Deltares | WAGENINGEN UNIVERSITY & RESEARCH | WACC Dynamic Research for Sustainable Life | DWRPIS | Nelen & Schuurmans | Royal HaskoningDHV Enhancing Society Together | GLOBAL IMPACT PARTNERS FOR WATER | PARTNERS FOR WATER | Netherlands Enterprise Agency

Freshwater Availability in the Mekong Delta Project (FAME)
Dự án Nguồn nước ngọt vùng đồng bằng sông Cửa Long

Online Workshop on / Hội thảo trực tuyến về:

ASR Pilot Installation and Upscaling Possibility of Aquifer Storage and Recovery - ASR systems in the Mekong Delta

Lắp đặt thử nghiệm mô hình trữ nước nhân tạo ASR và Tiềm năng nhân rộng trên vùng đồng bằng sông Cửu Long

21th December 2021 / Ngày 21 tháng 12 năm 2021

Workshop Agenda

21th December 2021

Time/Thời gian	Nội dung chương trình / Description	Người trình bày / Presenters
15:00 – 15:05	Chào mừng và Giới thiệu đại biểu và chào mừng / Panellists Introduction and Welcome section	TS./Dr. Nguyễn Hồng Quân (Đại học Quốc gia thành phố Hồ Chí Minh/ Vietnam National University HCM City)
15:05 – 15:10	Phát biểu khai mạc của Đại sứ quán Vương quốc Hà Lan tại Việt Nam / Opening Remarks by the Embassy of the Kingdom of the Netherlands in Vietnam	TS/Dr. Laurent Umans, Bí thư thứ nhất phụ trách Quản lý TN Nước và Biến đổi khí hậu / First Secretary Water Management and Cimate Change
15:10 – 15:20	Trình chiếu Video về dự án FAME / Video on FAME project	
15:20 – 15:30	Mô tả lắp đặt hệ thống thử nghiệm ASR tại Cầu Ngang, Trà Vinh/ ASR Pilot installation description at Cau Ngang, Tra Vinh province	Mr/Ông. Phạm Văn Hùng, Liên đoàn Quy hoạch và Điều tra Tài nguyên nước miền Nam / Division for Water Resources Planning and Investigation for the South of Vietnam

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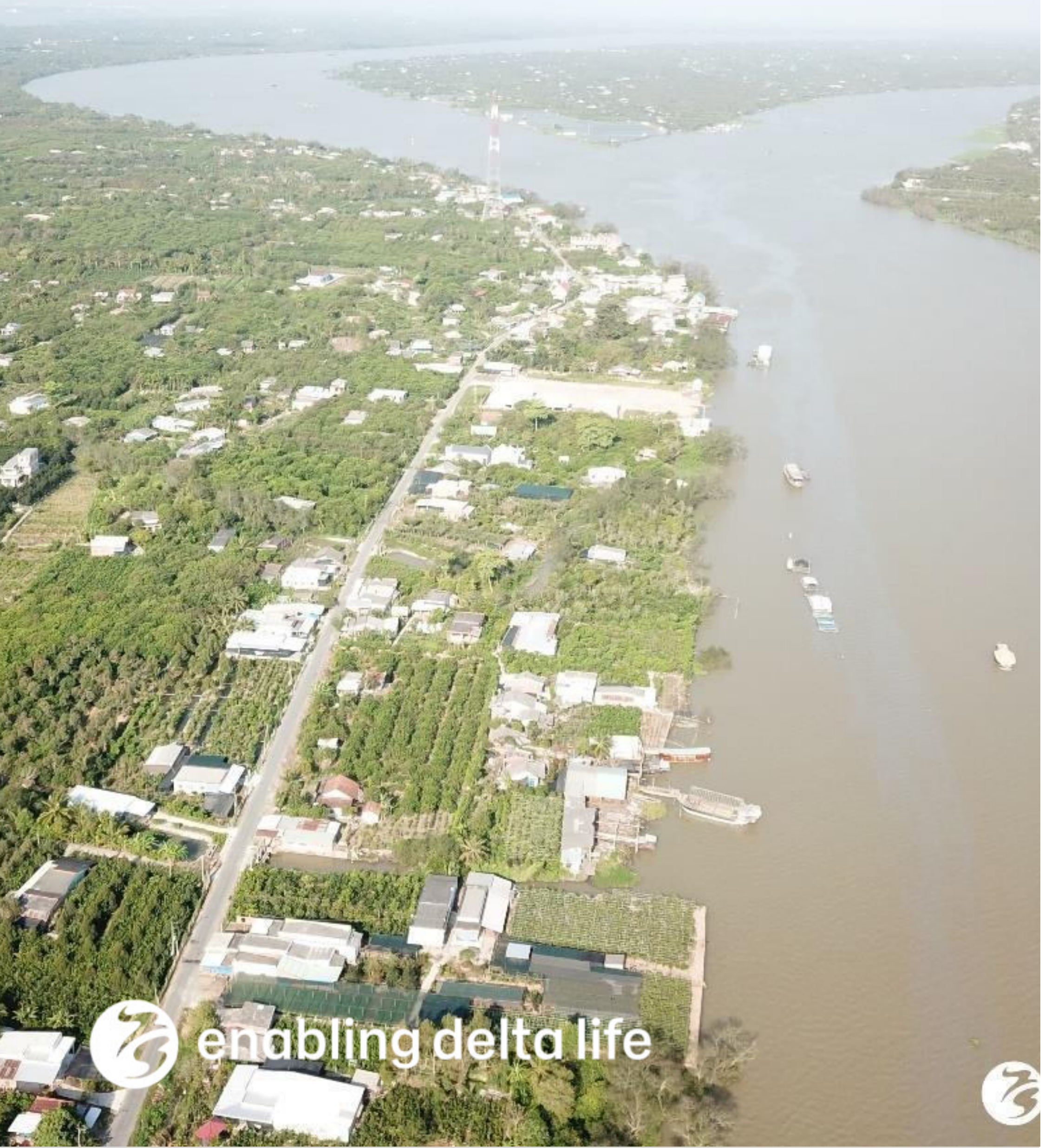
Workshop Agenda

21th December 2021

Time/Thời gian	Nội dung chương trình / Description	Người trình bày / Presenters
15:30 – 15:40	Sơ bộ thông tin quan trắc ban đầu từ hệ thống thử nghiệm / Initial pilot monitoring information	Ms/Bà. Mila Mahya, Deltares
15:40 – 15:50	Tiềm năng nhân rộng của ASR trên khu vực đồng bằng sông Cửu Long / Upscaling possibility of ASR in the Mekong Delta	TS/Dr. Nguyễn Hồng Quân (Đại học Quốc gia thành phố Hồ Chí Minh/ Vietnam National University HCM City)
15:50 – 16:15	Hỏi đáp và Thảo luận phiên / Q&A and Discussion	Các báo cáo viên và thành viên tham gia / Speakers and participants
16:15 – 16:20	Hướng tới dự án ASR tương lai / Pitching of future ASR project	TS/Dr. Gualbert Oude Essink (Deltares)
16:20 – 16:25	Tổng kết và Bế mạc Hội thảo / Wrap-up and Closing	TS/Dr. Gualbert Oude Essink (Deltares)



Aquifer Storage Recovery (ASR) Pilot installation description at Cau Ngang, Tra Vinh province

FAME: Freshwater Availability in the MEkong Delta

Contents

Pham Van Hung - Divison for water resource planning and investigation for the south of Vietnam

Gualbert Oude Essink

Marta Faneca Sanchez

Nguyen Hong Quan

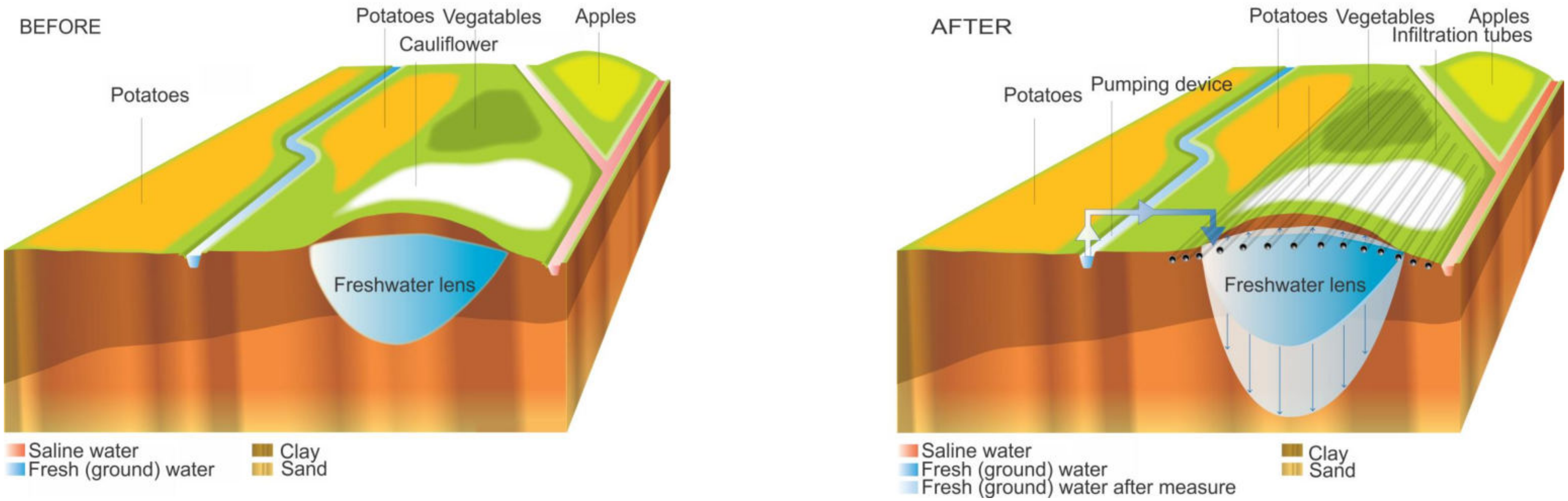
Philip Minderhoud

Mila Mahya

WHY AQUIFER STORAGE AND RECOVERY (ASR)?

