Aquifer storage and recovery (ASR) to enable water reuse across sectors: wastewater from food industry turned into irrigation water for greenhouses

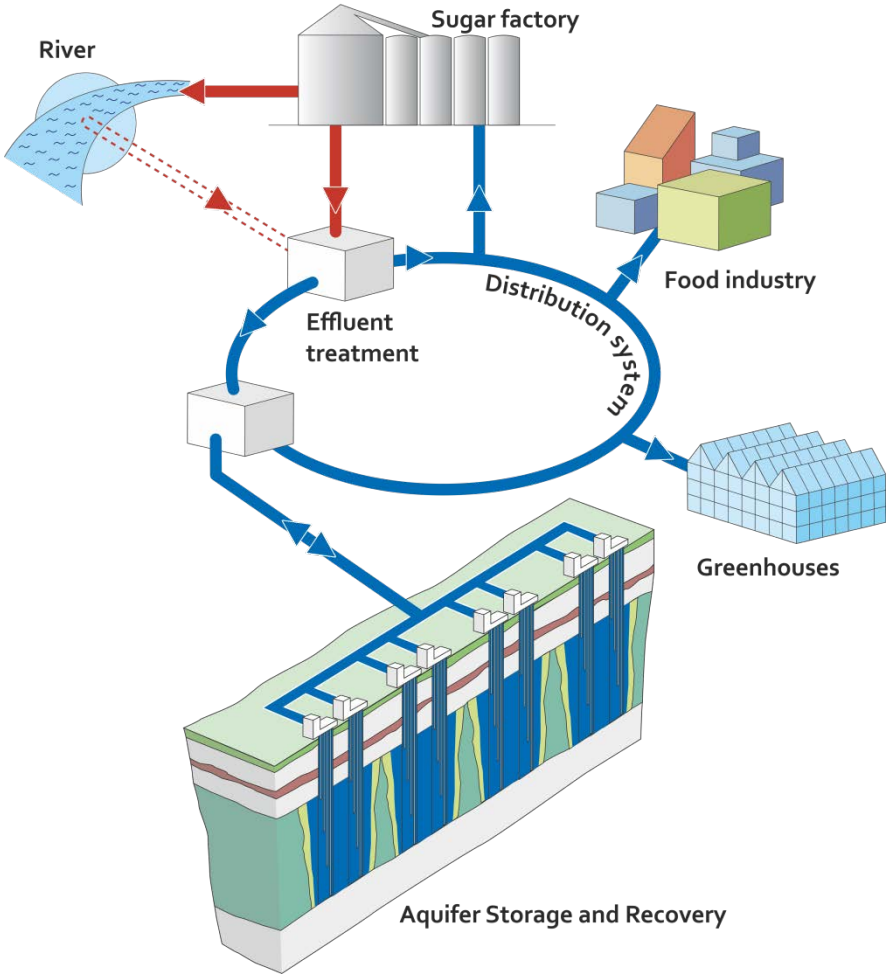
Klaasjan J. Raat, KWR Watercycle Research Institute, Nieuwegein, the Netherlands; Koen G. Zuurbier, Allied Waters, Nieuwegein, the Netherlands; Piet Janmaat, Tuinbouwontwikkelingsmaatschappij,'s Hertogenbosch, the Netherlands; Gerard A. van den Berg, KWR Watercycle Research Institute, Nieuwegein, the Netherlands

The continuous availability of freshwater of very good and reliable quality is a precondition for modern intensive greenhouse horticulture. For Dinteloord, the Netherlands, a 260 hectares greenhouse area under development, the freshwater availability was not self-evident. Although the water needs are largely satisfied through the collection of rainwater and its storage in surface basins, serious shortages arise during drought periods.

To guarantee the supply of irrigation water at all times, an advanced sustainable freshwater supply was realized. Effluent from the neighboring sugar factory is converted into large volumes of high-quality irrigation water in 3 treatment steps: rapid sand filtration, ultra-filtration, reverse osmosis. Aquifer storage and recovery (ASR) is applied to balance the availability of this reuse water in Autumn and Winter with the demand for additional irrigation water by the local farmers in Spring and Summer.

The ASR system has been in full operation since February 2018 and provides local farmers with 300.000 m^3 of freshwater per year, in addition to the rainwater that is already harvested and stored in aboveground basins. This additional freshwater is stored underground using eight ASR wells. The sugar factory, farmers and the ASR system are connected by a 5km distribution loop, guaranteeing a maximum supply of 200m^3 of fresh irrigation water per hour during dry spells. Consequently, farmers enjoy a year-round supply of sufficient high-quality irrigation water, without the need for a heavy load on the already minimal above-ground space. As well as delivering irrigation water to farmers, water is also re-distributed to the sugar factory and to nearby food processing industries.

The system is an example of hybrid grey and green infrastructure, demonstrating how the underground can contribute to water reuse in the circular economy: farmers grow their tomatoes and egg plants on reuse water from sugar beets. The system is collectively owned by the greenhouse farmers and costs are covered by a pay-per-use system.



