Guide to Interpreting Total Phosphorus and Secchi Depth Data from the Lake Partner Program (LPP)

The following information will assist volunteers with interpreting LPP total phosphorus and Secchi depth data. These results are posted in separate tables each year on the Lake Partner Program webpage (www.ontario.ca/lakepartner). Since 2002, total phosphorus (TP) analyses have been conducted at the Dorset Environmental Science Centre (DESC) water chemistry laboratory, which specializes in analyzing samples with very low TP concentrations. The data analysed at DESC are approximately ten times more precise than data reported before 2002. Thus, earlier TP results are presented as **Pre-2002 TP Means,** and expressed as annual means of all data collected before 2002. Because of their low precision, these earlier data should not be used to examine TP trends through time.

Above: Chemistry Technician at the Dorset Environmental Science Centre performs total phosphorus analyses on Lake Partner Program water samples.

Total Phosphorus

TP concentrations are commonly used to interpret a lake's trophic status, as phosphorus is the element that limits the growth of algae in most Ontario lakes. Increases in phosphorus,may decrease water clarity by stimulating algal growth. In extreme cases, elevated TP may contribute to algal blooms, causing a decline in aesthetic quality, increasing turbidity, depleting deepwater oxygen concentrations and, in some cases, producing a variety of toxic compounds.

Many limnologists place lakes into three broad categories with respect to trophic status. Lakes with less that 10 µg/L TP are considered oligotrophic. These are dilute, unproductive lakes that rarely experience nuisance algal blooms. Lakes with TP between 10 and 20 µg/L are termed mesotrophic and are in the middle with respect to trophic status. These lakes show a broad range of characteristics, from clear and unproductive, to showing susceptibility to algal blooms as TP concentrations approach 20 µg/L. Lakes over 20 µg/L are classified as eutrophic, and may exhibit persistent, nuisance algal blooms.

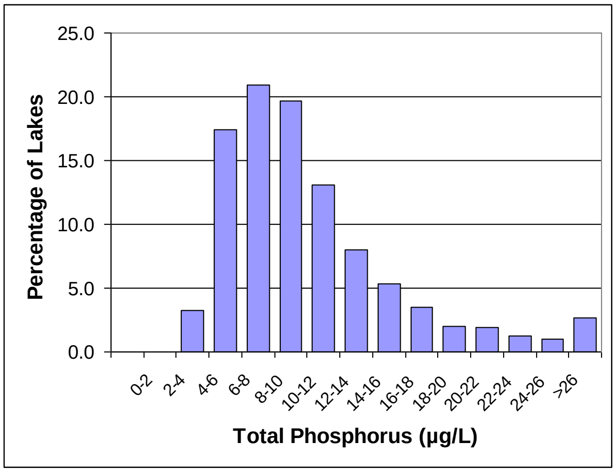

Figure 1. Distribution of total phosphorus concentrations in 1421 of Ontario's inland lakes. Lake concentrations are based on the lakewide averages of spring turnover concentrations.

Note: Tea stained lakes with high dissolved organic carbon (DOC), are called dystrophic lakes, and do not fit the algal/TP relationships described above. Generally, dystrophic lakes can be naturally higher in TP without the occurrence of algal blooms. The chemistry of these lakes is quite complex.

The Lake Partner Program database contains TP data from thousands of Ontario's inland lakes.

Figure 1 shows the distribution of TP concentrations in over 1400 of Ontario's inland lakes based on data from the Lake Partner Program. You may find this useful in understanding how the TP concentrations of your lake compare to other lakes in the province. This figure shows that more than 50% of the lakes in this dataset have TP concentrations between 4-10 µg/L.

Water Clarity – Secchi Depth readings

Increases in phosphorus may decrease water clarity by stimulating algal growth. However, water clarity cannot generally be used to infer the trophic status of Ontario's inland lakes. This is because light penetration in nutrient-poor lakes is more strongly controlled by dissolved organic carbon (DOC) or non-biological turbidity, which also influences the colour of the lake. Water clarity can also be altered by invading species such as zebra mussels. It is always best, therefore, to use TP to evaluate the trophic status of the lake. Water clarity readings are nonetheless valuable for tracking important changes in lakes (e.g. zebra mussel invasions or watershed disturbances).

Above: A Secchi disk is used to measure water clarity in a lake.