(also called Managed Aquifer Recharged (MAR))

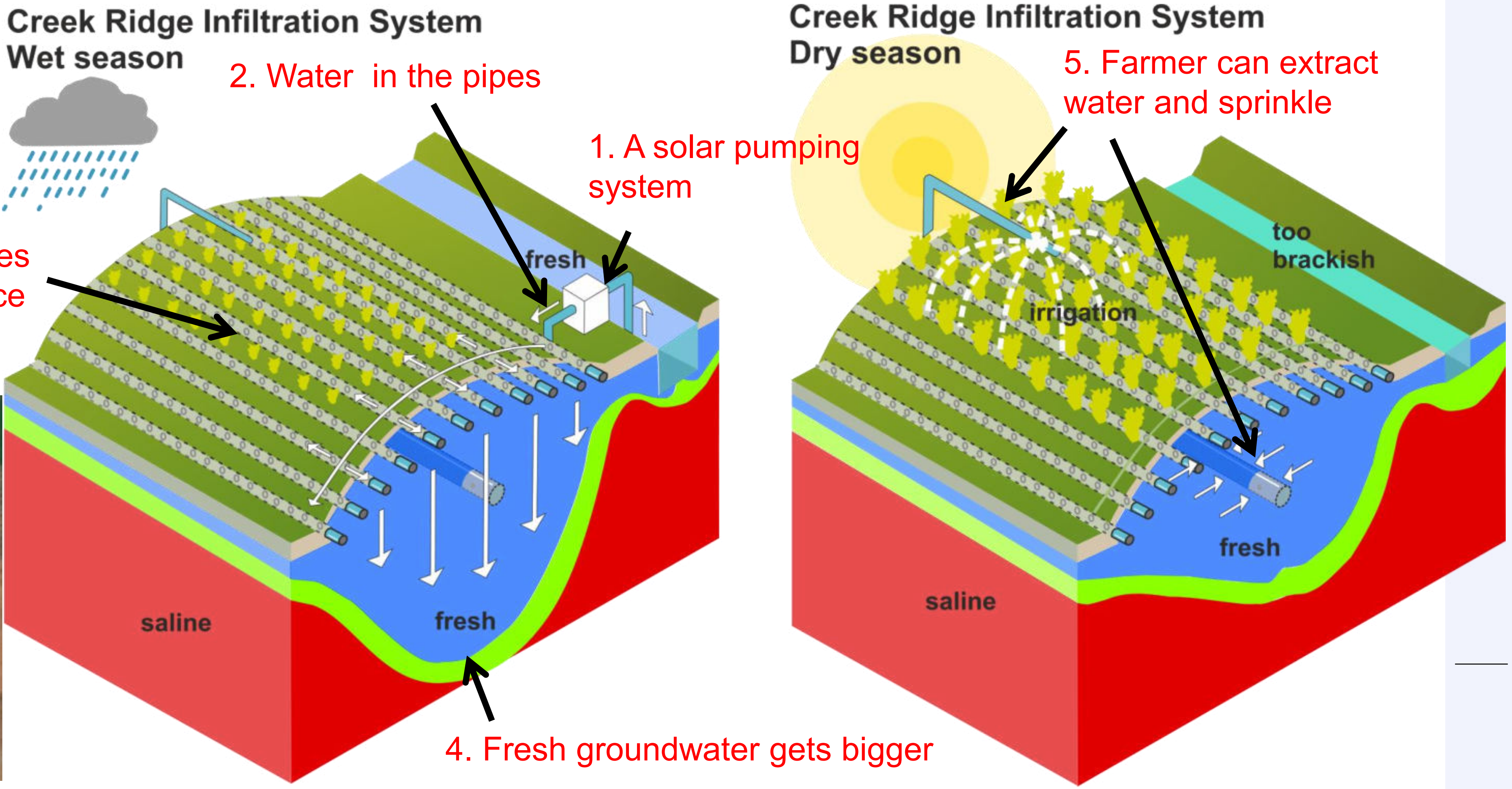
- ✓ Groundwater quantity during dry season is too low
- ✓ Groundwater level during dry season drop
- ✓ ASR system stores the water from the wet season so it can be used in the dry season



Pauw et al. (2015). Increasing a freshwater lens below a creek ridge using a controlled artificial recharge and drainage system: a case study in the Netherlands. Hydrogeology Journal. doi:10.1007/s10040-015-1264-z

ASR (Aquifer Storage and Recovery) SYSTEM

ASR is the process by which water is injected under pressure or allowed to infiltrate naturally into a permeable underground layer where it is stored until extracted, for when it is needed at a later date, e.g. when there are water shortages during the dry season.



ASR (Aquifer Storage and Recovery) SYSTEM

The advantages of the ASR system are:

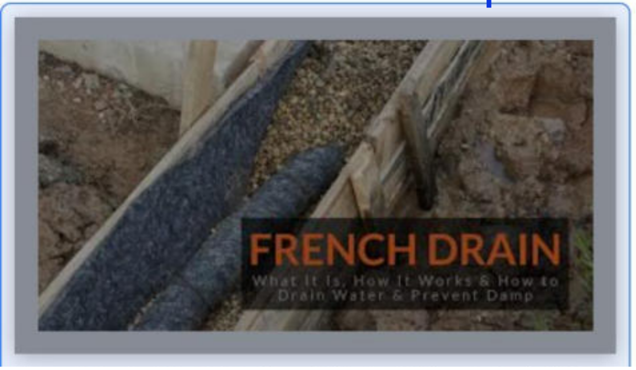
- ✓ Store water for long-term storage
- ✓ Buffer capacity for seasonal droughts
- ✓ Smooth out demand and supply fluctuations
- ✓ Reduce evaporation loss
- ✓ Improve water quality
- ✓ Store excess storm/flood water
- ✓ Manage salt water intrusion
- ✓ Manage land subsidence
- ✓ Strategic reserve for emergency situations
- ✓ Raising groundwater table
- ✓ Provide water for domestic, agricultural & industrial use
- ✓ Protect sewers of water overload during intense rain events

The disadvantages or limitations of the ASR system are:

- ✓ A part of the water that is infiltrated cannot be extracted
- ✓ Changes of water quality by mixing and reactions should be monitored

