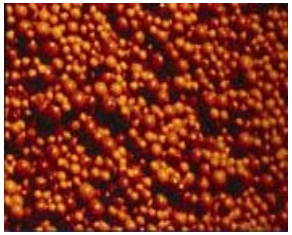
NYWEA Fall Watershed Conference

Session III: Wastewater

West Point, New York | Sept. 14, 2012

Innovative Trends in Wastewater Treatment For High Volume Hydraulic Fracturing

By: Edward Weinberg, P.E., President
ESSRE Consulting, Inc.



WATERSHED PROTECTION AND PARTNERSHIP COUNCIL

NYWEA
LEADING THE WAY IN WATER QUALITY MANAGEMENT

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Presentation Outline

Introduction & Background

- Hydraulic Fracturing and Flowback Waters
- Constituents of Concern (COCs)
- PADEP Environmental Impacts/Regulatory Responses
- Marcellus Waste Water Management – Recycle and Reuse
- Modular vs. Mobile Innovative Treatment Approaches

Pretreatment

- Filtration - Suspended Solids
- Metals Removal – Ca, Mg, Ba, Sr, Ra and Fe
- Conductivity Control

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Presentation Outline (Con't.)

- Treatment

  - Electrocoagulation (EC)
  - Dissolved Air Flotation (DAF)

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Marcellus Shale Hydraulic Fracing Flowback Water Characteristics

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High Volume Hydraulic Fracing

- Hydrofracing typically requires millions of gallons of water (2 to 7 MM gallons)
- Flowback water volumes average 20% (10 to 40%) of the hydrofracing volume
- Composition highly variable over time and from well to well
- Most of the volume comes to the surface in the first few days

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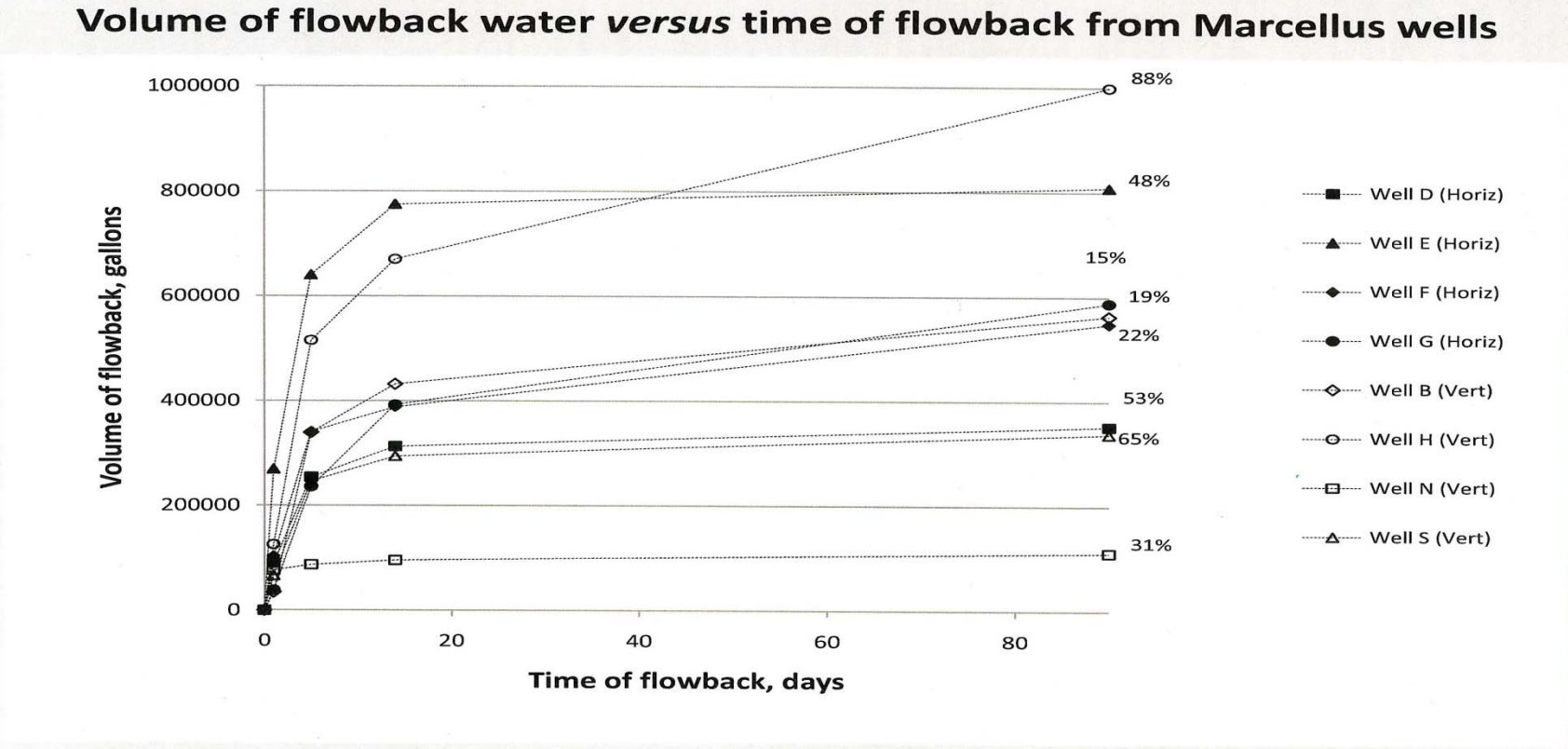
Marcellus Shale Hydraulic Fracing Flowback Water Characteristics



