

# **Dear Creek State Park Mount Sterling, Ohio**

## **Pretreatment Workshop**

**Powell Water Systems Inc.**  
Utilizing  
**Electrocoagulation**

**May 10, 2016**



# ELECTROCOAGULATION

## Pretreatment Capabilities

- **FOG**
- **BOD**
- **TSS**
- **TKN**
- **Phosphorous**
- **Metals**
- **Bacteria**
- **Viruses**
- **Pharmaceuticals**
- **Hydrocarbons**

# Powell Water Systems, Inc. 50 gpm Capacity



# Powell Water Electrocoagulation:

- **Uses patented chamber that passes electricity through water**
- **Converts AC to DC voltage (Power Supply)**
- **Works best between a pH of 4 and 12**



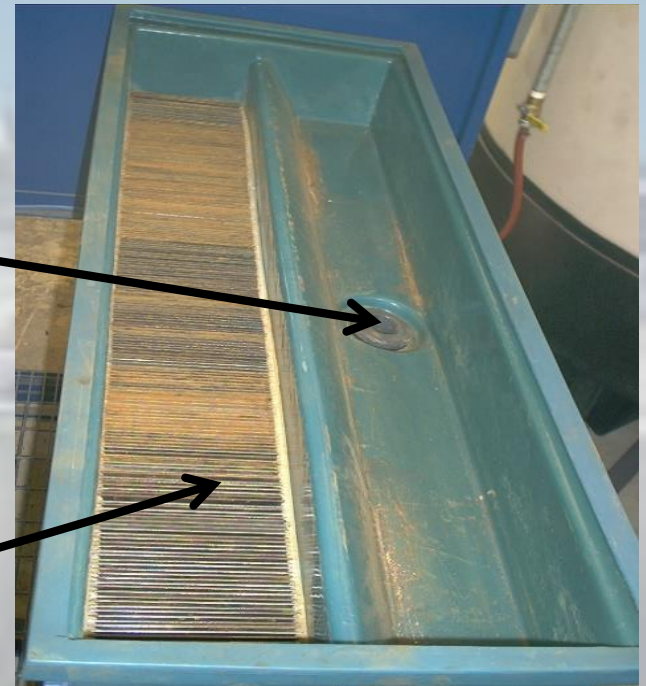
Power Supply

Programmable  
Logic Controller

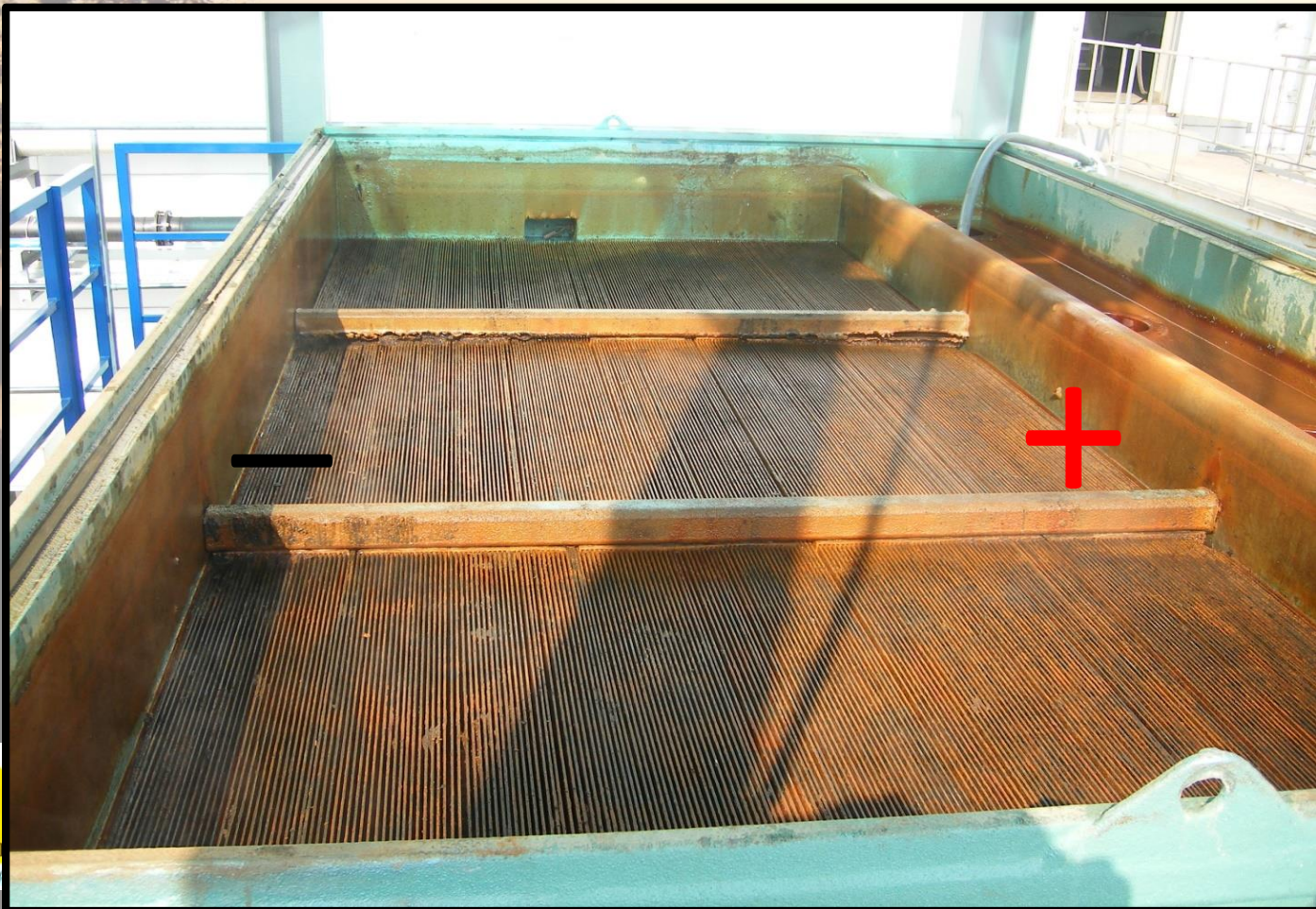
Overflow

Automatic  
Polarity  
Reversing

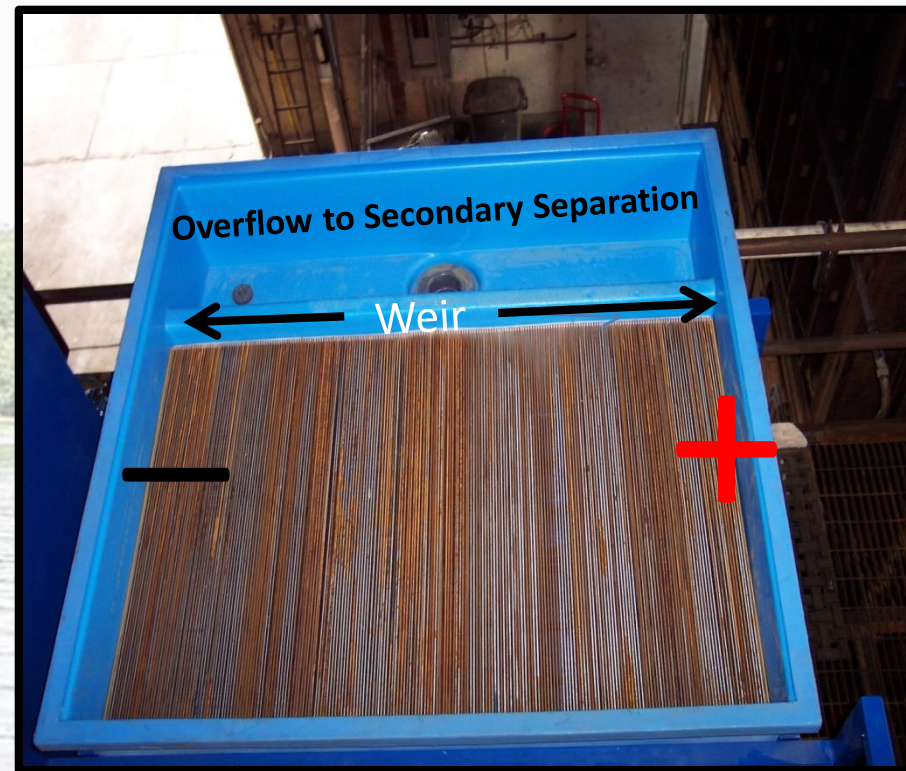
Patented  
Reaction  
Chamber



- Plates are placed vertically within the patented reaction chamber
- Direct current is applied to the first and last blade
- Untreated water is introduced into the bottom of the chamber
- Water is dispersed evenly as it moves upward through the blades
- Water conducts electricity throughout the chamber