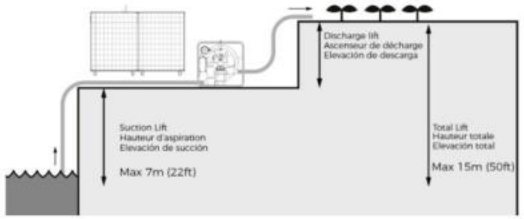
MATERIAL

Underground Drain Pipe



Solar pump

Futurepump SF2 solar pump

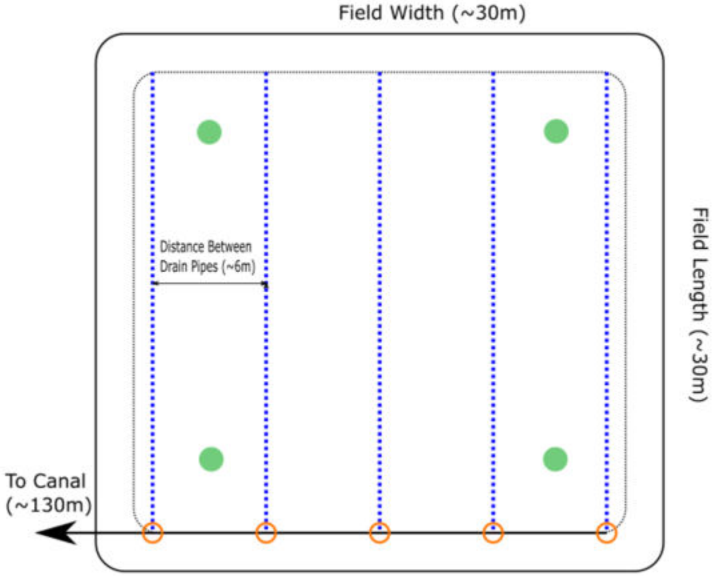


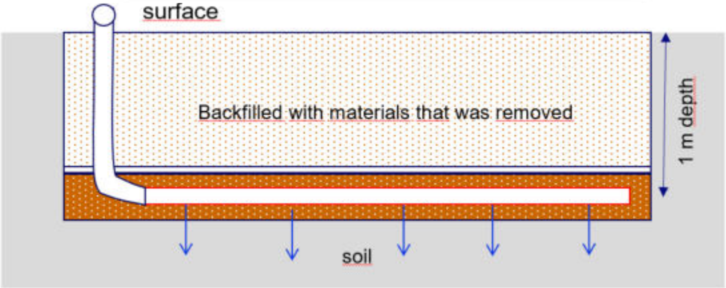
Max head: 15m

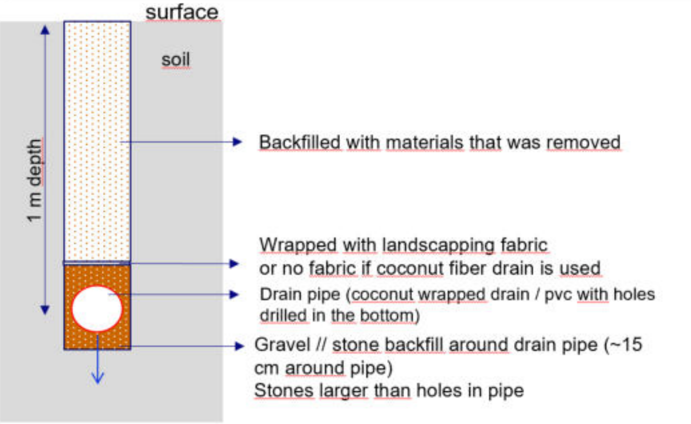
Geotextile and Gravel

Machine/workers

INSTALL THE ASR PILOT IN TRA VINH





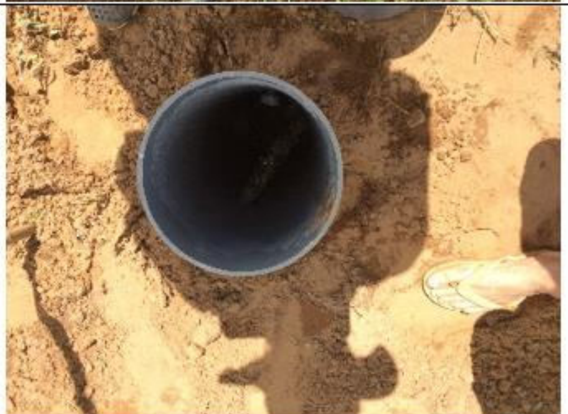








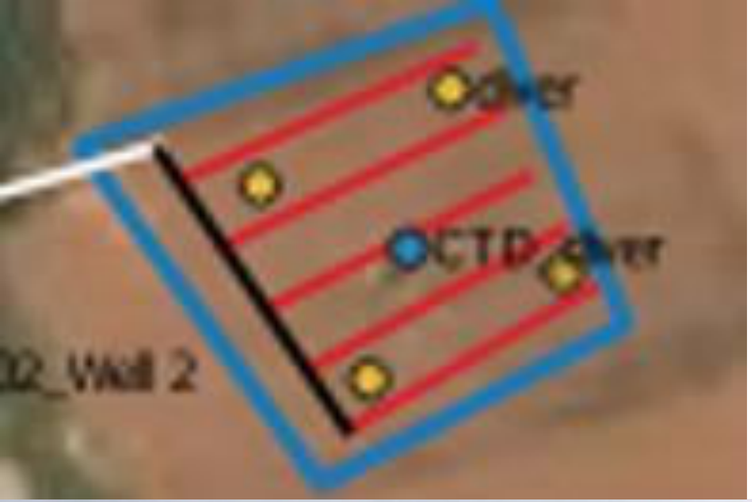




Water level and water quality monitoring

Monitoring

- Monitoring of groundwater table over time
- Monitoring of groundwater salinity over time
- Surface water quality monitoring
- Drain clogging



We want to continue to monitor the pilot in early 2022 to see the effects

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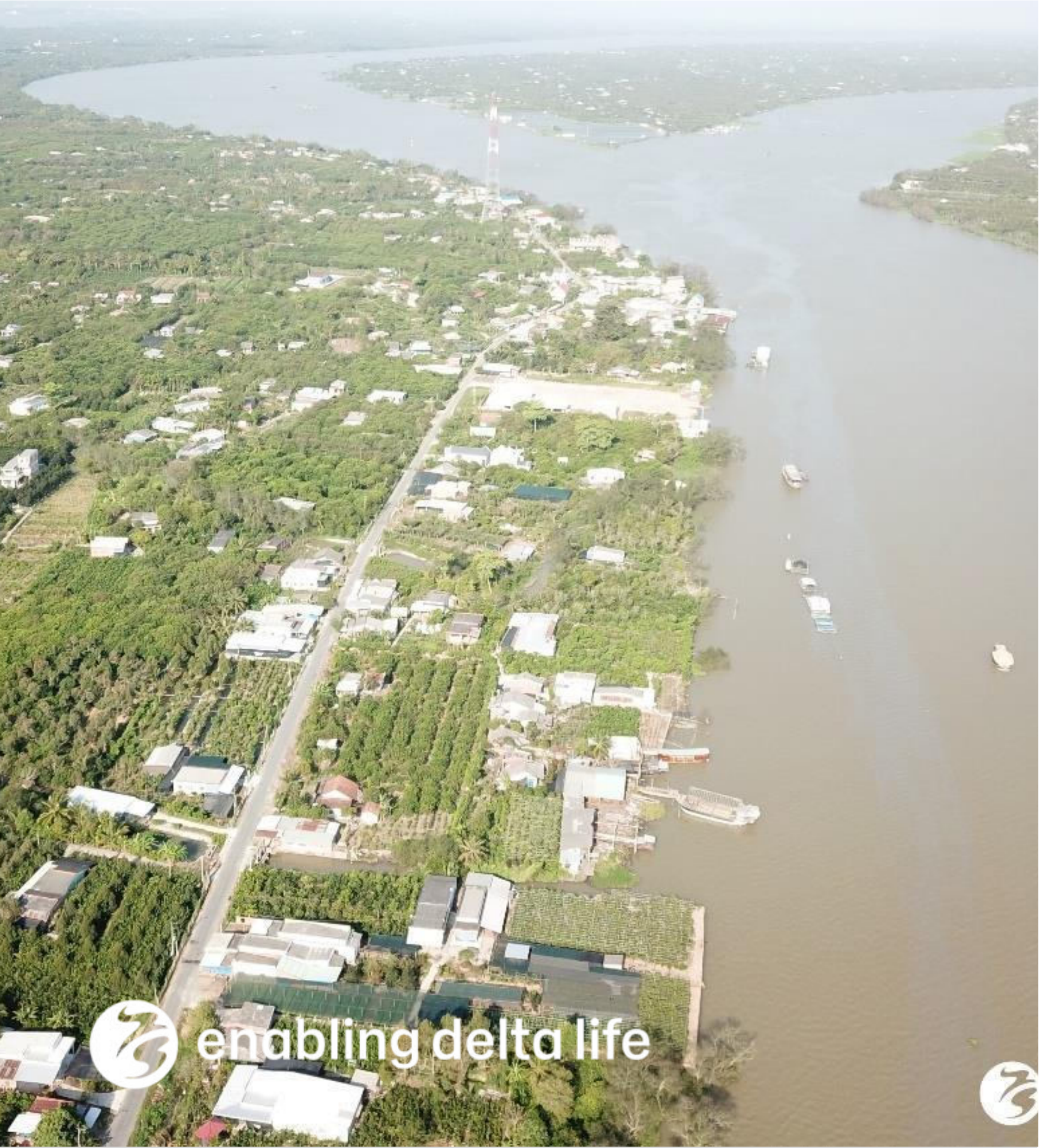


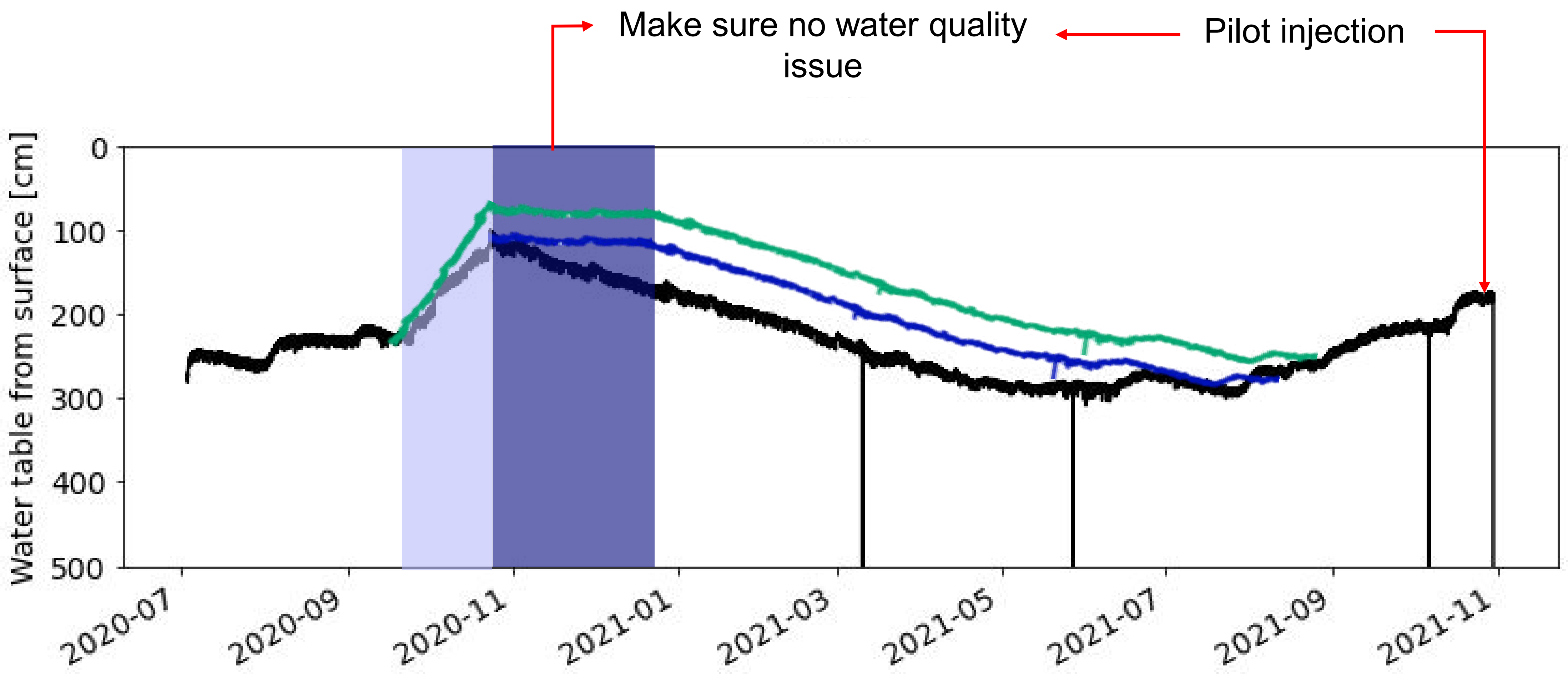
TV2 Monitoring

- Groundwater level
- Groundwater and reservoir water quality

Pham Van Hung, Stephan Jansen, Mila Mahya

21st December 2021

ASR and Water Level Monitoring



Observed water table before ASR

Expected water table after ASR

Window of opportunity for ASR infiltration

Other possible window for ASR infiltrattion

Pesticides during window of opportunity

Compound in reservoir	test result (μg/l)	quality limit (μg/l)
Aldrin	<0.020	0.100
Dieldrin	<0.020	0.020
Hexachlorobenzene	<0.005	0.100
4,4'-DDD	<0.200	1.000
4,4'-DDE	<0.200	
4,4'-DDT	<0.200	
Heptachlor	<0.020	0.200
Heptachlor epoxide	<0.020	

