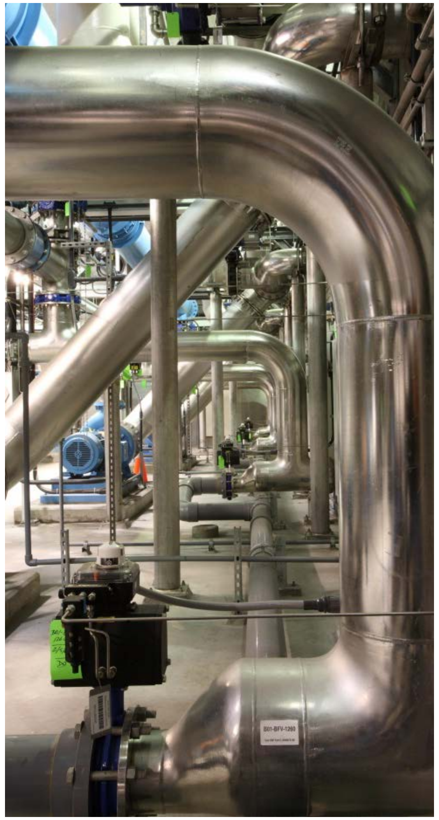
# Database of Permitting Practices for Seawater Concentrate Disposal



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WateReuse Webcast Series

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# A Few Notes Before We Get Started…

- Today's webcast will be 60 minutes.
- There is 1 (one) Professional Development Hour available.
- A PDF of today's presentation can be downloaded when you complete the survey at the conclusion of this webcast.
- Links to view the recording and to download the presentation will also be emailed later.
- If you have questions for the presenters, please send a message by typing it into the chat box located on the panel on the left side of your screen.
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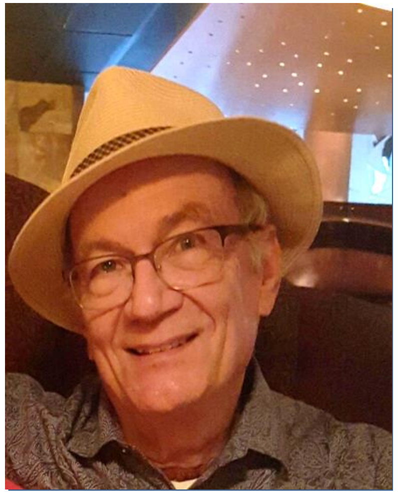
# Today's Presenters



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*Water Globe Consulting LLC*

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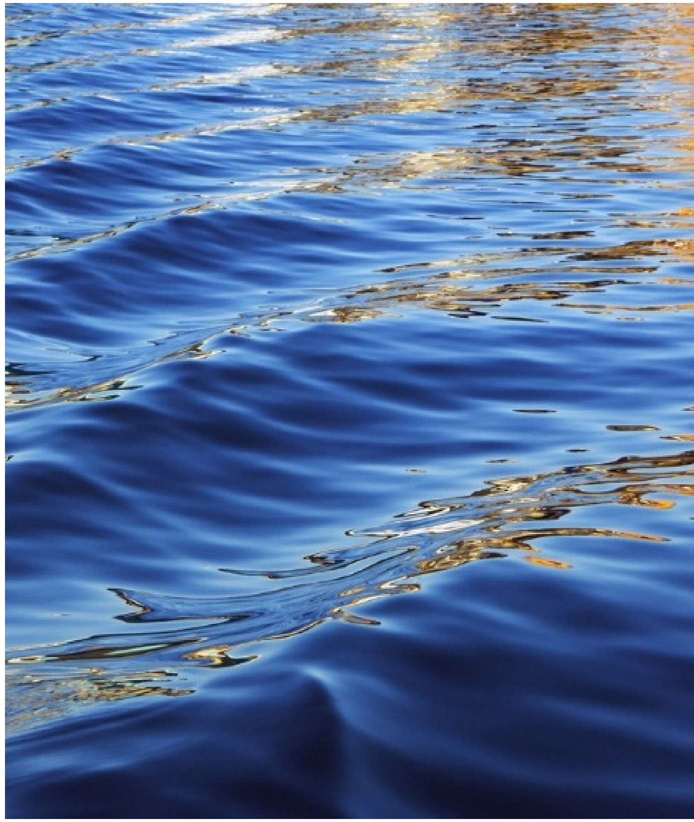
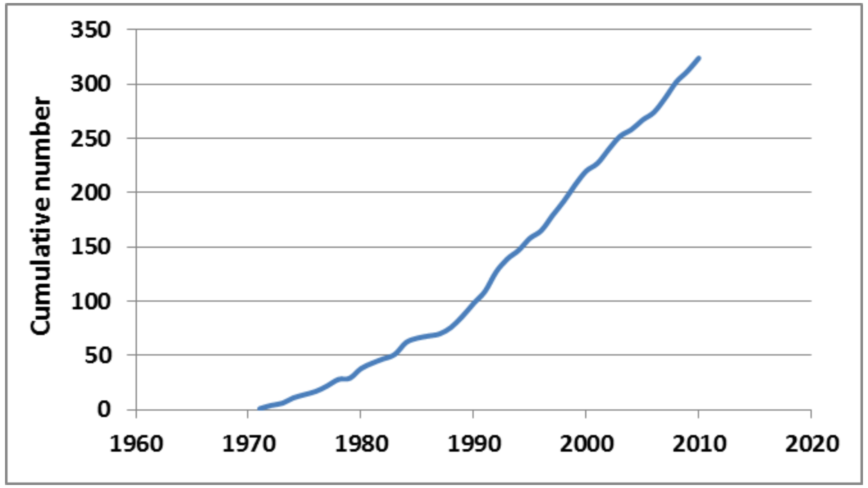
# INTRODUCTION & BACKGROUND



# Background – U.S. Municipal Desalination

- **Over 350 facilities**
- **< 4% are SWRO**
  - 1 large operating facility (Tampa Bay); Carlsbad is in construction; Huntington in final planning; others are small
- **Much interest in SWRO**
- **Primarily in California, Florida, and Texas**
- **Drivers for consideration of SWRO include:**
  - Prolonged drought in California
  - Growing coastal populations
  - Decreasing desalination costs
  - High quality product water

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# Background – U.S. SWRO

- **Three major limiting factors for developing SWRO in the U.S. have been:**
  - **Cost**
  - **Aquatic life impacts by the plant intake**
  - **Concentrate disposal**
- **U.S. regulatory issues and permitting protocols are in various stages of investigation, definition, and clarity that could benefit from broad consideration, study, and definition of appropriate guidelines.**
- PROJECT OBJECTIVE: "identify the discharge information that permitting agencies need and the decision-making process they go through to permit discharge methods in order to help desalination project proponents focus and expedite their permitting efforts"

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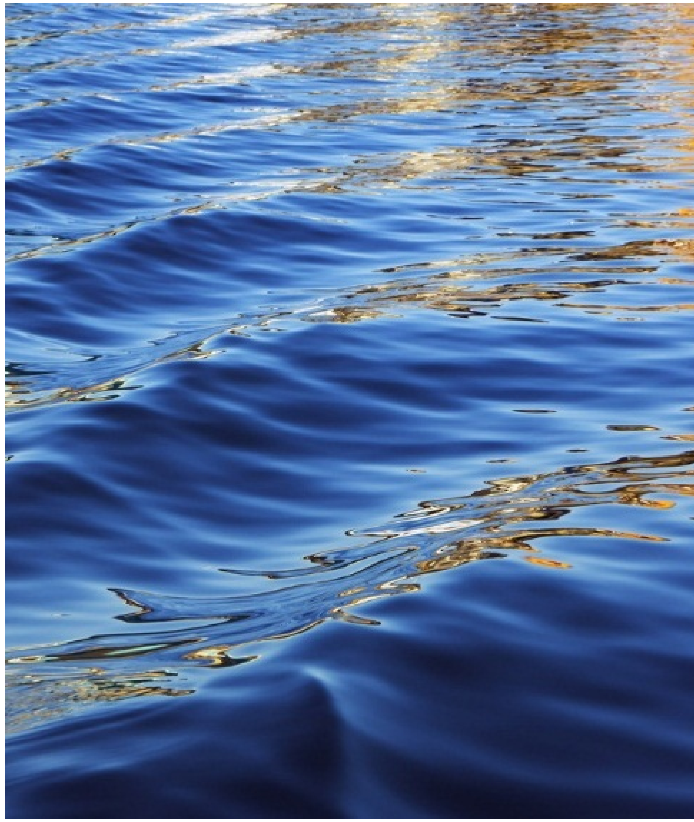
# Background – Areas of Focus

- **The project focuses on:**
  - **Seawater reverse osmosis (SWRO)**
  - **Medium and large plants**
  - **Discharge to the sea (**also disposal of other residuals**)**
  - **Regulations, permits, & decision making process involved**
  - **Permit:**
    - **National Pollutant Discharge Elimination System (NPDES) – in the U.S. and similar permits elsewhere**
  - **U.S. :**
    - **Federal framework**
    - **States:**
      - California
      - Florida
      - Texas
  - **International:**
    - **Australia**
    - **Israel**
    - **Spain**

# SWRO RESIDUALS



# Typical Residual Streams in SWRO Desalination Plants

Larger sidestreams:

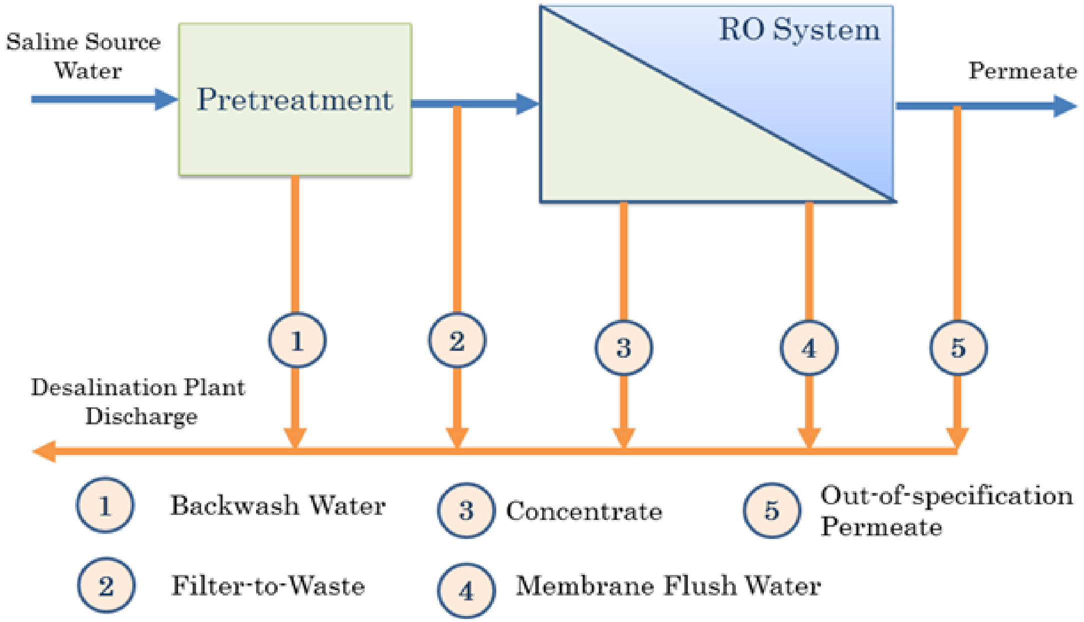
- Concentrate: (~90-95%)
- Backwash Water: (< 10%)

Smaller and intermittent sidestreams

- Membrane Flush Water (< 0.1%)
- Filter to Waste
- Out-of Spec Permeate

Large differences in:

