Groundwater Management in the MENA Region: Challenges and Opportunities for the Future

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Overview

Part A:

- Fresh, brackish, saline and brine/hyper-saline groundwater
- Requirements for “marginal” groundwater use

Part B:

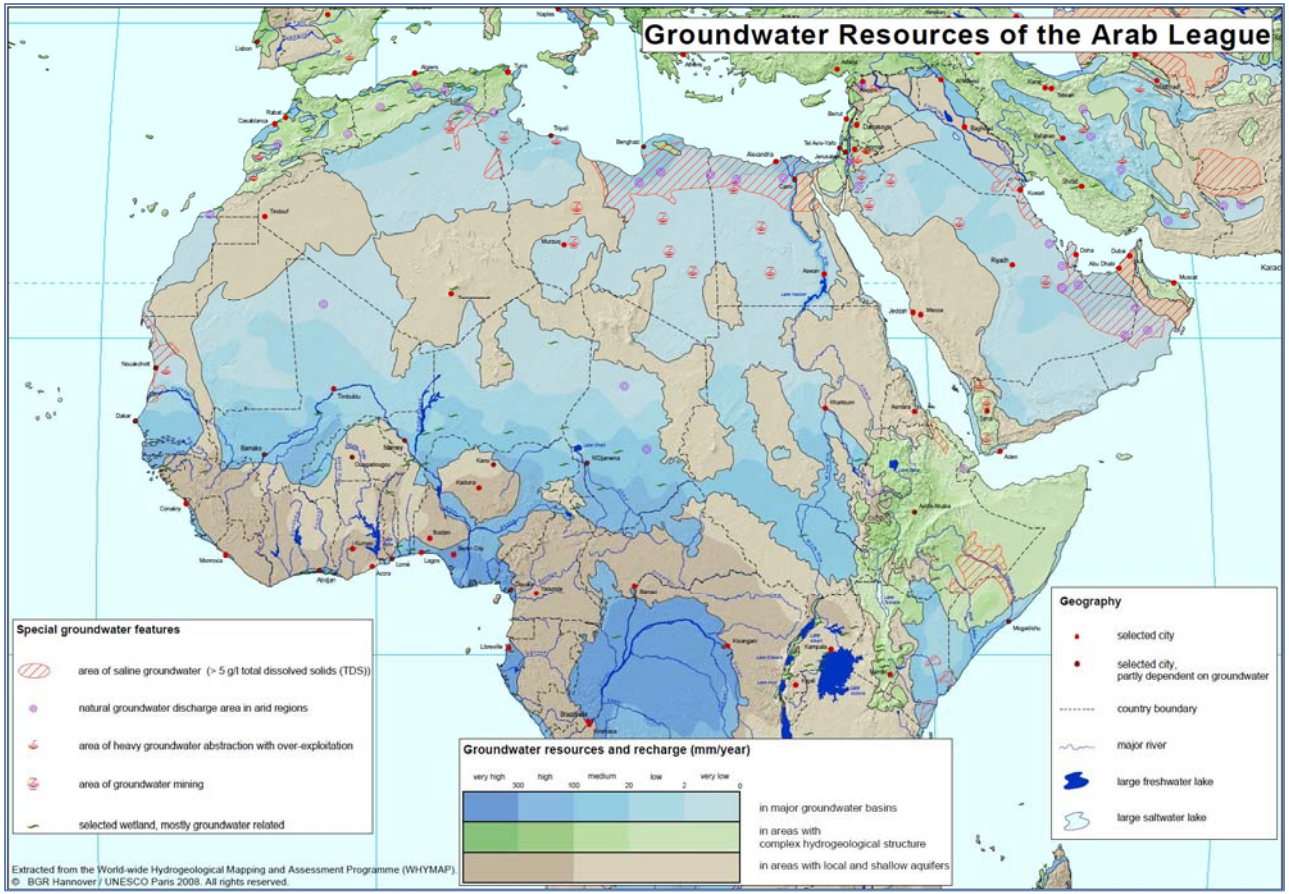
- SubSol - Coastal SUBsurface water SOLutions
- Preventing / remediating saline water intrusions through MAR

Conclusions & Recommendations

Groundwater Resources / Arab League

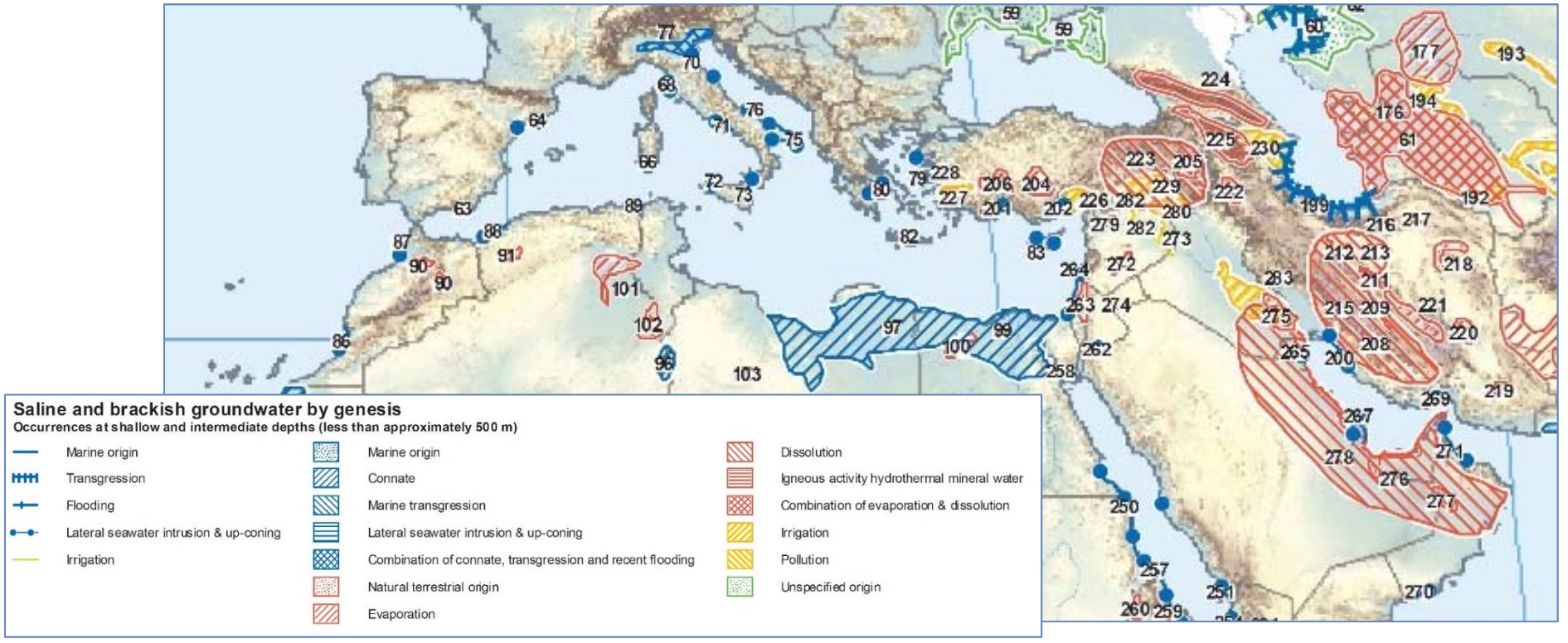
WHYMAP – **W**orld-wide **HY**drogeological **MAP**ping and Assessment Programme (BGR/UNESCO, 2008)

www.whymap.org



Saline Groundwater / Global

Global Overview of Saline Groundwater Occurrence and Genesis (draft, IGRAC, 2009)

