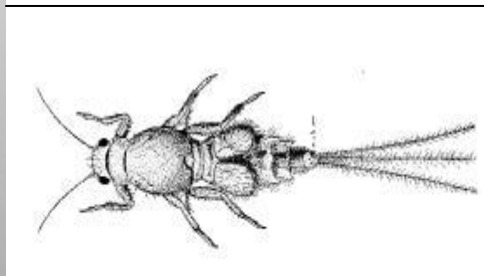
State of Ohio
Environmental Protection Agency

Division of Surface Water

Biological and Water Quality Study of Swan Creek and Selected Tributaries 2006

Watershed Assessment Units 04100009 070, and 04100009 080.

Fulton and Lucas Counties



OHIO EPA Technical Report EAS/2008-12-11

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Ted Strickland, Governor, State of Ohio
Chris Korleski, Director

Table 8. Sewer system overflows authorized by National Pollutant Discharge Elimination System during wet weather in the Swan Creek watershed.

Facility Name	Ohio EPA Permit No.	Receiving Stream	Location
Swanton WWTP	2PB00025008	AI Creek	Main St. Bridge
	2PB00025013	AI Creek	Dodge St. RR Bridge
	2PB00025016	AI Creek	High School Foot Bridge
	2PB00025018	AI Creek	Fulton St.
	2PB00025019	AI Creek	Main St. (apple orchard)
	2PB00025020	AI Creek	E. Garfield (Street Dept.)
	2PB00025024	Mary Wander Ditch	Brookside @ Crestwood
	2PB00025027	Mary Wander Ditch	Church St.
	2PB00025028	Mary Wander Ditch	Hallett @ Broadway
Toledo WWTP	2PF00000042	Swan Creek	Erie St. south of Hamilton
	2PF00000043	Swan Creek	Hamilton &Anthony Wayne Trail
	2PF00000045	Swan Creek	Ewing & Hamilton
	2PF00000046	Swan Creek	Hawley St. south of bridge
	2PF00000047	Swan Creek	Pere West, east of Gibbons St.
	2PF00000048	Swan Creek	Hillside & Chester St.
	2PF00000050	Swan Creek	Fearing St. in Highland Park

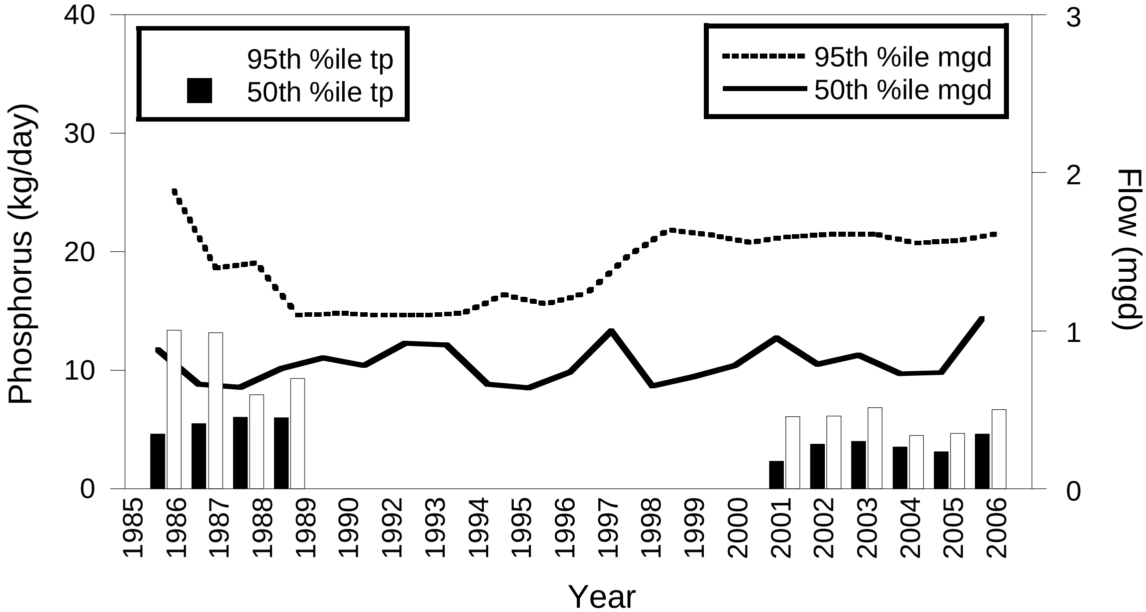

Figure 19. Annual total phosphorus loadings (kg/day) and flow from the Swanton WWTP, 1986 to 2006.

