Texas Desal 2017

DEVELOPING A DROUGHT-PROOF WATER SUPPLY

FLUENCE - PLATINUM SPONSOR

Sept. 21 & 22

Hyatt Regency Austin TX

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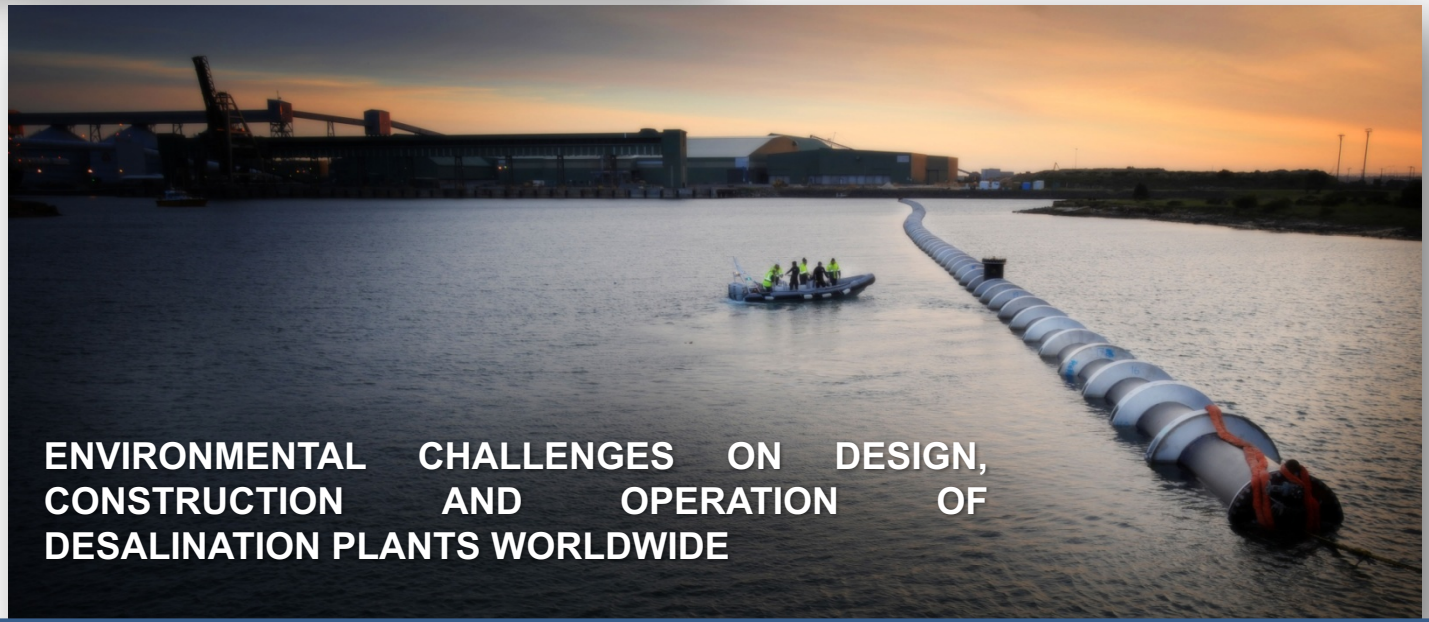

ENVIRONMENTAL CHALLENGES ON DESIGN, CONSTRUCTION AND OPERATION OF DESALINATION PLANTS WORLDWIDE

Presentation outline

Introduction
Desalination brines
Brine management strategies
Seawater brines
Brackish water brines
Brine concentration
Emerging technologies
Case studies (design and construction)
Case studies (monitoring)
Recommendations
Conclusions

Presentation will be focused on RO plants, being the most used technology

Introduction

Desalination - one of the world's most important non-conventional water resources

Together with the great benefits of desalination - opportunities for research and improvement, in reduction of energy consumption and environmental impact.

Main environmental concern: the management and solution to the concentrate or reject coming from the system (brines)

Brines are water streams concentrated in the salts extracted from the system

-different properties depending on:

- technology used
- origin and physical-chemical characteristics of raw water
- plant recovery

Brines

Concentrate or reject – salts extracted from the system
Discharge: also includes effluents (chemical cleaning of membranes, pretreatment, backwash, antiscalants and other chemicals, etc.)
Seawater is similar worlwide / Brackish: different casuistry and variability

Typical recovery for seawater is 40-45% --- Brine is concentrated aprox. x 2
Typical revovery for brackish water is 65-75% --- Brine is concentrated aprox. x 4

Plant	Aguilas (Spain)	SSDP (Australia)	Mantoverde (Chile)	Abrera (Spain)	Cuevas Almanzora (Spain)	University of Alicante (Spain)
Type	SWRO	SWRO	SWRO	BW-EDR	BWRO	BWRO
TDS (mg/l)	70,488	63,000	68,967	9,579	34,885	13,830
pH	7.9	7.8	7.9	6.9	7.4	7.7

