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Water availability along the Albert Canal in relation to the Meuse discharge

Patrick Willems, Hydraulics & Geotechnics Section, KU Leuven

based on studies for VRAG, De Vlaamse Waterweg and stakeholders

Drinking water supply in Flanders, based on Meuse water

40% of drinking water supply in Flanders is based on intake of Meuse water at Albertkanaal & Netekanaal

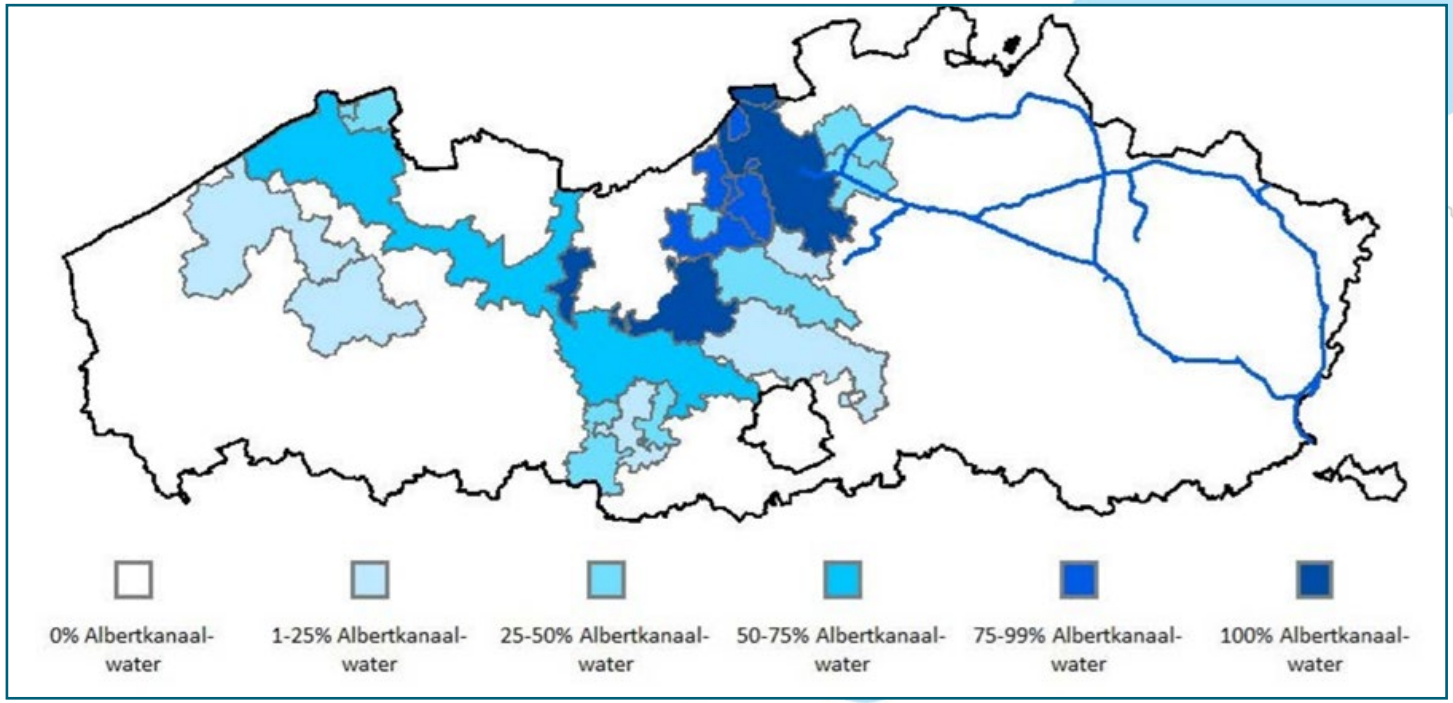
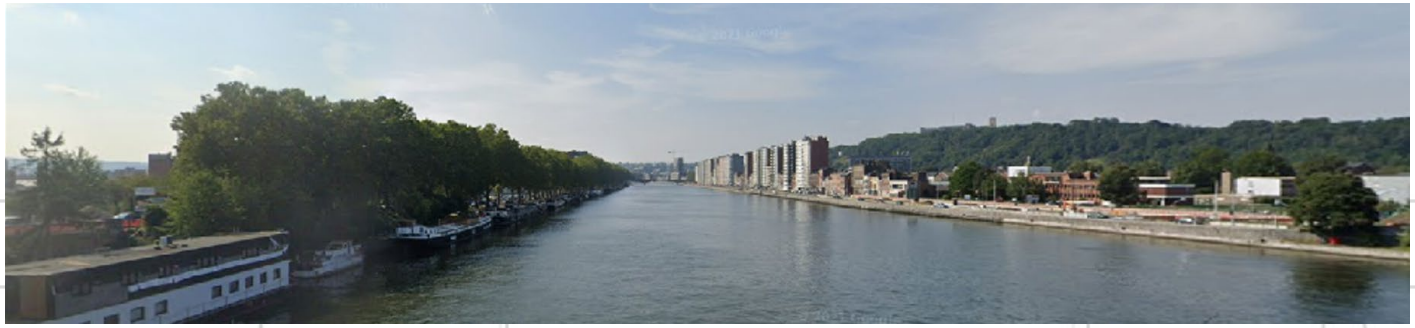
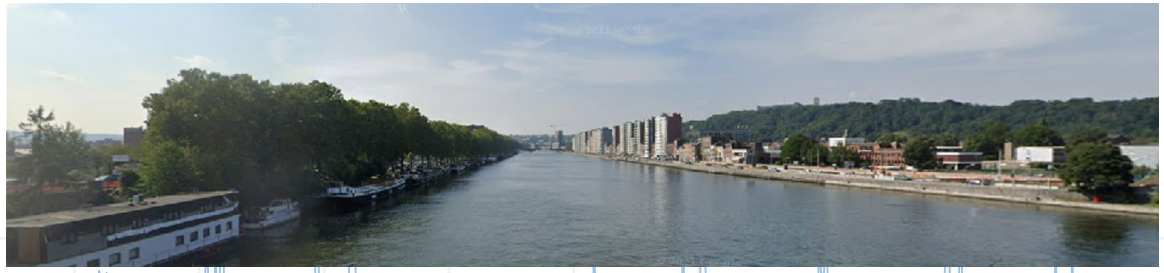


