Groundwater Recharge by Using Reclaimed Water

Panayiota Hadjigeorgiou

Chief Water Officer

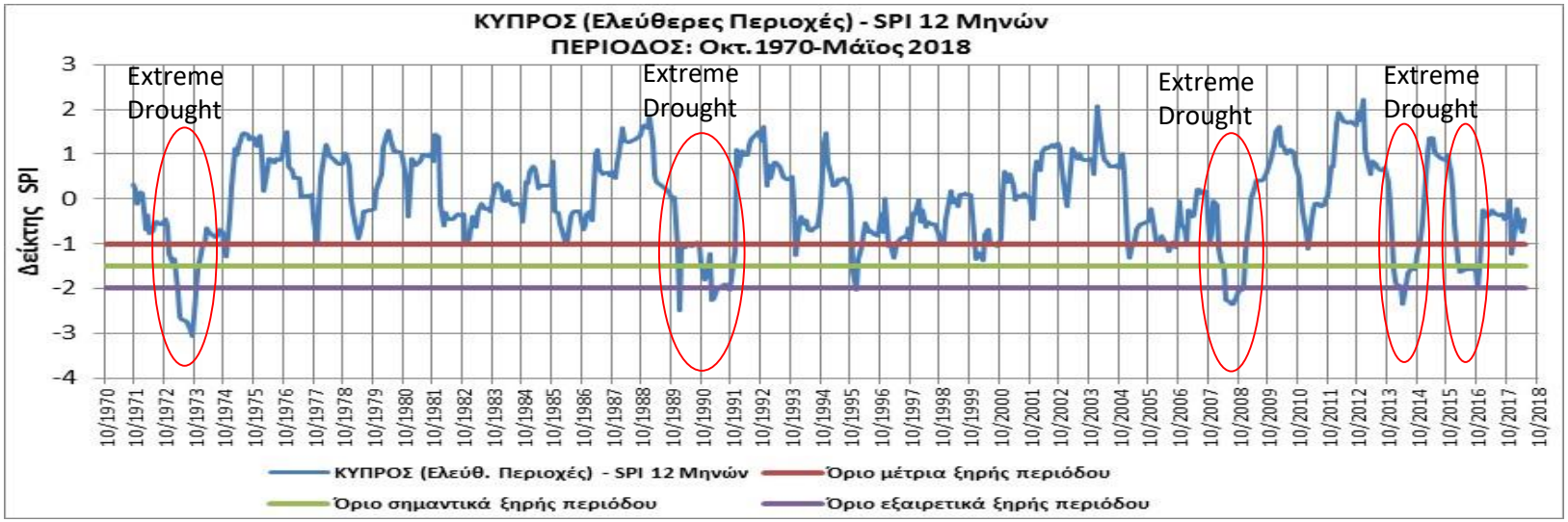
Water Development Department

Ministry of Agriculture, Rural Development and Environment of the Republic of Cyprus

Cyprus at a Glance

- Area: 9250 km²
- Population: 850,000 (under Government control)
- Tourism~ 3million/year
- **Semi arid climate**
- **Numerous small catchments**
  - No perennial flow

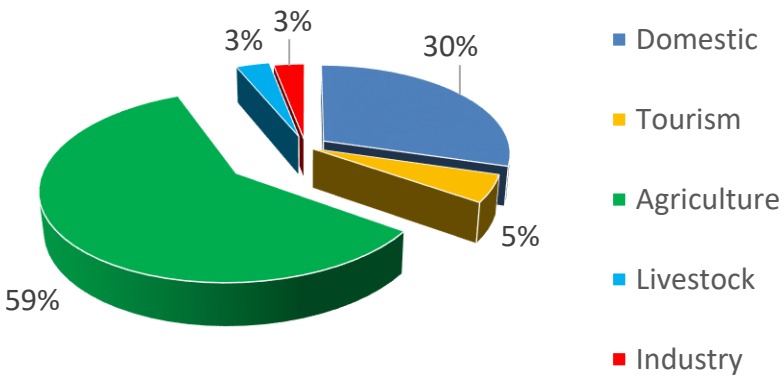
- **Unevenly distributed rainfall**
  - Temporally and geographically
- **Limited water resources**
  - Depend mainly on rainfall
  - Scarce & expensive to exploit
- **Frequent and prolonged droughts**
  - Water Stress Index = 73



