State of Ohio
Environmental Protection Agency

Division of Surface Water

Biological and Water Quality Study of Bass Lake, 2002

Munson Township, Geauga County, Ohio

Bass Lake. Photo: Chagrin River Land Conservancy, 2001

OEPA Technical Report: NEDO/2005-09-01

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Bob Taft, Governor
Joseph P. Koncelik, Director

NOTICE TO USERS

The Ohio EPA incorporated biological criteria for water resources (e.g., streams, creeks, rivers and their tributaries) into Ohio Water Quality Standard regulations (WQS; Ohio Administrative Code 3745-1) in February 1990 (effective May 1990). These criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish assemblage data, and the Invertebrate Community Index (ICI), which is based on benthic macroinvertebrates. Criteria for each index are specified for each of Ohio's five ecoregions (as described by Omernik (1988), and are further organized by organism group, index, site type, and aquatic life use designation. These biological criteria (along with the existing chemical and whole effluent toxicity evaluation methods and criteria) figure prominently in the monitoring and assessment of Ohio's surface water resources, however, they have not been calibrated to assess biological conditions in lentic (pooled) environments (e.g., wetlands, ponds, inland lakes, Lake Erie, reservoirs, estuaries, etc.).

All public and private inland lakes, except upground reservoirs, are designated Exceptional Warmwater Habitat (EWH) for protection of aquatic life in Ohio's Water Quality Standards (OAC 3745-1-07); upground reservoirs are designated Warmwater Habitat. The Public Water Supply (PWS) designation applies to all publicly owned lakes and reservoirs (except Piedmont Reservoir), and to all privately owned lakes and reservoirs that are used as a primary and secondary source of public drinking water (OAC 3745-1-07). All lakes and reservoirs, except upground reservoirs, and those meeting the bathing water definition, are designated Primary Contact Recreation (PCR). All lakes, ponds and reservoirs are protected as General High Quality Water under the antidegradation rule (OAC 3745-1-05) unless a more restrictive designation is identified in the rule. Some channel modified and dam impounded stream segments are assigned the Modified Warmwater Habitat (MWH) aquatic life use (OAC 3745-1-07, Table 7-16) where irretrievable human imposed modifications of hydrology exist. However, the MWH biological criteria do not apply to impounded lakes and reservoirs that are designated Exceptional Warmwater Habitat (EWH) [(OAC 3745-1-07 (B)(1)(c)]. The biological criteria in Table 7-16 of ORC 3745-1-07 cannot be applied to inland lakes and reservoirs to determine attainment of their EWH aquatic life designated use.

Reservoirs (e.g., impounded streams) act as watershed sinks for the upstream release of nutrients, soil, pesticides, and toxic pollutants. Natural glacial lakes, many over 10,000 years old, are unique water resources in Ohio. They are commonly associated with rare and endangered plant and animal species. Public lakes and reservoirs are the primary recreational and drinking water resource for millions of citizens. The most recent assessment by Ohio EPA of publicly owned lakes, ponds and reservoirs greater than five surface acres is summarized in the 1996 Ohio EPA Water Resource Inventory 305b Report, which is available online at the following URL:

http://www.epa.state.oh.us/dsw/documents/96vol3.pdf

Wetlands are an endangered water resource in Ohio, with greater than 90% of historical wetland area lost due to draining and filling activities. Biological criteria for surface waters that meet the definition of the "wetland" designated use (OAC 3745-1-53) currently are not incorporated into Ohio Water Quality Standards. However, the Ohio EPA has published two technical reports that provide standardized sampling protocols that can be used to determine existing conditions of aquatic life based on an Amphibian Index of Biotic Integrity (AmpIBI) and a Vegetative Index of Biotic Integrity (VIBI). These reports are available online at the following URLs:

http://www.epa.state.oh.us/dsw/wetlands/2002_Amphibian_report_final_rev.pdf
http://www.epa.state.oh.us/dsw/wetlands/standardized_veg_field_manual_v1_3rev01jul04.pdf

Ohio Water Quality Standards (OAC 3745-1-50 to 54) contain definitions, beneficial use designations, narrative criteria and antidegradation provisions for protection of wetlands (Ohio EPA 2004). All wetlands receive the "wetland" designated use (OAC 3745-1-53), and under the antidegradation rule (OAC 3745-1-54), wetlands are placed into one of three categories (Category 1, 2, 3) based on relative wetland functions and values, sensitivity to disturbance, rarity, and potential to be adequately compensated for by wetland mitigation. All Category 2 & 3 wetlands are protected as a General High Quality Water under the antidegradation rule; Category 1 wetlands are designated Limited Quality Water.

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SUMMARY

A chemical and biological survey of Bass Lake in Geauga County was conduced by Ohio EPA in 2002. The purpose of the study was to provide baseline data on existing conditions to assist in the development of a long-term comprehensive management plan for the lake and its associated wetland complex. Bass Lake has a glacial origin of 10,000 + years. Today the lake is very shallow, with an average depth of 4.84 feet (1.47 m) and maximum depth of 9.5 feet (2.89 m). Roughly 50% of the surface area of Bass Lake is less than 6 feet (1.83 m) in depth, providing excellent wetland habitat for a diverse flora and fauna. The amount of sediment that has accumulated over time is unknown, but is expected to be substantial. A low dam structure allows for lake water levels to be raised or lowered to meet multiple lake management needs, but also acts to trap sediment and thus increases the sedimentation process.

The trophic state of Bass Lake fluctuates seasonally between eutrophic (nutrient enriched, high primary production) and hypereutrophic (highly enriched) in response to changing levels of total phosphorus in the water column. Both internal (e.g., lake sediment) and external (e.g., point sources, tributary streams) sources of nutrients influence the water quality of Bass Lake, but their relative contributions are currently unknown. Algal production was limited by phosphorus availability in June as evidenced by high nitrogen to phosphorus ratios (> 17:1 N/P), shifting to nitrogen limitation in August (N/P = 9:1), a common seasonal dynamic in nutrient enriched lakes. High concentrations of phosphorus were recorded in two streams that flow into Bass Lake: (1) the lagoon area located north of Spring Brook (total phosphorus maximum of 1,590 ug/l), and (2) Beaver Creek (total phosphorus maximum of 1,510 ug/l). The bottom waters of the lake had low dissolved oxygen concentration in August (1.55 mg/l), which would stress aquatic life. Water hardness was relatively low (median = 105 mg/l). The concentrations of heavy metals in surface and bottom waters were at concentrations that would be protective of aquatic life. However, because many heavy metals have increased toxicity at low water hardness, the use of metal based (e.g., copper) pesticides and herbicides to control plant growth should be avoided.

A sample of the bottom sediment indicated that the concentrations of heavy metals and PCBs were not elevated as compared to other glacial lakes in Ohio. Although the level of mercury in the sediment of Bass Lake was not elevated, a survey of mercury level in recreational fish species is recommended. The statewide Ohio Department of Health fish consumption advisory limits consumption of fish to no more than one meal/week for any body of water in Ohio. Total phosphorus was elevated in the sediment, which suggests that release of phosphorus from lake sediment may be a significant source of internal nutrient loading to the water column when bottom sediments become anoxic. There was a significant (Student t = 0.05 p) 20% increase in the concentration of total phosphorus in bottom water samples (mean = 98.33 mg/l, N=3) compared to surface water (mean = 78.97, N = 3). Any future attempt to control nutrient loadings to Bass Lake will need to address this large potential reservoir of phosphorus that is present in the sediment of the lake and wetland complex.

Seven fish species were collected along the western shore during a single electro-fishing survey in late September, 2002. By relative number, the dominant species were black crappie (37.93%), bluegill sunfish (17.24%), and pumkinseed sunfish (13.79%). However, the total number of

individual fish collected (N = 29 fish) was very low for the level of sample effort (500 m zone). These data suggest that the fish community was under stress. DELT anomalies (deformities, eroded fins, lesions, tumors) were very high at 3.5% (normal DELT numbers are < 0.10% in streams). Excessive levels of nutrients in water are known to be one factor that can result in an increase of DELT anomalies (communication with Roger Thoma, fishery biologist). Overall the data suggest that a well balanced fish community was not present in Bass Lake at the time of the survey. It is important to note that the 2002 Ohio EPA fish survey was conducted after the dam had been modified in 2001 to lower lake water levels.

Twenty-two phytoplankton taxa (to the taxonomic level of genus/species) were identified from June and August samples. Blue-green algae were more common than green algae on both dates. Total phytoplankton counts (cells/ml) reached bloom conditions in August, dominated by blue-green species and diatoms. In June, the dominant blue-green species was *Aphanizomenon flos-aquae,* in August the diatom *Aulacoseira (Melosira) granulata* was dominant. *Microcystis aeruginosa* was found during the August 29, 2002 sample, but did not reach bloom concentrations. Microcystins are known to contribute cyanobacterial toxins into surface waters. Nine species of zooplankton were identified, with estimated numbers showing a large increase in August, most likely tracking the increase in algae cells that would serve as prey. In both June and August the protist *Difflugia urceolata* was the dominant zooplankton taxon. This zooplankton species is associated with lakes of glacial origin such as Bass Lake.

Very low bacteria counts were recorded in the open water areas of the lake at stations L-1 and L-2. Elevated level of fecal coliform and *E. coli* were found in one of four samples collected from the Bass Lake lagoon area, however, no violations of human health criteria for bacteria were documented.

Future management plans will require that a decision be made as to whether the Bass Lake Preserve is to be managed as a wetland, a recreational lake, or a combination of both strategies. Given its shallow depth, any attempt to manage Bass Lake as a recreational fishery will require that the lake be significantly deepened to an average depth of approximately 10 feet for at least 50 percent of its surface area. This approach was successfully taken by the Stark County Park District for Sippo Lake, a natural glacial lake with similar size and water depth as is currently found in Bass Lake (ms Consultants, 1999; NEFCO, 1992). Management of the Bass Lake Preserve for recreational fishing other than a sunfish type community (e.g., bass, perch, pike) will require that nutrient loadings be controlled from the small wastewater treatment plants, and home septic tank systems, that drain into the lake. Due to its extremely shallow depth and documented loss of dissolved oxygen in bottom waters, both summer and winter fish kills have a high probability of occurring in the future. Stocking of recreational fishing should not be a prime management goal for the Bass Lake Preserve at this time until the cause of low dissolved oxygen is identified. Boating should be limited to use of paddle boats, oars, and small electric motors to minimize resuspension of bottom sediment laden with organic matter.

Another management option is to allow Bass Lake to progress naturally via ecological succession into a shallow wetland-open water complex. Boating lanes could be maintained through weedy areas using plant harvesting equipment to allow for public access to lake water. Long-term scientific study of the natural process of wetland succession could become a focal point of an environmental education program for the Geauga County Park District.

There are a number of research projects the Geauga County Park District may wish to undertake to help guide future management decisions for the lake and wetland complex: (1) a water and nutrient budget including an estimate of the relative contribution of nutrients from internal loading vs point sources on an annual basis, (2) an evaluation of the watershed for the "lagoon area" to identify both point and non-point sources of bacteria and nutrients, (3) seasonal analysis of the blue-green alga *Microcystis* to determine if toxic chemicals are being released to lake water at concentrations that could affect aquatic life, (4) a survey of how the recreational fish community changes over time, (5) testing fish tissue for mercury, (6) mapping the extent of wetland aquatic plant coverage including density and biomass for dominant species, and (7) a survey of the amount of sediment that has accumulated and an estimate of cost to remove sediment to deepen the lake to enhance game fishery.