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Brine Management strategies

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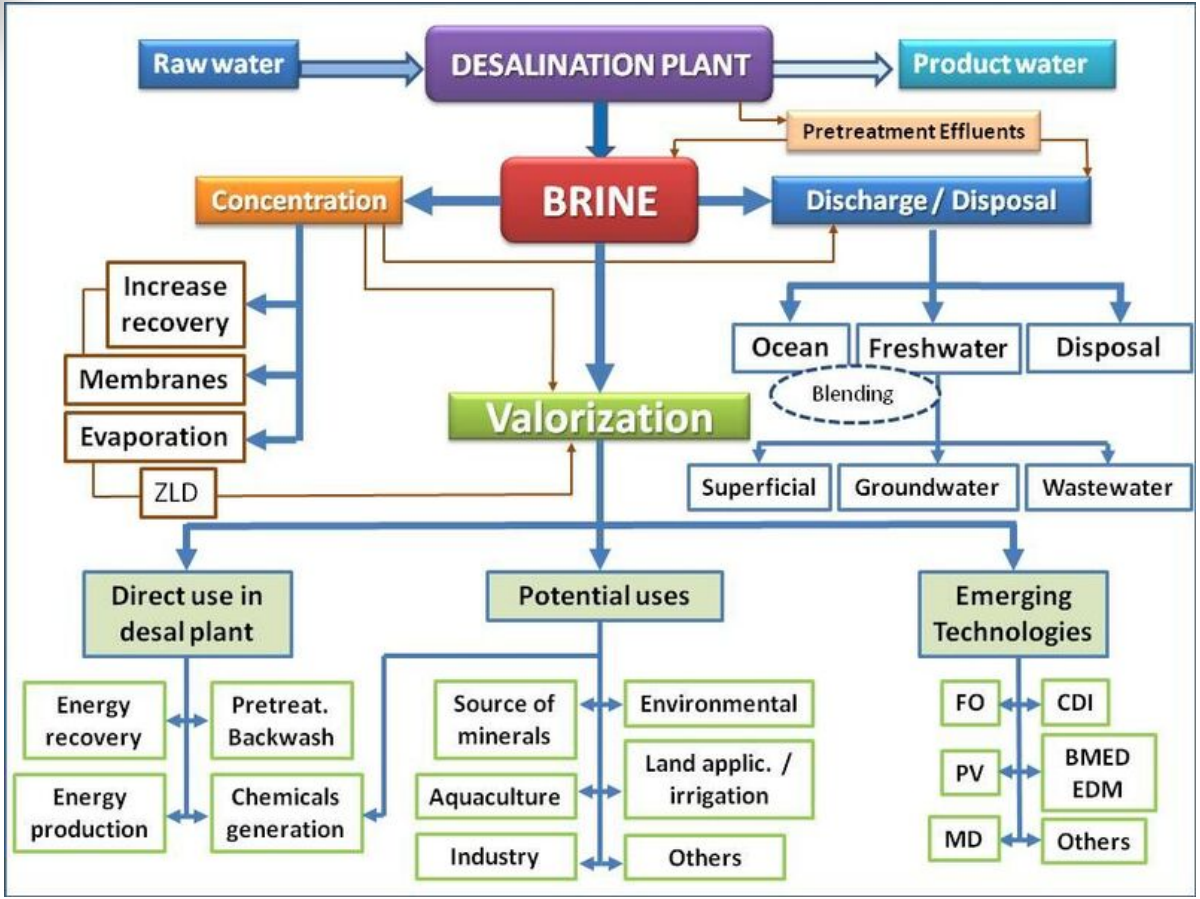


Seawater brines

Brine from seawater plants – concentrated seawater – impact concentrated in discharge point

Environmental impact affected by :
- discharge location
- marine species tolerance
- dilution and dilution devices

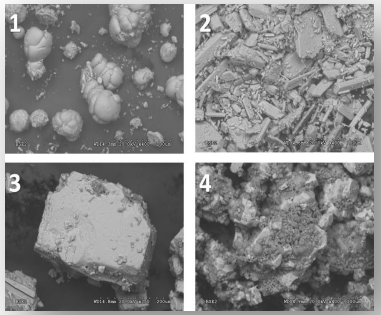
Characteristics:
- high salinity
- high density

Preventive actions:
- environmental impact studies (design stage)
- discharge point selection and discharge alternatives
- dilution design (mathematical models and scale simulations)
- previous dilution
- monitoring during operation stage and studies of impact over sensitive species

Brackish water brines

Brine from brackish water plants – can contain different salts (nitrates, sulphates), or toxic substances (arsenic, pesticides) complicating the management or even discharge to the sea

