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WHITE CLIFFS MUTUAL DOMESTIC WATER USERS ASSOCIATION REVERSE OSMOSIS WATER TREATMENT

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This morning I'd like to present to you a success story of the first water system in the state to use desalination in their drinking water supply: the White Cliffs Mutual Domestic Water Users Association (MDWUA). The White Cliffs MDWUA is a small water association just east of Gallup. They have about 40 connections, about 40 families, and serve 150 residents. It is a low-income Navajo community and their demand is about 15,000 gallons per day. Before the desalination facility was put into use, the majority of the residents purchased bottled water for drinking and cooking because of the poor quality of their water supply. Also, most residents have water softeners at the same time to treat the water for use within their households.

The water quality of existing wells is about 5,000 uS/cm of E-cond., total dissolved solids (TDS) of 3,400 mg/L, pH of 7.9, hardness of 172 mg/L, and sulfates of 1,720 mg/L. You can see this is not very palatable drinking water. Their water supply comes from three groundwater wells. Two wells are used primarily and are at 5,200 uS/cm with high TDS and high conductivity. Well 3 is used only occasionally because of its low production rate. The TDS and conductivity of Wells 1 and 2 tend to vary throughout the season depending on how much and how long they are being pumped. The wells pump into a storage tank that is gravity fed into the system. Occasionally the wells experience a sediment problem when they get plugs of sand and turbidity increases in the water supply.

About a year ago, the new owner of the water supply realized something needed to be done to make things better for the residents and he wanted to reduce the expense the customers were experiencing by purchasing bottled water and using water softeners. Given the high level of total dissolved solids and the variable water quality in their supply, along with a concern about arsenic in their water system, they decided to have their water supply treated. They came to us with their problem and we decided to use reverse osmosis to reduce their TDS as well as to reduce the arsenic. We found reverse osmosis showed excellent TDS reduction, greater than 80 percent recovery as well as a reduction in arsenic. This was done at a reasonable capital cost and a reasonable overall cost of water.

For those of you unfamiliar with reverse osmosis (RO), let me describe the process. In the natural system there is a process called osmosis where fresh water permeates through a semi-permeable membrane, such as a cell wall in plants and animals, into a more salty environment. It does so through osmotic pressure. If you go the other way, you reverse that osmotic pressure by putting a salty solution through a semi-permeable membrane to get fresh water. Figure 1 depicts these two processes.

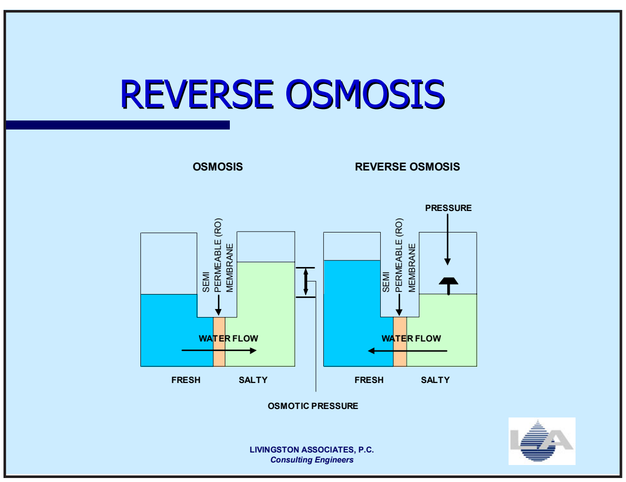

Figure 1.

Typically in a RO membrane situation, you have the RO membrane that is represented by the yellow line in Figure 1. That is a plastic material, a polyamide material. The mechanisms for removing salts or minerals out of the water are a number of different processes but the primary one is called a screening process where the holes in the membrane surface are small enough to let water molecules pass through, but salts and minerals, being large, cannot pass through the membrane. On the feed side of the membrane, which is where you are applying the water supply, you force the water through the membrane under high pressure and you get what is considered drinking water quality (similar to bottled water) out of the permeate side of the membrane. On the feed side of the membrane, the concentrated salts remain. This is a general description of how the reverse osmosis process works. Some terms that you may need to be familiar with:

1) Feed water is the supply water to the RO membrane system
2) Permeate is the drinking water quality that comes out of the low pressure side of the membrane, the drinking water.
3) Brine, or the more widely accepted term, concentrate, which has a less negative connotation to it than brine, is the terminology for the rejected salt stream.
4) Recovery is the amount of the initial water you get back as product water. If you put 100 gallons of water through the system and you get 75 gallons of treated water back out, the recovery is 75 percent.
5) Rejection is the percentage of the salts that do not pass through the membrane and are rejected by the membrane.