Aquifer Storage and Recovery (ASR) to enable water reuse across sectors

Wastewater from food industry turned into irrigation water for greenhouses

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Koen G. Zuurbier (KWR/Allied Waters), Piet Janmaat (TOM), Gerard A. van den Berg

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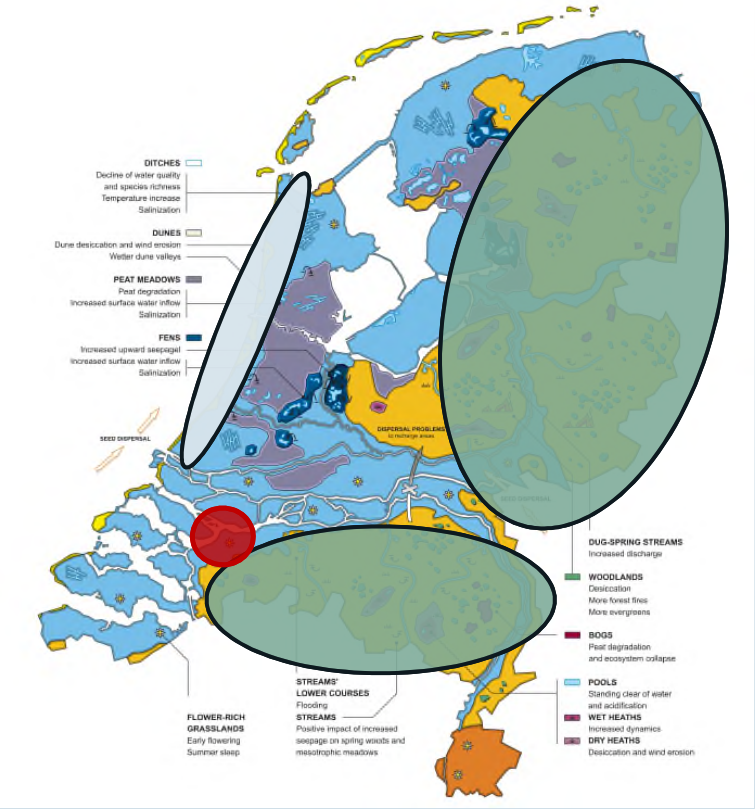
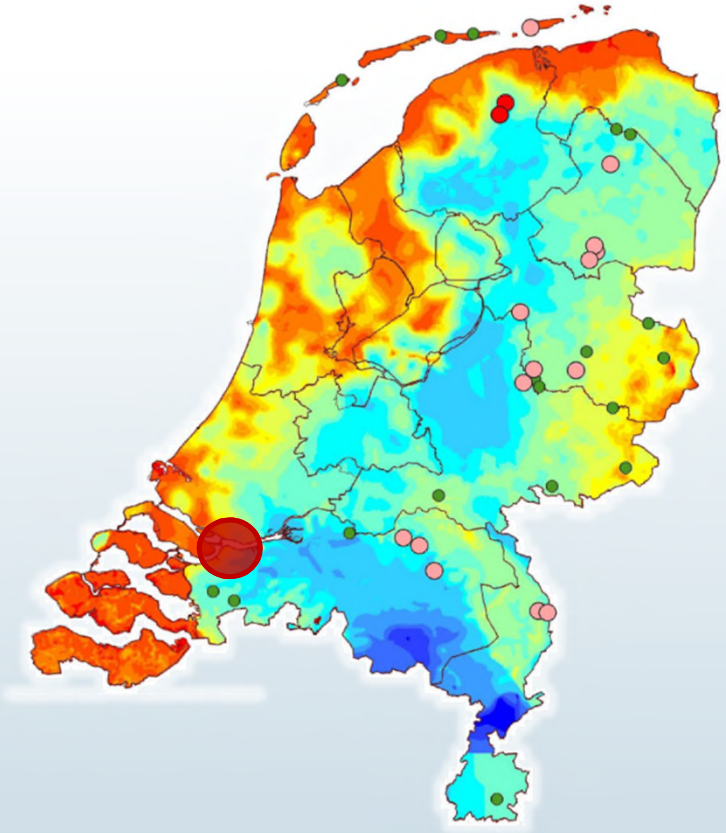
Water resources in the Netherlands



WITTE ET AL., 2012. HYDROL. EARTH SYST. SCI. 16: 3945-3957.



DEPTH OF THE FRESH-BRACKISH GROUNDWATER INTERFACE

ASR to enable water reuse across sectors

Dinteloord, a greenhouse area developed between 2010 - 2017

- 200 ha greenhouses (tomatoes, egg plants)
- 50 ha industry
- 120 ha sugar factory

- Rainwater in small basins = primary source
- Estimated 20% deficit (300.000m^3/yr)
- A single day without water will result in multi-million € damage