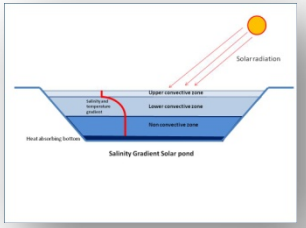
Options inland:
- discharges to sewer networks
- dilution
- deep well injection
- increase of recovery (concentration)
- evaporation – zero liquid discharge
- salt and chemicals recovery

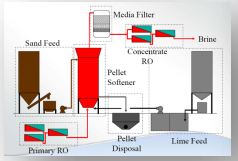


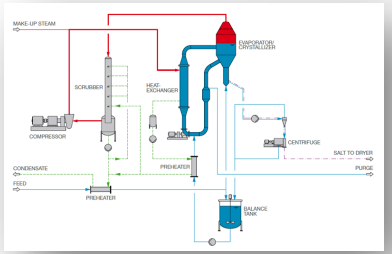
Brine concentration

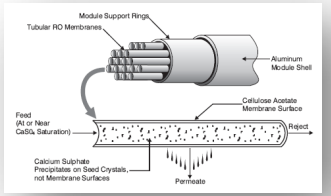
PROCESSES

- evaporation + crystallization (ZLD)
- evaporation ponds
- salinity gradient solar ponds
- 2 stages treatment with intermediate precipitation or biological reduction
- RO with previous or intermediate softening (HERO)
- EDR
- Dewvaporation (DW).
- Salt solidification and sequestration
- 2 stages nanofiltration
- Vibratory shear enhanced processing membrane system (VSEP).
- Advanced Solar dryer (ASD).
- Seeded slurry (SPARRO).
- Emerging technologies





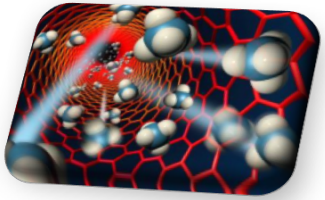


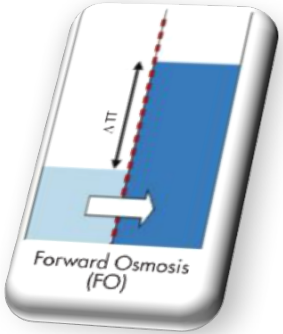


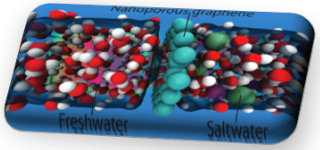
Emerging technologies

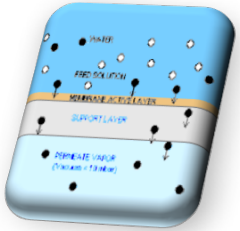
EMERGING TECHNOLOGIES

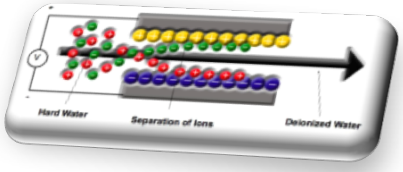
FORWARD OSMOSIS (PRO, etc)
PERVAPORATION
MEMBRANE DISTILLATION
CAPACITIVE DEIONIZATION
NANOPOROUS GRAPHENE
BIOMIMETIC MEMBRANES, AQUAPORINS
MICROBIAL FUEL-CELLS, BIOELECTROGENESYS
OTHERS (Ultrasounds, cavitation, etc.)