INTRODUCTION

A chemical and biological survey of Bass Lake was conducted in 2002 by the Northeast District Office of Ohio EPA as part of a comprehensive survey of the upper Chagrin River watershed. The purpose of the study was to provide baseline data on existing conditions to assist in the development of a long-term comprehensive management plan for Bass Lake and its associated wetlands. Additional biological and chemical data were collected from the Chagrin River mainstem upstream and downstream from Bass Lake, Beaver Creek, and small tributaries to Bass Lake. These stream data will be reported elsewhere in the 2003-2004 Ohio EPA Chagrin River Basin Biological and Water Quality Survey report (Ohio EPA, in progress), which is expected to be completed in 2006.

Bass Lake, once known locally as Munson Pond, was privately owned prior to 2003. Ownership of Bass Lake and surrounding land was transferred to the Geauga County Park District on February 7, 2003. This action resulted from the collective efforts of the Chagrin River Land Conservancy, the Trust for Public Land, Ohio EPA, Ohio DNR, and the Geauga Park District. Under the auspices of an acquisition and permanent protection plan (*Bass Lake Sanctuary Acquisition and Permanent Protection Plan*, Chagrin River Land Conservancy and Geauga Park District, undated), 578 acres of land and water were purchased for long term management and conservation easement as the "Bass Lake Preserve". The land purchased is roughly 10.7 % of the total Bass Lake watershed area. Total project cost was approximately $5.2 million. Funding was provided through the Water Resources Restoration Sponsorship Program (WRRSP) managed by the Ohio EPA Division of Environmental and Financial Assistance. Sponsors for this WRRSP project included the cities of Ravenna (Portage County), Willoughby Hills (Lake County), and New Philadelphia (Tuscarawas County).

Future plans by the Geauga Park District for management of the Bass Lake Preserve include its long-term use as a wildlife sanctuary, protection of rare and endangered flora and fauna, the establishment of some upland recreational areas (picnic areas), and limited boating and fishing (*Newsletter*, Geauga Park District, 2003). Opportunities for restoration of degraded stream segments that flow into Bass Lake and wetland enhancement will also be investigated.

Study Area Description:

Bass Lake is a 169 acre (0.26 mi^2; 68.4 ha.) glacial kettle lake (10,000 + years old) located in Munson Township, Geauga County, Ohio (Figure 1). The lake is situated within the extreme headwaters of the Chagrin River basin of the Erie-Ontario Lake Plains ecoregion. The lake and the Chagrin River at this locale are situated over a glacially modified buried valley of the historic Teays River drainage system. Bedrock outcrops and sub-crops associated with this buried valley serve as sources of cold and perennial flowing groundwater that recharges the surface waters throughout the Bass Lake watershed. A thorough explanation of the geology in the vicinity of Bass Lake and associated groundwater dynamics is presented in the Ohio EPA (1997) report by Jeff Rizzo, Ohio EPA Hydrogeologist. A dam structure allows for lake water levels to be raised or lowered to meet multiple lake management needs.

The watershed area draining into Bass Lake is 6,191.48 acres (9.68 mi^2; 2,505.9 ha.), roughly 36 times larger than the area that forms the open water-wetland complex of the Bass Lake Preserve. Land use within the watershed includes urban and mixed urban-industrial uses within the southern most sections of the village of Chardon, and mixed residential and light agricultural uses within Munson Township. The northern portion of the watershed is within the service area of the village of Chardon and served by sanitary sewers. The Heather Hill retirement complex is located south of the lake and discharges treated wastewater into Beaver Creek about 1000 feet upstream from Sherman Road. All other areas within the watershed utilize private on-lot sewage disposal systems. All one-two-three family wastewater disposal systems are regulated by the Geauga County General Health District. The number of on-lot sewage disposal systems per unit area within the watershed varies significantly depending upon the date of land development. A dense distribution of on-lot systems is located immediately adjacent to the lake on the north side in what is known as the "Bass Lake Community". This segment of the watershed was originally developed as a neighborhood of weekend and summer homes, but has since evolved into a year-round residential community. A few commercial entities discharge treated wastewater under NPDES permit into the upper Chagrin River mainstem in the village of Chardon.

The main tributaries to Bass Lake are the headwater mainstem of the Chagrin River that enters the lake from the northeast, Beaver Creek (confluence with Chagrin River at RM 47.40) from the south, and Spring Brook (RM 47.65 tributary to the Chagrin) from the north. Other significant sources of water that flow into the lake are Woodiebrook (RM 48.30 tributary to the Chagrin River), and direct ground water recharge from the adjacent wetland complex.

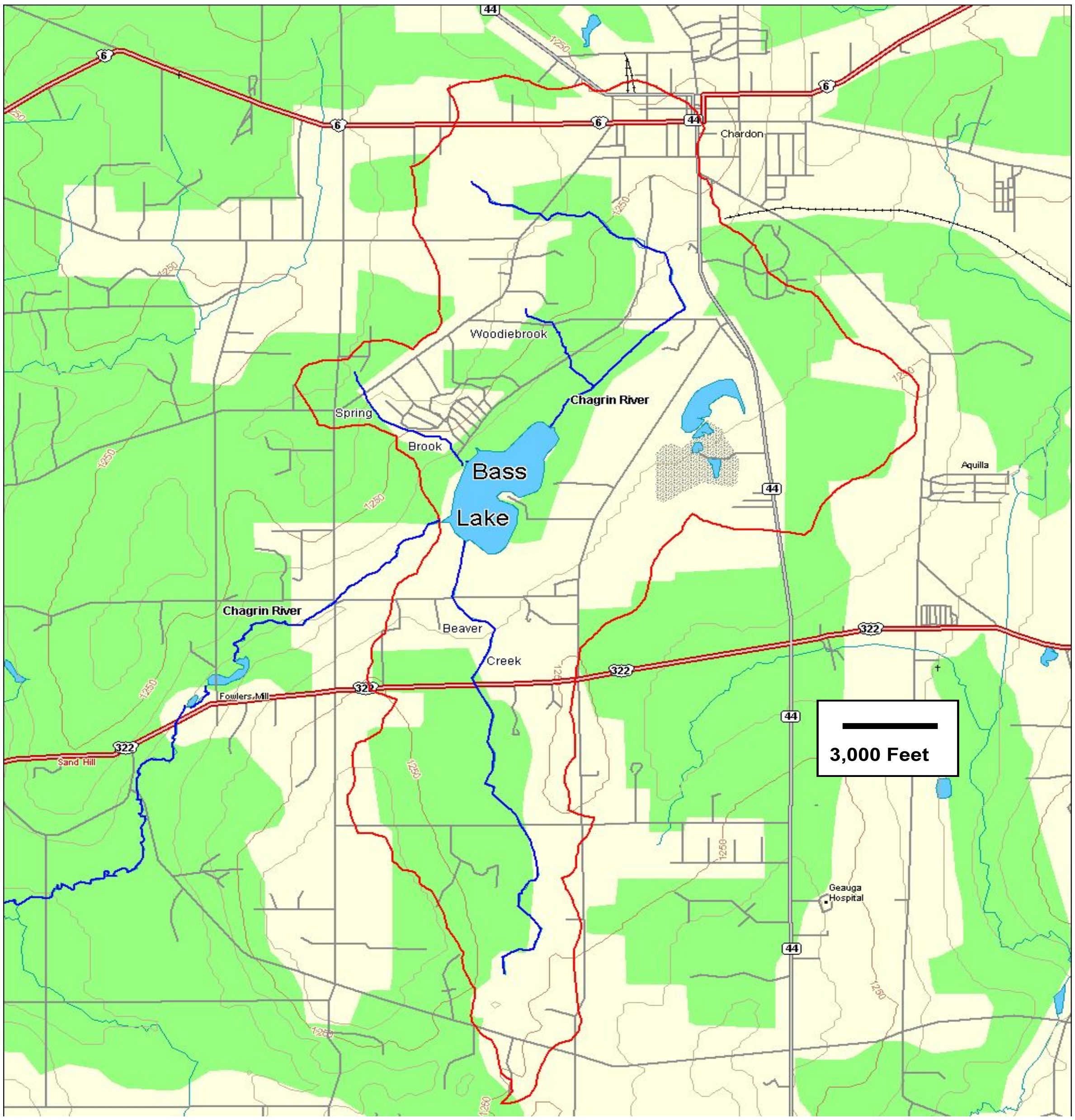


Figure 1. Location of Bass Lake in the upper Chagrin River watershed within the 11-digit HUC unit number 04110003030.

The surface water of Bass Lake is at an elevation of 1141 feet (USGS topographic map), and, based on well log data, is an expression of the Cuyahoga Formation, a single hydrostratigaphic aquifer unit composed of shales and sandstone (Ohio EPA, 1997). In the Bass Lake area the Cuyahoga Formation is overlayed by the shallow Sharon Sandstone/Conglomerate unit, which serves as the primary aquifer for well water domestic use. The Sharon Conglomerate is the ultimate source of groundwater recharge for numerous cold water tributaries that flow into Bass Lake such as Spring Brook and Woodiebrook. The Ohio EPA report (1997) recommended that future development of residential wells in the Bass Lake community should not utilize the shallow Sharon Sandstone/Conglomerate aquifer until such time that future study is conducted to identify how it serves to recharge Spring Brook and Woodiebrook, which maintain the last reproducing populations of native brook trout in Ohio. At least one home near Bass Lake along Parkway Drive uses the deeper Cuyahoga Formation for domestic water supply, yielding 25+ gpm (Ohio EPA, 1997; ODNR Well Log # 487716, Geauga County, Munson Township).

Bass Lake is designated Exceptional Warmwater Habitat-EWH [OAC Rule 3745-1-07 (B)(1)(c)] for protection of aquatic life and for Primary Contact Recreation (PCR). The mainstem of the Chagrin River upstream and downstream from Bass Lake is designated Warmwater Habitat (WWH), Primary Contact Recreation (PCR), Agricultural Water Supply (AWS) and Industrial Water Supply (IWS). The upper Chagrin River from Woodiebrook Road (RM 49.13) downstream to the confluence of the Aurora Branch of the Chagrin River (including Bass Lake proper) was designated a State Scenic River in 2002. This section of the Chagrin River is also designated Superior High Quality Water under the anti-degradation rule (OAC 3745-1-05), which became effective on July 1, 2003. The outlet of Bass Lake reforms the Chagrin River mainstem at RM 47.31. Both Spring Brook and Woodiebrook are designated Coldwater Habitat (CWH) for protection of aquatic life based upon the presence of the last known native populations of the brook trout in Ohio and a high number of cool water adapted benthic macroinvertebrate species. Beaver Creek is designated CWH in its headwaters and warmwater habitat in the lower few miles.

Sampling Locations:

The location of chemical and biological samples collected during the 2002 survey of Bass Lake, and the tributary streams in the upper Chagrin River watershed, are given in Table 1 and Figures 2 & 3. Samples were collected from two stations within Bass Lake (L-1 and L-2). An electro-fishing survey was conducted along the western shore of Bass Lake near the dam to assess the overall condition of the fish community. This report only presents data collected from Bass Lake; tributary data are reported in the 2003-2004 Chagrin River Basin Biological and Water Quality Survey Report (Ohio EPA, in progress).

