

# Solar Powered Circulation (SPC): An Ecological Approach to Solving Water Quality Problems while Reducing Atmospheric Emissions and Chemical Applications



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## Freshwater Harmful Algal Blooms



- FHAB Incidence & Duration is Increasing Rapidly Worldwide
- FHAB Toxins are among the Most Potent Known

| Component                   | LD <sub>50</sub> | EPA priority | Comparison                   | LD <sub>50</sub> |
|-----------------------------|------------------|--------------|------------------------------|------------------|
| Cyanobacteria               | 10               | Medium/High  | Ricin <sup>a</sup>           | 22               |
| Saxitoxin <sup>b</sup>      | 20               | Medium/High  | Caliche extract <sup>c</sup> | 185              |
| Anatoxin-a1 <sup>d</sup>    | 50               | Highest      | Sarin <sup>e</sup>           | 218              |
| Anatoxin-a2 <sup>f</sup>    | 200              | Highest      | Carar <sup>g</sup>           | 300              |
| Cylindrocapsin <sup>h</sup> | 200/180          | Highest      | Strychnine <sup>i</sup>      | 2500/100         |

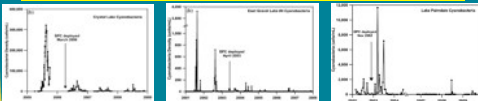
- FHABs & their Toxins are Risks for Human & Animal Health, Aquatic Ecosystem Sustainability & Economies
- There is NO U.S. POLICY or Research & Control Program for FHABs

## Algaecides such as Copper Sulfate are often used to terminate FHABs

- CuSO<sub>4</sub> has multiple adverse impacts
- CuSO<sub>4</sub> use is unsustainable, and cyanobacteria are becoming resistant

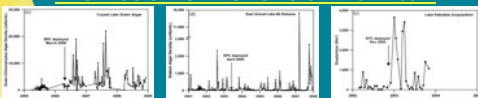
## SPC is an Ecological Approach to FHAB Suppression

- Promotes Natural Processes
- No Adverse Environmental Impacts
- No Grid Power or Chemicals used
- FHAB Suppression in 3 Source Waters



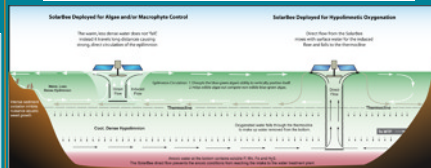
- Crustal Lake – No Algaecides used, Pre-SPC used other Source Water during FHABs
- EGL4 & Lake Palmdale – reduced algaecide applications by 85-92% during SPC

## Promotion of Beneficial Plankton



SPC Reduces FHAB Risks Near Term & Sustainably

## Solar Powered Circulation (SPC) Technology



- 3, 80 W Solar Panels & Battery
- High Efficiency Brushless Motor
- 24 hr/day, 7 day/wk Operation
- 0.91 Diameter Flexible Intake Hose
- Steel Plate Suspended 0.31 m below Hose causes Radial, Near-Laminar Flow Intake
- 80 RPM; 37,850 L/min Upflow
- Non-turbulent Surface Outflow
- Long Distance Circulation of Epilimnion; FHAB Suppression over 0.15 km<sup>2</sup>/unit Area

## Potable Water Storage

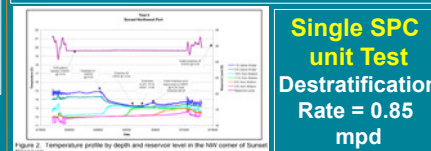
Mixing, De-stratification, and Break-Point Chlorination in San Francisco's Sunset Reservoir (Large Enclosed Potable Water Reservoir)