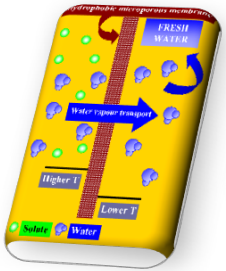




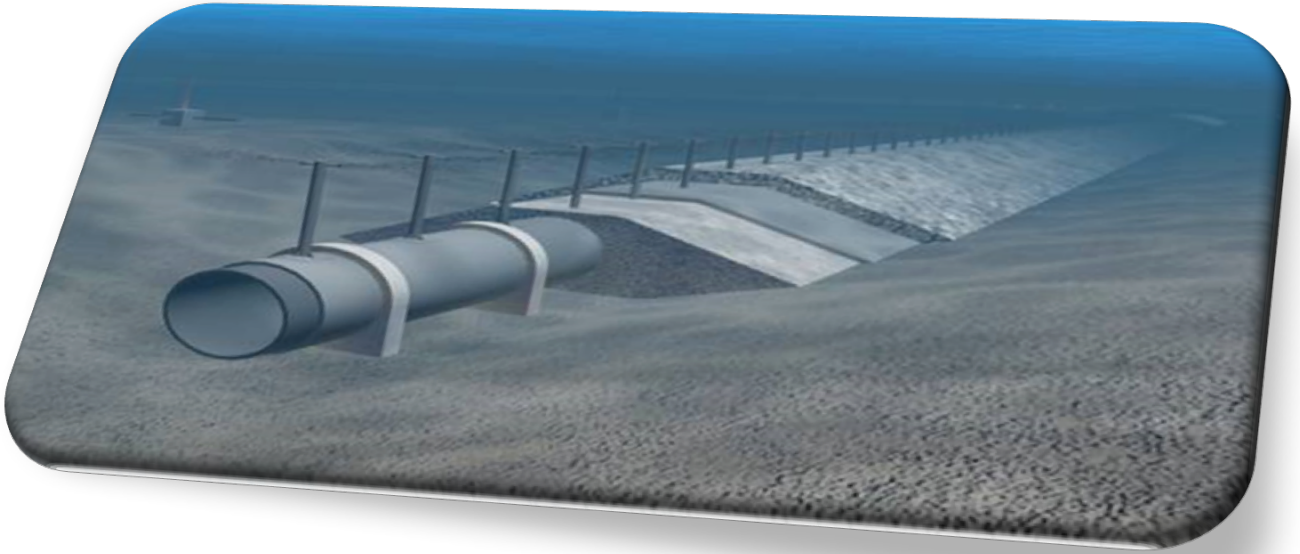








Case studies (design and construction)



Southern Seawater Desalination Plant (Australia – 306,000 m^3/day)

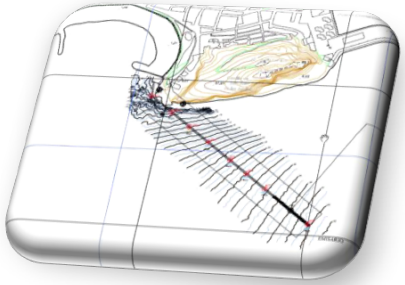
- **Production**: 306,000 m^3/day
- **Process Basics and distinctive characteristics:**
  - Intake-Pretreatment-RO-Potabilisation-Discharge
  - Plant capacity was doubled from 50Gl/y to 100Gl/y, 2013
  - Intake and discharge via microtunnel below dune system and beach (Alliance focus on sustainability and local community)
  - Ultrafiltration as pretreatment process step
  - Split/Hybrid RO membrane design
  - Sustainability focus drives low energy and chemical consumption

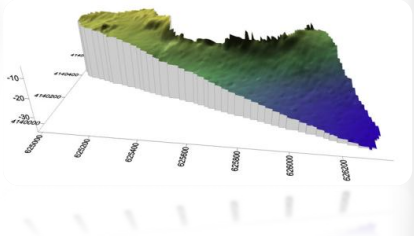
SWRO - Southern Seawater Desalination Plant (Australia) - Sustainability targets

- Sustainable source of energy (wind and solar farms)
- Control of marine environment
- Control of non autochtonous species
- Mammal observer during marine works
- Possum corridor (protected local species)
- Landscape and architecture integration
- Specific training for operators in handling of snakes and spiders
- Technology of non invasive marine works (micro-tunneling)
- No chemicals policy – UF backwash water discharged directly to the sea (brine)

SWRO Aguilas (Spain – 210,000 m3/day) -

- Plant was originally designed for 180,000 m^3/day (60 GL/year) capacity - further extension to 210,000 m^3/day (70 GL/year).





- Adopted measures
  - •Installation of 8 diffusers for brine diffusion, 310 mm diameter
  - •60 º angle of diffusers
- Results from modelization
  - • At the proximity of Posidonia Oceanica (protected algae specie), 500 m from diffusers, salinity is 38.5 psu
- This meets with environmental requirements

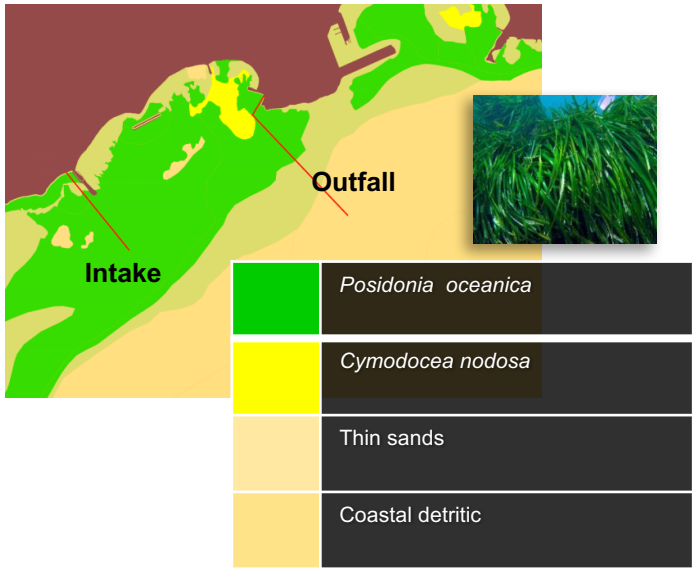
SWRO Aguilas (Spain)

Focusing on the marine environment:

Protected marine environment (Natura 2000 network): Special Areas of Conservation (SAC) "*Coastal Strip Submerged* of *the Region of Murcia*

Protected by Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora and by the Spanish Catalogue of Threatened Species Order 139/2011.