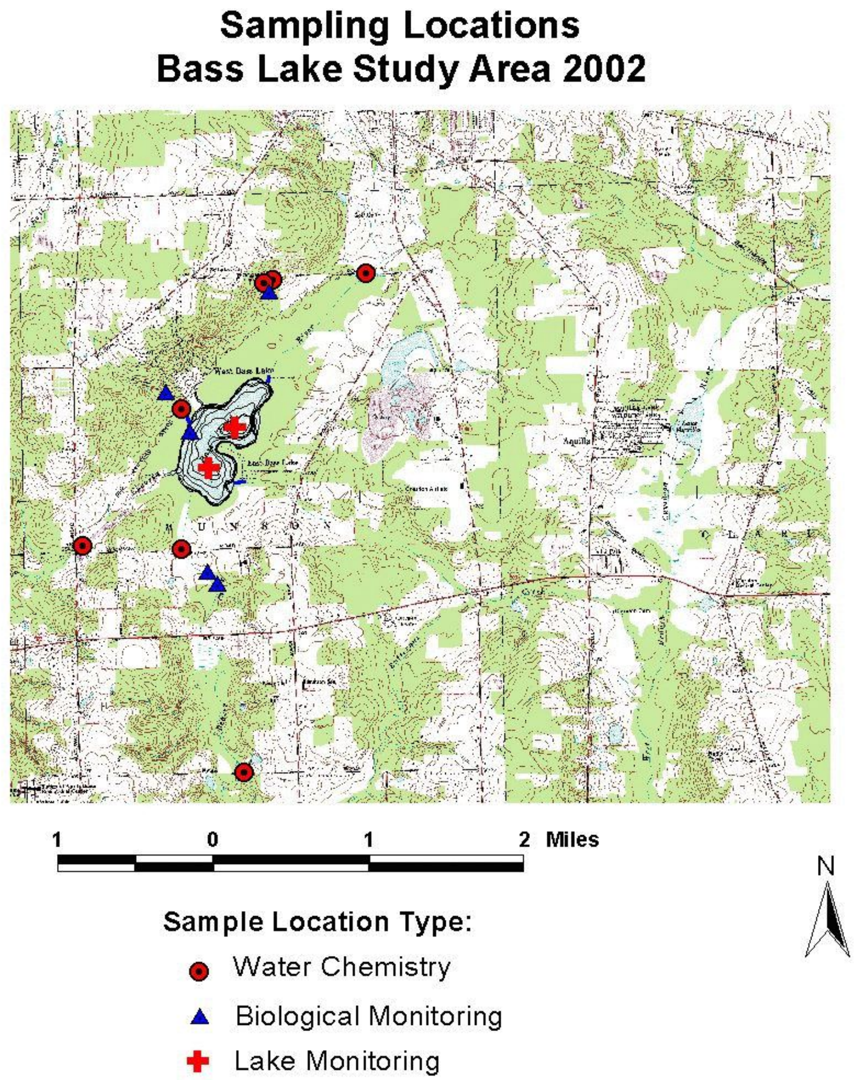


Figure 2. Chemical and biological sample locations in the Bass Lake watershed for the 2002 Ohio EPA survey. Results of tributary sampling will be provided in the 2003-2004 Chagrin River Basin Biological and Water Quality Survey report (Ohio EPA, in progress).

Methods:

Lake samples:

Chemical samples were collected twice (June 20 and August 29) at two deep hole locations (site L-1, southern; L-2, mid-lake; Figure 3). Grab water samples were collected using a Kemmerer sampler at a depth of 0.5 m from surface, and at 0.5 m above the lake bottom. All chemical, physical, and laboratory methods and procedures followed those specified in the manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (1995 revision). Fecal coliform and *E. coli* bacteria samples were collected at both lake stations, and an additional bacteria sample was collected near the lagoon area along the western shore. A sample of lake bottom surface sediment was collected at site L-1 on August 29, 2002, and analyzed for heavy metals, nutrients, pesticides and PCBs, and particle size. A bathymetric survey of the lake was conducted June 11 and 20, 2002, to map contours of water depth and estimate total water volume (see Figure 3). Field measurements for pH, temperature, dissolved oxygen, and conductivity were collected through the water column at fixed intervals at both lake stations. Field notes on condition of water and recreational uses were recorded. Secchi disk depth was measured with a black and white 20 cm disk.

Plankton samples were collected June 20 and August 29 at Site L-2 using a 11.5 cm diameter, 63 micron mesh, Wisconsin plankton tow. Duplicate samples were collected from vertical tows down to twice the measured Secchi disk depth. This depth is used to approximate the plankton community in the photic zone of the water column. Zooplankton samples were preserved in 75% ethyl alcohol for long term storage. Phytoplankton samples were preserved in a 1% Lugols iodine solution.

A survey of the Bass Lake fish community was conducted September 20 using standard Ohio EPA boat electro-fishing procedures (Ohio EPA, 1989). Fish were collected from a 550 m zone along the western shore upstream from the dam overflow. Water depths ranged from 0.2-0.5 m through the zone. All individuals were identified to species including hybrids.

Low level total phosphorus (5.0 ug/l detection limit) was analyzed using Ohio EPA laboratory method 260.2, which includes digestion of unfiltered lake water with ammonia persulfate and sulfuric acid. Duplicate samples for chlorophyll-a analysis were collected at site L-1 and site L-2 from a sample collected with the top of a Kemmerer sampler at 0.5 m depth, and field filtered through Whatman GF/C 1.2 micron glass microfiber filters. Samples were frozen until analyzed within 30 days of collection. Chlorophyll-a concentration was determined using a Turner Model fluorometer modified for chlorophyll-a analysis with correction for phaeophytin.

Carlson (1977) Trophic State Index values were calculated from total phosphorus, chlorophyll, and Secchi disk data using the equations below:

$$\text{TP TSI} = 14.42\ [\ \ln(\text{TP ug/l}) + 4.15]$$

$$\text{CHL TSI} = 9.81[\ \ln(\text{chl-a ug/l}) + 30.6]$$

$$\text{SD TSI} = 60 - [14.41\ \ln(\text{SD meters})]$$

The Ohio EPA uses an average of spring (April, May, June) total phosphorus and summer (July, August, September) chlorophyll-a Carlson TSI values to calculate annual Trophic State for lakes and reservoirs (Ohio EPA, 1996) following the equation below:

Equation 1.0 Annual Lake Trophic State (TSI) = ([$\bar{x}$ spring TP TSI + $\bar{x}$ summer CHL TSI]/2)

The annual lake TSI is then related to standard trophic state terminology as follows (Ohio EPA, 1996):

Oligotrophic	< 38	Annual TSI (from *Equation 1.0*)
Mesotrophic	38 - 47	
Eutrophic	48 - 66	
Hypereutrophic	> 66	

Secchi disk TSI values are not used by Ohio EPA to estimate lake trophic state, but are instead used to determine the potential affect of non-algal turbidity on TSI values calculated using total phosphorus and chlorophyll-a following the graphic approach of Dr. Robert Carlson (see Figure 4 on page I-28 of Ohio EPA, 1996). It is important that Secchi disk data be collected in conjunction with samples for total phosphorus and chlorophyll-a to allow for proper analysis of lake trophic state.

Stream samples:

Chemical and biological samples were collected from three tributary streams (Spring Brook, Woodiebrook, Beaver Creek) and the Chagrin River mainstem. Sample locations and type of data collected are given in Table 1. The results of tributary sampling will be discussed in the 2003-2004 Chagrin River Basin Biological and Water Quality Survey Report (Ohio EPA, in progress).

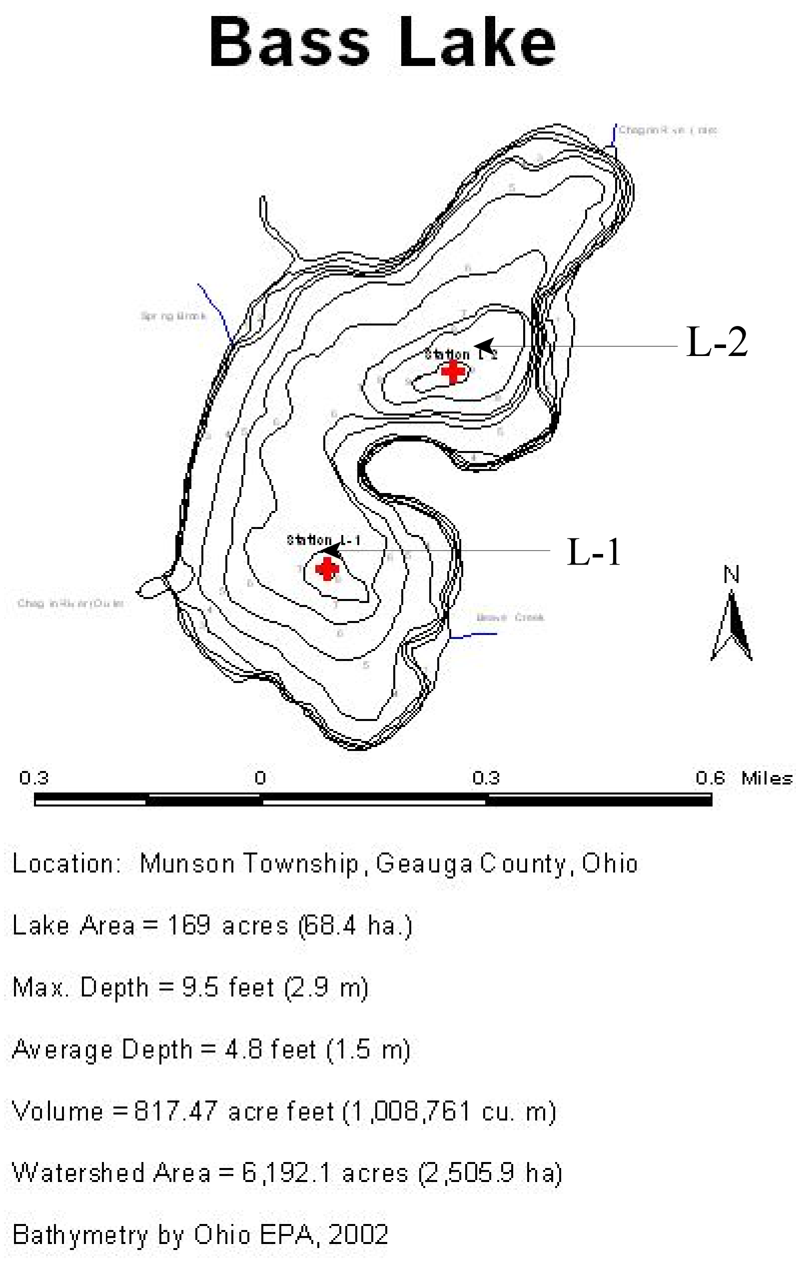


Figure 3. Bathymetric map of Bass Lake showing depth contours and the location of chemical sample stations at the two deep hole areas in 2002 (L-1 and L-2).

Table 1. Sampling locations for the Ohio EPA 2002 Bass Lake survey and the Ohio EPA (2003-2004) survey of the upper Chagrin River basin.