Between-year differences in TP concentrations

After collectiong data for several years, volunteers may want to examine their results for trends through time. Three years of data is the minimum number of years required to establish a reliable, long-term average. Although, the average of the last three years of data is a useful measure of the current trophic status of the lake, several years of data are required to examine trends over time. Some lakes show relatively large differences between years (e.g., Austin Lake, Figure 2). However, unless there are tangible reasons for these differences (e.g., large differences in rainfall between years, near the time of sampling), it is more likely that further data collection will identify these years as data anomalies. Most lakes do not usually show large, between-year differences in TP. Collecting data over multiple years allows us to quantify what typical between-year differences in concentrations. With several years of high quality TP data, it is possible to identify long-term trends (trends that maintain themselves through time), such as the slight downward trend noted for Runnings Bay in Charleston Lake (Figure 3).

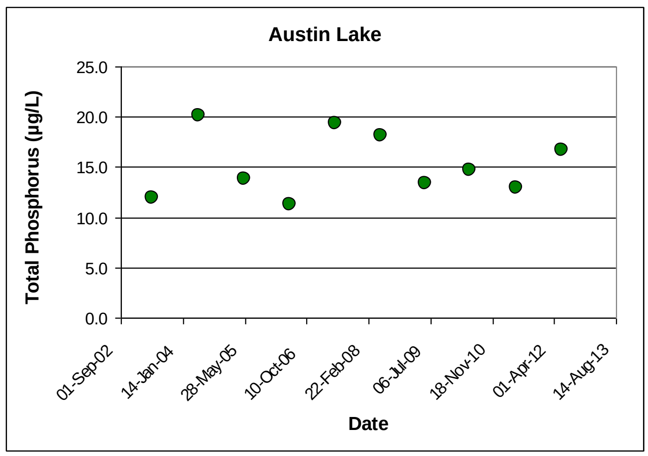

Figure 2. Between-year variation in total phosphorus (TP) concentrations for Austin Lake.

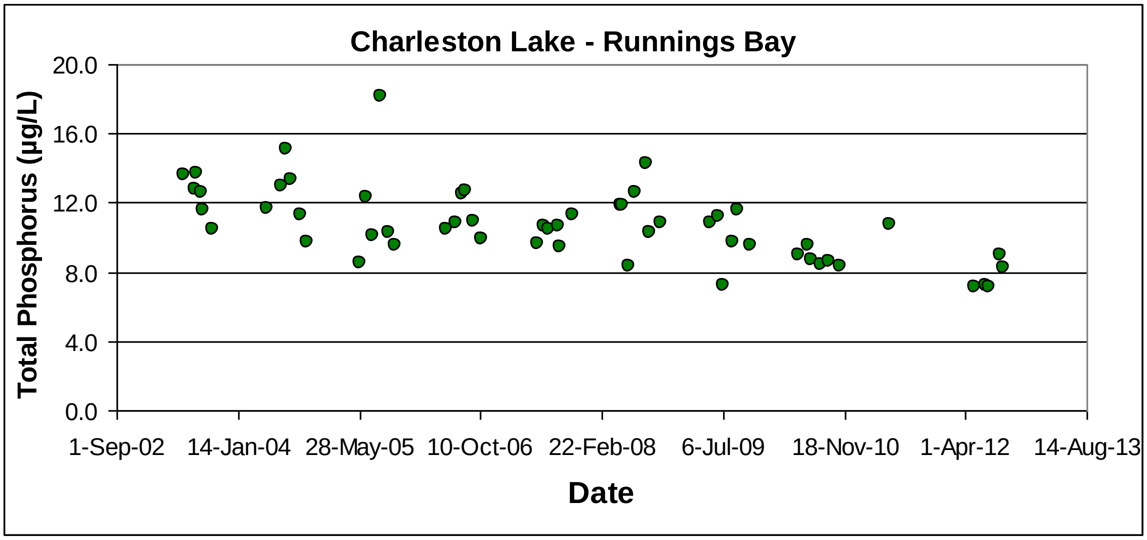

Figure 3. Long-term trend in monthly total phosphorus concentrations for 2003-2012 for Charleston Lake (Runnings Bay), sampled as part of the Lake Partner Program.

Seasonal differences in total phosphorus concentrations

Lakes that are off the Canadian Shield are sampled monthly because they are more likely to show large, seasonal differences in TP concentrations. In cases where concentrations increase over the summer, it is important to ascertain whether or not TP concentrations contribute to late summer algal blooms. In some cases (e.g., the Kawartha Lakes), TP concentrations increase considerably as the ice-free season progresses, with concentrations spanning two or even three of the classic trophic status categories (e.g., Figure 4). The complex seasonal processes in these lakes would be difficult to assess without the data that volunteers collect on a monthly basis.