- Frequency (continuous vs. intermittent)
- Relative volumes
- TDS
- Composition




**Concentrate TDS**
**~ 2X seawater TDS**

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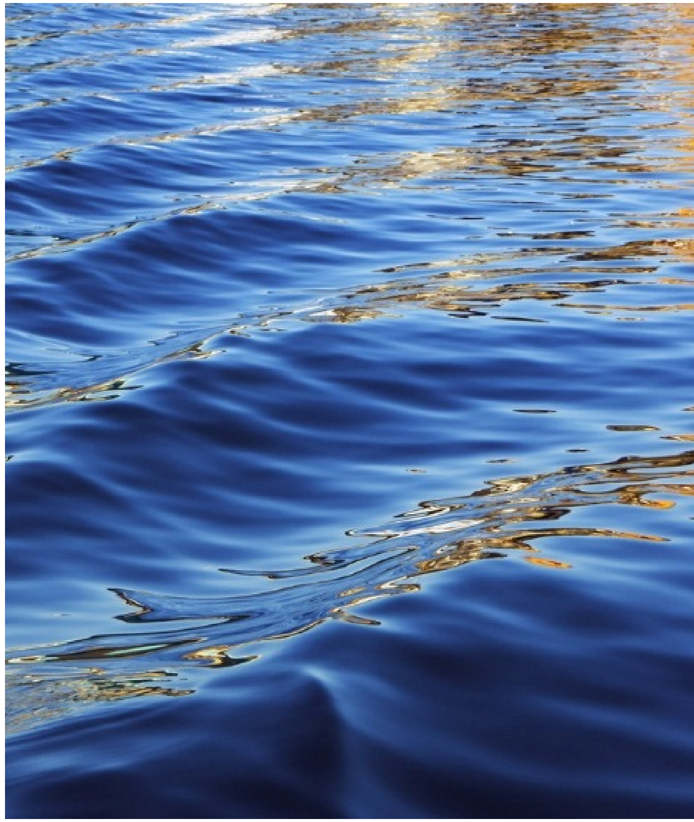
# DISCHARGE AND RESIDUAL MANAGEMENT OPTIONS



# Overview of Concentrate Disposal Alternatives

- Surface Water Discharge via New or Existing Outfalls
- Disposal to Sewer –
  - Typically Used for Brackish Water Plant Concentrate and Non-concentrate Waste Streams
- Subsurface Injection
  - Use of Shallow Coastal Exfiltration Galleries – Mainly Seawater Desalination Plant Concentrate
  - Deep Well Injection – Mainly for Brackish Desalination Plant Concentrate
- Evaporation Ponds
- Land Application
- Landfill Disposal

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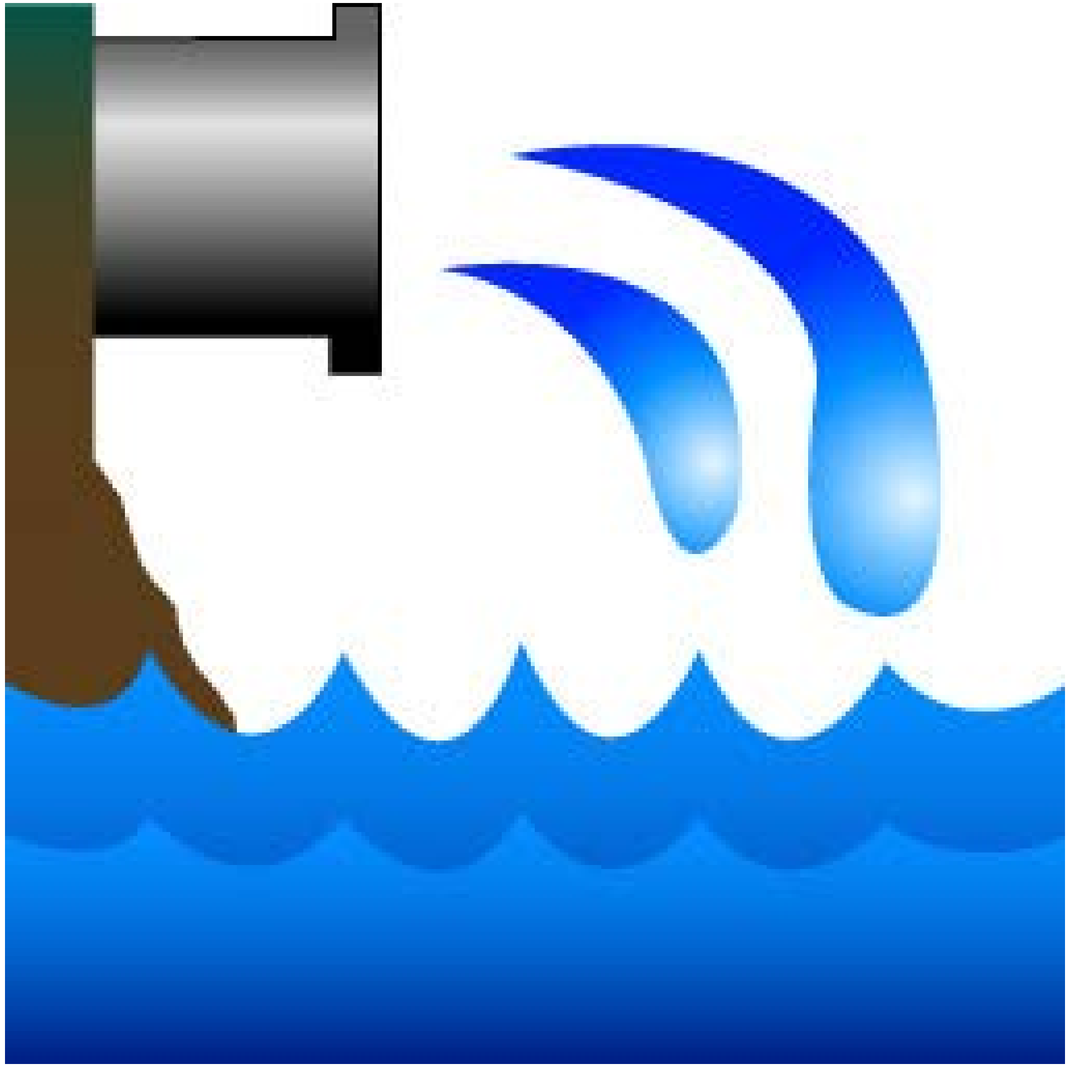
# Focus of This Study – Seawater Desalination Plant Concentrate Management

- Surface Water Discharge to the Ocean
- Medium and Large Desalination Plants
- Countries with Full-scale Project Experience and Advanced Regulatory Framework
  - USA
  - Australia
  - Spain
  - Israel

# Overview of the Types of Surface Outfall Discharges



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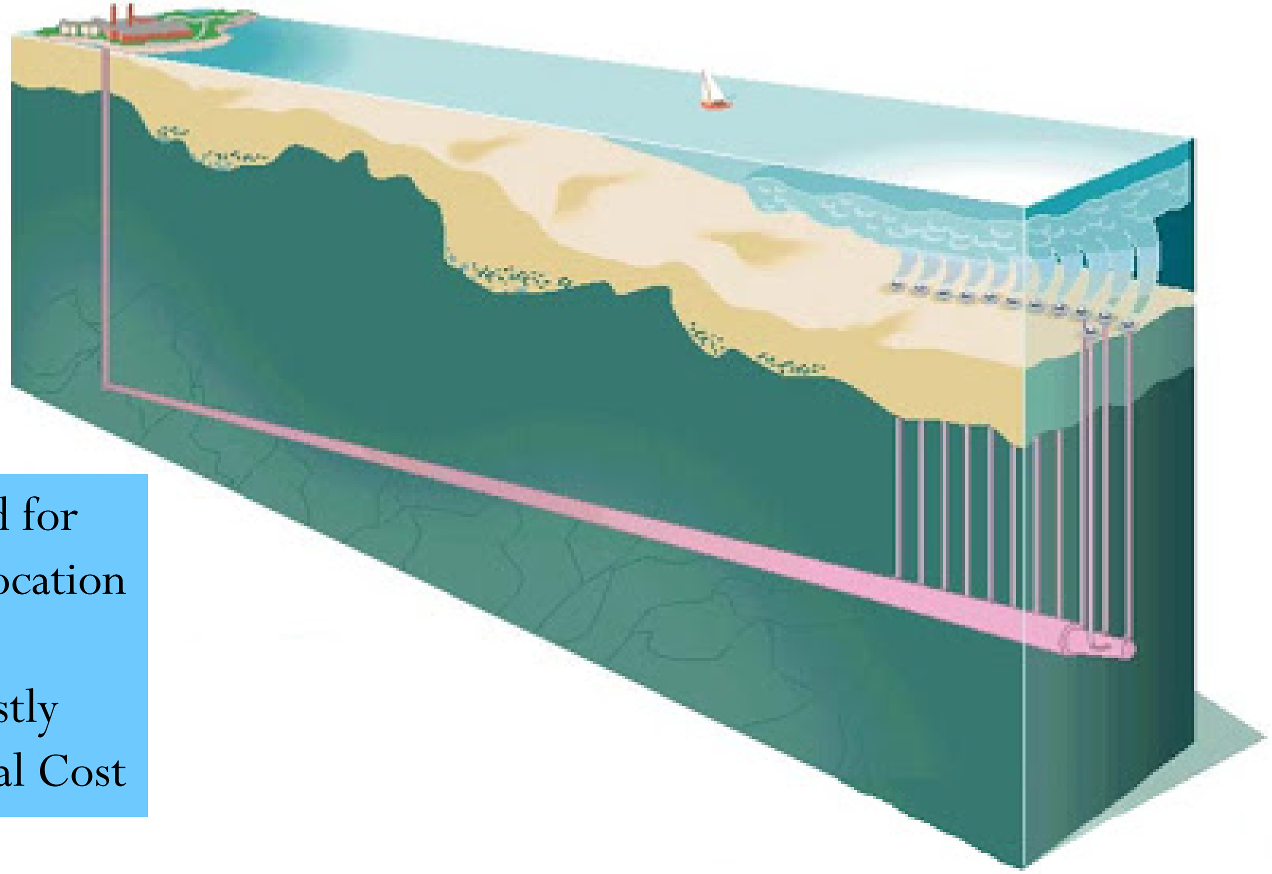
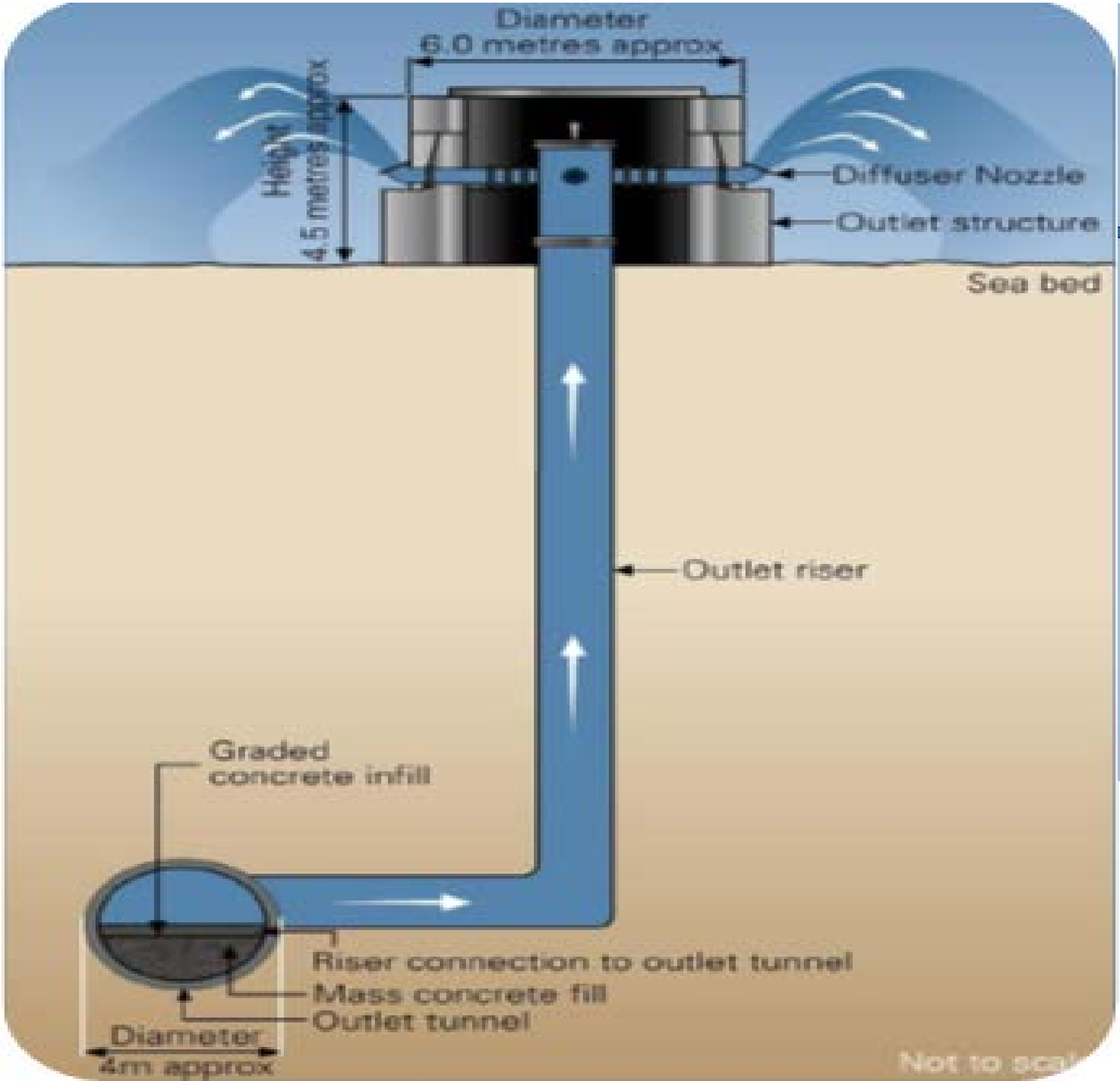
# New Offshore Discharge Outfall – Typical Configuration

