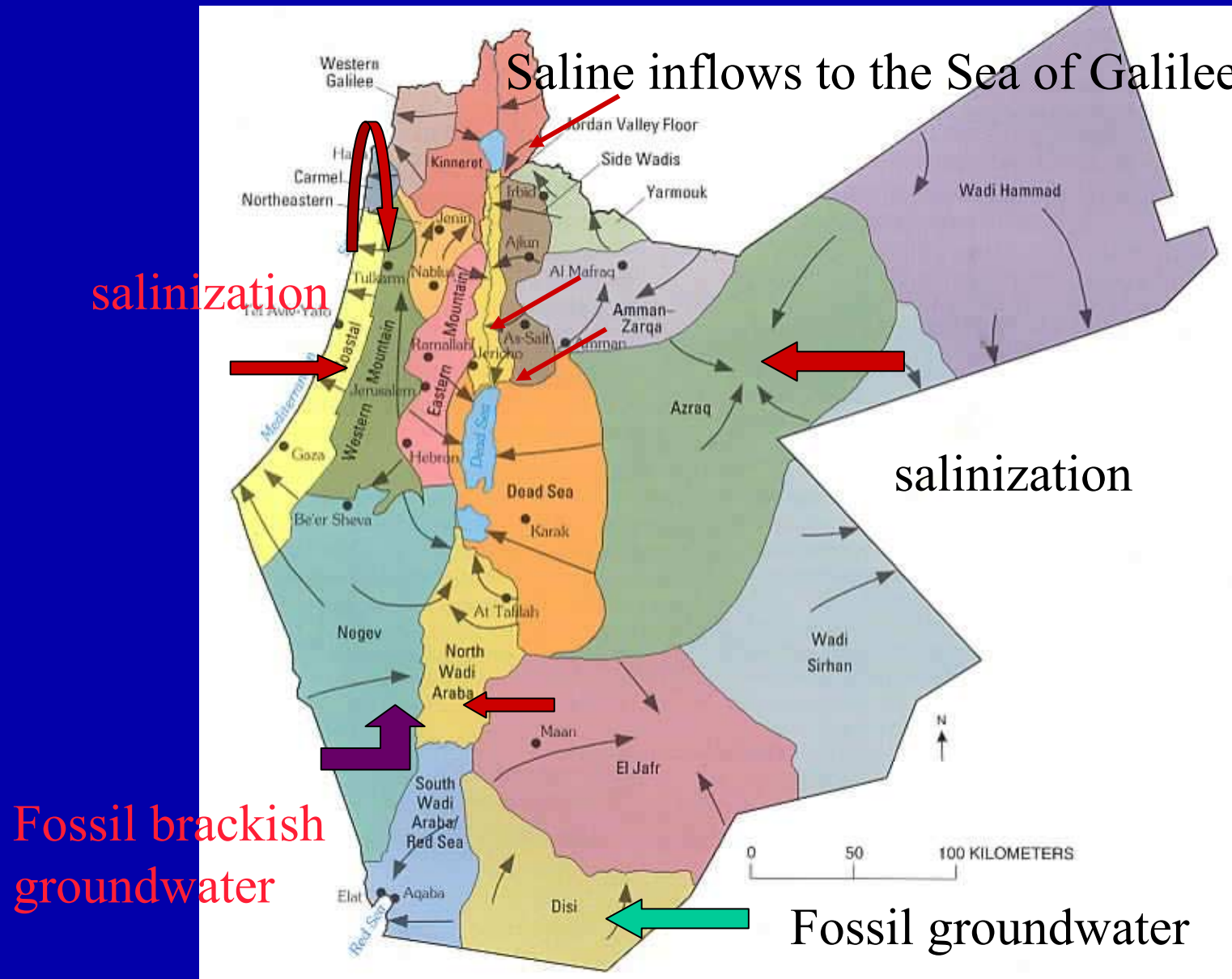


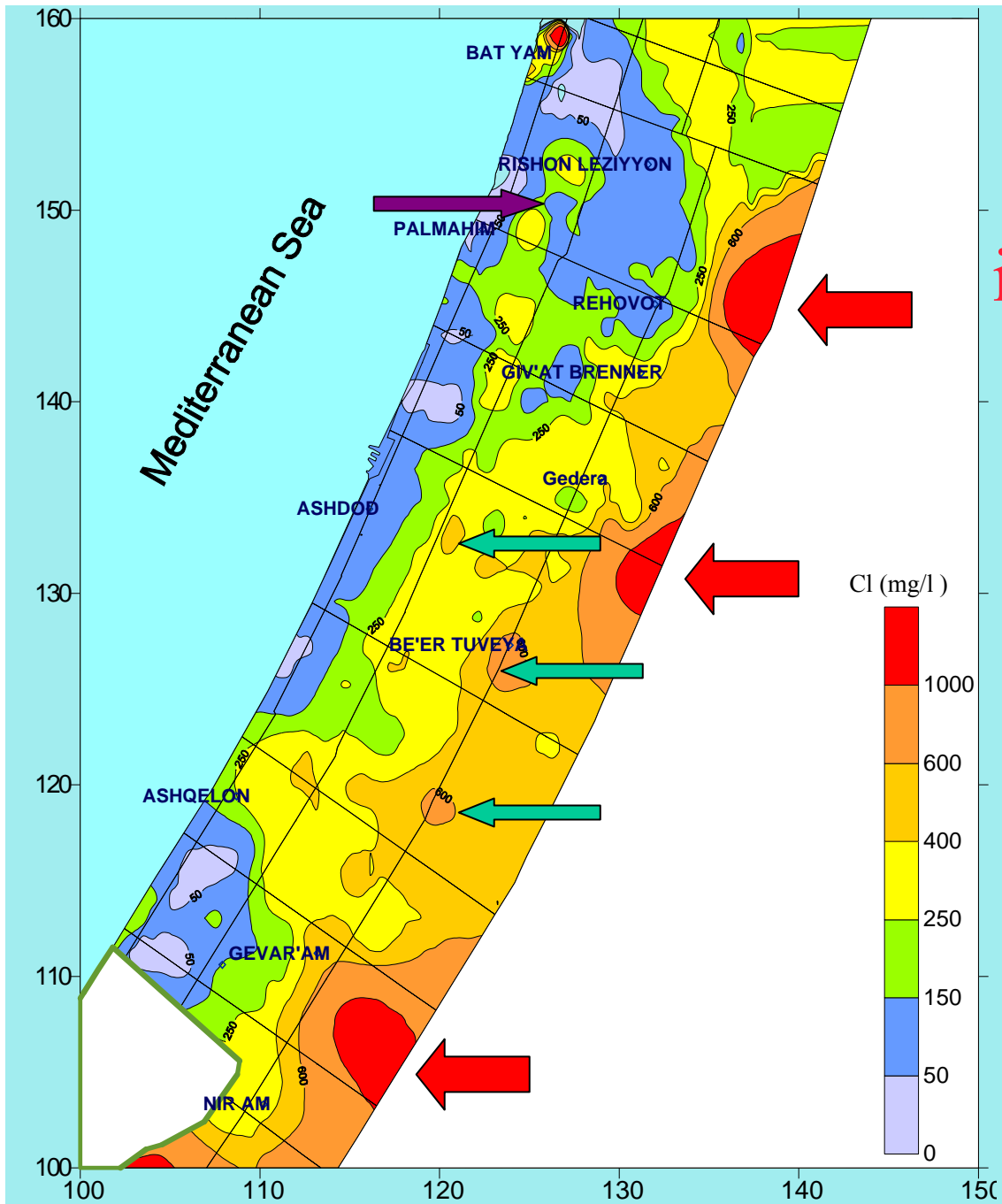
**An isotopic approach for elucidating
the sources of nitrate and chloride
contamination in the Mediterranean
coastal aquifer: Implementation for
the Gaza Strip**