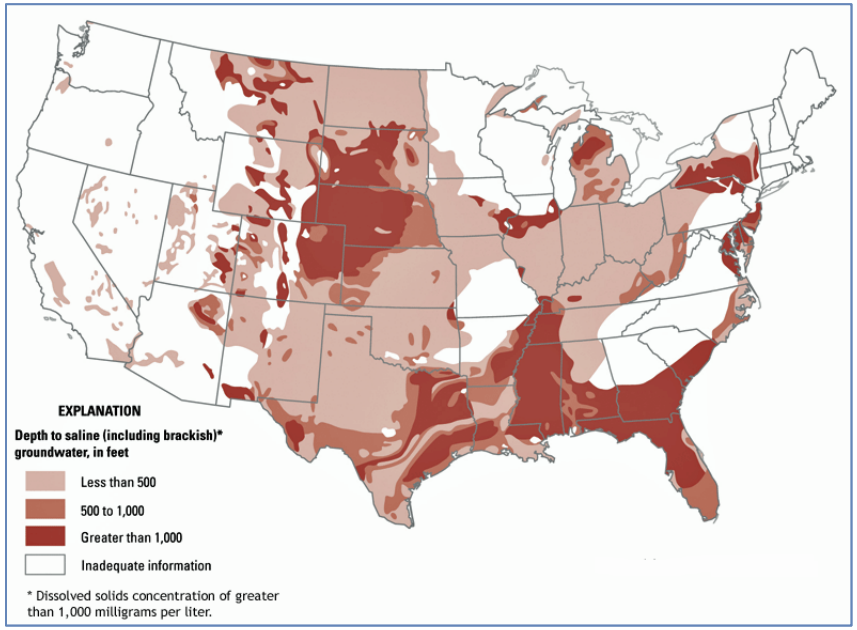


Fresh, Brackish, Saline and Brine/Hyper-Saline Groundwater

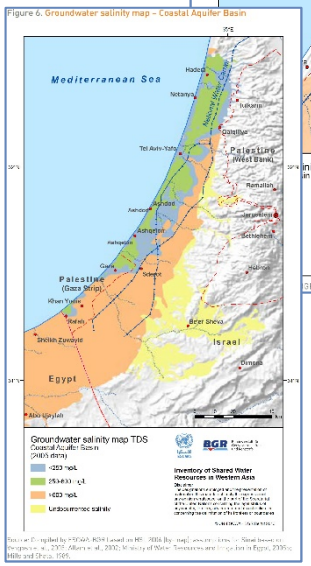
- Classification (after Freeze & Cherry, 1979)

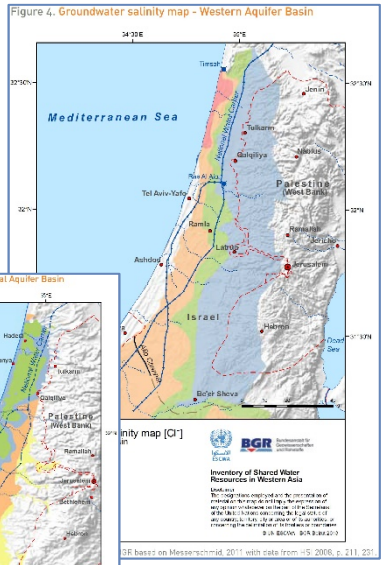
Class name	Class limits (TDS range, in mg/l)		
Fresh water	0	-	1,000
Brackish water	1,000	-	10,000
Saline water	10,000	-	100,000
Brine		>	100,000

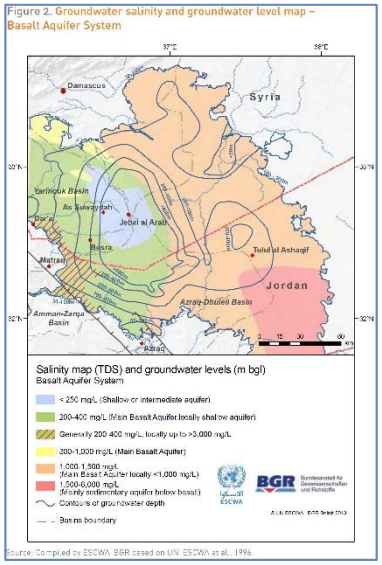
- National Brackish Groundwater Assessment (USGS, 1965/2013)

