

# Treatment of TRV Sewage Spills and Storm Water Surges with Electrocoagulation (EC) and Micro-algae Lagoons

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<http://www.powellwater.com>

**Slide 1**

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**MOU1** Microsoft Office User, 7/6/2019

## Summary of TRV Storm Water and Sewage Problems

- Trash flows throughout the TRV
- Tijuana River: Storm Water Surges and Sewage Spills,
  - *Conventional biological SBIWT Wastewater Treatment CANNOT React to “Surges”*
- Cross-Border Collectors - Wet Season Wastewater flows increase pathogens, toxic chemicals and metals,
- Punta Bandera pumps up to 40 MGD of Raw Sewage into Ocean - Pollutes US beaches
- Affordability: \$400 M Capital Expense and up to \$30 M/year in Operational Expense

**Slide 2**

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**MOU2**

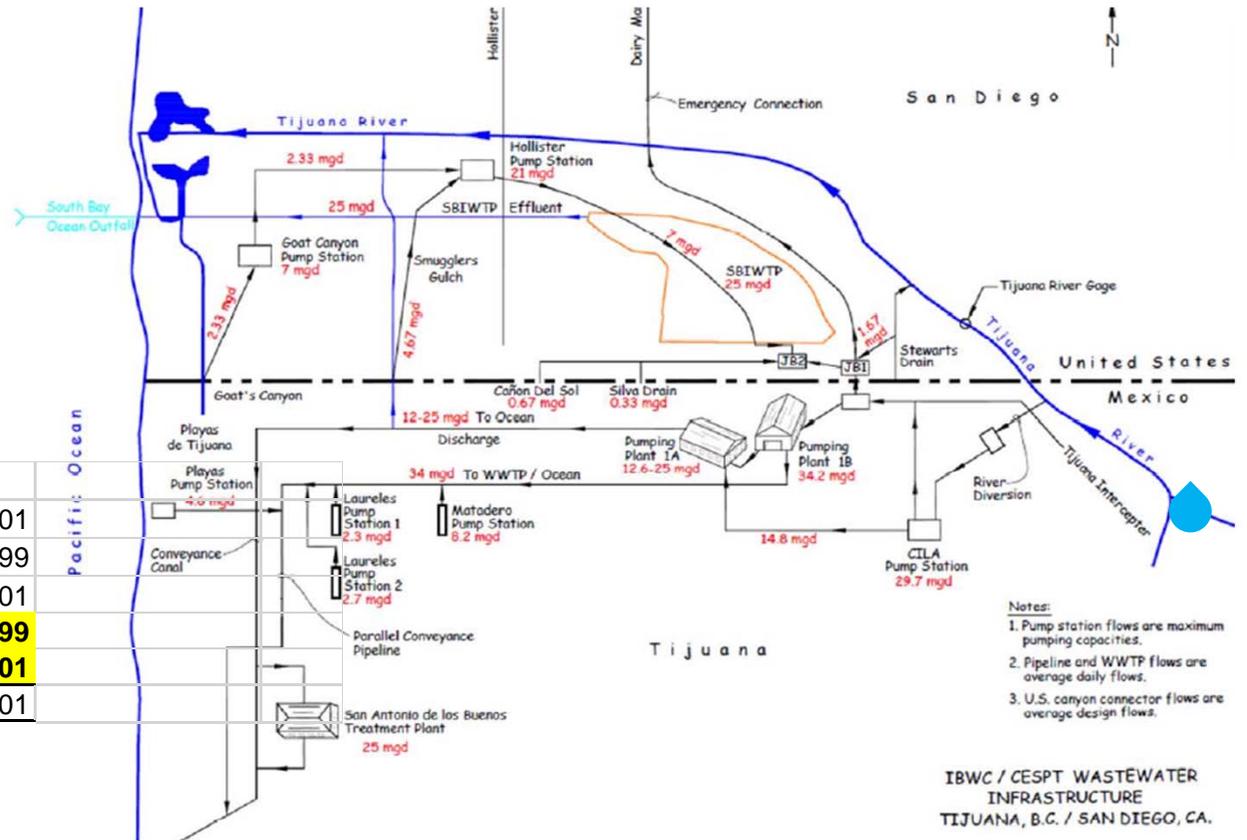
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## 2019 Beach Closures

<b>Tijuana Sloughs - 203 days</b>	<b>64%</b>
<b>Imperial Beach - 55 days</b>	<b>17%</b>
<b>Silver Strand - 26 days</b>	<b>8%</b>
<b>Coronado Shoreline - 18 days</b>	<b>6%</b>
<b>(316 days as of 11/12/2019)</b>	

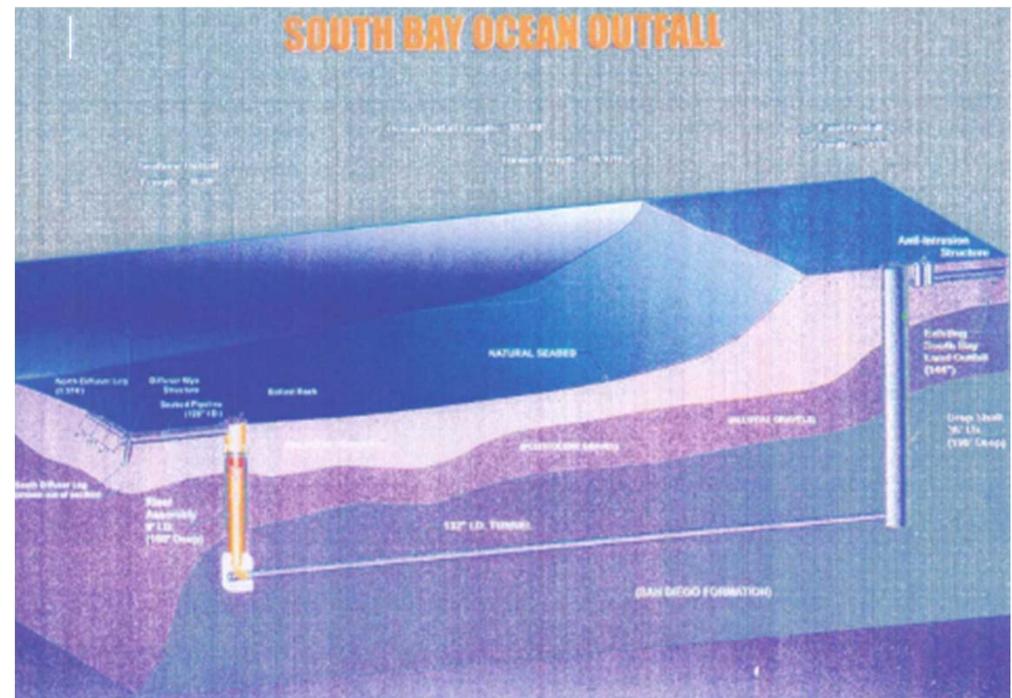
# Tijuana River Main Channel and Cross-Border Collector Flows