Location



Main impacts became from the actions:

- Dredging and digging the trenches of the pipelines.
- The construction of the dikes needed for dredging and digging

} Increase of turbidity and SS

Turbidity barriers

BWRO Cuevas de Almanzora (Spain) 30,000 m^3/day

- BWRO plant fed by 6 wells from an aquifer with marine intrusion
- Increasing salinity with time (6.000-18.000 μS/cm)
- Plant prepared to be transformed into a SWRO Plant
- It produces "a la carte" water for agriculture

BWRO Cuevas de Almanzora (Spain)

GROUNDWATER STUDIES AND ELECTRIC TOMOGRAPHY TO DETERMINE SEAWATER INTRUSION IN AQUIFER

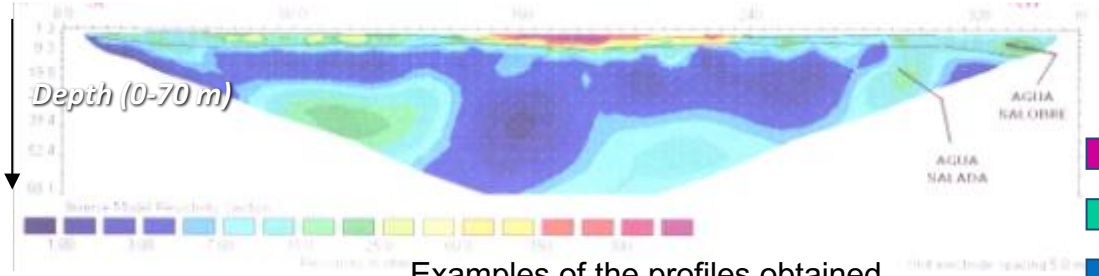
Studies:

- Infiltration and flows calculation (rainfall studies)
- Geologic and hydraulic environment
- Piezometric levels of groundwater, water quality and evolution with time
- List of water intakes
- Evaluation of resources
- Crops maps and water uses
- Pumping tests

These studies were completed with a campaign of geophysical exploration by mens of Electrical tomography (technology based in the analysis of electrical resistance of ground materials)

Those studies has allowed to determine;

- how to maintain salinity equilibrium in raw water
-most adequate area for well water intake and possible evolution
-most adequate area for future seawater intake if it's necessary
-- Posibility to injecting brine in the salty water area of aquifer (this solution was avoided finally with the construction of a brine pipe to the sea).



Examples of the profiles obtained

Water with low salinity

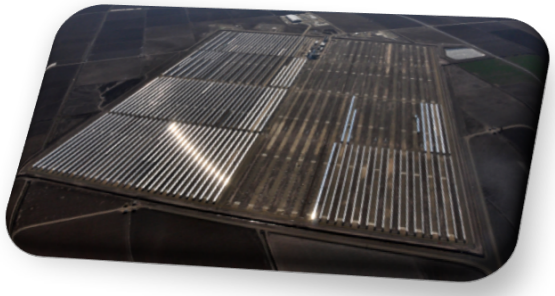
Brackish water

Salt water

BWRO Lebrija (Spain)

Solar-thermal plant in Lebrija (Seville), South of Spain

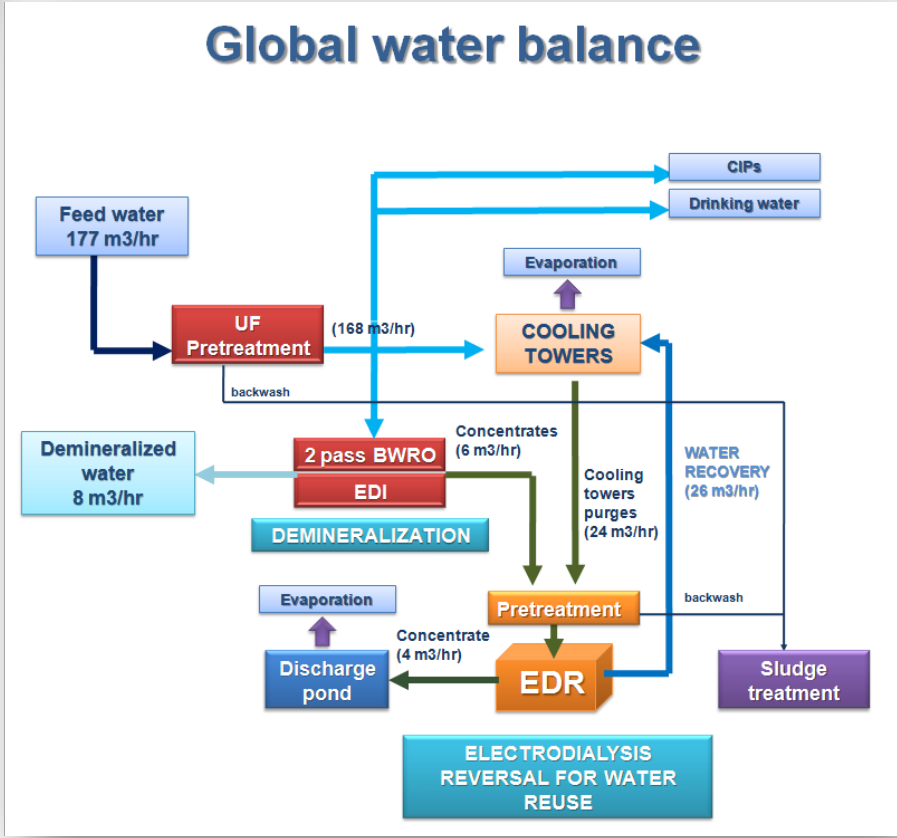
50 MW by cylinder parabolic technology (412,000 m² of mirrors)
Startup in January 2013 different water needs for
steam turbines and cooling towers