Avner Vengosh



Groundwater Resources in the Middle East

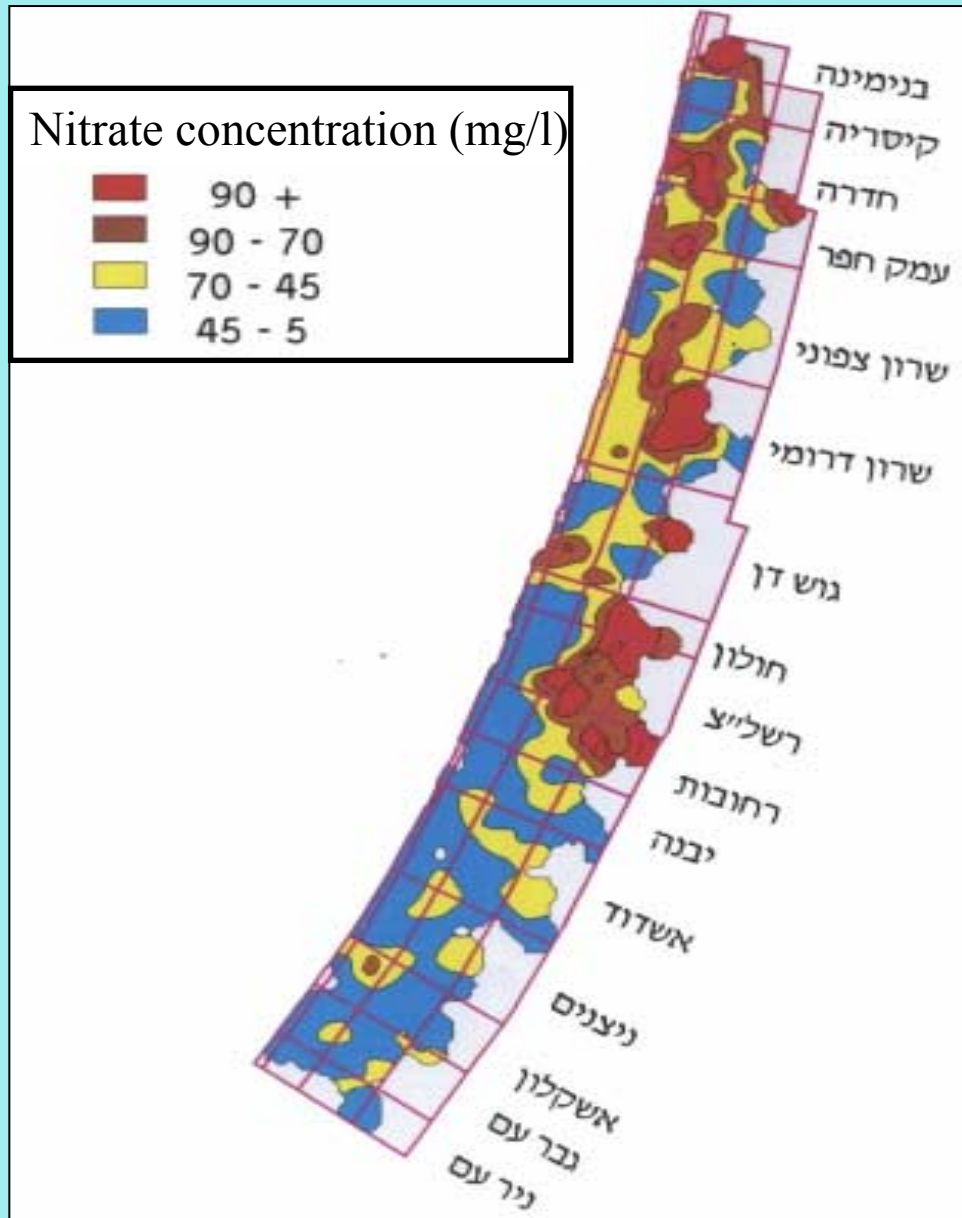


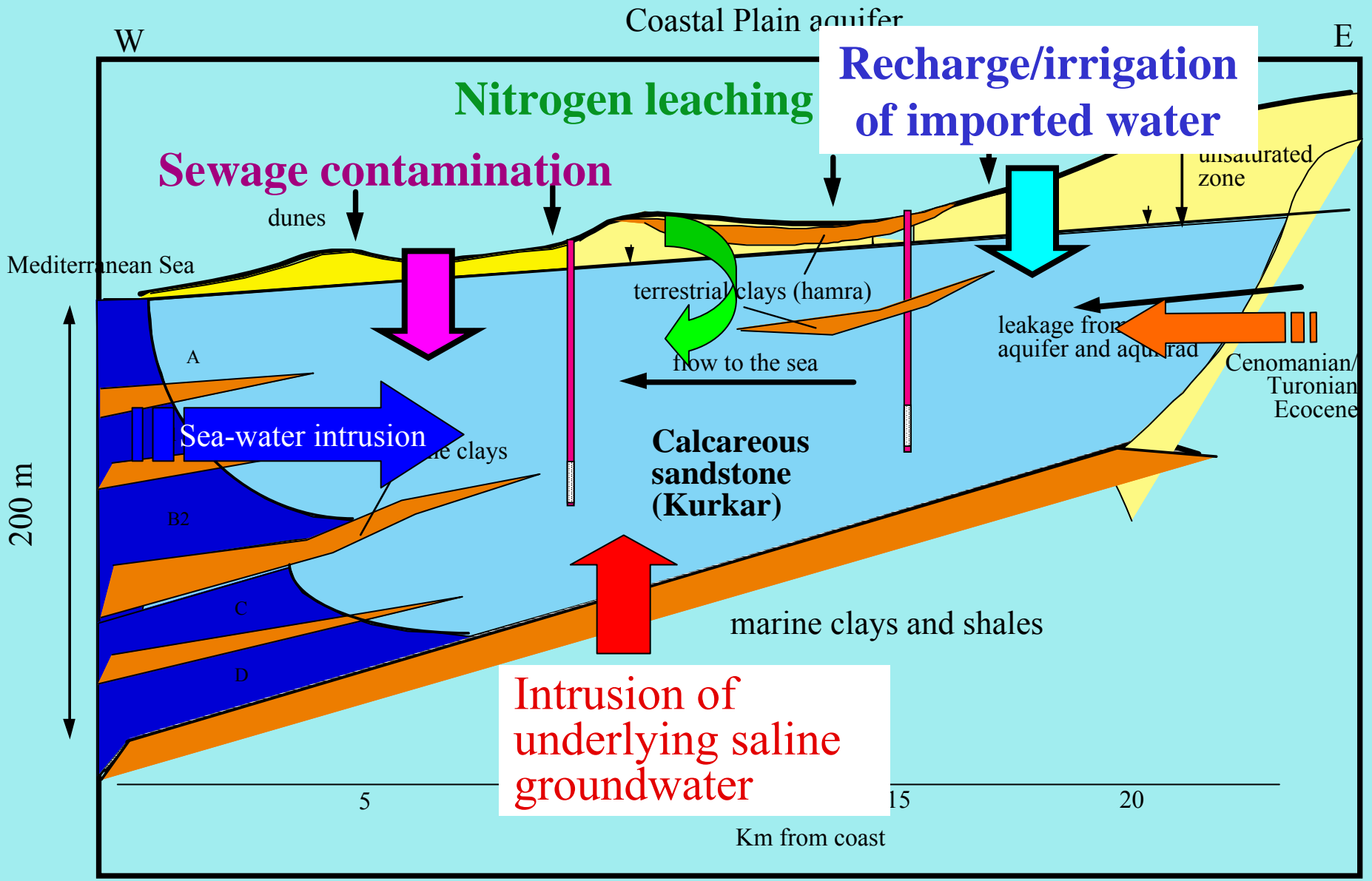


Chloride distribution
in pumping wells from
the
Coastal aquifer

Figure 1

A large-scale phenomenon: Nitrate pollution of groundwater from the Mediterranean coastal aquifer





Schematic hydrogeological cross section

Oxygen isotope distribution in ground water from pumping wells from the Coastal aquifer (n=200)

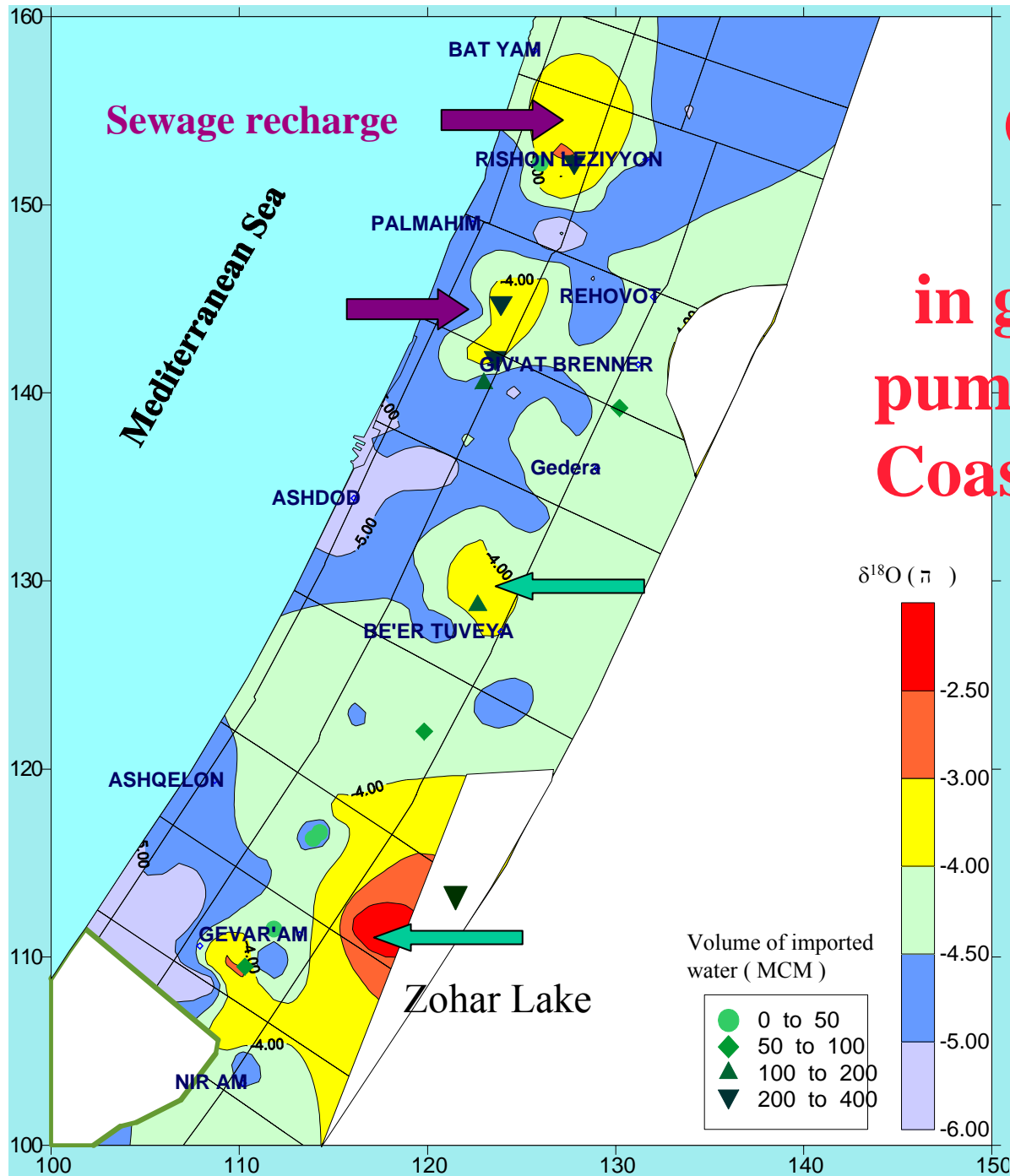
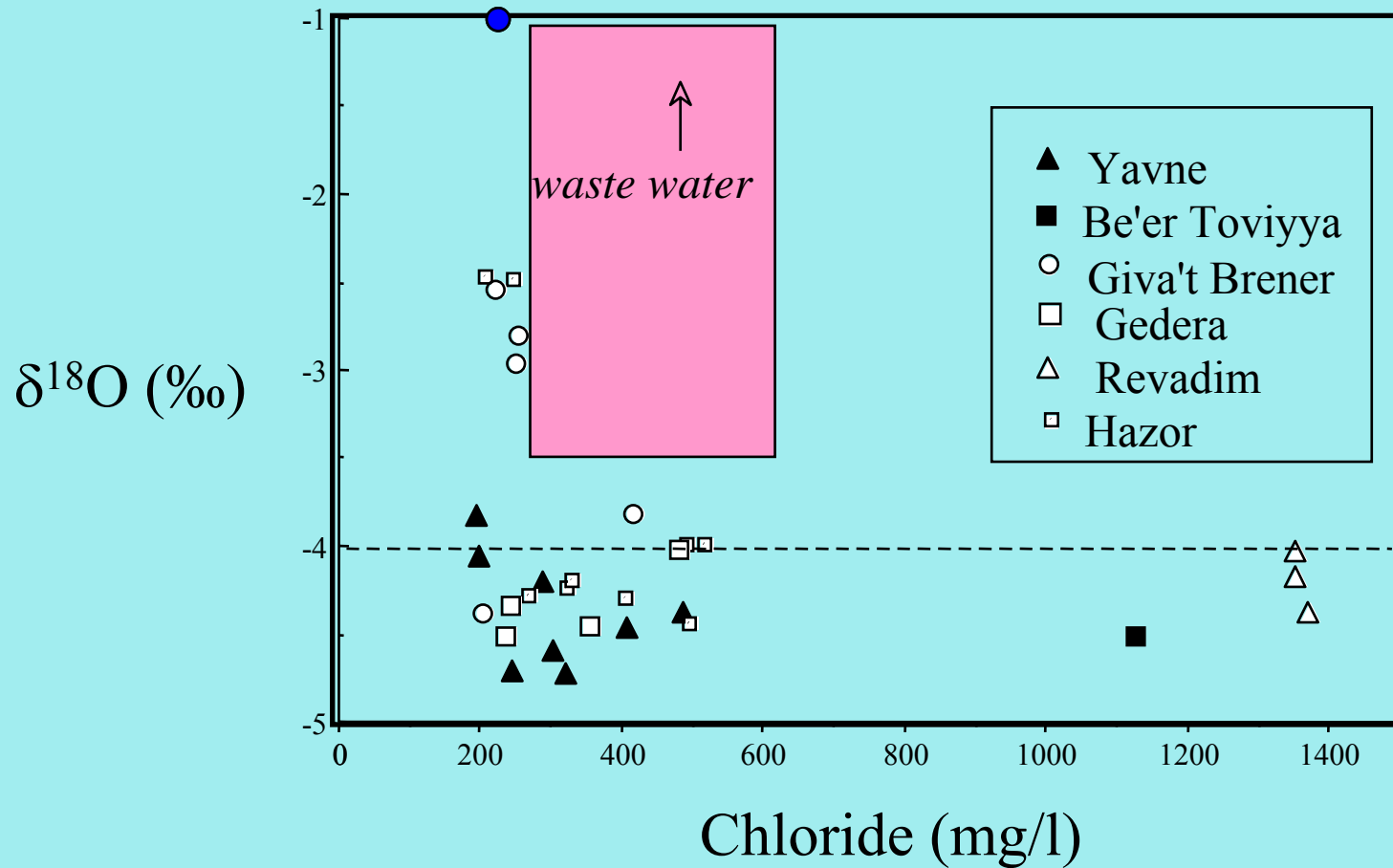


Figure 2

Sea of Galilee



Saline plumes in the inner parts of the aquifer are not derived from anthropogenic sources