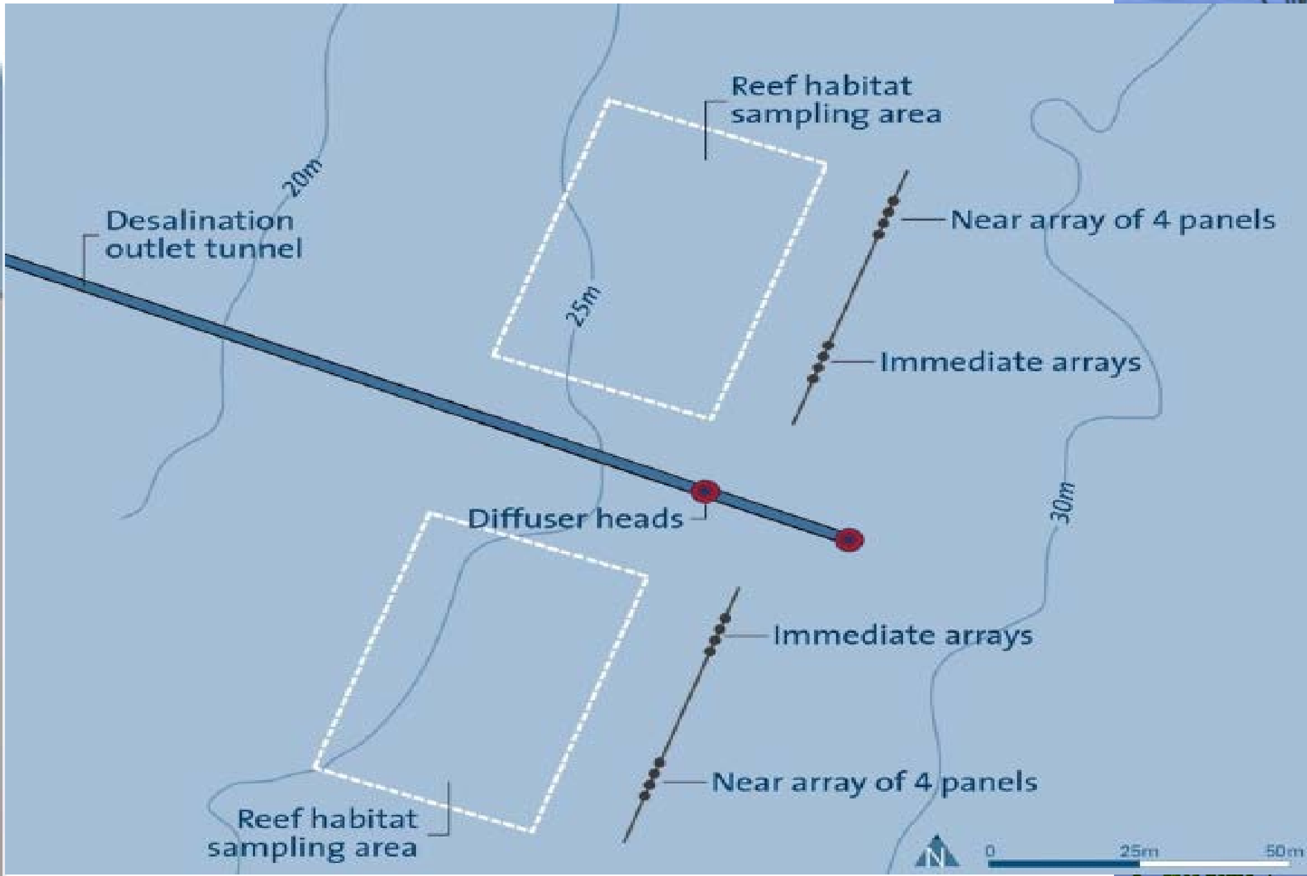


<u>Key Advantage</u> – Can be Used for Practically Any Size Plant and Location

<u>Key Disadvantage</u> – Very Costly (20 to 30% of Total Plant Capital Cost

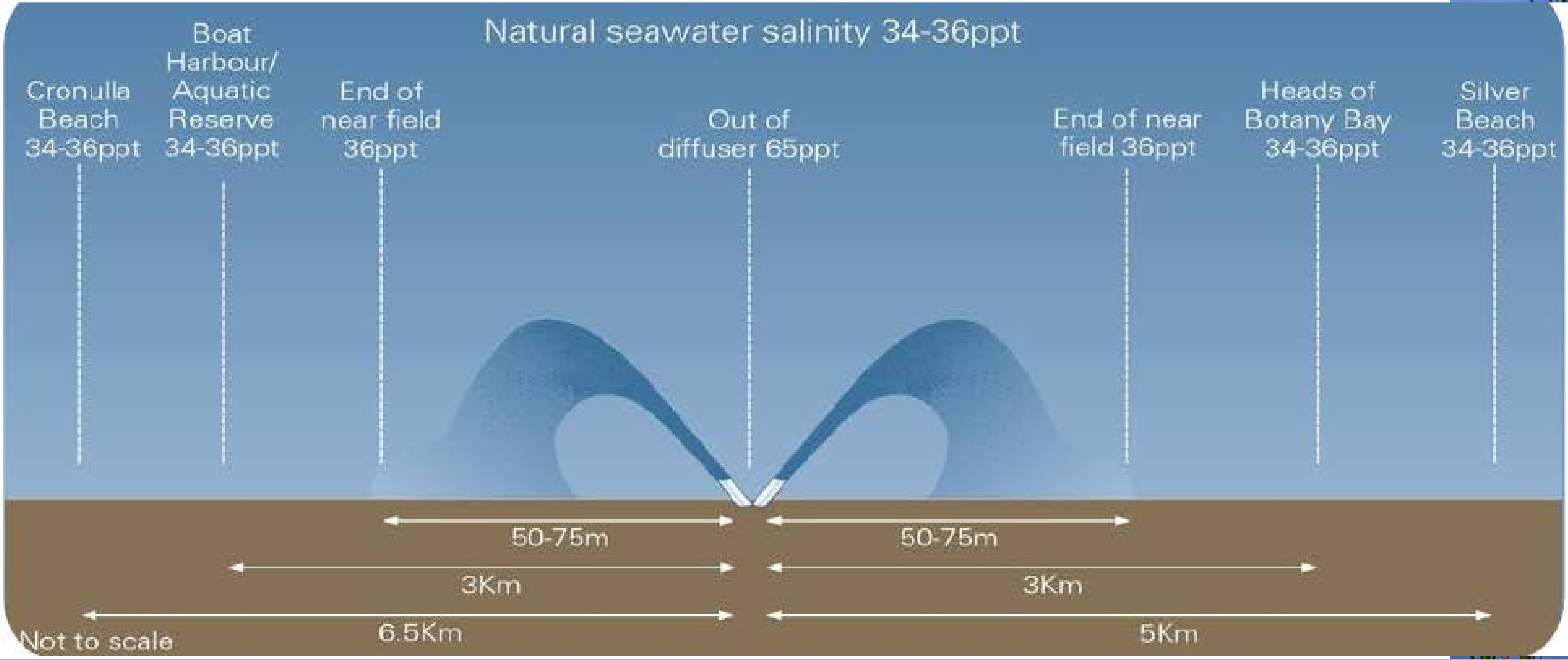
# Example - Sydney Desalination Plant – Diffuser Structure




**Discharge Outfall Tunnel
Extends 500 m
Offshore
1:45 dilution**

# Sydney Water Diffuser Discharge – Mixing Zone




**1:45 Dilution at the Edge of Near Field Concentration**
**Concentrate Salinity Within 10 % of Ambient**

# Near-Shore Discharge - Common Low-Cost Option
# Example – Hadera SWRO Plant, Israel

# Key Challenges Associated with Selecting Location for Desalination Plant Outfall

- Finding Area without Endangered Species
- Avoiding Areas Where Discharge May Reach Marine Reserves and Conservation Areas
- Avoiding Areas Inhabited by Marine Species of Low Salinity Tolerance
- Avoiding Areas with Frequent Ship Traffic Which Can Damage the Outfall Structure
- Selecting Location with Strong Underwater Currents to Accelerate Concentrate Dispersal

# Co-disposal of Seawater Concentrate and Wastewater Effluent – Example – 53 MGD Barcelona WWTP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# Key Benefits of Co-discharge With Wastewater Plant Effluent

