2003 Water Quality Report
for
Lower, Middle & Upper Range Ponds

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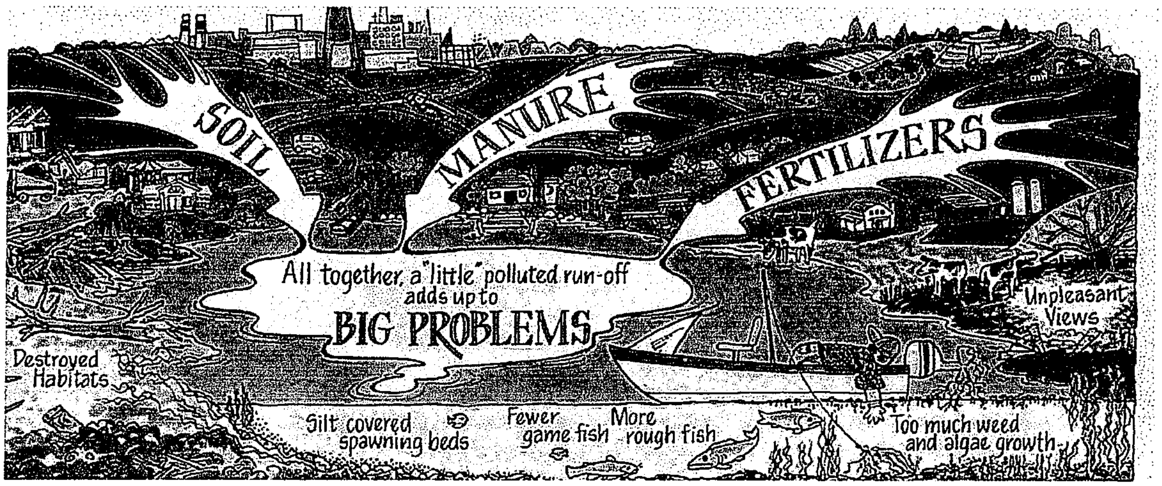
Lower Range Pond
(Photo Courtesy John Crouch)

This report summarizes the findings of the 2003 lake water quality monitoring program for Lower, Middle and Upper Range Ponds. Both professional and volunteer-gathered data were used in this document.

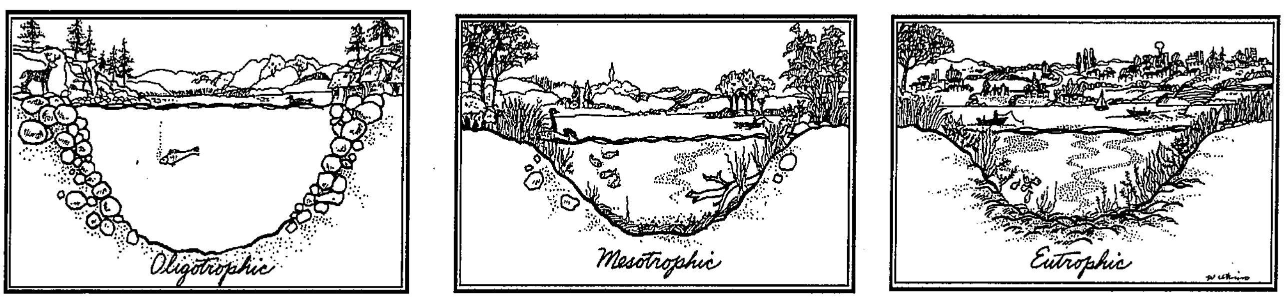
The most important time for monitoring Maine lakes and ponds generally occurs between the months of April and October. It is during this "open water" period that lakes Maine lakes are the most biologically productive, and symptoms of stress are most evident.

The primary threat to the water quality of Maine lakes is uncontrolled watershed development. The alteration of land in lake watersheds changes the quality and quantity of stormwater runoff from the watershed. Runoff eventually reaches lakes via streams, road ditches and other conveyances. Runoff from developed areas typically carries moderate concentrations of phosphorus and sediment from soil erosion and other sources. A study conducted in Maine by the DEP found that stormwater runoff from low-density residential areas may contain from five to ten times more phosphorus than runoff from natural, undisturbed watersheds. Protecting the water quality of lakes is ultimately about managing stormwater runoff from the watershed.