- **Metal blades react to the current by releasing charged metal ions**
- **This electron flooded water neutralizes charged particles, making constituents coagulate and thus separable (precipitate )**
- **Electron flooded / treated water overflows to secondary separation such as lamella or other clarifiers**
- **Heavy metals precipitate into acid-resistant oxide sludge that passes the Toxic Classification Leaching Procedure (TCLP), making the sludge non-hazardous**



# Sludge Comparison

## Sludge from Powell Water EC:

- Is in the pH 6-7 range
- metals in non-hazardous form as oxides
- does not leach at ambient landfill pH
- passes EPA TCLP and California Title 22 STLC and TTLC leach tests
- 83% less solids than lime softening per EPA
- hydrophobic – 76% improvement infiltration rate

## Sludge from Chemical Coagulation:

- is in caustic pH range
- metals in form of hydroxides
- metals can become soluble in the neutral pH range – leaching potential
- Large volumes
- Hydrophilic – difficult to dewater

# ELECTROCOAGULATION - EC

## Removal Mechanisms

**Fe (or Al) ions AND electrons are introduced into the aqueous solution**

- **Oxidation/reduction reactions**
- **Emulsion breaking - FOG**
- **Halogen complexing** – Pesticides, Herbicides
- **Bleaching by oxygen ions** - dyes, cyanides, bacteria, viruses, endocrine disruptors, biohazards, etc.
- **Seeding** – Complex metal ions
- **Electron flooding** - bacteria, cysts, and viruses



6 gpm EC Unit





**EC Handles mixed waste streams at the same time (colloids + metals + FOG + TSS, BOD, bacteria, viruses, endocrine disrupters, pharmaceuticals, etc.)**

# Powell Water EC Optimization

**Controlled by:**

- **Blade type**
- **Amperage density**
- **Voltage**
- **Flow rate**
- **Process time (residence)**
- **Conductivity of water**
- **pH**
- **Filtration technique**

# EC Does ...

- Efficiently remove constituents between **2<sup>nd</sup>** and **17<sup>th</sup>** column on periodic chart
- **Not** use a large quantity of electricity
  - Typically 2-7 kWh/1,000 gallons
- **Not** require clean power
  - Only low voltage PLC and computer requires uninterrupted power source (UPS)
  - battery can be used
  - Easier to operate in countries with poor electric grid

# Municipal Sewage from POTW Discharge Water:

<u>(002-156)</u>	<u>Raw</u>	<u>Treated</u>	<u>% Removal</u>
<b>BOD</b> (mg / l)	1,050	14	99% +
<b>TSS</b> (mg / l)	4,620	7	99% +
<b>Bacteria</b> (cfu)	110,000,000	2,700	99% +
<u>(002-187)</u>	<u>Raw</u>	<u>Treated</u>	<u>% Removal</u>
<b>BOD</b> (mg / l)	500	19	96%
<b>TSS</b> (mg / l)	3,245	14	99% +
<u>(006-646)</u>	<u>Raw</u>	<u>Treated</u>	<u>% Removal</u>
<b>BOD</b> (mg / l)	3,345	510	84%
<b>TSS</b> (mg / l)	16,500	165	99%
<b>Volatile Solids</b>	12,300	126	99%

# Vanderbilt Study

## Municipal Sewage from POTW Discharge Water:

	<u>Raw</u>	<u>Treated</u>	<u>% Removal</u>
<b>COD</b>	490	26	94.7%
<b>Total Solids</b>	602	401	43.4%
<b>Suspended Solids</b>	73	7	90.4%
<b>Total Hardness</b>	127	11	91.3%
<b>Alkalinity</b>	267	11	95.8%
<b>pH</b>	6.88	7.02	
<b>BOD<sub>5</sub></b>	220	9	95.9%
<b>Coliform</b>	318,000/ml	0	99% +
<b>Phosphates</b>	38	0	99% +