Data are from four horizontal and four vertical wells in Hayes (2009) that had data for 0 (injected water), 1, 5, 14, and 90-day flowback.

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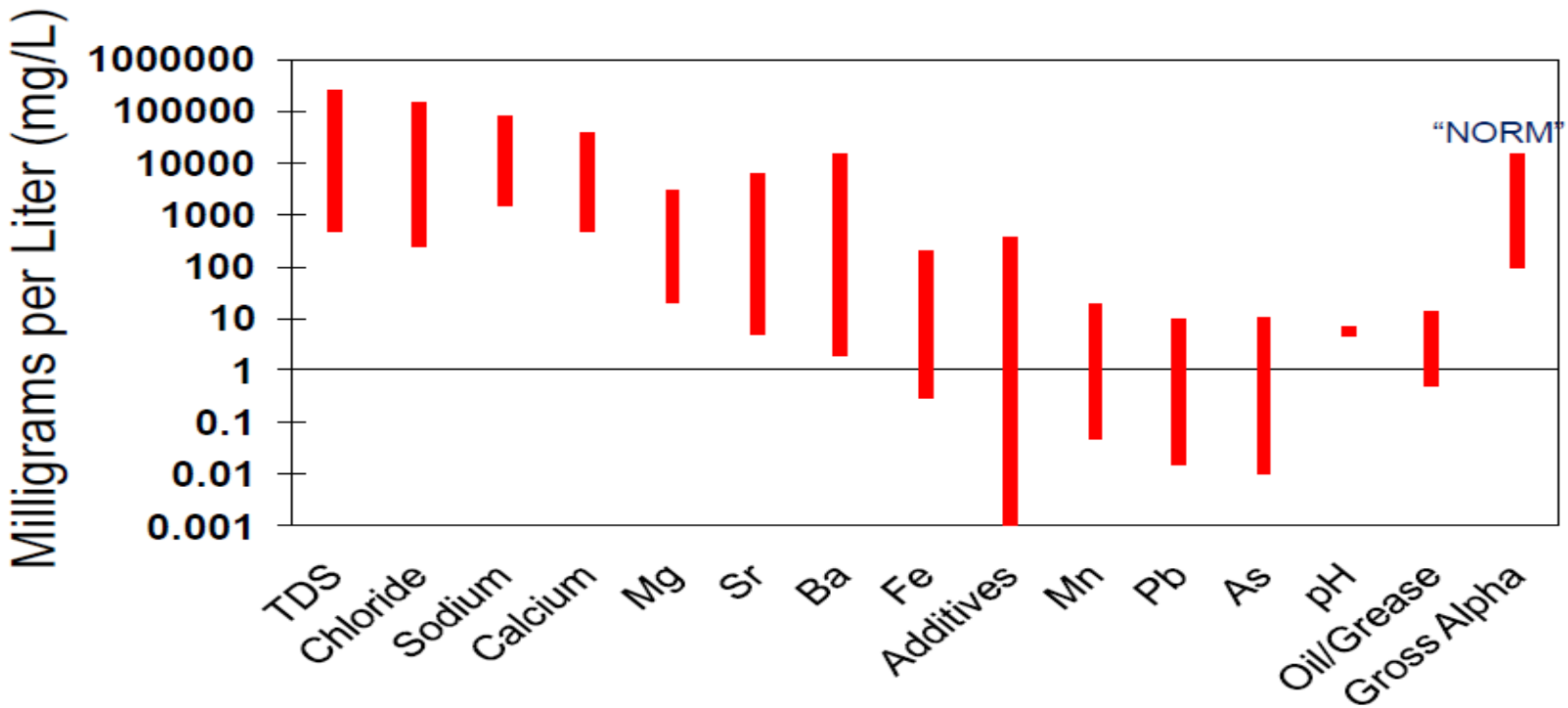
Marcellus Shale Hydraulic Fracing Flowback Water Characteristics

PENNSTATE

Wastewater Pollutants

(~20 wastewater samples)



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Constituents of Concern (COCs)

