REFLECTIONS: ***It may be oxygen bubbles to the fish, but its champagne to us.***

William P. Ruzzo[1], and Robert McGregor[2], April, 2008

According to Ed Dentry, Sports writer for the Rocky Mountain News in an article about the pending project in Cherry Creek Reservoir[3], fish will get "*high on oxygenated water and munch a tossed seafood salad*." This fisherman's dream may become a reality because of the recently installed destratification system at Cherry Creek Reservoir. To the Cherry Creek Basin Water Quality Authority (authority), seeing the bubbles for the first time in October 2007 may as well have been champagne flowing, as the event was a milestone in a 25 year effort to control algae in Cherry Creek Reservoir.

Nutrient enrichment study – the start of a solution. In 2003, the authority and the Water Quality Control Division co-sponsored a nutrient enrichment study of Cherry Creek Reservoir which was conducted by Dr. Bill Lewis, et. al., with the University of Colorado. The results of the study showed that algal growth was limited by nitrogen, not phosphorus. Dr. Lewis also noted[4] that "*reduction in phosphorus concentrations sufficient to induce phosphorus deficiency in the phytoplankton of year 2003 would involve decreases in upper water column concentrations of at least 50%, or about 30 μg/L*". What this means is that controlling algal growth by reducing nutrients in the Cherry Creek watershed alone is very difficult and that algae must also be controlled "…*based on non-nutrient factors*", according to Dr. Lewis. Even though the authority and others have implemented watershed controls with some success, watershed controls alone are not sufficient nor are the phosphorus reductions timely enough to control algae growth in the near future. Therefore, the need for supplemental strategies to control algae growth, such as in-lake management, became more apparent.

Dr. Lewis found that during periods when the reservoir was not being naturally mixed by wind activity, then algal growth activity was at its highest. He determined that the most practical approach to controlling this growth would be to artificially mix the reservoir. Since the reservoir is relatively shallow, it can usually be mixed by normal wind activity. Several times throughout the year, however, extended periods of hot, dry and windless weather cause the lake to stop mixing and to stratify. This stratification not only causes anoxic (lack of oxygen) conditions at the bottom of the reservoir, but also allows blue-green algae to bask in the sunlight on the surface of the reservoir, fixing all the nitrogen they need from the air. And, with plenty of phosphorus in the water, they can reproduce explosively. Thus, an algae bloom is created.

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[2] AMEC Earth and Environmental

[3] Ed Dentry, Rocky Mountain News November 23, 2006. *Tiny bubbles to zap algae, aid fish at Cherry Creek*

[4] Lewis, William M. Jr; Saunders, James F III; and McCutchan, James H. Jr. January 22, 2004. *Studies of Phytoplankton Response to Nutrient Enrichment in Cherry Creek Reservoir, Colorado*

Meanwhile, the anoxic water at the bottom of the reservoir allows previously settled particulate and organic phosphorus and nitrogen in the bottom sediments to dissolve into the water column, so that when the reservoir becomes remixed, due to renewed wind activity, all this re-dissolved phosphorus and nitrogen become available for the blue-green algae during the next round of stratification. To prevent this endless cycle, the authority began to investigate methods to keep the reservoir continuously mixed. By doing this, the blue-green algae would be circulated to the dark depths of the reservoir, preventing them from having access to nitrogen and sunlight at the surface, both of which they need to reproduce. This may also reduce phosphorus and nitrogen from dissolving from the bottom sediments and is the basis for the authority spending almost $900,000 to install a destratification system

Inland Marine installing air lines and diffusers

Feasibility, final design, and construction were the next steps. In 2005, the authority retained AMEC Earth and Environmental, an international consulting firm, to conduct a feasibility analysis[5] of various options to mix the reservoir. The AMEC team recommended the installation of a submerged mixing system in the 330 acre portion of the reservoir which is greater than 16 feet deep. The primary objectives for the mixing system were to:

1. Destratify and strongly mix the deepest portions of the reservoir,
2. Vertically mix algae to compromise their habitat and reduce production of blue-green algae, and
3. Oxidize of the deep bottom sediments to reduce the release of nutrients from the sediments into the water column.