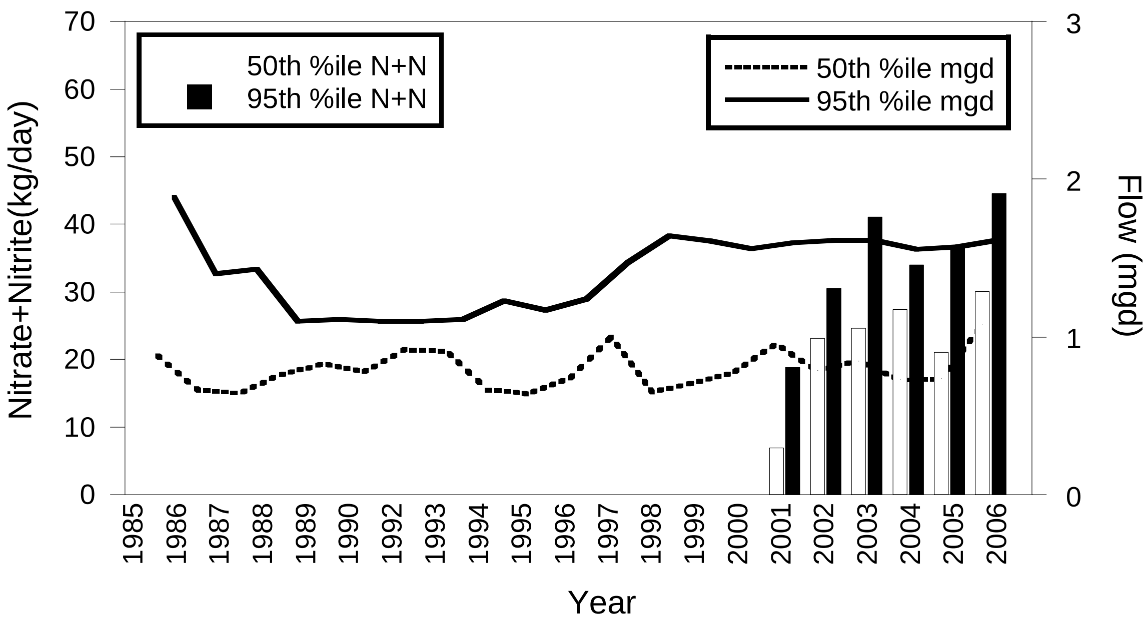

Figure 20. Annual total nitrate+nitrite loadings (kg/day) and flow from the Swanton WWTP. Nitrate+nitrite values only available from 2001 to 2006.

Swanton Reservoir

The monitoring and assessment of “lakes”, including natural lakes and man made impoundments and upground reservoirs, is an important compliment to the study of stream ecosystems. Lakes act as watershed sinks for the upstream loadings of sediment, nutrients, and pesticides. Thus, their assessment can be an important indicator of the combined effects that both point and non point pollution sources have on surface water quality.

Swanton Reservoir is a 25 acre upground reservoir that was built in 1937 to store drinking water and provide a source of recreation. The lake is open to public fishing and boating and a small launch ramp is provided. All watercraft are restricted to either hand power or electric motors. Fish management activities include fall stocking of rainbow trout. This is considered a “put and take” fishery and not a viable year round population. A survey done by Ohio DNR in 2005 indicated that the lake contains mostly a stunted population of panfish (i.e., bluegill, green sunfish). Swimming is not allowed at any time.