- <u>Authorities do not allow for the use of groundwater or surface water</u>

ASR to enable water reuse across sectors

Reuse water from food industry → irrigation water for farmers

Sugar factory

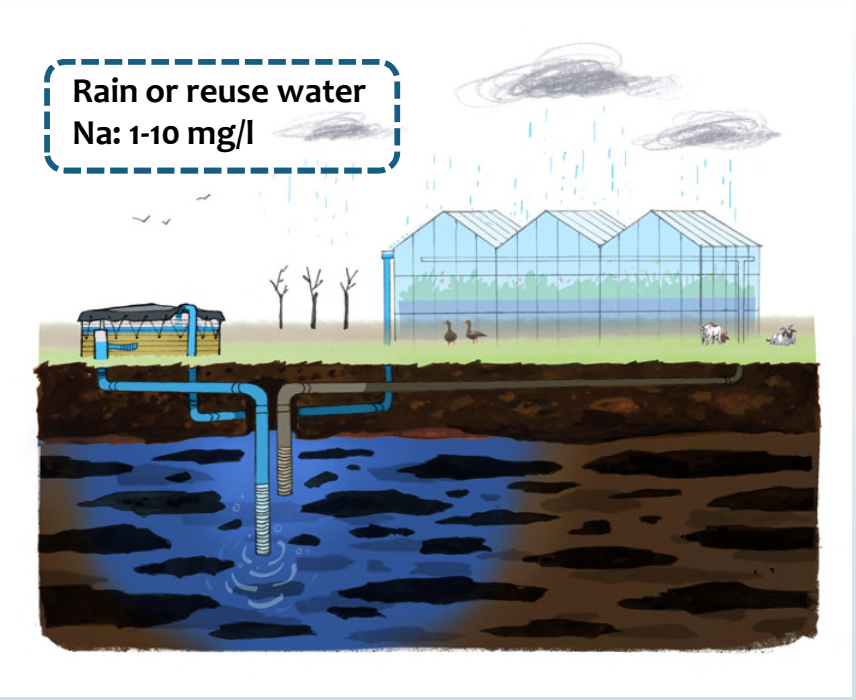
- 2,5 mln ton of sugar beets
- 1,8 mln m^3 of waste water produced (Sep – Jan)

- 420.000 m^3 is treated (reverse osmosis)
- 300.000 m^3 freshwater water produced (Na < 1mg/L)!
- 60 m^3/h from September to January

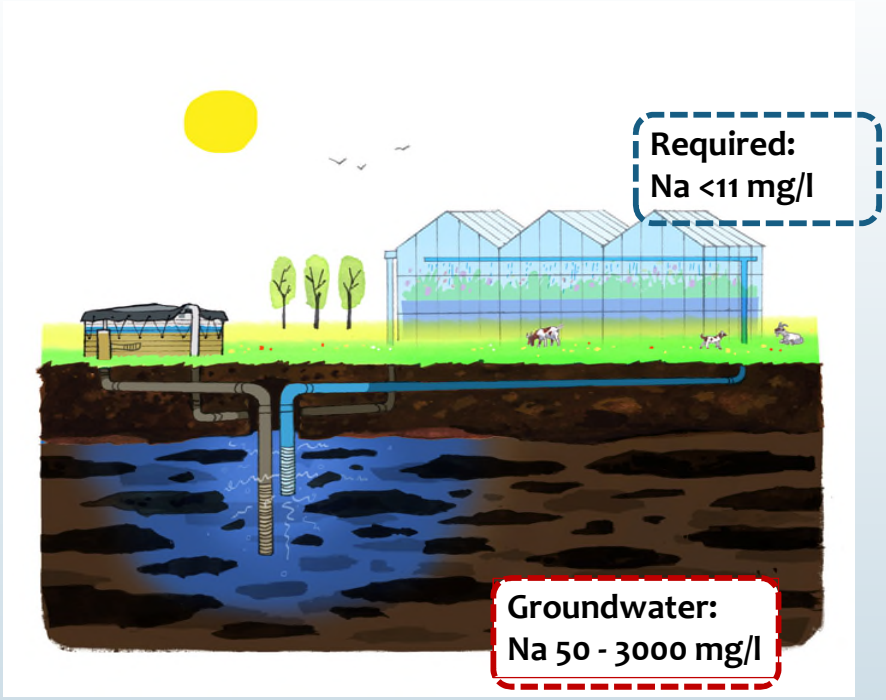
- <u>Where to water store until Spring and Summer?</u>

ASR to enable water reuse across sectors

ASR to balance water supply (autumn, winter) and demand (spring, summer)