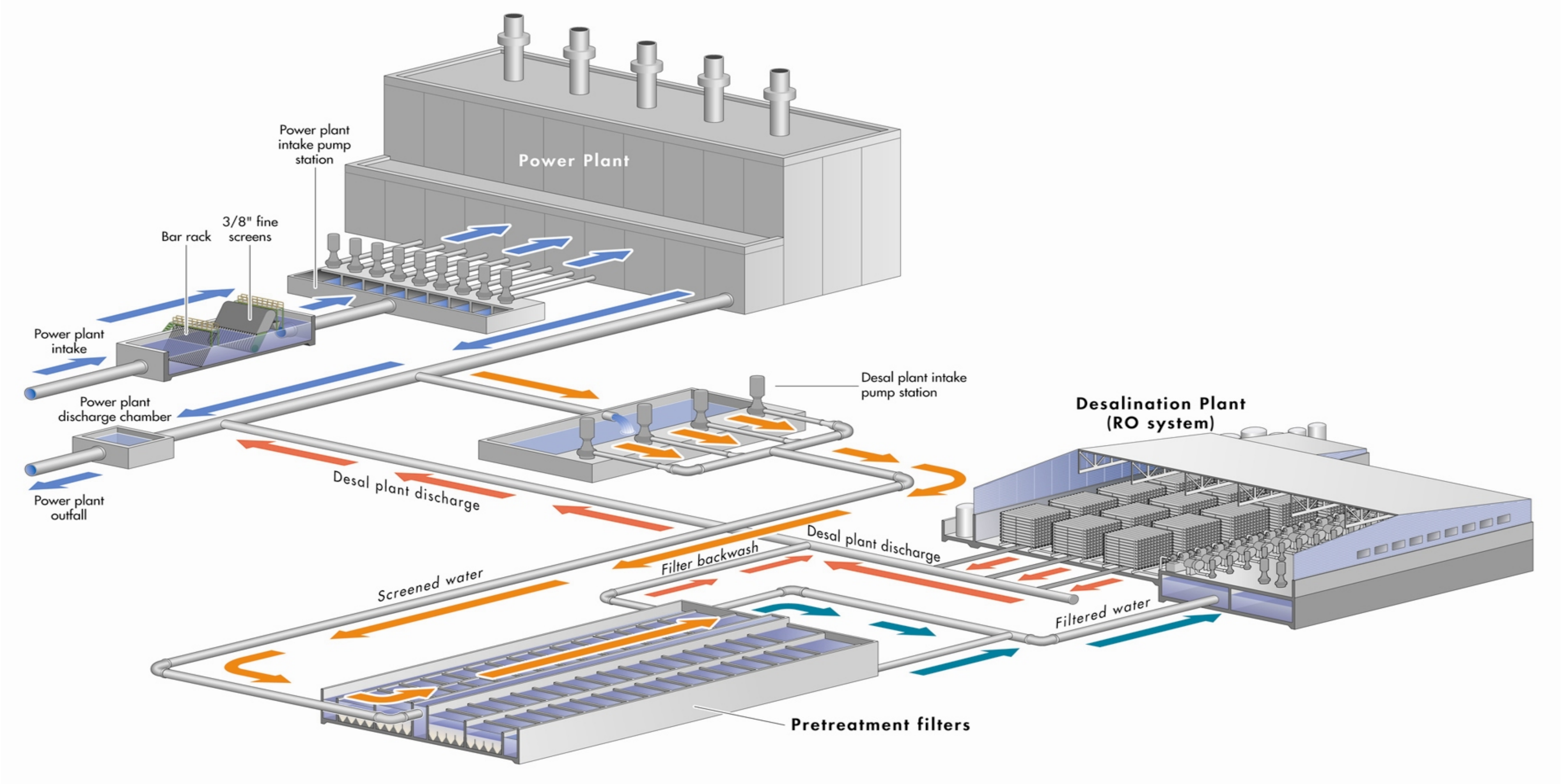
- Mutually Accelerated Dissipation of High-Salinity Concentrate and Low Salinity WWTP Effluent Plumes

- No Need for Construction of Separate Outfall – 10 to 30 % Construction Cost Savings

# Discharge to WWTP Outfall – Key Challenges

- Need for Modification of WWTP Discharge Permit and Sharing of Responsibility for Compliance
- Outfall Capacity Availability and Charges;
- Need for WWTP Outfall Diffuser Modification;
- Mitigation Fees/Measures for Destruction of Marine Organisms by the Diffuser Jet Force (New California Ocean Plan)
- Matching Concentrate and WWTP Effluent Volumes to Sustain Minimum Dilution Ratio;
- Whole Effluent Toxicity Caused by Ion Imbalance.

# Co-disposal with Power Plant Cooling Water

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# Key Benefits of Collocation With Power Plant

- Mutually Accelerated Dissipation of Salinity and Thermal Plumes

- No Need for Construction of Separate Outfall – 10 to 30 % Construction Cost Savings

- Minimal Environmental Impact:
  - No Beach or Ocean Floor Habitat Disturbance;
  - No New Ocean Source Water Collection – Minimized Impingement & Entrainment.

- Power Cost Savings.

# Co-disposal with Power Plant Cooling Water – Key Challenges

- Need for Modification of Power Plant Discharge Permit and Sharing of Responsibility for Compliance
- Outfall Capacity Availability and Charges;
- Need for Power Plant Outfall Diffuser Modification;
- Mitigation Fees/Measures for Destruction of Marine Organisms by the Diffuser Jet Force (New California Ocean Plan)
- Matching Concentrate and Cooling Volumes to Sustain Minimum Dilution Ratio;
- Legislation-related Constraints
  - New Legislation of California (2015 California Ocean Plan) Discourages Collocation and Aims to Eliminate Coastal Power Plants with Once-Through Cooling
  - Concentrate-discharge Related Legislation in Massachusetts Encourages Collocation
  - At Present Texas and Florida Regulatory Agencies Are Supportive of Collocation

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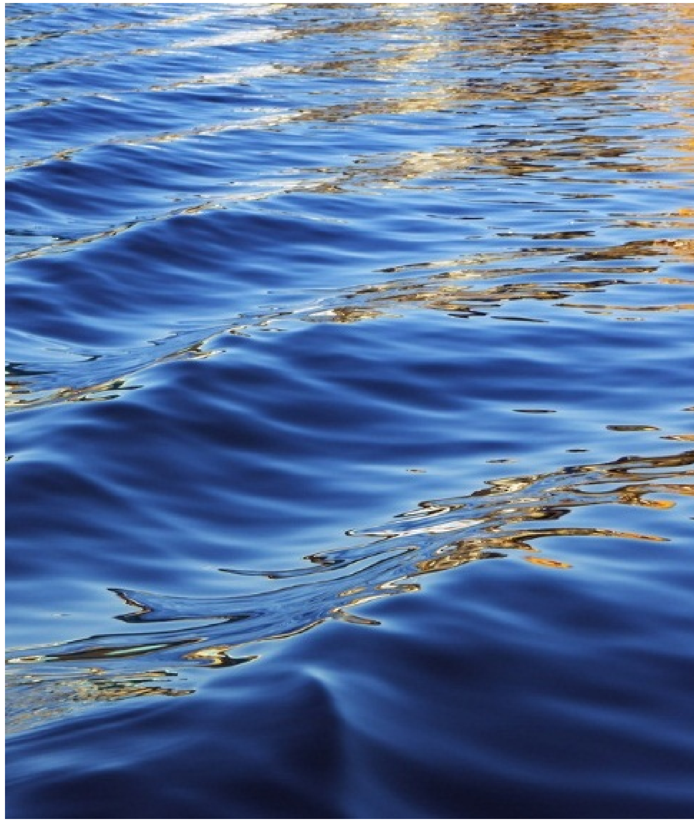
# REGULATION & PERMITTING PRACTICES IN THE U.S.



# U.S. Federal Regulatory Framework

**EPA (guidelines) → State regulations [if state is delegated]**

- States may choose to implement guidelines:
  - in different ways and
  - to have more stringent regulations than required by the Federal minimum requirements.

- At the time of development of these primary regulations:
  - A few very small seawater desalination plants in the U.S.
  - no appreciable consideration of the potential impacts or requirements specific to this form of discharge.

- Even today:
  - very limited precedents for the states for the development of a cohesive framework for desalination discharge permitting.

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# Discharge Standards

- Regulation is based on compatibility of concentrate with receiving water (salinity and individual constituents)

- Receiving **water quality standards** based on its use classification.

- Standards may be defined by:
  - Numeric limits for specific constituents and parameters
  - Narrative standards of specific constituents and parameters
  - Whole effluent toxicity (WET) test requirements
  - Meeting biological diversity parameters

- **water quality standards are to be met at the end of discharge pipe**

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# Mixing Zones

- In addition to water quality standards, states may, at their discretion, include policies that generally affect how the standards are applied or implemented
  – such as **Mixing zone policies**

- **Mixing zones are a dilution allowance**
  - A zone immediately surrounding an outfall where mixing with water in the zone takes place
  - Within the mixing zone water quality standards can be exceeded but due to the mixing will be met at the boundary of the mixing zone.

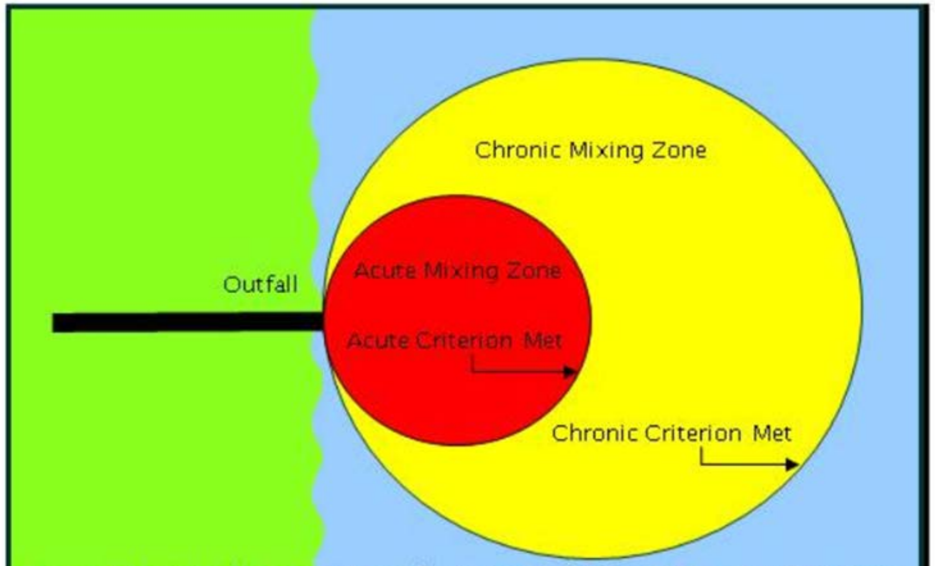

Figure 5.1: Example Mixing Zones for Acute and Chronic Aquatic Life Criteria

- Mixing zones are necessary for some constituents and parameters (such as salinity) that cannot meet water quality standards at the end of the discharge pipe.

- Allowable mixing zones can be separately defined for Salinity, Acute toxicity, Chronic toxicity, Individual constituents

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# Determination of Effluent Limitations

- If water quality standard CAN be met at the end of pipe:

  → Effluent Limitation = Water Quality Standard

- If water quality standard CANNOT be met at end of pipe:

  → **mixing zone / dispersion modeling effort is undertaken** to see water quality standards can be met at the edge of an acceptable mixing zone based on a reasonable, cost-effective diffuser discharge system.

- A successful modeling effort provides:
  - An acceptable diffuser discharge design
  - A numerical dilution ratio to use in in calculation of the effluent limitation

# Calculation of Effluent Limitations

- **Effluent limits (allowable discharge concentrations)** are calculated by a mass balance equation such as:

$$C_e = C_o + D_m * (C_o - C_s)$$

where:

- Effluent concentration limit (allowable discharge concentration), $C_e$
- Water quality standard, $C_o$
- Ambient concentration, $C_s$
- Dilution ratio determined from modeling, $D_m$

Similar equations are used for determining effluent toxicity limits

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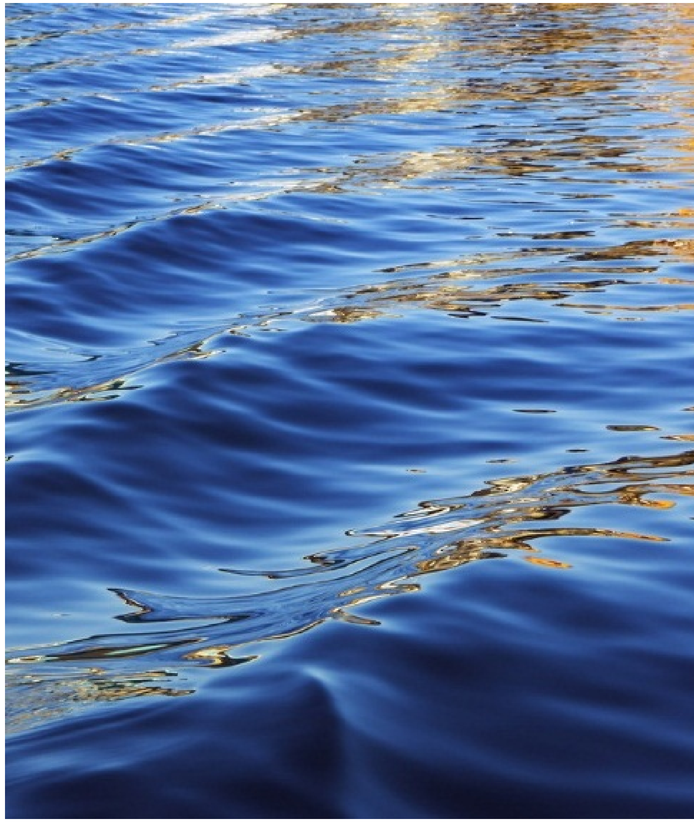
# ISSUES ASSOCIATED WITH DETERMINATION OF EFFLUENT LIMITS