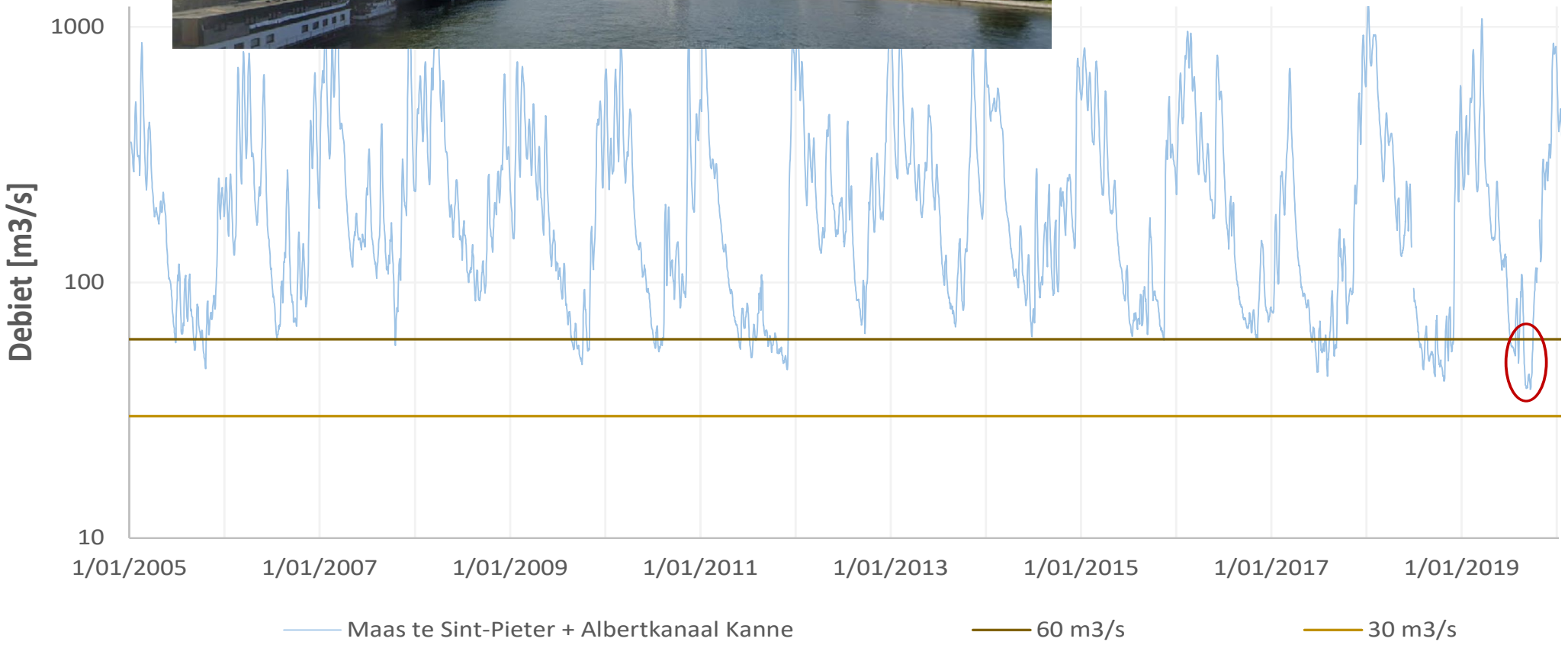
Figure: RIWA Maas

Meuse discharge at Monsin, summer 2022



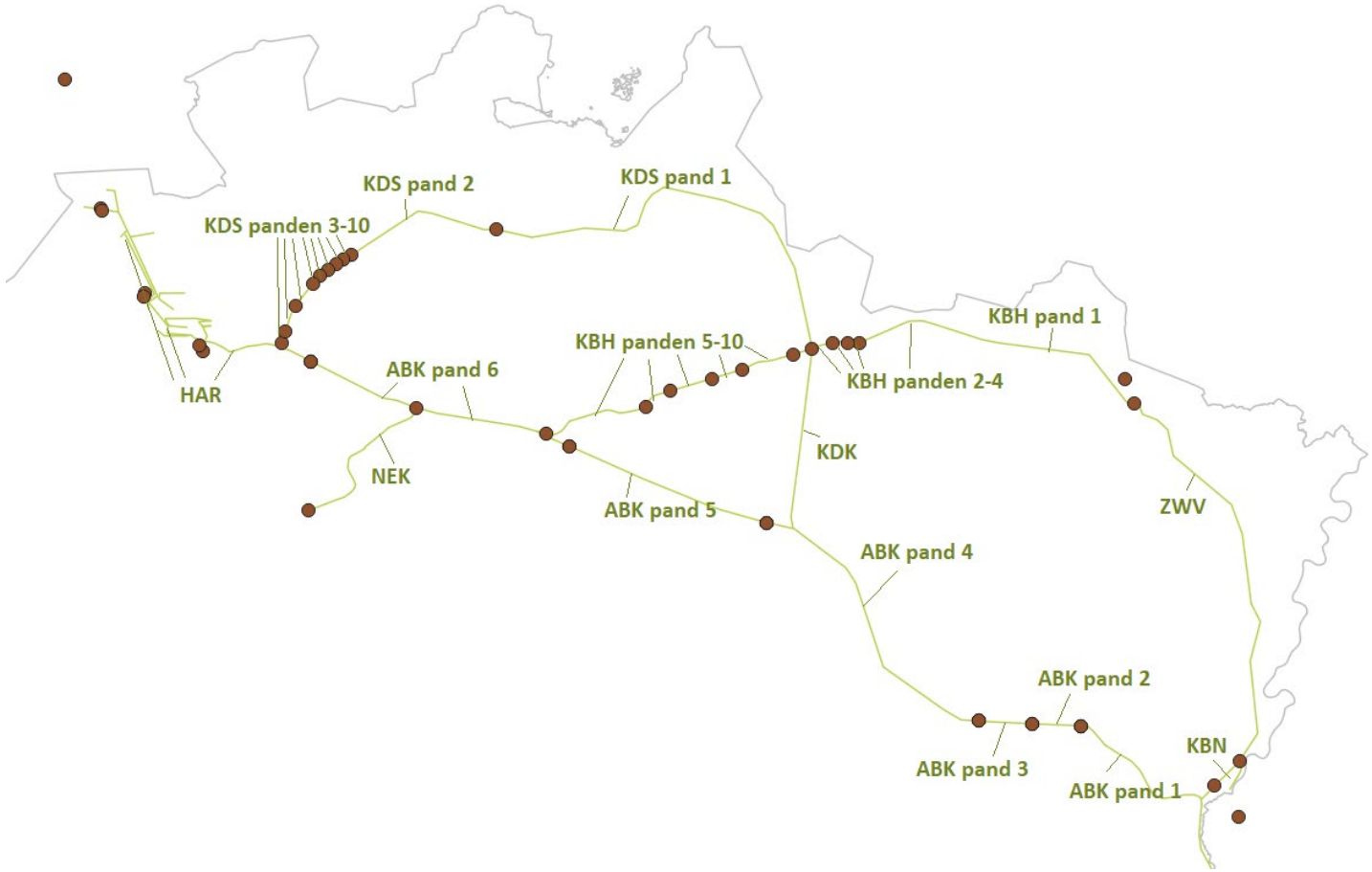
Meuse discharge at Monsin, 2005-2019





Albert Canal & Campine Canals

Water balance 13-22 Sept. 2019



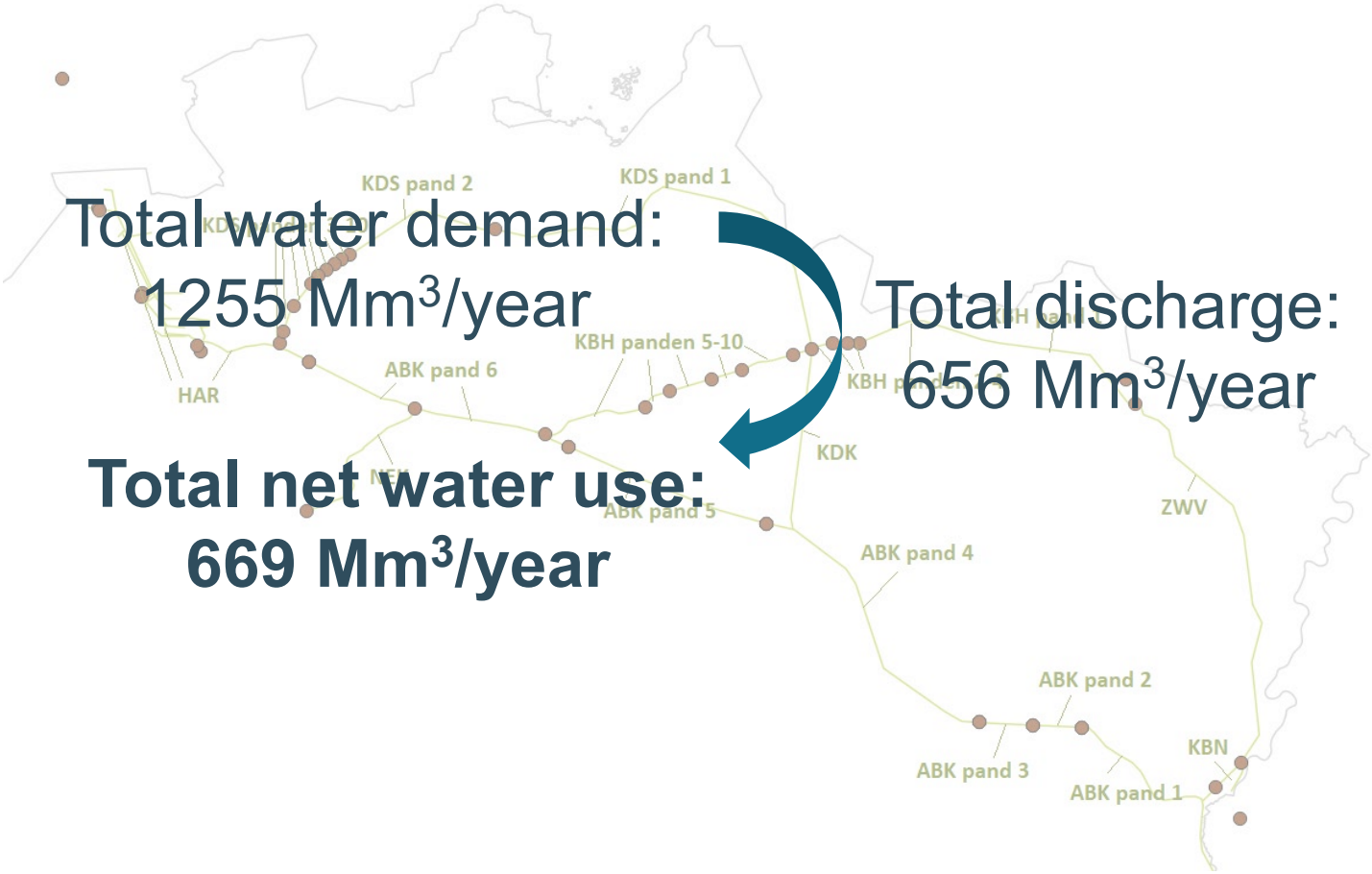
Albert Canal & Campine Canals

Water balance 13-22 Sept. 2019

Total water demand:
1255 Mm^3/year

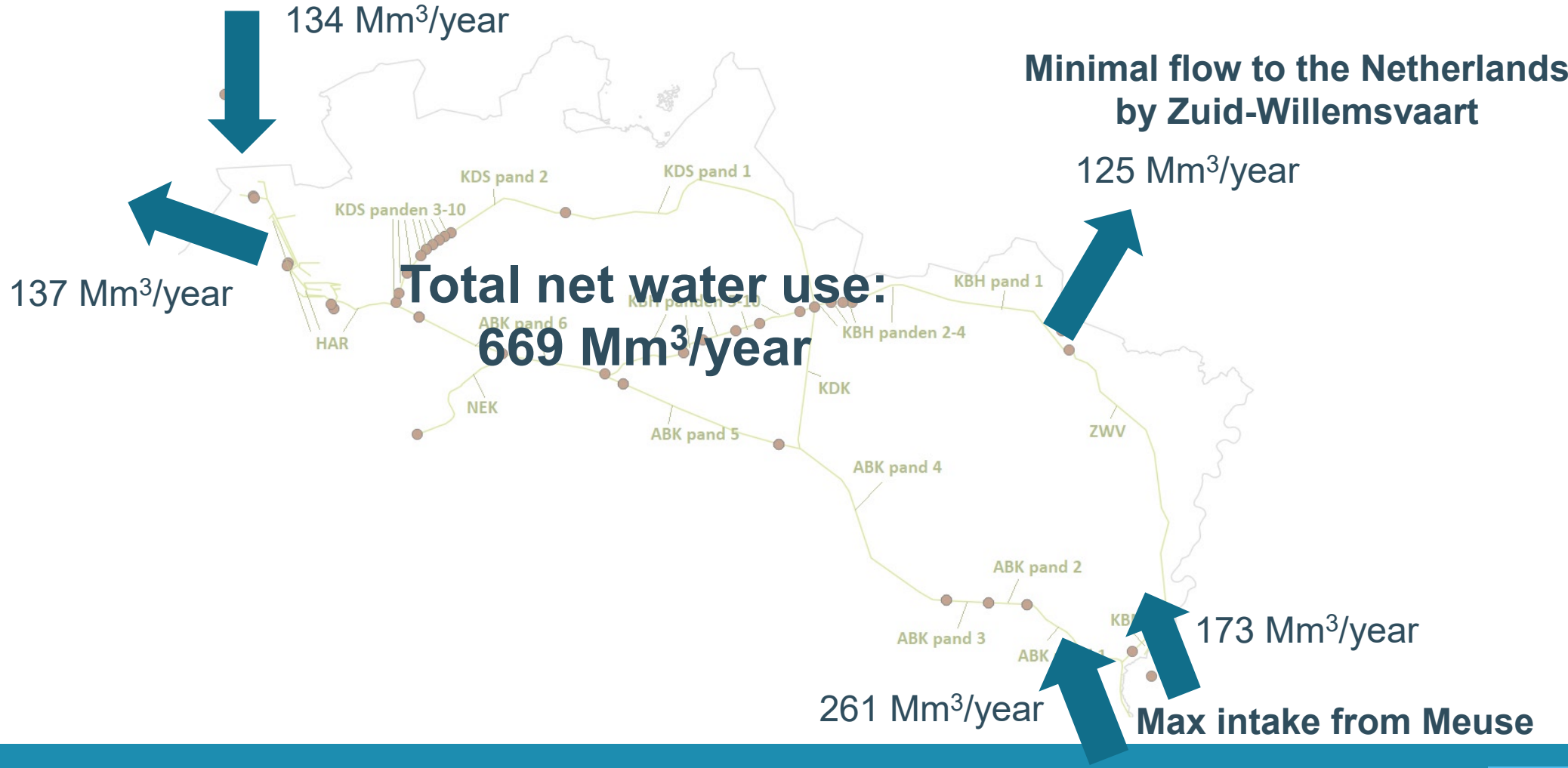
Albert Canal & Campine Canals

Water balance 13-22 Sept. 2019



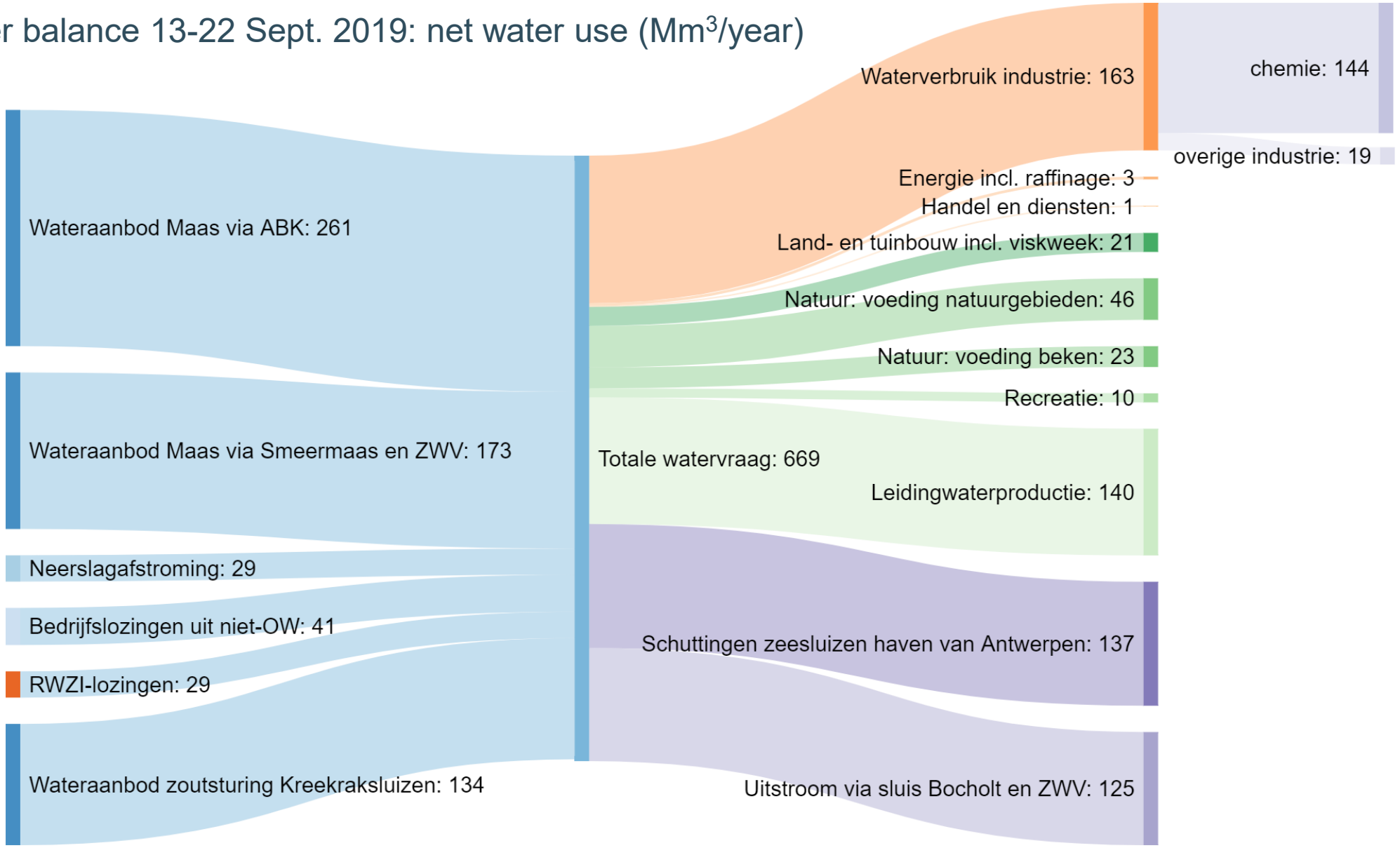
Albert Canal & Campine Canals

Water balance 13-22 Sept. 2019



Albert Canal & Campine Canals

Water balance 13-22 Sept. 2019: net water use (Mm^3/year)



