# The Barrimeter

A Publication of the Barr/Milton Watershed Association

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## Phased TMDLs with Adaptive Implementation

By Laurie Rink, FRICO

The BMW Association is currently underway with development of a pH Total Maximum Daily Load (TMDL) that will address pH impairment in both Barr Lake and Milton Reservoir (for an explanation of TMDLs see the *Barrimeter* Issue #9). An expected completion date is set for July of this year when the TMDL will be submitted to the state Water Quality Control Division (WQCD) and EPA for formal approval.

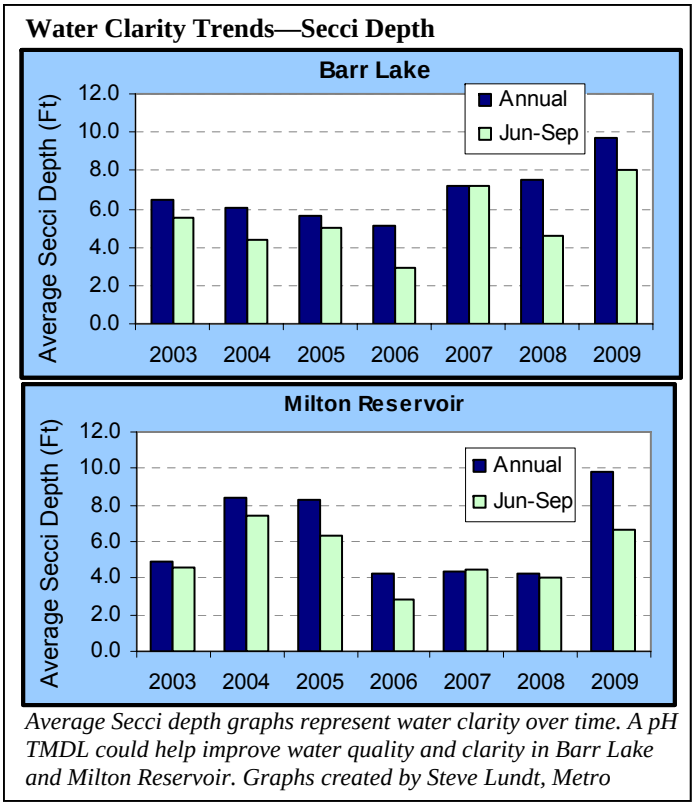
EPA has provided information to states and 3rd parties for how TMDLs should be developed in its publication "Guidance for Water Quality-Based Decisions: The TMDL Process" (April 1991). More recent and specific guidance is provided in an EPA memorandum "Subject: Clarification Regarding "Phased" Total Maximum Daily Loads" (August 2, 2006). These pieces of guidance along with pre-TMDL consultation from the WQCD and EPA have informed the Association's selection of a process for moving forward with pH TMDL development.

EPA's guidance allows for two general types of TMDLs: the traditional TMDL and the phased TMDL. This article focuses on the use of a phased TMDL since this is the type that the Association has chosen to develop. Per EPA, selection of a phased TMDL necessitates use of an "adaptive implementation" plan, which is also defined and described herein.

### Phased TMDLs

EPA recommends a phased approach where data only allow for "estimates" of necessary pollutant load reductions or where predictive tools may not be adequate to characterize the problem with a sufficient level of certainty. EPA stresses that the TMDL load reductions and pollutant allocations still need to be set at levels that meet water quality standards, but allows for revisions (in a second phase) of those loading capacities and allocation schemes as additional information is collected.

With the Association's pH TMDL, there is a lack of reservoir response data at the low end of the scale for phosphorus/chlorophyll concentrations which creates uncertainty around selection of specific numeric targets for these parameters. Quantitative numeric targets are necessary to determine, however, as they form the basis for calculating the allowable load of phosphorus that the lake can tolerate without exceeding the pH standard. The Association is currently planning additional studies designed to develop better correlations for phosphorus/chlorophyll that should help reduce




*Average Secci depth graphs represent water clarity over time. A pH TMDL could help improve water quality and clarity in Barr Lake and Milton Reservoir. Graphs created by Steve Lundt, Metro*

that uncertainty. Once those studies are complete, it may be necessary to revise the numeric targets, recalculate the allowable loads, and reassign allocations – this process forms the basis for a second phase of the TMDL. All TMDL revisions require re- approval by EPA.

