SWITCH

United Nations Educational, Scientific and Cultural Organization · International Hydrological Programme

Sixth Framework Programme (2002-2006)

MEKOROT ISRAEL NATIONAL WATER CO.

## The future of Urban Water:

## Solutions for Livable and Resilient Cities

**January 24-26, 2011 UNESCO Paris, France**

# Experience with SAT System in Israel and Future Plans


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# Content

- Wastewater and effluent figures
- History and general overview of the SAT in Israel
- Principles of the SAT technology
- The Third Line Reuse Project
- Future plans of Shafdan for the SAT System

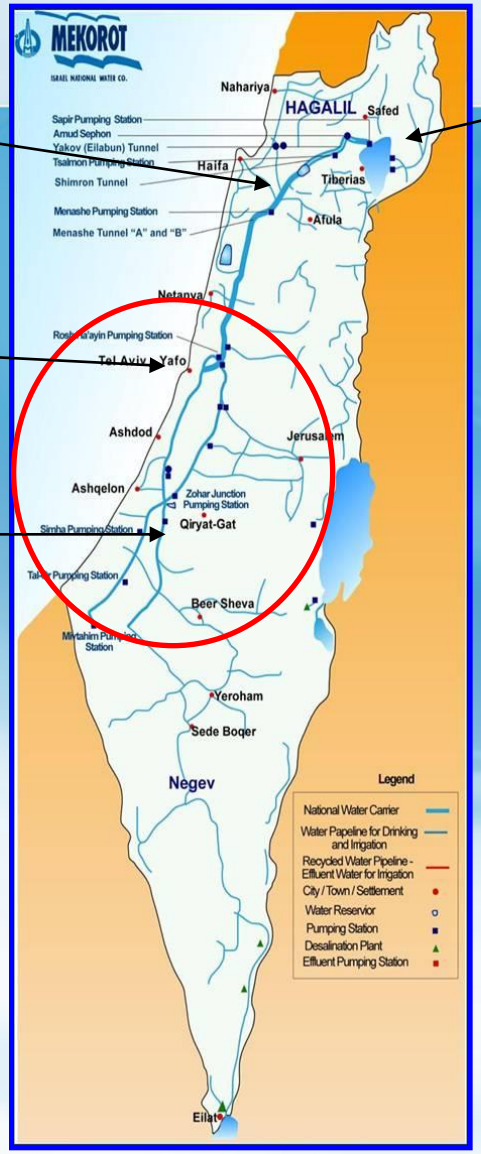
# National Water Carrier and Shafdan Irrigation Project

National Water Carrier

Galil Lake

Tel Aviv Metropolitan City

Irrigation Area of Reclaimed Water

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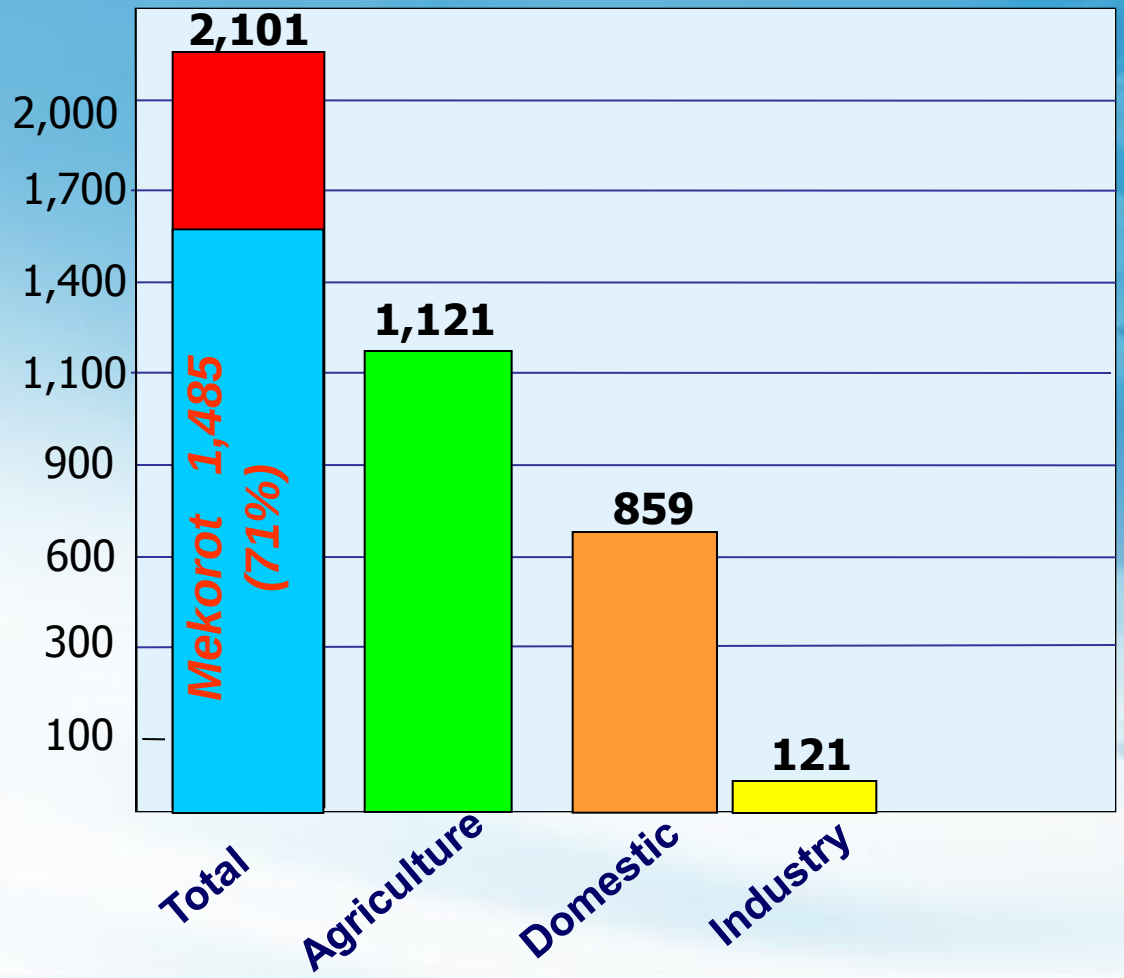
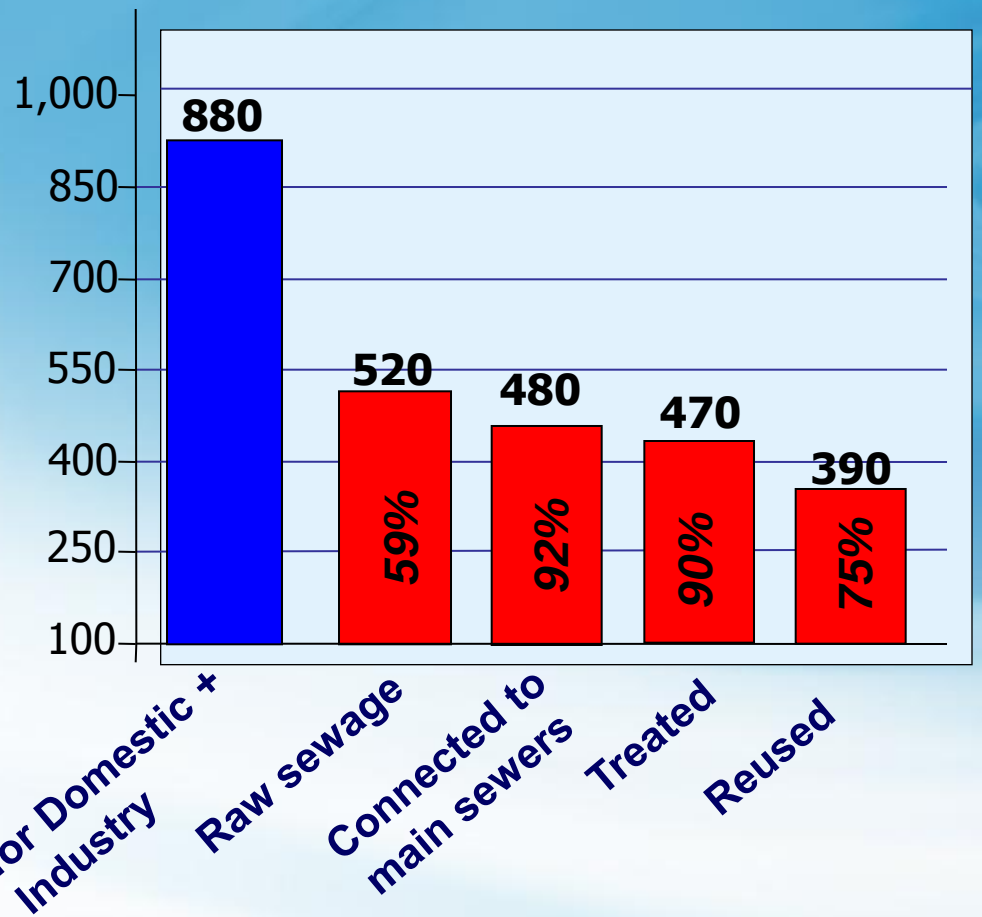
# Water consumption in Israel (Mm3/Year)

