City of Houston,

Mayor's Office – Environmental programming

Lake Houston "SolarBee" Project

The City of Houston produces and distributes over 146 billion gallons of superior quality safe drinking water annually to over 2 million customers in the Greater Houston Metropolitan Area. Therefore, we play an important role in the community as protector of our valuable source waters. Drinking water delivered by the City comes from three sources: numerous deep aquifer artesian ground water wells; Lake Houston; and the Trinity River. Ground subsidence in the area has resulted in a regulatory requirement to restrict future ground water withdrawals. As a result, the City embarked, a number of years ago, on an extensive and costly program of laying new surface water transmission lines to outlying portions of the county to provide an alternate source of drinking water to its customers.

The City will rely more heavily on surface waters for its source water going forward over the next thirty years. The use of these surface waters is shared with the community for recreational purposes, and they are an important part of our environmental ecosystem in Texas. The City has to achieve a balance between the protection of the integrity of these source waters for its drinking water needs and general use of the public. Lakes and rivers receive vast amounts of precipitation run-off as their source water, and therefore, the City also has an important role to play in regional pollution prevention of storm water. The City achieves this today in majority through its public educational programs.

However, surface waters are still subject to seasonal water quality changes, and surface waters require more treatment and processing to remove impurities than ground water. As the City strives to maintain a sustainable supply high quality source water, we have begun a program of evaluating alternative techniques for water quality management in large reservoirs. This program commenced with a unique, first of its kind, lake management program in Lake Houston. The project is a 2-year study designed to investigate ways to enhance natural ecological processes to improve water quality. The most challenging water quality concern for large open reservoirs is seasonal algal blooms.

These blooms may contain certain species of algae with release natural compounds that can impart an unpleasant taste or odor to water. The release of these compounds occurs under stress, as the algae are removed in the treatment process. The two thoughts on reducing the occurrence of taste and odor events in drinking water is to provide additional treatment techniques at the treatment plant aimed at removal of the specific chemical compounds that cause bad taste and odor; or, alternately, to prevent the occurrence of algal blooms. Providing additional treatment at the water plants is a costly solution.

The addition of chemicals such as copper sulfate to lakes to kill algae after the bloom has occurred is also very costly, and often the blooms reappear after a relatively short period of time. In addition, the presence of copper in these waters could adversely impact the normal biological system if not controlled properly.

City water quality experts studied the problem and found a potential low cost and effective solution for preventing algal blooms that did not involve the use of additional chemicals and which could work all year round. That solution, called "hypolimnetic aeration", involves using a slow mixing technique to keep lower waters oxygenated all year long, promoting the health of the natural ecosystem. Algal blooms only occur when the natural biosystem is altered in a way that favors the propagation of unwanted or "nuisance" species.

There are two ways to achieve this mixing action, which occurs naturally at the surface through wind action, by using electrically-powered mechanical mixers, or through the use of solar-powered laminar flow mixers. The solar-powered mixers require no electrical power source, and are low maintenance, enabling them to be freely employed in large open reservoirs.

The City was able to locate a commercial vendor for the solar-powered mixers, called "SolarBees". With assistance from the US Geological Services ("USGS"), whose federal mission is to study the science of natural resources such as lakes and rivers, the City was able to design and execute a pilot scale study to evaluate the potential future use of this technology for improvement of source water quality.

In partnership with the Houston Area Water Corporation (the "HAWC"), and the USGS,

20 SolarBees were deployed in Lake Houston in April 2006, near the intake of the City's Northeast Water Purification Plant. One of the challenges of water quality management in open reservoirs is the size of the water body and the complex flow patterns that exist. Knowing where to place the mixing units, and how many to install, is critical to the success of the technique.

The Lake Houston project is currently the largest application in a drinking water reservoir. The Lake Houston project is also unique in that only partial treatment, near the treatment plant intake, is being evaluated, as opposed to attempting to mix the entire lake. If successful, this partial application technique would increase significantly the cost effectiveness of the technology, and make it affordable and applicable to may other applications in similar water bodies.

Therefore, the City's Lake Houston project is being closely monitored by water utilities around the country to determine its success. With the help of the USGS, the City is collecting and analyzing extensive scientific data that will be published in later USGS Technical Reports. The scientific validation of the hypolimnetic aeration technique for preventing seasonal algal blooms and improving water quality, and for increasing our understanding of lake hydrology, will provide a valuable future tool for the City of Houston, as well as other cities around the State and country, to provide the highest possible quality water to customers.