More intense and severe droughts due to climate change are expected in the future

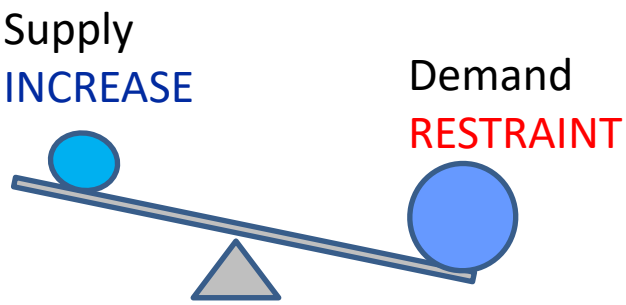
Water Availability Challenges

Total Water Needs: 250 MCM/Year



- Climate change is expected to impact adversely fresh water availability
- Increasing demand for domestic sector (population, tourism, lifestyle)
- Sharp decrease in fresh water allocation to agriculture (could reach up to 70%)

MUST reduce water imbalance

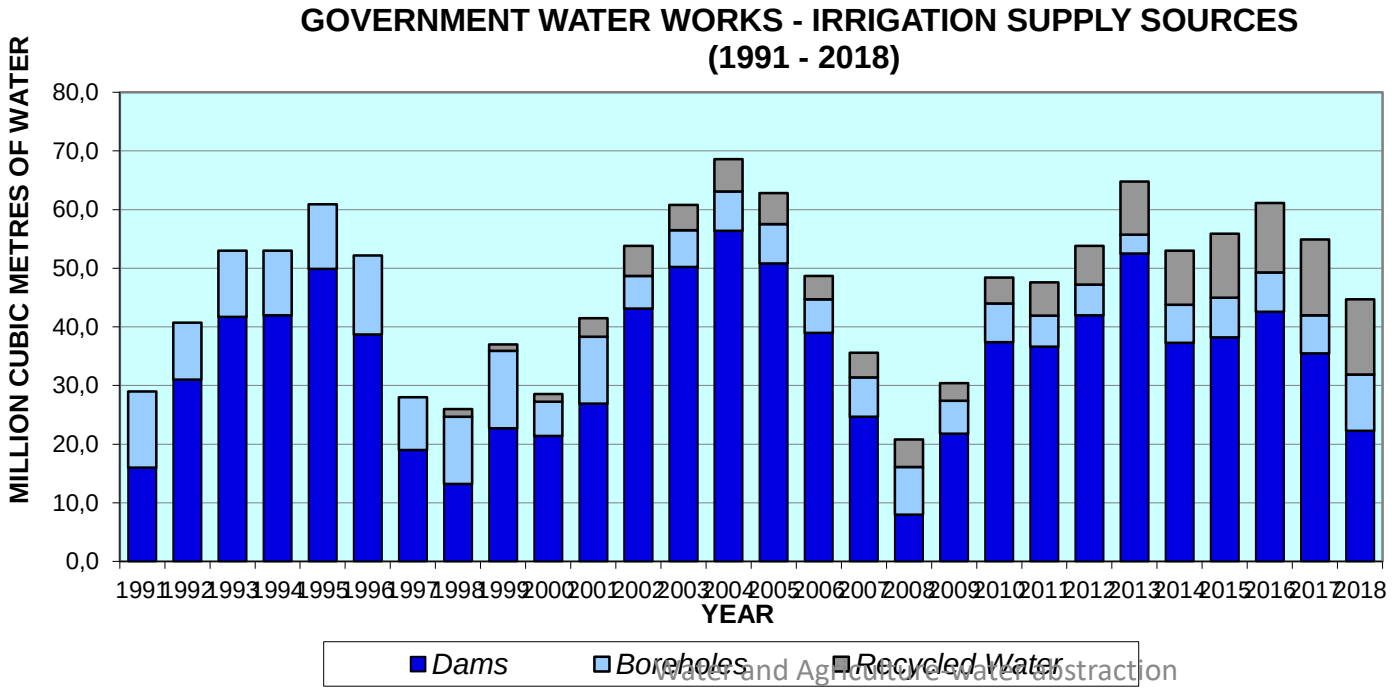


Augmentation with alternative sources is needed:

- Desalination for domestic use
  - to satisfy 100%
- **Effluent reuse for irrigation**
  - **to maintain a productive, yet sustainable agriculture**

Policy for Water Reuse

- Full exploitation of recycled water which will decrease the necessity to build more desalination plants