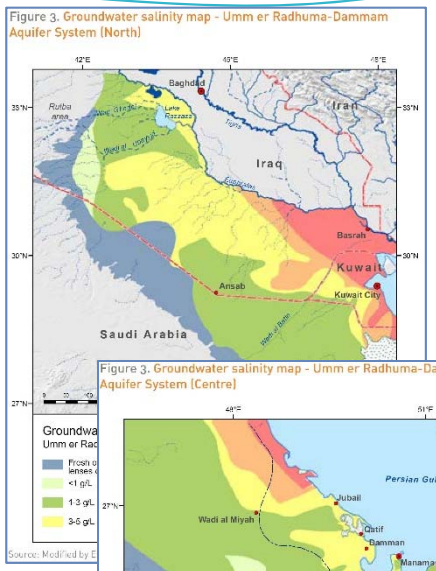


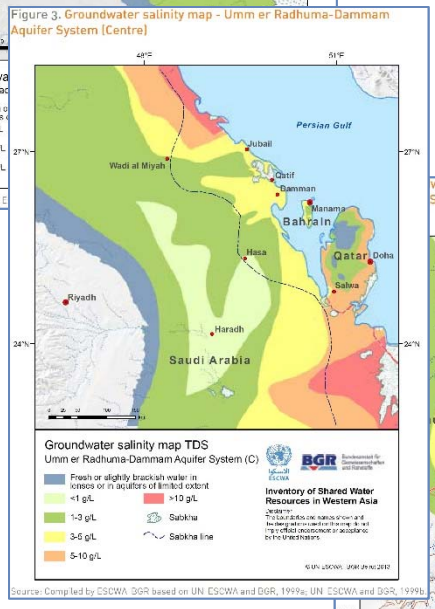
Groundwater Salinity in Western Asia

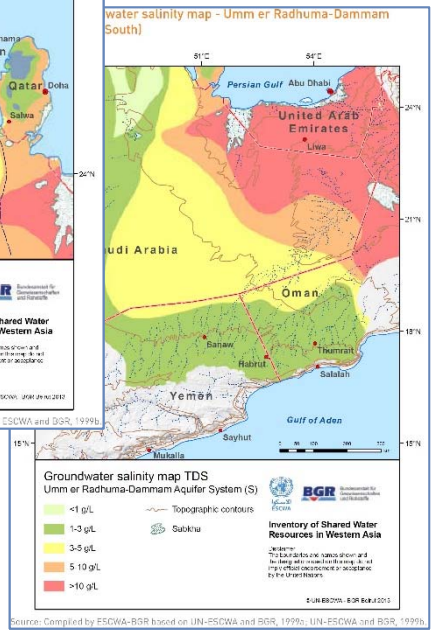










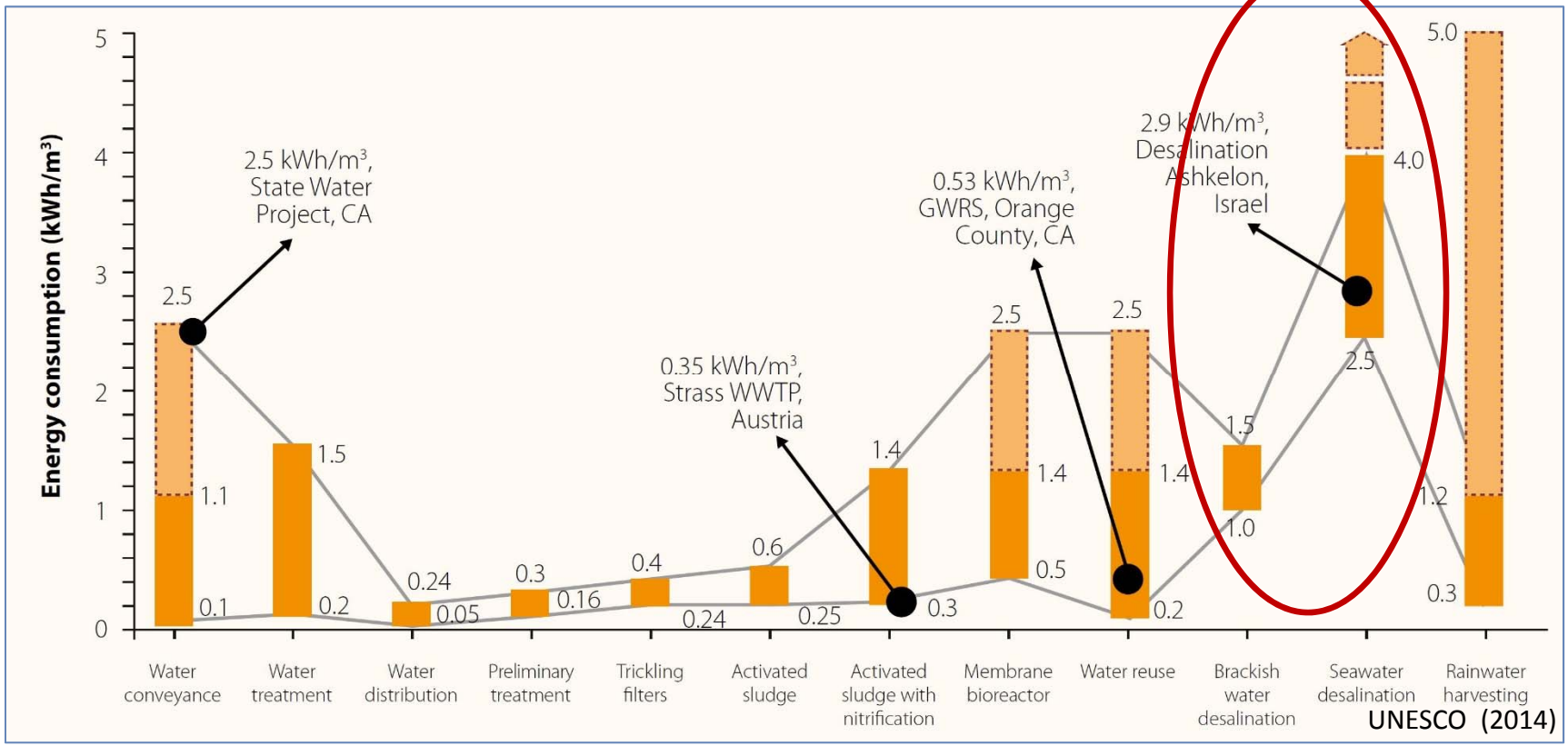


http://waterinventory.org

Socio-Economic Cost-Benefit Analysis

- Cost:
  Sum of transport and production cost
  - Option 1:
    Seawater (≥ 35 g/l) desalination
    transported from nearest sea coast inland
    and up to elevation
    - Higher costs for location of desal plant,
      due to competing land use in coastal areas
  - Option 2:
    Local brackish water (1-10 g/l) desalination
    transported from source up to elevation

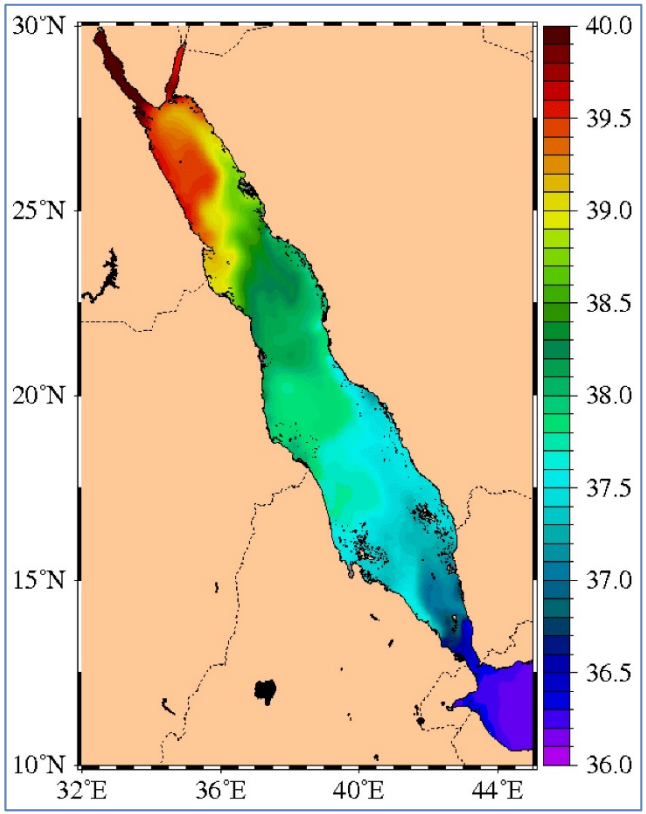
Socio-Economic Cost-Benefit Analysis

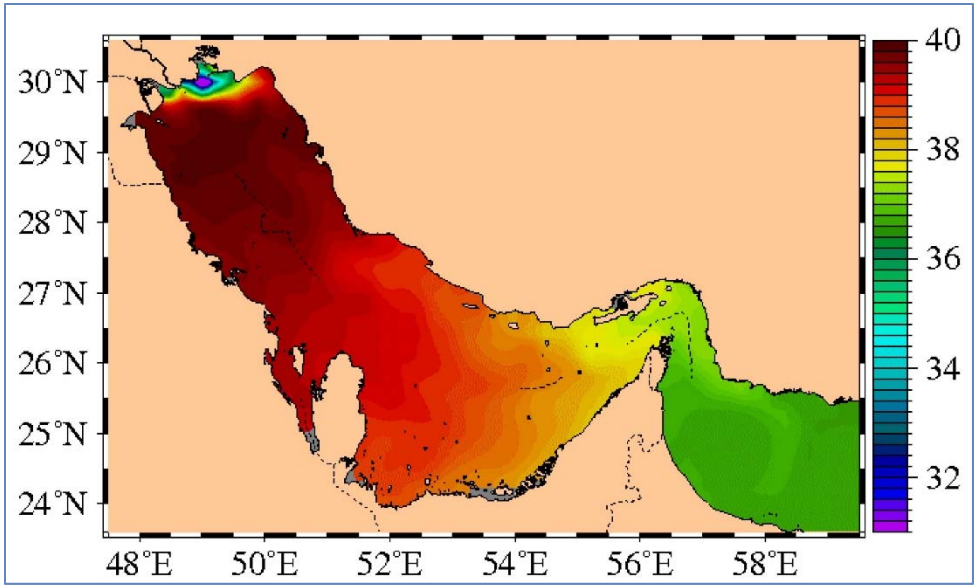


UNESCO (2014)

Socio-Economic Cost-Benefit Analysis

Salinity (g/l) of Seawater in Red Sea and Gulf





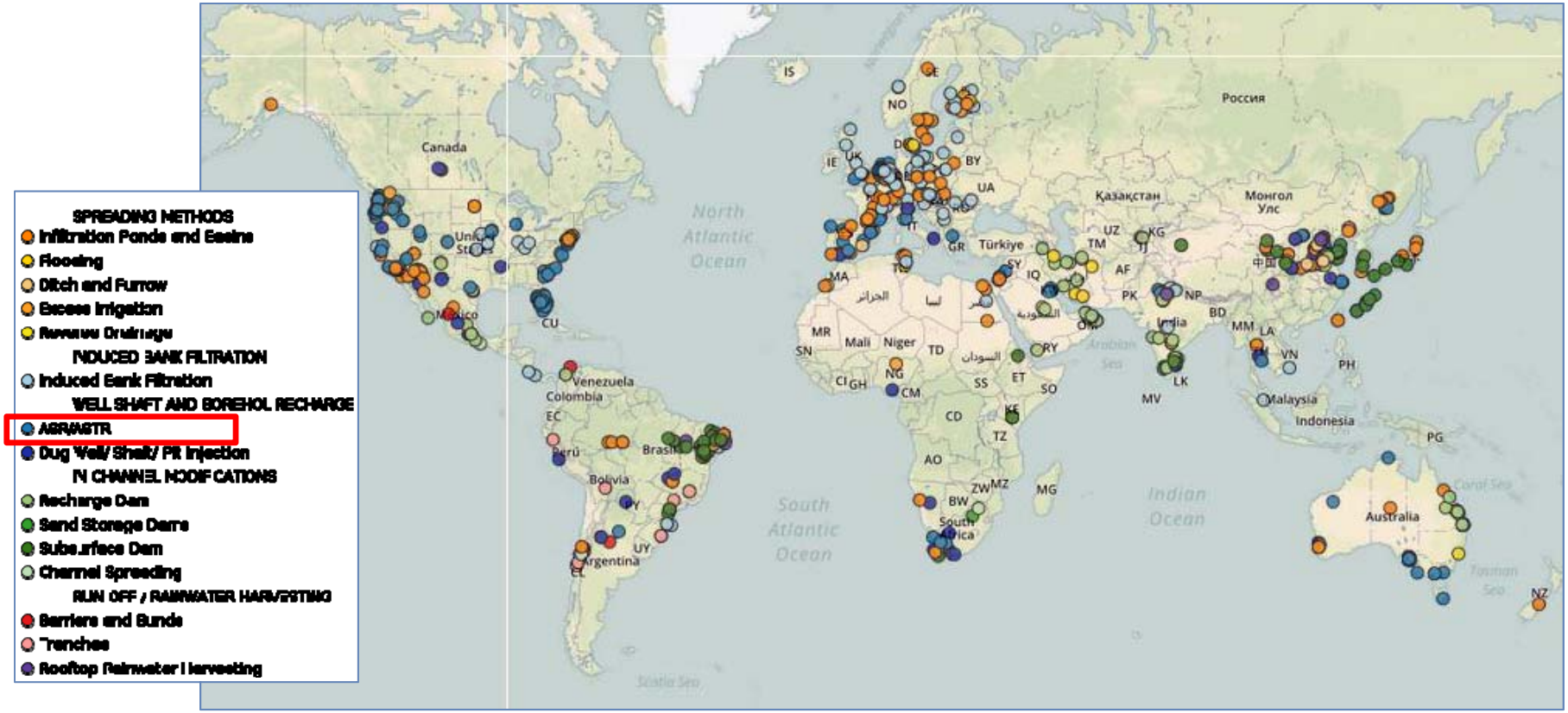
National Research Laboratory (2013)

