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1. ENVIRO WATER MINERALS COMPANY'S FULL RECOVERY DESALINATION®

2019 Case Study (Hightower, et al. 2019)

Management Approach: Concentrate Resource Recovery
Committee Member(s): Mike Hightower and Berrin Tansel (provided SI units)
Project Contact(s): Hubble Hausman, Principal, Enviro Water Minerals Company, Inc. ("EWM") , Houston, TX, hubble@envirowaterminerals.com
Project Name: Installation of EWM's Full Recovery Desalination® Technology
Project Location: El Paso, Texas, adjacent to Kay Bailey Hutchinson Desalination Plant
Desalination Process: Reverse osmosis (RO), nano-filtration (NF), electro-dialysis reversal (EDR), ion exchange (IX), electro-dialysis bipolar membrane (EDBM), and precipitation

WTP Information:

- Rated Capacity: 3 MGD (11.4 x 10^3 m^3/d)
- Max. Concentrate Flow: 1.3 MGD (4.90 x 10^3 m^3/d)
- Brackish Blend Water Flow: 1.3 MGD (4.90 x 10^3 m^3/d)
- Typical Potable Water Production: 2.5 MGD (9.50 x 10^3 m^3/d)
- Typical Chemical Products: Caustic soda, hydrochloric acid, agricultural gypsum, and magnesium hydroxide

Abstract
A major hurdle in inland brackish water desalination is managing the treatment concentrate. Traditional concentrate management approaches - surface or wastewater discharge, evaporation pond/mechanical concentration with landfill disposal, and deep well injection - all face environmental, cost, and sustainability issues, and highlights the need for less costly and more environmentally friendly concentrate management approaches. Concentrate resource recovery - recovering minerals and chemicals from the desalination concentrate to reduce disposal volumes and reduce costs - is one approach being actively pursued. While the approach has been technically and economically elusive, new processing approaches are making it increasingly viable.

This case study presents information on a 2.64 MGD (10.0 x 10^3 m^3/d) blended concentrate and brackish water recovery plant developed in El Paso using technology developed by EWM. The plant is located adjacent to El Paso's Kay Bailey Hutchinson (KBH) Desalination Plant and uses KBH RO concentrate and blended brackish water to produce high purity industrial chemicals and potable water. In using the EWM Full Recovery Desalination® process, Figure 1, the additional potable water made at the plant is sold to El Paso Water, while the industrial chemicals manufactured are sold to local industries to offset concentrate disposal and processing costs. Overall, the EWM Full Recovery Desalination® process increases total desalinated water recovery to 99% at this plant.

Process Design and Configuration

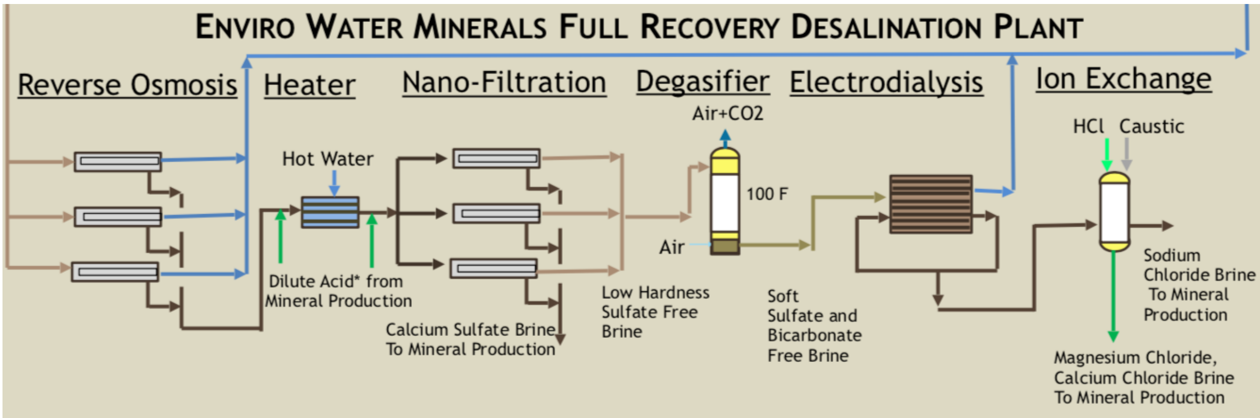

Figure 1. Schematic of Treatment System. (Source: EWM 2019)

Project background

The El Paso project began in 2013 as a result of discussions EWM had with El Paso Water Utilities (EPWU), now called El Paso Water (EPW), regarding EWM's Full Recovery Desalination® process, which is designed to cost-effectively produce potable-quality water and recover minerals and marketable products from desalination concentrate. In April 2017, commissioning of a large-scale, concentrate recovery process at their new concentrate resource recovery facility adjacent to El Paso's 31.7 MGD (120 x 10^3 m^3/d) KBH Plant in El Paso, Texas began.