- Formulation of national regulations taking into account human health, agronomic and environmental aspects (stringent than the Directive 91/271/EEC)
- Advanced tertiary treated recycled water irrespective of its use – agricultural and landscape irrigation/golf courses, and for aquifers recharge



Today, 20 MCM of recycled water are being produced (by 2026 will be 65MCM)

77% direct irrigation

20% aquifer recharge

3% discharge to dam or sea

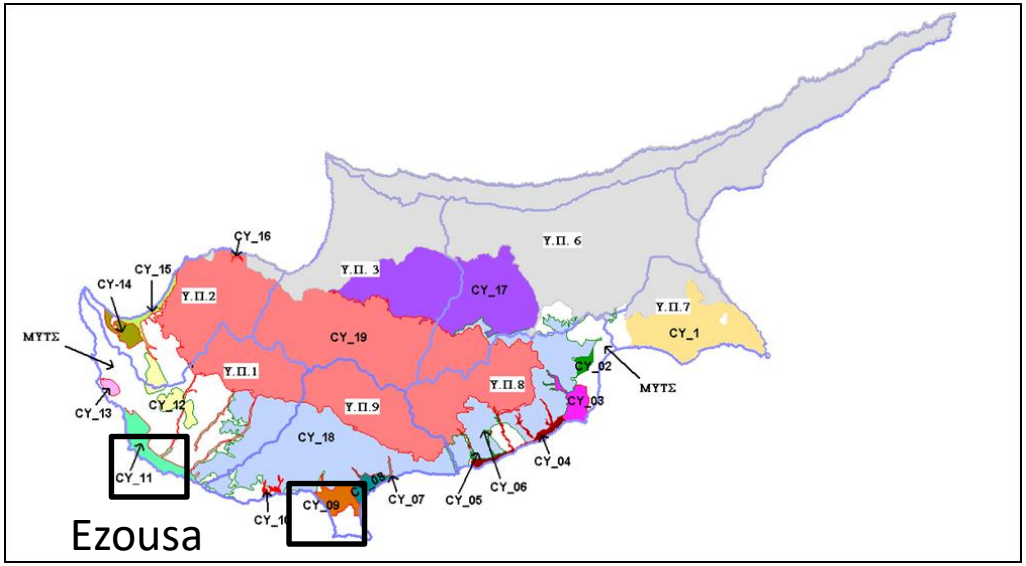
Artificial Recharge of Alluvial Aquifers

Disinfected **tertiary treated water**, is being used for **artificially recharging aquifers** during the winter months (when the irrigation demand is minimum)

Ezousa aquifer since 2004

Akrotiri aquifer since 2016

The reclaimed water after natural purification is pumped again from the aquifers for irrigation