SubSol – Coastal SUBsurface Water SOLutions

- Sophisticated MAR applications
- Improve water management in coastal areas
- Developed in the Netherlands
- Operational on pilot or full-scale
- Subject of further study in the EU financed project SubSol

- Managed Aquifer Recharge (MAR):
  The purposeful recharge of water to suitable aquifers under controlled conditions for subsequent recovery or environmental benefit

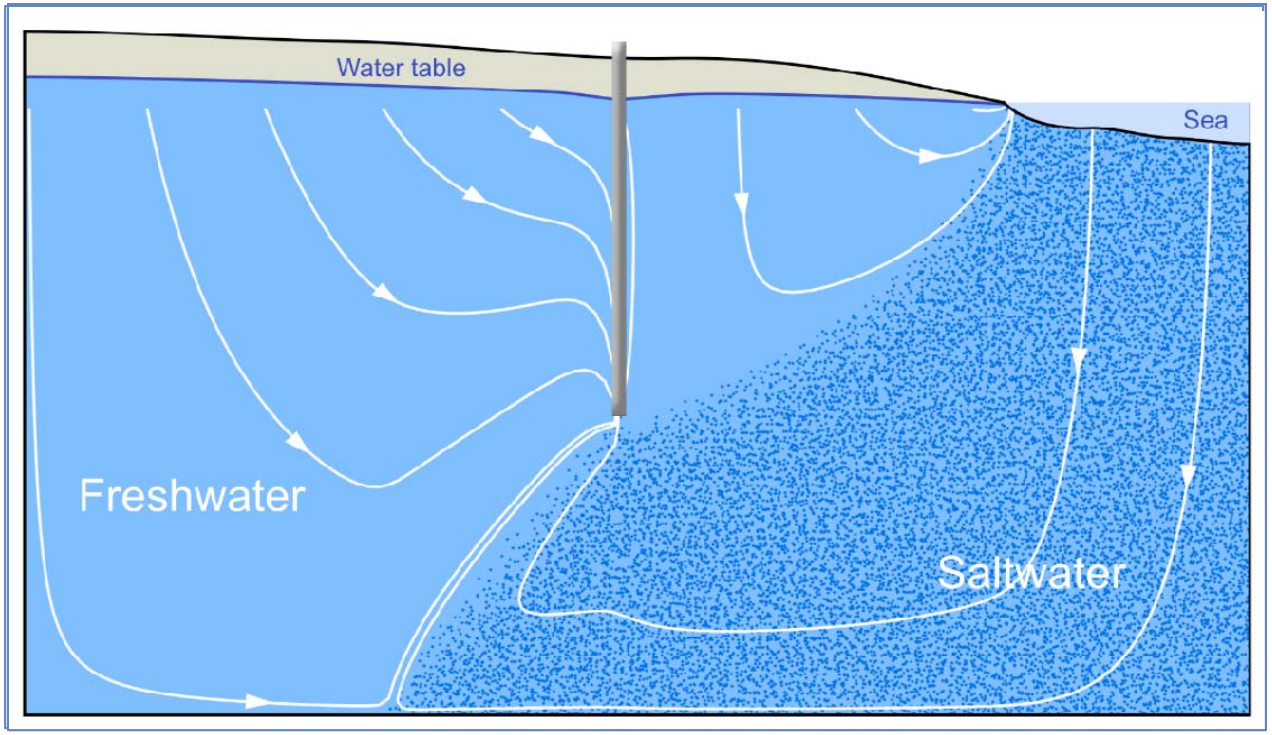
Managed Aquifer Recharge – Global MAR Inventory



- https://www.un-igrac.org/special-project/global-mar-inventory

Saline Groundwater in Coastal Settings

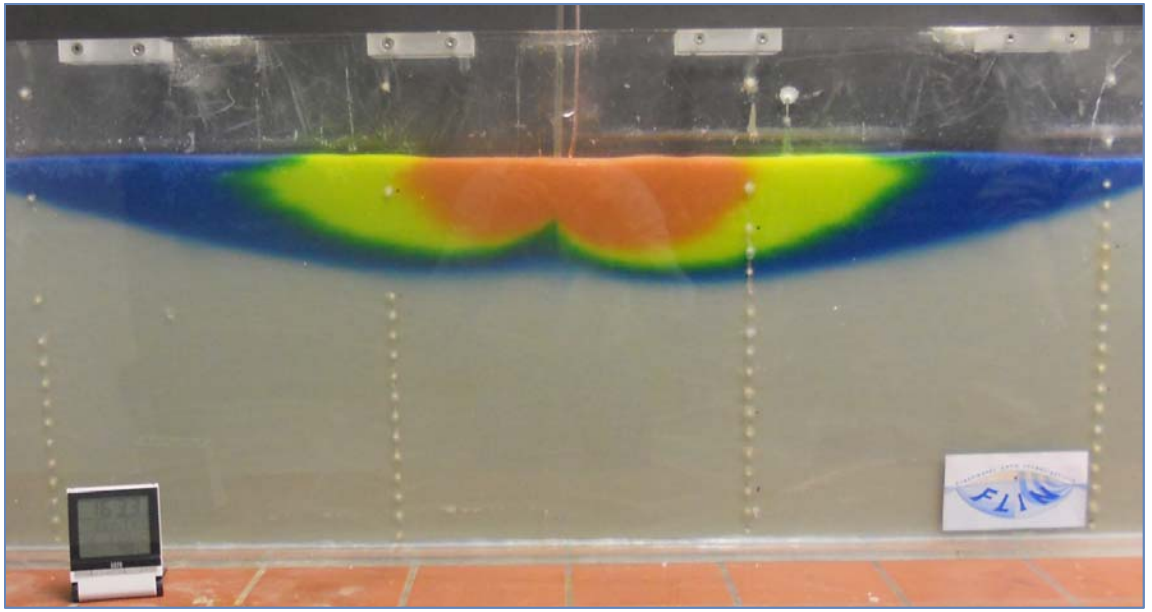
- Urbanization & industrialization - Increasing water demand
- Seawater intrusion into aquifers - Water unsuitable



Example:
Marine saltwater intrusion due to overpumping
Post (2016)

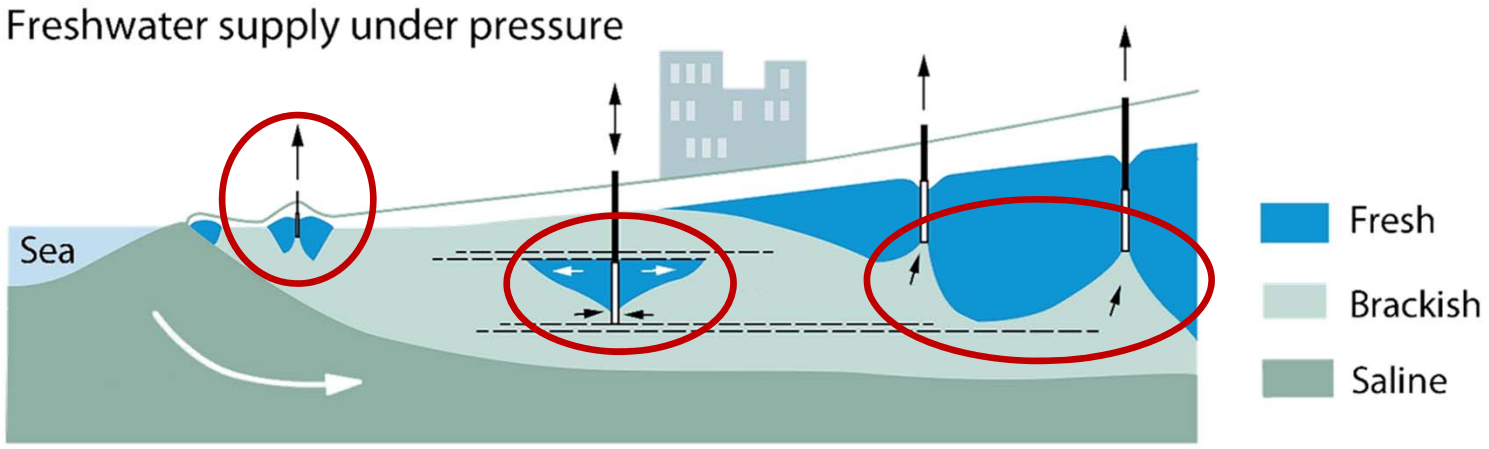
Saline Groundwater in Coastal Settings

- Understanding Freshwater Lenses, Freshwater Injections ASR Sand Tank Experiments