Stormwater runoff from land uses in lake watersheds is the primary means by which pollutants enter lakes
Sketch: Maine DEP

Phosphorus is a nutrient which, when added to lake water, can dramatically increase algal growth in lakes. The result of increases in polluted stormwater runoff over time from developed watershed areas to lake water often includes reduced water clarity, increased silt and sediment in the water, and the loss of dissolved oxygen. This process, in which the productivity of a lake ecosystem is accelerated as a result of human influences is referred to as cultural eutrophication. The diagram below illustrates the progression from low productivity (Oligotrophic) to highly productive (Eutrophic).



Drawings courtesy of University of Wisconsin - Extension and the USEPA
(Above) The three stages of Cultural Eutrophication. The Range Ponds are Mesotrophic

The changes described above can have profound implications for lake ecosystems. Lakes that support coldwater fisheries are particularly sensitive to cultural eutrophication.

However, this phenomenon can also have a negative influence on the aesthetic character of a lake, and studies conducted in Maine have shown that declining lake water quality can have a negative impact on shoreline property values and local economies.

Lake Water Quality Indicators:

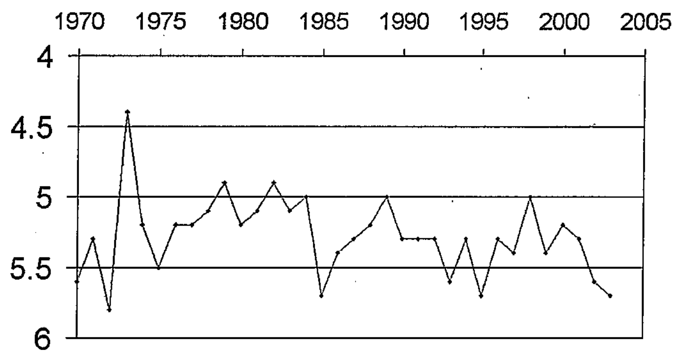
The sampling and testing conducted in 2003 was based on standard methods and procedures for lake monitoring. The Maine Department of Environmental Protection and the US EPA have established protocol to be used in the assessment of lake water quality. All of the work was conducted in accordance with these standards.

Lake monitoring to detect long-term trends in water quality typically takes place at the deepest point in the lake basin for a number of reasons. The "deep hole" is the best location for determining water clarity, or transparency. It is also the area that exhibits "worst case" dissolved oxygen losses. Note that the indicators that are used to assess the lake are intended to be representative of conditions throughout the lake. It is therefore desirable to avoid any near-shore influences on the sampling process. The maximum depths for the Range Ponds are listed with the data summary in this report.

A number of indicators are used to measure the effects of cultural eutrophication in lakes. These indicators provide information about current conditions, and over time they can be used to detect long-term changes, or trends. The algae that are suspended in the water throughout the lake (planktonic algae) are the primary indicators of biological productivity in lake water. An increase in planktonic algae growth over time generally represents an overall increase in lake productivity because the algae are at the base of the lake food chain. Indicators of productivity are generally referred to as "trophic state" indicators. Three trophic state indicators are commonly used to determine lake productivity. They are:

1. Transparency (water clarity): This simple test involves the use of a device referred to as a "Secchi disk". The disk is lowered into the water until it can no longer be seen. The transparency depth is then recorded. Lake clarity may vary substantially within a single season. A number of factors in addition to algal density may influence lake water clarity, including water color (see below) and sediment particles. One of the most prevalent influences on the variability of lake water clarity is the weather. Strong winds, moderate precipitation and other factors can cause short-term changes in the clarity of lake water. For this reason and others, many Secchi disk readings are needed over a period of several years to identify actual trends in water clarity. The range in water clarity for Maine lakes and ponds is dramatic – from less than one meter in our most productive lakes, to over 15 meters in Maine's clearest waters. The average

Secchi disk transparency for all Maine lakes was about 5.7 meters in 2003 (see chart below). When transparency drops to less than 2.0 meters (as a result of the concentration of algae in the water) a lake is considered to be experiencing a severe algal bloom. (Photo and Graphic courtesy of the Maine Volunteer Lake Monitoring Program)