# Food Processing Industry:

## Pork Slaughter, Processing and Packaging Plant

	<u>Raw (mg / l)</u>	<u>Treated</u>	<u>% Removal</u>
<b>TKN</b>	1,118.88	59.08	94.72%
<b>Nitrate</b>	21	12	42.86%
<b>Nitrite</b>	0.35	0.47	
<b>T-Phos</b>	120	2.5	97.92%
<b>Ammonia</b>	49	19.4	60.41%
<b>TSS</b>	4,040	60.0	99.57%
<b>BOD<sub>5</sub></b>	1,580	397.4	96.57%
<b>pH</b>	6.81 SU	10.17 SU	

# Food Processing Industry: Beef Rendering Plant

	<u>Raw (mg / l)</u>	<u>Treated</u>	<u>% Removal</u>
<b>BOD<sub>5</sub></b>	5,700	590	89.6%
<b>TSS</b>	4,540	260	94.3%
<b>FOG</b>	3,050	150	95.1%

# Food Processing Industry: Chicken Processing Plant

	<u>Raw (mg / l)</u>	<u>Treated</u>	<u>%Removal</u>
<b>BOD<sub>5</sub> (Total)</b>	4,328	480	89%
<b>BOD<sub>5</sub> (Soluble)</b>	303	39	87%
<b>TSS</b>	3,367	83	97%



# Food Processing Industry: Fish Processing and Packaging Plant

	<u>Raw (mg / l)</u>	<u>Treated</u>	<u>% Removal</u>
<b>BOD<sub>5</sub></b>	40,500	750	98.1%
<b>TSS</b>	33,667	107	99.7%
<b>FOG</b>	3,047	12.1	99.7%

# Food Processing Industry: Salad Dressing Production Plant Water

	<u>Raw (mg / l)</u>	<u>Treated</u>	<u>% Removal</u>
<b>BOD<sub>5</sub></b>	8,223	752	91.0%
<b>TSS</b>	14,528	86	99.4%
<b>FOG</b>	18,165	28	99.8%

# Metal Plating Client MO



<u>Analyte</u>	<u>(mg/l)</u>	<u>Raw</u>	<u>Post EC</u>	<u>% Reduction</u>
<b>Chromium (Cr) Total</b>		<b>37.9</b>	<b>0.10</b>	<b>99+</b>
<b>Chromium (Cr) hex</b>		<b>21.0</b>	<b>&gt;0.05</b>	<b>99+</b>
<b>Zinc (Zn)</b>		<b>18.1</b>	<b>0.16</b>	<b>99+</b>

# Results – Lead & Other Metals

Protected lead mining operation client in Missouri.

Results in ug/L

<u>Analyte</u>	<u>Raw</u>	<u>Post EC</u>	<u>% Reduction</u>
Cadmium (Cd) Total	36.0	0.15	99+
Copper (Cu) Total	3.0	ND	99+
Lead (Pb) Total	1,285.0	0.64	99+
Zinc (Zn) Total	6,675.0	13.0	99+

## Mining Results: Minute Constituent Removal (3 different mines)

<u>Constituent</u>	<u>Raw</u> mg/L	<u>Post EC</u> mg/L	<u>% Removal</u>
<b>Copper</b>	<b>0.0068</b>	<b>&lt;0.0019</b>	<b>72</b>
<b>Zinc</b>	<b>0.42</b>	<b>&lt;0.001</b>	<b>99+</b>
<b>Cadmium</b>	<b>0.00392</b>	<b>&lt;0.00006</b>	<b>98</b>
<b>Lead</b>	<b>0.00732</b>	<b>&lt;0.00003</b>	<b>99+</b>
<b>Silver</b>	<b>&lt;0.00003</b>	<b>&lt;0.00003</b>	
<b>Zinc</b>	<b>0.15</b>	<b>&lt;0.001</b>	<b>99+</b>
<b>Cadmium</b>	<b>0.00082</b>	<b>&lt;0.00006</b>	<b>93</b>
<b>Lead</b>	<b>0.00171</b>	<b>&lt;0.00003</b>	<b>98</b>
<b>Copper</b>	<b>0.798</b>	<b>0.002</b>	<b>99 +</b>
<b>Cadmium</b>	<b>0.1252</b>	<b>0.004</b>	<b>96.8</b>
<b>Lead</b>	<b>0.59</b>	<b>0.0032</b>	<b>99 +</b>
<b>Silver</b>	<b>0.0081</b>	<b>0.0006</b>	<b>92.6</b>