- **FLIN** – **F**reshwater **L**ens **IN**vestigations: www.bgr.bund.de/EN/Themen/Wasser/Projekte/laufend/F+E/Flin/flin_projektbeschr_en.html

Seawater Intrusion in Coastal Areas



Modified after KWR (2015)

Overexploitation
of freshwater lenses

Low efficiency
of conventional ASR systems

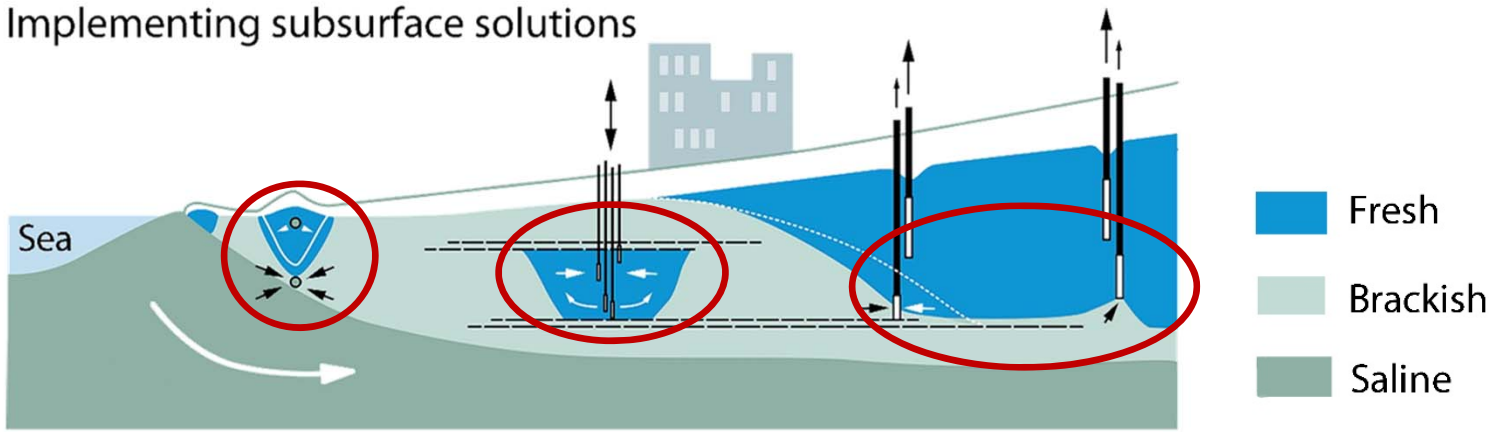
Upconing
of brackish/ saline water

SubSol Project

Freshmaker
Management of freshwater lenses

ASR Coastal
ASR with partially penetrating wells

Freshkeeper
Well configurations to prevent upconing



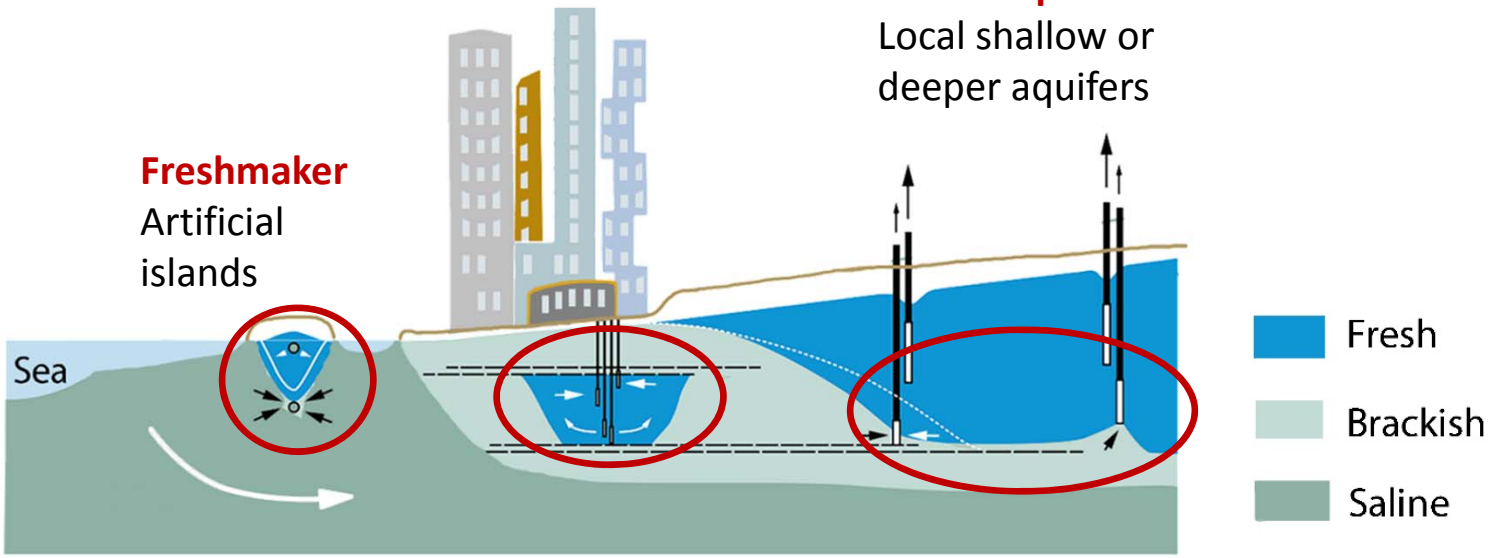
Modified after KWR (2015)

SWS in Different Coastal Settings

ASR Coastal
Modern
coastal cities

Freshkeeper
Local shallow or
deeper aquifers

Freshmaker
Artificial
islands



Modified after KWR (2015)