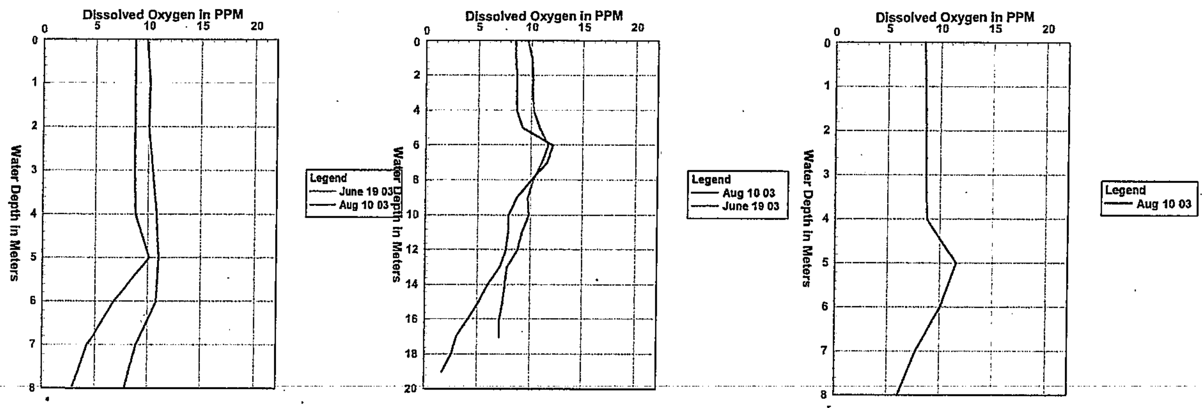
Average Water Clarity for All Maine Lakes from 1970-2003 (Source: MDEP)

2. Total Phosphorus: Algal growth is most directly influenced by the concentration of available phosphorus in lake water. Phosphorus is often referred to as the "limiting factor" in lake ecosystem productivity. The natural occurrence of phosphorus in Maine lakes and ponds is very low. As a result, when small amounts of phosphorus are added to lakes, algal growth can increase dramatically. Phosphorus is most often measured as "total phosphorus" (TP), indicating that both organic and inorganic forms are included in the measurement. That is because the two forms are typically in a state of flux. The measurement of total P is used to estimate both the current state of algae growth, as well as the potential for additional growth. The TP concentration in Maine lakes varies widely. Very clear lakes might have a TP concentration of ~2-3 parts per billion (ppb). Many Maine lakes have TP concentrations in the 5-8 ppb range. Lakes with average TP concentrations of only 15 ppb, or more are at risk of experiencing a severe algal bloom. The very small range in TP concentrations between Maine's clearest lakes, and those that experience algal blooms emphasizes the sensitivity of our lakes to this nutrient. The insert photo to the right shows an algal bloom that occurred in Pease Pond in Livermore, Maine during the summer of 2002 (Photo courtesy of the Maine DEP).

3. Chlorophyll-a: The most direct way of determining the concentration of algae in lake water is by measuring the level of chlorophyll-a (CHL). CHL is a pigment

contained in algal cells. The range of CHL concentrations in Maine lakes varies from as low as 1-2 ppb, for the clearest, least productive lakes, to greater than 40 ppb for a few lakes that have problems with severe algae growth. However, many lakes in Maine fall within the 2-6 ppb range.

