RECLAMATION *Managing Water in the West*

U.S. DEPARTMENT OF THE INTERIOR · BUREAU OF RECLAMATION

Evaluation of Slowsand Filtration for Reducing Costs of Desalination by Reverse Osmosis

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Summary

Why consider Slowsand (SS) Filtration for reverse osmosis (RO) pretreatment?

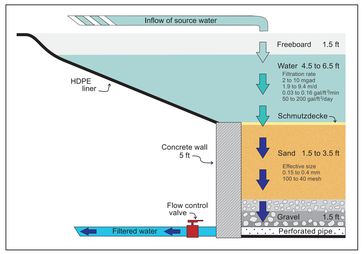
- SS has much lower costs than conventional treatment (with rapid-sand filters), microfiltration (MF), or ultrafiltration (UF).
- SS uses no chemical coagulants or coagulant aides (polymers) that can foul RO membranes.
- In combination with polyamide RO membranes, SS-RO offers lowest-cost desalination of surface waters for rural communities and cities with space for the SS filters.

What size SS filter area would the Yuma Desalting Plant (YDP) require to treat 100 million gallons per day (MGD)?

- 20 acres at a filtration rate of 5 mgad (4.7 m/d, 0.08 gal/ft^2/min).

How does SS Filtration work?

Geren Island Slowsand Treatment Facility. Salem, Oregon



How do we clean SS filters?

- Clean the top 1-inch depth of sand by in-place washing or by removing it with hand shovel or mechanical scraper for storage, washing, and reuse.

Geren Island Slowsand Treatment Facility. Salem, Oregon

How long does the SS filter operate between cleanings?

- Based on 2006 pilot tests, at a 5-mgad filtration rate:
  - For Colorado River water at Yuma, AZ, about 125 days with a rapid-sand "roughing filter" (RF) and 25 days without RF.
  - For YDP brackish (3,000-mg/L-TDS) water, about 97 days with RF and 15 days without RF.

How do we know it works?

- In 2001 - 2002, Reclamation conducted a successful SS-RO pilot test in Marana, AZ.
- In 2006 pilot tests at Reclamation's Water Quality Improvement Center (WQIC) in Yuma AZ:
  - On SS-filtered Colorado River water and YDP brackish source water, polyamide RO elements operated with little or no fouling.
  - For both waters, SS filtration reduced turbidity and SDI by 90 percent (see **Figures 1 & 2**).
  - For both waters, rapid-sand "roughing filters" (RFs) without coagulants reduced turbidity and SDI by 70 to 80 percent (see **Figures 1 & 2**) and extended SS filter runs by a factor of five (see **Figures 8 & 9**).

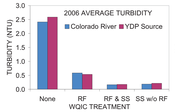


Figure 1. 2006 Average Turbidity

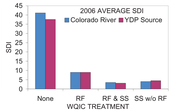


Figure 2. 2006 Average SDI

Next?

- 2007 pilot tests evaluate use of low-cost sand dredged from the Colorado River.
- Build and operate a 0.2-acre, 0.8-MGD SS filter as part of WQIC Pilot System 1.

Costs

For treating Colorado River water, Reclamation estimated in 2000 that SS filtration costs 75-percent less than either conventional treatment or MF or UF water treatment (see **Figure 3**).

For treating YDP brackish source water, CH2M Hill engineers estimated in 2005 that SS filtration may reduce YDP costs by an estimated 33 percent (see **Figure 4**).

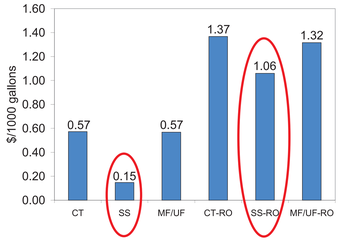


Figure 3. Estimated Colorado River water treatment costs. For treatments with RO desalination, concentrate disposal costs correspond to a Central Arizona Salinity Interceptor (CASI) pipeline to Yuma conveying 37.6 MGD from Tucson and Phoenix.

Acknowledgments

Reclamation's Science and Technology Program (Chuck Hennig, Program Manager) and Reclamation's Title I Salinity Control Research Program (Michael D. Norris, Program Manager) jointly funded this study. Burns and Roe Services Corporation built the WQIC SS pilot equipment and conducted the 2006 pilot tests.

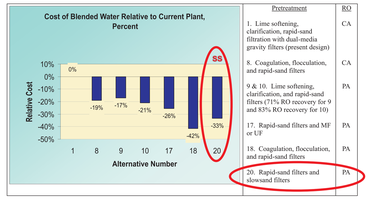


Figure 4. Estimated annualized costs relative to present plant design of the Yuma Desalting Plant. RO membrane types include cellulose acetate (CA) and polyamide (PA).

