TU Berlin Campus El Gouna
Department Water Engineering

Water and wastewater management in El Gouna, Red Sea, Egypt

In the frame of:
"Sustainable Use of Resources: Water and Energy for Egypt"
IWaTec winter school, Feb. 2015

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Outline

- Water resources
  Protection, preservation, control, etc.

- Water, wastewater quality
  Control, treatment

- Water, wastewater distribution
  Piping network, pumping stations

- Economical considerations
  Operation, maintenance, selling price, water losses

- Needs
  Drinking water, irrigation water

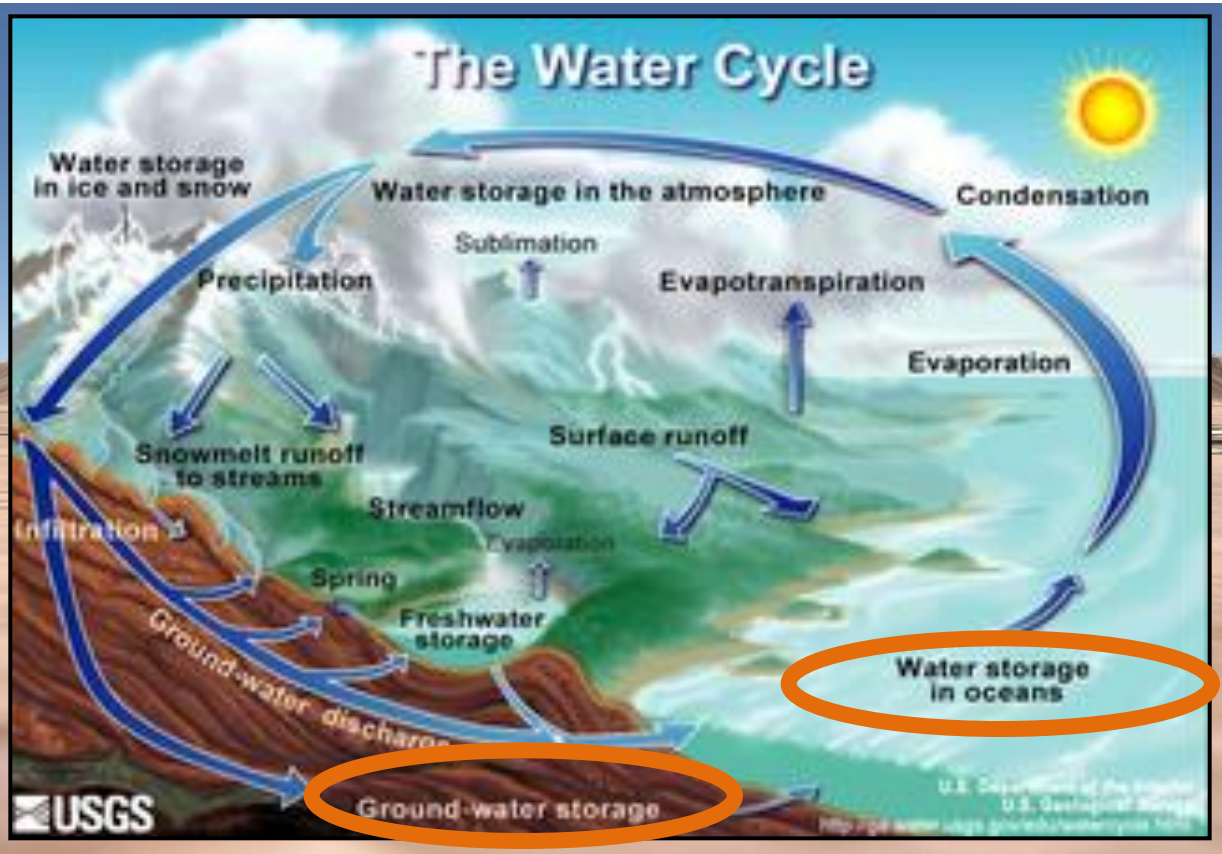
General

El Gouna

- 22 km north of Hurghada.
- 7,010,486 m^2 of developed area, coastal length 10 Km, green area covers 945,000 m^2
- Around 15-20,000 permanent residents.

Water management in El Gouna

❑ Water resources

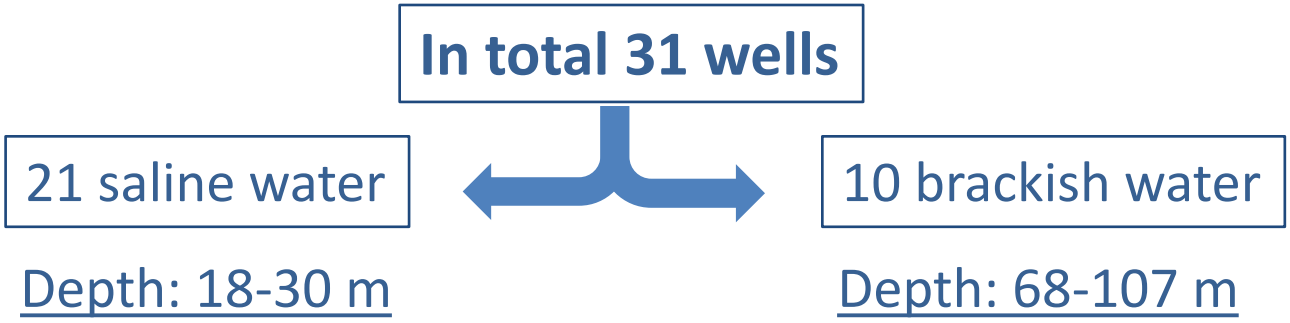


➢ Available water resources in El Gouna

Groundwater is the water that lies beneath the earth surface filling in the space between the rocks and the pores of the rocks, it moves under the influence of gravity and supplies wells and springs

Water management in El Gouna

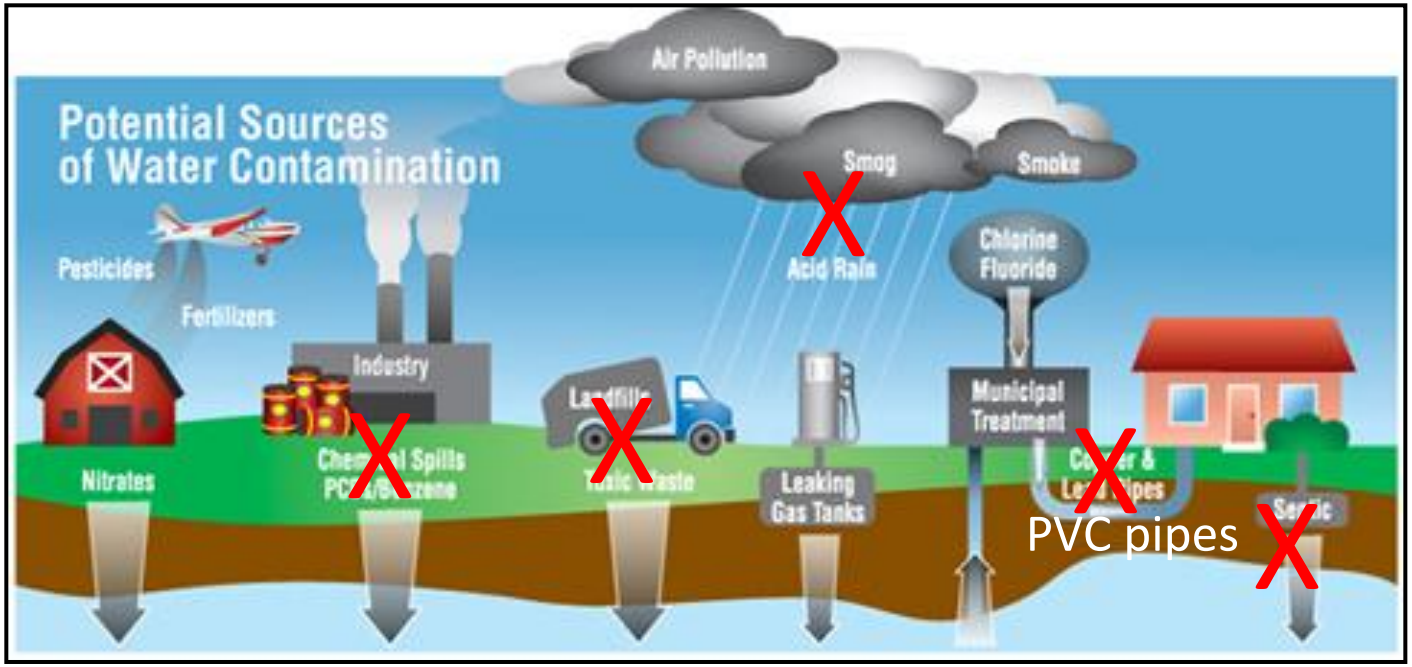
❑ Water resources



- Groundwater quality can be affected by:
  - Temporary, point or linear contaminations (e.g. accidents)
  - Continual, point or linear contaminations (e.g. leaky pipelines, roads, landfills)
  - Recurring diffuse inputs, e.g. fertilizers, biocides, sewage sludge, compost.
  - Continual diffuse contaminations (e.g. city areas).