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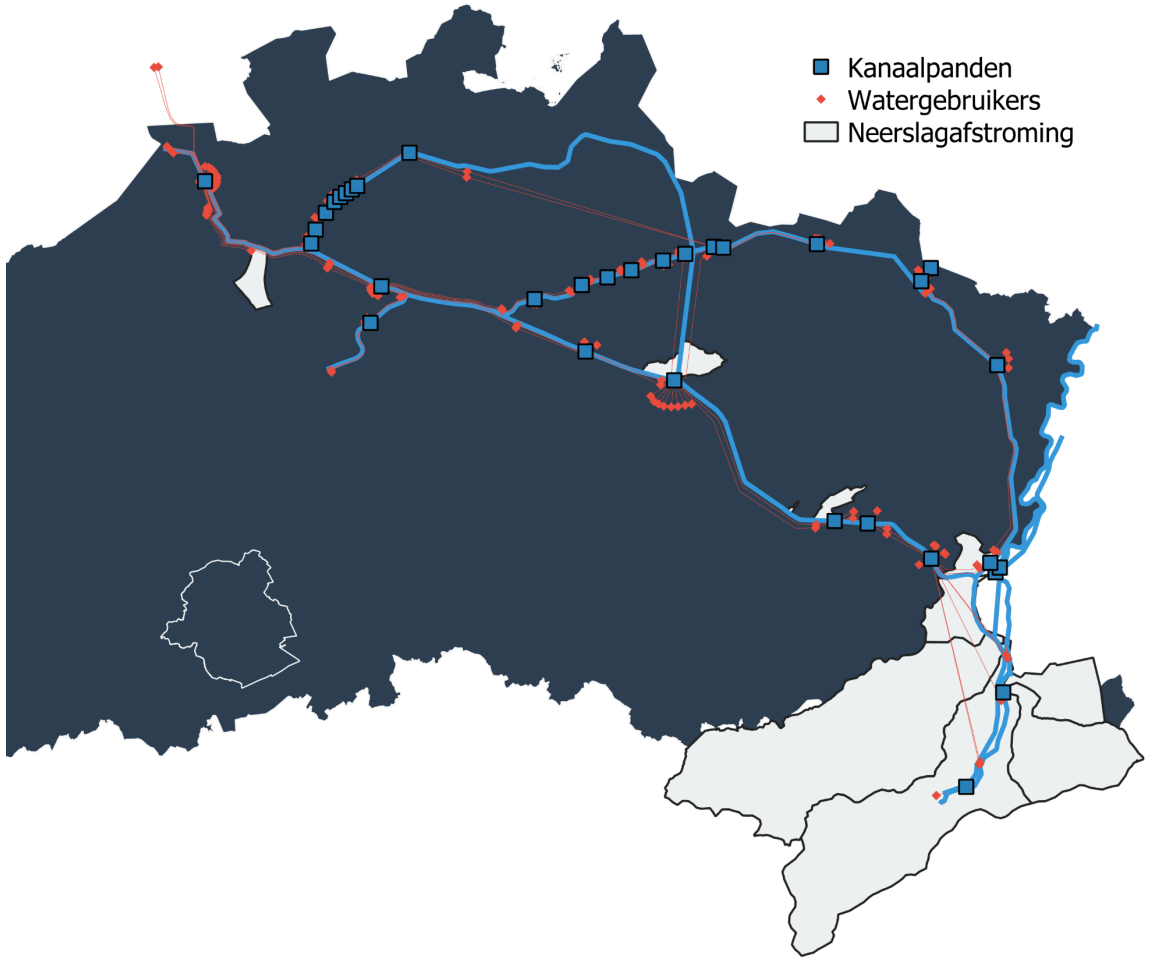
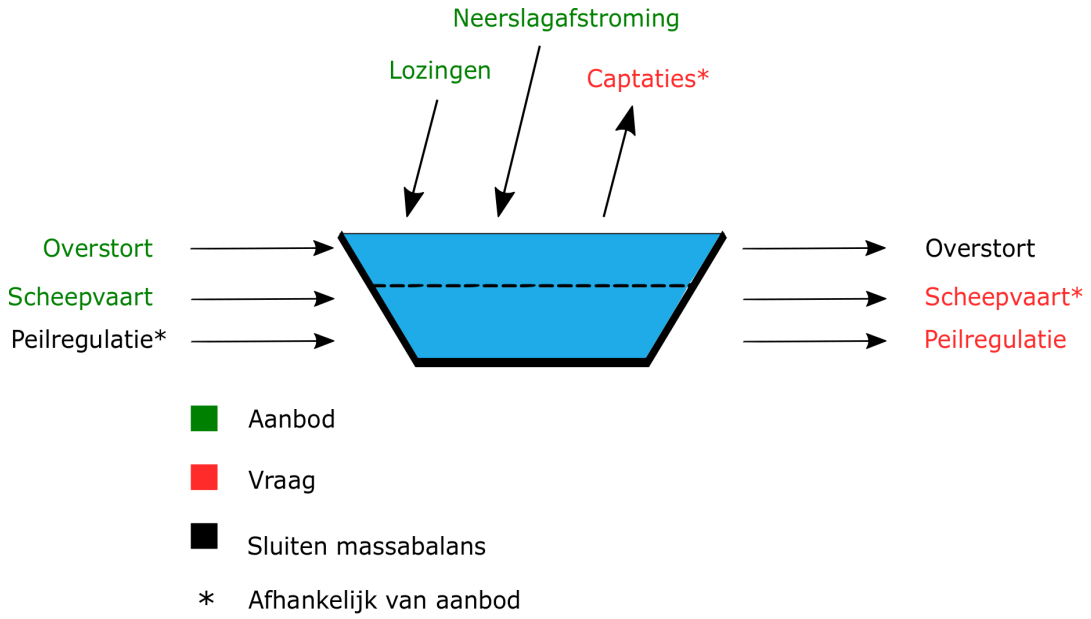
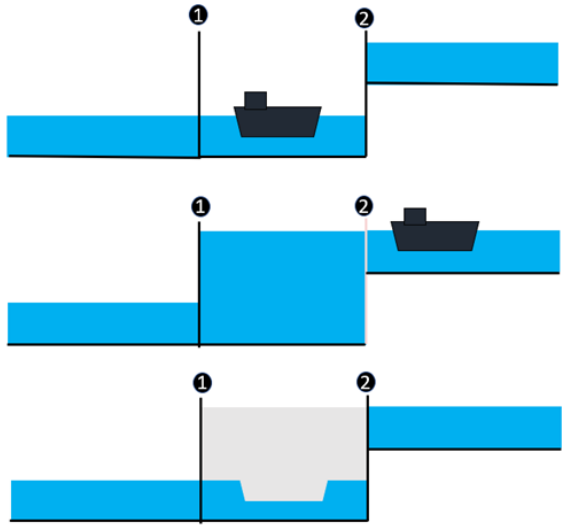
Water balance model Albert Canal & Campine Canals



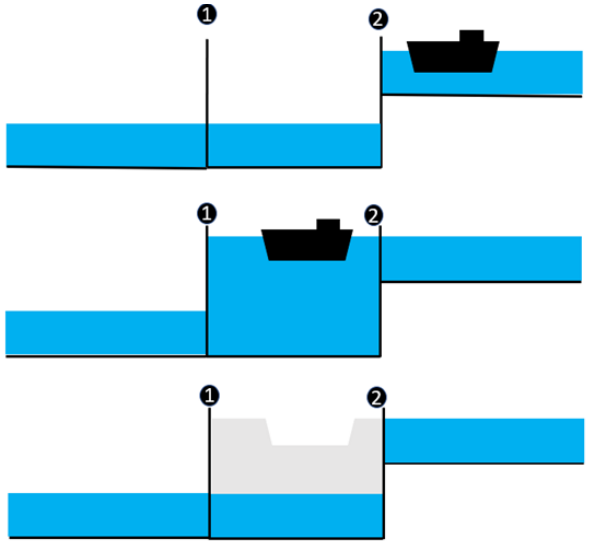


Water balance model Albert Canal & Campine Canals

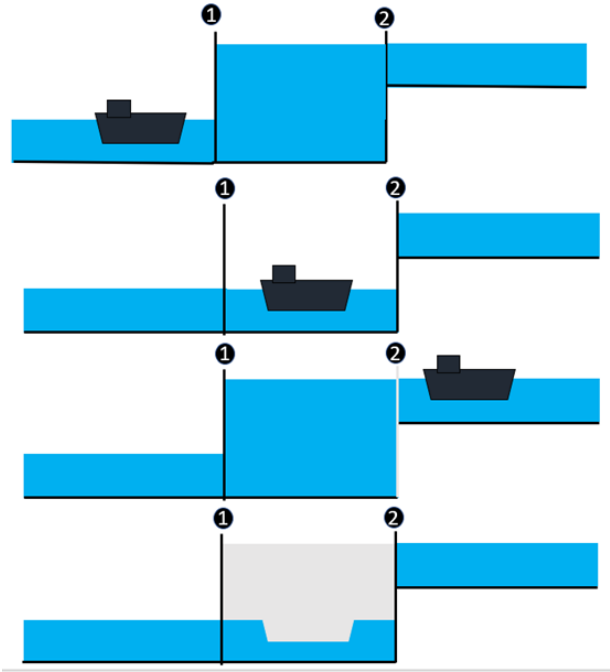
Schipping model



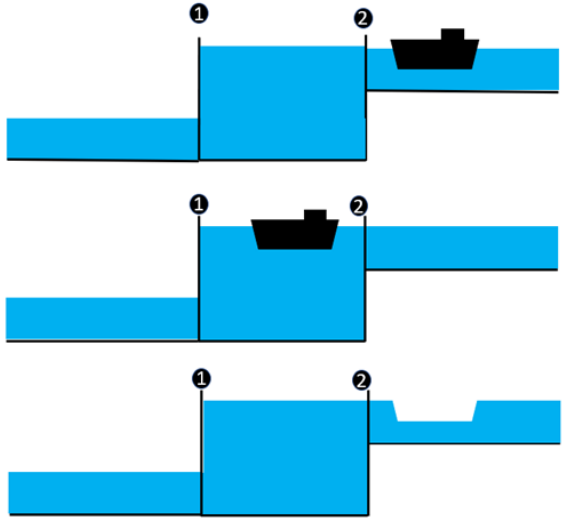
kolk = leeg
richting = opwaarts
versast volume = volume kolk + volume schip/schepen



Initiële toestand kolk = leeg
richting = afwaarts
versast volume = volume kolk - volume schip/schepen



Initiële toestand kolk = vol
richting = opwaarts
versast volume = volume kolk + volume schip/schepen

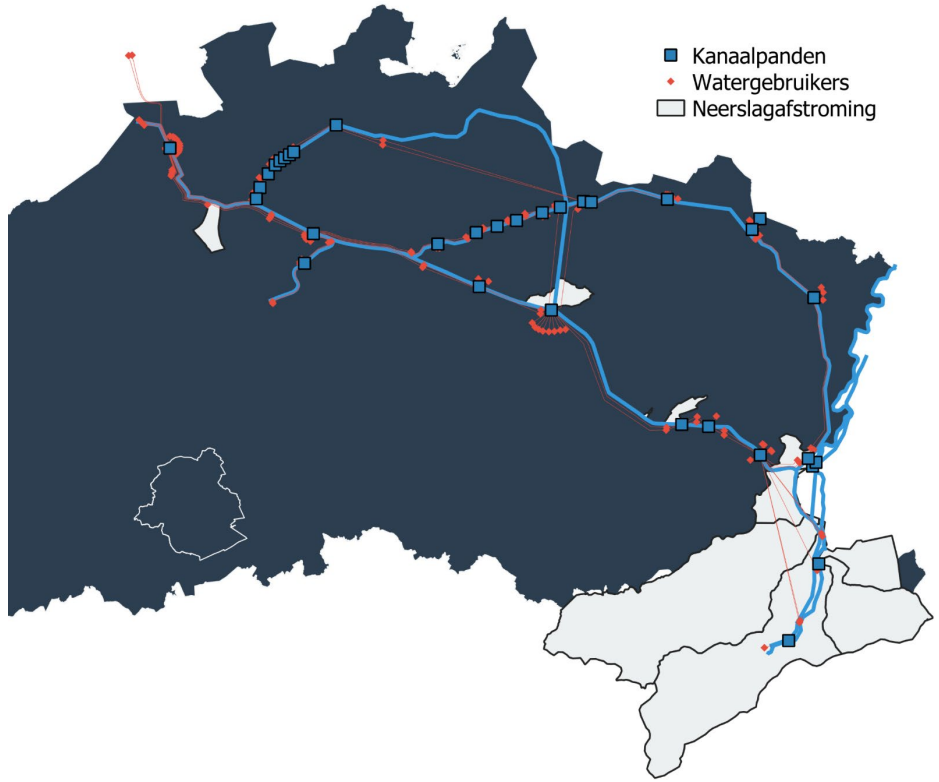


Initiële toestand kolk = vol
richting: afwaarts
versast volume = 0 - volume schip/schepen