After a request for proposals, EWM won the right to conduct a pilot demonstration to take concentrate from the KBH desalination plant and deliver potable-quality water in return, while creating high-purity commodity products to sell on the open market to subsidize the cost of desalination, thus improving water recovery and reducing the cost of concentrate disposal. In June 2015, after successful completion of pilot-testing, EPWU entered into a 30-year agreement to provide 1.3 MGD (4.90 x 10^3 m^3/d) of reverse osmosis concentrate and 1.3 MGD (4.90 10^3 m^3/d) of brackish ground water to the El Paso plant for processing, with the plant returning 2.5 MGD (9.50 x 10^3 m^3/d) of potable-quality water to EPW. The plant retains the minerals, products, and 0.08 MGD (300 m^3/d) of water to utilize in these products. The EPW concentrate treated represents 40% of KBH's full desalination operation and, therefore, gives the Full Recovery Desalination® process a steady design flow and redundancy for optimum operations.

Description of the solution

The full-scale concentrate resource recovery plant in El Paso, (See Figures 2 and 3), was constructed with approximately $70 M (U.S. dollars) adjacent to EPWU's KBH Plant. The plant utilizes commercially proven technologies, which have been sequenced in an innovative process order (EWM has more than 12 patents/patents pending) to achieve its results. The plant includes:

- 50,000 square feet (4,645 m2) of offices, lab, control room, and processing equipment;
- Indoor unit processes include, reverse osmosis, nano-filtration, electro-dialysis reversal, ion exchange, electro-dialysis bipolar membrane, and precipitation settling and filtration tanks;

- Outdoor unit processes including, acid/caustic concentrators, a cooling water system, a product tank farm, and truck loading stations; and a MW combined heat and power combustion turbine and steam generator for power and processing steam.

EWM's Full Recovery Desalination® process uses proven, commercially available technologies to chemically separate brackish water minerals using a refinery type approach where products are removed at different points in the overall recovery process. These chemical products are then sold in local markets to industries needing the chemical manufactured.

Based on the brackish water quality at El Paso, which has high levels of calcium, sulfate, and magnesium, and local agricultural and refinery chemical needs, the El Paso plant is operated to produce four major products including agricultural quality gypsum, magnesium hydroxide, hydrochloric acid, and caustic soda.

Data collection procedures

Operational, cost, and system performance data on the operation of the Full Recovery Desalination® process in El Paso is collected and maintained as company proprietary cost and performance information.

Permitting and regulatory overview and procedure

In July 2013, EWM contracted with Norris-Leal to develop pilot plant operations and testing protocols for the Texas Commission on Environmental Quality (TCEQ) for the potable water portions of the plant. By December 2013, TCEQ had approved the protocols necessary to begin pilot testing. Pilot testing was initiated in January 2014 and initial testing completed in April 2014. The pilot plant report was then submitted to TCEQ and approved in August 2014.

At that time, plans were started for a full-scale plant based on additional pilot testing, which was completed in June 2015. Development of full engineering plans and operational procedures for a full-scale potable water and industrial water treatment and chemical manufacturing plant were started in 2015. When completed, the plans were submitted to TCEQ for approval, which was granted in the fall of 2016.

Analyses of plant concentrate

The unique aspect of EWM's process is that there is no concentrate, all the minerals in the blended RO concentrate and the brackish water delivered to the plant are processed into industrial chemicals that are delivered to local customers. These include the agricultural sector along the Lower Rio Grande south of El Paso, and oil refineries in El Paso.

Economic evaluation

EPWU entered into a 30-year agreement with the El Paso plant to provide 1.3 MGD (4.90 x 10^3 m^3/d) of reverse osmosis concentrate and brackish ground water to the El Paso plant for processing, with the plant returning 2.5 MGD (9.50 x 10^3 m^3/d) of potable-quality water to EPW. Summary points of the agreement include:

- EPWU will purchase, at a nominal rate, the 2.5 MGD (9.50 x 10^3 m^3/d) of potable water from the El Paso plant,

- EPWU reduces by 40% the concentrate handling and disposal costs from the KBH Desalination Plant, which is a savings of approximately $1.5 M (U.S. dollars) per year,
- The plant retains the rights to the minerals and products, selling those into the local chemical market, and
- The plant uses 0.08 MGD (300 m^3/d) of the provided water in the manufactured chemical products.