Source water for the reservoir is obtained from Swan Creek via pumps located at River Mile 30.85. There is also a ground water well for back up during periods of drought. The reservoir storage capacity is about 100 million gallons. Pumping is suspended during runoff events. Pump is conducted when stream water quality is best. The lake does provide some preliminary treatment by permitting the settling of suspended materials and biological assimilation of nutrients. Lake water that is pumped into the Swanton WTP is treated by lime soda softening and sand filtration. Sludge from the clarifiers and filter backwash is piped to one of three settling lagoons. Supernatant from the lagoons is discharged to Swan Creek at River Mile 30.84 and regulated under NPDES permit # 2IW00252. It was noted that these lagoons were functioning very poorly because they were so full of sludge that not enough retention time was allowed to fully treat the wastewater.

Swanton is classified as a community public water system by the Ohio EPA Division of Drinking and Ground Waters (DDAGW). Standards and monitoring requirements that apply are defined in the Federal Safe Drinking Water Act and Ohio Public Drinking Water Standards. All community public water systems are required to prepare and distribute an annual Consumer Confidence Report that summarizes finished water quality. The only problem documented in the 2005 report was a violation for total trihalomethane. These compounds are suspected human carcinogens and form when chlorine combines with organic matter during the disinfection process.

Swanton Reservoir was assessed by the Ohio EPA during the 2006 field season. All testing was done at the deepest part of the lake in a creek channel not far from the outlet structure. Swan Creek was straightened and the channel relocated when the reservoir was built. During each of three sampling events profiles for temperature, dissolved oxygen, pH, and conductivity were recorded at 0.5 meter intervals and the secchi transparency depth was measured. Samples for lab analysis were collected from the water column at 0.5 meter below the surface and 0.5 meter above the bottom. An additional surface sample was field filtered to determine the chlorophyll a concentration and a vertical tow net was used to collect phytoplankton and zooplankton specimens. A sediment sample was also collected during one of the sampling events.

A variety of parameters were tested in the water column samples, including physical attributes, biochemical oxygen demand, nutrients, metals, and organic compounds. Results were compared to Ohio Water Quality Standards and Drinking Water Standards, although the latter only apply to the finished product distributed for consumption. Statewide Water Quality Criteria (3745-1-07) are established for the protection of aquatic life and Lake Erie Basin Criteria (3745-1-33) are established for the protection of human health and wildlife. Primary Drinking Water Standards (OAC 3745-81) are set for pollutants with serious human health implications and are usually expressed as maximum contaminant levels (MCLs). Some of these pollutants include metals, nitrate, pesticides, and organic disinfection byproducts. Secondary Contaminant Standards (OAC 3745-82) are set for pollutants associated with aesthetic constituents like taste, odor, and color. Some of these pollutants include dissolved solids, iron, and manganese.

Conditions in the Swanton Reservoir were poor at times based on results from the three sampling events. No herbicides, insecticides, or other organic compounds were detected in any of the samples. Most problems were documented in the bottom layer of water (i.e., hypolimnion) during periods of thermal stratification. This layer is essentially isolated from the surface layer (i.e., epilimnion) by a middle layer that creates a density barrier (i.e., metalimnion). The thermocline is the depth at which temperature falls 1°C or more for each 1 m of depth. The thermocline was at a depth of about 3 m on May 23. Dissolved oxygen in the hypolimnion was below statewide criteria established for warmwater habitat and was as low as 0.2 mg/L in the bottom sample. The manganese concentration was 723 µg/L in the bottom sample and this exceeds the secondary drinking water standard of 50 µg/L. The thermocline was at a depth of about 4 m on August 8 and the hypolimnion was anoxic (Figure 21). The water had a strong rotten egg odor (H_2S) and was light black in color. This indicated that anaerobic decomposition was taking place. The ammonia concentration was 13.3 mg/L in the bottom sample and this exceeded the statewide maximum aquatic life criterion. It is doubtful that any higher aquatic life can survive in this zone under these conditions. Manganese was again above the secondary drinking water standard in the bottom sample at a concentration of 1,610 µg/L. Turnover had taken place by the September 19 sampling event and there were no dissolved oxygen or ammonia problems. Turnover occurs when temperatures in the epilimnion cool enough to break the thermocline and allow the water column to mix. Manganese in the surface sample was above the secondary drinking water standard at a concentration of 56 µg/L.