Autumn, Winter

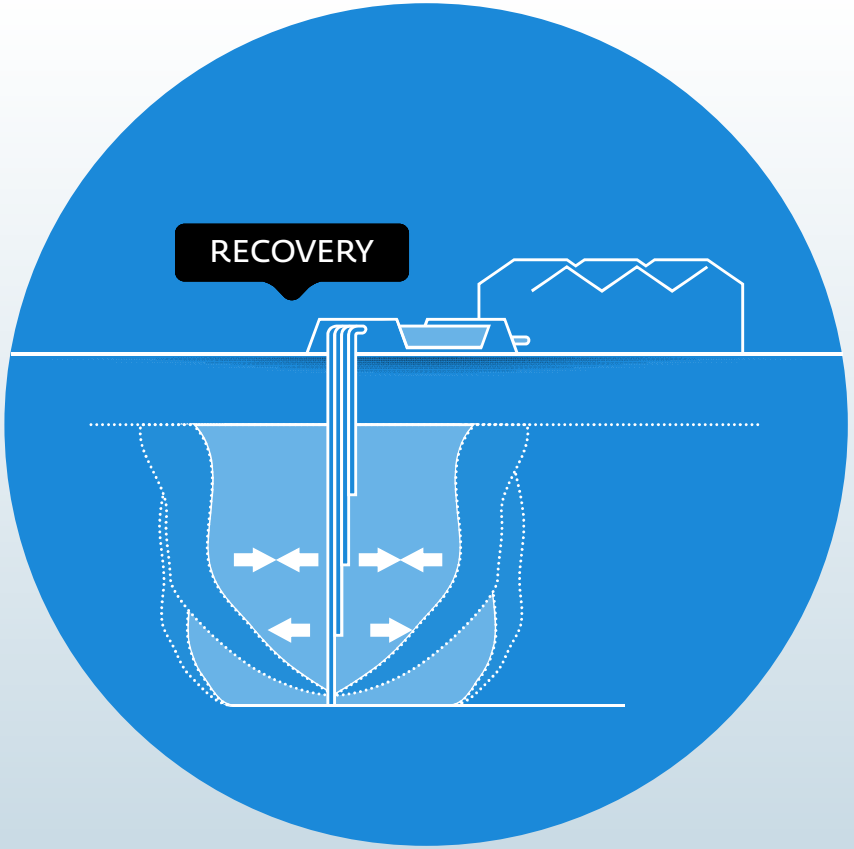


Spring, Summer

ASR to enable water reuse across sectors

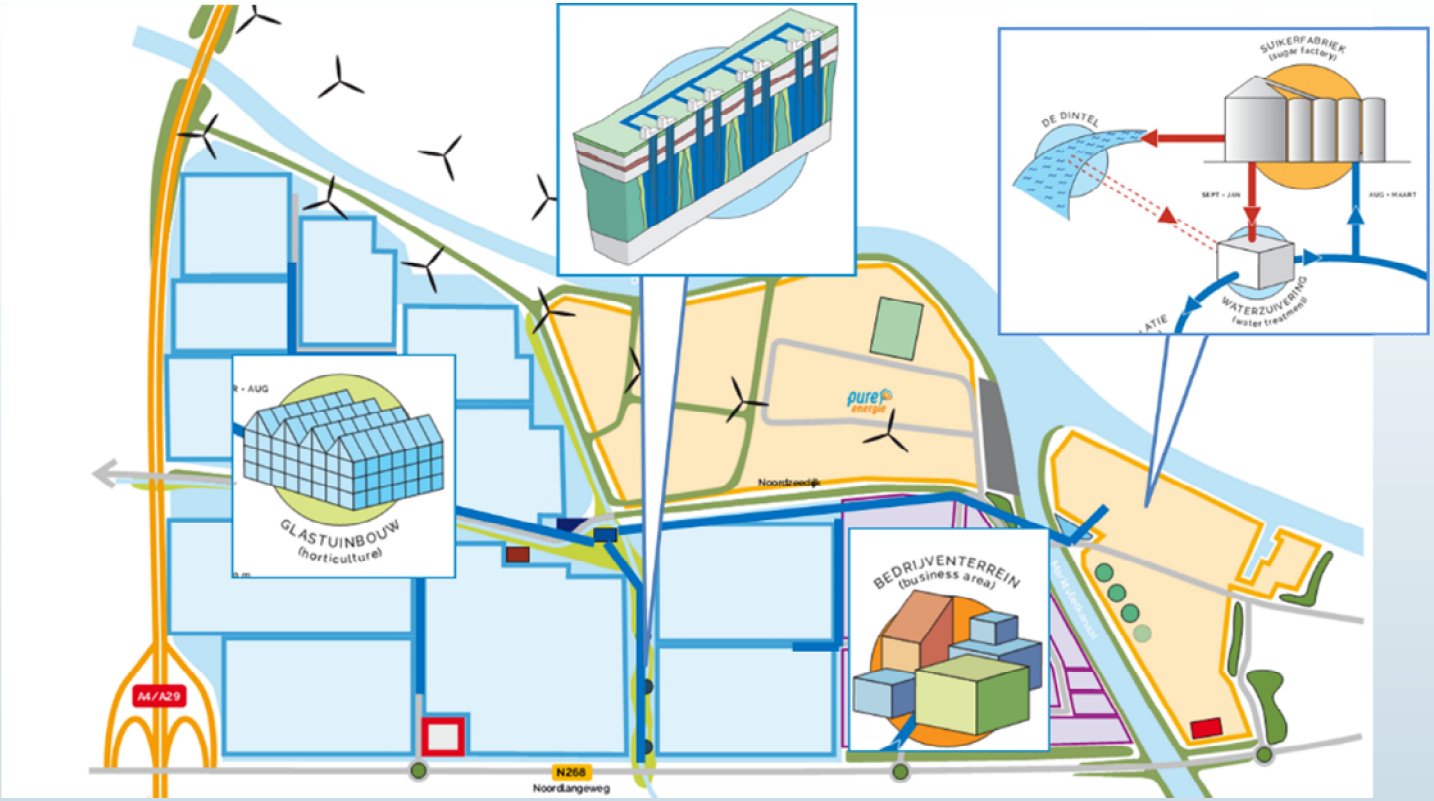
ASR tailor-made for application in saline groundwater environments