Water Body (ID)/ River Mile	Location	Latitude	Longitude	Type of Sampling[1]	USGS Topographic Map
Chagrin River (15-001)					
49.13	Woodiebrook Rd.	N 41° 33' 45.2"	W 81° 13' 23.7"	C	Chardon
46.54	upstream Auburn Rd.	N 41° 32' 13.6"	W 81° 14' 34.7"	C	Chardon
Woodiebrook (15-016) [unnamed tributary to Chagrin River RM 48.30]					
	East Tributary downstream Woodiebrook Rd.	N 41° 33' 44.3"	W 81° 13' 7.0"	C	Chardon
	Main Tributary at Woodiebrook Rd.	N 41° 33' 42.8"	W 81° 13' 10.9"	C	Chardon
Spring Brook (15-015) [unnamed tributary to Bass Lake RM 47.65]					
	upstream of "bear caves" spring	N 41° 33' 9.2"	W 81° 14' 9.1"	H	Chardon
	upstream of inter-urban culvert	N 41° 33' 3.9"	W 81° 13' 50.2"	M [2]	Chardon
0.28	at inter-urban culvert near mouth	N 41° 33' 0.5"	W 81° 13' 47.9"	C	Chardon
Beaver Creek (15-008)					
2.31	Bean Rd.	N 41° 30' 58.0"	W 81° 13' 22.3"	C	Chardon
0.90	upstream Heather Hill WWTP	N 41° 32' 1.6"	W 81° 13' 33.1"	F [3], M [3]	Chardon
0.76	downstream Heather Hill WWTP	N 41° 32' 6.1"	W 81° 13' 39.7"	F [3], M [3]	Chardon
0.55	Sherman Rd.	N 41° 32' 13.2"	W 81° 13' 49.2"	C	Chardon
Bass Lake (15-034)					
	Station L-1	N 41° 32' 40.2"	W 81° 13' 36.1"	C, S	Chardon
	Station L-2	N 41° 32' 53.7"	W 81° 13' 25.0"	C, P	Chardon
47.50	west shore north of lake outlet	N 41° 33' 0.6"	W 81° 13' 39.6"	F	Chardon

[1]Key to data types: C = water chemistry, F = fish community evaluation, M = macroinvertebrate community evaluation, P = plankton sample, S = sediment chemistry, H = Primary Headwater Habitat Evaluation. [2] Geauga County Park District data, [3] HzW Environmental Consultants, Inc.

Results:

Lake data:

Water Column Profiles:

Field data collected from the water column are shown in Table 2. The lake was not thermally stratified in summer, which is a common observation for shallow lakes. The level of dissolved oxygen in bottom waters was near 2.0 mg/l, a value that can be stressful to aquatic life. The reduced dissolved oxygen concentrations in bottom waters likely results from bacteria respiration as organic matter is decayed, mostly algae and aquatic plant biomass. Strong winds can relocate bottom waters with low dissolved oxygen into surface waters in shallow lakes such as Bass Lake that are not thermally stratified. Wind induced mixing of lake water in summer can lower the average dissolved oxygen concentration throughout the water column. Under severe situations this phenomenon can result in both summer and winter fish kills. If, in the future, Bass Lake should experience fish kills due to low dissolved oxygen concentrations, then the feasibility of installing a lake aeration system should be investigated. Supersaturated dissolved oxygen concentrations and elevated pH were observed in the surface water samples during the June 20^{th} sample, an indication of excessive plant photosynthesis, which is itself a consequence of elevated nutrients. The pH exceeded the 9.0 s.u water quality criterion, another potential stress on aquatic life. Field conductivity levels, a measure of total elemental ions, were normal in all samples.

Trophic State:

Data on trophic state are provided in Table 3. Bass Lake seasonally fluctuated between eutrophic (nutrient enriched, high primary production) and hypereutrophic (highly enriched) conditions. There was a significant increase in both chlorophyll-a and total phosphorus at station L-2 between the June and August time periods.

Carlson Trophic State Index (TSI) values for chlorophyll and total phosphorus ranged from TSI = 62 to 71 at station L-1 (near dam), and TSI = 64 to74 at station L-2 (mid-lake). The annual average TSI for Bass Lake was 68.5 (see *Equation 1.0, p. 9*), which places Bass Lake into a hypereutrophic trophic state classification on an annual basis. In their 1996 Water Resource Inventory, the Ohio EPA reported that only 16.6 % of 199 sampled public lakes in Ohio were hypereutrophic, making Bass Lake one of the most nutrient enriched lakes in the state. Hypereutrophic lake condition results from excessive nutrients (mostly phosphorus) and shallow water depths, which can lead to excessive blooms of algal biomass (chlorophyll-a). There are a variety of potential sources of nutrient loading to Bass Lake including inflow from tributary streams (e.g., wastewater treatment plant effluents, use of fertilizers, septic systems, natural wetlands), internal release of phosphorus from anoxic sediment in summer, direct leaching of nutrients from decayed organic matter, and pumping of nutrients from roots of macrophytes through stems and leaves into lake water. A detailed nutrient budget survey would need to be conducted to identify the relative contributions of the different external and internal pathways.

Table 2. Results of chemical field parameters from Bass Lake at stations L-1 and L-2, 2002.

Date	Depth (m)	Temp. °C	DO (mg/l)	pH (su)	Field conductivity (umhos)
20-June-2002					
	Station L-1 (Time: 1320)				
	0.5	24.86	14.28	**9.29***	292
	1.0	21.99	12.19	**9.05***	279
	Station L-2 (Time: 1345)				
	0.5	24.50	18.04	**9.64***	287
	1.0	22.39	13.45	**9.26***	279
	2.0	20.07	5.23	8.40	279
29-August-2002					
	Station L-1 (Time: 1100)				
	0.5	23.32	8.23	8.20	397
	1.0	23.12	7.36	8.08	398
	1.5	22.90	6.10	7.87	400
	Station L-2 (Time: 1000)				
	0.5	23.20	8.06	8.23	397
	1.0	23.13	7.81	8.15	397
	2.0	22.67	**1.55***	7.53	406

* Values in bold exceed water quality criteria in OAC 3745-1 and thus serve as stressors to aquatic life.

The ratio of total nitrogen to total phosphorus (N/P) in lake water is often used to predict which of the two nutrients limits the growth of phytoplankton at any point in time. In general, N/P ratios > 17:1 provide strong evidence of phosphorus limitation (Ohio EPA, 1996), whereas N/P < 9:1 suggest that nitrogen is in short supply. The nutrient data from Bass Lake (Table 3) show strong phosphorus limitation in June (> 17:1 N/P), shifting to nitrogen limitation in August. This seasonal shift from phosphorus to nitrogen limitation matches well the phytoplankton data which show an increase in the number of blue-green algae (cyanobacteria) from the June to August time period. Because blue-green algae are able to fix atmospheric nitrogen, they have a competitive advantage over other types of algae in late summer when nitrogen in the lake water is in short supply. Biologically available nitrate-nitrite ions were at very low concentrations in both surface and bottom waters in June and August, a situation that would provide an adaptive advantage to nitrogen fixing blue-green algae even when phosphorus ions were in low supply.

Samples collected from the largest inflow tributaries (Beaver Creek at Sherman Road, Spring Brook, Woodiebrook, the Bass Lake "lagoon" area, and the Chagrin River at Woodiebrook Road), indicate that the highest concentrations of total phosphorus and total nitrogen were from the "lagoon area" channel (total phosphorus as high as 1,590 ug/l) and Beaver Creek (total phosphorus as high as 1,510 ug/l). Data collected on the concentration of nutrients in Bass Lake sediment suggest that internal nutrient loading should be significant during summer months. There was a significant (Student t = 0.05 p) 20% increase in the concentration of total phosphorus in bottom water samples (mean = 98.33 mg/l, N=3) compared to surface water (mean = 78.97, N = 3, see Table 9). It is important to note that the samples from Beaver Creek before it empties into Bass Lake were collected prior to the 2003 upgrade at the Heather Hill WWTP, which included reduction in phosphorus concentrations in the discharge. Current phosphorus concentrations in Beaver Creek should be significantly lower than was recorded in the 2002 survey.

Electro-fishing Lake Survey:

Table 4 shows the results of the electro-fishing survey along the western shore of Bass Lake near the dam. Seven fish species were collected plus a hybrid of a bluegill x pumpkinseed sunfish. By number, the dominant species were black crappie (37.93%), bluegill sunfish (17.24%), and pumpkinseed sunfish (13.79%). Black crappie eat mostly zooplankton when small, and shift to a wide variety of animal prey (insects, small fish, crayfish) as adults. Sunfish eat a wide variety of zooplankton and small invertebrates and are known to be size selective predators. It has been reported that pumpkinseed sunfish can consume snails and small mussels in large numbers.

Table 3. Trophic state data collected from surface and bottom samples at Bass Lake, 2002. Ohio EPA data.

Lake Station/ Parameters	Date Collected (mouth/day) 06/20 Surface (0.5 m)	06/20 Bottom (1.5 m)	08/29 Surface (0.5 m)	08/29 Bottom (1.5 m)
Station L1 (near dam)				
Chl-a (ug/l)	23.61	----	----	----
Carlson TSI	62			
Secchi depth (meters)	1.17	----	0.49	----
Carlson TSI	58		70	
T Phosphorus (ug/l)	59.6	71.7	106	----
Carlson TSI	63		71	
NO2-NO3 (ug/l)	<100	<100	<100	----
TKN (Kjeldahl-N) (ug/l)	1180	1280	960	----
Total Nitrogen (ug/l) (NO2-NO3+TKN)	1230*	1320*	1010*	----
N/P Ratio	21:1	18:1	9:1	----
Station L2 (mid-lake)				
Chl-a (ug/l)	48.58	----	85.2	----
Carlson TSI	68		74	
Secchi depth (meters)	1.20	----	0.52	----
Carlson TSI	57		69	
T Phosphorus (ug/l)	62.8	80.3	116	114
Carlson TSI	64	----	73	----
NO2-NO3 (ug/l)	<100	<100	<100	<100
TKN (Kjeldahl-N) (ug/l)	1170	1360	970	960
Total Nitrogen (ug/l) (NO2-NO3+TKN)	1220*	1410*	1020*	1010*
N/P Ratio	19:1	18:1	9:1	9:1

* a value of ½ detection limit was used for NO2-NO3 in the determination of Total Nitrogen.

The number of individual fish collected during the electro-fishing survey was very low for a 0.55 km sample zone (N=29), suggesting that the fish community was under stress. DELT anomalies (deformities, eroded fins, lesions, tumors) were very high at 3.5%, indicating chemical stress (e.g., normal DELT numbers are < 0.10% in streams). Additional electro-fishing surveys are recommended to determine if the high percentage of DELT anomalies have continued over time. A previous fish survey (April 2,1998) by Paul Anderson of Ohio EPA, Phil Hillman and Vince LaConte of Ohio DNR, found a dominance of yellow perch and black crappie having good "condition factor" as determined by Ohio DNR game fish surveys. This 1998 survey was conducted before the lake water level was lowered by ~2-3 feet; the 2002 survey was conducted after the lake level was lowered. Yellow perch were not common during the 2002 survey. These data suggest that the lowering of the water level may have had a significant negative impact on yellow perch populations, s species adapted to deeper water conditions than presently exist in Bass Lake

Table 4. Fish species collected from the Bass Lake, September 30, 2002 electro-fishing survey. Distance fished = 0.55 km, time = 1684 sec, Sampler type = A (boat)

Species	# of Fish	Relative Number	% by Number	Relative Weight (gm)	% by Weight	Average Weight (gm)
Common Carp	2	3.64	6.90	22.36	65.13	6,150
Yellow Bullhead	2	3.64	6.90	1.56	4.53	428
Black Crappie	11	20.0	37.93	5.24	15.27	262
Largemouth Bass	2	3.64	6.90	2.18	6.34	599
Bluegill Sunfish	5	9.09	17.24	1.28	3.72	140
Pumpkinseed Sunfish	4	7.27	13.79	0.92	2.66	126
Yellow Perch	2	3.64	6.90	0.48	1.41	133
Bluegill x Pump. hybrid	1	1.84	3.45	0.32	0.93	176

Total Number of Fish	29
Number of Species	7
Number of Hybrids	1
DELT anomalies	3.5 %
Top Carnivores	7.0 %
IBI	26 *
MIwb	5.9 *

* The IBI and MIwb developed by Ohio EPA have not been calibrated to natural glacial lake fish communities and cannot be directly applied to biological criteria in OAC 3745-1-07.