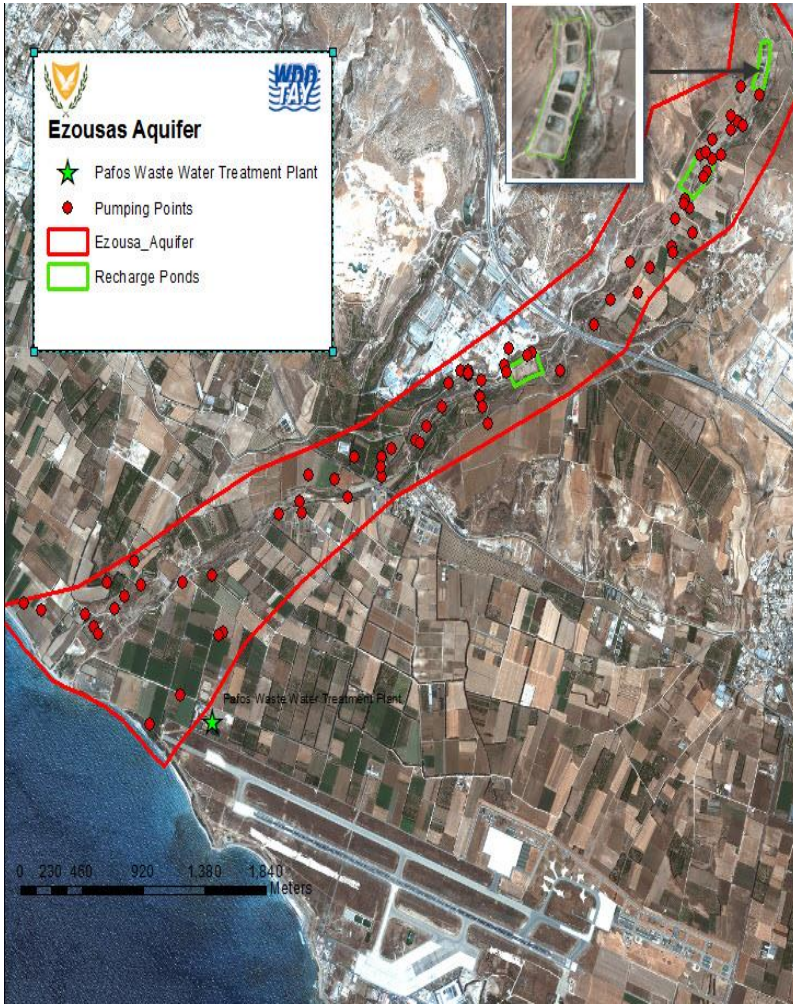
Groundwater quality is monitored regularly in accordance with the Discharge Permit regulated by:

- The Environmental Impact Assessment **Law** (No. 140(I)/2005)
- The Water Pollution Control **Laws** (106(I)/2002 to 2009)
- *The Water* Pollution *Control (Discharge of Urban Waste water)* ***Regulations*** *of 2003* (No. 772/2003)