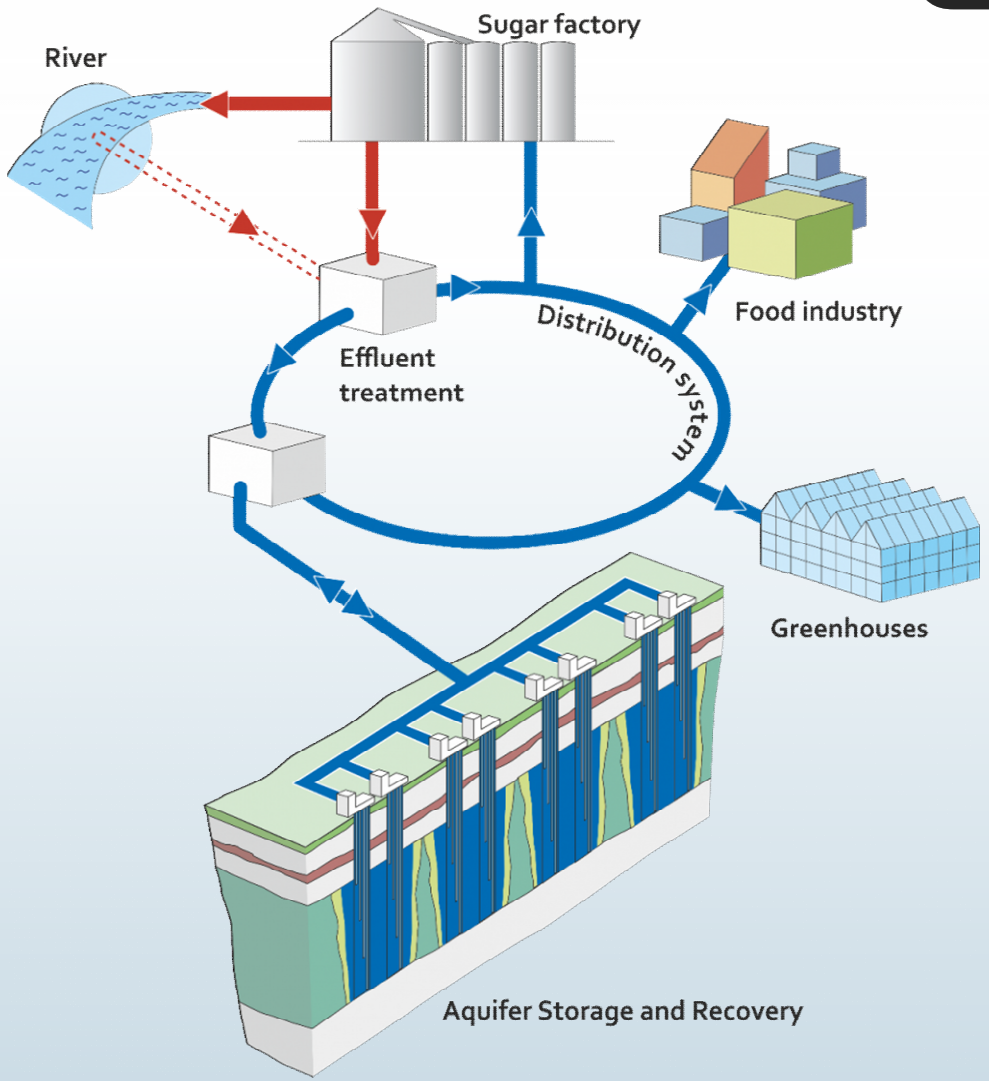
Multiple partially penetrating well



ASR to enable water reuse across sectors

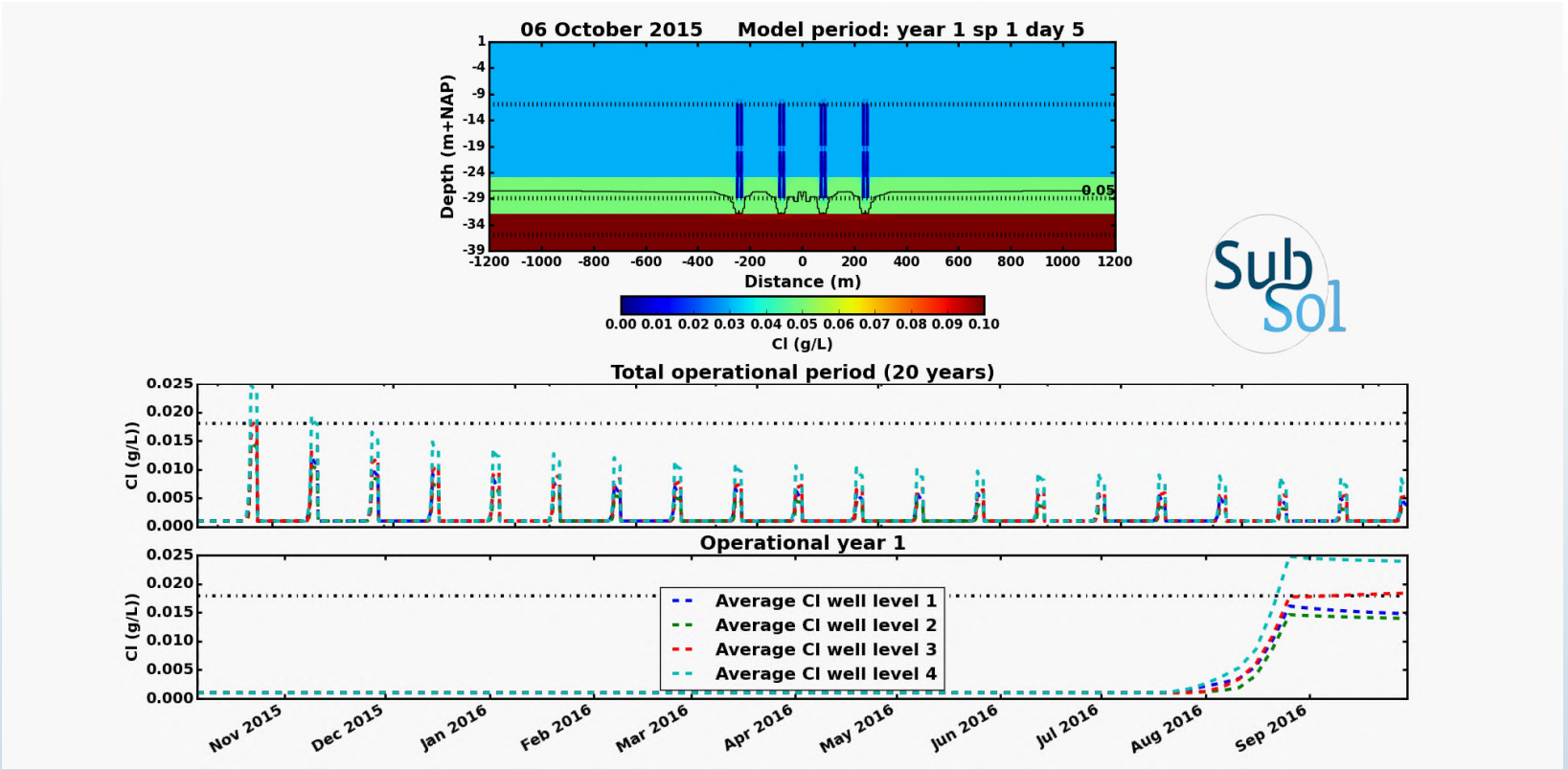
ASR reuse facility Dinteloord: treat, store, recover, reuse