After considering the various options and risks associated with such a high profile project, the authority board authorized final design of the destratification system in 2006, which was also prepared by AMEC. The destratification system selected was a fine-bubble aeration system. Separate construction contracts were awarded to supply the compressor, hoses, and fittings. Construction of the underwater work was awarded to Inland Marine of Centennial, Colorado. Construction of the compressor building and other non-underwater components was awarded to American Civil Constructors in Littleton, Colorado. After receiving approval from Colorado State Parks and the U.S. Army Corps of Engineers, construction began in early 2007.

One of 102 diffusers

[5] AMEC Earth and Environmental, Alex Horne and Associates, and Hydrosphere Resource Consultants December 5, 2005. *Feasibility Analysis Cherry Creek Reservoir Destratification*

What's involved in mixing an 850 acre water body? Lots of hose, fittings, diffusers, and a powerful compressor is the short answer. Air is pumped by a 125 hp compressor at 455 SCFM and 51 psig, which is housed in a 19 by 17 foot block building with a metal roof near the Marina. The air passes through over 40,000 feet of 1-1/4 inch hydraulic hose leading to 102 air diffusers placed at the bottom of the deepest part of the reservoir. These diffusers are expected to move about 1,000,000 gallons of water per minute (approximately 4,400 acre feet per day) which will "turn-over" the mixing zone about once per day.


The beginning of a popular trail

So how do you get all that air to the 102 diffusers? You construct what has turned out to be the beginning of a very popular trail across much of the face of the dam. Actually, the "trail" was first conceived as an above grade platform by which to contain the 4" HDPE pipe line with separate 1-1/4 inch hydraulic hoses for each of the five diffuser zones and to provide access for maintenance. When it became apparent that this maintenance access could function as a formal park trail, Colorado State Parks agreed to fund the additional costs of constructing the trail to their standards. Even during construction, when the work was shut-down for the evening, people were waiting to access the trail for hiking, fishing, running and simply enjoying the view.

How will we determine if the project works? The ultimate test of whether destratification works will be the reduction of algae biomass and density as measured by chlorophyll *a* and species identification and enumeration, particularly the blue-green species *cyanobacteria*. The more immediate test will be to determine if the reservoir stays mixed throughout the algae growing season from May through October, as measured by the vertical temperature and dissolved oxygen profile of the water column.

During the regular growing season, the authority contracts with GEI\Chadwick Division to conduct bi-monthly sampling in the reservoir at three locations. During each sampling episode on the reservoir, three main tasks were conducted, including: 1) determining water clarity; 2) collecting depth profile measurements for temperature, dissolved oxygen, and pH conductivity; and 3) collecting water samples for chemical and biological analyses. In anticipation of construction of the destratification system, the authority had GEI install three temperature arrays consisting of Onset HOBO® Water Temp Pro data loggers in the deepest part of the reservoir. These data loggers recorded temperature measurements on 15-minute intervals for each 1 meter water layer. This monitoring program will continue in 2008 to determine how well the reservoir stays mixed and may be extended beyond 2008.


Actual diameter of bubble disturbance area is about 4 feet at each aerator

In addition to the temperature loggers at the three monitoring sites, GEI will also perform monthly Oxidation Reduction Potential (ORP) profiles along a transect through the deep water zone, including

measurements near the water/sediment surface during the July to September period. The sample locations and transect will be consistent with locations previously established by AMEC during their destratification feasibility study.

In the mean time, the authority continues to implement watershed management strategies, construction of other more traditional BMPs, such as shoreline and stream stabilization, and education.

Additional information can be obtained from the authority's website at http://www.cherrycreekbasin.org/.