Location	MGD Dry	MGD Wet
Stewart's Drain	1.67	5.01
Silva Drain	0.33	0.99
Canyon Del Sol	0.67	2.01
<b>Goat Canyon</b>	<b>1.33</b>	<b>3.99</b>
<b>Smugglers Gulch</b>	<b>4.67</b>	<b>14.01</b>
<b>Total</b>	<b>8.67</b>	<b>26.01</b>



## South Bay Ocean Outfall (SBOO)

- 300 MGD SBOO capacity to divert, treat and transfer sewage spills and high river flows separately from the Tijuana River
  - 25 MGD for SBIWTP
  - 8 MGD for City of San Diego SBWRP
  - **300 MGD additional capacity for treated water from high river flows and sewage spills**
- SBOO Wastewater influent must be treated to Secondary standards
  - Reduced pathogens
  - Settle TSS (sand, silt & clay) and BOD with:
    - Electrocoagulation
    - Inclined Plate Settler Basins
    - **Reduce Suspended Solids to < 175 mg/L**



## Potential TRV Sewage Pollution and Storm Water Solutions

35 MGD EC + Inclined Plate Settler Basins on Tijuana River South Bank. Pump to SBOO:

*Trans Border Flow = 56 days/year*

100 MGD EC + Inclined Plate Settler Basins on Tijuana River South Bank. Pump to SBOO

*Trans Border Flow = 18 days/year*

100 MGD EC + Settler Basins near SBIWTP augmented by 200 million gallon Diversion Basin

*Trans Border Flow = 15 days/year*

# 35 MGD Diversion to SBOO: EPA/NADB Option 4b

	CAPEX		O&M		lbs	MGD	Days
EPA 4a	\$ 27.50	M	\$ 5.00	M	1,500	35	56
EPA 4b	\$ 48.00	M	\$ 7.00	M	1,500	35	56
Difference	\$ 20.50	M	\$ 2.00	M			

- Option 4b required. Tijuana River water has 770 to 4,416 mg/L suspended solids that must be reduced to 175 mg/L to enter the South Bay Ocean Outfall (SBOO)
- 35 MGD effluent flows to SBOO
  - 56 trans-boundary flow days/year
  - A 89% reduction from 168 to 56 days/year
- Treatment train:
  - Lift station,
  - Eight 1,200 GPM EC in 9,000 sq. ft. building
  - One 50 MGD slant plate settler basin (75' x 80')
  - Pump to SBOO
- Sludge:
  - Concentrate in 1 Vacuum Clarifier;
  - Transport < 1-mile to Nelson-Sloan Quarry



# 100 MGD Diversion to South Bay Ocean Outfall (SBOO)

- 100 MGD effluent flows to SBOO
  - 18 trans-boundary flow days/year
  - An 89% reduction from 168 to 18 days/year
- Treatment train:
  - Lift station,
  - Twenty-four 1,200 GPM EC in 9,000 sq. ft. building
  - Two 50 MGD slant plate settler basins (75' x 80')
  - Pump effluent to SBOO
- Sludge:
  - Concentrate in 2 Vacuum Clarifiers;
  - Transport < 1-mile to Nelson-Sloan Quarry
- Recycle 25 MGD of IWTP secondary-treated sewage on a not to interfere basis with TRV cleanup
- Potable Water: 'Pure Water' Treatment Modified
  - 25 MGD Ultra-Filter in 25,000 sq. ft. Building
  - Return 5% backflush water to EC and Settler Basins



## 200 Million Gallon Diversion Pond + 50 MGD Electrocoagulation (EC)

- 200 Million Gallon Diversion Pond:
  - Surface Area: 82-acres
  - Depth: 7.5 ft.
- 50 MGD EC System:
  - Twelve 5 MGD EC Machines
  - Capacity: 50 MGD @ 10-sec. HRT
  - 4-days to treat a 200 Million Gallons
  - Pump to SBOO or release to river
- Augment 100 MGD EC/Settler Basin Diversion System at SBIWTP



50 MGD EC System: Twelve (12) 3,600 GPM EC Systems

## Slide 9

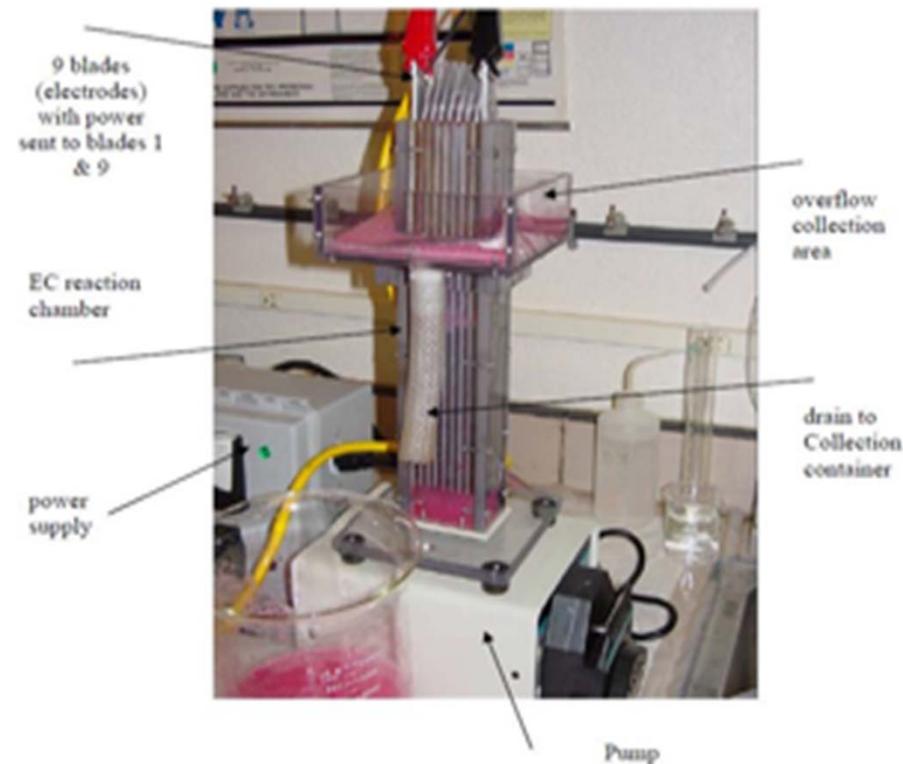
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**MOU4** The Diversion Pond would occupy 82-acres of agricultural land west (and upwind of) of San Ysidro housing. This pond would be north of the river and its location presents engineering challenges in pre treatment of water with Ec prior to diverting it into the pond and transporting this water across the river to the 11' diameter South Bay Ocean Outfall pipe. The associated 300 GPM lift station, head works, EC systems and clarifiers would require about 48,500 sq. ft. of space. The EC and clarifier systems would be available to recycle 25 MGD of secondary treated sewage to CA Title 22 water suitable for irrigation and industrial applicaions during the dDry Season