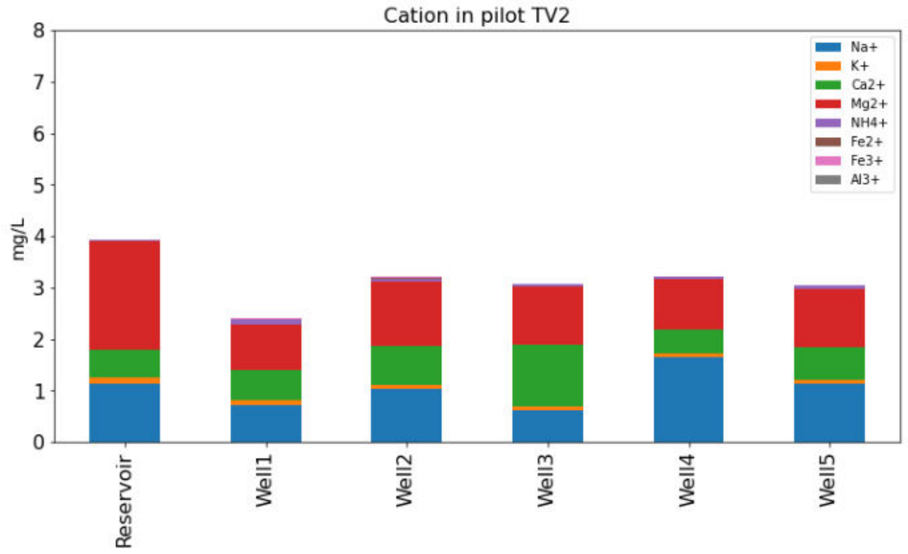
Compound in well	test result (μg/l)	quality limit (μg/l)
Aldrin	<0.020	0.100
Dieldrin	<0.020	0.020
Hexachlorobenzene	<0.005	0.100
4,4'-DDD	<0.200	1.000
4,4'-DDE	<0.200	
4,4'-DDT	<0.200	
Heptachlor	<0.020	0.200
Heptachlor epoxide	<0.020	

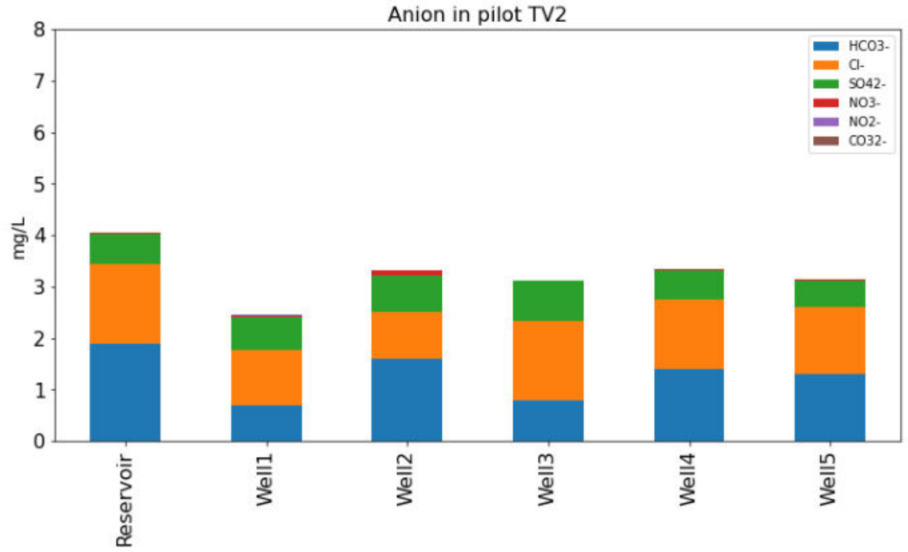
Pesticides are under maximum standard both in reservoir and well

Water quality during window of opportunity

Method	Parameter
Comprehensive sample	• Electrical Conductivity (EC) • pH • Hardness • Cations: Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+, Fe^{2+}, Fe^{3+}, Al^{3+} • Anions: HCO_3^- , Cl^-, SO_4^{2-}, NO_3^-, NO_2^-, CO_3^{2-} • Dry residue to determine the suspended-solids concentration
Contaminant Sample	• COD_{KMnO4} , NH_4^- , NO_2^- , NO_3^- , PO_4^{3-}
Fe sample	• Fe^{2+} and Fe^{3+}
Heavy metal sample	• As, Mn, Zn

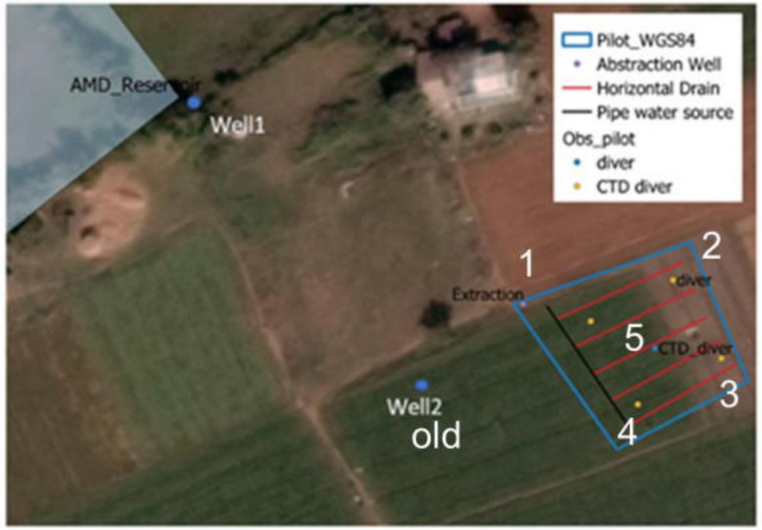
- **Ions, contaminant, and heavy metals are below maximum standard**



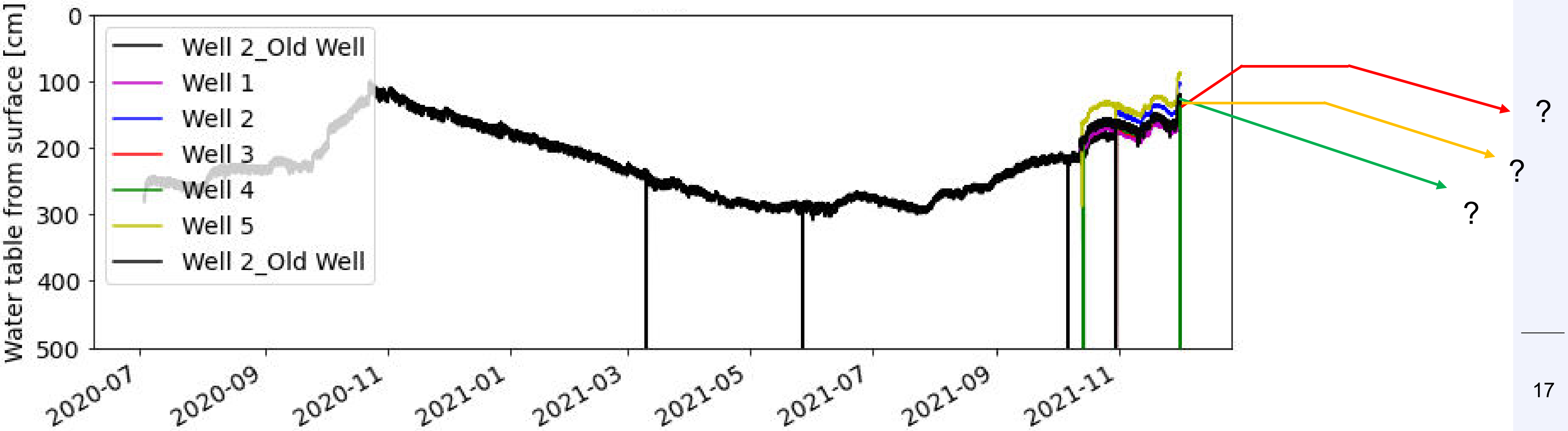


Next step ~1 year

1. Monitor water quality after ASR injection
   - Will the groundwater quality changes?
2. Monitor water table after ASR injection
   - Will infiltrated water stay within the sand dune until it is extracted?
   - Will the infiltrated water be enough for dry period?