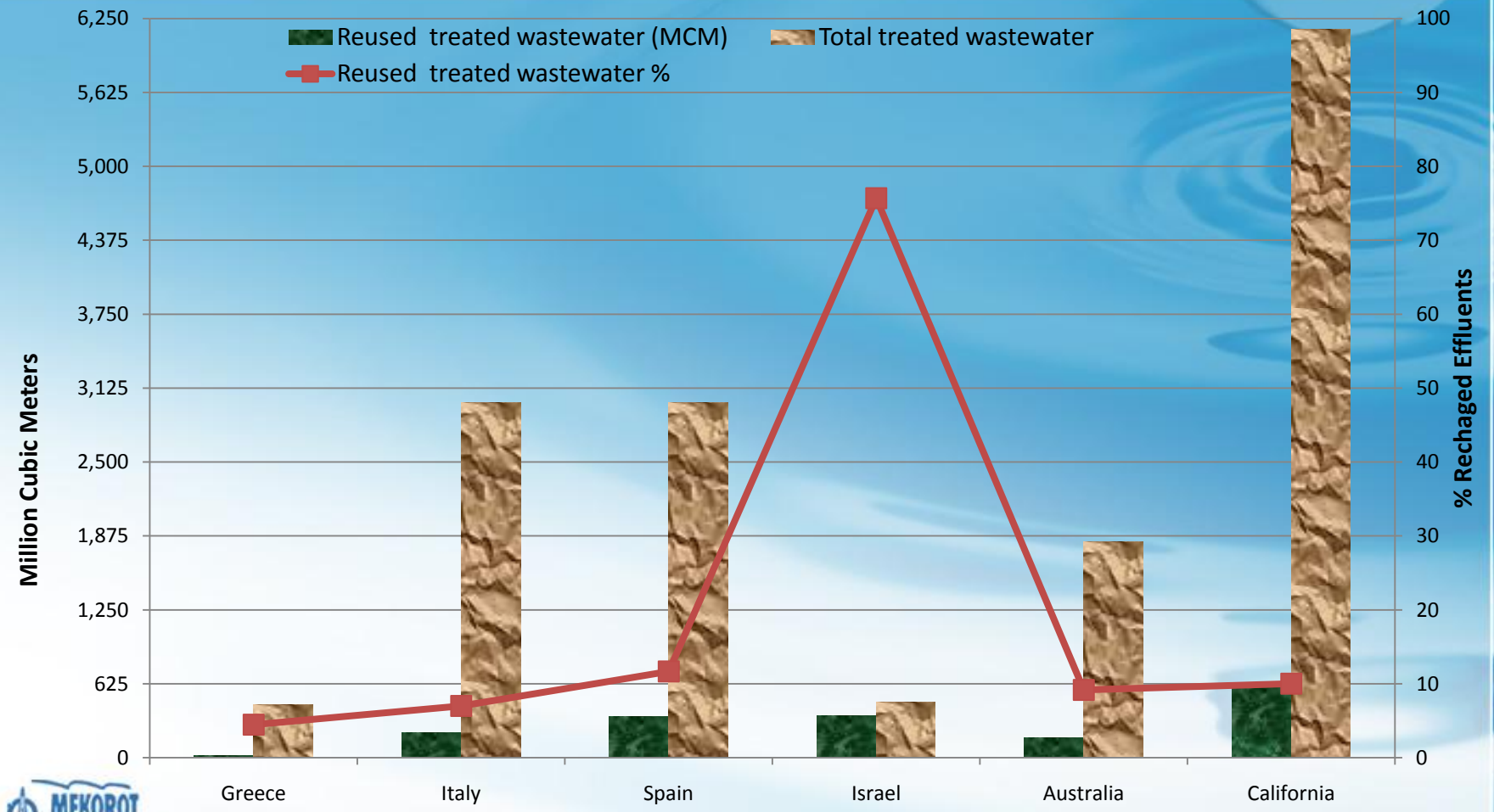
## (100 Mm3/Year to Jordan and Palestine)