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## What is Electrocoagulation (EC)

- Photograph shows a 1 Liter/minute EC machine used for small scale demonstration of EC in:
  - Killing Pathogens, 10 to 15 sec., 5 - 7 kWh/K-gal
  - Removing Suspended Solids,
  - Oxidizing Toxic Metals, and
  - Oxidizing Toxic Chemicals with > 6 Carbon atoms
- 1 Liter/minute EC was used to validate EC system designs for 150 Powell Water EC systems installed worldwide.



## Pathogens Killed with 60-seconds of EC Treatment

	PMMoV (copies/ml)	Phage, <i>E. coli</i> (Pfu/ml)	Phage, <i>B. subtilis</i> (Pfu/ml)	Fecal coliforms (CFU/ml)	Enterococci (CFU/ml)	HPyV (copies/ml)
Before EC Treatment	60,100	12,800	2,220	1,000,000	1,000,000	100,000
After EC Treatment	<b>Below detection</b>	<b>Below detection</b>	<b>Below detection</b>	<b>Below detection</b>	<b>Below detection</b>	<b>Below detection</b>

- Pathogen concentrations reduced 99.9975% to less than recreational water use standards
- *10-15 seconds of EC treatment would reduce pathogens > 99.99%*

## Slide 11

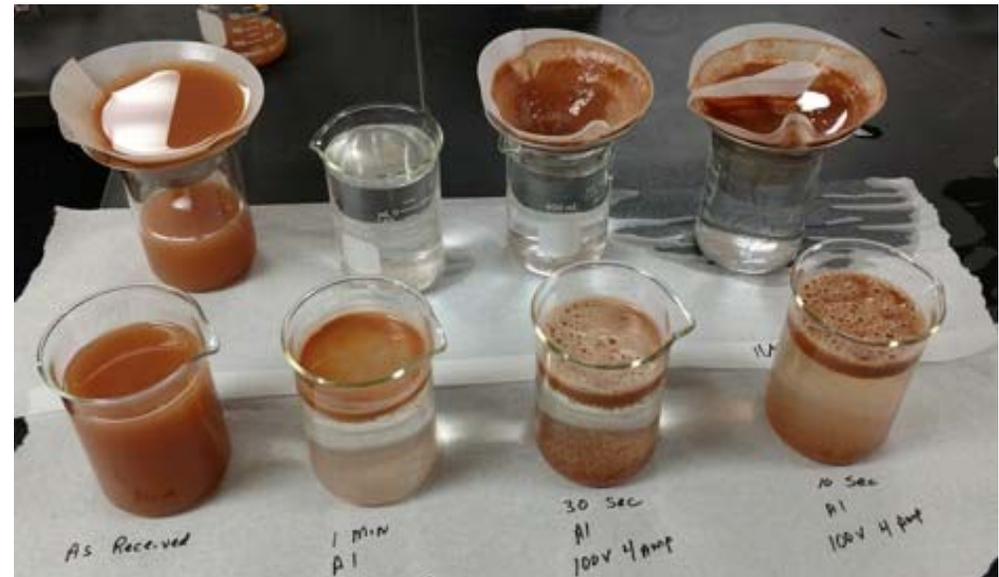
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**MOU8** This slide shows Ethe rPathogen removal results for 60-seconds of treatment raw sewage to achieve a 99.999% removal of pathogens. 10-seconds of EC treatment is expected to remove 99.99% of pathogens

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## Sedimentation of Clay Particles with Electrocoagulation (EC)

- Wet Season Tijuana River flows carry large volumes of silt (750 to 4,416 mg/L) that settle and clog the Tijuana River.
- *Reduce Suspended Solids to < 175 mg/L to use SBOO*
- The photograph shows:
  - Suspended clay particles held by Van-der-Waals forces (lower left beaker).
  - 60-, 30- and 10-sec. EC treatment of clay suspended in storm water to overcome Van-der-Waals forces.
- *> 95% of TSS removed with 10-sec. EC treatment*



## Slide 12

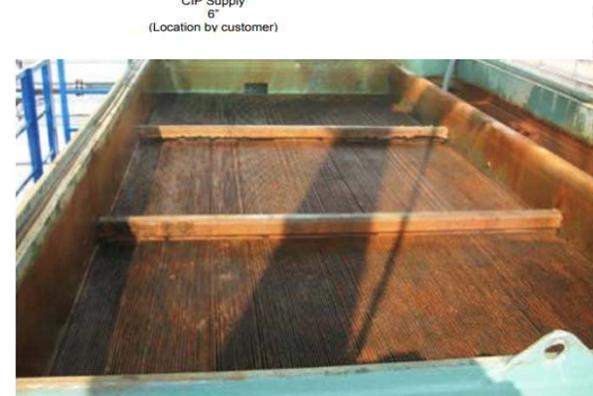
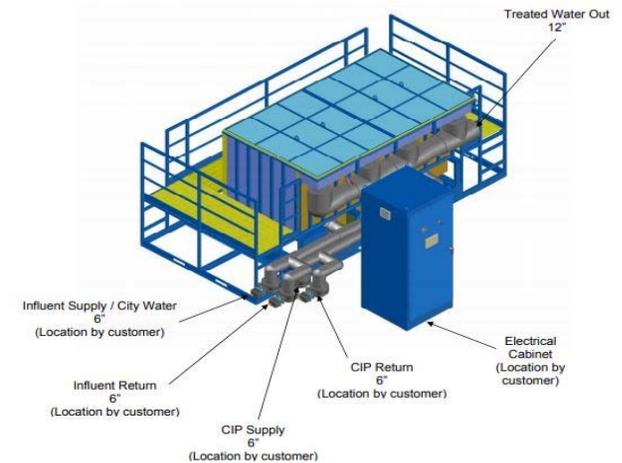
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**MOU7** Removal of sediment (suspended solids) from storm water is required prior to placing storm water in the SBOO. The most difficult sediment to remove are clay particles that are held in suspension with Van-Der-Waals electrical forces that are disrupted by EC treatment. The photograph shows grab samples of storm water with entrained clay. The four beakers on the bottom row show from left to right storm water as received (No EC), 60-sec EC, 30-sec EC and 10-sec EC. Given these results that would be duplicated EC and a Retention Pond or Clarifier, 10-sec of EC treatment is expected to remove 80 to 90% of suspended solids.