Tertiary Degree treatment > requirements of Directive 91/271/EEC

Ezousa Alluvial Aquifer

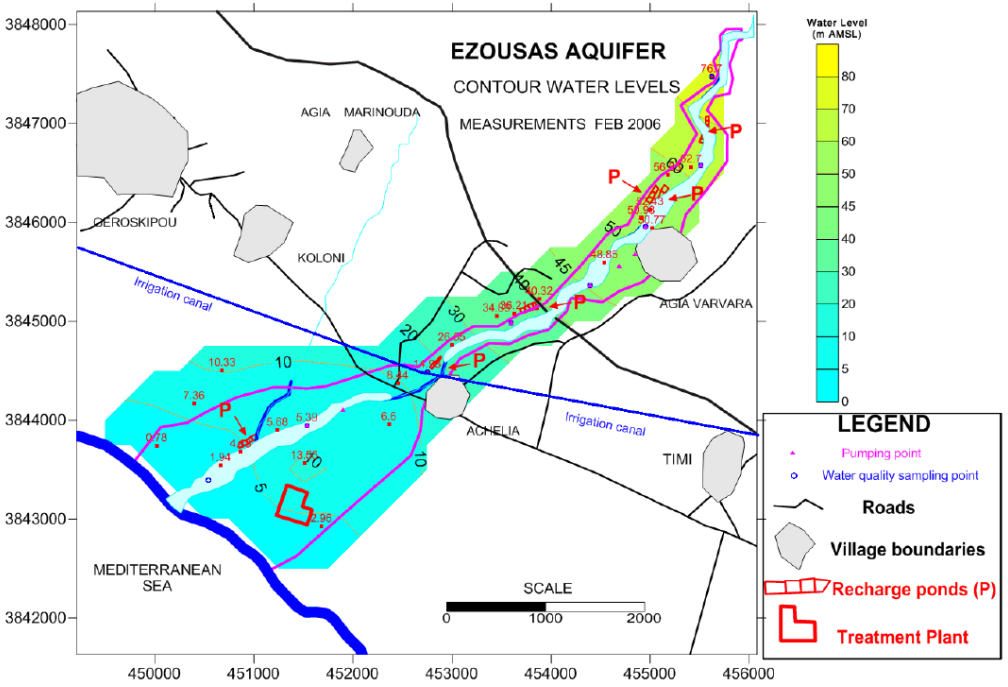
- A river alluvial aquifer, developed along the Ezousas river bed and coastal deposits of terraces, in Paphos District.
- It's enrichment is dependent on river flows. The construction of Kannaviou dam (26Km upstream) has reduced enrichment. However, it recovers quickly after periods of heavy rainfall

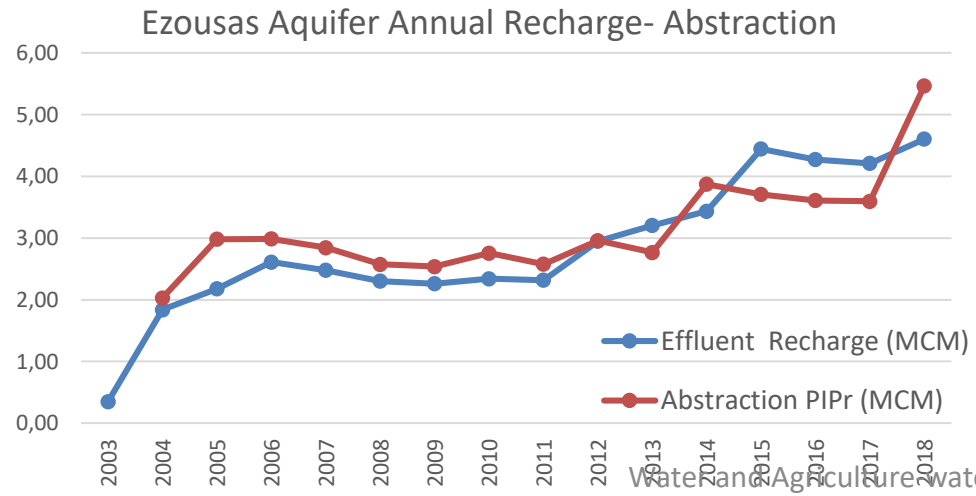


PRESSURES PRIOR TO RECHARGE

- **Physical factors**
  - High concertation of sulphates (gypsum) in both surface and groundwater (~450 mg/l)
  - High concertation of Boron (lavas)
- **High salinity**
  - Seawater intrusion in coastal areas
  - Over abstraction
- **Anthropogenic pollution**
  - Agriculture (nitrates, pesticides)
  - Urban activity (sewage)