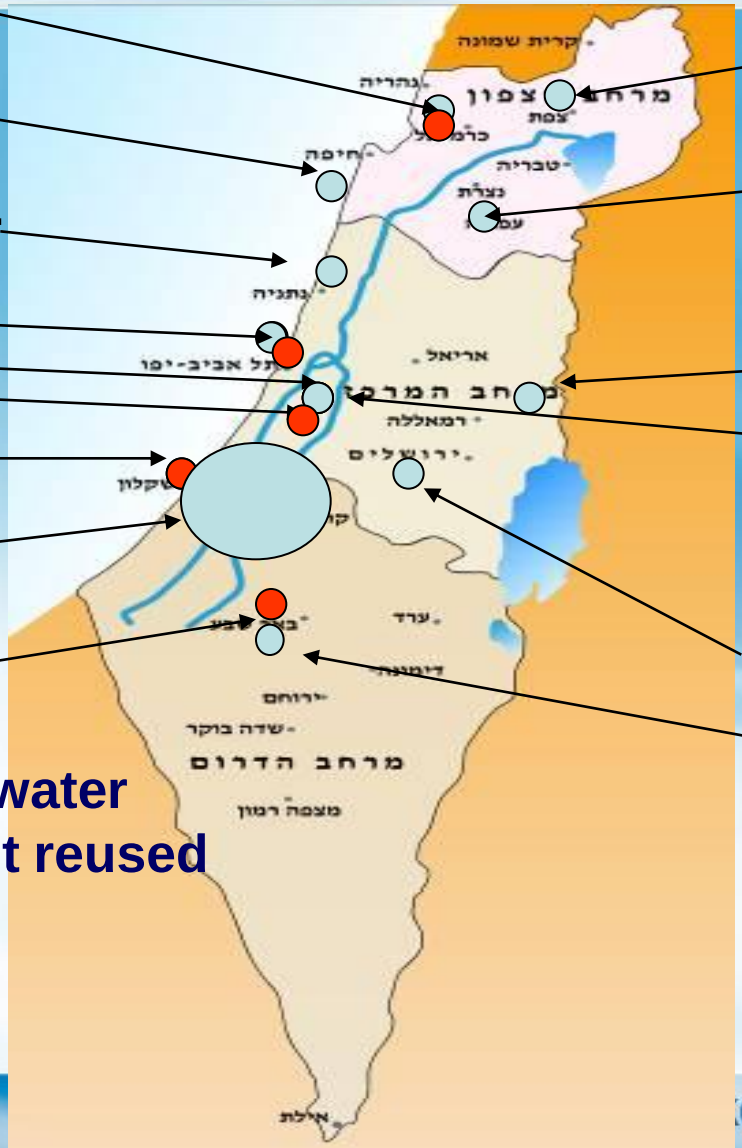
# Wastewater production in Israel ($Mm^3$/Year)



# Treated Wastewater Reuse in the World



# WWTP's and eff Reuse Projects in Israel operated by Mekorot




**37% of treated wastewater**
**Above 60% of effluent reused**

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# History of the SAT and the Third Line Project in Israel

- **Early days of the state:** Septic tanks( groundwater contamination)
- **In 50's:** Collection in main sewers, disposal to sea and rivers
- **1955:** The authorities with Mekorot decided on the SAT concept
- **60's:** Start treating sewage in oxidation ponds
- **70's:** Start recharge effluents after oxidation ponds to groundwater
- **80's :** Start **CAS** (Conventional Activated Sludge), CAS eff recharge with **SAT system**, Third Line operation to Negev ( South of Israel)
- **90's:** Extending **CAS** and the **SAT** system (infiltration basins)

# Sewage collection system of the Tel Aviv Metropolitan City (Dan Region)


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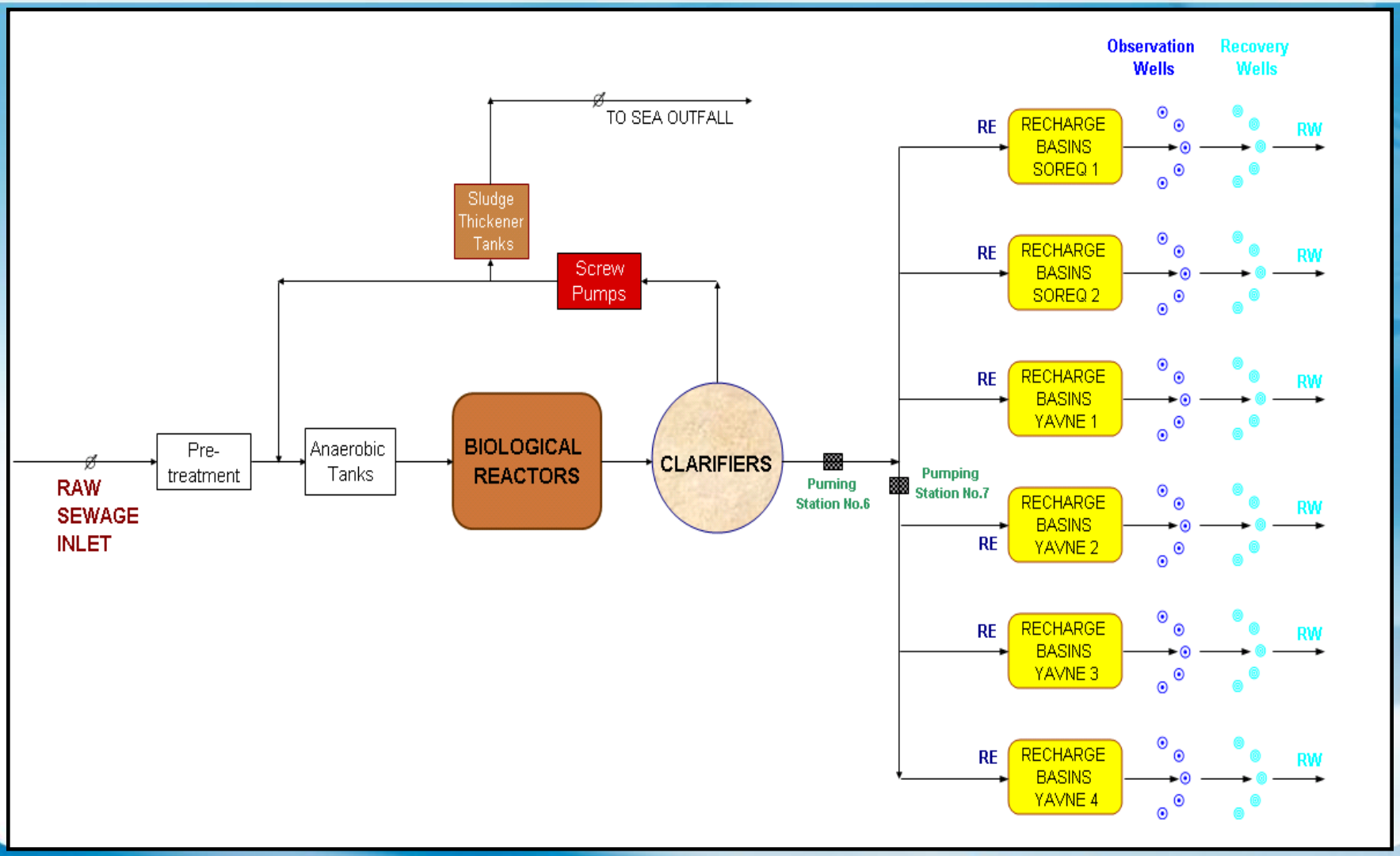
# Dan Region WWTP and Reclamation Project