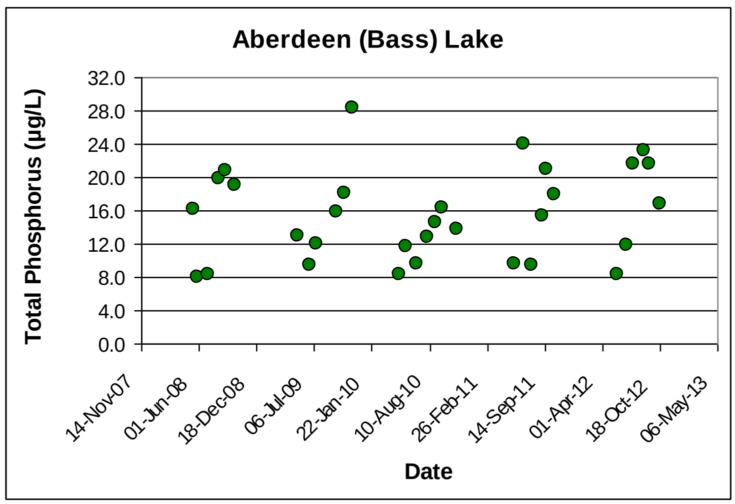

Figure 2. An example of a lake that shows seasonal differences in total phosphorus concentrations that span three of the classic trophic status categories (oligotrohic, mesotrophic and eutrophic).

Anomalous data points

When there are several years of precise TP data, it is **less** likely that anomalous data points will interfere with the interpretation of the data. These "outliers" can be the result of sample contamination in the field, such as a single zooplankton that was left in the tube after rinsing with unfiltered surface water. Anomalous data points represent a small percentage of the total number of samples and are easy to identify, especially after several years of data have been collected. In some lakes, there may be a consistent source of contamination (high zooplankton densities) that affects some samples, but they should not have an effect on the overall data set. This situation can be seen in the Cache Lake dataset, which shows slight between-year trends in TP in the lake, with one outlier in 2011 (Figure 5). This is an excellent data set that cannot likely be improved through any change in methods. We know that the percentage of outliers is approximately the same (2-5%), regardless of whether professionals or volunteers are collecting the samples.

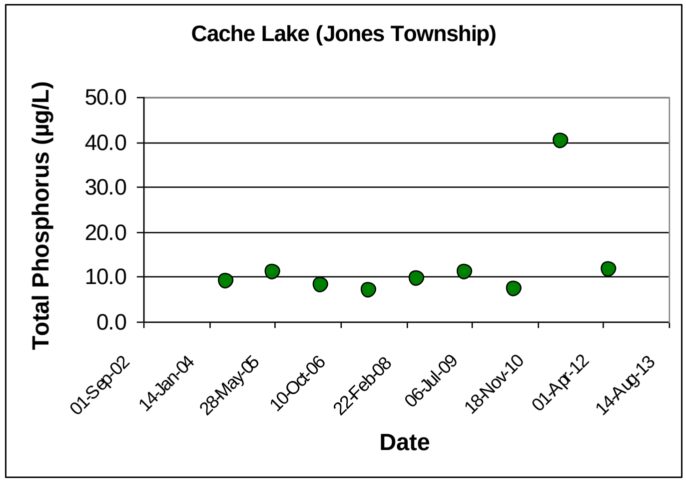

Figure 5. A lake that shows slight between-year trends in TP in the lake and one anomalous data point in 2011.

Common questions people ask about total phosphorus analysis:

What are TP1 & TP2? TP1 and TP2 are duplicate TP samples. These two "duplicate" samples help us to verify the results. It is normal for there to be small differences between these duplicates. However, if there are large differences between TP1 and TP2, one of the two samples was probably contaminated (usually the higher value). Contamination can occur in the field or in the laboratory (e.g., the sample may contain small zooplankton or other debris from the field, or the tube was not properly cleaned in the lab). We know that about 5% of the LPP duplicate TP samples are "bad splits" with large differences between TP1 and TP2. Analyzing two samples is also a contingency against one sample being lost due to breakage during shipment or laboratory accidents.

Why are we filtering water samples? Large zooplankton will add disproportionate amounts of TP to a sample. For example, if your lake is 10 µg/L, a single zooplankton can increase the reading to 35 µg/L. Filtering the samples removes this source of variation. Normally there are very few large zooplankton in a water sample, however, the incidence of unusually high TP readings has dropped significantly since we began filtering samples in 2003.

Why do we take our water samples from the deep spot location on my lake or bay? There are many different ways to design a lake monitoring program. The Lake Partner Program is designed to answer two simple but important questions: "What is my lake's trophic status?"; and, "How are the TP concentrations changing between years and over time?" We know from other studies that a mid-lake, surface water sample is considered to be representative of the TP concentration of a lake as a whole. Sampling at many different locations around the lake may not improve our understanding of deepwater nutrient concentrations.