

**AguaRaider, LLC  
Direct Evaporation Technology  
Wastewater Pretreatment Module  
'Clean Brine' Production**

**Introduction**

AguaRaider, LLC will integrate wastewater pretreatment module (WPM) into the AguaRaider Direct Evaporation Technology Unit (ARU) for pretreatment of wastewater to be the influent into the ARU. The WPM is intended to reduce the concentrations of total suspended solids, hydrocarbons, organics, inorganics, metals and total dissolved solids from the wastewater to be disposed of in the ARU. The purpose of the WPM is two-fold; (1) reduce the organics in the wastewater to reduce the total VOCs in the evaporated water (steam); (2) reduce hydrocarbons, metals and dissolved solids to improve evaporation efficiency and reduce fouling & deposition in the brine concentrate section of the ARU.

**Wastewater Pretreatment Module (WPM)**

The WPM process uses no chemicals, with the exception of potentially pH adjustment to achieve the results for pretreating the source wastewater to the ARU. The only waste stream is from the filtration section in the range of a few % of the total flow. The waste stream from the filtration section would be recycled to the source wastewater storage tank or with the brine concentrate stream from the ARU for disposal.

The WPM is comprised of (1) advanced oxidation section and (2) filtration section in a proprietary and patent pending process. The advanced oxidation section is the primary 'reaction' section for the WPM. The filtration section removes the resulting particulate from the treatment stream. The combined process may result in the reduction values below.

**ARU Influent from WPM**

WPM will pretreat the source wastewater to the ARU. The WPM unit, as configured will process approximately 2,000, +/- 400 barrels per day (BPD) effluent, thus providing an influent to the ARU of as much as 2,400 BPD. The volume per day of water treated and the subsequent waste stream volume will be dependent on the quality, predominantly total dissolved solids (TDS), organics, inorganics and other physical/chemical parameters of the source wastewater. The system will significantly reduce the % concentrations of parameters in produced water or flowback generated by the oil & gas producers and industrial wastewaters.

% Reduction of Organics	as much as 90%
% Reduction of Metals	as much as 50%
% Reduction of Hardness	as much as 50%
% Reduction of Oil & Grease (HEM)	as much as 90%
% Reduction of Total Suspended Solids (TSS)	as much as 90%
% Reduction of Total Dissolved Solids (TDS)	as much as 50%

Each water source will present a differing set of values that can be attained. The above values will cover a much broader spectrum of sources from different basins/ shale plays. These values above would vary based on each source water, side effect of pretreatment for that source and the individual characteristics of the source.

### Greater % Evaporation Efficiency with WPM

The ARU's % evaporation efficiency without pretreatment is limited on source wastewaters with high TDS. Integration of the WPM could increase the % evaporation efficiency by 50% or greater. The improved quality of the wastewater to the ARU will reduce the potential for fouling and deposition. The reduce metals in the wastewater to the ARU could alter the character of the deposition making it easier to 'sweep' the concentrated brine liquid solution in the brine concentrate section of the ARU. The reduced organic concentrations (both volatile and semi-volatile) could result in significantly lower stack emissions for environmental compliance.

### 'Clean Brine' Production

The concentrated brine liquid solution can be used as 'Clean Brine'. 'Clean Brine' is used during the oil or gas well drilling and fracking operations. The quality of the 'clean brine' needs to be low suspended solids, low metals, low hardness and high dissolved solids (primarily sodium and chlorides). The AguaRaider Evaporation Technology in concert with the Wastewater Pretreatment Module can produce 'Clean Brine' as a by-produce of the evaporation process. Depending on the TDS of the produced water, AguaRaider and produce the #10 Brine ('Clean Brine'). **Please note Appendix A** for a representative West Texas produced water treated with the AR Wastewater Treatment Module. The lists are parameter analytical results for the produced water Pre (prior to treatment) and Post (after the treatment). This sample's source concentration of total dissolved solids (TDS) is 99,900 mg/L. After treatment, the Post water sample contained 50,400 mg/L TDS, with the resulting TDS reduction of 49.5%. The predominate anion and cation remaining TDS are Chloride (Cl<sup>-</sup>) and Sodium (Na<sup>+</sup>). The Post results 97% reduction of Volatile Organic Compounds (VOCs) and 97% reduction of Semi-Volatile Organic Compounds. The organics will be contained in the evaporated water/steam and drafted to the atmosphere at significantly reduced concentrations. Concentrations well below the state air emissions standard limits, even in the most stringent states standards. Note Appendix A for additional parameter results with the AR/WPM.