Water management in El Gouna

- Water resources
  - Protection



- ✓ The anthropogenic (possibly) negative impact is limited in El Gouna

Water management in El Gouna

- Water resources
  - Protection

- Elementary protection standards of drinking water wells

X Fence around the well.

√ No septic tank in a distance of 25 m.

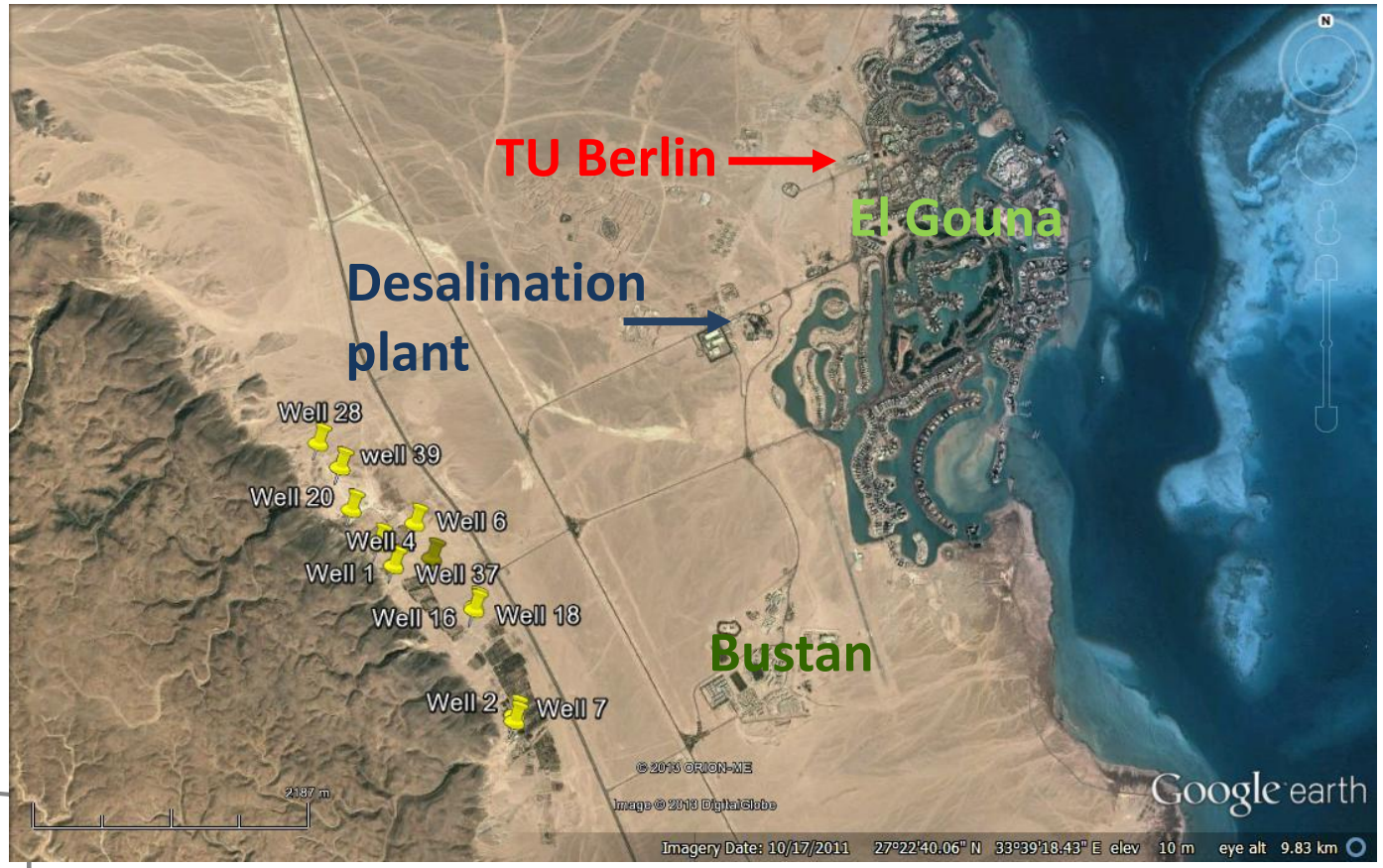
√ 50 m away any other construction or activity that could be a source of contamination

~ The well itself should have a house or an underground box for the direct protection
  - Most of the saline water wells protected
  - Brackish water wells not protected