- **Suspended Solids**
  - Fouling, Scaling: O&M Concerns
- **Metals**
  - Ca, Mg, Sr and Fe: Scaling O&M Concerns
  - **Ba, Ra**: Scaling and Env. Concerns
- **Organics & Bacteria**
  - Bacterial growth: O&M Concerns
  - Residual Fracing Additives: Health Concerns
  - Oil & Grease: O&M Concerns
- **Total Dissolved Solids (TDS)**
  - Environmental Water Quality Concerns

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Environmental Impacts/Regulatory Responses

- PADEP Highlights

- Jan 2011 - TDS Permit Ruling
  - Cl < 250 mg/L
  - SO_4 < 250 mg/L
  - TDS < 500 mg/L

- May 19, 2011 - Requests WWTPs not to accept flowback waters

- Dec 2011 - Special Conditions General Permit WMGR 123
  - Promotes beneficial reuse/recycle of "frac" waters from hydraulic fracturing

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Basis of Design for Marcellus Waste Water Management

- **Env. Rules/Regulations, Wastewater characteristics, Treatment Objectives, etc.**
  - Operators will accept recycle frac water up to approx. 20,000 mg/L Cl and 40,000 mg/L TDS
- **Tolerable Costs to Treat: $0.10 to $0.15 per gallon**
- **Modular (Mobile) Treatment vs. Centralized (Fixed)**

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The Benefits of Modular Treatment of Frac Fluids

- **Modular Benefits**
  - **Less Truck Traffic**
  - **Lower Capital Expenditures**: more responsive to needs and system capacity better matched to the volumes of wastewater
  - **Promotes Innovation**: lack of space for portability and lack of attenuation from multiple sources

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Pretreatment Summary

- **Filtration** - Suspended Solids
- **Metals Removal** - Chem. Sedimentation Clarification
- **Conductivity Control**
- **Residuals Management**

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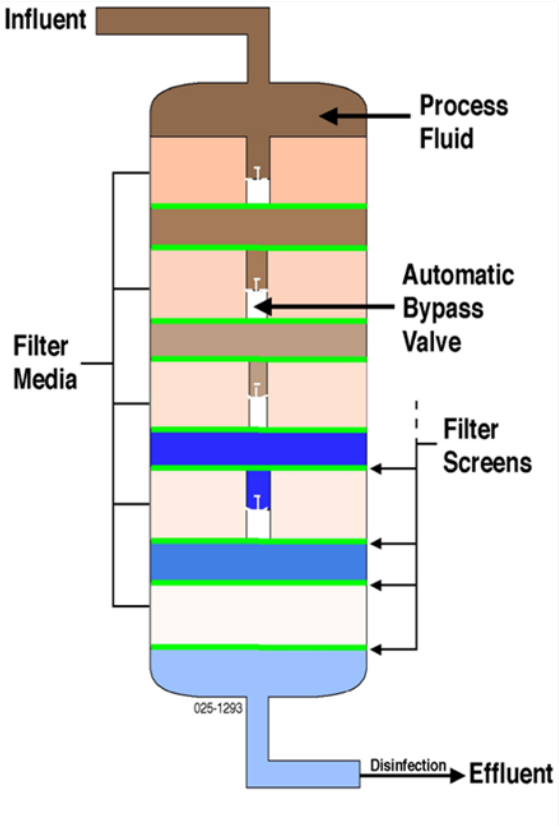
Media Filtration - Suspended Solids

ECOLOGIX MULTIMEDIA FILTER

FILTERSURE™ SCHEMATIC



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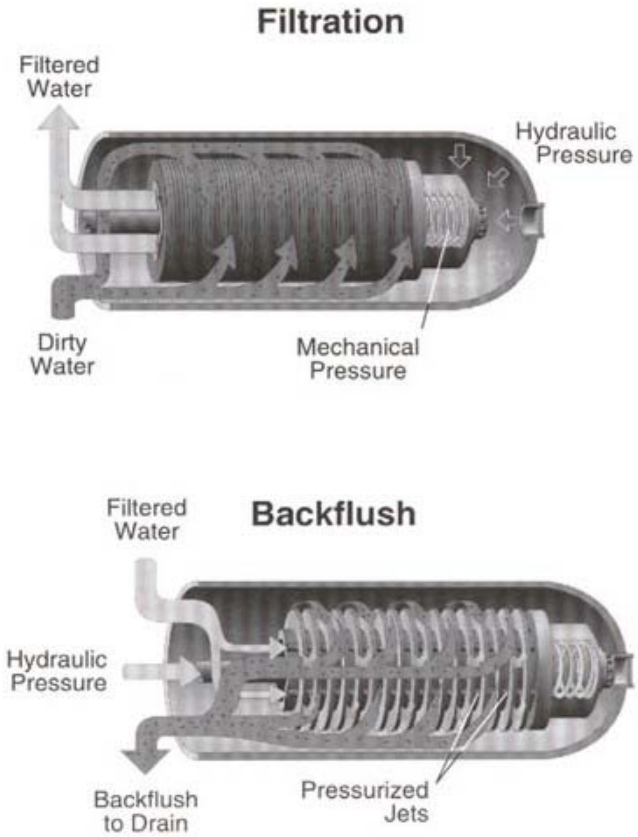
Disc Filtration - Suspended Solids