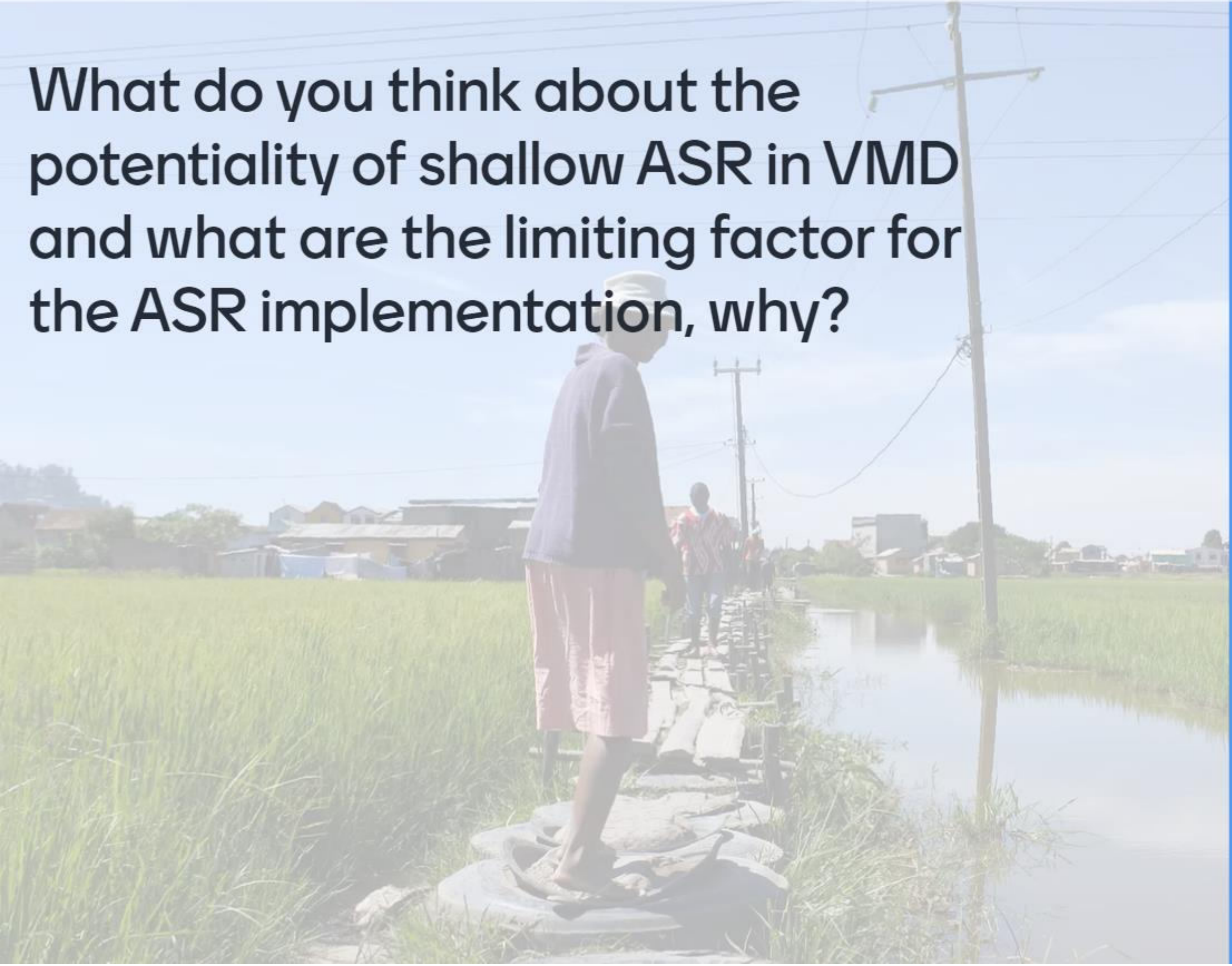


Monitoring ~ 1 year



Go to **www.menti.com** and use the code **2114 4214**

What do you think about the potentiality of shallow ASR in VMD and what are the limiting factor for the ASR implementation, why?



AQUIFER STORAGE AND RECOVERY:

FEASIBILITY FOR SCALING UP IN THE VIETNAMESE MEKONG DELTA

From a governance perspective

Nguyen Hong Quan[1, 2], Luu Thi Tang[2]

Institute for Circular Economy Development (ICED)

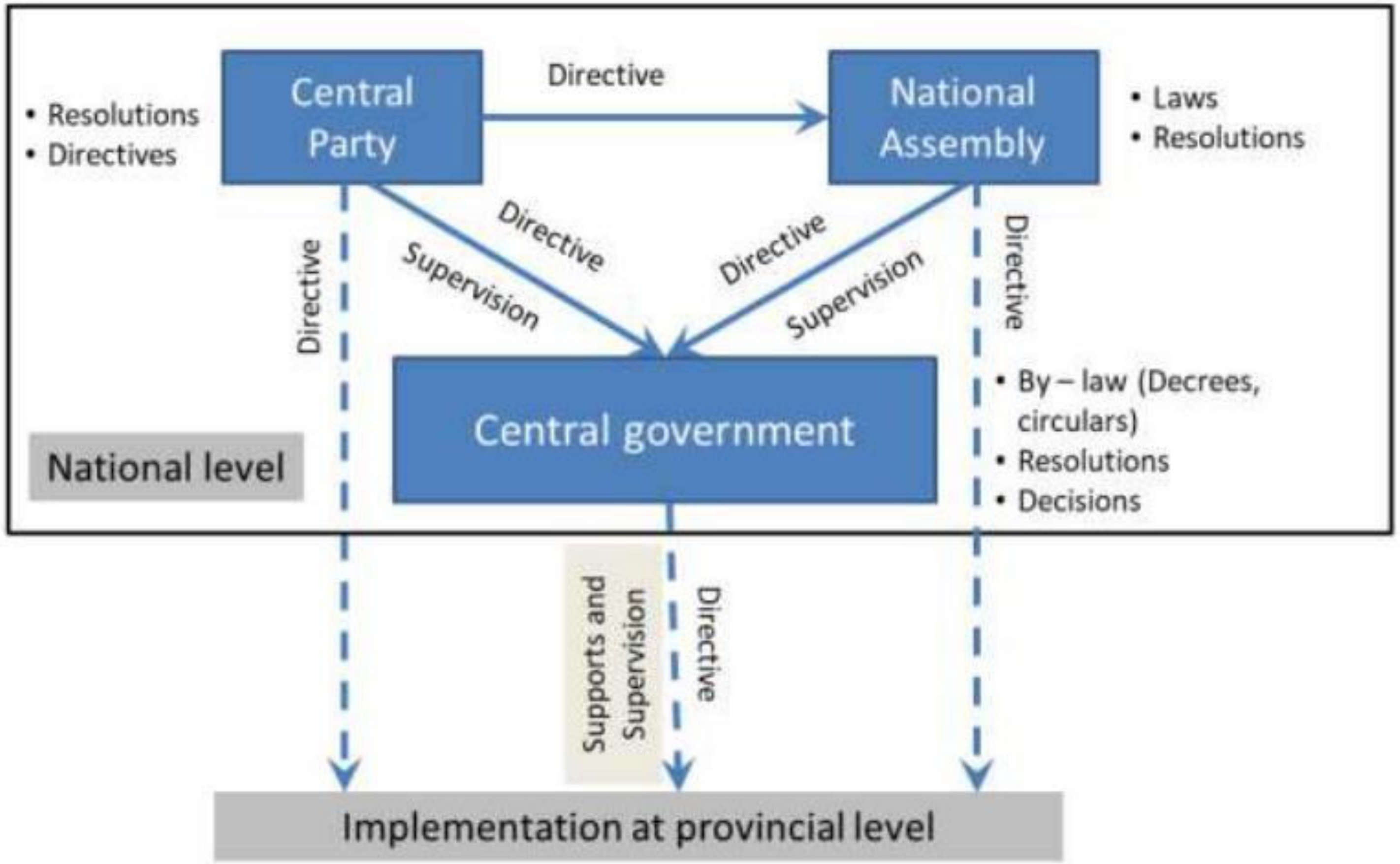
Vietnam National University, VNU-HCM, Vietnam

[1] Center of Water Management and Climate Change (WACC), VNU-HCM

Content

- General policy process
- Current status of groundwater extraction
- Relevant stakeholders
- General obstacles in groundwater governance
- The scaling up of the ASR
- Recommendation for solutions

General policy process



- Linkages between legislation development at the national level and implementation at the provincial level (source: (Nguyen et al. 2020)).

Relevant (diversed) stakeholders

- Agriculture and water management sectors
- Ministry of Natural Resources and Environment (MONRE)
- Ministry of Agricultural and Rural Development (MARD).
- Provincial DONREs and DARDs
- The Offices in the vertical line at the district and commune level
- Water supply companies, industry, households, and other private sectors.
- Local and international NGOs, experts, social media, and academia

Some issues in of groundwater management

- Extraction is not well-managed (Small groundwater are not registered; Illegal and over-extract activities)
- Limited monitoring and warning systems
- Saline intrusion and land subsidence (in Mekong delta)
- Limited alternatives, especially in the coastal region (e.g. Ca Mau)
- Hardly integrated with surface and rainwater harvesting and environment

General obstacles in groundwater governance

- Insufficiency of the policies and guidance from the central government on implementing and enforcing regulations locally
  - Difficult to identify the groundwater zones according to regulations, e.g. the Decree 167
  - Not clear and strict regulations
  - No finance allocated for closing the abandoned wells.
  - Not integrated and connected with Regional and Master plan
- Unclear and overlapped functions as well as insufficient collaboration of responsible units
  - Mismatch in aquifers' boundary and administrative implementation of regulations
  - Insufficient collaboration between MONRE and DONRE regarding licensing
- Groundwater has cheap price and easy to access
- Lack of monitoring system
- Insufficient data, esp. on deep aquifers

stakeholder participation

Opportunities

- ASR is mentioned in the Law of Water resources
- Groundwater recharge is a MUST to protect the Vietnamese Mekong delta from land subsidence
- Getting more and more attention from local and national government and strongly supported by international groups
- More and more proved cases in the world

The scaling up of the ASR

- **Institutional constrains**
  - No clear document to guide the implementation of regulations
  - Strict water quality regulation (although natural process)
  - Socializing water investment
- **Insufficiency of technical efficiency**
- **Hydro-geological complexity in the Mekong delta**
- **Cost-effective analysis**
- **Local expertise**

Recommendations

- MONRE as a leading agency to implement regulations for the whole delta. However, other Ministries (e.g. MARD, MPI) are also very important to support the implementation.
- Alternative fresh water sources (rainwater harvesting)
- Strict management mechanisms (plus alternatives for some extreme conditions areas)
- (Continuing) social media to enhance awareness
- Water saving plus agriculture transformation (less demand fresh water practices)
- The ASR seems to be one of very few solutions that may help to overcome the problem of over groundwater exploitation. ASR is a very typical nature based and multiple benefit solution that fits well to this direction.
- ASR can also bring other values, e.g., attracting Public-private partnerships (PPPs) investments

Thank you for your attention!
Questions are welcome!