- Wells contain saline or brackish water – Treatment is needed

Water management in El Gouna

- Water resources
  - Brackish water wells

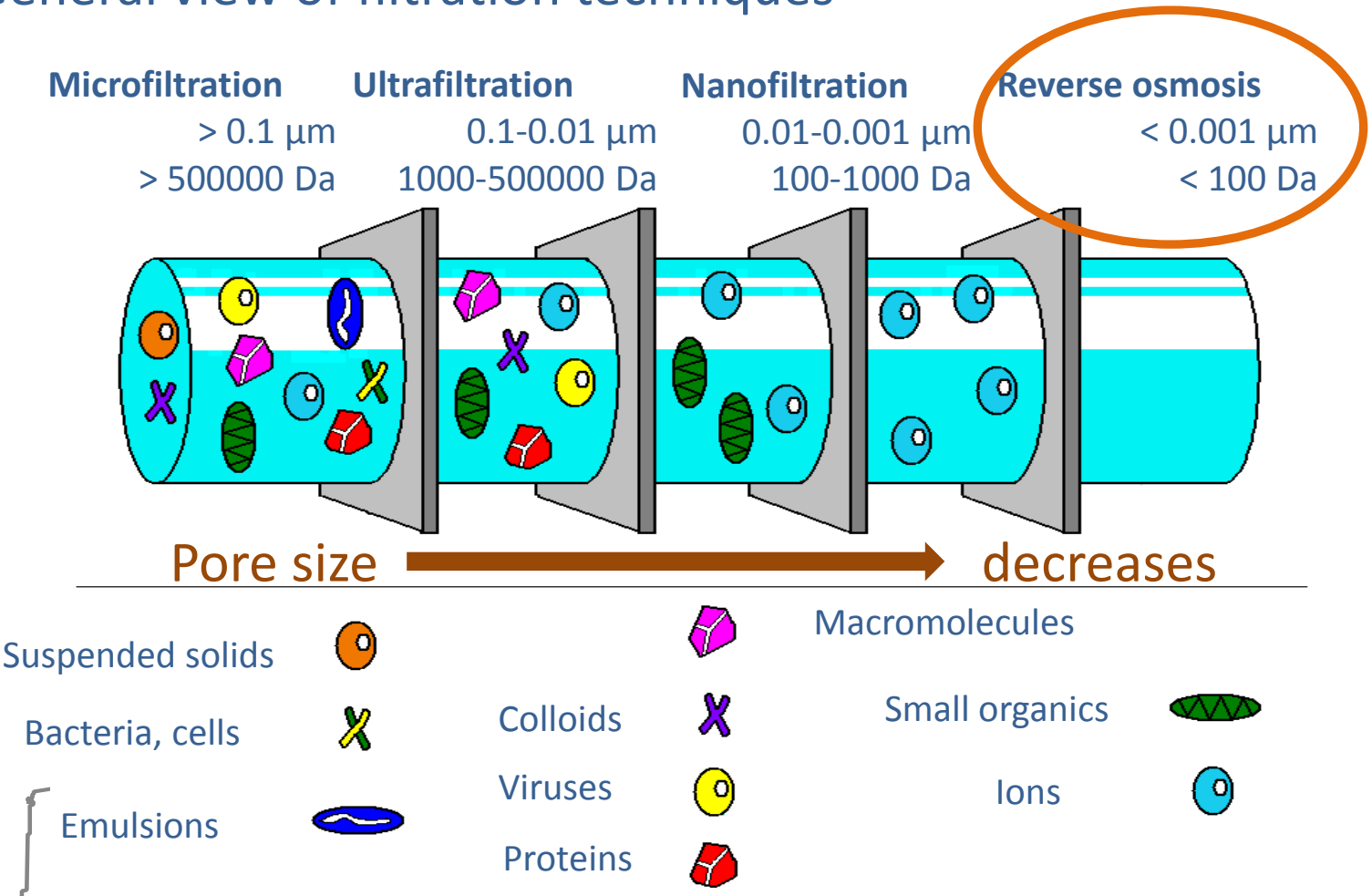


Water management in El Gouna

❑ Water quality

- Water treatment / desalination with Reverse Osmosis

General view of filtration techniques

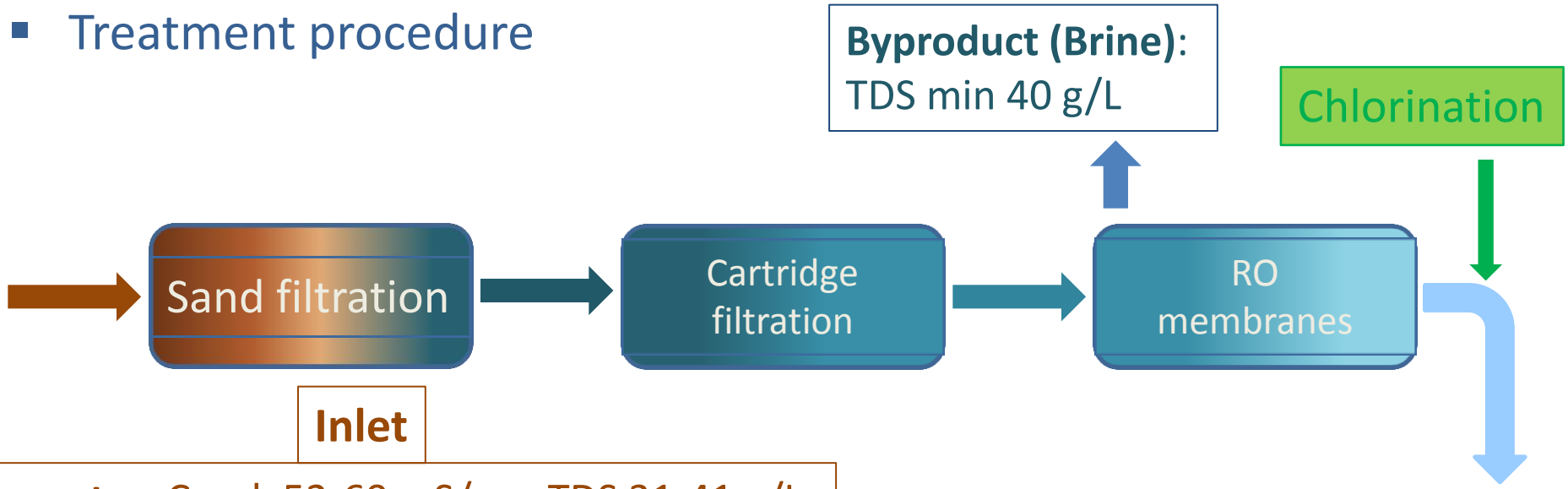


Water management in El Gouna

❑ Water quality

➢ Water treatment: desalination with Reverse Osmosis

- Treatment procedure



Inlet

Seawater: Cond. 52-60 mS/cm, TDS 31-41 g/L

Brackish: Cond. 8-11 mS/cm, TDS 6-8 g/L

Outlet: Cond. 0.5-1.0 mS/cm
TDS 0.3-0.7 g/L

Water management in El Gouna

- Water quality

- Water treatment: desalination with Reverse Osmosis

In total 15 units
Production: 9500 m^3/d

8 for seawater

Production: 5500 m^3/d

7 for brackish water

Production: 4000 m^3/d

Water management in El Gouna

❑ Water quality

➢ Water treatment: desalination with Reverse Osmosis

- Efficiency: 3 L of brackish water produce 2 L of drinking water
  3 L of saline produce 1 L of drinking water

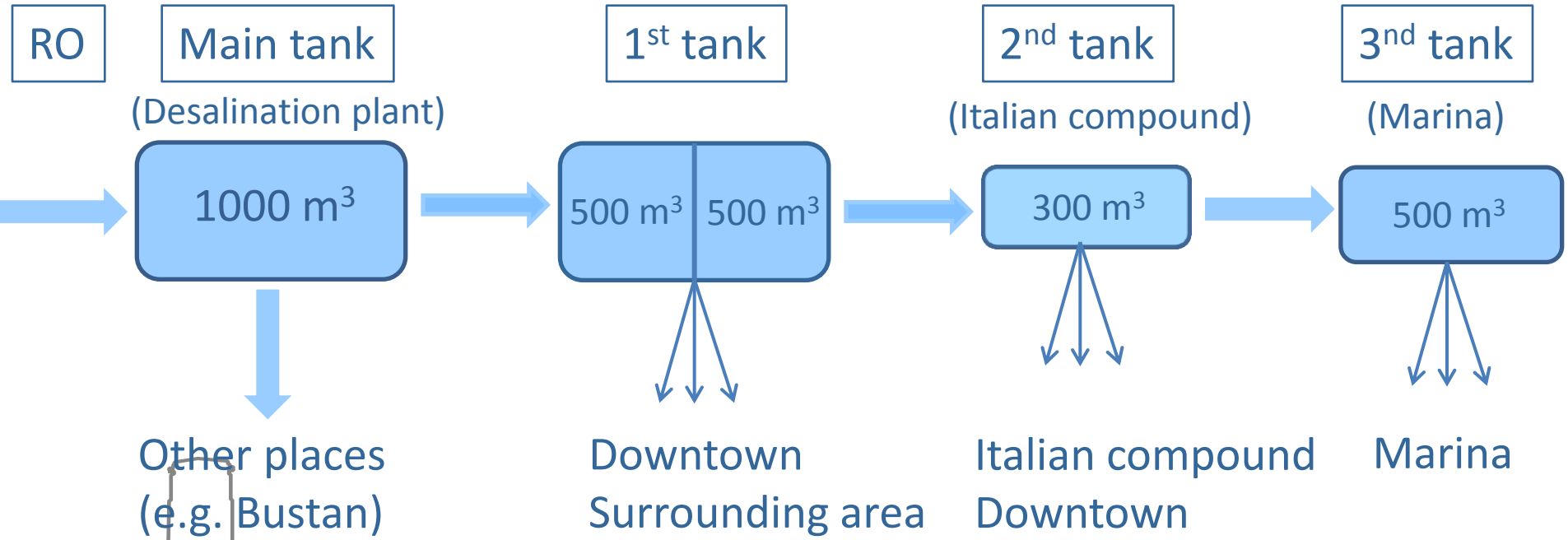

Cartridge filters

RO modules

Water management in El Gouna

❑ Water distribution

- Water distribution network: Pipes from PVC
- Hotels, villas, restaurants, apartments: Pipes from PE and/or metallic
- Use of centrifugal pumps

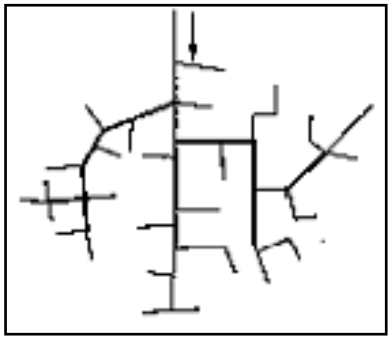


Water management in El Gouna

❑ Water distribution

- Water distribution network

Branched network



Water management in El Gouna

❑ Water distribution

- Water losses
  Difference between water output in the piping system (Network feed-in) and the measured water delivery to the consumer (including waterworks own consumption) **– Actual losses / Apparent losses**
- No detailed water loses study in El Gouna
- Relatively new distribution network – low water losses should be expected (< 5%)
- Water losses in El Gouna estimated to be 10 %

⟶ 950 m^3/d or 346750 m^3/a.

✓ Detailed water loses study should be conducted in El Gouna

Water management in El Gouna

❑ Water distribution

- Water losses in the Mediterranean region (2013)

Source: World Bank calculations - draft study report 2013

Water management in El Gouna

❑ Economical considerations

➢ Drinking water production costs (for **1 m³**)

- Energy needed for producing **1 m³** of drinking water: max. 5 KWh (2.5-5KWh)
- Energy cost: ca. 5 €cent/KWh

} Total energy costs: **0.25 €** **+** Chemicals, workers, etc. (operational costs) }