# Issues Related to Permitting of SWRO Discharge

Two areas:

- **Environmental issues/concerns** that are the drivers for discharge permitting concerns, actions and permit limits

- **Issues associated with regulatory guidance and the process of providing information for determination of discharge permit limits.**

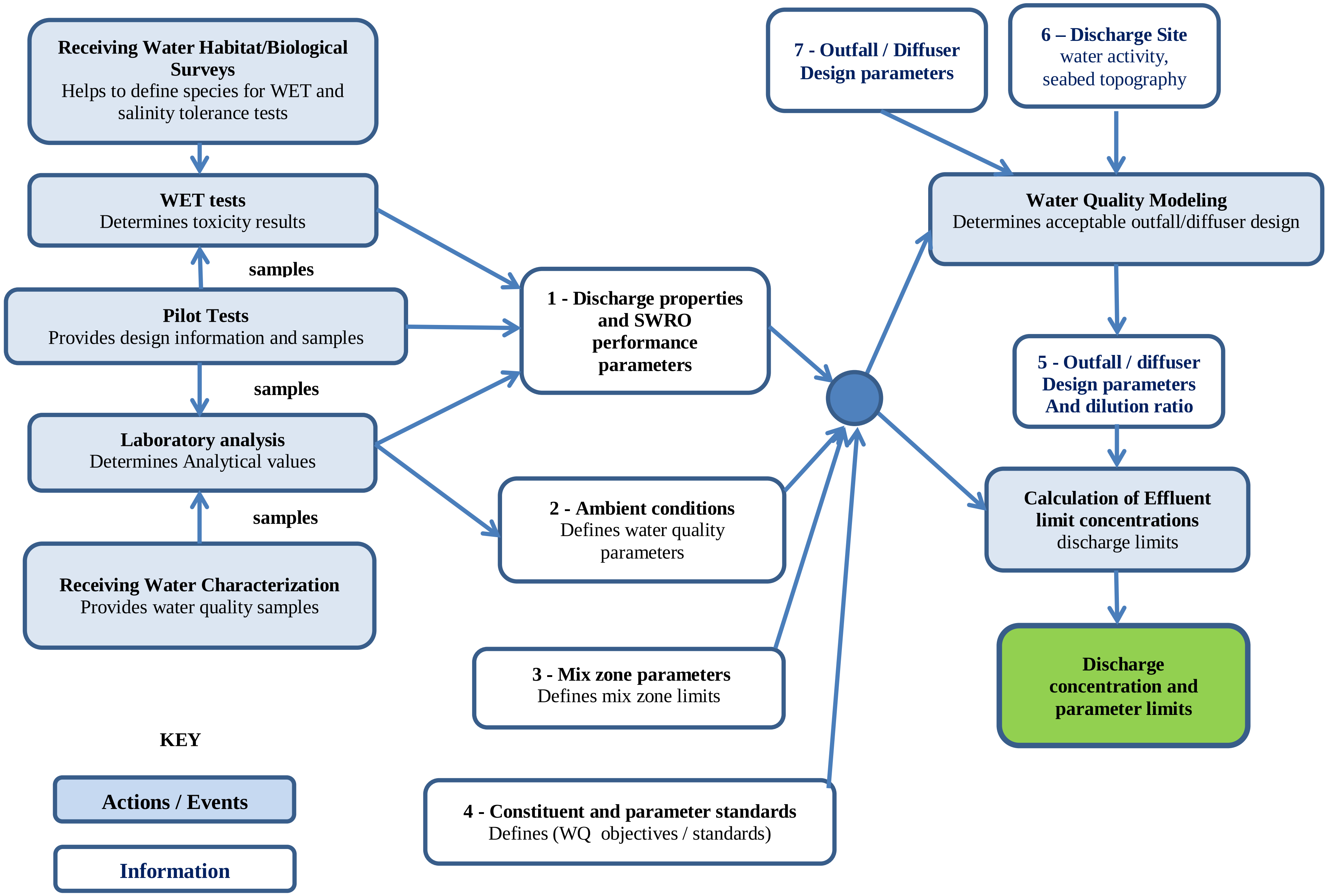
# Environmental Concerns

1. **Maintaining the receiving water quality within the salinity tolerance of aquatic species (determination of salinity tolerance of marine organisms in region of discharge)** **(highlighted for discussion)**

2. Avoiding concentration of source water constituents to harmful levels

3. Avoiding discharge which may cause discoloration of the receiving water body and which may lower oxygen content in the area of the discharge.

4. Shear and turbulence effects due to diffuser discharge of concentrate.


Receiving Water Habitat/Biological Surveys
Helps to define species for WET and salinity tolerance tests
WET tests
Determines toxicity results
samples
Pilot Tests
Provides design information and samples
samples
Laboratory analysis
Determines Analytical values
samples
Receiving Water Characterization
Provides water quality samples
1 - Discharge properties and SWRO performance parameters
2 - Ambient conditions
Defines water quality parameters
3 - Mix zone parameters
Defines mix zone limits
4 - Constituent and parameter standards
Defines (WQ objectives / standards)
7 - Outfall / Diffuser Design parameters
6 – Discharge Site
water activity, seabed topography
Water Quality Modeling
Determines acceptable outfall/diffuser design
5 - Outfall / diffuser Design parameters And dilution ratio
Calculation of Effluent limit concentrations
discharge limits
Discharge concentration and parameter limits
KEY
Actions / Events
Information

# Issues Associated with Regulatory Guidance and Process

- **Whole effluent toxicity (WET) testing of concentrate** (**highlighted for discussion**)
- Modeling of concentrate dispersion and recirculation to intake
- Protocols for analytical lab testing of high salinity samples in general and for various compounds contained in concentrate such as metals, total suspended solids (TSS) and organics.
- Status of State regulatory guidelines relevant to desalination plant discharges

# Salinity Tolerance and WET Tests

- **The main environmental impact of concentrate** on aquatic life in the vicinity of desalination plant discharge has typically been associated with the salinity of this discharge and **the ability of the native species to tolerate the salinity.**

- Determining this is complicated by:
  - Marine organisms have varying sensitivities to elevated salinity.
  - Many different species have differing tolerances to salinity at different life stages.
  - Exposure is complicated by the fact that many mobile organisms will exhibit avoidance behavior when confronted with a local unsuitable environment.
  - Elevated concentrate salinity impacts mainly depend upon the type of marine organisms inhabiting the discharge area and the length of time of their exposure.
  - Many marine organisms are naturally adapted to a range of changes in seawater salinity.

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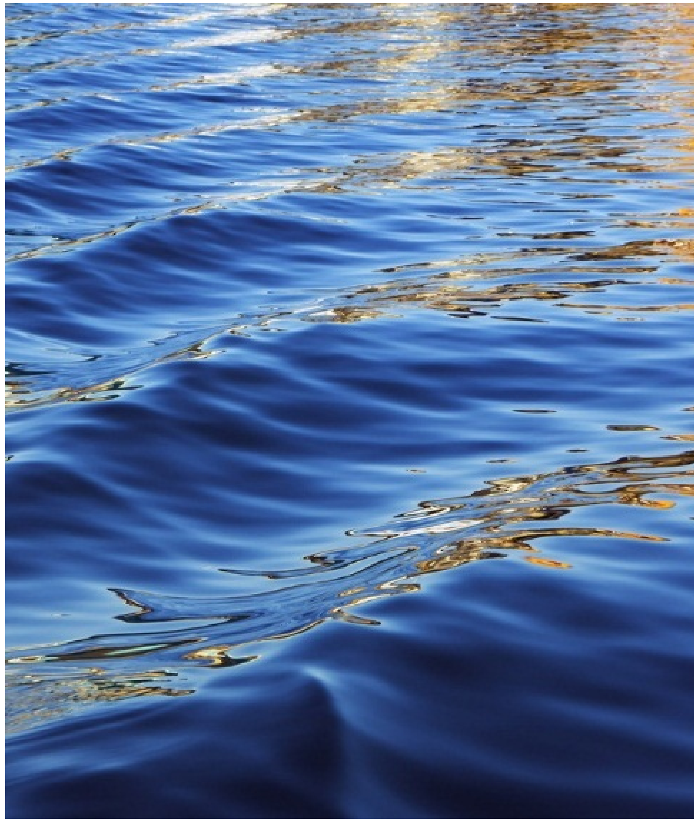
# Salinity Tolerance and WET Tests (continued)

- **Questions surrounding WET tests include:**
  - What organisms to use.
  - How many different organisms to use in the tests.
  - Whether to do chronic and/or acute toxicity tests.
  - What is the appropriate length of time for both acute and chronic tests.
  - What protocols to use for WET testing specific to the various life stages of test species.
  - How to acclimate species for testing; how to adapt test organisms to test salinity prior when testing depends on the age and type of organisms.
  - What protocols and standards apply for high salinity WET testing.
  - What dilution water to use for WET tests (use of actual seawater vs. artificial seawater).
  - Where/how to obtain lab testing protocols for local species relevant to the discharge site.

# STATE DISCHARGE REGULATIONS

CALIFORNIA, FLORIDA, & TEXAS



# Overview of Differences – California, Florida, & Texas Discharge Regulations

- Minor differences
  - Automatic inclusion of mixing zones (Texas) vs. mixing zones being granted on a case-by-case basis (CA and FL).
  - Definition of mixing zone parameters
  - Automatic inclusion of WET tests for municipal membrane concentrate (FL) vs. case-by-case inclusion (TX)
  - Different water quality standards (all must be as stringent as Federal guidelines)
  - Different degrees of implementation of TMDLs (Total Maximum Daily Load)

- Major differences
  - Number of regulatory bodies involved in permitting
    - California has several who issue permits or give permit approvals
    - Texas and Florida have only a few…
  - Salinity standards
    - Site-specific WET test-based salinity limit (all 3 states)
    - Non-site specific salinity limit (2,000 mg/L above ambient) – CA (in addition)

# 2015 Desalination Amendment to California Ocean Plan – Non-site-specific salinity standard

- California has moved to strengthen regulation of environmental impacts of desalination plants through multi-year study involving research and expert panels.
- The primary effect on ocean discharge was the definition of a non-site-specific salinity limit of 2,000 mg/l above ambient.
- It appears that Expert witness report on Impacts and Effects of Brine Discharges (2012) was not a consensus document and raised important research issues that should be taken into consideration in developing a policy on regulating the salinity of discharges.
- Yet the updated Ocean plan incorporated the discharge regulatory option of a non-site-specific salinity standard.
- The situation raises several questions (discussed in KEY FINDINGS later) and may lead to more complicated permitting, and bypass important research needs,

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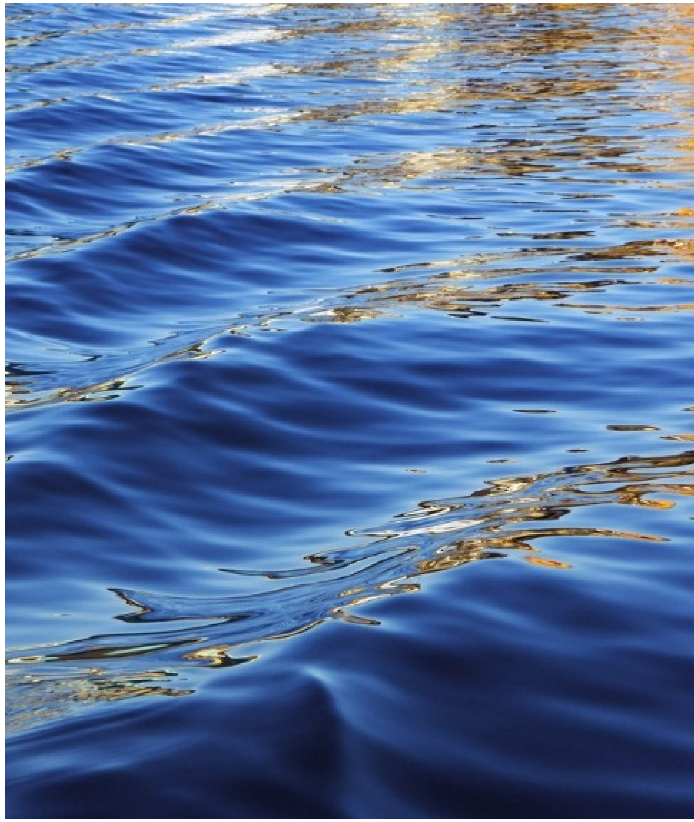
# U.S. CASE STUDIES