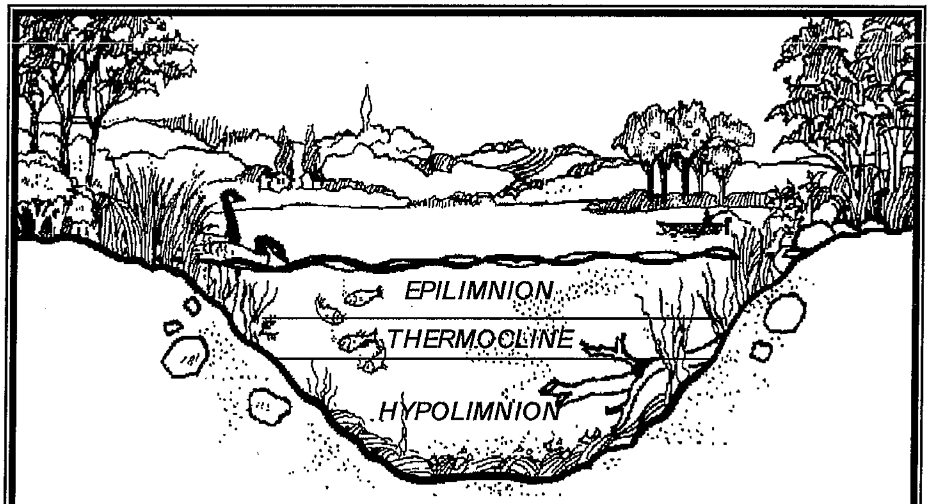
Another important indicator of lake water quality is the concentration of oxygen that is dissolved in the water, especially in the deepest area of the lake during the summer months. The dissolved oxygen (DO) levels in lakes and ponds can reveal a great deal about the overall health of the aquatic ecosystem. DO is critical to the healthy metabolism of many creatures that reside in the water. Some species are particularly sensitive to any loss of oxygen, such as coldwater fish like trout and salmon. Oxygen in lakes and ponds also acts as an important regulator of a number of chemical processes that are critically linked to water quality. The chart below shows the concentration of dissolved oxygen in the water column at Lower, Middle and Upper Range Ponds sampling stations on August 10, 2003.



Upper Range Middle Range Lower Range

Dissolved Oxygen Concentrations on August 10 at the Deep Hole Stations

The loss of dissolved oxygen in lake water during the summer months is usually associated with a process that is called thermal stratification. This phenomenon involves the development of temperature "layers", in which the water near the surface is uniformly warm to a depth that varies throughout the summer. Under the surface layer (referred to as the epilimnion) there is a zone of transition (thermocline) in which the water temperature drops rapidly. From the transition zone to the bottom of the lake is the layer of water that is the coldest (hypolimnion), and the most dense (heavy). During the summer months the coldest layer near the bottom is physically and chemically separated from the surface.



Thermal Stratification

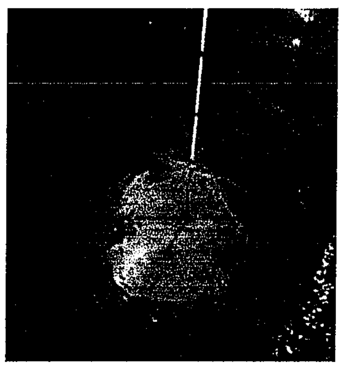
Figure 12

The bottom sediments in biologically productive lakes are rich in organic matter that has accumulated over time (algae and other plankton, and organic soil material). As this matter is degraded by microbes, oxygen is consumed from the overlying water. During the stratification period there may be no opportunity for oxygen to be replenished. Depending on the extent of the oxygen loss, coldwater fishery habitat may be reduced. Another possible result of oxygen depression or depletion is the potential release of biologically-available phosphorus from the bottom sediments.

Dissolved oxygen is replenished during the fall, when short days and cool air temperatures cause the lake to de-stratify or "mix". This process is also referred to as "turning over". Most lakes in Maine turn over twice each year – once in the fall and again in the spring shortly after the ice melts. The degree to which individual lakes experience thermal stratification depends on the depth and volume of the lake and the orientation of the lake basin to prevailing winds. Annual weather patterns and individual weather events strongly influence the degree and duration of thermal stratification.

