AQUA EWP

**1326 North Trinity**
**San Antonio, TX 78207**

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# Test Report Frac/Produced Water

September 2012

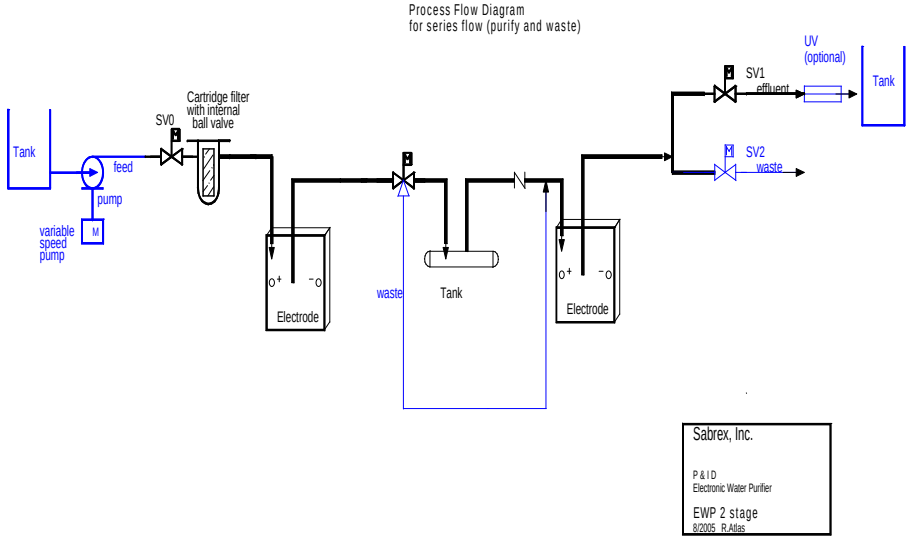
A test was run in 2012 using model P-6 four stages in series. The test was run at 900 LPH (approx 4 GPM, 135 BPD). The objective was to treat the water by removing the TDS from 10,000 mg/l to less than 1,000 mg/l CDO's and BOD's to zero, so it could be used for agricultural use.
The frac/produced water was from a customer site in the Eagle-Ford Shale area and is a result of frac water from exploration and produced water from existing wells.

The test results are as follows

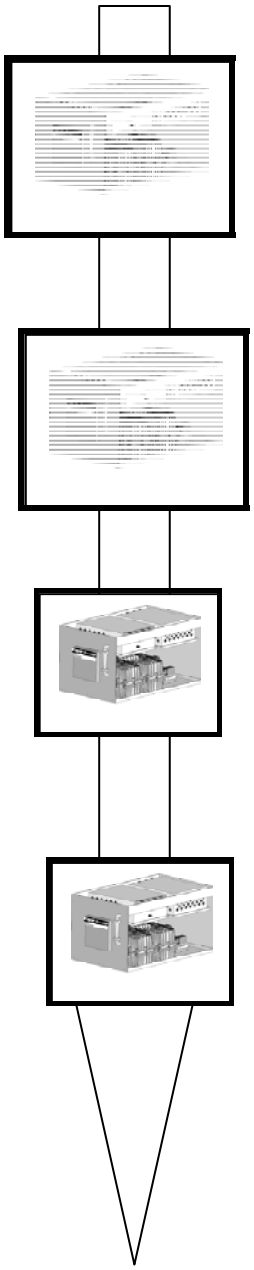
**Summary**

| Contaminants | Feed Concentration Mg/l | Purified Effluent Concentration mg/l | Acceptable limits |
|---|---|---|---|
| TDS mg/l | 10,500 | 750 | 1,000 |
| Recovery | 75% | | |
| Waste TDS mg/l | 44,000 | | |
| COD mg/l | 3,500 | 0 | |
| BOD NTU | 1,250 | 0 | |
| Power Used kwh/m3 | 2.5 | | |

The complete water analysis in included.