# Examples of Recently Permitted Desalination Projects in US Covered in the Project Report

- 50 MGD Carlsbad SWRO Desalination Project
- 50 MGD Huntington Beach SWRO Desalination Project
- 25 MGD Tampa Bay SWRO Desalination Plant

# Carlsbad SWRO Plant – Collocated with Encina Power Plant - Near-shore Outfall Discharge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# Carlsbad SWRO Project – Numerical Effluent Limitations

| Effluent Limitations – Desalination Discharge | | | | | | |
|---|---|---|---|---|---|---|
| | | MAX | Average | Average | Instantaneous | |
| Parameter/constituent | Units | Daily | Monthly | Weekly | MIN | MAX |
| Maximum Flow – median filtration | MGD | | 54 | | | |
| TSS | mg/L | | 60 | | | |
| pH | Standard units | | | | 6 | 9 |
| Oil and Grease | mg/L | | 25 | 40 | | 75 |
| Settleable Solids | ml/L | | 1 | 1.5 | | 3 |
| Turbidity | NTU | | 75 | 100 | | 225 |
| Chronic Toxicity | TU | 16.5 | | | | |

| Effluent Limitation – Combined Discharge | | | |
|---|---|---|---|
| Parameter | Units | Average Daily | Average Hourly |
| Salinity | ppt | 40 | 44 |

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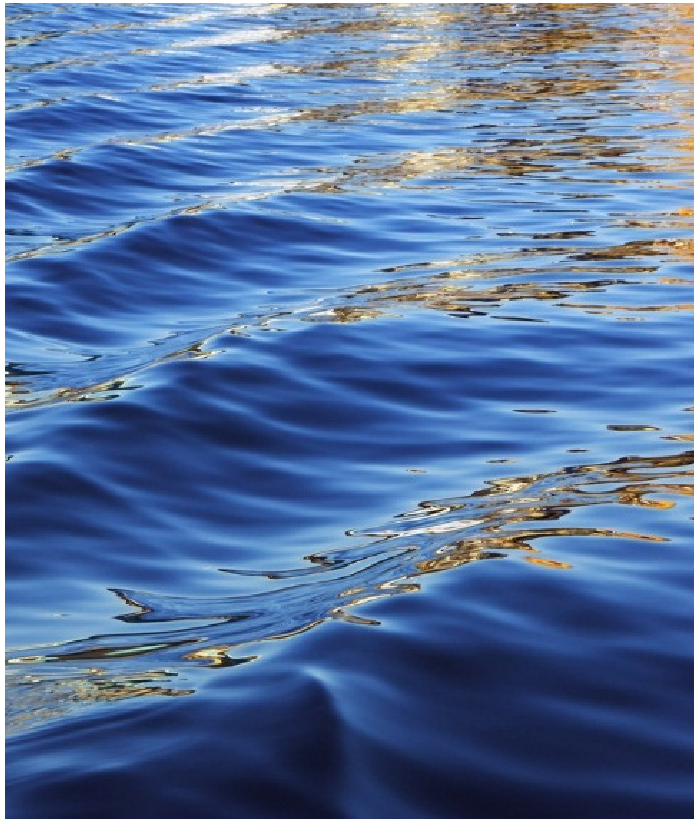
# Summary of US Projects Discharge Permit Requirements

| **Desalination Plant** | **Total Flow MGD (ML/d)** | **TDS (Avg.) (ppt)** | **TDS (Max.) (ppt)** | **Acute Toxicity ($TU_a$)** | **Chronic Toxicity ($TU_c$)** | **Dilution Ratio** |
|---|---|---|---|---|---|---|
| **Carlsbad:** 50 MGD (189 ML/d); 33.5 ppt TDS - source; 67.0 ppt - conc. | 54/60.3 (204/228) | 40 (daily) (19.4 % Above Ambient) | 44 (Max. Hourly) (31.3% Above Ambient) | 0.765 | 16.5 | Mixing Zone 15.1:1 |
| **Huntington Beach** 50 MGD (189 ML/d); 33.5 ppt TDS source; 67.0 ppt – conc. | 56.59 (214) (Conv. Pretreat) | None | None | None | 8.5 | Mixing Zone 7.5:1 Min. Dilution 2.24:1 |
| **Tampa** 25 MGD (95 ML/d); 26 ppt – TDS source; 43 ppt – TDS conc. | 22.8 (86) (Conv. Pretreat) | 35.8 (38% Above Ambient) | 35.8 (38% Above Ambient) | None | None | Dilution = 28.1 (20:1 Min.) |

Note: 1 part per thousand (ppt) = 1,000 mg/L

# INTERNATIONAL REGULATION AND PERMITTING

AUSTRALIA, ISRAEL, & SPAIN



# Overview of Concentrate Discharge-Related Regulations in Australia

- The Australian & New Zealand Environmental and Conservation Council (ANZECC) Establishes Guidelines which Are Applied by Individual State Jurisdictions.

- ANZECC Guidelines for Discharge to Fresh & Marine Waters:
  - Recognize Mixing Zone
  - Apply Water Quality Limits to the Boundary of the Mixing Zone
  - Consider Toxicity Testing as a Key Mechanism to Assess the Combined Toxicity Effects of All Pollutants
  - Establish Different Numeric Limits for Pollutants Depending on the Classification of the Discharge Area

- Classifications of Discharge Areas:
  - High Ecological Protection Area (HEPA);
  - Medium Ecological Protection Area (MEPA);
  - Low Ecological Protection Area (LEPA);

# Australian Regulations – Key Limits Applicable to All Discharge Areas

| Discharge Parameter | South-East Australia | Tropical Australia | South-west Australia | South-central Australia |
|---|---|---|---|---|
| Chlorophyll a – inshore/offshore, µg/L | 1 | 0.7-1.4/ 0.5-0.9 | 0.7/20<br>0.3/20 | 1 |
| Total Phosphorous – inshore/offshore, µg/L | 25 | 15/10 | 20 | 100 |
| Filterable Reactive Phosphate, µg/L | 10 | 5 | 5 | 10 |
| Total Nitrogen – inshore/offshore, µg/L | 120 | 100 | 230 | 1000 |
| Nitrates – inshore/offshore, µg/L | 5 | 2-8/1-4 | 5 | 50 |
| Ammonia – inshore/offshore, µg/L | 15 | 1-10/1-6 | 5 | 50 |
| Dissolved Oxygen (% of saturation) – lower & upper limits, % | 90/110 | 90 | 90 | 90 |
| pH – lower & upper limits | 8.0/8.4 | 8.0/8.4 | 8.0/8.4 | 6.5/9.0 |
| Turbidity, NTU | 10 | 20 | 2 | 10 |

# Australian Regulations – Limits Specific to Different Discharge Areas

| Permit Discharge Parameter | HEPA (protection of 99% of species) | MEPA (protection of 90% of species) | LEPA (protection of 80% of species) |
|---|---|---|---|
| Cadmium, µg/L | 0.7 | 14 | 36 |
| Chromium III, µg/L | 7.7 | 48.6 | 90.6 |
| Chromium IV, µg/L | 0.14 | 20 | 85 |
| Cobalt, µg/L | 1 | 14 | 150 |
| Copper, µg/L | 0.3 | 3 | 8 |
| Lead, µg/L | 2.2 | 6.6 | 12 |
| Mercury (inorganic), µg/L | 0.1 | 0.7 | 1.4 |
| Nickel, µg/L | 7 | 200 | 560 |
| Silver, µg/L | 0.8 | 1.8 | 2.6 |
| Vanadium, µg/L | 50 | 160 | 280 |
| Zinc, µg/L | 7 | 23 | 43 |

# Australian Regulations – Discharge Monitoring Requirements

- Whole Effluent Toxicity;
- Chemical and Biochemical Changes in Marine Organisms;
- Whole-sediment laboratory toxicity assessment;
- Structure of macro invertebrates and/or fish populations/communities using rapid, broad-scale or quantitative methods;
- Seagrass depth distribution;
- Imposex in marine gastropods (imposex is a disorder in sea snails caused by the toxic effects of certain marine pollutants. These pollutants cause female sea snails (marine gastropod mollusks) to develop male sex organs
- Frequency of algal blooms;
- Density of capitellids;
- In-water light penetration;
- Filter feeder densities;
- Sediment nutrient status;
- Coral reef thopic status;
- Habitat distributions;
- Assemblage distributions.

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# Overview of Concentrate Discharge-Related Regulations in Spain

- The Spanish Ministry of the Environment and Rural and Marine Affairs (MARM) Establishes Guidelines which Are Applied by Basin Agencies.

- Spanish Regulations Establish Standards Applicable to:
  - Point of Discharge ("Effluent Standards")
  - The Boundary of the Mixing Zone ("Ambient Standards")

- Specific Sets of Regulations Developed for The Three Phases of Implementation of Each Project:
  - Planning Phase;
  - Construction Phase;
  - Operation Phase

# Spanish Regulations Applicable to Planning Phase

- Biological survey of the discharge area;
- Water quality characterization near the ocean surface and the bottom of the discharge area including measurement of pH, TSS, DO, nitrates, total nitrogen, total phosphorus and algal content (chlorophyll – a).
- Bathymetric and current surveys;
- Numeric modeling of concentrate plume dispersion;
- Assessment of the biological significance and presence of endangered species in the discharge area. Mediterranean coast of Spain is characterized by the existence of large seabeds of two salinity sensitive sea grasses:
  - *Poseidon oceanica* – a sea grass, which grows in large beds along the coast and is sensitive to salinity exceeding over 40,000 mg/L. The Poseidonia sea grass beds can sometimes extend 1 to 2 miles offshore.
  - *Cymodsea nodosa* – a sea grass, which usually grows on sandy or muddy bottom at up to 66 ft (20 m) in depth. Cymodsea forms thick underwater lawns referenced as "sebadales" which are habitat for endangered marine species and are used for spawning by many aquatic organisms.

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# Spanish Regulations Applicable to Construction Phase

- Seawater quality monitoring to determine whether construction is impacting the nearby aquatic environment and take the necessary corrective measures;

- Tracking of the condition of sea grass beds in the area of the desalination plant construction site and discharge;

- Quality control and monitoring of the dredged materials;

- Monitoring and control of the increase of silt content in the seawater as a result of excavation and runoff activities.

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# Spanish Regulations Applicable to Operation Phase

- Compliance with numeric water quality parameters of the discharge and at the boundary of the mixing zone;
- Biodiversity of the aquatic habitat inside and outside of the zone of initial dilution;
- Structural integrity, functioning and condition of the discharge outfall.

