BANTAM LAKE
DIAGNOSTIC STUDY

Introduction

A diagnostic study is a method of investigation that seeks to understand why a lake is the way it is, not at one snap-shot in time, but over a period of several different time scales. Lake condition is the result of a complex interaction of many different physical, chemical, and biological factors. The three primary governing aspects for lakes are:

1. Rainfall cycles,
2. Watershed characteristics, and,
3. Lake basin shape, and depth,

The combination of the rainfall and watershed create a network of streams, and rivers, that supply the lake with water and nutrients. The shape and size of the basin dictates the affect this water supply will have on the lake and will ultimately determine one of the time scales important for lakes, the residence time, or the time it takes the total lake volume to be replaced by new water. A lake is dependent on the quantity and quality of the quantity of water supply from the watershed, without it the lake would cease to exist. A lake is also dependent on the quality of the water supply from the watershed, river quality is the governing agent dictating the overarching condition of the lake.

Once the water gets into the lake, the nutrients contained in the stream or river water is either dispersed throughout the lake as a dissolved component, which can be lost out the outlet, incorporated into biota, or is dropped to the sediments to become part of the bottom mud. Through the continuous process of inflow, residence, and outflow, the lake takes on a characteristic all of its own. The new aspects that add to the definition a lake are included in a diagnostic study:

4. Internal recycling,
5. Residence time, and,
6. Bottom sediments.

All of these physical, and chemical, factors, in turn, support the different organisms that exist in the lake. The organisms then, in turn, affect in some way the physical and chemical factors that support them. This is a feed-back loop between the lake and its biota. It takes on it greatest manifestation by the cycle of an algae bloom that is supported by the nutrients in the lake water. But dead algae sinks to the bottom where it is decomposed adding to the internal recycling of nutrients that can cycle back to support more algae.

Because all of the above factors are constantly changing over time the lake response likewise is constantly changing. A diagnostic study attempts to discern the Seasonal Cycle of a lake. This is the way a lake behaves over the time period between ice-out in the early spring, and ice-on in the winter. Sometimes under ice samples are also collected to know how winter conditions fit into this cycle. The assumption is that the seasonal cycle will tend to be the same from one year to the next, although in reality any two years are seldom the same.

The trick to a diagnostic study is to discover the trends in lake condition that repeat each year. This is partially guess work when only one seasons (here I use seasons to mean from ice-out to ice-on) worth of data is collected. It is easy to be persuaded that the trends obtained from one year of data are a template for regular repeatable trends. Generally however, they are not, because the more seasons of data you collect the more variability is accounted for in your data. To be reasonable confident that lake trends have been identified several years of data collection are required.

The goal of a diagnostic evaluation is to identify trends because these lead to the cause and affect relationships needed to find solutions. The larger the system, the more complex and variable are the seasonal trends of the different components. For a system as large as Bantam Lake there are several factors that will have wide ranging variably from year to year. The most notable will be the seasonal or annual water load and nutrient load. Changing the annual water load will cause the lake to take on different characteristics and hence exhibit a different set of season trends.

Some of the important components that exhibit seasonal trends in a lake:

Lake phosphorus concentration, at different depths,
Lake nitrogen concentration,
Water clarity,
Dissolved oxygen, especially the development of anoxia,
Phytoplankton types and densities,
Inflow phosphorus concentration and load,
Outflow phosphorus concentration and load,
Position and strength of thermal stratification,
Lake mixing and direction and speed of winds,
Sediment re-suspension and shoreline erosion.

Components of a Diagnostic Study

Task 1.1: Lake and Watershed Literature Review

The first step should be to compile available data, although this task can also be done simultaneously with the early months of data collection.

Review prior lake studies,
Hydrological data from the watershed,
Land-use watershed review,

Storm water discharge review,
Point source discharge record review, and,
Agricultural non-point source review,

Task 1.2: Watershed Collection of Chemical and Flow Data

It is helpful to have reviewed existing data about the watershed so that comprehensive water sampling can begin with the first visit but often this is an evolving aspect that expands over time as new sources are either found or considered to be important.

A monitoring program is designed to provide water chemistry and flow data for the Bantam Lake watershed. Sampling would include as many inlets to the lake that appear to be important but is probably going to be limited to the Bantam River at the beginning. The outlet is also sampled. The watershed sites should be visited monthly but more frequent visits may be important during some times of the year. The following is a list of the important parameters.

