ZwitterCo

Elevation Case Study

ZwitterCo RO Reduces Cleaning Frequency by Over 70%

at US-Based Power Plant

zwitterco.com sales@zwitterco.com

Elevation Case Study

Fast Facts

Industry:	Power Plant
Application:	Boiler feed for power generation
Location:	USA
Technology:	ZwitterShield™
System Configuration:	2 parallel trains, each 6:3:2 array and 6M
Element Type and Model:	Elevation Low Energy BWRO 8040
System Capacity:	590,400 gpd (410 GPM) 2,234 m3/d (93.1 m3/h)
Year of Installation:	2023

Key Highlights

- **Reduced CIP Frequency by 70%**
  Only 2 chemical cleanings in 12+ months vs. 7 for conventional RO.
- **Lower Cleaning Costs**
  Used generic chemicals (caustic, phosphoric acid, HCl) instead of expensive formulated cleaners.
- **No Downtime During Feedwater Upset**
  Maintained stable operation despite SDI spike from 0.93 to 4.97
- **Improved Uptime & System Reliability**
  Withstood unplanned upset without shutdown or cleaning.
- **Extended Membrane Lifespan:**
  Stable operation for 7+ months before first cleaning
- **Consistently Met Quality Targets:**
  Reduced conductivity from 230 to <30 μS/cm and removed TOC/color before ion exchange.

The Opportunity

Water is a critical component of power generation – in conventional power plants, water is heated to transform it into steam, which then spins the turbines that produce electricity. To meet their high-water demands, plants are often located near rivers, lakes, or oceans, where surface water contains impurities like suspended solids, bacteria, algae, and natural organic material (NOM). These must be removed before make-up water enters the boilers. Pretreatment methods are used to remove larger floating and suspended materials, reverse osmosis (RO) membrane elements are implemented to remove dissolved solids, and usually, downstream ion exchange systems are used to polish the water further before it is sent to the boilers. Despite pretreatment, surface water's high organic and biological content may cause organic fouling and biofouling in RO systems. Organic deposits on membranes may lead to a decline in RO system performance, requiring chemical cleaning. The more fouling the feed stream, the more frequent cleanings are required, leading to increased downtime, shorter membrane life, and higher operating costs.

The Challenge

A power plant in the Northwestern U.S. treats organic-laden river water for boiler make-up. Despite extensive pretreatment, organic fouling remains a challenge, causing frequent maintenance and downtime and ballooning operating costs. The plant performs chemical cleanings monthly or more and replaces RO elements every 12–18 months when they no longer meet water quality or production objectives. The site had also experienced a major fouling event that caused unexpected downtime which forced it to rent mobile units to keep the power plant running, costing tens of thousands of dollars in operating expenses. Because reliable water production is critical for power generation, the plant aimed to find a more economical solution that could reduce the frequency of chemical cleaning, improve system uptime, and extend membrane lifespan. The feedwater characteristics of the RO system are listed in Table 1.

Parameter	Value
Conductivity	230 µS/cm
Total hardness (CaCO3)	0.74 mg/l
Sodium (Na)	45 mg/l
Chloride (Cl)	12 mg/l
Sulfate (SO4)	52 mg/l
Silica (SiO2)	6.7 mg/l
Total Alkalinity (CaCO3)	28 mg/l
Total Organic Carbon (TOC)	3 mg/l
Color	< 2 Pt-Co
Silt Density Index (SDI)	< 1
pH	7.7
Temperature	95°F

Table 1: *Feedwater characteristics of RO system*

The Solution

ZwitterCo supplied its ZwitterShield™-powered Elevation Low Energy BWRO 8040 membranes for this installation. ZwitterShield is an additive membrane technology using ZwitterCo's patented zwitterionic chemistry that may be bonded to proven membrane chemistries to equip them with a permanent barrier to irreversible organic fouling. At this site, river water undergoes a rigorous pretreatment process before reaching the RO system as illustrated in the process flow diagram (PFD) below. It first passes through coagulation, hot-lime and zeolite softeners, chlorination, multimedia and cartridge filters, and dechlorination. This multi-step approach effectively removes larger particles, suspended organics, and reduces hardness. However, with 3 mg/L TOC and <2 Pt-Co color remaining, traces of natural organic matter persist. While these levels meet most membrane manufacturers' guidelines, they explain the site's history of frequent high-pH cleanings to maintain RO performance. To ensure a steady supply of high-purity water, the site runs two parallel RO trains, each a three-stage (6:3:2) array with 66 elements per train. Operating at 73% recovery, each train produces around 205 gpm (46.6 m^3/h) at a flux of ~11 gfd (~19 lmh). The polished permeate then flows to ion exchange beds to further reduce conductivity before feeding the downstream boilers.