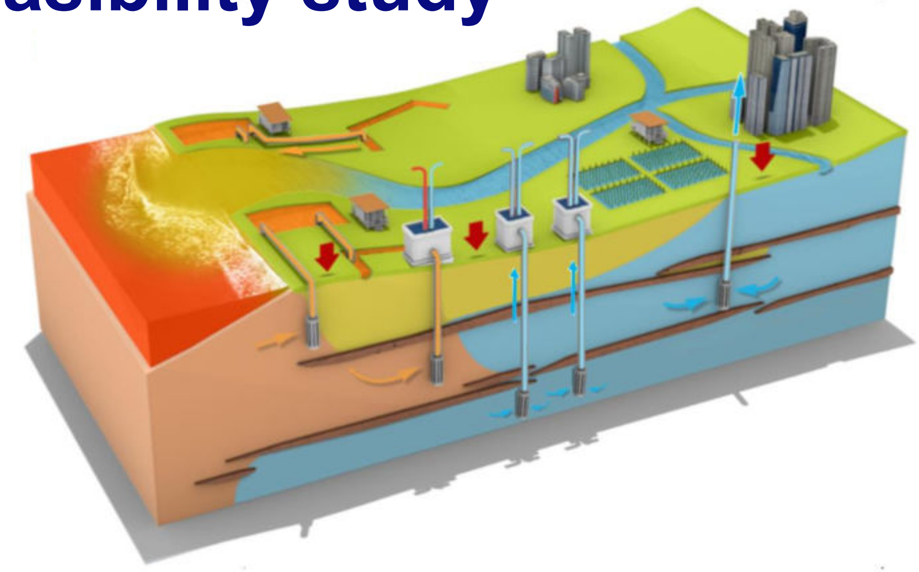
Some project's activities (Source: FAME report, 2021 (draft))

Dutch Water Operators

VEi

Deltares

On deep-well ASR system in VMD pre-feasibility study



Romano Radjkoemar, Adriaan Mels, Sepehr Eslami Arab, Gualbert Oude Essink

Government of the Netherlands

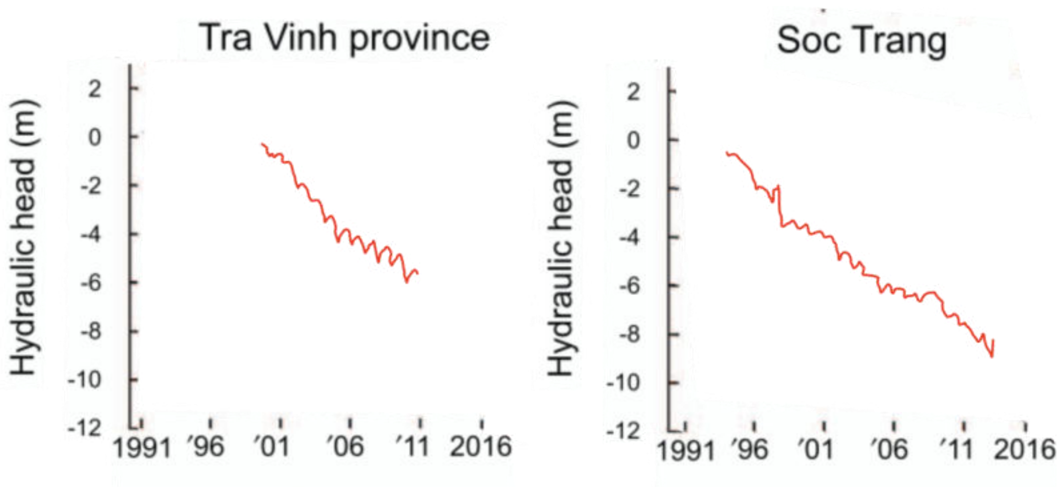
Deep-well Aquifer Storage and Recovery: Case Mekong Vietnam

Problem: the deeper groundwater system under stress

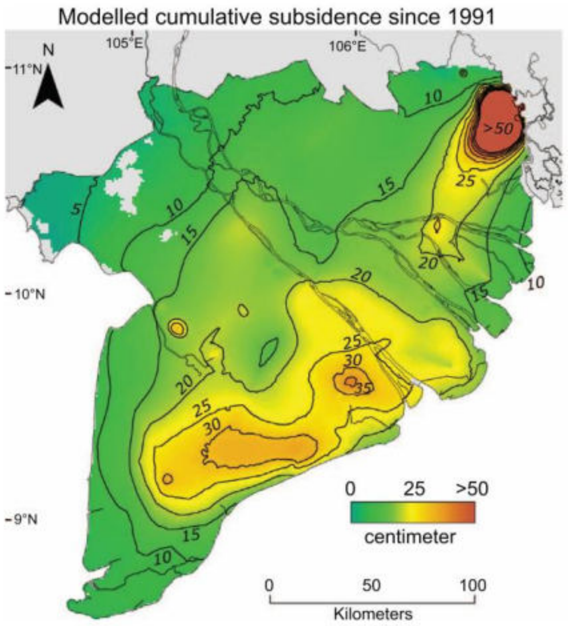
- Groundwater level has dropped over time
- Land has subsided
- Fresh groundwater has been exploited

Can we revitalize the deeper system?

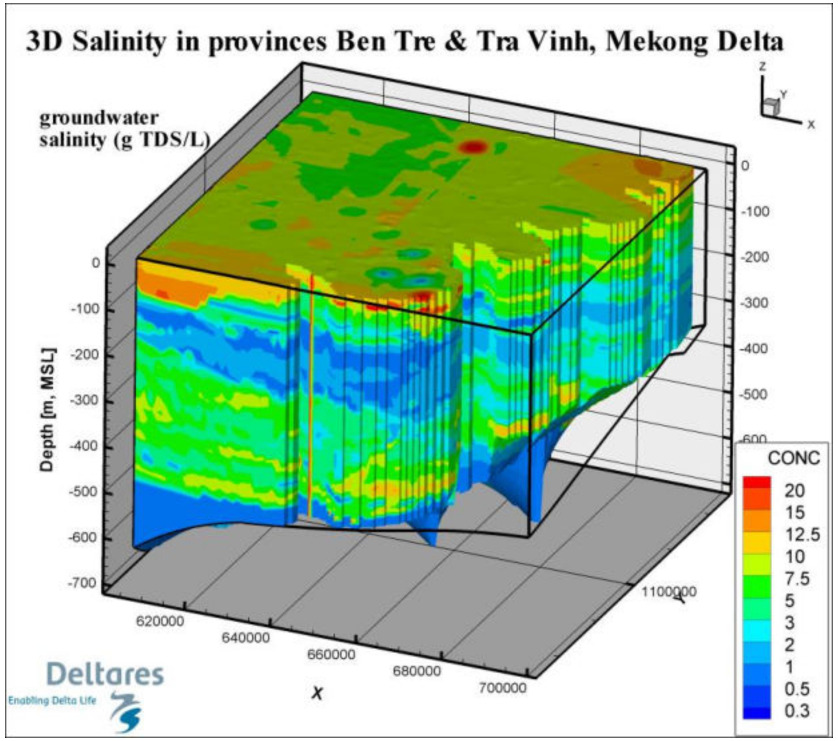
- Deep-well Aquifer Storage and Recovery
- For domestic and industrial water use
- Large freshwater volumes
- Scalable, decentralized
- Reducing saltwater instrution, and limiting the effect of sea-level rise