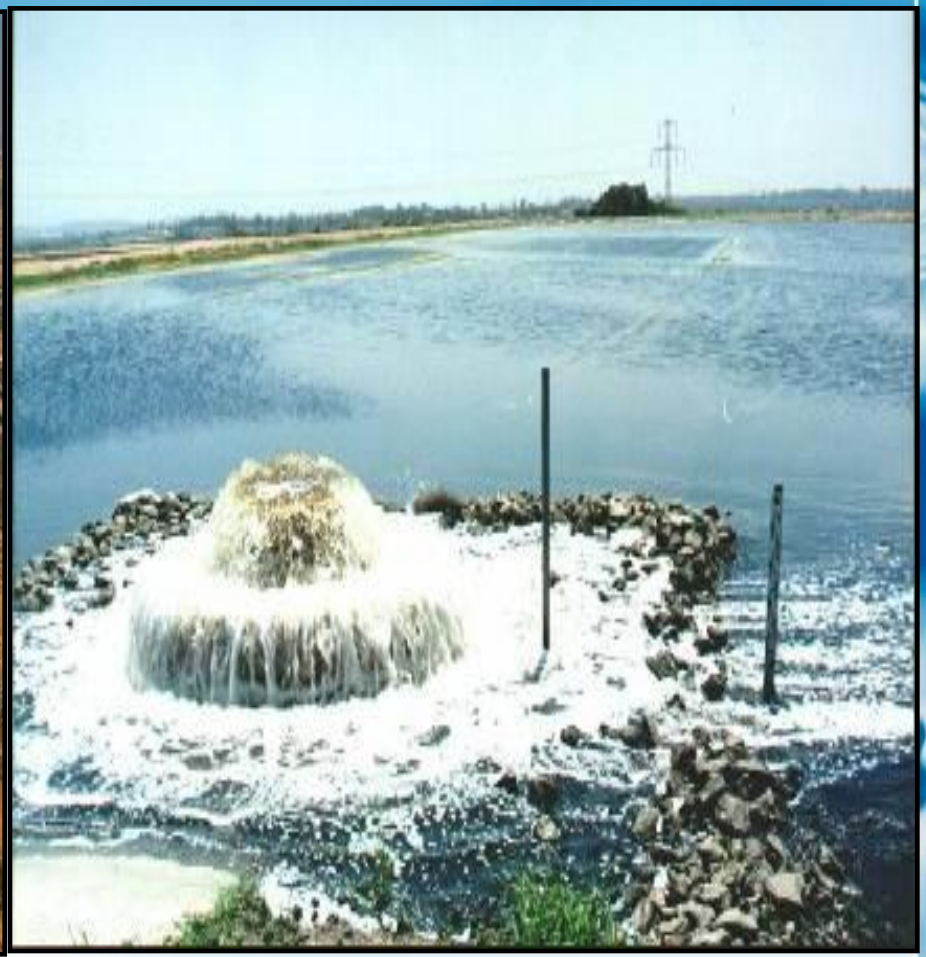
*Treating 140 MCM/Y of 2 .5 Million P.E*



# Dan Region WWTP and the Soil Aquifer Treatment System



# Shafdan – Yavne 4 Infiltration Field



# Automatic control of flooding basins

# The SAT (Soil Aquifer Treatment) Technology

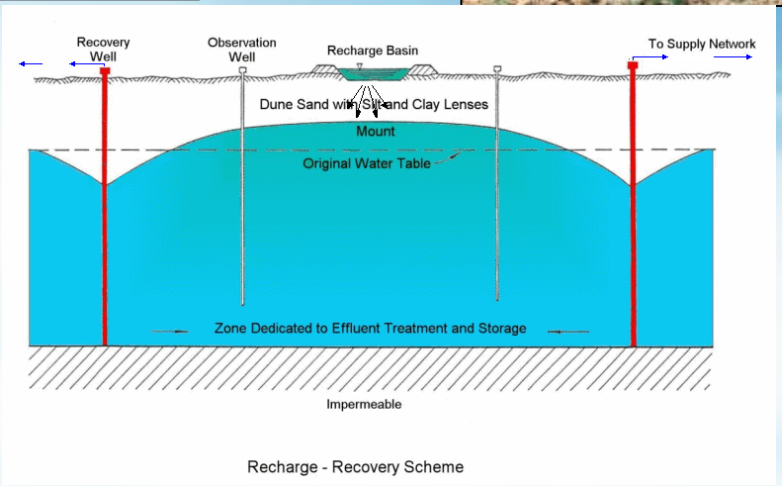
- Currently SAT process is being used
  - In USA as a non-potable resource (e.g., municipal and golf course irrigation) ⇨ Treated up to potable levels
  - In Israel for agricultural irrigation – stand on accidental drinking water standards
- A process of infiltration – percolation through Vadose (unsaturated) Zone to the groundwater aquifer
- Three components:
  - Surface infiltration
  - Percolation through Vadose Zone
  - Aquifer storage (and recovery)

