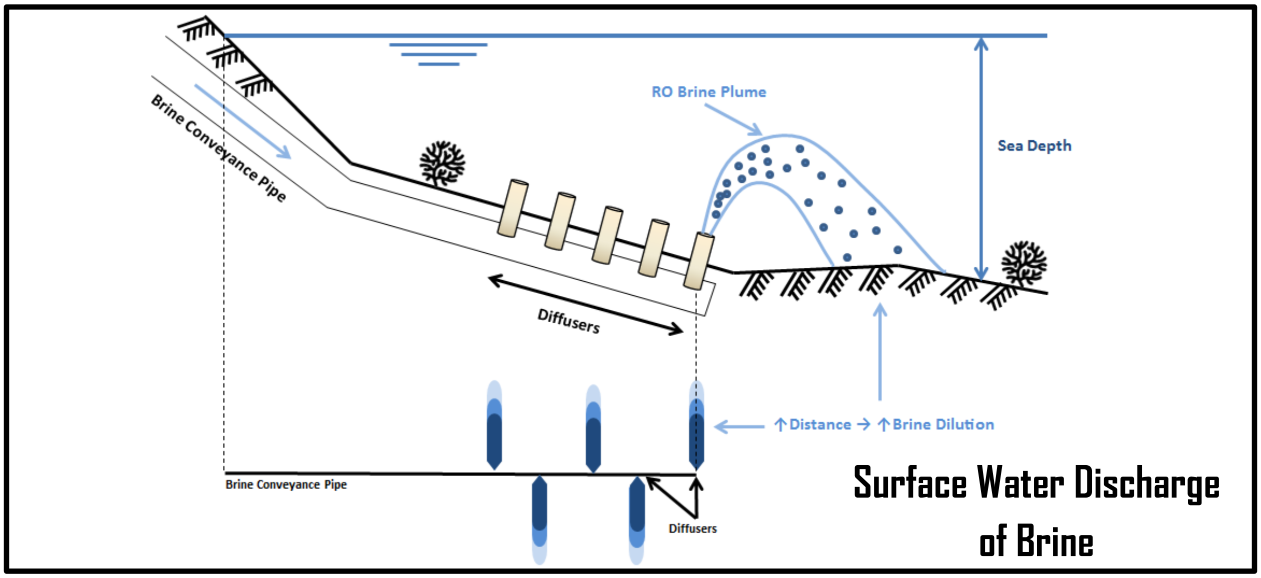

Brine is discharged on the surface of seawater or off shore through multiport diffusers installed on the bottom of the sea.

1. Surface Water Discharge

2. Potential Environmental Impacts

3. Potential SWRO Brine Treatment Requirements

4. Surface Water Discharge Costs

Advantages (+)	Disadvantages (-)
Can be used for all plant sizes	Negative impact to aquatic ecosystem
Cost effective for medium to large brine flow rates	Difficult and complex permit procedures

The surface water brine discharge to an open water body such as,

- a bay
- a tidal lake
- a brackish canal
- an ocean

The most used methods for brine discharge to surface water bodies are,

1) near or off-shore direct surface discharge
2) discharge to wastewater treatment plant

1. Surface Water Discharge

Surface discharge of brine and the rest of the desalination plant waste streams (near or off-shore) is applied mainly for SW desalination projects of all sizes. More than 90% of the large SW desalination plants worldwide get rid of their brine this way like for example the 462,000 m^3/day SWRO plant in Hadera, Israel, the 136,000 m^3/day Tuas SW desalination plant in Singapore, the 64,000 m^3/day Larnaka desalination facility in Cyprus, and the majority of large SWRO plants in Spain, Australia, and the Middle East.

The brine outfalls are designed to discharge the concentrate so as to minimize the size of the zone in which the salinity is elevated beyond the TDS tolerance of the aquatic ecosystem.

This is performed by accelerating the mixing of brine with the water of the receiving water body by,

1) the mixing capacity of the local tidal (surf) zone

2) discharging the brine beyond the tidal zone and installing diffusers at the end of the discharge pipe in order to improve mixing

Near-shore tidal zones usually have limited capacity of transporting and dissipating the high salinity load. If the salt load exceeds the capacity of the tidal zone's transport capacity, the excess salts will accumulate, resulting in a long-term salinity increase usually beyond the level of capacity of the aquatic ecosystem. The salinity mixing/transport capacity of the tidal zones can be determined using hydrodynamic modeling.