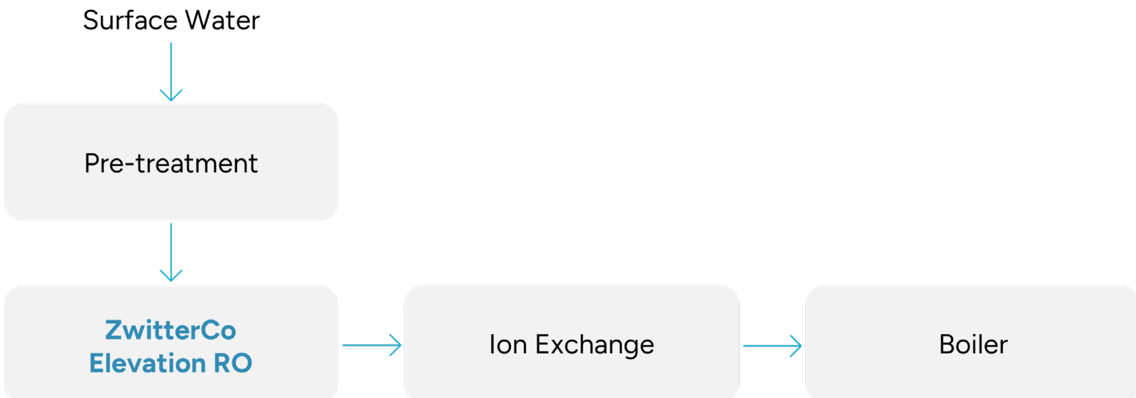

Figure 1: *PFD of the Boiler Feedwater System at the U.S. Power Generation Plant*

Results & Benefits

In October 2023, the site replaced one RO train with a new set of conventional fouling-resistant RO elements. In November 2023, the site replaced the second train with a new set of ZwitterCo Elevation RO elements, providing a great setup for a side-by-side comparison.

During the installation period, the plant experienced an unplanned upset - an accidental overdose of coagulant in the pretreatment process. This overdose caused the feed to the RO system to increase in SDI, climbing from 0.932 to 4.97 as shown in Figure 2.

Figure 2: Coupons showing the SDI increase from a coagulant upset in November 2023, confirming higher contaminant levels in the RO feed.

This increase in SDI confirmed the RO feedwater now contained a higher level of contaminants and immediately caused the conventional RO elements to foul. When the upstream upset hit in November, the conventional RO elements struggled; total permeate flow dropped as illustrated in figure 3, and differential pressure spiked in the first stage as shown in figure 4. To restore performance, the plant shut down the train for chemical cleaning three times - once immediately and twice more in December when the first attempt fell short.