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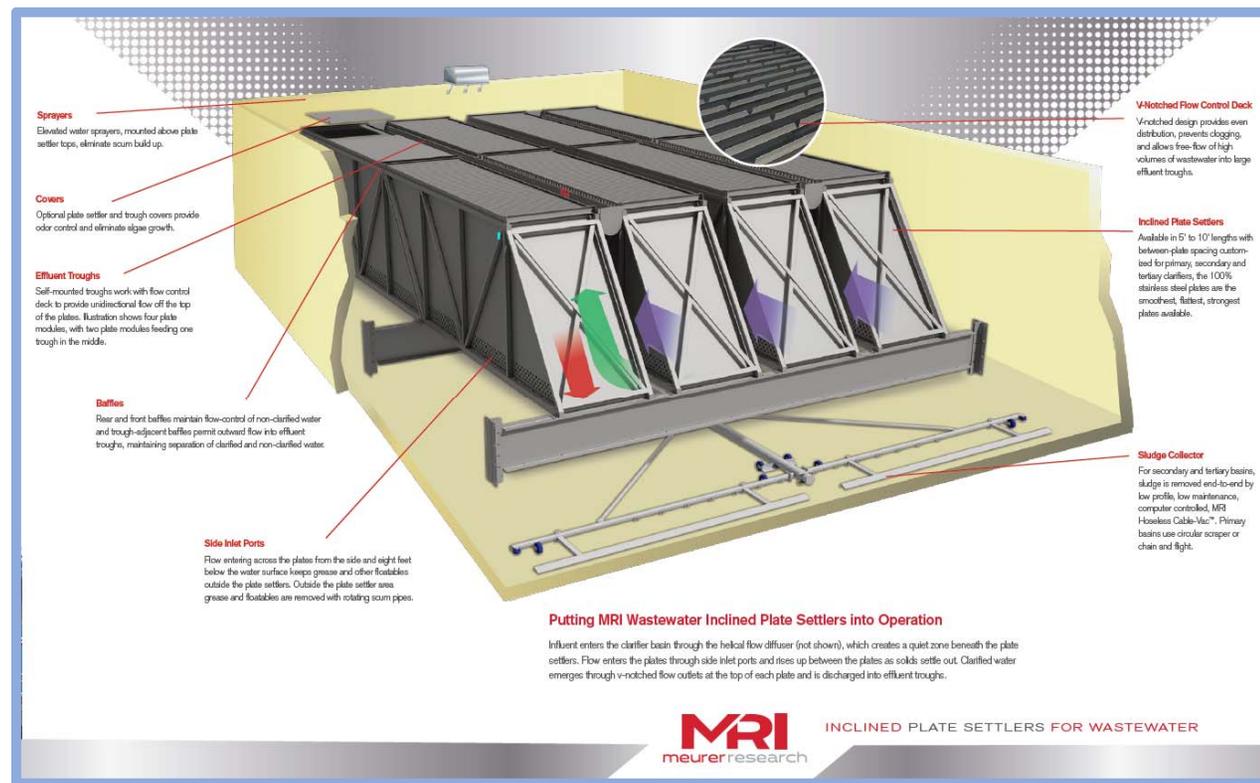
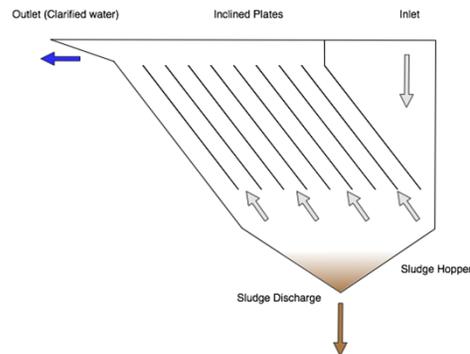
# EC = Sediment and Pathogen + Toxic Chemical and Metal Removal

- 10-seconds of EC treatment:
  - Enhances Sedimentation, and
  - Reduces bacteria in sewage from 110,000,000 (standard plate count) to 2,700 bacteria/mL - **a 99.9975% reduction**
- Pathogens are killed by electrocution and rupturing.
- EC coagulates pathogens, long carbon-chain (> 6 C atoms) compounds and oxidizes toxic metals.
- Diagram and photo show a 7,200 GPM EC System using a 10-second Hydraulic Retention Time (HRT).