Water balance model Albert Canal & Campine Canals

Water shortage analysis

Waterbeschikbaarheid Albertkanaal en Kempische Kanalen	Waterbeschikbaarheid [Mm3/jaar]	
	Jaargem 2005-2019	13-22 sept 2019
Albertkanaal		
Instroom uit Maas	630	261
ABK pand 1 (= opwaarts sluizen Genk)	145	-23
ABK pand 2 (= opwaarts sluizen Diepenbeek)	155	-132
ABK pand 3 (= opwaarts sluizen Hasselt)	160	-114
ABK pand 4 (= opwaarts sluizen Kwaadmechelen-Ham)	56	-220
ABK pand 5 (= opwaarts sluizen Olen)	41	-316
ABK pand 6 (= opwaarts sluizen Wijnegem)	123	-200
Haven van Antwerpen		
Instroom zoutsturing Kreekraksluizen	1	134
Uitstroom naar Zeeschelde via zeesluizen	487	152
Rest uitstroom Haven	-19	-14
Kanaal Briegden-Neerharen en Zuid-Willemsvaart		
Instroom uit Maas	305	173
Kanaal Briegden-Neerharen (tussen sluizen van Lanaken en Neerharen)	-1,2	-2,9
Uitstroom naar Nederland via sluis Bocholt	1	2
Uitstroom naar Nederland via Zuid-Willemsvaart	300	165
Kanaal Bocholt-Herentals		
KBH pand 1 (opwaarts sluis 1 te Lommel)	28,6	-37,2
KBH pand 2 (opwaarts sluis 2 te Mol)	29,3	-37,6
KBH pand 3 (opwaarts sluis 3 te Mol)	28,8	-38,4
KBH pand 4 (opwaarts sluis 4 te Dessel)	9,5	3,7
KBH pand 5 (opwaarts sluis 5 te Dessel)	8,7	3,7
KBH pand 6 (opwaarts sluis 6 te Mol)	5,9	1,0
KBH pand 7 (opwaarts sluis 7 te Geel)	5,5	1,0
KBH pand 8 (opwaarts sluis 8 te Geel)	5,7	0,9
KBH pand 9 (opwaarts sluis 9 te Geel)	5,9	0,9



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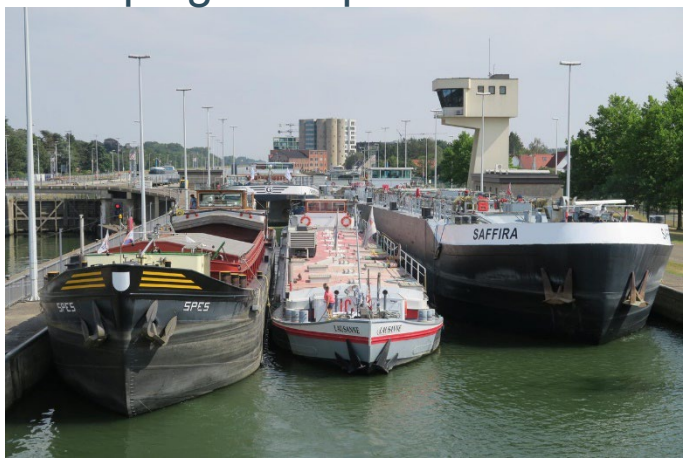
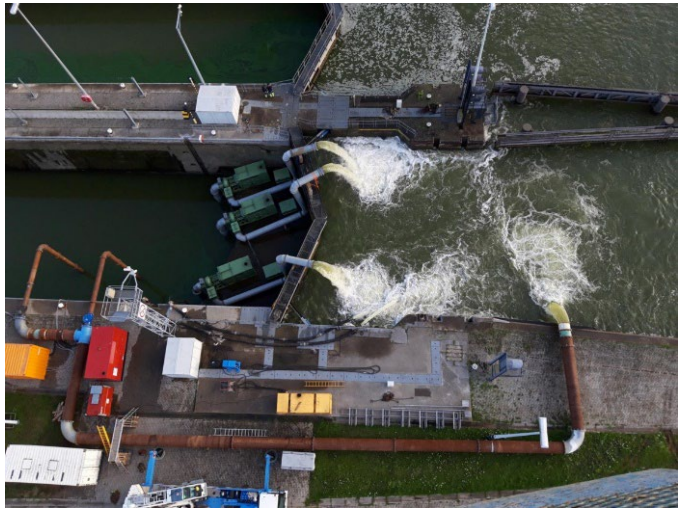
Reactive measures along Albert Canal in dry summers

Grouping of ships at locks

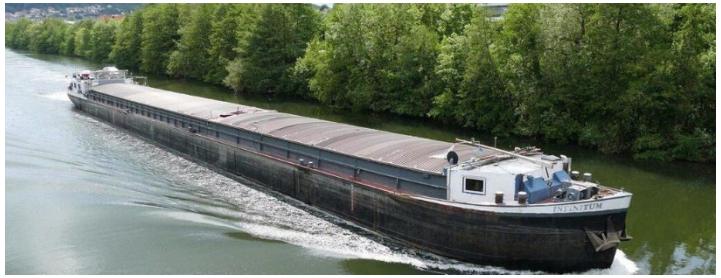


Hydropower stations discontinued

Mobile pumps at locks



Draft limitation



Intake of irrigation canals closed for 50% or 80%

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Reactive assessment framework

: what to do in case of water scarcity during extreme drought?

In case of **imminent water scarcity**
: which anticipatory measures ?

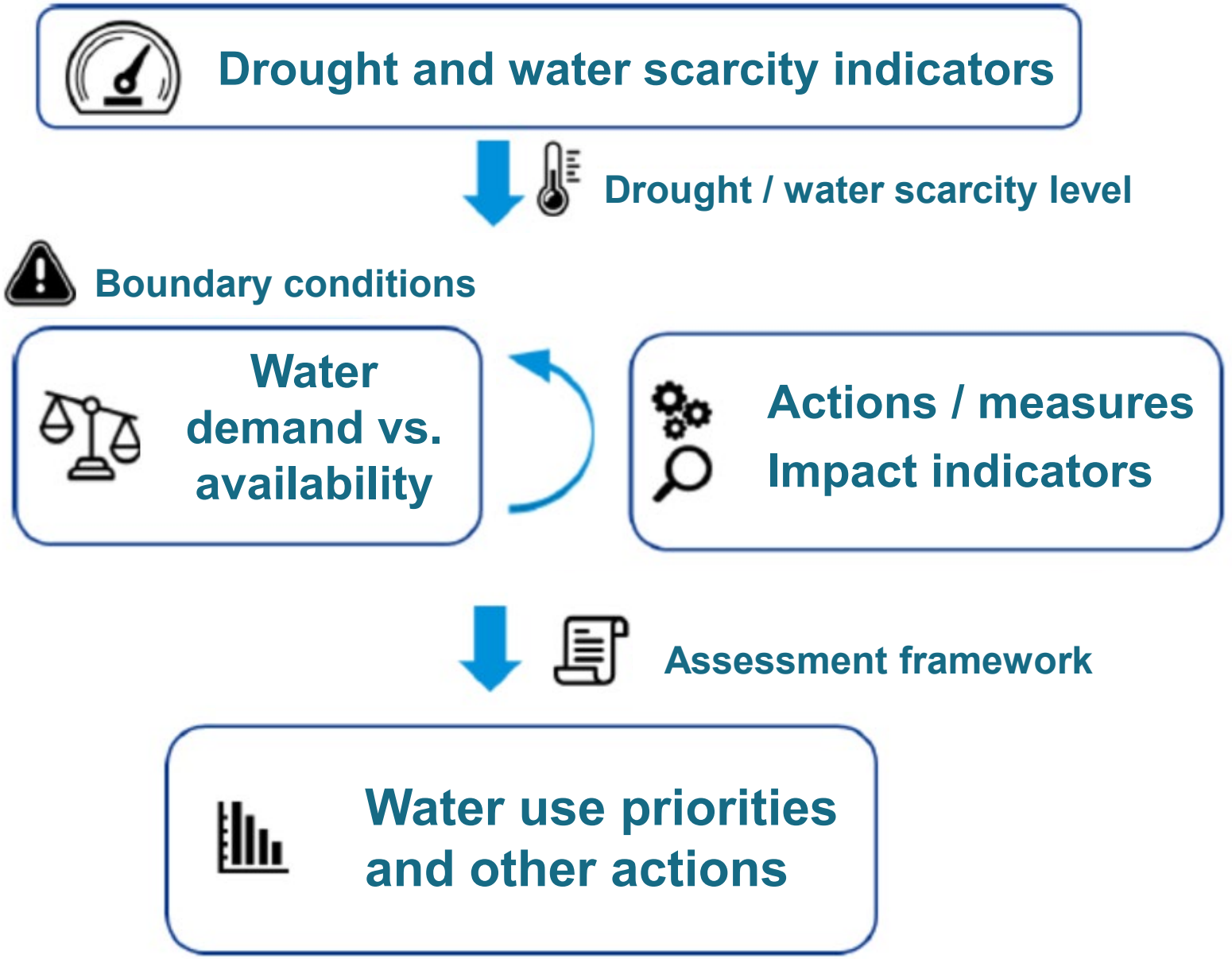
In case of **effective water scarcity**
: how to prioritize water use, taking into account socio-economic and ecological impact?

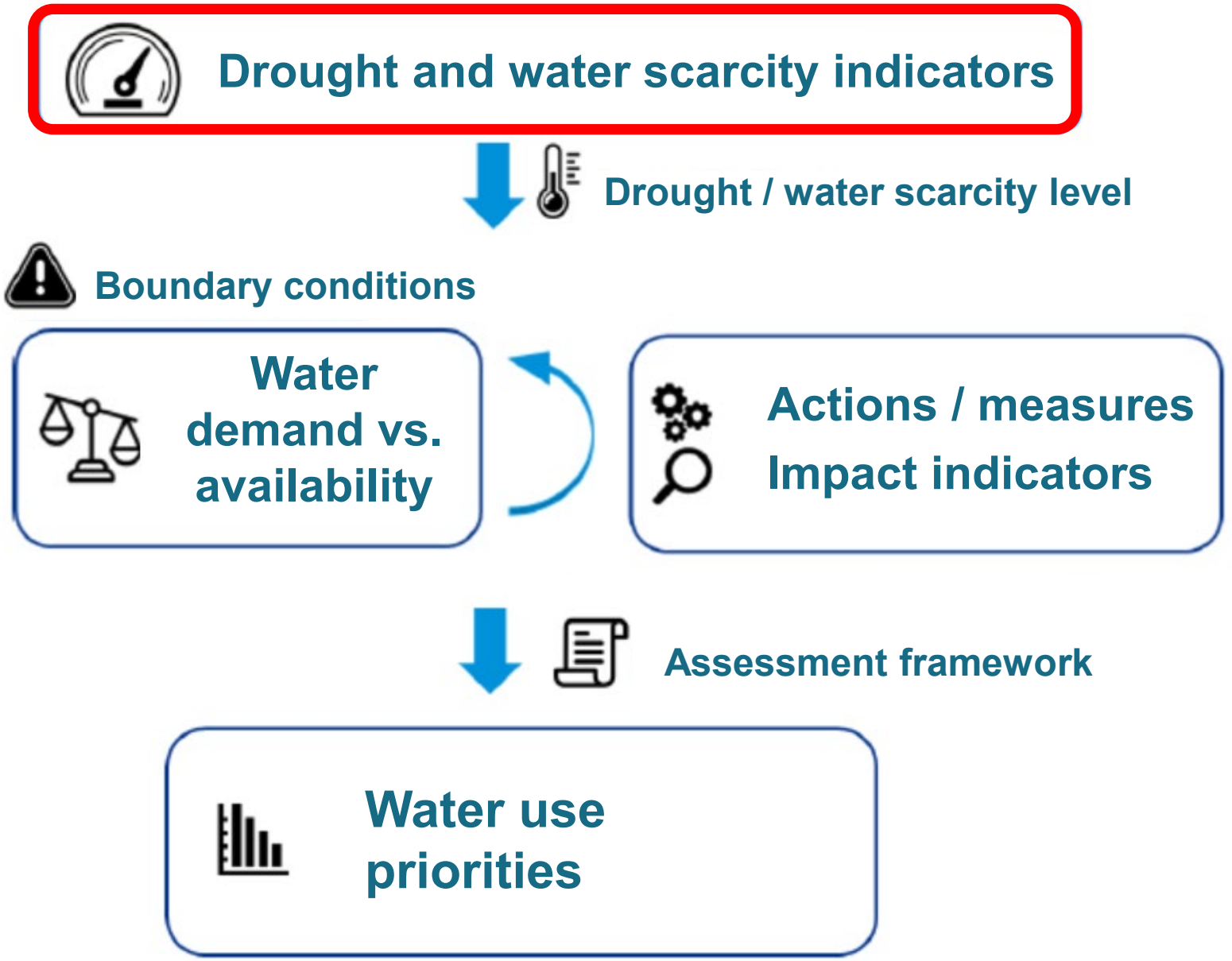
worked on for about a year
with **active involvement of stakeholders**

about 130 stakeholders from:

- ✓ **Authorities**: VMM, De Vlaamse Waterweg, Dep. MOW, Provincies, Polders en Wateringen, Steden en Gemeenten, Crisisdiensten, Dep. Omgeving, Dep. Landbouw en Visserij, Agentschap Natuur en Bos, Dep. EWI
- ✓ **Drinking water companies**
- ✓ **Industry**
- ✓ **Agriculture and horticulture**
- ✓ **Nature sector**
- ✓ **Shipping**
- ✓ **Water and sewage companies**
- ✓ **Advisory Councils**
- ✓ **Care and health**
- ✓ **Experts, research centers**

Vlaamse Overheid · VLAAMSE MILIEUMAATSCHAPPIJ · De Vlaamse Waterweg · DEPARTEMENT MOBILITEIT & OPENBARE WERKEN · DEPARTEMENT LANDBOUW & VISSERIJ · DEPARTEMENT OMGEVING · AGENTSCHAP NATUUR & BOS · DEPARTEMENT ECONOMIE WETENSCHAP & INNOVATIE · KU LEUVEN · Sumaqua · KPMG · Bodemkundige Dienst van België · Universiteit Antwerpen


Drought and water scarcity indicators
Drought / water scarcity level
Boundary conditions
Water demand vs. availability
Actions / measures
Impact indicators
Assessment framework
Water use priorities and other actions

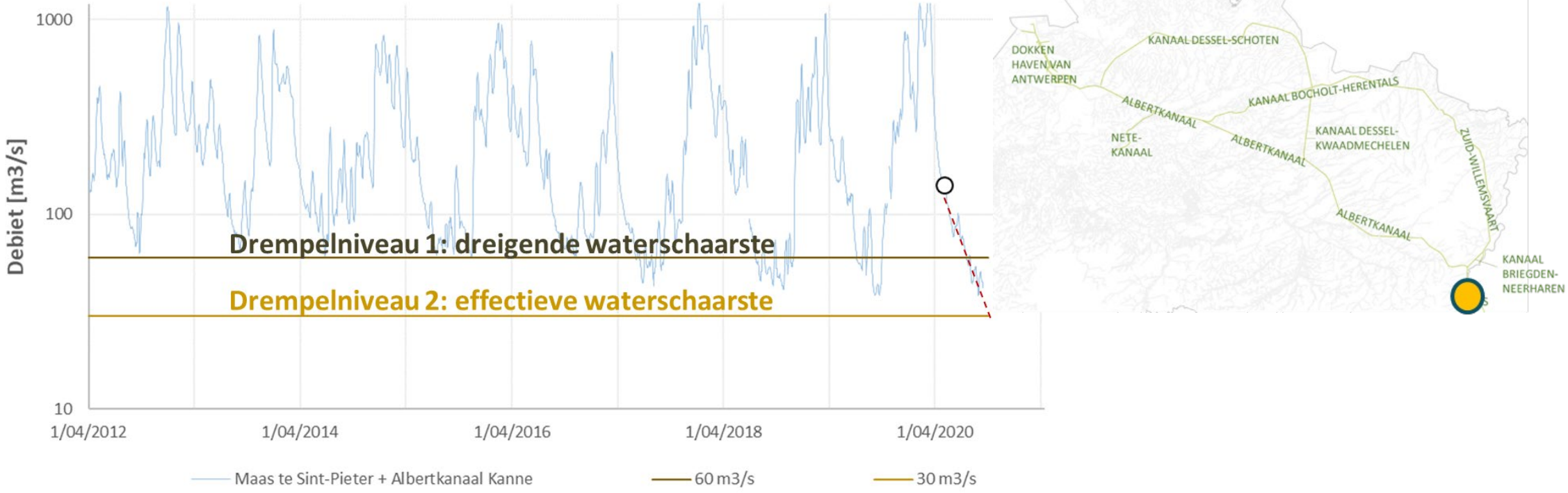

Drought and water scarcity indicators
Drought / water scarcity level
Boundary conditions
Water demand vs. availability
Actions / measures
Impact indicators
Assessment framework
Water use priorities

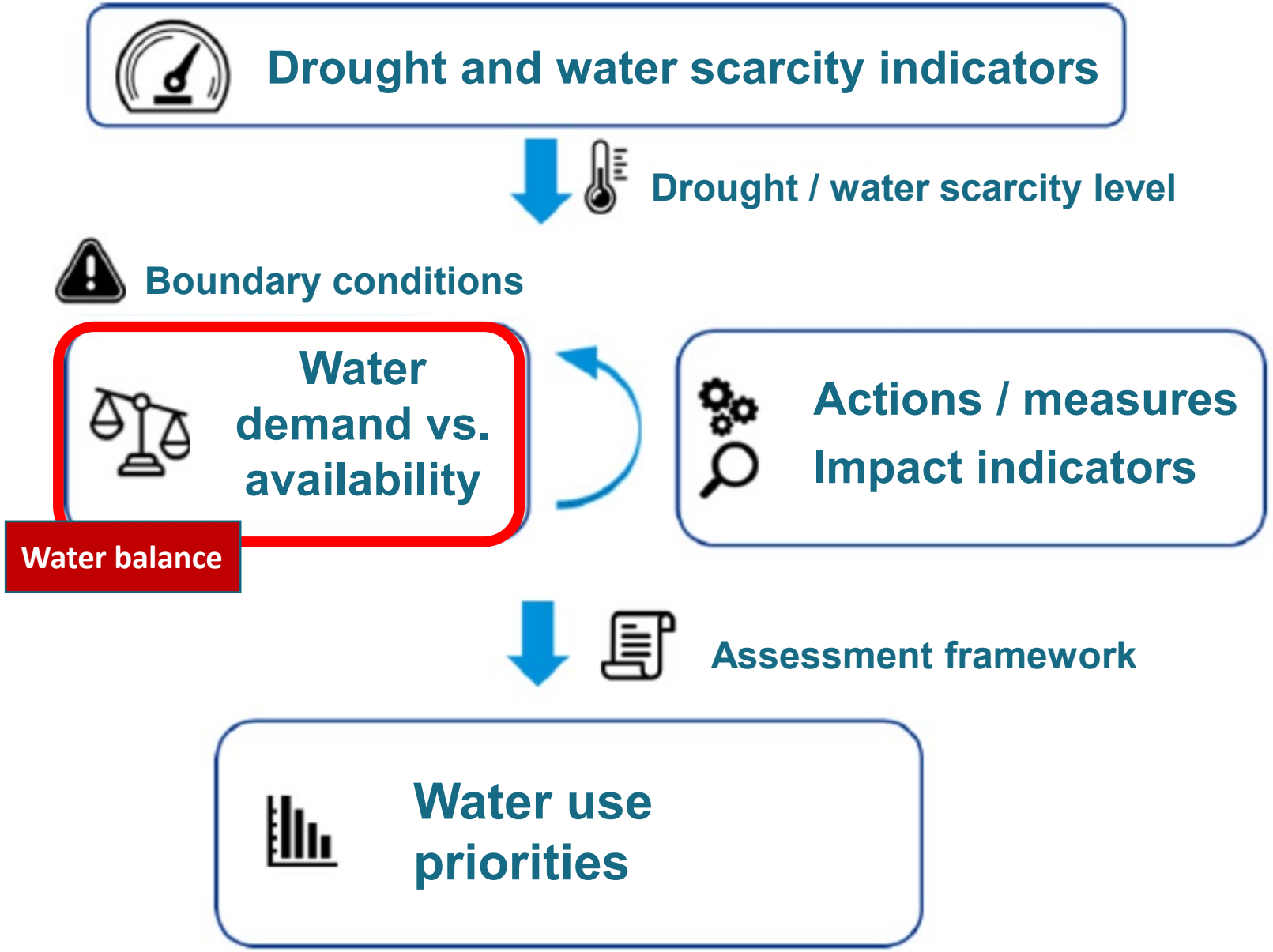
DROUGHT and WATER SCARCITY INDICATORS

Provide real-time information about:
Is there an imminent danger of water scarcity (for 1 or more sectors)?
Is there effective water scarcity?

Example Albert Canal:

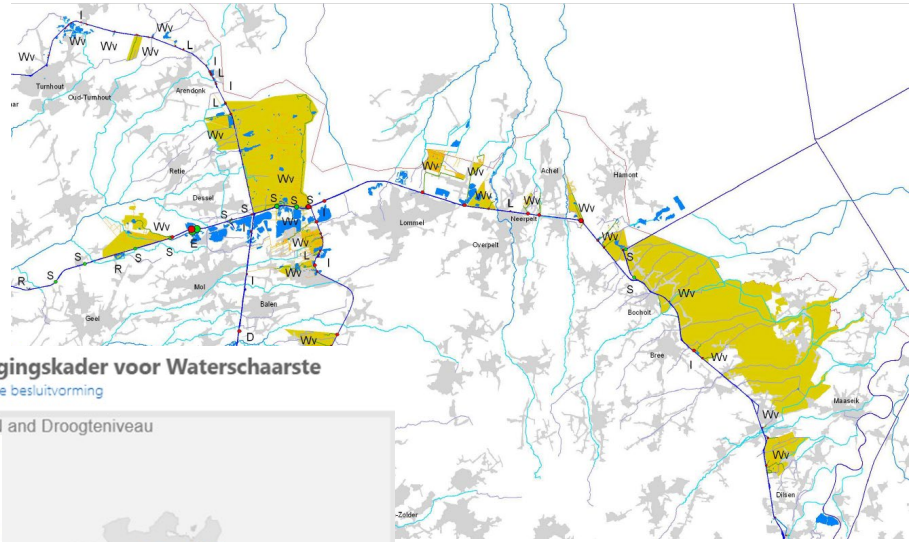
Meuse river discharge (water availability compared to the Meuse Water Treaty)

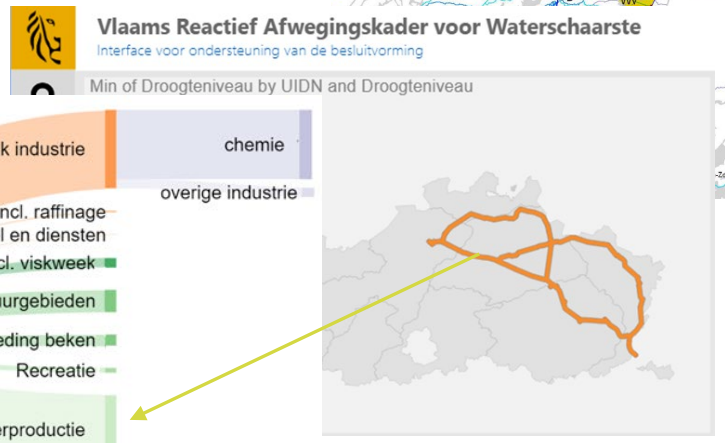


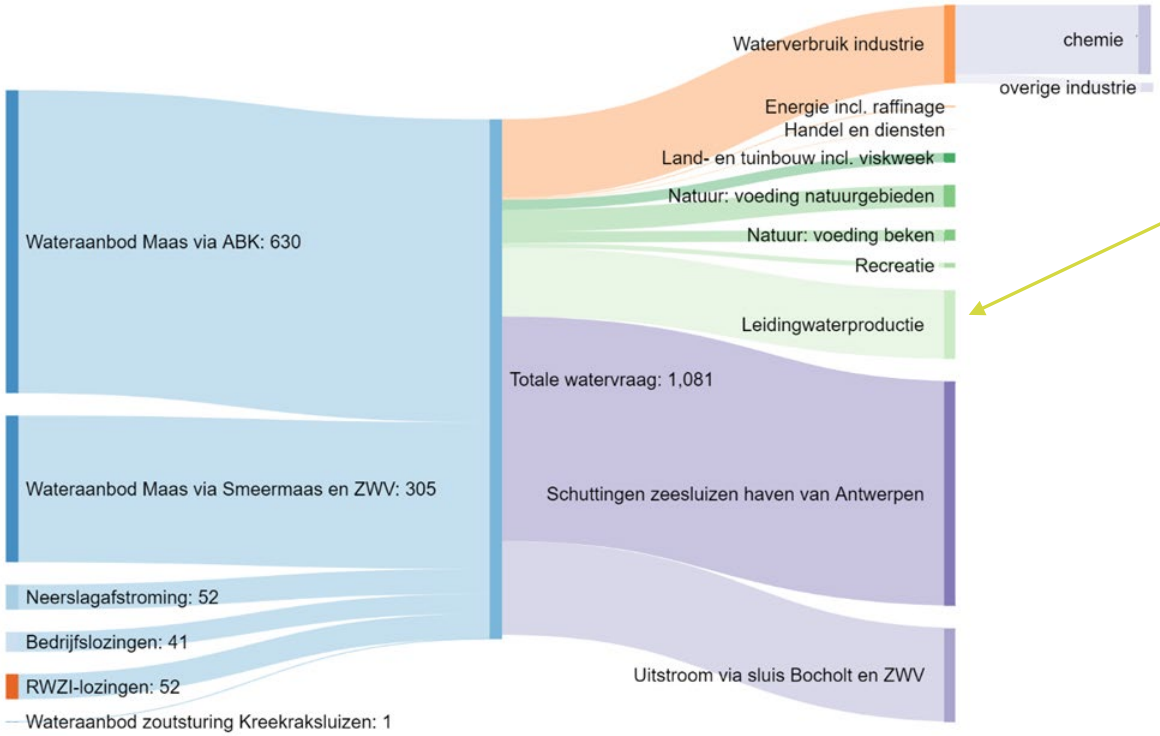

Drought and water scarcity indicators
Drought / water scarcity level
Boundary conditions
Water demand vs. availability
Water balance
Actions / measures
Impact indicators
Assessment framework
Water use priorities