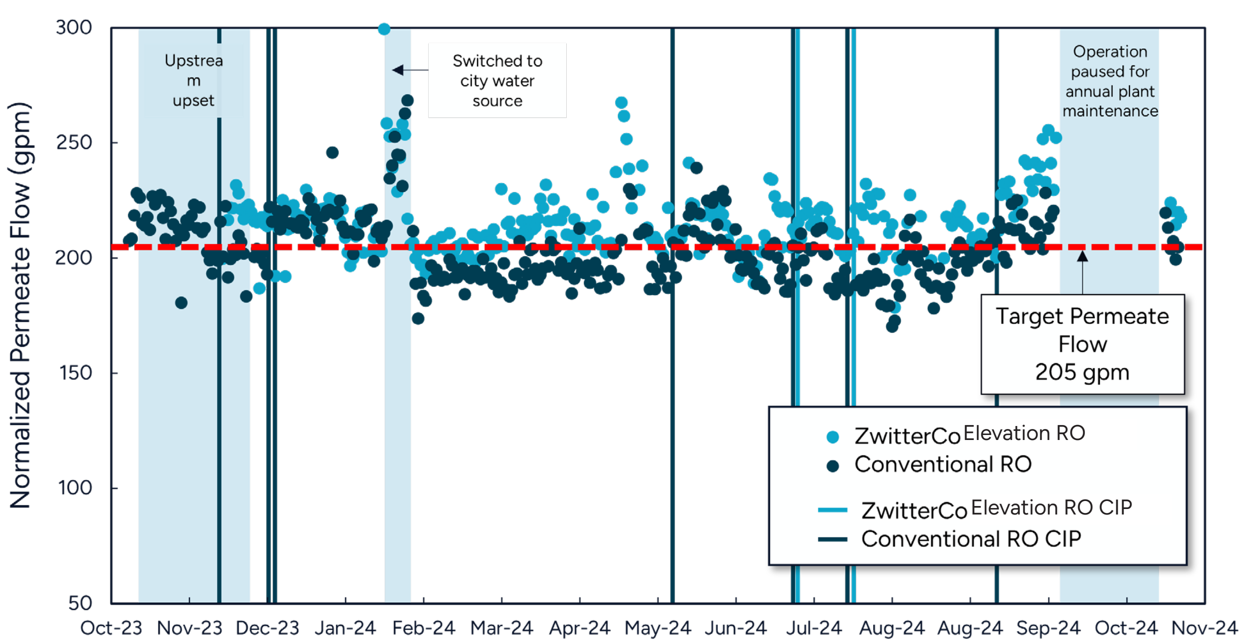

Figure 3: Normalized permeate flow over one year for ZwitterCo Elevation RO (light blue) and conventional RO (dark blue). ZwitterCo Elevation RO showed more stable performance, needing only two chemical cleans versus seven for conventional RO.

On the other hand, the ZwitterCo Elevation RO elements in the second train were unaffected by the upstream upset and continued to offer stable operation with minimal increase in differential pressure. Due to their consistent performance, the ZwitterCo Elevation RO elements did not require chemical cleaning.

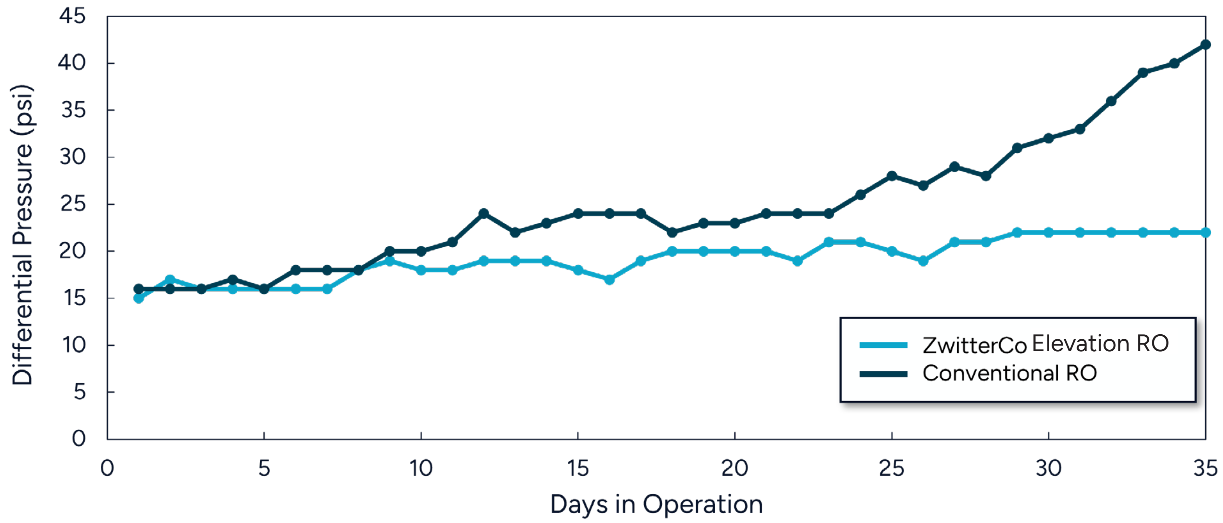

Figure 4: *First-stage differential pressure of both RO trains during and after the upstream upset. While conventional RO elements saw a significant increase, ZwitterCo Elevation RO elements remained stable with minimal change, indicating lower susceptibility to fouling.*

This allowed the plant to benefit from reliable operation and zero system downtime during this unplanned system upset. By the end of November, the plant could control the upstream upset and regain stable performance in both trains. In late January, the site briefly switched to city water. Almost immediately, the permeate flow for both conventional and ZwitterCo Elevation RO membranes surged likely due to the cleaner city water compared to their usual river source.

When they returned to river water, operations remained stable for months, but the conventional RO membranes saw a decline in normalized permeate flow from about 210 gpm (50 m^3/h) to 190 gpm (43.2 m^3/h). This led to a chemical cleaning of the conventional train in May, which was effective, but another was needed in June. Around the same time, the ZwitterCo Elevation RO membranes also experienced a gradual decrease, prompting their first chemical clean after 7+ months of operation. Notably, the site used expensive formulated cleaners for conventional RO elements but only generic chemicals (caustic, phosphoric acid, and hydrochloric acid) for ZwitterCo Elevation RO, enabling additional cost savings for the site.

Another chemical cleaning was performed on both trains in July. This time, the ZwitterCo Elevation RO elements were cleaned at pH 12 and 95°F (35°C), improving effectiveness over the previous clean at pH 11 and 86°F (30°C). From there, another cleaning was performed on the conventional RO elements in September, and not long after that, the system was shut down for its annual system maintenance. Over a year of operation, both trains consistently met the site's <30 μS/cm permeate quality target as illustrated in figure 5, ensuring optimal downstream ion exchange performance.