Plankton Surveys:

Phytoplankton and zooplankton data are reported in Tables 5-7. Twenty-two phytoplankton taxa were identified to the level of genus-species. Blue-green algae were more common than green algae in both June and August. Total phytoplankton counts (cells/ml) reached bloom conditions in August, dominated by blue-green species and diatoms. In June, the dominant blue-green species was *Aphanizomenon flos-aquae,* in August the diatom *Aulacoseira (Melosira) granulata* was dominant. The level of chlorophyll-a in Bass Lake was highly associated with the estimated phytoplankton count. A near doubling of algae cells in August resulted in a similar response in chlorophyll-a concentration in lake water (Table 6).

Excessive numbers of blue-green algae can significantly impact the grazer food chain of lakes (e.g., algae, zooplankton, small fish, predatory fish) and result in an impaired recreational game fishery. Most blue-green algae are not used as a preferred prey by zooplankton, which are a critical component of the food web of a well balanced fish community. The dominance of blue-green algae in spring is most likely a response to the measured hypereutrophic levels of phosphorus in the surface water.

Some species of blue-green algae can release toxic chemicals known as *cyanobacterial toxins*. Some of these toxins are known to attack the liver (hepatotoxins) or the nervous system (neurotoxins); others simply irritate the skin. One group of toxins produced and released by cyanobacteria are called *microcystins* because they are isolated from *Microcystis aeruginosa*. Microcystins are a very common source of cyanobacterial toxins in surface waters, as well as being the ones most often responsible for poisoning animals. Microcystins are extremely stable in water because of their chemical structure, which means they can survive in both warm and cold water and can tolerate radical changes in water chemistry, including pH. *Microcystis aeruginosa* was found in Bass Lake during the August 29, 2002 sample, but did not reach bloom concentrations. These algae are very common in Ohio lakes and it is only under extremely high abundances that toxic effects are of concern. It is recommended that research be conducted to determine if the genetic strain of *Microcystis* present in Bass Lake has the ability to release toxic chemicals at concentrations that can affect aquatic life.

Nine species of zooplankton were identified (Table 7), with numbers showing a large increase in August, most likely tracking the increase in algae that would serve as prey. In both June and August samples, the protist *Difflugia urceolata* was the dominant zooplankton taxon. This species is a type of amoebae that constructs a mineral shell for protection, and it has been associated with lakes that have a glacial origin. The high numbers of blue-green algae associated with *D. urceolata* suggests that it is not ingesting these blue-green species in large numbers. Various species of rotifers were of secondary dominant in the zooplankton community. Cladocera (*Bosmina*, *Daphnia*) and Copedopa (*Diaptomus*) were relatively rare in both June and August samples. These genera are usually common in the late spring/early summer in lakes with a well balanced fishery, and their low numbers again point to a fish community out of balance.

Table 5. Phytoplankton composition and abundances for Bass Lake Station L-2, 2002.

Division/ Species	20 June	29 August	Division/ Species	20 June	29 August
Cyanobacteria (Blue-Green Algae)			**Pyrrophyta (Dinoflagellates)**		
Anabaena flos-aquae	++	+	*Ceratium hirundinella*	O	O
Aphanizomenon flos-aquae	++++	++	**Eulenophyta (Euglenoids)**		
Microcystis aeruginosa		++	*Phacus helikoides*		O
Chlorophyta (Green Algae)			*Phacus longicauda*		O
Coelastrum microporum	O	+	*Phacus orbicularis*		O
Oocystis pusilla		+	*Trachelomonas volvocinia*		O
Pediastrum duplex	+	+	**Cryptophyta (Cryptophytes)**		
Pediastrum simplex	+	+	*Cryptomonas erosa*	O	+
Scenedesmus bijuga		O	*Cryptomonas ovata*		+
Scenedesmus quadricauda		O	**Unidentified**		
Sphaerocystis schroederti		+	*Unidentified flagellates*	O	+
Schoederia setigera		O			
Staurastrum sp. (cingulum?)		O			
Chrysophyta (Yellow-brown Algae)					
Chrysophyceae					
Chrysochromulina parva	O	+			
Bacillariophyceae (Diatoms)					
Aulacoseira (Melosira) granulata		+++			

Key: +++++: Species present in bloom conditions (based upon total abundance estimate) at abundances >80% of total relative abundance in the sample; ++++: Species present at greater than 80% of total relative abundance in the sample in non-bloom conditions; +++: Species present at >20% but less than 80% of total relative abundance in the sample; ++: Species present at <20% but > 5% of total relative abundance in the sample; +: Species presnt at <5% but >1% of total relative abundance in the sample; O: Species observed in sample (<1% total relative abundance).

Table 6. Narrative summary of phytoplankton community composition for Bass Lake Station L-2, 2002.

Parameter/Algal Division	20 June	29 August
Chlorophyll a (µg/l)	48.6	85.2
Estimated Phytoplankton Count (cells/ml)	5,269	10,557
Total Phytoplankton Abundance	**Very High**	**Bloom**
Cyanobacteria (Blue-green Algae)	Dominant	Abundant
Chlorophyta (Green Algae)	Common	Common
Chrysophyta (Yellow-brown Algae)		
Chrysophyceae	Rare	Rare
Bacillariophyceae (Diatoms)	Absent	Dominant
Pyrrophyta (Dinoflagellates)	Rare	Rare
Euglenophya	Absent	Rare
Cryptophyta	Rare	Rare

Key for narrative assessment of total algal abundance parameters (chlorophyll a and cell count):

Bloom: Algal abundance deemed to be extremely high due to highly nutrient enriched conditions, contributing to a significant impairment of lake uses. Chlorophyll a concentrations greater than the 90th percentile for the ecoregion. Phytoplankton community dominated by dense quantities of a small number (typically2-3) species.

Very High: Algal abundance typical of nutrient enriched conditions which would be perceived by the typical lake user, contributing to a impairment of some lake uses. Chlorophyll a concentrations greater than the 75th percentile for the ecoregion.

Key for narrative description of algal taxonomic group abundance:

Dominant: Species within the algal group constitute more than 50 percent of the total relative abundance of the phytoplankton present.

Abundant: Species within the algal group constitute greater than 10 percent of the total relative abundance of the phytoplankton present.

Common: Species within the algal group constitute greater than 1 percent but less than 10 percent of the total relative abundance of the phytoplankton present.

Rare: Species within the algal group constitute less than 1 percent of the total relative abundance of the phytoplankton present.

Absent:_ No species from the algal group observed in the sample.

Table 7. Zooplankton assemblage composition observed in Bass Lake Station L-2 samples, 2002. Abundance estimates in number of organisms per liter.

Taxonomic Group/ Species	20 June	29 August
Rhizopoda, Testaceae		
Difflugia urceolata	80	604
Rotifera, Monogonanta		
Keratella cochlearis	20	188
Keratella quadrata	10	12
Polyartha sp.	-	2
Trichocerca similis	-	188
Arthropoda, Crustacea, Cladocera		
Bosmina longirostris	-	16
Chydorus sphaericus	-	58
Daphnia galeata mendotae	2	14
Arthropoda, Crustacea, Copepoda		
Diaptomus sp.	1	4
nauplii	40	78
Total Abundance (organisms/liter)	153	1,164

Bacteria:

The numbers of fecal coliform and *E. coli* bacteria collected from Bass Lake and tributary streams are given in Table 8. Very low bacteria counts were recorded in the open water areas of the lake at stations L-1 and L-2. However, elevated levels of both fecal coliform and *E. coli* were found in one of four samples collected from the Bass Lake "lagoon" area. This lagoon area is located to the north of where Spring Brook empties into the lake. The maximum values reported in the lagoon area exceeded the Ohio EPA Primary Contact Recreation (PCR) criterion for streams and lakes; however, violations of Ohio Administrative Code (OAC 3745-1-07) were not documented (see text in Table 8). The lagoon area receives runoff and groundwater flow from a residential area where home sewage systems drain into leach fields. It is possible that these leach fields are hydraulically connected to the groundwater table of the shallow Sharon Formation, which serves to recharge headwater streams in the general Bass Lake area (Ohio EPA, 1997). Ammonia-nitrogen (2.07 mg/l) and total phosphorus (1.59 mg/l) were elevated in a single sample collected from the lagoon area (09/23/2002); both of these parameters are associated with human sewage. These data suggest that the lagoon area is an important source of external nutrient loading and bacteria to Bass Lake. Future studies are needed to identify the exact sources of bacteria and nutrients in the lagoon area.

Lake mapping:

The results of a bathymetric survey to map contours of water depth are shown in Figure 3. The average depth of water in Bass Lake was estimated to be 4.84 feet (1.47 m), maximum depth was 9.5 feet (2.89 m). Two deep hole zones at a depth of 8-9 foot were found. In general, areas with water less than six feet depth and emergent plant growth more closely resemble a wetland than a lake. As shown in Figure 3, roughly 50% of the surface area of Bass Lake is less than 6 feet in depth. According to the Davey Resource Group (1998) survey, these areas meet the definition of a shallow jurisdictional wetland system defined by the Army Crops of Engineers. The shallow nature of Bass Lake is largely a result of its 10,000 + year age, although some loss of water volume would also be expected from runoff of soils resulting from upstream construction and agricultural activities.

The total amount of sediment that has accumulated in Bass Lake is unknown. This information would be required if a decision is made to remove sediment to deepen the lake to enhance recreation. In 1998, the Stark County Park District completed a two-year dredging project for Sippo Lake, a glacial lake with an average depth of 5.1 feet, similar to Bass Lake. About 303,000 cubic yards of sediment were hydraulically dredged from Sippo Lake at a final project cost of $1,895,823.00 ($6.25/cubic yard-1998 dollars). The goal of the Sippo Lake project was to deepen the central area of the lake to an average depth of 10 feet to allow for recreational boating and fishing. A final report of the Sippo Lake dredging project can be viewed at this internet site: http://www.radford.edu/~rvannoy/rvn/407/finalrep.htm

Table 8. Results of bacteria samples collected in the Bass Lake Preserve.

Location	Date	Fecal coliform (#/100 ml)	E. coli (#/100 ml)
Bass Lake			
Station L-1	6/20/2002	<10	2
Station L-2	6/20/2002	<10	1
Station L-2	8/29/2002	<1	1
Bass Lake Lagoon area	6/05/2001	39	23
	6/20/2002	<23	<10
	9/23/2002	1,200	550*
East of Lagoon area	6/05/2001	68	25
Spring Brook at Interurban	7/18/2002	64	56
	9/23/2002	190	200
Woodiebrook at Woodiebrook Rd.	07/18/2002	520	610*
	09/23/2002	250	60
Woodiebrook at Peterson trib.	07/18/2002	180	85
	09/23/2002	10	8
Chagrin R. at Woodiebrook Rd.	07/18/2002	200	310*
	09/23/2002	360	250
Chagrin R. at Auburn Rd.	07/18/2002	<100	<100
Beaver Creek at Sherman Rd.	07/18/2002	1,800	1,200*
	09/23/2002	1,500	1,700*
Beaver Creek at Bean Rd.	07/18/2002	230	150

* Exceedence of Primary Contact Recreation (PCR) criterion where fewer than 5 samples are collected over a 30-day period are as follows: (for fecal coliform, shall not exceed 2,000/100 ml in more than ten per cent of samples taken during any 30-day period; for *E. coli,* shall not excced 298/100). These exceedences do not represent violations of numerical criteria for recreational use because, according to OAC 3745-1-07, Table 7-14, when both fecal coliform and *E. coli* data are available for a specific sample, "*for each [use] designation at least one of the two bacteriological standards (fecal coliform or E. coli) must be met*". Therefore, when both bacteria groups are sampled and one exceeds criteria and one does not, no human health violation exists. In all cases where the *E. coli* ten-per cent rule was exceeded, fecal coliform was not, thus no violations of OAC 3745-1-07 were documented in any of the Bass Lake samples.