# Typical Contaminant Removal Rates

Results are based on 60 second residence time in the EC chamber  
Higher removal rates can be achieved with longer residence time

Contaminant	Before (Mg/L)	After EC & Secondary Separation (Mg/L)	Removal Rate (%)
Aluminum	224	0.69	99+
Arsenic	0.0760	<0.0022	97.1
Cadmium	0.125	<0.004	96.8
Calcium	1,321	21.4	98.4
Chromium	139	<0.10	99+
Copper	0.7984	<0.0020	99+
Cyanide (Free)	723	<0.0200	99+
Iron	68.3	0.19	99+
Lead	0.59	0.003	99+
Magnesium	13.2	0.04	99+
Manganese	1.06	0.018	98.3
Mercury	0.72	<0.003	98.4

<b>Contaminant</b>	<b>Before (mg/l)</b>	<b>Post EC (mg/l)</b>	<b>Removal Rate (%)</b>
<b>Molybdenum</b>	<b>0.35</b>	<b>0.029</b>	<b>91.7</b>
<b>Nickel</b>	<b>183</b>	<b>0.07</b>	<b>99+</b>
<b>Petroleum Hydrocarbons</b>	<b>72.5</b>	<b>&lt;0.2</b>	<b>99+</b>
<b>Phosphate</b>	<b>28.0</b>	<b>0.20</b>	<b>99+</b>
<b>Platinum</b>	<b>4.4</b>	<b>0.7</b>	<b>84.5</b>
<b>Potassium</b>	<b>200</b>	<b>110</b>	<b>45</b>
<b>Silicon</b>	<b>21.1</b>	<b>0.1</b>	<b>99+</b>
<b>Silver</b>	<b>0.0081</b>	<b>0.0006</b>	<b>92.6</b>
<b>Tin</b>	<b>0.213</b>	<b>&lt;0.02</b>	<b>90.6</b>
<b>TSS</b>	<b>1,560</b>	<b>8</b>	<b>99+</b>
<b>Vanadium</b>	<b>0.2621</b>	<b>&lt;0.002</b>	<b>99+</b>
<b>Zinc</b>	<b>221</b>	<b>0.14</b>	<b>99+</b>
<b>Americium-241</b>	<b>71.9 pCi/L</b>	<b>0.57 pCi/L</b>	<b>99+</b>
<b>Plutonium-239</b>	<b>29.85 pCi/L</b>	<b>0.29 pCi/L</b>	<b>99+</b>
<b>Uranium</b>	<b>0.13 mg/L</b>	<b>0.0002 mg/L</b>	<b>99+</b>

# Electrocoagulation Demo



**I found  
this  
humerus**





50 gpm System  
Oklahoma Municipal Lagoon  
Tertiary Treatment  
Electrocoagulation



# Oklahoma Municipal Lagoon Illegal Production Water Through City Car Wash



**Prior to EC Treatment  
Lagoon Biologicals  
Killed**

**Post EC Treatment  
Hydrocarbons ND  
No Violation**



# Powell Water EC Manufactured for Efficiency and Cost Savings

## Efficiency –

- directs water flow in the same direction as air bubbles float
- eliminates pressure and resistivity buildup

## Savings –

- Blades are standard metal stock
- Blades slide directly into the chamber – no bolts, gaskets, or specialized fasteners needed



