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HYDRANAUTICS

WELL WATER PFAS TREATMENT WITH LOW ENERGY MEMBRANES

Case study

Producing Low or Non-detectable PFAS Water Using Low Energy NF & RO Elements When Treating the Concentrate from a 2 Stage RO System in San Diego, CA

The PROBLEM

Per and Polyfluoroalkyl Substances (PFAS) are a family of man-made chemicals that are defined by their strong carbon-fluorine bonds that repel both oil and water, provides thermal resistance, and are resistant to degradation by natural processes. PFAS have been found to readily accumulate in animals, humans, and the environment. Current research shows exposure to certain PFAS can lead to adverse health effects such as: developmental effects or delays in children, an increased risk of some cancers, and decreased fertility among others.

On March 14th 2023, the US Environmental Protection Agency (EPA) **proposed drinking water maximum contaminant level (MCL) regulations** for six PFAS species: PFOA, PFOS, PFNA, PFHxS, PFBS, and GenX (HFPO-DA). As of June 6th 2023, the EPA anticipates finalizing the regulation by the end of 2023.

The EPA currently only lists three treatment processes that are effective for PFAS removal:

- Granular Activated Carbon (GAC)
- Ion Exchange resins (IX)
- High Pressure Membranes (NF & RO)

Both IX and GAC are media filtration technologies that are susceptible to PFAS breakthrough due to either unexpected media exhaustion or bypass. As in-line monitoring technology for PFAS is not yet available, only membrane filtration provides an in-exhaustible and stable solution to remove PFAS in drinking water applications. Membrane filtration operates as an absolute barrier and any compromises to that barrier can be tracked with increases in permeate salinity.

The currently reported PFAS treatment capabilities of NF and RO membranes in literature vary substantially based on membrane type, PFAS species, and conditions of the water treated:

- Nano-Filtration.....71% to > 99% rejection
- Brackish Pressure RO.....82% to > 99% rejection
- High Pressure RO.....82% to > 99% rejection

In August 2023, Global Water Intelligence (GWI) released an article stating new data from the EPA's UCMR5 suggests that up to **30%** of all US public water systems are non-compliant with the proposed PFAS MCLs. NF elements have a significantly lower energy demand than their RO counterparts while still providing an absolute barrier. However, it is necessary to validate that NF filtration will be able to achieve the proposed PFAS MCLs for the type of water it treats.

March 2023 EPA NPDWR Proposed PFAS MCL

PFOA	4.0 ppt
PFOS	4.0 ppt

PFNA **PFHxS** **PFBS** **GenX**	1.0 (unitless) Hazard Index

Equation

$$\text{Hazard Index} = \left(\frac{[\text{GenX}_{\text{water}}]}{[10\text{ ppt}]}\right) + \left(\frac{[\text{PFBS}_{\text{water}}]}{[2000\text{ ppt}]}\right) + \left(\frac{[\text{PFNA}_{\text{water}}]}{[10\text{ ppt}]}\right) + \left(\frac{[\text{PFHxS}_{\text{water}}]}{[9.0\text{ ppt}]}\right)$$

The SOLUTION

Country	United States
Location	San Diego County
Feed Water	Well Water *(from RO Concentrate)*
Feed TDS	9,000 ppm
Feed TOC	10 ppm
Feed total PFAS	100 ppt to 115 ppt
Array	1:1 (1M)
Recovery	17%
Flux	17 gfd

Hydranautics field tested four types of membrane elements in a pilot to compare the PFAS rejection between three different NF membranes and one low pressure RO membrane.

- PRO-XS2 *(NF)*
- ESNA1-LF2-LD *(NF)*
- ESNA1-LF-LD *(NF)*
- ESPA2-LD MAX *(RO)*

The pilot was fed by the concentrate from the current RO system at a well water municipal facility in San Diego County, California. Despite being a well water source, the feed to the pilot contained 10 ppm TOC due to natural organics that had leached into the well from the time the land had been used for agriculture.