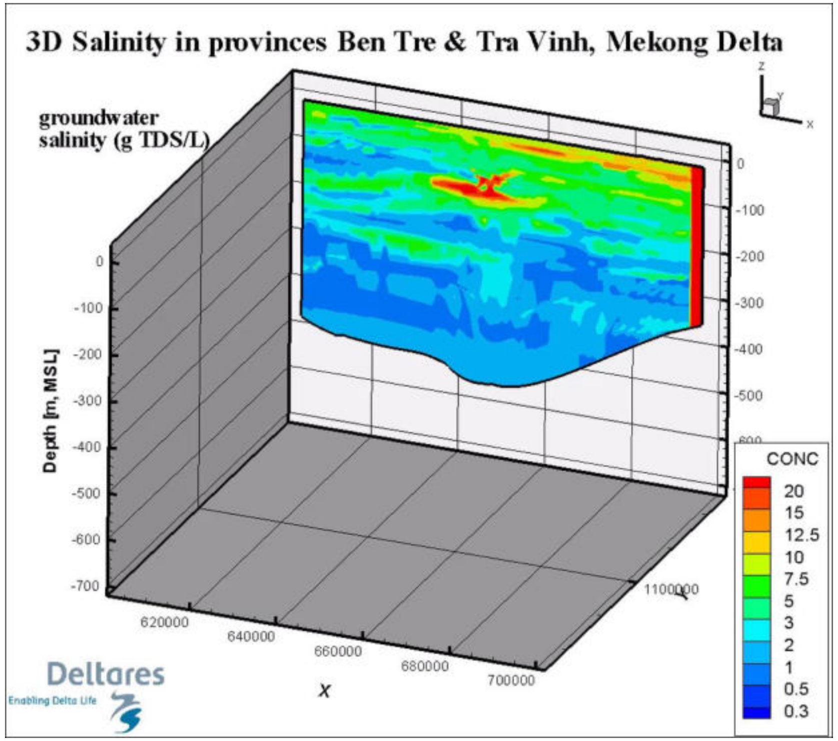


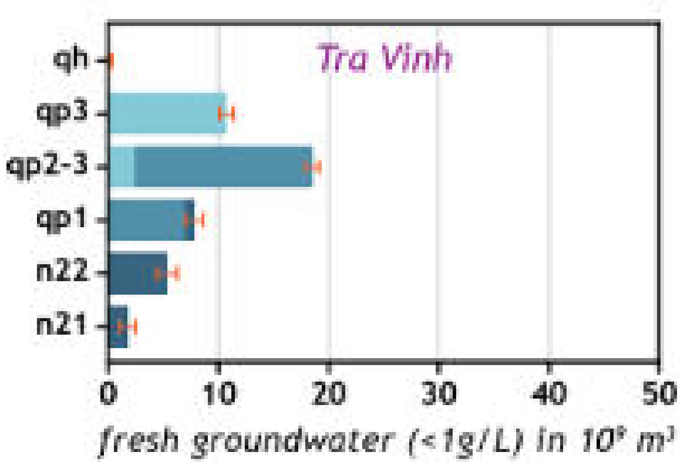
Minderhoud et al., 2017

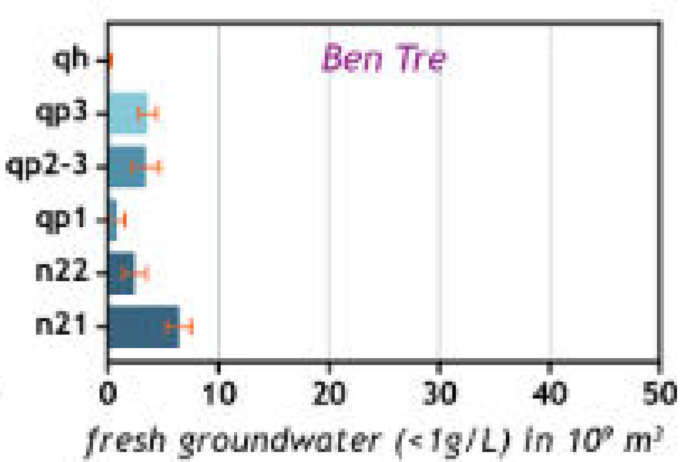


Distribution of fresh-saline groundwater, Ben Tre and Tra Vinh









ref:

Gunnink, J.L., Pham, V.H., Oude Essink, G.H.P., Bierkens, M.F.P. The 3D groundwater salinity distribution and fresh groundwater volumes in the Mekong Delta, Vietnam, inferred from geostatistical analyses. Earth Syst. Sci. Data 13, 3297–3319. https://doi.org/10.5194/essd-13-3297-2021

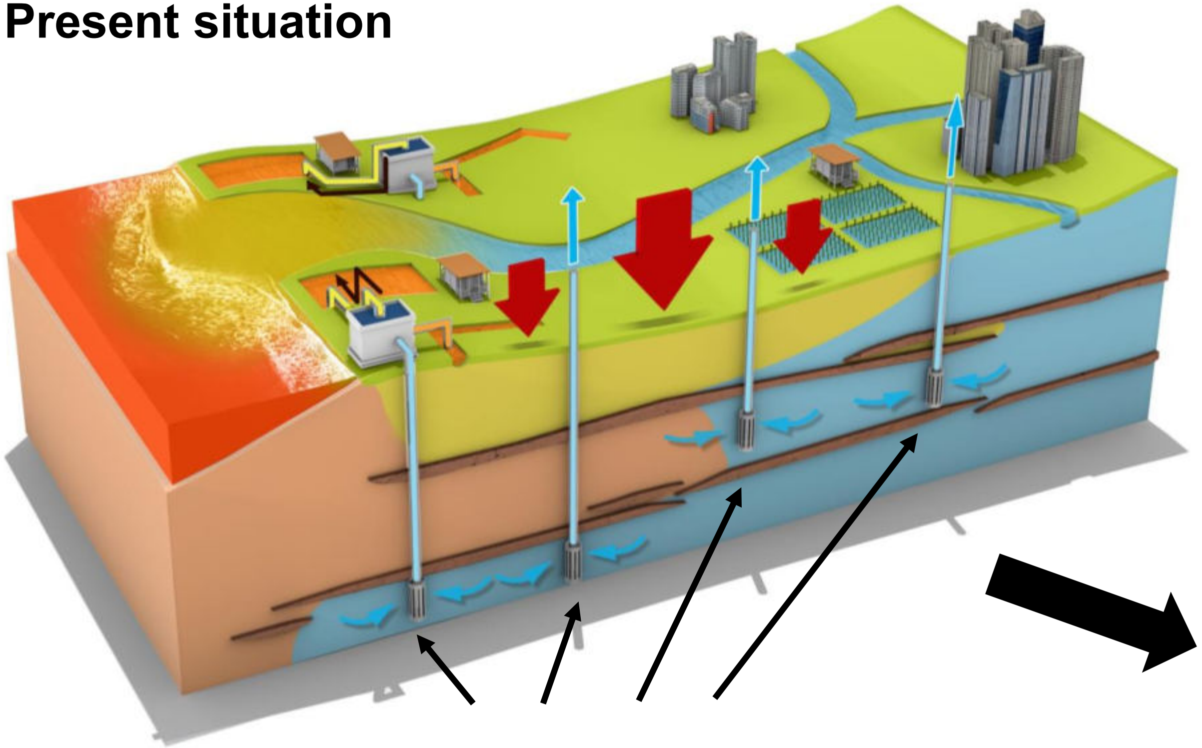
Deep-well Aquifer Storage and Recovery: Case Mekong Vietnam

Mitigate fossil groundwater extraction.

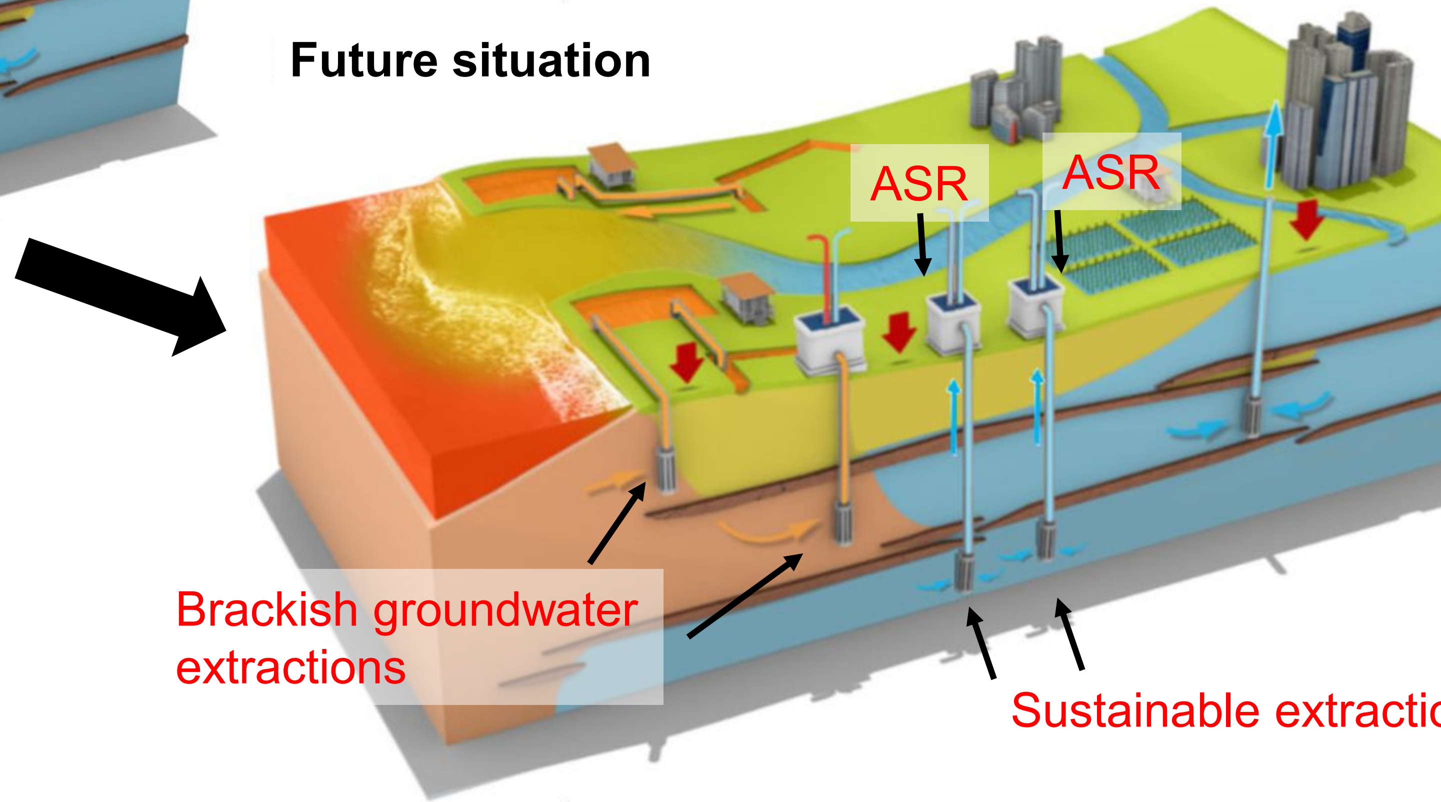
Mitigate land subsidence.

Mitigate salt water intrusion groundwater system.