Environmental issues; close to a National Park (4 km)
with very high environmental protection level.

BWRO Lebrija (Spain)

Cooling tower purges and RO brines are concentrated by EDR getting an almost - ZLD



With the proposed solution working at high recovery (85-87%), an increase by 15% of available water and reducing the final discharge to less than 2.3% of the feed water flow has been reached, with an specific energy consumption of 2.95 Kw-hr/m^3.

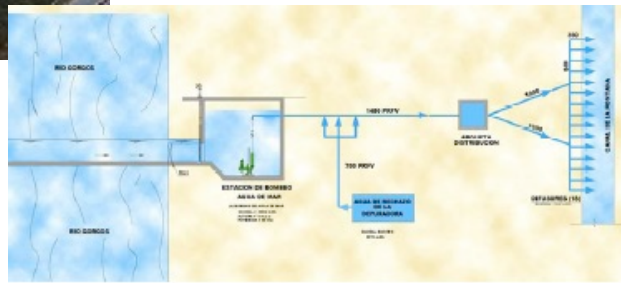
Case studies (monitoring)

SWRO Plant Javea (Spain)

Location of discharge in a channel

Figure 6: La Fontana Channel

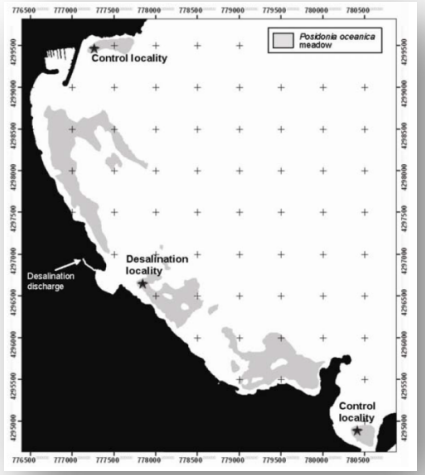
Diffusers



Previous dilution

SWRO Plant Javea (Spain)
Monitoring results 2002-2016

- Discharge modification (channel) has got environmental impact reduction
- In peak period (summer, 2-4 trains in operation), discharge plume is not detectable at more than 300 m from the channel. In winter (1 train in operation) complete dilution is produced a few meters away from the channel
- Discharge on the Fontana channel has avoided problems of anoxia and bad odors and it is enabling the recovery of fauna inside the channel
- Significant effects over marine sensible species (echinoderms), with high environmental value (Posidonia Oceanica), artisanal fisheries or soft-bottom fauna have not been detected
- It seems the only detectable effect is the attraction over some fish species



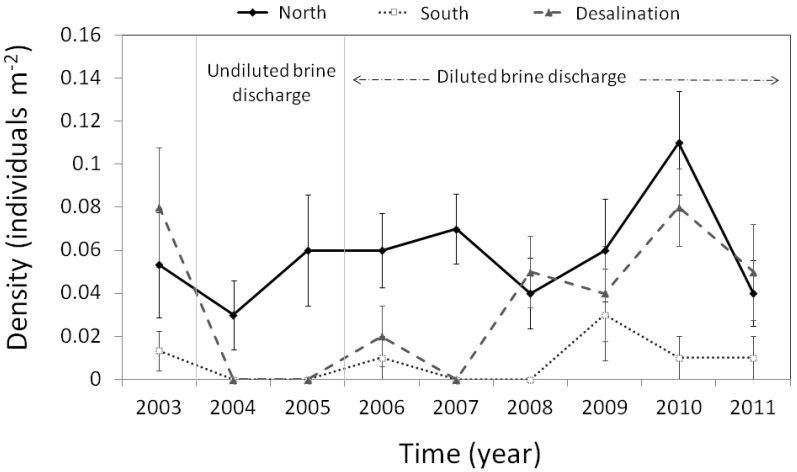
SWRO plants Alicante I and II (Spain)