Layne Integra Disc Filter

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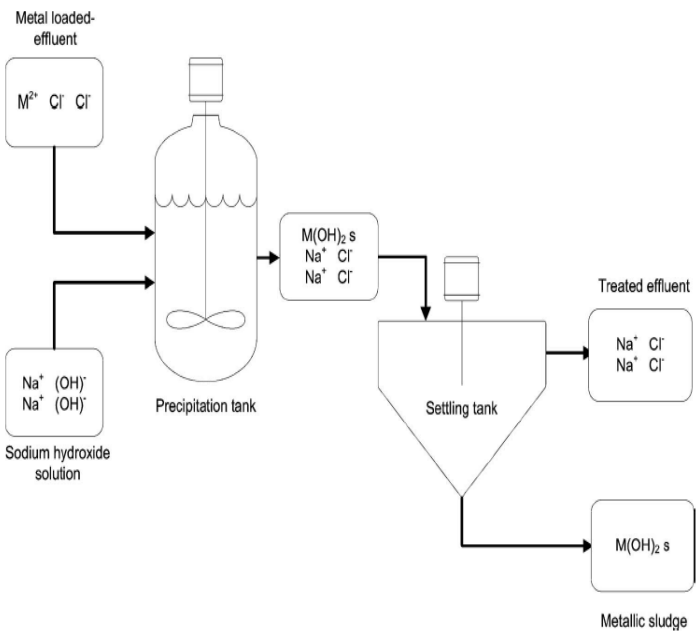
Metals Removal - Chem. Sedimentation Clarification

Scaling Metals Removal Schematic



High-Rate Unit

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Metals Removal - Chem. Sedimentation Clarification

- Fountain Quail Mobile ROVER

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Conductivity Control

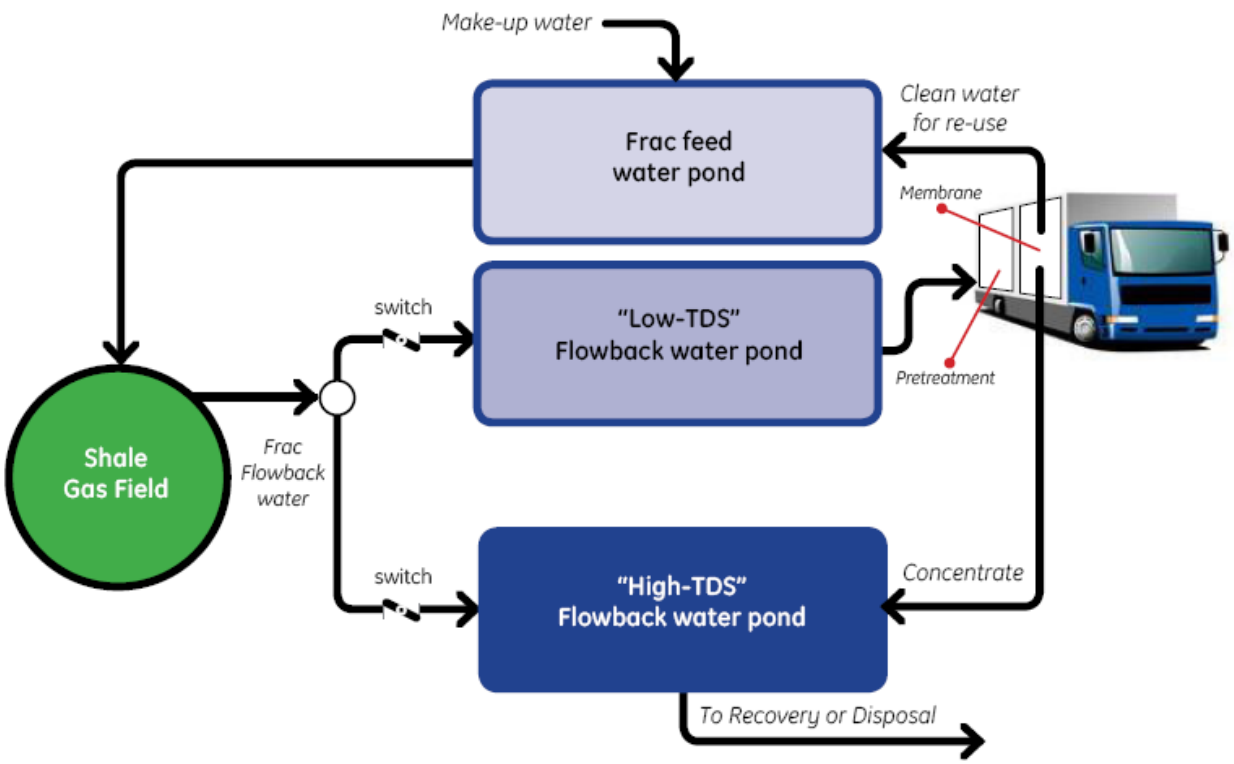

Figure 7. Proposed Process for Frac Flowback Water Treatment for Re-use.

