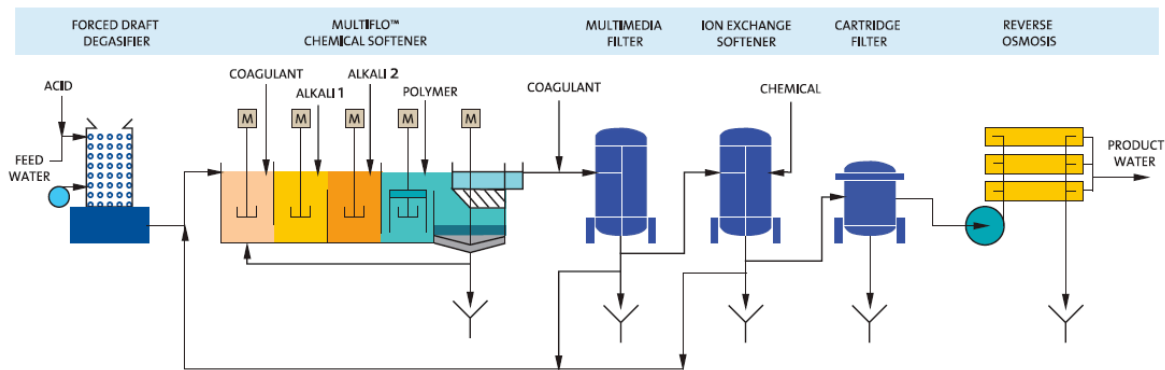


Veolia Water Solutions and Technologies: OPUS™

OPUS™ (optimized pretreatment and separation technology) is a unique pretreatment separation process for desalination of water with high concentrations of sparingly soluble solutes (e.g., SiO_2 , CaSO_4 , and $\text{Mg}(\text{OH})_2$), organic compounds, and boron. The system is able to achieve high recovery with high purity product water through the use of extensive pretreatment processes prior to water treatment with ion exchange (IX) and/or reverse osmosis (RO) sub-systems. The process is initiated by acidification and degasification of the raw feed stream. This is followed by a conventional coagulation, flocculation, and high-rate plate settler sedimentation process, termed Multiflo™ chemical softening. After this step, the feed stream is devoid of nearly all high molecular weight organic molecules and oxidized metals (particularly iron and manganese). Additionally, colloidal silica is partially removed by co-precipitation. Decant from the sedimentation basin is then filtered through a packed-bed media filtration column, which removes any micro-flocs and most suspended solids that would not settle on the plate settlers. The media filter may also achieve additional removal of low to medium molecular weight hydrophobic organic molecules, including any remaining oil and grease. Filtrate from the media filter is then processed through a mixed packed-bed IX column for further water softening and removal of microorganisms. A cartridge filter is then employed to remove any IX resin or any remaining suspended solids prior to contact with the RO membranes. Feed water is then pressurized and treated by brackish water RO membranes at an elevated pH. Operating the RO system under this condition reduces the fouling propensity of silica and increases the rejection of both silica and boron. The system is modular, but the large chemical storage containers required limit the mobility and thus the applicability of the technology for some sites. An illustration of the process is shown below.



Summary of technical assessment for: OPUS™

Criteria	Description/Rationale
Status of technology	System has undergone field trials at a steam-enhanced oil production field in San Ardo, CA.
Feed water quality bins	Manufacturer reports that the technology is applicable to water with TDS ranging from 500 to 10,000 mg/L. High removal of monovalent and divalent ions, metals, and organics is expected. System is likely to achieve additional silica and boron removal with high pH operation.
Product water quality	Treatment process permeate quality depends on feed water salinity and operating conditions. Early studies reported greater than 99% rejection of TDS and most multivalent solutes. System is likely to achieve more than 94% removal of sodium based on typical brackish water RO performance.
Recovery	Product water recovery is estimated to exceed 90%.

Summary of technical assessment for: OPUS™

Criteria	Description/Rationale
Energy use	Energy requirements are unknown.
Chemical use	<p>Multiflo™ pretreatment system requires various chemical agents for operation, including acids, bases, coagulants, and/or polymer based coagulants.</p> <p>Chemical cleaning frequency depends on feed water quality. Membrane cleaning is triggered when certain operating conditions are exceeded, and may require the use of NaOH, Na₄EDTA, or HCl. The IX process requires regeneration with strong acid, likely H₂SO₄ or HCl.</p>
Expected lifetime of critical components	No data is currently available.
Infrastructure considerations	<p>This treatment process requires a larger footprint than conventional RO or IX systems. Large chemical storage and sludge dewatering facilities are also required.</p> <p>System mobility is reduced compared to conventional RO systems. The Multiflo™ pretreatment process and the chemical storage components are the primary factors in limiting mobility.</p>
O&M considerations	<p>Substantial monitoring and control required for flow rates, chemical dosing, IX regeneration, and RO pressure.</p> <p>System may require moderate oversight to ensure proper operation of the primary RO stage brine management systems.</p> <p>Level of flexibility: Highly flexible system that may readily adapt to changes in feed water quality.</p> <p>Level of robustness: TFC membranes have high pH tolerance, but cannot be exposed to feed temperatures in excess of 113°F (45°C).</p> <p>Level of reliability: RO and IX systems operate semi-continuously with automated, short duration chemical rinses or osmotic backwashing cycles (for RO).</p> <p>Types of energy required: electrical.</p>
Capital and O&M costs	Capital costs are unknown.
Pretreatment of feed water	This process includes a pretreatment step.
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	<p>No special concentrate treatment is required. High recovery rates exceeding 90% generate very minor amounts of concentrated brine.</p> <p>Sludge from the sedimentation basin requires dewatering and landfill disposal.</p>
Status of technology	Excellent – Treatment provides robust pretreatment to limit foulant loading on high-pressure membranes.
Note: 42 gallons in a barrel.	