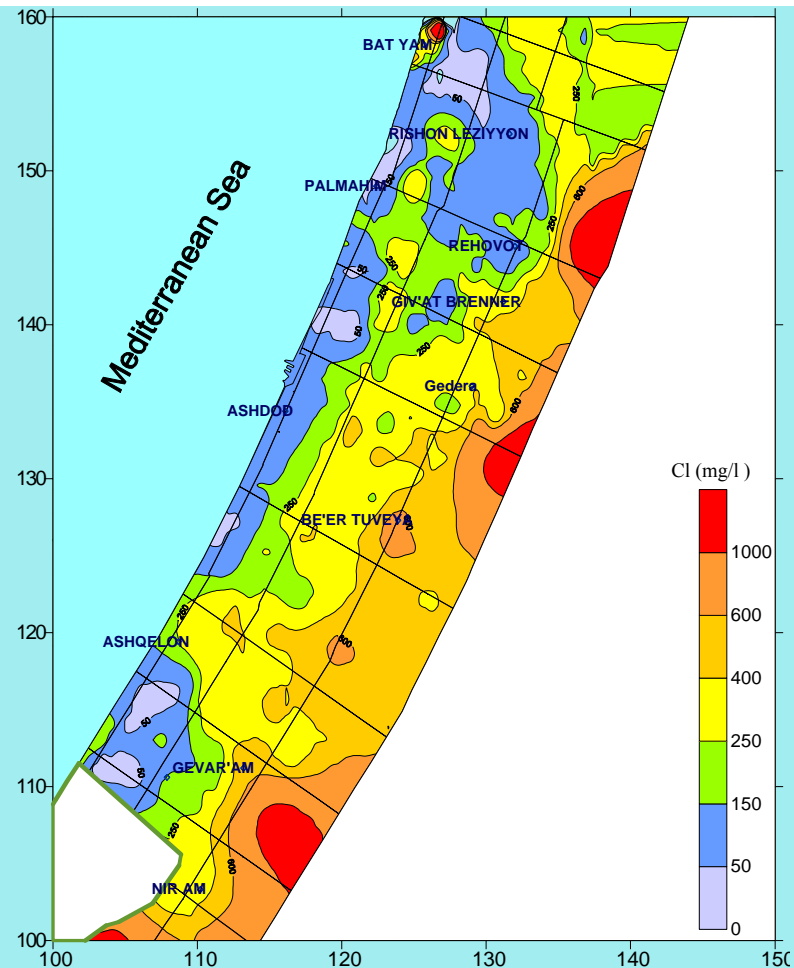
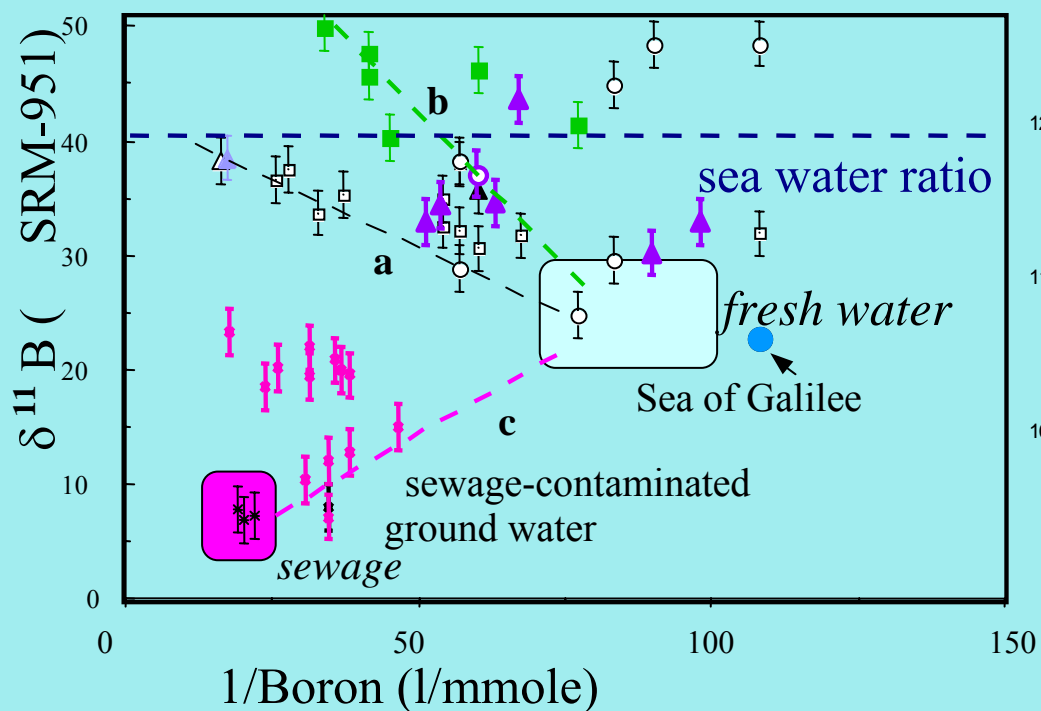
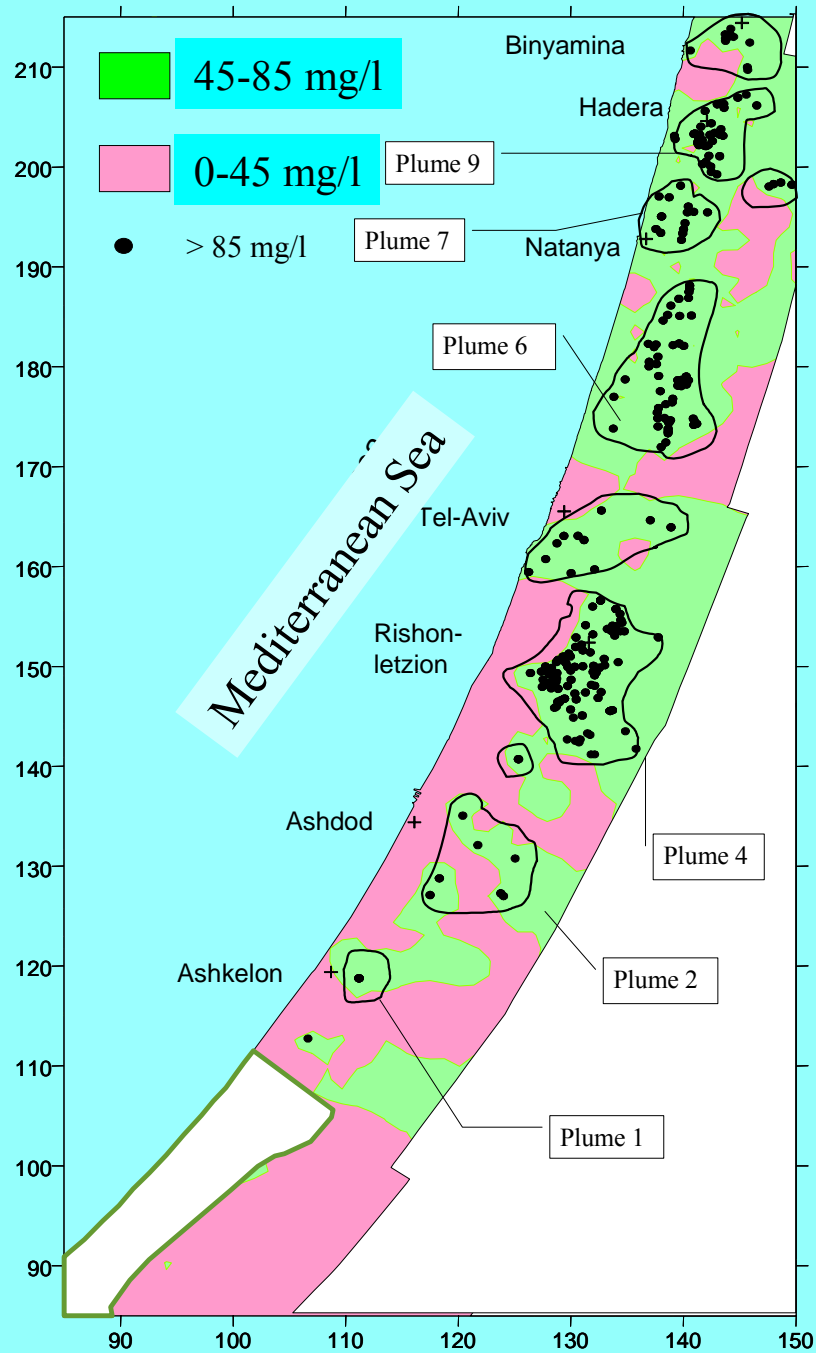


Figure 1

- Be'er Toviyya
- Giva't Brener
- Gedera
- Hazor
- ▲ Yavne
- ▲ Revadim
- ◆ sewage

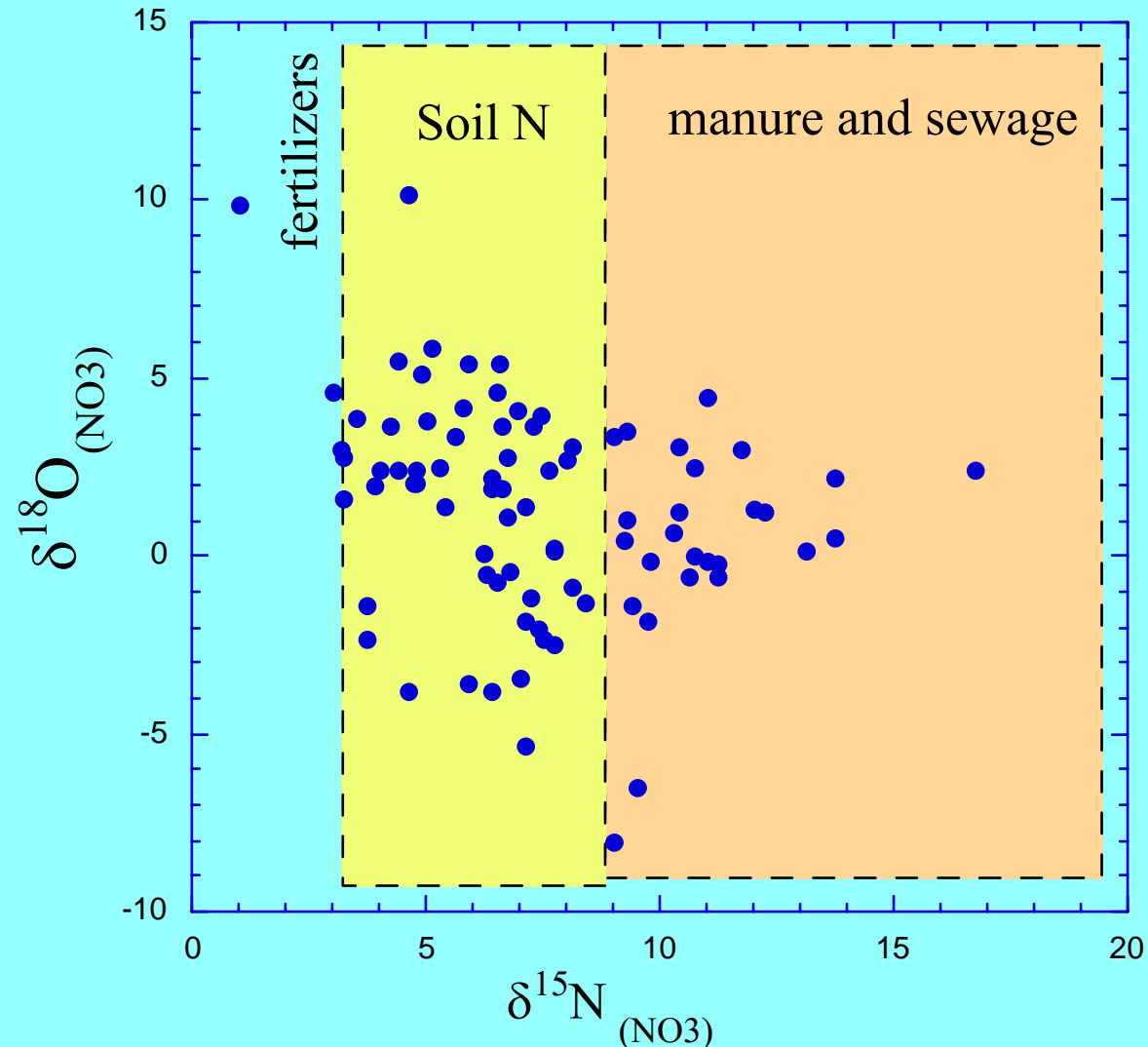


Sampling of 92 wells in the Coastal Plain aquifer

Setting a threshold of $\delta^{15}\text{N}=8\text{‰}$ enabled us to distinguish between nitrate sources:

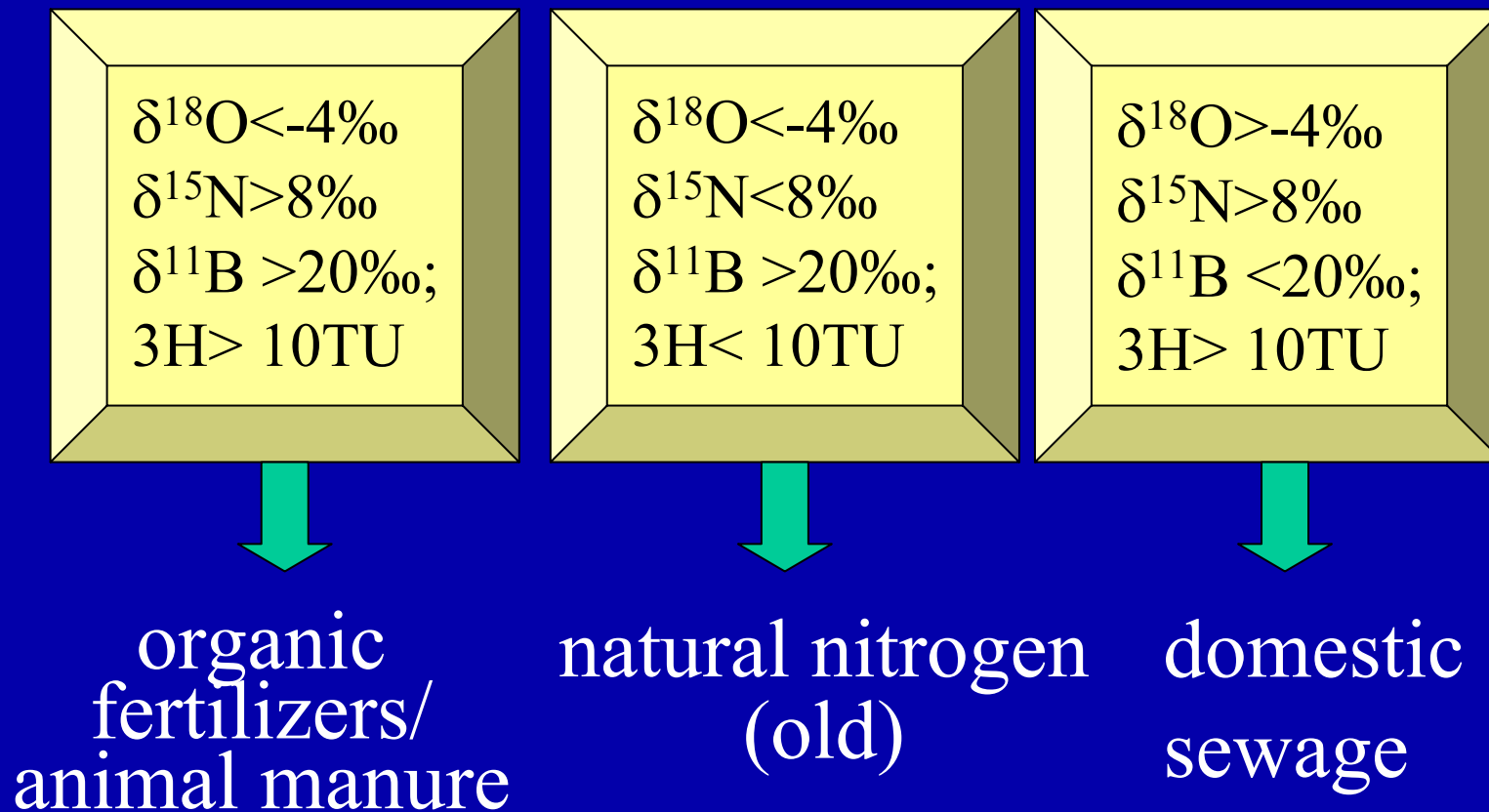
$>8\text{‰}$ - manure and/or sewage

$<8\text{‰}$ - natural soil nitrogen



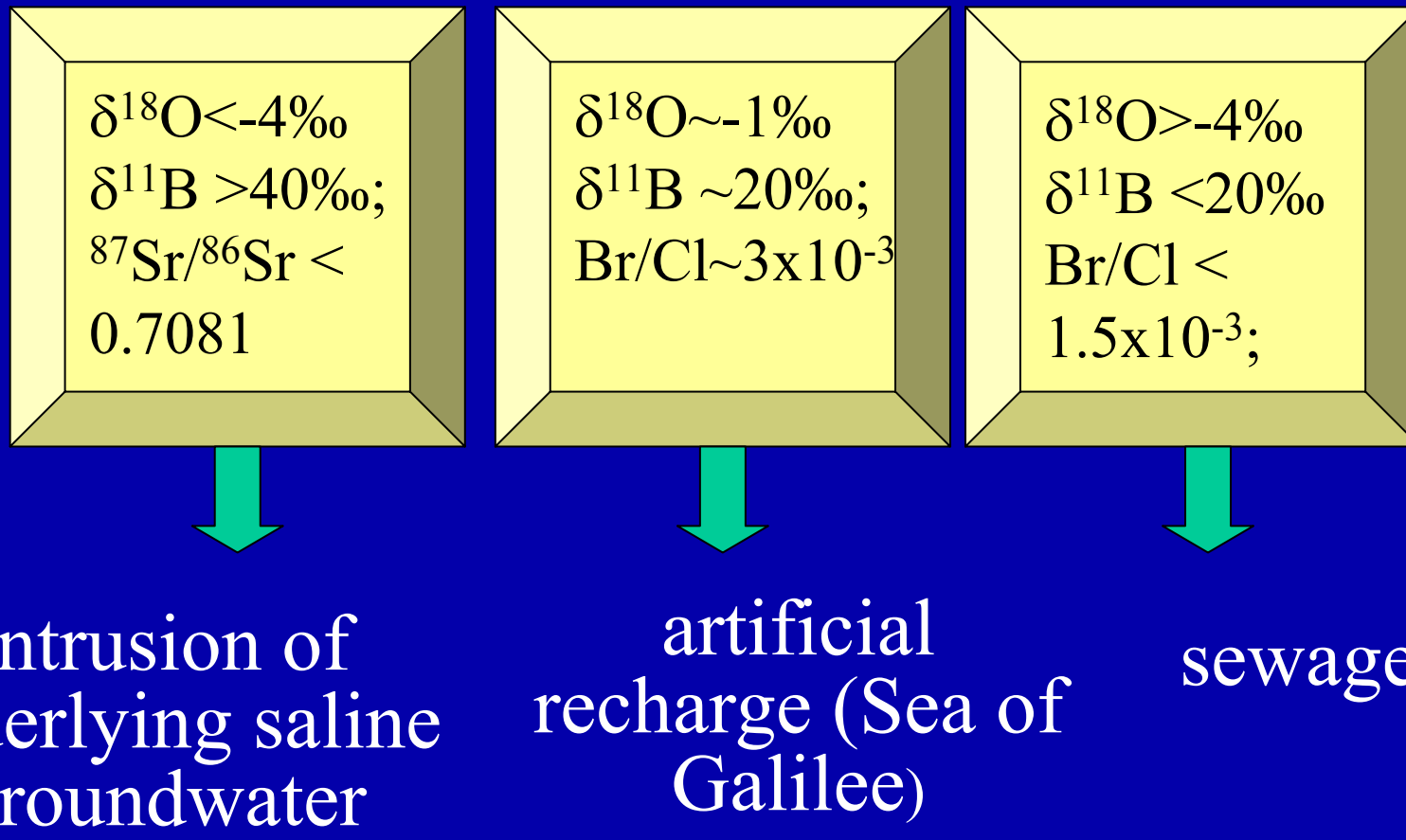
Integration of isotopic tools

Nitrate pollution



Integration of isotopic tools

Salinization



The Water Crisis in the Gaza Strip: Integration of Geochemistry, Numerical Modeling, and Policy

Avner Vengosh¹, Erika Weinthal², Amer Marei³, Alexis Gutierrez⁴, and Wolfram Kloppmann⁴

1. Ben-Gurion University, Beer Sheva, Israel
2. Tel Aviv University, Israel
3. Al-Quds University, West Bank
4. BRGM, Orleans, France

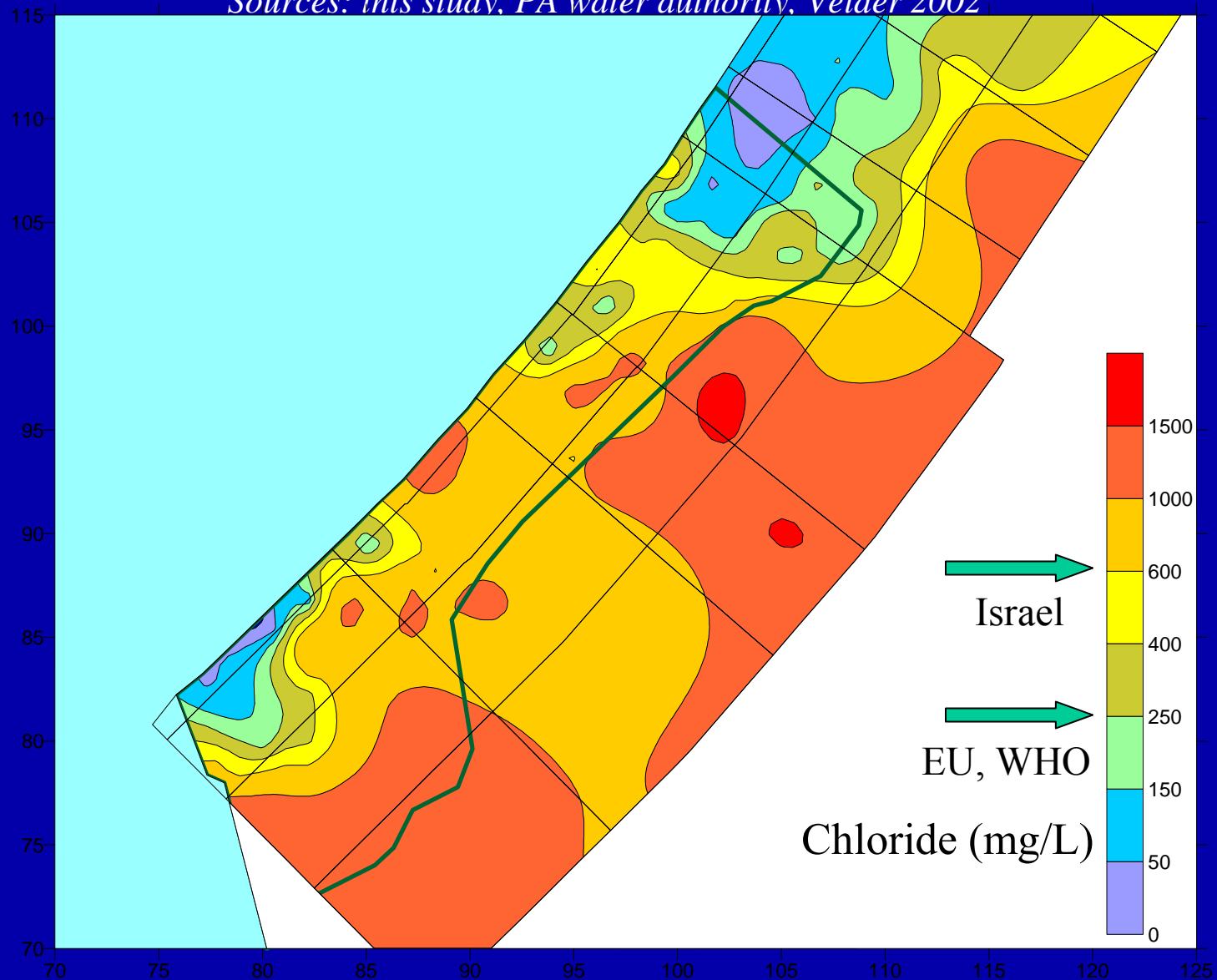
EU Project (EVK1-CT-2000-00046): *Boron Contamination of Water Resources in the Mediterranean Region: Distribution, Sources, Social Impact, and Remediation (BOREMED)*