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Marcellus Shale Hydraulic Fracing Flowback Water Characteristics

PADEP sample results from Marcellus Shall Well represent flowback waters over a 2-week period and approximately 1.5 MG. Samples were taken after the first third (1/3), second third (2/3) and at the end (3/3)

Parameter	1st Third	2nd Third	Final Third	Units
Bromide	124	479	753	
Chloride	18,600	80,000	109,000	
Hardness	4,160	23,500	52,200	
TKN	75	88.8	37.5	
O&G	17	5	<5	
BOD5	490	501	190	
COD	3,100	4,800	19,600	
TDS	**34,578**	**133,620**	**192,000**	
TSS	124	302	245	
Sulfate	20.8	<10	<20	
pH			6.67	SU
Barium	668	6,100	8,730	
Iron Dis.	10.2	7.44	47.5	
Gross Alpha	1159	22.41	18,950	pCu/L
Gross Beta	6500	9.68	7445	pCu/L
Radium 226	33	2.58	4.67	pCu/L
Radium 228	4.66	1.15	18.41	pCu/L

Units are mg/L unless noted otherwise

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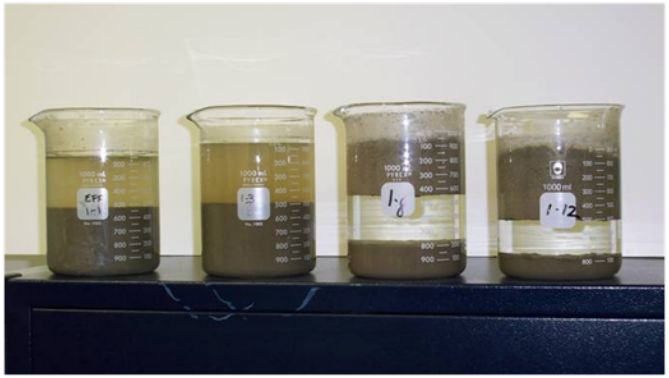
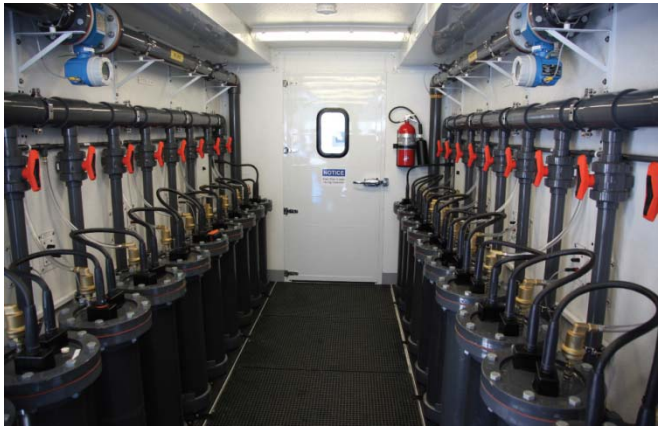
Electrocoagulation (EC)

- Features/Benefits of EC
  - Sedimentation w/o chemicals
  - Electro Floatation
  - Excellent to break Oil – Water emulsions, remove TPH
  - Electric field will deactivate microbes and bacteria
  - Greater settled solids specific gravity