Additional indicators of lake water quality that are used to compliment trophic state and dissolved oxygen data include:

1. Natural Color: The natural color of lake water is determined by the concentration of dissolved humic acids in the water. The acids leach from vegetation in wetland areas throughout the watershed. The range of natural color in Maine lakes varies widely. The water in highly colored lakes may have the appearance of tea, or root beer, as the photo insert shows. Although the color of lake



water is natural, it can have a strong bearing on other water quality indicators. For example, high color may reduce water clarity substantially. It is therefore important to know the background concentration of water color when considering Secchi transparency findings. Some of Maine's clearest lakes have very low color, in the range of 2-5 Standard Platinum Units (SPU). When color exceeds 25 SPU, it is considered to be high enough to reduce transparency (compared to a non-colored lake with other factors being similar). Photo courtesy of University of Wisconsin -Extension

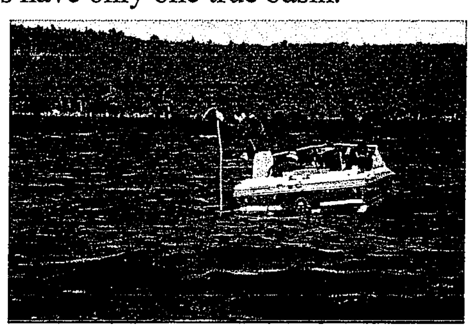
2. pH: is a measurement of the acid-base balance in lake water. Most Maine lakes for which there are data, have a circum-neutral to slightly acidic pH, in the 6.0-7.0 range. A smaller number have pH in the 7.0-8.0 range, from neutral to slightly alkaline. Although precipitation that falls in Maine is often highly acidic, research conducted throughout the state has indicated that some high-elevation lakes (above 2000 feet) are currently exhibiting evidence of acidification. Low elevation lakes are somewhat protected from this phenomenon by the buffering capacity of soils in the watershed. However, in general, Maine soils are thin and do not provide extensive buffering capacity, compared to the rich, deep soils throughout much of the country.

3. Total Alkalinity is a measure of the capacity of water to neutralize acids. TA is also sometimes referred to a "buffering" capacity. Maine lakes are generally poorly (relatively) buffered, primarily because of the relatively thin soils throughout much of the state. TA has an important bearing on pH. When TA drops below a critical threshold, pH may drop rapidly. It is therefore important to include alkalinity data with pH.

Sampling Methods:

The frequency of lake monitoring and sampling is often a function of budget. Ideally, lakes should be monitored every two weeks, beginning shortly after the ice melts in the spring, until September or October when the lake turns over. However, practical and financial limitations often limit sampling to only a few times during the summer, or sometimes to a single sampling during the month of August. Data collected by volunteers can be used to supplement professionally obtained data, thereby increasing the value of the information gathered.

As indicated above, lake monitoring typically takes place at the deepest location in the lake basin. Large lakes may have multiple basins, in which more than one sample station may exist. Lower, Middle and Upper Range Ponds have only one true basin.



Water samples are obtained in a number of ways, depending on what is being sampled, and how the information obtained from the sample will be used. A common method used for obtaining a sample that is intended to provide an "average" concentration for the indicator being measured is the "integrated epilimnetic core". A tube, or core of water is collected from the water surface to the upper part of the thermocline. Within this area of the "water column" most algal growth occurs. The depth of the core sample varies throughout the season, depending on thermal stratification boundaries.

Samples are sometimes taken near the bottom of the lake in order to determine whether or not phosphorus is being released from the sediments. Such discrete samples are commonly referred to as "grabs".

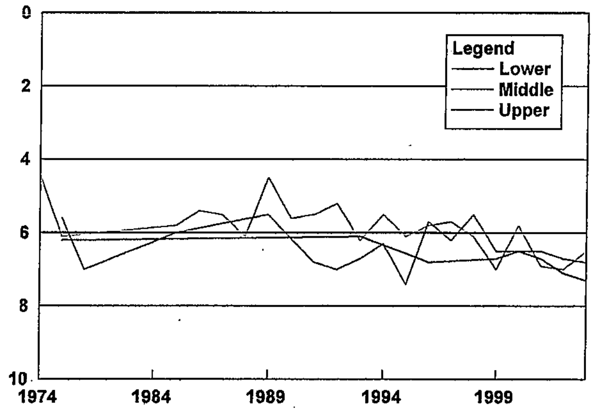
Dissolved oxygen and temperature are measured using an electronic probe that is connected to a meter via and cable. The probe is lowered into the lake and the water temperature and oxygen concentration are measured at regulars increments from the surface to the bottom of the lake.