Statement of the Problem

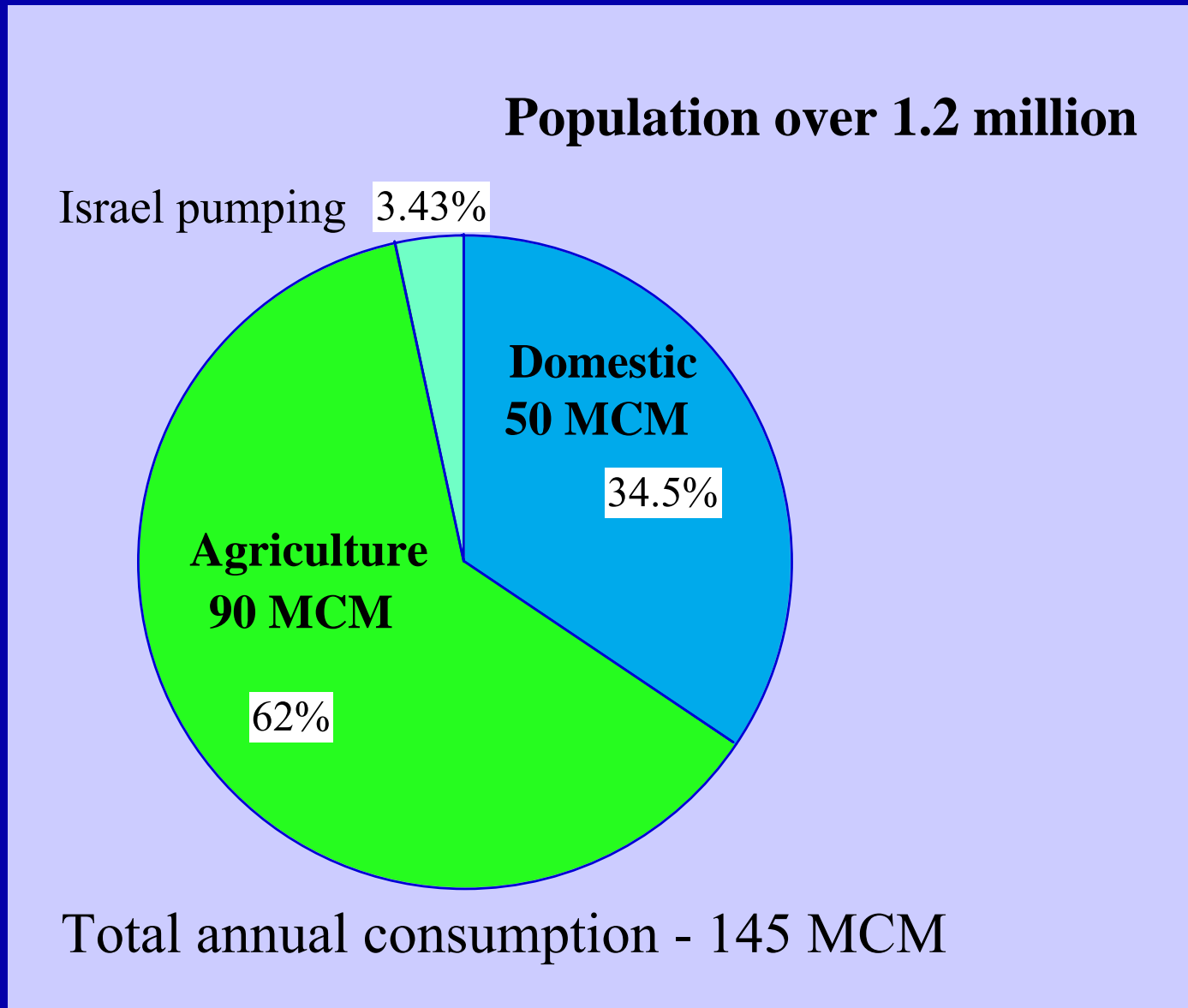
- The southern Mediterranean Coastal aquifer is a cross-boundary aquifer, shared by the Israelis and Palestinians (Gaza Strip).
- In the Gaza Strip (30x12 km) groundwater is the only source of water for over a million people. Degradation of the water quality has created an ecological disaster.

Chloride distribution in groundwater of the southern coastal aquifer (summer 2000).