Freshmaker - Concept

2 horizontal directional drilled wells (HDDW) – shallow and deep

Injection phase

Freshwater injection in shallow HDDW1

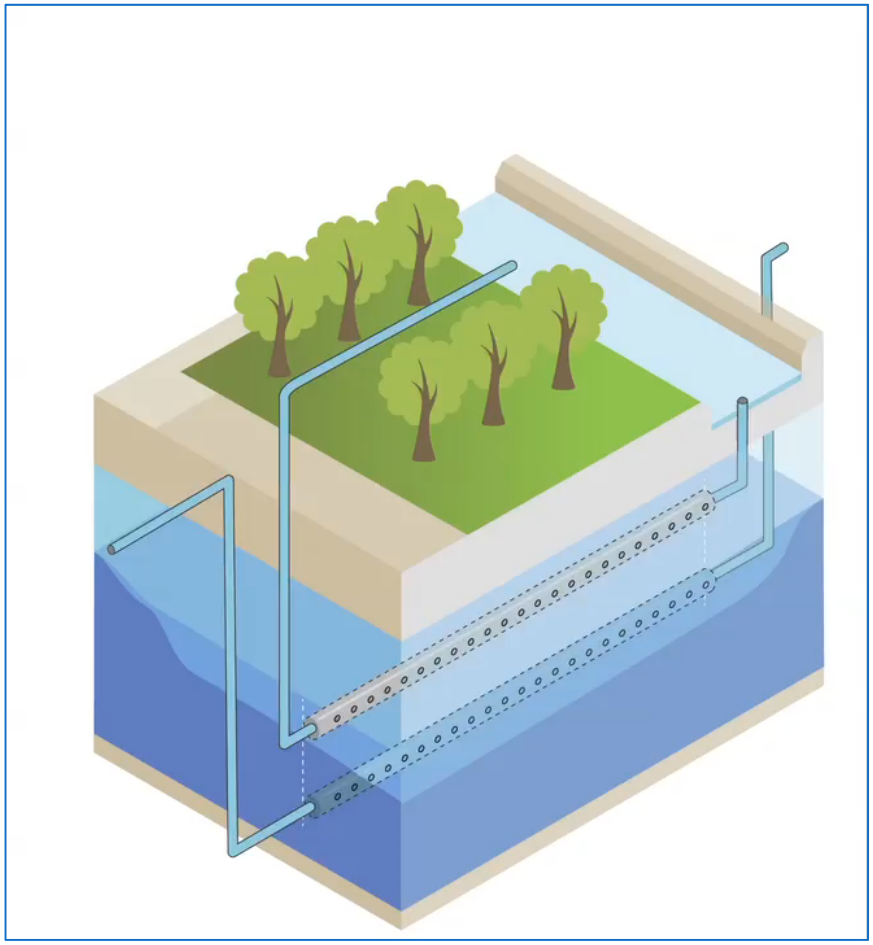
Saltwater abstraction in deep HDDW2

Abstraction phase

Freshwater abstraction in shallow HDDW1

Saltwater abstraction in deep HDDW2

→ Increase thickness of the freshwater lense; prevent upconing during abstraction



ASR Coastal - Concept

Infiltration, storage and recovery of freshwater using multiple partially penetrating wells (MPPW) to deal with ***buoyancy effects***

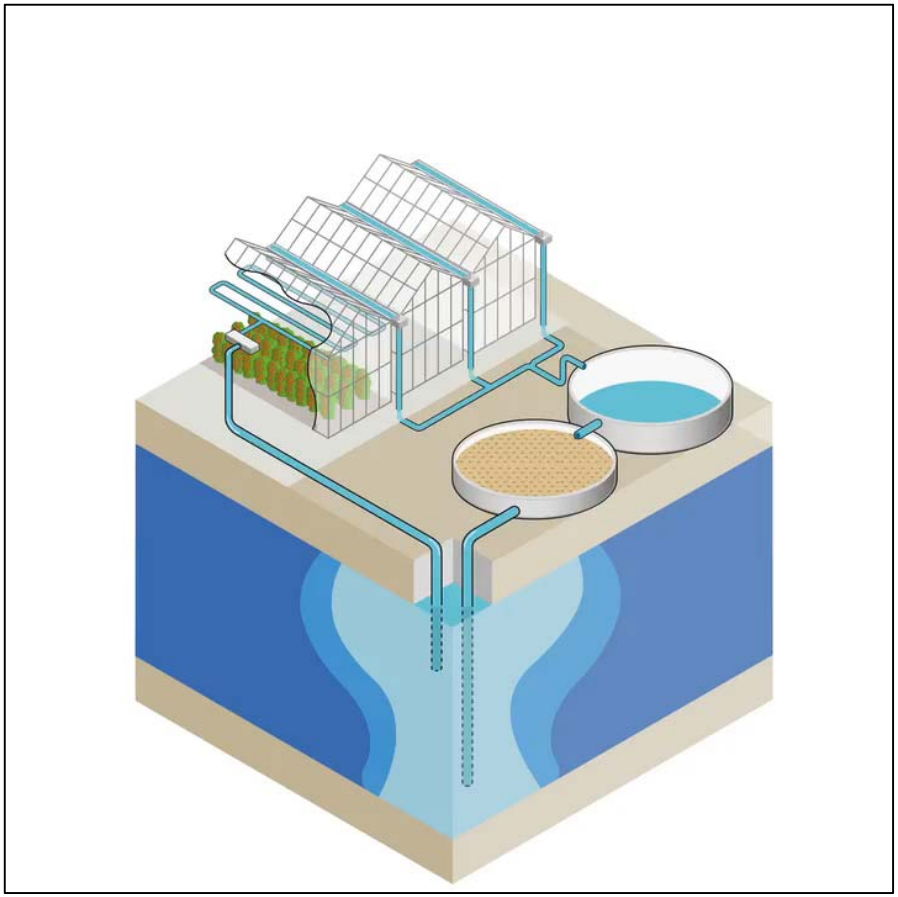
Injection phase

Freshwater injection in deeper wells

Abstraction phase

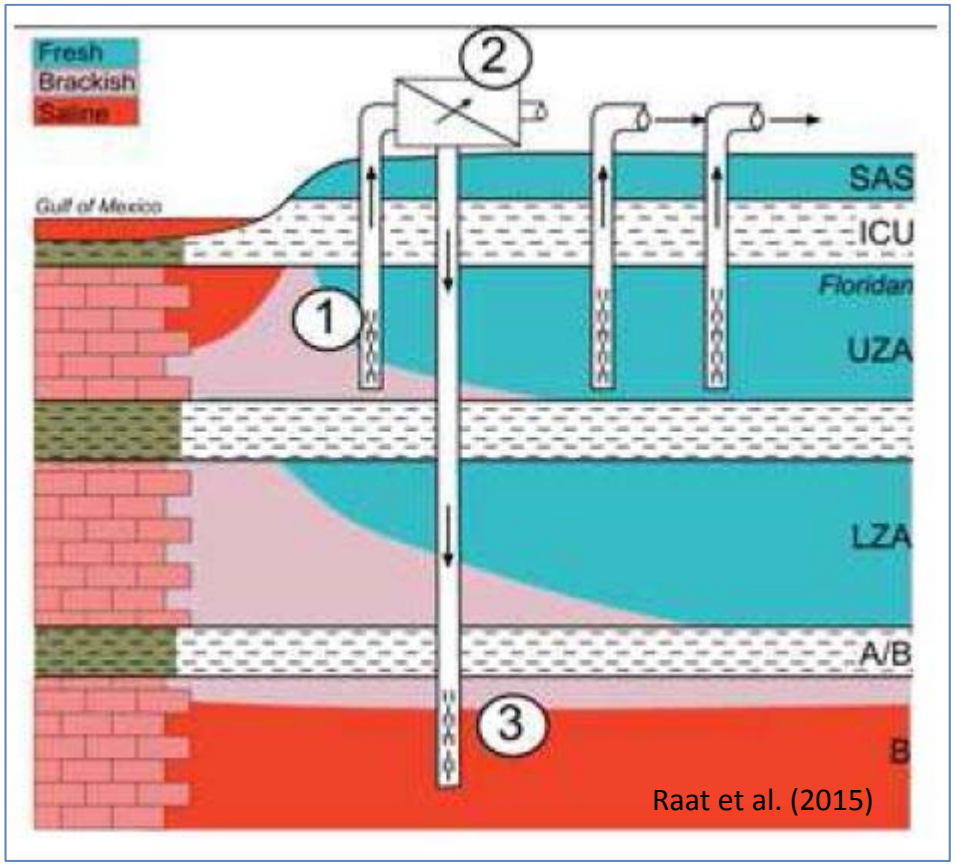
Option 1: Freshwater abstraction in shallow wells

Option 2: Additional brackish water abstraction in deeper wells; RO treatment



Freshkeeper - Concept

1. The freshwater wells inland are protected by interception of the intruding seawater.
2. The intercepted water is desalinated with reverse osmosis (RO)
3. The membrane concentrate is disposed to the underlying saline aquifer



Raat et al. (2015)

Conclusion & Recommendations

- Groundwater can be fresh, brackish or saline: **Brackish and saline groundwater** can provide important **marginal water resources** in local situation
- Need for **better mapping** of fresh, brackish and saline groundwater laterally and in depth
- Improve **socio-economic cost-benefit assessments** for potential use of brackish and saline groundwater
- **MAR/ASR** can offer solutions in coastal settings to **prevent and remediate saline water intrusion**
- **SubSol proven subsurface solutions for coastal settings** potentially also for GCC and Arab countries

Acknowledgement & Links

- **FLIN** – **F**reshwater **L**ens **IN**vestigations:
  Dr. Georg Houben, Dr.-Ing. Leonard Stöckl
  www.bgr.bund.de/EN/Themen/Wasser/Projekte/laufend/F+E/Flin/flin_projektbeschr_en.html
- **SubSol** - Coastal **SUB**surface water **SOL**utions:
  Dr. Maike Gröschke and SWS team, www.subsol.org
- Desalination, brackish and saline waters:
  Dr. Armin Margane