# Lamella Inclined Plate Settler Basins

- Proven Design - 220 MGD MRI Inclined Plate Settler system at the Miramar Water Treatment Plant
- EC + Inclined Plate Settler used with low viscosity EC-treated water could improve 95% solids separation



## 600 GPM Vacuum Clarifier

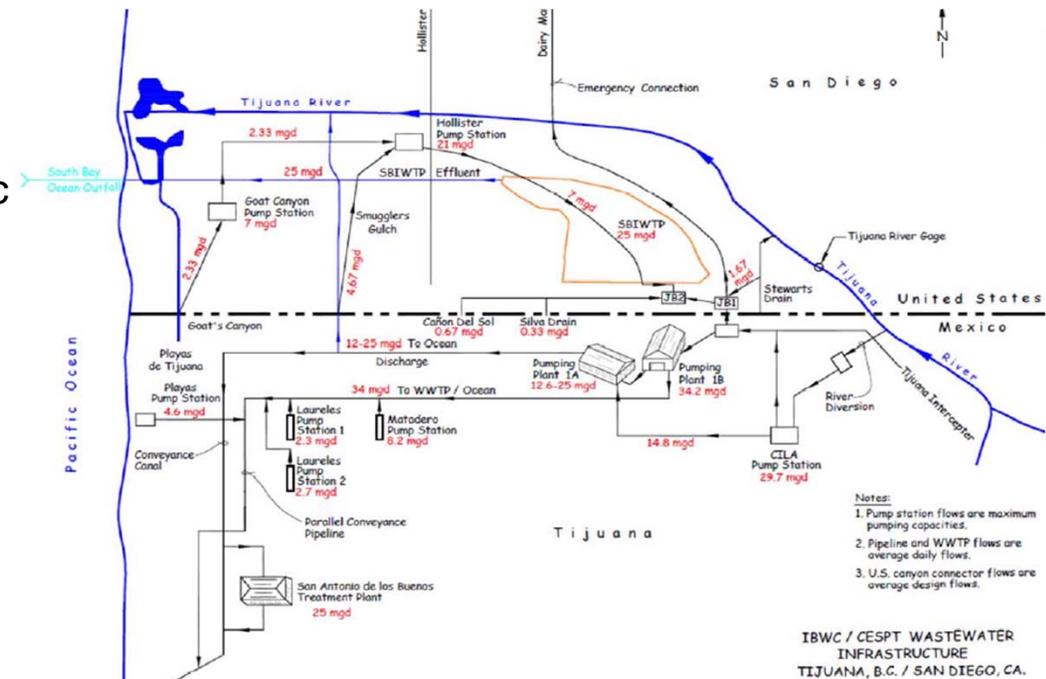
- Concentrates Settler Basin sludge from  $< 2\%$  to  $23\%$  solids.
- Four 600 GPM vacuum clarifiers could recover an additional 490 MGY
- Sale of additional recycled water pays for vacuum clarifiers





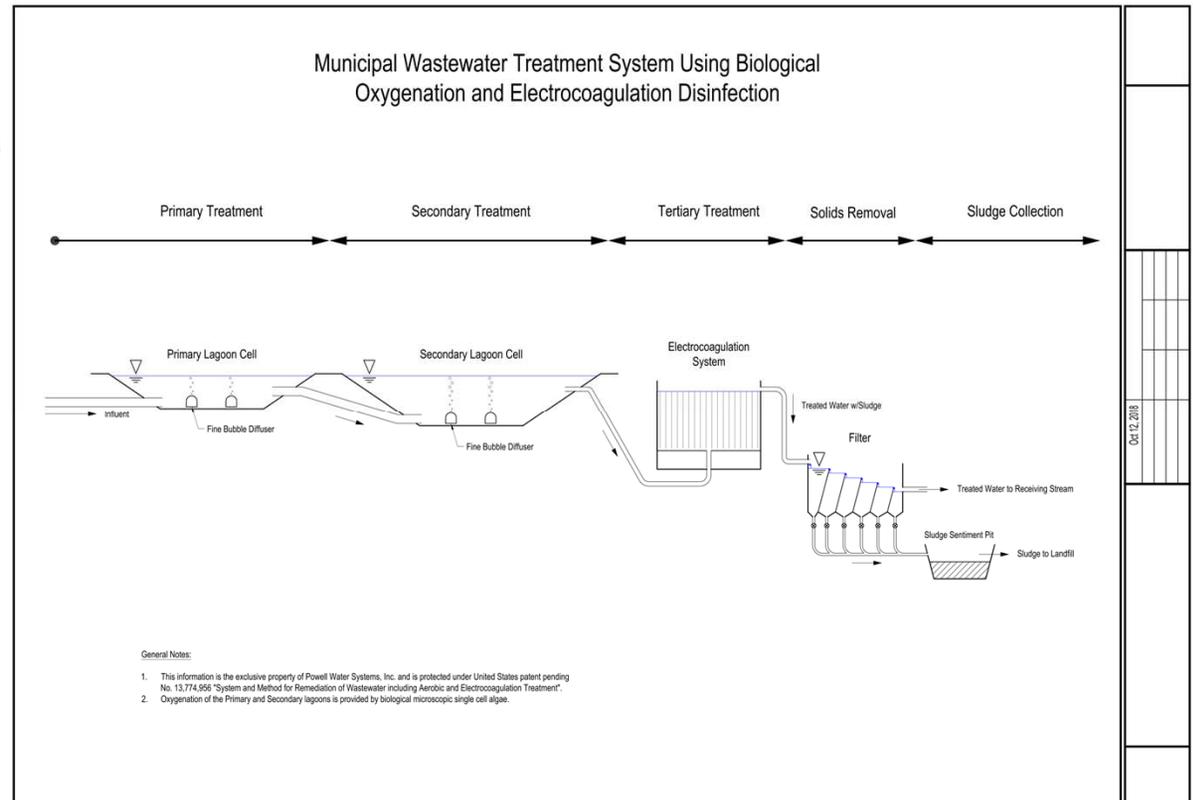
# Goat Canyon & Smuggler's Gulch Cross-border Collector Treatment

- Micro-algae Lagoons treat Short Carbon- Chain pollutants more efficiently than EC.
- EC oxidizes Long Carbon-chain Pollutants, Toxic Metals/Chemicals and **KILLS PATHOGENS!**
- Goat Canyon:
  - Pump up to 4 MGD to SBIWTP
  - 4-acres of Micro-algae Lagoons
  - Two 1,200 GPM (1.58 MGD) EC Systems
- Smuggler's Gulch:
  - Pump up to 14 MGD to SBIWTP
  - 14-acres of Micro-algae Lagoons
  - Six 1,200 GPM (1.58 MGD) EC Systems