River
Sugar factory
Food industry
Effluent
treatment
Distribution system
Greenhouses
Aquifer Storage and Recovery

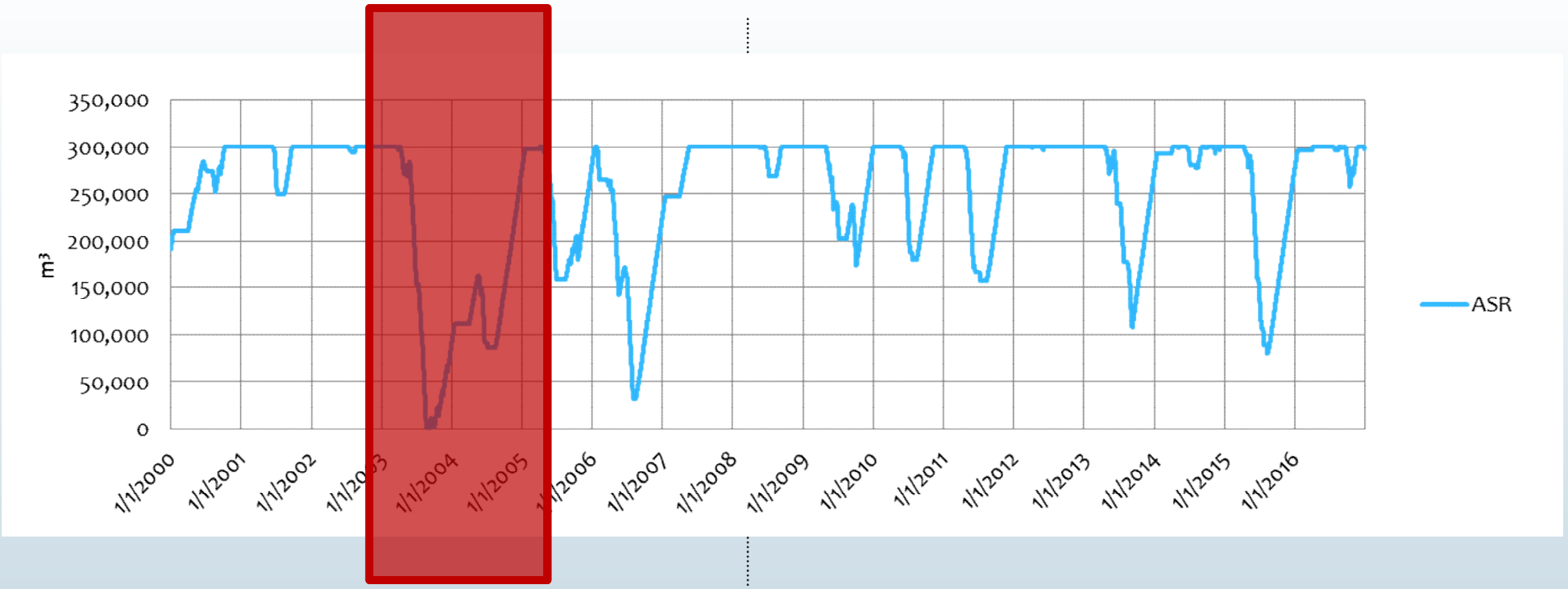
ASR to enable water reuse across sectors