Operation of the Artificial Recharge Scheme





- Tertiary disinfected treated water (4,5MCM), is pumped from the treatment plant to five shallow ponds in turns
- The water level in each pond reaches up to 0.5 m from where it slowly seeps into the ground
- Water from the aquifer is pumped from wells (20), which are located 100 m to 1000 m downstream of the recharge ponds, into a canal (open channel) at a ratio of 1:20 (aquifer water to dam water)
- The canal carries water from Asprokremmos dam to the Paphos irrigation scheme and passes across the Ezousas aquifer
- Pumping is carried out strategically so that retention time in the aquifer is maximized

Recharge Monitoring / Assessment

- In total 11 points are monitored surface and groundwater upstream and downstream of the recharge ponds for the five groups of substances (organics, pesticides, microbiological, nutrition, minerals)
- Assessment is done in according to WWTP permit limits and the Directives 2006/118/EC and 2014/80/EU for groundwater and the consolidated Directive 2008/105/EC, Directive 2013/39/EU for priority substances in surface water
- The nutrients evaluated at points of surface water based on the ecological assessment thresholds state of the river as defined by the Water Framework Directive 2000/60/EC
- Results obtained from monitoring of surface and groundwater points for the years 2006-2017 indicated that:

- Recharge with tertiary treated wastewater in Ezousa aquifer **has not affected negatively the quality of the water in the aquifer**
- No pesticides are detected in Groundwater
- A few sporadic tracers of organics (sub-products of chlorides) are not due to recharge
- Nutrient parameters (BOD, COD, Total P, N) are almost the same prior and after the recharge ponds
- Any tracers or sporadic exceedances of Guideline boundaries are not due to recharge

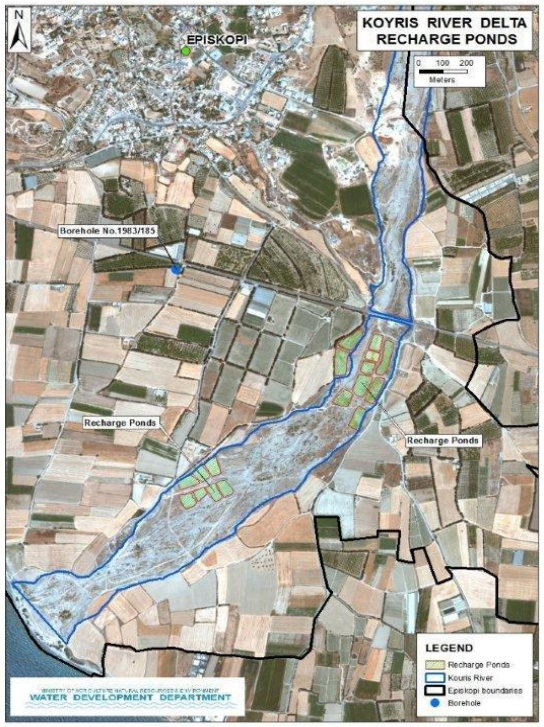
Lessons Learnt from Ezousa Recharge

Artificial recharge with effluent water is a good case study, which can be applied in areas with similar geological conditions suffering from droughts

- ✓ **Seawater** intrusion is being **controlled**
- ✓ **Provide storage** of effluent water for subsequent retrieval and reuse
- ✓ The aquifer serves as an eventual natural distribution system
- ✓ **Further purification** of effluent water is made (reduce biological load)
- ✓ **Saving** of equal quantities of fresh water for domestic use
- ✓ Conjunctive use of fresh and non-conventional water resources

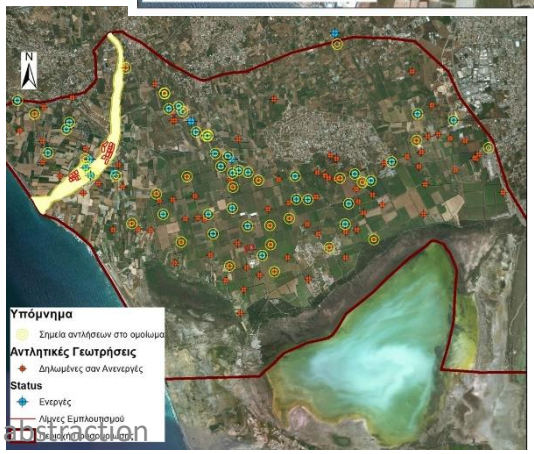
Artificial Recharge of the Akrotiri Alluvial Aquifer