Sediment is important to evaluate in lakes because it has an impact on storage capacity, recreation, water quality, and aquatic life communities. Loss of water storage capacity due to sedimentation can reduce the useful life of a lake and lead to costly dredging. Loss of capacity was not quantitatively measured in Swanton Reservoir. However, little loss was evident based on contour maps and field sonar measurements. It is still possible to distinguish the old creek channel, indicating that it has not filled in nearly 70 years after construction. Sedimentation from bank erosion is controlled by limestone riprap placed along the insides of the dikes to protect them from wind and wave action.

A sediment sample for lab analysis was collected by dredge and emptied into a mixing bowl. A portion of the sample was immediately placed in a container for volatile organic compound analysis. The remainder was homogenized and split into containers to measure physical attributes, nutrients, metals, semi-volatile organic compounds, chlorinated insecticides, and polychlorinated biphenyls (PCBs). The sample consisted of 21.9 % solids and 5.8 % organic carbon. Particle size distribution was 41.4% sand, 7.3% medium/coarse silt, 36.6% very fine/fine silt, 9.7% medium/coarse clay, and 5.0% fine clay.

The quantity and quality of sediment can affect recreation and human health. Too much sediment can cause excessive turbidity and damage lake aesthetics. Direct contact with sediment is a concern because certain chemicals cause skin cancer, such as polynuclear aromatic hydrocarbons (PAHs). No PAHs or other organic compounds were detected in the sample, so this problem should not be an issue. Other chemicals in sediment can bioaccumulate in the aquatic food chain and can trigger sport fish consumption advisories. No fish tissue was collected from Swanton Reservoir during the study. There is a statewide advisory that recommends not eating more than one meal a week of any species caught in Ohio because of mercury concentrations. Women of childbearing age and children 15 and under are most sensitive because high levels of mercury can damage the developing brains, kidneys, and developing fetuses.

Some compounds in sediment are toxic to benthic organisms at elevated levels. Sediment data were evaluated using guidelines established in "*Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems"* (MacDonald *et al*. 2000). The consensus-based sediment guidelines define two levels of ecotoxic effects. A *Threshold Effect Concentration* (TEC) is a level of sediment chemical quality below which harmful effects are unlikely to be observed. A *Probable Effect Concentration* (PEC) indicates a level above which harmful effects are likely to be observed. In addition, the Ohio Sediment Reference Values represent ecoregion background conditions based on data collected at Ohio reference sites.

Copper was found to be extremely elevated in Swanton Reservoir and was measured at 1,610 mg/kg. This concentration is considerably higher than the PEC of 149 mg/kg. The practice of applying copper sulfate to control algae blooms in the reservoir is likely the source. The WTP operator indicated that this management practice is no longer used (Mike Fields, Village of Swanton, personal communication).

The trophic state index (Carlson, 1977) is a means of classifying lakes by predicting algal biomass. The index can be calculated using either secchi depth, chlorophyll a, or phosphorus measurements. Table 9 summarizes trophic state index (TSI) values calculated for Swanton Reservoir. Since the parameters in the calculations are used to predict algal biomass, chlorophyll a is the best predictor. When secchi depth over predicts biomass, it is likely that water transparency is affected by small particles suspended in the water column such as silt and clay. When phosphorus concentrations under predicts biomass, it is likely the limiting growth nutrient.

Lakes with values ≤ 37 are considered oligotrophic, 38-47 mesotrophic, 48-66 eutrophic, and ≥ 67 hypereutrophic. This information is useful when making management decisions because lakes that fall within a particular trophic state exhibit certain characteristics. For example, at TSI values <30 the water is very clear, the hypolimnion has oxygen throughout the year, and coldwater fisheries dominate (i.e., Salmonid). However, at TSI values > 60 the water is turbid, the hypolimnion becomes anoxic, blue greens dominate the algal community and cause taste and odor problems, and warmwater fisheries dominate (i.e., black-bass). A method used by Ohio EPA to determine the final TSI of a lake averages summer chlorophyll a, secchi depth, and spring phosphorus values. Swanton Reservoir is considered eutrophic with a final TSI of 64.5 using this formula ([63.4+72.1+58.1] ÷ 3).