# Operation of SAT in Shafdan

**SAT basins – Each are divided to sub-basins**

**View from a sub-basin at the beginning of the filling cycle and a soil treatment machine**

**Cross Section of the Soil and Aquifer under the Recharge Area** →




Recharge - Recovery Scheme

← **Vadose Zone Aerobic/Anoxic**

← **Ground Water Level**

# Why SAT was chosen for effluent reuse in Israel

- Inexpensive
- Available open area and far from residential sites (today close to residential area)
- Warm climate
- Simple to operate
- Reliable process
- Seasonal storage in periods of low demand (winter),

# Capabilities of SAT process

- Removal of: TSS, DOC, and $UV_{abs}$
- Biodegradation of bacteria, viruses, parasites - die off during the prolonged time , or by adsorption
- Chemical precipitation and Immobilization by Ion exchange of P, Cu
- Continuous removal of N by Nitrification and Denitrification
- Effective removal of most micropollutants
- **Residence time needed in the aquifer**:
  - For **unrestricted irrigation quality > 1-2 weeks** ( mostly bacterial decay)
  - For **accidental drinking water Quality > 6 months** ( total microbial, chemical removal and removal of most micropollutants)
- .Use of the SAT as seasonal storage

# Operating Conditions for SAT

| Parameter | Units | Value |
|---|---|---|
| Hydraulic loading | m/d | 0.2 - 0.6+ |
| Wetting cycles | days | 1 |
| Drying cycles | days | 2 |
| Cleaning cycle | days | 15 - > 30 |
| Depth of Unsaturated Layer | m. | 5 - 30 |
| Depth to Saturated Layer | m. | 20 - 50 (max. 100) |
| Retention time in ground | months | < 6 - > 12 |
| Recovery | % | up to 100 % |

Key Design/Operation Factors:

- Hydraulic loading
- Sandstone layer - Minimum Clay
- Residence Time and Travel Distance
- Managing Redox conditions (oxidation-reduction)

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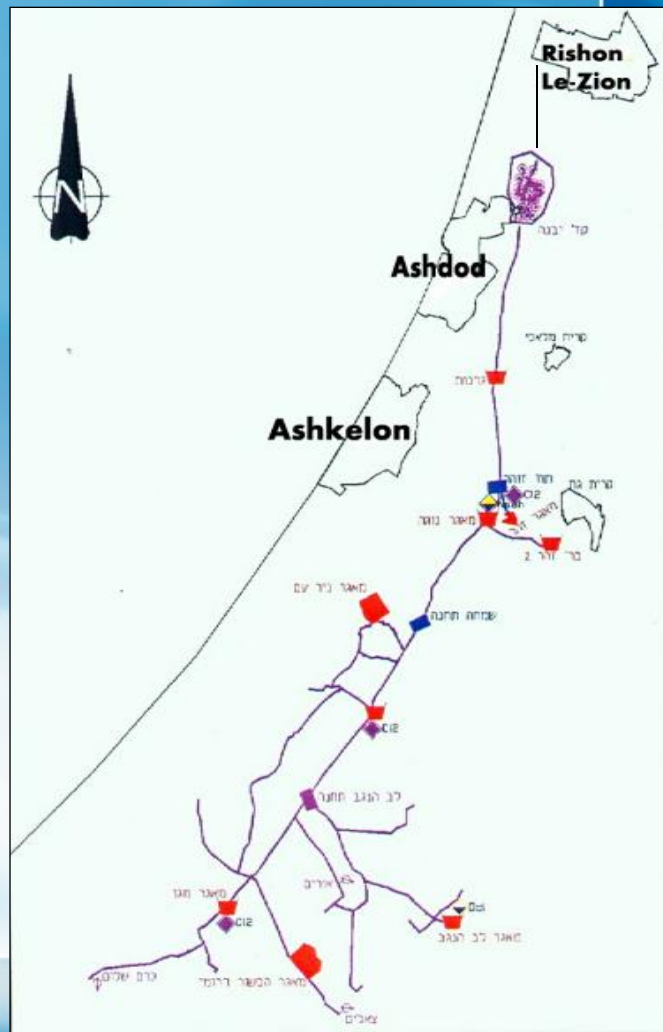
# The Third Line System to the Negev

**Distribution system of reclaimed water from Shafdan to Negev**




**<u>Reclamation Aims</u>**

- **Supply of 160 - 170 MCM/Year for irrigation, to replace fresh water with reclaimed water for agriculture**