Figure 2 shows a typical RO system. You would pump your groundwater well water through another high pressure pump and send it through some pretreatment before it goes to the RO system. Typically, sediment filtration removes any sediment that could potentially plug the membrane. You would feed some chemicals to the feed stream, either acids or scale inhibitors, to pre-treat the water. The water is then sent through the RO assembly and the permeate comes out the other side. The permeate then is often treated with a buffering chemical and the pH is adjusted. It then goes to the distribution system where the concentrate would come off for disposal. You might also have a bypass line that would pass around the treatment process and blend back into the permeate because you might not necessarily want to supply the system with “bottled water” quality water. The bypass will blend in some untreated water to get the salt level or mineral content back up to an accepted level, thereby increasing the overall recovery of the RO system.

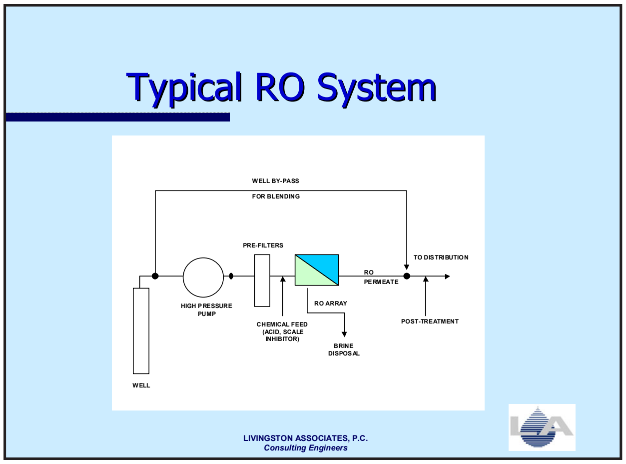

Figure 2.

Figure 3 shows what a typical small RO "Skid" looks like. In this particular case, you can treat about 30 gpm through the skid. This skid has six tubes that house the 18 reverse osmosis elements. This is set up in a 2:2:1:1 array, which I will talk about in a minute. The RO elements are 4" x 40" and each one of the RO tubes or housings will hold three elements. It has a Clean-in-place (CIP) System that is very operator friendly and low-tech type controls that are also easy to operate. It is not a very complicated or big system.

Figure 3. Typical Small RO "SKID"

The typical 2:2:1:1 RO array (Figure 4) is used for high recoveries. The feed water comes in and is split between the first tubes 1 and 2, and the permeate (or drinking water) comes off and is collected in the permeate tube. Coming out of the first two tubes is the concentrate that then gets fed as feed water into the next set of tubes, so you are continually retreating the concentrate until you get the desired water quality. Once again, the permeate comes off from tubes 3 and 4 and is collected; then the concentrate comes back out as feed water into tube 5; the concentrate comes out and is finally fed into tube 6 resulting in the final concentrate that is then disposed. The final permeate is collected and blended from all the tubes.

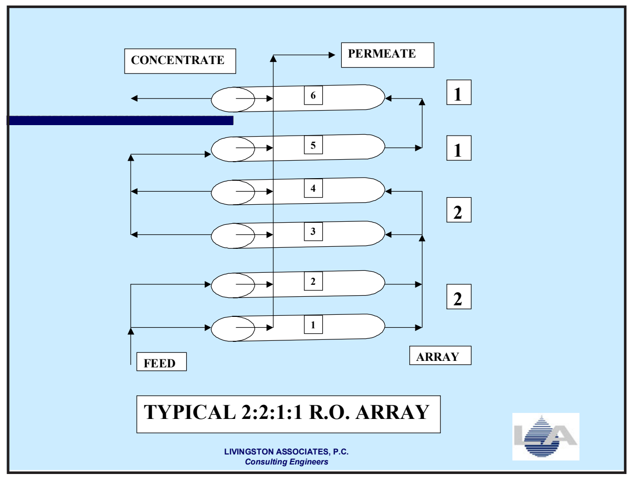

Figure 4.

Figure 5 shows Patrick, the operator of the White Cliffs RO Plant, taking data. He doesn't spend a lot of time at the plant, but does take data on a daily basis. You can see that this is a small plant and a building has been built to house the RO skid.

Figure 5. White Cliffs RO Plant

So how does the system perform? The TDS went from about 3,400 mg/L to less than 150 mg/L. It is operating at a feed pressure of about 115 psi, which is a low feed pressure for brackish water. The feed flow is at 12 gpm and the product flow is at about 10 gpm and is unblended; they use a straight permeate. The concentrate flow is at about 2 gpm and their recovery from the system is at 85 percent with the overall salt rejection of about 95 percent. This system performs very well.

Figure 6 shows a graph with the conductivity of the feed water, which is about 5,000 and product water of about 200, with the concentrate at about 15,000 or so. You can see where the salts were removed and where they were collected in the smaller stream. The product water shows a tremendous reduction of TDS and minerals in the water. The water did need to be pre-treated before the RO array and a scale inhibitor was added to control the saturation levels to allow for a higher recovery in the water. Pre-filtration was used through some five-micron filters to reduce the silt density index and any colloidal material that would be in the water so that the membranes would not plug up on the front end.