Lake sediment:

The results of a sediment sample collected at station L-1 in Bass Lake are shown in Table 9 and Figure 4. The data were compared to consensus based probable toxic effects levels (PEL) as published by MacDonald et al. (2000). None of the heavy metal parameters in the sediment of Bass Lake showed concentrations above toxic PEL values. PCBs were not detected at a detection limit of 199 ug/kg; a scan of historical use pesticides such as DDT showed non-detection at a detection level of 23.7 ug/kg. Only total phosphorus was significantly higher than average as compared against sediment samples collected by Ohio EPA in twelve other glacial lakes in Ohio (data compiled from Ohio EPA 1992, 1994, 1996) reports. The sediment phosphorus data for Bass Lake are consistent with the observed hypereutrophic conditions reported in lake water (see Table 3), and suggest that a significant source of total phosphorus to the water column of Bass Lake is internal nutrient loading from lake sediment. Any attempt to control nutrient loadings to Bass Lake will need to address this large reservoir of nutrients that are present in the sediment of the lake and wetland complex.

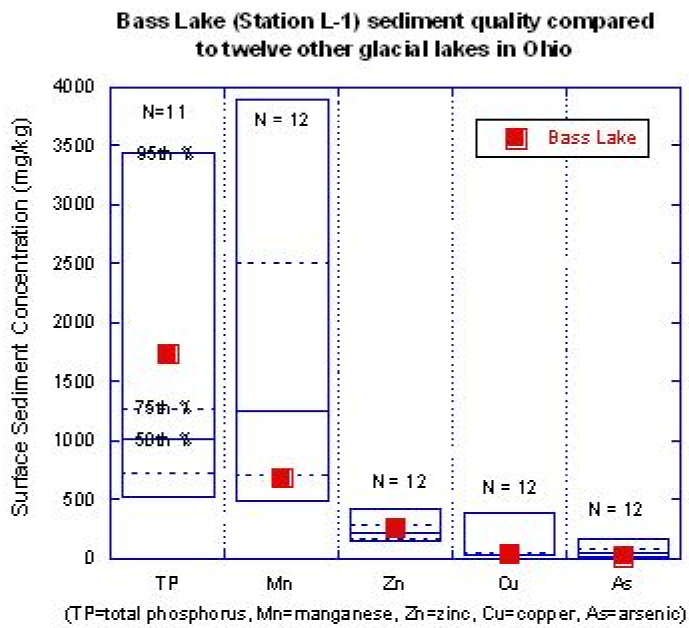
Mercury in fish tissue is a concern throughout Ohio, and has resulted in the Ohio Department of Health issuing a statewide fish consumption advisory to limit meals of fish from Ohio waters to one/week for women of child bearing age and children six years and younger. The mercury in the sediment of Bass Lake at a level of 0.172 mg/kg is very near the average recorded for other glacial lakes in Ohio (see Figure 4). Although the level of mercury in the sediment of Bass Lake was not elevated compared to other glacial lakes in Ohio, any future actions to increase recreational fishing should include a survey of mercury level in the fish tissue of game species to determine site specific risk levels for human consumption.

Water column heavy metals:

A summary of chemical data collected from the surface and bottom waters at Stations L-1 and L-2 is provided in Appendix 1. Water hardness ranged from 97 to 125 mg/l (median 105), which indicates that Bass Lake is a "soft water" lake. Many heavy metals such as copper, nickel, zinc, lead, etc.) have hardness dependent effects on aquatic life, with an increase in toxicity as water hardness lowers. The low water hardness of Bass Lake indicates that application of heavy metal (e.g., copper) based pesticides and herbicides should be avoided. Analysis of heavy metal concentrations in Bass Lake indicate that none were Ohio above water quality criteria.

Table 9. Sediment data from a surface grab sample collected August 29, 2002 from Bass Lake station L-1. All chemical units in mg/l except TOC (%) and Percent Solids (%). Where available, Bass Lake values are compared to literature values above which harmful effects to benthic aquatic are likely to be observed (MacDonald et al. 2000).

Parameter	Result	Consensus Based Probable Effect Level MacDonald et al. (2000)
Percent solids	17.0 %	--
TOC	7.9 %	--
	(mg/kg)	
Aluminum	57,500	--
Barium	307	--
Calcium	6090	--
Chromium	< 64	111
Copper	42.6	197
Iron	43,100	--
Lead	< 86	91.3
Magnesium	7240	--
Manganese	682	--
Nickel	< 86	48.6
Potassium	11,900	--
Sodium	< 10,700	--
Strontium	< 64	--
Zinc	264	459
Mercury	0.172	1.06
Arsenic	13.3	33.0
Cadmium	1.35	4.98
Selenium	< 4.44	--
Ammonia	330	--
Total phosphorus	1730	--
	(ug/kg)	
4-4-DDT (plus 18 other pesticides)	< 23.7	--
PCBs (1016,1221,1232,1242 1248,1254,1260)	< 119	--



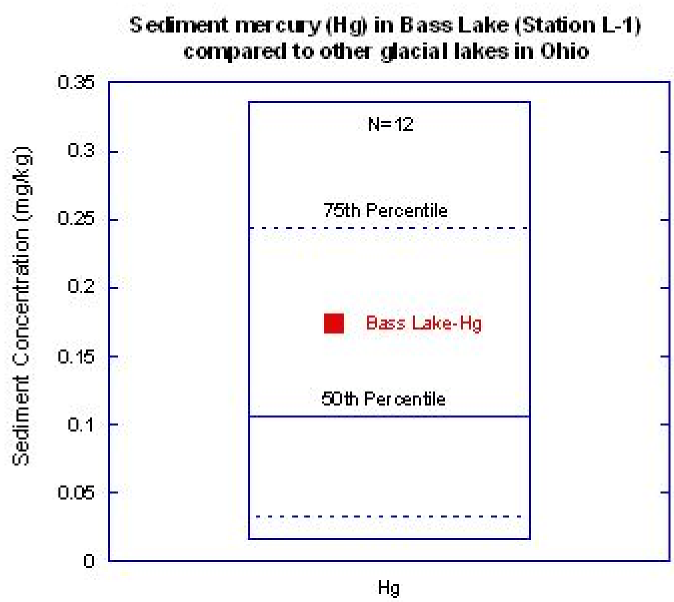


Figure 4. Frequency plots showing Bass Lake sediment quality for total phosphorus and select heavy metals as compared to twelve natural lakes with glacial origin in Ohio. Data for natural lakes from Ohio EPA surveys conducted between 1992 and 1995.

Pollutant loading from National Pollutant Discharge Elimination System (NPDES) regulated dischargers.

The largest NPDES permitted wastewater treatment plant (WWTP) located in the Bass Lake watershed is the Heather Hills Hospital located to the south of Bass Lake along Beaver Creek. The WWTP was expanded to a maximum effluent flow of 0.10 mgd effective May, 2003. The expanded plant includes a replacement of the influent trash trap with fine screens, the replacement of the two 30,000 gallon extended aeration tanks with 60,000 gallon extended aeration tanks, the addition of phosphorus removal through the use of chemical inactivation equipment, the replacement of the slow sand filter tertiary treatment with rapid sand filters, and the replacement of the chlorine disinfection system with an ultraviolet system.

Final effluent limits for the WWTP became effective on May 1, 2003. Final effluent limits were based upon *de minimus* load increases for $cBOD_5$, ammonia nitrogen, and suspended solids. Therefore, the expansion of the WWTP was excluded from the anti-degradation review requirements under the provisions of OAC Rule 3745-1-05(D)(1)(b). In addition, a thirty-day average total phosphorus limit of 1 mg/l was included as a final effluent limit in order to reduce nutrient loadings to Beaver Creek and Bass Lake. Because the 2002 water quality survey was conducted prior to these WWTP upgrades, significantly lower levels of phosphorus should now be present in Beaver Creek downstream from the WWTP. Future sampling is recommended to determine what effect, if any, these reductions have had on the chemistry and biology of Bass Lake.

Overall Lake Condition

Prior to 2000, the Ohio EPA used the Ohio Lake Condition Index (LCI) evaluation process to determine if various types of designated uses were being supported or achieved in Ohio's public lakes and reservoirs (see Ohio EPA 1996). The LCI assessed 14 different lake condition parameters to determine the overall health of the lake ecosystem for attainment of chemical criteria related to Aquatic life, Recreation, Public Drinking Water Supply, and Fish Tissue Consumption. However, due to changes in TMDL reporting requirement, and a new Credible Data Law adopted in 2005 in Ohio, the LCI evaluation process is no longer being used by Ohio EPA to formally assess lake condition and/or attainment of designated uses. New use assessment procedures are currently being developed.

Analysis of the 2002 data indicate less than full use condition using the prior LCI assessment process for the following 6 parameters out of 13 assessed (no data available for fish tissue): elevated nutrients, elevated chlorophyll-a, high Secchi disk turbidity, high potential volume loss, low dissolved oxygen in bottom waters, and excessive shoreline growth of aquatic plants that would impact recreational boating. Future lake management plans should focus efforts on these less than full use lake conditions.

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Appendix A. Water quality data for the Bass Lake study area, 2002.