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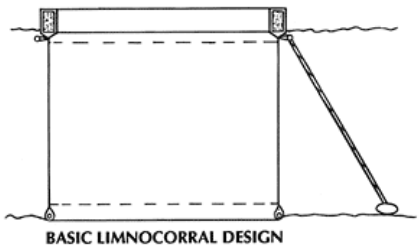
# Limnocorrals: What Are They and How Can They Help Barr and Milton?

**By Steve Lundt, Metro**

A limnocorral is an impervious, water-tight tube of fabric that isolates a vertical column of lake water without disturbing either the lake or the water inside the corral. The use of a limnocorral is basically a way to isolate a test lake inside of a lake. Limnocorrals are a proven way to test in-lake restoration techniques without the bias of a lab setting and without the risk or cost of doing an untested technique lake-wide.



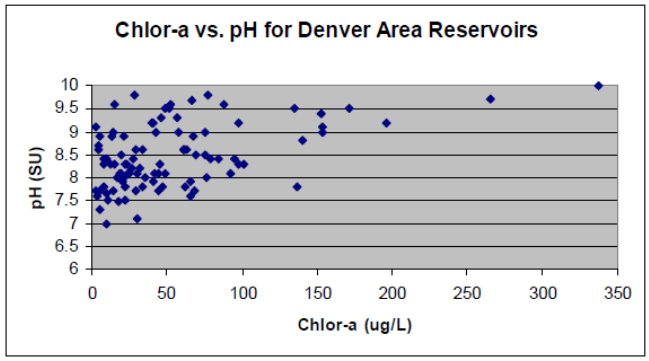
BASIC LIMNOCORRAL DESIGN

The BMW Association has applied for a Nonpoint Source Grant from the State to help fund a limnocorral study for 2011 to determine the actual amount of phosphorus that seeps into the water from lake bottom sediments. Partitioning of phosphorus from sediments to water is a nonpoint source called internal loading, and the recent modeling efforts indicate that without any in-reservoir treatment or removal to stop this source, the reservoirs are unlikely to achieve current pH standards. The recent modeling also shows that the amount of phosphorus loading from lake sediments is very hard to predict.

During the limnocorral study, internal loading from sediments will be measured by observing the increases in phosphorus concentrations within the limnocorral over time. Since the corral will isolate the water column from the rest of the lake, the only sources of phosphorus inside the limnocorral will be either from aerial deposition (which is a very minor source) or from the bottom sediments. Multiple limnocorrals may be used during the study. Some corrals will simply isolate a column of water to measure and quantify the loading from sediments. Other corrals may be used to test in-lake water treatment options. For example, aluminum sulfate can also be applied inside a limnocorral to remove phosphorus from the water, allowing the buildup of phosphorus from the sedi-

Another major goal of the limnocorral study is to help clear up some of the uncertainty around the chemical linkages between pH and chlorophyll-a (chl-a; a measure of the amount of algae in the water), and between chl-a and phosphorus. The thought is that, by lowering the concentrations of total phosphorus from around 600 ug/L during the summer down to about 100 µg/L, there will be less nutrient content to fuel algae growth, and therefore less algae (chl-a) which causes the high pH values.

Mathematically, there are plenty of unknowns about how these chemical linkages work. For example, the regression analysis between pH and chl-a only explains about 54% of variation. In other words, the cause-and-effect relationship between pH and chl-a is not good because it is graphically difficult to fit a straight line through the chl-a vs pH data. This difficulty in using existing water quality data to say that lower chl-a will cause lower pH will hopefully be reduced by conducting various tests within the limnocorrals.