# Smuggler's Gulch and Goat Canyon Micro-algae Lagoon Schematic

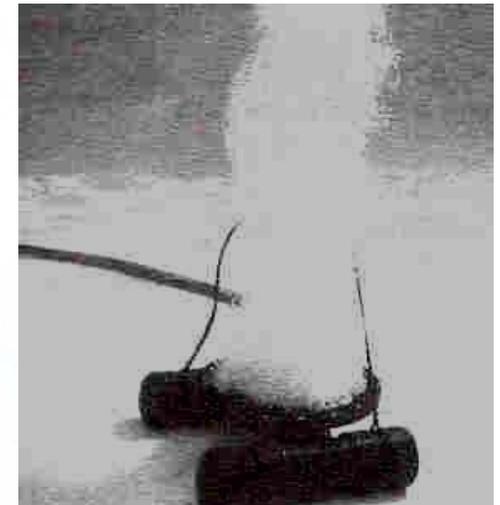
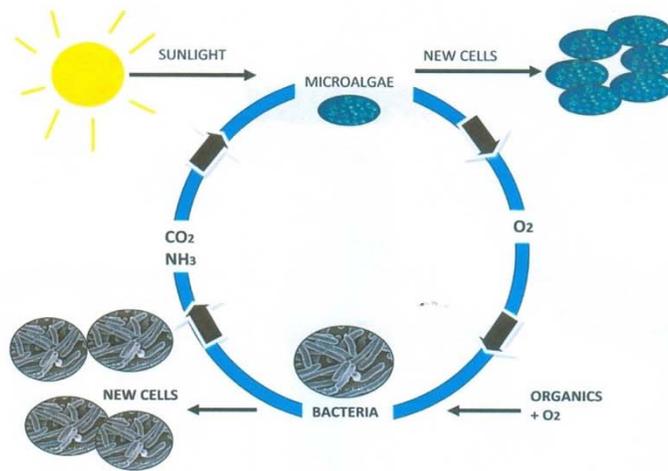
- Head Works
  - Separate Trash
  - Pump up to 50% of flow to SBIWTP
- Greenhouse
  - Breed Micro-algae
- Primary and Secondary Lagoons
  - Micro-algae
  - Fine Bubble Diffusers
- Tertiary Treatment
  - EC
  - Settling Pond
    - Permeate pumped to Slough
    - Solids Dried and Trucked to Quarry



# Micro-algae Green House Incubation and Lagoon Operation



Micro-algae incubation



Fine Bubble Diffuser

Micro-algae + sunlight + CO<sub>2</sub> + H<sub>2</sub>O **photosynthesis** additional microalgae + O<sub>2</sub>

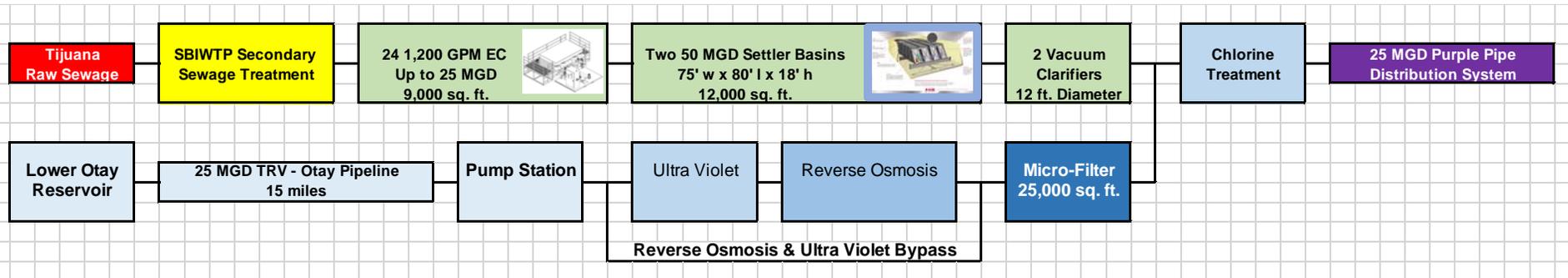
Organic waste + O<sub>2</sub> **lagoon process** bacteria + CO<sub>2</sub> + H<sub>2</sub>O

## Title 22 (Non-Potable) Recycled Water

- Recycle up to: 26,823 AFY of SBIWTP treated sewage with EC.
- South San Diego County 'Purple Pipe' market cannot use 25 MGD additional water
  - Insufficient 'Purple Pipe' Infrastructure - City of San Diego South Bay Wastewater Reclamation Plant (SBWRP) sells 6 MGD of 'Purple Pipe' water to Otay Water District through 2016.
  - Sale price is \$ 754/AF (\$1.73/HCF)
  - US Sales would qualify for a \$305/AF Metropolitan Water District Incentive for 20-years
- Need to Investigate:
  - 'Purple Pipe' and Potable Water sales to Mexico,
  - Upgrade to Indirect Potable Reuse (IPR) Water, and
  - Pump station/pipeline to transport 25 MGD of Potable Water to the Lower Otay Reservoir

# Indirect Potable Reuse (IPR) Recycled Water System

- EC Recycles SBIWTP Secondary-Treated Sewage to CA Title-22 Quality
- *“Pure Water” treatment without Reverse Osmosis & Ultra-Violet to provide IPR water*
- Removal of RO & UV would save ~ 65% of “Pure Water” life-cycle costs & energy use while adding EC would provide sufficient “barriers” against pathogens



## SBIWTP Secondary Sewage Treatment + 30-sec. EC

- **RED** > Drinking Water MCL
- **GREEN** < Drinking Water MCL
  - Meets EPA Drinking Water Standards
- "Pure Water" train uses U-F, RO & UV 'barriers' to prevent Pathogen breakthrough
- *EC reduces need for 'barriers'*
  - *30-sec. EC = 99.999% Pathogen Kill*
- *Low salt in Tijuana Sewage eliminates need for Reverse Osmosis (RO).*

SBIWTP Constituent	Influent mg/L	Effluent mg/L	% Removal w/ 60-sec. EC	Effluent + 30-sec. EC	EPA Drinking Water MCL
TSS	421	10.70	97.46%	5.37	
VSS	419	9.10	97.83%	4.57	
BOD	302	12.40	95.89%	6.32	
CBOD	348	9.10	97.39%	4.64	
TDS	1,594	1,452	8.91%		
Turbidity	219	2.27			
Ammonia	51	8.24	99.00%	4.16	10.00
Antimony	0.000946	0.00	50.00%	0.00	0.01
Arsenic	0.024	0.00	97.12%	0.00	0.01
Beryllium	0.0025	0.00	99.00%	0.00	0.004
Cadmium	0.16	0.00	96.81%	0.00	0.01
Chromium	0.00079875	0.00	99.92%	0.00	0.10
Chromium VI	0.0243245	0.00	99.92%	0.00	0.05
Copper	0.00490	0.00	99.75%	0.00	1.30
Cyanide	0.0000	0.00	99.99%	0.00	0.20
Grease and Oil (Max)	20.32	1.60	99.99%	0.00	
Lead	0.00139	0.00	99.46%	0.00	0.015
Mercury	0.00007	0.00	98.45%	0.00	0.002
Nickel	0.02289	0.01781	99.96%	0.01	
Selenium	0.00088	0.001	44.00%	0.00	0.05
Silver	0.0005187	0.00	92.59%	0.00	
Thallium	0.00055	0.00	50.00%	0.00	0.002
Zinc	0.0007556	0.02088	99.90%	0.01	
<b>Pesticides</b>					
Bis 2	0.01775	0.00	90.00%	0.00	
Phenol	0.01275	0.00	90.00%	0.00	
Chloroform	0.00145	0.00	90.00%	0.00	
Tolulene	0.00175	0.00	90.00%	0.00	
DCM	0.00828	0.00	90.00%	0.00	
Carbon Disulfide	0.00132	0.00	90.00%	0.00	