The pilot itself was a 1:1-1M array where each element listed was installed and operated at about 17 gfd and 17% recovery for 10 days. PFAS water samples were collected after the first 24 hours of runtime and after ten days of run time. Each sample was analyzed using EPA Method 533 for PFAS concentrations. The PFAS detection limit for the collected permeate samples was 0.2 ppt.

The IMPACT

The concentrated well water fed to the test Pilot contained 11 different measurable PFAS compounds. When combined, the total PFAS in the feed was found to fluctuate between 100 ppt to 115 ppt during the duration of testing.

Each of the four elements tested showed significantly reduced concentrations of PFAS in their resulting permeate. Only PRO-XS2 had detectable amounts of any PFAS compound its permeate after 10 days of stable operation as shown in the attached graph.

Any **PFAS** that could have been present **in the permeate** from the **ESNA1-LF-LD, ESNA1-LF2-LD, and ESPA2-LD MAX** elements after 10 days of operation **was below the 0.2 ppt detection limits**. As nearly all PFAS compounds were non-detectable in the permeate, an accurate PFAS rejection percent was unable to be calculated for any of the membranes tested. Instead, a minimum % PFAS reduction was calculated based on a PFAS compound's feed concentration in relation to the 0.2 ppt minimum detection limit.

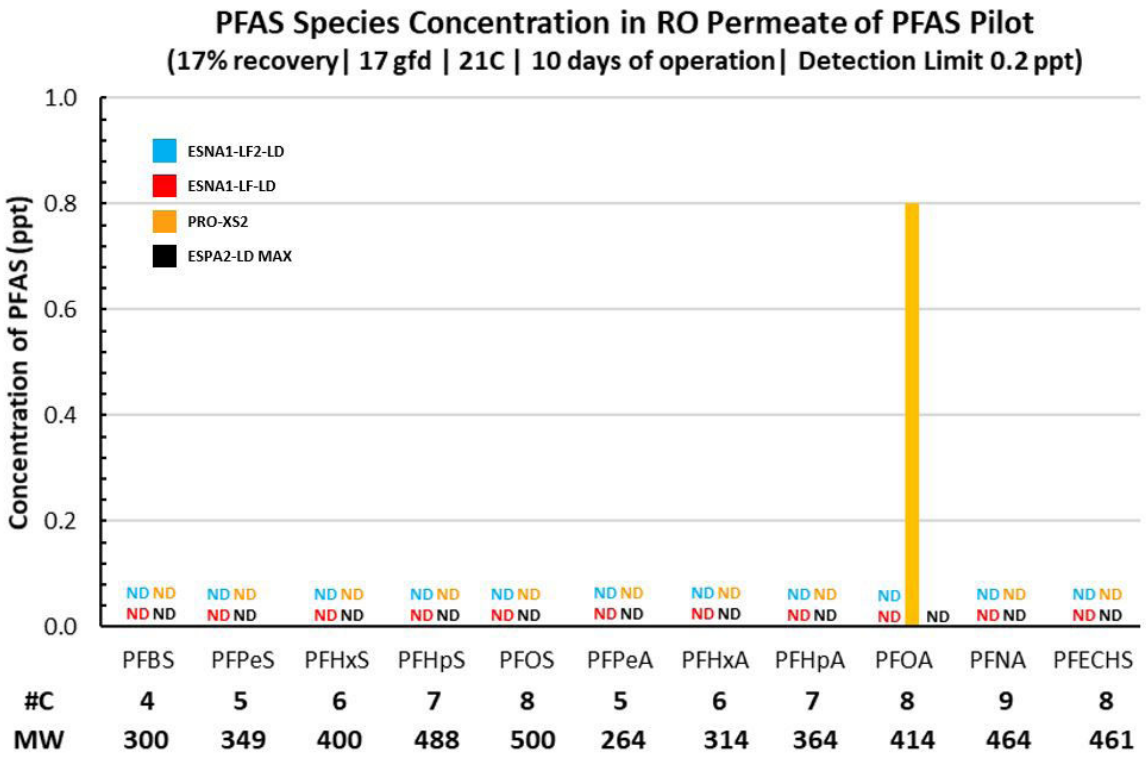
When comparing the performance results of all four tested elements, **ESNA1-LF2-LD** reduced the concentration of all of the **PFAS compounds** listed in the proposed NPDWR MCL that were present in the feed **below the detection limit of 0.2 ppt** while operating at a **60 psi lower feed pressure** than the low pressure RO element ESPA2-LD MAX.