7.5 EGP or 0.86 €

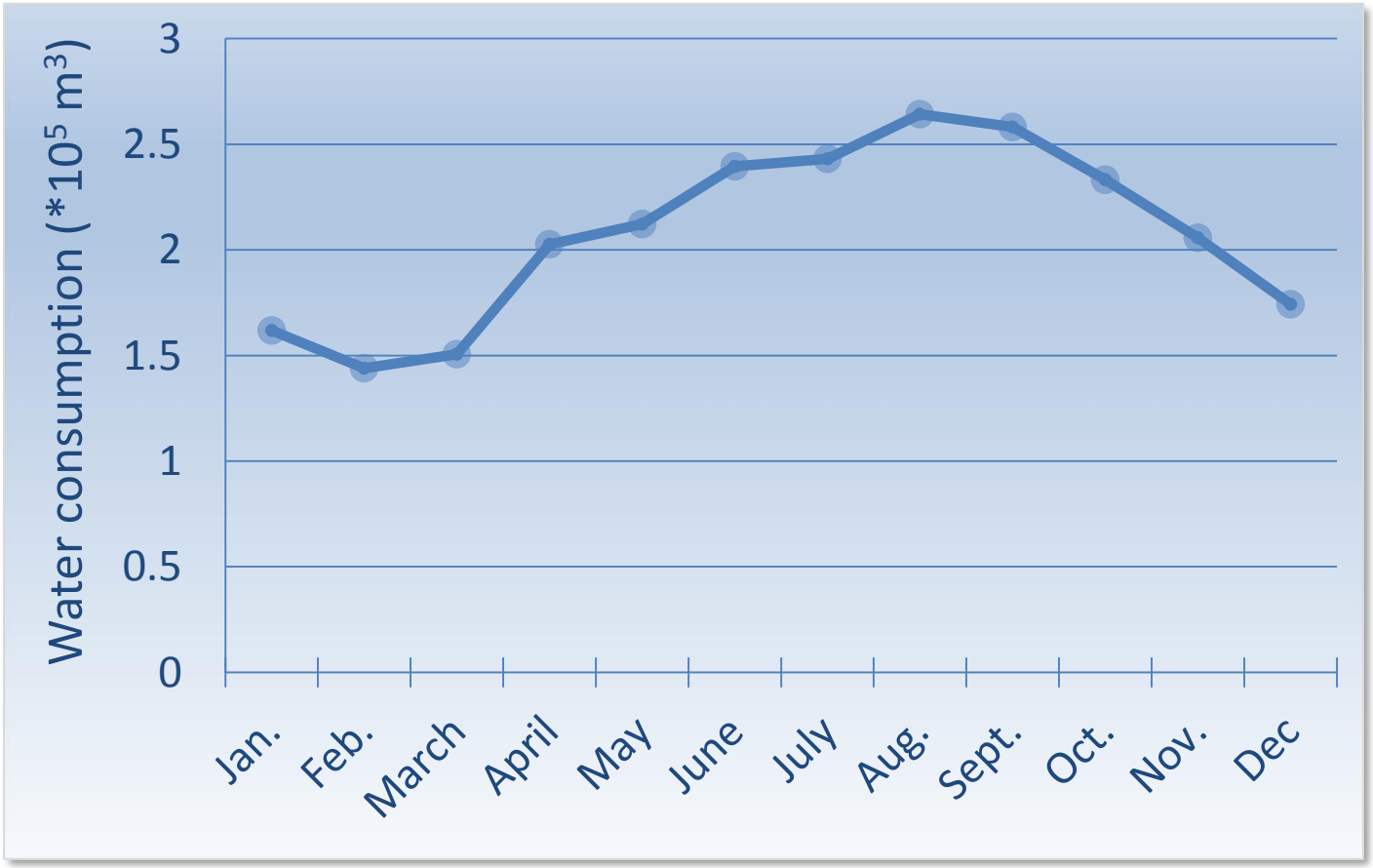
(Maintenance costs not included)

➢ Selling price: **15 EGP or 1.73 € / m³**

➢ Water demand in downtown: **1500 - 2200 m³/d**

Water management in El Gouna

❑ Drinking water consumption, 2014



Total	2,489,483 m³

Water management in El Gouna

❑ Water quality

- Brine water management – current status

Fish farm

Waste water management in El Gouna

❑ Wastewater production

- Type of wastewater.
  Hotels, villas, homes, restaurants, etc. - domestic wastewater
  Brewery, central laundry – industrial wastewater
- Downtown production: 600-1000 m^3/d
- No pre-treatment on site.
- Sewage piping system – centralized treatment
- Two waste water treatment plants (WWTP)
  - WWTP of El Gouna (domestic wastewater)
  - WWTP of Bustan (domestic and industrial wastewater)

Waste water management in El Gouna

❑ WWTP of El Gouna

- Consists of 3 separated units, each capable of treating **1000 m³/d**
- Each unit consists of 3 separated streams
- Treatment method: conventional activated sludge
- Treated water used for irrigation purposes

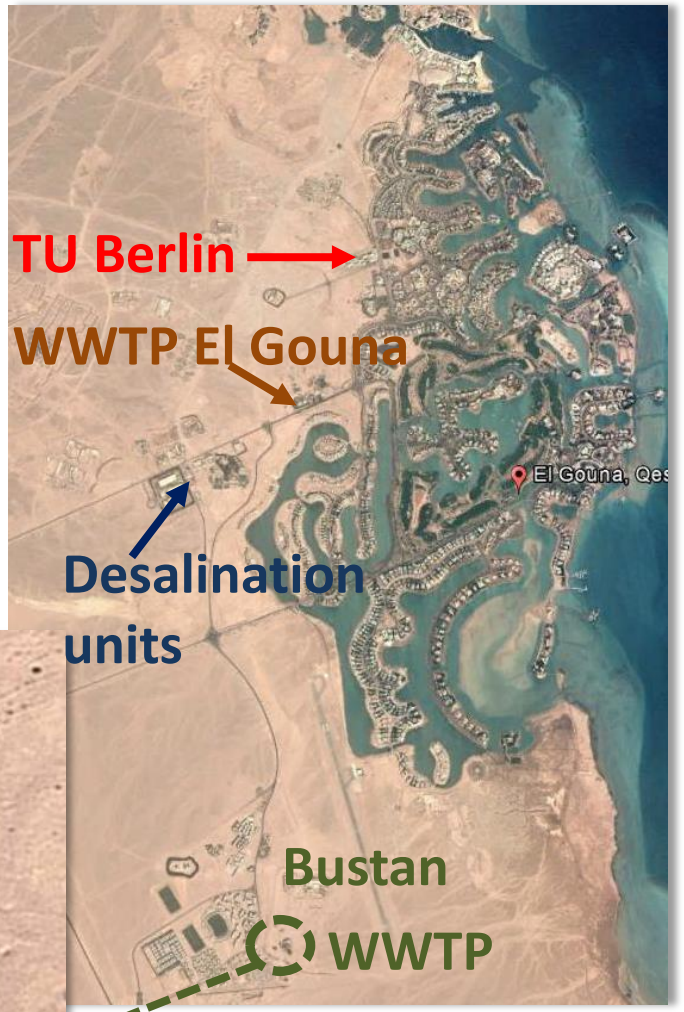
Waste water management in El Gouna

❑ WWTP of Bustan

- Consists of 2 separated units

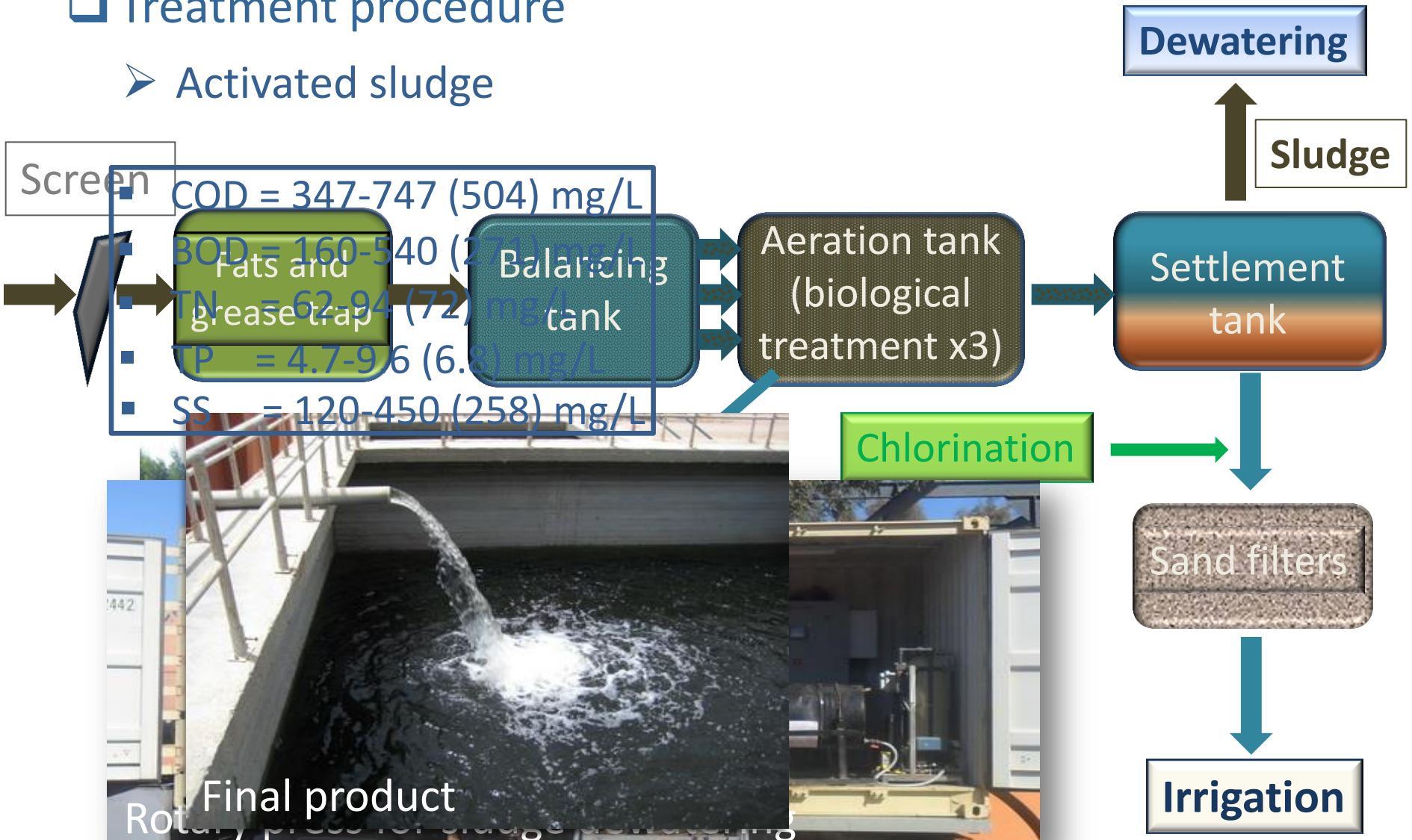
2 streams	3 streams
750 m^3/d	1000 m^3/d