Location	Sample Number	Date	Time	Station ID	Depth	Temperature P10	Dissolved Oxygen P299	D.O. Percent Saturation P00301
Reporting Units					meters	Deg C	mg/l	Percent
Beaver Creek @ Bean Rd	47734	06/20/02	1034	BL-S3		15.4	2.9	29
Beaver Creek @ Bean Rd	48678	07/18/02	908	BL-S3		15.4	8.4	84
Beaver Creek @ Bean Rd	48679	07/18/02	908	BL-S3		15.4	8.4	84
Beaver Creek @ Sherman Rd.	47733	06/20/02	1052	BL-S2		20.2	15.2	168
Beaver Creek @ Sherman Rd.	48677	07/18/02	731	BL-S2		21.0	2.1	23
Beaver Creek @ Sherman Rd.	50850	09/23/02	1439	BL-S2		19.8	14.1	155
Chagrin R. @ Woodiebrook Rd	47743	06/20/02	1013	BL-S1		16.6	3.5	36
Chagrin R. @ Woodiebrook Rd	48682	07/18/02	843	BL-S1		21.7	1.2	13
Chagrin R. @ Woodiebrook Rd	50849	09/23/02	1426	BL-S1		15.3	4.3	43
Chagrin R. ust Auburn Rd	47731	06/20/02	1106	D01P26		22.0	5.0	57
Chagrin R. ust Auburn Rd	48684	07/18/02	746	D01P26		23.4	2.2	27
Bass Lake Station L-1 Surface	47732	06/20/02	1306	BL-L1	0.4	24.9	14.3	173
Bass Lake Station L-1 Bottom	47738	06/20/02	1320	BL-L1	1.0	22.0	12.2	140
Bass Lake Station L-1 Surface	50109	08/29/02	1100	BL-L1	0.5	23.3	8.2	96
Bass Lake Station L-2 Surface Dup A	47737	06/20/02	1200	BL-L2	0.5	24.5	18.0	217
Bass Lake Station L-2 Surface Dup B	47740	06/20/02	1000	BL-L2	0.5	24.5	18.0	217
Bass Lake Station L-2 Bottom	47739	06/20/02	1345	BL-L2	2.0	20.1	5.2	58
Bass Lake Station L-2 Surface Dup A	50110	08/29/02	1000	BL-L2	0.5	23.2	8.1	95
Bass Lake Station L-2 Surface Dup B	50111	08/29/02	1000	BL-L2	0.5	23.2	8.1	95
Bass Lake Station L-2 Bottom	50112	08/29/02	1000	BL-L2	2.0	22.7	1.6	18
Bass Lake Lagoon	50854	09/23/02	1330		0.5			
Woodiebrook West Trib at Woodiebrook Rd.	46603	04/24/02	1229	WB-1		11.8	13.5	125
Woodiebrook West Trib at Woodiebrook Rd.	47741	06/20/02	953	WB-1		12.2	11.1	103
Woodiebrook West Trib at Woodiebrook Rd.	48683	07/18/02	818	WB-1		12.7	9.5	90
Woodiebrook West Trib at Woodiebrook Rd.	50852	09/23/02	1402	WB-1		13.2	10.7	102
Woodiebrook East Trib dst Woodiebrook Rd.	46602	04/24/02	1221	WB-2		12.9	12.6	120
Woodiebrook East Trib dst Woodiebrook Rd.	47742	06/20/02	1001	WB-2		16.1	6.4	65
Woodiebrook East Trib dst Woodiebrook Rd.	48680	07/18/02	826	WB-2		20.5	6.1	68
Woodiebrook East Trib dst Woodiebrook Rd.	50851	09/23/02	1353	WB-2			11.1	122
Spring Brook @ Interurban	46601	04/24/02	1210	D01W32		11.9	14.5	135
Spring Brook @ Interurban	47736	06/20/02	1139	D01W32		13.8	10.6	102
Spring Brook @ Interurban	48681	07/18/02	802	D01W32		14.6	9.7	95
Spring Brook @ Interurban	50853	09/23/02	1340	D01W32		13.2	10.7	102

Notes: K=analyte not detected, value indicates the analytical detection limit J=estimated concentration

Appendix A. Water quality data for the Bass Lake study area, 2002.

Location	pH, Field P400	pH (lab) P403	Conductivity, Field uncorrected P402	Field Conductivity, Corrected P94	Conductivity (lab) P95	Fecal Coliform P31611	E. coli P31633
Reporting Units	S.U.	S.U.	umhos/cm	umhos/cm	umhos/cm	col/100 ml	col/100ml
Beaver Creek @ Bean Rd	7.6		321	393	488		
Beaver Creek @ Bean Rd	7.71		363	444	530	230	150
Beaver Creek @ Bean Rd	7.71		363	444	530	230	150
Beaver Creek @ Sherman Rd.	8.55		383	422	513		
Beaver Creek @ Sherman Rd.	7.43		703	761	858	1800	1200
Beaver Creek @ Sherman Rd.	8.37		456	507	603	1500	1700
Chagrin R. @ Woodiebrook Rd	7.61		547	652	689		
Chagrin R. @ Woodiebrook Rd	7.38		529	565	601	200	310
Chagrin R. @ Woodiebrook Rd	7.32		297	364	411	360	250
Chagrin R. ust Auburn Rd	7.87		287	304	366		
Chagrin R. ust Auburn Rd	7.39		347	358	408	100 K	100 K
Bass Lake Station L-1 Surface	9.29	8.56	292	293	354	10 K	2
Bass Lake Station L-1 Bottom	9.05	8.58	279	296	356		
Bass Lake Station L-1 Surface	8.2	7.96	397	385	419		
Bass Lake Station L-2 Surface Dup A	9.64	8.65	287	290	358	10 K	1
Bass Lake Station L-2 Surface Dup B	9.64	8.70	287	290	356	10 K	1
Bass Lake Station L-2 Bottom	8.4	8.54	279	308	360		
Bass Lake Station L-2 Surface Dup A	8.23	7.94	397	383	429	1 K	1
Bass Lake Station L-2 Surface Dup B	8.23	8.04	397	383	428		
Bass Lake Station L-2 Bottom	7.53	7.68	406	387	430		
Bass Lake Lagoon					507	1200	550
Woodiebrook West Trib at Woodiebrook Rd.	8.56		319	427	453	20	20
Woodiebrook West Trib at Woodiebrook Rd.	7.98		282	374	460		
Woodiebrook West Trib at Woodiebrook Rd.	7.8		302	395	452	520	610
Woodiebrook West Trib at Woodiebrook Rd.	8.25		291	375	445	250	60
Woodiebrook East Trib dst Woodiebrook Rd.	8.06		252	328	350	60	10 K
Woodiebrook East Trib dst Woodiebrook Rd.	7.6		230	278	333		
Woodiebrook East Trib dst Woodiebrook Rd.	7.54		283	310	360	180	85
Woodiebrook East Trib dst Woodiebrook Rd.	8.12		268	297	353	10	8
Spring Brook @ Interurban	9.38		271	362	447	32	36
Spring Brook @ Interurban	8.25		296	376	458		
Spring Brook @ Interurban	7.84		312	390	443	64	56
Spring Brook @ Interurban	8.25		291	375	442	190	200

Notes: K=analyte not detected, value indicates the analytical detection limit   J=estimated concentration

Appendix A. Water quality data for the Bass Lake study area, 2002.

Location	Chlorophyll a P32209	Secchi Disk P00078	Aluminum P1105		Arsenic P1002		Barium P1007	Cadmium P1027		Calcium P916
Reporting Units	ug/l	meters	ug/l		ug/l		ug/l	ug/l		mg/l
Beaver Creek @ Bean Rd			420		7		93	0.20	K	71
Beaver Creek @ Bean Rd			646	J	9		114	0.20	K	79
Beaver Creek @ Bean Rd			367	J	8		112	0.20	K	78
Beaver Creek @ Sherman Rd.			200 K		2	K	31	0.20	K	47
Beaver Creek @ Sherman Rd.			200 K		3		54	0.27		55
Beaver Creek @ Sherman Rd.			200 K		3		45	0.20	K	57
Chagrin R. @ Woodiebrook Rd			200 K		3		62	0.20	K	57
Chagrin R. @ Woodiebrook Rd			285	J	7		105	0.20	K	60
Chagrin R. @ Woodiebrook Rd			200 K		5		54	0.20	K	52
Chagrin R. ust Auburn Rd			412		4		43	0.20	K	34
Chagrin R. ust Auburn Rd			381	J	7		47	0.20	K	39
Bass Lake Station L-1 Surface	26.4	1.17	200 K		2		35	0.20	K	32
Bass Lake Station L-1 Bottom			200 K		2		29	0.20	K	29
Bass Lake Station L-1 Surface		0.49	659		6		46	0.20	K	36
Bass Lake Station L-2 Surface Dup A	48.6	1.2	200 K		2		34	0.20	K	32
Bass Lake Station L-2 Surface Dup B			200 K		2		30	0.20	K	29
Bass Lake Station L-2 Bottom			200 K		2		31	0.20	K	29
Bass Lake Station L-2 Surface Dup A	85.2	0.53	489		6		47	0.20	K	37
Bass Lake Station L-2 Surface Dup B			477		7		47	0.20	K	37
Bass Lake Station L-2 Bottom			572		7		47	0.20	K	36
Bass Lake Lagoon										
Woodiebrook West Trib at Woodiebrook Rd.										
Woodiebrook West Trib at Woodiebrook Rd.			200 K		2	K	41	0.20	K	48
Woodiebrook West Trib at Woodiebrook Rd.			200 K		2	K	48	0.20	K	53
Woodiebrook West Trib at Woodiebrook Rd.			200 K		2	K	49	0.20	K	51
Woodiebrook East Trib dst Woodiebrook Rd.										
Woodiebrook East Trib dst Woodiebrook Rd.			200 K		2	K	63	0.20	K	35
Woodiebrook East Trib dst Woodiebrook Rd.			200 K		2	K	95	0.20	K	43
Woodiebrook East Trib dst Woodiebrook Rd.			200 K		2	K	105	0.20	K	41
Spring Brook @ Interurban										
Spring Brook @ Interurban			200 K		2	K	44	0.20	K	47
Spring Brook @ Interurban			200 K		2	K	40	0.21		47
Spring Brook @ Interurban			200 K		2	K	44	0.20	K	46

Notes: K=analyte not detected, value indicates the analytical detection limit J=estimated concentration

Appendix A. Water quality data for the Bass Lake study area, 2002.

Location	Chromium P1034	Copper P1042	Iron P1045	Lead P1051	Magnesium P927	Manganese P1055	Mercury P80082
Reporting Units	ug/l	ug/l	ug/l	ug/l	mg/l	ug/l	ug/l
Beaver Creek @ Bean Rd	30 K	10 K	1340	2 K	19	305	
Beaver Creek @ Bean Rd	30 K	10 K	1930	2 K	22	268	
Beaver Creek @ Bean Rd	30 K	10 K	1340	2 K	21	239	
Beaver Creek @ Sherman Rd.	30 K	10 K	407	2 K	11	20	
Beaver Creek @ Sherman Rd.	30 K	10 K	352	2 K	14	576	
Beaver Creek @ Sherman Rd.	30 K	10 K	398	2 K	14	254	
Chagrin R. @ Woodiebrook Rd	30 K	10 K	368	2 K	12	80	
Chagrin R. @ Woodiebrook Rd	30 K	10 K	1720	2 K	15	523	
Chagrin R. @ Woodiebrook Rd	30 K	10 K	1660	2 K	12	196	
Chagrin R. ust Auburn Rd	30 K	10 K	978	2 K	7	186	
Chagrin R. ust Auburn Rd	30 K	10 K	1530	2 K	8	412	
Bass Lake Station L-1 Surface	30 K	10 K	398	2 K	6	36	
Bass Lake Station L-1 Bottom	30 K	10 K	317	2 K	6	33	
Bass Lake Station L-1 Surface	30 K	10 K	1020	2 K	8	226	
Bass Lake Station L-2 Surface Dup A	30 K	10 K	280	2 K	6	26	
Bass Lake Station L-2 Surface Dup B	30 K	10 K	244	2 K	6	28	
Bass Lake Station L-2 Bottom	30 K	10 K	392	2 K	6	52	
Bass Lake Station L-2 Surface Dup A	30 K	2 K	768	2 K	8	190	
Bass Lake Station L-2 Surface Dup B	30 K	2 K	757	2 K	8	188	
Bass Lake Station L-2 Bottom	30 K	10 K	906	2 K	8	236	
Bass Lake Lagoon							
Woodiebrook West Trib at Woodiebrook Rd.							2 K
Woodiebrook West Trib at Woodiebrook Rd.	30 K	10 K	87	2 K	12	21	
Woodiebrook West Trib at Woodiebrook Rd.	30 K	10 K	79	2 K	13	12	
Woodiebrook West Trib at Woodiebrook Rd.	30 K	10 K	154	2 K	13	15	
Woodiebrook East Trib dst Woodiebrook Rd.							2 K
Woodiebrook East Trib dst Woodiebrook Rd.	30 K	10 K	558	2 K	9	97	
Woodiebrook East Trib dst Woodiebrook Rd.	30 K	10 K	742	2 K	11	126	
Woodiebrook East Trib dst Woodiebrook Rd.	30 K	10 K	513	2 K	11	75	
Spring Brook @ Interurban							2 K
Spring Brook @ Interurban	30 K	10 K	50 K	2 K	12	10 K	
Spring Brook @ Interurban	30 K	10 K	69	2 K	12	10 K	
Spring Brook @ Interurban	30 K	10 K	61	2 K	12	10 K	

Notes: K=analyte not detected, value indicates the analytical detection limit J=estimated concentration

Appendix A. Water quality data for the Bass Lake study area, 2002.