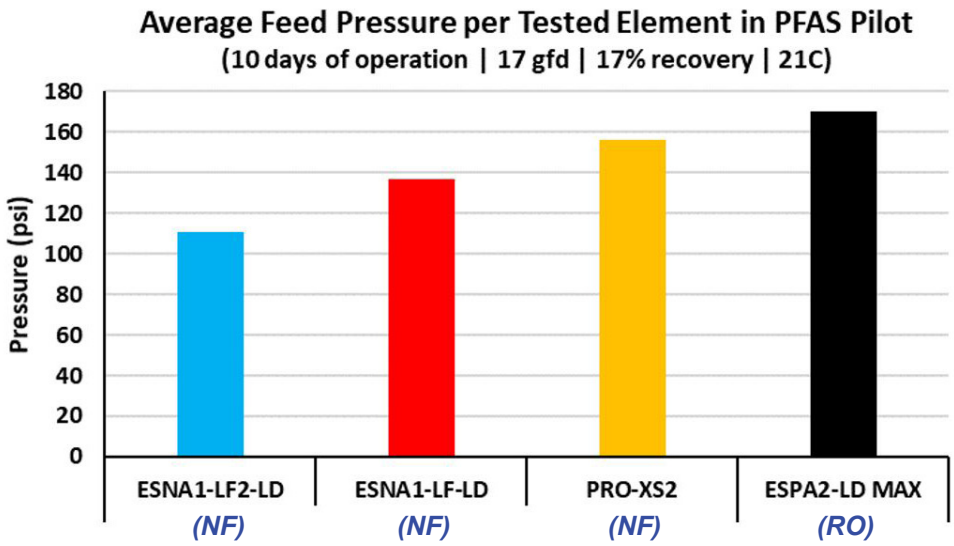
Preliminary testing has shown the NF membrane performance for PFAS rejection depends on water type, favoring surface waters or municipal waters with high naturally occurring organics. When treating waters containing high Natural Organic Matter (NOM) TOC, NF membranes are able to provide a low pressure and energy efficient alternative to RO while reducing PFAS concentrations.

Pilot's Estimated *Minimum* PFAS Reduction %

	ESNA1-LF2-LD *(NF)*	ESNA1-LF-LD *(NF)*	PRO-XS2 *(NF)*	ESPA2-LD MAX *(RO)*
PFOA	99%	99%	97%	99%
PFOS	99%	99%	98%	99%
PFNA	98%	98%	96%	99%
PFHxS	98%	98%	93%	99%
PFBS	82%	82%	58%	82%

For 2023 NPDWR Proposed Regulated PFAS Compounds assuming 0.2 ppt detection limit





For more information about Hydranautics case studies, contact us at **hy-marketing@nitto.com** or visit our website at **membranes.com**

About Hydranautics

Since our founding in 1963, Hydranautics has been committed to the highest standards of technology research, product excellence and customer fulfillment. Hydranautics entered the Reverse Osmosis (RO) water treatment field in 1970 and is now one of the global leaders in Integrated Membrane Solutions. Hydranautics became a part of the Nitto Group in 1987. Nitto is Japan's leading diversified materials manufacturer. The group offers over 13,000 high value specialty products worldwide including optical films for liquid crystal displays, automotive materials, reverse osmosis membranes for desalination and transversal drug delivery patches.

As leaders of high quality membrane solutions, we believe our commitments extend beyond manufacturing and selling our products. Our skilled staff of technicians, engineers and service professionals assist in designing, operating and maintaining a robust, reliable and efficient membrane system to meet your requirements and exceed your expectations.

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