Total phosphorus	Nitrate nitrogen
Ammonium nitrogen	Total Kjeldahl nitrogen
Suspended Solids	pH
Alkalinity	Turbidity
Conductivity	Flow
Temperature	Dissolved oxygen

Task 1.3: Hydrologic and Nutrient Loading

The data collected during Task 1.2 will be used to estimate the hydrologic budget and nutrient loading to the lake. The analysis will be performed by several methods; extrapolation from data, modeling from watershed and climatic data, calculation from in-lake empirical models, and modeling from watershed and hydrologic data, calibrated with real data. It is this task that provides insight into the contribution of the nutrients from the drainage basin to the lake, and establishes the level of enrichment that is occurring from the river inflow.

Task 1.4: Water Quality Monitoring and Analysis

Comprehensive lake water quality monitoring and analyses will be conducted of Bantam Lake in order to describe the existing seasonal trends in biology, chemistry, and physical conditions. Sampling will begin in April 2007, and continue monthly to October 2007. The number of in-lake sampling locations will have to be determined but a minimum of two should be considered at the start. These would be the North Bay and the main bay. However it would probably be important to consider an additional station in the south bay, at least until it can be determined that that part of the lake is identical to a mid-lake station. Other lake stations could be established to investigate specific aspects in the lake. For example, a station inside Deer Island to determine the conditions in that bay, or

a station in the northern part of the main bay to determine whether water flow from Bantam River is diverted directly to the outlet without mixing in the whole lake.

A each in lake station the following types of measurements will be made:

a. The Secchi disk depth, and temperature/oxygen profiles will be measured from 3 stations in the lake, beginning in April and ending in October.

b. Water samples for nutrient chemistry from three stations in the lake. At each station the samples will be drawn from up to four different water depths, beginning in April and ending in October. Water samples will be analyzed for parameters listed in Task 1.2, but will also include Redox (E_H), total iron and hydrogen sulfide when the water is found to be anoxic.

c. Each month one sample will be collected from the mid-lake station for analysis of phytoplankton composition, and zooplankton enumeration. The algae samples will be viewed under magnification and dominant cells will be identified and counted. The zooplankton community will be assessed to determine the overall numbers, and size classes.

d. Some limited sediment chemistry from selected deep water areas of the lake to determine the sediment phosphorus concentrations.

Task 1.5: Diagnostic Assessment and Draft Report

The results of tasks 1.1 – 1.4 will be combined into a draft Diagnostic Report that will describe the features of Bantam Lake. Water quality data from the monitoring conducted in 2006 - 2007 will be presented in tabular and graphic summaries with a narrative explaining the data and results and compared to historic water quality data to identify any long term trends. The hydrologic and nutrient loading modeling results will be presented in tabular summaries for each estimation method. A narrative description of each approach and its results with overall summary tables for water, phosphorus and nitrogen loads will be provided. Loading estimates will be provided for each subbasin of the watershed.

The Draft Diagnostic Report will outline the lake and its watershed management goals and associated needs, and any impediments to achieving those goals. The draft Diagnostic Report will discuss water quality problems, apparent causative agents, and the relative magnitude of nutrient inputs to the lake. Management options and constraints will be discussed.

The report will also provide limited analysis of lake and watershed data for the purposes of making recommendations for possible watershed and in-lake improvements. The

applicability of each potential technique will be considered and explained, and a short-list of feasible alternatives, if any are needed, will be developed. Advantages and disadvantages will be outlined in tabular form for ease of evaluation. A narrative with tabular summaries for each stated goal will, describe available options, and discuss the effectiveness, permit considerations, and affordability.

Task 1.6: Review Meeting.

A meeting/workshop to describe the draft Diagnostic Report will be held at a place to be determined by the Bantam Lake Protective Association. The purpose of this meeting will be to; 1) present the results of the first year of data collection, 2) describe, in detail, the specific problems facing the lake, 3) list the possible solutions for each of the problems, 4) develop an action plan for improving water quality of Bantam Lake, and, 5) establish goals for the next year. After the meeting the draft report will be finalized and submitted as a final report.

Bantam Lake Diagnostic Study Time Frame

	11-06	12-06	1-07	2-07	3-07	4-07	5-07	6-07	7-07	8-07	9-07	10-07	11-07	12-07	1-08	2-08	3-08
Task 1																	
Task 2																	
Task 3																	
Task 4																	
Task 5																	
Task 6																	