Weather Influences:

The weather has a major influence on the physical, biological and chemical processes in lakes and ponds. Wind, sunlight, and precipitation, before and during lake monitoring must be taken into account. Periods of prolonged drought may cause some lakes to become unusually clear because without precipitation and stormwater runoff, less phosphorus and sediment may flow into the water. Conversely, wet, windy weather may result in less clear water. It is important to emphasize that individual lakes respond differently to the influences of weather. While some lakes and ponds may fare better during dry summers, others may experience a short-term decline.

Many years of data are typically required in order to detect changes in the overall quality of lakes and ponds. This is largely due to the high degree of natural variability that occurs in the indicators that are used to assess lake water. Variability in the weather plays a major role in this natural process. Some lakes and ponds experience what might appear to be dramatic shifts in water quality within individual seasons, and from one year to the next. If sufficient data exist, it may be possible to "see through" this variation, and identify a trend. Subtle trends may only be detectable through statistical analysis of the data. The following graphic illustrates the variability in water clarity for the Range Ponds over a period of time. Please note that some years in this period show no data, and for some years only one or two readings were taken.

Water Clarity In Meters



This chart illustrates variability in transparency (clarity) in the Range Ponds over a period of time. Please note that for many years, no readings, or only single readings were available for each of the lakes.

2003 Monitoring Summary:

Lake Characteristics: The following tables contain information concerning physical and hydrologic characteristics of the Range Ponds. Please note that the flushing rate is the amount of time that it takes for the water in the lake basin to be replaced by inflowing water from the watershed. The flushing rate can play a role in the sensitivity of lakes to pollutants from the watershed. *(Data Source: Maine DEP)*

Characteristic	Lower Range
Appx. Max Depth	41 Feet
Average Depth	15 Feet
Surface Area	291.6Acres
Flushing Rate	3.83/yr
Volume	4832600 cubic meters
Direct Watershed Area	3.46 Sq. Miles

Characteristic	Middle Range
Appx. Max Depth	66 Feet
Average Depth	29 Feet
Surface Area	385.5Acres
Flushing Rate	0.95/yr
Volume	14105577.3 cubic meters
Direct Watershed Area	4.95 Sq. Miles

Characteristic	Upper Range
Appx. Max Depth	38 Feet
Average Depth	20 Feet
Surface Area	336.1Acres
Flushing Rate	0.70/yr
Volume	8716807 cubic meters
Direct Watershed Area	4.08 Sq. Miles

The following table lists summary information for the data collected in 2003, compared to data from the previous year, and to long-term (historical) averages (LTA) for individual water quality indicators. The table includes data for 2003 from several sources, including Secchi disk transparency data gathered by volunteer monitors for the Range Ponds, as well as historical information from the Maine Department of Environmental Protection and the Maine Volunteer Lake Monitoring Program.

2003 Data Summary

Station 01: Lower Range Pond

	Secchi Transparency in Meters	TP-C ppb	CHL-C in ppb	Apparent Color	pH	Total Alkalinity
2003 Range	6.2-8.3	6	3.8	9	7.0	12.0
2003 Average	7.3	6	3.8	9	7.0	12.0
2002 Average	7.1	NA	NA	NA	NA	NA
LTA	6.6	9	3.5	10	6.66	11.6
Comments						

Note: Includes historical data from Maine DEP and LWRMA

Table Key: Secchi = Secchi disk transparency (clarity) in meters.
TP-C = Total phosphorus concentration in parts per billion from a core sample
TP-G = Total phosphorus concentration in parts per billion from a grab sample
CHL-C = Chlorophyll-a sample in parts per billion from a core sample
Apparent color = Unfiltered color sample (core) in Standard Platinum Units
pH Core = pH from core sample
Total Alkalinity = Core sample in milligrams per liter

Station 01: Middle Range Pond

	Secchi Transparency in Meters	TP-C ppb	CHL-C_in ppb	Apparent Color	PH	Total Alkalinity
2003 Range	4.2-8.2	6-10	3.9-4.3	14-17	7.1	13-18
2003 Average	6.5	8	4.1	16	7.1	15.5
2002Average	7.0	8	3.7	10	6.9	11
LTA	5.8	9	4.5	14	6.87	11.6
Comments	Wide range of readings					