Performance modelling of eight (4x2) ASR wells



ASR to enable water reuse across sectors

ASR “fill grade” based on hystorical rainfall / water demand



ASR to enable water reuse across sectors

ASR reuse facility Dinteloord: treat, store, use

ASR to enable water reuse across sectors

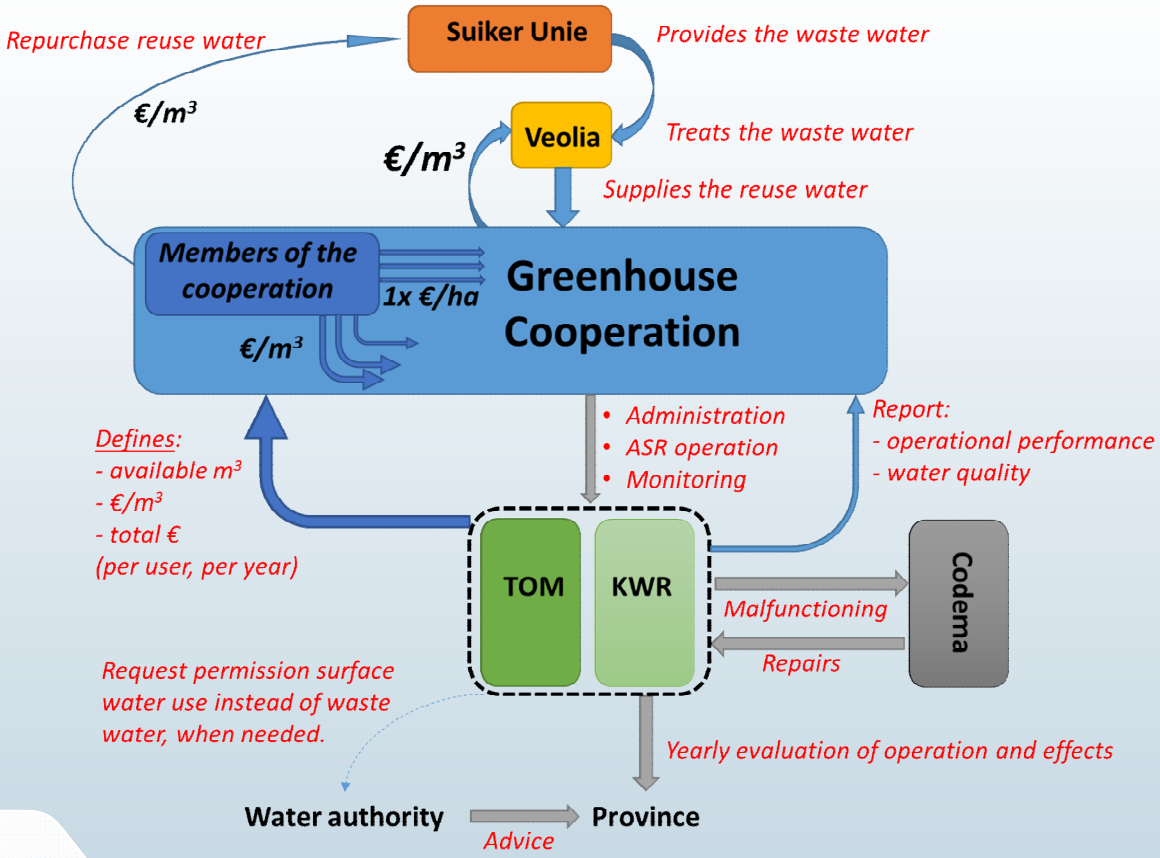
ASR reuse facility Dinteloord: treat, store, use