To select appropriate and successful management strategies, we need better than a 50/50 chance for explaining what is going on in Barr Lake and Milton Reservoir. Limnocorrals can be used to measure the pH and chl-a response to changing phosphorus levels, and will hopefully improve our understanding of the pH, chl-a, and phosphorus relationships.

If awarded the limnocorral nonpoint source grant, the BMW association will purchase and install 3 to 5 of these fabric tubes into the deepest area of Barr Lake in 2011. They will be anchored to the bottom of the lake, and floats will prevent waves from splashing into the test area. Then various management techniques such as alum, artificial mixing, aeration, and combinations of techniques will be tested inside the corrals. A vigorous sampling plan will closely monitor how the column of water reacts to each treatment method compared to the actual Barr Lake water outside of the corrals.

Limnocorrals are a great way to test various treatment options for lakes and reservoirs. You control the influences inside a limnocorral so that you can observe how all the various parameters and linkages interact. For Barr and Milton, will a total phosphorus of around 100 ug/L reduce the chl-a below 25 ug/L? Will this lower level of productivity be enough to keep pH below 9.0 85% of the time? This is a difficult question, but an effective way to find out is to use limnocorrals.

# Phased TMDLs with Adaptive Implementation (continued from page 1)

## Adaptive Implementation

Adaptive implementation is defined as an iterative TMDL implementation process that makes progress towards achieving water quality goals while using new data and information to reduce uncertainties and adjust implementation activities. This might include immediate actions, an array of possible long-term actions, success monitoring, and experimentation for model refinement. EPA cites the possible use of "flexible load allocation/waste load allocation schemes", for which EPA is working to further clarify.

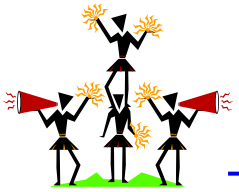
In addition to developing the phased TMDL, the Association is concurrently working on developing a TMDL implementation plan that utilizes the adaptive approach. The first task at hand is to take the current calculation of allowable load for phosphorus and equitably divide or allocate that load among the existing sources. This step is followed by the tougher step of determining how the existing sources will be reduced in order to meet the new, restricted load allocations.

Questions arise such as:

- which loads are most important to reduce initially,
- is the technology available to achieve pollutant reductions,
- how much time will it take to logistically implement the reductions, and
- what are the cost/benefits of achieving the required reductions.

Answers to each of these questions will factor in to the structure of the implementation plan.

As on-the-ground reductions occur, the Association plans to monitor the effects of these reductions on in-lake chemistry, essentially testing results predicted by the water quality models. It is possible that actual in-lake responses will be different from those calculated, thus requiring a shift in implementation activities. For example, as external loads of phosphorus are reduced, it is unclear how in-lake internal phosphorus loads will respond. This internal source may be larger or smaller than predicted and, depending upon the outcome, may be best addressed by in-lake treatments.



There is plenty of work to be done in order to develop the phased TMDL and adaptive implementation plan – most of which is best accomplished through the collaborative stakeholder process.

**Please participate in one of the TMDL subcommittees if you want your voice to be heard!**

# Florida Approaches Nutrient Standards for Flowing Waters

**By George Patten, Integral Consulting**

The development of numeric standards for phosphorus and nitrogen has been elusive in many areas that experience water quality effects from nutrient loading. A recent action by the EPA to impose limits on nutrients in Florida will be the first attempt by the Federal Government to create numerical standards for phosphorus and nitrogen entering surface waters. The proposed action to set a limit on nutrients that enter surface waters was developed in conjunction with Florida's state environment officials issued on January 14th of this year. The proposed action was generated in response to a lawsuit brought by five environmental groups against the EPA who claim that the agency failed to meet a requirement of the Clean Water Act under section 303(c) to establish numeric nutrient criteria to meet water quality standards. The EPA entered into a consent decree with the Florida Wildlife Federation to impose limits on nutrients, and released the proposed rulemaking for a public comment period.