Table 9. TSI values for Swanton Reservoir, 2006.

Date	TSI chlorophyll a	TSI secchi depth	TSI phosphorus
May 23	70.3	71.5	58.1
Aug. 8	63.4	60.7	27.4
Sept. 19	72.1	64.1	52.2

It is apparent that nutrients from Swan Creek and those released from sediment are stimulating algae blooms in the lake. Nutrient criteria for streams in Ohio are currently under development. In the interim, target values presented in "*Association between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams"* (Ohio EPA, 1999) are used as guidelines. Statewide values for wadeable streams (20 mi^2 ≥ drainage area < 200 mi^2) were applied to data obtained from stream samples collected during the study and include a value of 1.00 mg/L for nitrate-nitrite and 0.10 mg/L for phosphorus. Results from six sets of grab samples collected at the intake location June-August show that nitrate-nitrite values are considerably above target. Concentrations ranged from 1.17-14.0 mg/L with a median value of 8.42 mg/L. In contrast, phosphorus never exceeded target values and ranged from 0.044-0.092 mg/L.

Nutrient criteria for lakes in Ohio are also currently under development. Currently, federal ambient water quality criteria recommendations based on the 75th percentile calculated from regional reference sites are available (U.S. EPA, 2000). Table 10 presents the recommended federal criteria for aggregate ecoregion VI, which includes the Huron Erie Lake Plain, and summarizes nutrient based values from surface samples collected in Swanton Reservoir.

Table 10. Recommended federal criteria for aggregate ecoregion VI.

	T-phosphorus (µg/L)	T-nitrogen (mg/L)	chlorophyll a (µg/L)	secchi depth (m)
Reference	37.5	0.78	8.59	1.356
May 23	42	7.47	57.14	0.45
Aug. 8	5	3.16	28.20	0.95
Sept. 19	28	1.60	69.06	0.75

A value equal to one half the lab reporting limit was used in instances where the analytical result was less than the reporting limit. The total nitrogen value is equal to the sum of total nitrogen and nitrate-nitrite nitrogen. The chlorophyll a value is the arithmetic mean of the three replicate samples. Values that are shaded in the table exceeded the recommended federal nutrient criteria. Results show that surface samples exceeded recommended criteria in all instances except summer phosphorus.

Reducing nutrients in runoff from the watershed would be of great benefit to the lake ecosystem, improve the quality of drinking water, and likely reduce the cost of treatment. Row crop agriculture is by far the dominant land use in the source water protection area (74.3%). It will be imperative to implement best management practices to reduce the nutrient load from these areas. There is also a significant portion of land used for livestock production (13.1%). Home sewage treatment systems also contribute to the load and the Village of Brailey is an area not served by central collection and treatment facilities. Other sources include two mobile home parks served by package plants and a combined sewer overflow (CSO) at the Jackson Street lift station in the Village of Delta.

A reduction in nutrients would minimize the impact from nuisance algae blooms. These blooms are likely the cause of anoxic conditions in the hypolimnion during the summer because as algal cells die and sink to the bottom their decomposition depletes oxygen. Algae blooms also affect pH, contribute to taste and odor problems, and are probably the source of organic matter in the formation of trihalomethane compounds during the disinfection process. Another concern regarding algae is the potential for species that produce toxins.

Besides implementing management practices in the source water protection area, it might be necessary to manage nutrients within the lake. Dredging sediment would be one way of removing nutrients from the system. Another possibility would be chemical treatment to precipitate phosphorus from the water column and bind it in sediment. The introduction of herbivorous fish species might be a way to reduce the amount of algae in the water and reduce internal nutrient cycling.

It was surprising that such a strong thermocline developed in a lake as shallow as Swanton Reservoir. Apparently, the lake is protected enough that wind and wave action do not keep the water column mixed. Another management technique that would improve water quality would be to aerate the hypolimnion to increase dissolved oxygen levels. This would eliminate hypoxia and the subsequent release of nutrients (ammonia and phosphorus) and minerals (iron and manganese) from the sediment.