Disinfected tertiary treated water, is being used for **artificial recharge of Akrotiri aquifer since 2016** , **with the consensus of local stakeholders**



PRESSURES PRIOR TO RECHARGE

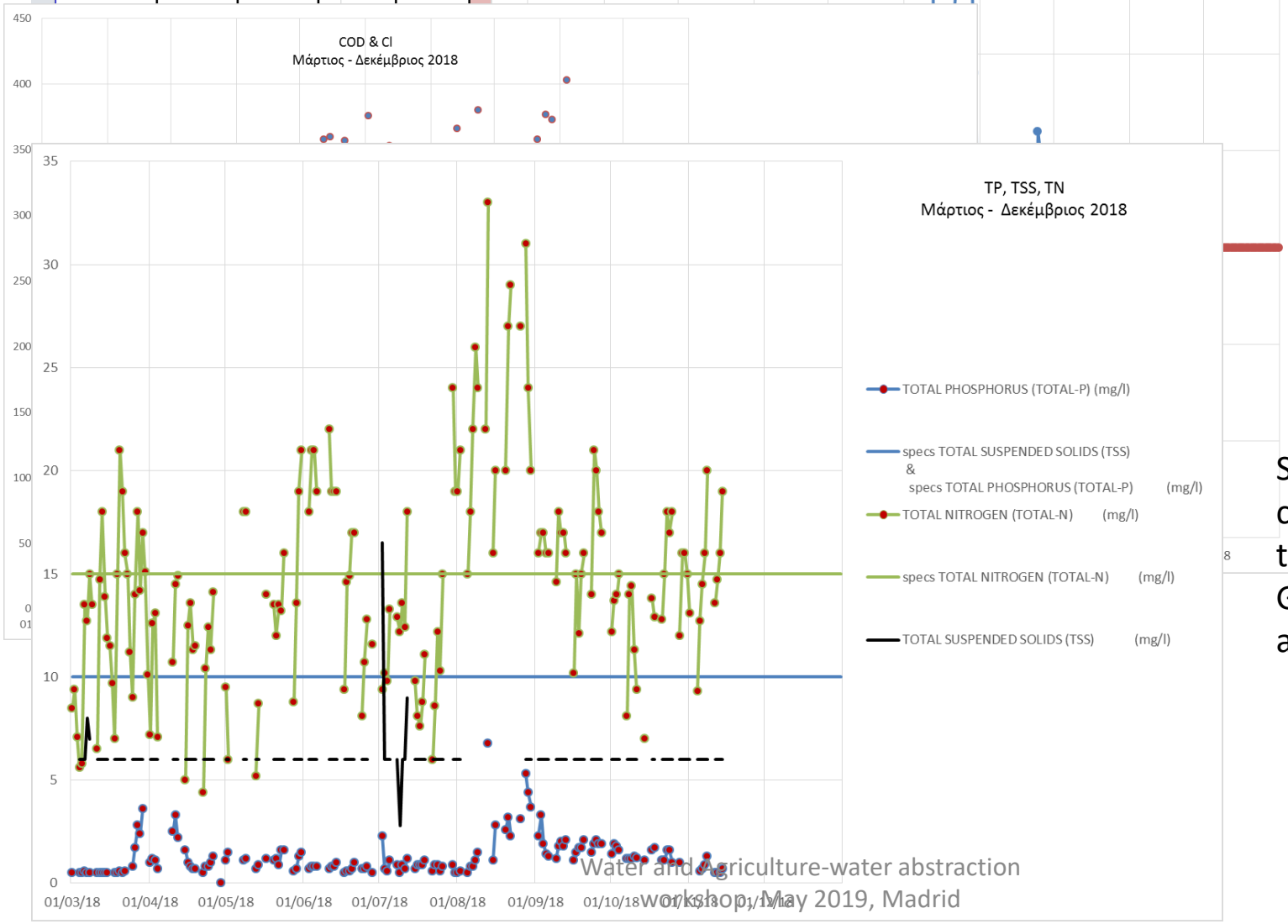
- **High salinity**
  - Seawater intrusion in coastal areas
  - Over abstraction
  - Kouris dam upstream reduce replenishment
- **Anthropogenic pollution**
  - Agriculture (nitrates, pesticides)
  - Urban activity (sewage)
- **Special considerations**
  - Akrotiri salt lake nearby
  - Drinking water boreholes upstream
  - Heavily dense populated area upstream