## TRV Wastewater Recycling and Solar-PV Benefits

- Produce and sell up to 26,823 AF of Recycled Water/year
  - Non-Potable “Purple Pipe” Water, and/or
  - Indirect Potable Reuse (IPR) Water
    - *IPR Sales to Otay Water District would pay ALL TRV Capital & Operational Expenses in 30-years*
- **Green Power** = *330 million kWh/year - Saves \$44.6 Million/year and 99,750 MT CO<sub>2</sub>*
  - Avoid purchase of 80 Thousand MWh/year of power costing ~ \$7 M/year with 80-acres of Solar-PV collectors.
  - *Avoid 250 thousand MWh/year to transfer 26,823 AFY over 254 mi MWD aqueduct vs. 15-mi Otay aqueduct*
- Beneficial Reuse of up to 148,600 yd<sup>3</sup> of sediment/year: **Market Value = \$1.5 Million**

# Punta Bandera Raw Sewage Discharge pollutes San Diego Beaches

- Tijuana produces 40 MGD of Raw Sewage discharge at Punta Bandera, 5-Miles South of the US-Mexican Border
- This sewage causes Ocean Bacterial Concentrations that exceed California Ocean Plan Standards and result in US beach closures - particularly at the Tijuana River Sloughs and Imperial Beach.
- *Treatment of Punta Bandera Sewage is a high priority requirement not currently shown in EPA, Surfrider Foundation, IBWC or San Diego County SB 507 Needs Assessment.*
- **Options:**
  - EC treatment to kill pathogens in 40 MGD of untreated Punta Bandera sewage for 15-seconds would require fourteen (14) 3,600 GPM EC machines **costing \$32 Million plus \$8.5 Million/year O&M Expense.**
  - **Alternatively, recycling 40 MGD of Punta Bandera sewage as potable water would cost \$91.8 M in Capital Expense and \$10.3 M/year (+ 3%/year) in Average O&M Expense.**

# Punta Bandera 40 MGD Sewage Recycling = Irrigation Potable Water

- Influent **Raw Sewage > EPA MCL**
- Effluent = **Potable Water < EPA MCL**
- Micro-algae Lagoons remove short carbon-chain pollutants

GPD	Gallons - 8 days	Acre-Feet	Lagoon Acres
40,000,000	320,000,000	982	70

- EC remove long carbon-chain pollutants & toxic metals
  - Forty 1,200 GPM EC machines
  - One 50 MGD Inclined Plate Settler Basin
  - Geotechnical Bag Filters (or Vacuum Clarifiers)
- EC kills 99.999% of Pathogens
- Treat permeate with Chlorine
  - 20% of normal Chlorine dose
- Locate between Pumping Plant 1A and the Punta Bandera.
- Construct and commission in 12-months

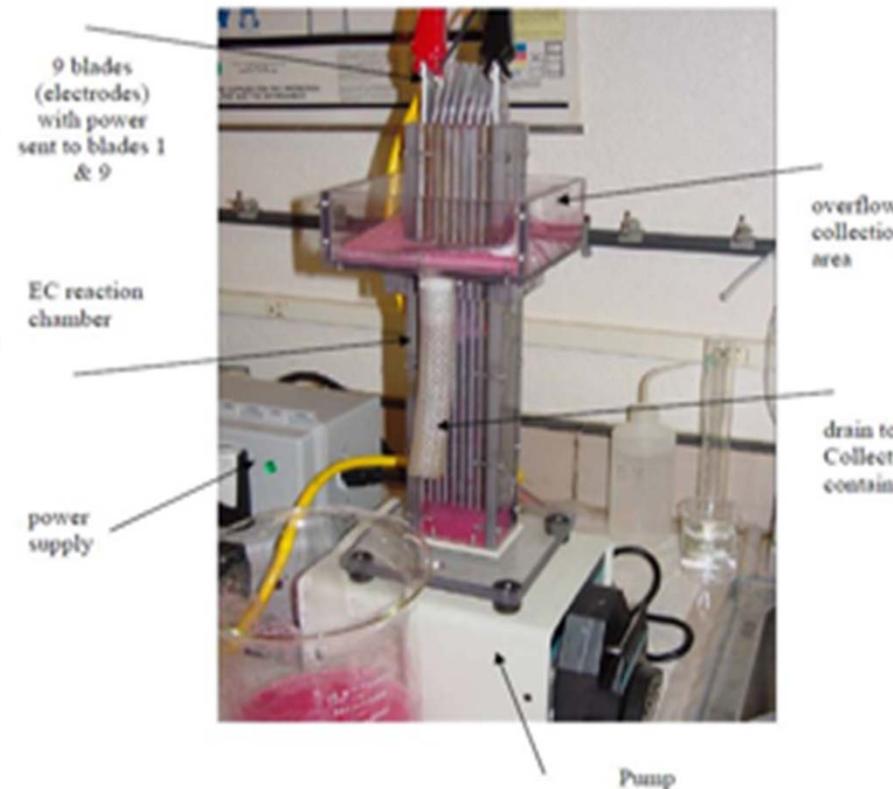
Punta Bandera Constituent	Influent mg/L	60-sec EC	EC Treated Sewage 60-sec.	EPA Drinking Water MCL
TSS	421	99.60%	1.684	
VSS	419	99.60%	1.676	
BOD	302	98.10%	5.738	
CBOD	348	98.10%	6.612	
TDS	1,594		15.710	
Turbidity	219		2.000	
Ammonia	51	99.00%	0.510	10.00
Antimony	0.0009			0.01
Arsenic	0.024	97.12%	0.0006912	0.01
Beryllium	0.0025	99.00%	0.000025	0.004
Cadmium	0.16	96.81%	0.005104	0.01
Chromium	0.00079875	99.92%	0.00000064	0.10
Chromium VI	0.0243245	99.92%	0.000019	0.05
Copper	0.00490	99.75%	0.000012	1.30
Cyanide		99.99%		0.20
Grease and Oil (Max)	1.60	99.98%	0.000320	
Lead	0.00139	99.46%	0.000008	0.015
Mercury	0.00007	98.45%	0.000001	0.002
Nickel	0.02289	99.96%	0.000009	
Selenium	0.00088	44.00%	0.000493	0.05
Silver	0.00052	92.59%	0.000038	
Thallium	0.00055			0.002
Zinc	0.00076	99.90%	0.00000076	
<b>Pesticides</b>				
Bis 2	0.01775	95.00%	0.000888	
Phenol	0.01275	95.00%	0.000638	
Tolulene	0.00175	95.00%	0.000088	1.00
DCM	0.00828	95.00%	0.000414	
Carbon Disulfide	0.00132	95.00%	0.000066	