- 2 SWRO plants close to the city of Alicante, Mediterranean SE Spain

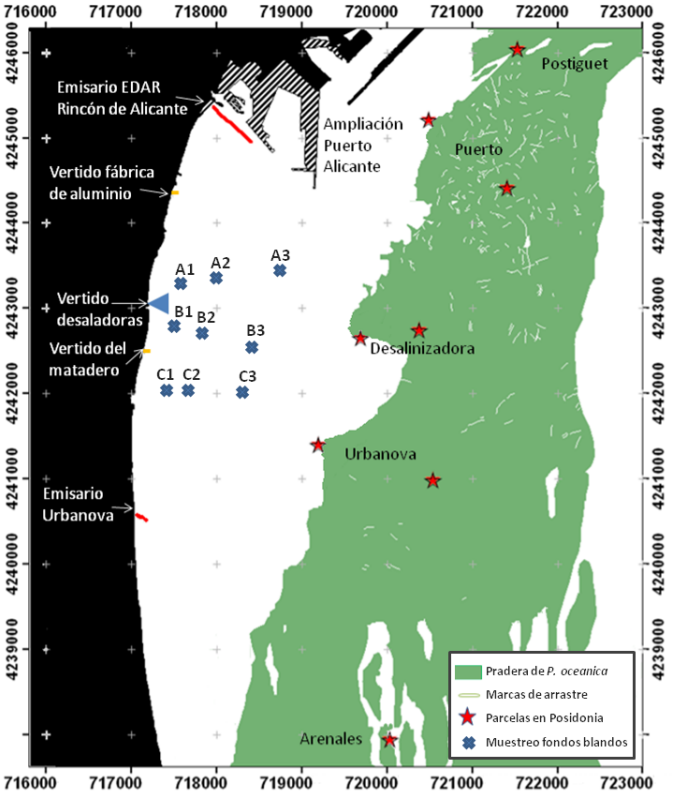
- Selection of location in a previously degraded point, with Posidonia meadows in decline 2 km away. Discharge on the coast
- The plant was modified with time:
  - 2003 - 50,000 m^3/day
  - 2006 - extension 65,000 m^3/day, including previous dilution of brine
  - 2008 - Alicante II plant (total both plants 150,000 m^3/day)
  - Management of brine adapted to the new changes and environmental requirements

SWRO Alicante (Spain)

Echinoderm (indicators) population recovery after brine dilution started. Posidonia meadows not affected by the discharge (14 years of sampling)

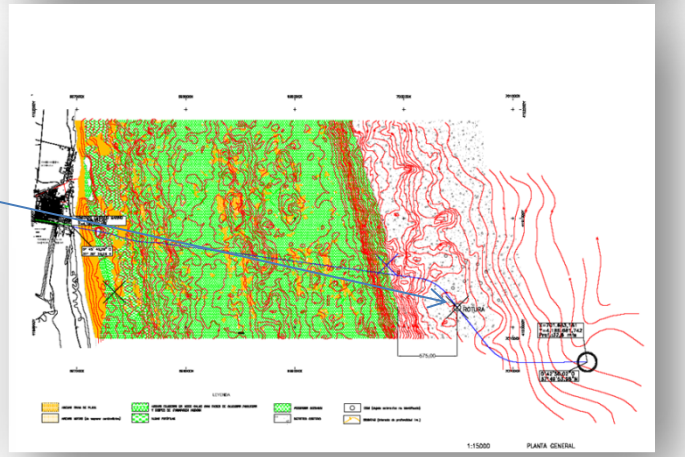


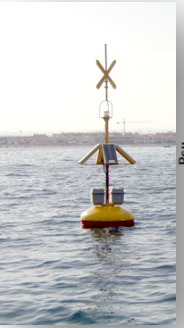
Monitoring has allowed to detect other environmental impacts (port extension, anchorage of large ships, and illegal trawl fishing

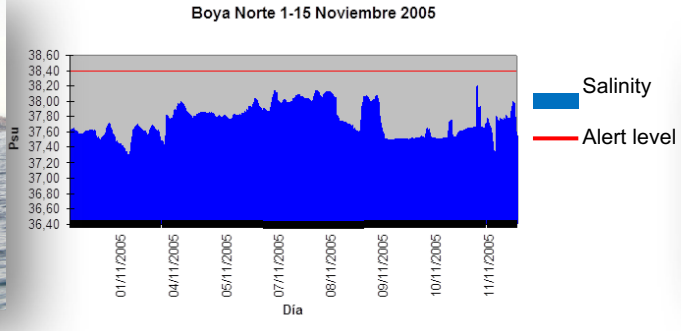


SWRO plants San Pedro del Pinatar (Spain)

- Plant built in 2 stages
- Location with high environmental quality and multiple forms of protection
- Discharge by submarine pipeline 5 Km long
- Approved provisionally discharge with dilution with very strict Monitoring plan (May-December 2005)
- Since 2006 discharge to the pipeline
- Pipeline was broken and repaired