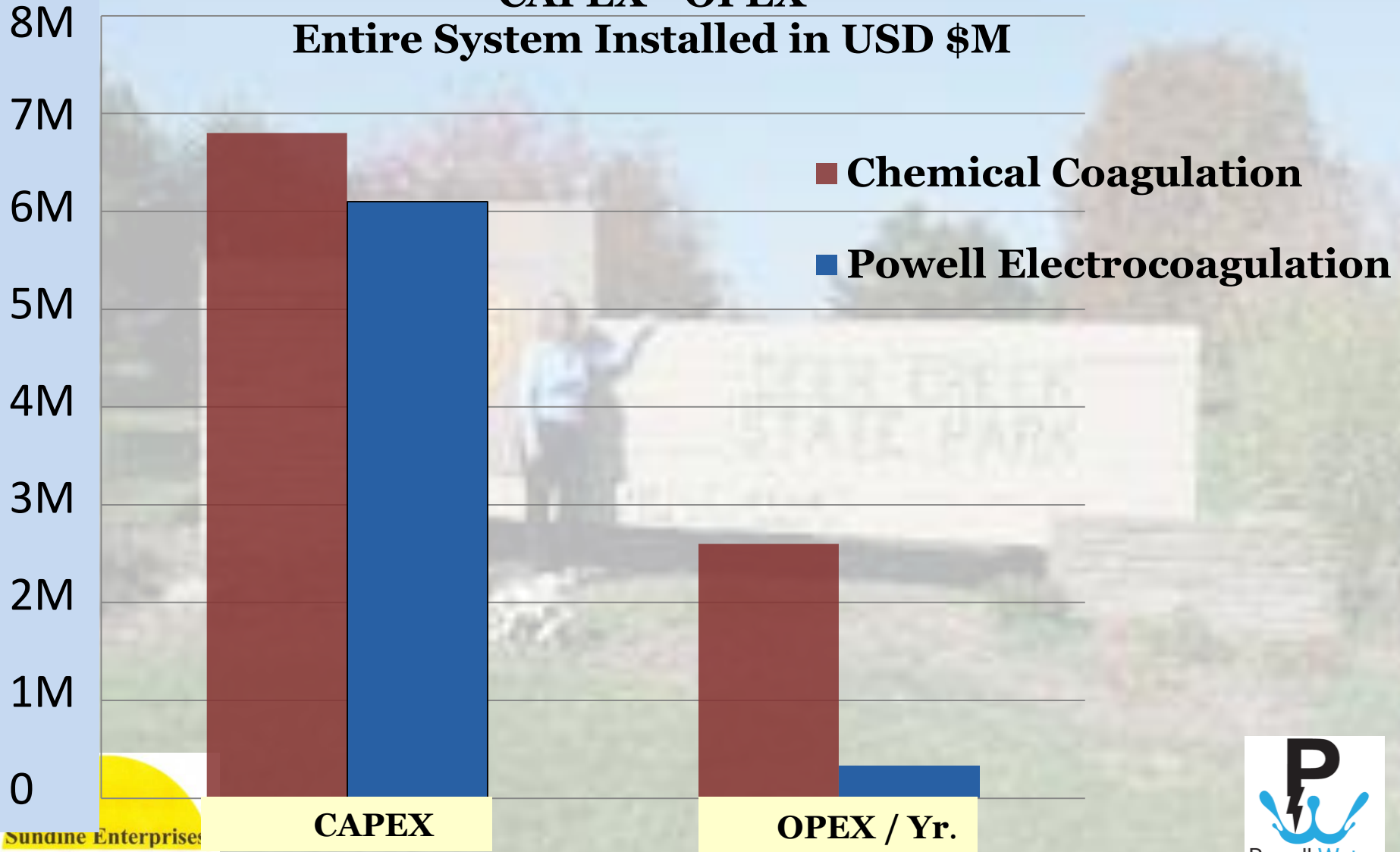
# Powell Water 2,500 gpm EC

vs.