- Treatment method: conventional activated sludge
- Treated water used for irrigation purposes



Waste water management in El Gouna

- Treatment procedure
  - Activated sludge



Waste water management in El Gouna

❑ Economical considerations

➢ Wastewater treatment costs (for **1 m³**)

- Energy
- \+
- Chemicals, workers, etc. (operational costs)

} **3 EGP or 0.35 €**

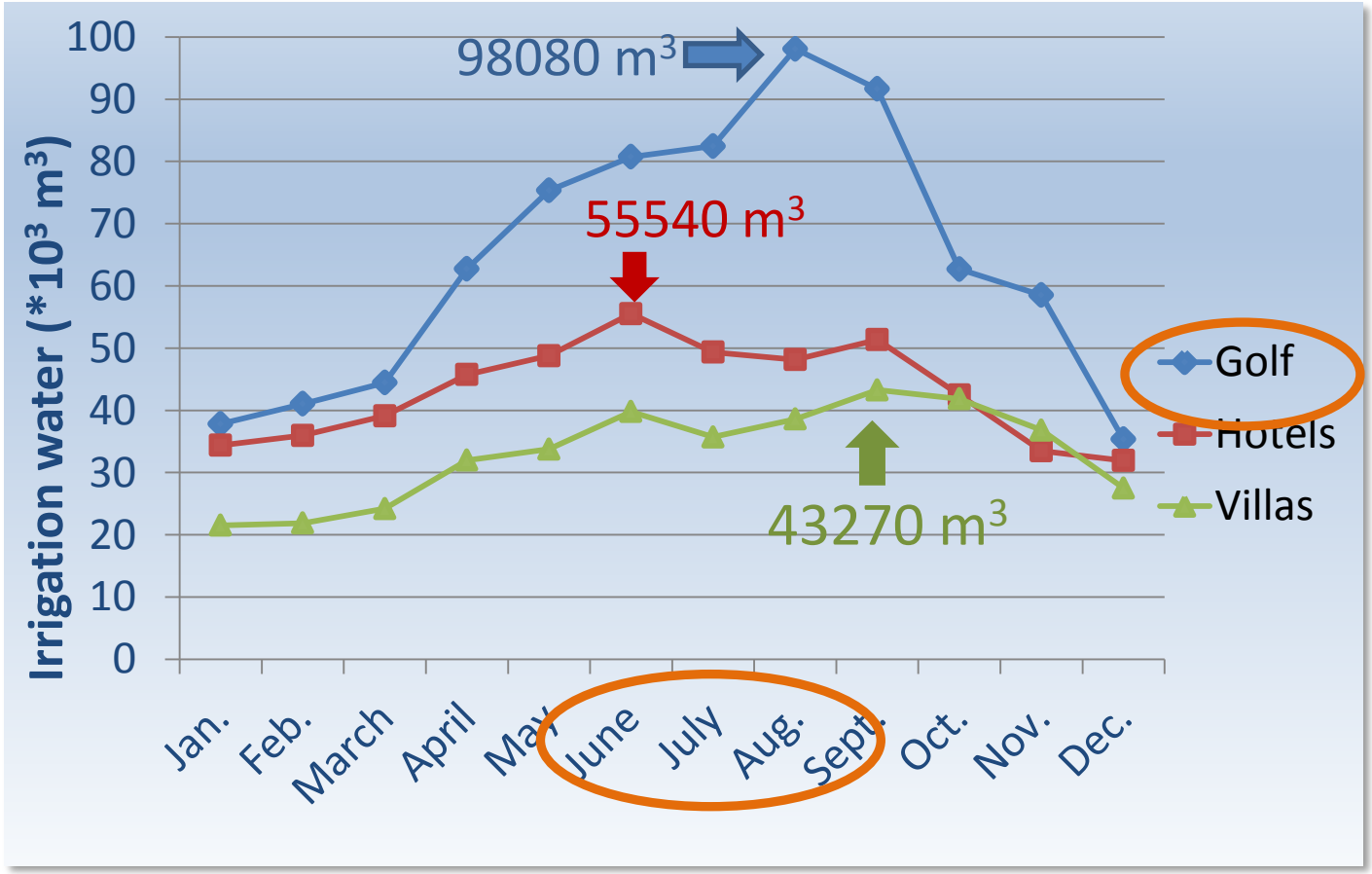
➢ Selling price: **5 EGP or 0.58 € / m³**

➢ Irrigation water used in downtown, December 2013: **64000 m³**

Irrigation in El Gouna

❑ Irrigation water consumption, year 2013

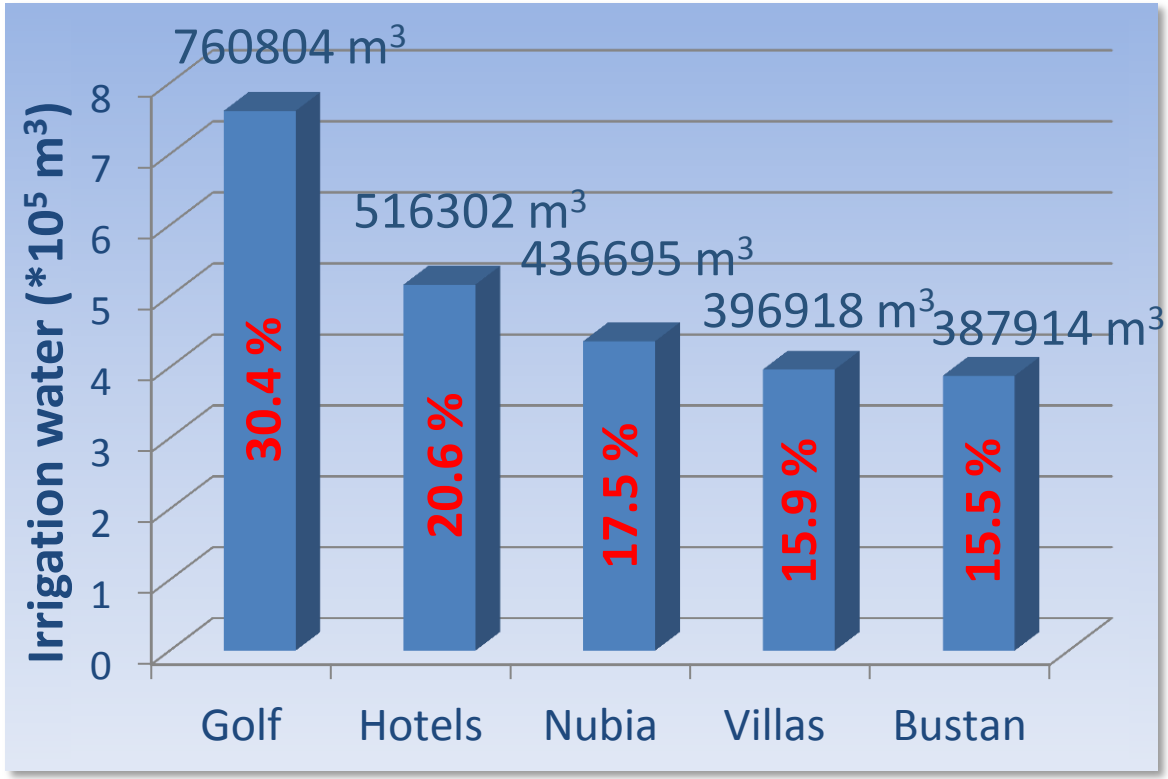
➢ Monthly variation according to the use