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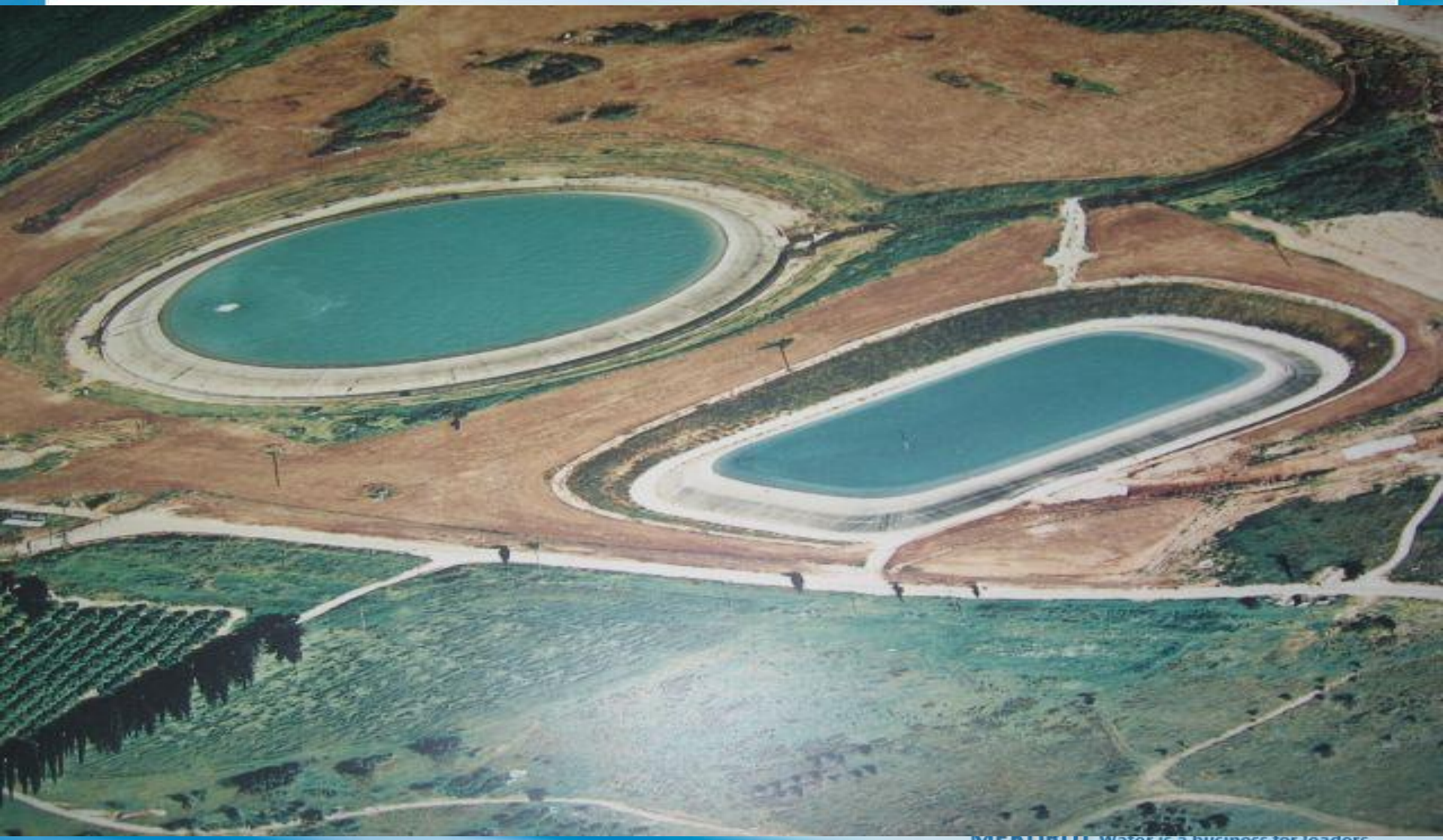
# Third Line Reuse Elements for Irrigation

- 150 **recovery wells** ,150 – 300 $m^3/h$ , 80-170 m' depth, 300-1700 m' from recharge basins.
- 70 **observation wells**, 35-190 m' depth, 30-1,000 m' from recharge basins
- 90 km of **main pipeline**, mostly 70"
- 8 **pump stations** up to 25,000 $m^3/h$ with up to 80 meter Head
- 6 **operational reservoirs** ,510,000 $m^3$
- 5 **seasonal reservoirs**, 17,500,000 $m^3$
- **Quantities supplied** – 170 $Mm^3/Y$
- **Quality** – Accidental Drinking Water Standards
- **Area irrigated** – up to 125,000 Acres
- **Crops irrigated** – orchards, wheat, vegetables, flowers, spices

# Granot pump station along the Third Line Project (25,000 CM/h)

# Seasonal Reservoir in the Third Line Project
# North Bsor - 2.2 Mcm

# Operational reservoir in the Third Line Project
# Granot B – 50,000 M3



# Water quality data of the SAT process in Shafdan

| | | Raw sewage | Sec. Eff | After SAT | Drinking stand. | Inbar Stand. |
|---|---|---|---|---|---|---|
| BOD | ppm | 430 | 4-8 | **<0.5** | | **10** |
| COD | ppm | 1060 | 40 | **10-20** | | **100** |
| TSS | ppm | 380 | 4-8 | **<o.1** | | **10** |
| TN | ppm | 65 | 20 | **5-10** | | **25** |
| NH4 | ppm | 35 | 4-6 | **0.1** | | **20** |
| UVabs | cm-1*10*3 | 450 | 212 | **25** | | |
| DOC | Ppm | 60-90 | 10-15 | **1-2** | | |
| Pt | Ppm | 8-12 | 1-2 | **<0.02** | | **5** |
| Det | ppm | 4-13 | <0.2 | **<0.1** | 1 | **2** |
| T.Coli | N/100ml | 1.1E8 | 5.6E5 | **0** | 3 ( 0 ) | |
| F.coli | N/100ml | 1.2E7 | 1.8E4 | **0** | 0 | **10** |
| MN | ppb | 50 | 25 | 30-500 | 500 | **200** |
| Fe | ppb | 1,100 | 80 | 10-100 | 1000 | **2000** |

# SAT treated water – Viruses, Phages and Spores analyses

| Microbiological analysis* | Units | Method** | 05/07 and 06/07 Secondary effluents | 05/07 and 06/07 Mey-Dan well #9 (after SAT) |
|---|---|---|---|---|
| Total Bacteria count (35 ºC) | cfu/mL | Heterotr. Plate Count (35 C. deg. / 48 hr.) | 890,000 | 340 |
| Faecal coliforms | cfu/100mL | MF | 30,000 | 0 |
| E.Coli | cfu/100mL | | 400 | 0 |
| Enterococci | cfu/100mL | Fecal st. MF | 4,000.00 | 0 |
| clostridium spores | cfu/100mL | | 100,000.00 | 0 |
| bacteriophages | pfu/mL | (amp F+)/10 L<br>(Somatic CN13/10L.<br>(f1MS2)/10L | 724<br>1,249<br>7 | 0<br>0<br>0 |
| Enterovirus | pfu/Vol. | /100 L | 14 | 0 |

*** In the context of the EU project RECLAIM (WP 2)**

**** All phages, spores and viruses analyses performed by the Health Ministry Lab. Dr. Yosi Manor**

# Treatment Alternatives for the Mn and Fe Problems

- Wells **shut off** in case of high Mn conc' (more than 500 ppb)
- **Flushing** of the main pipe-line at the beginning of the irrigation season
- **Mechanical cleaning** of the pipe-line (pigging)
- **Automatic control** of the flooding – drying cycles to ensure aerobic conditions in the Vadose Zone
- **Study** of the manganese dissolution causes