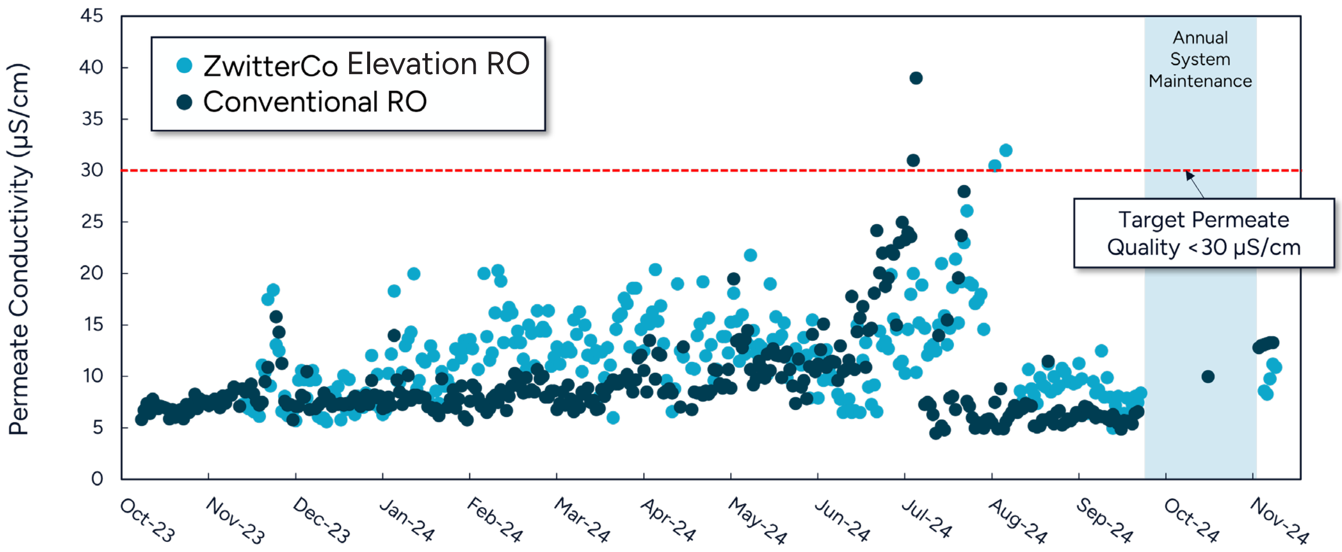

Figure 5: *Conductivity data for over 1 year of operation. As shown, both trains consistently met the plant's permeate quality requirements of <30 µS/cm*

After 1+ years of operation, the conventional RO elements required seven chemical cleans, while ZwitterCo Elevation RO elements needed only two-a 70% reduction in cleaning frequency. The ZwitterCo Elevation RO elements also withstood an unplanned system upset without maintenance, proving their resistance to organic fouling. This led to less downtime, lower operational costs, and savings from using generic instead of formulated cleaners. Overall, these membranes demonstrated that systems treating high-fouling surface waters can significantly cut cleaning needs, extend element life, and reduce costs, making water treatment more economical and reliable.

ZwitterCo Elevation Low Energy BWRO membranes delivered a significant operational advantage for a U.S.-based power plant treating challenging river water for boiler feed. The membranes not only maintained performance through a major upstream upset but also reduced chemical cleaning frequency by over 70%-cutting OPEX and downtime. The RO system consistently reduced feedwater conductivity from ~230 µS/cm to below the site's target of 30 µS/cm, while effectively removing residual organics (TOC) and color before the ion exchange system. This ensured high purity permeate, protected downstream equipment, and supported uninterrupted power generation. By resisting organic fouling and enabling the use of generic cleaning chemicals, ZwitterCo Elevation RO membranes extended element life and simplified maintenance-proving to be a cost-effective, high-performance solution for surface water applications where reliability is paramount.

ZwitterCo

ZwitterCo is the global leader in membrane solutions for challenging separations, helping industries treat complex wastewater, purify water for reuse, and maximize efficiency in food processing applications. The company leverages its breakthrough zwitterionic chemistry to build membranes with unprecedented fouling resistance, overcoming the longest-standing limitation with conventional filtration. Manufacturers in more than 20 countries across food and beverage, agricultural, and industrial sectors rely on ZwitterCo's membrane solutions to achieve their most ambitious sustainability and growth targets.

ZwitterCo
12 Cabot Rd, Suite B
Woburn, MA 01801

Contact Us
zwitterco.com
sales@zwitterco.com