Sources: this study, PA water authority, Velder 2002

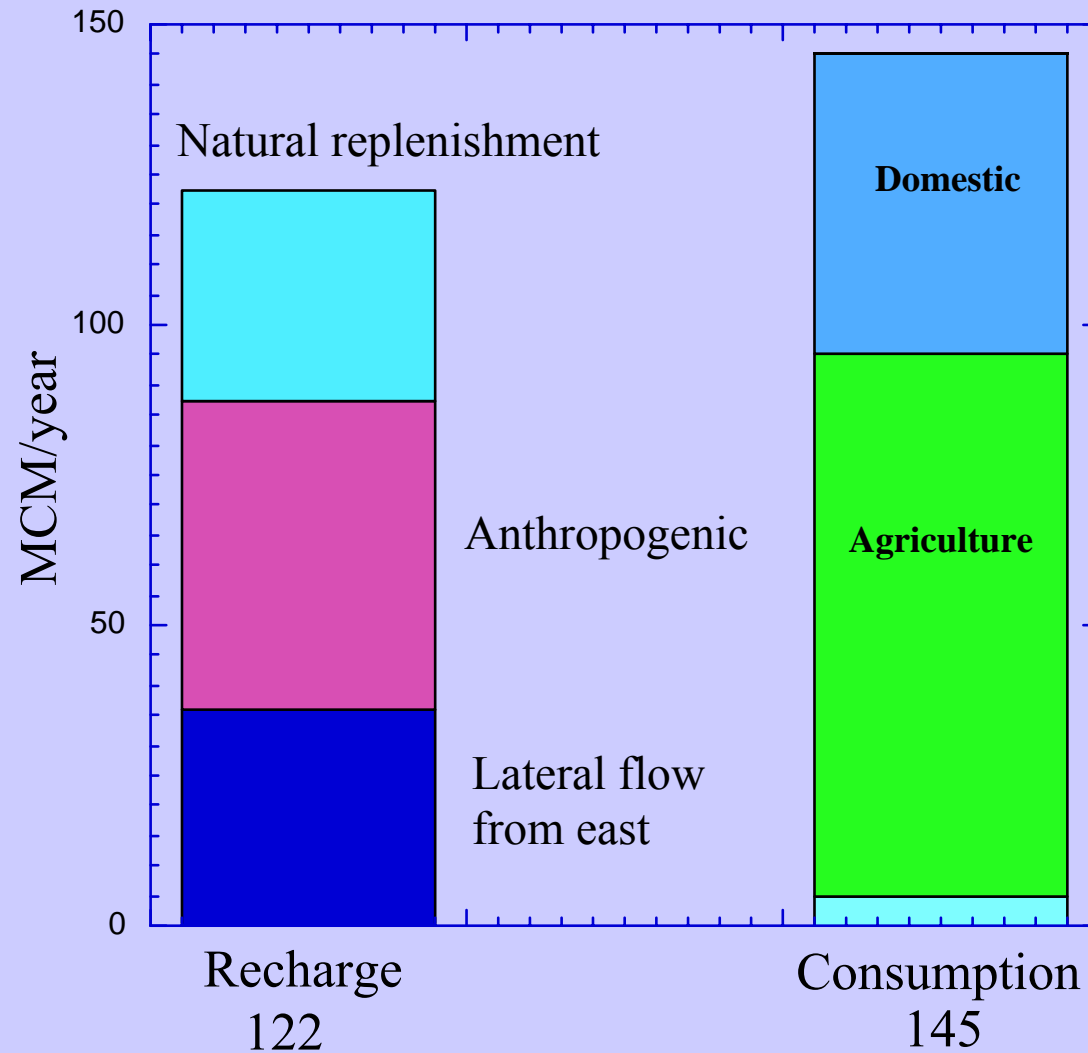


The Water Crises in the Gaza Strip



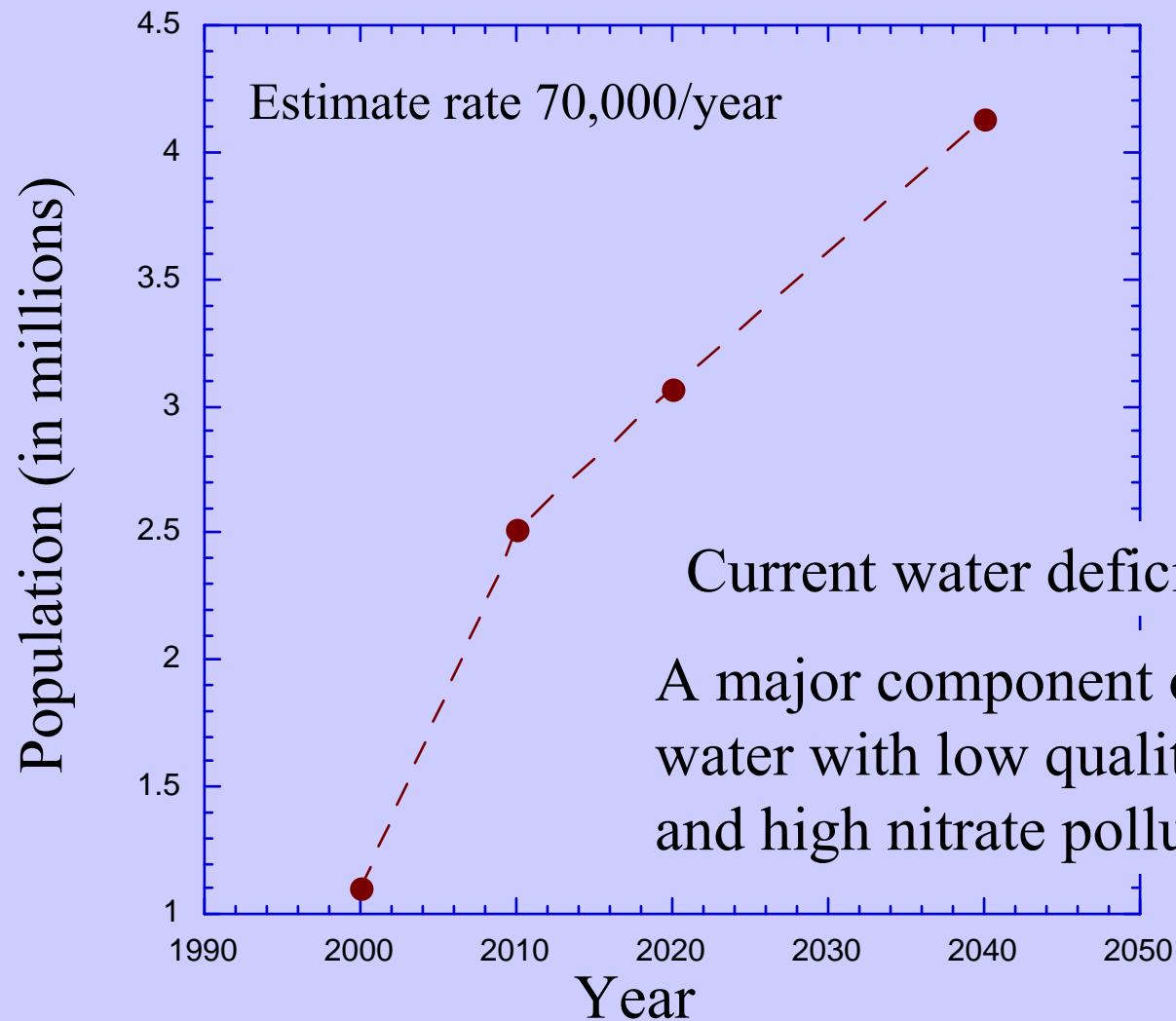
Data from UNEP

The Water Crises in the Gaza Strip



Data from UNEP

The Crises after the Storm

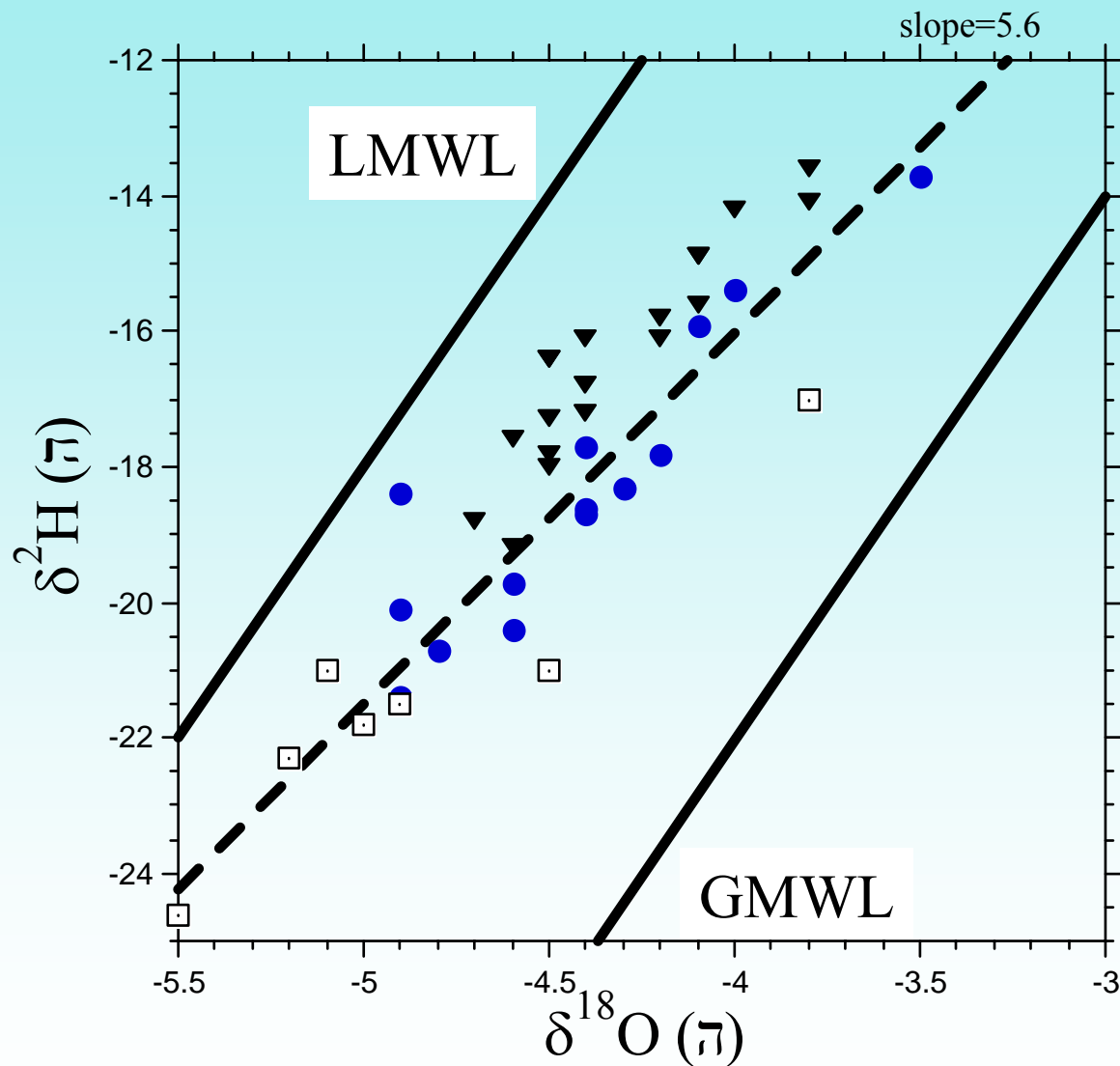


Current water deficit is ~23 MCM/y

A major component of the recharge is water with low quality: high salinity and high nitrate pollution

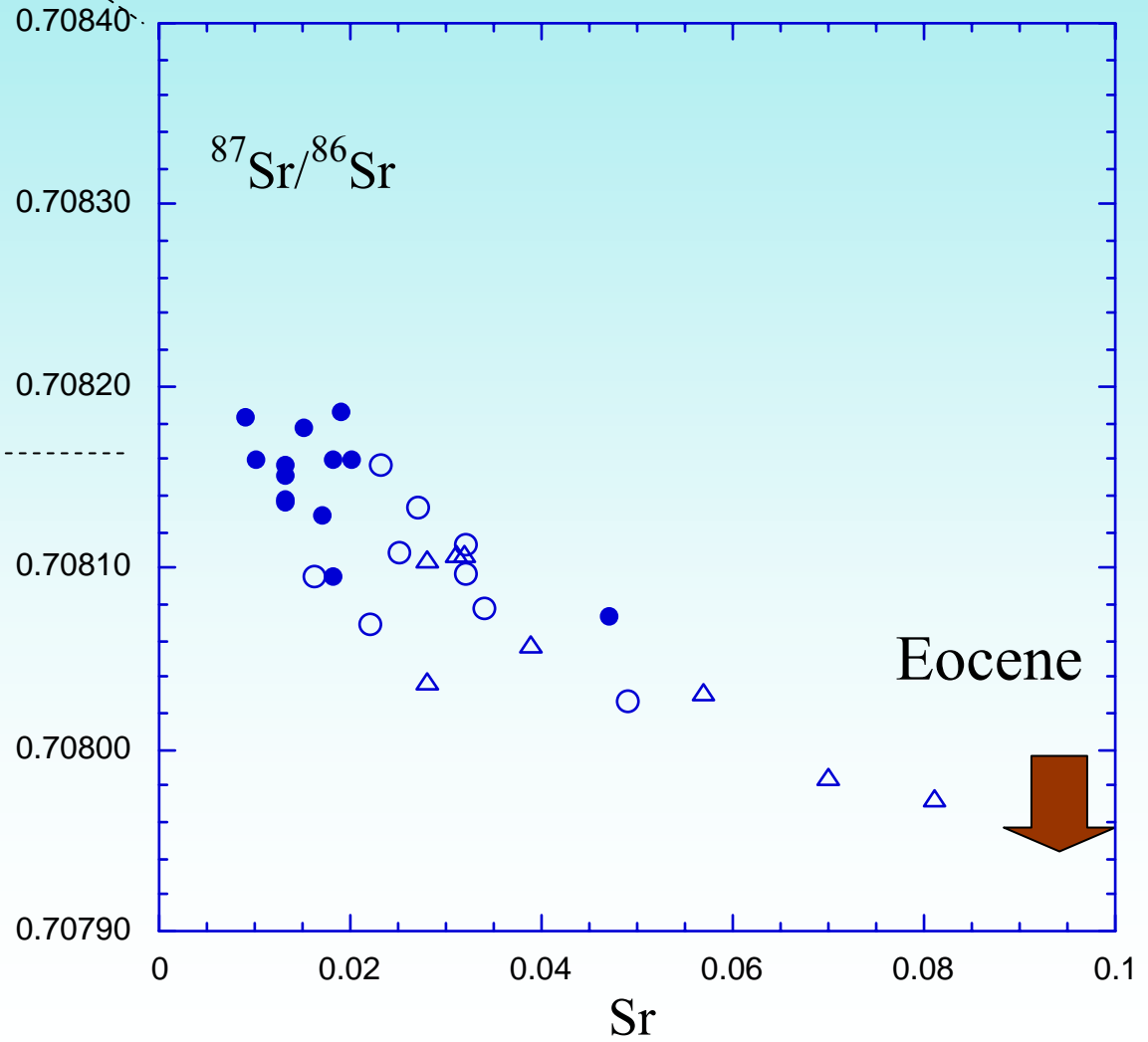
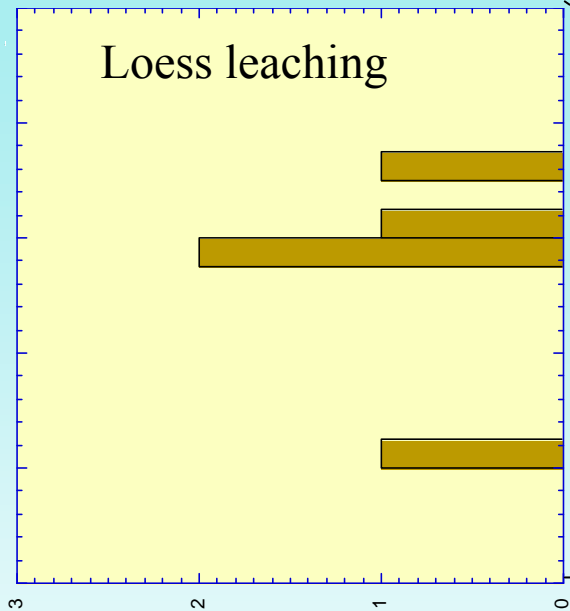
A joint Israeli-Palestinian-French project

- Field work
- Inorganic constituents (Ca, Mg, Na, K, Sr, Cl, SO₄, HCO₃, NO₃, Br, B @BGU and Al-Quds)
- Strontium, boron, oxygen isotopes (@BRGM)
- Nitrogen isotopes (University of Calgary, Canada)
- Numerical modeling
- Policy analysis

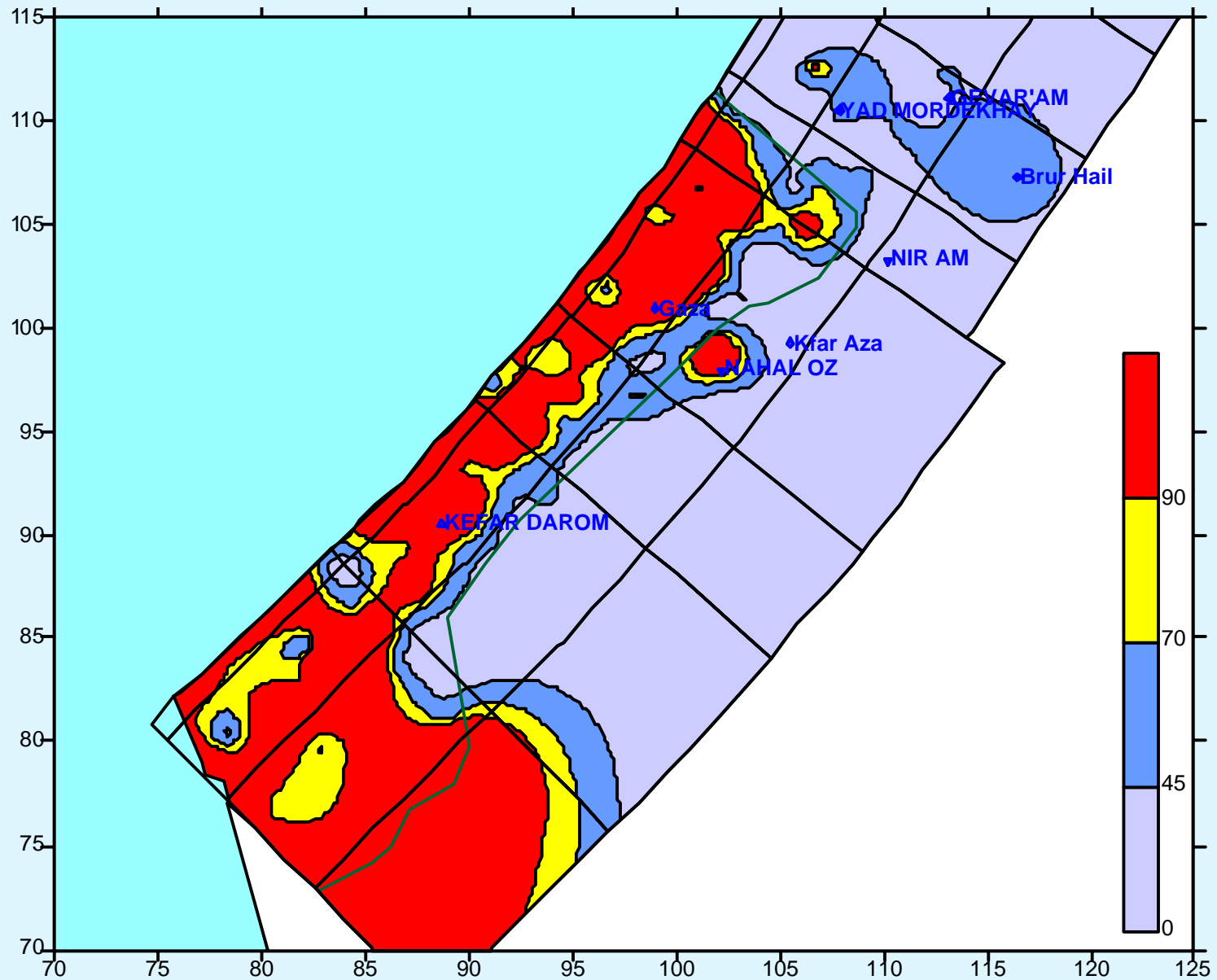


The $\delta^{18}\text{O}$ - $\delta^2\text{H}$ slope of groundwater in the Israeli side and Gaza Strip is identical to that of the slope in groundwater from the adjacent Eocene aquitard.