For side-by-side SS and UF systems in a water treatment plant in British Columbia:

Compared to UF, slowsand filtration provided *"three times the capacity at half the cost."*

Derrick V. Casey, Manager, Water Supply Services, Abbotsford, B.C. Canada, describing capital costs at the Norrish Creek Water Treatment Plant for two parallel treatment systems: slowsand filtration and Zenon UF. In 2001, the 90-ML/day (24-MGD) SS system had a capital cost of Can. $5 million, and the 30-ML/day (8-MGD) UF system had a capital cost of Can. $10 million.

Pilot Equipment

Figure 5. Slowsand pilot process area at the WQIC.

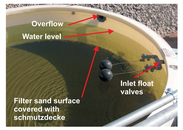


Figure 6. SS1 using roughing filter RF1.

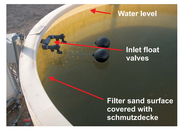
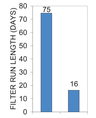


Figure 7. SS2 with no roughing filter.

2006 WQIC Pilot Tests with Colorado River Water



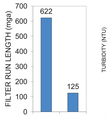
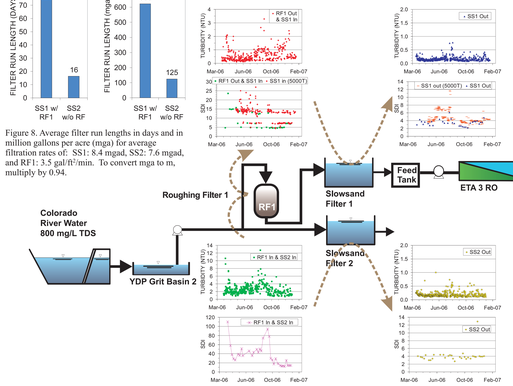
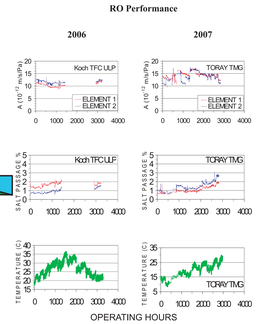


Figure 8. Average filter run lengths in days and in million gallons per acre (mga) for average filtration rates of: SS1: 8.4 mgad, SS2: 7.6 mgad, and RF1: 3.5 gal/ft^2/min. To convert mga to m, multiply by 0.94.





WQIC ETA 3 operated at 12-gfd water flux and 12-percent recovery with two Koch TFC ULP 2540 elements.
0 – 520 hours (3/11/06 – 4/24/06) used lime-softened YDP source water.
520 - 3280 hours (4/24/06 – 11/9/06) used SS1-filtered Colorado River water.

WQIC ETA 3 operated 1/3/07 – 5/13/07 at 12-gfd water flux and 12-percent recovery with two Toray TMG 2540 elements using SS1-filtered Colorado River water.

To convert A to gfd/psi, multiply y-scale by 0.0146.

2006 WQIC Pilot Tests with YDP Brackish Source Water

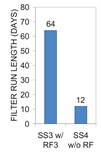
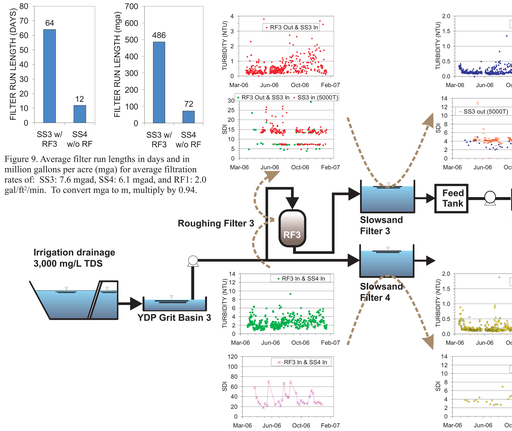
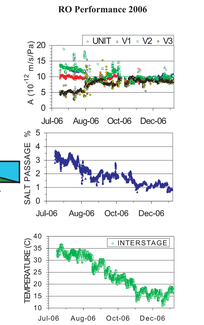


Figure 9. Average filter run lengths in days and in million gallons per acre (mga) for average filtration rates of: SS3: 7.6 mgad, SS4: 6.1 mgad, and RF1: 2.0 gal/ft^2/min. To convert mga to m, multiply by 0.94.





WQIC MU 4 operated at 12-gfd water flux and 80-percent recovery with three 7-element vessels. Stage 1 vessels 1 and 2 contain Hydranautics LFC3 2540 elements.

Stage 2 vessel 3 contains Hydranautics ESPA1 2540 elements.

To convert A to gfd/psi, multiply y-scale by 0.0146.

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