Irrigation in El Gouna

❑ Irrigation water consumption, year 2013

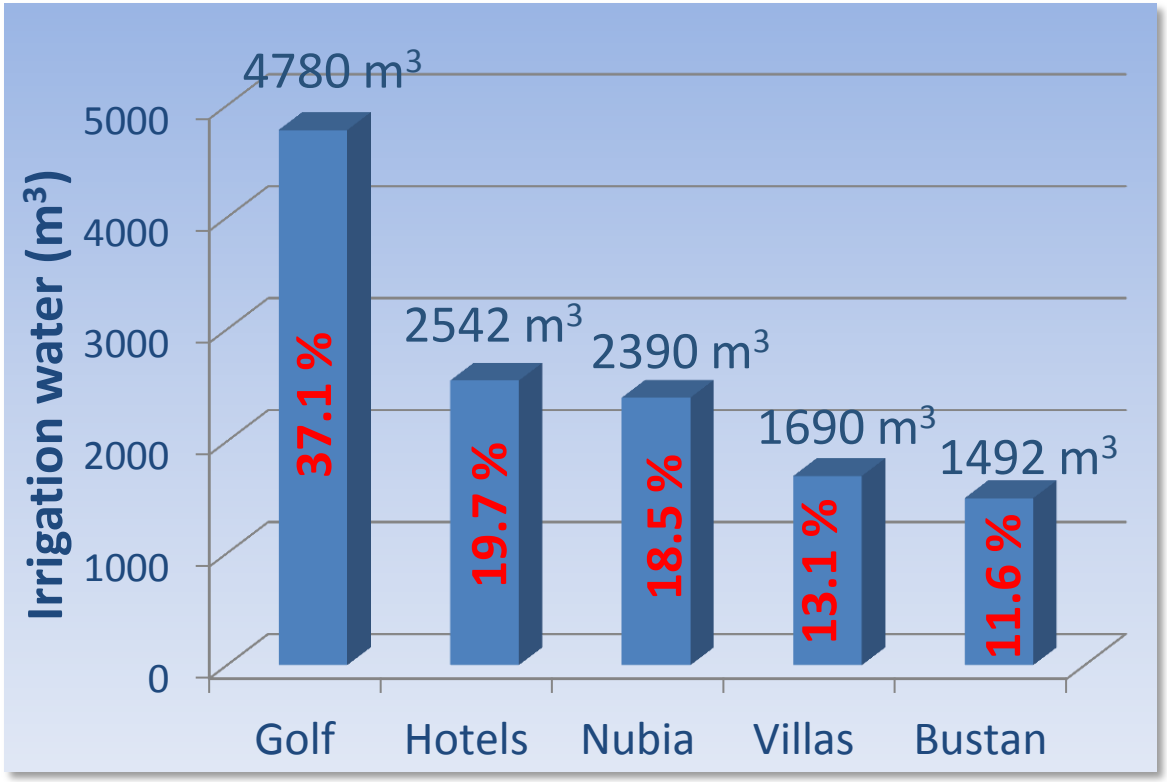
➢ Total consumption according to the use



Total	2.498.633 m³

Irrigation in El Gouna

- Irrigation water consumption, year 2013
  - Max daily according to the use



Total	12894 m³

Irrigation in El Gouna

❑ Irrigation water consumption, year 2013

➢ Consumption year 2013, average daily

Water use	Water amount (m^3/d)	% of total
Golf	**2102**	30.5
Hotels	1415	20.6
Nubia	1196	17.4
Villas	1088	15.8
Bustan	1084	15.7
Total	**6885**	**100**

✓ Total max. treated wastewater production: 4750 m^3

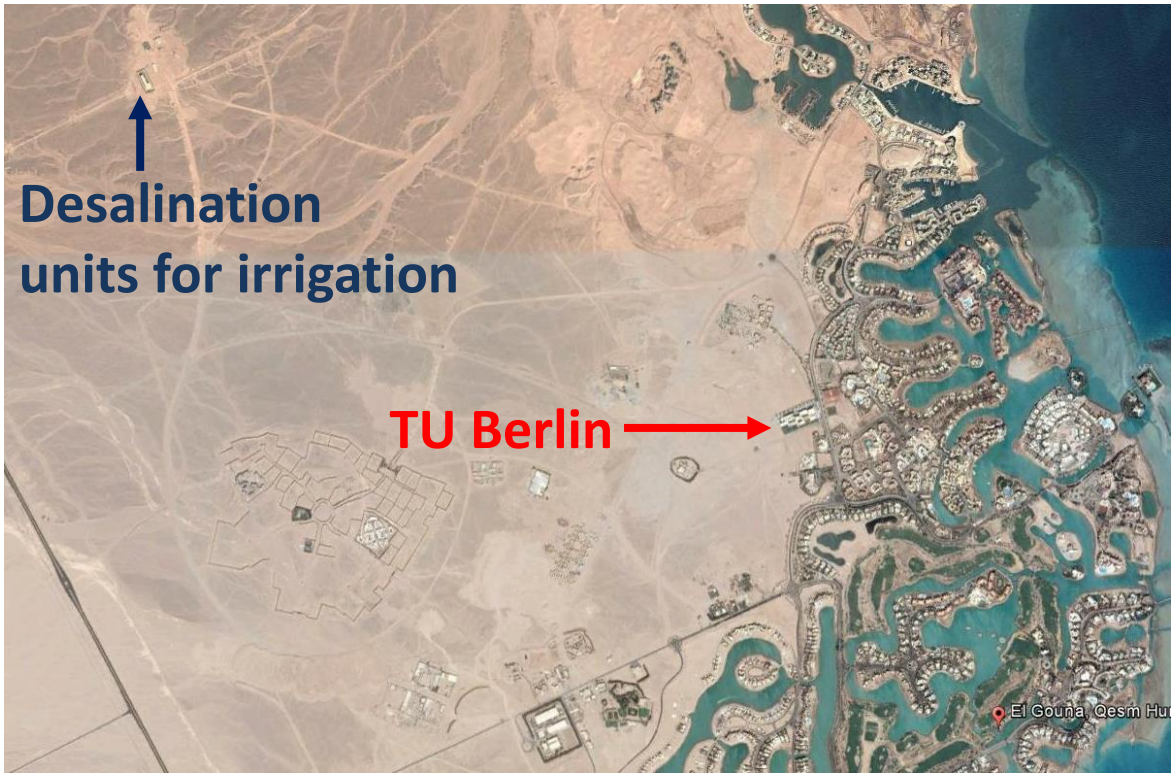
✓ **Desalinated water and wastewater from Hurghada are used to cover the additional needs**

Irrigation in El Gouna

❑ Irrigation water consumption

➢ Desalination for irrigation

- RO units producing water with lower quality than drinking water



Irrigation in El Gouna

❑ Irrigation water consumption

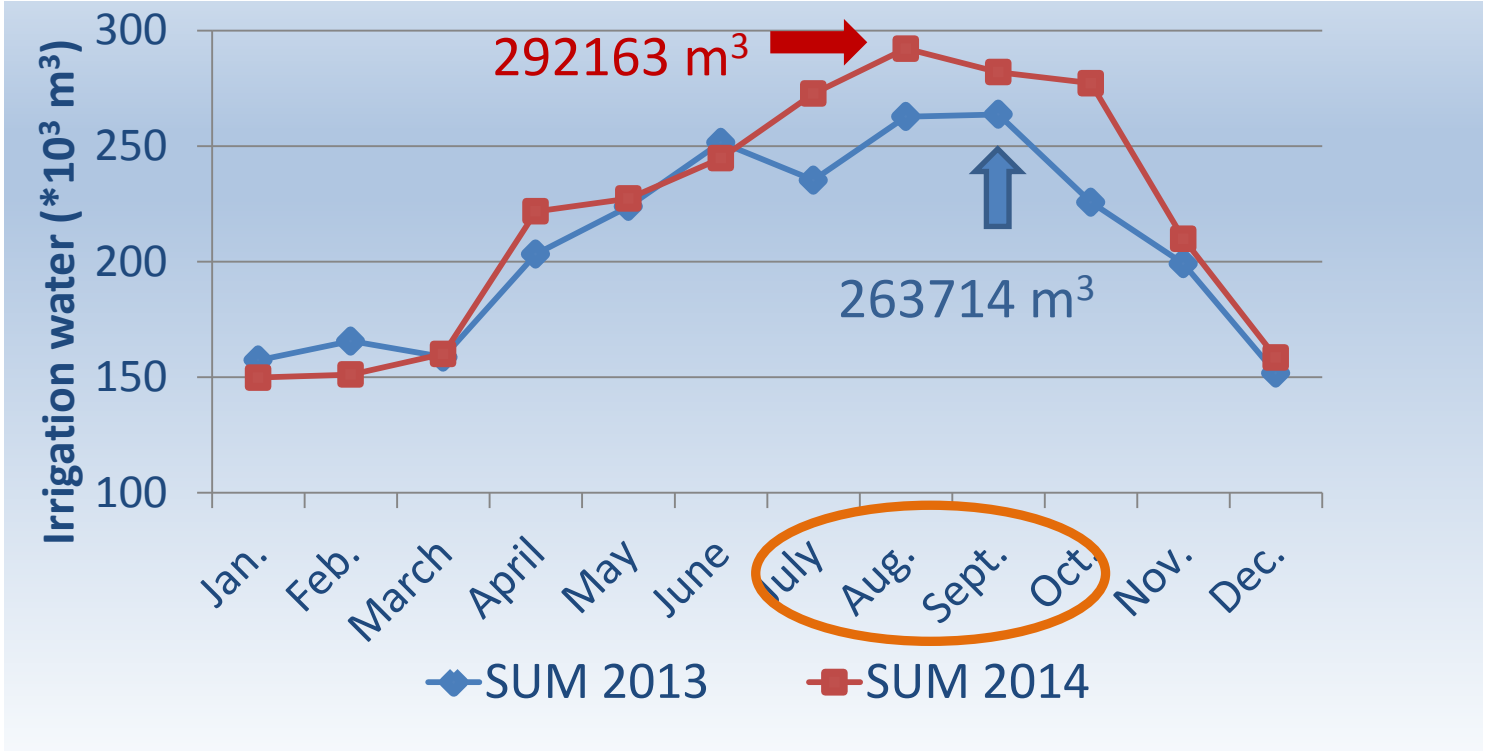
➢ Desalination for irrigation

- 2 RO units → Max. production: 1500 m^3/d (Lower quality than drinking water)
- 5 wells of brackish water → Depth: 42 – 53 m