Halliburton CleanWave^{SM} EC



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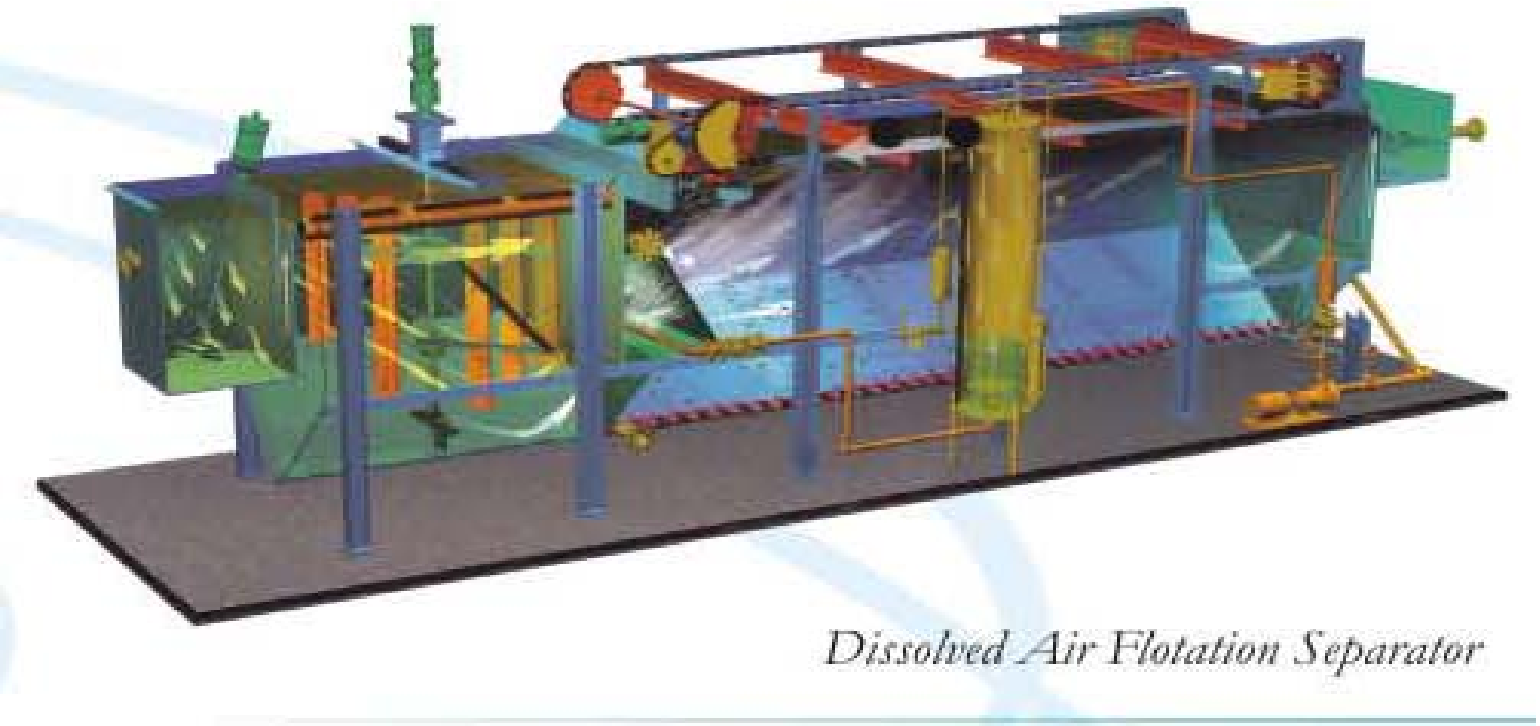
Conventional DAF Units

- Schematic Courtesy of Trevini Group



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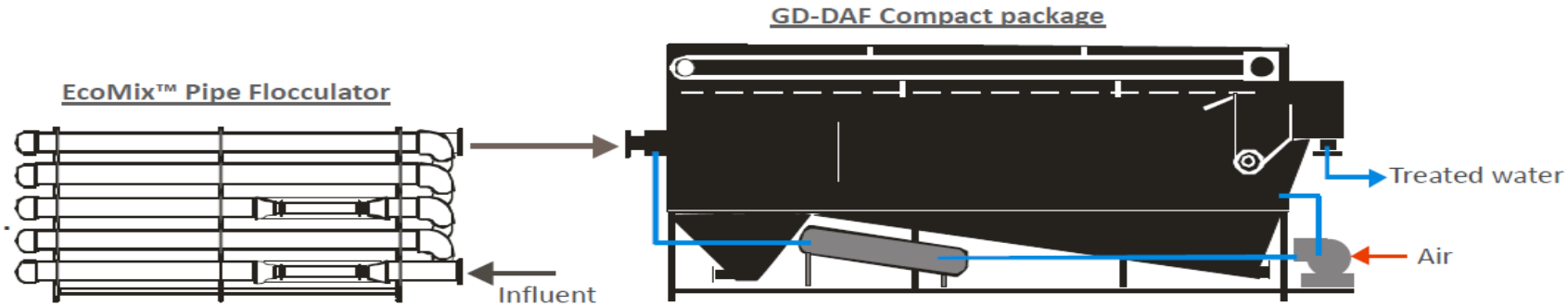
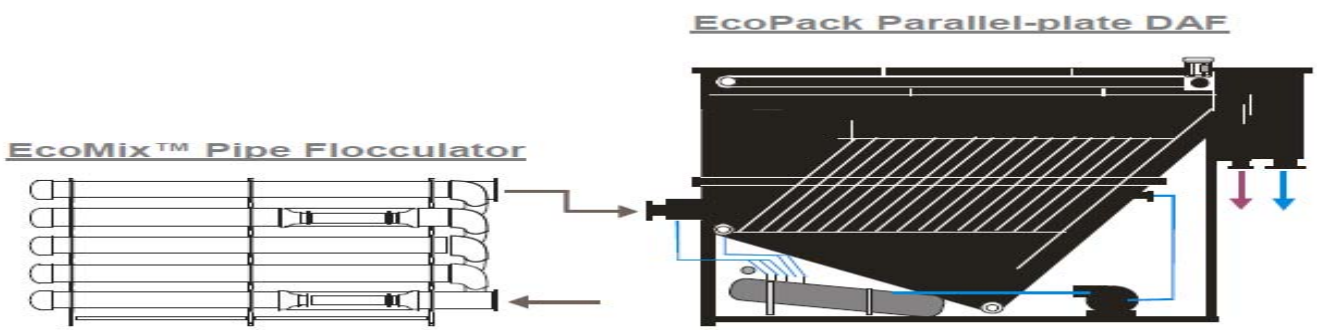
Compact DAF Units