For small desalination plants (≤1,000 m^3/day), the outfall is typically constructed as an open-ended pipe that extends several hundred meters into the receiving water body, relying on the mixing turbulence of the tidal zone to dissipate the brine and to reduce the salinity to ambient conditions. Most large seawater desalination plants usually extend their brine discharge beyond the tidal zone and equip their pipes with diffusers in order to provide the necessary mixing that will prevent the heavy saline plume from accumulating at the ocean bottom, taking into consideration hydrodynamic of the site-specific conditions.

2. Potential Environmental Impacts

The main issues for an appropriate location for a brine discharge system are,

1) find an area with no endangered species and stressed aquatic ecosystems
2) find a location with strong underwater currents that allows for fast and efficient dissipation of the high salinity discharge

3) avoid areas with ships traffic that could damage the brine discharge system and alter the mixing patterns
4) identify a discharge location in relatively shallow waters and close to the shoreline so as to minimize the construction costs

Key environmental related issues associated with brine disposal to surface waters include,

1) salinity tolerance of the local aquatic ecosystem
2) raising the concentration of some water constituents to damaging levels
3) discoloration and low oxygen content

The feasibility evaluation of a brine disposal to a surface water body include the following key issues

1) assessment of the discharge plume's dispersion and recirculation
2) evaluation of the discharge toxicity
3) evaluation of whether the discharge water quality meets the water quality standards by the relative regulatory agencies
4) assessment of the local aquatic ecosystem salinity capacity in order to design the discharge within a minimal distance

3. Potential SWRO Brine Treatment Requirements

Typically, SW desalination brine from open ocean intakes does not require treatment prior to discharge. Due to the fact that its ion composition is similar to that of that of the discharge ocean area and therefore does not usually pose an ion-imbalance threat to the local ecosystem. The brine then is discharged using a diffuser system or is blended with source seawater down to a salinity level that is safe for direct discharge (usually ≤40,000 mg/L) without need for further diffusion.

However if we use a well to collect feed seawater, the desalination concentrate may be discolored due to an increased concentration of iron, have a low concentration of oxygen or contain constituents that arise the need of treatment prior to discharge in the ocean.

Feed seawater collected from alluvial coastal aquifers by beach wells may contain high levels of iron (Fe) and manganese (Mn) in reduced form. In RO pretreatment the feed is kept without exposure to air or oxygen, which keeps Fe and Mn in a dissolved reduced form in which they are colorless. RO membranes easily reject the dissolved ions and they are retained in the desalination brine. If this concentrate is exposed to air, iron will convert from reduced form (typically ferric sulfide, Fe_2S_3) to oxidized form (ferric hydroxide, FeO(OH)). FeO(OH) has red color and it can degrade the visual appearance of the discharge area. So Fe in the feed water in reduced form needs to be oxidized and removed in the pretreatment system or the brine needs to be treated by sedimentation to remove the FeO(OH).

Also a large brine discharge with low-Dissolved Oxygen (DO) could cause oxygen depletion and stress to the local aquatic ecosystem. In such a case the brine has to be re-aerated.

4. Surface Water Discharge Costs

The costs for construction of surface water brine discharge are a function of the following site-specific factors,

1) brine discharge flow rate
2) near or off- shore discharge
3) materials of construction
4) complexity of the discharge diffuser system
5) costs of conveying the brine from the desalination plant to the surface water discharge outfall
6) brine treatment costs (if needed)
7) environmental monitoring of the discharge

We also have to take into consideration installation costs of the outfall pipeline above or below ground which will have affect the overall cost. Unusual ground conditions can significantly increase the cost of pipeline system installation. Underwater trenching is usually 3 to 5 times more expensive than trench excavation on dry land. So instead of installing the outfall in a trench, it is often laid down on the ocean bottom and secured by concrete blocks located at every 5 to 10 m along the entire outfall length.

The costs for concentrate conveyance are proportional to the brine flow rate and the distance between the desalination plant and the discharge outfall. The outfall construction costs, the outfall size and the diffuser system configuration (which is affected by the 1) brine volume, 2) salinity and 3) hydrodynamic conditions) are site-specific.

