Brackish Water Reverse Osmosis

Reverse osmosis (RO) is a pressure-driven membrane process. Hydraulic pressure is used to overcome a feed solution's osmotic pressure and induce diffusion of pure water (permeate) through a semi-permeable RO membrane. The solutes in the feed stream are concentrated during the process and leave the system as concentrated brine (referred to as retentate, or concentrate, or reject). Depending on feed water quality, more water can be recovered from the brine in downstream unit processes; otherwise, large volumes process residuals might requires disposal.

Brackish water RO (BWRO), compared to nanofiltration processes, may achieve high removal of divalent ions (e.g., calcium, magnesium, sulfate, iron, arsenic) and moderate to high removal of monovalent ions (e.g., sodium, potassium, chloride). Substantial removal of organic compounds may also be achieved. BWRO is commonly used for desalination of saline streams and aquifers.

Summary of technical assessment of BWRO

Criteria	Description/Rationale
Status of technology	Mature and robust technology for brackish water desalination in the municipal water treatment sector. Laboratory scale studies were conducted for oil and gas produced water.
Feed water quality bins	Most applicable for TDS ranging from 500 to 25,000 mg/L, and water containing monovalent (e.g., sodium, chloride), divalent (e.g., magnesium, calcium, barium, sulfate), multi-valent (e.g., iron, manganese) electrolytes, and radionuclides. Also applicable for specific classes of organic compounds.
Product water quality	The quality of BWRO permeate depends on feed water salinity and operating conditions. Typically, product water total dissolved solids ranges from 100 to 1,500 mg/L, ammonia rejection may range from 60% to 80%.
Recovery	Product water recovery is between 60% and 85%
Energy use	BWRO requires less energy than equivalent seawater RO systems for a specific feed water quality. BWRO requires between 0.5 and 3 kWh/kgal (0.02-0.13 kWh/bbl) of energy to power the system's high-pressure pumps.
Chemical use	Scale inhibitor and caustic may be required for process control to prevent scaling or fouling. Chemical cleaning rates depend on feed water quality. Cleaning will typically be initiated after a preset/design specifications are exceeded, and may require the use of NaOH, Na_4EDTA, HCl, $Na_2S_2O_4$, or H_3PO_4.
Expected lifetime of critical components	Depending on operating conditions, BWRO membranes will require replacement within 3 to 7 years.

Summary of technical assessment of BWRO

Criteria	Description/Rationale
Infrastructure considerations	BWRO requires an equivalent footprint when compared to seawater RO, and a minimal operational footprint compared to thermal desalination technologies. As with seawater RO, BWRO can be automated and be mobile.
O&M considerations	Monitoring and control required for feed pH, flow rates as well as vessel pressures. System automation lessens the demands for skilled labor, however a skilled technician is required to perform routine system maintenance. Level of flexibility: high sensitivity to organic and inorganic constituents in the feed water. Level of robustness: thin film composite membranes have high pH tolerance, but cannot be exposed to feed temperatures in excess of 113˚F (45˚C). Level of reliability: BWRO systems operate semi-continuously with automated, short duration chemical rinse or osmotic backwashing cycles. Types of energy required: electricity.
Capital and O&M costs	Capital costs vary from $0.8 to $4/gpd (or $35 to $170/bpd), depending on various factors including size, materials of construction and site location. Operating costs are approximately $0.70/kgal (or $0.03/bbl). Moderate reductions in energy costs can be obtained by implementing energy recovery subsystems.
Pretreatment of feed water	All high-pressure membrane technologies require extensive pretreatment to remove constituents that will otherwise foul or scale the membrane. Particular attention should be given to hydrophobic organic compounds and sparingly soluble salts. The silt density index of the feed stream should not exceed 5.
Post-treatment of product water	Product water may require pH stabilization or remineralization. This may be achieved by lime bed contacting or by blending small amounts of filtered and sterilized feed water with permeate.
Concentrate management or waste disposal	No special concentrate treatment is required, unless radionuclides are highly concentrated in the reject stream. Moderate recovery rates of 50% to 85% generate a large volume of concentrated brine. BWRO operations are commonly located inland and the concentrated brine typically requires deep well injection.
Applicability for produced water treatment	Excellent - with appropriate pretreatment technologies.
Note: 1 barrel = 42 US gallon	