Nutrients in sediment are a concern because they are released into the water column under certain conditions. Ammonia can be directly toxic to aquatic life if levels are elevated in pore water. In addition, bacteria convert ammonia into nitrate under aerobic conditions. Besides being a plant nutrient, nitrate in drinking water is a major concern because it can cause oxygen starvation in tissues if it is fed to pregnant women or babies and can result in a potentially fatal condition known as methemoglobinemia (blue babies). The ammonia concentration in Swanton Reservoir sediment was 270 mg/kg. This is considered slightly elevated when compared to a dataset of results from statewide lake samples collected by Ohio EPA 1993-1995 (n=32). The phosphorus concentration in Swanton Reservoir sediment was 760 mg/kg. This level is considered non elevated when compared to a dataset of results from statewide lake samples collected by NRCS 1988-1989 and Ohio EPA 1993-1995 (n=104).

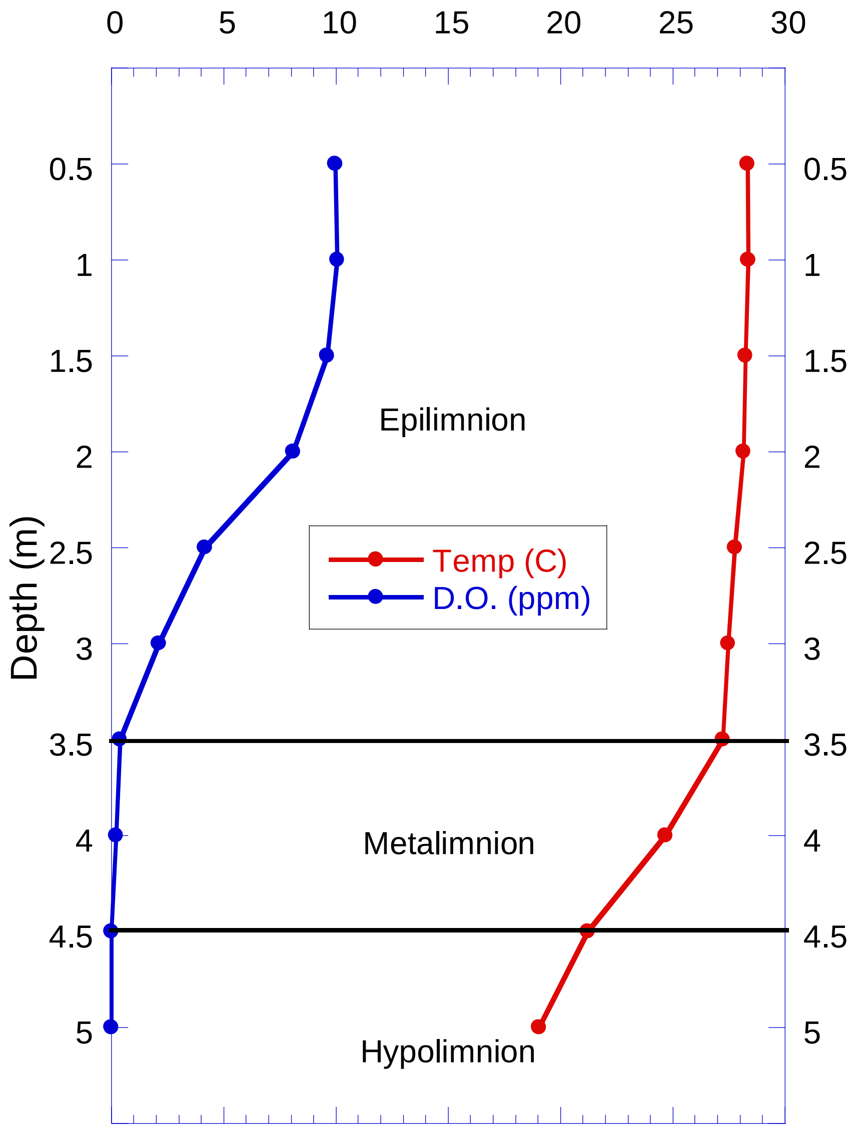

Figure 21. Temperature and dissolved oxygen profile in Swanton Reservoir on August 8, 2006.