Photo courtesy of Earthjustice by Richard Solveson

Photo courtesy of Earthjustice

The nutrient standards would set a limit on the amount of phosphorus and nitrogen that enter surface waters in Florida including rivers, streams, lakes and canals. Sources of these nutrients can come from stormwater runoff, crop fertilizers, municipal wastewater treatment plants and fossil fuel burning. The increased presence of these nutrients in lakes and streams can lead to algae blooms and higher in-stream productivity, which in turn can reduce water quality. The proposed action by EPA to limit nutrients would seek to reduce these impaired conditions and maintain better water quality. In addition to nutrient criteria, the EPA is also introducing a proposed framework for Florida to develop "restoration standards" for impaired waters specific to nutrients in the state. The proposed rulemaking on nutrient criteria are currently awaiting stakeholder input during a 60-day public comment period. Written comments will also be accepted until March 29, 2010. Information on the proposed nutrient criteria, including the technical support document, and comment period are available at EPA's website, http://www.epa.gov/waterscience/standards/rules/florida.

# Tech Corner

# Dissolved Oxygen and Ammonia in Barr Lake and Milton Reservoir

By Steve Lundt, Metro Wastewater

In February of 2010, Barr and Milton will be added to the 303(d) water quality impaired list for dissolved oxygen (DO) and ammonia. For Milton, the listing will be on the 303(d) list for both parameters. For Barr, the listing will include the Monitoring and Evaluation list for DO (which means that it is not clear if it should be officially listed) but fully listed on the 303(d) list for ammonia.

Why the listings? Low levels of DO and higher levels of ammonia are signs of eutrophication, as are low Secchi depth, high pH, and high chlorophyll-a. These are signs that a lake or reservoir is over-productive because of excessive nutrient loading. However, low DO and elevated ammonia at the bottom of lake is normal and expected, especially when the lake is thermally stratified during the summer..

The minimum DO standard is 5.0 mg/L for Class 2 Aquatic Life and 3.0 mg/L for Agriculture and Domestic Water Supply. There is an exemption for when a water body is thermally stratified (Figure X). The hypolimnion, the dense, bottom layer of water in a thermally-stratified lake, can have DO below 5.0 mg/L because of natural causes, and therefore may be exempt from the DO standard. Since Barr and Milton are too shallow to develop thermal stratification (polymictic), it is rare for them to be thermally stratified for long periods of time. This means that the hypolimnion exemption does not come into play very often.

Determination of compliance with the ammonia standard is complex and requires multiple parameters, fish species information, and several mathematical formulas. There is a chronic standard as well as an acute standard for ammonia, the difference being whether or not salmonid fish (such as trout) are absent (sa) or present (sp). For both Barr and Milton, the acute standard with salmonids does not apply since they are not considered cold water fisheries. There is also seasonality to take into consideration because of fish: early life stages present (elsp) (March – August) and early life stages absent (elsa) (September – February). Both seasons do apply for Barr and Milton. Of the four ammonia standard equations, three of them need to be used for Barr and Milton - elsp, elsa, and sa.

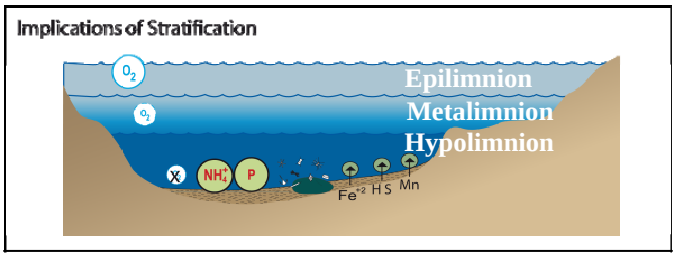



*Diagram of a thermally stratified lake. Modified from Queensland Wetlands Programme.*