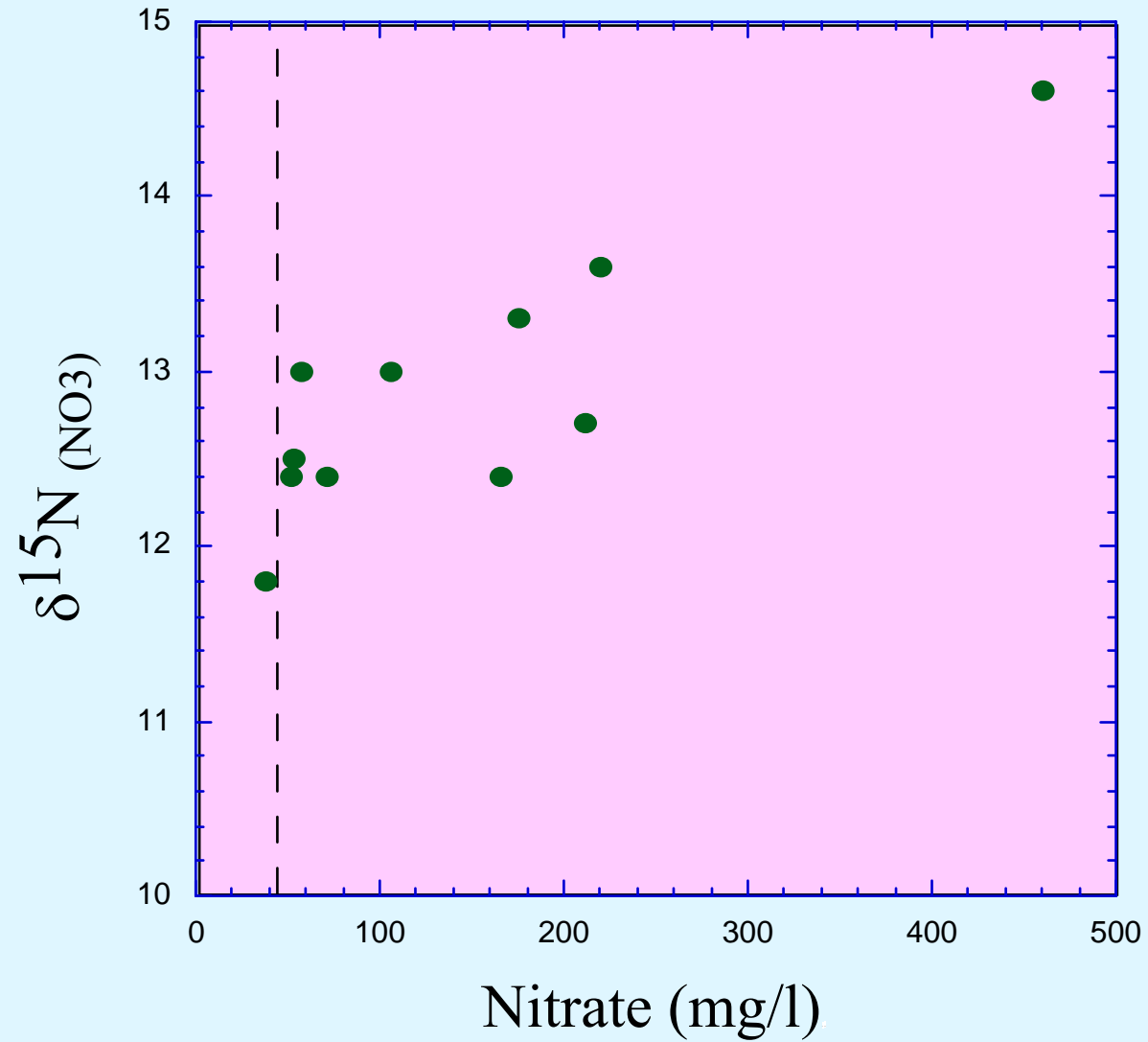
Loess water extractions (batch)