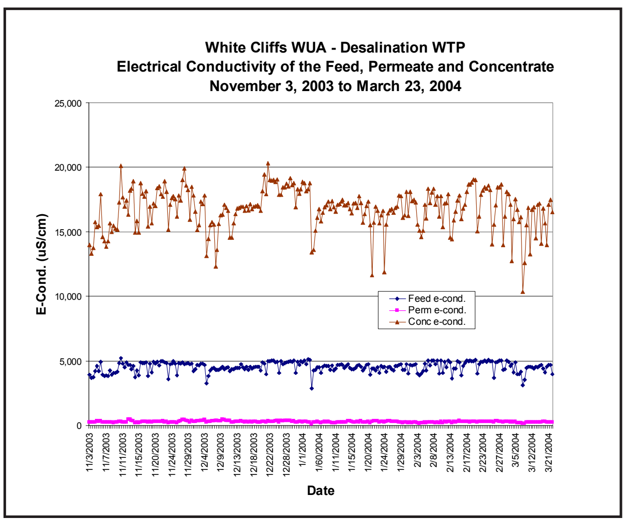

Figure 6.

Membrane scaling is really what controls what you can obtain from an RO system. If you think about a glass of tea (and I like to use this example because it is very descriptive), and pour a package of sugar into it and stir it, the sugar disappears. Then you add another package of sugar and if you are like some of us, you keeping adding sugar until the sugar doesn't dissolve anymore and it accumulates at the bottom of the glass an inch deep, and then you quit adding sugar. What happens is that the tea has been saturated with sugar and can't hold anymore so it stays on the bottom or it precipitates out and doesn't allow any more sugar to be dissolved into the tea. This is similar to what happens in an RO system when you get to the final stage: that final last tube #6 and all the salts that have been concentrated in the stream as feed. If you go beyond the saturation of those minerals, it will precipitate and you can get scaling on the membrane surface. This particularly happens with calcium sulfate and calcium carbonate, and it would cause scaling on the very last set of membranes. This will cause the operating pressures to increase and your recoveries to decrease.

RO membranes are cleaned with a low pH (pH 3-4) cleaner to remove scale build up in the tail-end elements. The high pH (pH 10-14) cleaner is used to remove any organics or colloidal fouling in the front-end of the system. Cleaning takes place at 6-month intervals. This system started up last November and they are just getting ready to do a second Clean-in-Place.

So what is done with the concentrate? The electrical conductivity as I've mentioned is about 15,000 and they generate about 2,500 gpd of brine flow a day. This is being discharged into the sewer system and they are making the overall conductivity of the wastewater "whole" again. If you think about it, you are taking high TDS water, treating it to basically bottled water quality, and that water goes through to the residences. There is very little landscaping to speak of, so the water is used almost exclusively for internal domestic use. That water comes back out as domestic waste and the RO concentrate is put into the sewer. When you combine it back again, the overall TDS is almost the same as it was when they started the process. Actually, they are finding that in some cases, the overall salt balance is less because many people are now off of their water softeners and the regenerate from those softeners was where the extra chlorides got into the wastewater stream. Treated effluent is sent into an evaporation pond where the wastewater is disposed of. The evaporation pond uses natural evaporation to dispose of the discharge and every so often, a series of sprayers are used to enhance the evaporation.

Figure 7 shows the disposal pond with the sprayers operating. Currently, the wastewater treatment system is being upgraded and they may decide to split the

Figure 7. Concentrate Disposal

streams and do something beneficial with the concentrate from the RO system.

The capital costs for this project was about $60,000, which included the complete RO system, the building, and a storage tank. That comes to about $2.50 per gal/day capacity for the installed plant. Operational costs amount to about $2.31/1000 gals, with most of that attributable to power costs of $1.89/1000 gals. The power cost is an estimate because they combine the power for the supply wells with the power used at the treatment plant. They don't have separate meters for each.

Patrick, the operator, spends about a half an hour a day at the plant checking the chemical levels in the scale inhibitor tank and recording data for that day. He comes back in the evening and checks the readings again. The estimated life of the membranes is about five years with proper care and cleaning performed at 6-month intervals.

The White Cliffs MDWUA is to be congratulated. They recently were awarded for having the best tasting drinking water in New Mexico by the Rural Water Users Association at their annual conference in March. The association is very pleased that they have done something right and that the residents are happy with their water. I have been told that water use is starting to increase because the residents are so happy with it – I guess this is to be expected. This is a success story for White Cliffs and they are now looking at possibly expanding and bringing in another system.

Thank you.