# Problems in the long term -SAT System

1.Deterioration in Recharge Capacity

2. No more new lands are available for infiltration

3. More available effluents for infiltration

4. Mn and Fe dissolution due to anoxic conditions in part of the SAT system forming afterwards oxides and clogging the irrigation systems

5. Bio-fouling of effluent pipelines before and after SAT

6. There are intentions of the Water Authority to reduce the actual infiltration areas (to treat by UF-RO instead of SAT and use the areas close to the cities for housing

# Alternative Solutions Investigated by Mekorot

1. Improvement of SAT process which is considered as the main technology

2. <u>Adding other hybrid treatments to the SAT</u>

2.1 - Treatment of the excess effluents that can not be infiltered: by UF and disinfection and introducing to the Third Line directly

2.2 - Diverting to other neighboring effluent reuse systems

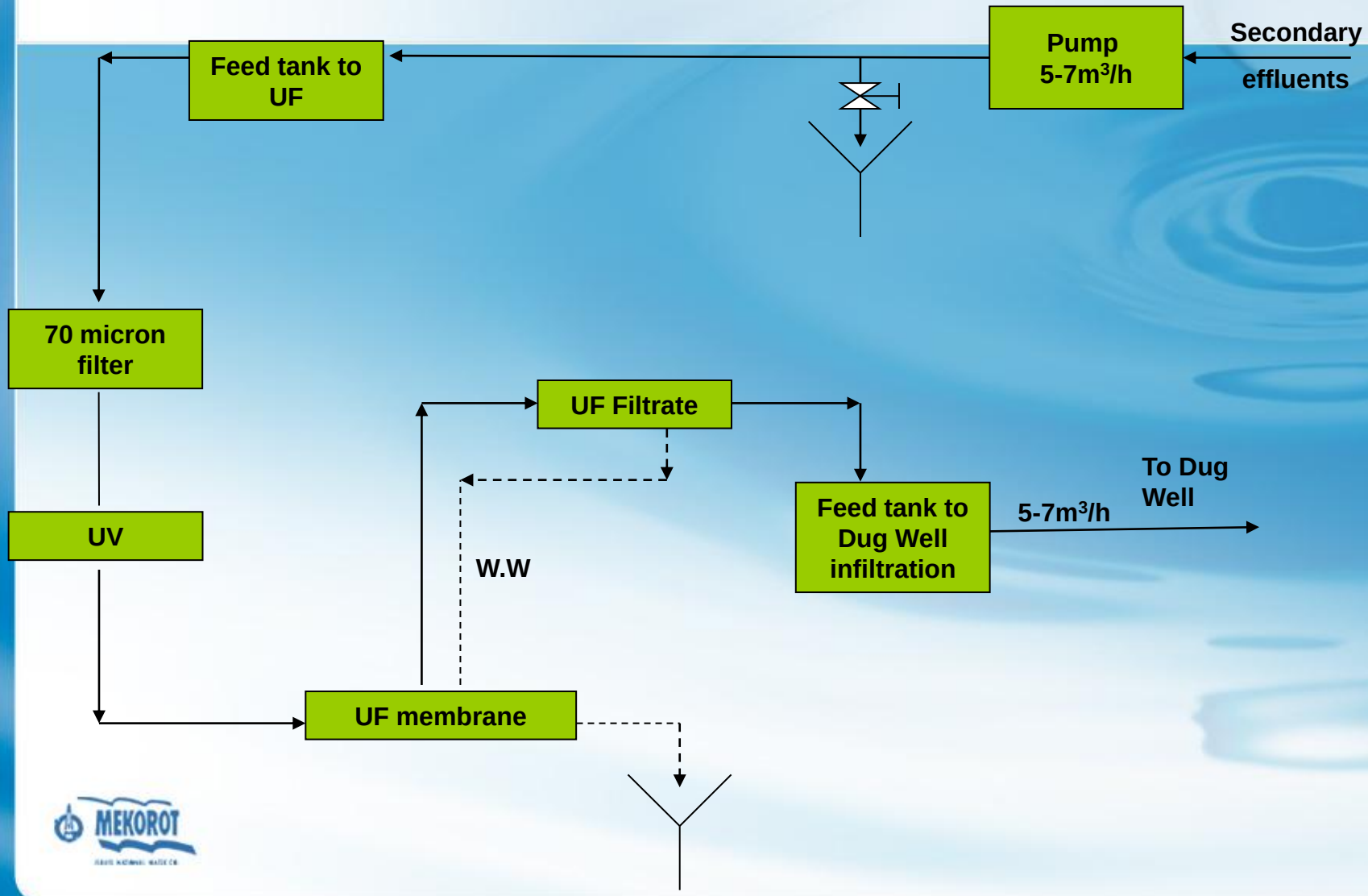
2.3 - UF before DUG WELLs and recovery at short retention times(RECLAIM)

2.4 - Short SAT and NF (SWITCH)