Bundesanstalt für Geowissenschaften und Rohstoffe

GEOZENTRUM HANNOVER

GRIPP
GROUNDWATER SOLUTIONS INITIATIVE FOR POLICY AND PRACTICE

Associated Partner

http://gripp.iwmi.org

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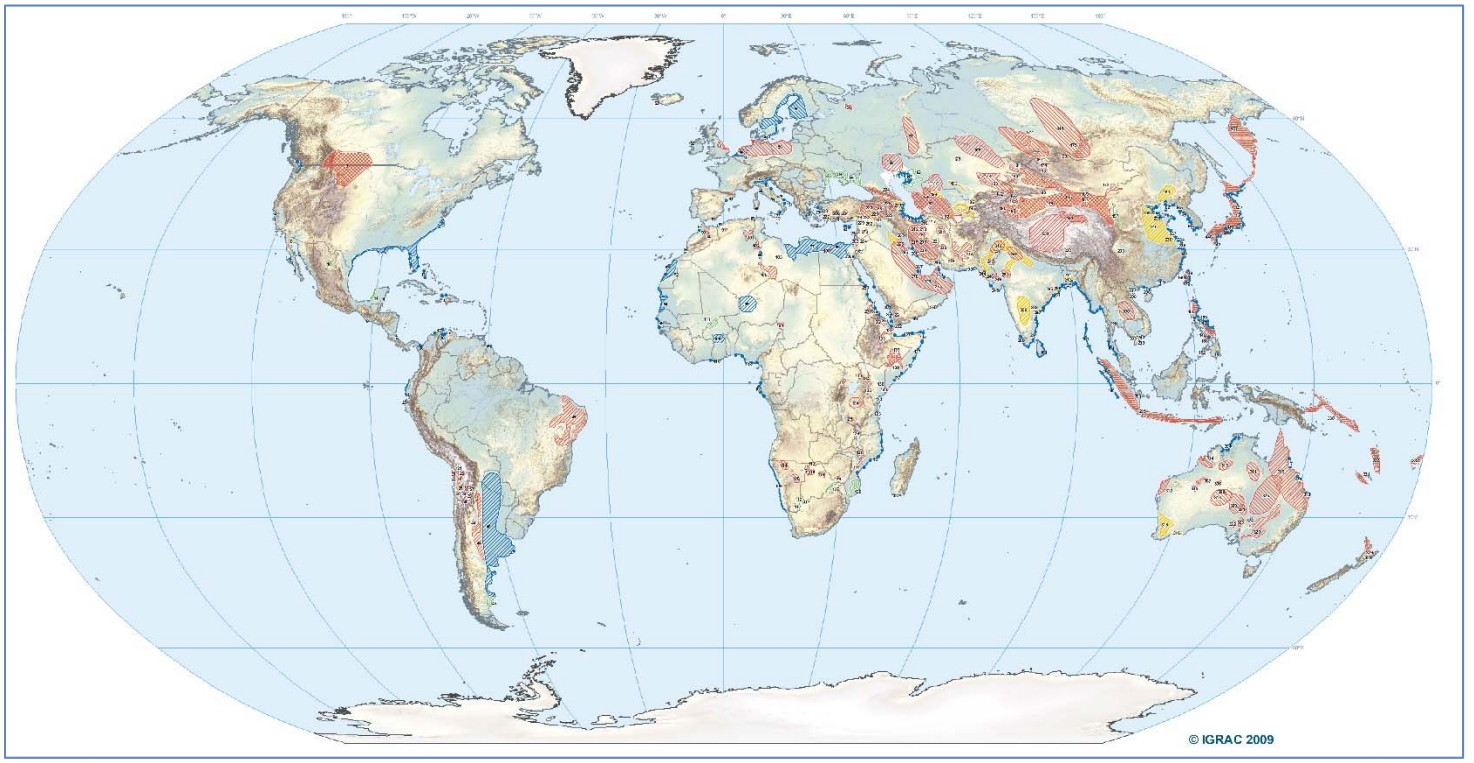
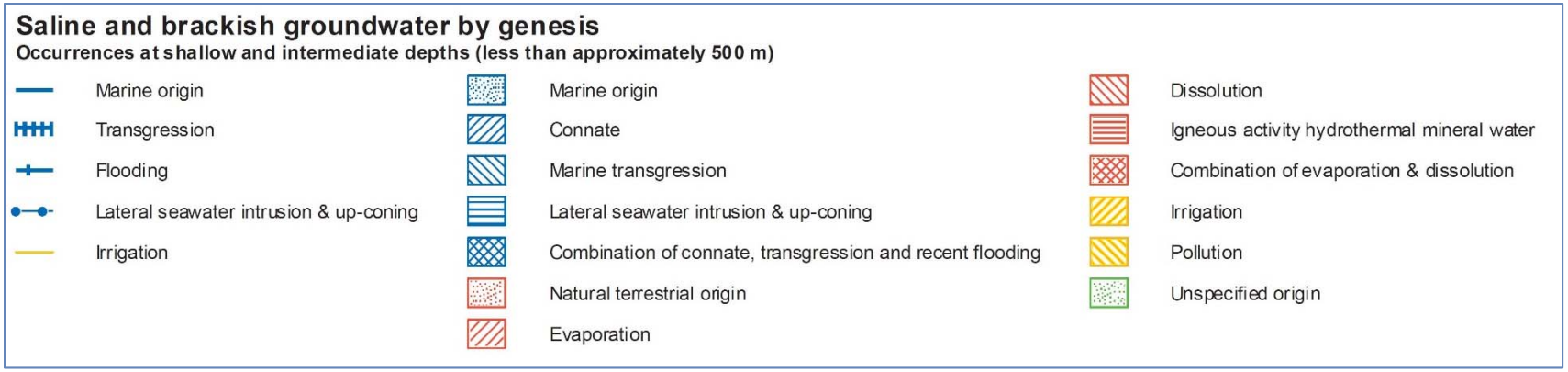


Status of Groundwater Resources

- Global Overview of Saline Groundwater Occurrence and Genesis (draft, leghend, IGRAC, 2008)



Freshmaker - Challenges

Depth of HDDW2 is important design parameter

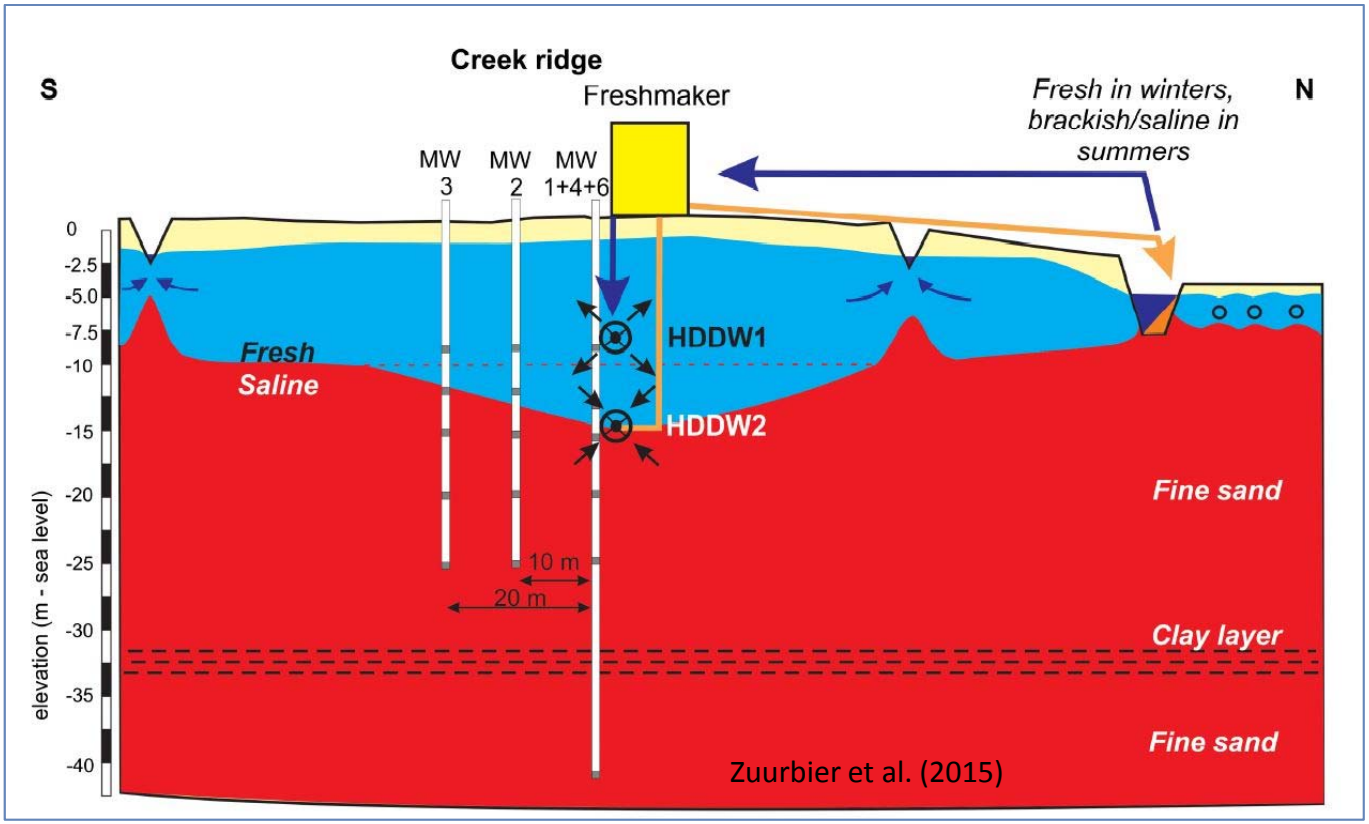
- if too shallow this HDDW can abstract costly freshwater
- if too deep it provides insufficient protection of the upper HDDW