Technical Data

Model	Flow rate (m^3/h)	Dimension L x W x H(mm)	Connect Schedule-Flange			
			Inlet	Outlet	Sludge	Drain
GD-DAF 6	6	2000 x 1600 x 1500	2″	2″	2″	1″



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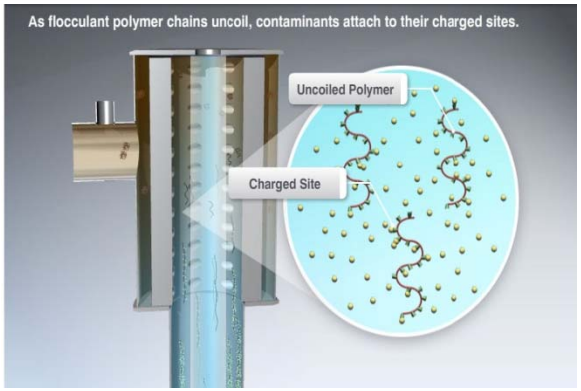
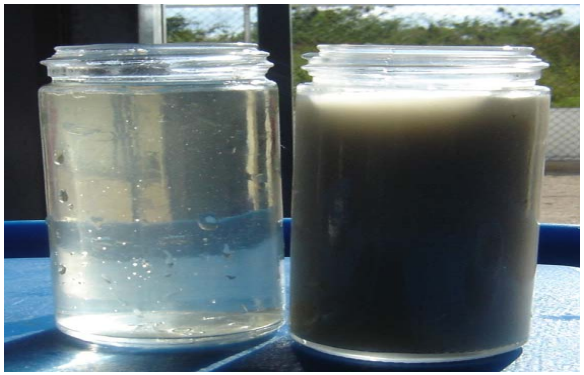
DAF Innovation
CWT GEM System





Proactive centrifugal mixing provides:

- Higher contaminant removal rates
- More control over mixing speed and energy
- More efficient chemical usage
- Drier sludge
- Smaller Footprint

200 GPM GEM System

200 GPM DAF System

Model	Flow Rate (gpm)	Dimensions (L x W x H)
GD-DAF 6 (previous page)	25	6.6’ x 5.3’ x 5.0’
GEM System 30	**30**	**6.0 x 4.3’ x 5.0’**

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Closing Comments

- Many Operators and Service Companies consider partially treating flowback waters sufficiently for reuse at the next hydraulic fracturing site.
- Benefits include reduced volume of wastewaters and hence costs and reduced water sourcing and transportation demands.
- All of the approaches have limitations based on waste volumes, water quality and economic viability.
- A water treatment expert is helpful to plan through and implement the many choices and extent of treatment for recycle/reuse.