Present situation



Future situation



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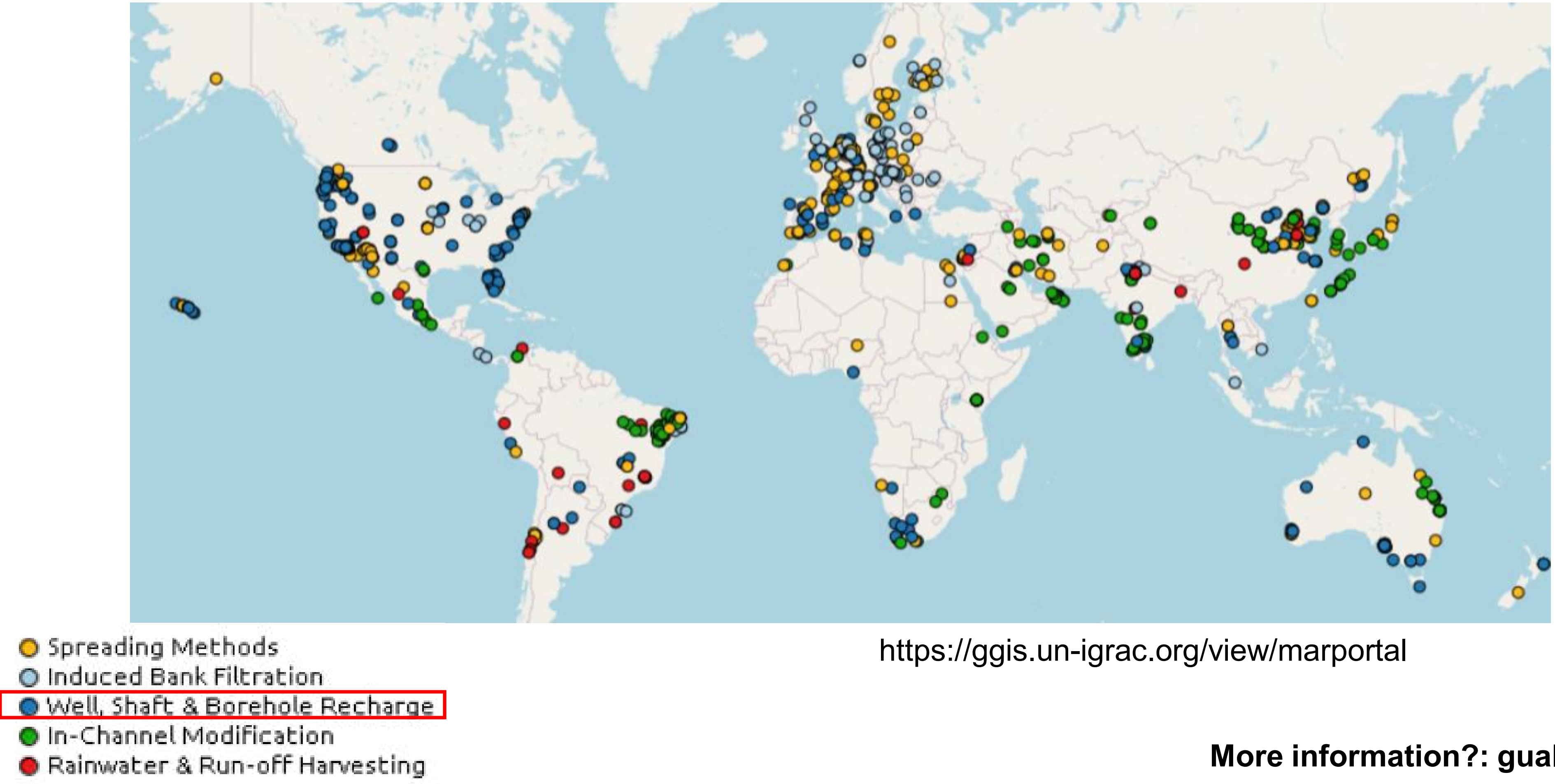
Pre-feasibility study deep-well ASR, focus on technical analysis

Dutch Water Operators

1. Existing data collection (fresh groundwater ánd surface water salinity availability over time)
2. Feasibility mapping of potential deep-well ASR locations
3. Quantifying potential environmental, hydrogeological and hydrogeochemical impacts
4. Quantifying sustainable extraction rates, using 3D groundwater salinity models
5. Cost Benefit Analysis and stakeholder engagement.
6. Design of a pilot study, including monitoring plan, well distribution, water quality requirements, water (pre-)treat techniques, infrastructure, regulation issues, etc.

More information: Romano Radjkoemar, Adriaan Mels, Sepehr Eslami Arab, Gualbert Oude Essink

Other areas around the world we can learn from.



https://ggis.un-igrac.org/view/marportal

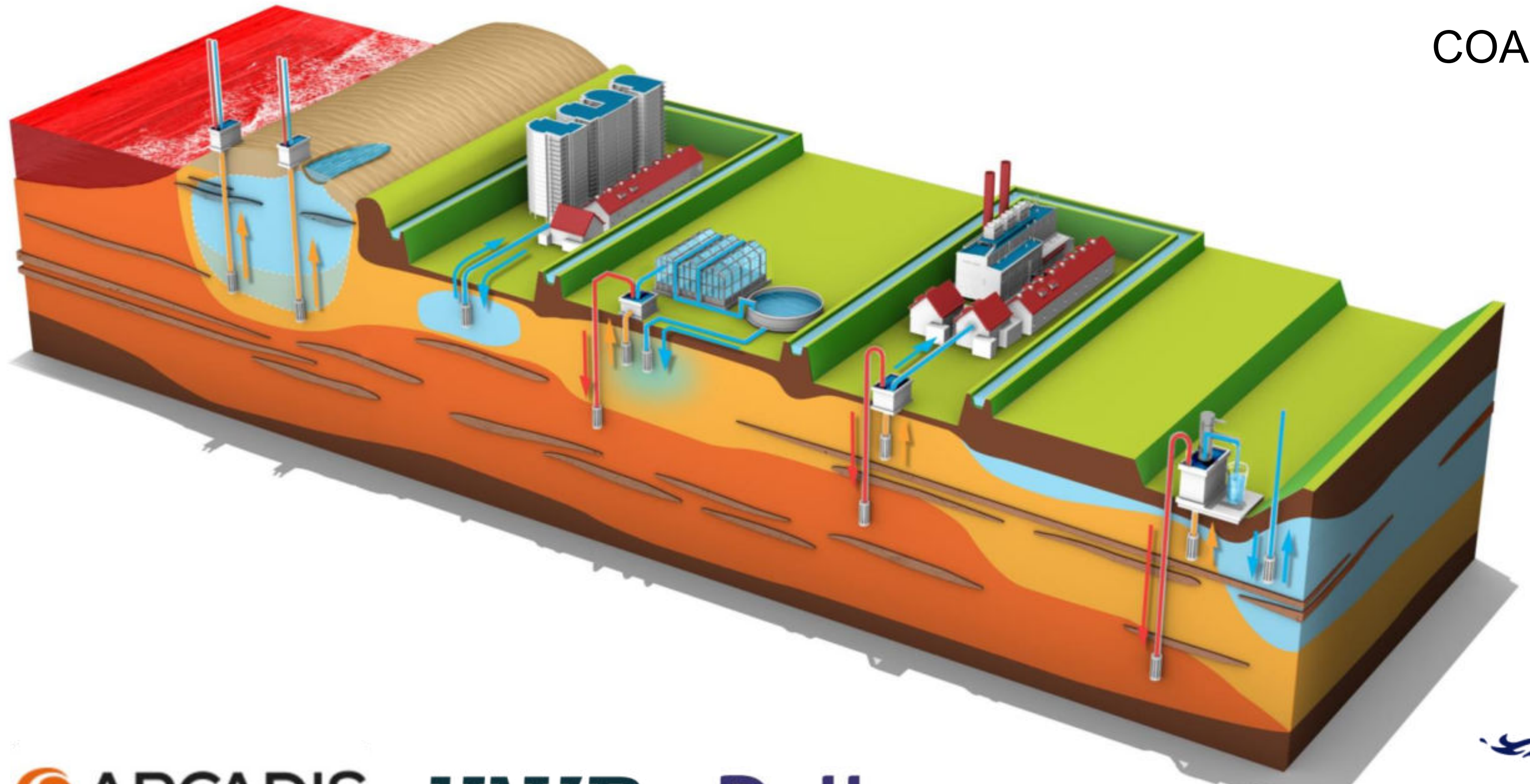
More information?: gualbert.oudeessink@deltares.nl

Example reference: Zheng, Y., Ross, A., Villholth, K.G., Dillon, P., 2021. Managed Aquifer Recharge; A Showcase for Resilience and Sustainability. UNESCO

COASTAR (COastal Aquifer STorage And Recovery)

Large scale use of subsurface solutions for a robust water supply and water management by:

- Closing the water gap between water supply and demand in space and time
- Prevent salinization by using brackish groundwater for fresh water production



COASTAR (Case The Netherlands)

provincie ZUID HOLLAND
Hoogheemraadschap van Delfland
Hoogheemraadschap van Rijnland
oasen drinkwater
evides waterbed
dunea DUIN & WATER
TOPSECTOR WATER & MARITIEM
gemeente Maassluis
GEMEENTE WESTLAND
LTO Glaskracht Nederland
MOS GRONDMECHANICA
Gemeente Rotterdam
ALLIED WATERS
Deltaprogramma | Zoetwater

ARCADIS KWR Deltares

Advantages Aquifer Storage Recovery / Managed Aquifer Recharge

1. Store water for long-term storage
2. Buffer capacity for seasonal droughts
3. Smooth out demand and supply fluctuations
4. Reduce evaporation loss
5. Improve water quality
6. Store excess storm/flood water
7. Manage salt water intrusion
8. Manage land subsidence
9. Strategic reserve for emergency situations
10. Raising groundwater table
11. Provide water for domestic, agricultural & industrial use
12. Protect sewers of water overload during intense rain events