Irrigation in El Gouna

❑ Irrigation water consumption, year 2014

➢ Total consumption, monthly variation

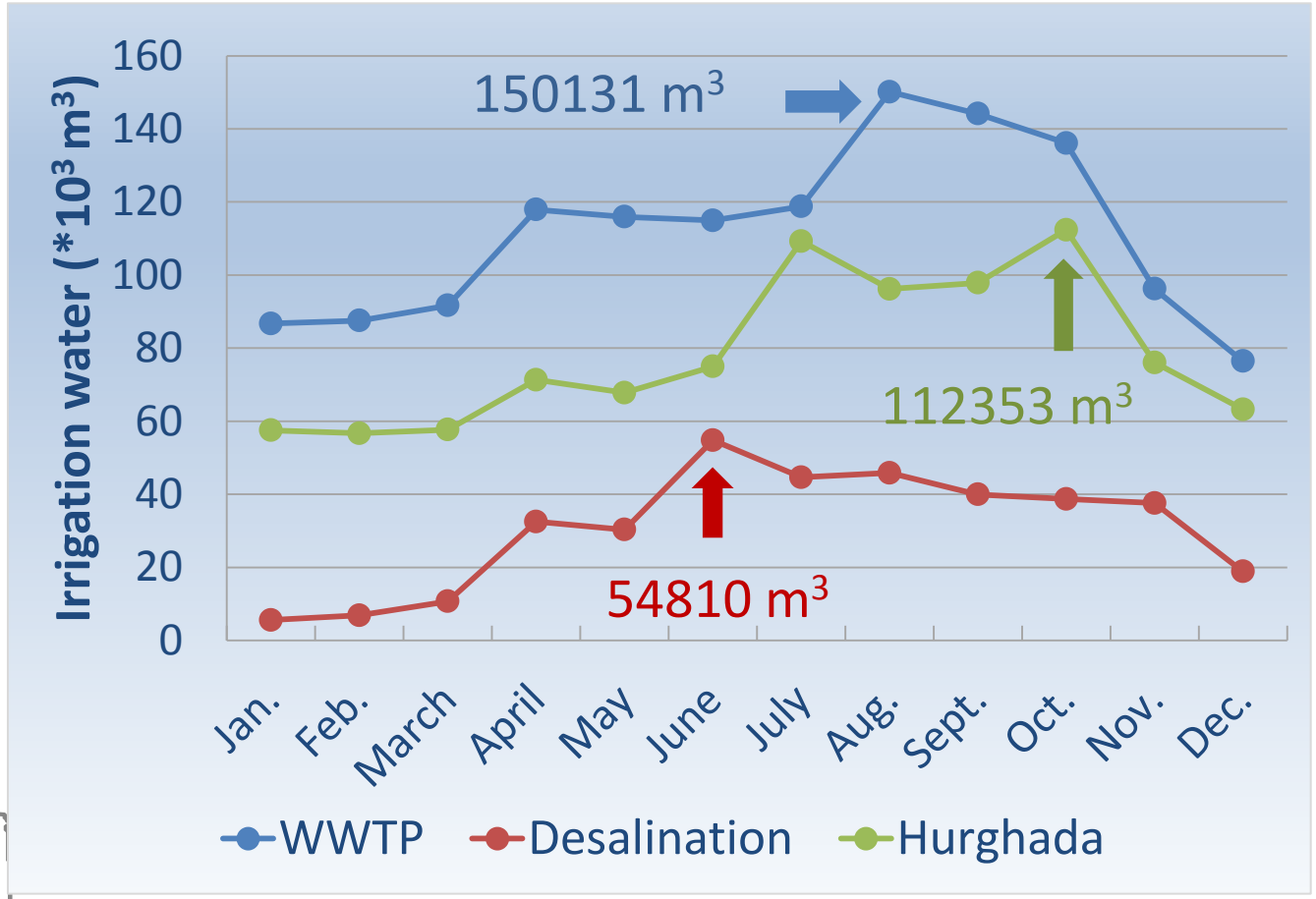


Total 2013	2498633 m³
Total 2014	2647284 m³

5.9 %

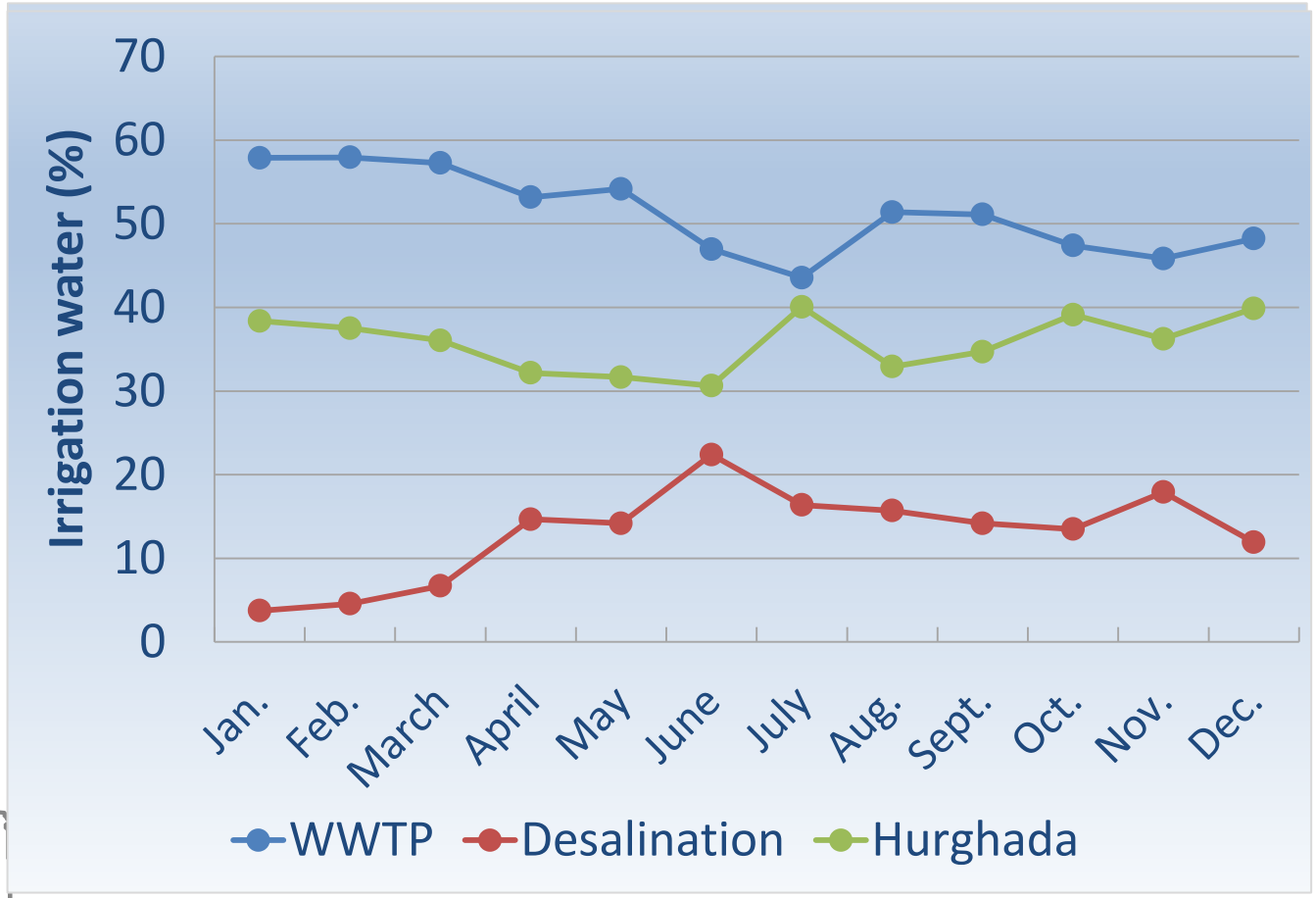
Irrigation in El Gouna

- Irrigation water consumption, year 2014
  - Consumption according to the water source