The potential volume of 'Clean Brine' produced is directly related to the % evaporation efficiency of the ARU. If the ARU influent is 100,000 ppm of TDS, 2,400 BPD and 50% evaporation efficiency, 1,200 barrels per day of water will be evaporated as steam. The remaining 1,200 barrels per day will be the 'Clean Brine' with 200,000 ppm TDS concentration in the brine, equating to 20# Clean Brine. Adjusting the % evaporation efficiency will produce more or less volume of 'Clean Brine'.

## Summary

AguaRaider, LLC offers a sustainable solution to reduce the volumes of E&P wastewaters and produce a reusable, beneficial 'Clean Brine' for E&P operations. Integration of the Wastewater Pretreatment Module adds significant potential for the AguaRaider Direct Evaporation Technology to successfully and efficiently dispose of wastewater with high total dissolved solids, produce a high quality 'Clean Brine' and expand the technology's application in the shale basins in the U.S. The Wastewater Pretreatment Module operational configuration can deal with wastewater quality that could vary from the source or sources, with the WPM's system proprietary and patent pending process control configuration.



AguaRaider's ARU, with the WPM, can produce a 'Clean Brine' used by the O&G E&P Producers in the drilling and fracking of oil and gas wells. The 'Clean Brine' will have very low suspended solids, very low metals concentration, very low organics and high salt concentration. Depending on TDS of the source water, the 'Clean Brine' weight would be in excess of 10# brine. The jar of liquid to the far right would be the treated wastewater (Post) from which water would be extracted (evaporated) resulting in high TDS 'Clean Brine'.

## **Appendix A**

**AguaRaider (E&P West Texas {Produced Water} Test  
Pre / Post Wastewater Pretreatment Module (WPM)  
'Clean Brine' Projected Quality**



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**AguaRaider (E&P West Texas Produced Water) Test (Pre/Post Wastewater Pretreatment Module)**  
**'Clean Brine' Projected Quality**

Method: 8260B - Volatile Organic Compounds (GC/MS)

Analyte	Unit	Pre-Result	Post-Result	MDL
1,2,4-Trimethylbenzene	ug/L	103	ND	0.170
1,3,5-Trimethylbenzene	ug/L	39.3	ND	0.170
2-Butanone (MEK)	ug/L	127	12.5	2.64
4-Isopropyltoluene	ug/L	7.80	ND	0.170
Acetone	ug/L	2070	719	2.66
Benzene	ug/L	1590	ND	0.200
Carbon disulfide	ug/L	0.512	ND	0.220
Cyclohexane	ug/L	1400	ND	0.130
Ethylbenzene	ug/L	62.3	ND	0.190
Isopropylbenzene	ug/L	13.7	ND	0.330
m,p-Xylene	ug/L	238.00	ND	0.38
Methylcyclohexane	ug/L	3290	ND	0.09
o-Xylene	ug/L	106.00	ND	0.2
sec-Butylbenzene	ug/L	7.98	ND	0.17
Toluene	ug/L	1220.0	ND	0.17
Xylenes, Total	ug/L	344.00	ND	0.58

% Reduction

99.8%
99.6%
97.9%
97.8%
99.9%
100.0%
57.0%
100.0%
99.7%
97.6%
99.8%
100.0%
99.8%
97.9%
100.0%
99.8%

**Average 96.7%**

Conc in Clean Brine  
Based on 50% Evaporation Eff

Organics will remain in the steam out the AguaRadier Evaporation Unit Stack

Method: 8270D - Semivolatile Organic Compounds (GC/MS)

Analyte	Unit	Pre-Result	Post-Result	MDL
2-Methylnaphthalene	ug/L	29.60	ND	0.302
3 & 4 Methylphenol	ug/L	93.60	ND	3.23
Naphthalene	ug/L	9.25	ND	0.386
Phenanthrene	ug/L	5.08	ND	0.333
Phenol	ug/L	94.50	ND	3.35