→ SEAWAT modelling to find optimum depth of HDDW2

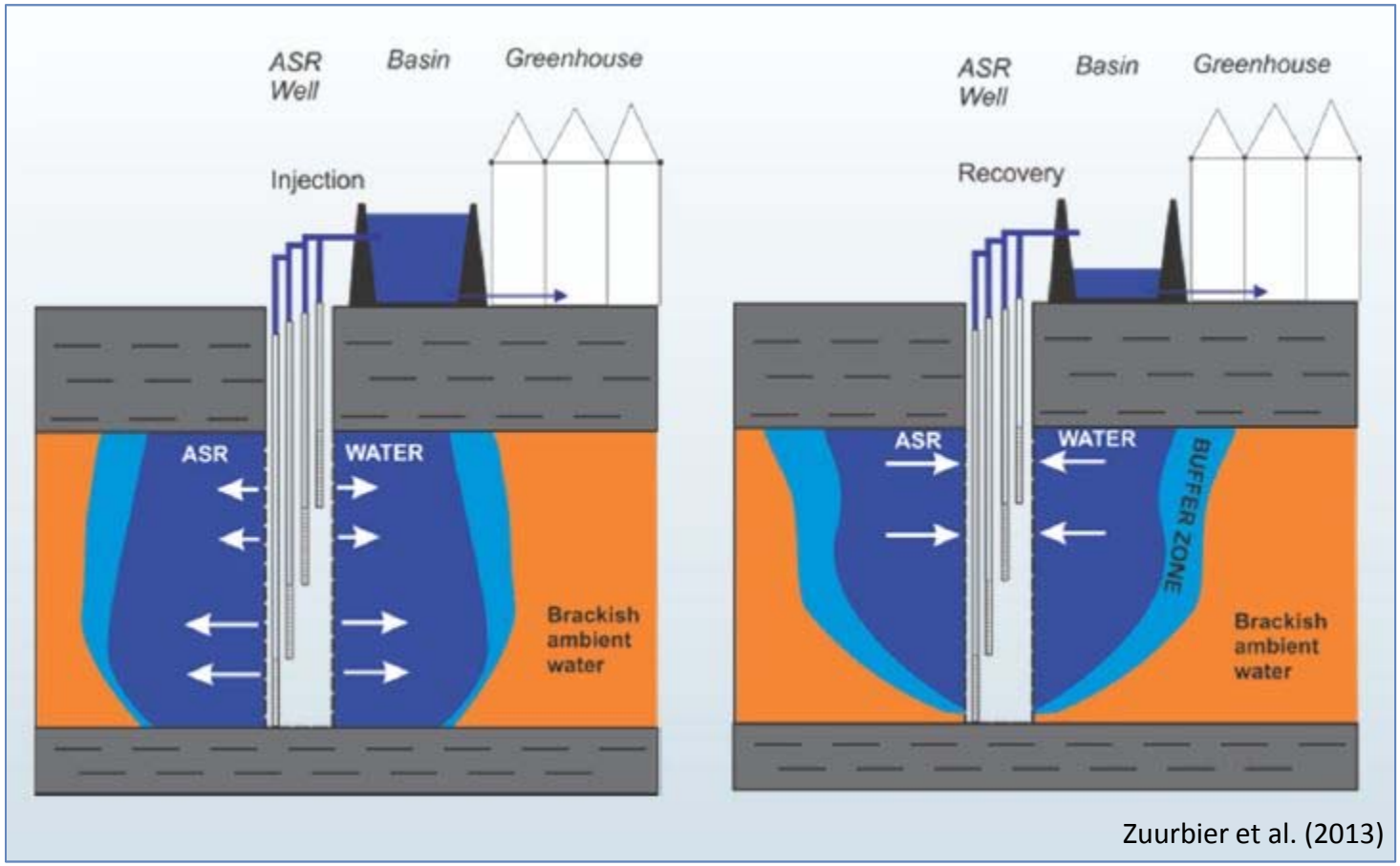
Freshmaker - Pilot
Ovezande, Southwest Netherlands

Freshwater is scarce due to the surrounding estuaries and saline seepage

Resources are limited to rainwater and local fresh groundwater lenses in sandy creek ridges



ASR Coastal - Option 1

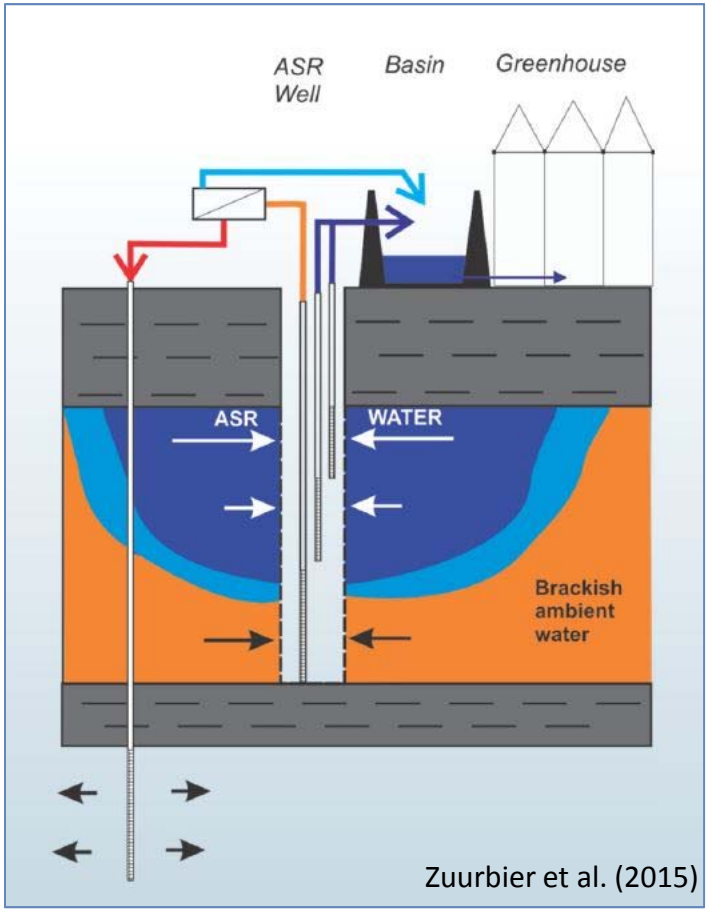


Zuurbier et al. (2013)

ASR Coastal - Option 2

Recovery Phase:

- Freshwater abstraction in shallow wells
- Brackish water abstraction in deepr wells feeding an RO system
- Injection of RO brines into deeper saline aquifer or disposal in sea/ocean



Zuurbier et al. (2015)

SubSol - Project

EU project SUBSOL
"bringing coastal subsurface solutions to the market"

- Continue with scientific evaluation of the full-scale systems (reference sites)
- Demonstrate applicability in different settings (replication sites)
  - Denmark, Greece, Mexico
  - Pilot scale studies
- Assess applicability worldwide (target regions)
  - Europe, Gulf of Mexico, China, Brazil, Vietnam
  - Pre-feasibility studies