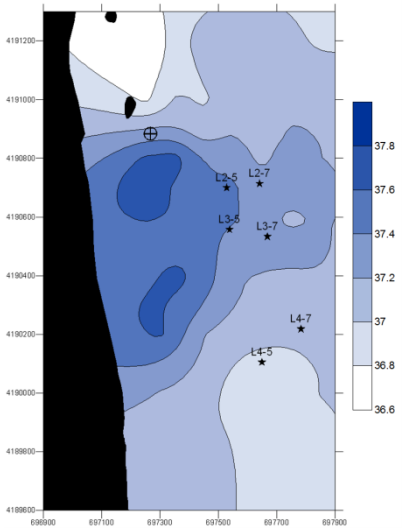




SWRO plants San Pedro del Pinatar (Spain)

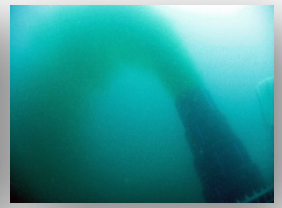
Provisional discharge

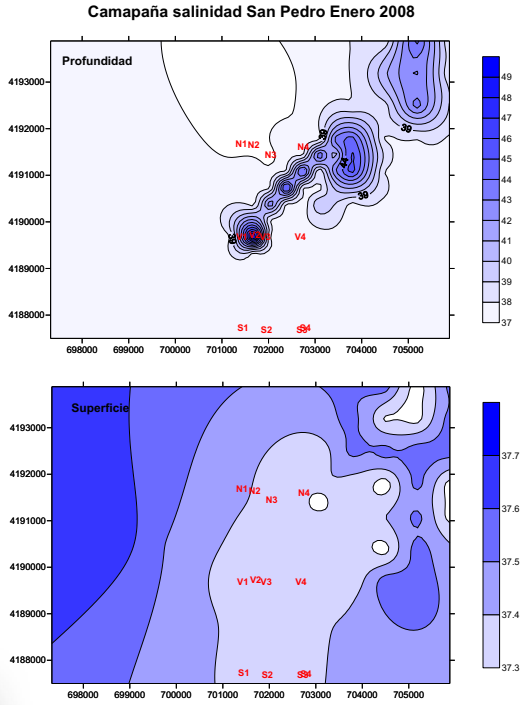
- Very restrictive limits
- Operation 1/3 capacity
- Environmental impact not detected



Definitive discharge

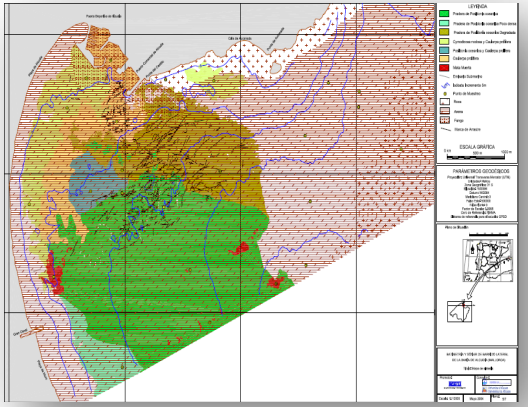
- Large influence but without impacts on key species
- Effects of wastewater discharges and aquiculture detected
- Detection of pipeline broken and repaired
- Installation of a new special piece at the end of the pipeline to reduce impacts
- Recovery of impacts





Recommendations for SWRO plants

Design:
Environmental impact studies
Marines studies
Discharge site selection
Modelization of discharge
Design of dilution and discharge



Follow up and monitoring of O&M:
Characterization of brine
Brine behavior
Follow up of sensible species
Follow up of environmental high-value species
Early detection of impacts

Monitoring plan:
- conductivity map (at different distances and depths)
- direct testing of affected species
- nutrients (P and N) control
- identification of different impacts which coincide in the same space

Recommendations for SWRO plants – Monitoring plans

Monitoring plan for brine discharges has to be adequate, balanced and specific:

- Sometimes designed environmental monitoring plans include parameters such as coliforms, eutrofization of sediments, etc. which don't make sense for desalination brines
- Sometimes limits are fixed without any scientific justification
- Avoid unnecessary and expensive descriptors (currents, daily or weekly reports)
- Avoid inadequate measure procedures (weekly calibration, poor sampling design)

Conclusions

-Along with the great benefits of desalination there is still room for research and improvement in aspects such as environmental impact or energy consumption reduction

-Discharge of brine to the sea has no significant impact over marine species if it is designed correctly, with previous environmental impact studies and monitoring plans during O&M stage

-Brines from brackish water treatment plants represent a problem without an universal solution, economically and technically feasible

-Follow up and monitoring of discharges are vital for early detection of environmental impacts and to apply corrective actions

-The monitoring plans have to be designed specifically for brines and considering the local conditions

Thank you!