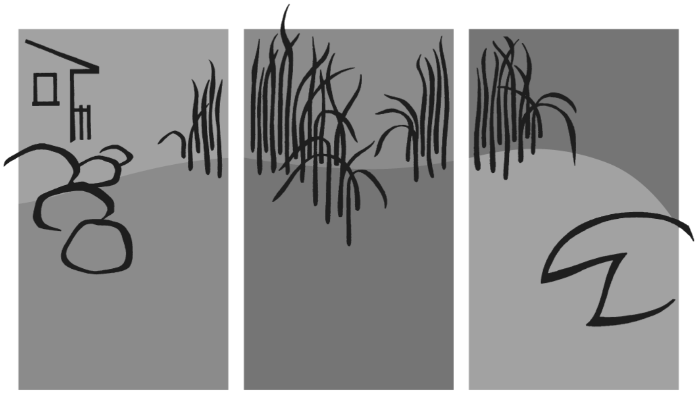

# From Shore to Shore

For Minnesota citizens promoting the health of our rivers & lakes

September 2004

#61

## Calendar of Events

### → Goods from the Woods

September 18-19, 2004 – Grand Rapids, MN

Marketplace, demonstrations, music, entertainment, and educational opportunities focusing on promoting a vibrant, diversified forest-based economy.

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### → Water Resources Position Announcement

The University of Minnesota Extension Service is recruiting candidates for a position specializing in Water Resources at the Fergus Falls Regional Center, in Fergus Falls, MN. For more details, contact: Naaz Babvania at 612-624-3717, babva001@umn.edu. For a position announcement, visit the Extension Web site at: http://www.extension.umn.edu/units/director/hr/positions.html.

## Shoreland Restoration: Making a Splash on Crooked and Portage Lakes

Submitted by: Mary Blickenderfer, University of Minnesota Extension Service and Water Resources Center, (218) 327-4616, blick002@umn.edu

Nearly 30 shoreland property owners on Crooked and Portage Lakes (Crow Wing County) turned out for a pontoon tour of three shoreland projects installed last year. The Crooked-Portage Lake Association sponsored the tour – including on-board refreshments and free plants – to highlight the restoration projects and to inspire other shoreland owners to do the same. It worked! After property owners at two of the three sites discussed why they decided to restore their shoreline, the steps involved in installation, and maintenance needs, several on the tour expressed interest in restoring their shorelines next year.

Rose Puckett, a property owner and graduate of Extension's shoreland revegetation program, designed and selected native plants for the three projects. When nearly 2,000 plants arrived on an owner's doorstep last summer, 15 lake association volunteers assisted in getting the plants in the ground. The shoreland owners were responsible for watering and weeding their sites until the plants became established.

"We really love it!" said one property owner one year later. "The flowers are beautiful, and we learned a lot in the process."

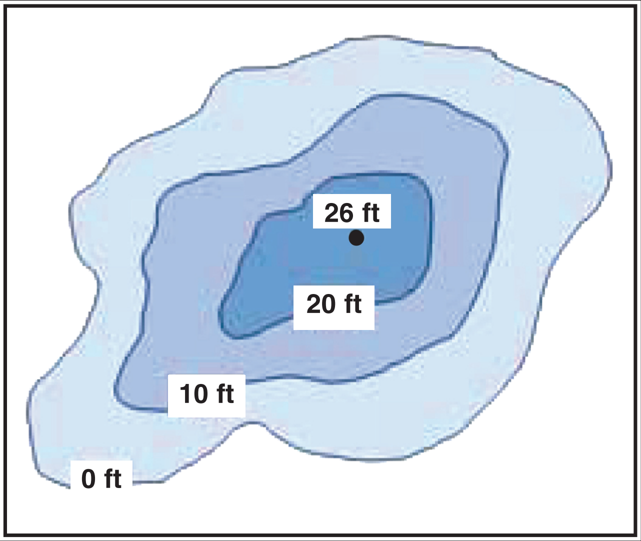
Assistance and funding for the three projects were provided by the Crow Wing County Water Plan, Mississippi Headwaters Board, Minnesota Pollution Control Agency, and University of Minnesota Extension. The Crooked-Portage Lake Association plans to apply for grants to help fund additional shoreland restoration projects in 2005.■

# Determining the Volume of Your Lake

Submitted by: Barb Liukkonen, Water Resources Education Coordinator, University of Minnesota Extension Service and Minnesota Sea Grant, (612) 624-9256, liukk001@umn.edu