2.5 - UF- Reverse Osmosis (RO) of part or all effluents

2.6 - Pretreatment of all effluents before SAT

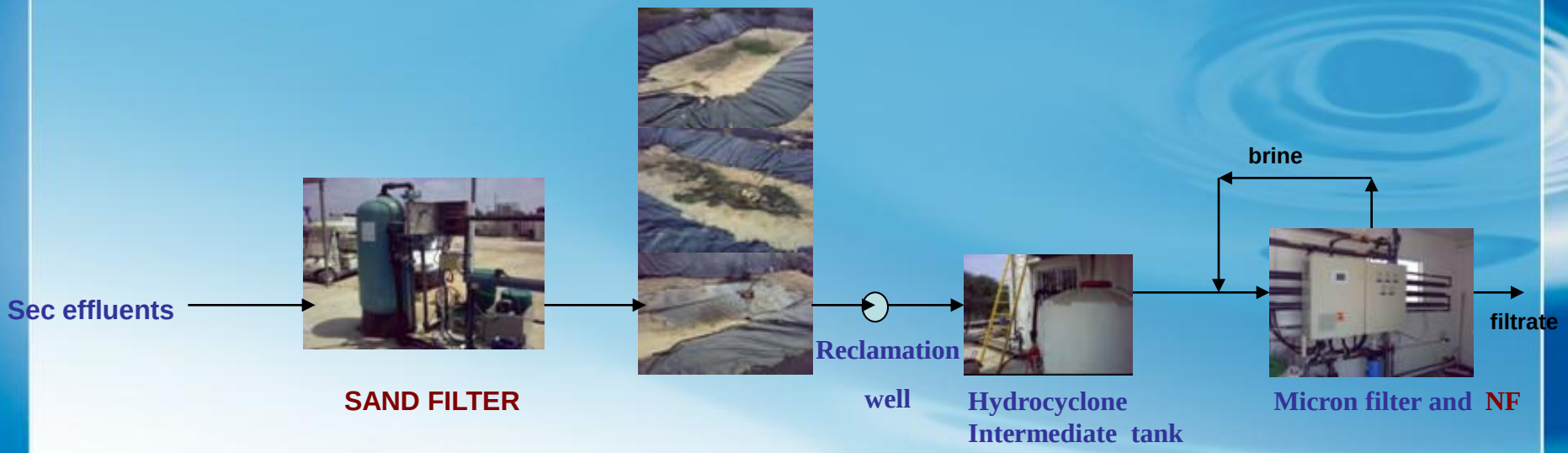
# Reclaim Pilot



# The Reclaim Pilot ( UF- Short SAT) Results and Comparison to the Conventional SAT

| | | | | |
|---|---|---|---|---|
| Conventional SAT | 1 day infiltration 2 days relaxation | 1 m/d | 6-12 months | DOC 0.5-1 mg/l, no bacteria and viruses, most micropollutants removed |
| UF- Short SAT | UF prefiltration and short SAT | 10 m/d | 1-2 month | DOC 2-3 mg/l, removal of all bacteria and viruses, some hardly biodeg. micropollutants not removed |

# SWITCH Pilot



# SWITCH

## Chemical parameters:

| Parameter | Unit | Sec. Effl. | A.Sh.SAT* | Rem. Eff. % (A.Sh. SAT-Sec. Effl.) | A. Nano Filter | Rem. Eff. % (A.NF-A. Sh.SAT) | CAS +LONG SAT** |
|---|---|---|---|---|---|---|---|
| COD | mg/L | 29 - 40 | 5.0 - 9.0 | 78-83 | 2.0 - 3.0 | 60-67 | 2-4 |
| DOC | mg/L | 9.5 - 10.3 | 1.8 - 2.3 | 78-81 | 0.2 - 0.3 | 87-89 | 0.6-0.9 |
| UVabs. | 1/cm* 1000 | 209 - 224 | 46 - 68 | 70-78 | 6.0 - 7.0 | 87-90 | 9-13 |
| Ammonia | mg/L | 3.17-4.2 | 0.4-1.0 | 76-87 | 0.03-0.1 | 90-93 | 0.02-0.05 |
| Phosphorous | mg/L | 0.66-1.4 | 0.03-0.08 | 94-96 | <0.03 | >63 | <0.03 |
| TDS | mg/L | 864 -900 | 786 - 897 | - | 687 - 718 | 13-20 | 796-852 |

* After 1 year infiltration. The analyses results relate to 30 days retention time in the aquifer

** After 30 years of infiltration. The analyses results relate to 300 days retention time in the aquifer

## Microorganism removal:

All microorganisms were removed by short retention time soil passage

- **F. Coli -5-6 logs,**
- **Enterococci -5 logs,**
- **Clostridium -4-5 logs**
- **MS 2 phage -4-5 logs**
- **Complete removal of Enteroviruses**

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# Micropollutants (antibiotics, AOI) Concentrations – Shafdan Effluents

(Concentrations from all data from Reclaim and Switch)

| Micropollutants / Process | Unit | CAS (Shafdan) | CAS+long SAT (conventional)** | CAS+ UF+RO (desalination) | CAS+ short SAT +NF (SWITCH)* | CAS+UF+ short SAT (RECLAIM)* |
|---|---|---|---|---|---|---|
| Clarithromycin | ng/l | 39-500 | 0-61 | 0 | 0 | 0 |
| Erythromycin -$H_2O$ | ng/l | 93-594 | 0-43 | 0 | 0 | 0 |
| Roxythromycin | ng/l | 55-787 | 0-108 | 0 | 0 | 0-118 |
| Sulfamethaxazole | ng/l | 173-657 | 10-363 | 0 | 0-43 | 24-120 |
| Sulfamethazine | ng/l | 0 | 0 | 0 | 0 | 0 |
| Trimethoprim | ng/l | 62-349 | 0-18 | 0 | 0 | 0 |
| AOI | µg/l | 13-42 | 11-12.6 | - | 0.6-3.5 | 13-22.7 |
| DOC | mg/l | 9.8-13.8 | 0.5-0.6 | 0.2-0.3 | 0.2-0.3 | 1.6-2.3 |

**CAS**:Conventional activated sludge

**CAS-UF-short SAT**: UF polishing of the CAS effluent and infiltration in a 30 days SAT

**CAS-short SAT-NF**: CAS effluents infiltered through short (30 days SAT) and polished by NF

**CAS-UF-RO**: CAS effluents polished in two stage membranal treatment (ultrafiltration and reverse osmosis)

**CAS-long SAT**: CAS effluent infiltred in a 300 days SAT (D9 well)

**Note:** German recommendation for drinking water values for micropollutants (antibiotics) max. concentration - 100 ng/l.

# Future Plans for the Shafdan Infiltration Project

## Actual Situation

Infiltration of most of effluents in Long SAT

↓

5-10% effluents not infiltered

## Future Plans

### 1. Pretreatment to all effluents before Long SAT

- 1.1 UF before SAT
- 1.2 Flocculation sand filtration before SAT
- 1.3 Intermittent Sand Filter before SAT
- 1.4 Short SAT –NF (SWITCH) process

### 2. Treatment to excess effluents that not infiltered in Long SAT

- 2.1 UF, disinfection and dilution with other long term SAT water
- 2.2 Effluents to be sent to other neighboring reuse systems
- 2.3 Building more operational reservoirs in Shafdan for secnondary effluents to keep the water in low infiltration rates
- 2.4 UF -Short SAT and mixing to the other long term SAT water

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# Thank you

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