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QUESTIONS

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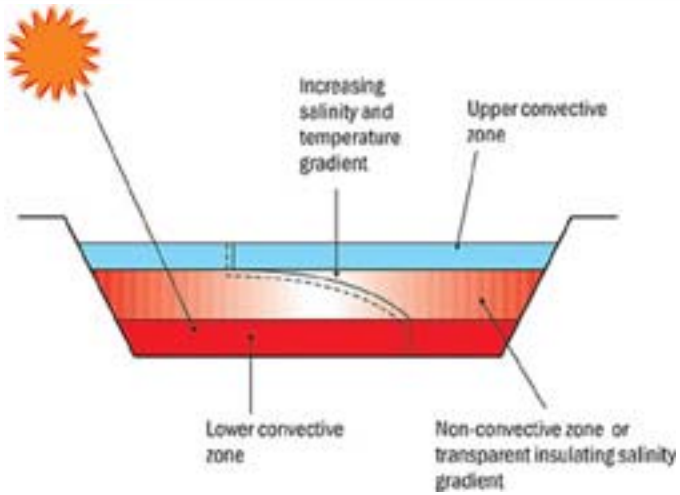
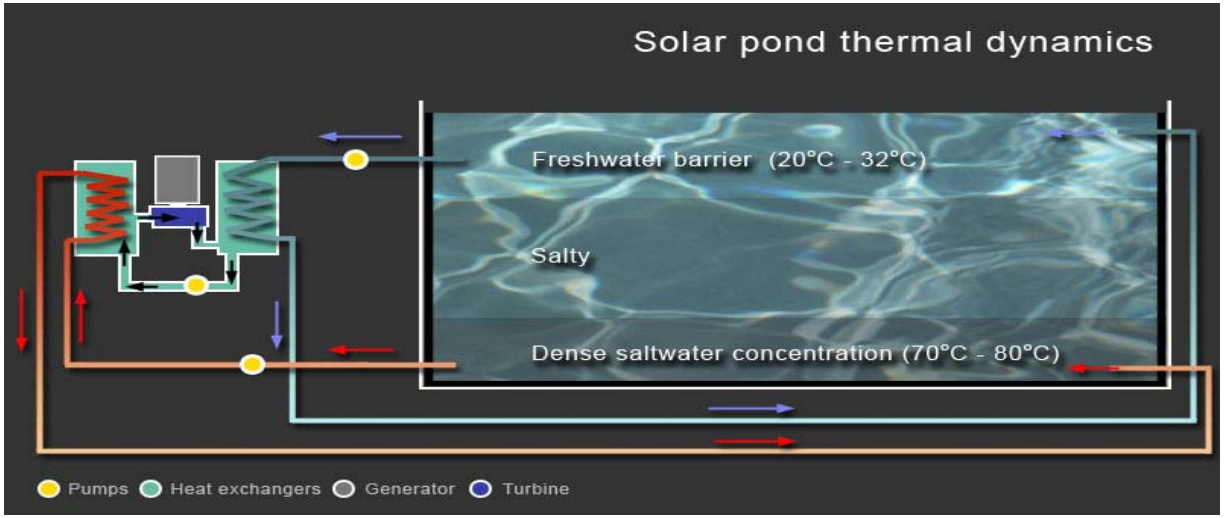
"The Best Things Come in Small Packages" - Proverb

Solar Salt Gradient Pond

- SSGRP Concepts





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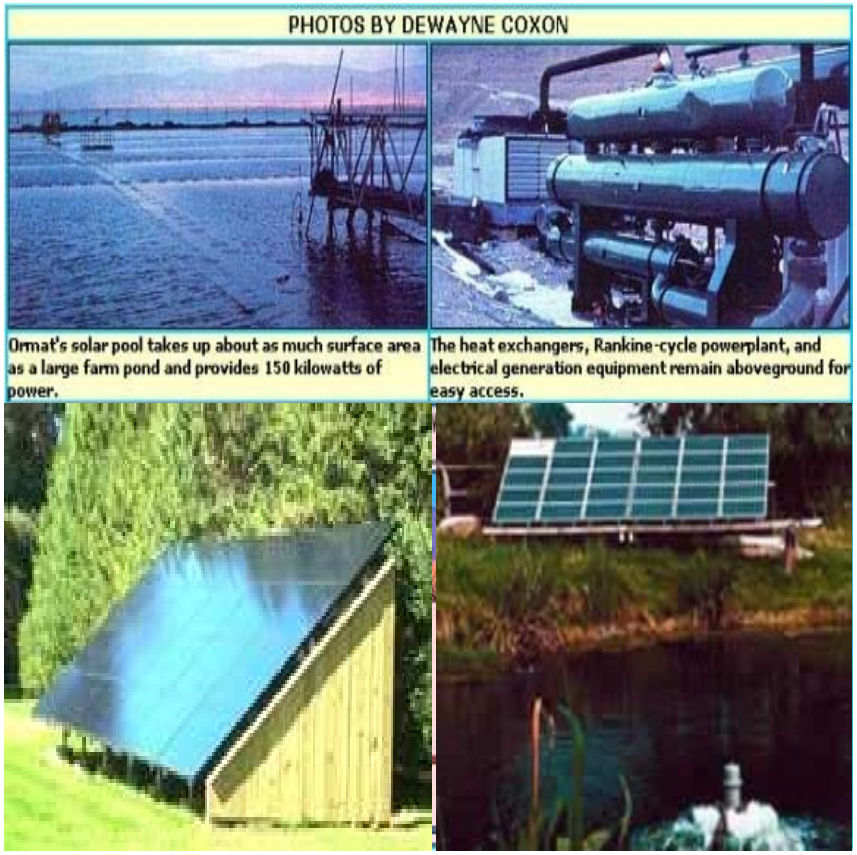
Solar Renewable Energy Park

SSGRP W/ORC AND PV SOLAR



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