Series Process



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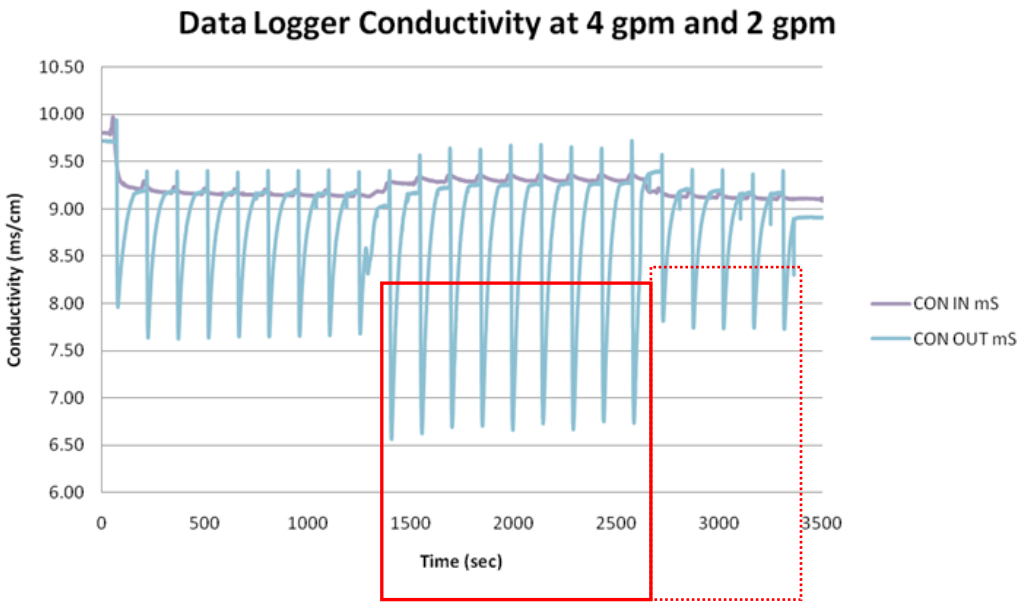
The purification curve is as follows




Purification Cycle

regeneration cycle

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**How does it Work?**

EWP technology is classified in a technology space called Capacitive Deionization (CDI). CDI has been around since 1950. The technology started to be refined in a 25 year period from 1980 by approximately 12 inventors. It's just that EWP has re-defined how CDI should operate with hundreds of installed systems around the world in both consumer, commercial and industrial applications.

Various Dissolved salts and Silica in water are the major components of TDS (total dissolved solids). These dissolved salts need to be removed on many applications, or they will form deposits and affect equipment performance. (Figure 1)

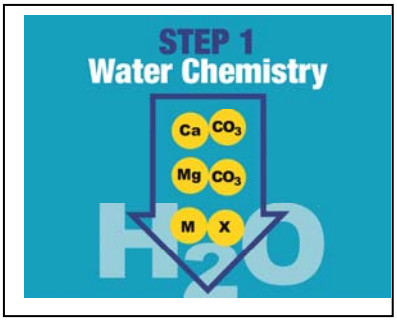


**Figure 1**

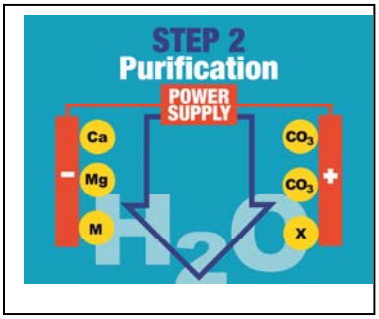


**Figure 2**

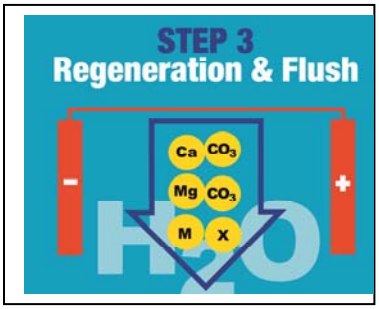


**Figure 3**

The Electronic Water Purifier makes patented technology available to generate DI quality water by removing these dissolved salts electronically.