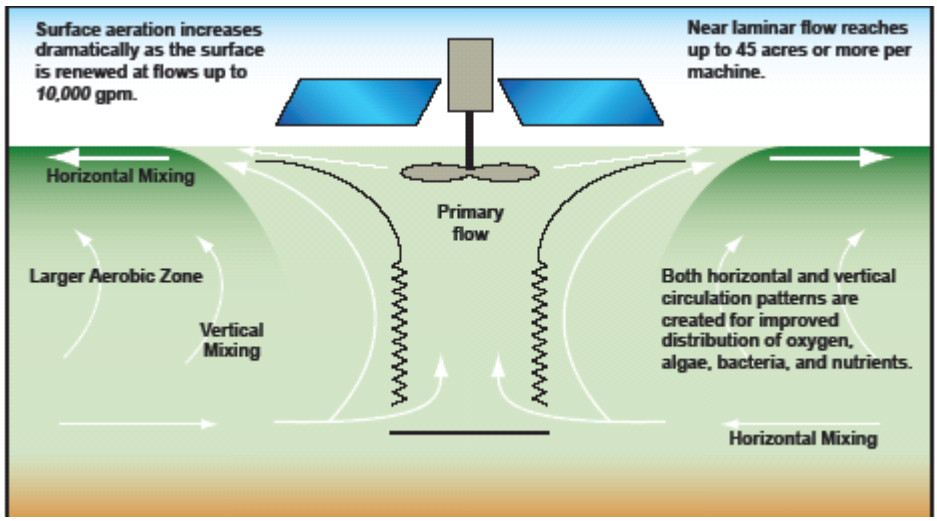
Initial results after almost a year into the study have already indicated positive benefits associated with hypolimnetic aeration. These benefits include"

- Avoidance or minimization of large seasonal algal blooms;
- Improvement in lake water clarity and dissolved oxygen levels;
- Reintroduction of natural beneficial aquatic plant species and fish; and
- Less variability in water quality conditions, which can translate into lower chemical treatment costs.

The following discussion provides more technical background on SolarBees and the Lake Houston project.

The SolarBee is a patented solar-powered water circulator. The use of SolarBees has been to control and prevent blue-green algae (cyanobacteria) blooms in water bodies

throughout North America. By circulating epilimnetic waters (i.e., surface waters above the thermocline), blue-green algae lose their preferred habitat of stagnant waters and are consequently out-competed by non-blue-green algae (e.g., diatoms, greens, etc.). Unlike the toxic and inedible blue-green algae, zooplankton and fish will consume diatoms and green algae, moving these beneficial algae up the food chain both materially and energetically. Typically, water clarity improves as the lake ecosystem becomes healthier.



The SolarBee's high flow mixing action accelerates the normal purification process in the lake through gentle, thorough mixing and surface re-aeration.

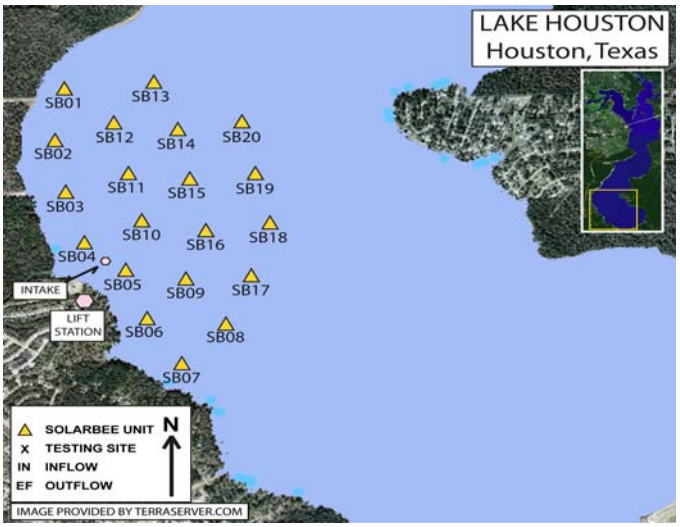
Previous research has shown that artificially induced mixing can cause species shifts from buoyant cyanobacteria to algal communities dominated by diatoms and green algae (Reynolds et al. 1983, Bailey-Watts et al. 1987, Harris and Baxter 1996, Visser et al. 1996). More recently, an experimental study demonstrated that sufficient water column mixing could shift the competitive balance between buoyant and sinking phytoplankton in a predictable manner. (Huisman et al. 2004, p. 2968). These peer-reviewed studies confirm what has been observed with SolarBee-induced circulation in ponds, lakes and reservoirs disrupting the blue-green algae habitat prevents blooms and restores lake ecosystems without having to control phosphorus or nitrogen inputs. Unlike the above studies, however, SolarBees accomplish this goal without destratifying the whole lake,

without bringing up oxygen-depleted bottom waters, and without any land-based energy requirements.

Performance of solar powered circulators is being documented elsewhere. The cities of Palmdale, CA and Thornton, CO both produced scientific papers showing how harmful algal blooms were eliminated in their lakes. The Ohio EPA and Iowa Department of Energy each published a study of benefits achieved in wastewater lagoons using solar powered circulators, and the California and Michigan EPAs support the use of solar powered circulation. Shell Oil recently published a paper on solar powered circulators solving water quality problems in a storm water holding pond located in a refinery. The City of San Francisco produced a 2-year study of solar powered circulators, and presented a paper at the AWWA national conference in 2005, regarding their choice to use solar powered circulators in potable water reservoirs.