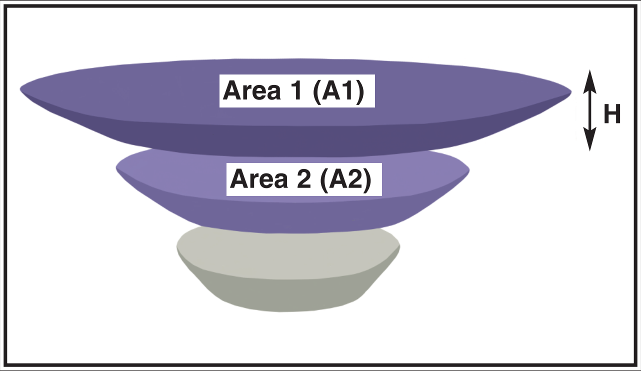
How much water is there in your lake? Knowing this value may prove to be useful. Maybe you want to figure out the residence time of water in your lake (see the next article). Maybe you need to determine the proper application of an aquatic herbicide (or check on your contractor's calculations). Maybe you just want to impress your lake association members or neighbors. Whatever your reason, here is a method you can use. It does require that you refresh your arithmetic skills and round up a bathymetric map, a measuring tool, and a calculator.

A bathymetric map shows contours, or lines connecting points of equal depth, in a lake. You can get bathymetric maps for many Minnesota lakes from local sporting goods stores or the Internet (e.g., go to the Minnesota Department of Natural Resources *Lake Finder* Web site www.dnr.state.mn.us/lakefind/index.html). You can create your own if you have a GPS unit, a depth finder, and a lot of spare time. Contour intervals on bathymetric maps are usually in 5- or 10-foot increments.




Typical bathymetric map

A formula is used to determine the volume of your irregularly shaped lake. The formula treats your lake like a series of layers, each layer shaped like a cone with the bottom chopped off (called a "frustrum"). You need to know the height and area of each layer in order to use the formula to calculate volume. Look at the depth zones drawing, which shows a 3D view of the bathymetric map above. Area 1 (A1) is equivalent to the 0 ft contour line, or the area of the whole lake. Area 2 (A2) is equivalent to the area encompassed by the 10 ft contour line, and so on. The difference in depth between two successive layers is the height (H) of that layer (in this example, 10 feet).




Depth zones in lake

Your first task is to calculate the surface area within each contour line to plug into the formula. You can do this in a number of ways, depending on what tools you have available.

(1) Trace around the contour lines with a mechanical planimeter.

(2) Use a computer program such as ArcView.

(3) Cut out the contours and weigh them to determine the relative percentage of the total area made up of each successive contour in the lake. The weighing method is quite accurate, but requires a sensitive balance, such as would be available in a high school science laboratory.

(4) The simplest method is to transfer your bathymetric map to graph paper and count how many squares fall within each contour line. This may reduce accuracy because you often have to estimate by half- or quarter-squares, but it works.

Consider making a table with rows for each contour interval (e.g., 0-10 feet, 10-20 feet, 20-30 feet, etc.), and columns for your measurements, surface area (in acres and/or square feet), and volume. The number of rows in your table will depend on how deep your lake is – you need a row for each contour interval. A table like this may help you manage the numbers you're going to generate. Sample determinations are included for a few layers.

| | (Use these columns for methods 3 and 4 above) | | | | |
|---|---|---|---|---|---|
| Contour Interval (H) | Relative area of each contour interval | Area of 0′ contour (square feet) | Area of contour interval (square feet)* | Acres (43,560 square feet/acre) | Volume in cubic feet or acre-feet (calculated from the formula) |
| 0 – 10′ | 1 | 2,178,000 | 2,178,000 | 50 | 396 acre-feet |
| 10′ – 20′ | .6 | 2,178,000 | 1,306,800 | 30 | 221 acre-feet |
| 20′ – 26′** | .3 | 2,178,000 | 653,400 | 15 | |
| Total | | | | | |

** The conversion factor you'll need to use will depend on the scale of your map.*
***See instructions below for calculating the area of the lowermost layer.*

Use the formula below to calculate the volume of water in each contour band of the lake (i.e., between 0 and 10 feet deep, between 10 and 20 feet, and so on). If your map has 5-foot contour lines, follow the same procedure (0-5 feet, 5-10 feet, 10-15 feet, etc.). The formula is:

$$V = H/3\ (A_1 + A_2 + /(A_1 \ x\ A_2))$$

$V$ = volume of water in each contour band
$H$ = difference in feet between two contour depths
$A_1$ = area of the lake within the outer contour
$A_2$ = area of the lake within the inner contour

Depending on the scale of your bathymetric map, you may want to convert to acres for ease of calculation. There are 43,560 square feet in one acre. If you use acres for surface area and feet for depth, the volume you calculate will be in acre-feet. An acre-foot of water is one acre of water one foot deep, i.e., 43,560 cubic feet (~326,000 gallons).

**The calculation for the lowermost layer (in this example – 20-26 ft) uses a geometric cone formula: volume = 1/3(HxA). This formula assumes that the maximum depth of 26 feet occurs in one small area. So, in our example, the height would be 6 feet and the area would be the area of the 20 foot contour interval.