Location	Nickel P1067		Potassium P937		Selenium P1147		Sodium P929	Strontium P1082	Zinc P1092		Hardness P900	Alkalinity P410
Reporting Units	ug/l		mg/l		ug/l		mg/l	ug/l	ug/l		mg/l	mg/l
Beaver Creek @ Bean Rd	40	K	2	K	2	K	9	177	10	K	256	204
Beaver Creek @ Bean Rd	40	K	2	K	2	K	7	194	15		288	235
Beaver Creek @ Bean Rd	40	K	2	K	2	K	7	195	12		281	233
Beaver Creek @ Sherman Rd.	40	K	2		2	K	44	146	10	K	163	148
Beaver Creek @ Sherman Rd.	40	K	6		2	K	105	226	24		195	228
Beaver Creek @ Sherman Rd.	40	K	3		2	K	45	173	10	K	200	142
Chagrin R. @ Woodiebrook Rd	40	K	2		2	K	87	218	17		192	157
Chagrin R. @ Woodiebrook Rd	40	K	3		2	K	43	209	13		212	168
Chagrin R. @ Woodiebrook Rd	40	K	4		2	K	14	108	10	K	179	151
Chagrin R. ust Auburn Rd	40	K	2		2	K	29	103	10	K	114	83
Chagrin R. ust Auburn Rd	40	K	2		2	K	33	128	20		130	110
Bass Lake Station L-1 Surface	40	K	2		2	K	30	100	10	K	105	80
Bass Lake Station L-1 Bottom	40	K	2		2	K	30	100	10	K	97	80
Bass Lake Station L-1 Surface	40	K	2		2	K	36	122	11		123	105
Bass Lake Station L-2 Surface Dup A	40	K	2		2	K	30	99	10	K	105	78
Bass Lake Station L-2 Surface Dup B	40	K	2		2	K	31	103	10	K	97	78
Bass Lake Station L-2 Bottom	40	K	2		2	K	31	101	10	K	97	80
Bass Lake Station L-2 Surface Dup A	40	K	2		2	K	36	124	10	K	125	102
Bass Lake Station L-2 Surface Dup B	40	K	2		2	K	36	123	10	K	125	105
Bass Lake Station L-2 Bottom	40	K	2		2	K	36	122	10	K	123	106
Bass Lake Lagoon												
Woodiebrook West Trib at Woodiebrook Rd.												
Woodiebrook West Trib at Woodiebrook Rd.	40	K	2		2	K	23	108	11		169	124
Woodiebrook West Trib at Woodiebrook Rd.	40	K	2	K	2	K	20	110	10	K	186	122
Woodiebrook West Trib at Woodiebrook Rd.	40	K	2	K	2	K	19	103	10	K	181	129
Woodiebrook East Trib dst Woodiebrook Rd.												
Woodiebrook East Trib dst Woodiebrook Rd.	40	K	2		2	K	16	88	13		124	80
Woodiebrook East Trib dst Woodiebrook Rd.	40	K	2		2	K	15	97	11		153	117
Woodiebrook East Trib dst Woodiebrook Rd.	40	K	2		2	K	14	92	10	K	148	120
Spring Brook @ Interurban												
Spring Brook @ Interurban	40	K	2	K	2	K	27	101	10	K	167	105
Spring Brook @ Interurban	40	K	2	K	2	K	23	103	12		167	114
Spring Brook @ Interurban	40	K	2	K	2	K	23	96	10	K	164	117

Notes: K=analyte not detected, value indicates the analytical detection limit J=estimated concentration

Appendix A. Water quality data for the Bass Lake study area, 2002.

Location	Acidity P70508	BOD5 P310	COD P340	Chloride P940	Sulfate P945	NO3-NO2-N P630	NO2-N P615	NH3-N P610
Reporting Units	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Beaver Creek @ Bean Rd	5 K	2.0 K	32	10	36	0.10	0.02 K	0.05 K
Beaver Creek @ Bean Rd	5 K	2.0 K	10	8	46	0.10 K	0.02 K	0.05 K
Beaver Creek @ Bean Rd	5 K	2.0 K	10	7	45	0.10 K	0.02 K	0.05 K
Beaver Creek @ Sherman Rd.	5 K	2.0 K	22	54	24	1.83	0.03	0.05 K
Beaver Creek @ Sherman Rd.	5 K	2.0 K	22	122	23	0.97	0.20	0.25
Beaver Creek @ Sherman Rd.	5 K	2.0 K	18	68.1	59.7	1.14	0.02 K	0.05 K
Chagrin R. @ Woodiebrook Rd	5 K	2.0 K	29	106	19	0.10 K	0.02 K	0.05 K
Chagrin R. @ Woodiebrook Rd	5 K	2.8	26	70	24	0.10 K	0.02 K	0.31
Chagrin R. @ Woodiebrook Rd	5 K	2.1	18	33	20.4	0.10 K	0.02 K	0.06
Chagrin R. ust Auburn Rd	5 K	2.2	22	45	24	0.10 K	0.02 K	0.18
Chagrin R. ust Auburn Rd	5 K	2.0 K	22	48	13	0.10 K	0.02 K	0.09
Bass Lake Station L-1 Surface		3.8			25	0.10 K	0.02 K	0.05 K
Bass Lake Station L-1 Bottom		4.0			33	0.10 K	0.02 K	0.05 K
Bass Lake Station L-1 Surface		6.7			12.3	0.10 K	0.02 K	0.10
Bass Lake Station L-2 Surface Dup A		6.0			29	0.10 K	0.02 K	0.05 K
Bass Lake Station L-2 Surface Dup B		4.7			32	0.10 K	0.02 K	0.05 K
Bass Lake Station L-2 Bottom		5.1			38	0.10 K	0.02 K	0.05 K
Bass Lake Station L-2 Surface Dup A		6.1			10.8	0.10 K	0.02 K	0.11
Bass Lake Station L-2 Surface Dup B		6.1			10.7	0.10 K	0.02 K	0.10
Bass Lake Station L-2 Bottom		5.1			9.9	0.10 K	0.02 K	0.24
Bass Lake Lagoon			130		15.4	0.10 K	0.02 K	2.07
Woodiebrook West Trib at Woodiebrook Rd.				50	30	0.95	0.02 K	0.05 K
Woodiebrook West Trib at Woodiebrook Rd.	5 K	2.0 K	10 K	43	40	1.01	0.02 K	0.05 K
Woodiebrook West Trib at Woodiebrook Rd.	5 K	2.0 K	10	39	24	1.00	0.02 K	0.05 K
Woodiebrook West Trib at Woodiebrook Rd.	5 K	2.0 K	10 K	43.4	32.4	0.97	0.02 K	0.05 K
Woodiebrook East Trib dst Woodiebrook Rd.				40	20	0.47	0.02 K	0.05 K
Woodiebrook East Trib dst Woodiebrook Rd.	5 K	2.0 K	10 K	24	30	0.42	0.03	0.09
Woodiebrook East Trib dst Woodiebrook Rd.	5 K	2.0 K	13	24	25	0.24	0.02 K	0.05 K
Woodiebrook East Trib dst Woodiebrook Rd.	5 K	2.9	12	29	21.9	0.12	0.02 K	0.05 K
Spring Brook @ Interurban				59	30	1.37	0.02 K	0.05 K
Spring Brook @ Interurban	5 K	2.0 K	10 K	51	25	2.00	0.02 K	0.05 K
Spring Brook @ Interurban	5 K	2.0 K	10	44	30	1.98	0.02 K	0.05 K
Spring Brook @ Interurban	5 K	2.0 K	10 K	47.7	31.7	1.95	0.02 K	0.05 K

Notes: K=analyte not detected, value indicates the analytical detection limit J=estimated concentration

Appendix A. Water quality data for the Bass Lake study area, 2002.

Location	TKN P625	Total Phosphorus P665	Total Solids P500	Percent Volatile Solids	Total Dissolved Solids P70300	Total Suspended Solids P530
Reporting Units	mg/l	ug/l	mg/l	percent	mg/l	mg/l
Beaver Creek @ Bean Rd	0.46	52			294	22
Beaver Creek @ Bean Rd	0.20 K	50 K			314	36
Beaver Creek @ Bean Rd	0.20 K	50 K			310	34
Beaver Creek @ Sherman Rd.	0.78	710			300	5 K
Beaver Creek @ Sherman Rd.	1.38	1510			468	18
Beaver Creek @ Sherman Rd.	0.94	530			356	5 K
Chagrin R. @ Woodiebrook Rd	1.20	60			408	5 K
Chagrin R. @ Woodiebrook Rd	0.95	150			328	15
Chagrin R. @ Woodiebrook Rd	0.74	120			238	6
Chagrin R. ust Auburn Rd	1.15	60			254	22
Chagrin R. ust Auburn Rd	0.71	130			232	23
Bass Lake Station L-1 Surface	1.18	60	226	44	234	6
Bass Lake Station L-1 Bottom	1.28	72	226	50	224	7
Bass Lake Station L-1 Surface	0.96	110	280	69	250	25
Bass Lake Station L-2 Surface Dup A	1.17	63	228	48	236	6
Bass Lake Station L-2 Surface Dup B	1.14	62	226	42	228	6
Bass Lake Station L-2 Bottom	1.36	80	226	48	228	9
Bass Lake Station L-2 Surface Dup A	0.97	120	280	62	250	22
Bass Lake Station L-2 Surface Dup B	0.96	120	276	64	256	20
Bass Lake Station L-2 Bottom	1.12	140	280	58	252	23
Bass Lake Lagoon	8.18	1590			284	82
Woodiebrook West Trib at Woodiebrook Rd.	0.30	50 K			254	5 K
Woodiebrook West Trib at Woodiebrook Rd.	0.20 K	60			284	5 K
Woodiebrook West Trib at Woodiebrook Rd.	0.20 K	50 K			242	5 K
Woodiebrook West Trib at Woodiebrook Rd.	0.20 K	49			256	5 K
Woodiebrook East Trib dst Woodiebrook Rd.	0.51	50 K			164	5 K
Woodiebrook East Trib dst Woodiebrook Rd.	0.57	50 K			220	5 K
Woodiebrook East Trib dst Woodiebrook Rd.	0.20 K	50 K			194	15
Woodiebrook East Trib dst Woodiebrook Rd.	0.47	49			202	5 K
Spring Brook @ Interurban	0.41	50 K			222	5 K
Spring Brook @ Interurban	0.20 K	53			270	5 K
Spring Brook @ Interurban	0.20 K	50 K			252	5 K
Spring Brook @ Interurban	0.20 K	182			248	5 K

Notes: K=analyte not detected, value indicates the analytical detection limit J=estimated concentration