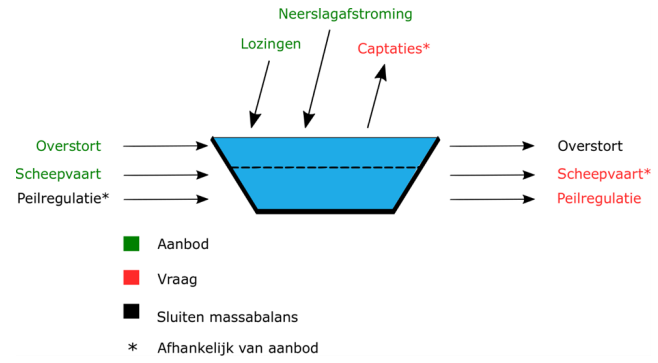
ASSESSING the WATER BALANCE

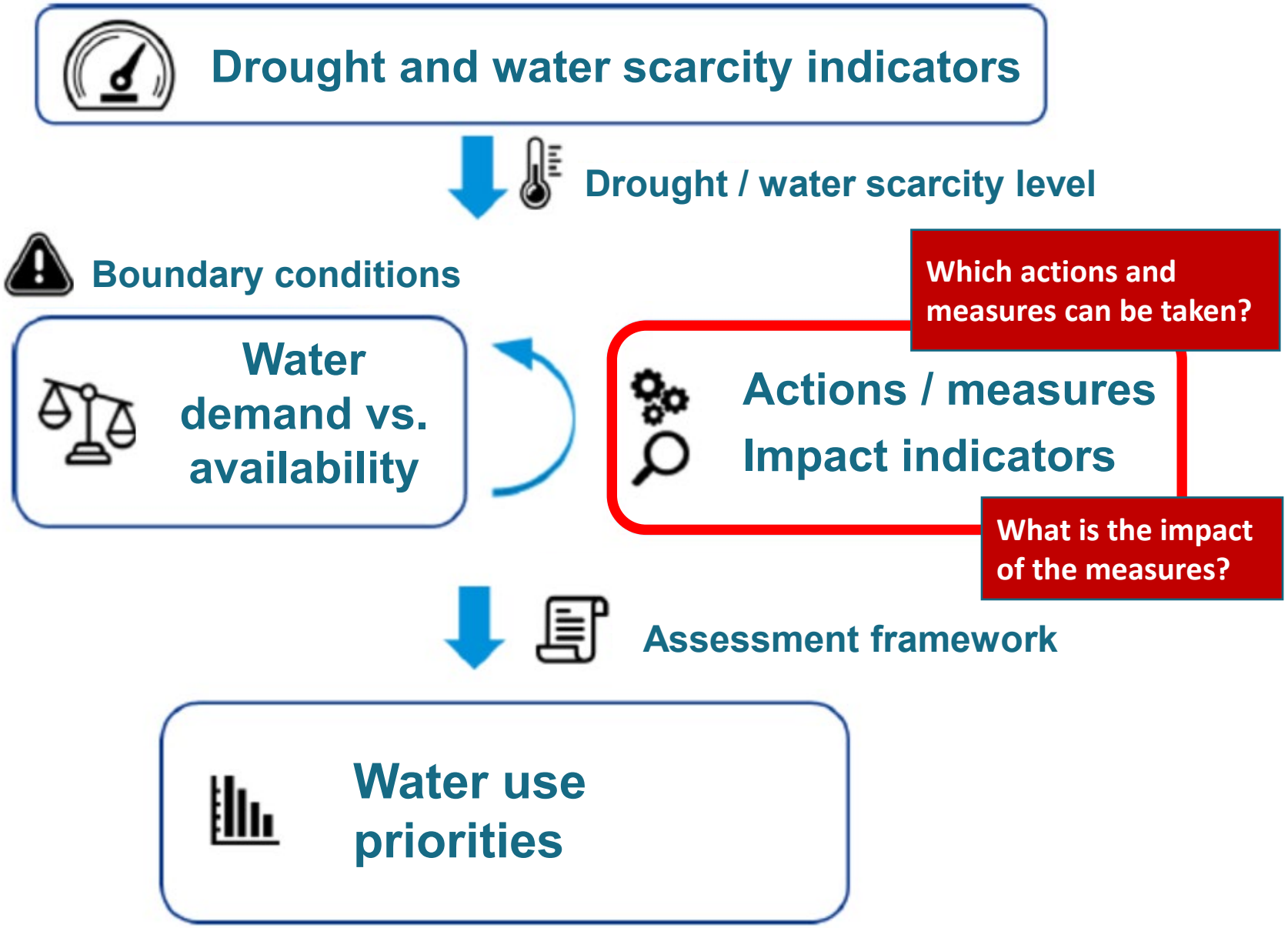
- per subcatchment and river or canal reach
- in real time depending on drought and water availability conditions










Drought and water scarcity indicators
Drought / water scarcity level
Boundary conditions
Water demand vs. availability
Which actions and measures can be taken?
Actions / measures
Impact indicators
What is the impact of the measures?
Assessment framework
Water use priorities

POSSIBLE REACTIVE ACTIONS and MEASURES

Water supply extension or regulation measures

- adjust hydraulic control and/or pump stations and/or mobile pumps
- switch to other water sources
- create additional water sources

Water use reduction measures or actions

- shipping: group ships at locks, draft restrictions, ban on shipping
- all water consumers (industry, households, drinking water companies, agriculture, nature, recreation, …): abstraction limitation
- agriculture: irrigation limitation

for the use of tap water, surface water, phreatic groundwater; for reuse of effluent water

POSSIBLE REACTIVE ACTIONS and MEASURES

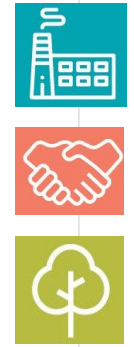
Water use reduction measures or actions (continuing)

- for salt concentration indicators along canals where reverse discharge management is applied at sea locks: **Stop reverse discharge management**
- after cyano algae bloom notification: **Ban on water abstraction for food and fodder crops and livestock**; water use not recommended for other applications
- after cyano algae bloom notification: **No water recreation**
- for water quality indicators or notification of botulism for recreational waters: **No water recreation**

IMPACT ANALYSIS of ACTIONS and MEASURES

Impact assessment:

- **Positive impact by reduced water shortages** (via water balance)
- **Positive impact by reduced consequences**
  - **Economic consequences** (e.g. company turnover, higher cost of switching to tap water use)
  - **Social consequences** (e.g. on company employment)
  - **Ecological consequences** (e.g. loss of ecosystem services, reintroduction cost)
- **Cost of measure** (e.g. production loss due to irrigation limitation, cost of mobile pumps, economic loss of navigation ban)