**Chronic:**

Early Life Stages Present (elsp)

$$\text{Chronic elsp} = \left[\frac{0.0577}{1+10^{(7.688-pH)}} + \frac{2.487}{1+10^{(pH-7.688)}}\right]\left[\min.\ 2.85,\ 1.45\times10^{0.028(25-T)}\right]$$

Early Life Stages Absent (elsa)

$$\text{Chronic elsa} = \left[\frac{0.0577}{1+10^{(7.688-pH)}} + \frac{2.487}{1+10^{(pH-7.688)}}\right]\left[\min.1.45\times10^{0.028(25-\text{Max.}(T,7.0))}\right]$$

**Acute:**

Salmonids Absent (sa)

$$\text{Acute sa} = \left[\frac{0.411}{1+10^{(7.204-pH)}} + \frac{58.4}{1+10^{(pH-7.204)}}\right]$$

As you can see from the dizzying equations above, pH and water temperature need to be measured when a water sample is collected in order to calculate the ammonia standard. Higher water temperature and pH values lead to lower (more strict) ammonia standards.

From 2004 to 2008 for Barr Lake, 3 to 4 DO violations were observed when DO fell below 5.0 mg/L in the metalimnion (the metaliminon is measured from 4 to 6 meters below the lake surface). For the most part, the thermal mixing of the entire water column and the high rate of photosynthesis keeps the water column DO above 5.0 mg/L. For Milton, there were more instances (6-7 violations) when the DO fell below 5.0 mg/L at several depths all the way up to the surface of the reservoir.

In June of 2010, the Water Quality Control Division will propose new methods to interpret DO profile data for compliance determination. If the Water Quality Control Commission accepts these changes, it is a good chance that Barr will no longer violate the standard, but Milton may still be in violation due to low DO measurements in the surface water layer (1 to 3 meter depths).

For ammonia, it seems that Barr had more violations than Milton between 2003 and 2004 but then improved. Milton then had more violations than Barr between 2006 and 2009. The violations for both reservoirs tend to occur more often in the hypolimnion than the epilomnion, which makes sense since ammonia elevations are caused by decomposition of organic matter in the lake sediments.

What does this mean in comparison to the pH 303(d) listing in 2002 and the overall big picture of water quality within both reservoirs? Not too much other than the fact a TMDL will have to be developed to delist these reservoirs for DO and ammonia. The good news is that the pH TMDL and

Continued on Page 6

# State Proposed Nutrient Criteria Standards

By Mary Dawson and Linda Boyle, City of Aurora

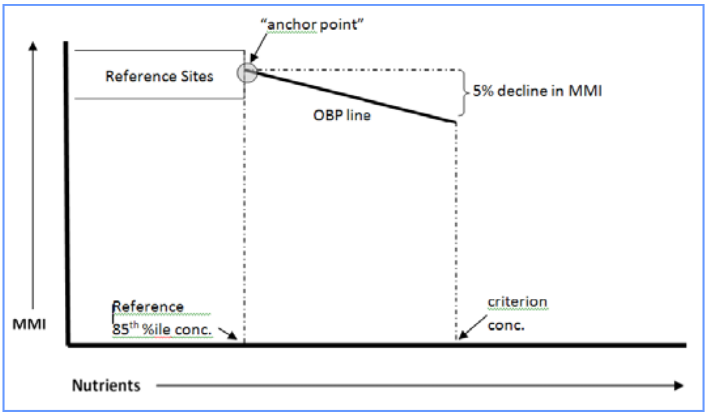
Last year, the Water Quality Control Division (WQCD) announced its intent to move ahead in the development of numeric criteria in regard to the State's lakes and reservoirs. On August 19, 2009, WQCD presented their development for such criteria and proposed table values for inclusion into Reg. 31. There are two classifications, recreation and aquatic life, with unique chlorophyll, total phosphorus and total nitrogen levels for each classification. The recreation levels were determined from recreational use surveys of the level of chlorophyll in a water body where people are willing to recreate and levels where they are wary about entering the water. The support of fisheries was the determining factor for the aquatic life criteria.

