# Barr-Milton Watershed: Modeling Workshop #2

The BMW Association has contracted ENSR to use existing data to develop both a watershed model for the Barr-Milton Watershed, and accompanying lake models for Barr Lake and Milton Reservoir. The models developed by ENSR will be used to guide management and planning for future growth in the Barr-Milton Watershed.

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In the recent past, the Barr-Milton Watershed has experienced rapid growth and has continued, at a somewhat more accelerated pace, the transition from a watershed largely dominated by agricultural landuses to one where suburban and even urban landuses are becoming more widespread. This transition places greater demands on the natural resources in the watershed and requires a significant degree of foresight and planning to ensure that the existing resources can be protected and managed, in a way that optimizes efficiency and maintains the integrity of the resources available. Numerical models can be used to assist in making a variety of management decisions and are particularly useful in extremely complicated systems, like the Barr-Milton Watershed. ENSR has worked extensively with the BMW Association to develop a detailed flow diagram for the Barr-Milton Watershed and to identify and quantify the movement of water and nutrients around the watershed. Information to support the modeling was derived from a variety of sources including the USGS, NOAA, data incorporated into the database developed by Hydrosphere, and from numerous dischargers, users, and managers operating within the watershed. To date, ENSR has completed the setup and preliminary calibration of the model and anticipates having the model ready for use simulating management scenarios by spring 2008.

## Objectives

There are three primary objectives of the watershed model development and application. First, is to setup and develop a watershed model that adequately represents the natural hydrogeologic and limnologic processes in the Barr-Milton Watershed. This first step is critical since the cumulative effect of what happens within the watershed translates directly into the loading of flow and nutrients entering both Barr Lake and Milton Reservoir. Second, is to setup, within the SWAT watershed model, lake models that adequately represent the physical, chemical, and biological processes occurring within Barr Lake and Milton Reservoir. This second step, like the first, is critical since an accurate replication of the in-lake processes, determinable through a comparison of predicted and measured in-lake volumes and concentrations, is necessary if the model is to be suitable for simulating management alternatives. Third, is to develop and simulate a series of management alternatives that can be used to understand the effects of altering the flows, concentrations, and timing of discharges, withdrawals, and transfers of water around the Barr-Milton Watershed on Barr Lake and Milton Reservoir water quality. This final objective is where the usefulness of the model can be realized and where the model can assist in the evaluation of management decisions.

# Methods

The ArcSWAT numerical modeling platform was selected and used to setup and execute the watershed and lake model simulations for the Barr-Milton Watershed. ArcSWAT is a GIS interface for the SWAT watershed model developed by the USDA. SWAT is the acronym for **S**oil and **W**ater **A**ssessment **T**ool, which is a watershed model developed to predict the impact of land management practices on water, sediment, and agricultural chemical yields in large complex watersheds with varying soils, landuse, and management conditions over long periods of time. The SWAT model is physically based and incorporates readily available information to simulate watershed and reservoir processes. The ArcSWAT interface facilitates the setup of the SWAT model files and, through the use of ArcGIS, greatly simplifies the incorporation and interpretation of raster based data that is already available from a multitude of sources.

To date, ENSR has set up and developed a preliminarily calibrated SWAT model for the Barr-Milton Watershed, having acquired and interpreted data from a multitude of sources. The development of the Barr-Milton Watershed Model proceeded according to the following steps:

- Acquire and install the most recent version of ArcSWAT http://www.brc.tamus.edu/swat/.
- Download USGS digital elevation data for the Barr-Milton Watershed http://seamless.usgs.gov/.
- Download MRLC landuse information for the Barr-Milton Watershed http://www.mrlc.gov/.
- Acquire meteorologic data for the Barr-Milton Watershed http://www.ncdc.noaa.gov/oa/ncdc.html.
- Identify all point sources, withdrawals, and transfers within the Barr-Milton Watershed.
- Use ArcSWAT to delineate watershed, develop HRUs, and setup inlet/outlet/discharge nodes.
- Acquire and summarize measured flow and water quality data for 2002-04 simulation period.
- Work with the USDA to have the SWAT code modified to correctly simulate water transfers.
- Calibrate the watershed and lake models using information available for comparison.

ENSR acquired and used a multitude of other informational resources during the setup and execution of the SWAT simulation of the Barr-Milton Watershed model, including data incorporated into the Hydrosphere database, and data provided by each of several dischargers in the basin. The step-by-step setup of the model has been automated to the extent possible and requires a detailed overview to be fully appreciated. The detailed description of the model setup and application will be provided throughout the remainder of ENSR's contract. This detailed description of steps will be necessary to transition the model to the BMW Association, and its representatives, and to facilitate some form of critical review of the model.

# Results

The SWAT model, developed for the Barr-Milton Watershed, is a simplified representation that captures the complexity associated with the number of dischargers and consumptive users, the magnitude and timing of the discharges and water transfers around the watershed, and the nature of water management in an arid environment, using a relatively limited dataset (see example to right). The SWAT model's usefulness in predicting nutrient cycling in Barr Lake and Milton Reservoir is considerably better than that of a simple set of lake models, primarily because the loads are predicted based on upstream conditions. A complete overview of the preliminary model results will be provided at the workshop and may be further refined based on comments offered during the presentation.

| Point Discharge | Flow ($m^3$/day) | CBOD (kg/day) | $NH_3$ (kg/day) | $NO_3$ (kg/day) | Diss. P (kg/day) |
|---|---|---|---|---|---|
| Big Dry Creek | 89,833 | 882 | 127 | 558 | 81 |
| Brighton WWTP | 7,301 | 175 | 21 | 72 | 5.0 |
| Centennial WWTP | 23,434 | 173 | 13 | 243 | 16 |
| Fort Lupton WWTP | 7,806 | 48 | 3.7 | 77 | 5.3 |
| Hudson WWTP | 3,785 | 76 | 2.0 | 37 | 2.6 |
| Littleton-Englewood_WWTP | 86,907 | 509 | 287 | 2,258 | 252 |
| Lochbuie WWTP | 2,838 | 68 | 3.8 | 16 | 1.9 |
| Metro_Pump_Works | 49,972 | 498 | 700 | 91 | 134 |
| Metro WWTP | 450,076 | 3,681 | 3,794 | 1,883 | 1,263 |
| South Adams WWTP | 10,581 | 212 | 78 | 100 | 119 |
| Xcel Arapahoe | ----- | ----- | ----- | ----- | ----- |
| Xcel Cherokee | ----- | ----- | ----- | ----- | ----- |

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|---|---|---|---|---|---|
| $n = 0$ | Not sampled | $1 \le n < 2$ | Monthly to bi-weekly | $4 \le n$ | Weekly to daily |
| $0 < n < 1$ | Less than monthly | $2 \le n < 4$ | Bi-weekly to weekly | | |

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