Electrodes used are made from activated carbon that has an ion selective coating and a conductive material. When these electrodes are layered using a DC power supply, the individual electrodes are charged with different polarities. The dissolved salts in the water have polarity charges and are attracted to the opposite polarity of the electrode, thus removing the dissolved salts from the water. These dissolved salts are adsorbed though a process we call electrochemical diffusion" through the coasting and onto the activated carbon electrode surface creating the pure water. (Figure 2)

When sufficient dissolved salts are deposited on the electrodes, the electrodes are regenerated initially by shorting the electrodes to ground. The contaminants fall off the electrode in the same chemical form as was removed. After the regeneration, the waste at 2 times the original concentration is discharged through a valve. The waste is discharged to a drain. (Figure 3) Upon completion of this cycle, the polarities are reversed for normal operation.

When cells are configured in series, there is a 4 log reduction in pathogens per stage and if the COD's are dissolved organics such as is the case with organic acids, the COD's are reduced also.

**Process Description**

The EWP uses a capacitive deionization principal to remove dissolved ions from water. The device consists of multiple layers including chargeable electrodes or layers that work in response to an applied DC potential (1 VDC). Each electrode on the device contains a conductive surface sandwiched between layers of activated carbon. A non-conductive spacer material separates the plates from each other. These electrodes are alternately connected to the two sides of a DC power supply via appropriate connecting leads.

The device works on the principles of capacitive deionization to purify water, via application of a low voltage DC potential to attract and discharge ions on the electrode surface. The high surface area carbon electrode layers attract and hold ions from a solution on its surface, flowing through the device. The positive ions are attracted to the negatively charged plate (anode), and the negative ions are attracted to the positively charged plate (cathode).

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Eventually, all the charged sites are filled and the device must then be regenerated by discharging the irons from the carbon surfaces. This is achieved by an appropriate combination of flow, shorting of the capacitor and reversing the polarity of the applied DC potential. Once a substantial amount of the new displaced ions are flushed into the waste stream, after a fixed length of time, the unit begins to charge once again by attracting ions from the feed solution under the influence of the reverse potential. This action then begins a service cycle that last 4 minutes.