Because the project is a private rather than a public effort, the terms and conditions, and costs of the project are proprietary information.

Key project lessons learned
In building and commissioning the first Full Recovery Desalination® plant, which is one of the largest desalination concentrate resource recovery projects to date, EWM learned many lessons about its process and uses that they will employ in future projects. Major lessons observed in working with a municipal desalination plant include the following.

Integrated Plants are Most Efficient. The most efficient resource recovery approach is having the entire desalination/concentrate recovery processes in one facility to avoid redundancy and the extra costs associated with building, staffing, operating, and maintaining essentially "two" desalination facilities. The concentrate recovery plant uses reverse osmosis as one of its processes, which is also used in most desalination facilities, so it is duplicative to have a separate resource recovery facility attached to a desalination plant. For existing desalination facilities needing a new concentrate management solution, this may not be an option, but where new plants are in the design stage, incorporating resource recovery into a system-level desalination technology solution is more economical from both a capital and operation and maintenance cost standpoint.

Creation of Markets. The sale of the chemicals and mineral products created by the EWM process is not just dependent on the source water quality, but also on the site location, costs of commodity transportation, types of products that can be made, product need and level of production possible, volatility of the market, and many other factors. EWM, however, worked with local users of the products to make special formulations to benefit the user, which in turn created markets for some products. EWM used chemical engineering expertise, chemical sales experience, and product user needs to assist in designing and operating the concentrate resource recovery plant. Therefore, coordination with local chemical users to match likely products with markets is required to maximize chemical product use, processing attractiveness, and overall cost-effectiveness.

Minimum Inland Plant Size. Given the technology requirements, infrastructure needs, costs of construction, cost of operation and the need to accumulate sufficient chemicals, minerals and water production to make the investment reasonable, it is clear to EWM that economies of scale definitely are important, meaning larger plants allow for better pricing and often reduced costs. This is because the chemicals being made typically are sold at commodity prices and therefore benefit from larger facility sizes. In general, assuming typical water constituents and markets, EWM has found that the minimum size of new facilities that seem attractive for resource recovery are around 5.3 MGD (20.0 x 10^3 m^3/d) for brackish waters with 2,000 – 3,000 mg/L water qualities. There could be exceptions to this size given individual factors, such as nearby desalination plants that could share a shared concentrate recovery plant. In general, EWM is currently focusing on plants of 5.3 MGD (20.0 x 10^3 m^3/d) and larger of concentrate flow.

Application of Concentrate Recovery to Different Saline Waters. As mentioned above, one of the benefits of resource recovery is the higher recovery of potable water, which is of major importance in inland applications. EWM, however, has considered applications for seawater and produced water desalination as well.

Although typical seawater desalination concentrate disposal is less costly than brackish water desalination concentrate disposal as a percentage of overall costs, seawater desalination is considerably lower potable water recovery, approximately 50% recovery. With a concentrate recovery approach like EWM used in El Paso, Texas, water recovery could be closer to 95%, making intakes smaller, smaller treatment systems, and reduced environmental issues of waste brine impacts. Furthermore, although significantly more chemicals and minerals would be produced, coastal plants could be constructed near ports for ease of transport of the produced chemicals and minerals to a wide spectrum of markets.

Waters produced from oil and gas production are typically brackish and disposed of in injection wells that have contributed to seismic activity in many states. Because of these issues, produced water resource recovery has garnered the attention of many state water, environmental, and energy agencies as well as oil and gas producers. Although the drivers and economics are different from those of a public water utility, the opportunities to reuse this water for beneficial uses and to support production of chemicals needed in the oil and gas industry is growing across the country. Therefore, applications of concentrate recycling are likely to emerge for oil and gas produced water in the future. This would help advance the knowledge, understanding, and most cost-effective applications of concentrate resource recovery.

Figure 2. Photo of the Full Recovery Desalination® plant in El Paso, Texas. (Courtesy of EWM 2019)

(a) Settling /precipitation

(b) Reverse osmosis and ion exchange

(c) Evaporator

(d) Electro-dialysis

Figure 3. Photos of selected process equipment. (Courtesy of EWM 2019).

Acknowledgements
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References

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