% Reduction

99.0%
96.5%
95.8%
93.4%
96.5%

**Average 96.3%**

Conc in Clean Brine  
Based on 50% Evaporation Eff

Organics will remain in the steam out the AguaRadier Evaporation Unit Stack

# AguaRaider (E&P West Texas Produced Water) Test (Pre/Post Wastewater Pretreatment Module)

## 'Clean Brine' Projected Quality

Method: 8015B - Nonhalogenated Organic Compounds - Direct Injection (GC)

Analyte	Unit	Pre-Result	Post-Result	MDL
Methanol	mg/L	6.74	ND	4.000

% Reduction

40.7%

Conc in Clean Brine  
Based on 50% Evaporation Eff

<8.0 mg/L

Method: 300.0 - Anions, Ion Chromatography

Analyte	Unit	Pre-Result	Post-Result	MDL
Bromide	mg/L	525	242	10
Chloride	mg/L	61,000	30,400	1,400
Sulfate	mg/L	311.0	147.0	12

% Reduction

53.9%

50.2%

52.7%

Average 52.3%

Conc in Clean Brine  
Based on 50% Evaporation Eff

484 mg/L  
60,800 mg/L  
294 mg/L

Method: 200.7 Rev 4.4 - Metals (ICP)

Analyte	Unit	Pre-Result	Post-Result	MDL
Barium	mg/L	2.63	1.88	0.025
Boron	mg/L	36.9	15.60	0.02
Calcium	mg/L	1490	658	0.5
Iron	mg/L	67.4	0.275	0.05
Lead	mg/L	0.0355	0.0100	0.01
Lithium	mg/L	33.6	15.60	0.02
Magnesium	mg/L	207	95.40	0.25
Manganese	mg/L	2.18	1.8100	0.025
Potassium	mg/L	565	255	2.5
Sodium	mg/L	36,400	16,300	20
Strontium	mg/L	486	248	0.3

% Reduction

28.5%

57.7%

55.8%

99.6%

71.8%

53.6%

53.9%

17.0%

54.9%

55.2%

49.0%

Average 54.3%

Conc in Clean Brine  
Based on 50% Evaporation Eff

3.76 mg/L  
31.2 mg/L  
1316 mg/L  
0.55 mg/L  
0.02 mg/L  
31.2 mg/L  
190.8 mg/L  
3.62 mg/L  
510 mg/L  
32,600 mg/L  
496 mg/L

Method: 200.7 Rev 4.4 - Metals (ICP) - Dissolved

Analyte	Unit	Pre-Result	Post-Result	MDL
Iron, Dissolved	mg/L	52.0	0.264	0.0500

% Reduction

99.5%

Conc in Clean Brine  
Based on 50% Evaporation Eff

0.528 mg/L

Method: SM 2340B - Total Hardness (as CaCO3) by calculation

Analyte	Unit	Pre-Result	Post-Result	MDL
Hardness as calcium carbonate	mg/L	4,570	2,040	5.00

% Reduction

55.4%

Conc in Clean Brine  
Based on 50% Evaporation Eff

4,080 mg/L

# AguaRaider (E&P West Texas Produced Water) Test (Pre/Post Wastewater Pretreatment Module)

## 'Clean Brine' Projected Quality

### General Chemistry

Analyte	Unit	Pre-Result	Post-Result	MDL
Specific Conductance	umhos/cm	137	73.7	10.0
<b>HEM (Oil &amp; Grease)</b>	<b>mg/L</b>	<b>68.9</b>	<b>ND</b>	<b>1.27</b>
Acidity as CaCO3	mg/L	338	79.7	10.0
Alkalinity	mg/L	353	192	5.00
<b>Total Dissolved Solids</b>	<b>mg/L</b>	<b>99,900</b>	<b>50,400</b>	<b>700</b>
<b>Total Suspended Solids</b>	<b>mg/L</b>	<b>143</b>	<b>9.80</b>	<b>0.700</b>
Ph	SU	6.5	7.200	0.100
Ammonia (as N)	mg/L	210	120	1.20
Chemical Oxygen Demand	mg/L	2,110	438	40.0
Nitrite as N	mg/L	0.0800	ND	0.0400

% Reduction	Conc in Clean Brine Based on 50% Evaporation Eff	
46.2%		
<b>98.2%</b>	2.54	mg/L
76.4%	159.4	mg/L
45.6%	384	mg/L
<b>49.5%</b>	100,800	mg/L
<b>93.1%</b>	19.6	mg/L
42.9%	240	mg/L
79.2%	876	mg/L
50.0%	0.8	mg/L