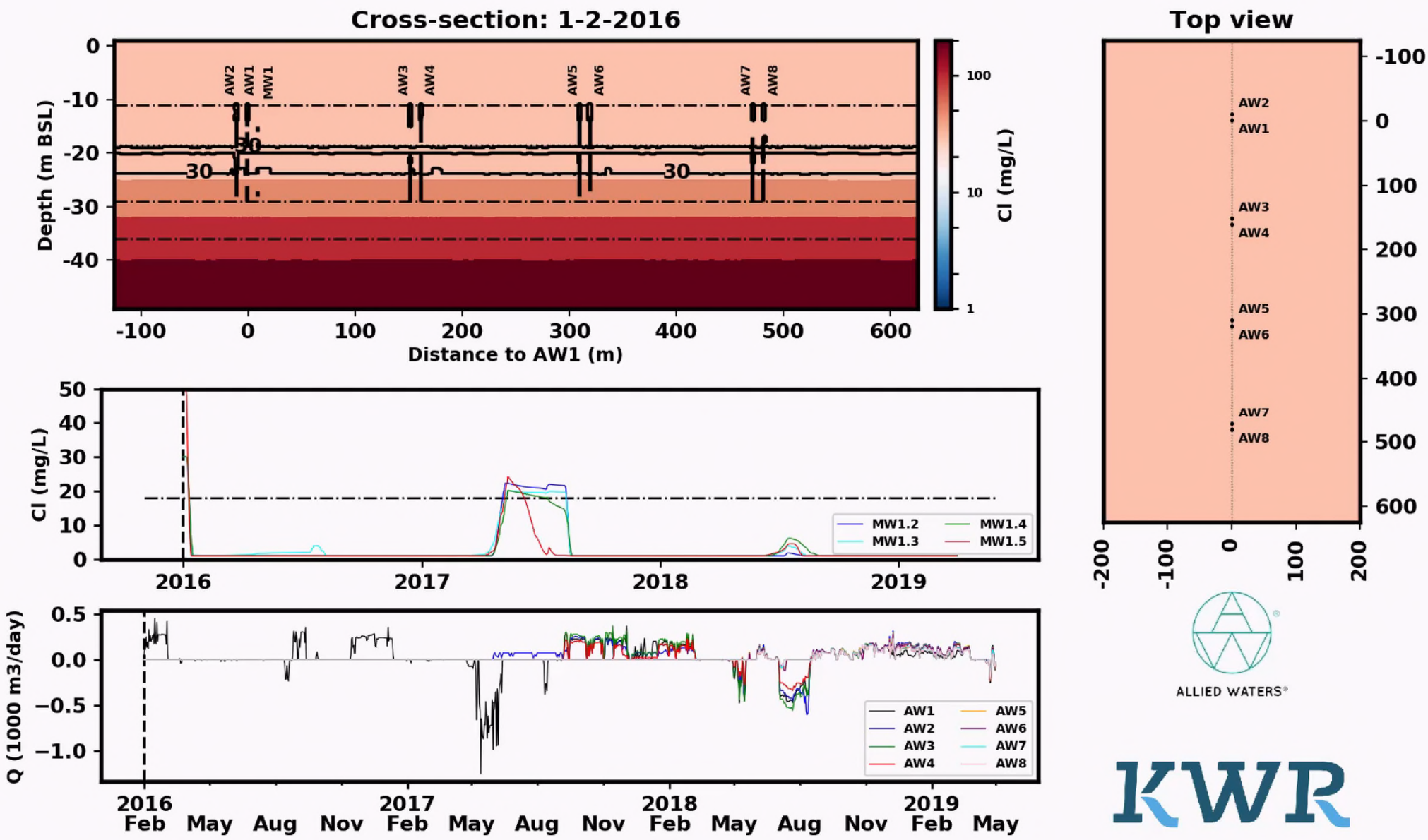
ASR PUMPING STATION

ASR WELL and DISTRIBUTION LOOP

ASR to enable water reuse across sectors

Succesful implementation requires a solid organization




Cross-section: 1-2-2016
Depth (m BSL)
Distance to AW1 (m)
AW2
AW1
MW1
AW3
AW4
AW5
AW6
AW7
AW8
30
Cl (mg/L)
Top view
Cl (mg/L)
MW1.2
MW1.3
MW1.4
MW1.5
Q (1000 m3/day)
AW1
AW2
AW3
AW4
AW5
AW6
AW7
AW8
ALLIED WATERS®
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ASR to enable water reuse across sectors

- Set clear restrictions, and reuse will follow
- It is not just about costs, it is also about financial risks
- Succesful implementation requires a solid organization

- IWA's principles for a water-wise world: reduce, reuse, replenish

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Patrick Smeets	Sun. 14:20
Workshop: AquaNES QMRA-tool: a webtool for quantitative microbial risk assessment of water reuse applications	
Klaasjan Raat	Mon. 11:20, MOA 5
Aquifer storage and recovery to enable water reuse across sectors	
Patrick Smeets	Mon. 14:20, MOA 5
Safe wastewater reuse in the United Arab Emirates	
Ruud Bartholomeus	Mon. 17:10, MOA 4
Matching agricultural water supply and demand using recycled water	
Luuk de Waal	Tue. 15:00. MOA 4
Poster. Enabling aquifer storage and recovery by high flowrate filtration	
Patrick Smeets	Tue. 15:50, MOA 5
Literature review on pathogen reduction by water treatment processes	
Kees Roest	Wed. 15:00, MOA 3
CoRe Water: from WWTP to a sustainable water factory	