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# Spanish Regulations – Key Discharge Permit Limits

| Parameter | Maximum Concentration |
|---|---|
| TSS, mg/L | 35 |
| pH | 6-9 |
| Total Nitrogen, mg/L | 15 |
| Total Phosphorus, mg/L | 2 |
| BOD5, mg/L | 25 |

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# Overview of Concentrate Discharge-Related Regulations in Israel

- Israel is the Only Country with National Master Plan for Desalination of Seawater – Key Goal - 550 MGD of Fresh Water (35% of Total Country Demand) to be Produced by Seawater Desalination by Year 2020

- The Israeli Ministry of the Environmental Protection (MEP) - Establishes Policy for Protection of the Mediterranean Marine and Coastal Environment

- Coastal Environment Protection Policy Has Requirements for:
  - Discharge Type and Characteristics;
  - Marine Outfall Configuration;
  - Discharge Monitoring Program

# Israeli Regulations – Characteristics Used to Access Discharge Impact

- Discharge composition – which is mainly driven by the source water quality and the type and quantities of chemicals used at the desalination plant;
- Pretreatment waste streams – what waste streams generated by the pretreatment system will be discharged to the ocean and would they be treated before discharge.
- Treatment chemicals – of specific interest are chemicals which can exhibit effluent toxicity such as antiscalants and membrane cleaning chemicals as well as such that can trigger algal bloom effects – i.e., phosphate antiscalants, phosphoric acid, citric acid, nitric acid and others.
- Plant recovery rate – the percentage of source water which is converted into fresh water.  Recovery rate dictates the salinity of the plant discharge and potential concentration of algal toxins, organics, solids or other compounds that may result in effluent toxicity.
- Operational regime – intermittent or continuous discharge of concentrate and spent filter backwash and associated maximum loads of solids and salinity spikes.
- Flow rate – which has impact on loads of solids discharged in a particular area.
- Increase of turbidity caused by the discharge should not be more than 10 % of the seasonal average.
- Suspended particulate matter (total suspended solids) should not exceed the seasonal average by more than 10 mg/L;
- Color of ambient water should not be affected by the discharge outside of the mixing zone.

# Israeli Regulations – Criteria for Marine Outfall Discharge Impacts

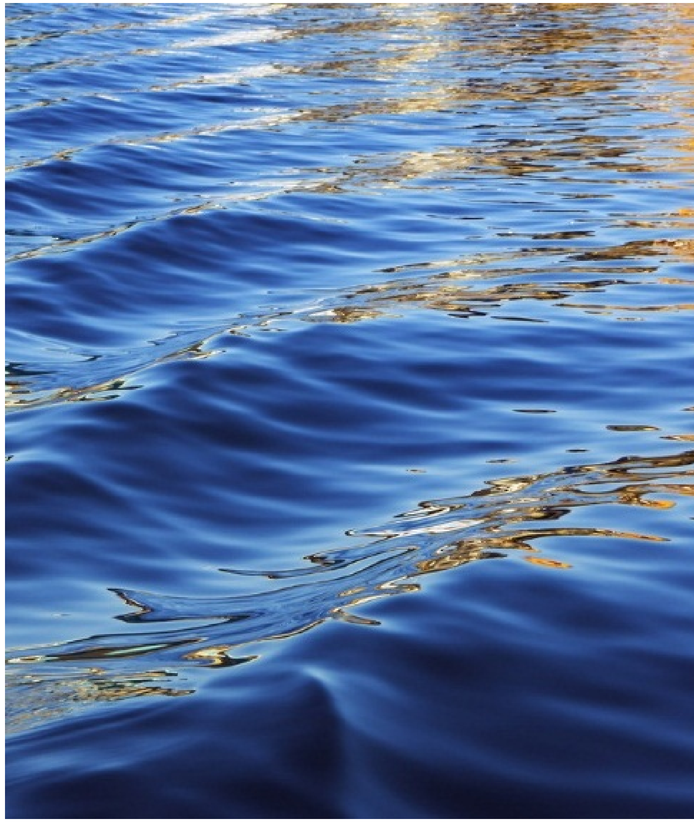
- Natural sand movement;
- Ecosystems in the coastal environment;
- Fishing activities;
- Marine vessel traffic;
- Safety of bathers and surfers in shallow waters;
- The impact of onshore coastal facilities servicing the plant outfall (i.e., pump stations, storage tanks, etc.).

# Israeli Regulations – Discharge Monitoring Program Requirements

- Periodic Water Quality Characterization Onshore and Offshore;
- Sediment Accumulation in the Discharge Area;
- Biota – Type and Biodiversity.

# INTERNATIONAL CASE STUDIES

AUSTRALIA, ISRAEL, SPAIN



# Examples of Desalination Projects in Australia, Spain and Israel Covered in the Project Report

- Australia
  - 38 MGD Perth I Desalination Plant
  - 35 MGD Gold Coast Desalination Plant
- Spain
  - 63 MGD Torrevieja SWRO plant
  - 6 MGD Javea Plant
  - 18 MGD Alicante 1 Plant
  - 18 MGD San Pedro del Pinatar Plant
  - 0.8 MGD Maspalomas II SWRO Plant (Canary Islands)
- Israel
  - 85 MGD Ashkelon Desalination Plant
  - 108 MGD Sorek Desalination Plant

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# 38 MGD Perth I Desalination Plant – Areal View

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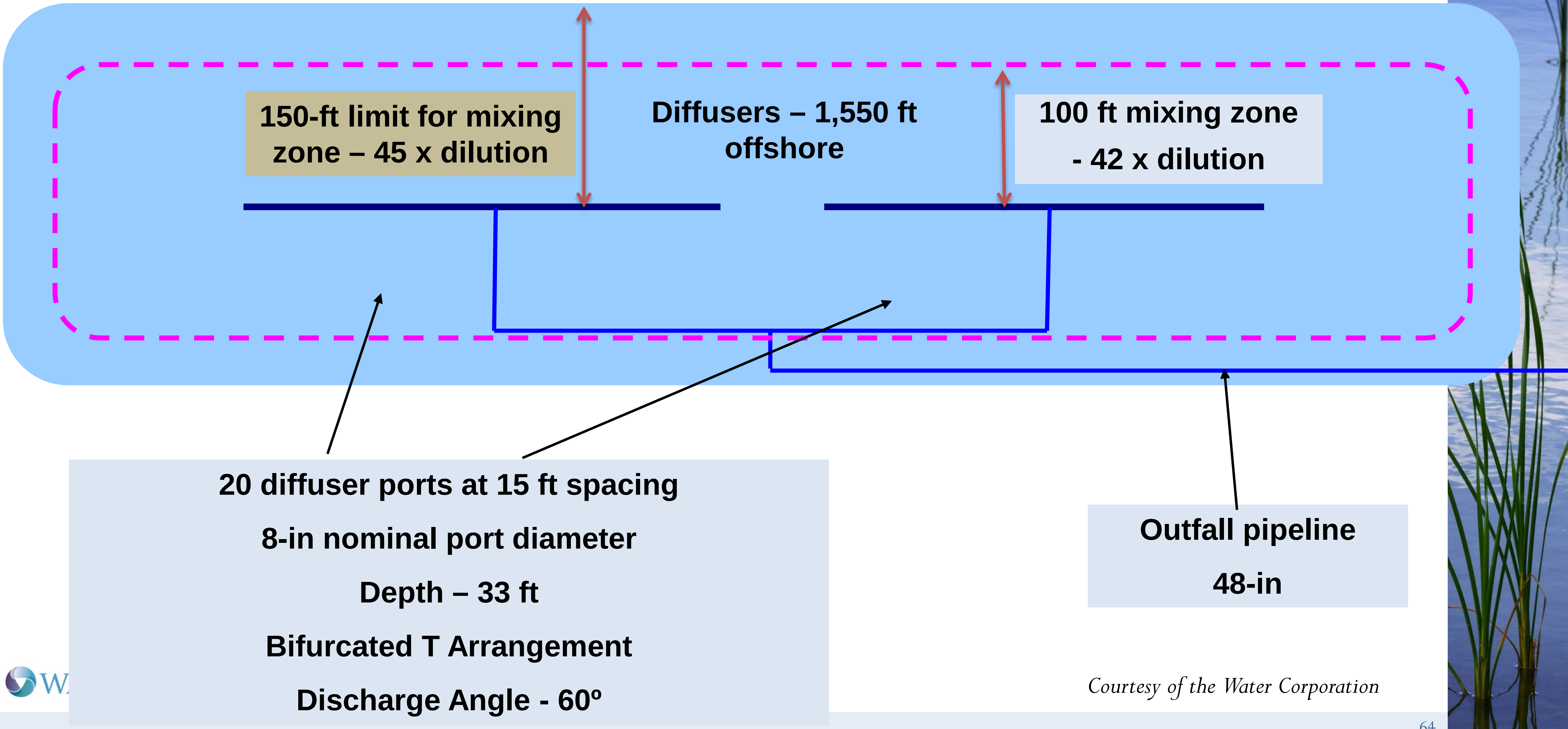
# Perth Seawater Desalination Project

## Offshore Concentrate Outfall Discharge System




*Courtesy of the Water Corporation*

# Perth 1 SWRO Project – Key Numerical Effluent Limitations

| Permit Discharge Parameter | Average | Maximum | Minimum |
|---|---|---|---|
| Distance Factor at the Edge of Mixing Zone | | | 1:45 |
| Distance from Diffusers to Edge of Mixing Zone | | 165 ft (50 m) | |
| Salinity Increment Above Average at the Edge of Mixing Zone | 0.8 ppt | 1.2 ppt | |
| Turbidity Concentration | | 8 NTU | |
| Oxygen Concentration | | | 5 mg/L |
| pH units | | 8.3 | 7.0 |
| Conductivity of Undiluted Concentrate | | 92,999 µS/cm | |

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# 63 MGD Torrevieja Plant, Alicante Spain – Areal View

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# Torrevieja Seawater Desalination Project
# Concentrate Dispersion

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# Torrevieja Seawater Desalination Project
# Offshore Concentrate Outfall Discharge

- Total Outfall Length = 5,280 ft
- Section of Outfall Pipes with Diffusers = 1,040 ft (last 20 % of Pipe Length)
- Two Steel Pipes with Diameters of 94-inch (2400 mm) & 78-inch (2000 mm)
- Each Outfall Pipe Has a Total of 64 Diffusers with Diameter of 6-inch
- Distance Between Diffusers = 16.5 ft
- Diffusers Oriented Upwards & Under 50% Inclination
- Design Exit Velocity = 14.8 fps
- Discharge Depth = 33 ft

# Torrevieja SWRO Project – Key Numerical Effluent Limitations

| Permit Discharge Parameter | Daily Average | Maximum | Minimum |
|---|---|---|---|
| Total Dissolved Solids, ppt | | 68.2 | |
| Total Suspended Solids Concentration, mg/L | | 3.5 | |
| pH | | 9.0 | 7.0 |
| Total Iron, mg/L | | 0.5 | |
| Total Phosphorus, mg/L | | 0.2 | |
| Total Nitrogen, mg/L | | 1.5 | |
| Total Organic Carbon, mg/l | | 3.0 | |
| Detergents (sodium lauryl sulfate) mg/L | | 0.5 | |
| Dissolved Oxygen (DO) Concentration mg/L | | 10 | >80% of Ambient |
| Temperature Increment Above Ambient | | 3.0 °C | |