# Conclusions

- EC + Plate Settlers can treat Tijuana River surges up to 100 MGD, kill 99.99% of sewage spill pathogens & pump to SBOO
  - **Would reduce Trans-Border Flows 87% from 138 days/year to 18 days/year**
- 200 Million Gallon Diversion Basin would augment 100 MGD EC, Settler Basin treatment and pump to South Bay Ocean Outfall
- Wet Season flows at Cross-border Collectors would transfer 50% to the SBIWTP and treat 50% with Micro-algae Lagoons + EC
- EC + Clarifiers can recycle up to 26,823 AFY of SBIWTP Secondary-treated sewage to produce CA Title 22 'Purple Pipe' water
  - The market for recycled 'Purple Pipe' irrigation water is small ~ 7 MGD during Dry Season less in Wet Season,
- Market for Indirect Potable Reuse (IPR) water is large.
  - Requires a \$241 Million CAPEX + \$759 Million in OPEX over 30-years + \$100 million in CAPEX plus 80 acres for Solar PV Collectors
  - **This could offset ALL Capital and Operational Expense for the TRV plus Water Recycling and Pumping Expenses over 30-years**
- EC can kill 99.99% of pathogens in the up to 40 MGD raw sewage outflow at Punta Bandera in B.C., Mexico
  - It is possible to recycle up to 40 MGD of wastewater to water meeting EPA Drinking Water Standards at \$415/AF - over 30-years
  - Sale of recycled water could pay for Punta Bandera Capital and Operational Expense over 30-years

## Next Steps

- Expand Cross-Border Collector analysis to include suspended solids, dissolved solids and flow data,
- Define markets for Recycled 'Purple Pipe' and IPR Water
- Determine availability of 80-acres for Solar-PV panels within the TRV
- Scaled demonstrations of EC with 1 Liter/min EC system.
- Demonstrate Pathogen Kills of Tijuana River sewage,
- Demonstrate suspended solids removal with EC + an inclined plate settler,
- Demonstrate Micro-algae Lagoon at Goat Canyon



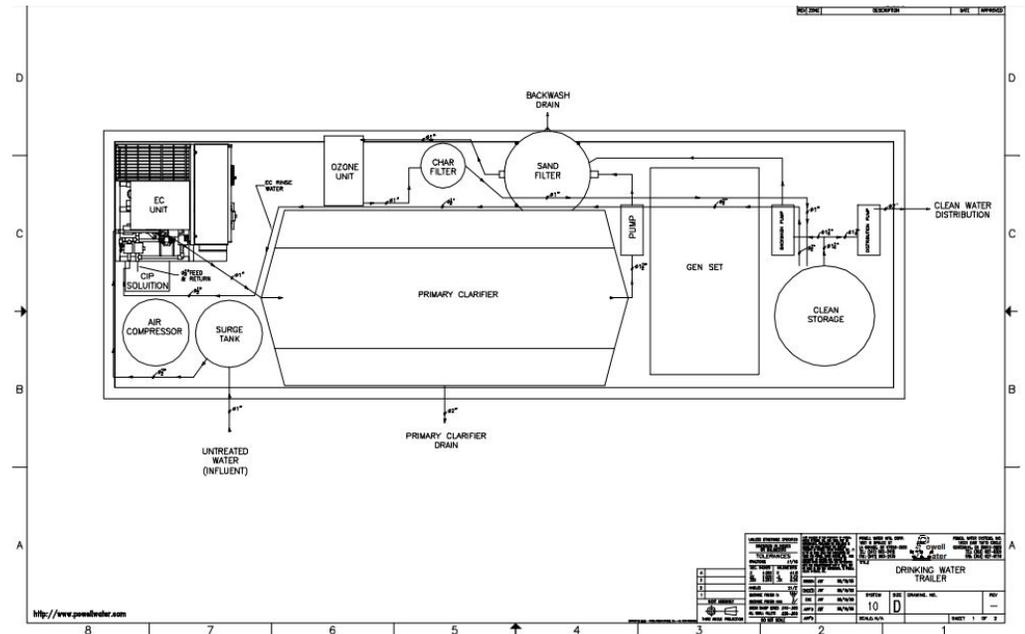
# Scaled EC Demonstration Support

- 10 GPM EC Drinking Water Trailer
  - Integrated EC, Clarifier, Filter and Ozone
  - 24 ft. x 8 ft.

- EC Trailer Scaled Demonstrations
  - Kill Pathogens
  - Treat Suspended Solids for Inclined Plate Settler
  - Support Micro-Algae Lagoon



12/10/2019



## Summary

- EC can **RAPIDLY KILL 99.99% of PATHOGENS** in:
  - Tijuana River,
  - X-Border Collectors, and
  - Punta Bandera
- EC reduces Suspended Solids 95% in River Surges to <175 mg/L for South Bay Ocean Outfall
- Micro-Algae Lagoons are more effective than Retention Ponds in Cross-Border Collectors
- Recycling Wastewater and Solar-PV can reduce TRV and Recycling System Life Cycle Costs
- Visit <http://www.powellwater.com> for more EC information

Questions?