White Paper  
October 2008

**San Francisco Public Utility Study**

- Storage Reservoir
- 0.05 km<sup>2</sup>, 87.3 MG

## De-stratification & Circulation



## Chlorine Dispersion

Complete Dispersion Time < 4.87 d

| Sampling Location & Depth | Distance (m) | Arrival Time (hrs) |
|---------------------------|--------------|--------------------|
| 100                       | 100          | 0.00               |
| 200                       | 200          | 0.00               |
| 300                       | 300          | 0.00               |
| 400                       | 400          | 0.00               |
| 500                       | 500          | 0.00               |
| 600                       | 600          | 0.00               |
| 700                       | 700          | 0.00               |
| 800                       | 800          | 0.00               |
| 900                       | 900          | 0.00               |
| 1000                      | 1000         | 0.00               |
| 1100                      | 1100         | 0.00               |
| 1200                      | 1200         | 0.00               |
| 1300                      | 1300         | 0.00               |
| 1400                      | 1400         | 0.00               |
| 1500                      | 1500         | 0.00               |
| 1600                      | 1600         | 0.00               |
| 1700                      | 1700         | 0.00               |
| 1800                      | 1800         | 0.00               |
| 1900                      | 1900         | 0.00               |
| 2000                      | 2000         | 0.00               |
| 2100                      | 2100         | 0.00               |
| 2200                      | 2200         | 0.00               |
| 2300                      | 2300         | 0.00               |
| 2400                      | 2400         | 0.00               |
| 2500                      | 2500         | 0.00               |
| 2600                      | 2600         | 0.00               |
| 2700                      | 2700         | 0.00               |
| 2800                      | 2800         | 0.00               |
| 2900                      | 2900         | 0.00               |
| 3000                      | 3000         | 0.00               |
| 3100                      | 3100         | 0.00               |
| 3200                      | 3200         | 0.00               |
| 3300                      | 3300         | 0.00               |
| 3400                      | 3400         | 0.00               |
| 3500                      | 3500         | 0.00               |
| 3600                      | 3600         | 0.00               |
| 3700                      | 3700         | 0.00               |
| 3800                      | 3800         | 0.00               |
| 3900                      | 3900         | 0.00               |
| 4000                      | 4000         | 0.00               |
| 4100                      | 4100         | 0.00               |
| 4200                      | 4200         | 0.00               |
| 4300                      | 4300         | 0.00               |
| 4400                      | 4400         | 0.00               |
| 4500                      | 4500         | 0.00               |
| 4600                      | 4600         | 0.00               |
| 4700                      | 4700         | 0.00               |
| 4800                      | 4800         | 0.00               |
| 4900                      | 4900         | 0.00               |
| 5000                      | 5000         | 0.00               |
| 5100                      | 5100         | 0.00               |
| 5200                      | 5200         | 0.00               |
| 5300                      | 5300         | 0.00               |
| 5400                      | 5400         | 0.00               |
| 5500                      | 5500         | 0.00               |
| 5600                      | 5600         | 0.00               |
| 5700                      | 5700         | 0.00               |
| 5800                      | 5800         | 0.00               |
| 5900                      | 5900         | 0.00               |
| 6000                      | 6000         | 0.00               |
| 6100                      | 6100         | 0.00               |
| 6200                      | 6200         | 0.00               |
| 6300                      | 6300         | 0.00               |
| 6400                      | 6400         | 0.00               |
| 6500                      | 6500         | 0.00               |
| 6600                      | 6600         | 0.00               |
| 6700                      | 6700         | 0.00               |
| 6800                      | 6800         | 0.00               |
| 6900                      | 6900         | 0.00               |
| 7000                      | 7000         | 0.00               |
| 7100                      | 7100         | 0.00               |
| 7200                      | 7200         | 0.00               |
| 7300                      | 7300         | 0.00               |
| 7400                      | 7400         | 0.00               |
| 7500                      | 7500         | 0.00               |
| 7600                      | 7600         | 0.00               |
| 7700                      | 7700         | 0.00               |
| 7800                      | 7800         | 0.00               |
| 7900                      | 7900         | 0.00               |
| 8000                      | 8000         | 0.00               |
| 8100                      | 8100         | 0.00               |
| 8200                      | 8200         | 0.00               |
| 8300                      | 8300         | 0.00               |
| 8400                      | 8400         | 0.00               |
| 8500                      | 8500         | 0.00               |
| 8600                      | 8600         | 0.00               |
| 8700                      | 8700         | 0.00               |
| 8800                      | 8800         | 0.00               |
| 8900                      | 8900         | 0.00               |
| 9000                      | 9000         | 0.00               |
| 9100                      | 9100         | 0.00               |
| 9200                      | 9200         | 0.00               |
| 9300                      | 9300         | 0.00               |
| 9400                      | 9400         | 0.00               |
| 9500                      | 9500         | 0.00               |
| 9600                      | 9600         | 0.00               |
| 9700                      | 9700         | 0.00               |
| 9800                      | 9800         | 0.00               |
| 9900                      | 9900         | 0.00               |
| 10000                     | 10000        | 0.00               |

## Wastewater Mixing

### The Problem

Oxygenation and mixing are required in many municipal and industrial wastewater treatment plants (WWTPs) to improve processing and shorten treatment durations. WWTPs often use mechanical aerators to both oxygenate and mix wastewater. However, much more aeration is needed to thoroughly mix than oxygenate the wastewater. This imbalance creates an operational inefficiency when excessive horsepower (HP) is used for mixing. Excessive HP usage increases electrical grid-power consumption, greenhouse gas emissions and operational costs.

## New Hampshire Department of Environmental Services' Study Goals

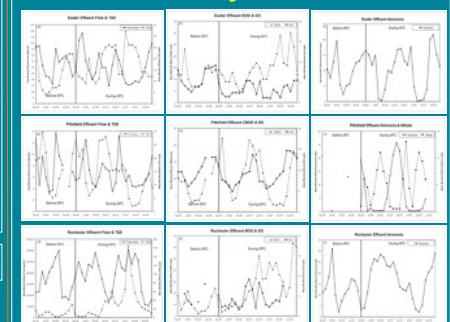
- Assess SPC at 3 WWTPs
- Maintain Effluent Water Quality
- Reduce kWh consumption & costs

Table 1. Study site descriptions, average HP, SPC units and kWh usage before & during study

| Location                | Total                 |                      | Total                    |             | Mean      |           | Mean      |  |
|-------------------------|-----------------------|----------------------|--------------------------|-------------|-----------|-----------|-----------|--|
|                         | Engines used in study | Surface Area (acres) | Volume (million gallons) | Aeration HP | SPC Units | kWh/month | kWh/month |  |
| Exeter <sup>a</sup>     | 4                     | 26.1                 | 77.4                     | 325.5       | 6         | 166,313   | 91,068    |  |
| Pittsfield <sup>b</sup> | 4                     | 5.2                  | 12.3                     | 76          | 4         | 50,043    | 28,373    |  |
| Rochester <sup>c</sup>  | 2                     | 18.3                 | 41.7                     | 140         | 2         | 83,400    | 7,709     |  |

<sup>a</sup> kWh is all electrical grid power used at the plants, including that used for aeration.  
<sup>b</sup> Partial mix pond system using aeration and mixing in the initial lagoons.  
<sup>c</sup> Activated sludge system using aeration and mixing in the raw sewage and sludge storage lagoons.

## Water Quality Maintained



- All NPDES Standards Met
- No Malodorous Events
- No Sludge Buildup

Operational Efficiency Improved  
 Exeter - 45% kWh↓, 3 Yr Payback  
 Pittsfield - 43% kWh↓, 3.9 Yr Payback  
 Rochester - 91% kWh↓, 1.5 Yr Paybk.