage treatment plant)



- 3 levels of sewage supply quality
- water retention tank
- sewage treatment plant

INFILTRATION MAP
(based on topography, green areas and soil permeability)