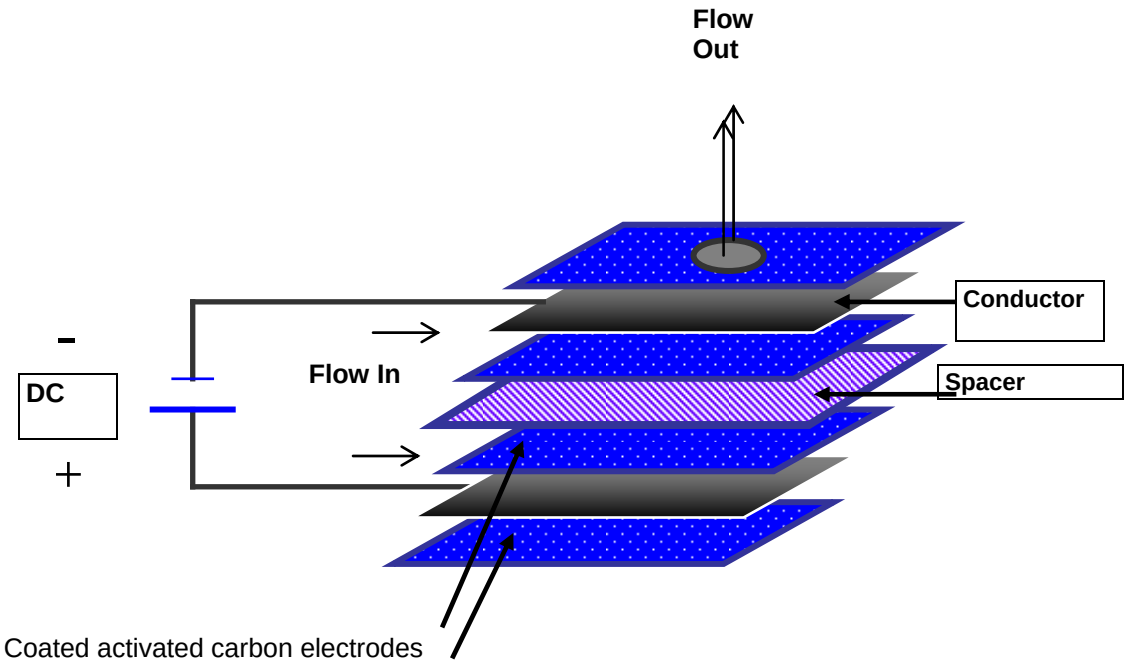


**Figure 1:** Cell Construction Diagram

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**High Salinity Model --test on diluted frac/produced water mixture**

| Analyte | Units | Feed | Purify | Waste | 2nd stage Purify | 2nd stage Waste | 3rd stage Purify | 3rd stage Waste | 4 stage Purify | 4 stage Waste |
|---|---|---|---|---|---|---|---|---|---|---|
| Alkalinity, Total as $CaCO_3$ | mg/L as $CaCO_3$ | 150 | 150 | 150 | 75 | 400 | 38 | 525 | 8 | 625 |
| $HCO_3$ | mg/L | 180 | 180 | 180 | 45 | 630 | 11 | 743 | 5 | 765 |
| $CO_3$ | mg/L | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| OH | mg/L | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| pH | - | 7.7 | 7.3 | 8 | 4 | 20 | 2 | 26 | 1 | 30 |
| Calcium | mg/L | 176 | 34 | 460 | 9 | 545 | 2 | 566 | 0 | 572 |
| Magnesium | mg/L | 750 | 130 | 490 | 33 | 815 | 8 | 896 | 2 | 918 |
| Sodium | mg/L | 5,835 | 2,312 | 15,881 | 1,156 | 19,734 | 578 | 21,661 | 231 | 22,817 |
| Potassium | mg/L | 273 | 67 | 685 | 34 | 797 | 17 | 853 | 7 | 886 |
| Strontium | mg/L | 3.5 | 0.8 | 9 | 0 | 10 | 0 | 11 | 0 | 11 |
| Barium | mg/L | 0.08 | 0.02 | 0.03 | 0 | 0 | 0 | 0 | 0 | 0 |
| Iron | mg/L | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Silica | mg/L | 0.006 | 0.003 | <0.001 | 0 | <0.001 | 0.003 | <0.001 | 0.003 | <0.001 |
| Boron | mg/L | <0.001 | <0.001 | 0.02 | <0.001 | 0.02 | <0.001 | 0.02 | <0.001 | 0.02 |
| Aluminum | mg/L | 0.006 | 0.02 | 0.001 | 0 | 0.001 | 0 | 0.001 | 0 | 0.001 |
| Manganese | mg/L | 0.003 | 0.003 | 0.004 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chloride | mg/L | 5,000 | 3,300 | 11,400 | 1,650 | 16,900 | 825 | 19,650 | 330 | 21,300 |
| Bromide | mg/L | <25 | <25 | <25 | <25 | <25 | <25 | <25 | <25 | <25 |
| Sulfate | mg/L | 900 | 100 | 2,500 | 50 | 2,667 | 25 | 2,750 | 10 | 2,800 |
| Nitrate | mg/L | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| COD | mg/L | 3,500 | 1750 | 9,333 | 100 | 14,833 | 0 | 15,167 | 0 | 15,167 |
| BOD | NTU | 1,250 | 550 | 3,583 | 0 | 5,417 | 0 | 5,417 | 0 | 5,417 |
| Turbidity | NTU | 0.7 | 0.8 | 0.5 | 0 | 2 | 0 | 3 | 0 | 3 |
| Total Dissolved Solids | mg/L | 10,500 | 7,500 | 21,500 | 3,750 | 34,000 | 1,875 | 40,250 | 750 | 44,000 |