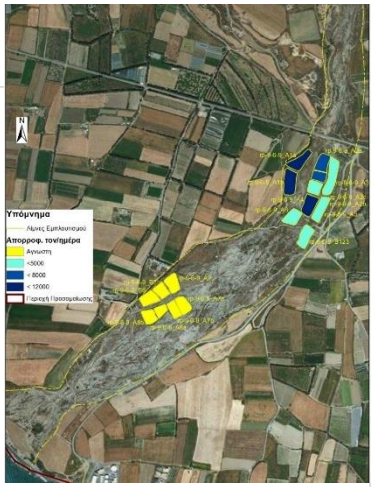


Recharge Monitoring / Assessment

1	ΤΜΗΜΑ ΑΝΑΠΤΥΞΕΩΣ ΥΔΑΤΩΝ
2	ΔΙΑΧΕΙΡΙΣΗ ΑΝΑΚΥΚΛΩΜΕΝΟΥ ΝΕΡΟΥ
3	TREATED EFFLUENT DATA RESULTS SHEET

ΗΜΕΡΟΜΗΝΙΑ ΔΕΙΓΜΑΤΟΛΗΨΙΑΣ	INLET FLOW (m^3)	OUTLET FLOW (m^3)	AMMONIUM NITROGEN (NH4-N) (mg/l)	CHEMICAL OXYGEN DEMAND (COD) (mg/l)	S… C… (n…





Strict quality controls continuous along with the monitoring of the GW both qualitative and quantitative

Simulation Model Insights

A 3D Hydraulic model was implemented to simulate as far as possible the Groundwater Body CY_9 with area 50Km2 (movement of water and pollutants as a steady flow period 2009-2017)

The period of recharge, even limited, gave the following indications:

- ✓ Controlling of seawater intrusion
- ✓ Potable boreholes (upstream) are not affected by the recharge but from sewage leachates
- ✓ NH_4+ concentrations exciting limits for many years (detected through the monitoring programme of the WFD 2000/60/EU)
- ✓ Denitrification / dilution of water during transport from the WWTP to the ponds (15-20%) is observed
- ✓ The max efficiency of recharge with the existing structures = 7MCM/year
- ✓ The maximum allowable concentration of Ammonium recommended = 10mg/l
- ✓ An operation and efficiency register for each recharge pond is recommended
- ✓ Yearly assessment of the simulation model

Taking on the Challenge

- **Need to intensify efforts to prepare for and manage growing water shortage**

- **Augment recycled water availability to maintain a productive and sustainable agriculture**

- **Recharge of alluvium aquifers with recycled water following strict quality criteria can be used as a Storage and Recovery case study**
  - **Reduce effluent to environment**
  - **Provide a constant source of water for irrigation**
  - **Increase availability of water in periods of droughts**
  - **Halt sea water intrusion in coastal aquifers**

- **Recycled water is an effective option and a critical element in the development of sustainable strategies for water resources management to compensate climate change**

Thank you for your attention

http://www.moa.gov.cy/moa/wdd

phadjigeorgiou@wdd.moa.gov.cy