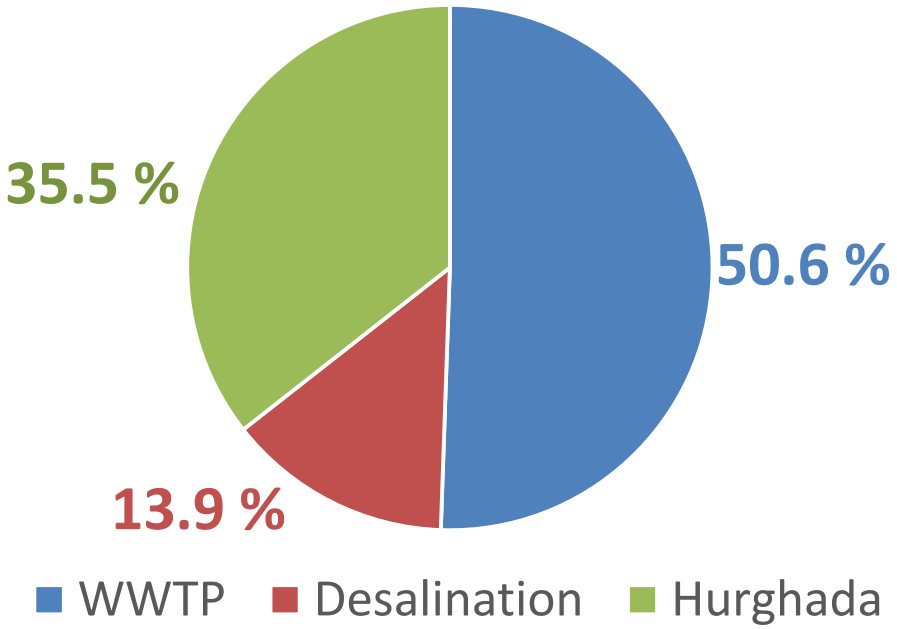
Irrigation in El Gouna

- Irrigation water consumption, year 2014
  - Consumption according to the water source (%)



Irrigation in El Gouna

- Irrigation water consumption, year 2014
  - Consumption according to the water source (%)



Waste water management in El Gouna

➢ Challenge

- Water demand increases (mainly for irrigation purposes)
- Another desalination plant is planned to be constructed to cover the additional needs (production ca. 5-10000 m^3/d)

Issues

- Water source (brackish or seawater)?
- Where to construct?
- Quality of produced water?
- Desalination method?
- Brine water management?

Energy

Costs

Environment

Considerations

- More efficient irrigation
  - Irrigation technique (applied: sprinkler, drip)
  - Time of irrigation
- Wastewater quality
  - Irrigation water – bad smell.
  - Inefficient fats/grease removal
  - Significant variation of WWTP's performance.
  - Undesired components at the product water (e.g. ammonia, nitrites!)
  - Cases with outlet parameters exceeding legislation limits for irrigation

Considerations

- Wastewater quality
  - ✓ Improvement of wastewater treatment
  - ✓ Performance monitoring - modifications and/or upgrading if necessary

- Relevant project
  - Performance monitoring / response to seasonal variation of visitors' number
  - Improvement of fats/grease removal
  - Investigation of aeration conditions - optimization
  - Optimization of nitrification process
  - Improvement of overall treatment performance

Finalized

Considerations

❑ Nitrification

Parameter	Inlet	Outlet	Limits for irrigation
NH_4-N (mg/L)	31.2-65.4 (av. 42.6)	1.5 – 18.6 (av. 8)	**5**
NO_3-N (mg/L)	0.6 – 4.1 (av. 1.3)	5.6 – 26.8 (av. 15)	**10**
NO_2-N (mg/L)		0.2 – 5.5 (av. 1.5)	

❖ Responsible: Low DO (< 0.5 mg/L)

- Oxygen requirement: 4.57 g O_2/ g N oxidized
- Minimum requirement: DO of 1 mg/L

$$NH_4^+ + 1.5\ O_2 \rightarrow NO_2^- + 2H^+ + H_2O$$
$$NO_2^- + 0.5\ O_2 \rightarrow NO_3^-$$
$$NH_4^+ + 2\ O_2 \rightarrow NO_3^- + 2H^+ + H_2O$$

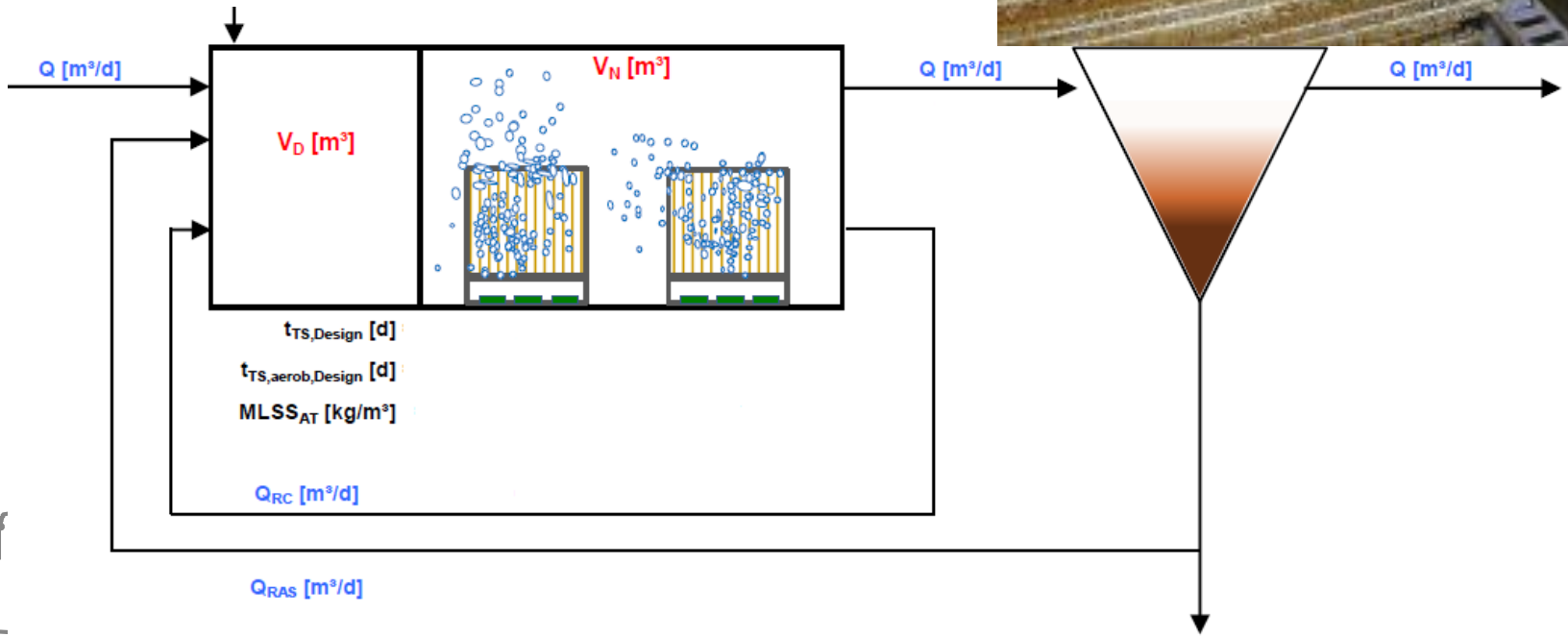
⇨ Increase of DO: > 1 mg/L ⇨ pH ↓ ⇨ **Buffer capacity?**

LOW!

Considerations

- New project

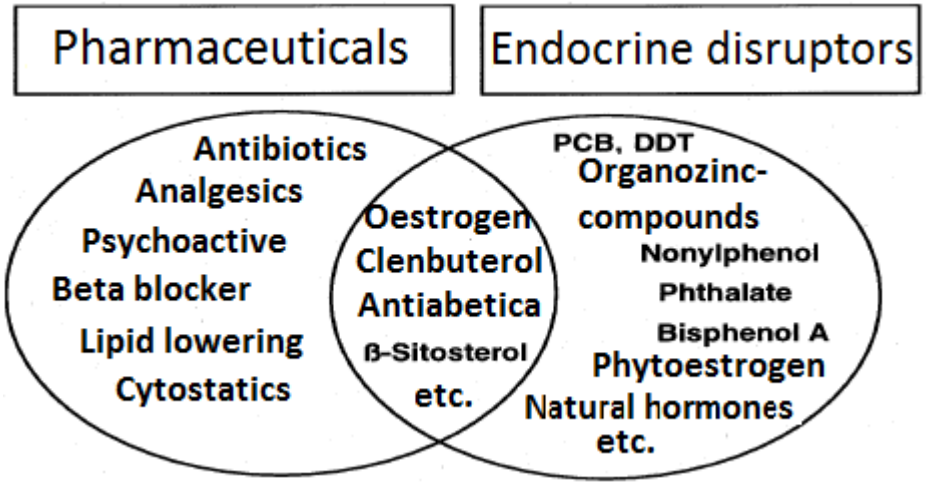
- Alternative biofilm carrier material
  - 69% Polyvinylidenchlorid filament
    31% Polypropylen filament
  - Weight: approx. 11 g/m



Considerations

- Wastewater quality (challenge)
  - Considerable number of residents
  - Hospital

} Hazardous substances may end up in the wastewater (micropollutants)



- ✓ Investigation is needed and, if necessary, modification/upgrading of the treatment procedure

Thank you for

your attention!