Note: If the maximum depth of 26 feet stretches over a broad area (determined by studying the bathymetric map, then encircle this area with a contour line, determine its area with a one of the methods described above, and use the frustum formula to calculate volume of the 20-26 foot zone. ■

*This article is partially based on: Taube, C.M. 2000. Instructions for winter lake mapping. Chapter 12 in Schneider, J.C. (ed.). Manual of Fisheries Survey Methods II: With Periodic Updates. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor.*

# Determining the Residence Time of Your Lake

Submitted by: Cindy Hagley, Great Lakes Environmental Quality Educator, Minnesota Sea Grant, (218) 726-8106, chagley@umn.edu

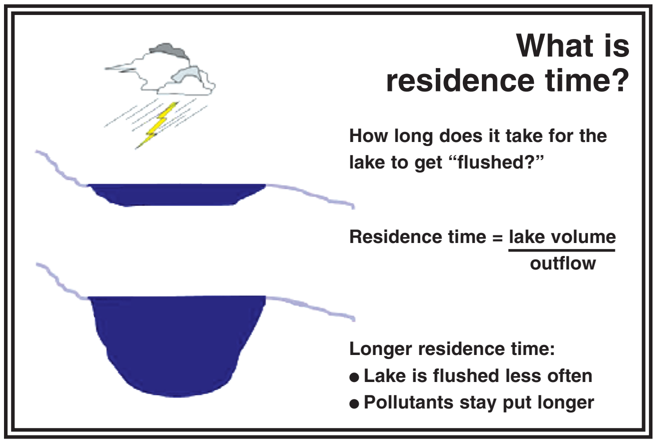
In the language of lakes, residence time (also called retention time) is the period required to completely replace a lake's water with an equal volume of "new" water. If you compare a lake to a bathtub, residence time might be easier to understand. Filling a bathtub takes just a few minutes if the drain is closed. The 5 or so minutes it takes would be the bathtub's residence time. However, if the drain is open or the faucet is only dripping, filling the tub will take longer; its residence time could be hours or possibly days. Of course, residence time also depends on how big the tub is. So, a lake's residence time depends on 3 major factors, the rate of water inflow, the capacity of the lake to hold water (its volume), and the rate of water outflow.

Residence time can vary greatly in lakes, from a few days in many reservoirs to hundreds of years. Lakes with small volumes and high flow rates have short residence times, and lakes with large volumes and low flow rates have long residence times. For example, Lake Superior has a residence time of roughly 191 years compared to Lake George, in Uganda, with a residence time of four months.

Why do we care about a lake's residence time? The longer a lake's residence time, the longer it takes to refresh its waters. Pollutants tend to hang around a lot longer in lakes with longer residence times. If your lake association has worked to reduce inputs of nutrients or other contaminants into your lake, knowing your lake's residence time will help you gauge how long it will take to see improvements in water quality. There are many other factors that impact water quality, so residence time by itself will not answer your questions, but it is an important characteristic to understand about your lake. It is necessary to know your lake's residence time to determine annual lake budgets for water, nutrients, heat, oxygen, contaminants, and herbicides.

A lake's residence time is calculated by dividing the lake's volume by its average annual water outflow. Lake managers calculate outflow on an annual basis so that seasonal variation doesn't unduly influence results. Volume (V) is usually expressed in acre-feet, and mean outflow is expressed as acre-feet/year. So the formula looks like this:

Residence time (years) = lake volume (acre-ft) / mean outflow (acre-ft/yr)




In lakes with very short residence times (i.e., a lake with a small volume and high inflow and outflow rates), algae may get flushed out of the lake so fast that they don't accumulate. Intermediate residence times allow algae and aquatic plants plenty of time to take advantage of the nutrients that are present. In lakes with longer residence times, phosphorus coming into the lake tends to have more time and opportunity to bind to particles, either through biological activity or through chemical and physical processes. These particles settle out of the water and are deposited in the sediments, making the attached phosphorus at least temporarily unavailable to algae and other plants. So lakes with long residence times can have lower phosphorus concentrations in the water. Residence time is one of the major variables that scientists incorporate into models predicting phosphorus retention and impacts in lakes. Determining residence time for your lake is probably not a job you can take on without some expert help, but it is an important characteristic of your lake. ■

*Sources:*

*Water on the Web (www.waterontheweb.org), Module 8, Lecture 1. www.waterontheweb.org/curricula/ws/unit_03/U3mod8_9.html*

*Holdren, C., W. Jones, and J. Taggart. 2001. Managing Lakes and Reservoirs. N. Am. Lake Manage. Soc. and Terrene Inst., in coop. with Off. Water Assess. Watershed Prot. Div. U.S. Environ. Prot. Agency, Madison, WI.*

*Wedepohl, R.E., D.R. Knauer, G.B. Wolbert, H. Olem, P.J. Garrison, and K. Kepford. 1990. Monitoring Lake and Reservoir Restoration. EPA 440/4-90-007. Prep. By N. Am. Lake Manage. Soc. for U.S. Environ. Prot. Agency, Washington, DC.*



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