# 85 MGD Ashkelon Desalination Plant, Israel – Areal View


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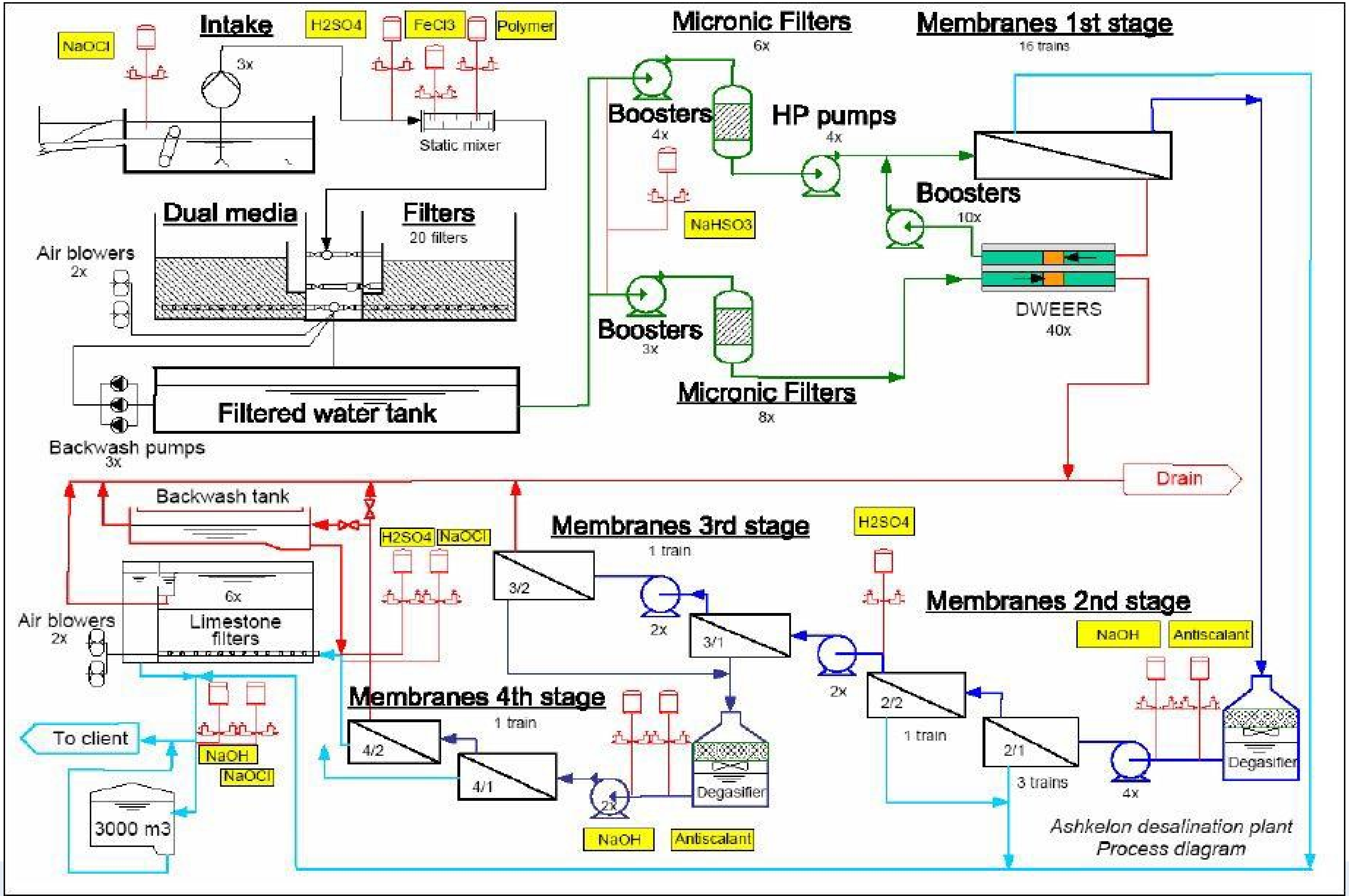
# Ashkelon Desalination Plant – Treatment Schematic

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# Ashkelon Desalination Plant – Onshore Discharge

Lowest Cost Discharge
One of the Key Reasons for
Low Cost of Water Production

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# Ashkelon SWRO Project – Key Numerical Effluent Limitations

| Permit Discharge Parameter | Daily Average | Maximum | Minimum |
|---|---|---|---|
| Suspended Solids Concentration, mg/l | 15 | 20 | |
| Turbidity (15-min average) | 15 NTU | 30 NTU not more than 4% of the time; 100 NTU not more than 1% of the time | |
| pH | | 9.0 | 6.5 |
| Total Iron | 2 mg/L | 190 tons/year | |
| Total Phosphorus | | 40 tons /year | |
| Temperature Increment above Ambient Water | | 5° C | |
| Total Nitrogen | | 11 tons/year | |
| Total Organic Carbon | | 24 tons/year | |
| Ag, As, Cd, Cu, Cr, Hg, Ni, Pb, Zn | | Within 10% from ambient water | |
| Dissolved Oxygen (DO) Concentration | | | ≥80% of ambient |

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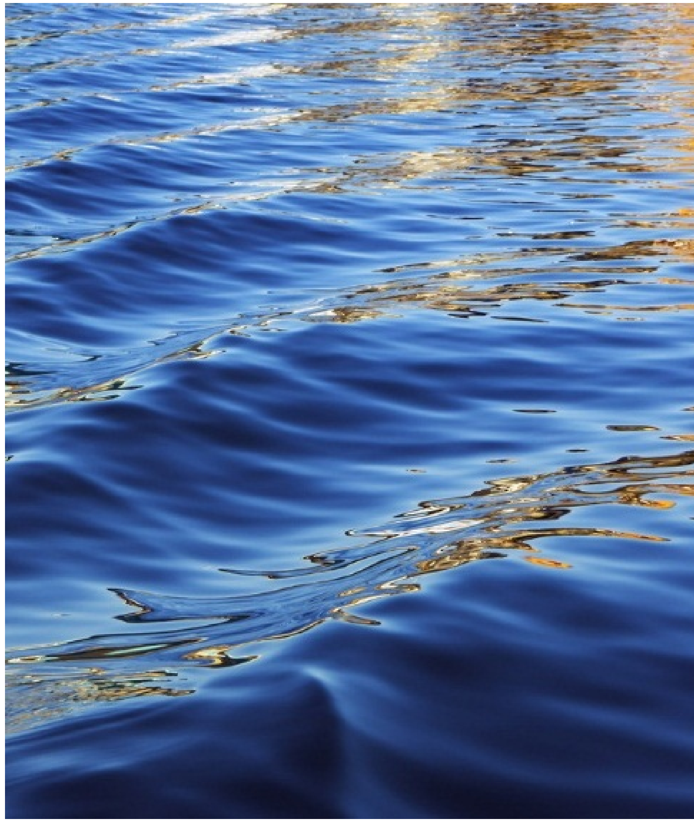
# Ashkelon Seawater Desalination Plant Discharge Compliance Observations

- Salinity of 10% of Ambient Achieved 1200 ft from Point of Discharge Under Worst-case Scenario
- Dilution Ratio with Power Plant Discharge – 35 to 42:1
- Dilution Ratio without Power Plant Discharge – 10:1 (Worse Case)
- Nutrients, Suspended Solids and Algae Dissipated Down to 10% of Ambient within 800 ft from the Point of Discharge.
- Discharge Discoloration Observed Due to Direct Discharge of the Spent Backwash Water Containing High Levels of Iron – Backwash Equalization Added
- All Other Israeli Plants Except Ashkelon Required to Have Solids Handling System (Lamella Settlers + Sludge Dewatering for Backwash Treatment)

# KEY FINDINGS & RECOMMENDATIONS



# Key Findings & Recommendations

## 1 – REGULATORY SYSTEMS & PROCESS

## Key Findings

- Considerable similarities exist between the US states of California, Florida, and Texas as all states must conform to the general federal regulations
- The process to define discharge limitations for the permitting of SWRO desalination projects in the U.S. generally applies to all large desalination plants in Australia, Israel, and Europe.
- Effluent limits are determined based on mixing zone considerations, which are, in turn, developed via the application of whole effluent toxicity testing requirements (defined in the regulations).
- Existing US federal guidelines for regulating surface water discharge define the general regulatory approach and provide the framework for states to define and implement specific regulatory policy. Currently - no legally binding regulatory guidelines for desalination in California, Florida, and Texas or Australia, Israel, and Spain containing technical requirements and engineering guidance.

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# Key Findings & Recommendations

## 1 – REGULATORY SYSTEMS & PROCESS (Continued)

## Recommendations

Development of Federal Regulatory Permitting Guidelines

- More specifically: the creation of a guidance document similar to the USEPA Water Reuse Guidelines. Include:
  - Technical details and engineering guidance related to necessary environmental studies
  - Design and planning recommendations to complete a successful desalination project

Preparation of Statewide Desalination Guidelines

- Guidelines would address desalination-specific permitting challenges and define state-specific regulatory requirements, data collection procedures and scope, and successful desalination project permitting practices.

- Federal guidelines will still allow some latitude or the states in defining more specific policy and protocols. State guidelines would address the state-specific details.

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# Key Findings & Recommendations

## 2 - TIME FOR PROJECT ENVIRONMENTAL REVIEW AND PERMIT ISSUANCE

### Findings

- **In General, the Time to Permit Desalination Projects in the US is Longer than Any Other Country!**

Factors that contribute to shorter timeframes in other countries include**:**

- Streamlined regulatory processes
- Priority review of desalination plants
- Superior expertise of regulatory agencies in permitting of desalination plants
- Sharing of regulatory expertise between various agencies involved in the desalination project permitting

### Recommendations

- Maintain staff with the expertise needed to complete and expedite review of desalination projects; this could include marine biologists, experts in outfall discharge modeling, and engineers with experience in desalination plant design and operation.

- Create Frequent Opportunities for State Regulatory Staff to Exchange Information, Share experiences and Practices

# Key Findings & Recommendations

## 3 - DISCHARGE SALINITY LIMIT

### Findings

- Presently, in the U.S., Australia, Israel, and Spain, salinity standards are determined via whole effluent toxicity (WET) tests and regulated through WET test-based limits.

- In addition to **site-specific WET test limits**, California has recently (2015) implemented a **non-site-specific general numeric salinity limit** of 2,000 mg/L above ambient salinity at the edge of the mixing zone.
- Use of the **non-site-specific salinity limit** raises questions including:
  - What is gained by the introduction of the TDS limit?
  - Why WET Testing is Not Adequate?
  - What are the implications of non-site-specific limitations in terms of project permitting time and costs?

### Recommendations

- Eliminate the Need for Non-site Specific Salinity Limit
- Use Enhanced WET Tests Instead

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# Key Findings & Recommendations

## 4 – WET TEST SPECIES AND CONDITIONS

### Findings

- State and countries reviewed vary in their use of standard test species or site-specific test species and on the life stage of species tested.
- Typically, WET test methods vary by several key issues:
  - Use of adult vs. embryo organisms for the tests
  - Use of test organisms gradually adapted to salinity vs. un-adapted organisms
  - Use of artificial seawater or concentrate within tests vs. actual seawater
  - Use of site-specific test organisms collected from the area of the plant discharge vs. standard test organisms.
  - Lack of standard protocol for conducting salinity tolerance tests for marine organisms

### Recommendations

Modify Existing WET Testing Procedures for Seawater Discharges

- Provide clarity to standard WET testing procedures and simplify the permitting of desalination projects.

- Specifically clarification of the following should be added:
  - Desalination project-specific guidelines for the selection and gradual adaption of marine species to elevated concentrate salinity and the determination of their salinity tolerance.
  - Clear definition of the test species' developmental phase (adult or embryo).

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# Findings & Recommendations

**5 - STANDARD METHODS OF ANALYSIS OF WATER AND WASTEWATER**

## Findings

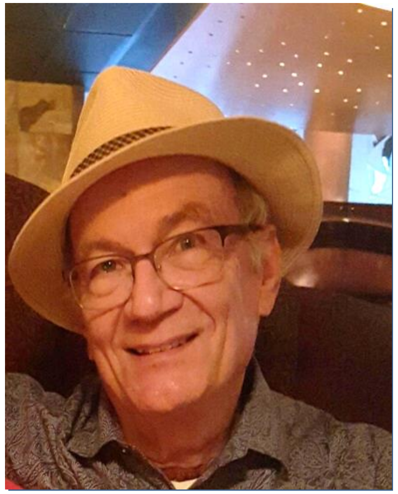
- Most laboratory analysis guidelines worldwide are developed for testing freshwater. The elevated salt content of the concentrate samples could interfere with the standard analytical procedures and can often produce erroneous results

- Specifically, methods for analysis of the concentration of total suspended solids, copper, nickel, and radionuclides are originally developed for fresh (low-salinity) water and wastewater and are not suited for higher salinity waters.

## Recommendations

- Develop suitable guidelines for testing of high salinity samples where needed.

# Questions?



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