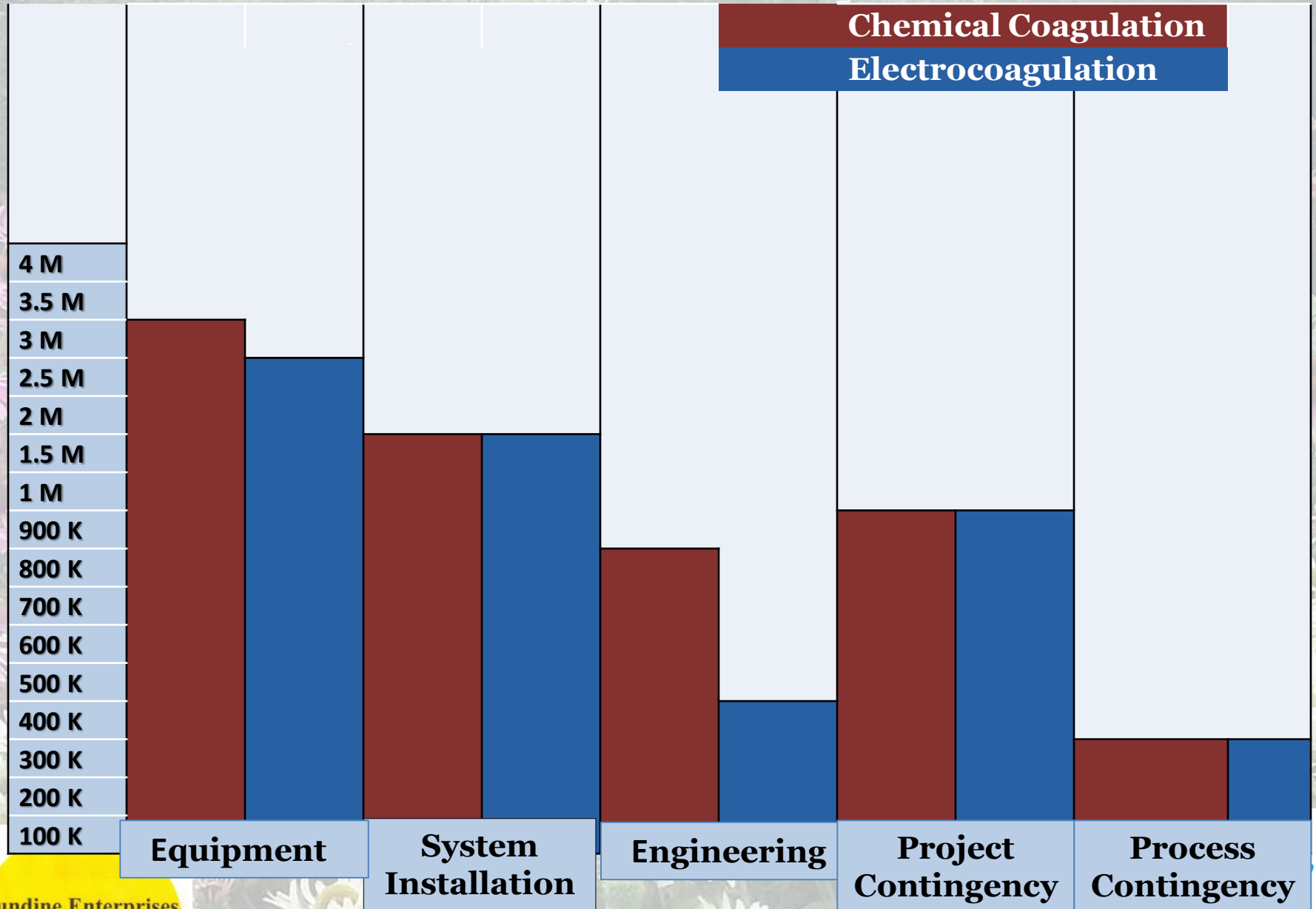
## Chemical Coagulation

### CAPEX - OPEX

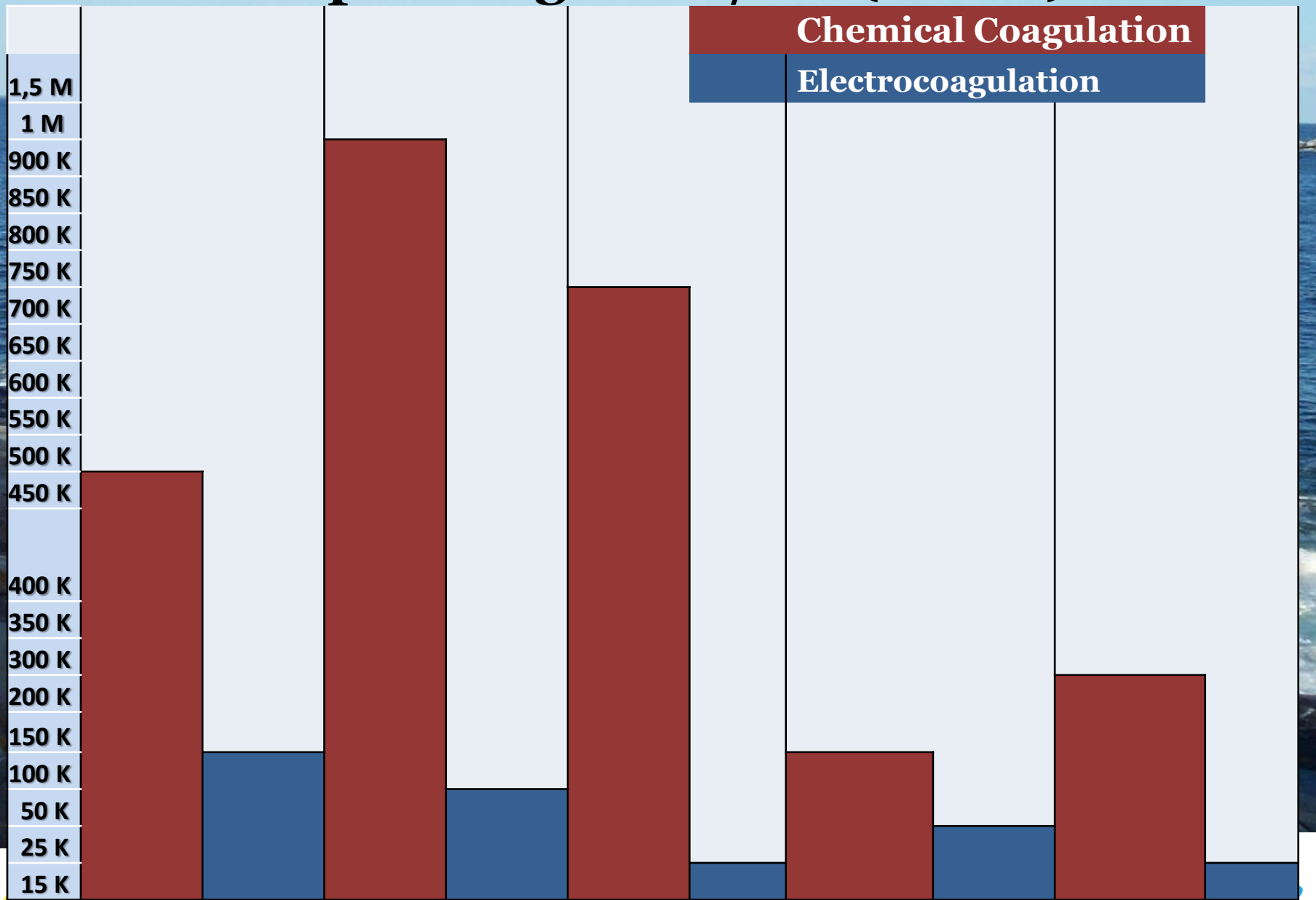
Entire System Installed in USD \$M



# Capital Cost (CAPEX)



# Operating Costs/Yr. (OPEX)



**Chemical Coagulation**

**Electrocoagulation**

# Powell Water EC Benefits for Wastewater Pretreatment

- 1. Very high removal rates**
  - ✓ suspended solids, BOD<sub>5</sub>, heavy metals and radioactive isotopes
- 2. Adaptable for seasonal operation changes**
  - ✓ flooding
- 3. Flexibility**
  - ✓ Quickly change operating parameters
- 4. Skid mounted for field operation**
  - ✓ Require little power or attention
- 5. Limited chemical usage (CIP and some pH changes)**

# **Powell Water EC Benefits for Wastewater Pretreatment**

- 6. Kills viruses, cysts, and coliform bacteria**
- 7. Produces 80% less solids (sludge)**
- 8. Sludge dewateres 76% faster (more readily filterable)**
- 9. Produces sludge that passes TCLP test (metals in oxide form)**
- 10. No hazardous waste disposal cost (lower sludge disposal costs)**
- 11. Reduces the use of expensive chemical agents**
  - ✓ (alum, lime, ferric chloride, ferric sulfate, ferrous sulfate, polymers, and other chemical additives)
- 12. Eliminates operator and transport personnel exposure to dangerous chemicals**





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**Thank You!**