Note: Includes historical data from Maine DEP and LWRMA

Station 01: Upper Range Pond

	Secchi Transparency in Meters	TP-C ppb	CHL-C in ppb	Apparent Color	PH	Total Alkalinity
2003 Range	6.7-6.8	6-13	2.5-3.6	14	7.1	12
2003 Average	6.8	10	3.1	14	7.1	12
2002 Average	6.7	8	3.7	8	7.1	12
LTA	6.4	8	4.7	14	6.9	11.9
Comments						

Note: Includes historical data from Maine DEP and LWRMA

Temperature & Dissolved Oxygen Profile Results

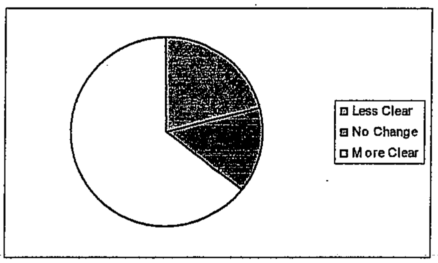
Each of the three Range Ponds experiences a moderate to severe loss of dissolved oxygen in the deepest water during the late summer period. The degree to which oxygen is depressed or depleted varies in each pond from year to year, depending on a number of influences, many of which are driven by the weather during the spring and summer period. Oxygen loss in lakes in ponds can limit and reduce the availability of coldwater fishery habitat. Oxygen depletion can cause phosphorus to be released (recycled) from the lake bottom sediments. The potential for this phenomenon to occur is moderate in Middle and Upper Range Ponds, and high in Lower Range Pond. This suggests that each of the lakes in the chain is to some extent stressed. If additional oxygen loss occurs in the future as a result of increased algal growth, the potential exists for a significant decline in each of the lakes.

Summary:

Lower Range Pond was clearer in 2003 than the long-term average for the lake. Total phosphorus and chlorophyll concentrations were also lower than the historical average (from limited data) for Lower Range.

Middle Range Pond was less clear than in 2002, but it was still much clearer than the historical average for the lake. Both total phosphorus and chlorophyll concentrations were also lower than the historical average in 2003.

Upper Range Pond was only slightly clearer in 2003, compared to 2002, and it was somewhat clearer than the historical average for the lake. Total phosphorus was somewhat higher than in 2002, as well as the historical average, but chlorophyll concentrations in 2003 were lower than in 2002, and lower than the historical average for the lake.



Dry weather may be causing many Maine lakes to become clearer – at least temporarily. Records from the Maine DEP and the VLMP showed that out of 462 lakes monitored in Maine in 2003, a large percentage (64.5%) were more clear than their historical averages, compared to only 14.5% that were less clear. The remainder were approximately as clear as they have been historically. (Graphic: Maine DEP and VLMP)

The statewide phenomenon of "clearer than average" lakes in 2003 may be from the continuing effect of the severe drought in 2001 and 2002. Without precipitation there is little or no stormwater runoff, and runoff is the primary means by which phosphorus and sediment are exported to lakes. Drought conditions may provide a valuable example of how clear many of our lakes could be if sources of polluted runoff from the watershed could be eliminated, or reduced.

The effects of the drought on Maine lakes in general, and the Range Ponds in particular, are subject to interpretation and discussion. Even if dry conditions have contributed to the generally good conditions observed in the lakes, other factors should also be taken into consideration, including ongoing efforts by the Range Ponds Environmental Association (RPEA) and the Androscoggin County Soil and Water Conservation District to work with landowners and towns in the watershed to employ land use practices that help to protect water quality.

Many thanks to the volunteer lake monitors on the Range Ponds for providing the larger part of the Secchi disk data for 2003! Reliable data from volunteers is critical to our understanding of and the protection of Maine lakes and ponds. **Thanks to Anne Gagne on Upper Range Pond, to Barry Kutzen and C.L. Townsend on Middle Range, and to John Crouch and Poppy Connor-Crouch on Lower Range for their data, without which much less would be known about the Range Ponds.** Our understanding of these sensitive and complex lakes is fundamental to our efforts to protect them.