The Lake Houston application is unique in that it represents the first study of the technology that will scientifically verify the specific benefits as they relate to drinking water treatment. It is also the largest partial in-lake treatment application, as shown below:

Lake Houston SolarBee Project



Units placed in service on April 18, 2006

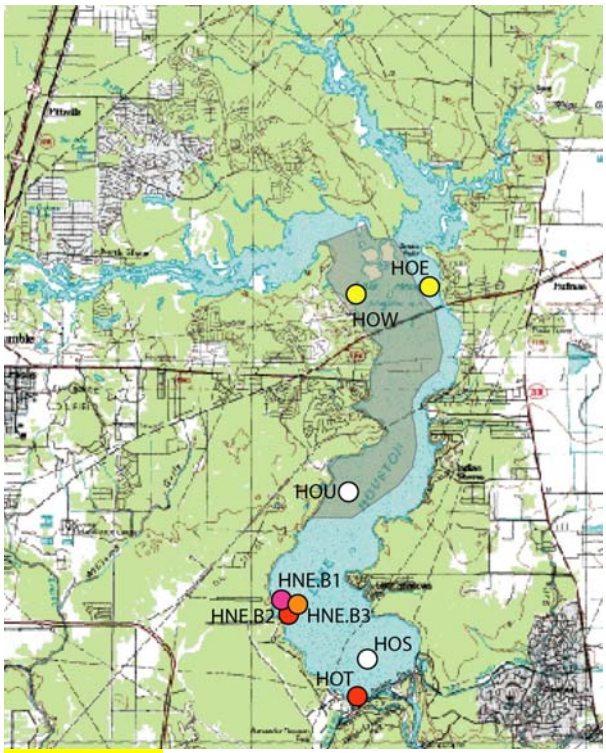
Covered area is 600 acres

Units upstream, at, and downstream of water treatment plant intake structure

Extensive water quality sampling program being conducted

Provides 30 day dissipation area for MIB

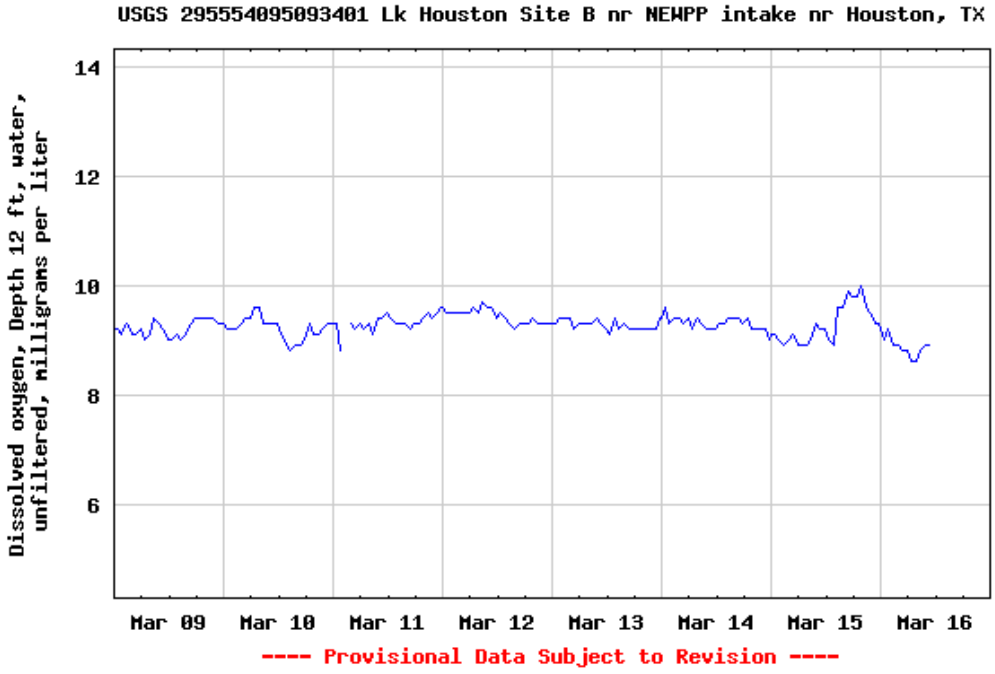
The USGS collaboration on the project included construction of three first in kind floating platform monitoring stations installed upstream, in stream, and downstream of zone of lake circulator influence. The USGS is monitoring real-time, multiple water quality parameters such as turbidity, chlorophyll a, specific conductivity and dissolve oxygen at several discrete depths in the lake. Meteorological data and hydrological data are also being recorded. In addition, the USGS will develop a predictive mathematical model for providing plant operations advance notice of significant changes in lake water quality. This will allow plant operators to adjust treatment processes accordingly to maintain the highest possible quality water delivered to City customers.



HOE, HOW – USGS Lake Houston Inflow Monitoring Locations

HOU, HOS – USGS Reference Monitoring Locations

HNEB1, HNEB2, HNEB3 – USGS Platform Monitoring Locations Upstream, In Stream and Down Stream of SolarBees



Depending on the outcome of the initial pilot study, the City will evaluate expansion of its source water protection initiatives including purchase of the 20 rental units; installation of additional units; monitoring treatment of Trinity River water; and installation of additional USGS real-time water quality monitoring stations.