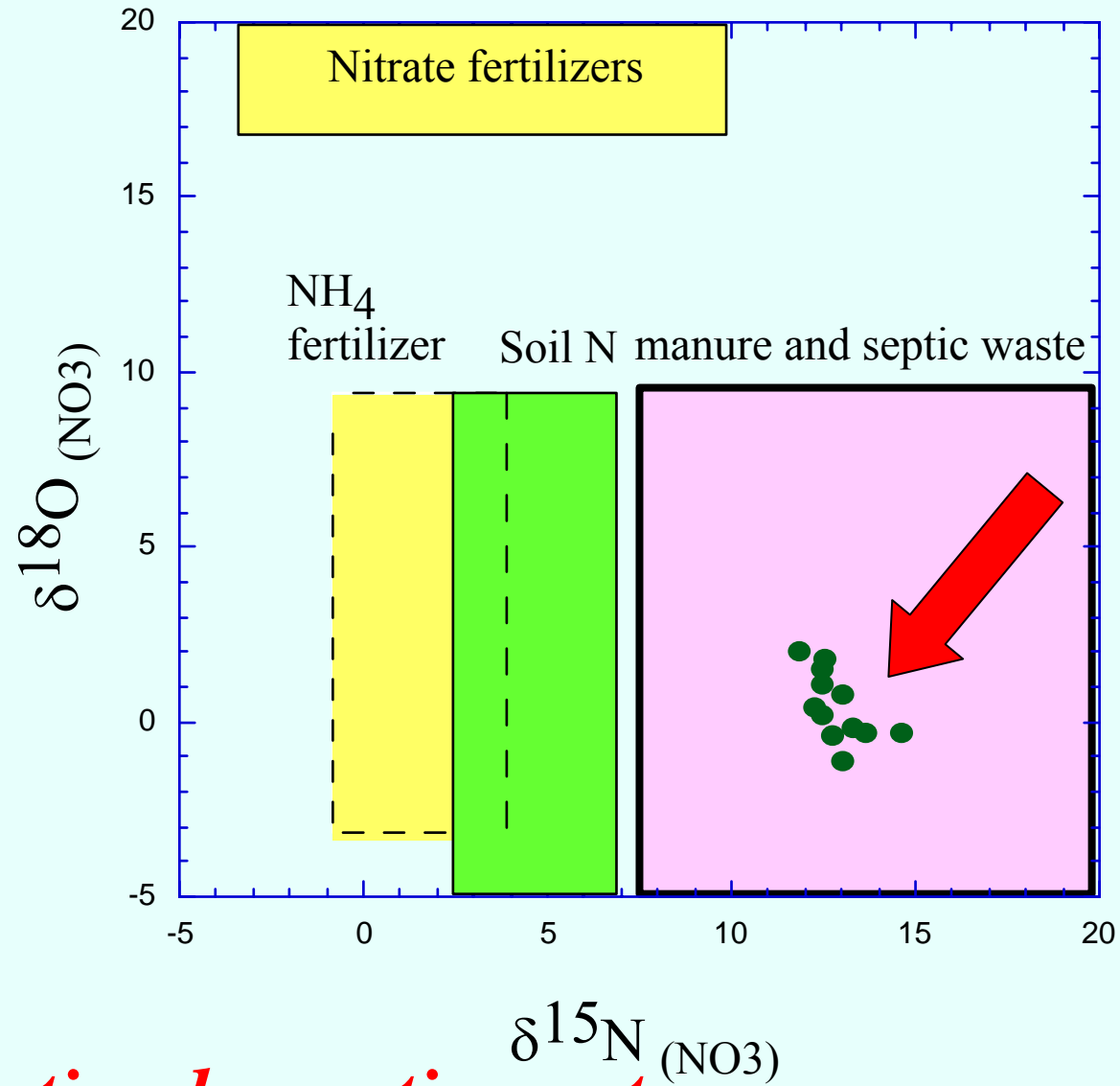
Nitrate pollution of the Gaza Strip



Gaza Strip



Gaza Strip



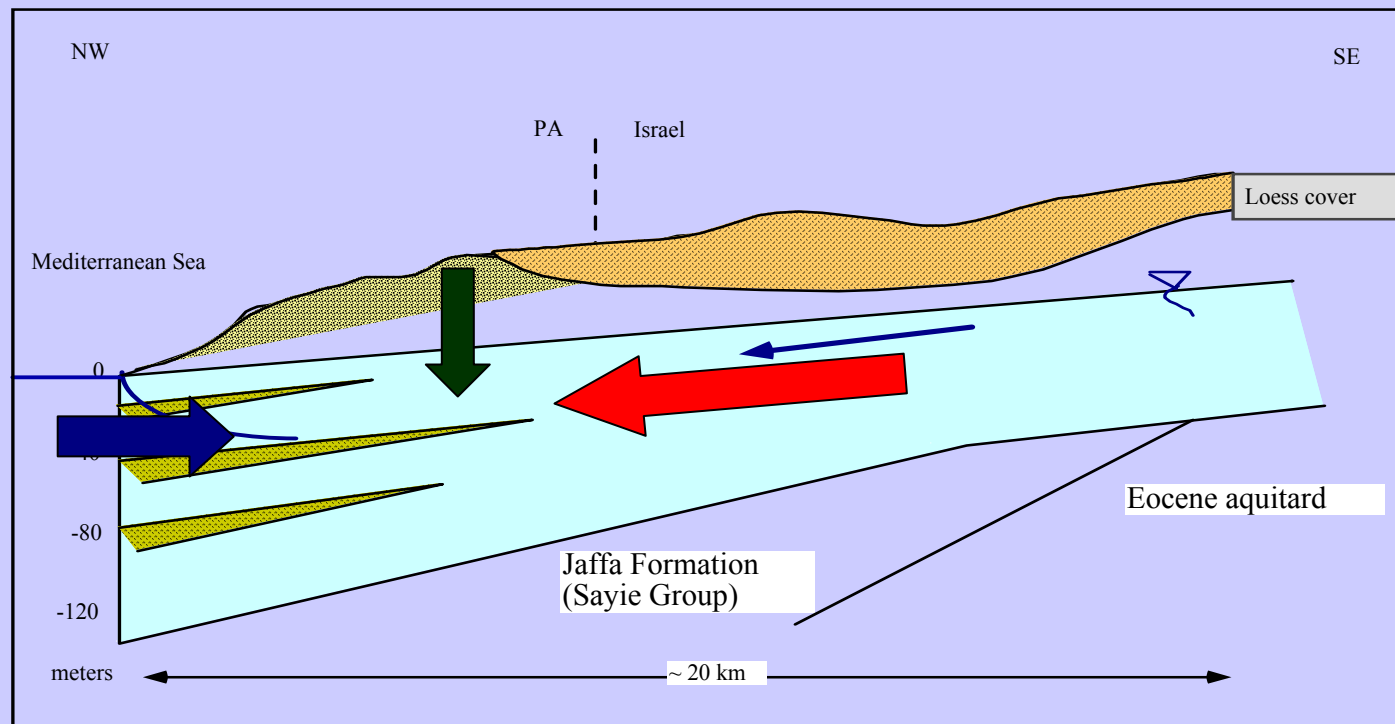
Nitrate pollution by septic waste

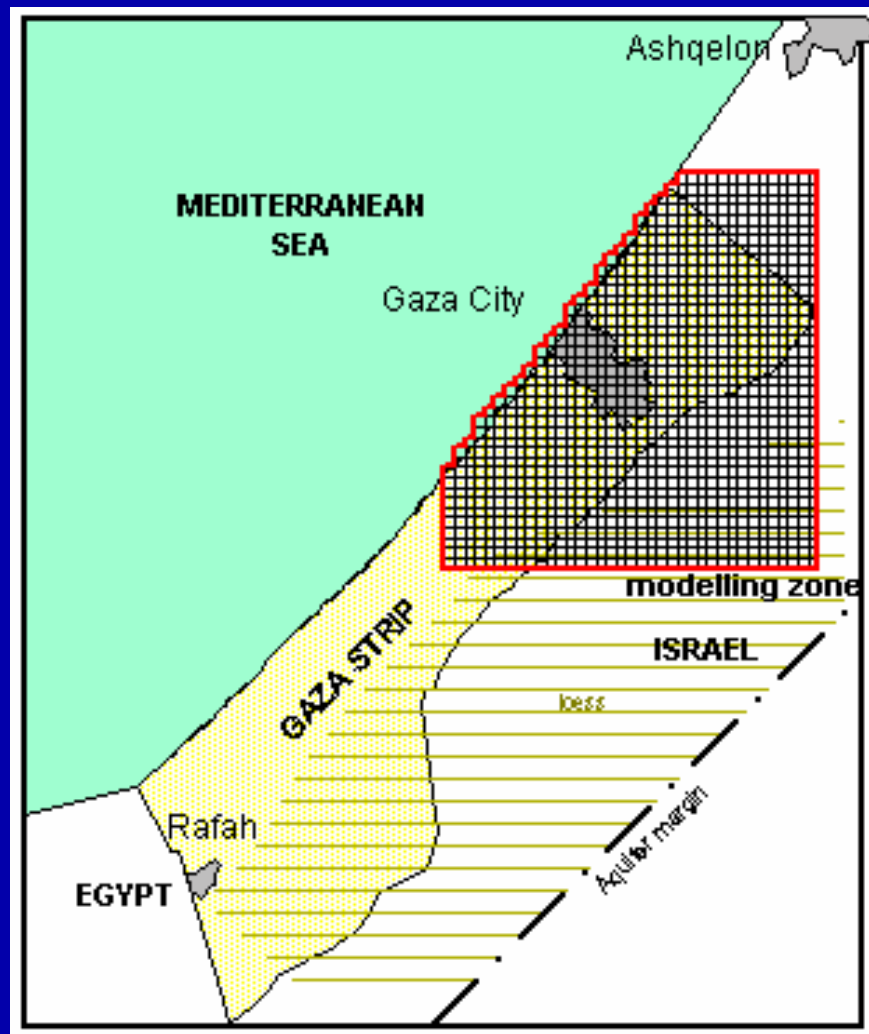
The Geochemistry data

- Saline groundwater in Israeli territory originates from a mixture of saline groundwater flowing from the adjacent (Eocene) aquifer and leaching of overlying loess. This is a natural (geogenic) long-term process.
- Sources of salinization within the Gaza Strip include seawater intrusion and anthropogenic (nitrate) pollution, but the major source of salinity is the flow of the saline natural groundwater from Israel to the Gaza Strip.
- The salinization rate in the Gaza Strip has increased due to over pumping, lowering groundwater level, and intensification of the water gradients between Israel and Gaza Strip.

Sources of salinity in the Gaza Strip

- Sea water intrusion
- Saline groundwater from the eastern part of the aquifer (Israel)
- Anthropogenic sources (sewage effluents within the Gaza Strip)

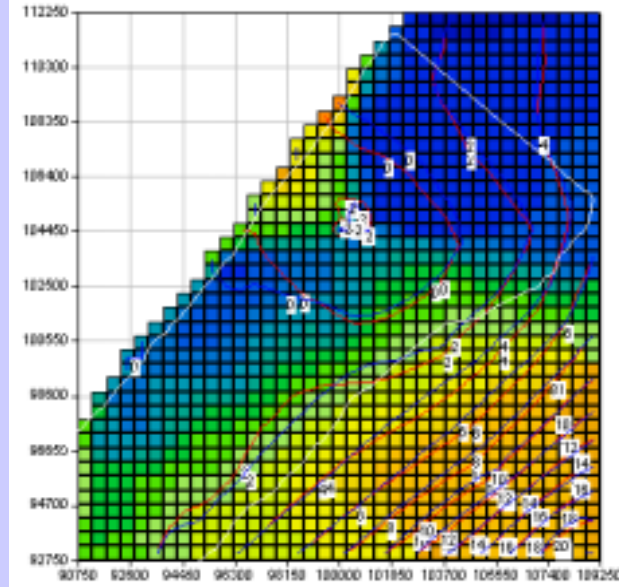
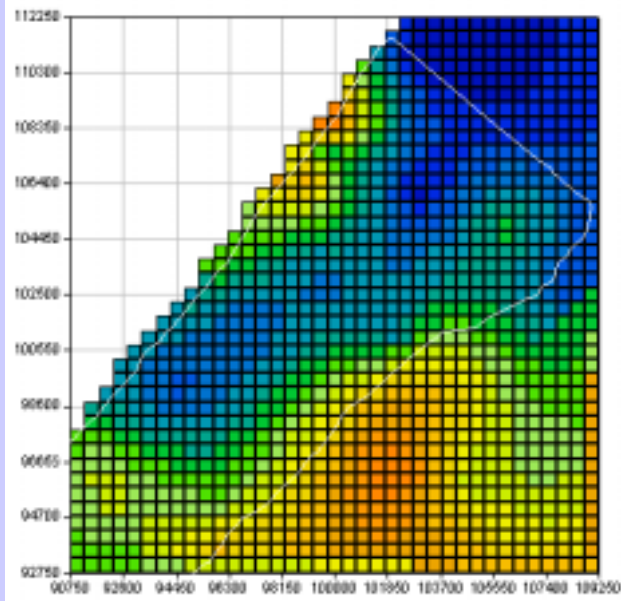




MARTHE - A mono-layer hydrodynamic two-dimension model

Grid: square meshes of 500 m

Applying the MARTHE model in the Gaza Strip



Simulated Cl_o ride pattern
(MARTHE software)

Water salinity components:

1. Northern, Cl=0 to 50 mg/l;
2. South-eastern, Cl=1500 mg/l;
3. Atmospheric, Cl=20 mg/l;
4. Ag return flow, Cl=300 mg/l

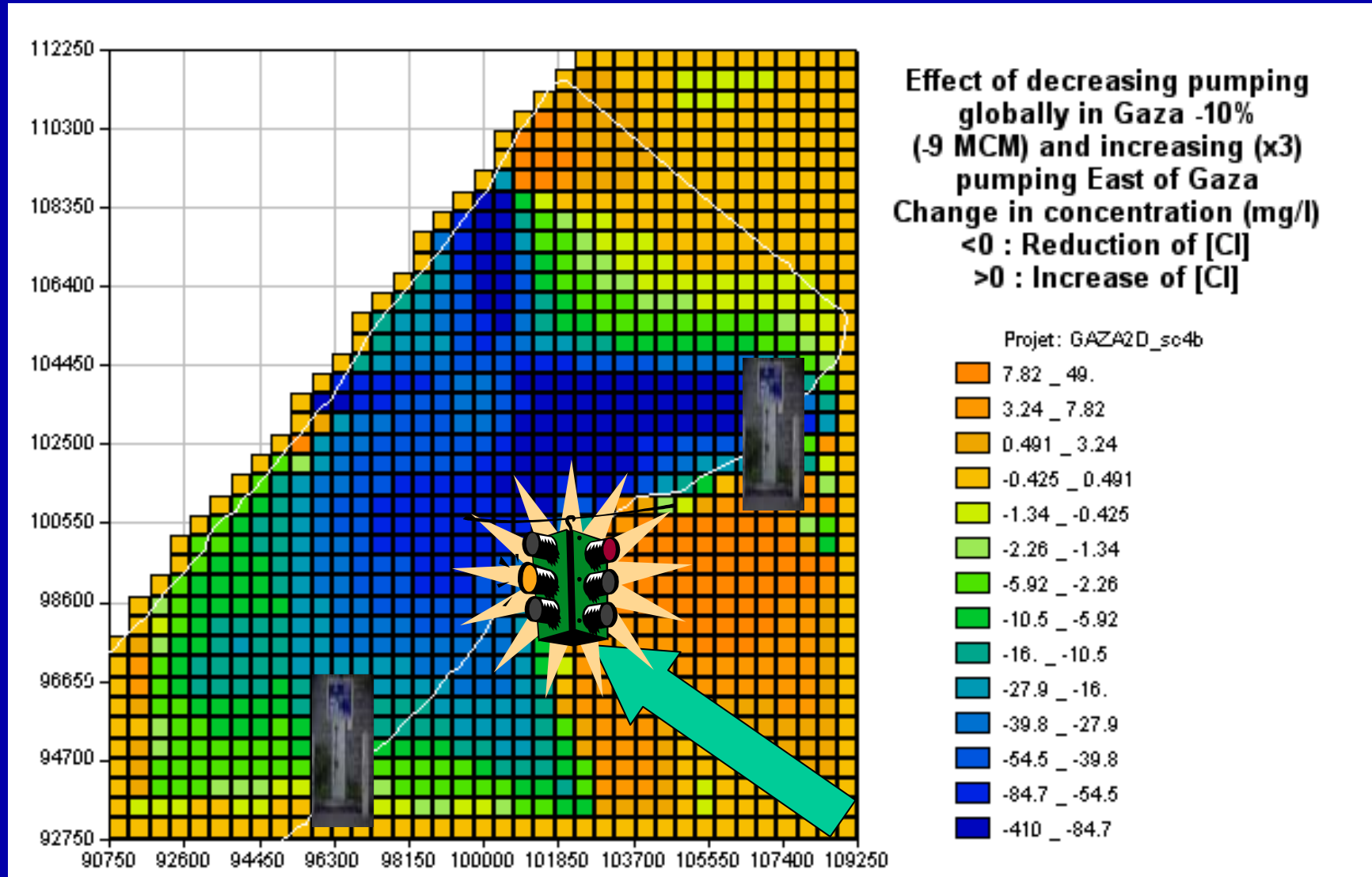
Water balance:

1. Natural and induced recharge (within the Gaza Strip only) = 55 MCM/y
2. Pumping = 90 MCM/y

Management model

1. Reduce salinization by increasing pumping (x3~12 MCM/y) in the eastern side.
2. Decrease pumping within the Gaza Strip at the same magnitude (81 instead of 90 MCM/y).
3. Desalination of the pumped saline groundwater and supply to the Gaza Strip.

Water quality remediation upon increasing pumping along the border



Long-term implications

1. Improve the quality of water that is utilized the Gaza Strip (health aspects)
2. Remediation of the salinity problem in the Gaza Strip
3. Establish a mechanism of cooperation between Israel and the PA for mitigating the water crisis and lessen the political tension. In contrast to the classic “upstream” versus “downstream” situation, increasing pumping in the upstream (Israel, or along the border) will improve the water quality downstream (Gaza Strip).
4. Lack of cooperation will lead to ecological and social disaster in the Gaza Strip.