A rough approach for the construction costs for near-shore ocean discharges as a function of the brine flow rate is presented on Figure 1. Figure 2 depicts the unit construction cost of HDPE pipeline and of concrete tunnel outfalls in US$/linear meter of outfall length without incorporating the costs of brine conveyance from the desalination plant to the outfall structure, for brine treatment (if such needed) or for offshore monitoring of the discharge. Environmental monitoring costs may be significant, especially if the discharge is in an environmentally sensitive area.

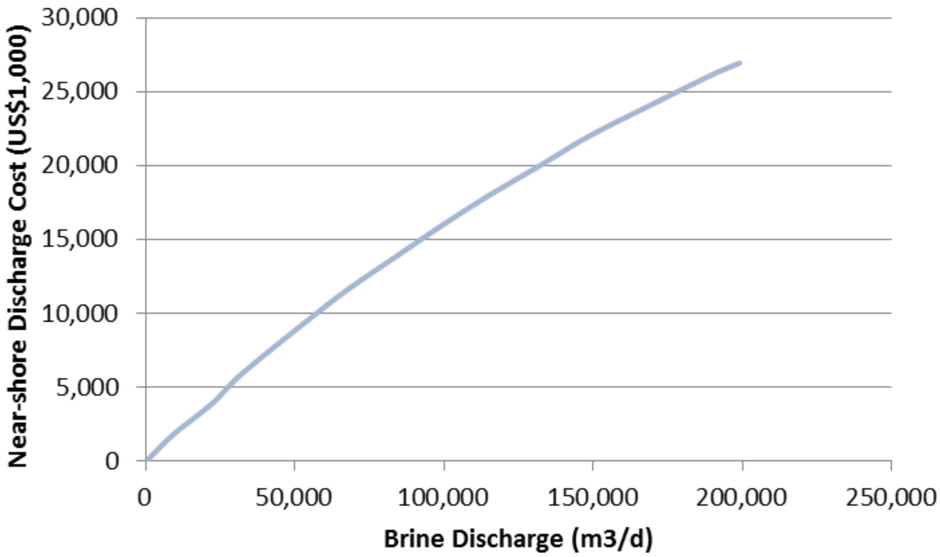

Fig.1, Construction costs of near-shore brine discharge

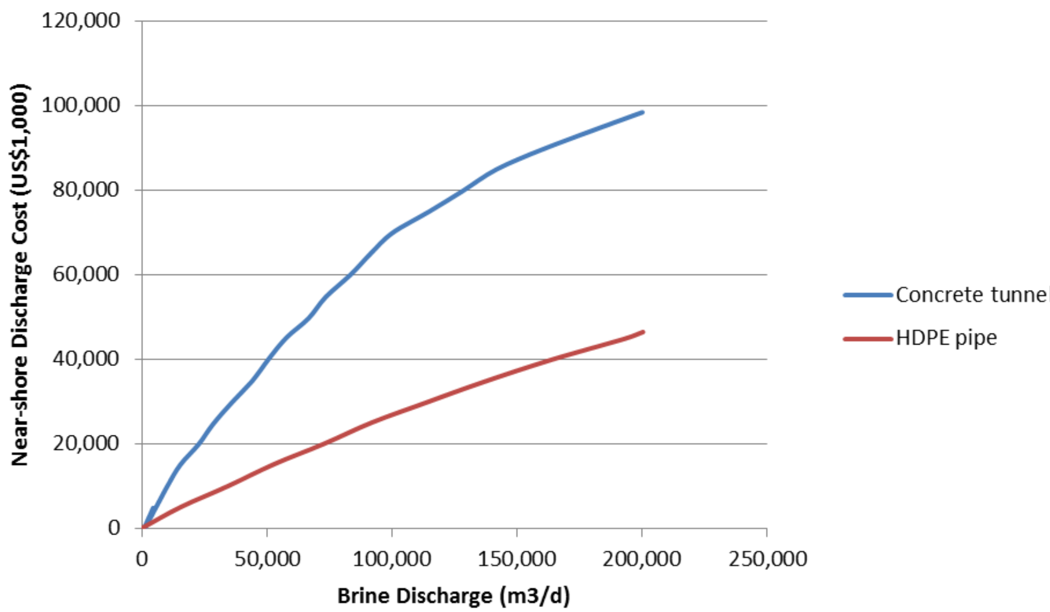

Fig.2, Near-shore brine discharge costs

Typically near-shore discharges are the least expensive option. A HDPE outfall of the same size is <30% more expensive and an underground tunnel is even more costly.

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