| *Initial* Nutrient Criteria for Lakes and Reservoirs | | | | |
|---|---|---|---|---|
| Classification | Recreation[1] | Aquatic Life[2] | | |
| | Chlorophyll (ug/L) | Chlorophyll (ug/L) | Total P (ug/L) | Total N (ug/L) |
| Cold Water Biota | 20 | 8 | 24 | 490 |
| Warm Water Biota | 30 | 20 | 82 | 960 |
| 1 – 85th percentile of simmer measurements | | | | |
| 2 – 80th percentile of summer average | | | | |

On February 9, 2010 WQCD presented its nutrient criteria for rivers and streams. The criteria levels for total phosphorus and total nitrogen were determined from the table representing the multi-metric indexes (MMI) and concentration of nutrients. The 85th percentile of nutrient concentration at the reference sites for cold water biota and warm water biota is the developed criteria. The analogy of the table is that as nutrient levels get higher the MMI level will become lower.

The MMI is determined by soil types, topography, climate, and macro-invertebrates. The reference sites were determined using GIS to locate sites with as close to natural parameters as possible. These sites will have minimal anthropogenic impacts such as roads, structures, and stream alterations. There are 104 cold water biota reference sites; 61 for a biotype 1 (montane streams) and 43 for a biotype 2 (mid-elevation streams). There are 29 warm water reference sites in warm plains and xeric streams.

| *Initial* Nutrient Criteria for Rivers and Streams<br>Proposed Criteria will be within the identified range, one value for each parameter in each biota-type | | | | |
|---|---|---|---|---|
| | Cold Water Biota | | Warm Water Biota | |
| | TP (ug/L) | TN (ug/L) | TP (ug/L) | TN (ug/L) |
| Possible Criteria1 (based on Observable Biological Potential (OBP) line) | 90 | 824 | 125 | 1316 |
| Upper and Lower Confidence Limits2 (based on OBP line) | 82 - 129 | 766 - 988 | 125 – 184 | 1251 - 1538 |
| 1 – The "possible criteria" represents the Division's best estimate of the criteria at this point in the process | | | | |
| 2– These confidence limits are provided to illustrate the confidence bands on the OBP line | | | | |




The Division intends to implement these standards in the same manner that chronic total metals standards are implemented, with a 1 in 3 year allowable exceedance frequency:

* 303(d) assessment: median of representative data
* Permits: 30-day average

The next steps prior to implementation will be continued data refinement including stressor-response relationships and statistical approaches, exploration of other empirical approaches and packaging datasets for distribution.

***Dissolved Oxygen and Ammonia (Continued from Page 4)***

current efforts to reduce nutrients from entering the reservoirs will help improve the DO and ammonia conditions as well. In the end, the goal is to focus on the problem (cultural eutrophication) causing pH, DO, and ammonia violations rather than on treating the symptoms. As standards are developed and new 303(d) listings occur, the BMW Association will continue to focus on holistic solutions to maintaining proper water quality in both reservoirs so that all of the water uses are met.

# SAVE THESE DATES

### BMW I/E Committee Meeting

**March 18, 2010** (1:30 pm – 3:30 pm) at Barr Lake State Park, Nature Center

### BMW Board Meeting

**March 23, 2010** (9:00 am – Noon) at Metro

### BMW Budget Committee Meeting

**March 25, 2010** (2:30 pm – 4:30 pm) at Littleton/Englewood Wastewater Treatment Plant

### Technical Committee Meeting

**April 22, 2010** (10:00 am – Noon) at Metro

### National Water Quality Monitoring Conference

April 25—29, 2010 Denver, Colorado

### BMW Stakeholder Meeting

**April 27, 2010** (9:00 am – Noon) Wes Brown Treatment Plant, Thornton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**Thank You City of Thornton for Printing Issue #11!**



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