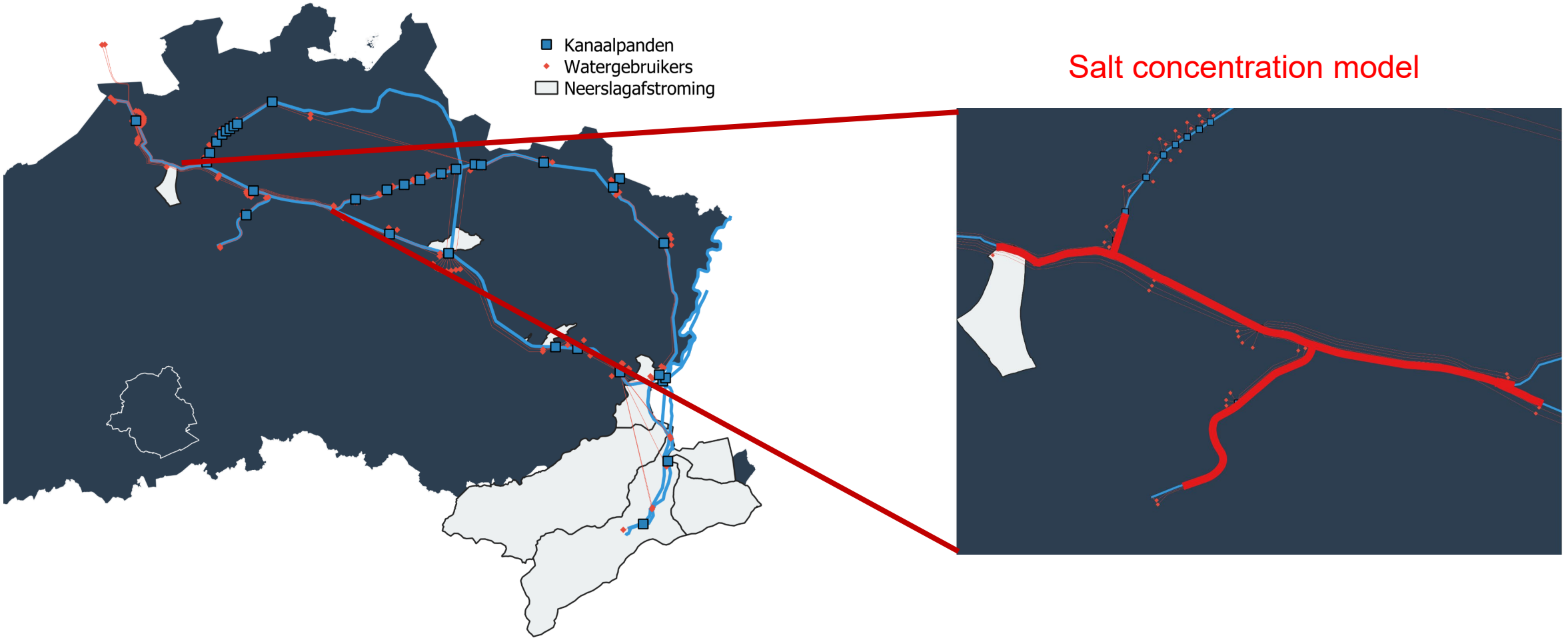


Prioritizing measures based on highest net benefit

So far: limited to direct, local costs & short-term damage

Ongoing: cascading effects of indirect costs and longer-term damage

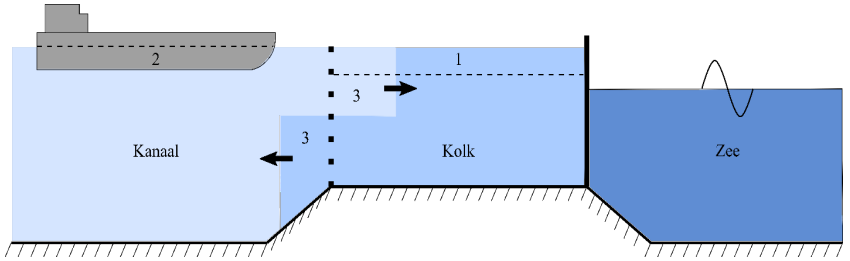
Salt intrusion model Albert Canal

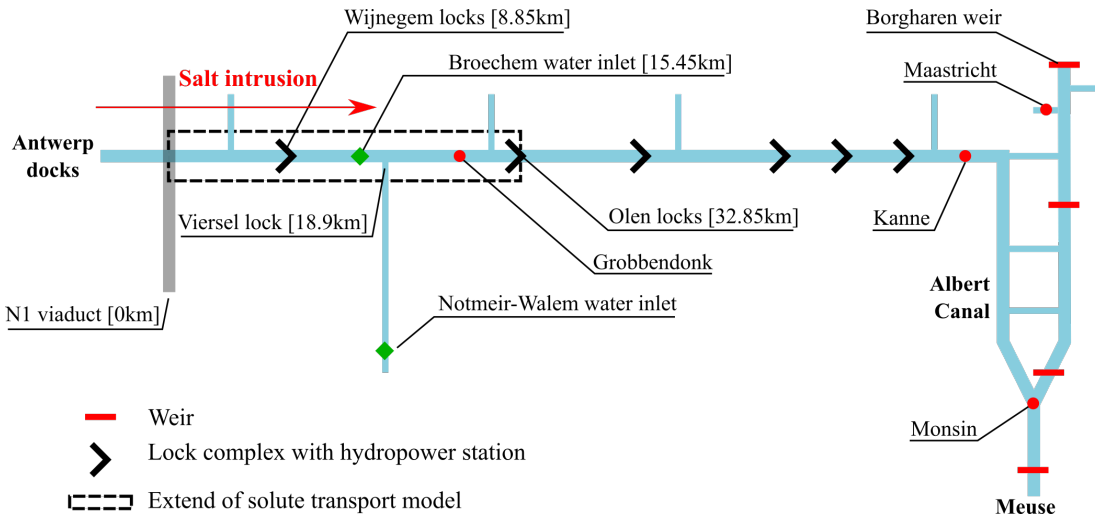


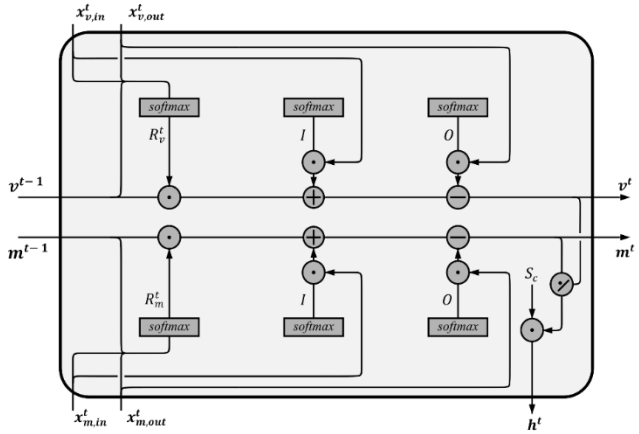
Salt intrusion model: methodology

Physics-informed machine learning method

- Model types tested:
  - Fine volume model flow & advection-dispersion equations
  - Conceptual model
  - Innovative approach: Physics-informed machine learning method for pollutant transport modelling in surface waters
- Boundary conditions:
  - Fixed concentrations for Meuse water
  - Inflow by density currents, i.e. sea locks with Scheldt:







Bertels, D., Willems, P. (2023), 'Physics-informed machine learning method for modelling transport of a conservative pollutant in surface water systems', Journal of Hydrology, 619, 129354, 1-14

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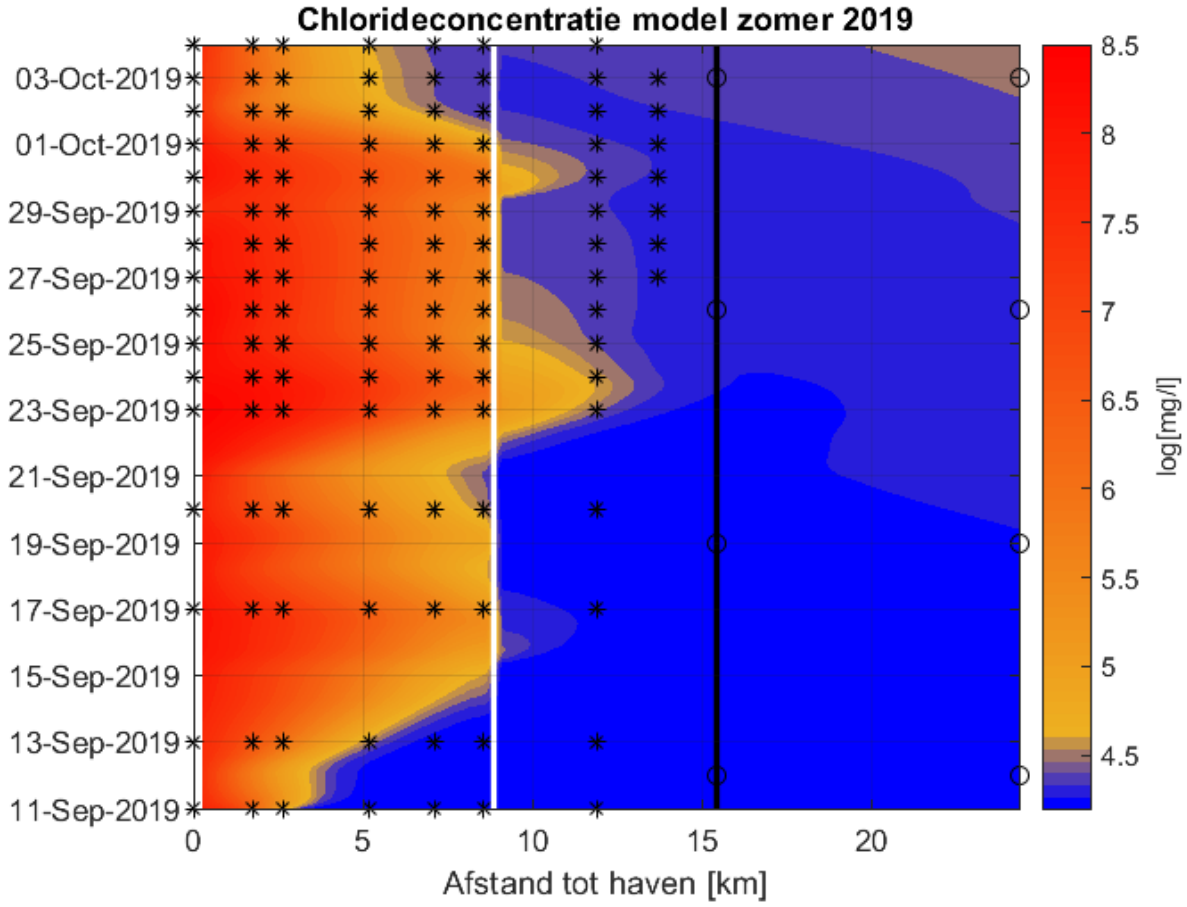
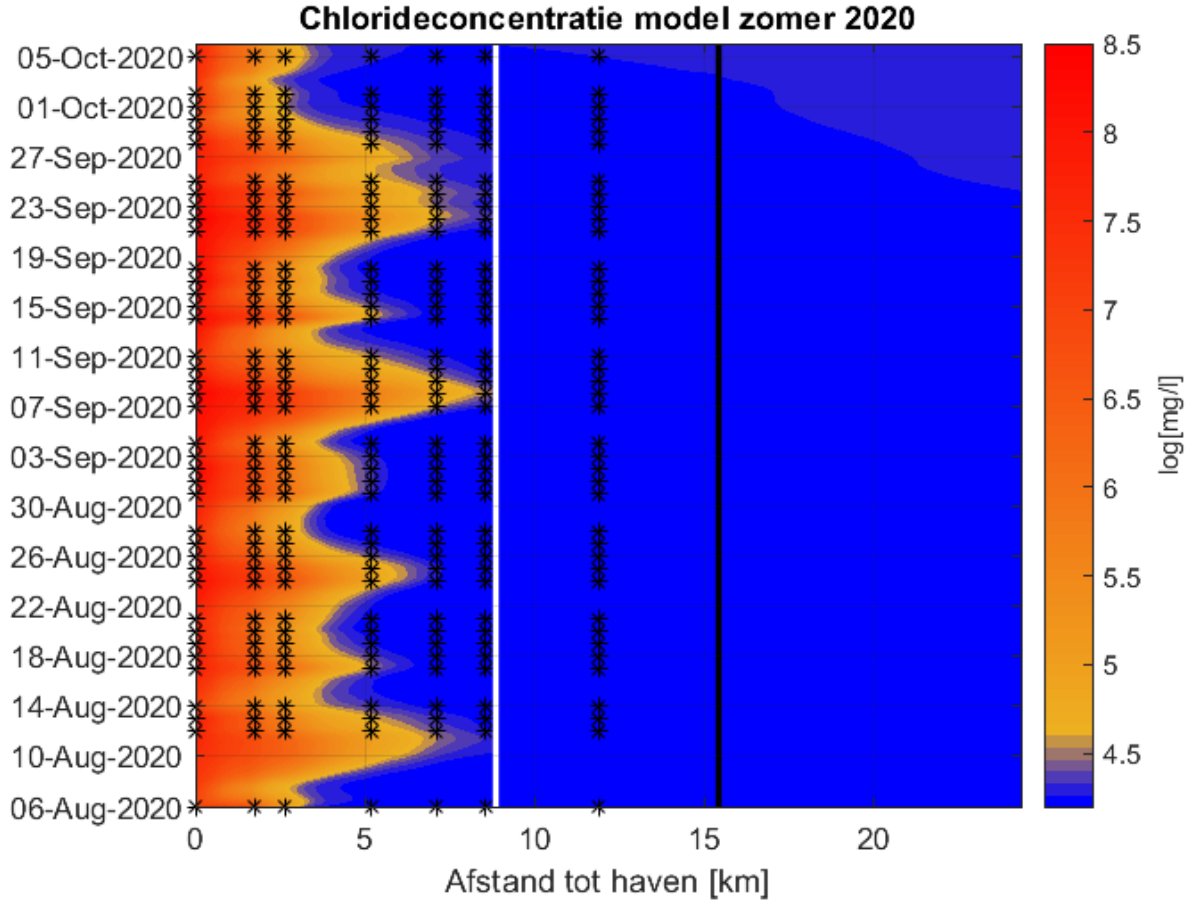
Salt intrusion model results

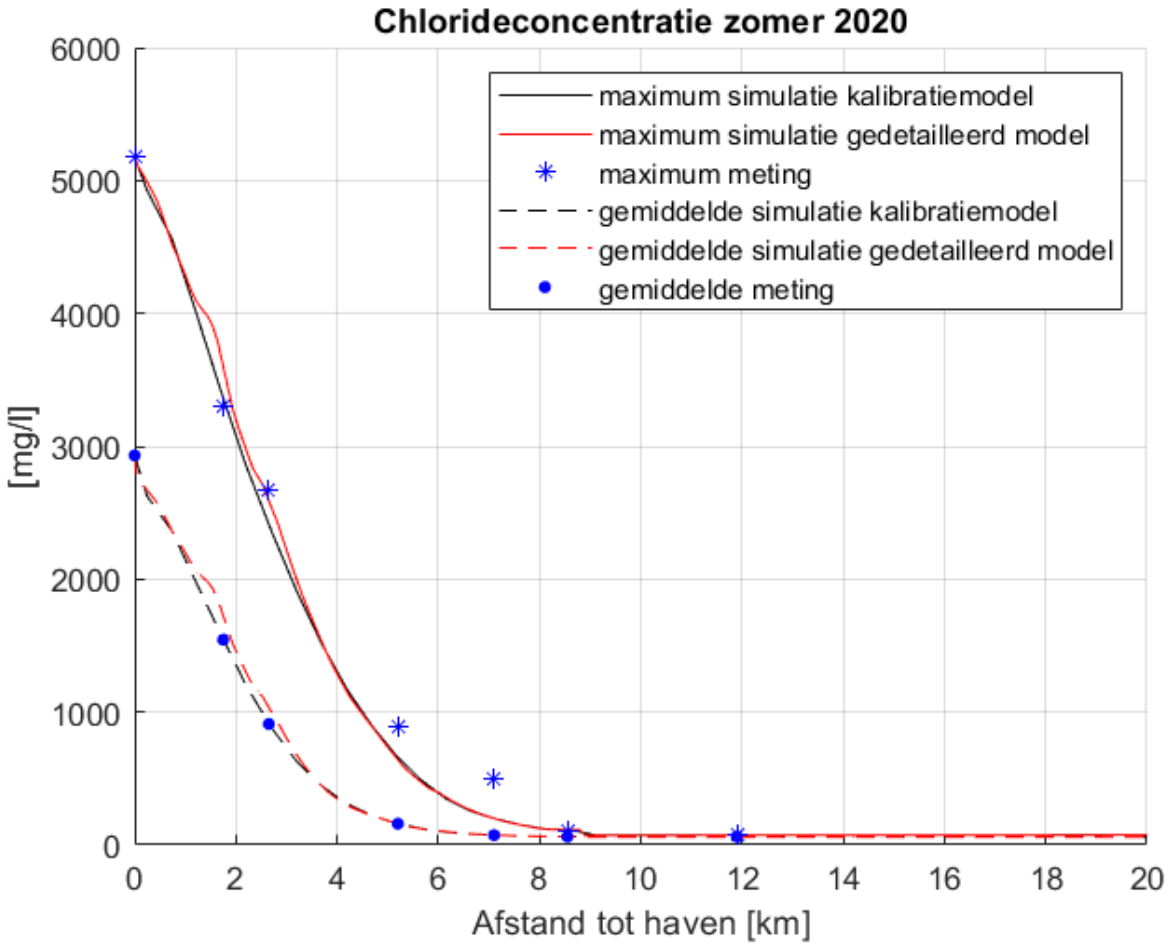
for summers 2019 & 2020:



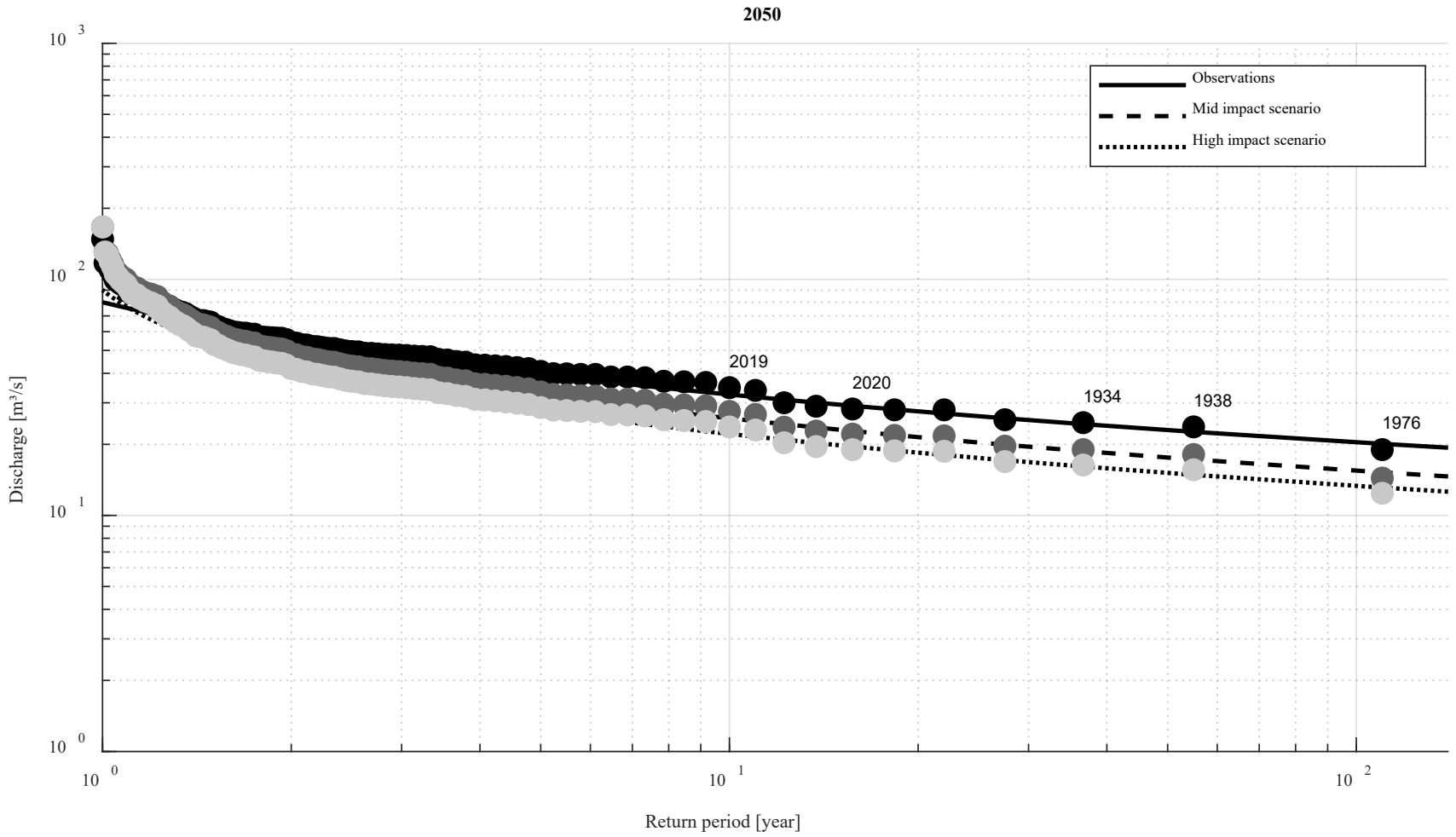


Salt intrusion model results

Validation for summer 2020



Impact of climate change scenarios on low Meuse flows at Monsin



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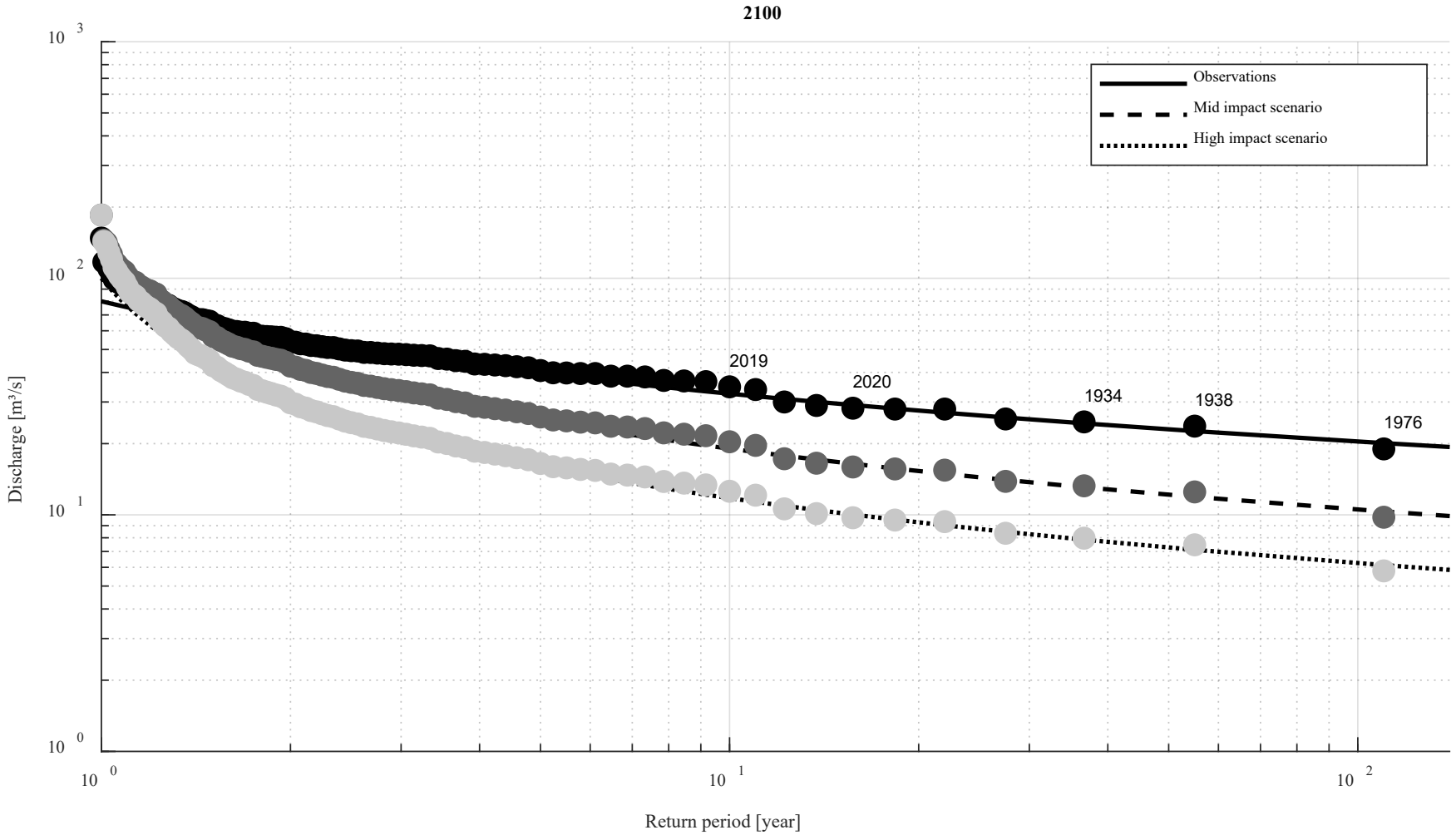
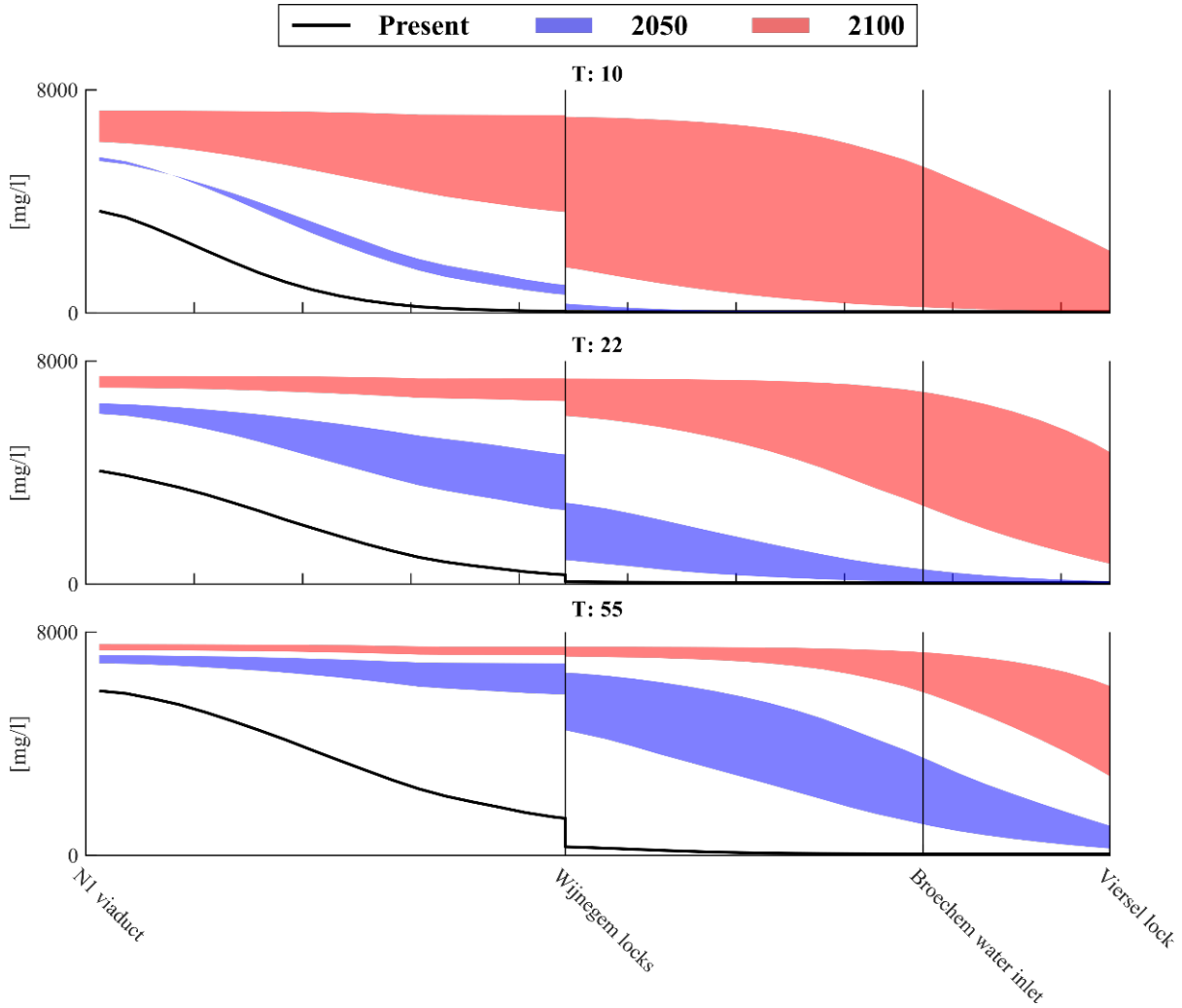


Impact of climate change scenarios on low Meuse flows at Monsin



Bertels, D., Willems, P. (2022), 'Climate change impact on salinization of drinking water inlets along the Campine Canals, Belgium', Journal of Hydrology: Regional Studies, 42, 101129

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patrick.willems@kuleuven.be